



Permian Brachiopods of West Texas, IV

(PART 1 – TEXT)

G. ARTHUR COOPER
and
RICHARD E. GRANT

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Permian Brachiopods of West Texas, IV

(PART 1 – TEXT)

*G. Arthur Cooper
and Richard E. Grant*

ISSUED
FEB 12 1976



SMITHSONIAN INSTITUTION PRESS

City of Washington

1976

ABSTRACT

Cooper, G. Arthur, and Richard E. Grant. Permian Brachiopods of West Texas, IV. *Smithsonian Contributions to Paleobiology*, number 21 (part 1: text; part 2: plates), pages 1923–2607, figure 41, plates 503–662, 1976.—The fourth of a six-part monograph on the Permian brachiopods from several mountain ranges in western Texas, especially the Glass Mountains of Brewster County, this volume contains descriptions of genera and species in the orders Rhynchonellida and Spiriferida. The Rhynchonellida contain 30 genera in the superfamily Rhynchonellacea and 3 genera in the superfamily Stenoscismatacea. The Spiriferida contain 2 genera of Cyrtiacea, 4 of Athyridacea, 9 of Spiriferacea, and 6 of Reticulariacea.

Permian Brachiopods of West Texas, I. *Smithsonian Contributions to Paleobiology*, number 14, 231 pages, 39 figures, 23 plates. Issued 29 December 1972.

Permian Brachiopods of West Texas, II. *Smithsonian Contributions to Paleobiology*, number 15, pages 233–793, figure 40, plates 24–191. Issued 16 April 1974.

Permian Brachiopods of West Texas, III. *Smithsonian Contributions to Paleobiology*, number 19 (part 1: text; part 2: plates), pages 795–1921, plates 192–502. Issued December 1975.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year*. SI PRESS NUMBER 5094. SERIES COVER DESIGN: The trilobite *Phacops rana* Green.

Library of Congress Cataloging in Publication Data

Cooper, Gustav Arthur, 1902–

Permian brachiopods of West Texas.

(Smithsonian contributions to paleobiology, no. 14–15, 19, 21)

Supt. of Docs: SI 1.30: 21

Includes bibliographies.

I. Brachiopoda, Fossil. 2. Paleontology—Permian. 3. Paleontology—Texas. I. Grant, Richard E., joint author. II. Title. III. Series: Smithsonian Institution. Smithsonian contributions to paleobiology, no. 14 [etc.]

QE701.S56 no. 14, etc. [QE796] 560'.8s [564'.8'097649] 72–4218

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Permian Brachiopods of West Texas, IV

G. Arthur Cooper and Richard E. Grant

Order RHYNCHONELLIDA Kühn, 1949

Rostrate, narrow hinged, with functional pedicle; delthyrium open in some Paleozoic genera but more commonly partially closed by deltidial plates. Dental plates usually present, obsolescent in some genera; spondylia rare. Brachial valve with variable hinge plate having socket ridge; crura attached to outer hinge plates or directly to crural base; inner hinge plates variable, divided, or fused; crura variable in type; median septum, when present, commonly supporting V-shaped chamber of variable proportions. Lophophore spirolophous with dorsal cones. "Mantle sinuses much branched with one pair in each mantle" (Ager in Williams et al., 1965: H552). Ornament commonly strongly costate, more rarely multicostate but with trends to costellation, multicostellation, and smoothness in late members of stocks. Impunctate. (Here it should be understood that in an effort to make the order more understandable we have excluded from this definition the punctate members and reference to the metanephridea, which are usually two in modern genera but in the Cryptoporidae there is only one.)

DISCUSSION.—Our study of the rhynchonellids of the Permian of West Texas has not been encumbered by the necessity to prepare serial sections. One of the disadvantages of that method, when specimens are scarce, is that it is impossible to get a good idea of the variability of the interior of the rhynchonellid shell. This has been one of the difficulties in classification. We do not know intimately

how the interior of the rhynchonellid shell is developed and how, after it reaches maturity, it may become modified by adventitious shell or by resorption of previously deposited shell substance. These are matters that could not be brought out by the preparation of many serial sections and the destruction of valuable material.

Most of the West Texas rhynchonellids reveal the interiors in fair condition, and in some of them we have been able to detect considerable variation in characters that are usually regarded as generic. For example, *Trophisina*, new genus, in the adult condition shows a development of the hinge plate from completely divided to completely bridged by fusion of the inner hinge plates. *Phrenophoria* Cooper and Grant, as portrayed by *P. perplexa*, new species, develops a minute chamber in the apex of the brachial valve, a structure not seen in other members of the genus. The septum is a structure not now well understood; it is strongly developed in some genera and seems to be a valid generic character, but in others such as *Pontisia* Cooper and Grant it is relict or absent. Some rhynchonellids that normally lack a median septum occasionally develop a minute one at the apex. Not much help in these matters has been obtained from recent rhynchonellids because there are too few of them. *Hemithyris* d'Orbigny and *Notosaria* Cooper are the only large ones that are fairly easily obtained, but we know of no studies on them along the lines mentioned above.

The rhynchonellids of the Permian of West Texas offer a fair sample of the order. They have some members that seem primitive because they do not have any deltidial plates. These are either

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not developed or completely absorbed. In others their development is spasmodic. Other genera show an advanced trend toward smoothness. Internally the West Texas shells are with or without median septa, and most of the possible changes in hinge plates are present. A trend toward obsolescence of the dental plates is detectable. The crura, on the other hand, seem to be fairly conservative, but in them, too, a developmental trend can be detected.

Rhynchonellids are fairly common in the West Texas Permian. They are not abundant in the Wolfcamp Series but are fairly common in the Leonardian. In some parts of the Word Formation they are abundant. Our treatment of the genera may have lead to some repetition because we have not been able to identify certain of our material with genera prepared by serial sectioning.

CRURA.—The crura are an important element in the interior of the rhynchonellid shell and therefore deserve attention in classification. No attempt has been made to differentiate the types of crura in the Paleozoic rhynchonellids but an attempt has been made to define various types in the Mesozoic. Ager (1965) recognizes 11 different types. Dagis (1968) in a discussion of Mesozoic rhynchonellid genera differentiates 13 different kinds. Cooper (1959) identified 5 types of crura in the Tertiary and Recent rhynchonellids. Inasmuch as the treatment of the crura by the various authors is different, definition and understanding of the various types is not clear. Ager and Dagis distinguish the types mainly by study of serial sections. Cooper, on the other hand, based his descriptions on three-dimensional study of the whole structure. It is unnecessary to section Recent shells and the Tertiary ones are easily excavated.

In our study of the Permian rhynchonellids we have not resorted to serial sections because all the genera have yielded material that can be studied directly. As a matter of fact, the silicified specimens obtained in residues would be very difficult to section serially because of their brittle and friable character. It would take special embedding techniques to make this possible. All this effort seems unnecessary when the actual structures can be obtained and observed for there is less ambiguity in studying them. Orientation is extremely important in serial sectioning. Not all authors section in the same way and this leads to difficulties in interpretation.

We recognize two definite types of crura in the West Texas rhynchonellids. The commonest type is the "falcifer," which also is common in the Mesozoic and is present in Recent brachiopods. The second type is in *Bryorhynchus* and is here termed "mucifer." Another type is recognizable but we regard it as an aberration of the falcifer type and discuss it under that heading.

FALCIFER TYPE.—The falcifer crus is best seen in modern shells in the Basiliolidae where it occurs in *Basiliola*, *Eohemithryis*, *Neorhynchia*, and *Rhytirhynchia*. It occurs in the Tertiary genera *Probolarina* and *Streptaria*. It consists of a moderately to strongly curved blade, crescentic in cross section and the convex side out. The blade is so tilted that the concave sides face each other and the cross section of the blades is vertical. The blades in section may vary from vertical to moderately oblique, with the anterior or dorsal edge of the blade nearest to the side. Attachment to the socket ridge is usually accomplished by means of an outer hinge plate of variable width, wide in some genera but narrow to almost nonexistent in others. *Neorhynchia* has a wide hinge plate, but that of *Probolarina* is narrow.

The small Permian genera, *Petasmatherus*, *Iotina*, *Ptygmactrum*, *Acolosia*, and *Elassonia* have short crura with fairly strong concavity facing medially, usually moderately curved and fairly wide apart. The distal end is not usually tapered but is obliquely truncated so that the free end of the crus nearest the pedicle valve is the more pointed.

Shells of intermediate size—*Allorhynchus*, *Anteridocus*, *Divaricosta*, *Deltarina*, *Cenorhynchia*, *Fascicosta*, *Livellaria*, *Strigirhynchia*, *Tricoria*, and *Wellerella*—usually are similar to the preceding but have a tendency toward a modification seen more commonly in the larger forms such as *Antro-naria*, *Holosia*, *Phrenophoria*, *Tautosia*, and *Pontisia*. This modification consists of an elongation of the crus and its slight rotation toward the interior, so that the concave part faces anteriorly or dorsally and the convex surface faces ventrally and toward the posterior. Two genera of smaller shells also have the crus so oriented: *Hemileurus* and *Aphaurosia*. The crus is definitely falciform but differs from the typical condition in having rotated medially about 90°. Many intermediates exist in which the section of the crus is oblique. Inasmuch as many of the falciform crura (in cross

TABLE 1.—*Summary of generic characters of Rhynchonellacea*
(toticostate = costae extending from back to anterior margin)

<i>Genus</i>	<i>Size</i>	<i>Outline</i>	<i>Development of fold, sulcus</i>	<i>Interareas</i>	<i>Ornament</i>
Acolosia	minute to moderate	elongate-oval	moderate	none	smooth to incipiently costate
Allorhynchus	small to medium	trigonal	moderate	none	toticostate direct
Amphipella	small	subpentagonal	faint, shallow	small or absent	smooth
Anteridocus	small	subpentagonal to rounded to trigonal	weak to moderate	none	anterior incipiently costate
Antronaria	fairly large	transversely subelliptical to subpentagonal	strong	none	strong costae, smooth umbo
Aphaurosia	small to medium	transversely elliptical to subtrigonal	poor	none	anterior weakly costate
Bryorhynchus	medium	subovate to rotund-trigonal	moderate	none	faint costae on fold, sulcus
Cenorhynchia	small to medium	trigonal to pentagonal	moderate	none	semicostate, flanks usually smooth
Chaeniorhynchus	medium	oval to subtrigonal	moderate	none	toticostate
Deltarina	small	trigonal	moderate	none	multicostate
Divaricosta	medium	subpentagonal to subtrigonal	moderate to strong	none	toti- and multicostate
Elassonia	minute to small	subtrigonal to subelliptical	none	small	toti- and multicostate
Fascicosta	small to medium	subelliptical to subtrigonal	moderate	none	toti- and multicostate
Hemileurus	small	elongate-subtriangular	weak	none	semicostate
Holosia	large	elongate-oval	weak	none	toticostate
Iotina	minute	pentagonal	strong	present	few costae but toticostate
Leiorhynchoidea	medium to large	rounded trigonal	moderate	none	costae irregular to strong
Lirellaria	small to medium	subpentagonal to subcircular	moderate	none	costellate
Madarosia	medium	subpentagonal	moderate	none	smooth, anteriorly lamellose
Paranorella	large	rounded to trigonal	moderate sulcate	none	smooth
Petasmatherus	small	trigonal to subovate	weak	present	strongly toticostate
Phrenophoria	small to large	elongate-subtrigonal	moderate	none	semicostate
Pontisia	small to medium	subpentagonal to trigonal	moderate	none	costate, smooth umbo
Ptilotorhynchus	medium	triangular	gentle	none	toti- and multicostate
Ptygmactrum	small	trigonal to elliptical	none	present	strongly toticostate, spines
Strigirhynchia	medium	subtrigonal to subcircular	gentle	none	finely toticostate
Tautosia	medium to large	transversely triangular	strong	none	strong costae, smooth umbo
Tricoria	medium	transversely triangular to pentagonal	fold sulcate	none	toticostate
Trophisina	medium	subcircular to longitudinally suboval	weak	none	toti- and multicostate
Wellerella	medium	subtriangular	strongly costate	none	semicostate

TABLE 1.—*Summary of generic characters of Rhynchonellacea (continued)*

<i>Genus</i>	<i>Profile</i>	<i>Commissure</i>	<i>Dental Plates</i>	<i>Hinge Plate</i>	<i>Median Septum</i>
<i>Acolosia</i>	biconvex	broadly uniplicate	strong	undivided, notched	none
<i>Allorhynchus</i>	unequally biconvex	uniplicate	strong, vertical	divided	none, low myophragm
<i>Amphipella</i>	flatly biconvex	broadly sulcate to uniplicate	short, thin, partly to wholly fused	notched or divided	none
<i>Anteridocus</i>	strongly biconvex	uniplicate	strong, vertical	undivided, deeply notched	short septal brace
<i>Antronaria</i>	unequally biconvex	strongly uniplicate	strong to obsolescent	undivided	none, thick, low myophragm
<i>Aphaurosia</i>	subequally biconvex	uniplicate	short, stout	undivided, notched	none to apical rudiment
<i>Bryorhynchus</i>	branchial valve inflated	uniplicate	short, convergent, obsolescent	divided	septum thick, low
<i>Cenorhynchia</i>	unequally biconvex	uniplicate	strong, vertical	undivided, notched	septum high, thin
<i>Chaeniorhynchus</i>	subequally biconvex	uniplicate	strong	undivided	septum high, thin
<i>Deltarina</i>	narrowly biconvex	uniplicate	thin, convergent	divided	median ridge
<i>Divaricosta</i>	unequally biconvex	uniplicate	short, often fused to valve	undivided	thick, median ridge
<i>Elassonia</i>	flatly biconvex	rectimarginate to weakly sulcate	short, fused	divided	median ridge thick, low
<i>Fascicosta</i>	unequally biconvex	uniplicate	short, convergent	divided	low, slender, variable ridge
<i>Hemileurus</i>	biconvex	broadly uniplicate	thin, long, subparallel	divided	low myophragm
<i>Holosia</i>	unequally biconvex	broadly uniplicate	short, obsolescent	broad, undivided	long, high, strong, thin
<i>Iotina</i>	unequally biconvex	narrowly uniplicate	obsolescent	divided	none
<i>Leiorhynchoidea</i>	unequally biconvex	uniplicate	short, usually obsolescent	divided	strong and thick
<i>Lirellaria</i>	unequally biconvex	uniplicate	thin and short	undivided	none
<i>Madarosia</i>	convexi-plane	uniplicate	short, ventrally convergent	undivided	long, strong, and thin
<i>Paranorella</i>	pedicle valve more convex	sulcate	receding, often obsolete	undivided	long and thin
<i>Petasmatherus</i>	flatly biconvex	rectimarginate to uniplicate	short, fused	divided	none, low myophragm
<i>Phrenophoria</i>	unequally biconvex	uniplicate	strong, vertical	undivided	strong and high
<i>Pontisia</i>	unequally biconvex	uniplicate	strong	undivided	none, myophragm
<i>Ptilotorhynchus</i>	unequally biconvex	uniplicate	present in young, absent in old	divided	myophragm
<i>Ptygmactrum</i>	flatly biconvex	rectimarginate to uniplicate	short, vertical	divided	low ridge
<i>Strigirhynchia</i>	strongly biconvex	gently uniplicate	strong to fused	undivided	high, thin, long
<i>Tautosia</i>	unequally biconvex	strongly uniplicate	strong	undivided	strong, high
<i>Tricoria</i>	unequally biconvex	rectimarginate to uniplicate	thin to obsolescent	divided	high, thin, long
<i>Trophisina</i>	strongly biconvex	uniplicate	strong, convergent	divided to undivided (old)	short, anteriorly threadlike
<i>Wellerella</i>	unequally biconvex	uniplicate	strong, vertical	undivided	apical, rudimentary

<i>Beak</i>	<i>Deltidial Plates</i>	<i>Brachial Umbo</i>	<i>Crura</i>	<i>Tongue</i>	<i>Special</i>
variable	none	swollen	short falcifer	moderately long	nearly smooth
straight to suberect	rudimentary, disjunct	convex	falcifer	long	toticostate
straight	none	convex	short falcifer?	very short	apricatria present
short, usually suberect	rudimentary, disjunct	convex to depressed	falcifer	short to mod. long	flanks weakly costate
straight to suberect	disjunct to conjunct	convex	mod. falcifer	moderately long	median costae of fold depressed
short, nearly straight	conjunct	swollen	mod. falcifer	moderately long	semicostate
erect-incurved	rudimentary to conjunct	swollen	mucifer	short	nearly smooth
short to moderately long, suberect to erect	none	convex	falcifer	moderately long	usually smooth flanks
suberect to erect	none	convex	falcifer	moderately long	completely costate
long, straight	rudimentary, disjunct	convex	short falcifer	short	divided costae
straight to suberect	conjunct	convex	falcifer	moderately long	multicostate
straight	none or rare	sulcate	falcifer	none	minute and multicostate
straight to suberect	absent	convex	falcifer	moderately long	bifurcated costae
nearly straight	small, disjunct	convex	mod. falcifer	moderately long	semicostate
nearly straight, short	disjunct	convex to flattened	mod. falcifer	short to long	completely costate
long, nearly straight	none	convex	falcifer	moderately long	tiny
erect to slightly incurved	none to conjunct	swollen	mucifer	short to long	exterior variable
suberect to erect	disjunct to conjunct	swollen	mod. falcifer	moderately long	costellate, rounded contours
suberect	none or marginal	flattened	falcifer	moderately long	margin lamellose
erect to incurved	none?	convex	mucifer?	dorsal tongue short	smooth, sulcate
nearly straight	small, disjunct	variable, often flattened to sulcate	falcifer	short	small, strong costae
nearly straight-suberect	disjunct to conjunct	variable	mod. falcifer	moderately long	strong median septum
suberect	disjunct to conjunct	convex	mod. falcifer	moderately long	septum absent
short, straight	conjunct, alate	concave	falcifer	short	alate deltidial plates
nearly straight	open or rudimentary	convex	falcifer	absent or short	small, often spiny costae
straight to suberect	open to conjunct	flattened to concave	falcifer	moderately long	dorsal umbo flat or concave
nearly straight to suberect	conjunct	convex to indented	mod. falcifer	short to moderately long	strong costae
nearly straight	none	convex	falcifer	short	anterior emarginate
suberect	small, disjunct	swollen	mucifer	moderately long	obese, low fold, costellate
nearly straight to suberect	conjunct	indented	mod. falcifer	moderately long	apical septum

section) are not vertical but oblique, this is not a great change. Consequently, we record the genera with the horizontal cross section as "mod." (for modified) "falcifer" on the table.

MUCRIFER TYPE.—The mucrifer crus is characteristic of the rhynchonellids hitherto placed under *Leiorhynchus* but now regarded as *Camarotoechia*, sensu stricto, as revised by Sartenaer (1961b). As revealed by *Bryorhynchus*, which is the reference genus for this type of crus, the hinge plate is divided and the crus is narrow and solid, somewhat square in section, long, and curved moderately. Distally it expands slightly and is flattened antero-posteriorly. Distally it is gently concave on the anterior side but flattened on the posterior side. The extremity is pointed, with the sharp end on the inside. Generally the plates diverge at a low angle. This type occurs in *Calvinaria* as well as the genera named above. It also occurs in *Leiorhynchoidea* and *Paranorella*. It is probably in all of the unquestioned *Camarotoechiinae* as listed in the *Treatise on Invertebrate Paleontology* (Williams et al., 1965).

Amphipella is difficult to place in either of the above categories; it is placed here with the falcifer type, but with a query. The crura of *Amphipella* are long but not strongly curved; they are laterally compressed and not all of them show the inwardly facing concavity, but it is there in some of them.

Superfamily RHYNCHONELLACEA Gray, 1848

PETASMATHERIDAE, new family

Minute to small costate Rhynchonellacea having well developed interarea on pedicle valve, deltidial plates absent to rudimentary, disjunct when present. Short dental plates in pedicle valve; brachial valve with widely divided hinge plate, falcifer crura, no median septum.

Genera in West Texas: *Petasmatherus* Cooper and Grant, 1969; *Elassonia*, new genus; *Ptygmactrum*, new genus; and *Iotina*, new genus.

These minute genera probably would never have been detected by ordinary collecting methods. *Petasmatherus* characterizes the Word Formation of the Glass Mountains and is present in the Guadalupe Mountains in the Cherry Canyon Formation. *Elassonia* is abundant in the Road Canyon Formation but *Ptygmactrum* is one of the rarest

genera in the Glass Mountains. *Iotina* is poorly known and occurs in the Sierra Diablo in the lower massive Bone Spring Formation.

Genus *Petasmatherus* Cooper and Grant, 1969

Petasmatherus Cooper and Grant 1969:12.

Small, rhynchonelliform, flatly biconvex; outline bluntly triangular to subovate; commissure slightly uniplicate or rectimarginate, with low fold and shallow sulcus; costae strong, beginning at beaks, becoming stronger anteriorly, crests sharp to rounded, no bifurcation or intercalation, intertroughs sharp to broadly rounded.

Pedicle valve beak sharp, nearly straight, apsacline interareas bounding delthyrium nearly flat transversely, longitudinally flat to slightly convex, orthocline to apsacline. Delthyrium triangular, wide, open, with small, disjunct deltidial plate; lateral pseudointerareas narrow, covered by slight overlap of valves.

Brachial valve with wide, blunt beak, nearly straight across, forming definite hinge line; beak completely external, not curved, and extending into pedicle valve.

Pedicle valve interior with sides abruptly widening anterior to delthyrium; teeth small, elongate, parallel to and attached to sides of valve; dental plates short, supporting teeth, fused in some specimens to sides of valve. Muscle area obscurely marked; adductor scars on slight thickening of floor between dental plates; diductor scars slightly excavated, lying on each side of median line, widening anteriorly. Median plication of exterior shell simulating median ridge.

Brachial valve interior with short, wide hinge plate, slightly to deeply divided in middle; major part of sockets lateral to hinge plate, parallel to hinge line, rather deep, long, wide, minutely corrugated; socket ridge small, inclined over socket; outer hinge plate fairly wide; crural base narrow; crura short, falcifer, strong, projecting forward from lateral edges of hinge plate, slightly diverging anteriorly, straight to slightly curved ventrally, cross section nearly round near bases, laterally flattened at anterior ends; no inner hinge plates. Median septum absent, low, broad median ridge present or absent. Muscle area elongate oval; posterior adductor scars elongate, narrow, widely sep-

arated, nearly parallel to median ridge, diverging slightly anteriorly; anterior adductor scars larger, slightly widening anteriorly, lying along median line.

TYPE-SPECIES.—*Petasmatherus opulus* Cooper and Grant (1969:12, pl. 2: figs. 8–14).

DIAGNOSIS.—Small straight-hinged Rhynchonellacea with well-developed interareas on pedicle valve and crura of the falcifer type.

COMPARISON.—*Petasmatherus* is characterized by its strong costation, barely perceptible uniplication, well-marked interareas, blunt brachial beak that forms a straight hinge line, with resultant narrowing and compressing (antero-posteriorly) of the hinge plate and sockets, its short, nearly straight, stout crura, and lack of a median septum. The strong costae that begin at the beaks distinguish it from *Wellerella*; the absence of a median septum distinguishes it from *Phrenophoria*, *Strigirhynchia*, new genus, and its slightly to deeply divided hinge plate and interareas distinguish it from *Allorhynchus*.

Two small species of different genera are similar to *Petasmatherus* and might be confused with it. *Ptygmactrum*, new genus, is small and transverse, has interareas, and is strongly plicated, but it differs from *Petasmatherus* in having broader angular ribs on the exterior. Small specimens of *Allorhynchus* resemble *Petasmatherus* but they lack interareas in the pedicle valve, have definite deltidial plates, and usually have a well-formed fold and sulcus. Another small brachiopod that may be mistaken for *Petasmatherus* is *Elassonia*, new genus. This little shell has strong interareas like those of *Petasmatherus* but is sulcate and has a strong median ridge.

DISCUSSION.—This genus combines many unusual features in one distinctive entity. The exterior is unusual because of the broad and well-marked interareas bounding the delthyrium. These extend directly to the lateral margins. In the very young the interareas are strongly apsacline but they become more nearly orthocline in adults. The young pedicle valve is flatly convex in lateral profile but fairly strongly arched in anterior profile thus accommodating the nearly flat or concave brachial valve.

The interarea bounds an elongate delthyrium which is open in the young and in young adults but is restricted by small deltidial plates at the

anterolateral extremities. The deltidial plates take the form of small barbs or small triangles with the apex directed medially. They are small and restrict the delthyrium only to the extent of rounding the anterior side of the aperture and producing an elongated tear-shaped foramen. In detached valves the deltidial plates can be seen best at the lateral angles of the delthyrium well posterior to the teeth. A deep trough lies between them and the teeth.

The exterior of the brachial valve is also distinctive, because the young are flat to concave and have a strong median depression. The young are thus anteriorly sulcate but with advancing age the commissure reverts to a uniplicate condition. Generally old shells retain the sulcate umbonal region, a fact that helps to separate this genus from many others. The hinge region of the brachial valve is unusually wide for a rhynchonellid and in old specimens produces small, poorly defined ears. In some old shells the posterior margin is gently concave because of the strong sulcation of the umbonal region.

The unusual and distinctive features of the exterior of this genus are matched by correspondingly distinctive characters on the inside. Many specimens of the pedicle valve are considerably thickened and show some of the features to advantage. The floor of the delthyrial cavity is usually much thickened and in some specimens produces a small platform with abrupt descent to the valve floor. This part probably lodged the pedicle capsule. Anterior to it the broad scar of the muscle field is subflabellate as usual in rhynchonellids, although individual scars are difficult to identify. In old specimens a low myophragm divides the field. This is partly produced by a median rib corresponding to the central interspace of the exterior. The height of this median rib is enhanced further by the development of a low myophragm on it.

The teeth are large and nearly parallel to the hinge region of the brachial valve, thus lying nearly horizontal when observed from the inside, with the beak directed away from the observer. No corrugations were seen on any of the specimens. The teeth are buttressed by small receding dental plates that define short and narrow umbonal chambers. In old shells these slitlike cavities are filled by adventitious shell and the dental plates

are thus rendered nearly unidentifiable.

The cardinalia of the brachial valve are distinctive because of the straightness of the hinge region. The socket plates are elevated, strong, and hang over the sockets. The floor of the sockets is formed by a plate extended laterally far beyond the socket ridge. The sockets are thus wide, narrow, deep, and fairly strongly corrugated when preservation is favorable. The outer hinge plate is exceptionally large and attaches the bladelike crural base and short crus to the socket ridge. The crura are short, have somewhat expanded distal ends which are obliquely truncated, and the anterior end is somewhat elongated. In cross section the crura are convex outward and of the falcifer type. No cardinal process in the form of a rounded boss is present nor does a pit at the beak serve as an adductor attachment. A ridge, continuous laterally with the socket ridge, appears along the posterior side of young specimens; adductor muscles attached to the median part of this ridge. With increase in size and age this ridge became greatly thickened, so much so that some specimens have a large flattened boss occupying the space between the crura. In some medium-grown specimens the cardinal process ridge takes the form of two bosses with a depression between them. These are located on the posterior angle of the outer hinge plate.

Anterior to the cardinalia the shell is often thickened to form a short broad ridge, that, in some specimens, has a short myophragm anterior to it. This indicates the location of the adductor field, although individual scars were not observed.

Petasmatherus depressus, new species

PLATE 503: FIGURE 23

Usual size for genus, subpentagonal in outline subequal in depth, wider than long, with rounded sides and anterior margin rounded but medially indented. Beak nearly straight, delthyrium open, no trace of marginal plates. Interareas narrow. Anterior commissure uniplicate. Surface costate, costae direct, straight. Both valves slightly sulcate, pedicle valve with 2 costae in sulcus but brachial valve with only 1. Flanks marked by 4 costae on pedicle valve and 5 on brachial valve.

Pedicle valve gently convex in lateral profile but flatly domed in anterior profile; sulcus shallow and

defined only from midvalve to anterior margin, flanks moderately convex. Brachial valve gently convex in both profiles and almost exactly like those of opposite valve. Sulcus defined from midvalve to anterior margin, shallow.

Interior not known.

MEASUREMENTS (in mm).—Holotype USNM 154614: length 4.0, brachial valve length 3.8, maximum width 4.4, thickness 2.5, apical angle 95°

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 721j.

DIAGNOSIS.—*Petasmatherus* with an indistinct fold on both valves.

TYPES.—Holotype: USNM 154614.

COMPARISON.—This species is intermediate between *P. recticardinus*, new species, and *P. opulus* Cooper and Grant. It is wider than the former and differently shaped; it is similar in outline to the latter but has definite sulci on both valves, whereas *P. opulus* has a poorly defined fold occupied by three costae in the brachial valve. This is a very rare species known only from the holotype.

Petasmatherus mundus, new species

PLATE 540: FIGURES 15-25

Small for genus, subtriangular in outline; length and width nearly equal; sides rounded and with maximum width anterior to midvalve. Anterior margin truncated; anterior commissure gently to moderately uniplicate. Beak short, suberect; delthyrium mostly open but restricted in anterolateral extremities by vestigial deltidial plates. Surface completely costate, costae numbering 3 on fold, 2 in sulcus, and 5 or 6 on flanks.

Pedicle valve gently convex in lateral profile; broadly and gently convex in anterior profile; median region gently swollen; sulcus shallow and poorly defined, originating near midvalve. Flanks gently convex and with moderately steep slopes.

Brachial valve moderately convex in lateral profile and more convex than opposite valve; anterior profile broadly and moderately convex; umbonal and median regions moderately convex; fold inconspicuous, scarcely visible except at front of valve; flanks gently swollen.

Pedicle valve interior with strong dental plates convergent in ventral direction. Brachial valve in-

terior with divided hinge plate, outer hinge plates moderately wide; socket ridges strong; no inner hinge plates seen on single interior available; crura short, strongly curved, flattened laterally and concave inward and obliquely truncated distally. No septum, but low rounded median ridge.

MEASUREMENTS (in mm).—

	brachial valve length	hinge width	maxi- mum width	thick- ness	apical angle (°)
USNM 702—low					
153472a (holotype)	5.1	4.3	2.0	4.8	3.0
153472b	5.2	4.6	2.1	5.1	3.4
153572c	4.9	4.1	1.9	4.6	2.8

STRATIGRAPHIC OCCURRENCE.—Hess Formation; Cathedral Mountain Formation.

LOCALITIES.—Hess: USNM 709h. Cathedral Mountain: 702—low.

DIAGNOSIS.—Small, closely costate, triangular *Petasmatherus* with length and width nearly equal.

TYPES.—Holotype: USNM 153472a. Figured paratypes: USNM 153472c,d. Measured paratypes: USNM 153472b,c. Unfigured paratype: USNM 153472b.

COMPARISON.—In general form and outline this species suggests *P. nitidus* and *pumilus*, both new, but it is smaller than they are, is more finely ribbed, is less convex, and has a less distinct fold and sulcus than the Road Canyon species. *Allorhynchus venustulum*, new species, although similar is not likely to be confused because it has much rounded and subdued costae and is a much rounder shell. *Petasmatherus mundus* is a very rare species.

Petasmatherus nitidus, new species

PLATE 540: FIGURES 26–55

Small, length and width about equal, outline subpentagonal to subtrigonal; sides rounded, anterior margin gently rounded; valves subequal in depth. Maximum width near midvalve. Anterior commissure gently uniplicate. Beak short, usually suberect; apical angle 80–90°. Surface costate, costae of both valves reaching beaks, narrowly rounded and with intertroughs of about equal width; fold with 5 costae, sulcus with 4, and flanks with 6.

Pedicle valve moderately and evenly convex in

lateral profile, and broadly but very gently convex in anterior profile; beak suberect; umbonal region narrow, gently convex; sulcus shallow, originating near midvalve, extended as short tongue. Flanks narrow, moderately steep. Foramen oval to narrowly elongate; deltidial plates small, anterior, disjunct.

Brachial valve moderately convex in lateral profile, maximum curvature in umbonal region; anterior profile narrowly domed and with precipitous sides. Umbonal and median regions swollen; fold low, gently rounded, defined first at midvalve; lateral bounding costa on each side of fold slightly depressed below level of three median costae. Flanks rounded and steep.

Pedicle valve interior with small teeth and delicate dental plates defining very narrow umbonal cavities. Muscle scars not clearly defined.

Brachial valve with divided hinge plate; socket ridge strong, inclined laterally and overhanging smooth sockets. Outer hinge plates narrow; crural bases narrow; crura curved, laterally broad, convex laterally and distally serrate. Median septum absent. Muscle marks not impressed.

MEASUREMENTS (in mm).—

	brachial valve length	hinge width	maxi- mum width	thick- ness	apical angle (°)
USNM 721j					
154884h (holotype)	6.8	5.6	6.8	4.8	88
USNM 721x					
154883a	7.4	6.3	6.7	5.6	85
154883b	6.8	5.9	6.8	4.7	75
154883c	7.3	6.1	6.8	4.6	85
154883d	6.7	5.8	6.3	4.2	85
154883e	5.9	5.1	5.5	4.0	80
154883f	5.2	4.3	4.8	2.7	85
154883g	4.9	4.1	4.5	2.2	85
154883h	4.0	3.3	3.2	1.8	85
154883i	3.5	2.8	3.0	1.6	80
154883j	8.0	7.0	8.1	5.4	90

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—AMNH 507; USNM 702c, 703d, 706f, 720d, 721j, 721x, 721z, 723a, 724a, 726d, 726e, 736x.

DIAGNOSIS.—Large, compact, elongate, finely ribbed *Petasmatherus* with short beak and low fold.

TYPES.—Holotype: USNM 154884h. Figured paratypes: USNM 154883a,b,j,k; 154884a–g; 154885a–c.

Measured paratypes: USNM 154883a-j. Unfigured paratypes: USNM 154883c-h,l,m; 154884i,j.

COMPARISON.—This species and *P. pumilus* Cooper and Grant (1969) occur in the same formation and may be confused as there is considerable resemblance between them. *Petasmatherus nitidus* can be distinguished by its better defined fold and sulcus, its shorter beak, generally less crowded costae, and usually less elongated outline. Although both species are equal in length and width or have the length slightly greater than the width, the longer beak of *A. pumilus* tends to give it a more elongated appearance.

Petasmatherus opulus Cooper and Grant

PLATE 503: FIGURES 1-20, 22

Petasmatherus opulus Cooper and Grant, 1969:12, pl. 2: figs. 8-14.

Small, flatly biconvex; outline bluntly triangular to subovate or tear-shaped, sides diverging between 65° and 105°, averaging near 90°; commissure gently uniplicate, fold low, sulcus shallow; costae strong, beginning at beaks, becoming higher and wider anteriorly, without intercalation or bifurcation, crests sharp to blunt, intertroughs sharp or rounded, costae numbering 3 or 4 on fold, normally 3, one less in sulcus, 3 or 4 on each flank. Concentric ornamentation absent; weak growth lines visible on some shells, especially near anterior margin.

Pedicle valve gently convex, flanks not reflexed; beak sharp, nearly straight, not attenuate, interarea adjacent to delthyrium transversely flat, longitudinally flat to slightly convex, projecting parallel to plane of commissure in some specimens, normally slanting ventrally to plane. Delthyrium large, triangular base slightly constricted by small, disjunct deltidial plates; lateral pseudointerareas narrow, partly covered by slight overlap of brachial valve. Umbonal region convex; sulcus shallow, originating near midvale.

Brachial valve slightly less convex, with barely perceptible fold originating posterior to midvalve, but umbonal region with shallow sulcus; beak blunt, normally nearly straight transversely, often slightly arched posteriorly, or slightly indented anteriorly on median line; apex of valve external,

not curved into pedicle valve. Flanks narrow, rounded.

Pedicle valve interior with sides abruptly widening anterior to delthyrium, becoming nearly parallel to transverse line of shell, to accommodate straight hinge line of brachial valve; teeth small elongate knobs, parallel to and attached to sides of shell, supported by short dental plates slightly diverging to floor and either free or fused to sides of valve. Floor of beak area slightly built up, probably for insertion of adductor muscles; diductor muscle scars slightly excavated, forming two lobes, one on each side of median line. Median plication built up in interior from sulcus, simulating median ridge.

Brachial valve interior with short, wide hinge plate often thickened on underside and with middle slightly to deeply notched, not completely divided in old shells; sockets lateral to outer hinge plate, deep, wide, parallel to nearly straight hinge line, not denticulate; crura short, slightly diverging from anterior lateral edges of hinge plate, separated from socket ridge by fairly broad outer hinge plate; cural bases stout, rodlike, concave medially, anterior extremities flattened, somewhat concave proximally, curving slightly ventrally; median septum absent; median ridge low when present. Muscle area elongate oval; posterior adductor scars long, narrow, widely separated, slightly diverging anteriorly; anterior adductor scars larger, slightly widening anteriorly, lying on each side of median line of valve.

MEASUREMENTS (in mm).—

	brachial valve length	width	thick- ness	apical angle (°)
USNM 706				
148302a	1.7	1.5	1.9	1.0
148302b	2.4	2.0	2.2	1.1
148302c	3.1	2.5	2.7	1.4
148302d	3.7	2.9	2.9	1.9
148302e	4.2	3.4	3.8	2.4
148302f	5.0	4.1	5.0	2.8
USNM 706b				
148305a (holotype)	5.8	4.9	5.9	3.6
148305b	5.8	4.7	5.4	3.1
USNM 706c				
148307a	3.1	2.3	3.0	1.4
148307b	4.9	3.9	4.8	2.3
148307c	5.0	4.1	4.8	3.0

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, and Appel Ranch members and lens between last two); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—China Tank: USNM 706c, 706z, 726r. Willis Ranch: 706, 706e, 724u, 735c. Lens: 706b. Appel Ranch: 704, 726t. Getaway: AMNH 21, 496, 600; USNM 728, 730, 732.

DIAGNOSIS.—*Petasmatherus* with broadly uniplicate anterior commissure.

TYPES.—Holotype: USNM 148305a. Figured paratypes: USNM 148305b,e,f. Unfigured paratypes: USNM 148305c,d. Figured hypotypes: USNM 148302f, 148305g-m, 148307c, 154609. Measured paratype: USNM 148305b. Measured hypotypes: USNM 148302a-f, 148307a-c. Figured specimen: USNM 148310.

COMPARISON.—This species is the largest and most abundant one known. It is characterized by broadly triangular form and straight hinge. It differs from *P. recticardinus*, new species, in its larger size, indistinct folds on both valves, and the rectimarginate anterior commissure. It differs from *P. pusillus* (Girty) in its more triangular outline, shorter beak, and more strongly developed fold and sulcus.

DISCUSSION.—This species occurs commonly in the Willis Ranch, China Tank, and Appel Ranch members of the Word Formation. It also appears in excellently preserved specimens in the residues from the lens between the Willis Ranch and Appel Ranch members.

Petasmatherus pumilus, new species

PLATE 521: FIGURES 10-21; PLATE 541: FIGURES 31-58

Smaller than average for genus, flatly to moderately strongly biconvex; outline elongate subtriangular, sides diverging between 60° and 100°; commissure gently uniplicate, fold low, flat to slightly arched in transverse section, gently convex in longitudinal profile; sulcus shallow, longitudinally uniformly convex. Costae strong, narrow, crowded, crests rounded, extending strongly to beaks, numbering 4 to 6 on fold, normally 4, one less in sulcus, 4 to 6, normally 5 on each flank; troughs about equal in width to costae, rounded, concentric striae closely spaced; growth lines not normally present.

Pedicle valve moderately convex, with flanks not reflexed; beak acute, straight to slightly curved dorsally; beak ridges blunt; lateral pseudointerareas narrow with slight overlap of valves. Delthyrium triangular, open but slightly constricted by rudimentary deltidial plates at base.

Brachial valve more strongly convex; umbonal area flattened in cross section; beak broad, blunt, apex within pedicle valve. Fold, strongest at anterior margin.

Pedicle valve interior with delthyrium abruptly widened anterior to deltidial plates, forming recess for apex of brachial valve; each side with elongate, knoblike tooth supported by vertical plate reaching floor of valve. Muscle area triangular; shape and location of adductor scars not observed, probably median and posterior in muscle area, as in other species of genus; diductor scars large, anteriorly widening, longitudinally striate.

Brachial valve interior with short, wide hinge plate divided by deep wedge-shaped median notch, bounded laterally by narrow, greatly elongate, anteriorly slightly widening, faintly denticulate sockets; each inner side of socket plate with crus projecting forward from anterior edge; crura strongly curved ventrally, may be twisted, dorsal edges carinate; some valves with low median ridge near apex. Muscle area elongate oval; posterior adductor scars elongate, narrow, diverging slightly toward anterior, their posterior ends widely separate; anterior adductor scars on each side of midline, anteriorly widening, partly bisected by low myophragm.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle (°)
USNM 707e					
148061a	2.3	1.75	2.0	1.1	—
148061b	3.5	2.8	2.7	1.3	—
148061c	4.4	3.8	3.8	2.5	c.86
148061d	5.7	4.8	5.0	3.5	90
148061e	6.6	5.3	5.5	3.5	85
(holotype)					
USNM 706f					
148063a	7.8	6.3	7.1	5.0	83
148063b	3.0	2.4	2.7	1.2	—

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation; Cibolo Formation.

LOCALITIES.—Road Canyon: USNM 703c, 703d,

706f, 707e, 710u, 710z, 712t, 721j, 721y, 721z, 722e, 722g, 724c, 732j, 736x. Cibolo: 738g, 738-l.

DIAGNOSIS.—Elongate *Petasmatherus* with low, poorly defined fold and sulcus, with narrow, crowded costae and long beak.

TYPES.—Holotype: USNM 148061e. Figured paratypes: USNM 148061d,g-l; 148063a; 154766a,b; 154886. Unfigured paratypes: USNM 148061a-c,f,i; 148063b. Figured specimens: USNM 154887a,b.

COMPARISON.—*Petasmatherus pumilus* is characterized by its small size, elongate triangular outline with narrowly diverging sides, wide, blunt brachial beak, very low fold and shallow sulcus, and its strong costae with rounded crests, rounded intertroughs that extend strongly to the apexes. Its size is about the same as that of *P. nitidus*, new species, but that species has a short pedicle beak, and stronger fold and sulcus. This species differs from *P. opulus* Cooper and Grant of the Word Formation in being larger, more elongate, with more crowded costae, and more elongated beak.

Petasmatherus pusillus (Girty)

PLATE 551: FIGURES 35-42

Pugnax? pusilla Girty 1909:319, pl. 24: figs. 18-18b.

Small size, strong costae extending from beak to anterior margin, sulcate brachial valve umbo and interareas bounding the delthyrium are definite characters that relate this small brachiopod to *Petasmatherus*. Compared to *P. opulus*, type species of the genus, Girty's form is more slender, has a narrower fold which is more strongly elevated, and it has 4 costae on the flanks, which is one more than usual for specimens of *P. opulus* of the same size. The beak of Girty's specimen is somewhat damaged but appears to have been shorter than that of *P. opulus*.

STRATIGRAPHIC OCCURRENCE.—"Basal black limestone below Delaware Mountain sandstone." "Low hills, about 2 miles south of El Capitan" = USGS 2967 (green). Two miles south of El Capitan puts this locality in the Bone Spring Formation.

DIAGNOSIS.—Small *Petasmatherus* with narrow, strongly elevated fold and thick valves.

TYPES.—Holotype: USNM 118571.

DISCUSSION.—R. E. King (1931:127) assigned *Pugnax? pusilla* Girty to the genus *Hustedia*. To

this Girty objected strenuously (Girty in P. B. King 1948:22). Our examination of the type specimen fails to reveal beak characters, punctae, or ornamentation features characteristic of *Hustedia*. All the characters of the shell are in harmony with assignment to *Petasmatherus*.

Petasmatherus recticardinus, new species

PLATE 503: FIGURE 21

Usual size for genus, longer than wide, trapezoidal in outline, widest part anterior to midvalve; sides moderately rounded; anterior broadly rounded. Apical angle 90°. Anterior commissure rectimarginate. Beak moderately long; delthyrium open, bounded by broad apsacline interareas. Costae narrowly angular, distant, 5 principal costae on brachial valve forming indistinct fold and middle 4 on opposite valve forming indistinct unit but not depressed; flanks marked by 2 costae on pedicle valve, 1 on brachial valve.

Pedicle valve gently convex in lateral profile, most convex anteriorly; anterior profile broadly and moderately domed with steep sides; umbonal region somewhat concave but median and anterior parts swollen. Median 4 costae forming poorly defined fold fitting opposite to that of brachial valve; flanks very narrow and steep.

Brachial valve with lateral and anterior profiles like those of pedicle valve; hinge wide and straight with prominent shoulders. Umbonal region flattened; costae subparallel on umbonal region; principal 5 costae forming broad low fold; flanks very narrow and steep.

Interior not known.

MEASUREMENTS (in mm).—Holotype USNM 152824: length 4.0, brachial valve length 3.5, maximum width 3.7, thickness 2.8, apical angle 90°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—AMNH 512.

TYPES.—Holotype: USNM 152824.

DIAGNOSIS.—*Petasmatherus* with rectimarginate anterior commissure and obscure folds on both valves.

COMPARISON.—The rectimarginate anterior commissure and lack of well-marked fold and sulcus as well as the distant costae distinguish this species from all others of the genus.

Elassonia, new genus

Small to minute, rhynchonelliform, flatly biconvex, anterior commissure rectimarginate to weakly sulcate; outline transversely subtrigonal to elongate subelliptical. Costae coarse, low or high, sharp or rounded, number increasing anteriorly by bifurcation, implantation or intercalation; concentric striae absent, growth lines weak. Pedicle valve with sharp beak, apsacline; beak ridges bordering interareas; delthyrium narrowly triangular or trapezoidal; deltidial plates normally absent, rarely present as narrow bands along sides of delthyrium; foramen often perforating apex. Lateral pseudointerareas absent: no overlap of valves. Brachial valve with blunt beak; hinge line curved to nearly straight. Umbo sulcate; median sulcus shallow at midvalve and at anterior margin.

Pedicle valve interior with small teeth, projecting forward, located on hinge margin just outside delthyrial edge; dental plates short, supporting hinge teeth, often fused to sides of valve. Muscle area tear-shaped; adductor scars small, median; diductor scars larger, anteriorly widening.

Brachial valve interior with small, longitudinally compressed and deeply divided hinge plate; socket ridges short, strongly elevated; fulcral plates unusually broad and flat, outer hinge plates narrow or nonexistent, sloping to crura, these strong, long, narrow, laterally compressed, slightly curved and obliquely terminated distally; inner edge of falcifer crura forming margin of notothyrial cavity; inner hinge plates not recognized; sockets small, with stout, wide fulcral plates. Median ridge moderately long, low. Muscle field narrowly elliptical; posterior adductor scars narrow, elongate and widely separated, slightly divergent and located at flanks of muscle field; anterior adductor scars larger, anteriorly widening, and lying along midline of the valve, extending farther forward; diductor pit small, shallow and located at apex.

TYPE-SPECIES.—*Elassonia micraria*, new species.

DIAGNOSIS.—Small rhynchonellaceans with well-developed interareas and rectimarginate to sulcate anterior commissure.

COMPARISON.—The small size of the members of this genus exclude it from comparison with most other forms having bifurcating costae. It is very unlike *Divaricosta* Cooper and Grant, which it resembles in shape, by having a much different

interior; it differs from *Deltarina*, new genus, in the structure of the hinge plate and presence of prominent interareas. It is actually most like *Petasmatherus* in exterior form but it is generally smaller than even that small form. *Elassonia* is readily distinguished from *Petasmatherus* by exterior and interior features. The bifurcating and implanting costae of *Elassonia* are distinctive exterior differences, while the cardinalia are distinctive internally.

DISCUSSION.—*Elassonia* is one of several minute rhynchonellids found in the residues. They are usually so small that they would be overlooked in the usual methods of collecting. This one, like the others, is characterized by having fairly broad interareas and a hinge wider than normal in rhynchonellids. Deltidial plates, as usually understood, are not developed, although elongated, elevated plates appear along the delthyrial margin that are similar to those seen in *Cryptopora* among modern brachiopods. The exterior ornament is fairly distinctive, consisting of direct costae radiating from the beak with intercalation of another generation near midvalve. Young specimens have fairly clear evidence of a fold and sulcus but these are lost or difficult to discern in the adult. The umbonal region of the young is narrowly convex and the median costa is larger than the rest. The opposite valve has a corresponding narrow groove at the apex. This does not constitute the fold and sulcus of more mature shells, because in young adults two strong costae bound the above-mentioned depression and widen rapidly anteriorly. Two costae are inserted between these two at about 0.25 mm anterior to the beak and these extend nearly parallel to the anterior margin. At the anterior, other costae are inserted on the outside of these two but within the two stronger costae mentioned above. The corresponding fold region on the pedicle valve is less clear. The median costa in all specimens is the strongest. The next strongest appear beside the median costa and diverge widely. The strongest costae and those that appear to define the most elevated part on the pedicle valve are the second pair of costae that appear anterior to the first. They appear at the anterior to be somewhat outstanding and thus form a visible fold but they correspond to only a part of the area bounded by the strongest ribs on the brachial valve, which bound a broadly sulcate region.

The pedicle valve has the appearance of a minute "*Orthis*" with wide hinge and broad interareas. The teeth are in accordance with this impression because they lie at the anterior angles of the delthyrium and are parallel to the hinge line in their widest direction. They are also notched slightly on the end toward midvalve, where they have small points. The teeth are buttressed by stout, receding dental plates but details of the musculature could not be ascertained.

The cardinalia of the brachial valve are distinctive and much modified from the normal pattern seen in many of the Permian rhynchonellids. The socket ridges are high and erect but much narrowed or shortened in the lateral direction. They form, with the outer hinge plates which are difficult to individualize, a steep face descending to the crura. The sockets are small and are located at the distal end of the socket ridges. The unusual feature of the sockets is the broad and exposed fulcral plate which occurs laterally outside of the socket ridge. In some specimens this plate is broad and thin and must serve as a brace for the crura as well as a platform on which the broad part of the tooth rests, the narrow medial projection being inserted into the socket. The arrangement is similar to that of some orthid brachiopods.

The crura form the margin of the notothyrial cavity and are long and slender. They are laterally compressed, bladelike, not concave toward midvalve, slightly curved, and slightly convergent proximally. The distal end is somewhat expanded when completely exposed, obliquely truncated with the sharp end posteroventrad. The distal end appears to have been ragged or serrated.

The median ridge is basically formed by the infolding of the shell by the median groove representing the initial sulcus of the young shell. This ridge is further thickened by shell substance deposited in the notothyrial chamber about it and proximal ends of the hinge plate. No definite inner hinge plates were identified. In the adult the ridge is short but thick and widens to support the hinge plate.

Elassonia micraria, new species

PLATE 504: FIGURES 1-16

Small, biconvex; outline transverse, subelliptical to subtrigonal, sides diverging between 90° and

135°; commissure variable from faintly uniplicate through rectimarginate to faintly sulcate. Costae coarse, round crested, beginning at beaks, increasing in number anteriorly by bifurcation, numbering 12 to 18 along anterior margin. Concentric striae not observed; growth lines weak but present over most of surface, producing weak, crenulated effect on crests and in troughs of costae.

Pedicle valve gently convex longitudinally and transversely; beak rather short, bluntly pointed, not attenuate, slanting ventrally, not curved dorsally; beak ridges sharp, outlining broad interarea; delthyrium relatively narrow, sides only slightly diverging, perforating apex of beak, producing nearly rectangular elongate foramen; deltidial plates absent or rudimentary; lateral pseudointerareas absent; no overlap of valves. Brachial valve faintly sulcate but more strongly convex than pedicle valve in profile; posterior margin of beak nearly straight, producing nearly straight hinge line, beak external, not curved into pedicle valve.

Pedicle valve interior with sides of valve meeting sides of delthyrium nearly at right angles; teeth broad, flat, projecting forward, top continuous with interarea; dental plates nearly ventical, supporting hinge teeth. Muscle area broadly semioval, occupying about one-half length of valve; details of pattern unknown.

Brachial valve interior with divided hinge plate nearly reduced to merely crural bases and socket ridges, spread wide along nearly straight hinge line; sockets deep, wide, denticulate; crura strong, short, only slightly diverging, slightly curved ventrally; crural bases extending as ridges from underside of outer hinge plates and along undersides of crura; median elevation prominent, short, continuing forward in some specimens as low median ridge for about one-third valve length. Muscle area subcircular; posterior adductor scars elongate, relatively large, diverging anteriorly, lying at posterolateral margins of muscle area; anterior adductor scars larger, median, anteriorly widening as two lobes along median line of valve.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 702c, 703a, 706f, 709c, 719x, 720d, 721o, 723a, 724j.

DIAGNOSIS.—Transverse *Elassonia* with strong costae.

TYPES.—Holotype: USNM 154620d. Figured par-

MEASUREMENTS (in mm).—	brachial			thick- ness	apical angle (°)
	length	length	width		
USNM 702c					
148250a	1.1	0.8	1.1	0.6	c.95
148250b	1.3	1.1	1.4	0.8	c.92
148250c	1.6	1.3	1.7	1.0	102
148250d	1.9	1.7	1.9	1.1	97
148250e	2.0	1.7	2.2	1.1	110
148250f	2.3	2.0	2.5	1.3	105
148250g	2.6	2.3	2.8	1.6	116
154620d	2.9	2.6	3.1	1.5	100
(holotype)					

atypes: USNM 154620a-c,e-k. Measured paratypes: USNM 148250a-g. Unfigured paratypes: USNM 154620b,m-r.

COMPARISON.—*Elassonia micraria* is characterized by its small size, transverse outline, nearly straight hinge line, straight margin, and strong rounded costae that increase in number anteriorly by bifurcation, with the newly added costae weaker and sharper than the ones that begin at the beaks. It most closely resembles the other small new species of the genus, namely, *E. petila*, *E. scitula*, and *E. sobrina*, differing from them in its normally more transverse outline, stronger and more numerous costae with more frequent bifurcations and weaker secondary costae, and its dental plates that are not fused to the sides of the valve. It differs from *Fascicosta longaeva* (Girty) in its much smaller size, more transverse outline and lower convexity, and from *Trophisina fenaria*, new species, by its small size, stronger and fewer costae.

This species resembles *Petasmatherus opulus* Cooper and Grant in its gross shape and outline, but is only about half the size, has more and weaker costae that are not simple but bifurcate, has a curved rather than straight hinge line, simpler and more proximally located hinge teeth, and much reduced fold, sulcus, and deltidial plates.

DISCUSSION.—This species is very abundant at USNM 702c, where it is found in the fine screenings of the residues. It is found in lesser abundance in bioherms at the same level in the vicinity of the Hess Ranch.

Elassonia petila, new species

PLATE 504: FIGURES 17-20

Small, moderately strongly biconvex; outline

elongate, tear-shaped, sides diverging between 70° and 90°; commissure rectimarginate to subtly uniplicate, fold and sulcus not apparent behind anterior margin but fold indicated by elevated median costa, sulcus by corresponding groove. Costae moderately strong, broadly rounded, beginning at beaks, increasing in number anteriorly by bifurcation, numbering 10 to 14 along anterior margin. Concentric striae not observed; growth lines weak, sporadically present, more frequent near anterior margins.

Pedicle valve flatly convex longitudinally, somewhat more convex transversely; beak elongate, bluntly pointed, not attenuate, normally slanting ventrally, not curved dorsally; beak ridges blunt, outlining interareas; delthyrium relatively narrow, sides only slightly diverging, without deltidial plates; foramen subrectangular, perforating apex of valve; lateral pseudointerareas absent; no overlapping of valves.

Brachial valve somewhat more convex, nearly circular in outline; beak bluntly pointed; hinge line curved.

Pedicle valve interior with small hinge teeth projecting anteriorly; dental plates fused to sides of valve. Muscle area subovate, extending about half length of valve; details of pattern unknown.

Brachial valve interior with moderately developed outer hinge plates supported by broadly and deeply depressed lateral thickenings between crura and supported by low brace proceeding forward as low median ridge; sockets elongate, anteriorly widening; crura short, stout, not strongly curved; crural bases extending from underside of hinge plate along dorsal edges of crura. Muscle pattern unknown.

MEASUREMENTS (in mm).—

	brachial			thick- ness	apical angle (°)
	length	length	width		
USNM 702					
148255a	1.4	1.1	1.3	0.6	86
(holotype)					
148255b	1.6	1.2	1.3	0.9	74
148255c	1.7	1.3	1.6	0.8	85
148255d	1.9	1.6	1.7	1.0	85

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—USNM 702, 702a, 702un.

TYPES.—Holotype: USNM 148255a. Figured par-

atypes: USNM 148255b,e,f. Measured paratypes: USNM 148255b-d. Unfigured paratypes: USNM 148255c,d,g-k.

DIAGNOSIS.—Elongate-oval *Elassonia* with fused dental plates and intercalated costae equal in size to the primary ones.

COMPARISON.—*Elassonia petila* is characterized by its small size, tear-shaped outline, slightly folded margin, relatively coarse bifurcating costae that have the new or added costae just as strong as the ones that begin at the beak, its small hinge teeth, dental plates that fuse to the side of the valve, and its broadly depressed hinge plate. It most nearly resembles *E. micraria*, new species, differing in its outline, folding of the margin, uniformly strong but fewer costae, fused dental plates, depressed hinge plate, and more strongly curved hinge line. Its outline is different from that of *E. scitula*, new species, its beak less attenuate, and the bifurcations of its costae more consistent and frequent.

Elassonia scitula, new species

PLATE 504: FIGURES 21-28

Small, flatly biconvex; outline transversely subelliptical to subcircular, sides diverging between 100° and 150°; commissure rectimarginate to very slightly uniplicate; fold and sulcus not apparent on surface. Costae weak to moderately strong, broadly rounded, simple on some shells but normally increasing anteriorly by bifurcation, numbering 8 to 12 along anterior margins. Concentric ornamentation not observed; growth lines weak, irregularly spaced over surface of shell.

Pedicle valve flatly convex; beak short, bluntly pointed, normally somewhat attenuate, slanting ventrally; beak ridges well defined, bordering interareas; delthyrium narrowly and bluntly triangular or subrectangular, open, without deltidial plates; lateral pseudointerareas absent; no overlap of valves.

Brachial valve somewhat more convex; outline approaching semicircular, with greatest width just anterior to hinge; beak broadly rounded, with hinge line gently convex posteriorly.

Pedicle valve interior with teeth projecting forward from platform of interarea; dental plates fused to sides of valve. Muscle area elongate subovate; diductor scars central, elongate; adductor

scars surrounding diductors, slightly widening anteriorly, each terminating anteriorly as sharp wedge.

Brachial valve interior with hinge plate widely divided, depressed, and with inner hinge plates fused to floor of umbo, thereby helping to support crura; median ridge low, extending forward short distance; sockets deep, anteriorly widening, finely denticulate; crura short stout, diverging, only slightly curved ventrally; crural bases strong, extending from underside of hinge plate to ends of crura. Muscle area subovate, slightly depressed; posterior adductor scars narrow, elongate, widely separate from one another, lying at flanks of larger, median anterior adductor scars.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 708u					
148261a	1.0	0.8	1.0	0.4	99
148261b	1.2	1.0	1.3	0.5	125
(holotype)					
148261c	1.4	1.2	1.4	0.5	150
184261d	1.7	1.5	1.7	0.7	113
148261e	1.9	1.6	1.8	0.1	102

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (base).

LOCALITY.—USNM 708u.

DIAGNOSIS.—*Elassonia* with widely elliptical outline.

TYPES.—Holotype: USNM 148261b. Figured paratypes: USNM 148260a-c, 148261a. Measured paratypes: USNM 148261a,c-e. Unfigured paratypes: USNM 148261c-e.

COMPARISON.—*Elassonia scitula* is characterized by its small size, short but somewhat attenuate beak, rounded bifurcating costae with secondary costae just as strong as those beginning at the beaks, its widely divided hinge plate, low median ridge, and especially by its subelliptical outline with the greatest width at the midline, a form which makes the brachial valve widest anterior to its midline. It differs from *E. micraria*, new species, in its outline and its less frequently and consistently bifurcating costae that all are of nearly equal strength. It is distinguished from the other small species, namely *E. petila*, new species, and *E. sobrina*, new species, by its short attenuate beak and posteriorly wide brachial valve.

Elassonia sobrina, new species

PLATE 504: FIGURES 29-33

Small, unequally strongly biconvex, brachial valve more convex; outline subtrigonal to bluntly subpentagonal, sides widely divergent between 70° and 110°; anterior commissure faintly sulcate to rectimarginate. Costae strong, round crested, beginning at beaks, normally with few bifurcations just anterior to beaks and none farther forward, numbering 8 to 10 along anterior margins. Growth lines weak, sporadically spaced.

Pedicle valve slightly convex in lateral profile, broadly and gently convex in anterior profile, attenuate, not curved, strongly apsacline; beak ridges sharp, bordering broad interareas; delthyrium triangular, open, without deltidial plates; foramen perforating apex of valve; lateral pseudo-interareas absent: no overlap of valve edges. Median costa prominent and elevated, forming a low fold.

Brachial valve moderately convex, most convex in posterior half; anterior profile broadly convex; beak bluntly pointed producing slightly curved hinge line. Sulcus broad and shallow, occupied by two intercalated costae.

Pedicle valve interior with small teeth; dental plates reduced, not extending forward as far as hinge teeth. Muscle area not observed. Brachial valve interior with divided hinge plate, delicate, slightly curved crura supported by keel-like crural bases, moderately high but short median ridge.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 702d					
148251a	0.9	0.6	1.1	0.4	92
(holotype)					
148251b	1.3	1.0	1.4	0.6	?
148251c	1.3	1.1	1.6	0.8	?
148251d	1.5	1.2	1.7	0.9	?

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member).

LOCALITY.—USNM 702d.

DIAGNOSIS.—Minute *Elassonia* with intercalation of costae near the beak in one generation only.

TYPES.—Holotype: USNM 148251a. Figured paratypes: USNM 148251b,d,e. Measured paratypes: USNM 148251b–d. Unfigured paratype: USNM 148251c.

COMPARISON.—*Elassonia sobrina* is characterized by its small size and relatively few strong costae that intercalate or branch only near the beaks, then continue directly to the anterior margins. It is closest in most features to *E. micraria*, new species, differing in its smaller size, fewer costae with less frequent branching, which have the secondary ones just as strong as the ones that start at the beak, its less transverse outline and less straight hinge line. Its outline is different from that of *E. petila* or *E. scitula*, both new species, its beak normally longer and its costae straighter.

Ptygmactrum, new genus

[Greek *ptygmatos* (folded) + *maktron* (napkin)]

Small, rhynchonelliform, triangular to transversely elliptical, flatly biconvex, lenticular convexo-concave in profile, valves subequally deep, strongly costate; commissure normally without median fold or sulcus, slightly uniplicate in some species; outline broadly triangular. Costae beginning at or near beaks, becoming very high anteriorly, without bifurcation or intercalation, angular to blunt, occasionally bearing spines; intertroughs similar in width.

Pedicle valve beak sharp, nearly straight, apsacline; interareas adjacent to delthyrium nearly flat; delthyrium triangular, normally open but some constricted at base by rudimentary deltidial plates.

Brachial valve beak blunt, not strongly curved, remaining on outside of pedicle valve; fold usually not developed.

Pedicle valve interior with sides diverging widely anterior to delthyrium, teeth knoblike, supported by short, vertical dental plates reaching valve floor. Muscle area not clearly observed: probably triangular, with apex between dental plates.

Brachial valve interior with hinge plate completely divided by wide, wedge-shaped notch, leaving only narrow socket ridges bounding deep sockets which are anteriorly widening and finely corrugated; no outer hinge plates; crural bases narrow; falcifer crura short, stout, laterally compressed, slightly diverging anteriorly, slightly curved ventrally, inner hinge plates rudimentary. No median septum, but a low median ridge may be present.

TYPE-SPECIES.—*Ptygmactrum extensum*, new species.

DIAGNOSIS.—Small Rhynchonellacea having a few strong costae, strong dental plates, no median septum, and widely divided hinge plate.

COMPARISON.—*Ptygmactrum* is characterized by its small size, strongly costate but gently uniplicate shell, divided hinge plate, and absence of a median septum. The attitude of its beak is similar to that of *Petasmatherus* Cooper and Grant, but *Ptygmactrum* differs in its more strongly and less numerously costate shell without definite fold or sulcus, more transversely triangular outline, curved instead of straight posterior marginal outline, and its widely divided hinge plate. Some species of *Terebratuloidea* Waagen appear to be externally similar to *Ptygmactrum*, but they are much larger, more strongly convex, have the beak curved dorsally and with a circular foramen, and have no dental plates in the pedicle valve. No other genus of rhynchonellid closely resembles *Ptygmactrum*.

DISCUSSION.—Rarity as well as small size is the characteristic that limits the size of the collection of this interesting genus, which is one of the rarest in the Glass Mountains. Its rarity also limits the number of interiors that are found or can be prepared, consequently much is still to be learned about its inner morphology.

The exterior is characterized by the extremely strong and generally angular character of the costae. Another feature is the peculiarity of the costae ending anteriorly in short spinelike processes. The costae are also direct from beak to margin and no bifurcation of them has been detected. The delthyrium is generally open but a few specimens exhibit rudimentary deltidial plates at the anterolateral angles. Broad interareas are another feature that lends distinction to this genus. Finally, the anterior commissure in most specimens is rectimarginate, but the margins are strongly serrated or toothed.

The pedicle valve interior is characterized by small teeth that are buttressed by strong divergent dental lamellae bounding wide and deep umbonal cavities. The brachial valve is characterized by simplified cardinalia. The socket ridges are erect, strong, and define wide and deep sockets that appear to be corrugated. The crural bases are attached directly to the socket ridges without the aid of outer hinge plates. The crural bases are narrow and one specimen shows rudimentary inner hinge plates. These are so slightly developed that

they might be easily overlooked. The crura are widely divergent, short, compressed laterally but concave toward midvalve. The distal extremity is frayed or serrate. No median septum is present in the brachial valve but a low ridge is developed just anterior to the notothyrial cavity in *P. extensum*, new species.

Ptygmactrum acutum, new species

PLATE 505: FIGURES 10, 11

Small, about usual size for genus, triangular, widest at anterior; wider than long; valves subequal in depth; sides straight, forming angle of 91°; interarea apsacline; anterolateral extremities narrowly rounded; anterior margin broadly rounded. Anterior commissure strongly zigzag but probably actually rectimarginate. Foramen large and oval, restricted anteriorly by minute, triangular deltidial plates. Surface strongly costate, 5 costae on brachial valve, 4 on pedicle valve, 2 on each side of deep, angular median depression. Each costa on both valves ending in blunt spine.

Pedicle valve flatly convex in posterior part but gently concave in anterior part in lateral profile; anterior profile flatly convex but convexity obscure by flaring anterior. Sulcus deep and angular, bounded by strongly elevated angular costae, lateral costae angular but lower than median costae; all costae flared strongly in ventral direction.

Brachial valve convex in umbonal region but concave anteriorly when viewed in lateral profile; anterior profile flat-topped, steep-sided, low dome; umbonal region swollen, marked by three costae rising anteriorly to flare in dorsal direction at front margin. Median costa more elevated than others, forming low keel. Flanks steep.

MEASUREMENTS (in mm).—Holotype USNM 154623: length 3.0, brachial valve length 2.6, maximum width 3.4, thickness at midvalve 1.4, apical angle 91°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 720d.

DIAGNOSIS.—Small triangular *Ptygmactrum* with four costae on the pedicle valve and five on the brachial valve, median costa of the brachial valve elevated above the others.

TYPES.—Holotype: USNM 154623.

COMPARISON.—This species is most like *Ptygmactrum angulatum*, new species, but has much more angular costae and the median costa strongly elevated. Further, the anterior spines are more prominent on *P. acutum*. It differs from *P. depressum* and *spiculatum*, both new, in the great angularity of the costae and their anterior flare. Neither of these species has the strongly elevated median costa of *P. acutum*. This is a very rare species and only the holotype is known.

***Ptygmactrum angulatum*, new species**

PLATE 505: FIGURES 1-9, 21-25

Average size for genus, wider than long, broadly triangular in outline, posterolateral margins forming obtuse angle; greatest width anterior to midvalve. Sides narrowly rounded. Anterior margin broadly rounded. Anterior commissure uniplicate; interarea strongly apsacline; interareas narrow; deltidial plates rudimentary. Surface paucicostate, costae broad and angular, 6 on pedicle valve and 7 on brachial valve. Anterior extremity of costae with stubby spines; one specimen with rows of spines on costae at ends of growth lamellae.

Pedicle valve gently concave in lateral profile and broadly convex in anterior profile. Umbonal region slightly convex; sulcus originating at umbo, widening and deepening anteriorly, angular and steep sided. Flanks triangular, gently concave.

Brachial valve flat or nearly so in lateral profile, with moderate curvature on umbo; anterior profile broadly and slightly convex. Fold originating on the umbo, steep-sided, high, strongly angular. Flanks gently convex and broadly triangular.

Pedicle valve interior with knoblike teeth supported by strong and well-defined dental plates. Brachial valve with widely divided hinge plate, strong but narrow socket ridges; other details not preserved.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	width		
USNM 702b				
148316a	2.6	2.2	3.4	105
148316b	3.1	2.8	3.8	92
USNM 703bs				
148317 (holotype)	2.7	2.3	3.8	110

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—USNM 702b, 703bs, 708u.

DIAGNOSIS.—*Ptygmactrum* with angular costae, distant and strong, and gently concave pedicle valve.

TYPE:—Holotype: USNM 148317. Figured paratypes: USNM 148316a-d, 148318, 154622. Measured paratypes: USNM 148316a,b.

COMPARISON.—The costae of this species are much more angular and elevated than those of *P. depressum* and *P. mordicum*, new species. The species most like *P. angulatum* is *P. spiculatum*, new species, which also has a concave pedicle valve. The latter species is larger, with wider costae and stronger spines on the extremities. Its outermost costae are stronger than those of the Glass Mountains species and the beak is more strongly apsacline.

DISCUSSION.—One specimen assigned to this species (USNM 148318) is unusual in having rows of spines along the crests of the costae near the anterior ends. These are produced at the tips and are progressively added with each addition of new growth lamellae.

***Ptygmactrum depressum*, new species**

PLATE 505: FIGURES 16-18

Average size for genus, triangular in outline, width greater than length, maximum width slightly anterior to midvalve. Posterolateral margins forming angle of more than 90°. Sides narrowly rounded; anterior margin broadly rounded. Anterior commissure rectimarginate. Beak elongated, delthyrium long; bounded by narrow interareas and partially restricted by rudimentary deltidial plates; interareas apsacline. Surface costate, costae distant, narrowly rounded, 6 on pedicle valve, 5 on brachial valve.

Pedicle valve gently convex in lateral profile but broadly and moderately convex in anterior profile, more convex in this view than brachial valve. Median region gently swollen; sulcus originating at beak, moderately wide and deep; flanks fairly widely triangular and moderately convex.

Brachial valve flatly convex in lateral profile but very broadly and gently convex in anterior profile. Umbonal region and median area slightly convex. Umbonal region sulcate, sulcus occupied by me-

dian costa or fold which is narrow, low and rounded, scarcely elevated above those on each side. Flanks widely triangular, moderately convex.

Interior unknown.

MEASUREMENTS (in mm).—From locality USNM 716xa specimen 148319 (holotype), and from USNM 721j, 152861, respectively: length 3.5, 2.7; brachial valve length 2.9, 2.0; width 4.0, 3.3; thickness 1.7, 1.0; apical angle 105°, 110°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 716xa, 721j.

DIAGNOSIS.—*Ptygmactrum* with distant, narrowly rounded, fairly low costae.

TYPES.—Holotype: USNM 148319. Figured and measured paratype: USNM 152861.

COMPARISON.—This species is not so wide as *P. mordicum* and *P. extensum* and therefore need be compared only with *P. spiculatum*, new species, from which it differs in its less angular, narrower costae, lower costae and in the absence of thorn-like projections on the anterior ends of the costae.

DISCUSSION.—This species is known from only two specimens, one of which is younger. The younger one retains the rudimentary deltidial plates and has a better preserved beak region.

Ptygmactrum extensum, new species

PLATE 505: FIGURES 31–58; PLATE 520: FIGURES 40–44

About average size for genus, moderately biconvex; outline strongly transverse, length about half of width, widely elliptical; commissure broadly uniplicate, with low fold and shallow sulcus; costae strong, extending from beaks to anterior margins, numbering 3 on fold, 2 in sulcus, normally 3 on each flank, totaling 7 or 9 on brachial valve, 6 or 8 on pedicle valve, crests and troughs rounded, without intercalation or bifurcation. Growth lines strong, giving shell rough, corrugated surface, more closely crowded near anterior margins.

Pedicle valve with beak blunt, but somewhat attenuated; in some specimens delthyrium wide, open, without deltidial plates; interareas flat, conspicuous, extending nearly to lateral margins; hinge line nearly straight; lateral profile evenly convex, without reflexing of flanks.

Brachial valve beak short, blunt; interarea slightly developed; convexity of valve low, even, slightly stronger longitudinally than laterally.

Pedicle valve interior with sides forming nearly straight angle anterior to delthyrium; teeth forming small knobs supported by strong, divergent dental plates reaching valve floor. Muscle field broadly triangular, weakly marked, muscle pattern not observed.

Brachial valve interior with hinge plate divided by wide median notch with narrow socket ridges; sockets deep, widening anteriorly, corrugated; crura not preserved on available specimens; myophragm short, low, rounded. Muscle marks not observed.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle (°)
USNM 703d					
148321a	2.7	2.3	4.7	2.2	ca. 175
148321b	3.4	2.9	7.0	1.8	174
(holotype)					
USNM 703c					
148320	3.0	2.5	5.9	2.1	ca. 170

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 703c, 703d, 721j.

DIAGNOSIS.—Fairly large *Ptygmactrum*, with width twice the length.

TYPES.—Holotype: USNM 148321b. Figured paratypes: USNM 148321a,c-e; 148320. Measured paratypes: USNM 148321a, 148320.

COMPARISON.—*Ptygmactrum extensum* is characterized by its gently uniplicate commissure, wide outline, nearly straight cardinal margin, extraordinarily well developed interareas, open delthyrium without deltidial plates, and its gentle and nearly uniform convexity without reflexed anterior margins nor thornlike projections on the crests of the costae. These features, and its somewhat stronger growth laminae, distinguish it from the other two species of the genus found in the Glass Mountains, *P. mordicum* and *P. spiculatum*, both new species.

DISCUSSION.—The interareas of *P. extensum* are unusually wide and the cardinal margin abnormally straight for a species of rhynchonellid. The other species of *Ptygmactrum* also show similar tendencies although in them they are not so well developed. All the peculiar features of the hinge region seem to be interdependent, with the broad interareas merely the result of the extreme diver-

gence of the side which has produced the nearly straight cardinal margin. Internally the hinge teeth and dental plates are arranged similarly to other species of the genus, according to the pattern typical of species in other genera of Permian rhynchonellids.

Ptygmactrum mordicum, new species

PLATE 505: FIGURES 19, 20

Average size for genus, flatly biconvex, strongly costate, with 7 or 9 costae on brachial valve, 6 or 8 on pedicle valve, beginning at or near beaks, anterior margin of crests slightly reflexed, occasionally bearing small thornlike projections, crests and intertroughs narrowly rounded, no bifurcation or intercalation; outline broadly triangular with posterolateral extremities forming angle of 96° to 107° ; commissure without fold or sulcus. Growth lines conspicuous, producing rough surface on shell, stronger and more crowded toward anterior margins.

Pedicle valve with sharp beak, interareas nearly flat, apsacline; delthyrium triangular, open, slightly constricted at base by rudimentary deltidial plates in some specimens. Sulcus originating at beak, narrow and deep. Flanks broad and gently convex.

Brachial valve moderately convex in lateral profile, broadly and gently convex in anterior profile. Fold formed by median costa, narrow and elevated above others. Flanks broadly triangular, gently convex.

Interior unknown.

MEASUREMENTS (in mm).—Holotype USNM 148315a: length 3.5, brachial valve length 3.0, maximum width 4.7, thickness 1.8, apical angle 107° .

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain and Road Canyon formations.

LOCALITIES.—Cathedral Mountain: USNM 702, 702b. Road Canyon: USNM 735a.

DIAGNOSIS.—Wide *Ptygmactrum* with closely crowded costae.

TYPES.—Holotype: USNM 148315a. Figured paratype: USNM 148315b.

COMPARISON.—This species is similar to *P. extensum*, new species, but is narrower and has stronger, narrowly rounded, and more crowded costae.

Ptygmactrum spiculatum, new species

PLATE 505: FIGURES 26–30

Large for genus, flatly convexo-concave in adult lateral profile, broadly triangular outline, posterolateral margins converging at angle of 90° to 100° . Lateral extremities subangular. Anterior margin broadly rounded, surface flattened. Beak long, delthyrium long and with rudimentary deltidial plates at basal angles. Interareas strongly developed, apsacline. Surface costate; costae angular, 4 on pedicle valve, 5 on brachial valve, each costa strongly angular and terminating in short, thornlike projection.

Pedicle valve with uneven lateral profile, posterior half very gently convex but anterior half bent at wide angle in ventral direction to give concave effect. Anterior profile nearly flat. Umbonal and median regions flatly convex; sulcus originating at beak, angular, deepening anteriorly and with steep and high bounding costae. Flanks somewhat concave and triangular.

Brachial valve very gently convex in lateral profile and very broadly and slightly convex in anterior profile. Umbonal region with faint sulcus occupied by median costa which anteriorly becomes high angular fold, moderately elevated above those on flanks. Lateral slopes of fold wide and steep. Flanks narrow, gently convex and triangular in outline.

Pedicle valve interior with small posteriorly notched teeth, supported by short, almost indistinguishable but thick dental plates. Median sulcus of exterior forming median ridge on interior. Muscle region not resolvable into individual scars. Brachial valve interior with strong socket ridges and divided hinge plate; other details not preserved.

MEASUREMENTS (in mm).—From locality AMNH 512 specimen 152862a (holotype), and from USNM 706b, 148323a, respectively: length 3.7, 2.3; brachial valve length 3.3, 2.0; width 4.3, 2.9; thickness 1.5, 1.5; apical angle 100° , 90° .

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member): Word Formation (lens between Willis Ranch and Appel Ranch members).

LOCALITIES.—Getaway: AMNH 512. Lens: USNM 706b.

DIAGNOSIS.—Fairly large *Ptygmactrum* with 5 strong angular plications.

TYPES.—Holotype: USNM 152862a. Figured par-

atypes: USNM 148323a,b, 152862b. Measured paratype: USNM 148323a.

COMPARISON.—*Ptygmactrum spiculatum* is fairly large for the genus, has strongly angular costae bowing outward, and a somewhat convexo-concave lateral profile. It differs from *P. mordicum*, new species, in its more apsacline beak, less well developed dental plates, lesser number and more strongly angular costae, lesser proportional width, and the tendency toward anterior concavity of the pedicle valve exterior.

DISCUSSION.—Features of note in this species are both exterior and interior. Knowledge of the species is limited by its extreme rarity: only two specimens from each locality. On the exterior the pedicle valve has a tendency anteriorly to become concave by a bending of the front half in a ventral direction. This is accompanied by an anterior thickening of the margin, which is complemented by thickening of the marginal region of the pedicle valve, producing a flattening of the anterior surface along the commissure.

Inside the pedicle valve the teeth are strongly notched on the posteromedian side, making them appear small and knoblike. The musculature could not be resolved, but the sulcus of the exterior is reflected on the inside as a median ridge that serves as a myophragm.

Iotina, new genus

[Greek *iota* (smallest letter in Greek alphabet)]

Minute, pentagonal in outline, beak long, nearly straight, long delthyrium not modified by deltidial plates. Unequally biconvex. Interareas well developed. Anterior commissure narrowly and strongly uniplicate. Surface costate, costae strong, direct, extending from beak to anterior margin.

Pedicle valve interior with thick teeth parallel to hinge edge; dental plates aborted. Muscle region not preserved.

Brachial valve interior with elevated socket ridges; outer hinge plates small; hinge plate deeply divided and with no inner hinge plates. Crura falcifer, short, laterally compressed, concave toward midvalve. No median septum.

TYPE-SPECIES.—*Iotina minuta*, new species.

DIAGNOSIS.—Minute Rhynchonellacea having no dental plates, divided hinge plate, strong fold and

sulcus, and strong direct costae covering the entire surface.

COMPARISON.—This is one of several genera of tiny rhynchonellids characterized by strong costae and prominent interareas on each side of the delthyrium. It differs from *Elassonia*, new genus, in having a narrowly, dorsally folded anterior commissure with prominent fold and sulcus. It also suggests *Petasmatherus* Cooper and Grant, but that genus has only a slight folding of the anterior commissure and it has no fold and sulcus on the exterior. *Ptygmactrum*, new genus, is also a small rhynchonellid but its few angular costae and generally rectimarginate valves separate the two genera. All three of the genera named have well-developed dental plates and thus differ from *Iotina*.

DISCUSSION.—The pedicle valve is notable for the absence of dental plates and for its fairly large teeth. The brachial valve cardinalia are elevated and have strong socket ridges but the outer hinge plates are only moderately wide. The crura form the notothyrial margin, are stout, short, scarcely curved, and laterally compressed. The inner hinge plates are not formed in the one good brachial valve interior available.

The genus is so far known only from a few specimens and is not likely to be collected by conventional means. It should be searched for in any residues from Bone Spring Limestone.

Iotina minuta, new species

PLATE 513: FIGURES 19–29

Minute, strongly pentagonal outline, maximum width somewhat posterior to midvalve, producing shouldered appearance. Sides moderately rounded; anterior truncated. Profile triangular, thickest at anterior margin, anterior commissure narrowly uniplicate. Beak long, straight to suberect, open delthyrium unmodified by deltidial plates. Surface strongly costate, two prominent costae on fold, one in sulcus and three or four on flanks. Costae direct, extending from umbones to front margin.

Pedicle valve flatly convex in lateral profile, moderately convex in anterior profile but median region deeply indented. Umbonal region narrowly swollen, marked medially by strongest costa. Sulcus originating on anterior slope of umbonal region, narrow but deep, and deepening anteriorly, there

bent toward opposite valve in moderately long tongue. Sulcus occupied by median costa from umbo to anterior margin.

Brachial valve nearly flat in anterior profile but with anterior region slightly swollen; anterior profile broadly convex but marked medially by narrow hump formed by fold. Umbonal region flattened and with shallow median sulcus. Fold originating slightly posterior to midvalve, narrow and heightening anteriorly to form prominent projection. Flanks moderately swollen and convex, depressed below fold.

Pedicle valve interior with large teeth and no dental plates. Brachial valve interior with divided hinge plate, no median septum.

MEASUREMENTS (in mm).—Specimens 152818a and b (holotype) respectively: length 4.2, 3.5; brachial valve length 3.4, 2.7; width 4.2, 3.4; thickness 2.2, 2.0; apical angle 90°, 80°.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Limestone.

LOCALITY.—AMNH 591.

DIAGNOSIS.—*Iotina* with long beak, thick anterior, deep sulcus, and high fold.

TYPES.—Holotype: USNM 152818b. Figured paratypes: USNM 152818a,i,j. Measured paratype: USNM 152818a. Unfigured paratypes: USNM 152818c-h.

COMPARISON.—No other species of this genus is known to which this one may be compared. It differs from other minute rhynchonellids described herein by its strong fold and sulcus and lack of dental plates.

DISCUSSION.—This is a rare species which is readily overlooked because of its small size.

Family TRIGONIRHYNCHIIDAE McLaren, 1965

TRICORIINAE, new subfamily

Small Rhynchonellacea with completely costate shell, rectimarginate to uniplicate with broad sulcus in fold, dental plates obsolescent; no deltidial plates. Brachial valve with strong median septum and variable hinge plate.

Genera in West Texas: *Tricoria*, new genus.

Very rare and locally restricted at the base of the Skinner Ranch Formation in the Glass Mountains.

Tricoria, new genus

[Latin *tricolor* (trickster)]

Moderate size, transversely triangular to pentagonal outline, profile oval; valves unequally convex, brachial valve deeper; beak of pedicle valve small, usually acute, straight to suberect. Delthyrium open, no deltidial plates. Anterior commissure rectimarginate to uniplicate but with fold bearing prominent sulcus beginning at umbo. Exterior costate, costae direct from beak to margin.

Pedicle valve with small teeth supported by thin dental plates in young, dental plates becoming obsolescent in adults. Muscle field anterior to delthyrial cavity, triangular in outline, individual scars not discernible.

Brachial valve interior with divided hinge plate having prominent, strong socket ridges overlying corrugated sockets; outer hinge plates broad, concave; crural bases narrow, ridgelike; inner hinge plates variable, usually not united but rarely uniting and producing elongated foramen. Falcifer crura long, slender blades with distal end obliquely pointed on ventral side, laterally compressed but thickest on ventral edge. Median septum long, strongly elevated, bearing short, oblique lateral plates attaching ventral edge of septum to inner side of crural bases, thus producing shallow chamber or septalium nowhere contacting valve floor. Adductor field not clearly visible.

TYPE-SPECIES.—*Tricoria hirpex*, new species.

DIAGNOSIS.—Rhynchonellaceans having a sulcate fold, obsolescent dental plates in the adult, and a shallow apical chamber on the median septum.

COMPARISON AND DISCUSSION.—This genus is most like *Cupularostrum* Sartenaer in its interior details and is undoubtedly related to it. The exterior is, however, entirely unlike that of *Cupularostrum*. Although some species of *Cupularostrum* have the dental plates forming a veneer on the valve wall, this is not the usual condition. The dental plates of *Cupularostrum* are generally fairly thick and are set off by well-marked umbonal cavities. *Tricoria* has well-marked dental plates in the young, but in old specimens these plates are nearly eliminated by filling of the umbonal cavities. Some specimens show no trace of the plates when the shell is seen in interior view.

Inside the brachial valve the cardinalia of both genera are clearly characteristic of the family

Trigonirhynchiidae. Generic differences appear in the formation of the apical chamber which, in *Cupularostrum*, is fairly large, deep, and attached on the floor of the valve at the apex. In *Tricoria* the plates of the chamber are not steeply inclined, are given off from the septum, and extend posterolaterally to join the crural bases, defining a depressed chamber. Inner hinge plates are more sporadically developed in *Tricoria* than in *Cupularostrum*. Most specimens, therefore, have a divided hinge plate, but in others the inner plates meet medially to produce a complete hinge plate like that of *Cupularostrum*. The median septum of *Tricoria* is generally more elevated than in *Cupularostrum*.

Although the differences just mentioned are mostly small, they are important in the aggregate. When the difference between the crural plates of *Tricoria* and *Cupularostrum* are added to the accumulated small differences mentioned above, the distinction between the two genera becomes evident. The crura of *Tricoria* are long, slender, diverge laterally, and are bladelike, with the blades laterally compressed. The crura of *Cupularostrum*, on the other hand, are just the opposite, being compressed in an anterior-posterior direction, curved in a posteroventral direction, and are concave toward the anterior side.

Tricoria is common at only one locality, but occurs sporadically in the lower part of the Skinner Ranch Formation with *Scacchinella*.

Tricoria hirpex, new species

PLATE 503: FIGURES 24-41; PLATE 507: FIGURES 57-71

Size moderate, outline transversely subtriangular to subpentagonal; profile flattened to strongly bi-convex; sides diverging between 60° and 120°, normally near 90°; commissure uniplicate, fold low to moderately high, extending nearly to beak, maximum convexity of profile near anterior margin; sulcus shallow, extending nearly to beak, uniformly convex in longitudinal profile; costae strong, sharp, extending to beaks, numbering 4 to 9 on fold, with the inside costae lower than those forming margin of fold, one less in sulcus, 2 to 5 on each flank. Concentric striae moderately strong; growth lines widely spaced posteriorly, becoming closely crowded near margins.

Pedicle valve moderately convex; flanks not reflexed; beak short, sharp, straight to slightly curved dorsally; beak ridges poorly developed, blunt; lateral pseudointerareas absent: no overlap of valves. Delthyrium triangular, open, without deltidial plates.

Brachial valve deeper and more strongly convex; fold normally with wide shallow median depression; beak blunt, somewhat attenuate, apex within pedicle valve.

Pedicle valve interior with sides of delthyrium widening to receive brachial beak; hinge teeth knoblike; dental plates supporting hinge teeth, extending to floor of valve, normally closely fused to side of valve or invisible. Muscle area triangular, with apex in beak area slightly excavated; adductor scars elongate, median, in posterior part of muscle area between and anterior to dental plates; diductor scars lateral and anterior to adductor scars, anteriorly widening, left and right scars meeting along median line in anterior part of muscle area.

Brachial valve interior with triangular hinge plate, divided by wedge shaped notch; two small plates converge from edges of notch to top of median septum, forming small, usually uncovered crural or apical chamber; sockets long, deep, anteriorly widening, smooth or indistinctly corrugated; crura diverging forward from anterior edges of hinge plate, strongly curved ventrally, dorsal edges carinate; median septum high, thin, short, bisecting posterior part of muscle area, upper edge of posterior end fused with pair of plates forming small V-shaped crural cavity. Inner hinge plates small. Muscle area elongate oval; posterior adductor scars elongate, narrow, widely separated, slightly diverging anteriorly; anterior adductor scars longer, anteriorly widening slightly, lying along median line of valve.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base).

LOCALITIES.—USNM 705a, 715v, 720e, 720g, 726h.

DIAGNOSIS.—Broadly triangular *Tricoria* with broadly sulcate fold on the brachial valve.

TYPES.—Holotype: USNM 154652. Figured paratypes: USNM 148155b-d,f,h,j-m,p. Measured paratypes: USNM 148155a-g. Unfigured paratypes: USNM 148155a,e,g,i,n,o.

COMPARISON.—*Tricoria hirpex* is characterized by its strong costae that extend to the beaks, nu-

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 705a					
148155a	4.1	3.8	4.3	2.3	75
148155b	5.8	5.4	5.8	3.0	73
148155c	7.2	6.3	6.2	4.6	60
148155d	7.4	6.8	8.1	5.4	97
148155e	8.1	6.9	9.2	4.9	95
148155f	9.2	8.2	10.9	7.1	102
148155g	9.5	8.4	11.9	7.0	119
154652	8.2	7.2	10.4	7.2	100
(holotype)					

merous costae on the fold, triangular outline, short but only slightly curved pedicle beak, sulcate fold, and its dental plates that normally are fused to the side of the pedicle beak area. In outline and number of costae this species resembles *Camarotoechia wynnei* (Waagen), differing in its sharper costae, transversely depressed rather than highly arched fold, lower convexity of the brachial valve, and weaker dental plates that are cemented to the sides of the valve. *Camarotoechia plicata* (Kutorga) is much larger and more rotund, and has broadly rounded costae rather than sharp costae as in *T. hirpex*.

The sulcate fold of *Pugnoides mesicostalis* Girty gives this species an appearance like that of *Tricoria hirpex* but Girty's species is much larger, wider, has a larger apical angle, more extended flanks, and the sulcation of the fold is narrower than that of *Tricoria hirpex*. Internally of course the two species are quite different. It is interesting to note that the fold with its depressed median costae also is similar to that of species of *Antronaria* which are so common in the Skinner Ranch Formation.

DISCUSSION.—The distinctive shape of this species is due to the union of the sulcus of the pedicle valve with the sulcate part of the median fold of the brachial valve. This is like the union of two opposite sulci in some of the Mesozoic rhynchonellids or terebratulids which produce an emarginate anterior. In the development of the interior, the young *Tricoria* is generally elongate and strongly triangular in outline. Widening takes place with age.

Tricoria hirpex varies in the shape of the shell and in the ribbing, especially of the fold and sulcus. The normal adult is generally much wider than

long but a small number of adults do not attain the usual width. The fold and sulcus generally contain numerous costae; a few specimens have as few as 4 on the fold, but one has 9.

The hinge plate of the brachial valve generally is divided by a narrow slit but in a few specimens the apical part is closed by the union of the inner hinge plates. In one specimen the inner hinge plates unite anteriorly and produce a hinge part with an elongate foramen, somewhat similar to that seen in *Cupularostrum*. The apical chamber of *Tricoria* is variable but usually is shallow because of shell substance deposited in it. The small oblique plates producing the chamber, which unite with the septum, are thin and short. This combination of plates produces a structure very similar to the septalium common in some of the Mesozoic rhynchonellid genera.

AMPHIPELLIDAE, new family

Small, smooth, broadly uniplicate to sulcificate Rhynchonellacea with dental plates and without deltidial plates. Brachial valve with divided hinge plate and falcifer? crura. Both valves with posterolateral pouches (apricatria).

Genus in West Texas: *Amphipella* Cooper and Grant.

Common in one area in five loose blocks at the base of the Cathedral Mountain Formation; very rare in the Road Canyon Formation nearby.

Genus *Amphipella* Cooper and Grant, 1969

Amphipella Cooper and Grant, 1969:11.

Shell small, smooth, rhynchonelliform, biconvex, broadly uniplicate to shallowly sulcificate; outline elongate to transversely subpentagonal; posterolateral slopes with small open slots perpendicular to plane of commissure, leading into apricate sinuses. Growth lines weak, strongest near anterior margins. Pedicle valve moderately strongly convex; sulcus shallow, barely visible anterior to margin; beak short or long, attenuate, straight or curved dorsally; beak ridges blunt, ill-defined; interareas small or absent; lateral pseudointerareas absent; delthyrium triangular, open, without deltidial plates. Brachial valve flat medially, abruptly deflected toward commissure; beak bluntly pointed,

not strongly curved; fold low, obscurely outlined, with broad shallow median depression.

Pedicle valve interior with small teeth, projecting anteriorly, supported by short dental plates, partly or completely fused to sides of valve; posterolateral margin invaginated to form deep, narrow-necked sulcus open to outside of shell. Muscle area weakly impressed; position of adductor scars not certain; diductor scars small, anteriorly widening, forming heart-shaped mark in posterior quarter of valve.

Brachial valve interior with hinge plate small, deeply notched or divided, medially unsupported; crura short, diverging anteriorly from edges of hinge plate, falcifer?, slightly curved ventrally, supported by crural bases extending from underside of hinge plate; sockets elongate, anteriorly widening, corrugated; median line of valve normally without septum, rarely with low ridge; posterolateral margins invaginated to form brachial halves of apicatria. Muscle area weakly impressed, short and wide, with several narrow lobes widening anteriorly; details of pattern uncertain.

TYPE-SPECIES.—*Amphipella arcaria* Cooper and Grant (1969:11, pl. 1: figs. 13–21).

DIAGNOSIS.—Small, smooth rhynchonellaceans having deep spoon-shaped invaginations of the shell on each side of the beak (apicatria).

COMPARISON.—*Amphipella* is characterized by its small size, pentagonal outline, sulcificate commissure, lack of deltidial plates and lateral pseudointerareas, divided or deeply notched hinge plate, lack of a median septum or brace, normal absence of a median ridge, thin, partly fused dental plates, and especially by its deeply recessed posterolateral slopes producing small subspherical sulci that open to the outside through narrow slots running perpendicular to the plane of commissure. We are calling each of these apicatrium (from Latin *apricus*, open, and *atrium*, vestibule); they are similar to but not the same as the “marginal pouches” of *Uncites* DeFrance (*Winterfeldia* Spristersbach; see Hall and Clarke, 1894:114, fig. 103, and Jux and Strauch, 1966) which are longer and cling to the sides of the shell, but do not open to the exterior through narrow slots. Most nearly similar are the “parathyridia” of the Pennsylvanian genus *Cardiarina* Cooper (1956a:527). These less fully formed channels appear to have formed similarly by indentation of the posterolateral margins, but they have not developed to the stage seen in

Amphipella where the opening to the outside is narrowly constricted and pouches are formed internally.

DISCUSSION.—The most distinct feature of *Amphipella* is the presence of the apicatria, one on each side of the beak, on the posterolateral slopes. These recesses form by invagination of the margins of both valves, and the complete sinus on each side is equal in each valve and a mirror image of its counterpart. Small juvenile shells do not have these sinuses; they form about 0.75 mm from the beak along the lateral slopes, so shells must be about 1.5 mm wide before they begin to develop. Actually, the apicatria do not begin to form until the shell is nearer 2 mm across and their sites are already present. The margins of shells smaller than 2 mm are normal, without any true invagination, only a pair of very small notches, one at the site of each sinus. As the shell gets larger the apicatria begin to form, starting as very shallow recesses and extending deeper with increasing size. In smallest shells in which they have begun to form they are mere pits; in larger shells they are recesses without constricted necks: the opening and the recess are about equal in width. The apicatria in larger shells increase in width as well as length, and become wider than their external openings, producing the appearance of constriction of the openings. The external openings of the apicatria do not change their size after the original recess is formed.

The function of the apicatria is not certainly known. Their construction and position are such that they must open along their plane of commissure when the valves open, thus providing a pair of posterior openings for the shell. Therefore we speculate that the apicatria were involved in the feeding of the animal, and acted as channels for incoming currents.

Amphipella arcaria Cooper and Grant

PLATE 512: FIGURES 1–47

Amphipella arcaria Cooper and Grant, 1969:11, pl. 1: figs. 13–21.

Biconvex, boxlike; outline sharply and nearly equilaterally pentagonal, sides diverging between 75° and 115°; commissure broadly and shallowly sulcificate; fold low and sulcus shallow, apparent

only at anterior margin, depression in fold present on shell surface; posterolateral slopes with small open slots perpendicular to plane of commissure, leading into apricatria. Costae and concentric striae absent; radial fibers faintly visible; growth lines weak, strongest near anterior margins.

Pedicle valve moderately convex, margins abruptly bent toward commissure; beak short, occasionally slightly attenuate, straight to slightly curved dorsally; beak ridges blunt, poorly defined; interareas small or absent; lateral pseudointerareas absent; no overlap of valves; delthyrium triangular, open, without deltidial plates. Brachial valve flatly convex medially, sides bent abruptly toward commissure; beak bluntly pointed, somewhat attenuate in some specimens, not strongly curved; fold low, with broad shallow median depression.

Pedicle valve interior with sides widely diverging anterior to delthyrium; lateral margins deeply invaginated to form pedicle half of deep, narrow-necked channels, open to outside of shell; teeth small, projecting forward from sides of valve just anterior and lateral to delthyrium; dental plates short, thin, nearly vertical, partly or completely fused to sides of valve. Muscle area weakly impressed; position of adductor scars uncertain, probably near dental plates; diductor scars small, anteriorly widening, forming heart-shaped mark extending about one-fourth length of valve.

Brachial valve interior with small hinge plate, divided or deeply notched; sockets wide, shallow, anteriorly expanding, finely and weakly corrugated; crura short, slender, slightly diverging anteriorly from edges of hinge plate, slightly curved ventrally, laterally compressed, supported by crural bases extending from underside of hinge plate and along dorsal edges. Median ridge low, rarely present, margins of posterolateral slopes deeply invaginated to form brachial halves of each apricatrium. Muscle area weakly impressed, short and wide, with several narrow lobes slightly widening anteriorly; details of pattern uncertain: proximal lobes probably belong to anterior adductor scars, lateral lobes to posterior adductor scars.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain (base).

LOCALITIES.—USNM 702, 708u.

DIAGNOSIS.—Pentagonal *Amphipella* having a box-like shape.

TYPES.—Holotype: USNM 148098a. Figured par-

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 708u					
148098a'	1.8	1.6	1.8	0.9	74
148098b'	1.9	1.5	2.0	0.9	88
148098c'	2.3	2.0	2.4	1.0	90
148098d'	2.5	2.2	2.4	1.3	91
148098e'	3.0	2.7	3.0	1.5	105
148098f'	3.5	3.2	3.3	2.3	103
148098g'	3.8	3.5	3.6	2.3	110
148098h'	4.0	3.7	4.0	2.2	112

atypes: USNM 148098b,d,e,a',d'. Figured hypotypes: USNM 148098f,g'; 154700a-l,n,o; 154702a,d,f,h,i. Measured hypotypes USNM 148098a'-h'.

COMPARISON.—*Amphipella arcaria* is characterized by its nearly equilaterally pentagonal outline, short pedicle beak, sulcinate commissure, boxlike shape with the greatest part of each valve flatly convex and the edges near the margins abruptly bent to the plane of the commissure, and relatively large apricatria. It is larger, more transverse than *A. attenuata*, new species, less strongly convex, and has a shorter pedicle beak and larger sinuses.

DISCUSSION.—In spite of the unusual feeding adaptation of *Amphipella*, this genus is basically a rhynchonellid, a fact manifest in the morphology of both valves. *Amphipella* is unusual among Paleozoic rhynchonellaceans in having a smooth exterior, and the folding of the anterior commissure is exceptional for a rhynchonellacean. The brachial valve has a broad fold that is medially broadly sulcate to produce the peculiar folding of the anterior commissure.

The stratigraphic occurrence of this species needs explanation. The majority of the specimens are from USNM 708u, which represents the yield from five loose blocks found about half a mile east of Split Tank, between the first bioherms of the *Institella* zone (USNM 702 inst) and the basal small-pebble conglomerate that was designated the base of the Leonard by P. B. King (=base of Cathedral Mountain Formation). These loose blocks were found together, but no others were found subsequent to the main discovery, although several exhaustive searches were made. These blocks probably represent parts of a single lens, including a mass of dead shells swept together. Oddly, the general assemblage constituting the fauna of these blocks (USNM 708u) is not known elsewhere, and

most of the species in it are unique to this group of blocks (see faunal list of USNM 708u).

Amphipella attenuata, new species

PLATE 512: FIGURES 48, 49

Small for genus, biconvex; outline elongate sub-pentagonal, sides diverging about 60°; commissure uniplicate; fold low, sulcus shallow, expressed only at anterior margin; posterolateral slopes with small open slots perpendicular to plane of commissure, leading into apiculate sinuses. Costae and concentric striae absent; growth lines weak, strongest near anterior margins.

Pedicle valve moderately and evenly convex; beak long, somewhat attenuate, gently curved dorsally; beak ridges blunt, obscure; interareas very small; lateral pseudointerareas absent; delthyrium wide, long, triangular, open, without deltidial plates. Brachial valve not known.

Interior with small hinge teeth; dental plates incompletely fused to sides of valve; lateral margins invaginated to form small, narrow necked apicatria. Muscle pattern unknown.

MEASUREMENTS (in mm).—Holotype USNM 148102: length 1.5, maximum width 1.3, thickness (?), apical angle 60°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 703a.

TYPES.—Holotype: USNM 148102.

DIAGNOSIS.—Long, slender *Amphipella*.

COMPARISON AND DISCUSSION.—*Amphipella attenuata* is characterized by its small size, narrow elongate pentagonal outline, long pedicle beak with large delthyrium, nearly uniform convexity without abrupt marginal bends, and its small apiculate sinuses located relatively far forward on the posterolateral slopes. It differs from the type species, *A. arcaria* Cooper and Grant in these features. Unfortunately only one valve of *A. attenuata* is available; perhaps when more are discovered further differentiating features will be observed.

Family WELLERELLIDAE Licharew, 1956

Subfamily WELLERELLINAE Licharew, 1956

Smooth, semicostate to completely costate Rhyn-

chonellacea with plicate anterior commissure; pedicle valve with strong dental plates; brachial valve with undivided hinge plate supported by elevated median septum; crura falcifer to modified falcifer.

Genera in West Texas: *Wellerella* Dunbar and Condra, 1932; *Phrenophoria* Cooper and Grant, 1969; *Holosia*, new genus; *Tautosia* Cooper and Grant, 1969; *Cenorhynchia*, new genus.

Genus *Wellerella* Dunbar and Condra, 1932

Medium, subtriangular, unequally biconvex, uniplicate; fold and sulcus strongly costate, flanks weakly to strongly costate; costae expanding anteriorly, rarely increasing in number, normally beginning 1 or 2 mm anterior to apexes of beaks. Concentric ornamentation weak, growth laminae rarely visible except near shell margins. Pedicle beak sharp, straight or curved; delthyrium normally anteriorly closed by small deltidial plates, producing oval, submesothyriddid foramen. Brachial valve beak blunt, apex inside pedicle valve, covered by deltidial plates.

Pedicle valve interior with strong nodular teeth, supported by vertical dental plates from floor of valve. Muscle area beginning at anterior ends of dental plates, extending from a third to a half valve length, its boundary subparallel to shell margin; adductor scar single or bilobed, elongate to round, surrounded by two wide diductor scars.

Brachial valve interior with triangular, undivided hinge plate bounded laterally by groove-like, laterally expanding sockets and supported by high or low, short median septum extended anteriorly as a low ridge in some specimens. Crura modified falcifer, diverging anteriorly, strongly curved toward pedicle valve, often twisted as much as 90°, usually longitudinally and dorsally carinate. Septum rudimentary. Muscle area small, transverse to elongate, bisected by median ridge, anterior adductor scars relatively large and median, posterior adductor scars small, elongate, diagonal, contiguous with part of anterior scar, or separated by low ridges.

TYPE-SPECIES.—*Wellerella tetrahedra* Dunbar and Condra (1932:291, pl. 37: figs. 11–16).

DIAGNOSIS.—Variable, semicostate rhynchonellaceans having dental plates, undivided hinge plate, and apically confined median septum.

COMPARISON.—*Wellerella* is distinguished by a

combination of characters of the exterior and the interior of the brachial valve. The most distinctive feature is the undivided hinge plate supported by an apical septum. Thus defined, *Wellerella* is externally similar to a number of semicostate rhynchonellids of the Pennsylvanian and Permian. It differs from *Cenorhynchia*, new genus, in having costate flanks and only an apical septum, the other genus having smooth flanks and a long median septum. *Pontisia* Cooper and Grant differs in having an undivided hinge plate but no median septum, apical or otherwise. Some species of *Phrenophoria* and *Tautosia* Cooper and Grant are homeomorphs of *Wellerella* but *Phrenophoria* contains a long median septum. *Aphaurosia*, new genus, is like *Wellerella* internally but the costae are finer and more even, giving a characteristic external appearance to the shell.

DISCUSSION.—Identification of *Wellerella* at present is difficult and, as with many other brachiopods, if the interior cannot be satisfactorily established, it is impossible to put a correct generic name to a species. Furthermore, by the usual serial sectioning methods an apical septum of small proportions can be overlooked. The type species of *Wellerella* is said to have an apical septum under the hinge plate, yet the one published serial section of the species shows no median septum; it may have been buried in the solid tissue of the brachial umbo and not be visible in an inked diagram. Two other species figured by Dunbar and Condra show the septum well in only one slice.

Stehli (1954:334) interpreted *Wellerella* as possessing a highly variable septum or none at all. His species, therefore, vary from having no septum, as in *W. longicosta*, to *W. magnisepta* in which this structure is conspicuous. It is difficult, however, always to be consistent in interpreting what is an "apical septum." Even the strictest attention to the septum of the brachial valve as a prime generic character cannot avoid simultaneous trouble with the ornament. This is true regardless of the combination of interior characters used. *Pontisia* appears to be as composite a group as *Wellerella* or *Phrenophoria* when their exteriors are compared. On the other hand sorting by exterior produces similar difficulties. We have therefore used the interior details as our chief generic guides.

Examination of Pennsylvanian species currently assigned to *Wellerella* indicates similar difficulties

because some of the wellerelliform shells have long and erect median septa, whereas others conform more strictly to the present generic diagnosis. Some forms that are wellerelliform but yet have occasional intercalated costae appear to be referable to camarotoechiid stocks.

The Glass Mountains species most characteristic of *Wellerella* is *W. girtyi*, new species, one of the most abundant rhynchonellids of the Word Formation. The species is not so rotund as the type species of *Wellerella* and is more robust and coarsely costated. It has the characteristic extremely short median septum in the apex. The hinge plate is narrow and the socket ridges are strong and elevated, bounding wide corrugated sockets. The outer hinge plates are short but the inner hinge plates are wide and stretch across the delthyrial cavity like a membrane. The suture may be visible or not, or the median junction in some specimens is antichinal. The crura are wide, concave toward midvalve, and lie somewhat oblique to the horizontal. The oblique distal edge is serrated. Although this species answers to the definition of *Wellerella*, it does not accord strictly with the type; this is true of most of the species we have assigned to the genus.

Wellerella? *bidentata* (Girty)

Pugnax bidentata Girty [part], 1909:318, pl. 21: figs. 20–20c [not pl. 24: figs. 17–17c, = *Wellerella swallovia* (Shumard)].

Not *Pubnoides bidentatus* (Girty), R. E. King, 1931:107, pl. 34: fig. 1.

One peculiar little specimen is the only one of its kind known. The species has been widely identified, but every example we have observed has been incorrectly determined. Rhynchonellids with two costae on the fold and one in the sulcus are uncommon, although several are described in this paper and some are known to us which we have not included here. Several specimens in the collection suggest Girty's species, but they are from widely scattered levels and from the Glass Mountains or elsewhere. Usual occurrences consist of single specimens, leading to the suspicion that they are aberrant. This may be true also of *W.?* *bidentata*. At any rate we have not found any other specimens of the species in the Cherry Canyon Formation or any other unit.

Wellerella? bidentata was found with *Bryorhynchus nitidum* and *Wellerella girtyi*, new species, and therefore must have come from the Cherry Canyon Formation as explained under discussion of *B. nitidum*. Bicostate forms occur fairly commonly as aberrancies in normally tricostate species. This is true also of narrowed and elongated forms. The rarity of *W. bidentata* may therefore be due to the fact that it is a deformed or aberrant form that lived under adverse and crowded conditions.

Types.—Holotype: USNM 118568.

Locality.—USGS 2920 (green).

Wellerella girtyi, new species

Medium size for genus, biconvex, flattened to globular; outline ovoid to bluntly triangular, sides diverging between 85° and 115°; profile lenticular to subtrigonal; commissure uniplicate; fold low, beginning 4 to 6 mm anterior to brachial beak, profile evenly convex from beak to anterior margin, occasionally slightly flattened where costae begin; sulcus correspondingly shallow, beginning 6 to 8 mm anterior to pedicle beak, rather uniformly convex from beak to anterior margin. Costae moderately high and sharp on fold and pedicle flanks, lower and more blunt in sulcus and on brachial flanks, beginning 3 to 6 mm anterior to beaks, numbering 2 to 4 on fold, normally 3, one less in sulcus, 3 to 5 on flanks. Concentric ornamentation faint; growth lines light, present on some specimens.

Pedicle valve moderately convex, slightly inflated in smooth area near beak, costae of flanks prominent, slightly reflexed in some specimens; beak sharp, somewhat attenuate, curved dorsally, beak ridges blunt; lateral pseudointerareas normally absent. Delthyrium triangular, base covered by two strongly arched deltidial plates; apical part open; foramen elongate oval. Brachial valve more strongly convex than pedicle valve; smooth part of posterior slightly flattened longitudinally, evenly rounded transversely; apex of valve within pedicle valve, covered by deltidial plates.

Pedicle valve interior with delthyrium widely expanding anterior to deltidial plates; teeth elongate parallel to valve edge, supported by strong vertical dental plates reaching floor of valve. Muscle area beginning just anterior to dental plates, transversely oval, multilobate; adductor scars

small, median, semioval to semicircular, separated by low median ridge or myophragm; diductor scars wide, surrounding smaller adductors laterally and anteriorly.

Brachial valve interior with large triangular hinge plate, bounded laterally by deep, elongate, anteriorly expanding, finely corrugated hinge sockets; inner hinge plates united to form flat plate between crura, bridging across notothyrial cavity. Crura projecting forward from anterior edges of hinge plate, diverging anteriorly, strongly curved ventrally, often twisted as much as 90 degrees, dorsal edges keeled; median ridge long, low, thin. Muscle area bisected by median ridge, elongate to transversely oval; posterior adductor scars small, elongate, anteriorly diverging, proximal ends separated by median ridge; anterior adductor area larger, oval, lying on both sides of ridge.

COMPARISON.—*Wellerella girtyi* is characterized by its average size for the genus, but small in comparison to several other Glass Mountains species, its rotund shape, relatively narrow flanks, moderately low fold that is convex near the anterior margin, brachial valve with the smooth part of the beak slightly flattened in profile, but normally not flattened transversely, and by its comparatively large hinge plate and thin, low median ridge. It differs from *Pontisia stehlii* Cooper and Grant (1969) in its smaller average size, normally lower fold (except for the low-fold variety, *P. stehlii tumidosa*, new subspecies), lower costae that begin farther forward on the beaks, and its thin narrow rather than broad median ridge.

A species from the Capitan Formation comparable in size to *W. girtyi* is *Tautosia elegans* (Girty) which differs in its more transverse outline, higher fold and deeper sulcus, less convex fold especially near the anterior margin, depressed median costa in the fold, and by its high bladelike septum.

Among foreign species the most similar is *Rhynchonella negrii* Gemmellaro (1899). *Wellerella girtyi* differs in its lower, less protruding fold, non-reflexed flanks, and greater number of costae on the flanks. *Pugnax utah* Marcou of Kozłowski (1914) from the Carboniferous = Wolfcampian of Bolivia also is similar, differing in its higher fold, reflexed flanks, and fewer costae on the flanks. *Pugnax pseudoutah* Huang (1933) from the Permian of China differs in its reflexed flanks with fewer costae, larger average size, and nearly straight,

rather than strongly convex, anterior portion of the profile of the fold.

Wellerella girtyi girtyi, new subspecies

PLATE 515: FIGURES 26-28; PLATE 528: FIGURES 1-46;
PLATE 553: FIGURES 33-34

This is the common subspecies in the Guadalupean of the Glass Mountains. It differs from *W. girtyi seorsa*, the new subspecies of the Guadalupe Mountains, in its sharper costae that are more numerous on the flanks (normally 4 rather than 3) and begin farther back on the beaks, and its more transverse, oval outline. The populations of *W. girtyi* in the two areas are sufficiently distinct to be recognized, and most individuals can be identified subspecifically if there are specimens available for direct comparison. There is morphological overlap, however, and not all individuals from the one area differ from all individuals of the other region.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706					
148556a	7.5	6.4	6.9	3.0	85
148556b	8.3	7.0	7.5	3.7	90
148556c	9.7	8.0	9.9	6.2	111
148556d	11.4	10.0	12.0	8.6	95
148556e	12.5	10.6	14.0	10.8	110
USNM 706e					
154732a	3.7	3.0	3.1	1.5	60
154732b	3.8	3.2	3.7	1.5	70
154732c	4.8	4.3	4.3	1.8	80
154732d	5.8	5.0	5.3	2.3	80
154732e	6.0	5.1	5.9	2.5	85
154732f	6.3	5.2	6.7	2.6	90
154732g	7.3	6.1	6.8	3.1	80
154732h	8.7	7.4	8.0	5.1	80
154732i	10.6	8.8	11.3	7.1	90
(holotype)					
154732j	11.4	9.7	12.1	8.5	95
154732k	13.4	10.8	14.0	10.5	90

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Word Formation (China Tank, Willis Ranch and Appel Ranch members and lens between Willis Ranch and Appel Ranch members); San Andres Formation.

LOCALITIES.—Getaway: AMNH 21, 496, 512, 600; USNM 728, 730, 732. China Tank: USNM 703e, 706c, 733q. Willis Ranch: AMNH 505; USNM 706,

706e, 718d, 723t, 724u, 735c. Appel Ranch: 715i, 719z, 722t, 727j. Lens: 706b. San Andres: AMNH B188-8.

DIAGNOSIS.—Average size *Wellerella* with rotund shape and large hinge plate.

TYPES.—Holotype: USNM 154732i. Figured paratypes: USNM 148565j; 154732a-h,j,k,m,n; 154733b; 154810; 154811a-g. Measured paratypes: USNM 148556a-e; 154732a-h,j,k. Unfigured paratypes: USNM 148565a-i, 154733a.

Wellerella girtyi seorsa, new subspecies

PLATE 527: FIGURES 32-39

This subspecies occurs in the Guadalupean (Cherry Canyon Formation, Getaway Member) in the Guadalupe Mountains. It differs from the Glass Mountains subspecies, *W. girtyi girtyi*, in its more rounded costae that begin slightly farther forward, its more elongate, triangular outline, and its lower, fewer costae on the flanks: normally 3 instead of 4. In other respects the two subspecies are the same. Not every individual is subspecifically distinct, but the populations from the two areas can be recognized without difficulty.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 728					
148582a	11.4	9.9	11.6	7.5	90
148582b	10.9	9.0	10.5	7.9	90
148582c	10.0	8.7	11.0	6.4	90
148582d	10.0	8.4	10.5	5.6	90
148582e	9.0	7.8	8.7	6.0	85
148582g	11.5	10.0	12.5	6.5	95
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Getaway: AMNH 21, 496, 512, 600; USNM 728, 730, 732.

TYPES.—Holotype: USNM 148582g. Figured paratypes: USNM 148582f,h,i. Measured paratypes: USNM 148582a-e. Unfigured paratypes: USNM 148582a-e.

DISCUSSION.—The collections from the Getaway Member contain some interesting variations. A few specimens occur with 4 costae on the fold but a fair number contain only 2 costae on the fold and 1 in the sulcus. These have been confused

with *Pugnax bidentata* (Girty) which has not yet been certainly identified generically.

Wellerella? nitidula, new species

PLATE 528: FIGURES 47-62

Small for genus, strongly biconvex; outline rounded, subcircular to subtrigonal, usually globular sides diverging between 65° and 105°; anterior commissure uniplicate, fold moderately high at anterior, standing high above flanks farther back, beginning 4-5 mm anterior to brachial beak; sulcus very shallow, only slightly depressed below flanks, but extending dorsally as broad tongue at anterior commissure, beginning 5-6 mm anterior to pedicle beak. Costae strong on fold and sulcus, weaker on flanks beginning 3-5 mm anterior to beaks, crests rounded to obtusely pointed, numbering 3 on fold, 2 in sulcus, 2 to 4 on each flank. Growth lines and concentric ornamentation normally not visible.

Pedicle valve with umbonal region somewhat swollen, evenly convex transversely and longitudinally; flanks gently curved, not reflexed; beak short to moderately long, slightly hooked, slightly attenuate; beak ridges sharp, short; lateral pseudointerareas narrow, elongate, partly covered by edge of brachial valve; delthyrium narrowly triangular, base of triangle narrowed by small, disjunct or barely conjunct deltidial plates with distal edges slightly flared outwardly, leaving elongate, oval foramen. Brachial valve with smooth part of umbo evenly convex, rarely slightly flattened; beak bluntly pointed, apex within pedicle valve beneath deltidial plates.

Pedicle valve interior with teeth parallel to side of valve, supported by vertical dental plates extending nearly vertically to floor. Muscle area tear-shaped, widening anteriorly, individual muscle marks not observed.

Brachial valve interior with semicircular or crescentic, undivided hinge plate, bounded laterally by elongate, deep, finely corrugated hinge sockets; crura keeled, diverging slightly forward from anterior edge of plate, moderately strongly curved ventrally, not twisted. Muscle area faintly impressed; posterior adductor marks small, elongate, one on each side of broad, only slightly raised median ridge; anterior adductor marks fused together, lying on midline of valve anterior

to end of median ridge, flanked by anterior ends of posterior adductor marks.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
AMNH 492					
152865a	5.8	5.0	5.9	3.0	90
152865b	6.0	5.0	5.7	4.0	86
152865c	6.8	5.9	6.6	5.4	92
AMNH 591					
152866a	6.6	5.6	6.8	4.8	90
152866b	7.5	6.6	7.7	5.8	100
152866c	8.7	7.7	8.5	7.2	84
(holotype)					
152866d	9.1	8.0	10.0	8.6	95
152866e	9.4	8.4	10.6	9.2	101
152866f	9.6?	8.6	10.7	8.5	95

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITIES.—AMNH 492, 497, 591, 592, 624; USNM 728g.

DIAGNOSIS.—Globular *Wellerella* with high fold.

TYPES.—Holotype: USNM 152866c. Figured paratypes: USNM 152866a,d,f,-i; 154812. Measured paratypes: USNM 152865a-c; 152866a,b,d-f. Unfigured paratypes: USNM 152865a-c; 152866b,e.

COMPARISON.—*Wellerella? nitidula* is characterized by its small size, rounded outline, fold that stands high above the flanks and bears 3 costae, normally evenly rounded brachial umbonal region, slightly swollen pedicle umbonal region, sharp beak ridges, and moderately well developed deltidial plates. Externally it most closely resembles *Pontisia franklinensis*, new species. *Wellerella? nitidula* attains a slightly larger size, is more rounded than triangular in outline, has the brachial smooth area more convex both longitudinally and transversely, sharper beak ridges, and elliptical rather than trigonal profile. *Tautosia podistra*, new species, is small, but is narrower, flatter and smoother than *W.? nitidula* and its fold is relatively low, standing in relief above flanks only at its extreme anterior. Juveniles of *Pontisia stehlii* Cooper and Grant are similar in some features to *W.? nitidula*, but differ in their longitudinally more convex folds that consequently do not stand as high at the anterior, their longer beaks with more fully developed deltidial plates, and less consistent number of costae on the fold.

DISCUSSION.—This species is common at AMNH

591 but most of the specimens are filled with silica, making it impossible to study the interior details. We have accordingly queried the generic designation but used *Wellerella* because the short median septum was observed in some specimens.

Genus *Phrenophoria* Cooper and Grant, 1969

Phrenophoria Cooper and Grant, 1969:12.

Small to large, rhynchonelliform, biconvex, uniplicate; generally slightly wider than long; outline bluntly elongate subtriangular, fold and sulcus moderately to strongly semicostate; fold usually sulcate in varying degree; flanks weakly to strongly semicostate. Concentric ornamentation weak. Growth laminae commonly weak, strongest and most frequent near anterior margins.

Pedicle valve moderately convex; beak sharp, nearly straight to suberect; beak ridges prominent; delthyrium triangular, closed at base by pair of large conjunct or disjunct deltidial plates, producing elongate oval mesothyridid to submesothyridid foramen; lateral pseudointerareas well developed where brachial valve overlaps pedicle valve; flanks convex to reflexed. Brachial valve more strongly convex and deeper than pedicle valve; umbonal region slightly flattened or indented; beak within pedicle valve under deltidial plates.

Pedicle valve interior with sides of delthyrium diverging, wider anterior to deltidial plates; teeth elongate, parallel to sides of delthyrium, supported by nearly vertical dental plate reaching valve floor. Muscle area beginning between anterior ends of dental plates, widening greatly anteriorly; adductor scars small, forming heart-shaped mark pointing anteriorly along midline in posterior part of muscle area; diductor scars large, surrounding adductor scars laterally and anteriorly, forming heart-shaped patch pointing posteriorly.

Brachial valve interior with large, undivided triangular hinge plate bounded laterally by deep, elongate, anteriorly expanding, corrugated sockets; crura modified falcifer, diverging anteriorly, strongly curved ventrally; crural bases extending from beneath hinge plate along dorsal edges of crura as sharp keels, making extremities of crura concave anteriorly; median septum high, bladelikey, supporting hinge plate, bisecting part of muscle

area, and extending about a third length of valve. Muscle area beginning about halfway along septum; posterior adductor scars, narrow, elongate, anteriorly slightly divergent, flanking larger, subelliptical anterior adductor scars.

TYPE-SPECIES.—*Phrenophoria subcarinata* Cooper and Grant (1969:13, pl. 1: figs. 4–12).

DIAGNOSIS.—Rhynchonellids having strong, long median septum, generally naked umbones, and strongly costate anterior regions.

COMPARISON.—*Phrenophoria* is characterized by its strong costae, usually sulcate fold, normally flattened or indented brachial umbonal region, well-developed lateral pseudointerareas, large conjunct deltidial plates, large undivided hinge plate, and its high, thin, bladelikey median septum. The high median septum separates it from *Wellerella* Dunbar and Condra and *Pontisia* Cooper and Grant, and the large conjunct deltidial plates and large undivided and unnotched hinge plate distinguish it from *Anteridocus*, new genus, and *Cenorhynchia*, new genus. Some species of *Phrenophoria* are leiorhynchiform in external appearance but differ in having the hinge plate without median trough, the sulcate fold on the brachial valve, and the flanks strongly costate. The latter feature distinguishes *Phrenophoria* from *Bryorhynchus* but more knowledge of the form of the hinge plate is needed to separate it confidently from *Leiorhynchoidea*.

Two other probably related genera with long median septa can be readily distinguished from *Phrenophoria*. *Tautosia* Cooper and Grant is usually transverse and has prominent anterolateral extremities on the ventral side as well as strong angular costae, features more exaggerated than those usually found in *Phrenophoria*. *Holosia*, new genus, is totally costate and elongate.

DISCUSSION.—Numerous species with a strong median septum and undivided hinge plate are assigned to this genus. Although every effort has been made to conform ornament types, it has not been possible to limit the assignments in strict conformity to the definition of the genus. It is thus possible to notice at least two groups of species. One of these, the *P. subcarinata* or *P. pinguis* group is the type form and thus strictly speaking is *Phrenophoria*. This one generally is hemicostate, has a sulcate dorsal umbo, the sulcus extending onto the fold and depressing one or more of the costae. The sulcus is not deep and the

anterolateral extremities of the ventral side are not strongly angular or protuberant. Another species group is less costate than the preceding and is characterized by *P. repugnans*, new species. In this type the pedicle valve is mostly smooth but is fairly deeply sulcate and has fairly prominent antero-lateral extremities. The brachial valve, however, is like that of the type species in having a sulcate umbonal region and a depression in the fold. *Phrenophoria corpulenta*, new species, is more rotund than usual and the costae invade more of the posterior than in the *P. subcarinata* group, but the brachial valve umbo is sulcate and the sulcus affects the fold. Like the bicostate species in other genera, *P. bicostata* is completely atypical on its exterior but no other niche can be found for it. *Phrenophoria nesiotes*, new species, is most like the *P. subcarinata* group and has all of the essentials of the genus but the valves are not as strongly costate as usual, nor so anteriorly truncated, and are quite wide.

Some species of *Phrenophoria* such as *P. pinguis*, *P. pinguiformis*, *P. nesiotes*, and *P. subcarinata* are strongly leiorhynchiform and might be confused with some genera of that family, especially earlier Paleozoic ones such as *Basilicorhynchus* Crickmay (1952). *Phrenophoria* might be confused with the young of *Leiorhynchoidea* Cloud, with which it occurs; but beak characters, nature of the fold, and interior details separate them.

Generally the beak of *Phrenophoria* is only moderately long and the foramen is small but usually elongate-oval and mesothyridid or submesothyridid in position. It is usually straight to suberect, with only a small amount of curvature. The teeth are elongated and are parallel to the lateral margins and are separated from the margin by narrow slots that receive the socket ridges. The musculature of the pedicle valve is fairly well shown in the type species. The field is large and somewhat cordate, with the lobate portion anterior and the point posterior. The adductor patch lies just anterior to the delthyrial cavity and is completely surrounded by the broadly expanded diductor scars. Other details of the interior have left no marks on the shell.

The brachial valve is characterized by a strong median septum in all species. These support an undivided hinge plate, although the latter feature is variable in gross form and in detail. The socket

ridge is strong, long, curved, and hangs over a minutely corrugated narrow socket. The outer hinge plates are moderately broad and attach long strong crura with a narrow keel. The crura, as shown by those of *P. pinguiformis*, are fairly wide, crescentric in cross section, but concave toward the anterior or anteromedially. The distal extremity is rough.

The inner hinge plates are developed variably in the same species, a fact well shown by *P. subcarinata*. Specimens show inner hinge plates that have grown horizontally and coalesced to form a nearly flat hinge plate, but others display varying degrees of concavity, with the result that the hinge plate has a narrow or shallow trough. In one specimen the inner hinge plates are overlapped, failing to meet medially and one grew over the other. Other species show similar variations. The median septum does not show great variation but in some specimens it is thickened posteriorly where it attaches to the hinge plate; rarely traces of a small chamber may be seen in connection with the inner hinge plates.

Phrenophoria is widespread in the Permian rocks from which brachiopods under discussion were taken. It is fairly common in the Word Formation and its equivalents, but less abundant above and below.

Phrenophoria anterocostata, new species

PLATE 519: FIGURES 19-23

Small for genus, subpentagonal in outline, maximum width at midvalve; length slightly greater than width. Sides broadly rounded; anterior truncated. Anterior commissure strongly uniplicate. Beak small, nearly straight; foramen narrowly elongate; deltidial plates small, disjunct. Posterior half naked but anterior half strongly costate: 2 costate in sulcus, 3 on fold, 3 on flanks. Costae in sulcus not extending beyond sulcus.

Pedicle valve barely convex in lateral profile and broadly concave in anterior profile. Umbonal region slightly but narrowly swollen to origin of sulcus, just anterior to midvalve. Tongue long and serrated. Flanks strongly reflected in ventral direction, serrate on anterior edges.

Brachial valve gently and evenly convex in lateral profile but narrowly and strongly domed in anterior profile. Umbonal region gently concave;

fold originating near midvalve, moderately elevated. Lateral slopes swollen and steep.

Median septum of brachial valve seen as long slit.

MEASUREMENTS (in mm).—Specimens USNM 153486a (holotype) and b, respectively: length 13.7, 11.8; brachial valve length 12.1, 10.6; width 12.3, 11.4; thickness 9.2, 8.2; apical angle 98°, 103°.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (lower).

LOCALITY.—USNM 721u.

DIAGNOSIS.—Small pentagonal *Phrenophoria* with costae of sulcus confined to sulcus.

TYPES.—Holotype: USNM 153486a. Figured paratype: USNM 153486b.

COMPARISON.—See *Phrenophoria? nudumbona* for comparison.

DISCUSSION.—An extremely rare species; only 2 specimens were obtained in the digestion of about 24 large blocks.

Phrenophoria bicostata, new species

PLATE 514: FIGURES 29–39; PLATE 515: FIGURES 30–35

Small for genus, subtriangular outline, rounded sides and truncated anterior margin; posterolateral margins converging at 90° or less; valves subequal in depth. Beak small, suberect, with submesothyrid foramen and small, conjunct deltidial plates occasionally with elevated rim on side against pedicle. Surface costate, costae direct from beak to anterior margin; 2 costae on fold, 1 in sulcus, and 4 or 5 on flanks.

Pedicle valve gently and evenly convex in lateral profile, broadly and flatly convex in anterior profile. Umbonal region narrowly convex; median region moderately convex; sulcus narrow, moderately deep, widening gradually anteriorly, originating posterior to midvalve. Flanks gently convex, moderately steep.

Brachial valve moderately and evenly convex in lateral profile, more broadly and gently convex in anterior profile with moderately steep sides. Median region moderately convex; fold originating posterior to midvalve, narrow, expanding slightly anteriorly, and narrowly grooved medially. Fold moderately elevated anteriorly, flanks moderately convex and with moderate slopes.

Pedicle valve with small knoblike teeth supported

by stout, vertical dental plates. Brachial valve interior with stout socket ridges, small sockets, and undivided hinge plate. Outer hinge plates narrow, but inner ones united without suture and broad with slight anterior notch. Crura long, laterally compressed, concave toward midvalve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 719z					
152825a	7.2	6.2	7.0	4.0	85
152825b	7.0	6.0	7.0	3.1	90
152825c	6.5	5.7	6.0	4.0	80
152825d	5.8	5.0	5.9	2.9	80
152825e	5.4	4.7	4.8	2.3	80
152825f	3.6	2.9	3.1	1.5	80
154729a (holotype)	5.8	4.8	5.8	3.5	83

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member).

LOCALITY.—USNM 719z.

DIAGNOSIS.—Small triangular *Phrenophoria* having 2 costae on fold and 1 in sulcus and strongly costate flanks, the costae reaching the umbo.

TYPES.—Holotype: USNM 154729a. Figured paratypes: USNM 152825i,k,m,n; 154729b,c. Measured paratypes: USNM 152825a–f. Unfigured paratypes: USNM 152825a–h,j,l.

COMPARISON.—No other *Phrenophoria* has only 2 costae on the fold and 1 in the sulcus.

DISCUSSION.—The exterior of this little species is atypical because of the bicostate fold and the fact that the costae almost reach the umbones. Despite this, the cardinalia are like those of the type species and the median septum in the brachial valve is long and slender. It is a rare species known from only one locality.

Phrenophoria? compressa, new species

PLATE 522: FIGURES 4–7

Small for genus, narrowly compressed, narrowly triangular in outline. Greatest width at midvalve. Sides gently rounded; anterior margin truncated. Anterior commissure uniplicate. Beak fairly long, suberect; foramen elongate-oval; deltidial plates vestigial (?). Surface with posterior half smooth but anterior half marked by strong, subangular costae, 3 occupying fold, 2 in sulcus, and 2 on flanks.

Pedicle valve gently convex in lateral profile, but narrowly and gently concave in anterior profile. Umbonal region with narrow elevation joining 2 costae in sulcus. Sides abrupt and steep. Tongue short. Sulcus originating anterior to midvalve, narrow and shallow and nearly completely occupied by 2 crowded costae. Flanks very narrow and slightly reflected in ventral direction.

Brachial valve evenly and gently convex in lateral profile but narrowly and roundly domed in anterior profile. Posterior half and umbonal region marked by narrow depression extending from beak to fold. Flanks, narrow, rounded, and somewhat inflated. Fold originating near midvalve, only slightly elevated and abruptly truncated anteriorly.

Interior unknown.

MEASUREMENTS (in mm).—Holotype USNM 153489: length 10.0, brachial valve length, 8.6, width 8.5, thickness 8.2, apical angle 70°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 706f.

DIAGNOSIS.—Elongate, narrow *Phrenophoria*? with short fold and sulcus and flanks laterally compressed and narrow.

TYPES.—Holotype: USNM 153489.

COMPARISON.—The elongate and compressed form of this species is unique. It has some characters of *P. planiventra*, new species, from the Road Canyon Formation but it is smaller, more finely ornamented, and much narrower in outline. The holotype is the only known specimen of the species.

Phrenophoria corpulenta, new species

PLATE 514: FIGURES 40–54

Shell about average size for genus, strongly bi-convex; outline narrowly to broadly subpentagonal, sides diverging between 95 and 120 degrees; commissure uniplicate, fold high and nearly square, not standing high above flanks behind anterior margin, beginning 6–8 mm anterior to brachial beak, bearing shallow, elongate median depression reaching nearly to beak with 3 costae; sulcus shallow, barely depressed below flanks, beginning about 8 mm anterior to pedicle beak, extending forward as flat, strongly geniculated tongue at anterior. Costae low, crests subangular, beginning about 3 mm from beaks along median line, about 7 mm

from beaks on each side, numbering 3–5 on fold, one less in sulcus, 4–7 on each flank. Growth lines faint, not preserved on most specimens.

Pedicle valve gently convex except at anterior, there strongly curved toward commissure; beak short, sharp, slightly attenuate, somewhat depressed, with sharp beak ridges, not strongly curved; lateral pseudointerareas narrow, elongate but short, covered by edge of brachial valve; delthyrium broadly triangular, constricted by small, nearly conjunct, outwardly flaring deltidial plates, leaving nearly circular foramen. Brachial valve strongly convex in profile, umbonal region flattened, anterior part strongly curved toward commissure; deep median trough extending from smooth part of umbonal area along fold, lowering median costae; beak blunt, within pedicle valve, beneath deltidial plates.

Pedicle valve interior with strong, corrugated hinge teeth, supported by nearly vertical dental plates reaching valve floor. Muscle area heart-shaped, adductor scars small, subcircular, in posterior part of area; diductor scars larger, surrounding adductors, widening anteriorly.

Brachial valve interior with large, subtrigonal hinge plate. Socket ridges strong, overhanging corrugated sockets; outer hinge plates broad, sloping medially, crural bases narrow, depressed; inner hinge plates broad, conjunct medially and with suture line unhealed; median septum high, blade-like extending about a third valve length. Muscle area on floor of valve on each side of median septum; individual muscle marks not observed.

MEASUREMENTS (in mm).—

		<i>brachial</i>			<i>apical</i>
	<i>length</i>	<i>valve</i> <i>length</i>	<i>width</i>	<i>thick-</i> <i>ness</i>	<i>angle</i> (°)
AMNH 678					
152826a	7.0	6.8	9.0	2.4	100
152826b	10.6	9.8	12.4	5.4	110
152826c	10.6	10.0	11.6	9.5	108
152826d	10.8	9.6	12.0	8.5	106
152826e	11.5	10.6	12.2	9.4	109
152826f	13.0	12.0	14.8	9.6	116
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (Cutoff Member).

LOCALITIES.—AMNH 678, USNM 747.

DIAGNOSIS.—Medium-sized, rotund *Phrenophoria* with a broad depression or sulcus in the fold.

TYPES.—Holotype: USNM 152826f. Figured paratypes: USNM 152826a,d,h; 154718. Measured paratypes: USNM 152826a–e. Unfigured paratypes: USNM 152826b,c,e,g.

COMPARISON.—*Phrenophoria corpulenta* is characterized by its rotund shape, each valve flexed toward commissure near its anterior margin, by its numerous, strong but rather low costae that begin far from the beaks, and especially by its deep, wide median trough in the brachial valve that begins near the beak and depresses the crest of the fold along its entire length. It looks most like *P. pinguis* (Girty), from which it differs in its smaller size, normally wider outline, more numerous and narrower costae, deeper median trough in the brachial valve, more abrupt bending of the anterior part of each valve and lack of a gablelike ridge along the median line of the pedicle valve. In addition, *P. pinguis* has noticeable radiating fibers, and strong growth lines concentrated near the margins of the valves, whereas *P. corpulenta* has only faint hints of radiating fibers, and few visible growth lines. *Antronaria mesicostalis* (Girty) is superficially similar to *P. corpulenta*, but the latter differs in its smaller size, more abruptly bent contours, deep trough along the fold (instead of one depressed costa), and by internal generic features, mainly its high median septum.

DISCUSSION.—This species at first glance suggests *Rhynchopora* with its squarish front, broadly rounded costae, and short beak. It is typically phrenophoriform in having a strong depression in the fold of the brachial valve and in the character of the cardinalia which do not have the apical chamber so characteristic of punctate *Rhynchopora*. *Phrenophoria corpulenta* is a very rare species.

Phrenophoria depressa, new species

PLATE 514: FIGURES 55–71

Small for genus, outline subtriangular, usually slightly wider than long as adult, maximum width at midvalve; lateral margins rounded; anterior margin truncated and medially emarginated. Anterior commissure uniplicate. Beak short, straight; deltidial plates small. Surface hemicostate, anterior half marked by subangular costae, 3 on fold, median costa deeply depressed, 2 in sulcus and 3 or 4 on flanks.

Pedicle valve nearly flat in lateral profile and gently concave in anterior profile. Umbonal region nearly flat; sulcus originating at midvalve; abruptly deepening and extended into narrow tongue. Flanks nearly flat, slightly deflected anteriorly, and strongly protuberant at anterolateral extremities.

Brachial valve bulbous, fairly strongly convex in lateral profile, narrowly and roundly domed in anterior profile, sides precipitous. Umbonal region swollen, but medially sulcate, narrow, shallow sulcus extending into fold and strongly depressing median costa, or median two. Fold originating at midvalve, moderately elevated and with steep sides. Flanks swollen, and considerably depressed below fold.

Pedicle valve interior with short, thin dental plates separated from valve wall by very narrow cavities. Brachial valve interior with curved socket ridges, narrow outer hinge plates and wide, inner hinge plates with deep reentrant. Crura not well preserved. Median septum long and delicate.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 707d					
148773a (holotype)	8.8	7.8	10.1	6.8	90
148773b	9.6	8.2	9.6	5.4	80
148773c	8.7	7.6	9.4	4.3	90

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Sullivan Peak Member).

LOCALITY.—USNM 707d.

DIAGNOSIS.—Small *Phrenophoria* with flat pedicle valve, bulbous brachial valve with deeply depressed median costa in the fold.

TYPES.—Holotype: USNM 148773a. Figured paratypes: USNM 148773b,h,i. Measured paratypes: USNM 148773b,c. Unfigured paratypes: USNM 148773c–g.

COMPARISON AND DISCUSSION.—This is a very rare species, most similar to *P. planiventra* and *repugnans*, both new species. It differs from the former in its much smaller size and more strongly costate flanks. It has almost the same size as *P. repugnans* but has more strongly costate valves, more triangular shape, and deeper brachial valve. In spite of the differences, the three species seem to form a characteristic group.

Phrenophoria incomitata, new species

PLATE 521: FIGURES 1-9

Small for genus, elongate oval outline, well but broadly rounded sides, posterolateral margins forming angle of 90° . Anterior margin narrowly rounded. Maximum width near midvalve. Beak moderately long, nearly straight. Surface semicostate, 3 costae on fold, 2 in sulcus, 2 on flanks; median costa of fold wide and strongly depressed.

Pedicle valve moderately and fairly evenly convex in lateral profile, faintly concave in anterior profile. Umbonal region slightly swollen; sulcus originating at midvalve, shallow, moderately wide, forming moderately long tongue. Flanks gently convex and protruding moderately anterolaterally.

Brachial valve about same depth as pedicle valve, moderately convex in lateral profile but anterior somewhat geniculated; anterior profile a flat-topped dome with very steep sides. Fold originating somewhat anterior to midvalve, inconspicuous but slightly elevated above flanks anteriorly; fold in sulcus originating in umbonal region and strongly depressing median costa of fold. Flanks moderately swollen but with precipitous sides.

Pedicle valve interior with small teeth but strong dental plates. Brachial valve with small hinge plate and strong median septum.

MEASUREMENTS (in mm).—Holotype USNM 152827a: length 11.9, brachial valve length 10.6, maximum width 9.9, thickness 7.2, apical angle 90° .

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (Cutoff Member).

LOCALITY.—AMNH 678.

DIAGNOSIS.—Small oval *Phrenophoria* with three costae on the fold.

TYPES.—Holotype: USNM 152827a. Figured paratype: USNM 152827b.

COMPARISON AND DISCUSSION.—Although only two specimens of this species are known we have named it because so little is known of the Cutoff Shale fauna. The specimens consist of a complete one conveniently broken on one side to reveal the hinge plate and median septum, so that little doubt exists as to its correct generic determination. The other specimen is a pedicle valve interior displaying the dental plates and teeth.

The specimen, judging by its interior and the strong development of the fold, is clearly an adult. It is most like *P. subcarinata* Cooper and Grant of

the Word Formation in the Glass Mountains, but differs from it in a number of particulars. Specimens of *P. subcarinata* of comparable size have stronger and more rounded costae, a much less prominent sulcus in the fold of the brachial valve, more of the posterior smooth, and narrower flanks. No other species of *Phrenophoria* is similar.

Phrenophoria irregularis, new species

PLATE 525: FIGURES 13-25

Medium size for genus, wider than long, transversely pentagonal in outline. Widest at midvalve; sides rounded; anterior margin broadly rounded. Anterior commissure narrowly uniplicate. Beak short, straight; deltidial plates small, conjunct. Surface multicostate, costae generally narrowly rounded, irregular in strength, occasionally intercalated, generally numbering 4, often 3 on fold, one less in sulcus; costae on flanks numbering 3 to 5; umbones smooth; strong growth lamellae crowded at anterior.

Pedicle valve gently convex in lateral profile, greatest convexity in posterior half; anterior profile very gently concave medially. Umbonal and median regions somewhat narrowly swollen, swelling continuing into sulcus, there merging with surface; sulcus broad and shallow, originating anterior to midvalve, forming long, strongly geniculated tongue. Flanks gently concave and slightly deflected. Anterolateral extremities protruding moderately.

Brachial valve moderately convex in lateral profile, most convexity in posterior third. Anterior profile broadly and strongly domed, median region conspicuously flattened. Umbonal region moderately swollen but marked medially by narrow shallow sulcus merging with fold but not reaching margin. Fold originating slightly anterior to midvalve, fairly broad and flattened, not conspicuously elevated at front. Flanks strongly swollen and only slightly depressed below fold at front margin.

Pedicle valve interior with elongated large teeth situated on valve edge; dental plates thick, short, and separated from valve wall by very narrow chambers. Muscle field large, occupying median region, with deeply impressed, large adductor patch located just at anterior ends of dental plates.

Brachial valve interior with fairly wide and strongly corrugated sockets bounded by thick,

curved socket ridges. Hinge plate, narrow, variable, divided or undivided depending on age (?); outer hinge plates narrow; inner hinge plates concave (?) to flat, united or not, depending on age. Median septum strong, thin, highly elevated and reaching midvalve there serving as myophragm to divide lateral halves of large rounded adductor field.

MEASUREMENTS (in mm).—

		brachial valve		thick- ness	apical angle (°)
	length	length	width		
AMNH 512					
152836a	12.9	11.2	15.6	8.2	110
(holotype)					
152836b	11.8	10.6	13.3	7.0	110
152836c	11.5	10.6	13.7	6.5	110

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—AMNH 512; USNM 728.

DIAGNOSIS.—Transversely pentagonal *Phrenophoria* having irregularly developed costae and crowded growth lamellae at the anterior.

TYPE.—Holotype: USNM 152836a. Figured paratypes: USNM 152836c–e. Measured paratypes: USNM 152836b, c. Unfigured paratypes: USNM 152836b.

COMPARISON AND DISCUSSION.—This species is characterized by its rounded outlines and transverse form. It also has small and narrow costae and fairly numerous costae on the flanks. It is not like *Tautosia magnisepta* (Stehli), which has numerous costae, because of its greater width, stronger costae, and rounded contours. This is an uncommon species.

Phrenophoria nesiotes, new species

PLATE 516: FIGURES 6–42

About average size for genus, variable, biconvex; outline roundly and bluntly triangular to subpentagonal, normally transverse; sides diverging between 80° and 120°, averaging about 105°; commissure narrowly to broadly uniplicate, fold anterior, low to moderately high, beginning 8 to 10 mm anterior to brachial beak, slightly arched transversely, profile flatly convex, with slight dorsal flexure at anterior boundary of smooth area of umbo; sulcus shallow, beginning 9 to 11 mm anterior to pedicle beak, longitudinal convexity

uniform. Costae weak to moderately strong, strongest on fold and pedicle flanks, usually wide, beginning 6 to 11 mm anterior to beaks, crests angular, numbering 3–5 on fold, one less in sulcus, 2–6 on each flank. Concentric striae faint, closely crowded over surface of shell; growth lines irregularly spaced, prominent only near anterior margins.

Pedicle valve nearly flat, umbonal area with blunt, low median crest; flanks slightly reflexed, with anterior terminations blunt; beak short, sharp, not attenuate, not curved dorsally, but pointing slightly ventrally; beak ridges sharp, short; lateral pseudointerareas narrow, sharply delimited, partly covered by edge of brachial valve. Tongue strongly geniculated, fairly long. Delthyrium triangular, base normally covered by pair of small deltidial plates; apex open, forming elongate oval submesothrydid foramen. Brachial valve more strongly convex transversely than longitudinally; umbonal region with shallow median longitudinal impression; apex of valve within pedicle valve, covered by deltidial plates. Flanks moderately swollen.

Pedicle valve interior with delthyrium open anterior to deltidial plates, sides moderately divergent; teeth small, elongate; dental plates supporting hinge teeth, slightly converging apically and toward floor of valve, forming narrow delthyrial cavity; umbonal chambers wide. Muscle area heart-shaped, lying between and anterior to forward edges of dental plates; adductor scars small, median, narrow; diductor scars larger, surrounding adductors, widening anteriorly, meeting at median line; adjustor scars elongate, narrow, lying along posterior flanks of diductors.

Brachial valve interior with large, triangular, undivided hinge plate, often medially depressed, simulating crural cavity; median notch shallow; sockets elongate, deep, finely corrugated, slightly widening anteriorly; crura slender, strong, diverging anteriorly, strongly curved ventrally, dorsal edges carinate. Median septum high, thin in the young, long, bisecting part of muscle area; posterior end supporting hinge plate, often thickened. Outer hinge plates narrow; inner hinge plates with healed suture, flat or subangularly arched. Muscle area elongate oval; posterior adductor scars relatively large, subelliptical, lying at posterior flanks of slightly larger, subcircular anterior adductor scars.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (base).

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 708u					
148355a	1.6	1.4	1.5	0.7	90
148355b	3.7	3.0	3.4	1.1	90
148355c	6.0	5.5	6.2	2.0	86
148355d	8.9	8.2	9.7	3.1	87
148355e	11.3?	10.6	12.9	4.9	104
148355f	13.0	11.7	16.3	8.4	120
148355g	14.4	13.4	16.8	9.8	109
148355h	16.7	15.9	19.3	11.0	105
(holotype)					

LOCALITIES.—USNM 702, 708u.

DIAGNOSIS.—Large, transverse *Phrenophoria* with broad costae and posteriorly thickened median septum.

TYPES.—Holotype: USNM 148355h. Figured paratypes: USNM 148355a,b,c,f,g,i,j,a'; 148673a–d; 154375a–e. Measured paratypes: USNM 148355a–g. Unfigured paratypes: USNM 148355d,e,h.

COMPARISON.—*Phrenophoria nesiotes* is characterized by its transversely triangular to subpentagonal outline, its short beak that is not dorsally curved, its fold and sulcus that begin far forward, fold with 3 to 5 broad costae beginning far forward, visible adjustor muscle scars in the pedicle valve, posterior and anterior adductor muscle scars in the brachial valve that are subequal in size, and the posteriorly thickened median septum in old adults. It most nearly resembles juveniles of *Tautosia fastigiata*, new species, differing in its more rounded outline, shorter and less attenuate beak that points ventrally instead of curving dorsally as in most species, more numerous costae on the fold, transversely slightly arched fold, and its only slightly reflexed pedicle valve flanks whose costae terminate bluntly, curving slightly dorsally anterior to the commissure. Other species of *Phrenophoria* from West Texas are easily distinguishable from *P. nesiotes*, especially by their costae that begin farther back.

Phrenophoria nesiotes resembles *Pugnax osagensis* Swallow of Tschernyschew (1902:64, 482, pl. 23: figs. 5–9), differing in its rounder outline and less attenuate pedicle beak, less sharply reflexed flanks, normally more costae on the fold, absent crural cavity, and its high median septum rather than low median ridge (Tschernyschew, 1902:65).

DISCUSSION.—As with the rest of the fauna with

which *P. nesiotes* occurs, this species is unusual in its appearance. Its costae are broadly angular but subdued and the adult form does not have the usual squared-off front of the type species and related forms. Furthermore, the posterior half of the shell is completely bare of costae. These characters and the fairly transverse outline make this form distinctive. The interior is as distinctive as the exterior. The dental plates are very short, fairly approximate, and subparallel; the muscle field is small and does not reach midvalve, is well rounded, and is not strongly expanded laterally. The cardinalia of the brachial valve are delicate and with narrow crura, but concave anteriorly and with the broad posterior surface nearly horizontal. The inner hinge plates are well developed and show the same types of variation as those of the type species. Some specimens have a median suture when the plates are not completely united, but others have a small fold along the midline.

Phrenophoria? nudumbona, new species

PLATE 522: FIGURES 1–3

Small for genus, subpentagonal outline, length and width about equal; brachial valves much more convex than pedicle valve. Greatest width near midvalve. Anterior commissure strongly uniplicate. Surface with posterior half smooth but anterior half strongly costate, fold having 3 costae, flanks 2 or 3.

Pedicle valve gently convex in lateral profile, broadly but gently concave in anterior profile; maximum convexity anterior to umbo. Beak nearly straight, apical angle 102°; foramen elongate oval; surrounded by convex but disjunct deltidial plates. Sulcus originating at midvalve, deepening abruptly and producing long, serrated tongue. Costae on tongue extending to umbo. Flanks abruptly and strongly reflected in ventral direction.

Brachial valve unevenly convex in lateral profile, umbonal region flattened, maximum convexity in anterior half. Anterior profile narrowly and strongly domed. Umbonal region gently and longitudinally concave, concavity extending to fold beginning at midvalve. Fold moderately elevated anteriorly with short, steep lateral slopes. Flanks swollen and steep sided.

MEASUREMENTS (in mm).—From locality USNM

703d holotype USNM 148373: length 11.9, brachial valve length 10.2, width 12.3, thickness 8.8, apical angle 102° .

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 703d, 721r.

DIAGNOSIS.—Small, pentagonal *Phrenophoria*? with deep sulcus and costae of sulcus extended onto umbonal region.

TYPES.—Holotype: USNM 148373.

COMPARISON.—This species is of about the same size, shape, and general aspect as *P. anterocostata*, new species, but differs from that species by having the costae of the sulcus extended posteriorly to the umbonal region, by having a stronger development of the deltidial plates, a narrower sulcus, and a more convex pedicle valve. *Phrenophoria repugnans* resembles *P. (?) nudumbona*, but differs in having less angular costae, the median costa of the fold depressed, the beak suberect, and more costae on the flanks.

Phrenophoria pentagonalis, new species

PLATE 517: FIGURES 36, 37

Small for genus, transversely pentagonal in outline, width greater than length; maximum width anterior to midvalve; sides narrowly rounded; anterior margin truncated. Anterior commissure moderately uniplicate. Beak small, suberect; foramen elongate-oval; deltidial plates vestigial, disjunct. Surface with posterior half smooth but anterior moderately strongly costate. Costae narrowly rounded, numbering 3 on fold, 2 or 3 on flanks.

Pedicle valve gently convex in lateral profile, maximum convexity in posterior half; anterior profile broadly and gently concave. Umbonal region longitudinally swollen, swelling extending to originating point of costae. Sulcus, originating at midvalve, fairly narrow and moderately deep. Slopes of flanks long and gentle. Flanks marginally deflected in ventral direction; flanks flattened.

Brachial valve evenly and gently convex in lateral profile; broadly domed in anterior profile. Umbonal region gently inflated and bearing narrow, shallow depression extending from beak to fold; fold low, short, originating near midvalve. Flanks moderately swollen and with moderately steep slopes.

Median septum of brachial valve long and sharp, viewed from break in holotype.

MEASUREMENTS (in mm).—Specimens USNM 148575a (holotype) and b, respectively: length 9.4, 10.4; brachial valve length 8.6, 9.5; width 12.4, 13.0; thickness 6.6, 6.4; apical angle 116° , 98° .

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 703d.

DIAGNOSIS.—Small pentagonal *Phrenophoria* with narrowly rounded flanks, short fold and sulcus, and costae of sulcus not extending posterior to midvalve.

TYPES.—Holotype: USNM 148575a. Figured paratype: USNM 148575b. Measured paratype: USNM 148575b.

COMPARISON.—*Phrenophoria pentagonalis* has a fairly common type of exterior but the combination of characters is different from any others. It is like *Tautosia elegans* (Girty) in general outline and ornament but has finer costae, a more convex brachial valve, and the median costa of the sulcus is not depressed. Another species having the same general expression as *P. pentagonalis* is *T. shumardiana* (Girty) but that is a much larger species with prominently depressed costa or costae in the fold of the brachial valve. *Tautosia transenna*, new species, is differently shaped, more robust, with stronger costae, and more costae on flanks than *P. pentagonalis*.

Phrenophoria perplexa, new species

PLATE 508: FIGURES 34–39; PLATE 516: FIGURES 43–58;
PLATE 521: FIGURES 65–73

Usual size for genus, leiorhynchiform, length and width nearly equal; sides well rounded; posterolateral margins forming angle of 100° to 110° ; outline subpentagonal. Anterior margin truncated. Anterior commissure strongly uniplicate. Beak short, with small elongate submesothyriddid foramen; deltidial plates well formed, conjunct. Surface mostly costate but umbonal regions smooth; costae broad, angular, 4 or 5 on fold, one less in sulcus and 2 or 3 flattened costae on flanks. Concentric lamellae crowded at anterior margin.

Pedicle valve unevenly convex in lateral profile, most convexity just anterior to umbo; anterior profile broadly concave. Umbonal region narrowly

convex, convexity merging into sulcus near midvalve. Sulcus broad and shallow, originating anterior to midvalve and extending into long, blunt, serrated tongue. Anterolateral extremities subangular and fairly prominent.

Brachial valve much deeper than pedicle valve, evenly and moderately convex in lateral profile but narrowly domed and strongly convex in lateral profile and with precipitous sides. Umbonal region marked by shallow sulcus extending onto fold nearly to front margin. Fold originating just anterior to midvalve, flattened and low, not strongly differentiated anteriorly. Flanks moderately swollen, very steep.

Pedicle valve interior with small teeth elongated parallel to shell margin and offset from it by narrow slit. Dental plates short, with poorly defined and narrow umbonal cavities. Muscle field cordate, adductors surrounded by diductors and possible adjustor muscle scars appearing outside diductors anterior to dental plates.

Brachial valve interior variable. Cardinalia moderately large with strong socket ridges and finely corrugated sockets. Outer hinge plates of moderate size attaching keeled crural bases to socket ridges. Inner hinge plates variously developed, some healed to close median notch but others with inner plates only modestly developed and hinge plate divided. Crura long, curved, concave anteriorly and flattened posteriorly. Median septum variously developed and forming an apical chamber in some specimens.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 725f					
152828a	16.6	13.2	15.4	7.7	100
152828b	17.3	16.1	17.2	12.6	100?
152828c	18.3	16.8	17.0	12.0	110
USNM 740j					
154595a (holotype)	16.6	15.6	20.0	9.6	110

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, and Rader members).

LOCALITIES.—Hegler: USNM 731, 732a, 740c. Pinery: USNM 725n, 733. Rader: AMNH 403; USNM 725f, 725g, 740a, 740i, 740j.

DIAGNOSIS.—Leiorhynchiform *Phrenophoria* with costae extending to umbonal region, flanks with flattened costae, and fold with four or five costae.

TYPES.—Holotype: USNM 154595a. Figured paratypes: USNM 152828a, 154595a,b; 154665a,b; 154736-l, 154770a-d; 155074f,c; 155075-l. Measured paratypes: USNM 152828a-c. Unfigured paratypes: USNM 152828b,c; 154736a-k; 154665b.

COMPARISON.—This is a much larger and differently ornamented species than *P. pinguis* (Girty). The costae are more angular and broader, the brachial valve is much deeper, and the pedicle valve develops a long anterior tongue. It differs from *P. pinguiformis*, new species, in having much more delicate valves, a much more convex brachial valve, and a different shape and outline. It is not likely to be confused with *P. subcarinata* Cooper and Grant, which has stronger costae, is more elongated, has more nearly equally deep valves, and the costae do not extend as far posteriorly as on the Bell Canyon species. The elongate costation, inequivalved profile, long tongue on the pedicle valve, and the costation of the flanks separates *P. perplexa* from *P. nesioties*, new species.

DISCUSSION.—The exterior of this species, with its broad and irregular costae that become somewhat vague on the lateral slopes, has a strong leiorhynchid aspect. The costae are stronger, however, than on most leiorhynchids and extend farther toward the beaks. The interior of this species also presents some interesting features in the brachial valve.

The inner hinge plates in all the adult specimens available do not coalesce but act in the nature of deltidial plates partly bridging the gap between the proximal ends of the crura. In one of the largest specimens the anterior ends of the inner plates approach closely but do not join. It is probable that they do join in some specimens to leave a dorsal foramen. The inner hinge plates at the posterior appear to join the valve floor apically to form a small apical chamber that is only visible in broken specimens. Anteriorly the chamber seems to be closed by dorsal coalescence of the plates to form the median septum which is always apical and never conspicuous.

Perhaps the most perplexing feature of this species is the erratic development of the median septum. In some specimens it is well formed and quite typical of *Phrenophoria*. In others it seems to be aborted, perhaps partially resorbed, but at any rate not well formed. It is possible that the septum in these specimens was not well silicified

but the good preservation of other features is not in accordance with this view. In two specimens the hinge plate meets the valve floor apically and the median septum is extended anteriorly as a low ridge. It seems evident from the specimens at hand that this is a variable feature in a possibly unstable species.

Phrenophoria pinguiformis, new species

PLATE 518: FIGURE 1-24

Large for genus, outline subtrigonal to oval; apical angle of adult 90° to 100°; posterolateral extremities straight, lateral margins somewhat narrowly rounded; anterior margin truncated but medially emarginate. Anterior commissure broadly uniplicate. Beak short suberect; foramen small submesothyriddid. Surface strongly semicostate, costae few, broad, narrowly rounded to subangular. Valves of unequal depth, brachial valve deeper.

Pedicle valve gently convex in lateral profile, maximum convexity posterior to midvalve, where narrow keel forms; anterior profile nearly flat. Umbonal and posterior region marked by low, subangular ridge extending from beak to about midvalve; there lost in sulcus. Beak ridges short but strongly angular. Sulcus broad and shallow, defined only at anterior half, occupied by two or three costae. Flanks gently sloping, occupied by three or four costae.

Brachial valve unevenly convex in lateral profile, most convex in posterior half, anterior half flattened; anterior profile broadly domed, top slightly concave at midvalve, sides strongly curved and nearly parallel. Umbonal region marked by shallow, narrow sulcus extending to anterior margin and occupied by 2 costae. Fold low, flattened, usually composed of 4 or 5 costae, median two depressed below level of bounding ones. Flanks swollen. Anterior usually strongly geniculated to meet fold of pedicle valve.

Pedicle valve interior with small, elongated, corrugated teeth parallel to valve margin; dental plates thick, subparallel and forming somewhat narrow delthyrial chamber. Muscle field subtrigonal to trapezoidal in outline, narrow proximal extremity just within anterior end of delthyrial cavity, adductor scars forming long triangular patches united medially and surrounding adductor scars.

Brachial valve interior with small cardinalia; socket ridges moderately thick and overhanging corrugated sockets; outer hinge plate small and narrow; crural bases narrow; inner hinge plates variable, attached to median septum, depressed and medially grooved in some specimens but in others with healed suture and flat surface. Median septum delicate, and uniformly thin throughout its length.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	length	width	
USNM 728				
148394a	9.6	8.0	9.8	4.4 80
148394b	12.6	10.8	11.3	6.3 85
148394c	14.2	12.4	13.6	6.9 90
148394d	15.5	14.1	17.2	11.5 95
148394e	17.4	15.2	17.9	11.0 90
(holotype)				
148394f	17.7	15.8	17.7	10.6 95
148394g	18.5	16.6	18.0	10.6 95

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—AMNH 512, 600; USNM 728, 732.

DIAGNOSIS.—Large coarsely costate *Phrenophoria* with emarginate anterior.

TYPES.—Holotype: USNM 148394e. Figured paratypes: USNM 148394d,h,n-p. Measured paratypes: USNM 148394a-d,f,g. Unfigured paratypes: USNM 148394a-c,f,g,i-m.

COMPARISON.—This species suggests *P. pinguis* (Girty) and *P. subcarinata* Cooper and Grant of the Glass Mountains. It is readily distinguished from the former by its thicker shell, broader and more rounded costae, more robust form, swollen valves, and its geniculated front. It is unlike the Glass Mountains species in having a wider outline, less swollen valves, a wider fold and sulcus, emarginate anterior, and a more prominently sulcate umbonal region.

DISCUSSION.—This species has thick and robust valves on which the details of the musculature are fairly well impressed and in which the various interior structures are well developed. The exterior is variable, but the collection is too small to be sure of anything more than the extremes. Most specimens have 4 costae on the fold, but one has 3. The costae of some specimens are wider than that of others and give them the appearance of being more numerous costate, but the numbers are the same.

Inside the pedicle valve the dental plates are fairly long and the musculature is well impressed; the field is somewhat triangular, with rather straight sides to the diductor scars. The adductor scars are well enclosed. In the brachial valve the sockets are strongly corrugated and the hinge plate shows the same types of variation noted in the type species. Several specimens have a narrow groove between the two inner hinge plates; in one specimen the inner hinge plates are overlapping, in others they unite with healed suture.

A feature seldom seen in late Paleozoic rhynchonellids is the scar of attachment of the diductor muscles on the dorsal hinge plate. In one exceptional specimen this appears as a short but wide pit under the apex. This pit has each extremity roughened. The structure is similar to that figured by Cooper (1959, pl. 6, figs. 14–17) in the Recent genus *Notosaria*. The adductor scars are fairly well preserved and form an elongate scar on each side of the median septum.

Phrenophoria pinguis (Girty)

PLATE 518: FIGURES 25–32; PLATE 522: FIGURES 8–13

Pugnax pinguis Girty 1909:319, pl. 21: figs. 21–21c.
Not *Pugnoides pinguis* (Girty), R. E. King, 1931:106, pl. 34:
figs. 15–17 [= *Antronaria voluminosa*, new species].

The residues from the Guadalupe Mountains have produced only three specimens referable to this species, and we have not found it among any of the collections obtained by more conventional methods. The species may be rare, but it is also possible that the type specimen is so badly damaged that we have been unable to identify any others with it. Actually the damage does not seem sufficient to prevent discernment of the true character of the species. The specimen has been squeezed sideways to such an extent that the right side (when viewed from the dorsal side) has been telescoped into the left side. Nevertheless, it seems clear that the holotype has a strong median septum which is one of the requisite characters of *Phrenophoria*.

The holotype is said to come from the "Dark Limestone" on the north side of Pine Spring Canyon (chiefly float), probably from the Pinery Member of the Bell Canyon Formation. We have it from the Hegler Member at USNM 732a, the Pin-

ery Member at USNM 725n, and the Capitan Formation at USNM 748a.

The three specimens besides the type are two brachial valves showing the interior well. The third specimen is a nearly perfect complete one. They all have the characteristic strong and long median septum of *Phrenophoria* as well as the undivided hinge plate.

TYPES.—Holotype: USNM 118570. Figured hypotypes: USNM 154755, 154784.

Phrenophoria planifrons, new species

PLATE 518: FIGURES 33–38

Large for genus, strongly pentagonal in outline, width slightly greater than length; sides moderately rounded; posterolateral extremities short, forming right angle. Valves subequal in depth. Anterior margin nearly flat and strongly truncated. Anterior commissure strongly uniplicate. Beak short, suberect; foramen moderately large, submesothyridid. Maximum width near midvalve. Surface finely costate, costae not reaching umbones. Growth lines crowded at anterior.

Pedicle valve evenly and moderately convex in lateral profile; broadly and gently convex in anterior profile. Umbonal region slightly convex medially, convexity extending to sulcus; median region gently convex. Sulcus originating anterior to midvalve, broad and shallow, defined best at margin, forming broad and flat tongue geniculated about 90°. Sulcus occupied by 5 costae. Flanks gently concave and marked by 5 costae.

Brachial valve gently convex in lateral profile, umbonal region most convex; anterior profile forming square dome with straight and parallel sides and flat top except for slightly concave median region. Umbonal region marked by shallow sulcus extending to anterior margin. Fold flat, low, short, defined at anterior, occupied by 6 costae, median four depressed and median two more deeply sunk than others. Flanks narrow, rounded and precipitous, marked by 4 costae, these more rounded than those on flanks of opposite valve.

Interior not known.

MEASUREMENTS (in mm).—Specimens USNM 148378a holotype and b (paratype), respectively: length 15.2, 15.3; brachial valve length 13.0, 13.1; maximum width 16.6, 15.8; thickness 13.6, 12.7; apical angle 90°, 90°.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (*Institella* Zone).

LOCALITY.—USNM 702b.

DIAGNOSIS.—Pentagonal *Phrenophoria* with greatly flattened anterior.

TYPES.—Holotype: USNM 148378a. Unfigured but measured paratype: USNM 148378b.

COMPARISON AND DISCUSSION.—This species is unusual for thick shell, triangular lateral profile, and the flat front with its strongly lamellose ornament. The anterior surfaces of both valves are strongly geniculated, the two geniculated parts meeting to form the broad base for the shell. The ornament is fairly fine and the fold and sulcus subdued. The fold has the median costae sunken in a shallow sulcus as usual for the genus. No other species has this bizarre form.

Phrenophoria planiventra, new species

PLATE 518: FIGURES 39–50

Medium size for genus, longer than wide, outline oval to subtrigonal; posterolateral margins straight and forming angle of 90°. Sides narrowly rounded; anterior margin truncated. Anterior commissure strongly uniplicate; valves very unequal in depth and curvature, brachial valve having the greater degree of each. Surface semicostate, costae confined to anterior slopes that occupy anterior third. Costae broad and rounded. Beak suberect; foramen small, submesothyridid.

Pedicle valve slightly convex in lateral profile, most convex in umbonal region; anterior profile irregular, median region narrowly convex, areas bounding middle gently concave, with flanks narrow and abruptly deflected. Umbonal and median regions marked by narrow fold disappearing at sulcus; fold strongest near midvalve. Sulcus broad and shallow, originating just anterior to midvalve, occupied by 2 broad costae and extending into short tongue geniculated at angle of about 90°. Flanks with 3 marginal costae. Beak ridges strong; planareas narrow.

Brachial valve strongly convex in lateral profile, narrowly domed and with parallel sides in anterior profile. Umbonal and median regions swollen and marked by shallow, narrow, but prominent sulcus extending from beak to anterior margin; fold low convex longitudinally but flattened transversely,

marked medially by depression of median costa continuous with sulcus from umbonal region. Flanks swollen and steep, marked by 3 or 4 broad, indistinct costae.

Interior not known.

MEASUREMENTS (in mm).—From locality USNM 703 holotype USNM 148381a: length 14.5, brachial valve length 12.5, maximum width 13.6, thickness 9.8, apical angle 90°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 703, 707e.

DIAGNOSIS.—Medium-sized *Phrenophoria* having valves of greatly disproportionate convexity and depth and a few strong costae.

TYPES.—Holotype: USNM 148381a. Unfigured paratype: USNM 148381b. Figured specimen: USNM 154754.

COMPARISON AND DISCUSSION.—This species is similar to *P. repugnans*, new species, and *P. depressa*, new species, in the more than half of the posterior part that is smooth, and in the short costae. It is bigger than either of these two species and is more strongly costate than *P. repugnans* but less strongly costate than the other. This is a rare species in the Road Canyon Formation, only three specimens having been found.

Phrenophoria repugnans, new species

PLATE 519: FIGURES 1–18

Small for genus, moderately to strongly unequally biconvex; outline narrowly oval to subpentagonal, sides diverging between 75° and 110°; anterior commissure narrowly uniplicate; fold narrow, anteriorly standing in high relief above flanks, beginning about 7 mm anterior to brachial beak; sulcus rather shallow, broadly trough-shaped, beginning about 6 mm anterior to pedicle beak, projecting as broad, strongly geniculated tongue into fold. Costae weak to moderately strong on fold, with middle one normally somewhat depressed, fine and low on flanks, beginning 6–8 mm anterior to beaks, numbering 3 on fold, 2 in sulcus, 3–6 (normally about 5) on each flank. Growth lines absent over most of shell, rather strong and closely crowded near margins.

Pedicle valve fairly flat in lateral profile, broadly concave in anterior profile; low longitudinal gable

on smooth part of umbonal region; flanks normally slightly concave, prominent or reflexed in ventral direction; beak sharp, straight, flattened, with sharp beak ridges; lateral pseudointerareas wide, extending from valve edge to beak ridge, only partly covered by overlapping edge of brachial valve; delthyrium triangular, with deltidial plates conjunct in adults, leaving elongate, eye-shaped, submesothyridid foramen.

Brachial valve strongly convex transversely, only slightly less convex longitudinally along crest of fold; umbonal region slightly flattened or longitudinally indented, continuing course of depression of median costa; beak blunt, apex within pedicle valve, beneath deltidial plates.

Pedicle valve interior with strong hinge teeth, supported by strong, nearly vertical dental plates reaching floor of valve and with anterior edges distinctly separate from sides of valve. Muscle area subtriangular, with apex between anterior edges of dental plates; individual marks not observed.

Brachial valve interior with large undivided but medially notched hinge plate, bounded laterally by deep, anteriorly widening, apparently denticulate sockets; crura diverging forward from anterior edge of hinge plate, strongly curved ventrally, flat dimension parallel to valve floor; median septum moderately high, but short, supporting hinge plate. Muscle area extending about one third length of valve, further details not observable.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
AMNH 591					
152829a	5.0	4.4	5.5	2.2	97
152829b	7.8	6.8	8.0	3.3	94
152829c	9.3	8.3	9.9	4.6	88
152829d	9.7	9.1	9.9	8.1	92
152829e	10.4	9.6	11.4	8.7	106
152829f	11.0	9.9	11.8	9.0	97
152829g	9.8	8.9	10.8	8.3	88
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation; Skinner Ranch Formation (Sullivan Peak Member).

LOCALITIES.—Bone Spring: AMNH 591. Sullivan Peak: USNM 722-1.

DIAGNOSIS.—Small *Phrenophoria* with flatly concave pedicle valve, strongly swollen brachial valve,

and median costa of fold depressed below the others on the fold.

TYPES.—Holotype: USNM 152829g. Figured paratypes: USNM 152829b–e, 154759a, 154760. Measured paratypes: USNM 152829a–f. Unfigured paratypes: USNM 152829a,f; 154759b.

COMPARISON AND DISCUSSION.—*Phrenophoria repugnans* is characterized by its relatively flat pedicle valve and strongly convex brachial valve, sharp beak ridges, 3 costae on the fold with the middle one normally depressed, numerous fine costae on the flanks, and by its moderately high, but rather short, median septum. The low median gable on the smooth part of the pedicle valve, and the slightly longitudinal depression of the umbonal region in the brachial valve are reminiscent of similar features in *P. subcarinata* Cooper and Grant and to a less degree in *P. corpulenta*, new species. Its flatly concave pedicle valve with winglike flanks bearing many fine costae, and its shortened median septum distinguish it from both of these species. The depressed median costa of the fold is similar to that in *Tautosia elegans* (Girty), but *P. repugnans* differs in its narrower outline, finer and weaker costae on the flanks, and flatter pedicle valve with less sharply reflexed flanks. *Phrenophoria repugnans* is similar to *T. galbina*, new species, in shape, but attains a greater size, has stronger costae on the fold, a flatter pedicle valve, more prominent beak ridges, and depressed median costa on the fold.

Phrenophoria subcarinata Cooper and Grant

PLATE 522: FIGURES 14–50; PLATE 553: FIGURES 35–39

Phrenophoria subcarinata Cooper and Grant 1969:13, pl. 1: figs. 4–12.

Larger than average for genus, strongly biconvex; outline bluntly triangular to elongate oval, sides diverging between 90° and 115°; anterior commissure uniplicate, fold low, beginning 6–9 mm anterior to brachial beak, sharply to gently geniculate near anterior; sulcus shallow, beginning 8–10 mm anterior to pedicle beak, strongly geniculate near anterior margin, forming short tongue. Costae broad, low, beginning 3–6 mm anterior to beaks, numbering 4–6 on fold, one less in sulcus, 4 or 5 on flanks. Concentric ornamentation consisting of faint striae; growth lines prominent or abundant

only near margins of some individuals, producing lamellar appearance.

Pedicle valve with subcarinate crest or ridge along smooth part of beak area, flattening toward sulcus; beak sharp, not attenuate, slightly curved dorsally to suberect; beak ridges prominent, sharp, giving beak flattened aspect; lateral pseudointerareas very narrow or absent, covered by overlap of brachial valve. Delthyrium triangular, base covered by pair of slightly arching deltidial plates, forming elongate oval submesothyriddid foramen. Brachial valve with shallow longitudinal depression on smooth part of umbonal area posterior to fold; apex within pedicle valve, covered by deltidial plates. Flanks gently swollen, sloping steeply to margins.

Pedicle valve interior with sides of delthyrium widely diverging anterior to deltidial plates, teeth parallel sides, supported by vertical dental plates reaching floor of valve. Muscle area lying anterior to edges of dental plates; adductor mark small, subcircular, in posterior part of muscle area; diductor scars larger, anteriorly expanding, surrounding adductor mark laterally and anteriorly.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by strong socket ridges overhanging elongate, anteriorly widening, finely corrugated sockets; outer hinge plates broad, crura diverging anteriorly, strongly curved ventrally, dorsal edges carinate; inner hinge plates fused, concave to convex; median septum high, thin, long, supporting hinge plate, extending forward to near anterior edge of muscle area, bisecting it. Muscle area elongate oval; posterior adductor scars elongate, narrow, oriented diagonally, diverging anteriorly, contiguous with larger suboval anterior adductor scars.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, and Appel Ranch members; lens between Willis Ranch and Appel Ranch members).

LOCALITIES.—China Tank: USNM 703e, 706c. Willis Ranch: AMNH 505. USNM 706, 706e. Appel Ranch: USNM 704, 715i, 719z, 727j. Lens: USNM 706b.

DIAGNOSIS.—Oval, coarsely costate *Phrenophoria* with posterior of pedicle valve subcarinate and posterior of brachial valve sulcate.

TYPES.—Holotype: USNM 148385e. Figured paratype: USNM 148385c,d,f-i. Unfigured paratypes:

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706b					
148385a	12.9	11.0	11.2	9.3	70
148385b	13.0	11.4	11.0	9.1	70
148385c	13.8	12.0	11.9	9.4	80
148385d	15.6	14.1	14.9	10.8	90
148385e (holotype)	17.5	15.6	17.5	14.4	100
USNM 719z					
152830a	15.5	13.0	13.6	14.0?	80
152830b	17.3	16.6	19.2	10.3?	100
USNM 706c					
148387a	19.0	16.8	16.9?	15.0	95

USNM 148385a,b. Measured paratypes: USNM 148385a-d. Figured hypotypes: USNM 148387a; 152830a,b; 154783; 154785. Measured hypotypes: USNM 148387a; 152830a,b.

COMPARISON AND DISCUSSION.—This species is fairly common in the Word Formation especially in the Willis Ranch Member. It is generally an elongate oval form of moderate size for the genus, with strong rounded to subangular costae. At the anterior margin the fold and sulcus are not strongly differentiated but generally three costae appear on the fold and the median one is depressed below the others.

This species belongs to the same group as *P. pinguis* (Girty), and the new species *P. pinguiformis*, *P. perplexa*, and *P. vetula*. It differs from the first of these in generally being smaller, having thinner shells, in having a more oval outline rather than triangular as in *P. pinguiformis*, the Getaway species, and in having less costae. It differs from *P. perplexa* in being smaller, having stronger and a lesser number of costae, in having an oval outline, and in having the two valves more nearly the same depth. It differs from *P. vetula* in size, shape, and ornamentation.

***Phrenophoria ventricosa*, new species**

PLATE 523: FIGURES 1-11

Small for genus, strongly inequivalved, brachial valve strongly ventricose; outline longitudinally oval to subtrigonal; maximum width anterior to midvalve; sides gently rounded; anterior margin gently rounded. Beak short, straight to suberect;

deltidial plates conjunct. Surface costate, costae narrowly rounded, 3 on fold, 2 in sulcus, and 3 or 4 on flanks.

Pedicle valve gently convex in lateral profile, maximum convexity near midvalve; anterior profile gently concave. Umbonal region subcarinate and marked by extension of two costae of sulcus onto umbo, terminating near beak in some specimens, farther anteriorly in others. Sulcus originating at midvalve, narrow and deep, forming long narrow tongue; flanks narrow and flattened but extending moderately at anterolateral extremity.

Brachial valve very deep and strongly convex in lateral profile, very narrowly and strongly domed in anterior view, with sides precipitous and parallel. Umbonal region marked by shallow, narrow sulcus extending onto fold but not depressing median costa significantly. Midregion strongly bellied. Fold originating at midvalve, low and following curvature of valve; fold narrow. Flanks moderately swollen and depressed below anterior part of fold.

Pedicle valve interior with strongly developed dental plates. Brachial valve interior with undivided hinge plate and long slender crura concave toward midvalve. Median septum, long and slender.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle
					(°)
USNM 703d					
148382a	10.5	9.4	10.0	8.8	80
(holotype)					
148382b	9.5	8.0	8.6	7.5	70
148382c	8.7	7.5	8.3	6.1	80
148382d	8.2	7.4	7.9	6.4	80
148382e	9.6	8.2	9.8	8.0	80

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 703d.

DIAGNOSIS.—Small, strongly ventricose *Phrenophoria* with narrow fold and sulcus.

TYPES.—Holotype: USNM 148382a. Figured paratypes: USNM 148382b,e-g. Measured paratypes: USNM 148382b-e. Unfigured paratypes: USNM 148382c,d.

COMPARISON AND DISCUSSION.—This is a small and very ventricose species not at all typical of the genus. Its form and size suggest those of the new species *P. planiventra*, *P. repugnans*, and *P. depressa*. It differs from the first in being smaller and

more completely costate; from the second in having a swollen brachial valve and the costae farther posteriorly; and from *P. depressa* it differs in being more completely and more strongly costate, although it is about the same size.

The most remarkable features of these specimens are the concentric bands of darker color that suggest a possible gaily colored shell. The bands are narrow and fairly evenly spaced. Only 4 of the 6 specimens exhibit the bands. If these prove to be color bands, this will be one of the few colored rhynchonellids known (Richter 1919:83).

Phrenophoria vetula, new species

PLATE 518: FIGURES 51-59; PLATE 519: FIGURE 38;
PLATE 524: FIGURES 10-14; PLATE 541: FIGURES 59-63;
PLATE 552: FIGURE 17

Large for genus, wider than long, outline sub-trigonal; posterolateral margins gently convex, forming angle of 90° to 110°. Sides narrowly rounded; anterior margin truncated. Anterior commissure uniplicate. Beak nearly straight, short, with fairly large submesothyridd foramen. Surface costate but umbones smooth; costae broad and rounded, 3 on fold, 2 in sulcus, and 4 on each flank; costae of brachial valve lower and more rounded than those of opposite valve.

Pedicle valve moderately convex in lateral profile, broadly convex in anterior profile, medial region narrowly convex. Umbonal region subcarinate, forming low fold uniting with median costae occupying sulcus. Sulcus originating anterior to midvalve, extending into short tongue. Flanks concave, narrow.

Brachial valve moderately convex in lateral profile, broadly domed in anterior profile. Umbonal region moderately deeply sulcate, sulcus depressing median costa of fold. Median region moderately swollen. Fold low, defined only at anterior third; flanks moderately swollen and rounded.

Pedicle valve interior not known. Brachial valve interior with thin socket ridges, broad outer hinge plates and inner hinge plates united with healed suture. Median septum delicate, high, and long, reaching about to midvalve.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—USNM 702, 702b, 702inst, 702-low, 721u.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 721u 154757a (holotype)	17.7	15.5	17.3	12.7	101
USNM 702 152832	14.6+	13.3	15.5	12.4	95
USNM 702inst 152831	15.0?	12.6?	17.8	7.8?	105

DIAGNOSIS.—Large *Phrenophoria* with keeled pedicle umbo and strong rounded costae.

TYPES.—Holotype: USNM 154757a. Figured paratypes: USNM 148373, 152832, 154757b, 154888, 154914. Measured paratypes: USNM 152831, 152832.

COMPARISON AND DISCUSSION.—This is a rare species and the specimens are not well preserved. Nevertheless, this is one of the earliest species of the genus and an important representative of it. The specimens are most like *P. subcarinata* Cooper and Grant in having the keeled pedicle valve umbo, the depression in the fold of the brachial valve, and strong costae. It differs from *P. subcarinata* in having coarse, rounded costae with 3 on the fold, and in having a more transverse outline and smaller cardinalia. It is quite unlike *P. pinguiformis*, new species, in shape, outline, and thickness of costae as well as interior details. It is also larger and more strongly costate than *P. pinguis* (Girty).

Inside, the brachial valve has an undivided hinge plate with the inner hinge plates united without suture but a minute chamber is present between these plates and the long median septum.

One of the specimens assigned to this species is elongated and not characteristic. It is similar to an elongate form which is a variant of *P. pinguiformis*. It is likely that elongate forms may appear among any of the species groups.

Phrenophoria species 1

PLATE 519: FIGURES 35–37

A fine species of *Phrenophoria* is indicated by two brachial valves and a fragmentary third. The best specimen measures 14 mm in length, 15 mm in width, and 7.5 mm in thickness. The sides are well rounded and the umbonal region is sulcate, the sulcus continuing onto the fold, which is short and flattened on its surface. The fold orig-

inates at about midvalve, is low and slightly spreading, and contains 6 costae, the median ones of which are slightly depressed. The flanks are well rounded and swollen, with steep sides. They have 6 costae and a possible faint seventh.

The interior has corrugated sockets, a small undivided hinge plate supported by a long, delicate but strong median septum.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Sullivan Peak Member).

LOCALITIES.—USNM 707d, 722h.

Phrenophoria species 2

A second named species of *Phrenophoria* is represented by three specimens, two of which are complete but partly crushed. They are wider than long, strongly costate, one with 4 costae on the fold but the other with only 3. The flanks are provided with 5 costae which are smaller and more angular than those of the fold. A marked depression runs from the umbonal region through the fold to the anterior margin. The better preserved specimen measures 14.8 mm long, 17.9 mm wide, and 9.7 mm thick. The specimens come from the Road Canyon Formation at USNM 707e.

Phrenophoria species 3

PLATE 508: FIGURES 68–71

A large semicostate brachial valve with narrow, undivided hinge plate supported by a long, thin, elevated median septum indicates an undescribed species. The specimen is from the Road Canyon Formation at USNM 721j.

Holosia, new genus

[Greek *holos* (all)]

Holosia is suggested for a group of species having the internal characteristics of *Phrenophoria* but having elongated shells that are completely costate.

TYPE-SPECIES.—*Holosia regularis*, new species.

DISCUSSION.—This genus includes only a few species at the present time, all rare. They make a striking contrast to such typical specimens of *Phrenophoria* as the type species and the widely triangular form called *Tautosia* Cooper and Grant (1969).

Holosia ovalis, new species

PLATE 523: FIGURES 12-23

Large for genus, elongate oval in outline, sides gently expanding to widest part anterior to midvalve, there narrowly rounded; anterior margin rounded; anterior commissure uniplicate. Beak short, suberect, foramen submesothyridd. Costae narrowly rounded, nearly reaching beaks, 4 on fold, 3 on flanks.

Pedicle valve gently convex in lateral profile, maximum convexity posterior to midvalve; anterior profile gently concave with flanks sharply reflected in dorsal direction. Umbonal region smooth, narrowly convex; median region gently convex to concave; sulcus shallow, broad, originating at midvalve, forming strongly geniculated short tongue at anterior. Sulcus containing 2-4 costae; flanks flattened, beak ridges short, angular.

Brachial valve moderately convex in lateral profile, strongly domed in anterior profile, sides subparallel. Umbonal region smooth, median region moderately swollen. Fold low, narrow, originating at midvalve, occupied by 3 or 4 costae. Flanks swollen but precipitous, occupied by 6 curving costae.

Interior imperfectly known; median septum long, strongly elevated and thin, supporting broad, undivided hinge plate.

MEASUREMENTS (in mm).—Holotype USNM 152833c: length 15.5, brachial valve length 13.4, width 13.9, thickness 12.4, apical angle 80°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 707e.

DIAGNOSIS.—Elongate *Holosia* with nearly completely costate valves, only the umbones being smooth.

TYPES.—Holotype: USNM 152833c. Figured paratypes: USNM 152833a,b,d.

COMPARISON.—This species is like *Holosia ovoidea*, new species, but differs in having a less elevated fold and less pronounced sulcus, stronger costae, and a truncated anterior.

DISCUSSION.—This species is represented by four specimens, two of them complete and fairly well preserved, a third with one side broken away revealing the interior with its long median septum, and the fourth a brachial valve showing the hinge plate.

Holosia ovoidea, new species

PLATE 523: FIGURES 24-28

Large for genus, elongate oval in outline, sides gently rounded, anterior margin somewhat narrowly rounded; valves of unequal depth, brachial valve deeper; apical angle 90°. Anterior commissure strongly uniplicate. Beak short; foramen not seen; surface nearly completely costate except in umbonal regions of both valves. Costae fine and narrow, 5 on fold, and 4 or 5 on flanks. Concentric lines crowded along anterior commissure.

Pedicle valve moderately and evenly convex in lateral profile except for sharply geniculated tongue; anterior profile broadly and gently convex; umbonal and median regions slightly keeled; sulcus scarcely discernible, marked only at anterior. Flanks narrow and merging into convexity of valve.

Brachial valve gently convex in lateral profile except in vicinity of fold, there strongly geniculated in ventral direction; anterior profile narrowly domed, top nearly flat, flanks sharply deflected and approximately parallel. Umbonal and median region gently swollen; umbonal region with shallow narrow sulcus beginning near midvalve. Fold scarcely defined at anterior, best seen along commissure. Flanks flatly convex, precipitous.

Interior details, except for long crura, not visible.

MEASUREMENTS (in mm).—Holotype USNM 148398: length 15.8 plus, brachial valve length 14.5, width 14.1, thickness 12.0, apical angle 90°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—USNM 728.

DIAGNOSIS.—Oval *Holosia* with poorly developed fold and sulcus.

TYPES.—Holotype: USNM 148398.

COMPARISON.—Only one other species, *Holosia ovalis*, new species, is like this one, but the two are different in detail. *Holosia ovalis* has a well-marked fold and sulcus and much stronger costae than the Guadalupe Mountains species. The peculiar geniculation at the anterior of the brachial valve of *H. ovoidea* is unlike the steep but evenly convex slopes of the Glass Mountain species.

DISCUSSION.—Only a single specimen of this species has been found. When one considers the large samples of other species obtained at this locality, the great rarity of this species becomes evident. The specimen is broken at the beak and thus the

crura can be seen. A trace of the median septum is visible on the outside, in the middle of the umbonal depression.

The ornament of this specimen is unusual for the complete cover it makes of the entire shell including the beaks. The costae are also very regular and evenly spaced. Nevertheless, the brachial valve bears a median depression suggesting *Phrenophoria*. The hinge plate is narrow and the inner hinge plates are united in a small anticline. The median septum is stouter than usual in *Phrenophoria*.

Holosia regularis, new species

PLATE 523: FIGURES 22–32

Usual size for genus, longer than wide, long posterolateral margins converging at about 70°. Maximum width anterior to midvalve; outline elongate subtrigonal; sides narrowly rounded and anterior margin gently rounded. Anterior commissure gently and broadly uniplicate. Beak short, straight, with small deltidial plates. Costae extending from beaks to anterior margin, direct and regular, and broad and angular, 5 on fold, one fewer in sulcus, and 4 on flanks.

Pedicle valve moderately but unevenly convex in lateral profile, most curvature in anterior region; anterior profile broadly, evenly and moderately convex. Umbonal region moderately convex but median region somewhat swollen. Sulcus broad and very shallow, not well defined, beginning anterior to midvalve; tongue short and broad. Flanks narrow, convex, steep.

Brachial valve about same depth as pedicle valve, fairly evenly and moderately convex in lateral profile; anterior profile broadly and moderately convex with moderately steep sides. Umbonal and median regions gently convex; fold originating anterior to midvalve, broad and flattened, scarcely elevated; flanks narrow, moderately swollen, and steep.

Pedicle valve interior with small knoblike teeth, dental plates plastered against valve wall, visible but without umbonal cavities. Muscle field small.

Brachial valve interior with small narrow hinge plate having stout socket ridges, narrow outer hinge plates, narrow crural bases, and inner hinge plates coalesced to form elevated ridge. Median

septum elevated, stout, supporting hinge plate but extending anteriorly only about a fifth of valve length.

MEASUREMENTS (in mm).—Holotype USNM 152834: length 11.0, brachial valve length 10.0, width 10.9, thickness 7.5, apical angle 70°.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Rader Member).

LOCALITY.—AMNH 401.

DIAGNOSIS.—Medium-size *Holosia* having completely costate valves and nearly obsolete dental plates.

TYPES.—Holotype: USNM 152834.

COMPARISON.—This species is readily distinguished from *Phrenophoria subcarinata* Cooper and Grant, and *P. pinguiformis*, new species, by its smaller size and the completely costate shell. In the latter respect it resembles *Holosia ovoidea*, and *H. ovalis*, both new species, but it is much smaller, has different proportions, stronger costae less thickness, and lacks the long anterior tongue of the other two species.

Holosia species 1

PLATE 519: FIGURES 39, 40

A large nearly circular brachial valve 16 mm long by 19 mm wide and completely costate represents an undescribed species. The median region and umbonal area are marked by a shallow depression which becomes a low fold anteriorly. Costae are narrowly rounded and number 6 on the low poorly perceptible fold and about 8 on the flanks. The strong median septum supports a narrow hinge plate not quite completely united or damaged.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank Member).

LOCALITY.—USNM 706c.

Genus *Tautosia* Cooper and Grant, 1969

Tautosia Cooper and Grant 1969:14.

Tautosia includes a group of species related to *Phrenophoria* that externally is typically wellerelliform. The species are generally transverse and have a strong fold and sulcus, are usually paucicostate, and have strong, angular anterolateral extremities

on the pedicle valve. Internally these species are like *Phrenophoria* with a strong median septum in the brachial valve and an undivided hinge plate with modified falcifer crura.

TYPE SPECIES.—*Tautosia fastigiata* Cooper and Grant (1969:14, pl. 4: figs. 11–14).

DISCUSSION.—As with many genera, a clean line of distinction cannot always be drawn between some species. We have placed under *Phrenophoria* a few species that in external appearance are somewhat wellerelliform but which do not completely accord with *Tautosia*. Generally the name *Phrenophoria* may be used for the somewhat elongate or oval forms with leiorhynchiform exterior and *Tautosia* for those transverse species with strong costae.

Tautosia angulata, new species

PLATE 521: FIGURES 22–29

Usual size for genus, widely and angularly pentagonal in outline; wider than long with posterolateral shoulders narrowly rounded and sides sloping medially; posterolateral margins gently concave, apical angle about 111° . Anterior margin truncated; anterior commissure uniplicate. Surface semicostate, costae thick and distant, 3 on fold, possible on each flank.

Pedicle valve much shallower than brachial valve, gently convex in lateral profile but broadly and fairly deeply concave in anterior profile. Sulcus and median costae originating at midvalve; posterior half somewhat flattened with moderate slopes to posterolateral extremities; flanks narrow, concave, and with steep slopes.

Brachial valve flatly convex in lateral profile with most convexity in anterior region; anterior profile strongly domed with gently rounded top but precipitous slopes. Fold originating near midvalve, flat-topped, not strongly elevated. Flanks depressed, very narrow, and narrowly rounded.

Pedicle valve interior unknown. Brachial valve interior with long slender median septum.

MEASUREMENTS (in mm).—Holotype USNM 154767: length 10.5, brachial valve length 10.3, width 13.2, thickness 8.2, apical angle 111° .

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 732j.

DIAGNOSIS.—Angularly pentagonal *Tautosia* with thick and rounded costae on fold and sulcus and flanks consisting of one costa.

TYPES.—Holotype: USNM 154767.

COMPARISON.—In its squat pentagonal outline and strong distant costae this species is unlike any other known *Tautosia*. The specimen is mostly silica filled, but a part of the long slender median septum is clearly exhibited in a fracture in the shell made after the specimen was photographed.

Tautosia distorta, new species

PLATE 544: FIGURES 41–47

Small for genus, subpentagonal in outline; wider than long; maximum width anterior to midvalve; sides narrowly rounded; anterior margin broadly curved. Beak erect; foramen small; deltidial plates conjunct. Anterior commissure strongly uniplicate. Posterior surface smooth but anterior strongly costate; costae few and angular, 3 on fold, 2 or 3 on flanks.

Pedicle valve gently but unevenly convex, umbonal region moderately swollen; anterior profile broadly concave. Sulcus originating just anterior to umbonal region and posterior to midvalve, broad and deep with long steep slopes to tongue; costae in sulcus extending onto umbonal region. Tongue long and strongly serrated, with broad angle of geniculation. Flanks narrow and strongly deflected in ventral direction.

Brachial valve nearly flat to slightly concave in lateral profile but forming flat-topped, broad dome in anterior profile. Lateral slopes short but steep. Umbonal region marked by long depression ending at distal termination of median costa of fold; fold originating near midvalve, nearly flat to slightly concave, distal margin slightly elevated; flanks depressed, narrow, and completely occupied by costae.

Interior of pedicle valve with strong dental plates and small teeth. Interior of brachial valve with long median septum visible through hole in holotype.

MEASUREMENTS (in mm).—Holotype USNM 153488a: length 12.0, brachial valve length 10.0, width 13.3, thickness 10.0, apical angle 91° .

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member).

LOCALITY.—USNM 727j.

DIAGNOSIS.—Small *Tautosia* with angular outline, oblique fold, and depressed lateral profile of the brachial valve.

TYPES.—Holotype: USNM 153488a. Figured paratype: USNM 153488b.

COMPARISON.—This species is unique in the genus, with its depressed profile and relatively shallow valves. It is similar to *Tautosia transenna* from the Word Formation, but that species has a less prominent fold, weaker costae, and different profiles. The two type specimens are the only ones of this species recovered from the residues.

Tautosia elegans (Girty)

PLATE 519: FIGURE 24; PLATE 523: FIGURES 33–51;

PLATE 553: FIGURE 40; PLATE 780: FIGURES 66–68 (in part V)

Pugnax elegans Girty, 1909:315, pl. 15: figs. 13–14a.

Not *Pugnoides elegans* (Girty) R. E. King, 1931:106, pl. 33: figs. 12–13 [= *Pontisia stehlii* Cooper and Grant, 1969] or pl. 34, fig. 4 [= *Antronaria speciosa*, new species].

Not *Wellerella elegans?* (Girty) Stehli, 1954:335, pl. 25: figs. 13–17 [= *Antronaria speciosa*, new species].

Not *Pugnax bidentata* Girty [part], 1909:318, specimen USNM 118569b.

Average size for genus, biconvex, somewhat inflated; outline bluntly and transversely triangular, sides diverging between 80° and 120°; profile narrowly subtrigonal; commissure strongly uniplicate; fold beginning 6–8 mm anterior to dorsal beak, increasing in height to anterior margin, profile of fold slightly convex; sulcus moderately deep, beginning 6–8 mm anterior to ventral beak, maximum convexity between anterior points of costae on flanks. Costae weak to moderately strong, beginning 5–8 mm anterior to beaks, crests angular on fold and pedicle flanks, bluntly rounded in sulcus and on brachial flanks, numbering 2–4 on fold, normally 3, with median costa slightly, to strongly depressed, one less in sulcus, 2–5 on each flank, normally 3. Concentric ornamentation not observed; growth lines normally present only near margins.

Pedicle valve slightly inflated on smooth posterior area anterior to beak; flanks slightly to strongly reflexed; lateral profile gently convex; anterior profile broadly and gently concave; beak sharp, moderately attenuate, with blunt beak

ridges; lateral pseudointerareas narrow, partly covered by slightly arched trapezoidal conjunct deltidial plates anteriorly labiate or alate in adults, foramen elongate oval, mesothyridid to submesothyridid.

Brachial valve deeper and more strongly convex from beak to flanks than opposite valve; smooth part of beak area slightly flattened or evenly arched transversely; apex within pedicle valve, covered by deltidial plates. Flanks moderately swollen and convex.

Pedicle valve interior with delthyrium spreading widely anterior to deltidial plates; teeth elongate, parallel to sides, supported by dental plates reaching valve floor. Umbonal cavities narrow, muscle area bluntly triangular, lying just anterior to dental plates; adductor scars median, forming small oval impression; diductor scars large, lateral to adductors, converging to median line anterior to adductors.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by deep, anteriorly expanding, finely corrugated sockets; crura strong, attached to sloping, broad outer hinge plates, diverging anteriorly and strongly curved ventrally, slightly twisted, with dorsal edges keeled; inner hinge plates united, often medially arched at their junction. Median septum variable, usually high, thin, long, supporting hinge plate, extending to near middle of muscle area, bisecting it. Muscle area oval; posterior adductor scars narrow, anteriorly diverging from median septum, anterior adductor scar large, extending beyond median septum.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 738					
148332a	8.0	7.0	8.1	4.4	88
148332b	8.8	8.2	10.0	c. 5.	95
148332c	10.4	9.2	12.3	c. 6.	98
148332d	12.0	10.6	14.0	6.9	117
148332e	11.0	10.0	15.3	9.3	112
118565	11.0	10.1	14.4	7.8	105
(lectotype)					
118565a	8.9	7.9	10.8	7.4	105
USNM 738b					
152835a	7.3	6.7	8.0	3.9	90
152835b	8.3	7.7	10.3	4.9	105
152835c	10.0	8.8	11.5	6.0	100
152835d	10.3	9.1	12.4	7.9	95

STRATIGRAPHIC OCCURRENCE.—Capitan Formation; Bell Canyon Formation (Pinery, Rader, and Lamar members).

LOCALITIES.—Capitan: USGS 2926 (green); USNM 737a, 739, 740, 740n, 740k. Pinery: USNM 733. Rader: AMNH 403; USNM 725g, 740j. Lamar: AMNH 37, 38, 40, 401, 430; USNM 725e, 728p, 738, 738b.

DIAGNOSIS.—Triangular *Tautosia* with median costa of fold depressed.

TYPES.—Lectotype: USNM 118565. Figured hypotypes: USNM 154758; 157490c,d; 154791a,c,d,e; 154921.

COMPARISON.—*Tautosia elegans* is characterized by its triangular outline, only slightly convex brachial profile along the crest of the fold, commonly slightly depressed median costa on the fold, weak costae on the brachial flanks, and its prominent, thin, long median septum in the brachial valve. It most nearly resembles *T. transenna*, new species, from lower in the Guadalupian, differing in its wider outline (in adults), normally depressed middle costa of the fold, normally 2 or 3 weaker costae on the flanks instead of 3 or 4 strong costae, somewhat more convex profile of the fold, and costae that begin farther back toward the beaks. The depressed middle costa of the fold produces a recess in the anterior margin of this species, a feature not present in *T. transenna*. *Tautosia elegans* also is externally similar to *Wellerella girtyi*, new species, from which it differs in its less longitudinally convex, and therefore more protruding fold, its normally depressed median costa on the fold, more transverse and triangular outline, and high median septum. These features also distinguish it from *Pontisia stehlii*, new species, from the Leonardian of West Texas, and *Wellerella osagensis* (Swallow) from the Pennsylvanian.

Apparently on the basis of the depressed median costa, this species was identified by R. E. King (1931) and Stehli (1954) with specimens that now are called *Antronaria speciosa*, new species. *Tautosia elegans* is a rare Guadalupian species, and does not occur in the Leonardian with *A. speciosa*, from which it differs in its smaller size, less strongly and less consistently depressed median costa, less strongly transverse outline, fewer and weaker costae on the flanks, and especially in its high median septum.

The general aspect of *T. elegans* is rather com-

mon, and several foreign species are similar. *Pugnax pseudoutah* Huang (1933) from the Permian of China is similar in profile, but is not as transverse nor as triangular, and it has stronger costae on the fold, of which the median one is not depressed, and fewer, weaker costae on the flanks. *Rhynchonella edelsteini* Tschernyschew (1914) is smaller, more convex in profile, and less transverse in outline, although it has a similarly depressed median costa on the fold. *Tautosia elegans* differs from *Rhynchonella negrii* Gemmellaro (1899) in its depressed median costa, more consistently 3 costae on the fold, more transverse outline, larger size, and more prominent fold.

DISCUSSION.—This is a variable species on the exterior. The collection includes a fair number of lots from several localities but none is represented by a collection large enough to give a good idea of its variation. It is possible that subsequent collecting will show the presence of more than one species.

Tautosia expansa, new species

PLATE 524: FIGURES 1-9

Small for genus, wider than long, maximum width near midvalve; outline subtrigonal to subpentagonal; posterolateral margins forming angle of about 90°; sides narrowly rounded; anterior margin truncated to slightly emarginate. Anterior commissure uniplicate. Beak moderately long, foramen oval, often encroaching on apex, deltidial plates disjunct. Surface except umbones costate, costae broadly rounded and somewhat flaring anteriorly, 3 or 4 (rarely 2) on fold, one less in sulcus, and 4 or 5 on flanks.

Pedicle valve gently but unevenly convex in lateral profile, maximum convexity between midvalve and umbo; anterior profile very slightly convex, flanks scarcely deflected. Umbonal region swollen; sulcus originating near midvalve, usually fairly broad and shallow, and produced into short tongue. Flanks flattened and slightly deflected.

Brachial valve slightly deeper than pedicle valve, moderately and evenly convex in lateral profile, moderately and broadly domed in anterior profile, sides moderately steep. Umbonal region moderately convex but median region swollen; fold originating at midvalve, low, anteriorly spreading, moderately

convex in longitudinal section, only slightly elevated anteriorly. Flanks moderately swollen, slightly depressed below fold.

Pedicle valve interior with strong dental plates. Brachial valve interior with strong socket ridges and broad outer hinge plates supporting long curved crura, narrow near base but expanding distally, giving appearance of being twisted near junction with hinge plate. Inner hinge plates medially coalesced but anteriorly notched. Median septum thin, not extending to midvalve.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 747					
148589a	7.2	6.1	8.1	4.6	90
148589b	7.4	6.4	8.0	4.3	90
148589c	6.7	5.8	7.4	4.2	90
148589d	6.4	5.6	6.9	3.5	85
(holotype)					
148589e	6.4	5.5	6.9	3.8	85
148589f	6.0	5.0	6.3	3.4	80

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (Cutoff Member).

LOCALITY.—USNM 747.

DIAGNOSIS.—*Tautosia* with soft contours and low fold.

TYPES.—Holotype: USNM 148589d. Figured paratypes: USNM 148589c,e,g. Measured paratypes: USNM 148589a–c,e,f. Unfigured paratypes: USNM 148589a,b,f.

COMPARISON.—This species superficially looks like *Wellerella girtyi*, new species, but that species is a larger one with half the valve smooth at the posterior end. *Wellerella nitidula* and *Pontisia franklinensis* are small new species but both of them are strongly convex and attain a greater thickness than the Cutoff specimens. This is true also of most of the Pennsylvanian species figured by Dunbar and Condra (1932) except for *W. delicata*. The latter is ornamented quite differently from the Cutoff species.

Tautosia fastigiata Cooper and Grant

PLATE 524: FIGURES 15–53; PLATE 525: FIGURE 1

Tautosia fastigiata Cooper and Grant, 1969:14, pl. 4: figs. 11–14.

Large for genus, biconvex, flattened to some-

what inflated; outline transversely triangular, about one third wider than long; sides diverging between 80° and 120°, averaging 104°; profile subtrigonal; commissure uniplicate; fold high, beginning 6–8 mm anterior to brachial beak, increasing in height anteriorly, ending abruptly, not flexed at anterior, transversely nearly straight or slightly arched; sulcus deep, beginning 10–12 mm anterior to pedicle beak, evenly curved anteriorly, not geniculate. Costae strong, angular, beginning about 6 mm anterior to brachial beak, about 9 mm anterior to pedicle beak, numbering 3–7 on fold, normally 5, invariably one less in sulcus, numbering 5–7 on flanks; crests of costae nearly concordant. Concentric ornamentation obscure; growth laminae prominent only near margins.

Pedicle valve slightly convex longitudinally from beak to flanks, with greatest convexity about 4 mm anterior to beak; strongly convex from beak through sulcus; gently convex transversely; beak straight, sharp, flat, attenuate, may have slight median crest, more-or-less prominent beak ridges; lateral pseudointerareas narrow to moderately wide, straight, extending from posterior costa of flanks to edge of delthyrium, width dependent upon amount of overlap by brachial valve. Delthyrium on dorsal side of beak, narrowly triangular, base covered by two flat trapezoidal deltidial plates, leaving apical part open as elongate oval mesothyridid foramen. Brachial valve moderately convex along median line, strongly convex toward flanks, strongly convex transversely; smooth part of umbo flattened or slightly indented, producing gently rounded beak ridges; apex of beak within pedicle valve, just beneath deltidial plates.

Pedicle valve interior with delthyrium wide open anterior to deltidial plates, each side with a strong nodular, elongate tooth, parallel to edge of delthyrium, supported by strong, vertical dental plate reaching floor of valve. Muscle area anterior to ends of dental plates; adductor scars small, oval, bilobed at posterior end, lying along each side of median line; diductor scars somewhat wider, elongate, lateral, and anterior to adductor scars.

Brachial valve interior with triangular undivided hinge plates bounded laterally by deep elongate corrugated hinge sockets; crura projecting forward from edge of hinge plate, on each side of midline, diverging anteriorly and strongly curving toward pedicle valve, normally only slightly twisted, dorsal

edge carinate; median septum high, supporting hinge plate to apex of valve, extending about half-way along septum; posterior adductor scars small, elongate, anteriorly divergent; anterior adductor scars larger, lying on either side of septum, but extending beyond end of septum, slightly expanding anteriorly.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 702b					
148342a	4.0	3.1	3.2	1.2	85
148342b	4.9	3.9	4.2	1.5	90
148342c	5.9	4.8	4.9	1.5	70
148342d	8.0	6.3	7.6	2.5	83
148342e	8.9	7.0	7.8	2.9	80
148345a	12.7	?	12.8	?	90
148345b	18.0	15.4	21.6	12.2	90
148345c	18.3	16.5	20.0	8.3	97
148345d	20.9	18.0	25.0	11.4	100
148345e	22.4	19.6	28.3	12.8	111
148345f (holotype)	21.7	18.7	29.5	15.0	111

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Skinner Ranch Formation.

LOCALITIES.—Cathedral Mountain: AMNH 500F, 500H, 500M; USNM 702, 702b, 702un, 703b, 726x, 731b. Skinner Ranch: 724q.

DIAGNOSIS.—Large, wide *Tautosia* with straight beak.

TYPES.—Holotype: USNM 148345f. Figured paratypes: USNM 148345e. Figured hypotypes: USNM 148342c,e; 154792a–c; 154793a,c–f; 154794a,c,d; 154795; 154796a. Measured paratypes: USNM 148345a–e. Measured hypotypes: USNM 148342a–e. Unfigured paratypes: 148345a–d.

COMPARISON.—*Tautosia fastigiata* is characterized by its large size, transverse outline, strong and numerous costae whose crests are nearly equal to one another in height, its attenuate beak with beak ridges, flattened or slightly indented dorsal umbo, and by its high, bladeliike median septum. Among species of the Glass Mountains it closely resembles *Antronaria voluminosa*, new species, in its size and outline. *Tautosia fastigiata* differs in its somewhat smaller, sharper and more numerous costae (normally 5 on the fold, in contrast to 4 on the fold of *A. voluminosa*), more attenuate beak with beak ridges, and less widely divergent sides,

and higher median septum. In *A. voluminosa* the crests of the costae on the fold bend sharply ventrally immediately posterior to the commissure, whereas in *T. fastigiata* the crests terminate abruptly, forming a sharp point. Furthermore, the sulcus of *T. fastigiata* is nearly uniformly convex from beak to anterior margin, but that of *A. voluminosa* is more strongly flexed at some point near, but posterior to the anterior margin.

Another large and transverse species is *A. mesicostalis* (Girty). However, it is smaller than the average specimen of *T. fastigiata*, more transverse, and its costae lower and finer. The middle costa of the fold of *A. mesicostalis* is depressed in most specimens below the level of the others.

DISCUSSION.—*Tautosia fastigiata* varies in size, convexity, outline, and number of costae. Most adult specimens have 5 costae on the fold, but most juveniles smaller than 10 mm in length have only 3. When the shell is between 7 and 12 mm in length, 2 costae are normally added, one on each side of the fold. Juveniles are sufficiently different from the adults to produce confusion unless a continuous growth series is available for study. The features that are constant from juvenile to adult, and which unite the species are the dorso-ventrally flattened pedicle valve that is only slightly curved dorsally and has sharp beak ridges, the relatively large smooth area of the umbones, with the brachial umbonal area flattened and normally slightly longitudinally indented, and the high median septum. The species that is most likely to be confused with the juveniles of *T. fastigiata* is *Pontisia stehlii* Cooper and Grant. The above-mentioned characters distinguish them, and, in addition, juveniles of *T. fastigiata* are rather sharply bent at the posterior edge of the smooth area of the brachial umbo, whereas in *P. stehlii* the convexity of the brachial valve is more uniform, producing a much more elevated anterior end of the fold.

Nearly full grown specimens of *Antronaria dissona*, new species, bear some resemblance to juveniles of *T. fastigiata*. The latter may be distinguished by their less transverse outline, more frequent possession of more than 3 costae on the fold, flattened pedicle beak with sharp beak ridges, and especially by the high median septum in the brachial valve.

Tautosia galbina, new species

PLATE 525: FIGURES 2-12

Small for genus, biconvex; outline bluntly triangular, sides diverging between 80° and 110°; profile lenticular; anterior commissure uniplicate, fold low to moderately high, beginning 3-6 mm anterior to brachial beak, profile gently convex; sulcus shallow, beginning 4-6 mm anterior to pedicle beak, maximum convexity between anterior ends of costae of flanks. Costae weak to moderately strong, narrow crests rounded, beginning 4-6 mm anterior to beaks, strongest on fold, there numbering 3, 2 in sulcus; costae strong on pedicle flanks, numbering 4-6, becoming weaker laterally, weakest on brachial flanks. Concentric ornamentation absent; growth lines faint and few.

Pedicle valve moderately convex, smooth part of umbonal area slightly inflated; flanks slightly convex to slightly reflexed; beak relatively blunt, slightly flattened, not attenuate, suberect; beak ridges sharp, short; lateral pseudointerareas very narrow or absent; little overlap of valves. Delthyrium triangular, base covered by two small, slightly arching deltidial plates; apical portion open, forming elongate oval submesothyridid foramen. Brachial valve strongly and narrowly convex in anterior profile; smooth area of umbo flattened in profile, slightly flattened to evenly arched transversely; beak within pedicle valve, covered by deltidial plates.

Pedicle valve interior with widely expanding delthyrium, with elongate teeth, supported by short dental plates reaching valve floor. Muscle area large, between and anterior to dental plates, widely expanding anteriorly, occupying as much as half valve length; adductor scars median, forming small subcircular mark; diductor scars surrounding adductors laterally and anteriorly, much larger, greatly widening anteriorly.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by elongate, deep, anteriorly widening, finely corrugated sockets; crura diverging anteriorly from forward edges of hinge plate, strongly curved ventrally, often twisted, dorsal edges keeled; median septum high, bladellike, long, bisecting posterior part of muscle area, supporting hinge plate. Muscle area elongate oval; posterior adductor scars elongate, anteriorly

divergent, flanking larger, median, anteriorly widening anterior adductor scars.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 707e					
148352a	5.6	5.1	6.5	3.4	90
148352b	6.2	5.6	6.1	4.0	85
148352c	6.9	6.0	6.7	4.5	91
148352d	7.7	6.4	7.8	5.0	100?
USNM 722g					
154798b (holotype)	7.2	6.2	7.7	4.5	101

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—AMNH 509; USNM 703, 707e, 722g.

DIAGNOSIS.—Small *Tautosia* with flanks having many costae.

TYPES.—Holotype: USNM 154798b. Figured paratypes: USNM 148352a,d,e; 154797; 154798a. Measured paratypes: USNM 148352a-d.

COMPARISON.—*Tautosia galbina* is characterized by its small size, slightly flattened smooth part of umbonal area, low costae on the flanks, and its high, bladellike median septum. A similar species is *Wellerella tetrahedra* Dunbar and Condra (1932, pl. 37: figs. 11-16) from the Pennsylvanian of Missouri. *Tautosia galbina* differs in its more numerous lateral costae, normally nonreflexed pedicle flanks, less inflated brachial umbonal area, and especially in its much higher and longer median septum.

The species does not closely resemble others from the West Texas Permian. It is similar to *Cenorhynchia frasca*, new species, from which it differs in its smaller maximum size, more transverse outline, less strongly curved pedicle beak, and especially its many costae on the flanks. This is a smaller and very rare species. The collection contains only four lots and none with abundant specimens.

Tautosia lenumbona (Stehli)

PLATE 525: FIGURES 26-35

Terebratuloides? lenumbona Stehli, 1954:338, pl. 25; figs. 28-30.

Small for genus, slightly wider than long; subtriangular to subpentagonal in outline, maximum width near midvalve; sides somewhat narrowly

rounded; apical angle variable up to 100°. Anterior commissure uniplicate. Deltidial plates rudimentary; beak short, acute, generally erect. Surface, except beaks and umbonal region, costate, costae narrowly rounded, direct, usually 4 or 5, rarely 6, on fold, one less in sulcus, and 3 or 4 on flanks.

Pedicle valve very gently convex in lateral profile and nearly flat in anterior profile; umbonal region narrowly swollen; sulcus originating posterior to midvalve, broad and shallow, extending into long tongue. Flanks fairly strongly deflected, narrow, gently concave.

Brachial valve fairly strongly convex in lateral profile, broadly domed and with very steep sides in anterior profile. Umbonal region moderately swollen. Fold beginning near midvalve, low, flattened, only slightly elevated above flanks at anterior. Median region marked by narrow, shallow sulcus extending along midline to anterior margin and depressing median costae of fold. Flanks fairly strongly swollen.

Pedicle valve interior with small teeth, elongated and attached just inside valve margin; dental plates variable, usually thin, with very narrow umbonal chambers filled by shell in some specimens, thus obscuring dental plates. Muscle field short, triangular.

Brachial valve with strong curved socket ridges and corrugated sockets; hinge plate undivided, with broad outer hinge plates and long slender, bladelike flattened crura. Median septum thin, strong and extending to midvalve; adductor field forming heart-shaped pattern with point posterior. Anterior adductors lying inside posterior pair.

MEASUREMENTS (in mm).—Hypotypes USNM 152837 and 152838, respectively: length 7.3, 6.8; brachial valve length 6.4, 6.0; width 8.2, 6.8; thickness 4.5, 3.8; apical angle 90°, 80°.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITIES.—AMNH 625, 629; USNM 728f, 728h.

DIAGNOSIS.—Small *Tautosia* with 4 or more costae on the fold; sulcus originating posterior to midvalve.

TYPES.—Holotype: AMNH 27320/1:1. Figured paratype: AMNH 27320/1:2. Figured hypotypes: USNM 152837, 154799a, 155105a-c.

COMPARISON AND DISCUSSION.—This species is characterized by its numerous costae and its small

size. Stehli assigned it to *Terebratuloides* with a query, in the belief that it had no dental plates. He also did not have the brachial valve. We obtained additional specimens and have both valves. The species proves to have dental plates and the brachial valve has a thick median ridge. It is therefore not referable to *Terebratuloides*.

Among Sierra Diablo species it might be confused with *Tautosia magnisepta* (Stehli), but it is smaller than that species, commonly has more costae on the fold and in the sulcus, and is differently shaped. It is also similar to *Pontisia longicosta* (Stehli) but is larger; the pedicle valve of that species is flatter, more triangular, the fold and sulcus have only 3 and 2 costae, respectively, and dorsal valve lacks a median septum. *Tautosia expansa*, new species, from the Bone Spring Formation (Cutoff Shale Member) is similar, but the Sierra Diablo species has more costae and they extend farther posteriorly than those of *T. expansa*.

Tautosia magnisepta (Stehli)

PLATE 525: FIGURES 36-45

Wellerella magnisepta Stehli, 1954, pl. 25: figs. 10-12.

Medium size for genus, length and width about equal; maximum width at midvalve; outline subtriangular, sides long and rounded but anterior narrowed and truncated. Anterior commissure strongly uniplicate. Beak short, deltidial plates small, conjunct. Surface costate, except for beaks and umbonal regions. Costae narrow and angular, 4 or 5 on fold, median costae generally depressed; 3 or 4 costae in sulcus and 4 or 5 on flanks.

Pedicle valve with gently convex lateral profile, most of curvature posterior to midvalve; anterior profile nearly flat, varying from slightly concave to slightly convex. Umbonal and median region slightly carinated and marked by posterior extension of median costae. Sulcus originating anterior to midvalve, broad and shallow and extending into strongly geniculated but short tongue. Flanks slightly concave; anterolateral extremities slightly extended.

Brachial valve moderately convex in lateral profile, most convex in posterior part; anterior profile strongly and broadly domed with top flattened.

Fold low and inconspicuous, originating at about midvalve, usually with median depression extending from umbonal region to anterior margin, depressing median costae. Flanks swollen and slightly depressed below fold at anterior part.

Pedicle valve interior with elongated teeth located on shell margin; dental plates stout, vertical, slightly divergent. Muscle field somewhat posterior in location, subtriangular; adductor scars small, situated near ends of dental plates.

Brachial valve with long thick socket ridges and corrugated sockets; hinge plate undivided, not medially indented, separate elements not clearly defined. Outer hinge plates broad, inner hinge plates narrow, usually tightly welded; apex with minute pit.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 728f					
148355a	10.8	8.8	10.9	7.0	95
148355b	12.7	?	14.4	?	100
148355c	?	10.6	13.6	?	?

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITIES.—AMNH 629, USNM 728f.

DIAGNOSIS.—Nearly completely costate *Tautosia*, costae fine, and with short sulcus and low fold.

TYPES.—Holotype: AMNH 27334/1:2. Figured paratypes: AMNH 27334/1:2,3. Figured hypotypes: USNM 148355a–d, 154800. Measured hypotypes: USNM 148355a–c.

COMPARISON AND DISCUSSION.—This species is characterized by its fairly large size, the numerous costae, and their extension onto the umbonal region of both valves. They differ from *Tautosia lenumbona* (Stehli) in size, in generally having less costae on the surface, and in having more elongated valves. The prominent median septum serves to distinguish *T. magnisepta* from any species of *Wellerella*. This is an uncommon species in the Sierra Diablo.

Several specimens of this species have the inner hinge plates united without suture and the hinge plate surface is nearly smooth. A few specimens, however, have the inner hinge plates overlapped medially but not anteriorly united. No evidence of an apical chamber was seen in any of the specimens.

Tautosia podistra, new species

PLATE 525: FIGURES 46–51

Small for genus, biconvex; outline bluntly equilaterally triangular to subpentagonal, sides diverging between 70° and 115°; anterior commissure uniplicate, fold moderately low, beginning 3 or 4 mm anterior to brachial beak, profile gently convex, curvature strongest near anterior margin; sulcus shallow, beginning 3–5 mm anterior to pedicle beak, curvature of profile nearly uniform. Costae moderately high, crests blunt, beginning 2 or 3 mm anterior to beaks, strongest on fold and pedicle flanks, numbering 3 on fold, 2 in sulcus, 2 or 3 on flanks. Concentric ornamentation absent; growth lines few, faint.

Pedicle valve with smooth part of umbo slightly inflated; flanks moderately convex, normally not reflexed or only slightly reflexed; beak sharp, somewhat attenuate, moderately curved dorsally; beak ridges blunt, short; lateral pseudointerareas narrow or absent, only slight overlap of valves. Delthyrium triangular, base covered by pair of triangular to trapezoidal conjunct deltidial plates, slightly arched dorsally; apical part open, forming elongate oval foramen. Brachial valve moderately convex, longitudinal profile of smooth part of umbonal area flattened, transverse profile flattened to slightly indented; highest part of fold slightly convex; beak within pedicle valve, covered by deltidial plates.

Pedicle valve interior with delthyrium expanding at same rate as externally, each side with an elongate tooth, supported by vertical dental plate reaching floor of valve. Muscle area lying anterior to dental plates, narrowly expanding anteriorly; adductor scars not observed: probably as in other species of genus.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by elongate, deep, anteriorly expanding, finely corrugated sockets; crura diverging forward from anterior edge of hinge plate, strongly curved ventrally, dorsal edges carinate; median septum short, high, supporting hinge plate, descending anteriorly as moderately long, thin ridge bisecting posterior part of muscle field. Muscle area oval, subdivisions on available specimens too faint to be observed.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Sullivan Peak Member).

MEASUREMENTS (in mm).—					
		brachial valve		thick- ness	apical angle (°)
	length	length	width		
USNM 707-1					
152839a	4.4	3.6	4.0	2.0	71
152839b	6.0	5.0	6.1	4.4	89
152839c	6.9	5.9	7.1	4.9	102
(holotype)					
152839d	7.3	5.9	8.2	4.5	110
USNM 710r					
152840a	8.5?	7.4	8.4	6.2	100
152840b	8.6?	7.5	10.0	c.6.5	111

LOCALITIES.—Sullivan Peak: USNM 707-1. Skinner Ranch: 710r, 712p.

DIAGNOSIS.—Small *Tautosia* with flattened brachial umbo.

TYPES.—Holotype: USNM 152839c. Figured paratypes: USNM 152839e,g. Measured paratypes: USNM 152839a,b,d; 152840a,b. Unfigured paratypes: USNM 152839a,b,d,f.

COMPARISON.—*Tautosia podistra* is characterized by its small size, flattened profile of the brachial umbonal area, slightly inflated pedicle umbonal area, relatively narrow outline, and its high blade-like median septum. It most nearly resembles juveniles of *Tautosia fastigiata* Cooper and Grant from the Cathedral Mountain Formation of the Glass Mountains, differing in its narrower outline, less attenuate pedicle beak with blunt beak ridges, fewer costae on the flanks, costae on the fold that begin much farther back, and especially by its small maximum size. It is distinguished from *Pontisia kingi*, new species, which also occurs in the Wolfcampian, by its smaller size, less strongly hooked pedicle beak, and high median septum. Externally it is somewhat similar to *Wellerella girtyi*, new species, from the Guadalupian, and to *Pontisia stehlii* Cooper and Grant, from the Leonardian, but differs from both of these in its smaller size, more flattened profile of the brachial umbonal area, and by the presence of a high median septum.

Tautosia pulchra, new species

PLATE 515: FIGURE 29; PLATE 526: FIGURES 1-20

Medium size for genus, subtrigonal to subpentagonal in outline, posterolateral margins straight, forming apical angle of 80° to 95°. Sides narrowly rounded, maximum width near midvalve. Anterior margin broadly rounded to truncated. Anterior

commissure fairly strongly uniplicate. Beak short, foramen small, submesothyriddid and bounded anteriorly by conjunct, gently convex deltidial plates, some specimens with elevated rims. Surface semicostate, costae subangular, appearing near midvalve, and usually somewhat variable. Concentric lines weak or not preserved.

Pedicle valve gently convex in lateral profile, most convex in posterior half; anterior profile flatly convex with flanks only slightly deflected. Umbonal region swollen narrowly and forming indistinct fold extending to sulcus; median region slightly swollen. Sulcus originating at midvalve, broad and shallow, occupied by 2 costae, more in rare specimens. Flanks flattened, slightly deflected in dorsal direction and marked by 4 or 5 costae.

Brachial valve fairly strongly and evenly convex with maximum convexity near midvalve; anterior profile somewhat narrowly domed but median region narrowly and gently sulcate and sides steeply descending. Umbonal region moderately swollen and medially sulcate. Median region strongly swollen, producing fairly steep anterior slope. Fold low, formed of 3 costae, median one slightly depressed. Flanks swollen, steep, marked by 4 costae.

Pedicle valve interior with strong but small teeth and strong, subparallel dental plates. Brachial valve interior with thin socket plates overhanging elongate, corrugated sockets; outer hinge plates narrow; crura long and slender; inner hinge plates united, usually flat but concave in some specimens, united with strong but thin and long median septum, this not reaching midvalve.

MEASUREMENTS (in mm).—

		brachial valve		thick- ness	apical angle (°)
	length	length	width		
USNM 702					
148374a	11.8	10.4	12.6	7.4	90
148374b	12.0	10.1	13.4	7.8	90
(holotype)					
USNM 702ent					
148368a	3.0	2.4	2.6	1.1	80
148368b	4.2	3.3	3.8	1.4	80
148368c	5.7	4.7	5.4	1.7	90
148368d	7.4	6.3	7.1	2.5	80
148368e	8.2	7.1	8.0	4.0	85
148368f	8.8	7.7	9.6	4.7	85
148368g	10.0	8.4	10.3	6.0	90
148368h	10.8	9.1	9.9	6.6	85
148368i	11.5	10.0	13.0	6.4	90
148368j	11.8	10.2	13.2	8.2	95

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—USNM 702a, 702, 702ent, 702 low, 708, 721u.

DIAGNOSIS.—Paucicostate *Tautosia* with anterior of brachial valve moderately geniculated.

TYPES.—Holotype: USNM 148374b. Figured paratypes: USNM 148368b-d, f-h; 148374a; 154801a,c; 154730. Measured paratypes: USNM 148368a-j, 148374a. Unfigured paratypes: USNM 148368a,e; 154801b. Figured specimen: USNM 154730.

COMPARISON AND DISCUSSION.—This is a variable species with 3-5 costae on the fold and a consequent difference in the size of the costae. The species is unlike any of the other septum-bearing wellerelliiform species. It has some resemblance to *Tautosia transenna*, but its sides are rounder and softer in appearance and its costae distinctly less coarse. It suggests *Pontisia stehlii* Cooper and Grant (1969), but has finer costae, is a less robust species, and has the geniculated front not present in other species.

Although *T. pulchra* is about average size, the shell is extremely thin and delicate. The hinge plate is small but the septum is stout. The hinge plates are healed and no trace of an apical plate was seen.

Tautosia shumardiana (Girty)

PLATE 526: FIGURES 21-51; PLATE 553: FIGURES 1-9;

PLATE 757: FIGURES 8-17 (in volume 5)

Pugnax shumardiana Girty, 1909:316, pl. 15; figs. 15-17c.

Not *Pugnoides shumardianus* (Girty) R. E. King, 1931:107, pl. 34; figs. 13-14 [= *Pontisia* cf. *P. stehlii* Cooper and Grant, 1969].

Large for genus, biconvex, somewhat flattened to inflated; outline elongate to transversely triangular, sides diverging between 75° and 115°; profile elongate lenticular to convexly subtriangular; commissure uniplicate; fold moderately high, beginning 7-10 mm anterior to brachial beak, longitudinal profile flatly convex; sulcus shallow, strongest longitudinal convexity just behind anterior margin, continuing nearly to pedicle beak as slight indentation of smooth part of umbo. Costae weak, beginning 4-7 mm anterior to beaks, highest on fold, weak in sulcus and on pedicle flanks, weak or absent on brachial valve flanks, numbering 3-5 on

fold, 5 formed by branching of lateral two, middle one commonly depressed, one less in sulcus than on fold, 3 or 4 on flanks. Concentric ornamentation weak or absent; growth lines faint.

Pedicle valve strongly convex longitudinally near beak; transverse profile indented by backward continuation of sulcus; flanks gently convex, slightly reflexed in few individuals; beak sharp, attenuate, dorsally curved; beak ridges rounded; lateral pseudointerareas absent, with no overlap of valves. Delthyrium triangular, open, without deltidial plates. Brachial valve more strongly convex, profile somewhat flattened along crest of fold; apex only slightly curving into pedicle valve.

Pedicle valve interior with widely expanding delthyrium; teeth elongate parallel to side of delthyrium, supported by vertical dental plates reaching floor of valve. Muscle area just anterior to edges of dental plates, oval, with small median adductor scar surrounded laterally and anteriorly by larger diductor scars.

Brachial valve interior with triangular undivided hinge plate bounded laterally by elongate, anteriorly widening, finely corrugated hinge sockets; crura diverging anteriorly from edges of hinge plate, curving ventrally, dorsal edges carinate; median septum long, thin, bladeliike, moderately high. Muscle area large, oval, located in smooth area of umbo, details of pattern unknown.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	width		
USNM 740				
148680a	7.8	7.3	3.4	84
148680b	9.8	8.7	5.3	95
148680c	13.3	11.2	8.0	104
USNM 737a				
148675	10.9	10.0	5.6	114
USGS 2926				
118566a (holotype)	15.2	13.2	9.9	94

STRATIGRAPHIC OCCURRENCE.—Capitan Formation; Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Capitan: AMNH 804, 847; USGS 2926 (green); USNM 725-l, 732q, 737a, 738a, 739, 740, 740k, 740m, 740n, 750a, 750b. Hegler: USNM 731. Pinery: AMNH 33, 398, 401, 524; USNM 725n. Rader: USNM 725g, 740a, 740i. Lamar: AMNH

347 (=L-2), 348 (=L-3), 430; USNM 725e, 728p, 728r, 738.

DIAGNOSIS.—Large *Tautosia* with weakly costate flanks.

Types.—Holotype: USNM 118566a. Unfigured paratypes: USNM 118566c (not 118566b=?). Figured hypotypes: USNM 148675; 148680c,d; 154802b; 154803a-d; 154804; 154805; 154920a-c.

COMPARISON.—*Tautosia shumardiana* is characterized by its triangular outline, longitudinally flattened fold with 3 costae, or with 5 if the lateral two have branched, weakly costate to smooth brachial flanks, costae that begin far forward of the beaks, sulcus that extends as a shallow indentation nearly to the apex of the pedicle beak, and its thin, prominent median septum. Some individuals resemble specimens of *T. elegans* (Girty) but the greatly extended sulcus and weakly costate flanks distinguish them. The triangular outline and pedicle indentation distinguishes *T. shumardiana* from the more nearly round outline and brachially indented *Phrenophoria pinguis* (Girty). *Anteridocus swalloviensis* (Girty) is smaller, has a triangular to pentagonal outline, no median septum, and greatly inflated rather than indented or troughed beak areas.

DISCUSSION.—As with most of the rhynchonellid species of the Bell Canyon Formation members and the Capitan Limestone it is difficult to obtain large lots. This is true of *T. shumardiana*. Consequently the full range of variation cannot be stated for the species. As usual the number of costae on the fold is variable, some specimens having 4 or 5 rather than 3, and in some the median costa or costae are more strongly depressed than in others. Two specimens from the Pinery Member have the costae bounding fold more strongly elevated than in most specimens, and they may be a separate species. The median septum is somewhat variably developed but is generally fairly strong.

Tautosia transenna, new species

PLATE 527: FIGURES 1-31; PLATE 553: FIGURES 41-44

Wellerella? sp. Stehli, 1955:73, figs. 37-39.

Average size for genus; biconvex; outline bluntly triangular to pear-shaped, sides diverging between 85° and 125°; lateral profile subtrigonal; anterior

commissure uniplicate, fold beginning 6-8 mm anterior to brachial beak, longitudinal convexity low, anterior termination sharp; sulcus moderately deep, beginning 6-8 mm anterior to pedicle beak, maximum convexity between anterior proximal ends of flanks. Costae strong with sharp crests on fold and pedicle flanks, weak to moderately strong with blunt crests in sulcus and on brachial valve flanks, beginning 4-7 mm anterior to beaks, numbering 2-4 on fold, normally 3, one less in sulcus, 2-5 on each flank, normally 3. Concentric ornamentation not seen; growth laminae faint, widely spaced.

Pedicle valve with low crest along smooth area forward of beak; profile from beak to flanks gently convex to slightly reflexed; beak sharp, somewhat attenuate; beak ridges blunt, short; lateral pseudo-interareas narrow, obscurely delimited, partly covered by overlapping edge of brachial valve. Delthyrium triangular, base covered by two slightly arched trapezoidal deltidial plates, forming elongate submesothyriddid oval foramen.

Brachial valve strongly convex from beak to flanks, and transversely slightly convex along fold, anterior end of fold slightly reflexed; smooth part of umbonal region slightly flattened transversely; apex broad, concealed within pedicle valve, covered by deltidial plates.

Pedicle valve interior with delthyrium spreading widely anterior to deltidial plates, teeth elongate, parallel to edge of delthyrium, supported by vertical dental plates reaching valve floor. Muscle area subtrigonal to oval, lying just anterior to dental plates; adductor scars small, median, in posterior part of muscle area, forming oval to circular mark; diductor scars large, anteriorly expanding, surrounding adductor mark laterally and anteriorly.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by deep, wide, anteriorly expanding, finely corrugated sockets; crura diverging anteriorly, strongly curved ventrally, slightly twisted, dorsal edges keeled; median septum high, thin, long, supporting hinge plate, bisecting posterior half of muscle area. Muscle area oval; posterior adductor scars elongate, narrow, diverging anteriorly from median septum, fused to posterolateral edges of larger, anteriorly expanding anterior adductor scars.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Word Formation

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706b					
148402a	1.9	1.6	1.8	0.7	?
148402b	3.0	2.4	2.6	1.5	?
148402c	5.1	4.5	4.2	2.0	c.110
148402d	6.9	6.2	5.7	3.2	80
148402e	9.2	7.8	8.8	4.0	80
(holotype)					
148402f	10.1	8.7	10.1	7.4	80
148402g	10.7	9.2	11.3	8.7	80
148402h	11.4	9.6	12.2	10.1	85
148402i	11.9	10.3	12.0	11.5	85
USNM 728					
148409a	6.9	6.1	7.1	3.8	86
148409b	10.0	8.6	11.5	7.1	108
148409c	12.0	10.8	13.0	8.3	106
148409d	13.3	12.1	15.0	12.3	98
148409e	13.7	12.2	15.2	9.2	100
USNM 706					
148399a	8.5	7.5	8.9	5.5	94
148399b	9.9	8.6	9.9	6.8	85

(China Tank, Willis Ranch, Appel Ranch members and lens between the last two).

LOCALITIES.—Getaway: AMNH 512, 600; USNM 728, 732. China Tank: 706c, 713. Willis Ranch: 706, 706e. Lens: 706b. Appel Ranch 706d, 719z.

DIAGNOSIS.—*Tautosia* with median costa of fold not depressed.

TYPES.—Holotype: USNM 148402e. Figured paratypes: USNM 148402c,d; 148409e; 154807a–e; 154808a–c; 154809a,b,c. Measured paratypes: USNM 148399a,b; 148402a–d,f–i; 148409a–e. Unfigured paratypes: USNM 148402a,b,d,f–i; 148409a,b,d.

COMPARISON.—*Tautosia transenna* is characterized by its bluntly triangular outline, slightly convex to slightly reflexed longitudinal profile of the fold, abrupt anterior termination of the fold, nondepressed median costa of the fold, anterior margin without embayment at juncture of fold and sulcus, and its high median septum. It appears to be closely related, probably ancestral to *T. elegans* (Girty), a rare, late Guadalupian species. It differs from that species in its normally less transverse outline, more strongly costate flanks, more nearly flat profile of the fold, normally nondepressed median costa of the fold, more flattened smooth area of the brachial umbo, its unindented smooth area of the brachial umbo, and its unindented anterior margin. It differs from *Anteridocus swallowianus*

(Shumard) in its larger size, more triangular outline, less inflated umbones, stronger costae, more flattened profile of the fold, and its high median septum.

This species is distinguished from *Cenorhynchia fracida*, new species, also Guadalupian in age, by its strongly costate flanks, costae that begin farther back, greater proportional width, and especially by its broader, flattened brachial umbonal area. *Antronaria speciosa*, new species, from the Hess Formation also is similar; *T. transenna* differs in its narrower outline, less strongly reflexed pedicle flanks, smaller average size, high median septum, nondepressed middle costa of the fold, and its unindented anterior margin. *Pontisia kingi*, new species, from the Wolfcampian also has a fold with only slightly convex profile. *Tautosia transenna* is distinguished by its somewhat larger size, broader outline, less strongly convex fold profile, straight pedicle beak, deeper sulcus, and high median septum. Other West Texas species differ from *T. transenna* in having the convex profiles of their folds more strongly convex, reducing greatly the thickness from the anterior end of the fold to the anterior end of the fold to the anterior end of the pedicle flanks, and normally displacing the position of the point of maximum thickness from the anterior end to nearer the middle of the shell.

Among foreign species "*Pugnax*" *pseudoutah* Huang (1933) most nearly resembles *T. transenna*. That species is narrower, proportionately somewhat thicker, has an inflated brachial umbonal area, and less strongly costate flanks than does *T. transenna*. The interior of *P. pseudoutah* is unknown, so comparison is impossible. Externally it appears to belong to *Wellerella*, but nevertheless it might have a high median septum, or a low median ridge. Specimens regarded by Huang (1933:65) as conspecific with the "cotypes" lack the median septum, further contrasting that species with *T. transenna*. *Rhynchonella edelsteini* Tschernyschew (1914) also is similar, but its brachial valve is inflated, its flanks have fewer and weaker costae, and the median septum of the fold is slightly depressed, as in *T. elegans*. *T. transenna* differs from *Rhynchonella negrii* Gemmellaro (1899) in its less inflated pedicle umbonal area, more strongly costate flanks, and sharper anterior termination of the fold. The interior of Gemmellaro's species is not known.

DISCUSSION.—*Tautosia transenna* occurs in the

Word Formation with *Wellerella girtyi*, new species. Although the two are similar, the strong median septum of *Tautosia* is a ready means of separation. The species is not common. Brachial valve interiors have a fairly large hinge plate and the inner hinge plates are sealed without suture in most cases. In some specimens the inner hinge plates are slightly domed.

Cenorhynchia, new genus

[Greek *kenes* (empty) + *rhychos* (beak)]

Small, rhynchonelliform, biconvex, uniplicate; outline bluntly trigonal to subpentagonal; fold and sulcus smooth to weakly semicostate, flanks normally smooth, rarely weakly costate. Concentric ornamentation and growth lines weak. Pedicle valve moderately convex; beak sharp, short to moderately long, not attenuate, slightly to strongly curved dorsally; beak ridges blunt, poorly defined; delthyrium triangular, open, without deltidial plates. Valves meeting without overlap, hence no lateral pseudo-interareas. Brachial valve strongly convex; umbonal area normally not flattened or depressed; beak bluntly pointed, not strongly incurved.

Pedicle valve interior with small knoblike hinge teeth supported by vertical dental plates reaching floor of valve. Muscle area beginning between anterior edges of dental plates, cordate, widening anteriorly, occupying about a fourth to a third of valve length; adductor scars small, median, lying in posterior part of muscle area; diductor scars large, lobe-shaped, surrounding diductors laterally and anteriorly, meeting one another along midline of valve in anterior part of muscle area.

Brachial valve interior with well-developed hinge plate moderately deeply notched at midline, may have median groove with sides dipping to meet top of median septum; hinge sockets deep, narrow, elongate, widening anteriorly, finely corrugated; crura falcifer, slightly diverging anteriorly from edge of hinge plate, only slightly twisted, dorsal edges carinate, keels extending under hinge plate as crural bases; median septum thin, bladellike, supporting hinge plate, bisecting posterior part of muscle area, extending about a fourth length of valve. Muscle area subelliptical, posterior adductor scars small, narrow, anteriorly divergent, flanking larger, rounded, medially located anterior adductor scars.

TYPE-SPECIES.—*Cenorhynchia fracida*, new species.

DIAGNOSIS.—Smooth to anteriorly costate rhynchonellids with strong median septum and absent or incipient deltidial plates.

COMPARISON.—*Cenorhynchia* is characterized by its small size, weak costae, absent lateral pseudo-interareas, open delthyrium without deltidial plates or with incipient plates, widely notched and commonly medially troughed undivided hinge plate, and its distinct, thin dorsal median septum. Lack of deltidial plates or their incipient development distinguishes it from *Wellerella* Dunbar and Condra and *Phrenophoria* Cooper and Grant which resembles it externally; its median septum distinguishes it from *Wellerella* Dunbar and Condra, *Pontisia* Cooper and Grant, and *Anteridocus*, new genus. Lack of a well-developed apical chamber and its straight pedicle beak and shorter costae differentiate it from *Shumardella* Weller (1910). *Acolosia*, new genus, is similar externally but has no median septum.

DISCUSSION.—Most species of this genus are small, ranging in length from 5 to 10 mm. Most of the smaller species are smooth, or at any rate noncostate, but the larger ones have costae, largely confined to the margins of the fold and sulcus, or occasional costae on the margins of the flanks. The beak usually is straight or suberect and either has an unmodified delthyrium or shows traces of deltidial plates at the anterolateral extremities of the delthyrium. The valves are usually subequal in depth but some species have a deeper brachial valve.

Internally the pedicle valve is characterized by small knoblike teeth supported by strong dental plates standing out from the walls and defining deep umbonal chambers. The musculature lies anterior to the ends of the dental plates.

The brachial valve of most specimens has an undivided hinge plate that is supported by a strongly elevated thin median septum. The socket ridges are strong, slightly incurved and with a thickened rim, bounding deep, finely corrugated sockets. The outer hinge plates are broad and gently concave. The crural bases form the margin of the outer hinge plate and all these plates are welded by fusion of the broad inner hinge plates. These meet in a plane or are medially arched in many specimens. The crura are slender, keeled, concave toward midvalve, and have expanded distal

extremities. Their bases are keeled and the keels extend along the underside of the hinge plate. The muscle area is divided medially by the median ridge.

Cenorhynchia atmata, new species

PLATE 543: FIGURES 34-50

Average size for genus, strongly biconvex; outline tear-shaped, sides diverging between 60° and 90°; commissure uniplicate, fold moderately high only at commissure, but standing in low relief above flanks farther posteriorly, beginning about 3 mm anterior to brachial beak; sulcus not depressed below flanks except at extreme anterior in largest specimens. Fold not costate; flanks smooth or with 1 costa on each side, adjacent to fold. Growth lines weak, irregularly spaced; other concentric ornament absent; radial ornament absent except for weak fibrous texture of shell.

Pedicle valve somewhat inflated, strongly convex transversely, moderately convex longitudinally through sulcus; beak sharp, slightly curved dorsally; beak ridges blunt, short; lateral pseudointerareas absent, so valves meeting without overlap; delthyrium narrow, triangular, open, without deltidial plates. Brachial valve strongly convex transversely, moderately convex longitudinally, most strongly curved at posterior; beak blunt, apex within pedicle valve.

Pedicle valve interior with small, knoblike or elongate teeth, dental plates short, nearly vertical, close to sides, normally partly fused to sides; muscle area elongate, heart-shaped, apex between dental plates; adductor scars not observed; diductor scars separated by faint myophragm.

Brachial valve interior with hinge plate deeply notched anteromedially; sockets deep, relatively wide, very short, finely corrugated, crura delicate, anteriorly diverging, ventrally curved, untwisted or only slightly twisted; median septum thin, blade-like, highest immediately below hinge plate, reducing to become low median ridge at anterior end. Muscle area on floor of valve on each side of median septum; individual muscle marks not observable.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 710u					
148162a	3.0	2.6	2.3	1.6	60
148162b	3.8	3.0	2.9	2.1	68
148162c	4.5	4.0	3.5	2.8	64
148162d	5.1	4.6	4.0	3.3	72
(holotype)					
148162e	5.5	4.9	4.5	3.6	71

LOCALITIES.—USNM 702c, 703a, 709c, 710u, 719x, 721o, 724j, 726f.

DIAGNOSIS.—Small, smooth *Cenorhynchia* with poorly developed median septum.

TYPES.—Holotype: USNM 148162d. Figured paratypes: USNM 148162e,f,h; 154896; 154897a; 154898a,b. Measured paratypes: USNM 148162a-c,e. Unfigured paratypes: USNM 148162a-c,g; 154897b.

COMPARISON.—*Cenorhynchia atmata* is characterized by its narrow outline, smooth shell, low fold and shallow sulcus, inflated umbonal regions, dental plates that fuse to the shell walls, and its short median septum. The lack of costation and any vestige of deltidial plates distinguishes it from *C. fracida*, *C. saginata*, and *C. ventricosa*, all new species. Its narrower outline and shorter beak distinguish it from *C. hebata*, new species. The low median septum that becomes reduced anteriorly to a low median ridge separates *C. atmata* from all the above species.

Cenorhynchia camerata, new species

PLATE 510: FIGURES 27-32; PLATE 521: FIGURES 48-57, 62-64

Usual size for genus, length and width nearly equal, rounded subpentagonal in outline with narrowly rounded sides and posterolateral margins forming angle from 85° to 95°. Beak suberect, delthyrium open, no trace of deltidial or lateral plates seen. Surface paucicostate, posterior half smooth; anterior half with poorly and variably developed costae, 3 or 4 on fold, one less in sulcus; flanks with 1 costa.

Pedicle valve gently and evenly convex in lateral profile; anterior profile broadly and gently concave; sulcus originating posterior to midvalve, wide and shallow forming broad, long serrated tongue. Umbonal region moderately swollen.

Flanks demarcated by low ridge and with steep slopes.

Brachial valve fairly evenly and gently convex in lateral profile but narrowly and roundly domed in anterior profile; sides of dome steep. Fold originating near midvalve, low, somewhat flattened but moderately elevated above gently swollen flanks.

Pedicle valve interior with well-marked dental plates in young, but with umbonal cavities filled and dental plates obsolete, or nearly so, in adults. Brachial valve interior with undivided hinge plate; socket ridge strong; outer hinge plates narrow; inner hinge plates fused without suture, anteriorly notched and folded in ventral direction. Median septum thin, strong, attached to hinge plate apically, often forming minute chamber just anterior to place of contact.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	width			
USNM 727e					
155069a	8.5	7.5	8.6	6.4	93
155069b	8.7	7.6	8.2	7.2	89
155069c	7.8	6.9	8.2	6.4	90
155069d	8.5	7.6	8.5	6.9	90
(holotype)					
155069e	8.2	7.3	7.7	5.8	92
155069f	7.7	7.0	7.4	5.0	91

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (bed 4).

LOCALITY.—USNM 727e.

DIAGNOSIS.—*Cenorhynchia* with valves nearly equal in length and width, variable number of costae on fold, and dental plates obsolete in the adult.

TYPES.—Holotype: USNM 155069d. Figured paratypes: USNM 155069a,g-i. Measured paratypes: USNM 155069a-c,e,f. Unfigured paratypes: USNM 155069b,c,e,f.

COMPARISON AND DISCUSSION.—This species has some similarities to *C. mitigata*, new species, but that species has a more transversely elliptical form, coarser costae, and fewer of them. *Cenorhynchia saginata*, new species, has wider costae more anteriorly confined than those of *C. camerata*, more costae on the flanks, and in the adult, well-defined dental plates, which can scarcely be seen in adults of *C. camerata*.

The dental plates of *C. camerata* are evidently

eliminated by filling of the umbonal cavities. Young specimens about half the size of adults have clearly defined dental plates with narrow umbonal cavities between them and the shell. These were filled in as the shell reached adulthood.

Cenorhynchia fragida, new species

PLATE 515: FIGURES 1-4, 36-42; PLATE 544: FIGURES 1-21;

PLATE 552: FIGURES 11-13

Slightly larger than average size for genus, unequally biconvex, often dorsally inflated; outline elongate suboval, sides diverging between 55° and 100°; profile subtriangular to wedge shaped; commissure strongly uniplicate; fold low, confined to anterior part only, slightly convex in profile, anterior termination abrupt; sulcus shallow, beginning 5-8 mm anterior to pedicle valve beak, longitudinal convexity rather uniform and gentle. Costae few, weak, blunt, confined to anterior third or quarter, strongest at anterior end of fold, there usually numbering 3, one less in sulcus; costae weak in sulcus and on pedicle valve flanks, numbering 2 or 3 on flanks and normally visible only near commissure. Concentric ornamentation not observed; growth lines weak and widely spaced.

Pedicle valve slightly inflated in beak area, narrowly arched transversely; gently convex toward flanks, margins of flanks not reflexed; beak sharp, strongly curved, suberect, without beak ridges; lateral pseudointerareas absent, no overlap of valves. Delthyrium triangular, normally open, base rarely narrowed by rudimentary deltidial plates; foramen small, triangular. Brachial valve strongly convex toward flanks, inflated on smooth part of umbonal area, narrowly arched transversely, without flattening or indentation; beak narrow, sharp, apex covered by curvature of pedicle beak.

Pedicle valve interior with delthyrium widely expanding, teeth small and narrow, supported by short vertical dental plates that reach valve floor. Muscle area anteriorly expanding, longitudinally striated, lying anterior to dental plates; muscle marks faint. Diductor marks narrowly expanding anteriorly.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by deep, elongate, anteriorly widening sockets; socket ridges thick, overhanging sockets, crura diverging ante-

riorly from edge of hinge plate, long and strongly curved ventrally, often twisted, dorsal edges carinate; median septum high, thin, long, bisecting muscle area and supporting hinge plate but not forming chamber. Muscle area elongate; posterior adductor scars elongate, anteriorly diverging, flanking larger, anteriorly widening anterior adductor scar.

MEASUREMENTS (in mm).—From locality USNM 706b specimens 148167a (holotype) and b, respectively: length 9.8, 7.8; brachial valve length 8.2, 6.7; width 8.7, 6.7; thickness 6.8, 6.4; apical angle 70°, 65°.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch and Appel Ranch members; lens between Willis Ranch and Appel Ranch members). Cherry Canyon Formation (Getaway Member).

LOCALITIES.—China Tank: USNM 706c. Willis Ranch: USNM 706e, 735c. Appel Ranch: USNM 727j. Lens: USNM 706b. Getaway: USNM 730.

DIAGNOSIS.—Elongate-oval *Cenorhynchia* with strong median septum.

TYPES.—Holotype: USNM 148167a. Figured paratypes: USNM 148167b,d; 148168a-c,f,g; 154721; 154722. Measured paratype: USNM 148167b. Unfigured paratypes: USNM 148167c; 148168d,e.

COMPARISON.—*Cenorhynchia fracida* is characterized by its elongate outline, normally narrowly diverging sides, hooked pedicle beak, narrowly arched umbonal area of the brachial valve, costae that are weak on anterior parts of the shell, and very low or absent on the brachial flanks, and its high, bladeliike median septum. The longitudinal profile of the fold is relatively flat, aligning this species with others having that feature: *Tautosia elegans* (Girty), *T. transenna*, new species, *Anteriodocus swallowianus* (Shumard), *Antronaria speciosa*, new species, and *Pontisia kingi*, new species. Among Guadalupian species it most closely resembles *T. elegans* from the Guadalupe Mountains, differing in its hooked beak which has obsolescent deltidial plates or none at all, nondepressed middle costa of the fold, and especially in its smooth, nearly uncostate flanks and evenly arched, unflattened brachial umbonal area. Several of the features that separate it from *T. elegans* suggest *P. kingi* from the Wolfcampian. *Cenorhynchia fracida* differs in its narrower outline, costae that begin farther forward, noncostate flanks on the brachial valve, and

especially in its high median septum. The other species mentioned above all differ from *C. fracida* in their markedly stronger costation, slightly to strongly reflexed pedicle flanks, and flattened or slightly indented smooth part of the brachial umbonal area.

Cenorhynchia fracida also resembles *C. saginata*, new species, but it is longer than the Road Canyon form, more ovate, and attains a larger size.

Cenorhynchia hebata, new species

PLATE 544: FIGURES 22–40

Small for genus, biconvex; outline bluntly sub-trigonal to elongate subpentagonal, sides diverging between 75° and 95°; commissure uniplicate, fold low, strongly arched transversely, crest extending to brachial beak; sulcus shallow, barely perceptible except at commissure. Costae normally absent, occasionally present as slight, weak indentation near anterior end of fold; flanks smooth. Concentric ornamentation not observed; growth lines weak, strongest near anterior margins.

Pedicle valve moderately convex, flanks not reflexed; beak short, somewhat blunted, nearly straight to nearly erect; beak ridges blunt, poorly defined; delthyrium small, triangular, open, without deltidial plates; lateral pseudointerareas absent: no overlap of valves. Brachial valve more strongly convex transversely; profile gently convex, without flattening; beak rather prominent, not strongly incurved.

Pedicle valve interior with sides widely divergent; teeth supported by nearly vertical dental plates reaching floor of valve and solidly fused to side of valve. Muscle area broadly triangular, beginning between edges of dental plates; details of pattern unknown, probably as in other species of genus.

Brachial valve interior with hinge plate small, anteriorly notched, solid or with median groove, depressed at posterior apex to form shallow pit for attachment of diductor muscles; sockets narrow, elongate, anteriorly widening, shallow; median septum high, thin, short, extending about a fifth valve length; crura delicate, diverging slightly anteriorly from forward edge of hinge plate, crural bases extending from underside of hinge plate

along dorsal edges of crura. Muscle area small, subelliptical, details of pattern unknown.

MEASUREMENTS (in mm).—

	brachial valve		mid-	maxi-	thick-	apical
	length	length	width	width	ness	angle
						(°)
USNM 701a ³						
148186a	1.8	1.7	1.4	1.6	0.8	?
148186b	3.9	3.4	2.7	3.0	2.1	81
USNM 701d						
148182a	2.7	2.5	2.1	2.1	1.3	?
148185a	4.3	3.9	3.1	3.7	2.5	90
(holotype)						
148185b	5.5	5.0	4.4	4.8	3.7	92
148185c	6.2	5.8	5.3	5.3	5.0	96

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (Beds 2,4, 9–14).

LOCALITIES.—Bed 2: USNM 701. Bed 4: USNM 701d, 721g 727d, 727e, 742c. Beds 9–14: USNM 701a³, 701c, 701k, 712w.

DIAGNOSIS.—Small, seldom costate, elongate *Cenorhynchia* with dental plates fused to shell wall.

TYPES.—Holotype: USNM 148185a. Figured paratypes: USNM 148185b,e–g. Measured paratypes: USNM 148182a; 148185b,c; 148186a,b. Unfigured paratypes: USNM 148182a.

COMPARISON.—*Cenorhynchia hebata* is characterized by its comparatively small size, short beak, lack of costae, low fold and shallow sulcus, dental plates that are fused to the shell walls, and its slightly excavated or depressed hinge plate. It is smaller and smoother than *C. saginata*, new species, and *C. fracida*, new species. It differs from *C. mitigata*, new species, in its somewhat smaller size, lower fold, shallower sulcus, shorter beak, and normally absent costae.

Cenorhynchia mitigata, new species

PLATE 545: FIGURES 1–28

Average size for genus, biconvex; outline elongate subelliptical to subtrigonal or subpentagonal, sides diverging between 70° and 105°; commissure uniplicate, fold low, convex in profile, strongly arched transversely, extending nearly to brachial beak; sulcus shallow, extending forward as broad tongue, backward as shallow trough to within 2 or 3 mm of pedicle beak. Costae absent or weak, normally 2 low, rounded, short asymmetrical costae on fold, 1 in sulcus, flanks smooth. Concentric

ornamentation absent; growth lines faint, strongest near anterior margins.

Pedicle valve moderately convex, flanks not reflexed; beak sharp, moderately long, not attenuate, slightly curved dorsally; beak ridges blunt, short; delthyrium triangular, open, without deltidial plates; lateral pseudointerareas absent; no overlap of valves. Brachial valve moderately convex in profile, strongly convex transversely, without flattening of umbonal area; beak somewhat prominent, blunt, not strongly incurved.

Pedicle valve interior with elongate teeth supported by nearly vertical dental plates reaching floor of valve. Muscle area heart-shaped, with point between edges of dental plates; adductor scars small, median, lying in posterior part of muscle area; diductor scars larger, anteriorly widening, meeting one another at midline anterior to adductor marks.

Brachial valve interior with hinge plate widely notched, deep groove along median line, forming small crural cavity with sides dipping down to meet top of median septum; sockets elongate, anteriorly widening, corrugated; beak of valve slightly elevated above hinge plate, providing surface for attachment of diductor muscles; median septum high, thin, bladelike, relatively short, extending about a fifth to a fourth length of valve; crura slightly diverging forward from anterior edge of hinge plate, moderately strongly curved ventrally, strengthened by crural keels extending from underside of hinge plate and along dorsal edges of crura. Muscle area not observed, pattern probably as in other species of genus.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle
					(°)
USNM 702a					
148193a	4.8	4.1	3.9	2.4	85
148193b	5.1	4.7	4.7	3.0	85
148193c	6.0	5.4	5.0	3.4	85
148193d	6.0	5.4	5.5	3.3	85
148193e	6.7	6.0	6.5	4.6	90
148193f	6.7	6.0	6.4	4.6	88
148193g	8.9	8.0	8.2	6.0	89
148193h	9.3	8.4	9.2	7.1	90
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Road Canyon Formation.

LOCALITIES.—Cathedral Mountain: AMNH 500F;

USNM 700x, 702, 702a, 702b, 702-low, 702un, 708, 727p, 727q, 731b. Road Canyon: AMNH 507; USNM 702c, 716x, 719x, 721o, 721w.

DIAGNOSIS.—Nearly smooth *Cenorhynchia* with fold and sulcus nearly reaching beaks.

TYPES.—Holotype: USNM 148193h. Figured paratypes: USNM 148205a; 148193e,f; 154899; 154900; 154901a,b. Measured paratypes: USNM 148193a-g. Unfigured paratypes: USNM 148205b; 148193a-d,g.

COMPARISON.—*Cenorhynchia mitigata* is characterized by its fold and sulcus that nearly reach the beaks, smooth convexity, and absent or weakly developed costae. It is larger and more convex than *C. hebata*, new species, its beak is longer and somewhat more strongly curved, and its fold and sulcus are stronger and begin much farther posteriorly. The brachial valve of *C. mitigata* has a profile more convex than that of *C. saginata*, new species, and its costae are fewer and weaker. It differs from *C. fracida* and *C. ventricosa*, both new species, in its smaller size, weaker costae, wider outline, less convex brachial valve, and less strongly curved pedicle beak.

Cenorhynchia nasuta, new species

PLATE 545: FIGURES 42-51

Small for genus, length and width about equal; outline and profile strongly triangular; maximum width near midvalve; sides strongly rounded; apical angle 80°-90°. Anterior strongly nasute; anterior commissure uniplicate. Beak short, suberect; no deltidial plates. Surface nearly smooth except for costae at anterior ends of fold and sulcus; fold with 3 costae, each flank with 1 poorly defined costa.

Pedicle valve lateral profile unevenly convex, posterior part gently convex but anterior strongly geniculated. Anterior profile gently to moderately concave. Umbonal region somewhat narrowly swollen; sulcus originating somewhat posterior to midvalve, shallow to deep and extended anteriorly as long narrow tongue. Flanks narrow, gently convex, slightly deflected. Anterolateral extremities protruding moderately.

Brachial valve gently convex in lateral profile but narrowly domed in anterior profile; umbonal region narrowly swollen to subcarinate. Fold originating well anterior to midvalve rounded to sub-

carinate, median costae elevated above lateral ones. Flanks moderately swollen, steep.

Pedicle valve interior with small teeth and short, thin, dental plates. Brachial valve interior with variable hinge plate supported by strong, thin, and long median septum.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
AMNH 512					
152813a	10.5	9.0	9.5	7.0	90
152813b	9.2	8.3	8.9	5.7	90
152813c (holotype)	9.6	8.7	10.0	8.8	95

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—AMNH 512, 585.

DIAGNOSIS.—Elongate triangular *Cenorhynchia* with nasute anterior.

TYPES.—Holotype: USNM 152813c. Figured paratypes: USNM 152813a,d; 154903a,b. Measured paratypes: USNM 152813a,b. Unfigured paratype: USNM 152813b.

COMPARISON.—This species is characterized by its narrow and nasute anterior and pentagonal form. In the latter respect it is readily separated from *C. fracida* and *C. triangulata*, both new. It is also a thicker shell than the latter. Although it has a somewhat pentagonal form, it is readily distinguished from *C. pentagonalis*, new species, by the wider fold which usually has 4 low costae rather than 3 strongly angular ones. This is an extremely rare species: only 9 specimens are known.

Cenorhynchia parvula, new species

PLATE 545: FIGURES 29-41

Small for genus, usually longer than wide, somewhat tear-shaped, with rounded sides and the maximum width anterior to midvalve. Unequally biconvex, brachial valve deeper and more convex. Anterior commissure uniplicate. Beak short, suberect, with open, unmodified delthyrium. Surface smooth except for incipient costa in sulcus and 1 on each flank.

Pedicle valve fairly and evenly convex in lateral profile; nearly flat in anterior profile except for dorsally and abruptly deflected flanks. Umbonal

region moderately convex; sulcus broad and shallow, originating anterior to midvalve and in adults occupied by short median costa; sulcus anteriorly bounded by short costa; median region gently convex and flanks narrowly rounded.

Brachial valve fairly evenly and moderately convex but with maximum curvature near midvalve, umbonal region strongly curved under beak of pedicle valve; anterior profile narrowly and strongly domed with long gently swollen flanks; fold, short, narrow, and anteriorly indented in adults, originating in anterior quarter and strongest when viewed from anterior.

Pedicle valve interior with small, obliquely elongated teeth notched at posterior end; dental plates receding, strong but with narrow umbonal cavities. Muscle field anterior to delthyrial cavity, not strongly impressed and without detail.

Brachial valve interior with cardinalia variable, socket ridges strong, outer hinge plates narrow, and crura short. Inner hinge plates varying from incompletely closed to complete, concave to convex, usually concave in young. Median septum short, best defined at apex.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 703a					
148189a	1.4	1.2	1.2	0.7	?
148189b	2.3	2.1	2.0	1.2	70
148189c	2.9	2.6	2.5	1.5	84
148189d	4.1	3.8	3.2	2.2	78
148189e	5.0	4.3	3.7	2.8	70
148189f	5.4	4.7	4.4	3.9	85
148189g (holotype)	6.8	6.0	5.5	4.4	74

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain and Road Canyon formations.

LOCALITIES.—Cathedral Mountain: USNM 703a¹, 703b, 703bs. Road Canyon: AMNH 507; USNM 702c, 703a, 708c, 721s, 724b.

DIAGNOSIS.—Small *Cenorhynchia* with reduced median septum and incipient costa in sulcus in the adult.

TYPES.—Holotype: 148189g. Figured paratypes: USNM 148189f,h; 154902a,b. Measured paratypes: USNM 148189a–f. Unfigured paratypes: USNM 148189a–e.

COMPARISON.—This species is most like *C. atmeta*, new species, also from the Road Canyon Forma-

tion, in size and general outline. It is, however, more robust, with greater development of the median septum, and attains larger size, is deeper, and has the development of the costa at the anterior margin.

Cenorhynchia pentagonalis, new species

PLATE 520: FIGURES 1–10, 49

Large for genus, slightly wider than long, outline pentagonal. Maximum width near midvalve; sides narrowly rounded; apical angle near 90°. Anterior margin truncated; anterior commissure uniplicate. Beak moderately long, pointed, straight to suberect, no deltidial plates. Surface nearly smooth except for fold with 4 narrowly rounded costae; flanks each with 1 costa.

Pedicle valve gently convex in lateral profile, strongest curve near midvalve; anterior profile gently concave. Umbonal and median regions slightly convex; sulcus originating anterior to midvalve, broad, shallow, and extended into long tongue geniculated at nearly right angle. Flanks, narrow, slightly convex.

Brachial valve fairly evenly and gently convex in lateral profile, most curvature in umbonal region; anterior profile narrow, steep-sided dome, flattened on top. Umbonal and median regions swollen; umbo not sulcate. Fold low, inconspicuous, originating anterior to midvalve; flanks swollen, depressed slightly below fold.

Pedicle valve interior with delicate, subparallel dental plates. Brachial valve interior with variable hinge plate, divided in young, complete in adults. Crura long, curved, concave toward midvalve; inner hinge plates small, uniting but attached to long, high, thin median septum nearly reaching midvalve.

MEASUREMENTS (in mm).—From locality USNM 706c specimen 152814a (holotype): length 9.9, brachial valve length 8.0, width 10.0, thickness 6.8, apical angle 90°.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank Member).

LOCALITIES: Word: USNM 731u. China Tank: USNM 706c.

DIAGNOSIS.—Pentagonal, fairly large *Cenorhynchia* with 4 subequal, crowded costae on the fold.

TYPES.—Holotype: USNM 152814a. Figured par-

atypes: USNM 152814b,d,f,g,j. Unfigured paratypes: USNM 152814c,e,h,i.

COMPARISON.—This is one of the larger species of *Cenorhynchia* which is readily distinguished from *C. triangulata* and *C. fracida*, both new, by its pentagonal form and comparatively broad fold, with 4 costae at the anterior end. It shares a pentagonal form with *C. nasuta*, new species, which differs in its narrow fold, with only 3 costae. *Cenorhynchia pentagonalis* is very rare; only 10 specimens have been recovered from many large blocks.

Cenorhynchia saginata, new species

PLATE 508: FIGURES 65–67; PLATE 510: FIGURES 33–37;

PLATE 515: FIGURES 45–56; PLATE 546: FIGURES 1–24

Average size for genus, biconvex; outline sharply trigonal to bluntly subpentagonal, widest anterior to midvalve, sides diverging between 70° and 105°; commissure uniplicate, fold moderately high at anterior end, nearly flat in lateral and transverse profiles, crest becoming lower posteriorly, extending to beak; sulcus shallow, extending as barely perceptible trough to within 2 or 3 mm of pedicle valve beak. Costae moderately strong at anterior end of fold, numbering 2–4, normally 3, weak and low elsewhere, normally numbering 1 or 2 on flanks. Concentric ornament absent; growth lines weak over most of shell, slightly stronger near anterior margins.

Pedicle valve with strongest convexity near umbo, flanks not reflexed but nearly flat; beak sharp, moderately long, somewhat attenuated, straight to suberect, curvature increasing with size of shell; beak riges short, blunt; delthyrium narrow, triangular, open, without deltidial plates; lateral pseudointerareas absent: no overlapping of valves. Brachial valve more convex transversely, gently convex in anterior profile; beak somewhat prominent due to crest of fold, blunt, not strongly incurved.

Pedicle valve interior with sides diverging widely anterior to delthyrium, teeth small, supported by nearly vertical dental plates reaching floor of valve. Muscle area cordate, pointing posteriorly, details of pattern unknown.

Brachial valve interior with hinge plate deeply and narrowly notched, having shallow median

groove and small crural cavity; apex of beak arched over hinge plate forming place of attachment for diductor muscles; sockets deep, elongate, anteriorly widening, corrugated; crura slender, diverging slightly from forward edge of hinge plate, moderately strongly curved ventrally; crural bases extending from underside of hinge plate along dorsal edges of crura; median septum high, thin, blade-like, connected at posterior to plates forming small crural cavity or to center of hinge plate, extending forward about a fifth valve length. Muscle area faintly defined; posterior adductor marks elongate, anteriorly diverging, flanking larger subelliptical anterior adductor scars lying adjacent to midline of valve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 702c					
148212a	2.0	1.7	1.7	0.9	?
148212b	2.3	2.0	1.9	1.2	?
148212c	3.6	3.0	2.9	2.0	?
148212d	4.5	3.9	4.0	2.5	88
148212e	5.3	4.5	4.2	2.2	73
148212f	5.7	4.8	5.7	2.8	81
148212g	7.1	6.1	7.0	3.6	82
148212h	8.2	7.2	8.6	5.1	88
148212i	9.0	7.8	8.8	5.5	92
148212j	10.0	9.0	11.3	8.4	95
(holotype)					
USNM 706f					
148170a	4.8	4.0	3.9	1.8	81
148170b	6.2	5.1	5.0	2.7	85
148170c	7.1	6.0	5.9	3.8	70
USNM 707e					
148174a	7.8	6.9	7.3	5.9	70
148174b	8.4	7.0	8.1	6.3	94

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain, Road Canyon, and Cibolo formations.

LOCALITIES.—Cathedral Mountain: USNM 702, 702–low. Road Canyon: USNM 702c, 703d, 706f, 707e, 719x, 721j, 721t, 726z, 726za. Cibolo: USNM 738g, 738–l.

DIAGNOSIS.—Large *Cenorhynchia* with compressed valves and costae on fold and in sulcus.

TYPES.—Holotype: USNM 148212j. Figured paratypes: USNM 148212g–i,k,m,n; 148174a,b; 148176; 153487; 154666a; 154731a–c; 154904. Measured paratypes: USNM 148212a–i; 148170a–c; 148174a,b. Unfigured paratypes: USNM 148212a–f,l; 154666b.

COMPARISON.—*Cenorhynchia saginata* is charac-

terized by the flat profile of its fold which gives the fold a moderately high anterior end, the short but relatively strong costae on the anterior end of the fold of adults, the suberect beak of adults and the rather strong angularity of its outline. It is larger and more strongly costate than either *C. hebata* or *C. mitigata*, both new. It most nearly resembles *C. fracida*, new species, from which it differs in its more triangular and less pentagonal outline, lower convexity, less strongly curved pedicle beak, lower fold, and fewer costae on the fold.

Cenorhynchia transversa, new species

PLATE 521: FIGURES 42-47

Usual size for genus, wider than long, valves subequal in depth: subpentagonal outline with narrowly rounded sides and long flattened posterolateral margins; anterior margin truncated: anterior commissure moderately uniplicate, serrate. Foramen open, no deltidial plates. Surface semicostate, costae low and narrow, strongest at anterior, 5 on fold, 1 distinct one on each flank and trace of a second.

Pedicle valve moderately convex in lateral profile, broadly domed in anterior profile, dome broadly flattened on top and with short steep sides. Umbonal and median regions moderately convex; sulcus wide and shallow originating just anterior to midvalve, forming short serrated tongue. Interior unknown.

Brachial valve has same convexity as opposite valve in lateral profile but broadly and evenly domed in anterior profile. Sides moderately steep; umbonal and median regions gently inflated; fold poorly defined and originating in anterior half.

Brachial valve interior with narrow outer hinge plates rising to narrow socket ridges; hinge plate undivided, slightly domed medially; crura short; median septum moderately elevated, extending about a third valve length.

MEASUREMENTS (in mm).—Holotype USNM 154769: length 7.8, brachial valve length 7.1, width 9.0, thickness 6.1, apical angle 97° .

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 732j.

DIAGNOSIS.—Wide *Cenorhynchia* with 5 costae on the fold.

TYPES.—Holotype: USNM 154769.

COMPARISON.—This species is fairly large and need be compared only to the larger species of *Cenorhynchia*. It is similar to *C. mitigata*, new species, but differs in having a lower fold and sulcus with more costae on the fold. It differs from *C. saginata*, new species, in the same characters. It is smaller than *C. pentagonalis*, new species, and has a less well-defined fold and sulcus than that species. Only a single specimen of *C. transversa* is known.

Cenorhynchia triangulata, new species

PLATE 546: FIGURES 26-39

Large for genus, triangular in outline, maximum width just anterior to midvalve. Posterolateral margins straight; sides narrowly rounded and anterior truncated. Valves unequal in depth, brachial valve deeper. Anterior commissure strongly uniplicate. Surface semiplicate, fold with 3 costae, flanks usually with 1.

Pedicle valve unevenly convex in lateral profile, greatest convexity in posterior half, anterior half somewhat flattened; anterior profile medially gently concave to slightly convex, flanks narrow and abruptly deflected. Umbonal region convex; sulcus originating just anterior to midvalve and drawn anteriorly into fairly long tongue deflected toward opposite valve at angle of almost 90° . Sulcus bounded by narrow, short costa. Beak suberect to erect, elongate; delthyrium modified by incipient deltidial plates.

Brachial valve moderately convex in lateral profile, most convex in umbonal region; highly and narrowly domed in anterior profile. Umbonal region narrowly swollen; flanks gently inflated and marked by single costa.

Pedicle valve interior with small teeth and stout dental plates with narrow umbonal cavities. Musculature not known. Brachial valve interior with hinge plate divided; socket ridges strong; outer hinge plates broad; crura long and slender, strongly curved and with strong keels. Inner hinge plates long and narrow not meeting medially. Median septum long, strongly elevated, extending nearly to midvalve.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member).

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706					
148165a	10.6	9.3	9.4	5.8	64
148165b	10.2	8.6	8.9	6.0	70
(holotype)					
148165c	9.4	8.2	8.1	5.2	70

LOCALITY.—USNM 706.

DIAGNOSIS.—Triangular *Cenorhynchia* with strong median septum.

TYPES.—Holotype: USNM 148165b. Figured paratypes: USNM 148165a,d–f. Measured paratypes: USNM 148165a,c. Unfigured paratypes: USNM 148165c.

COMPARISON.—This species is completely unlike *C. pentagonalis* and *C. nasuta*, both new, in its elongate triangular outline and generally lesser depth. It is similar to *C. fracidia*, new species, but is still more triangular than that form, with a more subdued median fold and less deep brachial valve. Like those species with which it is compared, this one is extremely rare.

Cenorhynchia unicastata, new species

PLATE 519: FIGURES 25–34

Small for genus, subpentagonal to subtriangular in outline; widest near midvalve; wider than long; sides narrowly rounded; anterior margin slightly emarginate; anterior commissure uniplicate; deltidial plates disjunct. Surface paucicostate: fold marked by two subangular costae with deep median indentation; sulcus with one strong costa and flanks with one or two costae.

Pedicle valve very gently convex in lateral profile, anterior half strongly geniculated to form long tongue with two distal teeth; anterior profile broadly concave. Umbonal region moderately swollen. Flanks widely extended, gently concave to flat. Sulcus originating at midvalve but median costa arising just anterior to umbo.

Brachial valve having much greater depth than pedicle valve, fairly strongly convex in lateral profile but strongly domed in anterior profile, top of dome deeply notched and with two points on each side, sides of dome rounded and very steep.

Fold originating just posterior to midvalve, strongly elevated and with steeply sloping flanks.

Pedicle valve interior with strong dental plates having deep umbonal cavities. Brachial valve with strong socket ridges overhanging finely corrugated sockets. Outer hinge plates narrow; inner hinge plates united; hinge plate often widely notched. Median septum strong, slender, and high.

MEASUREMENTS (in mm).—Specimens USNM 153485a (holotype) and c, respectively: length 10.6, 9.3; brachial valve length 8.9, 7.9; width 12.3, 10.2; thickness 8.9, 7.3; apical angle 99°, 99°.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (*Institella* zone).

LOCALITY.—USNM 721u.

DIAGNOSIS.—Small *Cenorhynchia* with 2 costae on the fold.

TYPES.—Holotype: USNM 153485a. Figured paratypes: USNM 153485b,e–h. Unfigured paratypes: USNM 153485c,d.

COMPARISON.—The ornament of this species with its single costa in the sulcus and the 2 strong costae forming the fold is unique to the genus. This is a rare species, seen only at USNM 721u.

Cenorhynchia ventricosa, new species

PLATE 547: FIGURES 1–5

Large for genus, biconvex; profile bulbous; outline bluntly triangular, sides diverging about 90°; commissure uniplicate, fold high, beginning 7 mm anterior to brachial beak, profile highly convex; sulcus fairly deep, beginning 6 or 7 mm anterior to pedicle beak. Costae low, fine, crests rounded to sharp, beginning 7 mm anterior to beaks, numbering 5 on fold, 4 in sulcus, 1 or 2 on flanks.

Pedicle valve somewhat inflated, uniform convexity from beak to anterior margin, slightly convex toward nonreflexed flanks; beak short, strongly curved dorsally; beak ridges short, blunt; lateral pseudointerareas narrow or absent: little or no overlap of valves. Delthyrium triangular, open, no deltidial plates observed. Brachial valve strongly inflated; profile from beak to anterior margin moderately convex; transverse profile strongly and narrowly arched; smooth part of umbo strongly arched, not flattened; beak slightly protrusive, within pedicle valve.

Interior unknown.

MEASUREMENTS (in mm).—Holotype USNM 148762: length 12.5, brachial valve length 11.0, width 12.7, thickness 11.3, apical angle 85°.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (beds 12–14).

LOCALITY.—USNM 701d.

DIAGNOSIS.—Large *Cenorhynchia* with strongly ventricose and subcarinate brachial valve.

TYPES.—Holotype: USNM 148762.

COMPARISON.—*Cenorhynchia ventricosa* is characterized by its prominent fold with 5 fine costae, strong and uniform convexity of profile, and sharp convexity transversely, without flattening; also its hooked pedicle beak, and open delthyrium. It most nearly resembles *C. fracida*, new species, differing in the convexity of the profile of the fold, much more prominent fold, larger size, and normally 5 costae on the fold. *C. fracida* has the smooth area of the pedicle umbo slightly flattened in profile, producing a lower fold.

Cenorhynchia species 1

PLATE 517: FIGURES 26–35

A species of this genus is represented by 5 specimens of subpentagonal outline and small size. Specimen 153492a is 7.5 mm long, 7.4 mm wide at the widest point, which is anterior to midvalve, and is 4.5 mm thick. The specimens are mostly smooth except for the anterior margins which are costate, 2 costae on the fold and 1 in the sulcus and another on the flanks. All are marked this way except one which has two costae in the sulcus. The valves are subequal in depth.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation.

LOCALITY.—USNM 726h.

TYPES.—Figured specimens: 153492a,b.

STRIGIRHYNCHINAE, new subfamily

Completely costate, hinge plate undivided and supported by median septum. Falcifer crura.

Genera in West Texas: *Strigirhynchia* Cooper and Grant, 1969; *Madarosia*, new genus; and *Chaeniorhynchus*, new genus.

These genera are all rare and stratigraphically restricted, the first and second to the Guadalupian, the third to the Leonardian.

Genus *Strigirhynchia* Cooper and Grant

Strigirhynchia Cooper and Grant, 1969:14.

Medium size, rhynchonelliform, strongly biconvex; outline bluntly triangular to nearly circular; commissure gently uniplicate; fold low, sulcus shallow; costae distinct but fine, low, beginning at or near apexes of beaks, crests sharp, or blunt without bifurcation or intercalation. Concentric ornamentation consisting of faint, closely spaced striae. Beak of pedicle valve sharp, straight to suberect; delthyrium triangular, may be completely open, or closed at base by deltidial plates; lateral pseudointerareas wide to absent; little or no overlap of valves; regions lateral to beaks smooth, may be somewhat flattened or pinched.

Brachial valve inflated, cross section of umbonal area flattened or moderately deeply indented; beak within pedicle valve.

Pedicle valve interior with sides of delthyrium moderately diverging, teeth knob-shaped, supported by vertical dental plates reaching floor of valve, fused to side of valve. Muscle area triangular, widening anteriorly; adductor scars narrow, elongate, median and posterior, located in beak area between dental plates; diductor scars anteriorly expanding, one on each side of median line.

Brachial valve interior with undivided triangular hinge plate; hinge sockets deep, long, finely denticulate, anteriorly expanding; median septum high, thin, long, bisecting part of muscle area, posterior end beneath hinge plate terminating bluntly against plate; crura diverging forward from anterior edges of hinge plate, strongly curved ventrally, dorsal edges carinate. Muscle area elongate oval; posterior adductor scars elongate, narrow, widely separate, flanking larger, anteriorly widening, medially contiguous anterior adductor scars.

TYPE-SPECIES.—*Rhynchonella? indentata* B. F. Shumard (1860:393; Girty, 1909:321, pl. 15: figs. 20a–c, as interpreted herein and with neotype designated by Cooper and Grant, 1969:14).

DIAGNOSIS.—Medium-sized Rhynchonellacea having fine, direct costae, concave brachial valve umbo, and undivided hinge plate supported by a long, thin septum.

COMPARISON.—*Strigirhynchia* is characterized by bulbous convexity, fine, low, rounded, nonbifurcating costae that begin at or near the apexes of the beaks, and by its undivided hinge plate and high

median septum. Internally it is identical to species of *Phrenophoria* Cooper and Grant in which the median septum is high. It differs from those species in its completely or nearly completely costate shell, and costae that are finer, lower, and more densely arranged, and begin normally nearer to the beaks than is usual in semicostate *Phrenophoria*. *Allorhynchus* Weller is similar externally, but *Strigirhynchia* differs in its undivided hinge plate and high median septum. It is distinguished from genera of the Camarotoechiidae by its lack of a septalium or cural cavity between the top of the median septum and the underside of the hinge plate.

Strigirhynchia elongata, new species

PLATE 510: FIGURES 1–12, 38

Small for genus, elongate, triangular in outline with broadly rounded sides and narrowly rounded anterior margin; sides forming angle of 64° . Beak long, suberect, foramen oval, submesothyridd; deltidial plates large, conjunct. Anterior commissure uniplicate. Valves costate except for umbonal regions, costae crowded, narrow, 4 on fold, 3 in sulcus, and 7 or 8 on each flank.

Pedicle valve moderately convex in lateral profile and moderately domed in anterior profile, lateral slopes short but moderately gentle. Sulcus broad and shallow, originating well anterior to midvalve; tongue short; flanks narrowly rounded, slightly protruding anterolaterally.

Brachial valve of about the same depth as pedicle valve, flatly convex in lateral profile, broadly but flatly domed in anterior profile with short steep sides. Umbonal region concave; fold originating about two-thirds distance from beak, low, narrow, defined best by wider costae forming.

Brachial valve with undivided hinge plate and strong, thin, bladelike septum. Other details not preserved.

MEASUREMENTS (in mm).—Holotype USNM 154688a: length 10.0, brachial valve length 7.9, width 8.2, thickness 5.5, apical angle 64° .

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member).

LOCALITY.—USNM 728p.

DIAGNOSIS.—Elongate, narrowly triangular *Strigirhynchia*.

TYPES.—Holotype: USNM 154688a. Figured paratypes: USNM 154687, 154688b.

COMPARISON.—The long slender form and long beak distinguish this species from the other two members of the genus.

Strigirhynchia indentata (Shumard)

PLATE 508: FIGURES 6–29; PLATE 520: FIGURES 35–39;

PLATE 521: FIGURES 30, 31

Rhynchonella? indentata Shumard, 1860:393.—Girty, 1909: 321, pl. 15: figs. 20–20c.

Strigirhynchia indentata (Shumard) Cooper and Grant, 1969: 14.

Moderately large, biconvex, adults somewhat globose; outline bluntly triangular, sides diverging between 85° and 105° ; profile elongate oval to lenticular; anterior commissure uniplicate; fold low, beginning 6–8 mm anterior to brachial beak, evenly convex in profile except for flattening near umbo; sulcus shallow, beginning 7–9 mm anterior to pedicle beak, profile evenly convex. Costae low, narrow, crests rounded, beginning 3–6 mm anterior to beaks, numbering 4–7 on fold, one less in sulcus, 7–10 on each flank. Concentric ornamentation consisting of zigzag striae; growth lines weak.

Pedicle valve moderately strongly convex along sulcus and toward flanks; beak sharp, attenuate, not curved dorsally; beak ridges short, rounded; lateral pseudointerareas long, broad, bounded on pedicle valve by sharp, slightly arcuate line, strongly overlapped by brachial valve along lateral commissure. Delthyrium triangular, base covered by pair of large conjunct deltidial plates, foramen oval to nearly circular.

Brachial valve slightly more strongly convex, umbonal area longitudinally indented; sides of umbonal area pinched and flattened opposite flat lateral pseudointerareas of pedicle valve, making brachial beak somewhat attenuate, producing strong beak ridges between flattened sides and flattened umbo; apex within pedicle valve, covered by deltidial plates. Fold broad, flattened to moderately concave medially.

Pedicle valve interior with sides of delthyrium diverging anterior to deltidial plates, teeth elongate, parallel to valve sides and supported by vertical dental plates reaching floor of valve. Muscle area beginning near anterior edges of dental plates,

slightly excavate, triangular to oval; adductor area oval to round, small, median, surrounded laterally and anteriorly by larger, anteriorly expanding diductor scars.

Brachial interior with undivided triangular hinge plate, bounded laterally by elongate, anteriorly widening, deep, finely denticulate sockets; crura long, diverging forward, strongly curved ventrally, concave toward midvalve, dorsal edge carinate; median septum high, thin, delicate, moderately long, and supporting hinge plate, extending into muscle area. Muscle area elongate oval, posterior adductor scars small, elongate, anteriorly diverging from midline of valve; anterior adductor scars large, anteriorly expanding, separating posterior scars.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 737a					
148530a	8.2	7.4	8.0	3.6	93
148530b	9.7	8.6	9.6	6.6	93
148530c	10.9	9.6	10.5	8.4	86
USGS 2926 (green)					
118572 (neotype)	12.9	11.5	14.6	9.4	95
AMNH 806					
154662	11.9?	10.6	11.7	8.6	90

STRATIGRAPHIC OCCURRENCE.—Capitan Formation. Bell Canyon Formation (Rader and Lamar members).

LOCALITIES.—Capitan: AMNH 799, 806, 847, 853; USGS 2926 (green), 7404 (blue); USNM 725i, 725-l, 737a, 738a, 739, 740k, 740n, 740o. Rader: USNM 740g. Lamar: USNM 725e, 728p, 738.

DIAGNOSIS.—Moderate size, variable *Strigirhynchia*, usually elongate or slightly transverse.

TYPES.—Neotype: USNM 118572. Figured hypotypes: USNM 148530a; 148531; 154659a; 154660; 154661a; 154762a,b; 154771; 155107; 155108. Measured hypotypes: USNM 148530a–c, 154662.

COMPARISON.—*Strigirhynchia indentata* is characterized by its high convexity, small and numerous costae that arise near the beaks very gradually rather than abruptly, low fold and shallow sulcus, and especially by its indented brachial umbonal area, pinched sides, and large, flat lateral pseudointerareas. It differs from the other known species of the genus, *S. transversa*, new species, in its narrower form, wider fold and sulcus, smaller angle

of divergence of sides, and more narrowly rounded lateral extremities.

An externally similar species is *Rhynchonella salinasi* Gemmellaro (1899:120, pl. 27: figs. 43–47), which has a similarly pinched brachial beak and wide lateral pseudointerareas. However, Gemmellaro's species is indented longitudinally on both valves, the indentations extend farther forward, costae begin nearer the beak than in *S. indentata*, and the commissure is not uniplicate. The internal characters of *R. salinasi* are unknown, so its generic position is not certain.

DISCUSSION.—The generic position of this species has been questionable since it first was described, because the interior was poorly known. Shumard (1860) did not illustrate his specimens, so the present concept of the species is Girty's (1909) interpretation of Shumard's description. The species is so distinctive, however, and its stratigraphic position so consistent that there is little doubt that it has been correctly identified. Specimens from the Guadalupe Mountains in the Museum collection have the internal features well preserved. Externally they appear to be conspecific with Girty's illustrated specimen; internally they have generic characters that relate them to *Strigirhynchia*.

Shumard's measurements indicate a specimen about 14 mm long by 13 mm wide, but none of the specimens in the Museum collection conform to these measurements. His specimen is distinctly longer than wide which is not true of Girty's illustrated specimen which is distinctly wider than long although it agrees well in other respects. Shumard also speaks of the beak being moderately incurved which is not in accordance with any of our specimens. Our illustrated specimen USNM 148530c is much more in accordance with Shumard's species.

King (1931) assigned several specimens to "*Cam-arophoria?*" *indentata* (Shumard). His description is based on an admittedly atypical individual from Mexico, but his specimens from the Glass Mountains differ from the Mexican one only in being somewhat more convex. There is no mention of an indented brachial umbonal area, pinched sides, nor broad lateral pseudointerareas. He mentions internal features that include a spondylium in the pedicle valve, but no hinge plate in the brachial valve. As King (1931:111) has said, "It may be seen that the description does not accord very well in some respects with that of Shumard," and we

believe that his specimens are not *S. indentata*, but an elongated *Stenosisma*.

Strigirhynchia transversa, new species

PLATE 514: FIGURES 1–28

Large for genus, transversely triangular in outline, greatest width anterior to midvalve; postero-lateral margins gently concave; sides narrowly rounded; anterior margin slightly emarginate. Anterior commissure uniplicate. Lenticular in profile. Beak small, pointed, straight to suberect. Surface costate, costae fine and numerous, 7 or 8 on fold, one less in sulcus; 7–10 on flanks.

Pedicle valve gently convex in lateral profile; anterior profile broadly concave except for gently convex flanks; umbonal region, gently and narrowly convex; sulcus originating near midvalve, broad and shallow. Anterolateral extremities moderately protuberant. Flanks narrow. False interarea broad, almost completely overlapped by brachial valve.

Brachial valve moderately convex in lateral profile but umbonal region conspicuously flattened. Anterior profile broadly and moderately domed. Umbonal region flattened and indented by conspicuous oval trough. Fold originating at midvalve, low, not well defined anteriorly and often with shallow median sulcus tending to depress anterior margin of fold. Flanks gently convex and only slightly deflected below fold.

Interior details unknown except for dental plates and long delicate median septum in brachial valve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 750a					
152863a	13.0	11.5	17.1	8.2	105
(holotype)					
152863b	13.0	11.6	17.2	11.3	105
USNM 725k					
152864a	11.1	9.4	12.4	6.1	90
152864b	8.2	7.1	7.6	4.0	75
USNM 740					
148534	11.0	9.7	13.0?	4.7	80

STRATIGRAPHIC OCCURRENCE.—Capitan Formation.

LOCALITIES.—USNM 725k, 725-l, 738a, 740, 750a, 750b.

DIAGNOSIS.—Transverse *Strigirhynchia* with wide fold and sulcus.

TYPES.—Holotype: USNM 152863a. Figured paratypes: USNM 152863b,c; 154716; 154717. Measured paratypes: USNM 148534; 152863b; 152864a,b.

COMPARISON.—This species differs from *S. indentata* (Shumard) by its strong width compared to length and the more prominent fold and sulcus.

DISCUSSION.—Young of this species tend to be elongate rather than transverse as is usual in young rhynchonellids. Furthermore, the concave umbonal region occupies nearly the entire brachial valve except for the marginal 2 mm in a specimen 8 mm long. Another juvenile with the brachial valve 10 mm long has a depressed area measuring 7.5 mm.

Chaeniorhynchus, new genus

[Greek *chainos* (open) + *rhynchus* (beak)]

Average size for rhynchonellid, valves subequal in depth, usually elongate brachial valve slightly larger; outline oval to subtrigonal; anterior commissure uniplicate. Beak long, suberect to erect; delthyrium open; no deltidial plates. Surface completely costate.

Pedicle valve interior with small teeth parallel to shell margin; dental plates well developed. Muscle field not well impressed.

Brachial valve interior with strong socket ridges and uncorrugated sockets. Outer hinge plates broad; crural bases keeled; crura falcifer, curved, appearing to be twisted and flattened at distal extremity; inner hinge plates united medially without visible suture. Median septum slender, strong, high, extending anteriorly for about a third valve length, and acting as myophragm to divide elongate adductor muscle field.

TYPE-SPECIES.—*Chaeniorhynchus inauris*, new species.

DIAGNOSIS.—Completely costate Rhynchonellacea having dental plates, undivided hinge plate, and long thin median septum.

COMPARISON.—This genus in its completely costate exterior is similar to *Allorhynchus* Weller but differs in having an undivided hinge plate and a strong median septum, both of which are lacking from *Allorhynchus*.

DISCUSSION.—This genus also has the exterior expression of *Trophisina*, new genus, but the fine

ribs and aborted median septum of that genus separate *Chaeniorhynchus* and prevent confusion. Absence of deltidial plates in large specimens of *Chaeniorhynchus* is an unusual feature in such a relatively late, geologically speaking, rhynchonellid genus. Most of the genera of the late Paleozoic rhynchonellids have the deltidial plates well developed, or at least in a rudimentary state. It shares this unusual feature with the new genus *Tricoria*.

The interior of the pedicle valve appears to have no unusual features, but as in some other genera, the dental plates have the tendency to lie close to the walls of the valve and are not always easy to see. The brachial valves of young specimens have the hinge plate undivided, a feature that is established at an earlier age than in the related genus *Trophisina*. Unfortunately, most brachial valve interiors available for study do not have well-preserved crura. Two good specimens indicate slender elongate crura that are compressed laterally, as is common in many Permian genera. The median septum is variable but generally is long and slender.

Chaeniorhynchus inauris, new species

PLATE 507: FIGURES 1-20

Average size for genus, biconvex, bulbous; outline somewhat pear-shaped, sides diverging between 80° and 110°; profile oval; anterior commissure uniplicate; fold low, evenly convex longitudinally, strongly arched transversely, bearing 4 or 5 fine low costae; sulcus shallow. Costae fine, low, crests sharp or rounded, extending to apexes of beaks; surface entirely costate except posterior lateral surfaces near hinge; flanks bearing 5-7 lower, finer costae. Concentric ornamentation absent, growth lines infrequent.

Pedicle valve strongly convex; beak sharp, weakly to strongly curved dorsally; beak ridges weak; lateral pseudointerareas not present, no overlap of valves lateral to beaks. Delthyrium triangular, open, deltidial plates absent. Brachial valve strongly and evenly convex; apex within pedicle valve.

Pedicle valve interior with small hinge teeth, elongate, parallel to shell edge, supported by strong vertical dental plates reaching valve floor. Muscle area oval, lying anterior to ends of dental

plates; scars too faint to be differentiated. Brachial valve interior with broadly triangular, undivided hinge plate, bounded laterally by elongate, finely denticulate sockets; crura projecting forward, diverging anteriorly, strongly curved ventrally, dorsal edge carinate; median septum high, blade-like, supporting hinge plate, extending forward about a third length of valve. Muscle area small, oval, posterior adductor scars obscurely separated from larger anterior adductor scars.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 702					
148520a	10.3	9.1	9.1	7.4	80
148520b	9.2	7.9	8.8	7.3	80
USNM 702-low					
148784a (holotype)	10.0	8.4	8.8	c.6.0	86

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—USNM 702, 702-low, 735b.

TYPES.—Holotype: USNM 148784a. Figured paratypes: USNM 148520a,b; 154654a-c,e. Measured paratypes: USNM 148520a,b. Unfigured paratypes: USNM 148784b; 154654d,f.

DIAGNOSIS.—*Chaeniorhynchus* having strongly developed fold and sulcus occupied by few costae.

COMPARISON.—*Chaeniorhynchus inauris* is characterized by its small size, bulbous convexity, low fold and sulcus, numerous fine costae that extend to the apexes of the beaks, open delthyrium without deltidial plates; its complete costation of the shell distinguishes it from species of *Wellerella* that occur in the Glass Mountains; and its undivided hinge plate and median septum distinguish it from externally similar species of *Allorhynchus*. *Pontisia longicosta* (Stehli, 1954:336) from the Bone Spring Formation in the Sierra Diablo is costate to the apexes of the beaks. *C. inauris* differs from it in its larger size, proportionately finer costation, greater convexity, and especially by its high median septum, which is in contrast to the "low broad ridge" of *P. longicosta*.

DISCUSSION.—This is one of the rarest of the brachiopods from the prolific Split Tank area of the Cathedral Mountain Formation.

Chaeniorhynchus salutare, new species

PLATE 507: FIGURES 21–31

Usual size for genus, length and width nearly equal but some slightly elongate; outline elongate oval to subtrigonal. Maximum width slightly anterior to midvalve. Sides moderately to strongly rounded; divergence of sides 80° to 90° . Anterior commissure strongly uniplicate. Beak fairly long, strongly suberect; delthyrium open, long and narrow. Surface costate, costae narrowly rounded, 5 or 6 on fold, one less in sulcus, about 6 on each flank.

Pedicle valve fairly evenly and moderately convex in lateral profile; anterior profile slightly convex but median region slightly concave. Umbonal region narrowly convex; sulcus originating near midvalve, broad and shallow, scarcely deepening anteriorly. Flanks gently swollen, narrowly rounded, not strongly differentiated from median region.

Brachial valve fairly strongly and evenly convex in lateral profile; strongly and narrowly domed in anterior profile, top well rounded. Umbonal and median regions swollen. Fold poorly defined, visible chiefly where slightly elevated above flanks. Fold originating near midvalve. Flanks inflated but steep.

Pedicle valve interior with small teeth and strong dental plates extended forward. Brachial valve with strong socket plates and smooth sockets. Hinge plate and crura not well preserved. Median septum thin and extending about a quarter valve length.

MEASUREMENTS (in mm).—

	brachial valve length	length	width	thick- ness	apical angle (°)
USNM 703a					
148522a (holotype)	11.9	10.0	10.4	8.7	80
148522b	11.0	9.6	10.7	8.0	85
148522c	10.0	8.7	8.8	5.0?	80?
148522d	7.8	7.0	7.6	5.5	80

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 703a.

DIAGNOSIS.—*Chaeniorhynchus* having a fairly wide but shallow and low sulcus and fold.

TYPES.—Holotype: USNM 148522a. Figured paratypes: USNM 154653b,g. Measured paratypes:

USNM 148522b–d. Unfigured paratypes: USNM 148522b–d; 154653a,c–f.

COMPARISON.—This species differs from *C. inauris*, new species, in reaching slightly greater size, in having a less prominent fold and sulcus, but in having, generally, more costae on these features. The Road Canyon species is somewhat less rotund than the earlier one and the tongue of the pedicle valve is longer. Inside the brachial valve the median septum of *C. inauris* is more strongly developed than that of the Road Canyon species.

DISCUSSION.—This species is as rare as its relatives in the Cathedral Mountain Formation, only a dozen specimens having been recovered.

Chaeniorhynchus transversum, new species

PLATE 508: FIGURES 48–55

Large for genus, pentagonal outline, wider than long, sides narrowly rounded and anterior margin broadly rounded; posterolateral margins forming angle of 94° . Anterior margin broadly uniplicate; beak suberect, delthyrium open, no trace of deltidial plates. Surface completely costate, costae direct, not intercalated, 6 on fold, 5 on each flank.

Pedicle valve evenly and gently convex in lateral profile, broadly and gently domed in anterior profile with very short sides. Median and umbonal regions moderately swollen; sulcus originating near midvalve, broad and shallow, forming short serrated tongue anteriorly; geniculation of tongue gradual and gentle. Flanks gently convex, slopes gentle.

Brachial valve deeper than pedicle valve, strongly and evenly convex in lateral profile; anterior profile forming strong evenly rounded dome with very steep sides. Fold poorly defined, scarcely elevated above swollen flanks. Interior not known.

MEASUREMENTS (in mm).—Holotype USNM 148523: length 12.1, brachial valve length 10.3, width 12.5, thickness 9.0, apical angle 94° .

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 703b.

DIAGNOSIS.—Large transverse *Chaeniorhynchus* with poorly defined fold and sulcus.

TYPES.—Holotype: USNM 148523.

COMPARISON.—This species is most like *C. salutare*, new species, but that species is smaller, has a

more incurved beak, finer costae, a narrow and better defined fold and sulcus, narrower shell, and longer tongue than *C. transversum*. *Chaeniorhynchus inauris*, new species, is smaller, has weaker costae, is narrower, and is more narrowly shouldered than *C. transversum*. Only one specimen of this rare species has been found. Unfortunately the dorsal structures are covered by silica but strong dental plates are visible through a hole in the anterior.

Madarosia, new genus

[Greek *madaros* (bald)]

Medium size, subpentagonal outline; inequivalved, brachial valve deeper; profile convexiplane; uniplicate, anterior commissure strongly plicated but fold weakly developed. Beak suberect. Delthyrium open, deltidial plates absent or marginal. Exterior smooth except for short lamellae at anterior margin.

Pedicle valve interior with short dental plates defining narrow delthyrial chamber; muscle field extending anterior to anterior ends of dental plates.

Brachial valve interior with small and delicate cardinalia; hinge plate concave to flat, undivided; socket ridges small; outer hinge plates broad; crura falcifer, delicate, long, slender, and with keeled dorsal edge. Median septum long, slender, elevated, and supporting hinge plate.

TYPE-SPECIES.—*Madarosia anterolamellata*, new species.

DIAGNOSIS.—Smooth rhynchonellaceans having narrowly confined cardinalia; undivided hinge plate having wide outer hinge plates and a strong median septum.

COMPARISON.—In sorting specimens from Bell Canyon residues this genus is often confused with *Bryorhynchus*. Although the exteriors are similar, *Madarosia* has no costae or costellae, no deltidial plates or a mere trace of them, and the tongue of the ventral valve is angular rather than rounded as in most of the Camarotoechiids. Internally *Madarosia* is very distinct from *Bryorhynchus* because it has an undivided hinge plate whereas that of *Bryorhynchus* is divided and the crura are longer and more strongly curved. The smooth shell and subpentagonal form distinguish *Madarosia* from

all of the costate and semicostate genera.

DISCUSSION.—The almost complete lack of deltidial plates in this genus is a primitive character. Although the collection is not large, only one pedicle valve showed any indication of deltidial plates and these are mere traces on the delthyrial margins of specimen USNM 154916h.

Madarosia anterolamellata, new species

PLATE 517: FIGURES 48–54; PLATE 552: FIGURES 38–58

Medium size, subpentagonal in outline, wider than long, maximum width near midvalve; sides rounded; anterior truncated. Anterior commissure narrowly rounded to angular. Surface smooth except for short growth lamellae at anterior.

Pedicle valve with small beak and triangular delthyrium; umbonal region narrowly swollen, swelling not extending to midvalve; flanks flattened to narrowly concave and depressed below lateral margin; sulcus originating just anterior to midvalve, abrupt but shallow and forming long, narrowly rounded to angular tongue.

Brachial valve gently convex in lateral profile; umbonal region flattened; anterior half broadly arched transversely to form low fold; flanks descending steeply.

Interior of both valves as described for genus.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	length	width	
USNM 725f				
154744a	12.0	10.5	13.5	7.4
(holotype)				
154744b	11.3	10.6	13.2	7.2
USNM 740j				
154916b	10.0	9.3	10.2	5.3
154916c	12.0	11.0	14.6	7.0?
154916d	10.5	9.2	12.1	7.0
USNM 731				
154933	11.8	10.4	13.4	6.7

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, and Rader members).

LOCALITIES.—Hegler: USNM 731. Pinery: AMNH 33. USNM 736. Rader: USNM 725f, 740j.

DIAGNOSIS.—*Madarosia* with narrow anterior lamellae in the adult.

TYPES.—Holotype: USNM 154744a. Figured paratypes: USNM 154744b,c; 154916a–h. Measured

paratypes: USNM 154744b, 154916b-d, 154933. Unfigured paratypes: USNM 154933.

COMPARISON.—This species differs from *M. pentagona*, new species, in its somewhat smaller size, less thickness, and the presence of the growth lamellae at the anterior. Differences also appear in the brachial valves of the two species, that of *M. anterolamellata* being much more delicate but with a proportionately longer hinge plate and more prominent outer hinge plates.

DISCUSSION.—This is a rare and delicate species. It occurs in the lower three members of the Bell Canyon Formation but has not yet been taken from the Lamar Member. The shell is so thin that some specimens were lost in handling them for study.

Madarosia pentagona, new species

PLATE 513: FIGURES 39-41; PLATE 548: FIGURE 18

Large for genus, pentagonal in outline, wider than long, with gently rounded sides and truncated anterior. Unequally biconvex, pedicle valve gently convex, but brachial valve deeper. Anterior commissure strongly angular and extended in dorsal direction. Delthyrium open, no deltidial plates. Surface smooth.

Pedicle valve interior with short dental plates sloping medially and defining narrow delthyrial chamber. Muscle field narrow and extending anterior to delthyrial cavity.

Brachial valve interior with short, undivided hinge plate; outer hinge plates moderately wide; crura long and slender, dorsally keeled and with flattened distal extremity. Median septum long and slender.

MEASUREMENTS (in mm).—Specimen USNM 154930 (holotype): length 13.0, brachial valve length 11.3, width 14.1, thickness 9.0, apical angle 116°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—AMNH 512.

DIAGNOSIS.—Thick *Madarosia* without anterior lamellae and with fairly stout cardinalia.

TYPES.—Holotype: USNM 154930.

COMPARISON.—This is a more robust species than *M. anterolamellata*; it is much thicker and has stouter cardinalia. The hinge plate is less extended

anteriorly than that of *M. anterolamellata* and the outer hinge plates not so prominent. This is a very rare species; only one specimen was taken from the vast amount of residues from AMNH 512=USNM 728.

ALLORHYNCHIDAE, new family

Rhynchonellacea with ventral fold and dorsal sulcus, completely or nearly completely costate. Pedicle valve with dental plates and variable deltidial plates; brachial valve without median septum but with divided hinge plate. Crura falcifer or modified falcifer.

Genera in West Texas: *Allorhynchus* Weller, 1910; *Ptilotorhynchus*, new genus; *Deltarina*, new genus; *Fascicosta* Stehli, 1955; *Hemileurus*, new genus.

Genus *Allorhynchus* Weller, 1910

Allorhynchus Weller, 1910:509; 1914:197.—Stehli, 1955:74.

Shell rhynchonelliform, biconvex; outline bluntly triangular; profile subtrigonal to semiovate; anterior commissure uniplicate, fold low, sulcus shallow; costae low but distinct, crests rounded, without bifurcation or intercalation, beginning at or near beaks. Concentric ornamentation and growth laminae weak. Pedicle beak sharp, straight to moderately curved dorsally; delthyrium triangular, sides slightly constricted by rudimentary, usually disjunct, deltidial plates; lateral pseudointerareas narrow, normally covered by slight overlap of brachial valve. Brachial beak rounded, lying inside pedicle valve beneath small disjunct deltidial plates.

Pedicle valve interior with delthyrium widened to receive beak of brachial valve; teeth supported by vertical dental plates reaching valve floor. Muscle area triangular, between and anterior to forward edges of dental plates; adductor scars small, forming elongate oval mark in posterior part of muscle area; diductor scars lateral and anterior to adductor scar, widening abruptly at posterior end, gradually expanding from there forward.

Brachial valve interior with medially divided or deeply notched hinge plate, bounded laterally by deep, anteriorly widening, finely to coarsely corrugated hinge sockets; socket ridges strong, crura

falcifer, diverging anteriorly, strongly curved ventrally, commonly appearing twisted, dorsal edges carinate, with keel extending beneath hinge plate; median septum absent; low myophragm present or absent. Muscle area elongate oval; posterior adductor scars narrow, elongate, posterior ends separate, diverging anteriorly, flanking larger, anteriorly widening, lobate anterior adductor scars.

TYPE-SPECIES.—*Rhynchonella heteropsis* N.H. Winchell, 1865:121.

TYPES.—Lectotype: USNM 142567a from Winchell's type lot.

COMPARISON.—*Allorhynchus* is distinguished by its relatively low fold and shallow sulcus, fine, blunt costae that cover the shell, usually extending to the beaks, by its divided hinge plate, and lack of a median septum. Its costate umbonal areas and divided hinge plate distinguish it from *Wellerella*. *Strigirhynchia*, new genus, is costate to the beaks, but its undivided hinge plate and high median septum separate it from *Allorhynchus*.

DIAGNOSIS.—Completely costate Allorhynchidae having a divided hinge plate and no median septum.

DISCUSSION.—Stehli (1955:74) remarked that the combination of features characterizing *Allorhynchus* is distinctive, and not likely to be confused with that of other genera. But he assigned his Permian specimens only tentatively to the genus, giving two reasons for his doubt. One is the absence of known species of *Allorhynchus* from the Pennsylvanian. The other involves anatomical details of the shell. He cites the presence of concentric striae on the Mississippian shells and their absence on the Permian species known to him. One new species in the Museum collections has faint concentric striae, but we consider that to be a specific character at most, certainly not eliminating from the genus the two other species which do not exhibit it. Furthermore, that feature may be destroyed by silicification of the shell, leaving concentric ornamentation visible only on a few specimens. The other feature that Stehli believes may distinguish the Mississippian species from the Permian species is denticulation of the hinge sockets. This feature cannot be observed on the calcareous specimens of the type species from Iowa, but minute denticulation or corrugation is present in a few silicified Mississippian specimens of a species from the Warsaw Formation of Tennessee. Coarse

silicification can destroy fine denticulation, so it is not visible on all specimens of that Mississippian species, but its presence on a few is sufficient to link them generically with the more coarsely denticulate Permian species. We believe that all the known species have generic characters in common, and that assignment of Permian species to the Mississippian genus need not await discovery of species of *Allorhynchus* in Pennsylvanian strata.

The type-species *A. heteropsis* (Winchell) shows the exterior characters to perfection, with the beaks and umbones of both valves covered by costae. We here select specimen USNM 142567a as type specimen for the species. This specimen was formerly one of Winchell's cotypes. It shows all of the exterior characters and, in addition, the nature of the deltidial plates may be clearly seen. They are small and disjunct. This feature is fairly general among species of the genus. Only one specimen of a new species from the Mississippian (Warsaw) of Tennessee shows conjunct deltidial plates. Two additional specimens show the socket plates and the myophragm of the brachial valve. The Permian specimens and the new species from the Mississippian (Warsaw) of Tennessee alluded to above yielded most of the information on the interior details.

The specimens from Tennessee are small, rotund forms. The teeth of the pedicle valve are almost horizontal and are flattened in the direction of the shell width but they have a strong socket on their posterior side. The teeth of the Permian species are more knoblike but also have a deep socket on the outside of the tooth. The dental plates of the Mississippian forms are strong and have deep umbonal chambers but the Permian ones usually have narrow, slitlike umbonal cavities. The muscle scars were not clearly discerned in any of the specimens but they lie anterior to the ends of the dental plates.

Inside the brachial valve the sockets are minutely corrugated in the Permian forms but these structures were not seen in the Mississippian specimens. The socket ridges of the Mississippian examples are strong and somewhat elevated. They bear broad and concave outer hinge plates that are bordered by the crural bases. Inner hinge plates can be seen on both Mississippian and Permian specimens but they were not seen to unite in any of the speci-

mens. The divided hinge plate is thus a persistent character in the genus.

The falcifer crura of the Mississippian specimens are generally long, slightly bowed, somewhat expanded anteriorly, and form hollow plates with the concavity facing toward the midline of the shell. The plates are crescentic in cross section. On the underside of the hinge plate the crura are strongly keeled and the keels extend to the apex. The Mississippian specimens have a strong myophragm that divides the muscle field but does not reach the apex. In most of the Permian species no trace of a myophragm was seen.

A semicostate allorhynchid from the Neal Ranch Formation is here separated as the new genus *Hemileurus* in allusion to this difference in its exterior. Some of the Permian specimens have non-costate umbones but this shell is half smooth and thus presents a greatly different appearance from typical *Allorhynchus*.

Allorhynchus is common at several levels but it is not abundant at any place in the Glass or Guadalupe Mountains.

Allorhynchus circulare, new species

PLATE 780: FIGURES 19–24 (in part V)

Medium size for genus, subcircular to roundly subpentagonal in outline, length slightly greater than width; sides strongly rounded; anterior margin broadly rounded. Posterolateral margins forming angle of 80°. Valves subequal in depth. Deltidial plates small, disjunct. Surface costate, costae crowded, 5 on fold and 5 on flanks. No concentric ornament preserved.

Pedicle valve evenly and moderately convex in lateral profile and broadly and gently convex in anterior view; sulcus originating just posterior to midvalve, shallow throughout and forming short, serrated tongue. Flanks rounded.

Brachial valve moderately convex in lateral profile but somewhat more so in anterior view; fold poorly defined, originating posterior to midvalve but never highly elevating. Flanks rounded and convex, only slightly depressed below fold at anterior.

Pedicle valve interior with strong dental plates. Brachial valve with strong socket ridges, narrow

sockets, narrow to nonexistent outer hinge plates, and short crura.

MEASUREMENTS (in mm).—Holotype USNM 148059a: length 7.5, brachial valve length 6.2, width 6.9, thickness 5.3, apical angle 80°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—USNM 732.

DIAGNOSIS.—Rotund, thick and rounded *Allorhynchus* with poorly defined fold and sulcus.

TYPES.—Holotype: USNM 148059a. Figured paratypes: USNM 148059b,c. Unfigured paratypes: USNM 148059d–m.

COMPARISON.—The intermediate size of this species limits comparison to *A. concentricum*, new species, from which it differs in its narrower outline, more circular form, greater thickness, and lack of any concentric ornament such as is conspicuous on *A. concentricum*.

Allorhynchus concentricum, new species

PLATE 509: FIGURES 74–77

Usual size for genus, length and width nearly equal; valves subequal in thickness; outline pentagonal, sides rounded; posterolateral margins forming angle of 110°. Anterior commissure gently uniplicate. Delthyrium open, no trace of deltidial plates. Fold with 5 costae, 6 or 7 on flanks; entire surface covered by fine concentric lines.

Pedicle valve gently and evenly convex in lateral profile; anterior profile broadly and gently convex; beak somewhat elongated; umbonal region moderately inflated; sulcus originating at about midvalve, wide and shallow; tongue short. Flanks somewhat flattened, with gentle slopes.

Brachial valve gently convex in lateral profile but moderately domed in anterior profile with short steep sides. Median region and umbonal region swollen; fold originating slightly posterior to midvalve, poorly defined, barely elevated above moderately swollen and steep flanks.

Interior unknown.

MEASUREMENTS (in mm).—Holotype USNM 154676: length 8.6, brachial valve length 7.6, width 8.9, thickness 5.5, apical angle 110°.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 732j.

DIAGNOSIS.—Finely costate *Allorhynchus* with low fold, shallow sulcus, and strong concentric lines.

TYPES.—Holotype: USNM 154676.

COMPARISON.—In size this species suggests *A. triangulatum* and *A. variabile*, both new, but it is much more finely costate than either of these species. It also suggests *Petasmatherus nitidus*, new species, but is larger, has more and crowded costae, and is provided with concentric lines which do not appear on *P. nitidus*.

Allorhynchus formulosum, new species

PLATE 540: FIGURES 4–14

Average size for genus, subtrigonal to subpentagonal in outline, sides rounded, maximum width anterior to midvalve. Anterior margin truncated. Anterior commissure strongly uniplicate. Apical angle usually about 90°. Completely costate, but indistinct at apexes; costae moderately elevated, narrowly rounded with fairly wide interspaces, 5 costae on fold, 4 or 5 on flanks, last ones indistinct.

Pedicle valve moderately convex in lateral profile, greatest convexity just posterior to midvalve; anterior profile gently and broadly convex. Beak short, straight or nearly erect, with oval foramen and small disjunct deltidial plates. Median and umbonal regions gently convex; sulcus wide, shallow, originating at midvalve, forming moderately long tongue. Flanks narrowly elevated in antero-lateral extremities, short but steep.

Brachial valve gently convex in lateral profile but strongly domed and with precipitous sides in anterior profile. Umbonal region moderately convex; median region moderately swollen. Fold, short, low, poorly defined, originating at midvalve. Flanks moderately swollen and steep.

Pedicle valve interior with narrow, oblique dental plates oriented parallel to shell margin and located well forward of deltidial plates. Dental plates thin, delicate, short, and defining narrow umbonal chambers. Muscles not clearly impressed.

Brachial valve interior with strong socket ridges and moderately wide outer hinge plate. Inner hinge plates rudimentary. No median septum or myophragm. Crura moderately long.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
AMNH 585					
154881a	8.2	7.3	9.3	5.5	98
(holotype)					
154882a	3.4	3.0	3.5	1.4	80
154882b	4.4	3.6	4.2	1.8	80
154882c	5.1	4.2	4.8	2.2	80
154882d	5.4	4.7	5.3	2.8	80
154882e	7.0	6.2	7.4	3.6	85
154882f	7.6	6.6	8.0	4.6	90
154882g	7.5	6.7	8.3	4.8	85
154882h	8.6	7.7	10.4	5.5	105

LOCALITIES.—AMNH 585; USNM 730.

DIAGNOSIS.—Fairly wide, short *Allorhynchus* with broad fold, shallow sulcus, and short beak.

TYPES.—Holotype: USNM 154881a. Figured paratypes: USNM 154881c,d; 154882g,h. Measured paratypes: USNM 154882a–h. Unfigured paratypes: USNM 154881b,e,f.

COMPARISON.—This species approaches *A. permianum* Stehli in size but no specimen actually attains the size of that species. The two may be distinguished, beside the size, by the stronger ribbing of *A. formulosum* when compared to *A. permianum* of the same size, the generally wider form and much shorter beak of the pedicle valve of *A. formulosum*. Specimens of similar size must be compared because the young of *A. permianum* are more elongate than adults of *A. permianum* of the same size.

Allorhynchus aff. *A. macrum* (Hall)

PLATE 780: FIGURES 69–77 (in part V)

Aff. *Rhynchonella macra* Hall, 1856:11.

Aff. *Allorhynchus macrum* (Hall) Weller, 1914:199, pl. 25: fig. 1–4.

Figures of a Mississippian species of *Allorhynchus* are introduced here for comparison with the interiors of the Permian species assigned to the genus. The figures illustrate well the divided hinge plate.

STRATIGRAPHIC OCCURRENCE AND LOCALITY.—Warsaw Formation, Clarksville, Tennessee.

TYPES.—Figured specimens USNM 155071.

Allorhynchus permianum Stehli*Allorhynchus? permianus* Stehli, 1955:74, figs. 18–31.

Large for genus, biconvex; outline bluntly triangular to subpentagonal, sides diverging from 50° in juveniles to 120° in largest adults; profile lenticular to semiovalate; commissure uniplicate, fold high, with moderately convex profile; sulcus shallow, evenly convex longitudinally. Costae moderately high, strong, beginning at beaks or slightly anterior, numbering 4 or 5 on fold, normally 5, one less in sulcus, 6 or 7, rarely 8 on each flank.

Pedicle valve slightly inflated in umbonal area, gently convex toward nonreflexed flanks; beak sharp, somewhat attenuate, slightly curved dorsally; beak ridges blunt, relatively short; lateral pseudointerareas narrow, entirely or partly covered by overlapping brachial valve. Delthyrium triangular, in adults constricted along sides by disjunct deltidial plates, open in juveniles; foramen eyeshaped or rounded triangular.

Brachial valve strongly convex toward flanks, gently convex longitudinally along fold; umbonal area slightly flattened in transverse cross section, some with shallow longitudinal indentation; beak often attenuate, end blunt, within pedicle valve below deltidial plates.

Pedicle valve interior with sides of delthyrium abruptly widened anterior to deltidial plates, forming notch to accommodate brachial beak, each side with one knob-shaped, slightly elongate hinge tooth supported by a vertical dental plate reaching floor of valve. Muscle pattern roughly triangular, lying between and anterior to forward edges of dental plates; adductor scars elongate, in posterior part of muscle area, one on each side of median line, surrounded laterally and anteriorly by wider, longer, anteriorly expanding diductor scars.

Brachial valve interior with hinge plate divided by wedge-shaped notch, bounded laterally by deep, anteriorly widening, socket ridges which define finely to coarsely denticulate hinge sockets; crura short, diverging anteriorly, strongly curved ventrally, often twisted, dorsal edges carinate; myophragm low, rounded, bisecting posterior part of muscle area, often completely absent. Muscle area elongate oval; posterior adductor scars narrow, elongate, widely separated, slightly diverging anteriorly, flanking larger, bilobate, anteriorly widening anterior adductor scars.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation; Word Formation; Cherry Canyon Formation (Getaway Member).

LOCALITIES.—See subspecies below.

DIAGNOSIS.—Large for the genus with high fold having 5 costae.

TYPES.—Holotype: AMNH 27905/5. Figured hypotypes: USNM 148054a–h. Measured hypotypes: USNM 148078; 148088; 148094a,b.

COMPARISON.—*Allorhynchus permianum* is characterized by its comparatively large size, high fold with 5 strong costae that extend to the beak or close to it, relatively short crura, strongly corrugated sockets, and broad low myophragm in the brachial valve. It differs from *A. heteropsis* (Winchell) from the Mississippian of Iowa in its large size, more numerous costae, and absence of a well-defined median groove on the exterior of the brachial umbonal area. It differs from *Hemileurus runcinatus*, new species, from the Neal Ranch Formation in its larger size, more numerous and stronger costae that begin farther back on the beaks, longer and less strongly curved pedicle beak, and valves that overlap slightly anterior to the beaks, commonly producing a narrow lateral pseudointerarea.

Allorhynchus permianum permianum Stehli

PLATE 541, FIGURES 1–30

Allorhynchus? permianus Stehli 1955:74, figs. 18–31.

COMPARISON.—This subspecies occurs in the Getaway Member of the Cherry Canyon Formation in the Guadalupe Mountains, Guadalupian in age. Its costae extend to the apexes of the beaks, a feature that distinguishes it from the otherwise similar Glass Mountains subspecies, *A. permianum wordense*, new subspecies.

MEASUREMENTS (in mm).—From locality USNM 728 specimen AMNH 27905/5 (holotype): length 12.5, brachial valve length 10.5, width 13.9, thickness 9.5, apical angle 105°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—AMNH 496, 512, 547, 600; USNM 728.

DOUBTFUL OCCURRENCE.—Bell Canyon Formation (Hegler and Lamar members). Capitan Formation.

LOCALITIES.—Hegler: USNM 731. Lamar: AMNH 37; USNM 728r. Capitan: 738a, 740, 750.

Allorhynchus permianum wordense, new subspecies

PLATE 542: FIGURES 1–51

COMPARISON.—This subspecies occurs in the Word Formation of the Glass Mountains. It is distinguished from the subspecies from the Guadalupe Mountains by its incomplete costae that normally begin 1–2 mm anterior to the apexes of the beaks. In other characters the two groups are indistinguishable.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Hess Canyon, and Willis Ranch members; lens between Willis Ranch and Appel Ranch members).

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706					
148084a	5.5	4.6	4.3	2.2	55
148084b	7.7	6.2	7.0	3.3	60
148084c	9.3	7.8	9.0	3.7	80
148084d	10.0	8.5	9.9	6.0	80
148084e	9.3	8.2	9.4	3.7	80
148084f	10.0	8.3	10.6	6.7	96
148084g	15.0	12.6	15.4	10.6	113
154889c (holotype)	12.9	11.2?	13.7	9.7	88
USNM 706b					
148088a	4.1	3.2	3.1	1.6	?
148088b	4.6	3.6	3.9	1.9	?
USNM 706e					
148078	11.9	10.4	12.6	8.0	114
USNM 706z					
148094a	13.8	11.8	15.8	9.0	100
148094b	5.9	5.3	5.5	2.9	65

LOCALITIES.—China Tank: USNM 703e, 706c, 706z, 713, 726r. Willis Ranch: AMNH 505; USNM 706, 706e. Appel Ranch: USNM 715i, 719z, 722t, 724u. Lenses: USNM 706b, 732c, 737w. Word Formation (undifferentiated): USNM 731p.

TYPES.—Holotype: USNM 154889c. Figured paratypes: USNM 148081a–e; 148084e–g; 154889a–f,h; 154890a–d. Measured paratypes: USNM 148078; 148084a–g; 148088a,b; 148094a,b. Unfigured paratypes: USNM 148084a–d, 154889g, 154890e.

Allorhynchus triangulatum, new species

PLATE 542: FIGURES 52–60

Medium size, longer than wide in all growth stages; elongate triangular outline with apical angle approaching 89°. Sides gently rounded; maximum width anterior to midvalve. Anterior margin straight. Surface nearly completely costate but beaks variable, ranging from costate to nearly smooth. Surface marked by crowded, rounded to subangular costae, 4 or 5 on fold, usually 4, one less in sulcus. Flanks marked by 3–5 costae, last two usually indistinct.

Pedicle valve shallower, evenly and moderately convex in lateral profile; medially flat to slightly concave in anterior profile. Beak long, suberect, with large elliptical to oval foramen. Deltidial plates small, disjunct. Umbonal region narrowly swollen; sulcus originating just anterior to midvalve, shallow and narrow, approximating about half valve width. Tongue long and flattened. Flanks narrow, rounded.

Brachial valve moderately convex in lateral profile, most convex in posterior half; anterior profile narrowly domed and with steep parallel sides. Umbonal region moderately convex; fold originating near midvalve, narrow, moderately strongly elevated at anterior end. Flanks gently swollen and only slightly depressed.

Pedicle valve interior with moderately long dental plates separated from valve wall by narrow slits; muscle scars not impressed.

Brachial valve interior with long crura, crescentic in section, concave toward midvalve, and with keels under crural base. No inner hinge plates.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706c					
148092a	12.0	9.8	11.4	10.0	77
148092b (holotype)	9.7	7.9	9.3	7.9	75
148092c	9.2	7.6	8.3	5.7	72
148092d	8.9	7.6	7.3	5.5	64
148092e	8.9	7.3	7.8	6.0	68
148092f	7.6	6.3	6.8	5.4	64
148092g	5.3	4.2	4.5	3.3	63

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, and Appel Ranch members and lens between the last two).

LOCALITIES.—Word: USNM 731u, 732s. China Tank: USNM 706c, 733q. Willis Ranch: AMNH 505; USNM 706, 706e, 724u. Appel Ranch: USNM 714o. Lens: USNM 742b.

DIAGNOSIS.—Elongate, thick *Allorhynchus* with narrow fold and long beak.

TYPES.—Holotype: USNM 148092b. Figured paratypes: USNM 148092c–e, h, i. Measured paratypes: USNM 148092a, c–g. Unfigured paratypes: USNM 148092a, f, g.

COMPARISON.—This species occurs with *A. variable*, new species, but is readily distinguished by its long, triangular outline, and narrow fold. Its narrow form, narrow fold, and fine costae distinguish it from *A. permianum* Stehli.

Allorhynchus variable, new species

PLATE 543: FIGURES 1–13

Medium size for genus, slightly wider than long in adults, subtrigonal in outline; valves subequal in depth. Sides narrowly rounded; maximum width at or slightly anterior to midvalve. Anterior margin truncated. Apical angle about 90° or slightly greater. Surface nearly completely costate; costae narrow, rounded; interspaces narrower than costae; costae numbering 4–6 on fold, usually 4; one less costa on sulcus; flanks marked by 3–7, last ones usually indistinct.

Pedicle valve evenly and moderately convex in lateral profile, slightly sulcate in anterior profile. Beak moderately long, suberect, pointed; foramen elongate, elliptical, usually restricted anteriorly by disjunct deltidial plates. Umbonal region moderately swollen; sulcus originating at midvalve, deepening rapidly. Flanks narrow, gently convex.

Brachial valve moderately convex in lateral profile, maximum curvature in posterior part and flattened anteriorly; anterior profile narrowly domed with steep sides. Fold low, somewhat spreading anteriorly, occupying more than half of width and originating just anterior to midvalve. Flanks rounded, gently depressed.

Pedicle valve interior with short dental plates, defined by narrow umbonal cavities. Brachial valve interior with divided hinge plate, no inner hinge plates. Socket ridges low; crura short, curved, and with strong keels.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 706c					
148090a	10.6	9.0	12.0	8.0	95
(holotype)					
148090b	10.1	8.6	11.0	6.8	88
148090c	9.4	7.8	9.5	6.7	78
148090d	7.7	6.3	7.4	4.7	73
148090e	7.0	5.9	6.7	4.1	73
148090f	7.5	6.4	7.4	4.5	77

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank and Willis Ranch members).

LOCALITIES.—China Tank: USNM 706c. Willis Ranch: 706.

DIAGNOSIS.—Medium size, transverse *Allorhynchus* with low fold marked by five costae and smooth umbones.

TYPES.—Holotype: USNM 148090a. Figured paratypes: USNM 148090a–h; 154892a, b. Measured paratypes: USNM 148090b–f.

COMPARISON.—In the adult form this species is slightly wider than long and has fairly crowded costae. It is smaller than *A. permianum* Stehli, with more even and finer costae and with a somewhat narrower sulcus in the young and some adults, but this feature is variable. The costae of the fold of *A. permianum* are strong and conspicuous but those of *A. variable* are subdued and fairly even in size.

Allorhynchus venustulum, new species

PLATE 542: FIGURES 61–64; PLATE 543: FIGURES 14–33

Rhynchonella longaeva Girty, 1909:322, pl. 15: figs. 19a–c [not 18].

Small, with rounded contours and subtrigonal to subpentagonal outline; apical angle about 75°; lenticular in profile, brachial valve having slightly greater depth; sides rounded but maximum width slightly anterior to midvalve; anterior margin gently rounded; anterior commissure gently uniplicate. Surface completely costate but costae often indistinct at umbones; costae broad and gently rounded and with narrow interspaces, 3–5 on fold and 5 or 6 on each flank.

Pedicle valve evenly and gently convex in lateral profile but broadly and moderately domed in anterior profile. Beak nearly straight to suberect,

usually short, except in young; foramen elongate oval; deltidial plates small, lateral and basal, disjunct; posterior and median regions gently convex; sulcus, shallow and poorly defined, originating near midvalve and producing short tongue. Flanks short and moderately steep.

Brachial valve moderately convex in lateral profile, most curvature in umbonal region; anterior profile broadly and moderately domed and with short steep sides. Median and umbonal regions moderately inflated; fold low, poorly defined and best seen at anterior; flanks swollen and moderately steep.

Pedicle valve interior with narrow teeth, compressed in the direction of width and located well anterior to deltidial plates; dental plates delicate, short, defining very narrow delthyrial chamber; muscle field anterior to delthyrial cavity, but scars poorly impressed.

Brachial valve interior with strong, inclined socket ridges defining narrow, corrugated sockets; outer hinge plates narrow, crural bases narrow; inner hinge plates moderately developed. Crura of falcifer type. Median ridge low, wide, clearly secondary, adductor scars near midvalve.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 738b					
152804a	2.9	2.2	2.7	1.2	60
152804b	3.5	2.7	3.0	1.9	60
152804c	4.5	3.5	4.0	2.1	60
152804d	6.0	4.8	5.4	3.8	60
152804e	7.0	5.7	5.8	4.0	70
152804f	6.8	5.7	6.3	4.0	70
152804g	7.4	6.4	7.1	4.7	75
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Hegler: USNM 731. Pinery: USNM 725h. Rader: USNM 725g. Lamar: AMNH 38, 40, 347 (=L-2), 348 (=L-3), 351 (=L-6), 430; USNM 725e, 728i, 728p, 728r, 738, 738b.

DIAGNOSIS.—Small elongate *Allorhynchus* with low, rounded costae.

TYPES.—Holotype: USNM 152804g. Figured paratypes: USNM 152804f, 154891a-d, 154893a-d, 154894, 154895. Measured paratypes: USNM 152804a-f. Unfigured paratypes: USNM 152804a-e.

COMPARISON.—This is a small elongated species and may be compared only to *Petasmatherus nitidus* and *pumilus*, both new. It is readily distinguished from the latter by its stronger and somewhat subdued ribbing and less elongated beak of the pedicle valve. It is more like *P. nitidus* but is generally a smaller species, with less well-defined fold and sulcus, more variable costation in the fold and sulcus, and more subdued costation. It is much smaller and more trigonal than any of the species of *Allorhynchus* from the Word Formation of the Glass Mountains or the Getaway Member in the Delaware Basin.

DISCUSSION.—The species is rare, and has been found only in the dark limestones of the Bell Canyon Formation.

Allorhynchus species unidentified

The above named species do not include all of the forms this genus takes in the residues or broken from their matrix in the Glass Mountains. Specimens referable here were taken from the Skinner Ranch Formation (Decie Ranch Member) at USNM 711d; a coarse-ribbed species occurs in the Road Canyon Formation at USNM 703d, and 721j. Another more rotund species occurs in the Willis Ranch Member of the Word Formation at USNM 723w; a specimen of *Allorhynchus* comes from the Word Formation at USNM 731m.

In the Guadalupe Mountains the Getaway Member of the Cherry Canyon Formation produced a rotund species at AMNH 496. A species occurs in the Cutoff Shale Member of the Bone Spring Formation at AMNH 678.

Small collections from the Capitan and Bell Canyon formations also cannot be assigned to known species. These occur in the Capitan at USNM 738a, 740, 750, and in the Bell Canyon Hegler Member at USNM 731, and Lamar Member at AMNH 37, USNM 728r.

Ptilotorhynchus, new genus

[Greek *ptilotos* (winged) + *rhynchus* (beak)]

Rhynchonellid about medium size, triangular in outline, biconvex and strongly inequivalve, brachial valve deeper and more convex. Anterior commissure uniplicate, fold low, sulcus shallow but

long. Beak short, straight; deltidial plates conjunct and strongly alate. Surface multicostellate, costellae increasing by implantation and bifurcation in several generations.

Pedicle valve interior with small teeth and dental plate greatly reduced or obsolete in adults. Muscle area large and rounded.

Brachial valve interior with deeply notched hinge plate with non corrugated sockets and thick socket plate; outer hinge plates narrow; crura, flattened falcifer, moderately long, laterally compressed blades with broad faces toward midline of valve; inner hinge plates not formed in young, forming short narrow arch in adults. Median ridge confined to apex in adult and supporting hinge plates, not present in young; median ridge often thick; adductor field elongate and divided medially by low, thin myophragm.

TYPES-SPECIES.—*Ptilotorhynchus delicatum*, new species.

DIAGNOSIS.—Rhynchonellida with numerous bifurcated costellae, obsolescent dental plates, and a median ridge in the brachial valve supporting a deeply indented hinge plate.

COMPARISON.—This genus can be recognized easily by its distinctively marked exterior with the bifurcating costellae. In this respect it resembles *Fascicosta* Stehli and *Divaricosta* Cooper and Grant, but differs from both of them in having the dental plates of the pedicle valve aborted or obsolete and the hinge plate deeply indented. The strongly alate deltidial plates, which are carried from youthful stages to the adult, are also an unusual feature that lends distinction to the genus. In the above respects it differs from the multicostate forms as well as those with direct costae.

DISCUSSION.—This interesting genus has a number of characters peculiar to it. The alate deltidial plates are a rarity among Paleozoic genera. They occur in the Glass Mountains fauna in the young of *Rhynchopora*, where they are conspicuous but usually not so strongly developed as in the present genus. Perhaps, if the young of more Paleozoic rhynchonellids were known, these peculiar plates would prove to be of wider occurrence. In *Ptilotorhynchus* they are developed in the adult as well as in the young and are as strongly marked as in some of the late Mesozoic genera. They serve to strengthen the foraminal margin and help to produce a pedicle tube.

Another feature unique to this genus among the Glass Mountains and other West Texas rhynchonellids is the obsolescence of the dental plates. These are greatly reduced in the leiorhynchids but are seldom lost completely. The Permian faunas of Russia have rhynchonellids, such as *Pseudowellerella* and *Denticuliphoria*, (both Licharew 1956), in which the dental plates have atrophied. In *Ptilotorhynchus* dental plates were not observed in the young specimens available. These specimens were, perhaps, in a young-adult stage rather than immature, only their size suggests their youth. The teeth in this genus are very small; running in a curve from them along the lateral shell wall is a low ridge that probably represents the growth track of the tooth and is not a remnant of a dental plate.

The cardinalia of this genus are also unusual for Permian rhynchonellids. In the smaller specimens, probably young adults, the hinge plate is deeply indented, with no trace of inner hinge plates; but in the largest specimen, truly an adult, the inner hinge plates form a low ridge between the crural bases. The outer hinge plates are narrow and the crural bases are a keel on their inner edge. The crura are laterally compressed blades, rather rigid, and with the concave side facing midvalve. In the younger specimens no trace of a median septum is evident, although in the largest specimen a rudimentary ridge occurs at the apex and joins the inner hinge plates in the support of the hinge plate. Anteriorly the ridge is extremely short, but between the adductors in this large specimen a narrow myophragm appears as a continuation of the ridge. In some of the younger specimens the median depression on the brachial valve is translated in the interior to a broad rounded ridge.

Ptilotorhynchus delicatum, new species

PLATE 508: FIGURES 72–76; PLATE 513: FIGURES 1–18;
PLATE 552: FIGURES 15, 16

Medium size for rhynchonellid, elongate oval to subtrigonal in outline, sides diverging at about 90°. Maximum width near midvalve. Sides broadly rounded. Anterior commissure uniplicate with moderate amplitude. Beak short, straight. Surface multicostellate, fold poorly defined, costellae narrowly rounded, with interspaces about same size as costellae; fila strong in interspaces.

Pedicle valve moderately convex in lateral profile, maximum convexity near midvalve; anterior profile flatly and broadly concave. Umbonal region nearly flat. Sulcus variable, originating just anterior to umbo, shallow and narrow, deepening and widening anteriorly, but nowhere very deep; flanks moderately rounded; sulcus occupied by 11 costellae in one specimen. Flanks moderately convex, narrowly rounded and usually moderately strongly marked.

Brachial valve of about equal or slightly greater depth than pedicle valve; strongly convex in lateral profile, maximum convexity near midvalve; anterior profile narrowly domed, sides steep and precipitous. Umbonal region moderately concave, especially in young, but lessening in adults and giving way to low, inconspicuous fold slightly posterior to midvalve; fold variable, generally low and rounded in both profiles; flanks somewhat swollen and not strongly deflected.

Interior details of both valves as described for genus.

MEASUREMENTS (in mm).—Holotype USNM 148219: length 13.9, brachial valve length 12.5, width 12.6, thickness 10.6, apical angle 90°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member), Capitan Formation, Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Getaway: USNM 732. Capitan: USGS 7404 (blue); USNM 725j, 739, 740. Hegler: USNM 731, 740c. Pinery: USNM 733. Rader: USNM 725g, 740a, 740g, 740i, 740j, Lamar: AMNH 430; USNM 725e, 728p, 738, 738b.

DIAGNOSIS.—*Ptilotorhynchus* with long, shallow sulcus in the pedicle valve.

TYPES.—Holotype: USNM 148219. Figured paratypes: USNM 154710a,e,h; 154711; 154712a,b; 154713; 154714; 154668a,b; 154670. Unfigured paratypes: USNM 154710b–d, f,g.

COMPARISON.—This is the only species of this genus known, but inasmuch as species of *Divaricosta* and *Fascicosta* have similar exteriors they might be confused with it. The lack of dental plates and the nature of the hinge plate of *Ptilotorhynchus* distinguishes them readily.

DISCUSSION.—The available material on which this species and genus is based indicates either variable species or possibly more than one species. Specimens from USNM 725e include young and adult individuals. The young are variable, some

specimens being widely triangular but others elongate triangular. The adults have the long shallow sulcus on the pedicle valve that appears to be a generic as well as specific character. The measured paratype is preserved in limestone and is undistorted. It is elongate triangular and appears more elongate than the specimen from AMNH 430. The latter is crushed, however, and does not reveal its true character. It has seemed best to regard all of the specimens as belonging to a single variable species.

Deltarina, new genus

[Greek *delta*]

Small, triangular in outline, with narrowly rounded sides; subequivalve; lenticular in profile, both valves shallow. Greatest width anterior to midvalve; anterior commissure broadly to narrowly uniplicate. Beak straight, moderately long, narrow and sharply pointed; foramen elongate triangular; deltidial plates rudimentary, disjunct. Interareas small. Surface multicostate, costae strong and prominent.

Pedicle valve with small narrow teeth lying parallel to shell margin and posteriorly grooved; dental plates thin, convergent, with narrow umbonal cavities, often difficult to distinguish; muscle field fairly strongly impressed, with large diductor scars.

Brachial valve with smooth sockets defined by cup-like fulcral plates and strong inner socket ridges overhanging sockets. Hinge plate divided; outer hinge plates narrow, bearing laterally flattened, short falcifer crura; inner hinge plates not developed, or rudimentary. Median ridge slender or absent. Adductor field not impressed strongly enough to distinguish details.

TYPE-SPECIES.—*Deltarina magnicostata*, new species.

DIAGNOSIS.—Strongly and completely costate rhynchonellids with rudimentary, disjunct deltidial plates, divided hinge plate, and with brachial valve septum absent or rudimentary.

COMPARISON.—The exterior of this genus is very distinctive in having the fold composed of two costae and the one corresponding costa in the sulcus, and with the flanks having occasional bifurcation or intercalation. Lack of deltidial plates (or at best, mere vestiges) combined with a fairly long

tapering beak are characteristic. The genus suggests *Divaricosta* Cooper and Grant, but in that genus the fold and sulcus are occupied by numerous costae and the deltidial plates are elaborate. It differs from *Fascicosta* Stehli (1955) in lacking numerous bifurcations and intercalations of the costae, and in having more pronounced costae and a shorter beak.

Deltarina is like *Ptygmactrum*, new genus, *Petasmatherus* Cooper and Grant and *Elassonia*, new genus, in the possession of a divided hinge plate, but it differs from all three in size but more especially in the ornamentation. The first has a few direct angular costae, and the second has a peculiar straight hinge, while *Elassonia* has a broadly sulcate anterior commissure.

DISCUSSION.—This interesting but rare genus has a distinctive exterior with its triangular outline, narrowly lenticular profile, and strong costae that increase by intercalation or bifurcation. The beak is fairly long, with a long triangular foramen which, at first glance, appears to be unmodified. The deltidial plates are usually so narrow that they escape attention in complete specimens. The separated valves reveal them readily because of the small notch at their anterior where the curved umbonal region of the brachial valve is inserted under or against them.

Inside the pedicle valve the dental plates are variably developed, although easily seen. They are delicate and convergent. In some specimens the cavities between them and the inner wall of the valve are so narrow that they might be overlooked. The teeth bear notches at the posterior where they are inserted under the strongly overhanging inner socket ridge.

Inside the brachial valve the cardinalia are narrow but thick, and are elevated considerably above the sides of the shell. All the plates except the crura are fairly thick. This is true of the young as well as adults and old age specimens. In the very young the outer hinge plates are narrow or not developed but they expand with age. A septum or ridge seems not to play a role in the development of the cardinalia.

The sockets are defined by thick fulcral plates as well as the bounding socket ridges. The outer hinge plates are broad but the inner hinge plates are variously developed. In most specimens they are united medially, but in some they are deeply

notched, in others united posteriorly so that the hinge plate seems undivided. The crura are moderately long and curved, are keeled anteriorly, and lie oblique to the midline; the distal extremity is obliquely truncated, the sharper, narrower extremity on the posterior side.

This genus is not common at any locality but dissolution of large blocks usually yields a few specimens. It is necessary to dissolve a considerable quantity of limestone to obtain a collection adequate for detailed study.

Deltarina magnicostata, new species

PLATE 507: FIGURES 32–56; PLATE 508: FIGURES 30–33; PLATE 552: FIGURES 18–21; PLATE 780: FIGURES 1–6 (in part V)

Small, broadly triangular in outline and long, sharply pointed beak. Posterolateral sides slightly concave; lateral margins narrowly rounded and anterior margin broadly rounded to truncated. Anterior commissure broadly to narrowly uniplicate. Surface multicostate, costae strong and fairly broadly rounded. Growth interruptions distant.

Pedicle valve evenly and gently convex in lateral profile, broadly and gently convex in anterior profile. Umbonal region narrow and convex; sulcus originating at beak and extending to anterior margin as short tongue. Sulcus marked by single costa implanted anterior to beak and extending to anterior margin; flanks marked by 4 costae. Flanks somewhat flattened.

Brachial valve evenly convex in lateral profile, more convex than opposite valve, maximum convexity near midvalve. Anterior profile broadly and moderately domed. Fold broad, originating as shallow sulcus with single intercalated bifurcation just posterior to midvalve to form 2 prominent costae elevated above flanks to form fold. Flanks gently rounded, occupied by 3 or 4 costae.

Interiors as described for genus.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Hegler: USNM 731. Pinery: AMNH 398, 401; USNM 725h, 725n, 733. Rader: AMNH 410; USNM 725f, 740a. Lamar: AMNH 37, 347 (=L-2), 373, 430; USNM 725e, 728p, 728q, 738, 738b.

TYPES.—Holotype: USNM 154651c. Figured par-

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 738					
152815a	5.3	4.2	5.4	2.7	74
152815b	8.1	6.8	8.2	4.4	81
152815c	8.6	7.4	9.2	5.5	83
152815d	9.7	7.7	9.8	6.0	80
152815e	9.2	7.6	9.6	4.7	84
USNM 725e					
154651c	8.8	7.3	9.8	6.6	97
(holotype)					
USNM 738b					
152816	8.5	7.3	9.2	5.0	90

atypes: USNM 152815d; 154651a,b,d-f; 154656a,c-e, g-i; 154658; 154915; 155109a,b. Measured paratypes: USNM 152815a-e, 152816. Unfigured paratypes: USNM 152815a-c,e; 152816; 154656b,f.

DIAGNOSIS.—Strongly costate, triangular *Deltarina*.

COMPARISON.—No other species of the genus is known to which this one can be compared.

DISCUSSION.—The folding in this species indicates a reversion from a youthful sulcate condition to a uniplicate commissure in the adult. The smallest specimen in the collection is 3 mm long and has a smooth ventral beak for a short distance. It is convex, and on the umbonal region is preserved a shallow sulcus, also smooth. On the pedicle valve of this small specimen the smooth part becomes a fairly deep narrow sulcus in which a single costa is inserted 1.5 mm from the beak. On the brachial valve, about 0.5 mm anterior to the beak, a single costa is inserted which immediately bifurcates and extends to the anterior margin. The costae bounding the initial sulcus on the pedicle valve extend from beak to margin and really define the fold, but they are usually not elevated to a height equal to that of the median two which are the more conspicuous. On the pedicle valve the costae bounding the sulcus meet the troughs on the outside of the median bifurcated pair of costae. These sulcus-bounding costae are slightly elevated above those on the flanks. Together with the sulcus this pair makes a sort of fold.

Genus *Fascicosta* Stehli, 1955

Fascicosta Stehli, 1955:71.

Small, rhynchonelliform, biconvex, uniplicate;

outline subelliptical to subtrigonal, transverse to elongate. Anterior commissure uniplicate. Costae fine or coarse, beginning at beaks, number increasing anteriorly by bifurcation; concentric ornament absent; radial costellae and growth lines weak. Pedicle valve flatly to moderately convex; beak sharp, straight, suberect or slanted ventrally; beak ridges bordering interareas; delthyrium triangular or trapezoidal, may perforate beak; deltidial plates absent; lateral pseudointerareas absent: no overlapping of valves. Brachial valve somewhat more convex, umbonal area may be flattened or indented; beak blunt, may be nearly straight, producing nearly straight hinge line; apex external or curved into pedicle valve.

Pedicle valve interior with small teeth; dental plates short, convergent, supporting hinge teeth. Muscle area tear-shaped; adductor scars central or near posterior apex of muscle area, small, subelliptical; diductor scars larger, anteriorly widening.

Brachial valve interior with divided hinge plate supported by a low, thin median ridge; sockets deep, denticulate, anteriorly widening; socket ridges thick; outer hinge plates broad; crura falci-form, long and slender, expanded distally, diverging slightly from anterior edge of hinge plate, curved ventrally; crural bases strong, extending from underside of hinge plate along dorsal edges of crura; inner hinge plates poorly developed. Muscle area narrowly elliptical; posterior adductor scars elongate, narrow, widely separate from one another, diverging slightly anteriorly, located at flanks of muscle area; anterior adductor scars somewhat larger, anteriorly widening, lying along midline of valve, extending farther forward; diductor muscle pit shallow, small, located in apex of hinge plate.

TYPE-SPECIES.—*Rhynchonella? longaeva* Girty, 1909:322, pl. 15: figs. 18–19. The larger of Girty's two syntypes (118573a) is selected as lectotype.

DIAGNOSIS.—Rhynchonellacea having bifurcated and intercalated costae, divided or deeply notched hinge plate, and median ridge.

COMPARISON.—*Fascicosta* is characterized externally by its rhynchonelliform shape, costae that begin at the beaks and increase in number anteriorly by bifurcation, nearly straight beak with wide delthyrium and with rudimentary or absent deltidial plates. Internally it is distinguished by the convergent dental plates in the pedicle valve, and, in the brachial valve, by the divided hinge plate

that is supported by a thin median ridge, and by the relatively narrow muscle area with only slightly diverging posterior adductor muscle scars. Externally it most nearly resembles *Divaricosta* Cooper and Grant in its bifurcating costae, differing in its open delthyrium, straighter hinge line, smaller, more knoblike hinge teeth without lateral sockets, absent lateral pseudointerareas, and lack of overlap of valves lateral to beaks. In shape and outline it resembles species of *Petasmatherus* Cooper and Grant or *Allorhynchus* Weller, but it is easily distinguished by its bifurcating costae, lack of pseudointerareas, and strong median septum.

Although Stehli (1955) assigned specimens from the Getaway Member to *Fascicosta*, these are not congeneric with *Rhynchonella? longaeva* Girty, which he designated as the type species; for a discussion see *Divaricosta* (below) and Cooper and Grant (1969:11).

DISCUSSION.—Disappointingly few specimens of this genus have been taken from the residues from the Guadalupe Mountains. Nevertheless, it is possible to give many important details of the interior. The pedicle valve has proved not to have deltidial plates, a fact that helps to distinguish this genus from some of the larger species with bifurcated costae such as those of *Ptilotorhynchus*, new genus, and *Strigirhynchia* Cooper and Grant. Inside the pedicle valve the dental plates converge toward the valve floor. Old specimens fill in the cavities between the dental plate and side wall, tending to obscure the dental plates. Although this has taken place in some of the specimens, no instance of the dental plates having been eliminated by this means was seen.

The hinge plate is deeply notched, having broad outer plates, but poorly developed inner plates. The latter are seldom well developed but in some specimens may meet near the apex. The median ridge is generally fairly strong and moderately long, simulating a septum, but does not usually reach midvalve.

Fascicosta bella, new species

PLATE 505: FIGURES 12–15; PLATE 509: FIGURES 68–73; PLATE 552: FIGURES 30–37; PLATE 780: FIGURES 28–33 (in volume 5)

Small, subpentagonal in outline, inequivalved, brachial valve deeper; sides narrowly rounded; an-

terior margin broadly rounded; posterolateral margins forming angle of 102° . Anterior commissure uniplicate. Beak erect to suberect; delthyrium open, no trace of deltidial or marginal plates. Surface costate, 4 on fold and 3–5 on each flank.

Pedicle valve gently convex in lateral profile, maximum convexity in posterior half; anterior profile flatly convex but with broad depression representing sulcus. Umbonal region swollen but with sulcus beginning at beak and expanding anteriorly, occupied by 3 costae, 1 originating at beak but 2 intercalated just anterior to beak; tongue short, not strongly geniculated. Costae bounding fold stronger than others; flanks convex, moderately steep.

Brachial valve moderately convex, posterior half more strongly convex than flattened anterior half; anterior profile moderately convex, dome flattened on top; umbonal region swollen, with fairly wide depression containing 2 costae at beak and extending to anterior margin; additional costa implanted on each side of primary two just anterior to beak, forming fold consisting of 4 costae; costae bounding depression at beak anterior depressed, forming bounding costae of swollen flanks.

Pedicle valve interior with short convergent dental plates; brachial valve interior with divided hinge plate and low median ridge not supporting hinge plate. Other details not clear.

MEASUREMENTS (in mm).—From locality USNM 725g specimen 154621 (holotype) and from AMNH 410 specimen 154679, respectively: length 6.9, 7.5; brachial valve length 5.8, 6.4; width 8.2, 8.5; thickness 4.8, (?); apical angle 102° , 102° .

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Rader, and Lamar members).

LOCALITIES.—Hegler: USNM 731, Rader: AMNH 410; USNM 725f, 725g; Rader: 740i, 740j. Lamar: USNM 728i.

DIAGNOSIS.—*Fascicosta* with two median primary and two implanted costae on the fold.

TYPES.—Holotype: USNM 154621. Figured paratypes: USNM 154513a–c, 154679, 155079a. Unfigured paratype: USNM 154678. Measured paratype: USNM 154679.

COMPARISON.—This species is smaller than *F. longaeva* (Girty) and very differently ornamented. There are fewer costae, and those of the fold and sulcus are fairly regular: 1 primary and 2 intercalated in the sulcus and 2 median primary and 2 intercalated on the fold. This species could be con-

fused with specimens of *Divaricosta* Cooper and Grant which also has considerable intercalation of costae but that species has an undivided hinge plate.

The specimen from the Lamar Member is not in complete accordance in its costation with the Rader Member specimens. It has primary costae like those of the Rader specimens, but the intercalation is irregular, a costa appearing near the beak but that on the opposite side appearing near midvalve and all the costae somewhat distant. Discovery of more specimens may indicate two species.

Fascicosta elongata, new species

PLATE 509: FIGURES 62–67; PLATE 780: FIGURES 13–18
(in volume 5)

Small, elongate triangular in outline, sides rounded, maximum width slightly anterior to midlength. Beak long, narrow, suberect, foramen long, triangular; modified slightly by rudimentary disjunct deltidial plates. Costae narrow and subangular, crowded and bifurcating in three generations. Anterior commissure narrowly uniplicate.

Pedicle valve about same depth as brachial valve, moderately convex in lateral profile, greatest curvature in umbonal region; broadly and flatly convex in anterior profile. Sulcus narrow and shallow, not defined until midvalve, occupied by single costa on umbo, second costa intercalating 2 mm anterior to beak and extending to anterior margin. Flanks narrow, moderately swollen and occupied by 6–8 costae, sides unequal because of uneven bifurcation. Tongue short and narrow.

Brachial valve with moderate convexity in lateral profile, maximum convexity at midvalve; anterior profile somewhat narrowly domed. Fold narrow, low, defined just anterior to midvalve, occupied by 3 costae, 2 initial ones and 1 intercalated. Flanks flatly convex and somewhat depressed, occupied by 6 or 7 costae.

Interior not known.

MEASUREMENTS (in mm).—Holotype USNM 152817: length 8.4, brachial valve length 6.8, width 7.8, thickness 5.7, apical angle 74°.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Hegler: USNM 731, 732a, 740c.

Pinery: AMNH 33; USNM 725h. Rader: USNM 725f, 725g. Lamar: AMNH 430.

DIAGNOSIS.—Small, narrowly triangular *Fascicosta* with long beak and narrow costae.

TYPES.—Holotype: USNM 152817. Figured paratype: USNM 155110.

COMPARISON.—This species will not be confused with the type species *F. longaeva* (Girty) because of its narrower outline, more slender costae and the more prominent but narrower fold and sulcus.

DISCUSSION.—Although only a few specimens of this species are known, it is so unlike *F. longaeva* that the two cannot be confused at any stage in their growth. It is probable that *F. elongata* would prove a variable species because of the sporadic way in which intercalation and bifurcation of costae takes place. The beak of the brachial valve is marked by a short sulcus, as usual in youthful rhynchonellids, but, in less than 1 mm, 2 costae appear that oppose the initial costa intercalated in the sulcus of the pedicle valve. Both of these costae bifurcate about 1.5 mm from the beak, the left bifurcation of the right primary costa continues to the anterior margin and forms the center costa of the fold; the right hand bifurcation becomes the outer costa of the fold but bifurcates near midvalve, the bifurcation descending into the trough bounding the fold. A few short bifurcations appear in the anterior third of the flanks.

Fascicosta longaeva (Girty)

PLATE 509: FIGURES 27–59

Rhynchonella? longaeva Girty, 1909:322, pl. 15; figs. 18–19.

Not *Fascicosta longaeva* (Girty) Stehli, 1955:71–73, figs. 1–17
[= *Divaricosta squarrosa* Cooper and Grant, 1969:12].

Average size for genus, moderately strongly bi-convex; outline bluntly transversely subtrigonal to subpentagonal, sides diverging between 90° and 120°; anterior commissure gently and broadly uniplicate; fold low, moderately convex longitudinally and transversely, obvious only at anterior end; sulcus very shallow, only slightly depressed below level of flanks, extending forward for short distance as broad, flat tongue. Costae strong, fine, with sharp crests, beginning at beaks, number slightly increased anteriorly by bifurcation, most bifurcations located within 7 mm of beaks; costae numbering 5–7 on fold, one less in sulcus, 5–8 on each

flank. Concentric striae absent; growth lines weak, irregularly spaced over surface of shell, not obviously concentrated or stronger near margins. Shell substance coarsely fibrous.

Pedicle valve rather strongly convex, flanks not reflexed; beak short, suberect, slightly curved dorsally; delthyrium wide, triangular; deltidial plates disjunct, rudimentary or absent; beak ridges short, blunt; lateral pseudointerareas absent: no overlap of valves.

Brachial valve slightly more strongly convex; umbonal region with strongest convexity transversely and longitudinally, without flattening or indentation; beak bluntly rounded, curved into pedicle valve.

Pedicle valve interior with small teeth; dental plates reaching valve floor, converging but not meeting. Muscle field located anterior to delthyrial cavity, moderately deeply impressed, nearly circular. Scars difficult to distinguish.

Brachial valve interior with divided hinge plate supported by median ridge extending forward but not reaching midvalve. Sockets elongate, corrugated and widening anteriorly; socket ridges stout; length of crura not known; outer hinge plate narrow. Muscle area broadly semioval, extending about a third valve length, but details unknown.

MEASUREMENTS (in mm).—

	brachial valve length	mid- width	maxi- mum width	thick- ness	apical angle (°)
USNM 737a					
148247a	8.7	8.0	9.5?	9.8	6.0
148247b	11.0	9.5	13.2*	13.2*	7.8
USGS 2926					
118573a (lectotype)	9.1	8.2	?	9.4	6.2
USNM 750b					
152816a	9.2	8.3	9.3	10.3	5.3

STRATIGRAPHIC OCCURRENCE.—Capitan Formation; Bell Canyon Formation (Pinery, Rader, and Lamar members).

LOCALITIES.—Capitan: USGS 2926 (green); USNM 737a, 740o, 750a, 750b. Pinery: AMNH 524; USNM 725n, 736. Rader: AMNH 410; USNM 725g. Lamar: USNM 725e, 728i, 728p, 728r, 738, 738b.

DIAGNOSIS.—*Fascicosta* with rounded outline and strong costae.

TYPES.—Lectotype: USNM 118573a. Figured hypotypes: USNM 148246; 148247a; 152816a,b;

154677; 144771. Measured hypotypes: USNM 148247a,b; 152816a. Paratypes: USNM 118573b.

COMPARISON.—*Fascicosta longaeva* is characterized by its rather strong convexity, sharp bifurcating costae, slightly curved pedicle beak, lack of deltidial plates, low fold and shallow sulcus, nonoverlapping valves with absence of lateral pseudointerareas, and more convergent dental plates. It suggests *Strigirhynchia indentata* (Shumard) but differs in its more lenticular profile, less strong convexity, and much coarser, more angular and more widely spaced costae that bifurcate less frequently. It differs from *F. elongata* in its more rounded outline and larger size.

DISCUSSION.—*Rhynchonella? longaeva* Girty was designated by Stehli (1955) as the type species of his genus *Fascicosta*. He described and illustrated a species from the lower Guadalupian (Cherry Canyon Formation) of the Guadalupe Mountains which he identified with *Rhynchonella? longaeva*. Study of Girty's collection of syntypes of this species, shows that *R.? longaeva* is not the same species as that illustrated by Stehli, and in our opinion is not congeneric. That species now constitutes the type species of a different genus, and is discussed under *Divaricosta squarrosa* Cooper and Grant.

Fascicosta longaeva has proved to be rare and difficult to identify. A few specimens have been found among the Geological Survey collections and among those made by members of the National Museum in the Guadalupe Mountains. Disappointingly few specimens have been recovered from the residues and most of these have not had well preserved interiors. The assignment of this species to *Stenosisma* by Branson (1948:525) is entirely erroneous because the type specimen does not have a spondylium or camarophorium.

Hemileurus, new genus

[Greek *hemi* (half) + *leuros* (smooth)]

Small; subtriangular in outline; pedicle valve with elongate, nearly straight beak; foramen elliptical to oval, modified by rudimentary, disjunct deltidial plates. Broadly uniplicate. Surface anteriorly costate, umbones and posterior part smooth; shell smooth in young.

Pedicle valve interior with stout teeth supported by long, subparallel dental plates. Brachial valve

with divided hinge plate; socket ridges strong, bounding deep, uncorrugated sockets; outer hinge plates broad and concave; crura modified falcifer, long, curved, concave toward midvalve, keeled under crural base. Inner hinge plates rudimentary, not uniting. Muscle marks not preserved. Myophragm low and indistinct.

TYPE-SPECIES.—*Hemileurus runcinatus*, new species.

DIAGNOSIS.—Interior like *Allorhynchus* but with the posterior half or less of both valves noncostate.

COMPARISON.—The divided hinge plate of this genus eliminates it from comparison with a large body of rhynchonellid genera. Its distinction from *Allorhynchus* Weller, to which it is related by its interior details, is based on its partially noncostate exterior. *Deltarina*, new genus, has a divided hinge plate but it is multicostate; the same may be said for *Fascicosta* Stehli. The completely multicostate exterior of *Ptilotorhynchus*, new genus, is a ready means of separation on the exterior character but the absence of dental plates in the pedicle valve is further confirmation of the difference.

Hemileurus runcinatus, new species

PLATE 539: FIGURES 1–8

Average size for genus; outline bluntly triangular to subovate, sides diverging between 60° and 110°, normally about 90°; profile subovate to globose; shell frequently distorted; commissure uniplicate, fold low, with uniformly convex profile; sulcus shallow, barely depressed in some specimens. Costae low, fine, beginning 2–5 mm anterior to beaks, arising very gradually, point of origin obscure, umbonal areas normally smooth, but with faint hints of incipient costae; number of costae 3–8 on fold, normally 5, one less in sulcus, from 3–6 on each flank.

Pedicle valve uniformly convex along median line, moderately convex toward nonreflexed flanks; beak sharp, moderately to strongly curved dorsally; beak ridges poorly defined; lateral pseudointerareas absent, valves normally not overlapping. Delthyrium triangular, completely open in juveniles, sides slightly constricted in adults by small, disjunct deltidial plates.

Brachial valve more strongly convex, smooth part of umbonal area often slightly flattened trans-

versely; beak relatively sharp, projecting slightly into pedicle valve below deltidial plates.

Pedicle valve interior with sides of delthyrium abruptly widening anterior to deltidial plates, each side with elongate, knoblike tooth supported by vertical dental plate reaching valve floor. Muscle area roughly triangular; adductor scars narrow, median, elongate, lying between and anterior to edges of dental plates; diductor scars producing “shoulders” on triangular muscle area, lying lateral and anterior to adductors, anteriorly widening slightly, one on each side of median line.

Brachial valve interior with hinge plate divided by deep, wedge-shaped median notch, bounded laterally by deep, anteriorly narrowly expanding, minutely corrugated hinge sockets; crura diverging anteriorly, strongly curved ventrally, commonly twisted, dorsal edges carinate; median ridge or myophragm completely absent. Muscle area oval to nearly circular, relatively small, lying in umbonal area; posterior adductor scars nearly circular, lying laterally and far back, partly under forward edges of hinge sockets; anterior adductor scars larger, median, slightly farther forward.

MEASUREMENTS (in mm).—

	brachial valve length	length	width	thick- ness	apical angle (°)
USNM 701k					
148071a	2.3	2.0	2.0	1.0	
148071b	3.0	2.8	2.5	1.4	65
148071c	4.7	4.0	3.8	2.5	74
148071d	6.4	5.6	5.3	3.5	91
148071e	7.3	6.4	6.5	4.1	84
148071f	8.6	7.5	8.6	5.4	90
148071g	9.5	8.0	9.0	6.4	90
148071h (holotype)	11.2	9.7	10.6	7.5	100

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (beds 4–14).

LOCALITIES.—USNM 701c, 701d, 701h, 701k, 712w.

DIAGNOSIS.—Shape and costation variable.

TYPES.—Holotype: USNM 148071h. Figured paratypes: USNM 148071g,i–l; 154876a,c. Measured paratypes: USNM 148071a–g. Unfigured paratypes: USNM 148071a–f, 154876b.

COMPARISON.—This is the only species of this genus known.

DISCUSSION.—An extremely variable species, not only as to the shape of the valves but also the costation. The fold is variable and is occupied by

3–8 costae. The specimens with narrow fold having a low number of costae are usually elongate and narrow: the others are more widely triangular and the fold may contain as many as 8 narrow crowded costae or as few as 4. Obese forms in which the valves are greatly swollen and the shell very rotund are common. The anterior commissure is variable but is usually not strong. Generally the tongue of the pedicle valve is short and the fold low.

PONTISIIDAE, new family

Semicostate to completely costate Rhynchonellacea with plicate anterior commissure; pedicle valve with dental plates; deltidial plates variable. Brachial valve with undivided hinge plate, no median septum; crura falcifer to modified falcifer.

Genera in West Texas: *Pontisia* Cooper and Grant, 1969; and *Aphaurosia*, *Acolosia*, *Anteridocus*, *Antronaria*, *Lirellaria*, and *Divaricosta*, all new genera.

Genus *Pontisia* Cooper and Grant, 1969

Pontisia Cooper and Grant, 1969:13.—Stehli and Grant, 1970: 33.

Small to medium, triangular to subpentagonal; unequally biconvex, brachial valve deeper; anterior commissure strongly uniplicate; beak suberect; foramen elongate-oval; deltidial plates usually disjunct, or uncommonly conjunct. Surface costate, costae strong, usually not extending to beaks.

Pedicle valve interior with small teeth; dental plates strong but defining narrow umbonal chambers; muscle field anterior to delthyrial cavity; diductors and adjustors subflabellate; adductors central.

Brachial valve interior with undivided hinge plate; crura modified falcifer; socket ridges strong, inclined over smooth sockets; outer hinge plates fairly wide, separating narrow crural bases from socket ridge; inner hinge plate forming bridge, often convex, over notothyrial cavity. Median septum absent but myophragm or thick secondary swelling developed in some old specimens. Adductor field with small posterior adductors at end of median ridge, and larger pair anterior to latter and median ridge.

TYPE-SPECIES.—*Pontisia stehlii* Cooper and Grant (1969:13, pl. 4; figs. 7–10).

DIAGNOSIS.—Hinge plate similar to that of *Wellerella* but not supported by a median septum.

COMPARISON.—The exterior of members of this genus strongly resemble *Wellerella*, at least at the anterior part. Some species are likely to differ in having the costae extended farther back, nearly to the beaks, thus resembling *Allorhynchus*, which is usually completely costate; but other species strongly resemble *Wellerella* with their semicostate valves. The interior of the pedicle valves of *Wellerella* and *Pontisia* are almost the same, but the brachial valves have a fundamental difference. In *Wellerella* the inner hinge plate is supported by the median septum which is a high, blade-like plate of varying length. It extends to the hinge plate, whereas in *Pontisia* young adults have no trace of a median septum but usually have a low ridge. In old specimens the low ridge often swells to a boss posteriorly under the hinge plate. This simulates *Wellerella*, but the boss is never a septum although it may help to support the hinge plate.

Pontisia costata, new species

PLATE 529: FIGURES 8–26

Average size for genus, wider than long, widest slightly anterior to midvalve; subtrigonal in outline; posterolateral margins forming right angle or somewhat less; lateral margins narrowly rounded. Anterior margin truncated. Anterior commissure strongly uniplicate. Beak short, deltidial plates small, disjunct. Surface strongly costate but with naked umbonal region; costae thick, rounded on flanks, subangular on fold, 3 costae on fold, median costa often slightly shorter than others, 2 in sulcus, and 4 or 5 on flanks stronger and more prominent.

Pedicle valve very gently convex in lateral profile, nearly flat in anterior profile. Umbonal and median regions gently convex. Sulcus originating near midvalve, narrow and shallow, forming moderate tongue. Flanks flattened and moderately inclined.

Brachial valve very gently convex in lateral profile, broadly but gently convex in anterior profile but with steep sides. Umbonal and median regions flatly convex; fold originating near midvalve, some-

what flattened on top, slightly elevated above the flanks anteriorly; flanks swollen, steep.

Pedicle valve with small teeth and stout dental plates. Brachial valve with strong but short socket ridges; outer hinge plates narrow; crura falcifer, long, laterally compressed, hollow toward midvalve; inner hinge plates short, coalesced and with deep reentrant.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 705a					
152843a (holotype)	8.1	7.3	8.9	5.0	90
152843b	7.7	6.7	8.2	5.8	90
152843c	8.2	7.0	9.1	5.6	90
152843d	7.4	6.5	7.6	5.2	90
152843e	7.2	6.4	8.9	4.3	90
152843f	5.1	4.3	5.0	3.4	80

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base).

LOCALITIES.—USNM 705a, 720f, 724q.

DIAGNOSIS.—Medium size *Pontisia* with strongly costate flanks and subtrigonal outline.

TYPES.—Holotype: USNM 152843a. Figured paratypes: USNM 152843b; 154815a,b; 154816a-c,r. Measured paratypes: USNM 152843b-f. Unfigured paratypes: USNM 152843c-f, 154816d-q.

COMPARISON.—This species suggests *Pontisia longicosta* (Stehli) and *P. nanas* (Stehli) from the lower Bone Spring Formation. It differs from the former in having larger size, somewhat stronger costae, although the numbers are about the same, greater depth to the valves, more laterally flaring costae on the flanks, and a shorter beak.

Pontisia costata has about the same size and appearance as *P. nanas* (Stehli) but it differs in having costae which are more closely crowded, extend farther posteriorly, and are more numerous on the flanks. Moreover, the fold and sulcus of this species are narrower and less pronounced than those of *P. nanas*.

DISCUSSION.—This species was found only in the lower part of the Skinner Ranch Formation. The species is especially distinctive for the prominently ornamented flanks and the fact that the costae extend far posteriorly. In a few specimens bifurcation of costae appear to take place on the flanks. Specimens are commonly crushed at USNM

705a but several survived the geological processes and acidizing treatment.

Pontisia franklinensis, new species

PLATE 529: FIGURES 64-70

Small for genus, biconvex; profile subtrigonal; outline transversely subovate to subtrigonal, sides diverging between 90° and 120°; commissure uniplicate; fold low, beginning 3-4 mm anterior to brachial beak, profile moderately convex near anterior margin; sulcus shallow, beginning about 4 mm anterior to pedicle beak, maximum curvature between ends of flanks. Costae low, short, crests blunt, beginning about 3 mm anterior to beaks, numbering 3 on fold, 2 in sulcus, 2 or 3 on flanks. Concentric ornamentation or growth lines not observed.

Pedicle valve with smooth part of umbonal area gently convex, flanks not reflexed; beak short, blunt; beak ridges short, blunt; lateral pseudointerareas narrow or absent; slight overlap of valves. Delthyrium triangular, deltidial plates small. Brachial valve with smooth part of umbonal area nearly flat in profile, slightly flattened transversely; beak blunt, within pedicle valve.

Pedicle valve interior with sides of delthyrium widely diverging, teeth supported by vertical dental plates reaching floor of valve. Muscle area triangular, anteriorly expanding, slightly excavate, scars of separate muscles not observed, probably located as in other species of genus. Brachial valve interior with undivided triangular hinge plate, bounded laterally by elongate, deep, anteriorly widening, hinge sockets; crura diverging anteriorly from forward edge of hinge plate, strongly curving ventrally, twisted, dorsal edges carinate; median ridge low, rounded. Muscle area not observed: probably subdivided into posterior and anterior adductor scars as in other species of genus.

STRATIGRAPHIC OCCURRENCE.—Hueco Canyon Formation.

LOCALITIES.—USNM 712e, 712m, 720b, 725z.

DIAGNOSIS.—Small, trigonal, transverse *Pontisia* with few strong, rounded, short costae.

TYPES.—Holotype: USNM 152846a. Figured paratypes: USNM 152846b,c,f. Measured paratypes: USNM 152846b-e, 152847a-e. Unfigured paratypes: USNM 152846d,e; 152847a-e.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 712m					
152846a (holotype)	7.8	6.9	9.8	5.7	110
152846b	6.9	6.2	8.6	5.6	110
152846c	6.5	5.9	7.7	5.0	110
152846d	5.9	5.4	6.7	4.0	100
152846e	5.3	4.7	5.7	3.7	90
USNM 720b					
152847a	7.7	6.5	9.8	6.8	110
152847b	7.3	6.2	8.2	6.0	100
152847c	7.0	6.0	7.8	5.6	100
152847d	6.3	5.3	6.5	5.1	100
152847e	4.7	4.3	4.9	1.8	90

COMPARISONS.—*Pontisia franklinensis* is characterized by its small size, transverse outline, low, blunt costae, nearly equiangular trigonal profile with flattened smooth part of brachial umbonal area, fold that is high at the margin relative to the pedicle valve, but low relative to the brachial flanks, and its low median ridge. Externally it most nearly resembles *Tautosia podistra*, new species, from the Wolfcampian of the Glass Mountains, differing in its weaker, relatively shorter costae, more strongly bulging profile of the brachial valve, lower fold and shallower sulcus, and especially in its low median ridge in the brachial interior. It differs from *P. kingi*, new species, also from the Wolfcampian of the Glass Mountains, and from *P. stehlii* Cooper and Grant, from the Leonardian, in its smaller size, weaker costae, more transverse outline, more equiangularly trigonal profile, blunter beak, flatter brachial umbonal area and consequently more highly elevated anterior end of the fold.

Pontisia franklinensis also resembles *Wellerella nitidula*, new species, but that species generally is somewhat larger in its mature forms, is rounded, has more strongly costate flanks, and is not so flatly truncated anteriorly.

DISCUSSION.—This species occurs in countless numbers in the lower part of the Hueco Canyon Formation north of Hueco Inn. It does not appear to be the same species referred incorrectly by R. E. King to "*Pugnoides texanus* (Shumard). Although the species occurs by the thousand at this place it is difficult to obtain good interior details. The vast majority of the specimens occur with both valves

in contact. The Hueco Group contains other species of rhynchonellids, some undoubtedly related to *Pontisia* but others of unknown generic affinities.

Pontisia kingi, new species

PLATE 520: FIGURES 31–34; PLATE 530: FIGURES 16–32

Average size for genus, profile subtrigonal; outline bluntly triangular to suboval, sides diverging between 80° and 120°; commissure uniplicate, fold low to moderately high, beginning 4–8 mm anterior to brachial beak, longitudinal convexity low, anterior termination abrupt; sulcus moderately deep to deep, beginning 5–8 mm anterior to pedicle beak, longitudinal convexity greatest between anterior ends of costae on flanks. Costae moderately high, broad crests normally blunt, beginning 3–5 mm anterior to beaks, strongest on fold and pedicle flanks, moderately strong in sulcus, weak on brachial valve flanks, numbering 2–5, normally 3 on fold, one less in sulcus, 2–4, normally 3 on flanks. Concentric ornamentation faint, closely spaced striae; growth laminae weak, widely spaced.

Pedicle valve moderately inflated on smooth area near beak, strongly convex through sulcus, slightly convex toward flanks; inner costae of flanks longitudinally slightly convex to strongly hooked dorsally; beak ridges prominent, blunt, short; lateral pseudointerareas very narrow or absent, little or no overlap of valves. Delthyrium triangular, base covered in adults by small, nearly flat deltidial plates; apical part open, forming elongate oval foramen. Brachial valve slightly convex along fold, strongly convex toward flanks and transversely; smooth part of umbonal area normally evenly arched transversely, may be somewhat flattened; apex of valve within pedicle valve, covered by deltidial plates.

Pedicle valve interior with sides of delthyrium widely expanding, teeth elongate, parallel to sides, supported by vertical dental plates reaching floor of valve. Muscle area elongate, relatively narrow, beginning just anterior to edges of dental plates, slightly expanding anteriorly; adductor scars in posterior part of muscle area astride median line, forming small oval mark; diductor scars elongate, anteriorly expanding, surrounding adductor scars laterally and anteriorly.

Brachial valve interior with undivided triangu-

lar hinge plate, laterally bounded by narrow, only slightly expanding, finely corrugated sockets; crura diverging forward from anterior edge of hinge plate, strongly curved ventrally, often twisted, dorsal edges carinate; median ridge broad, low, rising near beak and forming short septum supporting hinge plate, extending forward into muscle area bisecting it. Muscle area elongate; posterior adductor scars narrow, diverging anteriorly from median ridge, flanking anterior adductors, fused with them; anterior adductors narrowly expanding anteriorly, one on each side of median ridge.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 701a ³					
154837a	1.5	1.2	1.3	0.5	?
154837b	1.9	1.6	1.6	0.7	92
154837c	3.2	2.8	2.5	1.8	90
154837d	4.5	4.0	3.9	2.4	87
154837e	4.8	4.2	3.9	2.6	70
	5.0	4.6	4.1	3.4	85
USNM 701d					
148593a	6.0	5.2	5.6	3.6	80
148593b	7.7	6.4	8.3	6.0	90
148593c	9.5	7.9	10.0	6.9	100
148593d	10.0	8.4	12.5	10.0	112
USNM 701-l					
148598	12.3	10.5	14.4	9.0	112
USNM 721g					
152848a	10.6	9.2	11.8	7.8	95
152848b	11.1	9.6	12.6	8.0	105
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Neal Ranch Formation (beds 2–4, 9–14); Lenox Hills Formation.

LOCALITIES.—*Uddenites*: USNM 701e, 701q, 701v. Neal Ranch, bed 2: USNM 701; bed 4: USNM 701-l, 727e; beds 9–14: USNM 701a³, 701c, 701d, 701g, 701k, 721g. Lenox Hills: USNM 705m, 705s.

DIAGNOSIS.—*Pontisia* of medium size having narrow flanks, and flattened brachial profile.

TYPES.—Holotype: USNM 152848b. Figured paratypes: USNM 148593d; 148597; 148598; 152848a; 154762a,b; 154763a; 154836a,b,d. Measured paratypes: USNM 148593a–d, 148598, 152848a, 154837a–e. Unfigured paratypes: USNM 148593a–c, 154763b–d, 154836c.

COMPARISON.—*Pontisia kingi* is characterized by its relatively narrow flanks, longitudinally only

slightly convex fold, transversely evenly arched, or slightly flattened brachial beak area, hooked pedicle beak, normally 3 costae on the fold, with the middle one commonly slightly depressed, its low median ridge, and relatively narrow muscle areas. The deltidial plates begin to grow rather late in life, so are absent on juveniles and small on adults, also there is little overlap of the valves lateral to the beaks, so the lateral pseudointerareas are reduced or absent.

This species is similar to *Antronaria speciosa* and *Wellerella girtyi*, both new species, and to *P. stehlii* Cooper and Grant. It differs from *A. speciosa* in its narrower flanks (the widest specimen of *P. kingi* is about the same width as a narrow specimen of *Antronaria speciosa*), less consistently and less strongly depressed middle costa on the fold, consequently less deeply indented anterior margin, hooked pedicle beak, low median ridge in the brachial interior, and costae that begin farther forward. It is distinguished from *W. girtyi* by its flat fold profile, hooked beak and especially by its low median ridge instead of a high, thin septum. Its primary differences from *P. stehlii* are its proportionately broader outline, broader and blunter costae, commonly depressed middle costa on the fold, flattened profile of the fold, more strongly hooked beak, and smaller average and maximum size.

Three stratigraphically remote species that resemble *P. kingi* externally are *Wellerella osagensis* (Swallow) from the Pennsylvanian of the Midcontinent, *Tautosia elegans* (Girty), and *T. transenna*, new species, from the Guadalupian of the Glass and Guadalupe Mountains. From *W. osagensis*, *P. kingi* differs in its somewhat broader outline, commonly depressed middle costa of the fold, more flattened profile of the fold, costae that start farther forward of the beaks, more strongly curved pedicle beak, and its low median ridge rather than a high median septum. From *T. elegans* and *T. transenna* it differs in its smaller deltidial plates, less strongly inflated pedicle umbonal area, more strongly hooked pedicle beak, and especially by its low median ridge.

DISCUSSION.—This is a very thin and delicate species that is difficult to recover from the residues, as it often falls apart when completely decalcified. Nevertheless it is distinctive and attractive, although somewhat variable in its present makeup.

It is an uncommon species, and the large quantity of blocks dissolved from USNH 701d and 721g is the only reason the collection of it is adequate.

Variation is seen in the form of the fold and sulcus, some specimens having these narrowly pinched whereas a few have them more spread out. Narrow forms also occur as well as some with 2, 4, or 5 costae on the fold. Such variations appear to be normal in most of the rhynchonellid species.

The species is named in honor of R. E. King in recognition of his important work on the brachiopods of the Glass Mountains.

Pontisia longicosta (Stehli)

PLATE 530: FIGURES 33-45

Wellerella longicosta Stehli, 1954:336, pl. 25: figs. 23-27.

This small and distinctive species is referred to *Pontisia* because it has no median septum, the medial part of the valve being marked by a broad, low ridge. The species is one of the most easily recognized of the genus because the costae extend almost to the beak, which is unusual for members of this genus. Furthermore, it has a distinctive sharply triangular outline, and a peculiar sulcus on the pedicle valve. This sulcus is narrow and is occupied by two large costae which crowd the narrow space. The sulcus is also extended into a narrow tongue that is sharply geniculated at right angles to the commissure.

Stehli failed to fix a type for the species. We select, therefore, AMNH 27319/1:1, which is a complete specimen illustrated by figure 23 of his plate 25.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITIES.—USNM 728f, 728h.

DIAGNOSIS.—Neatly and sharply triangular *Pontisia* with the narrowly angular costae reaching almost to the beaks.

TYPES.—Lectotype: AMNH 27319/1:1. Figured hypotypes: USNM 154835a-f.

COMPARISON.—No other small species of the genus has the costae occupying nearly all of the valves. It cannot therefore be confused with *P. magnicostata*, new species, and *P. stehlii* Cooper and Grant, both also nearly complete costate.

Pontisia magnicostata, new species

PLATE 531: FIGURES 1-8

Large for genus, wider than long, outline roundly elliptical. Maximum width at midvalve; sides strongly rounded; anterior margin broadly rounded. Anterior commissure uniplicate. Beak short, bluntly pointed; deltidial plates short, conjunct. Surface except for umbones strongly marked by wide, elevated subangular costae, 3 on fold and 4 on each flank.

Pedicle valve very gently convex in lateral and anterior profiles; umbonal and median regions gently inflated; sulcus originating at midvalve, shallow, forming moderately geniculated tongue; sulcus crowded by 2 large costae; flanks gently convex to concave, slightly deflected.

Brachial valve moderately deep and gently convex in lateral profile; broadly domed and with top flattened in anterior profile; umbonal region slightly convex; median region flattened; fold originating near midvalve, fairly strongly elevated anteriorly, gently convex longitudinally; median costa not depressed. Flanks moderately inflated, steep sides, and moderately depressed below fold.

Pedicle valve interior not known. Brachial valve interior with undivided hinge plate, having strong socket ridges bounding minutely corrugated sockets; outer hinge plates narrow; crura concave medially, broad; inner hinge plates wide, slightly folded medially. No median septum. Median ridge low, forming inconspicuous myophragm. Adductor field just posterior to midvalve small, posterior adductors narrow and together forming crescent; anterior scars larger and more rounded.

MEASUREMENTS (in mm).—Specimens USNM 152850a (holotype) and b (paratype), respectively: length 15.3 (beak estimated), 12.8; brachial valve length 14.0, 11.4; width 17.9, 14.5; thickness 11.5, 7.3; apical angle 110°, 110°.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (bed 12 of P. B. King).

LOCALITY.—USNM 722w.

DIAGNOSIS.—Large, rounded, elliptical *Pontisia* with strong, thick costae.

TYPES.—Holotype: USNM 152850a. Figured paratypes: USNM 152850c. Measured and unfigured paratype: USNM 152850b.

COMPARISON.—This species in its coarse ornament and almost complete costation is similar to

Pontisia stehlii Cooper and Grant. It differs in its greater size and the magnitude of its costation, which is the coarsest of any of the Glass Mountains rhynchonellids.

DISCUSSION.—This species is known from only three specimens, but it is so large and distinctive, and the interior so clearly displayed in the brachial valve, that we did not hesitate to name it. Another unusual feature is its large size and the fact that it comes from the Neal Ranch Formation. Hitherto only small rhynchonellids have been taken from this stratigraphic unit.

Pontisia nanas (Stehli)

PLATE 515: FIGURES 43,44; PLATE 531: FIGURES 39–58

Wellerella nanas Stehli, 1954:336, pl. 25: figs. 18–22.

Small for genus, elongate triangular in outline with narrowly pointed apex, rounded sides, and somewhat narrowed anterior. Anterior commissure uniplicate. Beak short, suberect, and with conjunct deltidial plates. Surface semicostate, costae subangular, 3 on fold (median one depressed), 2 on sulcus, and 2 or 3 on each flank.

Pedicle valve gently convex in anterior and lateral profile; beak and umbonal region smooth and gently convex; sulcus originating near midvalve, short and deep, forming moderately long and strongly geniculated tongue. Costae in sulcus occupying complete width and extending onto umbo just beyond midvalve. Flanks narrow, slightly convex, and with strong angular posterolateral extremities.

Brachial valve flatly convex in lateral profile but narrowly domed in anterior profile, median region flattened, sides subparallel and nearly perpendicular. Fold originating at midvalve, flattened; flanks rounded and moderately depressed below the fold at anterior.

Pedicle valve interior with dental plates; brachial valve interior without median septum or ridge; hinge plate deeply notched medially, inner hinge plates narrowly arched. Outer hinge plates broad; sockets not corrugated.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation; Skinner Ranch Formation (base and Sullivan Peak Member); Hess Formation (Taylor Ranch Member).

LOCALITIES.—Bone Spring: AMNH 625, 631, 634;

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 728e					
152853a	6.4	5.5	6.4	4.5	90
152853b	5.7	4.9	5.6	4.0	90
152853c	5.4	4.6	5.3	3.2	90

USNM 725c, 728e, 728f, 728h, 745. Skinner Ranch (base): USNM 720e. Sullivan Peak: USNM 707d, 722-l. Taylor Ranch: USNM 702d.

DIAGNOSIS.—Very small, triangular *Pontisia* with depressed median costa in fold.

TYPES.—Lectotype: AMNH 27318/1. Figured paratypes: AMNH 27318/1:2. Figured hypotypes: USNM 154728a,b; 154842a,c-j. Measured hypotypes: USNM 152853a-c.

COMPARISON.—This species suggests *Pontisia franklinensis*, new species, and is also externally like *Wellerella nitidula*, new species. It is smaller than either of these species and is readily distinguished by the narrowing of the anterior, by the more depressed median costa, and less developed costae on the flanks. It is readily distinguished from *P. longicosta* (Stehli) by its smooth posterior half.

DISCUSSION.—This is a rare species in the Sierra Diablo but specimens have appeared in the Glass Mountains in the *Scacchinella* beds at the base of the Skinner Ranch Formation. The hinge plate is variable and is usually fairly wide. The median part is deeply notched and the inner hinge plates unite in a small fold or in a flat area or a shallow depression. The median ridge appears not to be variable to any marked degree.

Pontisia parva, new species

PLATE 520: FIGURES 23–30

Small for genus, subtrigonal in outline; length and width nearly equal; sides rounded, anterior margin truncated; posterolateral margins nearly straight, forming angle of 85°–95°. Anterior commissure uniplicate. Deltidial plates conjunct; foramen mesothyridid, oval. Front flattened from rapid growth along anterior edges of both valves. Surface semicostate, posterior half smooth but anterior half costate, 3 costae on fold and 2 or 3 on each flank.

Pedicle valve nearly flat in lateral profile, posterior region slightly convex; anterior profile slightly

concave; sulcus narrow, short, originating anterior to midvalve; umbonal and median regions slightly inflated; flanks slightly concave, poorly demarcated and with scarcely any slope to posterolateral margins.

Brachial valve deeper, gently convex in lateral profile but strongly domed in anterior profile, with gently rounded top but nearly straight sides. Fold short and narrow, slightly elevated above strongly rounded flanks.

Pedicle valve interior with short but strong plates. Brachial valve interior with fairly wide outer hinge plates and small socket ridges; inner hinge plates united, forming undivided hinge plate with anterior edge turned slightly ventrad. Crural bases slender; crura laterally compressed, falcifer.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 727e					
154928a	8.1	6.9	7.8	6.4	91
154928b	7.6	6.5	8.2	7.0	93
(holotype)					
154928c	7.5	6.7	8.8	7.3	92

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (bed 4).

LOCALITY.—USNM 727e.

DIAGNOSIS.—Small, subtriangular *Pontisia* with truncated front and narrow fold and sulcus.

TYPES.—Holotype: USNM 154928b. Figured paratypes: USNM 154928a,c–e. Measured paratypes: USNM 154928a,c.

COMPARISON.—This species differs from *Pontisia costata*, new species, in its semicostation, although the two species are nearly the same size. It is a smaller species than *P. kingi*, new species, and has a narrower fold and sulcus and much flattened anterior. From *P. franklinensis*, new species, it differs in its more triangular shape, narrower fold and sulcus, and broad flat front. It suggests *P. nanas* (Stehli) but differs in its narrow fold and sulcus, triangular shape, and the flattened front.

Pontisia robusta, new species

PLATE 508: FIGURES 1–5

Large for genus, subpentagonal in outline, wider than long, sides narrowly rounded; anterior margin

broadly rounded; posterolateral margins forming angle of 104°. Beak erect. Deltidial plates conjunct, foramen oval, mesothyridid. Surface costate except in umbonal region of both valves, costae thick and subangular with narrower interspaces, 4 on fold, and 4 on each flank.

Pedicle valve with lateral profile gently convex in posterior half, fairly strongly geniculated toward brachial valve in anterior half; anterior profile broadly and gently concave. Sulcus originating at midvalve, broad and shallow, containing 3 costae. Flanks narrow, not strongly deflected anterolaterally but with steep slopes.

Brachial valve deeper than pedicle valve, gently convex in lateral profile with maximum curvature at umbo; anterior profile narrowly domed with top of dome flattened and serrated by costae of fold, sides very steep. Umbonal region and flanks swollen; fold originating near midvalve, low, not rising strongly above steep flanks.

Interior without median septum.

MEASUREMENTS (in mm).—Holotype USNM 154664a: length 13.5, brachial valve length 11.7, width 15.7, thickness 11.7, apical angle 104°.

STRATIGRAPHIC OCCURRENCE.—Cibolo Formation (Breccia Zone of Udden).

LOCALITY.—USNM 728-I.

DIAGNOSIS.—Large *Pontisia* with thick, crowded costae.

TYPES.—Holotype: USNM 154664a. Unfigured paratypes: USNM 154664b–d.

COMPARISON AND DISCUSSION.—This species is like *Pontisia kingi* and *P. magnicostata*, both new, and *P. stehlii*, Cooper and Grant. From the first it differs in being larger, having stronger and more crowded costae, and stronger costae on the flanks. From the second it differs in having more crowded costae, those of *P. magnicostata* having much wider interspaces. *P. stehlii* is variable, especially in the costation of the fold, but the costae are not so thick and crowded as those of *P. robusta*, and those on the flanks are much less crowded; furthermore, the anterolateral extremities are more prominent.

That *P. robusta* is variable is shown by paratype 154664b, a young individual that has only three costae on the fold and two in the sulcus. Nevertheless, the costae are crowded in the sulcus and indicate close resemblance to the type when fully grown. Three other paratypes, all poorly preserved, give glimpses of the interior. In the two in which it

might be preserved no septum was seen, nor can any trace of a septum be seen on the type when the shell is moistened.

Pontisia stehlii Cooper and Grant

Pontisia stehlii Cooper and Grant, 1969:13, pl. 4: figs. 7-10.

COMPARISON.—*Pontisia stehlii* is characterized by its moderate size, bulbous shape, convex profile of the fold, relatively narrow flanks with costae that are not reflexed, costae that begin far back on the beak, and its low median ridge in the brachial valve. A similar appearing species in the Hess Formation is *Antronaria speciosa*, new species, from which *P. stehlii* differs in its nondepressed median costa of the fold, much more strongly convex profile of the fold, so that the ends of the costae slope ventrally rather than terminate abruptly, its narrower flanks with nonreflexed costal crests, and its costae that begin farther back on the beak. In the Capitan Formation, *Tautosia elegans* (Girty) is externally similar but it differs in most of the same features that distinguish *A. speciosa*.

A species that resembles *P. stehlii* externally is *Wellerella girtyi* from the Word Formation in the Glass Mountains and the Cherry Canyon Formation of the Guadalupe Mountains: the external form is so similar that King (1930) considered them to be the same, yet they are really generically different. *Pontisia stehlii* is larger, has somewhat wider flanks that bear more costae, its costae begin farther back on the beaks, and its dorsal umbonal area is flattened or indented instead of being evenly arched transversely.

DISCUSSION.—Many specimens exhibit the interior of the species and make excellent material on which to base the genus. The deltidial plates of the pedicle valve are conjunct, narrow, elevated toward the anterior, and have elevated rims part way around the foramen. The teeth are small, knoblike, and jut out from under the shell rim, and thus are grooved on the outside. Underneath, the deltidial plates are buttressed by an arching deposit which thickens them and is attached to the dental plates. The dental plates are nearly vertical and nearly parallel. The muscle field is large, located anterior to the delthyrial cavity, and with large rounded diductor scars enclosing the adductors.

The sockets of the brachial valve are strongly

but minutely corrugated, and are bounded by strong ridges that bear slightly concave broad outer hinge plates. These attach the crura, which are strongly keeled below and are strengthened by an extension of the outer hinge plate along its side. The crura are long, crescentic in section and concave toward midvalve. The inner hinge plates are variable but wide, in some specimens coalescing to form a concave plate or flat or uniting in a slight anticline. No trace of a median septum can be seen under the hinge plate, and the median ridge, when present, is low and inconspicuous.

This is the most abundant species of *Pontisia* in the Glass Mountains and a fair sample of it has been obtained from several localities. As here described, it has a somewhat longer stratigraphic range than most of the other species, since it occurs in the *Institella* Zone at the base of the Cathedral Mountain Formation and extends into the Road Canyon Formation. Its greatest abundance is at the base of the Road Canyon. A species with as wide a vertical and geographic range is certain to have considerable variation. This is true of *P. stehlii*, which exhibits variation in both vertical and horizontal dimensions.

The type locality for the species is USNM 702c, where specimens are mostly trigonal, rather thick anterior to midvalve, and with a fairly long beak. The species is usually elongate until it reaches about 10 mm length, at which point the width becomes greater and the species wider than long. The costae are usually crowded and thick. These features characterize many of the specimens from the *Institella* Zone in the Split Tank region, and while no real problem in identifying them as *P. stehlii* is encountered, several aberrations create difficulties. Some specimens are rounder than usual and the costae invade the umbonal region. Furthermore, the spaces between the costae are deeper and wider than in the type group and in some specimens the costae are enormously thickened and the shell is a gross example of the rounded forms. Intermediates are readily found, however, making it clear that these are all related. In fact, odd specimens from the type locality exhibit the same gigantism in the ribbing.

Interesting horizontal variations also occur. At USNM 702c over 87 percent of 56 specimens counted have only 3 costae on the fold; these are crowded and the fold is high; 7 percent of the specimens

have 4 costae on the fold and 6 percent have 5 costae. At USNM 721s, of 50 specimens counted, 2 percent have 7 costae on the fold, 22 percent have 5 costae, 34 percent have 4 costae, and 42 percent have only 3 costae on the fold. This is considerably different from those of USNM 702c. The collection from USNM 721o is still different. Of 88 specimens counted, 59 percent have only 3 costae on the fold, but 28 percent have 4 costae, and only 13 percent have 5 costae on the fold. From USNM 719x, 39 specimens showed 69 percent with 3 costae, eighteen percent with 4, and thirteen percent with 5 costae on the fold. Inasmuch as each of these lots come from separate local bioherms, it suggests that the variation is due to local conditions. In each case a good solid core of specimens were most like the types in having 3 costae on the fold.

Along with these variations are distorted obese or deformed specimens that may appear in any considerable lot of rhynchonellids. We have named as *P. stehlii tumidosa* a few specimens that are rounded, tumid, globular in outline, and in which the costae extend far onto the umbo. These suggest some of those from the *Institella* Zone but they are generally more tumid and the characters more persistent. They come, however, from the Road Canyon Formation rather than the earlier beds although they are suggestive of the older forms.

Pontisia stehlii stehlii Cooper and Grant

PLATE 517: FIGURES 21–25, 38–47; PLATE 533: FIGURES 39–60;
PLATE 534: FIGURES 1–49; PLATE 552: FIGURE 14

Pugnoides texanus R. E. King [not Shumard], 1931:108, pl. 34: figs. 5–9.

Pugnoides elegans [part] R. E. King [not Girty], 1931:106, pl. 33: figs. 12, 13; pl. 34: figs. 4 [not figs. 2, 3 (= *Antronaria speciosa* Cooper and Grant, new species)].

Average size for genus, biconvex, normally somewhat bulbous, brachial valve much deeper than pedicle valve; outline transversely triangular to nearly oval, sides diverging between 80° and 110°; profile subtrigonal; anterior commissure uniplicate; fold low to moderately high, beginning 5–7 mm anterior to brachial beak, profile flattened near beak, abruptly convex near anterior margin; sulcus shallow to moderately deep, beginning 8–10 mm anterior to pedicle beak, convexity strongest between highest points of flanks. Costae strong, broad

and crowded, sharp or blunt, beginning 4–5 mm anterior to beaks, numbering 2–6 on fold, normally 3, one less in sulcus, 2–6 on each flank, normally 4, those on flanks lower and less sharp than on fold. Concentric ornamentation absent; growth lines few and faint.

Pedicle valve somewhat inflated forward of beak, strongly convex through sulcus, slightly convex toward flanks; inner costae of flanks prominent but not reflexed; beak sharp, dorsally curved, normally somewhat attenuate; beak ridges blunt to sharp; lateral pseudointerareas narrow, partly covered by overlapping brachial valve. Delthyrium triangular, base covered by trapezoidal plates, curved to form low arch; foramen elongate oval. Brachial valve moderately to strongly convex transversely and longitudinally; smooth part of umbo flattened or slightly indented; apex of valve within pedicle valve, covered by deltidial plates.

Pedicle valve interior with sides of delthyrium widely diverging anterior to deltidial plates; teeth elongate, supported by vertical dental plates reaching floor or valve. Muscle field bluntly triangular to transversely oval, lying anterior to ends of dental plates; adductor scar median, small, nearly circular to longitudinally oval; diductor scars wide, tear-shaped, surrounding adductor scar laterally and anteriorly.

Brachial valve interior with undivided but deeply notched, triangular hinge plate, bounded laterally by deep, anteriorly expanding, strongly corrugated sockets; falcifer crura projecting forward and anteriorly diverging, strongly curved ventrally, may twist as much as 90°, dorsal edges carinate; median septum reduced to small median keel on underside of hinge plate and low median ridge along floor of valve. Muscle area partly divided by median ridge; posterior adductor scars elongate, anteriorly diverging, flanking large, oval anterior adductor scars.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain, Road Canyon, and Word (Willis Ranch Member) formations.

LOCALITIES.—Cathedral Mountain: AMNH 500G; USNM 702, 702a, 708, 721u, 726o, 726u, 726y, 735b. Road Canyon: USNM 702c, 703a, 703c, 703d, 709u, 716x, 719x, 720d, 721j, 721o, 721s, 721t, 726f. Willis Ranch: USNM 723w.

DIAGNOSIS.—*Pontisia* with deep brachial valve and closely crowded broad costae but smooth beaks and umbones.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 702c					
148710a	0.7	0.5	0.7	0.3	—
148710b	1.5	1.3	1.4	0.7	—
148710c	2.8	2.3	2.2	1.0	—
148710d	4.2	3.5	3.5	1.9	—
148710e	5.5	4.6	5.0	2.0	c.100
148710f	7.0	6.0	6.7	2.7	c.100
148710g	9.0	7.6	8.8	4.0	85
148710h	9.4	7.7	9.3	6.0	101
148710i	11.5	9.7	11.6	7.3	102
148710j	12.4	10.9	14.7	6.2	108
148710k	12.4	10.6	13.5	10.9	102
148710-l	14.4	12.2	15.8	11.8	108
148710m	15.5	13.4	18.5	13.0	100
153835a (holotype)	13.7	11.6	14.3	12.3	98

TYPES.—Holotype: USNM 153835a. Figured hypotypes: USNM 148710h,i; 153835b-i,m-p,r; 154743a,b; 154745a-j; 154848a-c,e; 154849; 154850a; 154851a,b; 154852a-c. Measured hypotypes: USNM 148710a-m.

COMPARISON.—*Pontisia stehlii stehlii* may have descended from the related *P. s. tumidosa*, new subspecies, which differs from *P. s. stehlii* in having a more convex pedicle valve, lower fold and shallower sulcus, and the costae extending farther onto the umbo, in some specimens suggesting almost complete costation but usually the beaks are smooth. *Pontisia s. stehlii* usually has a longer beak on the pedicle valve than *P. s. tumidosa* and it is usually more flattened anteriorly. *Pontisia s. tumidosa* is generally more rounded in outline than *P. s. stehlii*, which generally is more trigonal.

Pontisia stehlii tumidosa, new subspecies

PLATE 510: FIGURES 56-62; PLATE 535: FIGURES 52-66

Medium size for genus, subcircular to subtrigonal in outline, brachial valve deeper than pedicle valve; posterolateral extremities approaching 110°. Sides rounded, greatest width near midvalve; anterior margin moderately rounded to subtruncate. Anterior commissure uniplicate. Beak short, sharply angular, with elongate oval foramen and elevated, conjunct but short deltidial plates. Surface variably costate, usually with 3 broadly rounded, crowded costae on fold, rarely 4 or 5 and 3 or 4 on each

flank. Interspaces much more narrow than costae.

Pedicle valve moderately convex in lateral profile, broadly and gently convex in anterior profile; umbonal region narrowly convex; median region gently convex; sulcus originating near midvalve, broad, shallow and poorly defined, crowded with costae. Tongue moderately long, strongly geniculated and convex transversely. Flanks narrow, rounded, slightly inflated and with poorly developed anterolateral extremities.

Brachial valve fairly strongly convex in lateral profile but evenly and strongly domed in anterior profile with nearly vertical sides. Umbonal region gently convex; fold originating near midvalve, moderately wide, only slightly elevated above flanks from origin to anterior margin. Flanks rounded and steep.

Interior same as that of typical subspecies.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 702c					
148623a	8.0	7.0	7.8	5.9	90
148623b	8.5	7.1	8.5	8.4	90
148623c	8.7	7.2	9.2	6.6	100
148623d	9.4	7.5	9.5	8.2	90
148623e	9.5	7.8	9.3	8.5	90
148623f	9.8	8.0	9.8	7.5	90
148623g	10.3	8.7	10.4	8.7	100
148623h (holotype)	11.4	9.5	11.5	7.9	100

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain and Road Canyon formations.

LOCALITIES.—Cathedral Mountain: AMNH 500; USNM 702, 702a, 702b, 702inst, 702-low, 702un, 703a¹, 703b, 703bs, 708, 726u. Road Canyon: USNM 702c, 703a, 703c, 719x, 721o, 724c.

DIAGNOSIS.—Rotund and bulbous *Pontisia stehlii* with costae extended to but not onto the beaks.

TYPES.—Holotype: USNM 148623h. Figured paratypes: USNM 148623b,c,g; 154682a,b; 154686a-c. Measured paratypes: USNM 148623a-g. Unfigured paratypes: USNM 148623a,d-f.

Pontisia truncata, new species

PLATE 516: FIGURES 1-5

Medium size for genus, subpentagonal in outline, wider than long, with narrowly rounded sides

but broadly truncated front margin; apical angle 94° . Beak erect. Anterior commissure uniplicate and serrate; deltidial plates conjunct; foramen oval, submesothyridid. Surface costate except for umbonal regions, costae elevated and narrowly rounded with narrow interspaces, 3 on fold, and 3 on each flank.

Pedicle valve less deep than brachial valve; gently convex in lateral profile but broadly and gently concave in anterior profile; sulcus originating at about midvalve, wide and shallow, forming short serrated tongue; flanks concave but elevated above sulcus and sharply angular.

Brachial valve moderately convex in lateral profile, maximum convexity in anterior part; anterior profile broad, rounded dome somewhat flattened on top. Fold low, and flat topped, defined only at front and originating near midvalve. Flanks swollen and rounded but depressed slightly below fold.

Pedicle valve interior with small teeth but thick dental plates; muscle field cordate, large, lying anterior to delthyrial cavity. Brachial valve interior with moderately wide outer hinge plates forming ridges overhanging sockets; inner hinge plates united, with slightly elevated suture line and moderately deep anterior notch. Crura not preserved.

MEASUREMENTS (in mm).—Holotype USNM 154734: length 13.0, brachial valve length 12.1, width 15.8, thickness 11.5, apical angle 94° .

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 732j.

DIAGNOSIS.—Widely pentagonal *Pontisia* with low fold and only 2 costae in the sulcus.

TYPES.—Holotype: USNM 154734.

COMPARISON AND DISCUSSION.—This species is similar to several of the medium-sized *Antronaria* such as *Antronaria dissona*, *A. specialis*, new species, and *A. mesicostalis* (Girty). It differs from all of these in not having a median costa or costae depressed below the level of the fold. *Pontisia stehlii* Cooper and Grant is marked like *P. truncata* in some of its forms but differs in having a higher fold and greater thickness. Other specimens of *P. stehlii* are like *P. truncata* but are thicker, less wide, with thicker costae, and less prominently angular flanks.

The brachial valve of *P. truncata* has no median septum and is typical of the genus in all respects. Unfortunately, silica deposition in the adductor

field made it impossible to differentiate the pattern of muscles.

Pontisia ventricola, new species

PLATE 520: FIGURES 50–55; PLATE 536: FIGURES 28–51

Pugnoides texanus R. E. King [not Shumard], 1931:108, pl. 34: figs. 5a–d; 6a–d; 8a, b [not 7a–c]; 9.

Medium size for genus, length and width about equal; outline subpentagonal with broadly rounded sides and gently rounded anterior margin. Valves unequal in depth, brachial valve slightly deeper. Sides diverging at obtuse angle in adults. Anterior commissure strongly uniplicate. Beak small, nearly straight; deltidial plates conjunct, defining small, oval, submesothyridid foramen. Surface paucicostate, posterior one-half to one-third smooth, anterior one-half to two-thirds marked by strong, broad, rounded to subangular costae, 2–4 occupying fold, usually 3, and one less in sulcus; each flank with 2 or 3 costae, third costa usually not strong.

Pedicle valve fairly evenly and moderately convex in lateral profile, broadly and slightly convex in anterior profile, costae of the sulcus somewhat protuberant. Umbonal region narrowly convex; median region usually conspicuously swollen where costae of sulcus originate. Sulcus starting anterior to midvalve and anterior to origin of costae. Sulcus short, with long transversely convex tongue only slightly depressed below anterolateral extremities. Flanks very narrow, flattened, sloping slightly.

Brachial valve fairly evenly and moderately convex in lateral profile; anterior profile broadly and moderately domed with short but with precipitous sides. Umbonal region moderately convex but median region fairly strongly swollen. Fold slightly spreading, originating anterior to midvalve, occupying slightly more than half width; fold transversely flattened anteriorly, slightly elevated above flanks at anterior. Flanks steeply sloping, swollen.

Pedicle valve interior with short dental plates; muscles not impressed. Brachial valve interior with undivided hinge plate having median region depressed or elevated; socket ridges slender; falcifer crura moderately long, strongly curved, crescentic in section with concave side facing medially. No trace of median septum.

STRATIGRAPHIC OCCURRENCE.—Hess Formation (top).

MEASUREMENTS (in mm).—					
	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 726n					
152860a	4.6	4.1	4.2	1.7	76
152860b	5.6	4.7	5.6	2.4	80
152860c	6.4	5.4	5.5	2.5	70
152860d	7.3	6.3	6.9	3.0	72
152860e	8.0	6.9	8.2	5.1	84
152860f	8.8	7.8	8.6	5.6	90
152860g	9.0	8.1	9.3	6.2	93
152860h	9.2	8.3	9.2	6.3	93
152860i	10.0	8.6	10.5	6.2	97
152860j	9.7	8.7	9.5	6.8	96
152860k	10.5	9.3	10.4	6.8	96
152860l	9.4	8.2	9.4	6.8	85
152860m (holotype)	11.2	9.7	11.6	7.8	103
152860n	10.6	9.4	10.5	7.8	94
152860o	11.7	10.5	11.3	6.4	98
152860p	10.7	9.4	10.8	7.5	108
152860q	11.0	9.8	10.9	7.1	99
152860r	11.3	10.3	11.5	7.2	97
152860s	12.4	11.3	13.1	7.7	107
King 223					
YPM 12530	11.4	10.3	12.3	7.8	107

STRATIGRAPHIC OCCURRENCE.—Hess Formation (top).

LOCALITIES.—King 223; USNM 726n.

DIAGNOSIS.—Seminude, coarsely costate *Pontisia* with medially inflated valves.

TYPES.—Holotype: USNM 152860m. Figured paratypes: USNM 152860b,d,h,j,k,s; 154866a–e. Measured paratypes: USNM 152860a–l,n–s. Unfigured paratypes: USNM 152860a,c,e–g,i,l–r.

COMPARISON.—The swollen median areas of both valves and the strong spreading costae characterize this species. Bicostate specimens differ from *Anteriodocus bicostatus*, new species, in having their length and width nearly equal, being more strongly costate farther posteriorly, and in having much less strongly developed anterolateral extremities. *Pontisia ventricola* is larger and more robust than *P. franklinensis*, new species, from the Hueco Canyon Formation. The valves of *P. ventricola* are more strongly swollen medially than those of *P. kingi*, new species, from the Neal Ranch Formation. It is much larger than *P. nanas* (Stehli) and has a less deep sulcus on the pedicle valve. *Pontisia ventricola* is not so wide as specimens of *Antronaria spectabilis*, new species, of the same size, but that species attains a much larger size than the Hess

species. Furthermore, *P. ventricola* does not have the depressed median costa in the fold which characterizes the Bone Spring species. *Pontisia stehlii* Cooper and Grant is much larger and much more variable than the Hess species but has less spreading and narrower costae in many specimens and is not swollen medially as is *P. ventricola*.

An undescribed species from the Hueco Canyon Formation is most like *P. ventricola*. A specimen of this species was identified by King with the Hess species (1931:108, pl. 34: fig. 7a–c). This Hueco species (YPM 12527) is readily distinguished by the nearly complete costation of the valves, whereas *P. ventricola* is usually about half smooth posteriorly.

DISCUSSION.—Most specimens of this species have 3 costae on the fold and 2 in the sulcus. Out of 104 specimens 5 had 2 costae on the fold and 5 had 4 costae on the fold. A costa on one specimen was bifurcated to produce 4 on the fold. The young are thin, long beaked, and their sides form an acute angle. The brachial valve is slightly concave anteriorly. This species is abundant at the top of the Hess but is not known elsewhere.

Pontisia wolfcampensis, new species

PLATE 520: FIGURES 11–18

Small for genus, wider than long, subpentagonal in outline; sides rounded, anterior margin truncated, apical angle about 100°. Anterior commissure uniplicate; valves unequal in depth, brachial valve deeper. Deltidial plates variable, from disjunct to conjunct in specimens of same size; foramen oval, permesothyridid. Surface semicostate, 3 on fold, 2 in sulcus, and 3 on each flank; costae on tongue and anterior side of fold with shallow groove.

Pedicle valve gently convex in lateral profile but flatly to gently concave in anterior profile. Umbonal and median regions moderately swollen; sulcus originating at midvalve, wide, producing long tongue. Flanks flattened, somewhat deflected in anterolateral direction; flanks narrow and rounded.

Brachial valve narrowly domed in anterior profile with moderately rounded top but precipitous sides. Fold originating at midvalve, low and flattened on top, not strongly elevated above inflated flanks.

Pedicle valve interior with slender dental plates.

Brachial valve interior with small cardinalia; outer hinge plates fairly wide; socket ridges slender; inner hinge plates fused and anteriorly notched. Crura laterally compressed, long and curved.

MEASUREMENTS (in mm).—Specimens USNM 154764c (holotype) and b (paratype), respectively: length 9.1, 8.4; brachial valve length 8.0, 7.9; width 10.7, 9.8; thickness 8.8, 6.3; apical angle 100°, 100°.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (Bed 4).

LOCALITY.—USNM 727e.

DIAGNOSIS.—Small *Pontisia*, semicostate, with short, low fold and small cardinalia.

TYPES.—Holotype: USNM 154764c. Figured paratypes: USNM 154764a,d,e. Measured and unfigured paratype: USNM 154764b.

COMPARISON.—This species need be compared only to *P. parva*, new species, with which it occurs, because it differs in the same degree from the species to which the latter species was compared. It also shares some of the characteristics of *P. parva*, new species, such as the broadly flattened front due to rapid growth along the anterior margins of both valves. It differs from *P. parva* in being larger, wider, having somewhat stronger costae, and a wider fold and sulcus.

Lirellaria, new genus

[Latin *lirella* (small ridge)]

Medium size for rhynchonellacea, with rounded contours and subpentagonal to subcircular outline; anterior commissure strongly uniplicate. Beak short, suberect to erect, with submesothyridid foramen and conjunct, small deltidial plates. Beak ridges strong, surface costellate, costellae direct, reaching or nearly reaching beaks.

Pedicle valve interior with small teeth supported by thin, short, strong dental plates.

Brachial valve with large undivided hinge plate having strong socket ridges, small outer hinge plates and broad coalesced inner hinge plates. Median septum absent. Crura modified falcifer, broad, curved, concave toward midvalve.

TYPE-SPECIES.—*Lirellaria costellata*, new species.

DIAGNOSIS.—Medium, costellate rhynchonellacea having an undivided hinge plate, no median septum.

COMPARISON.—This genus suggests *Allorhynchus*

Weller and *Pontisia* Cooper and Grant but differs from both in having a costellate exterior. It further differs from *Allorhynchus* in having an undivided hinge plate. It differs from *Wellerella* Dunbar and Condra in the absence of a median septum and in the costellate exterior. It also differs from *Phrenophoria* Cooper and Grant in ornamentation and lack of a median septum.

It differs from other costellate genera in having the costellae direct and undivided. *Ptilotorhynchus*, new genus, is multicostellate but differs from *Lirellaria* in having a divided hinge plate and elaborate deltidial plates. *Strigirhynchia* Cooper and Grant is costellate but it has a long, high median septum and a concave brachial valve umbo. *Lirellaria* differs from *Aphaurosia*, new genus, in its ornament, the valves being almost completely costellate rather than half smooth as in *Aphaurosia*.

Lirellaria also suggests *Trophisina*, new genus, but is usually not so globular as that genus. It is also possible that species of *Lirellaria* of globular form will be found. Sufficient difference exists, however, in the character of the cardinalia to distinguish the two. *Trophisina* has a well-formed median septum, a feature not present in *Lirellaria*. *Trophisina* is also not provided with conjunct and strong deltidial plates as is *Lirellaria*.

DISCUSSION.—Some features of both valves of *Lirellaria* are worthy of note. In the pedicle valve the teeth are set inside the valve, with a deep groove between them and the valve margin. The dental plates are thus narrowed and elongated and the cavities between them and the valve wall in some specimens are almost completely filled. The dental plates and teeth are thus like these structures in some modern rhynchonellids. As usual with thin-shelled, silicified branchiopods we have not been able to determine the form and individual scars of the muscle field.

Concerning the inside of the brachial valve we have information from only a few specimens, consequently the inside variation is not understood. The hinge plate in both species has the crura tied to the socket plate by broad outer hinge plates; but in *L. crassa*, new species, the inner hinge plates are not well developed and the gap between them is plugged by shell tissue. No specimen preserves the crura in perfect condition. They are keeled, moderately long, gently curved, and concave toward midvalve.

Lirellaria costellata, new species

PLATE 508: FIGURES 56–64; PLATE 511: FIGURES 1–20;
PLATE 780, FIGURES 44–50 (in part V)

Medium size, subcircular in outline, margins rounded; posterolateral extremities converging at about 90°; sides and anterior margin broadly rounded. Anterior commissure strongly uniplicate. Beak short, suberect with small foramen and short deltidial plates. Surface costellate, 8 costellae on fold of adults, one less in sulcus, and 12 on each flank.

Pedicle valve evenly and moderately convex in lateral profile but broadly and gently convex in anterior profile. Umbonal and median regions swollen. Sulcus originating anterior to midvalve, broad and shallow but produced into long broadly rounded tongue geniculated nearly at right angle. Flanks narrow and moderately convex.

Brachial valve moderately and evenly convex, somewhat more rounded at umbo in lateral profile; anterior profile somewhat narrowly domed but smooth and steep sided. Umbonal and median regions swollen; fold originating anterior to midvalve, low and with soft contours and only slightly elevated at anterior. Flanks swollen and steep.

Pedicle valve interior with strong dental plates. Brachial valve interior with undivided hinge plate having broad, coalesced inner hinge plates and stout laterally compressed crura.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 728p					
155073a	7.6	7.0	8.5	4.4	90
USNM 738					
152820	5.8?	4.8	5.8	4.2	90
AMNH 40					
152821c	10.0	9.0	10.0	6.5	90

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member).

LOCALITIES.—AMNH 37, 38, 40; USNM 725e, 728p, 738.

DIAGNOSIS.—Finely costellate *Lirellaria* with short, low fold and shallow sulcus.

TYPES.—Holotype: USNM 155073a. Figured paratypes: USNM 152819; 152821a,c; 154667; 154692a,b; 154693a,b; 154696a; 155073b; 155112a,b. Unfigured

paratypes: USNM 152821b; 154696b,c.

COMPARISON.—Differs from *L. crassa*, new species, in the greater abundance of, and finer, costellae, especially on the fold and sulcus, and in its smaller size.

DISCUSSION.—This is a rare species in the Lamar Member but the specimens, although slightly distorted, display their internal characters well. In the few specimens collected, variation in the strength of the ornament was seen.

Lirellaria crassa, new species

PLATE 780: FIGURES 57–65 (in part V)

Usual size for genus; length and width nearly equal; valves subequal in depth; outline subcircular to subpentagonal; greatest width slightly anterior to midvalve; posterolateral margins meeting at about 90°–105°; sides rounded; anterior margin broadly rounded. Beak short with strong beak ridges, oval foramen, and small disjunct deltidial plates. Surface costellate, costellae strong, in adults three on fold, one less in sulcus, and 5 or 6 on flanks, outermost ones small.

Pedicle valve evenly and flatly convex in lateral profile and broadly but gently convex in anterior profile. Umbonal and median regions swollen; sulcus originating near midvalve, broad and shallow, but produced into a short tongue geniculated at obtuse angle. Flanks narrow, moderately convex, moderately steep.

Brachial valve moderately but unevenly convex in lateral profile, with the front convex. Anterior profile broadly and gently domed and with steep sides. Umbonal and median regions swollen; fold low, originating near midvalve, flattened, and only slightly elevated at anterior. Flanks swollen, with long, steep slopes.

Pedicle valve interior with dental plates obscure. Brachial valve interior with long, curved, laterally compressed crura and inner hinge plates not completely coalesced.

MEASUREMENTS (in mm).—Specimens 155072a (holotype) and b, respectively: length 8.7, 7.8; brachial valve length 7.5, 6.5; width 8.9, 7.1; thickness 4.6, 4.7; apical angle 105°, 98°.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member).

LOCALITY.—USNM 728p.

TYPES.—Holotype: USNM 155072a. Figured paratypes: USNM 155072b,c. Measured paratype: 155072b. Unfigured paratypes: USNM 155072d-h.

DIAGNOSIS.—Strongly costellate *Lirellaria*.

COMPARISON.—This species differs from *L. costellata*, new species, in having stronger costellae and smaller size.

Lirellaria diabloensis, new species

PLATE 511: FIGURES 23-25

A single specimen preserving both valves, conveniently broken at the anterior of the brachial valve, measures 9.5 mm long, 10.0 mm wide, and 6.4 mm thick. The valves are of about equal depth, the sides rounded, and the anterior commissure shows evidence of uniplication. The pedicle valve is moderately convex in both profiles, and has a somewhat keeled umbonal region and flattened anterior. The brachial valve is moderately convex in both profiles but the fold at the anterior is obscure. The beak of the pedicle valve is moderately long and suberect, with a small foramen defined by conjunct and strong deltidial plates. The surface is costellate, the costellae becoming faint but still present in the umbonal regions.

The interior is not well preserved and the cardinalia are thickened by siliceous deposit, nevertheless the hinge plate is undivided, unsupported, and medially notched.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITY.—AMNH 591.

TYPES.—Holotype: USNM 152822.

COMPARISON.—This species is larger than the others except *Lirellaria?* sp. 1; it is more robust, has more numerous costellae than *L. crassa*, new species, but is not so finely ornamented as *L. costellata*, new species.

Lirellaria? species 1

PLATE 511: FIGURES 21, 22

A possible species of *Lirellaria* is indicated by a single pedicle valve measuring 13 mm in length and 15 mm in width. It is subpentagonal in outline and has a long, wide, and rounded tongue. The sulcus originates near midvalve, is wide and

shallow, and poorly differentiated except at its anterior. The surface is covered by numerous costellae, 12 in the sulcus and 15 or 16 on the flanks. The umbonal region is broadly carinate, the carination melting into the sulcus at about midvalve. The flanks are fairly broad, moderately convex, but not strongly deflected.

The beak is short and the posterolateral boundaries converge at an angle of 110°. The foramen is small, submesothyridid and bounded anteriorly by conjunct deltidial plates. The teeth are small and lie inside of but parallel to the shell margin. Dental plates are long and stout. The muscle field is small, with a truncated anterior margin and large diductor scars surrounding the adductors.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member).

LOCALITY.—USNM 706e.

Genus *Divaricosta* Cooper and Grant, 1969

Divaricosta Cooper and Grant 1969:11.

Medium size, biconvex; outline bluntly subtriangular to subpentagonal; uniplicate, fold low, sulcus shallow to moderately deep. Costae beginning at beaks, increasing anteriorly by bifurcation; concentric striae faint, fine; growth lines weak over most of shell, becoming strong laminae near anterior margins.

Pedicle valve moderately convex, flanks not reflexed; beak short, bluntly pointed, straight, or dorsally curved, apsacline; delthyrium wide, nearly completely closed by conjunct deltidial plates, foramen small, subcircular, mesothyridid; lateral pseudointerareas narrow, partly covered by edge of opposite valve.

Brachial valve somewhat more convex; beak bluntly rounded, apex covered by deltidial plates.

Pedicle valve interior with recess in delthyrium for brachial beak; teeth strong, somewhat curved; dental plates vertical, supporting hinge teeth, often fused to sides of valve. Muscle area narrowly triangular, beginning between dental plates, expanding anteriorly; adductor muscle scars small, lying near center of muscle area, surrounded by larger diductor scars.

Brachial valve interior with large undivided hinge plate; hinge sockets deep, wide, strongly denticulate; with strong outer socket ridges articu-

lating with sockets on outside of teeth. Crura falci-fer, diverging slightly from forward edge of hinge plate, not twisted, gently curving ventrally; crural bases extending from underside of hinge plate along undersides of crura; median ridge moderately high, thick, broadly rounded, extending into posterior part of muscle area. Posterior adductor muscle scars elongate, narrow, widely separated from one another, slightly diverging anteriorly, lying lateral to larger, anteriorly slightly expanding anterior adductor scars along median line; diductor muscle impression at apex of valve, at posterior extremity of hinge plate.

TYPE-SPECIES.—*Divaricosta squarrosa* Cooper and Grant (1969:12, pl. 4: figs. 1–6).

DIAGNOSIS.—Medium-sized rhynchonellacea having numerous bifurcating and intercalated costae and an undivided hinge plate.

COMPARISON.—*Divaricosta* is characterized by its costae that begin at the beaks and increase in number anteriorly by bifurcation or intercalation, its low fold and moderately shallow sulcus, its large, conjunct deltidial plates, the narrow lateral pseudointerareas that are partly covered by the overlapping edges of the brachial valve, the large, undivided hinge plate, and thick, high median dorsal ridge, but absent median septum. It resembles *Fascicosta* Stehli (1955) in its bifurcating costae, differing in its large conjunct deltidial plates, overlapping valves that produce lateral pseudointerareas, undivided hinge plate, and median dorsal ridge but no brace or septum.

Ptilotorhynchus, new genus, is similar to *Divaricosta* in external appearance but the deltidial plates have winglike protuberances and a divided hinge plate. *Divaricosta* differs from *Deltarina*, new genus, in more numerous bifurcations of the costae, an undivided hinge plate, and a thick median ridge.

DISCUSSION.—The type species of *Divaricosta*, *D. squarrosa* Cooper and Grant, was described and illustrated by Stehli (1955:71, 73) as *Fascicosta longaeva* (Girty). Stehli did not designate any of these specimens as the type for *Fascicosta*, but instead chose Girty's species under the mistaken opinion that it belonged to the same species as his Get-away specimens. Our study of Girty's *Rhynchonella? longaeva*, including the illustrated holotype (Girty, 1909, pl. 15: fig. 18) and all paratypes in the U.S. Geological Survey collections, leads us to conclude

that the resemblance between *R.? longaeva* and *D. squarrosa* is only in the bifurcation of the costae, and that they are otherwise generically distinct.

Several features of interest may be pointed out in the shell anatomy of *Divaricosta*. The deltidial plates of the pedicle valve are very thick and conjunct but clearly show the suture. The anterior surface of the deltidial plates is excavated into a broad crescent to receive the movement of the brachial valve. The teeth are unusual in that they protrude into the valve from the side and are tied to the valve wall by horizontal plates. The teeth are buttressed by strong dental plates that stand away from the valve wall. The teeth are thus set off by a wide gap or socket between the tooth and the valve wall. This receives an elongated tooth that occupies the outside of the socket in the opposite valve. In old specimens the cavity between the dental plate and the valve wall is filled by shell substance but the horizontal plate and the deep sockets between the tooth and the valve edge is well developed.

Old specimens of the pedicle valve are characterized by a broad shelllike extension of the posterolateral margin just anterior to the teeth. In one specimen these shelves extend in a dorsal direction as high as the anterior tongue. This shelf is overlain by the posterolateral region of the brachial valve in a strong overlap.

The hinge plate is notable for its solidity and the peculiar development of the socket. The socket is strongly corrugated and bounded by a thick, strong socket plate. On the outside a thin plate forms the outer boundary of the socket, but this plate is inside the margin of the brachial valve. This plate is an accessory tooth in the brachial valve that articulates with the socket on the outside of the tooth. This arrangement makes for a strong articulation.

The hinge plate is composed of the socket ridge which hangs over the socket and to which is fixed a broad outer hinge plate which attaches the crural bases that are anteriorly keeled. The hinge plate also is marked by a fairly elongated fulcral plate under the socket. The inner hinge plates unite medially in a fairly broad fold. These plates are buttressed by a median support that varies from a fairly slender median septum to a thick and solid ridge, usually the latter.

The crura are moderately long, stout, slightly

curved and keeled on the ventrolateral edge. The distal end is oblique, being sharply pointed toward the inside but obtuse dorsolaterally.

***Divaricosta squarrosa* Cooper and Grant**

PLATE 509: FIGURES 1-26; PLATE 552: FIGURES 6-10

Fascicosta longaeva [not Girty] Stehli, 1955:71-73, figs. 1-17.
Divaricosta squarrosa Cooper and Grant, 1969:12, pl. 4: figs. 1-6.

Small, moderately strongly biconvex; outline bluntly subtrigonal to subpentagonal, sides diverging nearly 100°; anterior commissure uniplicate; fold low, beginning inconspicuously, gently convex longitudinally and transversely; sulcus shallow, deeper at anterior, beginning 3 or 4 mm anterior to beak. Costae strong, narrow, ropelike, beginning at beaks, increasing anteriorly by bifurcation and intercalation, numbering 3-5 on fold, one less in sulcus, 6-9 on each flank. Concentric striae fine, closely spaced; growth lines weak and widely spaced except near anterior margins, there strong, closely spaced, laminar.

Pedicle valve moderately convex in lateral and anterior profiles, flanks not reflexed; beak short, bluntly pointed, slightly attenuate, straight or with delthyrial area slanted ventrally away from hinge; delthyrium wide, triangular, nearly completely closed by large, thick, conjunct deltidial plates, leaving small, round foramen; lateral pseudointerareas present, width variable, more-or-less covered by overlapping edge of brachial valve.

Brachial valve moderately convex, umbonal area slightly flattened or indented; beak bluntly rounded, slightly prominent, apex covered by deltidial plates.

Pedicle valve interior with shallow recess for accommodation of brachial beak; teeth strong, tusklike, continuous, with nearly vertical dental plates that are discrete or fused to sides of valve. Muscle area narrowly triangular, beginning between anterior edges of dental plates, expanding slightly anteriorly to about a third valve length, often slightly excavate; adductor scars small, lying near center of muscle area, completely surrounded by larger diductor scars.

Brachial valve interior with large semicircular, undivided hinge plate, bounded laterally by deep, wide, strongly denticulate sockets having high, thin outer socket ridges; inner socket ridges curved, narrowly overhanging sockets; outer hinge plates

narrow, crura diverging anteriorly from forward edge of hinge plate, narrow, curved ventrally, moderately long, not twisted; crural bases vertical, narrow but strong ridges on underside of hinge plate, extending as keels along dorsal side of crura; median ridge moderately high, thick, broadly rounded, extending about a fourth to a fifth valve length. Muscle area subelliptical, slightly depressed; posterior adductor scars narrow, elongate, slightly diverging anteriorly, lying lateral to elongate, anteriorly slightly widening anterior adductor scars located along median line of valve, lateral and anterior to median ridge.

MEASUREMENTS (in mm).—Specimen USNM 148221: length 6.9, brachial valve length 6.3, mid-width 6.9, width 7.1, thickness 4.0, apical angle 100°.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—AMNH 512 (=USNM 728).

DIAGNOSIS.—*Divaricosta* with ragged anterior lamellae.

TYPES.—Lectotype: AMNH 27904/1; Figured paratypes: AMNH 27904/2, 4, 6. Figured hypotypes: USNM 148221, 154675a-c.

COMPARISON.—*Divaricosta squarrosa* is characterized by its strong, ropelike, bifurcating costae, large, thick deltidial plates, small, mesothyridid foramen, thick shell with strong growth laminae which make ragged margins, and internally by its nearly vertical dental plates and strong dorsal median ridge. It differs from *Fascicosta longaeva* (Girty) in its stronger, higher, more bluntly rounded costae that bifurcate or intercalate more frequently, its less inflated umbones, higher fold and deeper sulcus, slightly overlapping posterolateral valves edges that produce narrow lateral pseudointerareas, prominent and crowded growth laminae near the margins, and more nearly vertical dental plates.

DISCUSSION.—The details of the interior have been described under the generic discussion. This species is rare in the Getaway Limestone but it has not been seen at any other level in the Guadalupe Mountains.

***Divaricosta vagabunda*, new species**

PLATE 509: FIGURES 60, 61

Usual size for genus, wider than long, greatest width at midvalve, outline transversely elliptical,

median ridge that swells and extends for about a quarter the valve length, but does not give any notable support to the hinge plate.

Antronaria emarginata, new species

PLATE 530: FIGURES 1-15

Medium size for genus, wider than long, and widely cordate in outline, posterolateral margins forming angle of 90° to 110°, anterolateral extremities narrowly lobed and anterior margin variably lobate and usually deeply emarginate. Beak usually long and straight to slightly curved. Foramen small. Surface costate, costae narrowly angular, variable in number, usually 4 or 5 in sulcus and 5 or 6 on fold, median ones deeply depressed to form strong sulcus in fold, thus producing deep emargination. Flanks with 3-7 costae. Costae marked by zigzag, concentric lines.

Pedicle valve unevenly convex in lateral profile, umbonal region having most convexity; anterior profile nearly flat to gently concave. Umbonal region narrowly swollen. Sulcus originating at midvalve, deepening and widening suddenly and forming short strongly geniculated tongue, leaving flanks as narrowly rounded lobes with parts bordering sulcus strongly protuberant. Flanks gently convex and narrow.

Brachial valve fairly strongly convex in lateral profile; anterior profile broadly and strongly domed but deeply sulcate medially; umbonal and median regions somewhat swollen; fold originating slightly posterior to midvalve, defined by outer costae or outer pair of costae; sulcus originating just posterior to point of origin of fold, narrow and very deep, helping to form deep anterior emargination. Flanks narrow and rounded.

Interior with short dental plates in pedicle valve but no septum and only slight development of median ridge in brachial valve.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch and Sullivan Peak members).

LOCALITIES.—Decie Ranch: USNM 707a, 727u. Sullivan Peak: USNM 707, 726h.

DIAGNOSIS.—Medium-sized *Antronaria* with deeply emarginated anterior and numerous costae.

TYPE.—Holotype: USNM 154838a. Figured paratypes: USNM 148662, 152844. Measured paratypes: USNM 152844a,b; 152845a-d. Unfigured paratypes: USNM 154838b-d; 152844a,b; 152845a-d.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 707a					
152844a	12.6?	11.4	17.8	7.8	110
152844b	14.0	11.9	17.5	11.6	115
USNM 727u					
152845a	13.2	11.8	17.2	8.9	110
152845b	13.5	11.7	16.2	8.9	105
152845c	11.5	10.4	15.0	7.6	110
152845d	12.7	10.8	15.1	7.6	105
154838a	13.2	11.6	17.3	8.8	104
(holotype)					

COMPARISON.—This species is most similar to *Antronaria mesicostalis* (Girty) but differs in having a more extreme development of the sulcate fold and the anterior emargination. It differs from *A. speciosa*, new species, which is also deeply emarginate, in having more numerous costae.

DISCUSSION.—This is a rare species of which only unsilicified specimens are available. Therefore, we do not have all of the details of the interior but from exfoliated specimens come indications that it is typical for *Antronaria*.

Antronaria indentata, new species

PLATE 531: FIGURES 9-24

Medium size for genus, widely subpentagonal in outline, sides narrowly rounded, anterior margin with strong emargination. Apical angle 111°. Anterior commissure deeply uniplicate. Deltidial plates conjunct, foramen mesothyridid. Surface unevenly costate, posterior third smooth but anterior costate. Costae strong, subangular numbering three on fold, median costa short, deeply sunk below bounding costae, producing emargination; three costae on flanks.

Pedicle valve gently convex posteriorly but strongly geniculated anteriorly in lateral profile; anterior profile broadly concave with exaggerated flanks. Umbonal region moderately swollen; sulcus originating posterior to midvalve, narrow and very deep but forming short tongue. Flanks concave and reflected anteroventrally and strongly serrated.

Brachial valve fairly strongly convex, most so in anterior region in lateral profile; anterior profile broadly domed, narrowly indented on top; sides

steep; fold originating about one-third distance from beak, not strongly elevated and marked by two bounding costae. Flanks swollen, steep, depressed below fold.

Pedicle valve interior with strong dental plates. Brachial valve interior with undivided hinge plate, narrowly notched medially; crura long.

MEASUREMENTS (in mm).—From locality USNM 725c specimens 154839a holotype and b (paratype), respectively: length 11.9, 9.3; brachial valve length 10.1, 7.8; width 16.0, 13.2; thickness 11.0, 9.4; apical angle 111° , 111° .

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITIES.—AMNH 696; USNM 725c.

DIAGNOSIS.—Transverse, deeply indented *Antronaria* with strongly reflected anterolateral extremities in the pedicle valve.

TYPES.—Holotype: USNM 154839a. Figured paratypes: USNM 152851a–c; 154839b.

COMPARISON.—This species need be compared only to the deeply indented species that characterize the Skinner Ranch, Cathedral Mountain, and Bone Spring formations. It is smaller than *A. emarginata*, new species, from the Decie Ranch Member, and is strongly costate and not so elongated. It resembles *Antronaria speciosa*, new species, but that is a larger and more robust species, having longer valves but less deeply emarginate. It differs from *Antronaria mesicostalis* (Girty) in being more emarginate and having less costae forming the fold and in the sulcus.

Antronaria mesicostalis (Girty)

PLATE 517: FIGURES 1–17; PLATE 531: FIGURES 25–38;
PLATE 552: FIGURES 22–29

Pugnoides mesicostalis Girty, 1929:413, pl. 1: figs. 22–28.
Leiorhynchus? mesicostale (Girty) Branson, 1948:382.

Large for genus, biconvex; outline strongly and narrowly transverse, sides diverging between 100° and 145° and very narrowly rounded; profile sub-trigonal; anterior emarginate; anterior commissure uniplicate; fold moderately high, wide, beginning about 6 mm anterior to brachial beak, rather strongly but evenly convex longitudinally; sulcus moderately deep, beginning about 8 mm anterior to pedicle beak, evenly convex or geniculate near anterior margin. Costae rather fine, low, numerous,

beginning 3 mm anterior to beaks, sharpest on fold, there numbering 3–5, usually 5, with one on the median line normally deeply depressed; one less in sulcus, 4–6 on flanks, averaging 5; concentric ornamentation weak; prominent growth lines rare.

Pedicle valve flat and shallow, maximum convexity on umbonal region, or near anterior margin of sulcus, flanks nearly flat to gently concave or slightly reflexed. Tongue short, deeply serrated; beak short, rather thick, apex sharp, slightly curved dorsally, beak ridges gently rounded, obscure; lateral pseudointerareas narrow or absent. Delthyrium triangular, on dorsal side of beak, base covered by two flat or slightly arching deltidial plates, leaving apex open as oval foramen.

Brachial valve more strongly and evenly convex longitudinally and transversely than opposite valve; smooth part of umbo flattened or slightly indented, indentation becoming deeper anteriorly, merging with depressed median costa of fold; apex of valve within pedicle valve, covered by deltidial plates. Flanks gently swollen, with steep slopes.

Pedicle valve interior with sides of delthyrium widely diverging anterior to deltidial plates; teeth small, elongate, parallel to edge of delthyrium, supported by strong vertical dental plate reaching floor of valve. Muscle area anterior to dental plates; adductor scars small, oval, central, surrounded laterally and anteriorly by long, anteriorly broad diductor scars.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by deep, elongate, finely corrugated (?) sockets; crura long, modified falcifer, projecting forward from hinge plate, diverging anteriorly, curving strongly ventrally and twisting as much as 90° , dorsal edge keeled; inner hinge plates narrow. Median ridge low, broadly rounded, extending anteriorly between posterior adductor muscle scars to near center of anterior adductor scars. Muscle area oval to nearly circular, posterior adductor scars narrow, elongate, anteriorly diverging, their posterior ends separated by median ridge, anterior ends contiguous with broadly ovate anterior adductor scar.

STRATIGRAPHIC OCCURRENCE.—Bone Spring and Cibolo formations (Breccia Zone of Udden).

LOCALITIES.—Bone Spring: AMNH 497, 625, 632, 697, 699; USNM 725c; 728e. Cibolo: USNM 738c, 738s.

DIAGNOSIS.—Strongly transverse, deeply emarginate

MEASUREMENTS (in mm).—

	<i>brachial valve</i>			<i>thick- ness</i>	<i>apical angle (°)</i>
	<i>length</i>	<i>length</i>	<i>width</i>		
152852a (lectotype)	10.8+	9.9	16.5	7.8	125
152852b	11.6+	10.5	14.3	9.4	120
USNM 725c					
152851a	9.6	8.4	13.3	6.0	115
152851b	10.7+	10.0	15.8	6.5	120
152851c	8.9	7.8	11.6	5.0	110
152851d	8.5	7.0	11.2	?	105
152851e	11.7	10.6	16.0	11.0	115

nate *Antronaria* with one costa in the fold conspicuously depressed.

TYPES.—Lectotype: USNM 152852a. Figured hypotypes: USNM 154511; 154742a-d; 152851a-c; 1544839a,b; 154840; 154841a,b. Measured paratype: USNM 152852b. Measured hypotypes: USNM 152851a-e.

COMPARISON.—*Antronaria mesicostalis* is characterized by its fairly large size, strongly transverse outline, small and numerous costae, with the middle one of the fold normally deeply depressed, and its low median ridge in the brachial valve. It is nearly as large as *A. spectabilis* and *A. voluminosa*, both new; it differs from the former in its longitudinally more convex brachial valve, thicker beak without sharp beak ridges, strongly depressed median costa on the fold, and its greater width. It differs from *A. voluminosa* by its smaller size, more numerous costae, more strongly transverse outline, and by the depressed median costa on the fold.

This species is commonly emarginate anteriorly and in this respect is like *A. speciosa* and *A. emarginata*, both new. It differs from the former in being shorter and more transverse and in having more numerous costae; it differs from the latter in having less numerous costae and generally being less emarginate but generally shorter and wider.

DISCUSSION.—*Antronaria mesicostalis* has mistakenly had R. E. King's *Pugnoides transversus* added to its synonymy (R. E. King, 1931:108, footnote). We have large collections of King's species from several localities and they are consistently larger and have more numerous costae than Girty's species, and are seldom emarginate. We are, therefore, recognizing King's species as separate and distinct.

Branson (1948) recorded this species as belonging to the genus *Leiorhynchus*. Its ornamentation char-

acteristics and the absence of a median septum in the brachial valve as well as the form of the dental plates argue against this assignment. The brachial valve has the low median ridge characteristic of *Pontisia* and *Antronaria* which is not primarily a hinge plate support.

Girty had two specimens of this species and named the wider of the two as the type. It is different in shape from the paratype, which is narrower and subtriangular, but it has the same type of fold and sulcus with the same strongly depressed median costa. Obviously the two specimens could be aberrations of some more intermediate form but it is impossible to tell. The stratigraphic level from which Girty's specimens came is not known. Although we have collections from the Apache Canyon region, this species was not found. Specimens suggesting it were taken at the north end of the Baylor Mountains (USNM 725c) and from the Victorio Canyon region. These also indicate a species of considerable variation, the extremes being greater than those seen in the type lot.

The lots from the Baylor Mountains are extremely wide and suggest *A. speciosa* but are not so large or coarse, have more costae, and are usually deeply emarginate. Costae on the fold vary from three to five but those on the flanks are more constant. Specimens with only 3 costae on the fold tend to have a different appearance from those with 5 costae, yet they come from the same strata, have the same general transverse form, and seem to belong to the same species.

Specimens from AMNH 625 and USNM 728e are more like the types and have both transverse and narrow forms that can be matched closely to the types. In view of the paucity of specimens available, we are recognizing forms from both areas as the same species. It is probable that it will be necessary to have collections from the Lower Bone Spring all along the Sierra Diablo and from the Baylor Mountains before the species can be clearly understood.

Antronaria pluricosta, new species

PLATE 535: FIGURES 7-25

Large for genus, transversely triangular in outline, apical angle variable, usually up to 110°; maximum width slightly anterior to midwidth;

sides narrowly rounded; anterior margin strongly truncated but slightly emarginate medially. Anterior commissure strongly uniplicate. Beak fairly long, straight to suberect, with fairly large foramen and well-developed conjunct deltidial plates. Surface semicostate, costae narrow on fold and sulcus, broader on flanks, usually subangular; costae numbering 4 or 5 on fold, usually 5, one less in sulcus, and usually 3 or 4 on flanks.

Pedicle valve very gently convex in lateral profile, maximum convexity just anterior to umbonal region; anterior profile broadly concave. Umbonal and median regions slightly swollen; sulcus originating anterior to midvalve, broad and shallow but forming strongly geniculated tongue; flanks narrow, slightly deflected and with anterolateral extremities strongly projecting.

Brachial valve very gently convex but median region conspicuously flattened and anterior sharply but narrowly geniculated to meet edge of pedicle valve; anterior profile squarely domed, sides steep and subparallel, top flattened. Umbonal region with shallow sulcus extending to anterior margin depressing median costa or costae. Fold originating anterior to midvalve, flat and wide, only moderately elevated at anterior margin. Flanks anteriorly swollen, moderately depressed below level of fold.

Pedicle valve interior with short dental plates separated from valve wall by narrow cavities that become filled with shell in old age; muscle field deeply impressed, situated just anterior to ends of dental plates, somewhat cordate in outline.

Brachial valve with undivided but medially indented hinge plate; crura curved, concave toward midvalve; inner hinge plates united. Median ridge thick, supporting hinge plate and extended anterior to posterior side of rounded adductor impression which occupies midvalve.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
AMNH 591					
152854a	15.0	12.8	18.1	13.7	100
152854b	14.6	12.5	17.5	11.7	100
152854c	13.2	10.9	15.0	9.5	90
152854d	12.8	10.5	15.8	10.5	90
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITY.—AMNH 591.

DIAGNOSIS.—Large, triangular *Antronaria* with conspicuously flattened median region on brachial valve and thick median ridge.

TYPES.—Holotype: USNM 152854d. Figured paratypes: USNM 152854b,c,i,k. Measured paratypes: USNM 152854a–c. Unfigured paratypes: USNM 152854a,e–h,j.

COMPARISON.—This species is distinctive in having a strongly triangular lateral profile, strongly truncated and broad front, and the depressed median costae in the fold. It suggests *Antronaria dissona*, *A. speciosa*, *A. spectabilis*, and *A. specialis*, all new, but differs from them in its shape and especially in the broadly flattened to slightly emarginate anterior. *Antronaria speciosa* is often flattened anteriorly from rapid growth at the anterior margin but it is ornamented so differently from *A. pluricosta* that no confusion between them is likely.

DISCUSSION.—*Antronaria pluricosta* has a thick shell, with the result that the musculature is well impressed. The pedicle valve has a narrowly cordate muscle field with the diductor scars crescentic in outline and wrapped around the adductor scars. In the brachial valve the adductor scars make, at the anterior end of the median ridge, a rounded patch, which does not completely bisect the scar. The median ridge is also distinctive, being low and rounded and swelling somewhat under the hinge plate. It cannot be construed to be a median septum and is entirely typical of *Antronaria*. The crura are slender for such a thick shell but have the form usual in the genus.

Antronaria specialis, new species

PLATE 532: FIGURES 1–23

Moderately large, broadly subtrigonal to subelliptical in outline with narrowly rounded sides and truncated anterior margin. Apical angle varying from 80° to about 110°. Anterior commissure uniplicate. Maximum width near midvalve. Beak somewhat elongated, narrow; deltidial plates conjunct. Surface about two-thirds costate, costae subangular, usually 4 on fold, occasionally 3 or 5; one less in sulcus; flanks usually with 4 costae.

Pedicle valve gently convex in lateral profile, broadly flattened to slightly concave in anterior profile. Beak and umbonal region narrowly, gently

inflated. Sulcus originating at midvalve moderately broad, shallow, forming short tongue; flanks gently concave, slightly deflected.

Brachial valve gently convex in lateral profile, broadly domed in anterior profile with short, abrupt, and steep sides. Umbonal region faintly sulcate, sulcus continuing to anterior margin, slightly depressing median costa. Fold usually low; flanks moderately swollen, moderately depressed below fold.

Pedicle valve interior with short and erect dental plates; muscle field lightly impressed. Brachial valve interior with short and narrow hinge plate fairly deeply indented medially; outer hinge plates broad; inner hinge plates small; crura fairly broad, strongly curved toward pedicle valve, concave inward. Median ridge low and inconspicuous.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
AMNH 492					
152856a	9.0	7.9	9.5	3.7	80
152856b	11.5	9.7	13.9	6.0	90
152856c	12.2	10.0	14.7	7.3	90
152856d	12.7	10.6	16.0	10.0	100
152856e	14.5	12.0	17.0	10.5	95
152856f	15.2	13.3	19.7	11.4	105
(holotype)					
152856g	16.7	13.8	21.2	11.2	105

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITIES.—AMNH 492, 591, 624; USNM 728g.

DIAGNOSIS.—Medium-sized to large *Antronaria* with 4 or 5 costae on the fold.

TYPES.—Holotype: USNM 152856f. Figured paratypes: USNM 152856d,g; 154843a-c; 154844b-g; 154845f. Measured paratypes: USNM 152856a-e,g. Unfigured paratypes: USNM 152856a-c,e; 154844a; 154845a-e.

COMPARISON.—This species suggests several of the larger new species of *Antronaria* such as *A. titania* and *A. voluminosa*, both new, but it is readily distinguished from them by their lesser size and more especially by the greater width of these two species. In size and general form it is most like *A. spectabilis*, new species, of the Sierra Diablo and *A. dissona*, new species, of the Glass Mountains. It differs from the former in having finer costae and in having 4 or 5 costae on the fold rather than 3 strong angular ones as in *A. spectabilis*.

Antronaria dissona is about the same size as *A. specialis* but has only 3 costae on the fold and is usually somewhat narrower than *A. specialis*. Occasional aberrancies of these species may cause confusion, but *A. specialis* with 3 costae on the fold are as rare as are specimens of the other two species with 4 or 5 on the fold.

DISCUSSION.—This species is fairly common in Apache Canyon of the Sierra Diablo, where it occurs in a dolomitic rock near the bottom of the Bone Spring Formation with species of *Antronaria* and *Stenoscisma*. Typically it is widely triangular and has a narrow hinge plate. This is, however, entirely characteristic of *Antronaria*, as it is unsupported by a septum or even a swelling of the median part of the valve.

Full growth stages of the species are available. As usual with these rhynchonellids the young have a concave brachial valve and are completely smooth. Costation starts at the 5–6 mm stage with the appearance of costae in the median region. Costae appear on the flanks in the next stage, at about 7 or 8 mm. During these stages the brachial valve changes to gently convex and the shell is essentially adult.

Antronaria speciosa, new species

PLATE 532: FIGURES 24–61

Pugnoides elegans [part] R. E. King [not Girty], 1931:106, pl.

34: figs. 2, 3 [not pl. 33: figs. 12–13, or pl. 34: fig. 4 (= *Pontisia stehlii* Cooper and Grant)].

Wellerella elegans Stehli [not Girty], 1954:355, pl. 25: figs. 13–17.

Large for genus, biconvex; outline triangular, slightly bilobate, normally wider than long; sides diverging between 90° and 120°, averaging about 110°; profile subtrigonal; anterior commissure uniplicate; fold very high, beginning 5–7 mm anterior to brachial beak, anterior margin sharply bent toward commissure; sulcus deep, beginning 7–9 mm anterior to pedicle beak, rather evenly convex from beak to anterior commissure. Costae strong, crests normally blunt, beginning 2–5 mm anterior to beaks, numbering 3 on fold, rarely 4 or 5, one less in sulcus, 3–6 on flanks; middle costa on fold normally depressed, producing indentation of anterior margin. Concentric ornamentation faint; growth lines rare except near margins.

Pedicle valve relatively flat; profile broadly sig-

moidal, with ends of costae on flanks reflexed; beak sharp, somewhat attenuate, straight to slightly curved dorsally; beak ridges poorly to fairly well developed; lateral pseudointerareas normally absent, very narrow where present. Delthyrium triangular, base covered by two flat to slightly arched trapezoidal deltidial plates; apex open, forming elongate oval foramen. Brachial valve slightly to moderately convex along median line, strongly convex from beak to flanks and transversely; smooth part of umbo flattened or slightly indented; apex of valve within pedicle valve, covered by deltidial plates.

Pedicle valve interior with delthyrium open anterior to deltidial plates, sides moderately to strongly divergent, each with a hinge tooth, elongated parallel to delthyrial edge; teeth supported by strong vertical dental plates extending to floor of valve. Muscle area heart-shaped, lying anterior to side of dental plates; adductor impression heart-shaped, indented at posterior midline, pointing anteriorly; diductor scars wider, lying lateral and anterior to adductors, indented at anterior midline.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by deep, elongate, anteriorly expanding, finely corrugated sockets; crura projecting forward from edge of hinge plate, diverging anteriorly and curving strongly ventrally, maybe twisted, dorsal edge carinate; median ridge low, thick-rounded, higher under hinge plate, providing support, anterior end within oval muscle area. Posterior adductor scars elongate, curved around posterolateral borders of anterior scars, posterior ends separated by median ridge; anterior adductor scars semicircular to semioval.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle (°)
USNM 702d					
148682a	5.8	5.1	5.7	2.6	c.103
148682b	8.5	7.7	9.6	4.0	99
148682c	10.9	8.7	10.0	5.9	90
148682d	12.2	10.5	13.9	5.5	101
148682e	11.7	10.1	15.4	8.7	105
148682f	12.0	10.0	14.4	11.0	103
148682g	14.0	11.4	16.0	12.0	105
148682h	15.5	13.2	19.4	12.0	112
152847d (holotype)	13.4	11.4	18.0	12.6	109

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Sullivan Peak Member); Hess Formation (Taylor Ranch Member); Cathedral Mountain Formation.

LOCALITIES.—Sullivan Peak: USNM 729h. Taylor Ranch: AMNH 501; USNM 702d, 702e, 702f, 702m, 716n, 716o, 722p. Cathedral Mountain: AMNH 500M; USNM 702, 702ent, 702-low, 702un, 703b.

DIAGNOSIS.—Large *Antronaria* with strong, thick costae, deeply depressed median costa in fold, and strong anterior emargination.

TYPES.—Holotype: USNM 154847d. Figured paratypes: USNM 148682d,f; 148686; 148688; 154846; 154847a-c,e,f,h. Measured paratypes: USNM 148682a-h. Unfigured paratypes: USNM 148682a-c, e,g,h; 154847b,g.

COMPARISON.—*Antronaria speciosa* is characterized by its moderately large size, rather few and large costae, with the middle one on the fold deeply depressed, and the lateral ones on the flanks of the pedicle valve normally slightly reflexed, its flattened dorsal umbonal area, only slight convexity along the midline from brachial beak to anterior margin, and by the low median ridge in its dorsal interior. It differs from *A. mesicostalis* (Girty), which also has a depressed median costa, by its less widely divergent sides, fewer and broader costae on fold and flanks, less convex pedicle umbonal area, and normally larger size. Its depressed median costa, more transverse and less bulbous shape, reflexed pedicle flanks, and only slightly convex dorsal profile (along the crest of the fold) distinguish it from *Pontisia stehlii* Cooper and Grant.

A similar appearing species is *Tautosia elegans* (Girty), from the Guadalupian Capitan Formation of the Guadalupe Mountains. From it *A. speciosa* differs in its stronger and more numerous costae on the flanks, deeper indentation of the anterior margin, larger size, and low median ridge instead of the high median septum present in *T. elegans*.

Among foreign species only *Rhynchonella* (Pugnax) *edelsteini* Tschernyschew bears strong resemblance to *A. speciosa*, which, however, is larger, more transverse, more strongly costate, especially on the flanks, and has a sharper beak. The interior of *P. edelsteini* is not known, so internal comparisons cannot be made.

DISCUSSION.—This species is one of the most distinctive in the Glass Mountains but it has only a limited distribution. It is moderately variable, some

variation taking place in the costation, with the inevitable development of a few specimens with more or fewer costae on the fold and sulcus. Variation in width is also fairly common but in most of the narrower forms relationship to the wider ones remains clear.

Some specimens revealing the interior have the muscle scars fairly well preserved. The ventral muscle field is fairly large and the outline of the scar is somewhat rectangular, with the margins nearly straight and the anterior margin somewhat truncated. The diductors enclose the adductor scars. The dorsal adductor scars lie anterior to the front end of the median ridge. The ridge is moderately well formed in some specimens but in others not a vestige may be seen. This suggests the secondary nature of the structure, dependent on age and, perhaps, other physiological characters.

Antronaria speciosa is fairly common in the Taylor Ranch Member of the Hess Formation, where it occurs in two types of lithology. Most specimens are found in the fairly pure limestones of sponge bioherms but some were taken from silty muds surrounding the bioherms. Probably the true habitat was the bioherm, living on and among the sponges and other solid skeletons. The ones found in the silty limestone may have drifted into their environment after death.

Antronaria spectabilis, new species

PLATE 533: FIGURES 1-38

Wellerella elegans Stehli [not Girty], 1954:335, pl. 25: figs. 13-17.

Large for genus, with highly exaggerated costae and anterolateral projections on pedicle valve; transversely pentagonal in outline in adults, more trigonal in young. Maximum width at midvalve. Anterior margin gently rounded to sharply truncated. Anterior commissure strongly and narrowly uniplicate. Beak moderately long, generally erect. Foramen small; deltidial plates conjunct. Surface coarsely costate, costae of fold and sulcus extending posterior to those of flanks; beaks and umbonal regions of both valves smooth; costae strongly angular except on flanks of brachial valve, there being rather subangular. Costae usually numbering 3 on fold, median one slightly depressed, 2 in sulcus, and usually 3 on each flank.

Pedicle valve gently convex in lateral profile, but with anterolateral areas strongly projecting in ventral direction. Anterior profile deeply concave. Umbonal region narrow, slightly convex; sulcus originating at midvalve, narrow, deepening rapidly and forming strongly geniculated narrow tongue. Flanks gently concave.

Brachial valve moderately and evenly convex in lateral profile but broadly domed and steep-sided in anterior profile. Median region slightly swollen; fold originating at midvalve, heightening fairly strongly anteriorly and projecting well beyond depressed flanks; median line marked by shallow, barely perceptible sulcus extending from umbo to anterior margin, depressing median costa of fold slightly.

Pedicle valve interior with small teeth supported by strong, short dental plates. Muscle field somewhat elongated, located just anterior to delthyrial cavity and usually lightly impressed. Brachial valve interior with narrow hinge plate, deeply indented medially and supported by low median ridge; socket ridges thin; outer hinge plates fairly broad; inner hinge plates narrow and medially united; crura long, concave toward midvalve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 728g					
152857a	17.4	15.1	22.7	17.8	115
152857b	16.9	14.7	20.5	15.5	110
152857c	15.8	13.7	21.0	13.8	110
152857d	14.7	12.8	19.7	13.1	115
152857e	14.7	12.4	18.9	13.7	105
152857f	13.4	11.7	17.7	11.0	100
152857g	12.8	11.0	15.8	9.8	100
152857h	11.8	10.0	13.8	8.7	90
152857i (holotype)	10.5	8.8	12.2	9.1	90
USNM 728f					
152858a	15.2	13.3	19.5	11.0	110
152858b	15.0	13.0	19.2	12.0	110

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITIES.—AMNH 492, 497, 591, 629; USNM 728e, 728f, 728g, 728h, 745, 746.

DIAGNOSIS.—Large, widely sulcate, robust *Antronaria* with median costa of fold very slightly depressed.

TYPES.—USNM 152857i. Figured paratypes: USNM 152853a-d; 152857d,g; 152858b; 154854a-e.

Measured paratypes: USNM 152857a–h, 152858a,b. Unfigured paratypes: USNM 152857a–c,e,f; 152858a.

COMPARISON.—This species has the depressed median costa characteristic of several species. *Antronaria spectabilis* does not attain the great size or great width that is seen in *A. titania* and *A. voluminosa*, new species, but it is similar to *A. dissona*, *A. specialis*, and *A. speciosa*, new species. It is distinguished from the last by its completely different costation and the exaggerated anterior emargination of *A. speciosa*. It is easily separated from *A. specialis* by the more numerous costae on the fold and in the sulcus of that species. It is most like *A. dissona*, from which it differs in having stronger costae, larger size, longer beak, more protuberant anteromedian extremities at sides of the sulcus, and a deeper brachial valve.

DISCUSSION.—This species is based primarily on specimens from USNM 728g that are large and robust. With it have been placed specimens from several other localities. Those from AMNH 492 and 497 are identical, but the specimens from USNM 728f are somewhat variable. On the brachial valve the costae do not extend so far onto the umbonal region as is those on the specimens from Apache Canyon.

Antronaria titania, new species

PLATE 538: FIGURES 12–37

Large for genus, adults transversely elliptical but young forms elliptical; sides narrowly rounded; apical angle variable, 100° to 130°. Anterior margin generally flatly truncated, seldom emarginate. Anterior commissure widely uniplicate. Beak short and narrow, straight to suberect. Foramen small; deltidial plates small, conjunct. Surface costate, except for beaks of both valves; costae usually strong and angular; costae on brachial valve flanks larger than others; costae well separated, numbering from 4–9 but usually 5 or 7 on fold, median one always depressed, median 3 often depressed; costae on flanks 4–8. Width of sulcus greater than half valve width.

Pedicle valve gently convex in lateral profile, greatest convexity just anterior to beak; anterior profile varying from nearly flat to broadly concave. Region anterior to umbo moderately swollen. Sulcus originating at midvalve, wide, variable in depth;

tongue short. Flanks flattened to gently concave, with gentle slope.

Brachial valve evenly and moderately convex in lateral profile but broadly and steeply domed in anterior profile, top flattened by fold. Umbonal region with shallow sulcus extending through fold to anterior margin. Fold flat-topped, wide, fairly elevated to midvalve where it originates. Flanks depressed below fold, swollen and with long steep, slopes.

Pedicle valve interior with short but strong dental plates. Brachial valve interior with small hinge plate, medially deeply indented; median ridge thick.

MEASUREMENTS (in mm).—

	brachial valve		sulcus		thick- ness	apical angle (°)
	length	length	width	width		
USNM 707a						
148660a	10.6	9.2	13.5	8.8	6.5	100
148660b	13.3?	11.2	18.5	11.6	9.4	130
148660c	12.8?	11.8	18.0	10.5	10.6	130
148660d	14.4	12.8	20.0	13.0	8.5	120
148660e	14.9	12.8	21.7	13.6?	12.0	120
148660f	15.8	13.7	23.7	14.4?	11.0	120
148660g	16.2	14.3	23.8	15.0	12.4	130
148660h	17.6	15.2	23.6	15.5	17.7	120
148660i	17.4	15.2	26.8	18.9	14.2	130
148660j	17.4	14.7	26.8	18.0	13.9	130
(holotype)						

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch and Sullivan Peak members). Hess Formation.

LOCALITIES.—Decie Ranch: USNM 707a, 715a, 727u, 733h. Sullivan Peak: USNM 715f. Skinner Ranch (base): USNM 705a, 707w, 708q, 711d, 712p, 716p, 719y, 720e, 726j. Skinner Ranch: USNM 723s. Hess: USNM 723b.

DIAGNOSIS.—Exceptionally large, transverse *Antronaria* with wide fold and sulcus.

TYPES.—Holotype: USNM 148660j. Figured paratypes: USNM 154871; 154872a,b; 154873; 154874. Measured paratypes: USNM 148660a–i.

COMPARISON.—This is one of three species of *Antronaria* that attains an unusually large size. The other two are *A. transversa* (R. E. King) and *A. voluminosa*, new species. It is not likely to be confused with the former because that species is much more finely costate on both fold, sulcus, and the flanks. *Antronaria transversa* is commonly somewhat emarginate and usually has a shallower sulcus than *A. titania*. It also has the median costae of the

sulcus, which has as many as 7 costae, medially depressed as is common in *A. mesicostalis* (Girty). *Antronaria voluminosa* is very much like *A. titania* and the two are not always easy to separate. The latter usually has more costae in the fold and sulcus than *A. voluminosa*, but variants of both species may look alike, although *A. titania* is usually more transverse.

DISCUSSION.—Like their associates in the Decie Ranch Member, *A. titania* is a giant of its kind. It is probably the largest of the species of *Antronaria*. Like most other species of the genus it is quite variable, often having costae numerous enough to make it look like *A. transversa*, but often sparsely costate and suggesting *A. voluminosa*. Few interiors of the species were obtained, but these do not have a septum, and examination of the dorsal beaks of unsilicified specimens confirms this fact.

Antronaria transversa (R. E. King)

PLATE 536: FIGURES 1-27; PLATE 538: FIGURES 38-52

Pugnoides transversus R. E. King, 1931:108, pl. 33: figs. 14-17.

Unusually large for genus, variable, transversely subelliptical to broadly subtrigonal in outline; apical angle varying in adult from about 100° to 135°. Sides narrowly rounded, maximum width near midvalve; anterior margin truncated to slightly emarginate. Anterior commissure moderately uniplicate. Beak short, suberect; deltidial plates small, conjunct. Surface costate except for umbonal regions of both valves which are smooth; costae numerous, narrowly rounded, crowded, and of fairly uniform size; fold with 4-7 costae, median one strongly depressed but some specimens with costa on each side of median one also depressed; flanks with 5-8 costae. Width of sulcus about half valve width.

Pedicle valve gently convex in lateral profile but broadly and gently concave in anterior profile; umbonal region gently swollen, costae of sulcus continued onto anterior part of umbonal region; sulcus originating near midvalve or slightly posterior, broad, shallow, and extended with moderate geniculation as blunt, short tongue. Flanks slightly convex, not strongly deflected.

Brachial valve moderately convex in lateral profile, broadly and strongly convex in anterior profile, with median region somewhat elevated and flat-

tened by broad fold, extending to anterior margin and including 1-3 depressed costae. Fold moderately well defined and moderately elevated; flanks swollen, depressed below fold, with steep slopes.

Pedicle valve interior with strong dental plates. Brachial valve interior with narrow cardinalia; hinge plate deeply emarginate, with fairly wide outer hinge plates but small inner plates. Crura long and slender, strongly keeled.

MEASUREMENTS (in mm).—

	brachial valve			sulcus	thick- ness	apical angle (°)
	length	length	width	width		
USNM 702d						
148645a	16.2	14.1	22.0	7.2	12.9	120
148645b	15.8	12.4	19.7	?	9.7	110
148645c	12.6?	11.5	17.8	9.6	10.0	110
148645d	13.4	11.4	15.9	10.6	10.0	95
148645e	10.5	9.3	11.2	11.2	6.0	90
148645f	9.1	8.3	11.2	12.8	4.8	90
USNM 702e						
148651a	12.8	11.4	17.9	10.5	9.8	120
148651b	14.4	12.7	18.2	8.0	10.5	100
148651c	13.8?	12.0	19.4	10.0	10.8	120
USNM 716n						
154932	17.6?	15.6	28.5	15.2	16.0	133
USNM 716o						
148668a	16.7	14.4	24.3	11.9	13.0	120
148668b	16.5+	15.0	24.9	13.6	15.8	120
148668c	17.9	16.0	26.1	12.5	14.5	130
148668d	15.5	13.0	23.4	12.4	11.2	120
148668e	14.8	13.3	22.4	10.3	10.8	120
YPM 12518 (holotype)	?	14.3	24.6	12.3	10.0	?

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member); Skinner Ranch Formation (Sullivan Peak Member).

LOCALITIES.—Taylor Ranch: USNM 702d, 702e, 702f, 713x, 716n, 716o, 722p; King 222. Sullivan Peak: USNM 707. Skinner Ranch: USNM 705r, 714p, 715v.

DIAGNOSIS.—Large, transverse *Antronaria* with numerous fine costae, 5 or more costae on the fold, and 6 on the flanks.

TYPES.—Holotype: YPM 12518. Paratypes: YPM 10674, 12519. Figured hypotypes: USNM 148645a,e; 148651a; 148668a; 154865a,b; 154932. Measured hypotypes: USNM 148645a-f; 148651a-c; 148668a-e; 154932.

COMPARISON.—This species, with its depressed median costae in the fold and its great width suggests *Antronaria mesicostalis* (Girty), but the two are so different in size and ornament that no con-

fusion between them should result. This species approaches some specimens of *Antronaria titania*, new species, which also is very large and includes specimens with a large number of costae on the fold and sulcus. That species, however, has a wider sulcus than *Antronaria transversa*, usually equaling more than half the width of the valve, whereas the sulcus of *A. transversa* is about equal to half the width. The nature of the ribbing of the two species is different, the costae of *A. titania* generally is stronger and more angular. Variants of the latter also tend toward stronger and more angular costae.

DISCUSSION.—This species is fairly common in silty limestone of the Taylor Ranch Member but is rare in the associated bioherms. It is seldom well preserved, being often crushed, deformed, or broken. To obtain a perfect beak is difficult. We believe that its environment was that of the silty muds. Because of the difficult nature of the matrix few interiors have been obtained; the dorsal valve has a low median ridge. Variations occur in details of the costation and in the width, some specimens never attaining the great width of the normal specimens.

Antronaria voluminosa, new species

PLATE 537: FIGURES 1-51

Large for genus, biconvex, normally somewhat inflated; outline transversely subelliptical to transversely and nearly equilaterally triangular, sides diverging between 105° and 125° degrees, averaging about 115°; profile subtrigonal; anterior commissure uniplicate; fold high, beginning posterior to midvalve, 7-9 mm anterior to brachial beak; abruptly flexed at anterior end, just behind commissure; sulcus moderately deep, beginning 10-12 mm anterior to pedicle beak, strongly bent near anterior end, meeting edge of fold at commissure, making straight angle in adults. Costae strong, crests angular, beginning 4-6 mm anterior to beaks, numbering 3-5 on fold, one less in sulcus, 2-5 on flanks, with 5 most common; relative height of crests of costae variable. Concentric ornamentation and growth lines obscure, not appreciably better developed near margins.

Pedicle valve somewhat inflated anterior to beak, strongly convex along median line, weakly convex toward flanks, with costae on flanks gently reflexed: profile of pedicle valve broadly sigmoidal; beak

sharp, attenuate, normally slightly curved dorsally, beak ridges absent or poorly defined; lateral pseudointerareas narrow, normally completely covered by overlapping brachial valve. Delthyrium triangular on dorsal side of beak, base covered by trapezoidal deltidial plates, conjunct, curved to form low arch; apical part open forming elongate oval foramen.

Brachial valve moderately strongly convex longitudinally and strongly domed transversely; smooth part of umbo flattened or slightly indented, and laterally producing gently rounded beak ridges; apex of valve within pedicle valve, covered by deltidial plates.

Pedicle valve interior with delthyrium open anterior to deltidial plates, teeth slightly elongate parallel to edge of delthyrium, supported by strong vertical dental plates reaching valve floor. Muscle area broadly bilobed, lying anterior to forward ends of dental plates; adductor scars elongate, narrow, lying along median line, together forming oval mark, shorter than surrounding broadly lobate diductor scars.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by deep, elongate, finely corrugated sockets; crura projecting forward from hinge plate, diverging anteriorly, curving strongly toward pedicle valve, dorsal edge carinate; median ridge low, crest rounded, extending only to posterior edge of anterior adductor scar. Muscle area nearly circular, posterior adductor scars elongate, anteriorly diverging, posterior ends adjacent to median ridge, anterior ends continuous with larger, oval anterior adductor scar.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle
					(°)
USNM 708e					
148736a	7.2	6.4	6.9	2.8	95
148736b	8.8	7.4	8.4	3.0	93
148736c	9.0	7.9	9.0	4.0	101
148736d	10.8	9.5	11.6	3.9	92
148736e	11.5	10.4	12.5	5.3	97
148736f	12.2	10.5	12.7	7.7	108
148736g	13.8	11.8	15.9	8.5	108
148736h	14.9	13.0	18.0	8.0	114
148736i	19.0	16.5	22.3	14.4	110
148736j	20.2	17.7	26.4	13.5	124
148736k	21.5	18.1	29.0	16.0	119
148736-l	22.0	19.8	33.0	19.5	120
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation, Decie Ranch, (Poplar Tank and Sullivan Peak members); Bone Spring Formation.

LOCALITIES.—Skinner Ranch (undifferentiated): USNM 715n. Decie Ranch: USNM 707a, 715a. Poplar Tank: USNM 718v. Sullivan Peak: USNM 707, 707d, 707g, 707-l, 707v, 708e, 715f, 722-l. Skinner Ranch (top): USNM 705n, 710r, 722m, 723-l, 723o. Bone Spring: AMNH 497.

DIAGNOSIS.—Very large, transverse *Antronaria* with 5 costae on the fold but none of them depressed.

TYPES.—Holotype: USNM 148736-l. Figured paratypes: USNM 148736b,d,f,g,i; 148742; 154868a,b; 154869a-d; 154870. Measured paratypes: USNM 148736a-k. Unfigured paratypes: USNM 148736a,c,e,h,j,k.

COMPARISON.—*Antronaria voluminosa* is characterized by its large size, transverse outline, inflated pedicle beak area, reflexed costae on the pedicle flanks, nearly geniculate fold and sulcus that meet to form a straight angle in adults, high, strong, broad costae, and low, short median ridge in the brachial interior. In size and exterior features it most nearly resembles *Tautosia fastigiata* Cooper and Grant, differing primarily in the height and number of costae whose crests are not necessarily concordant, blunt or absent pedicle beak ridges, curved pedicle beak with arching deltidial plates, and its low median ridge instead of a high septum in the brachial interior. Both fold and sulcus are flexed in *A. voluminosa*, and strong growth laminae are rare, whereas in *T. fastigiata* they are more uniformly convex and the costae of the fold terminate in sharp points at the line of commissure, or at the first prominent growth lamina.

Antronaria mesicostalis (Girty), *A. transversa* (R. E. King), and *A. titania*, new species, are large, but the average size of the former is less than that of *A. voluminosa*. It is more transverse, and more finely costate, with more costae on the fold and flanks. Juveniles of *A. voluminosa* most nearly resemble adults of *Tautosia shumardiana* (Girty), but have more widely divergent sides, more strongly costate flanks, and a flattened brachial beak area. *Antronaria voluminosa* is also readily distinguished from *A. titania* by its less numerous and stronger costae on fold and flanks. No other large species of *Antronaria* is similar enough to be confused with *A. voluminosa*.

Aphaurosia, new genus

[Greek *aphauros* (feeble)]

Small to medium rhynchonellids, transversely elliptical to subtrigonal in outline with valves of subequal depth, brachial valves somewhat deeper. Sides widely divergent. Anterior commissure uniplicate. Beak short, nearly straight; deltidial plates conjunct; foramen small, submesothyridid. Surface irregularly and weakly costate, costae low, rounded, fine to coarse, often faint, and usually with smooth posterior half.

Pedicle valve interior with small teeth supported by short, stout dental plates. Muscle area occupying region in front of dental plates nearly to midvalve.

Brachial valve with undivided but notched hinge plate. Socket ridges stout; sockets uncorrugated. Outer hinge plates thin and broad; crural bases keeled; inner hinge plates coalesced medially, thin and usually notched along anterior. Crura modified falcifer, long and slender, concave toward midvalve. Median septum absent or vestige at apex, usually visible only on broken valves.

TYPE-SPECIES.—*Aphaurosia scutata*, new species.

DIAGNOSIS.—Rhynchonellacea having irregular radial ornament, rounded outline, generally smooth posterior halves, dental plates in the pedicle valve, and an undivided hinge plate but no septum in the brachial valve.

COMPARISON.—This genus has the general appearance of some of the leiorhynchids and of the genera with fine radial ornament and partly smooth posteriors. The absence of a median septum separates it from leiorhynchids. It suggests some species of *Cenorhynchia*, new genus, but differs in having more costae on the flanks and in lacking a median septum. It suggests some species of *Phrenophoria* Cooper and Grant, but that genus is supplied with a strong median septum. From species of *Pontisia* Cooper and Grant it may be separated by its strongly notched hinge plate and generally more irregular and weaker ornament. It differs from *Hemileurus*, new genus, in its rounded subpentagonal rather than trigonal outline and its undivided hinge plate.

DISCUSSION.—*Aphaurosia* has a fairly distinctive exterior with its smooth umbones and costellate to costate anterior; the costae are best developed along the margin. Inside the pedicle valve the teeth are small but are supported by long and stout dental

plates. The musculature in these thin shells is not well impressed on the surface and the different scars have not been distinguished.

Inside the brachial valve the cardinalia are delicate, the hinge plate undivided, and with strong socket ridges. The outer hinge plates are broad and the same is true of the inner hinge plates, which are well developed and unite medially but have an anterior notch. The crura are long, keeled, stout, concave medially and thus crescentic in cross section. No median septum is formed but a short, thick buttress underlies the inner hinge plates as in *Wellerella*.

Aphaurosia rotundata, new species

PLATE 504: FIGURES 37-54; PLATE 511: FIGURES 26-64;
PLATE 521: FIGURES 32-41

Usual size for genus, usually slightly wider than long, maximum width just anterior to midvalve; posterolateral margins diverging at about 90°. Sides well rounded; anterior margin broadly rounded. Anterior commissure uniplicate. Beak moderately long, suberect. Surface weakly costate, costae variable in length and usually beginning beyond midvalve; posterior parts smooth.

Pedicle valve evenly and moderately convex in lateral profile; broadly and gently convex in anterior profile; umbonal region swollen; sulcus originating anterior to midvalve, short, narrow, moderately deep and extended anteriorly as fairly long narrow tongue. Flanks swollen and gently convex not strongly demarcated.

Brachial valve gently and evenly convex in lateral profile but strongly domed and with steep slopes in anterior profile. Umbonal region moderately convex but median region strongly swollen. Fold low and narrow, marked by 4 or 5 weak costae, originating well anterior to midvalve and well differentiated only near anterior margin. Flanks swollen and steep.

Pedicle valve interior with small teeth but stout dental plates. Muscle area somewhat heart-shaped, diductor scars surrounding adductor scars.

Brachial valve interior with long laterally compressed crura, and complete hinge plate. Socket ridges short but stout. Outer hinge plates broad; inner hinge plates forming narrow fold and anterior notch.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 728p					
154509c	8.5	7.3	10.3	8.2	90
154509d	9.1	7.9	10.0	7.5	92
(holotype)					
USNM 738					
152806a	9.0	7.8	9.3	5.5	95
152806b	9.2	7.8	8.4	6.6	90
USNM 725e					
152807a	11.3	9.8	11.4	7.8	90
152807b	9.0	7.7	8.7	6.9	90
USNM 403					
152808	10.3	9.2	10.8	6.9	95

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar and Rader members).

LOCALITIES.—Lamar: AMNH 37, 347, 430; USNM 725e, 728p, 738. Rader: AMNH 403.

DIAGNOSIS.—Medium size *Aphaurosia* with length and width nearly equal and numerous fine costae.

TYPE.—Holotype: USNM 154509d. Figured paratypes: USNM 152806a,b; 152807b; 152808; 154509a-c,e-j; 154694b; 154695a-c,e; 154927. Measured paratypes: USNM 152806a,b; 152807a,b; 152808; 154509c. Unfigured paratypes: USNM 154509d, 154694a, 154695d.

COMPARISON.—This species differs from *A. scutata*, new species, in its more nearly circular outline, the length and width being nearly equal, in the finer ornament, and the narrower fold and sulcus.

DISCUSSION.—An uncommon species in the Guadalupe Mountains, it is thin shelled and is often crushed. Nevertheless, several excellent specimens showing the interiors were obtained. The interiors show no rudiments of a median septum.

Aphaurosia scutata, new species

PLATE 515: FIGURES 12-25; PLATE 552: FIGURES 1-5

Average size for genus, flatly biconvex; outline transversely ovoid to bluntly triangular, sides diverging between 90° and 130°; profile lenticular; anterior commissure uniplicate, fold low, broad, convexity slight, beginning 5-7 mm anterior to brachial beak; sulcus shallow, strongest between ends of flanks, bent to form right angle with plane of commissure. Costae low, rounded, faint, begin-

ning 5–8 mm anterior to beaks, numbering 3–5 on fold, normally 5, one less in sulcus, 3–7, very obscure, on flanks. Concentric ornamentation absent; growth lines few and indistinct.

Pedicle valve slightly inflated near beak, flatly convex toward flanks; beak sharp, suberect, not attenuate; beak ridges sharp, making beak look flat; lateral pseudointerareas absent: no overlap of valves. Delthyrium triangular, base narrowed by disjunct deltidial plates, apical portion forming elongate oval foramen. Brachial valve nearly flat along fold, more strongly convex toward flanks and transversely; apex within pedicle valve, beneath rudimentary deltidial plates.

Pedicle valve interior with sides of delthyrium widely diverging, teeth small, supported by short vertical dental plates reaching floor of valve. Muscle area small, subtriangular, slightly excavate, lying just anterior and between edges of dental plates; adductor scars median and posterior, subcircular, surrounded by larger, anteriorly widening diductor scars.

Brachial valve interior with undivided triangular hinge plate, bounded laterally by narrow, elongate, anteriorly widening, finely corrugated sockets. Crura divergent, slender, flattened, joined to socket ridges by narrow outer hinge plates. Inner hinge plates narrow, attached to median ridge. Thick median ridge short, supporting hinge plate, extending anteriorly as low median ridge bisecting posterior half of muscle area. Posterior adductor scars narrow, elongate, diverging anteriorly, flanking larger, oval, anteriorly expanding anterior adductor scars.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 738					
152809	9.1	8.2	12.0	5.5	120
154727	8.8	7.2	12.2	5.4	117
154726	9.9	8.7	12.0	7.1	100
(holotype)					
AMNH 430					
152810	10.3	9.0	12.8	4.5	120
USNM 738b					
152811a	10.8	9.6	13.0	6.7	115
152811b	13.8	11.7	16.6	6.5	115
USNM 725c					
152812	9.7	8.5	11.9	6.5	100

STRATIGRAPHIC OCCURRENCE.—Bell Canyon For-

mation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Hegler: USNM 731. Pinery: USNM 725n. Rader: USNM 725e. Lamar: AMNH 430; USNM 728i, 728p, 738, 738b.

DIAGNOSIS.—Transverse *Aphaurosia* with numerous costae and shallow valves.

TYPES.—Holotype: USNM 154726. Figured paratypes: USNM 154724a,b; 154725b; 154727; 154913. Measured paratypes: USNM 152809; 152810; 152811a,b; 152812, 154727. Unfigured paratype: USNM 154725a.

COMPARISON.—*Aphaurosia scutata* is characterized by its moderate size, low convexity, transverse outline, numerous but low and fine costae that begin far forward, its sharp beak ridges, and its median ridge in the brachial valve. It is about the same size as *Anteridocus swalloviensis* (Shumard), but is distinguished by its lower convexity, much finer costae, and nonreflexed flanks. The widely triangular outline of some specimens is similar to that of *Tautosia shumardiana* (Girty), but *Aphaurosia scutata* attains a smaller size, is normally much less convex and more transverse, has sharp beak ridges, more and finer costae, and has a median ridge instead of a median septum.

This species resembles *Bryorhynchus? nitidum* (Girty, 1909) from the Bone Spring Formation of the Guadalupe Mountains but differs in its more rounded triangular outline, rather than the sharply pentagonal outline of *B. nitidum*; it has weak costae on the flanks, whereas *B. nitidum* has none, and stronger costae on the fold. The profile of the fold of *A. scutata* is more convex than that of *B. nitidum*, and it has sharp beak ridges.

Acolosia, new genus

[Greek *akolos* (morsel)]

Minute to moderate size, elongate oval outline; biconvex but brachial valve deeper than pedicle valve. Anterior commissure broadly uniplicate. Beak short; delthyrium open; no deltidial plates. Surface smooth except for incipient anterior costation developed at front margin and strongest on fold and sulcus.

Pedicle valve interior with small teeth supported by strong dental plates.

Brachial valve interior with undivided but

notched hinge plate; socket ridges stout; outer hinge plates fairly wide and attaching to laterally compressed but inwardly concave, short crura, falci-fer; inner hinge plates united but leaving anterior notch. Median septum absent, but threadlike ridge serving as myophragm.

TYPE-SPECIES.—*Acolosia glabra*, new species.

DIAGNOSIS.—Small, mostly smooth Rhynchonellacea having an undivided hinge plate without median septum.

COMPARISON.—This genus resembles some small stocks of *Cenorhynchia*, new genus, but differs in lacking a median septum. It differs from *Aphaurisia*, new genus, in size, outline, and lack of anterior costae.

DISCUSSION.—Some species of this genus, with their smooth shell and small size, suggest at first glance that they are juveniles. This is denied, however, by their folding and the interior development, which is truly adult. Like several other larger genera in the Permian, these species have no deltidial plates. Whether this is a primitive or an advanced character is not easily decided.

Inside the pedicle valve the teeth are small and supported by strong dental plates that have a fair amount of callus thickening on the delthyrial cavity floor. Musculature in these small and thin shells cannot be resolved.

In the brachial valve the hinge plate is angularly notched and has strong socket ridges with wide outer hinge plates attaching the keeled crural bases to them. Inner hinge plates are thin and delicate and usually united posteriorly but form a notch anteriorly. Neither a median septum nor a median ridge is developed. The crura are keeled and laterally compressed.

These small shells are uncommon and some details of their anatomy will have to await the collecting of more specimens. We have not found them abundant or even common at any locality.

Acolosia? anomala, new species

PLATE 512: FIGURES 50-56

Small, widely triangular, maximum width anterior to midvalve; posterolateral margins long and straight, forming angle of 80°. Sides narrowly rounded and anterior margin broadly truncated. Anterior commissure broadly uniplicate. Beak

short, sharp, narrow, with small delthyrium and no deltidial plates, point of beak partly resorbed by pedicle pressure. Surface nearly smooth but with anterior costation, 5 costae on fold and 2 on each flank, median 3 costae of fold depressed into broad sulcus.

Pedicle valve moderately and evenly convex in lateral profile, broadly and fairly strongly convex in anterior profile, depth and convexity greater than brachial valve. Umbonal and median regions moderately swollen; sulcus originating at midvalve by appearance of 2 bounding costae, but costae corresponding to those of fold obscure. Flanks very narrow and rounded, scarcely differentiated from rest of valve.

Brachial valve less deep than pedicle valve, gently convex in lateral profile, broadly and gently convex in anterior profile. Umbonal region narrowly swollen, swelling extending into moderately inflated median region. Fold defined by two prominent costae appearing at midvalve and extending to anterior margin. Sulcus within fold broad and shallow. Flanks very narrow and abruptly rounded, slopes steep.

Pedicle valve interior with small teeth but strong dental plates with narrow, slitlike umbonal cavities. Brachial valve interior with narrow undivided hinge plate having narrow outer hinge plates, moderately long, broad-bladed moderately curved crura, concave toward midvalve. Inner hinge plates short but strongly coalesced. No trace of median septum.

MEASUREMENTS (in mm).—Holotype USNM 152799a: length 7.2, brachial valve length 6.6, width 8.2, thickness 4.8, apical angle 80°.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member).

LOCALITY.—USNM 706e.

DIAGNOSIS.—Triangular *Acolosia* of large size with depressed, broad sulcus in fold.

TYPE.—Holotype: USNM 152799a. Unfigured paratype: USNM 152799b.

COMPARISON.—This is the largest species assigned to this genus; it is distinguished from others by its broadly triangular form and the peculiar sulcation in the brachial valve fold.

DISCUSSION.—This species is assigned with a query to *Acolosia*. Similarities to *Acolosia* are in its pedicle valve beak and its lack of a median septum supporting the hinge plate. It is unlike most *Acolosia*, however, in its large size and transversely

triangular outline. The holotype is a unique complete shell but another pedicle valve furnished some details of the teeth and dental plates. A hole was broken into the pedicle valve of the holotype to show details of the interior.

Acolosia elliptica, new species

PLATE 513: FIGURES 30-38

Small for genus, elongate oval in outline with gently rounded sides and rounded anterior margin. Posterolateral extremities converging to acute angle. Anterior commissure faintly uniplicate in adults. Beak moderately long, nearly straight. Surface smooth with no trace of costation.

Pedicle valve moderately and evenly convex in lateral profile; broadly and moderately convex in anterior profile. Umbonal and median regions moderately swollen. Anterior flattened but no sulcus developed.

Brachial valve moderately convex in lateral profile and gently domed with moderately steep sides in anterior profile. Umbonal and median regions moderately swollen; anterior gently swollen with no development of fold visible except at commissure.

Pedicle valve interior with short dental plates. Brachial valve interior with well-developed hinge plate with strong socket ridges but very reduced outer hinge plates. Crura laterally compressed, moderately long, and slightly curved. Inner hinge plates membranous, strongly developed but with deep angular anterior notch.

MEASUREMENTS (in mm).—Holotype USNM 148203a: length 3.4, brachial valve length 2.9, width 2.5, thickness 1.7, apical angle 55°.

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member).

LOCALITY.—USNM 702d.

DIAGNOSIS.—Small *Acolosia* with incipient fold and long slender outline.

TYPES.—Holotype: USNM 148203a. Figured paratype: USNM 148203b. Unfigured paratype: USNM 148203c.

COMPARISON.—The nearly rectimarginate anterior commissure of this species separates it from other members of the genus. The somewhat elliptical outline and small size also help to distinguish *A. elliptica*. On the interior the membranous inner

hinge plates and the poorly developed outer hinge plates are unlike the hinge plates of the other species.

DISCUSSION.—This species is very rare and may be easily overlooked because of its small size. Its most remarkable feature is the large development of the inner hinge plates in the brachial valve. These unite posteriorly but leave a deep and angular notch anteriorly. The crura are short and stout.

Acolosia^p exasperata, new species

PLATE 515: FIGURES 8-11

Large for genus, elongate triangular in outline, maximum width toward anterior; posterolateral margins long and straight, forming angle of 65°. Anterolateral margins narrowly rounded. Anterior margin truncated. Anterior commissure uniplicate. Beak narrow, incurved, erect, with small narrow delthyrium unmodified by deltidial plates. Valves unequal in depth, brachial valve deeper. Surface of posterior two-thirds smooth; anterior incipient costae, 3 on fold, 1 on each flank.

Pedicle valve evenly and gently convex in lateral profile; anterior profile gently convex with narrowly rounded flanks. Umbonal region narrowly convex; median region gently convex; sulcus originating posterior to midvalve, broad and shallow but with moderately long tongue. Flanks narrowly and abruptly rounded and very steep.

Brachial valve evenly and moderately convex, slightly more so than pedicle valve in lateral profile; anterior profile narrowly and strongly domed with steep sides. Umbonal and median regions swollen. Fold originating near midvalve, low, defined only in anterior part. Flanks inflated, sharply deflected and precipitous.

Pedicle valve interior with strong dental plates. Brachial valve interior with undivided hinge plate and no median septum.

MEASUREMENTS (in mm). Specimens 152800a (holotype) and b, respectively: length 9.0, 8.1; brachial valve length 8.2, 7.4, width 8.2, 6.9; thickness 6.3, 5.2; apical angle 65°, 60°.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base).

LOCALITY.—USNM 720e.

DIAGNOSIS.—Large *Acolosia* with elongate triangular outline.

TYPES.—Holotype: USNM 152800a. Unfigured paratype: USNM 152800b.

COMPARISON.—The only large *Acolosia* to which this one can be compared is *A. ? anomala* from the Word Formation (Willis Ranch Member). The two are not likely to be confused because the Word species is transversely triangular whereas this one is longer than wide. Other differences appear in the fold and sulcus, the fold of *A. ? anomala* being complicated by a broad sulcus and five costae in the fold, while the fold of *A. ? exasperata* has only three costae and none of these is conspicuously depressed.

DISCUSSION.—Only two specimens of this unusual species were taken and neither is well preserved. The paratype was opened from the ventral side but the cardinalia are partly covered by siliceous material. Although it was possible to see the hinge plate, no median septum could be found.

Acolosia glabra, new species

PLATE 513: FIGURES 42–56

Small, elongate oval to elongate subpentagonal in outline, maximum width anterior to midvalve; posterolateral margins diverging at less than 90°; anterolateral margins narrowly rounded; anterior margin truncated. Anterior commissure uniplicate. Beak moderately long, with large delthyrium, strong, incurving, generally suberect. Surface smooth in young adults but with 3 incipient costae on fold, 1 on each flank of old shells.

Pedicle valve evenly and moderately convex in lateral profile but flatly and broadly convex, with narrowly deflected flanks in anterior profile. Umbonal and median regions gently swollen. Sulcus originating anterior to midvalve, inconspicuous, broad and shallow but with strongly geniculated, short tongue. Flanks convex, abruptly deflected and steep.

Brachial valve moderately and evenly convex in lateral profile; strongly and evenly domed in anterior profile, with smooth lines and steep sides. Umbonal and median regions swollen. Fold inconspicuous, best defined at commissure, originating anterior to midvalve and only slightly elevated at margin. Flanks moderately swollen but steep.

Pedicle valve interior with strong and stout dental plates. Muscle region not defined. Brachial valve interior with small hinge plate not supported by

median septum, with wide outer hinge plates and short, stout, laterally compressed crura.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 706c					
148173a	6.2	5.5	5.7	4.3	85
148173b	6.1	5.5	5.1	3.8	80
148173c	5.7	5.0	4.9	3.9	80
148173d	5.4	4.8	4.5	3.4	75
148173e	5.1	4.6	4.4	3.4	80
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank Member).

LOCALITY.—USNM 706c.

DIAGNOSIS.—Large *Acolosia* with anterior costation.

TYPES.—Holotype: USNM 148173e. Figured paratypes: USNM 148173a,b,d; 154715c–e. Measured paratypes: USNM 148173a–d. Unfigured paratypes: USNM 148173c; 154715a,b.

COMPARISON.—The large size of this species suggests *A. magna*, new species, and the strongly inflated valves suggests *A. recepta*, new species, but the incipient costae on the fold and sulcus separate *A. glabra* from the others.

Acolosia magna, new species

PLATE 525: FIGURES 52–55

Large for genus, elongate oval in outline; posterolateral margins meeting at less than right angle; maximum width near midvalve; sides broadly rounded; anterior margin truncated. Anterior commissure strongly uniplicate. Beak moderately long, suberect. Surface smooth but with faint trace of costation at midvalve and on anterolateral extremities.

Pedicle valve gently convex in lateral profile and very faintly convex in anterior profile. Umbonal region moderately convex. Sulcus broad and shallow, originating near midvalve and forming moderately long tongue. Flanks narrow, flattened and gently sloping.

Brachial valve deeper than pedicle valve, moderately convex in lateral profile, greatest curvature at umbo; anterior profile strongly and evenly domed and with steep lateral slopes. Umbonal and median regions swollen. Fold poorly formed, incon-

spicuous, originating anterior to midvalve. Flanks swollen and steep.

Brachial valve interior, as seen through decorticated shell, lacking median septum.

MEASUREMENTS (in mm).—Holotype USNM 148207: length 6.0, brachial valve length 5.4, width 5.2, thickness 3.3, apical angle 75° .

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch Member).

LOCALITY.—USNM 714t.

DIAGNOSIS.—Large *Acolosia* with poorly defined fold and sulcus originating at midvalve.

TYPES.—Holotype: USNM 148207.

COMPARISON.—This is the largest of the known species of this genus, but it is easily separated from the others on characters other than size. It is the most strongly folded of the species and has a visible sulcus on the pedicle valve, a feature not shared by the other species. The valves of *A. magna* are not so swollen as those of *A. recepta* or *A. glabra*, both new.

Acolosia recepta, new species

PLATE 513: FIGURES 57–64

Usual size for genus, valves subequal in depth and convexity, longer than wide, oval outline, maximum width anterior to midvalve. Divergence of posterolateral margins less than a right angle. Sides broadly rounded; anterior margin gently rounded. Anterior commissure broadly uniplicate. Beak short, slightly incurved, with large delthyrium; surface smooth.

Pedicle valve evenly and moderately convex in lateral profile; moderately domed in anterior profile. Umbonal and median regions swollen; sulcus scarcely formed, showing chiefly as wave in commissure and short, wide, tongue. Flanks swollen and steep.

Brachial valve moderately strongly convex in lateral profile, moderately domed in anterior profile, and with fairly steep sides. Umbonal, median, and anterior regions fairly strongly swollen; fold scarcely discernible, originating near anterior margin, best defined at commissure. Flanks swollen.

Pedicle valve interior with strong dental plates plastered against valve wall. Brachial valve interior with stout socket plates and narrow outer hinge plates supporting long narrow crura. Inner hinge

plates uniting posteriorly and deeply notched. Median region of valve marked by low thick ridge.

MEASUREMENTS (in mm).—Holotype USNM 152801a: length 4.5, brachial valve length 4.0, width 3.4, thickness 2.7, apical angle 80° .

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Poplar Tank Member?).

LOCALITY.—USNM 707h.

DIAGNOSIS.—Strongly biconvex *Acolosia* with broad, simple fold of the anterior commissure and slender crura.

TYPES.—Holotype: USNM 152801a. Figured paratypes: USNM 152801b,c.

COMPARISON.—This species is about average in size for the genus, but its valves are fairly deep and their depth is about equal. It can be distinguished readily from the other species of *Acolosia* by its broad and uncomplicated fold, which is lower than that of *A. magna*, new species, stronger than that of *A. elliptica*, new species, and not serrated by costae like that of *A. glabra*, new species. Other characters separate it from the other species: it is wider than *A. elliptica* and more strongly convex; it is smaller than *A. magna* and does not have a sulcus on the pedicle valve; it is not incipiently costate as is *A. glabra*, and is much smaller.

Anteridocus, new genus

[Greek *anteridos* (braced) + *dokos* (beam)]

Small, rhynchonelliform, biconvex, uniplicate; outline bluntly trigonal to transversely subpentagonal; anterior commissure uniplicate, fold and sulcus weakly to strongly semicostate; flanks smooth to weakly costate. Concentric ornamentation and growth lines weak. Pedicle valve moderately convex; beak short, sharp, usually suberect; beak ridges short, sharp to blunt; delthyrium triangular, open, base of triangle slightly constricted by rudimentary, disjunct deltidial plates; valves meeting without overlap, hence no lateral pseudointerareas. Brachial valve strongly convex; beak bluntly pointed, not strongly incurved.

Pedicle valve interior with knoblike teeth supported by vertical dental plates reaching valve floor. Muscle area heart-shaped, pointing posteriorly, beginning between ends of dental plates; adductor marks small, forming subelliptical scar along median line in posterior part of muscle area;

diductor scars large, widening anteriorly, surrounding adductor scars laterally and anteriorly.

Brachial valve interior with undivided hinge plate deeply and widely notched, forming narrow platform under beak, sockets deep, anteriorly widening, finely corrugated; socket ridges narrow; outer hinge plates and crural bases narrow; crura falcifer, diverging anteriorly, strongly curving dorsally, strong, wide, with carinate dorsal edge and extending beneath hinge plate as keel; hinge plate supported by short inner hinge plates uniting medially to form shallow trough, hinge plate supported by short median septal brace reaching valve floor, normally not extending forward but rarely continuing for short distance as low, narrow median ridge. Muscle area not clearly observed.

TYPE-SPECIES.—*Anteridocus gongylus*, new species.

DIAGNOSIS.—Small triangular semicostate rhynchonellids having rudimentary deltidial plates and an undivided hinge plate supported by a short brace.

COMPARISON.—*Anteridocus* is characterized by its small size, rotund shape, rudimentary deltidial plates, lack of lateral pseudointerareas, broadly notched but undivided hinge plate that is supported by a short brace instead of a high septum, and its strong, curved crura. Its tiny deltidial plates and lack of a septum distinguish it from *Cenorhynchia*, new genus; its broad notched hinge plate and disjunct deltidial plates distinguish it from *Wellerella* Dunbar and Condra; the disjunct deltidial plates, and lack of a median septum and lateral pseudointerareas distinguish it from *Phrenophoria* Cooper and Grant. From *Acolosia*, new genus, it is distinguished by its rotund form and round outlines.

DISCUSSION.—Features to be remarked in this genus are the deltidial plates of the pedicle valve and the cardinalia of the brachial valve. The deltidial plates are small, triangular barbs at the anterolateral angles of the delthyrium. They are very small and usually difficult to see. They are not always flush with the delthyrial edge but extend in a dorsomedial direction. The dental plates are usually somewhat receding but define fairly large umbonal chambers.

The cardinalia are fairly distinctive and fairly complex. The diductor muscles were attached in a pit under the obtuse beak of the brachial valve. Probably the posterior rim shared in this duty. The socket ridges are thick and hang over the wide

sockets, which are minutely and closely corrugated. The long narrow crural bases are attached to the socket ridge by a variable but usually narrow outer hinge plate.

The inner hinge plate is shallow and gently concave, attached to the inner edges of the crural base, usually deeply indented medially and with its margins extending as a small shelf along the inside of the crura. The median part of the inner hinge plate is supported below by a thin and short median ridge. In young shells this slight septal brace does not extend anterior to the distal margin of the inner hinge plate. In old shells and in some aberrant ones, however, the brace is extended anteriorly for some distance along the valve floor, but is usually thin and inconspicuous.

In old specimens the inner hinge plate is built anteriorly for some distance and strongly overhangs the septal brace underneath. The lateral margins of this plate, in at least one specimen, are built anterolaterally across the outer hinge plate as a ridge. The median part of the hinge plate varies from nearly flat to fairly deeply concave; it never forms a chamber and is always strongly indented medially. The hinge plate ensemble thus has the appearance of being divided but actually is complete.

The crura are broad-bladed, convex outward, and lie slightly obliquely, the posterior edge toward the interior and the anterior edge toward the outside. The thin, sharp underside, or dorsal edge, extends as a sharp keel under the edge of the outer hinge plate. The crus is expanded distally and truncated obliquely to leave the ventral edge the longer, and usually ending in a point.

Anteridocus bicostatus, new species

PLATE 510: FIGURES 44–47; PLATE 520: FIGURES 45–48;
PLATE 529: FIGURES 1–7

Small, subpentagonal outline, sides rounded, diverging from beak at about 100°. Anterior margin broadly rounded. Anterior commissure uniplicate. Beak small, foramen small, and small conjunct deltidial plates. Surface paucicostate, costae occupying anterior half, broad and rounded to subangular, 2 on fold, 1, 2, or 3 on each flank.

Pedicle valve gently convex in lateral profile, maximum curvature anterior to umbo; anterior

profile broadly and gently concave to flat. Umbonal region slightly swollen; sulcus broad and shallow, originating anterior to midvalve; flanks flattened to slightly concave, anterolateral extremities protruding moderately.

Brachial valve deeper than pedicle valve, moderately convex in lateral profile; moderately domed in anterior profile. Umbonal region swollen. Fold fairly prominent, originating anterior to midvalve, moderately elevated. Flanks swollen, depressed below fold.

Pedicle valve interior with strong, short dental plates. Brachial valve interior with undivided but strongly indented hinge plate, not supported by median septum.

MEASUREMENTS (in mm).—From locality AMNH 417 specimen USNM 152841 and from USNM 738b specimen 152842a (holotype), respectively: length 8.3, 8.6; brachial valve length 7.5, 7.6; width 9.2, 10.3; thickness 5.5, 5.7; apical angle 100°, 100°.

STRATIGRAPHIC OCCURRENCE.—Carlsbad Formation; Bell Canyon Formation (Hegler and Lamar members); Bone Spring Formation (Cutoff Member).

LOCALITIES.—Carlsbad: AMNH 417. Hegler: USNM 731, 732a. Lamar: AMNH 40, 347 (=L-2), 401. USNM 725e, 738b. Cutoff: AMNH 678.

DIAGNOSIS.—*Anteridocus* with two costae on the fold and one in the sulcus.

TYPES.—Holotype: USNM 152842a. Figured paratypes: USNM 152841, 154685, 154813, 154814, 152842a. Unfigured paratypes: USNM 152842b-d.

COMPARISON.—*Anteridocus* with only two costae on the fold is rare indeed and comparison with only three other presently described species is pertinent, since two of the species to be compared are bicostate as an aberration rather than a normal character. One of these is *Anteridocus seminudus*, new species, which is distinguished by its very small size and subtriangular shape. The other species is *Anteridocus swallowianus* (Shumard) which is more triangular, narrower, and has a strong depression in the dorsal umbo, one of the chief marks of the species. *Anteridocus subcarinatus*, new species, is prominently bicostate but its small size, globular outline, and subcarinate brachial valve umbo distinguish it without difficulty.

Pugnax bidentata (Girty) is another species having two costae on the fold but it is very narrowly triangular and is not likely to be confused with *A. bicostatus*.

DISCUSSION.—This is a rare species and, because of its rarity, it might be suggested that it is an aberration of some normally tricostrate or multicostrate species. The distribution of specimens suggests to us that this is not true; we have it from eight different localities and three different stratigraphic levels.

Anteridocus erugatus, new species

PLATE 539: FIGURES 9-39

Average size for genus, moderately strongly bi-convex; outline transversely subelliptical to sub-pentagonal, sides diverging between 80° and 110°; commissure uniplicate, fold low, convex longitudinally, arched transversely, beginning 4-5 mm anterior to pedicle beak. Costae weak, low, rounded, beginning about 5 mm anterior to beaks, numbering 1 or 2 on fold, one less in sulcus, flanks normally smooth, may have 1 or 2 weak short costae. Concentric striae faint, closely crowded; growth laminae weak, normally visible only near anterior margins.

Pedicle valve moderately and smoothly convex, flanks not reflexed; beak short, sharp, straight, or slightly curved; beak ridges sharp, short, prominent; delthyrium triangular, base slightly narrowed by minute disjunct remnants of deltidial plates; no overlap of valves, no lateral pseudointerareas. Brachial valve more strongly convex; umbonal area normally evenly convex transversely, may be slightly flattened in profile; beak bluntly pointed, not strongly incurved.

Pedicle valve interior with sides widely diverging anterior to delthyrium, each side with one elongate knoblike hinge tooth supported by nearly vertical dental plate reaching floor of valve. Muscle area bilobed, heart-shaped, pointing posteriorly; adductor scars small, forming subelliptical to pear-shaped mark along midline of valve in posterior part of muscle area; diductor scars larger, surrounding adductors laterally and anteriorly.

Brachial valve interior with small deeply and widely notched hinge plate not completely divided; hinge sockets elongate, anteriorly widening, denticulate; beak of valve curved up over hinge plate, forming small recess for attachment of diductor muscles; crura diverging slightly anteriorly from forward edge of hinge plate; crural bases extending

from underside of hinge plate, forming keel along dorsal edges of crura; hinge plate supported by short median brace that may extend forward as short, low median ridge; no true median septum. Muscle area not clearly observed: probably consisting of posterior and anterior adductor marks arranged as in *Wellerella*.

MEASUREMENTS (in mm).—

	brachial		mid-		thick-	apical
	valve	length	width	width	ness	angle
	length	length	width	width	ness	(°)
USNM 702c						
148118a	1.0	0.8	0.9	1.0	0.6	—
148118b	1.9	1.7	1.5	1.7	1.1	—
148118c	2.8	2.5	2.1	2.3	1.5	—
148118d	3.9	3.6	3.2	3.5	2.4	84
148118e	4.9	4.2	4.2	4.5	2.9	87
148118f	5.7	5.0	5.5	5.8	3.7	92
148118g	6.8	5.9	6.0	6.8	4.4	97
148118h	7.9	6.8	7.5	8.1	5.5	102
148118i	8.2	7.2	8.6	9.2	5.1	103
154878b	6.8	5.8	6.9	7.0	5.4	100
(holotype)						
154878c	7.3	8.1	7.5	7.8	5.0	100

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain and Road Canyon formations.

LOCALITIES.—Cathedral Mountain: AMNH 500N; USNM 702, 702a, 702ent, 708. Road Canyon: USNM 702c, 709c, 710u, 716x, 719x.

DIAGNOSIS.—Nearly smooth *Anteridocus* with costae confined to fold and sulcus.

TYPES.—Holotype: USNM 154878b. Figured paratypes: USNM 148123a; 154685; 154877a–n; 15487a,c. Measured paratypes: USNM 148118a–i, 154878c. Unfigured paratypes: USNM 148122b–d, 154878d.

COMPARISON.—*Anteridocus erugatus* is characterized by its nearly smooth shell with few low costae on the fold and normally smooth flanks. It differs from *A. gongylus*, new species, in its more transverse outline, somewhat larger average and maximum size, much weaker and more rounded costae, and less bulbous form. It is smaller than *A. eximius*, new species, and differs in its weak or absent costae.

Anteridocus eximius, new species

PLATE 540: FIGURES 1–3

Large for genus, unequally biconvex; pedicle valve deeper, outline transversely subelliptical to

subpentagonal, sides diverging between 95° and 120°; commissure uniplicate; fold high, narrow, standing high above flanks only at anterior, beginning about 5 mm anterior to brachial beak; sulcus moderately deep, deepest near anterior, beginning 4–6 mm anterior to pedicle beak. Costae strong on fold, weak on flanks, crests rounded, beginning 4–5 mm anterior to beaks, numbering 2 or 3 on fold, one less in sulcus, 1–3 on each flank. Growth lines and concentric ornamentation not preserved; shell with faint radial fibers.

Pedicle valve flatly convex to slightly concave transversely, moderately convex longitudinally through sulcus; smooth region of umbo slightly swollen; beak short, blunt, suberect beak ridges blunt, obscure; lateral pseudointerareas absent, edges of valves butting; delthyrium broadly triangular, sides constricted by small, widely disjunct deltidial plates, leaving elongate, slotlike or slightly triangular foramen. Brachial valve strongly convex transversely and longitudinally; smooth region of umbo swollen, evenly rounded or slightly flattened along midline, crest nearly flat in profile; beak bluntly pointed, apex within pedicle valve.

Pedicle valve interior with strong hinge teeth supported by short vertical dental plates reaching valve floor, each plate fused to side of valve toward posterior. Muscle area subtriangular, apex between dental plates; individual muscle marks not observed.

Brachial valve interior with broad, crescentic, medially notched but undivided hinge plate; sockets elongate, anteriorly widening, deep, finely corrugate; crura diverging and strongly curved dorsally; median ridge low, rounded, slightly higher just beneath hinge plate forming small supporting brace. Muscle area on floor of valve, near anterior end of median ridge; anterior adductor scars forming rounded mark with posterior half divided by median ridge; posterior adductor marks small, widely separated, one on each side of anterior mark, converging slightly posteriorly.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (Cutoff Member).

LOCALITY.—AMNH 678.

DIAGNOSIS.—Large *Anteridocus* with broad outline, costate fold and sulcus, and nearly smooth flanks.

TYPES.—Holotype: USNM 154880d. Figured paratypes: USNM 154880f,g. Measured paratypes:

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle
					(°)
AMNH 678					
154880a	8.4	7.5	8.5	5.0	104
154880b	9.0	8.0	10.3	5.9	106
154880c	9.7	8.8	11.0	7.8	105
154880d	10.5	9.4	10.0	6.6	100
(holotype)					
154880e	9.7	8.8	10.5	7.2	100
154880f	9.2	8.3	9.5	6.1	86

USNM 154880a–c,e,f. Unfigured paratypes: USNM 154880a–c,e.

COMPARISON.—*Anteridocus eximius* is characterized by its relatively large size, broad outline, high fold with strong costae, nearly smooth flanks, and swollen brachial umbonal region. Its average size is about twice that of *A. gongylus*, new species, and its nearly smooth flanks contrast with the abundantly costate flanks of that species. *A. erugatus*, new species, is similar in shape, but smaller, and its nearly smooth shell with costae normally absent or obscure, even on the fold, distinguishes it from *A. eximius*. The posterolateral edges of the valves of species of *Cenorhynchia* abut instead of overlap, a feature that links them to *Anteridocus* and contrasts them to most other Permian rhynchonellids; however, only *C. fracida*, new species, becomes as large as *A. eximius*, and its narrow outline, hooked pedicle beak, and high median septum distinguish it clearly from *A. eximius*.

Anteridocus gongylus, new species

PLATE 538: FIGURES 53–58; PLATE 539: FIGURES 40–59

Average size for genus, strongly biconvex; outline subcircular to roundly subpentagonal, sides diverging between 90° and 110°; anterior commissure uniplicate; fold low, beginning 3–4 mm anterior to brachial beak, profile strongly and evenly convex, slightly arched transversely; sulcus shallow, beginning 4–5 mm anterior to pedicle beak. Costae rather strong, beginning 3–5 mm anterior to beaks, normally numbering 3, rarely 2 or 4 on fold, one less in sulcus, normally 3 or 4, rarely 2 or 5 on flanks. Concentric ornamentation consisting of faint rounded, closely spaced striae; growth laminae sporadically present, most frequent near anterior margins.

Pedicle valve moderately convex, flanks not reflexed; beak sharp, short, slightly curved dorsally; beak ridges sharp to blunt, prominent; delthyrium triangular, base normally slightly constricted by minute rudimentary deltidial plates; lateral pseudointerareas absent, no overlapping of valves. Brachial valve strongly convex longitudinally and transversely; umbonal area evenly convex to slightly flattened transversely or in profile; beak bluntly pointed, not strongly incurved.

Pedicle valve interior with sides diverging widely anterior to deltidial plates; teeth supported by vertical dental plates reaching valve floor. Muscle area heart-shaped, with point between anterior edges of dental plates; adductor scars small, forming elliptical mark along midline of valve in posterior part of muscle field; diductor scars larger, surrounding adductor scars laterally and anteriorly, widening greatly anteriorly and meeting at midline of valve to form anterior part of muscle area.

Brachial valve interior with hinge plate small, deeply and widely notched but undivided; beak curved over hinge plate and forming small recess for attachment of diductor muscles; sockets elongate, anteriorly widening, corrugated; crura strong, slightly diverging anteriorly from forward edge of outer hinge plate, braced along dorsal edges by keels extending under hinge plate, making crura concave dorsally and proximally; hinge plate supported by short median septal brace to floor of valve, rarely extending forward as low median ridge. Muscle pattern not clearly observed.

MEASUREMENTS (in mm).—

	brachial valve		mid-	maxi-	thick-	apical
	length	length	width	mum	ness	angle
				width		(°)
USNM 702a						
148105a	2.5	2.0	2.4	2.6	1.0	–
148105b	3.0	2.5	3.0	3.0	1.3	–
148105c	5.5	4.6	5.1	5.3	4.5	95
148105d	6.0	5.0	5.8	6.3	4.6	105
USNM 702						
148103a	3.8	3.2	3.2	3.5	1.7	86
148103b	4.7	4.0	3.9	4.2	2.1	88
148103c	5.0	4.3	4.5	4.9	3.0	89
148103d	6.6	5.6	6.1	6.4	4.8	97
148103e	7.0	6.4	6.8	7.6	4.9	109
148103f	7.3	6.4	7.3	7.7	6.0	98
148103g	6.9	6.3	7.1	7.3	5.1	100
USNM 702a						
154875k	7.2	6.3	7.6	7.8	6.0	97
(holotype)						

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—AMNH 500, 504; USNM 702, 702a, 702b, 702ent, 702-low, 702un; 703a¹, 703b, 703bs, 708.

DIAGNOSIS.—Rotund *Anteridocus* with moderately strong costae.

TYPES.—Holotype: USNM 154875k. Figured paratypes: USNM 148105f,g; 154875a-f,i,j,l; 154879a,b. Measured paratypes: USNM 148103a-g, 148105a-d. Unfigured paratypes: USNM 148103a-g; 148105a-c; 154875g,h,m.

COMPARISON.—*Anteridocus gongylus* is characterized by its bulbous form, moderately strong costae on the flanks as well as on fold and sulcus, and the slightly flattened profile of its brachial umbonal area. It is distinguished from *A. erugatus*, new species, by its sharper, stronger and more numerous costae, more nearly circular outline, more bulbous form, somewhat smaller maximum size, and strong costae on fold and flanks.

Anteridocus paucicostatus, new species

PLATE 515: FIGURES 5-7; PLATE 535: FIGURES 1-6

Small, subtrigonal outline, length and width about equal; posterolateral margins straight, forming angle about 90°. Sides rounded; maximum width near midvalve; anterior margin truncated. Beak short, foramen elongate oval, deltidial plates small, disjunct. Surface with anterior half costate but posterior half smooth. Costae broad and rounded, three on fold, two on each flank.

Pedicle valve gently convex in lateral profile, maximum curvature anterior to umbo; anterior profile broadly and gently concave. Umbonal region convex; sulcus originating at midvalve broad and shallow and with short tongue. Flanks narrowly rounded and steep.

Brachial valve evenly and moderately convex in lateral profile but broadly and moderately domed in anterior profile. Umbonal region swollen; fold originating at midvalve, defined by costae, only slightly elevated. Flanks moderately depressed and fairly swollen.

Pedicle valve interior with stout dental plates having wide umbonal chambers. Brachial valve

interior with undivided hinge plate having narrow outer hinge plates, coalesced inner hinge plates, stout crura concave inward, and no median septum.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 714y					
148590a	2.6	2.1	2.5	1.4	—
148590b	3.0	2.6	3.0	1.5	88
148590c	3.2	2.7	2.9	1.7	80
148590d	3.5	2.8	3.0	1.8	73
148590e	4.2	3.5	4.0	2.2	82
148590f	4.9	4.2	4.7	2.7	75
148590g	5.9	5.0	5.7	3.7	92
148590h	6.0	5.1	6.0	3.5	87
148590i	6.4	5.5	6.9	3.9	94
USNM 707h					
148615a	5.8	5.1	5.4	3.6	90
USNM 733j					
154723b (holotype)	5.1	4.2	4.8	3.2	83

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Poplar Tank and Sullivan Peak members).

LOCALITIES.—Poplar Tank: USNM 707h. Sullivan Peak: 714y, 733j.

DIAGNOSIS.—Small, anteriorly costate *Anteridocus* usually with two costae on flanks and low fold.

TYPES.—Holotype: USNM 154723b. Figured paratypes: USNM 148590a,b,e; 154723a-c. Measured paratypes: USNM 148590a-i, 148615a. Unfigured paratypes: USNM 148590c,d,f-i; 148615a-k.

COMPARISON.—The only species suggesting this one are *Pontisia nanas* (Stehli) which is much larger and with stronger, longer costae, and *Anteridocus seminudus*, new species, in which the costae are only noticeable along the margins but there are more of them on the flanks of *A. seminudus* and the latter has a longer and sharper beak which makes the posterolateral margins gently concave. Furthermore, the young of *A. seminudus* are long and slender and quite differently shaped from the wider *A. paucicostatus*.

DISCUSSION.—This is a rare species, having been found only in two localities but at two different stratigraphic levels. The species includes a few specimens that are wider than usual, as might be expected in a rhynchonellid species. No trace of a septum was seen in any of the brachial valve interiors.

Anteridocus seminudus, new species

PLATE 517: FIGURES 18–20; PLATE 535: FIGURES 26–51

Usual size for genus, wider than long in adults, but longer than wide at youth; outline subtrigonal; profile unequally biconvex, brachial valve deeper and more convex. Sides rounded; maximum width slightly anterior to midvalve; anterior margin truncated. Anterior commissure uniplicate. Beak short, pointed acutely, straight; deltidial plates rudimentary, disjunct. Surface paucicostate, costae confined to marginal region, 2 or 3 on fold, one less in sulcus, and 1–3 on each flank.

Pedicle valve unevenly convex in lateral profile, maximum curvature anterior to umbonal region and just posterior to midvalve; anterior profile faintly convex. Umbonal and median region somewhat narrowly swollen; sulcus originating at midvalve, shallow, forming short tongue; flanks slightly inflated and slightly deflected.

Brachial valve fairly strongly convex, maximum curvature in umbonal region; anterior profile broadly and evenly domed, sides sloping moderately to steeply. Umbonal and median regions fairly strongly inflated; fold, low, inconspicuous, originating anterior to midvalve, slightly elevated anteriorly. Flanks swollen and slightly depressed.

Pedicle valve interior with small knoblike teeth and delicate, slightly divergent dental plates. Brachial valve interior with strong, elevated socket ridges hanging over smooth sockets; hinge plate undivided, with variable anterior margin; outer hinge plates narrow; inner hinge plates variable, united, convex, flat or moderately deeply concave; median septum obsolete, remnant, not reaching floor, occasionally attached to underside of hinge plate. Median ridge small and threadlike, extending to about midvalve, but variably preserved.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 709c, 721t, 721x, 721y, 722f, 724b, 726c, 726d.

DIAGNOSIS.—Small, paucicostate *Anteridocus* with the costae confined to the margins.

TYPES.—Holotype: USNM 152855h. Figured paratypes: USNM 152855f,h; 154746a–c; 154863a–e; 154864a–c. Measured paratypes: USNM 152855a–g. Unfigured paratypes: USNM 152855a–e, 154746a.

COMPARISON.—This species has a triangular form,

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 722f					
152855a	7.2	6.1	7.5	3.8	90
152855b	5.9	5.0	6.0	3.4	90
152855c	5.5	4.7	5.8	3.2	90
152855d	5.4	5.0	4.9	2.8	80
152855e	4.3	3.5	4.0	2.4	70
152855f	3.8	3.1	3.2	1.9	60
152855g	3.3	2.7	3.0	1.4	60
152855h (holotype)	3.6	2.5	2.6	1.4	60
USNM 724b					
154746a	6.2	5.3	6.7	3.5	100

fairly wide at the front but the posterior three-fourths of the valve are smooth. The species need be compared only to the smaller species of *Pontisia*. It is unlike *P. franklinensis*, new species, and *P. nanas* (Stehli) because it has a less thick shell, finer costae, and has more of the surface noncostate than either of these species. In size and shape it is most like *Anteridocus paucicostatus*, new species, but has shorter costae, has a somewhat larger maximum size, and a narrower, shallower sulcus on the pedicle valve.

DISCUSSION.—This species proved to be common at USNM 722f where young as well as mature specimens were found. The young are smooth and strongly triangular and do not become costate until they attain about half their adult size. The beak is long and the delthyrium is constricted only slightly at its lateral extremities by rudimentary deltidial plates that are, in some specimens, elevated for a short distance on the delthyrial edge. The crura are fairly wide and stout for a small shell. The median septum is not formed but may appear as a minute ridge scarcely meeting the floor on the underside of coalesced inner hinge plates. Externally the species has a tendency to bicostation.

Anteridocus subcarinatus, new species

PLATE 551: FIGURES 43–46

Medium size for genus, length slightly greater than width; pentagonal in outline; maximum width slightly anterior to midvalve. Posterolateral margins slightly less than 90°; sides narrowly rounded;

anterior margin subnasute. Anterior commissure uniplicate. Beak moderately long, incurved, erect. Delthyrium open; deltidial plates absent. Surface paucicostate, umbones with 2 costae on pedicle valve and 1 on brachial valve, 2 on fold, and 1 in sulcus, and 2 on each flank. Costae, broad, low and rounded.

Pedicle valve strongly convex in lateral profile; broadly but flatly convex in anterior profile. Umbo narrowly swollen; sulcus originating on anterior side of umbo, widening and deepening slightly to anterior margin. Sulcus occupied by median costa originating about 3 mm anterior to beak and extending to anterior margin. Tongue moderately long and wide. Flanks rounded, narrow.

Brachial valve strongly convex in lateral profile, maximum curvature near umbo. Anterior profile narrowly domed, fold slightly protuberant in middle. Umbo narrowly carinated by median costa which is divided just posterior to midvalve to produce narrow strongly elevated fold, strongly convex longitudinally. Flanks swollen and considerably depressed below fold.

Pedicle valve interior with deeply entrenched, long diductor scars and dental plates obsolete. Brachial valve interior without median septum and with strongly divided hinge plate having fairly wide outer hinge plates.

MEASUREMENTS (in mm).—Holotype USNM 152980: length 8.3, brachial valve length 7.3, width 8.1, thickness 6.9, apical angle 85°

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Pinery and Hegler members).

LOCALITIES.—Hegler: USNM 731. Pinery: 725n.

DIAGNOSIS.—*Anteridocus* with bicostate fold, rotund appearance, and few costae.

TYPES.—Holotype: USNM 152980.

COMPARISON.—This species is most similar to *Anteridocus bicostatus*, new species, but differs in having deeper valves, more rotund appearance, a keeled umbo, narrower fold and sulcus, more strongly incurved beak, and the costae appear in the posterior half of the shell.

DISCUSSION.—This is an extremely rare species, known from only four specimens, but the characters are so strongly marked that we do not hesitate to propose it as a new species.

Anteridocus swallowianus (Shumard)

PLATE 534: FIGURES 50–64; PLATE 538: FIGURES 1–11

Camerophoria swallowiana B. F. Shumard, 1860:394, pl. 11: figs. 1a–e.

Pugnax swallowiana (Shumard) Schuchert, 1897:336.—Girty [part], 1909:314, pl. 15: figs. 8–11b [not figs. 12–12d (= *Tautosia elegans* (Girty))]. [Not of Hall and Clarke, 1894:240, pl. 60: figs. 27–32 (= *Wellerella*).]

Not *Pugnoides swallowiana* (Shumard) King, 1931:107, pl. 34: figs. 10 [= *Wellerella girtyi girtyi*], 11, 12 [= ?].

Small for genus, biconvex; both valves strongly inflated; outline bluntly triangular to pentagonal, sides diverging between 75° and 105°; profile sub-trigonal to elongate oval; anterior commissure uniplicate; fold low to moderately high, beginning 5–7 mm anterior to brachial beak, terminating abruptly anteriorly, profile of fold only slightly convex; sulcus rather shallow, beginning 5–7 mm anterior to pedicle beak, evenly convex longitudinally, or flexed dorsally near anterior margin. Costae low, sharp on fold and pedicle flanks, blunt on brachial flanks and in sulcus, beginning 4–6 mm anterior to beaks, numbering 3 or rarely 2 on fold, one less in sulcus, 2–4 on flanks. Concentric ornamentation faint or absent; growth lines present but weak.

Pedicle valve strongly inflated in smooth area near beak, gently convex toward flanks or with ends of costae on flanks slightly reflexed; beak short, curved, sharp, with obscure beak ridges; lateral pseudointerareas absent, valves meeting without overlap. Delthyrium in adults partly or completely covered by small deltidial plates, apical part open forming elongate oval foramen. Brachial valve strongly inflated in smooth area near beak, may be flattened or indented there, or evenly convex transversely; apex of valve within pedicle valve.

Pedicle valve interior with sides of delthyrium widely diverging anterior to deltidial plates, teeth parallel and supported by vertical dental plates reaching floor of valve. Muscle area elongate oval, lying just anterior to edges of dental plates; adductor scars median, small, surrounded laterally and anteriorly by larger diductor scars.

Brachial valve interior with triangular, anteriorly notched hinge plate, laterally bounded by deep, anteriorly expanding, finely corrugated sockets; crura projecting forward from anterior edges of hinge plate, anteriorly diverging, strongly curved

ventrally, dorsal edge carinate; median ridge greatly reduced or absent. Muscle area in smooth part of beak area, faintly impressed, details unknown.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 740					
152859a	6.1	5.7	5.5	3.4	85
152859b	6.6	5.9	6.6	5.5	80
152859c	7.9	7.3	7.8	6.8	79
152859d	8.4	7.7	9.0	6.5	92
USGS 2926 (green)					
118562a	8.8	8.1	10.5	6.0	98
118562b	9.3	8.2	10.0	6.2	100
118562c	9.9	8.8	11.7	7.1	104

STRATIGRAPHIC OCCURRENCE.—Capitan Formation; Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar Members).

LOCALITIES.—Capitan: AMNH 801, 804, 840, 847; USGS 2926; USNM 725j, 725k, 725-l, 728u, 732q, 735j, 738a, 739, 740, 740-l, 740m, 740n, 740o, 748a, 750a. Hegler: USNM 731, 732a, 740c. Pinery: AMNH 33, 398, 524; USNM 725h, 725n, 733. Rader: USNM 725g, 740a, 740h, 740i, 740j. Lamar: AMNH 37, 40, 347, 401; USNM 725e, 725f, 728p, 728q, 728r, 738, 738b.

DIAGNOSIS.—Semicostate *Anteridocus*, small and triangular, with swollen valves but flattened and concave umbonal region on the brachial valve.

TYPES.—Figured hypotypes: USNM 154855a-d; 154856; 154857; 154858; 154859d; 154860a,b,d; 154861a; 154929. Measured hypotypes: USNM 152859a-d, 118562a-c.

COMPARISON.—*Anteridocus swallowianus* is characterized by its small size, inflated umbones, with depression in dorsal one, prominent anterior end of fold, short beak with dental plates small or absent, low costae that extend only about half valve length, and the reduced or absent median septum. Similar species are *Tautosia elegans* (Girty) and *T. shumardiana* (Girty). Each of these species becomes larger than *A. swallowianus*, lacks the inflated umbones, and has a high, bladeliike median septum in the brachial valve. "*Pugnoides osagensis* var. *occidentalis*" (Girty) is somewhat inflated and to that extent resembles *A. swallowianus*, but its flanks have stronger and more numerous costae, and the longitudinal profile of its fold is more strongly convex. This variety was considered by

King (1931:107) to be a synonym of *A. swallowianus*, but his interpretation was based on comparison with his specimens, not any of which are *A. swallowianus* (see synonymy).

Fredericks (1932a, pl. 1: figs. 2a-d) figured the exterior of a specimen similar to ours as *A. swallowianus*. To judge by his illustrations, his identification of *A. swallowianus* in the "Upper Carboniferous" of Pechora-land is correct. However, the interior is not exhibited, consequently the identification must be held uncertain.

DISCUSSION.—Girty's illustrated (1909) specimens of *Pugnax swallowiana* and *P. bidentata* represent forms that differ considerably in outline and stratigraphic level. They are similar in profile, however, and both have the specific characters of swollen umbones and weakly costate brachial flanks. The latter does not have the umbonal pit so characteristic of *A. swallowianus*. The National Museum collections contain specimens of *A. swallowianus* with two costae on the fold intermediate between the narrow extreme of *P. bidentata*, and the transverse extreme of Girty's *A. swallowianus*. Shumard's (1860, pl. 11: figs. 1c-d) illustrations of the holotype show a specimen that is intermediate in width. We have been unsuccessful in attempts to separate the two forms into two consistently differing groups of specimens. The number of costae on the fold is reliable for distinction of species only in a broad way, and the difference between specimens with 2 and those with 3 is insignificant. In fact, Girty (1909, pl. 15: fig. 12) illustrated a specimen with 2 costae on the fold, assigning it to *A. swallowianus* (although we now consider that specimen to belong to *Tautosia elegans*).

The specimen illustrated by Girty (1909, pl. 21: fig. 19) as an interior of *Pugnax swallowiana* has a short but well developed low median ridge. Most of the Museum specimens from the Guadalupe Mountains have no median septum. We believe that Girty's specimen represents a different species.

An interesting feature of this species, unlike that in any other species of *Anteridocus*, is the deep depression of the umbonal region of the brachial valve. Other species from the Capitan Limestone and its equivalents have the same sort of concave umbo, such as *Strigirhynchia* and *Ptilotorhynchus*, new genera. This suggests the possibility that *A. swallowianus* may be related to some other generic stock rather than to *Anteridocus*.

Anteridocus triangulatus, new species

PLATE 521: FIGURES 58-61

Usual size for genus, roundly triangular outline, length and maximum width nearly equal. Anterolateral extremities rounded; posterolateral margins forming angle of 78° . Anterior commissure uniplicate. Beak strongly curved and closely appressed to brachial valve umbo; surface paucicostate, posterior half smooth; anterior with costae, four on fold, flanks with one indistinct costa.

Pedicle valve fairly strongly and evenly convex in lateral profile, anterior profile broadly domed, only slightly convex on top and with short steep sides. Sulcus originating near midvalve, wide and shallow; umbonal region swollen; flanks convex and steep.

Brachial valve slightly deeper, moderately convex in lateral profile but narrowly domed and with steep sides in anterior profile; umbonal region swollen; fold beginning at midvalve, poorly defined throughout length; flanks swollen and rounded.

Brachial valve interior with undivided hinge plate but no median septum.

MEASUREMENTS (in mm).—Holotype USNM 154768a: length 7.8, brachial valve length 7.0, width 7.5, thickness 6.4, apical angle 78° .

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITY.—USNM 732j.

DIAGNOSIS.—Triangular *Anteridocus* with 4 costae on the fold.

TYPES.—Holotype: USNM 154768a.

COMPARISON AND DISCUSSION.—The subtriangular outline and the 4 costae on the fold distinguish this species from all others of *Anteridocus*. Paratype USNM 154768b is a smaller individual of which the valves have been separated. The dorsal valve preserves the hinge plate which is without a median septum. The crural bases of this hinge plate extend unusually far below the undersurface of the hinge plate.

Family CAMAROTOECIIDAE Schuchert and LeVene, 1929

Subfamily CAMAROTOECIINAE Schuchert and LeVene, 1929

Rhynchonellacea with valves partly to completely

costate, the costae often dividing. Pedicle valve usually with open delthyrium and short, often obsolescent, dental plates; brachial valve with hinge plate divided; small apical chamber thickened and obsolescent in old shells. Crura mucrifer.

Genera in West Texas: *Bryorhynchus* Cooper and Grant, 1969; *Leiorhynchoidea* Cloud, 1944.

Bryorhynchus has not been found outside of the Guadalupe and Delaware Mountain areas except for one rare occurrence in the Glass Mountains. It is abundant in the black limestones of the Hegler and Pinery members of the Bell Canyon Formation. Like most camarotoechiids, it favored an environment dominated by dark or black muds. Hence, its rarity from the Glass Mountains where black limestones are few.

Genus *Bryorhynchus* Cooper and Grant, 1969

Bryorhynchus Cooper and Grant, 1969:11.

Medium size, strongly biconvex, brachial valve inflated near umbo; outline transversely to longitudinally subovate or roundly trigonal; commissure uniplicate, height of fold increasing with size of shell; costae weak or absent, normally present only near anterior margins of fold and sulcus, without bifurcation or intercalation. Concentric ornamentation weak or absent; growth lines widely spaced over most of shell, more closely crowded toward anterior margins. Pedicle beak short, erect to incurved; delthyrium triangular, open, with obscure deltidial plates, rarely with conjunct plates; beak ridges long, bordering long, narrow, lateral pseudointerareas; slight overlapping of lateral pseudointerareas by edge of brachial valve; umbonal area somewhat inflated, with blunt median longitudinal crest. Brachial beak blunt, apex within pedicle valve; fold may have flat crest or slight longitudinal median indentation extending into umbonal area.

Pedicle valve interior with sides widely diverging anterior to delthyrium, each side with one knoblike elongate tooth parallel to it; dental plates converging toward valve floor often fused to sides of valve. Muscle area narrowly triangular, expanding anteriorly, sides straight or curving laterally just anterior to dental plates; adductor scars small, median, posterior, lying just anterior to dental plates, each broadly rounded posteriorly, narrowed to a point anteriorly, together forming heart-shaped

scar; diductor scars larger, beginning posteriorly as narrow lines in beak area, posterior and lateral to adductor marks, widening anteriorly, curving around adductor marks, contacting one another at median line of valve, anteriorly surrounding adductor marks.

Brachial valve interior with short, wide, hinge plate, partly divided by narrow, wedge-shaped notch; sockets wide, deep, anteriorly expanding, strongly corrugated, bounded laterally by slight thickening along posterior margins; crura mucrifer, long, fragile, projecting from hinge plate, one on each side of median notch, slightly diverging anteriorly, curved strongly toward pedicle valve; median septum low, normally present just below hinge plate, attached to it with shallow crural cavity that may be filled with callus, simulating an undivided hinge plate; anteriorly, septum continuing low and thin to near midline of valve, or may be low, rounded median ridge, or may be absent. Posterior adductor muscle marks very long, posterior ends touching median septum or ridge, diverging slightly anteriorly, with anterior ends contacting small, elliptical to nearly circular anterior adductor scars.

TYPE-SPECIES.—*Camarophoria? bisulcata* Shumard (1859:296).

COMPARISON.—*Bryorhynchus* is characterized by its nearly smooth shell, rotund outline, bulbous brachial valve, short, hooked pedicle beak, divided hinge plate with shallow crural cavity, low median septum or median ridge, and strongly denticulate hinge sockets. It is related to *Leiorhynchus* Hall and *Leiorhynchoidea* Cloud, as evidenced by its similar muscle pattern and external shape. It differs from *Leiorhynchus* in its low, often obsolete median septum, or ridge, and strongly denticulate hinge sockets. The low median ridge also distinguishes it from *Leiorhynchoidea*, as do its divided hinge plate and crural cavity.

DISCUSSION.—Specimens of *Bryorhynchus* occur in countless numbers in the dark limestone members of the Bell Canyon Formation (Hegler through Rader members). In many places these specimens are well silicified, consequently it is possible to obtain an abundant supply of fine specimens that give nearly all the details of the shell anatomy. The specimens in the National Museum collection show to perfection the considerable variation of the interior consequent to deposition of callus shell, a phenomenon that may cause the obliteration

of generic characters such as the brachial valve septum.

Bryorhynchus is usually very unevenly calcified, the posterior ends being thick and heavy but the anterior very thin and fragile. This results in some distortion of specimens and, in many specimens, loss of the anterior part. Nevertheless these posterior parts are superb study materials for all details of the cardinalia and delthyrial region.

The deltidial plates are so small and fragile that they are not preserved in all specimens. The individuals that do show good development of these structures indicate that the deltidial plates are usually disjunct. The beak is usually strongly incurved and in *B. bisulcata* (Shumard) is pressed tightly to the dorsal umbo, suggesting that the pedicle was no longer functional and that the shell lived loose on the sea bottom. The heavily weighted posterior would tend to hold that part down and permit the anterior end to extend obliquely upward out of the mud.

The teeth of the pedicle valve are often very large and consist of several parts. In old specimens they are broadly triangular and protrude into the interior. They are attached to the valve wall by a thin plate lying just under the margin, suggesting the fulcral plate of the opposite valve. Indeed its function is essentially the same as that of the fulcral plate, because it defines the elongate trough, or socket, separating the shell edge from the outer side of the tooth. Thus the tooth is hook-shaped in section and the dental plate is welded to the inner sloping face of the tooth. In some specimens the cavities between the dental plates and shell wall are filled with tissue and the tooth appears to be unsupported.

The dental plates are short and usually strongly recessive. They extend forward to the inside of the tooth but then recede posteriorly to line the wall of the delthyrial cavity. Anterior to the anterior ends of the dental plates the narrowly triangular muscle field is usually strongly impressed. In old shells this is deeply etched into the valve floor, but in the young it is not usually easily seen. At the posterior, or apical, end of the triangle two thickened patches extend anteriorly. These fill in the spaces between the posterior ends of the centrally placed adductor scars, which are anteriorly surrounded by the diductors.

The cardinalia are distinctive but vary with age.

The socket ridges are conspicuous parts of the cardinalia as they form a ridge around the posterior margin of the hinge plate. In many specimens the ridge is somewhat alate and elevated at its distal end. The socket ridges define deep, corrugated sockets which at their distal end are generally floored by a well-defined fulcral plate. The outer hinge plates are broad and are usually concave. They are bounded externally by the socket ridge and on their inside by the thickened and elevated crural base. Inner hinge plates were not seen.

Attached to the somewhat rounded, narrow and thick crural base is a long crus, rodlike proximally but flattened to somewhat spatulate distally, the flattening taking place in an anteroposterior direction. Proximally, the rounded but slender crus is laterally expanded to form a long crural keel that unites with the median septum to produce a V-shaped chamber. The hinge plate is thus divided by a narrow slit bounded by the crural bases and forming a narrow apical cavity. Some specimens appear to have an undivided hinge plate because the apical chamber is progressively filled from the apex anteriorly by adventitious shell. In such specimens the hinge plate is variously notched; the notches are broad in some but narrowly slitlike in others.

Deposition of the tertiary shell layer affects other structures as well as the cardinalia. The entire apical region of the brachial valve is often covered by shell tissue that buries all or part of the median ridge. In some specimens the septum is moderately long, high, and slender but in the majority it is merely a myophragm separating the lateral halves of the adductor field, which is a narrowly elongate oval scar usually fairly well defined.

Bryorhynchus bisulcatum (Shumard)

PLATE 508: FIGURES 40-47; PLATE 546: FIGURE 25;
PLATE 547: FIGURES 6-79; PLATE 548: FIGURES 6-17

Camarophoria? bisulcata Shumard, 1859:296; 1860:394, pl. 11: fig. 2.

Pugnax? bisulcata (Shumard) Girty, 1909:310, pl. 21: figs. 11-12.

Bryorhynchus bisulcatum (Shumard) Cooper and Grant, 1969:11.

Average size for genus; outline transversely sub-elliptical; anterior commissure uniplicate, fold moderately high at anterior margin of adults,

beginning 8-12 mm anterior to brachial beak; sulcus shallow; costae normally weak, rarely absent on adults, present near anterior margins of fold and sulcus, rarely on flanks, numbering 3 to 5 on fold, one less on sulcus. Concentric ornamentation not visible; growth lines widely spaced over most of shell, crowded near anterior margins.

Pedicle valve moderately convex, umbonal area with bluntly rounded longitudinal median crest, giving way anteriorly to shallow sulcus; beak short, abruptly tapered, oblique to erect, not tightly hooked, not in contact with brachial umbo; delthyrium triangular, open, perforating apex of beak; beak ridges long, bordering exposed narrow pseudo-interareas; slight overlapping of pseudointerareas by edge of brachial valve. Brachial valve strongly convex, umbonal area inflated; fold often with flat to slightly indented crest extending into umbonal area.

Pedicle valve interior with hinge teeth forming elongate knobs parallel to sides of valve, supported by dental plates reaching valve floor; dental plates converging but not meeting, partly or completely fused to sides of valve. Muscle area triangular; adductors forming small, median, bilobed, heart-shaped scar, with apex pointing anteriorly; diductors beginning between dental plates as narrow lines, widening anteriorly to form heart-shaped area with apex pointing posteriorly.

Brachial valve interior with short, wide, divided hinge plate, bounded laterally by deep, elongate, anteriorly expanding, strongly corrugated sockets; crura projecting from hinge plate, slightly diverging anteriorly, strongly curved ventrally; median ridge low, rounded, rarely high enough to be considered a septum; crural cavity small, formed by convergent plates beneath notch in hinge plate, meeting on crest of median ridge, often filled with callus. Posterior adductor muscle scars long, narrow, slightly curved, diverging anteriorly, meeting posterior edges of larger, elongate elliptical to nearly circular anterior adductor marks.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members); Capitan Formation.

LOCALITIES.—Getaway: Moore 31; USNM 732. Hegler: USNM 731, 732a, 740c, 740d. Pinery: AMNH 33, 524, 537, 435; USNM 725h, 725n, 733. Rader: AMNH 388, 397, 403, 410; USNM 725f,

MEASUREMENTS (in mm).—

	brachial valve length	length	width	thick- ness	apical angle (°)
USNM 731					
148132a	c.5.5	?	6.0	?	?
148132b	c.7.0	?	8.9	?	?
148132c	9.5	?	9.5	?	?
148132d	18.4	16.1	21.0	8.0?	120
USNM 733					
148130a	11.5	10.8	11.6	8.9	110
148130b	13.9	12.9	13.9	9.8	110
Moore 31					
148128	13.0	12.0	12.9	9.8	123
USGS 2930 (green)					
118558a (neotype)	14.1	13.2	15.8	10.8	110
AMNH 33					
148135a	14.3	12.0	15.5	9.6	110
148135b	12.6	11.5	13.0	8.7	95
148135c	11.0	10.0	11.3	8.2	90
148135d	9.6	8.6	9.7	5.4	90

725g, 725o, 740a, 740i, 740j. Lamar: AMNH 40; USNM 728p. Capitan: USNM 748a; USGS 2930.

DIAGNOSIS.—*Bryorhynchus* with fold and sulcus anteriorly plicated and beak not in contact with the brachial valve umbo.

TYPES.—Neotype: USNM 118558a. Paratype: USNM 118558b. Figured hypotypes: USNM 154905a–c; 154906a–e; 154907; 154908a–d,f,g,i,j; 154909a–d,h–k,m,o; 154910a,b; 154931a,b. Measured hypotypes: USNM 148128; 148130a,b; 148132a–d; 148135a–d.

COMPARISON.—*Bryorhynchus bisulcatum* is characterized by its transversely subelliptical outline, moderately high fold that normally has a few weak costae near the anterior margin, low median ridge, rarely a median septum, short curved beak that is not in contact with the brachial umbo, and lateral pseudointerareas that are exposed, not completely covered by overlapping of the edge of the brachial valve. These features distinguish the species from *B. gratiosum* (Girty).

DISCUSSION.—R. E. King (1931:105, pl. 33: figs. 1–8) assigned several specimens to "*Leiorhynchus*" *bisulcatum* (Shumard). Shumard's (1860: pl. 11: fig. 2) illustrations are not strictly accurate, but they show a specimen that differs from King's in several important features. King's specimens are more strongly costate, with costae on the flanks as well as the fold and sulcus, and they have the sulcus beginning far back on the umbo to where Shu-

mard's specimen has a ridge instead of a trough. Shumard illustrates the profile (fig. 2d) of the shell, showing the beak to be nearly straight. His description (1859:296) portrays the beak, as, "incurved nearly in contact with the opposite valve," which is true of *B. bisulcatum*, but not of King's specimens. We believe that King's are specimens of *Leiorhynchoidea amygdaloidea*, new species.

Bryorhynchus gratiosum (Girty)

PLATE 548: FIGURES 1–5

Pugnax? bisulcata (Shumard) var. *gratiosa* Girty, 1909:312, pl. 21: figs. 10–10c.

Pugnax? bisulcata (Shumard) var. *seminuloides* Girty, 1909:312, pl. 21: figs. 13–16, pl. 29: fig. 9.

Average size for genus; outline subelliptical to bluntly subtrigonal; anterior commissure uniplacate; fold normally low at anterior margin of adults, beginning 8–12 mm anterior to brachial beak, sulcus shallow; costae normally absent, rarely faintly present at anterior end of fold or sulcus. Concentric ornamentation not visible; growth lines closely spaced, stronger near anterior margins.

Pedicle valve moderately convex, umbonal area somewhat inflated, with bluntly rounded longitudinal median crest giving way anteriorly to shallow sulcus; beak moderately long, abruptly tapered, strongly curved, normally erect and in tight contact with brachial umbo except at posterior extremity; delthyrium triangular, open, producing minute perforation at apex of beak; beak ridges short, rounded; lateral pseudointerareas narrow, obscurely delimited, mostly covered by edge of brachial valve. Brachial valve strongly convex, umbonal area strongly inflated; fold often with slight longitudinal indentation along crest, extending into umbonal area.

Pedicle valve interior with narrow elongate knob-like hinge teeth, dental plates reaching floor of valve, converging but not meeting, normally not fused or cemented to sides of valve. Muscle area elongate triangular, sides straight; adductors forming small, median heart-shaped scar with apex forward; diductors beginning between dental plates as narrow lines, proceeding forward, lateral to adductors, there expanding slightly, each forming small triangle with apex posterior.

Brachial valve interior with short wide hinge

plate, divided by narrow wedge-shaped notch, bounded laterally by deep, narrow, moderately strongly denticulate hinge sockets; crura projecting forward from edges of hinge plate, slightly diverging anteriorly, strongly curved ventrally, converging posteriorly beneath hinge plate to form small crural cavity; median septum low, long, thin, rarely low enough to be median ridge, posterior end in contact with crural cavity. Posterior adductor muscle scars long, narrow, slightly diverging anteriorly, extending forward to small subcircular anterior adductor marks.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 736					
148148a	6.8	6.1	6.5	2.6	?
148148b	7.7	7.0	8.0	2.9	95
148148c	9.6	8.8	10.9	5.6	?
USNM 735					
148153a	10.5?	10.0	11.7	6.3	?
148153b	11.2	10.2	12.4	7.6	110
148153c	13.4	11.9	14.0	8.2	105
148153d	15.0	13.9	15.0	10.6	105
148153e	15.5	13.8	16.8	9.7	110
USGS 2930 (green)					
118559	15.6	14.8	15.6	12.3	110
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Bell Canyon Formation (Hegler, Pinery, and Rader members).

LOCALITIES.—Getaway: AMNH 512. Hegler: USNM 731. Pinery: USGS 2930 (green); USNM 736. Rader: USNM 735.

DIAGNOSIS.—Usually noncostate *Bryorhynchus* with pedicle valve beak closely appressed on the umbo of the brachial valve.

TYPES.—Holotype: USNM 118559. Measured hypotypes: USNM 148148a–c, 148153a–e.

COMPARISON.—*Bryorhynchus gratiosum* is distinguished from *B. bisulcatum* (Shumard) by its more triangular outline, low fold, normally noncostate shell, low thin median septum, strongly hooked pedicle beak that normally is in close contact with the brachial umbo, obscure lateral pseudointerareas, normally straight-sided brachial muscle area, and its pedicle dental plates that are not fused to the sides of the valve.

DISCUSSION.—Girty (1909:312) distinguished *Pugnax? bisulcata* vars. *gratiosa* and *seminuloides*

from *P.? bisulcata* on the basis of the number and strength of costae on the fold. He admitted that such a criterion left some specimens intermediate between two varieties. We believe that the length and curvature of the pedicle beak, plus the other distinguishing characters mentioned above, are more useful as criteria for separating the two kinds of shells. However, this formula still offers no valid method for distinguishing Girty's variety *seminuloides*, and we have accordingly included it with *B. gratiosum*.

Bryorhynchus? nitidum (Girty)

PLATE 510: FIGURES 39–43

Pugnax nitida Girty, 1909:313, pl. 24: figs. 15–15c.

We have found only one specimen referable to this species in all the residues from the Guadalupe Mountain region in the collections of the National Museum of Natural History and the American Museum of Natural History. The type specimen is small, measuring 9 mm in length, 10.6 mm in width and 6.0 mm in thickness. The specimen is characterized by its wide fold and shallow sulcus, with no ornament except on the margin of the pedicle valve tongue where 5 indistinct costae appear. The exterior features thus suggest *Bryorhynchus*, which is so common in the upper parts of the Guadalupe Permian. This suspicion is confirmed by the presence of a long median septum, visible from the exterior when the shell is moistened. Two somewhat closely spaced and convergent dental plates are also visible under the same conditions.

The location and horizon from which *B? nitidum* was taken have been a matter of speculation. Girty's map (1909, pl. 1) shows the location of this species, USGS 2920 (green), as west of the big bend of the highway in the pass, and it is stated that the location is in a small canyon in the foothills 2 miles south of Guadalupe Peak. This places the locality, within the mapped band of Bone Spring Formation, which is confirmed by P. B. King in his Guadalupe studies (1948:21, 22). The stratigraphic level of this species and its associates "*Pugnax? bidentata* Girty and "*P.? osagensis* Girty (not Swallow) is from the black Bone Spring Formation.

TYPES.—Holotype: USNM 118563.

Bryorhynchus plicatum, new species

PLATE 550: FIGURES 8-19

Usual size for genus, subcircular in outline with well rounded sides and truncated anterior margin; maximum width at midvalve. Valves unequally convex, brachial valve much deeper than pedicle valve. Anterior commissure strongly uniplicate. Maximum width slightly anterior to midvalve. Surface smooth in posterior third to half, marked by low, broad plicae in anterior half, 3 on fold, each flank marked by 2 to 3.

Pedicle valve gently convex in lateral profile, maximum convexity in median region; anterior profile unevenly and flatly convex, narrow median elevation flanked by slightly concave to flat flanks. Umbonal region narrowly convex, convexity extending and increasing to midvalve, there merging onto tongue. Flanks narrowly concave with margins slightly reflected in ventral direction. Sulcus broad and shallow, defined only at anterior and extending onto long, rounded tongue.

Brachial valve strongly convex in lateral profile, umbonal region flattened, maximum swelling in anterior half; anterior profile strongly rounded with long, steep sides. Umbonal region flattened to slightly concave; fold originating near midvalve, low and spreading, and not strongly differentiated.

Interior with long, thin median septum in brachial valve reaching to midvalve. Dental plates of pedicle valve short.

MEASUREMENTS (in mm).—

	brachial valve length	width	thick- ness	apical angle (°)
USNM 731z				
153484a	16.3	15.4	17.3	12.7
(holotype)				
153484b	17.5	15.4	17.6	10.5
153484c	15.0	14.8	16.5	11.3
				beak missing

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member).

LOCALITY.—USNM 731z.

DIAGNOSIS.—*Bryorhynchus* of usual size with smooth posterior and broadly plicated anterior.

TYPES.—Holotype: USNM 153484a. Figured paratypes: USNM 153484b,d. Measured paratypes: USNM 153484b,c. Unfigured paratypes: USNM 153484c,e-i.

COMPARISON AND DISCUSSION.—This species is unlike any of those from the Bell Canyon Formation of the Guadalupe Mountains in which the costation is usually less coarse when present and which are usually more nearly smooth. It is also unlike species of *Leiorhynchoidea* which all have a more pronounced sulcus and have more costae.

This species has been placed in *Bryorhynchus* because of its rounded and compact outline, its strongly swollen brachial valve, and the abruptly geniculated tongue of the pedicle valve. It is rare in the Glass Mountains.

Genus *Leiorhynchoidea* Cloud, 1944

Leiorhynchoidea Cloud, 1944:57.—Williams et al., 1965:H581.

Interior details of *Leiorhynchoidea* are different from those of *Bryorhynchus*. Although some specimens attain large size, the teeth of the pedicle valve are small and knoblike and the deltidial plates when present are conjunct. These plates are small and the junction is very narrow, consequently many specimens do not preserve them. The dental plates are commonly obsolete because of filling in of the umbonal chambers.

The construction of the cardinalia of the brachial valve is much like that of *Bryorhynchus*, but the median septum is much stronger and the V-shaped chamber is small and commonly filled in to create a solid plate across the septum. The mucifer crura are very long, slender, and have horizontally flattened distal extremities.

Members of this genus are rare at most places in the Glass Mountains and, when silicified, are extremely fragile. It is thus difficult to obtain complete and perfectly preserved specimens. The genus appears also to be rare in the lower Guadalupian rocks in the Guadalupe Mountains, except in the black limestone of the South Wells Member, where thickened posterior parts of both valves yielded good details of the interior.

TYPE-SPECIES.—*L. schucherti* Cloud (1944:58, pl. 18: figs. 28-31, pl. 19: figs. 2-4, 6-8).

DIAGNOSIS.—Large, often coarsely costate Camerocheiinae with undivided hinge plate, conjunct deltidial plates, and a high, slender median septum in the brachial valve.

Leiorhynchoidea amygdaloidea, new species

PLATE 548: FIGURES 19–38

Leiorhynchus bisulcatum R. E. King [not Shumard], 1931:105, pl. 33: figs. 1–8.*L. weeksi nobilis* R. E. King [not Girty], 1931:105, pl. 33: figs. 9–11.

Small for genus, biconvex; outline transversely subelliptical to elongate oval; anterior commissure uniplicate, fold low, broadly arched, beginning 8–10 mm anterior to brachial beak, profile gently convex, maximum convexity near beak, anterior half nearly straight; sulcus shallow, longitudinal convexity nearly uniform; costae low, crests rounded, beginning 3–6 mm anterior to beaks, numbering 3 on fold, 2 in sulcus, 3 or rarely 4 on flanks, strongest on fold and sulcus, low and obscure on flanks; costellae fine, converging toward crests of costae, increasing anteriorly in troughs. Concentric ornamentation absent; growth lines weak, widely spaced.

Pedicle valve moderately convex longitudinally through sulcus, flatly convex transversely, with slight median longitudinal crest giving way anteriorly to sulcus; beak curved, oblique to erect; beak ridges sharp, long, bordering long narrow lateral pseudointerareas partly covered by edge of brachial valve; delthyrium triangular, base covered or constricted by small, disjunct deltidial plates. Brachial valve nearly flat along fold, strongly convex transversely, 3 costae of fold extending farther back toward umbo than lateral costae.

Pedicle valve interior with sides abruptly widened anterior to deltidial plates; teeth small, elongate denticulate knobs, supported by slightly convergent dental plates reaching floor of valve, not fused to sides of valve; edges of valve anterior to hinge teeth with small flaps forming internal extensions of lateral pseudointerareas. Muscle area elongate triangular; adductor scars small, elongate, one on each side of median line, located anterior to ends of dental plates; diductors large, lobate, each beginning as narrow line near edge of dental plate, expanding slightly around small adductor scar, widening abruptly anterior to adductor, diductors meeting at median line.

Brachial valve interior with undivided triangular hinge plate, medially notched, with small crural depression or cavity often filled with adventitious

material; median septum high, thin, long, joined to small plates forming crural cavity; hinge sockets long, narrow, finely denticulate, bounded internally by socket ridges from hinge plate; crura long, flat, narrowly diverging from anterior of hinge plate, gently curved ventrally and expanding distally. Posterior adductor muscle scars long, narrow, closely adjacent to median septum on each side; anterior adductor scars not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706					
148264a	7.3	6.6	7.4	2.8	90
148264b	14.4	13.2	13.7	9.2	90
148264c	18.0	16.6	16.0	11.5	100
USNM 706b					
148268a	15.0	13.8	15.7	8.4	110
148268b	17.2	?	19.8	?	110
King 144					
YPM 12552 (holotype)	18.9	17.4	18.0	11.1	95
USNM 721p					
148282	14.2	13.0	13.2	7.5	90

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch members, and lens just above Willis Ranch Member).

LOCALITIES.—China Tank: USNM 721p. Willis Ranch: USNM 706, 706e; King 144. Lens: USNM 706b.

DIAGNOSIS.—Small *Leiorhynchoidea* with fairly strong costae and delicate interior structures.

TYPES.—Holotype: YPM 12552. Figured paratypes: USNM 148263a, 148265, 148268a, 148282. Measured paratypes: USNM 148264a–c; 148268a,b; 148282. Unfigured paratypes: USNM 148263b, 148268b.

COMPARISON.—*Leiorhynchoidea amygdaloidea* is characterized by its relatively small size, narrow outline, strong convexity but nearly flat profile of the fold, strongly curved pedicle beak, normally 3 costae on the fold and 2 in the sulcus, and low rounded, weak costae on the flanks. It differs from *L. schucherti* Cloud in its flatter fold profile and correspondingly higher fold, 3 costae on the fold instead of 4, and its stronger costae on fold and sulcus and on the flanks. Its normally narrower outline and its costae distinguish *L. amygdaloidea* from *L. laevis* Cloud. It differs from *L. claudi* Cooper in its smaller size, weaker and more rounded

costae, lower convexity, and less strongly curved pedicle beak. It differs from *L. scelestia*, new species, in its smaller size, weaker, more rounded costae, narrower outline, weaker growth lines, greater convexity of both valves, and higher fold.

Leiorhynchoidea rotundidorsa, new species

PLATE 550: FIGURES 20-37

Average size for genus, moderately biconvex; outline transversely and roundly elliptical; wider than long; maximum width at midvalve; anterior commissure uniplicate; fold low, broadly arched, defined best at commissure beginning about slightly anterior to midvalve; profile evenly convex, without strongly convex umbonal area; sulcus shallow; costae low, beginning 3-5 mm anterior to beaks, crests rounded, numbering 3 or 4 on fold, 2 or 3 in sulcus, 4 or 5 on each flank. Concentric ornament absent; growth lines widely spaced over most of shell, more closely crowded and stronger toward anterior margins.

Pedicle valve gently convex longitudinally and transversely; umbonal area with low, blunt median crest giving way anteriorly to sulcus near midvalve; beak moderately curved, normally oblique; beak ridges sharp, long bordering narrow anteriorly expanding lateral pseudointerareas; delthyrium triangular, wide, perforated at apex, base constricted or closed by disjunct small deltidial plates (?). Brachial valve moderately convex longitudinally, strongly convex transversely; edges of valve overlapping lateral pseudointerareas of pedicle valve.

Pedicle valve interior with sides abruptly widening anterior to deltidial plates, each side with small knoblike tooth; dental plates converging toward valve floor, diverging anteriorly, normally not fused to sides of valve. Muscle area small, subcircular; adductor scars small, elongate, one on each side of median line; diductor scars beginning between edges of dental plates as narrow lines, widening anteriorly, surrounding adductor scars laterally and anteriorly.

Brachial valve interior with short, wide grooved hinge plates; outer hinge plates small; inner hinge plates uniting with median septum to form nar-

row groove; median septum high, strong, long, posterior end joining plates of crural cavity; crura with stout bases, but distal extremities broken; sockets elongate, narrow, finely denticulate, bounded internally by narrow socket ridges; muscle marks faint; posterior adductor scars long, narrow, outwardly slightly bowed; anterior adductor scars not clearly observed, probably small, subcircular, as in other camarotoechiids.

MEASUREMENTS (in mm).—

	brachial valve length	width	thick- ness	apical angle (°)
USNM 728				
148285a	11.0	10.0	12.0	4.7
148285b	18.8	?	22.7	?
(holotype)				
148285c	?	16.0	21.0	8.5
148285d	19.4	?	21.6	?
148285e	?	16.3	21.4	9.8

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—USNM 728.

DIAGNOSIS.—*Leiorhynchoidea* of medium size with strongly convex and swollen brachial valve and delicate cardinalia.

TYPES.—Holotype: USNM 148285b. Figured paratypes: USNM 148285a,c,d,f. Measured paratypes: USNM 148285a,c-e. Unfigured paratypes: USNM 148285e.

COMPARISON.—*Leiorhynchoidea rotundidorsa* is characterized by its many low costae, transverse outline, low fold, strongly and uniformly convex brachial valve, grooved hinge plate, and relatively large crural cavity. It differs from *L. schucherti* Cloud in its more strongly costate flanks and more transverse outline. Presence of costae distinguishes it from *L. laevis* Cloud; its larger size more numerous costae on fold and flanks, more transverse outline, lower fold, fused dental plates, and slightly excavated umbonal area in the pedicle interior distinguish it from *L. mexicana* (Cloud). It is smaller and less strongly costate than *L. nobilis* (Girty), *L. cloudi* Cooper, or *L. scelestia*, new species. In addition, its beak is less strongly curved, fold lower, and costae more numerous (although weak) than in *L. cloudi*, and it is much more strongly convex than *L. scelestia*.

Leiorhynchoidea scelestia, new species

PLATE 549: FIGURES 1-28; PLATE 550: FIGURES 38-53

Unusually large for genus, flatly biconvex; outline transversely subelliptical to bluntly trigonal, anterior commissure uniplicate; fold low, beginning about 10 mm anterior to brachial beak, profile nearly flat, height increasing only slightly anteriorly, increase due to convexity of flanks; sulcus shallow; costae broad and angular, low, except at margins of large adults, beginning 3-5 mm anterior to brachial beak, 5-7 mm anterior to pedicle beak, numbering 3 on fold, 2 in sulcus, 3-5 on each flank; costellae very fine, crowded, converging toward crests of costae. Concentric ornamentation absent; growth lines inconspicuous and widely spaced over most of shell, strong and closely crowded near anterior margins.

Pedicle valve moderately convex longitudinally and nearly flat to slightly concave transversely; umbonal area with blunt longitudinal crest, giving way anteriorly to sulcus, slightly posterior to mid-valve; beak short, blunt, strongly curved, oblique to erect; delthyrium wide, triangular, apex may perforate beak, base closed or constricted by small, conjunct deltidial plates; beak ridges moderately sharp, well marked, bordering long narrow lateral pseudointerareas. Brachial valve flatly convex longitudinally, slightly more strongly convex transversely; posterior lateral edges of valve slightly overlapping lateral pseudointerareas of pedicle valve; apex of valve within pedicle valve, covered by deltidial plates.

Pedicle valve interior with sides of delthyrium abruptly widening, teeth small and narrow; supported by short convergent dental plates reaching valve floor but not meeting, not fused to sides of valve in young but obsolete in old specimens. Muscle area elongate, bluntly subtrigonal; adductors elongate, median, extending about three-fourths of muscle area, along median line; diductor scars lateral to adductors, anteriorly widening, meeting at median line anterior to adductors.

Brachial valve interior with large, triangular undivided hinge plate, with shallow crural cavity usually filled with adventitious material; hinge sockets narrow, elongate, strongly corrugated, median septum high, thin, base may be thickened near posterior end, edge meeting convergent plates

of crural cavity. Muscle pattern not clearly observed, apparently camarotoechiid, with greatly elongate, narrow, outwardly bowed posterior adductor scars, one on each side of septum, meeting small, subcircular anterior adductor scars near middle of valve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 715i					
148277	20.4	18.7	22.3	8.8	90
148276a	20.2	18.4	23.7	8.3	110
148276b	33.7	29.6	36.1	16.0	110
USNM 719z					
152882a	38.4	36.0	48.4	14.0	115
152882b	33.7	35.2	40.2	15.6	110
152882c	30.3	22.7	33.7	13.0	110
152882d	25.1	22.2	30.3	9.0	110
(holotype)					
152882e	22.3	19.5	22.5	9.7	110

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Appel Ranch: USNM 715i, 719z, 722t, 727j, 731z. Getaway: AMNH 496, 512, 600; USNM 728, 730.

DIAGNOSIS.—Unusually large *Leiorhynchoidea* with broad angular costae.

TYPES.—Holotype: USNM 152882d. Figured paratypes: USNM 148276a,c; 152882a-h,k,l,o-q,t,w; 154911a,b. Measured paratypes: USNM 148276a,b, 148277, 152882a-c,e. Unfigured paratypes: USNM 148276b, 152882i,j,m,n,r,s,u,v.

COMPARISON.—*Leiorhynchoidea scelestia* is characterized by its broad costae, strongly curved pedicle beak, undivided hinge plate with shallow crural cavity commonly filled, and its strong, high median septum. It differs from *L. laevis* Cloud and *L. schucherti* Cloud in its much stronger costae that are present on the flanks as well as on the fold and sulcus. Internally the muscle patterns of all three species appear to be similar, but it is not certainly known whether the hinge sockets of *L. scelestia* are denticulate as in *L. laevis* and *L. schucherti*. *L. scelestia* differs from *L. mexicana* (Cloud) in its larger size, wider, more elliptical outline, less strongly curved pedicle beak, much lower convexity, and lower fold.

Leiorhynchoidea claudi Cooper from the Monos Formation of Sonora, Mexico, is a similar appear-

ing, nearly completely costate species but is much smaller, with costae less broad and less angular, and much thicker in youthful forms, than *L. scelestia*.

Pugnax weeksi nobilis Girty is the same type of shell as our *L. scelestia* but it is a much smaller species, with strong rounded ribs rather than angular ones as in the Word species.

DISCUSSION.—Fragmentary specimens of a *Leiorhynchoidea* from AMNH 512 (=USNM 728) are referred to this species tentatively. Only the posterior part is preserved, but this indicates a species with strong costae that begin near the beaks on both valves. The apical angle of the pedicle valves is 120°, suggesting that the species was large. No complete adult specimens appear in the collection, consequently a closer comparison or a positive identification cannot be made.

Leiorhynchoidea sulcata, new species

PLATE 504: FIGURES 34–36; PLATE 550: FIGURES 1–7

Medium size for genus; roundly subpentagonal in outline, maximum width near midvalve; sides somewhat narrowly rounded; anterior margin truncated; valves of unequal depth, brachial valve deeper; anterior commissure strongly uniplicate; apical angle varying between 100° and 120°. Surface variable, costae originating on umbo and extending to anterior margin; 1–3 costae in sulcus and 3 or 4 on the fold; flanks varying from smooth to having occasional indistinct costae.

Pedicle valve moderately convex in lateral profile, broadly and gently convex in anterior profile, middle slightly depressed; beak small, closely appressed to dorsal umbo; sulcus originating at umbo and deepening anteriorly to form long subacuminate tongue; flanks flattened but with gentle slopes.

Brachial valve moderately convex in lateral profile but strongly domed and with steep sides in anterior profile. Fold originating between umbo and midvalve, low, not strongly defined anteriorly but forming deep slightly angulated reentrant. Flanks moderately swollen.

Interior not seen.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (South Wells Member).

LOCALITIES.—AMNH 414; USGS 7641, 7649.

DIAGNOSIS.—Anteriorly deeply sulcate *Leiorhynchoidea*.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
AMNH 414					
155054	20.0	18.4	21.4	14.0	109
(holotype)					
USGS 7649					
155056a	19.1	17.3	21.9	13.6	116
155056b	20.0	17.8	19.1	13.6	112
155056c	18.7	16.9	21.0	13.4	114
155056e	16.9	15.5	18.4	10.5	108
155056g	11.7	10.7	12.8	5.7	123

TYPES.—Holotype: USNM 155054. Figured paratypes: USNM 154619b, 155056b. Unfigured paratypes: USNM 155056a,c–g. Measured paratypes: USNM 155056a–c,e,g.

COMPARISON.—This species is most like *L. schucherti* Cloud from the Permian at Las Delicias, Mexico, but is smaller, more deeply sulcate at the anterior, and with a longer, more carinate tongue. It is a more pentagonal, more deeply sulcate, and differently proportioned species than *L. amygdaloides*, new species, from the Glass Mountains.

Leiorhynchoidea sulcata is common in parts of the South Wells Member, where it occurs with *Paranorella* Cloud and *Glossothyropsis* Girty. *Leiorhynchoidea* is associated with *Paranorella* in the black nodules and shales of the Permian in Las Delicias.

Leiorhynchoidea species unidentified

PLATE 520: FIGURES 19–22

Specimens of *Leiorhynchoidea* are extremely rare in the residues from the Glass Mountains and Sierra Diablo partly because they are not abundant but also because they are extremely fragile. If the shells have survived the rigors of transport and burial they may not withstand the still harsher treatment received in the acid tubs. Some of the specimens are extremely thin-shelled, a few so thin that they are translucent. Specimens are listed below by formation.

BONE SPRING FORMATION (Plate 520: figures 19–22).—From the lower Bone Spring in the Sierra Diablo, 4 specimens have been taken, 2 pedicle valves and 2 brachial valves, each from a different locality. The specimens, however, suggest the same species. The larger pedicle valve is 15 mm long by

16.7 mm wide, and has a short beak, strongly rounded sides, and small delthyrium. On the exterior, the posterior half is smooth; the sulcus originates not far anterior to midvalve and is broad and shallow but is produced into a long tongue. The sulcus is marked by 4 costae. The dental plates are short and delicate.

The brachial valve is small and delicate, with a low fold that posteriorly becomes a shallow, narrow sulcus extending to the umbonal region, similar in some respects to *L. mexicana* (Cloud). The hinge plates are fairly wide, the crura narrow and thin at their bases but not preserved in entirety. The outer hinge plates are wider than usual but the median groove is completely filled and only a trace of it is left. The median septum is long and delicate.

Pedicle valve USNM 152883 comes from USNM 728e and USNM 152867 from 728f; the brachial valves were taken at USNM 728h (USNM 152868) and AMNH 632.

Figured specimens: USNM 152867, 152868.

GAPTANK FORMATION.—One crushed pedicle valve from USNM 701p.

ROAD CANYON FORMATION.—All the specimens from this formation are very fragmentary and it is impossible to get a good idea of the exterior of the species. In most of the pedicle valves the dental plates are fused to the valve wall and in some specimens are obsolete. The muscle region is triangular. The exterior is smooth. The one brachial valve has a thick median septum solidly fused with the hinge plate but still exhibiting the median groove. The crura are thick and rounded.

Two localities are represented; USNM 720d and 721j.

Described specimens: USNM 152870, 152869.

WORD FORMATION (CHINA TANK MEMBER).—A single fragment (USNM 148269) of a pedicle valve was found at USNM 706c.

WORD FORMATION (WILLIS RANCH MEMBER).—A single fragment of a pedicle valve (USNM 148279a) and one dorsal valve (USNM 148279b) were taken from USNM 706e. No dental plates appear in the fragment of pedicle valve.

The ornament of the brachial valve is most unusual because the posterior half which is fairly convex and swollen is marked by numerous narrow costae, but the fold originates near midvalve and is marked by 4 thick angular costae, and the flanks by a few large costae. All costae are a sudden

expansion in size and angularity of the finer costae of the posterior, the change taking place at midvalve. The specimen is 23 mm long and somewhat wider at midvalve.

PARANORELLINAE, new subfamily

Smooth, sulcate Camarotoechiidae.

Genus in West Texas: *Paranorella* Cloud.

This is an excessively rare shell but it has been found in many of the formations. A trace of it was found in the Sierra Diablo at the base of the Bone Spring Formation and in equivalent beds of the Skinner Ranch Formation in the Glass Mountains. In the latter area it was also seen in the Cathedral Mountain (lower) and Road Canyon formations. In the Word Formation it was found in the China Tank and Willis Ranch members and in the lens between the latter and the Appel Ranch Member (USNM 706b).

In the Guadalupe Mountains only two specimens were taken from the Getaway Member of the Cherry Canyon Formation. It is fairly common in the black limestone of the South Wells Member of the Cherry Canyon Formation, but is not well preserved. It occurs in Permian black limestone and shale at Las Delicias, Coahuila, Mexico.

Genus *Paranorella* Cloud, 1944

Paranorella Cloud 1944:59.—Williams et al., 1965: H 582.

This is a poorly known genus which, for a time, had not been found outside of Mexico. It is now known from the Guadalupe and Glass Mountains but in both places it is extremely rare. Several specimens preserving the interior confirm Cloud's view (1944:60) that this peculiar genus is similar internally to *Leiorhynchus* and *Camarotoechia* (sensu Sartenaer, 1961b).

The feature that gives *Paranorella* its distinctive character is the reversed fold and sulcus from that usual in the rhynchonellids. In *Paranorella* the pedicle valve is the larger, more bulbous, and has an anterior median fold. The brachial valve is shallower, but convex, and bears a fairly strong median sulcus. *Paranorella* is thus like some other genera that have this reversal of fold and sulcus such as the Triassic rhynchonellid *Norella*, the Mississippian rhynchonellid *Sanjuanina*, the Permian stenos-

cismatacean *Camarophorina*, and the Recent rhynchonellid *Neorhynchia*. The last is very thin-shelled and is a deep-water species.

The pedicle valve interior of *Paranorella* has receding dental plates that are often rendered obsolete by filling in of the umbonal cavities. As in *Leiorhynchoidea* the teeth are small for so large a shell. The pedicle valves of all available specimens are too badly damaged to determine the nature of the deltidial plates, if any. The muscle field is small and oval with the diductor scars surrounding nearly central adductor scars.

The interior of the brachial valve of *Paranorella* has a deeply notched undivided hinge plate which has strong socket ridges bounding corrugated sockets. The outer hinge plates are much reduced but the crural bases are stout. Their keels unite with the median septum which is strong and thick, to form a narrow V-shaped chamber that is not closed by adventitious shell in any of the specimens. Crura thickened, mucrifer?. The adductor field is small and is located near midvalve and is divided by the median septum.

Paranorella has a fairly long range as indicated by spasmodically occurring isolated valves of great rarity. It occurs in the Poplar Tank Member of the Skinner Ranch Formation and in the Road Canyon Formation below the Word. It is more common in the Word Formation where it has been taken from the China Tank and Willis Ranch members.

In the Sierra Diablo and Guadalupe Mountains it is known from the Bone Spring Formation at USNM 728f, the Getaway Member of the Cherry Canyon Formation at AMNH 600, and the South Wells Member at AMNH 414.

TYPE-SPECIES.—*Paranorella imperialis* Cloud (1944:60, pl. 19: figs. 5, 9–16, 20).

Paranorella aquilonia, new species

PLATE 551: FIGURES 6–12

Large but average size for genus, moderately bi-convex; outline subelliptical, widest slightly anterior to midline; anterior commissure broadly sulcate, fold low, weak, beginning about 15 mm anterior to pedicle beak, profile of fold flatly convex; greatest convexity of valve posterior to fold; brachial valve with shallow sulcus originating at midvalve; costation absent; growth lines irregularly

spaced, stronger, and more closely crowded near anterior margins; growth lamellae strong and distant.

Pedicle valve moderately convex longitudinally and transversely; beak blunt, suberect; apex perforated by foramen; delthyrium small, open, without deltidial plates; beak ridges blunt, inconspicuous, nearly coincident with valve edge. Brachial valve gently convex in anterior and lateral profiles, slightly inflated near umbo.

Pedicle valve interior with sides of delthyrium widely diverging; each with one large knoblike, weakly corrugated hinge tooth, elongated; dental plates supporting hinge teeth, widely divergent anteriorly and dorsally, firmly fused to sides of valve or partly buried. Muscle area cordate, small; adductor scars small, elongate, forming subelliptical mark along median line; diductor scars larger, surrounding adductor mark and forming two lobes anteriorly, narrowed to fine lines posteriorly; posterior part of muscle area bisected by low, rounded myophragm.

Brachial valve interior with small, deeply divided hinge plate, reduced to two rounded, anteriorly projecting crural bases; sockets narrow, deep, elongate, corrugated, formed between edge of shell and thick, high, curved socket ridges; crura diverging anteriorly, length and shape unknown; median septum low, short, thickened posteriorly, joining plates of narrow crural cavity beneath notch in hinge plate. Adductor field elongate oval; scars long, narrow, distally bowed, one on each side of median septum, converging on midline of valve anterior to end of septum; posterior and anterior adductor scars probably continuous with one another.

MEASUREMENTS (in mm).—From locality AMNH 600 specimen 148296 (holotype) and from AMNH 347, 148298 (paratype), respectively: length 25.0, (?); brachial valve length 23.6, 24.7; width 28.0, 27.6; thickness 10.5, 6.4; apical angle 115°, (?).

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Bell Canyon Formation (Lamar Member).

LOCALITIES.—Getaway: AMNH 600. Lamar: AMNH 347 (=L-2).

DIAGNOSIS.—*Paranorella* of average size having a broad shallow sulcus originating at midvalve.

TYPES.—Holotype: USNM 148296. Figured and measured paratype: USNM 148298.

COMPARISON.—*Paranorella aquilonia* is characterized by its shallow valves, low, noncostate fold and sulcus, median septum without any knob on the crest, nonraised dorsal muscle area with posterior and anterior adductor scars not distinctly discontinuous. These features distinguish it from *P. comptula*, new species, which occurs in the Word Formation (China Tank Member).

This species is distinguished from *P. imperialis* Cloud by its lesser convexity and shallower sulcus that does not extend past midvalve as it does so conspicuously in the Mexican species. It also has a less prolonged beak and much less swollen median region on the pedicle valve than the Mexican species. It also differs from *Paranorella* species 1 from the Glass Mountains in having a smaller size, shorter, narrower median septum in the brachial valve, and in not having the conspicuous sulcus in the median and posterior parts of the pedicle valve.

Paranorella comptula, new species

PLATE 551: FIGURES 13–18

Average size for genus, flatly biconvex; outline transversely subelliptical, widest near midline; anterior commissure broadly and shallowly sulcate; fold low, beginning far forward about 20 mm anterior to pedicle beak, profile nearly flat; sulcus shallow; costae low, weak, rounded, present only on fold and sulcus, numbering about 5 or 6 on fold, one less in sulcus; growth lines faint, most closely spaced near anterior margins.

Pedicle valve most strongly convex in umbonal region; beak blunt, oblique to erect, apex perforated by foramen; delthyrium small, open, without deltidial plates; beak ridges absent. Brachial valve nearly flat except for slight swelling of umbonal area.

Pedicle valve interior with wide delthyrium, teeth knoblike, elongate, supported by dental plates, tightly fused to sides of valve, or buried in adventitious shell. Muscle area lobate; adductor scars small, elongate, lying along median line, together forming elliptical mark; diductor scars larger, beginning near edges of dental plates, surrounding adductor marks, greatly widening anteriorly, meeting at median line forward of adductor scars; posterior part of muscle bisected by low, faint median ridge.

Brachial valve interior with small, deeply divided

hinge plate, reduced to a pair of anteriorly projecting crural bases and a part of high socket ridges; sockets deep, elongate, anteriorly widening, faintly corrugated; crura diverging anteriorly, length and anterior course unknown; median septum moderately high, thickened along base and at posterior end, joining plates of crural cavity beneath median notch of hinge plate; small knob projecting from crest of septum near posterior end of muscle area which is greatly elongated, subelliptical, slightly thickened and with edges somewhat raised; posterior adductor scars elongate, one on each side of median septum; anterior adductor scars somewhat larger, more nearly circular.

MEASUREMENTS (in mm).—Specimen USNM 148293 (holotype): length 28.0, brachial valve length 27.0, width 33.2, thickness (crushed), apical angle 127°.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank Member).

LOCALITY.—USNM 706c.

DIAGNOSIS.—*Paranorella* with anterior end of fold and sulcus costate.

TYPES.—Holotype: USNM 148293. Figured paratypes: USNM 148292a,b,c.

COMPARISON.—*Paranorella comptula* is characterized by its relatively flat shell, elliptical outline widest at the midline, costate fold and sulcus, non-indented pedicle umbonal area, small hinge teeth, moderately high median septum with a small boss on the crest, raised edges of the brachial muscle area, and fairly large posterior adductor muscle marks. It differs from *P. imperialis* Cloud (1944) in most of these features, but most conspicuously in the lower convexity, costation of fold and sulcus, and raised edges of the brachial muscle area. The little knob on the crest of the septum is at the posterior end of the muscle area and probably is part of its raised edge.

Paranorella imperialis Cloud

PLATE 551: FIGURES 1–5

Paranorella imperialis Cloud, 1944:60, pl. 19: figs. 5, 9–16, 20.

Illustrations of *Paranorella imperialis* Cloud have been introduced for comparison with the mostly fragmentary specimens from the Glass Mountains.

TYPES.—Figured specimen: USNM 148295a.

Paranorella species 1

PLATE 551: FIGURES 19–30

Large for genus, wider than long, roundly elliptical outline; sides broadly rounded; anterior margin truncated. Anterior commissure broadly sulcate; beak short, suberect; delthyrium open. Surface marked by concentric lamellae of growth, distantly placed; no costae.

Pedicle valve fairly evenly and gently convex in lateral profile; broadly domed in anterior profile; umbonal region swollen; median region moderately inflated and usually marked by shallow sulcus. Fold low and inconspicuous usually marked only at anterior. Flanks generally inflated.

Brachial valve known only from incomplete specimens, flatly convex, sulcus confined to anterior part.

Pedicle valve interior with elongated teeth located just inside lateral margin and supported by short, insignificant dental plates lying against valve wall with very narrow cavities. Muscle field unusually small for large shell, somewhat cordate with narrow tear-shaped diductor scars wrapping around central elongate, elliptical adductor field.

Brachial valve interior with narrow sockets bounded by short socket ridges; outer hinge plates small, attaching stout crural bases to socket ridges. Crura rounded in section, moderately stout and bounding small apical chamber. No inner hinge plates. Median ridge stout proximally, tapering anteriorly and dying out before midvalve but forming low myophragm that divides the posteriorly situated, elongated elliptical adductor patch.

MEASUREMENTS (in mm).—From locality USNM 706b specimens 148290a and b, respectively: length 26.6, 28.6; brachial valve length (?); width 26.0, 32.8; thickness 9.6, 9.8; apical angle 110°, 120°.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member; lens between Willis Ranch and Appel Ranch members).

LOCALITIES.—Willis Ranch: USNM 706e, lens: USNM 706b.

DIAGNOSIS.—Large *Paranorella* with shallow sulcus on pedicle valve in addition to fold.

TYPES.—Figured specimens: USNM 148290a–c, 148297, 154912a–c.

COMPARISON.—The few specimens of this species indicate the largest species known, but one that was probably not so robust as *P. imperialis* Cloud from Mexico. The most distinctive feature of the

species is the sulcus on the pedicle valve, but indications point to the sulcus having been wide and the fold low and inconspicuous. Unfortunately no good brachial valves have yet been taken of this very rare fossil.

DISCUSSION.—The muscle field of the pedicle valve seems unusually small for such a large shell. It is only 9 mm wide in the largest specimen and has a length of about 8 mm. The cardinalia of the brachial valve appear to have been correspondingly small but no complete specimens are known.

Paranorella species 2

PLATE 510: FIGURES 13–20; PLATE 551: FIGURES 31–34, 47

Another species besides those suggested herein and *P. imperialis* Cloud is indicated by several fragmentary specimens from the Sierra Diablo and one from the Glass Mountains. This may be regarded as average for the genus. It is subcircular in outline, with the pedicle valve fairly convex in lateral profile and moderately convex in anterior profile. The fold and sulcus are not strongly marked and are not costate.

Inside the pedicle valve the teeth are small and the dental plates are readily visible and have narrow but fairly strong umbonal cavities. The muscle field is strongly impressed, elongate oval in outline and small for the size of the shell. The brachial valve interior is represented only by small parts of the posterior end, but they show delicate structures. The socket ridges are strong; outer hinge plates are narrow and recessed, and the crural bases are stout and slender but none of the specimens has complete crura. The median septum is long, low, and stout and extends to about midvalve and divides the adductor field, which is located at about midvalve and is small.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower); Skinner Ranch Formation (Poplar Tank Member, lower).

LOCALITIES.—Bone Spring; USNM 728f. Poplar Tank: USNM 729f.

DIAGNOSIS.—Medium-sized *Paranorella* with narrow, elongate, small muscle area in the pedicle valve.

TYPES.—Figured specimens: USNM 154690a–c; 152874a,c,d; 152875.

DISCUSSION.—This is a very rare species of which

only fragmentary specimens have been taken from the Bone Spring Formation. Not enough specimens have been found to give a proper idea of the exterior of the species, although the interior with its elongate muscle field in the pedicle valve and the long median septum and median adductor field in the brachial valve are fairly distinctive. The single brachial valve known from the Glass Mountains has features such as the long septum and size that suggest relationship to the Sierra Diablo specimens. The association is tentative.

Paranorella species 3

A single specimen of a fine pedicle valve measuring 11.5 mm long by 12.5 mm wide indicates a new species or a young individual, possibly of *P. aquilonia*, new species, from the Cherry Canyon Formation (Getaway Member) at AMNH 512.

TYPES.—Described specimen: USNM 155053.

Paranorella species 4

PLATE 183: FIGURES 18–21 (in volume 2)

The lots on which this description is based consist of the two figured specimens and another lot of five fragments of the posterior showing cardinalia and dental plates. The largest specimen (USNM 153565a) is a pedicle valve, subpentagonal in outline with rounded anterolateral extremities but a truncated anterior. It is fairly strongly convex in both profiles but the medial region is moderately swollen. There is no marked fold, but the anterior margin has a broad wave toward the ventral side that would have accommodated a small tongue from the opposite valve. On the inside the dental plates are short and inconspicuous and the muscle field is very small for such a large shell.

The brachial valve (USNM 153565b) is fragmentary but it shows the presence of a sulcus originating near midvalve. The median ridge is thick and the notothyrial cavity is a slit between the crural bases. One of the fragmentary specimens in lot USNM 152873 has a thick socket ridge but a narrow, rounded crural base. In a still younger specimen the outer hinge plate is visible and there is evidence of a small V-shaped chamber.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 721u.

TYPE:—Figured specimens: USNM 153565a,b.

Paranorella species 5

PLATE 504: FIGURES 55–60

This lot consists of seven specimens, all fragmentary, four of them adult but the others juvenile. The two largest and most complete specimens are in matrix and the details of the exterior cannot be seen. The pedicle valve is deep and appears to be somewhat swollen on the exterior. The fold is not clearly discernible. The dental plates are plastered against the inner wall of the shell with the merest slit between them and the wall. The brachial valve is less deep and shows evidence of an anterior tongue. The median septum is thin and delicate and forms an obscure shallow V-shaped chamber. The socket ridges are rounded and slender and separated by a deep indentation from the crural bases, which are rounded and delicate for such a large shell and which unite at their proximal extremity. The interior is unlike any other species except *Paranorella* species 2.

Two pedicle valves from USNM 721j (USNM 152871) and five pedicle valves from USNM 732j (USNM 155055) are also referred here, but they are not well preserved.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 721j, 726d, 732j.

TYPES.—Figured specimens: USNM 152872a–e.

Paranorella species 6

PLATE 510: FIGURES 21–26

Three very poorly preserved valves, two pedicle and one brachial valve, indicate the presence of a species in the Skinner Ranch Formation (Dugout Mountain Member, at USNM 732e). The pedicle valves are moderately convex but the brachial valve seems more convex than usual. The cardinalia are incomplete, with only the outer hinge plates revealed.

TYPES.—Figured specimens: USNM 154689a,b.

TROPHISININAE, new subfamily

Camarotoechiinae with finely costellate shells.

Genera in West Texas: *Trophisina*, new genus.

This very rare genus is known only from the lower Cathedral Mountain Formation in the vicinity of Split Tank.

Trophisina, new genus

[Greek *trophis* (well fed)]

Small to medium size, strongly biconvex in profile, subcircular to longitudinally suboval in outline. Valves unequal in depth, brachial valve deeper; sides rounded, greatest width near midvalve; anterior commissure uniplicate, folding usually best defined at anterior. Beak suberect; foramen large, elongate oval; deltidial plates small and disjunct. Dorsal umbo swollen. Surface multicostellate.

Pedicle valve interior with small teeth supported by strong convergent dental plates; muscle field lightly impressed, elongate rectangular in outline; adductor scars medial, posterior; diductors subflabellate.

Brachial valve interior with divided hinge plate in young but with complete, undivided hinge plate in adults; sockets defined by concave socket plates; inner socket ridge strongly overhanging sockets; outer hinge plates broad; crural bases narrow and forming keels along dorsal edge of crura; crura mucrifer, moderately long and curved toward ventral valve; inner hinge plates uniting medially along median suture line, outer edge attached to the sloping edge of outer hinge plate. Median septum very short, attached to midline of inner hinge plates and extended anteriorly to midvalve or beyond as threadlike elevated line.

TYPE-SPECIES.—*Trophisina fenaria*, new species.

DIAGNOSIS.—Strongly biconvex and rotund rhynchonellids having disjunct deltidial plates, multicostellate exterior, and undivided hinge plate in the adult supported by a very short median septum.

COMPARISON.—Costellate rhynchonellids are sufficiently rare that comparison of *Trophisina* is not difficult.

Trophisina may be confused with three genera—*Strigirhynchia* Cooper and Grant, and *Lirellaria* and *Chaeniorhynchus*, both new. *Strigirhynchia* is generally much larger and has a long, thin, and high median septum that contrasts with the short one in *Trophisina*. Its dental plates in adults tend

to fuse with the sides of the valve and it has a deeply concave umbonal region on the brachial valve. This is one of the most conspicuous features of *Strigirhynchia*, which is not shared by *Trophisina*.

Lirellaria is not difficult to separate from *Trophisina* because it has no median septum in the brachial valve and has small, but conjunct deltidial plates in the pedicle valve. *Chaeniorhynchus* is like *Trophisina* because its exterior is very similar, although it usually is more strongly ornamented and has no trace of deltidial plates as presently known. Inside the brachial valve the hinge plate is undivided and is supported by a long, strong median septum, whereas in *Trophisina* the hinge plate becomes a solid piece only in the older adults, and the median septum is usually short and stout and, in some specimens, much reduced.

DISCUSSION.—Costellate rhynchonellids are rare in all eras and especially so in the Paleozoic. The general aspect of this unusual genus suggests *Hypothyridina* of the Devonian in the rotundity of the valves and the strongly convex profiles. They are, however, not flattened anteriorly, as are species of *Hypothyridina*, and they have a median septum, which is lacking from the Devonian genus. *Trophisina* is thus a very distinctive shell in the Permian and one that is recognized readily. The costellae are variable, in some specimens being fairly narrow but in others approaching costae in width, especially in the fold and sulcus. The costellae increase by bifurcation and intercalation. The adult is not flattened in the umbonal region of the brachial valve as in *Ptilotorhynchus*, another costellate new genus from the Guadalupe Mountains.

A fair abundance of specimens of all sizes permits a view of the shell development from specimens about 1.5 mm long to fully grown adults. In the youngest stages the pedicle valve is the deeper and is nearly flat, with a long beak that is inclined ventrally. The brachial valve is flat in profile except for the umbonal region, and is marked medially by a sulcus. This valve is less deep than the pedicle valve. The valves become about equal in depth when a length of 7.5 mm is attained. After that the brachial valve in the larger specimens becomes slightly to markedly deeper than the pedicle valve. The smallest specimens are smooth in the posterior half or more and have costellae developed at the margin only. The beak attitude

changes from fairly strongly ventrad (apsacine) to suberect (anacline). At 4–5 mm from the beak, the sulcus of the brachial valve flattens, and usually cannot be detected in an adult. The reversion of the anterior commissure from a broadly sulcate condition in the young to uniplicate in the adult is gradual. Specimens about 7 mm long are usually rectimarginate or nearly so.

The delthyrium of the youngest specimens is elongate triangular and its margin is unmodified. At a length of approximately 2 mm the margin of the delthyrium is thickened by addition of small deltidial plates, thickest and widest along the basal part of the delthyrium. In somewhat larger specimens these have a rounded, concave margin against the pedicle. These deltidial plates are fairly conspicuous in young and youthful individuals; in fully grown adults they are wider and have a flat surface, but never unite.

The interior of the pedicle valve does not exhibit the muscle region well because of the unusual delicacy of the shell. The teeth are small and narrow, but fairly protrusive. They lie oblique to the median line of the valve, with a northwest-southeast slant essentially parallel to the shell margin. The posterior side of the tooth bears a small notch. The dental plates are stout and have fairly deep umbonal chambers setting them off from the valve wall. They are somewhat receding in a posteroventral direction and are moderately convergent ventrally but remain well separated. The muscle area is not well impressed and lies anterior to the delthyrial cavity. It is trapezoidal in outline but the individual scars cannot be resolved.

Interior details of the brachial valve, especially the hinge plate, are variable in the adult. The smallest brachial valve interior is 1.5 mm in length. Its crura are closely tied to the strong elevated socket ridges, and descend to the valve floor with a slight anterior excavation beneath. A strong, thick, median ridge formed by the sulcus of the exterior divides the narrow but deep pits of the adductor scars. Essentially the same arrangement appears in specimens 2.5 mm long, but in these the inner hinge plates are concave and are supported by the median ridge, at this stage somewhat narrowed. In succeeding stages up to 5 mm long the inner hinge plates in their forward growth tend to flatten and the median ridge becomes a slender but short

septum supporting them. A chamber is not developed, but the median line of attachment of inner hinge plates and median septum is usually depressed and forms a narrow groove.

The socket ridges are strong plates throughout the development of the cardinalia and strongly overhang the sockets, locking into the grooves on the outer faces of the teeth. The socket is floored by a curved fulcral plate that grows obliquely forward with advancing age. This appears to be corrugated in some adults, but it is not possible to make certain of this feature in all specimens. In adults the fulcral plate is deep and moderately thick.

Outer hinge plates between the socket and the crus appear not to exist in the very young but can be detected at a length of 5 mm. These become more prominent with advancing age. The crus of the young is a simple blade, with its inner edge approximately parallel to the median line of the shell. With advancing age the crus is much elongated, becomes fairly deeply curved with the concavity toward the pedicle valve. The crus is concave in cross section, the concavity facing medially. It is strongly keeled on the dorsal side, the keel extending under the hinge plate to form the crural base. The distal end of the crus is oblique, with a sharp point on the ventrad end. The crus thus proves to be of the mucrifer type.

As indicated above, the median ridge in septal development goes from a broad ridge in the youngest specimens, to a short septum and ridge, finally to a very short septum. The length and development of the septum in the adult are variable. In some specimens the septum extends from inner hinge plate to valve floor but is confined to the apex. This kind of septum is usually extended anteriorly as a fine elevated thread to the adductor field or beyond. In some specimens, however, no septum supports the hinge plate. In these the septum has probably been resorbed or may not have been well silicified.

In old specimens the adductor scars are narrow, deeply entrenched, separated by a median thread or secondary ridge (myophragm) and are arranged in anterior and posterior pairs, the former slightly the longer and the latter slightly oblique and outside the former.

Trophisina fenaria, new species

PLATE 506: FIGURES 1-42

Average size for rhynchonellids, juveniles flatly biconvex, adults globose; outline tear-shaped to nearly circular, sides diverging between 70° and 110°; commissure uniplicate, fold low, indistinct except at commissure; sulcus shallow but extending forward as moderately long broad tongue, flat on top. Costae fine, low, rounded, beginning at beaks, number increasing anteriorly by bifurcation, numbering 15-45 along anterior margins, averaging about 30. Concentric striae absent; growth lines weak, normally visible only near anterior margins.

Pedicle valve nearly flat in juvenile, strongly convex in adults; beak sharp, straight to nearly erect; delthyrium wide, triangular, sides narrowed by rudimentary, disjunct deltidial plates that tend to coverge only in largest shells; lateral pseudointerareas absent: no overlap of valves.

Brachial valve strongly convex transversely, moderately convex along crest of fold; beak bluntly pointed, slightly curved into pedicle valve.

Interior as described for genus.

MEASUREMENTS (in mm).—

	brachial valve length	mid- length	width	thick- ness	apical angle (°)
USNM 703b					
148236a	1.9	1.5	1.7	1.7	0.8
148236b	2.7	2.1	2.1	2.1	1.0
148236c	3.2	2.8	2.8	2.8	1.1
148236d	3.7	3.0	3.0	3.0	1.5
148236e	4.8	4.0	3.7	4.0	1.8
148236f	5.8	5.0	4.7	4.9	2.1
148236g	6.7	5.6	5.5	5.8	3.0
148236h	8.2	7.2	7.3	7.4	5.5
148236i	8.9	7.9	8.0	8.0	6.9
USNM 702un					
148224a	7.6	6.6	6.9	6.9	4.7
148224b	10.5	9.2	8.6	8.6	7.9
USNM 702-low					
148242a	9.0	8.2	8.3	8.4	8.0
USNM 702					
148231	9.6	8.3	9.0	9.0	8.6
USNM 702un					
148225 (holotype)	10.0	8.8	9.6	9.6	8.4

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation. (*Institella-Torynechus* Zone).

LOCALITIES.—AMNH 500B; USNM 702, 702-low, 702un, 703b, 735b.

TYPES.—Holotype: USNM 148225. Figured paratypes: USNM 148224a; 148236f,g,i-q,s,t; 148238a-f; 148242a,b; 154640a-o. Measured paratypes: USNM 148224a,b; 148231; 148236a-i; 148242a. Unfigured paratypes: USNM 148224b; 148236a-e,h,r.

DIAGNOSIS.—Globular rhynchonellacea with costellate exterior, short median septum, and with the adult hinge plate undivided.

COMPARISON.—*Trophisina fenaria* is characterized by its flat juveniles and globose adults, its low, flat-topped fold usually expressed only at the line of commissure and rarely posteriorly on the shell, its rudimentary disjunct deltidial plates that begin to constrict base of delthyrium only in largest adults, its large, normally not divided but deeply notched adult hinge plate, and especially by its very fine, low, numerous and bifurcating costae. It is about the same size as *Fascicosta longaeva* (Girty), but is more globose, and its costae are much finer, lower, and more numerous.

In its globose shape and its normal size *T. fenaria* resembles *Chaeniorhynchus inauris*, new species, differing primarily in its bifurcating costae, disjunct deltidial plates, and lack of a high median septum in the brachial valve.

DISCUSSION.—Inasmuch as only the type species of this genus is known the development of the hinge plate and other generic details are discussed under the genus heading. The species is rare and is confined, so far as known, to the *Institella* Zone in the Split Tank and Word Ranch areas.

Superfamily STENOSCISMATACEA Oehlert, 1887

Aberrant Rhynchonellacea having spondylium in pedicle valve and camarophorium in brachial valve. Deltidial plates conjunct.

Family STENOSCISMATIDAE Oehlert, 1887

Stenoscismatacea with stolidium in some stage of development.

Subfamily STENOSCISMATINAE Oehlert, 1887

Stenoscismatidae with costae beginning anterior to beaks.

Genera in West Texas: *Stenoscisma* Conrad, 1839.

This is an abundant genus in the Glass Moun-

tains, less abundant in the Guadalupe Mountains and Sierra Diablo. It occurs sparingly in Wolfcampian rocks of the Glass Mountains but is common in the Hueco Formation of the Hueco Mountains. It becomes common in Leonardian rocks but tapers off to rarity in the Guadalupian rocks of West Texas.

Genus *Stenosisma* Conrad, 1839

- Stenosisma* Conrad, 1839:59.—Cooper, 1944:315.—Grant, 1965a:138 [for synonymy and discussion].
Stenocisma Conrad, Dall, 1877:65.—Cooper, 1942:229.—Shaw, 1962:633. [Not of Hall, 1847:142; 1867:335.]
Stenoschisma Conrad, Oehlert, 1887:1309. [Not of Hall and Clarke, 1894:187].
Camerophoria W. King, 1844:313; 1845:254; 1846:89.
Camarophoria W. King, Herrmannsen, 1846:161.—W. King, 1850:113.
 Not *Stenochisma* Conrad, Grabau, and Shimer, 1907:288.—Kozłowski, 1929:146.

A more complete synonymy and a discussion of use of the name *Stenosisma*, its various spellings and type species, and the extended competition between it and the name *Camerophoria* can be found in Grant (1965a:138–143).

Shell rhynchonelliform, biconvex; small to large; outline subtrigonal to elongate or transversely subelliptical; commissure uniplicate, lateral and anterior margins of either or both valves typically extended to form large or small "stolidium"; costae beginning at or considerably anterior to beaks, normally stronger on fold and sulcus than on flanks, simple, anteriorly bifurcating, or intercalated; radial striae absent; concentric ornament consisting only of fine, closely spaced growth lines and occasional stronger growth laminae.

Pedicle valve normally gently convex transversely, strongly convex through sulcus; beak blunt or slightly attenuate, nearly straight to strongly incurved against brachial umbo; beak ridges blunt, short, ill-defined; delthyrium small, triangular, normally nearly completely filled by small deltidial plates or by umbo of brachial valve; foramen narrow, elongate oval; lateral pseudointerareas elongate, narrow, normally covered by overlapping edge of opposite valve. Brachial valve strongly convex transversely, gently convex along crest of fold; beak blunt to slightly attenuate, apex within pedicle valve, hidden by deltidial plates or by strongly hooked pedicle beak.

Pedicle valve interior with small blunt teeth elongate parallel to sides of valve; dental plates converging in gentle curve, fused along median line, forming deep, scoop-shaped spondylium, supported by low median septum. Muscle marks in spondylium weak and undifferentiated; transverse pallial troughs (vascula media) sporadically present on floor of valve, diverging nearly at straight angle immediately anterior to end of median septum.

Brachial valve interior with subtrigonal hinge plate greatly thickened at apex to form knoblike or lobate cardinal process; sockets elongate, narrow, finely corrugated, formed between socket ridges of hinge plate and valve margins; brachial processes elongate, slender, outwardly bowed and ventrally curved; median septum high, capped by anteriorly expanding, spoon-shaped camarophorium; short and low intercamarophorial plate supporting hinge plate along median line. Muscle marks in camarophorium faint; posterior adductor scars apparently subelliptical, one on each side of intercamarophorial plate; anterior adductor pattern uncertain, apparently consisting of several narrow, elongate, anteriorly diverging and widening scars on anterior portion of camarophorium.

TYPE-SPECIES.—*Terebratula schlotheimi* Buch (1835:59–60, pl. 2: figs. 32a–c), by monotypy in Conrad (1839:59).

COMPARISON.—*Stenosisma* is characterized by its normally subtrigonal outline, prominent pedicle beak with small foramen, more strongly convex brachial valve, and, normally, by the presence of a stolidium around the margins. Internally the genus is distinguished by its large spondylium and short septum in the pedicle valve, and the high median septum, large spoon-shaped camarophorium, long, gracefully curved brachial processes, and prominent cardinal process of the brachial valve. It most nearly resembles *Psilocamara* Cooper, differing in its costate shell; *Nantanella* Grabau, differing in its lack of a brachial umbonal sinus; and *Camarophorinella* Licharew, differing in its undivided hinge plate and presence of an intercamarophorial plate. Externally it resembles some of the larger species of *Wellerella* Dunbar and Condra and *Phrenophoria* Cooper and Grant; but normally its pedicle umbonal region is thicker, its brachial valve less bulbous, and its margins bear the characteristic stolidium. Internally *Stenosisma* bears little resemblance to those two genera.

The interior of *Stenosisma* is similar to that of *Torynechus* Cooper and Grant (1962), except for its shallower camarophorium and shorter intercamarophorial plate. Externally *Stenosisma* differs in its fewer and coarser costae, higher fold, less inflated and attenuate brachial beak, and absence of anterior levigate surfaces.

DISCUSSION.—The spondylium in *Stenosisma* is supported by a median septum, even in the smallest and youngest specimens that were studied. However, as the shell increases in size, the more the apical area along the septum in some individuals becomes filled with adventitious shelly material, making it appear that the spondylium had been sessile in the earlier growth stages.

The spoon-shaped structure in the brachial valve of this genus has received several names given by various authors. W. King (1850:114) referred to it simply as a "large spatula-shaped process," and Waagen (1883) followed that usage. Tschernyschew (1902) called it a dorsal spondylium, but Weller (1914) and R. E. King (1931) used the term "cruralium." Kozłowski called the structure simply a plate or a small tongue in his 1914 paper on the Bolivian fauna; in 1929 (p. 1–3), however, he proposed the term "camarophorium" for the so-called "cruralium" of the genus *Camarophoria* (= *Stenosisma*), pointing out that it bears no genetic or structural relation to the cruralium of genera of the Pentameracea. Subsequently, Stehli (1954:338) combined the previous nomenclature in referring to the, "spoon-shaped cruralium (camarophorium)," and Cooper (1956a:521) coined the new term "torynidium" for the same plate. The ambiguity in this sequence arises from Kozłowski's (1929) use of the generic names *Camarophoria* King and *Stenoschisma* (sic) Conrad for separate and distinct genera. It is apparent from the serial sections of *Stenoschisma* Conrad is based upon Hall's (1869:335, pl. 54) interpretation of the genus, and in fact is *Machaeraria* Cooper. This application of the name is entirely different from the present usage that equates *Camarophoria* with *Stenosisma*. Strong dental plates are present in the pedicle valve of *S. althi*, and they do not join to form a spondylium; the brachial valve there has a slender cardinal process, no median septum, and no camarophorium. However, Kozłowski's idea of *Camarophoria* is clearly presented in his 1914 paper and agrees precisely with the modern concept of *Stenosisma*.

His discussion (1929) of the internal structures of *Camarophoria* also indicates that he means the genus that now is called *Stenosisma*.

Grant (1965a:14) in an extended discussion of *Stenosisma* recommended adoption of Kozłowski's name camarophorium because this is the earliest name and was based on a clear and unambiguous definition.

Kozłowski (1929:131) and Licharew (1936:60) studied the construction of the small septum within the camarophorium and concluded that it was not a continuation of the medium septum from the floor of the valve. Licharew proposed a distinguishing term, the "intercamarophorial plate." Study of silicified specimens leads us to the same conclusion, on the grounds of the shape and length of the two septa. Grant (1965a,b) made serial sections of shells in most of the stenoscismatacean genera and confirmed Licharew's idea of the intercamarophorial plate. Despite the median position of the intercamarophorial plate, it is normally not as thick as the median septum. The anterior edges of the two plates coincide only fortuitously: normally the edge of the median septum is much farther anterior.

The hinge plate of *Stenosisma* bears an apical thickening of varying shape. It is rounded on some species and polylobate on others, but its form is not consistent within a species. Its surface normally is striated as a result of the attachment of muscles. The form, function, and position of this protuberance is that of a cardinal process, and we agree with Kozłowski (1914) and Licharew (1936) that that is what it should be called.

The lateral and anterior margins of many species of *Stenosisma* bear the thin shelly expansion or skirt for which Grant (1965a) proposed the term "stolidium." Stehli (1954:338) speculated that the stolidium enabled the shell to rest lightly on the surface of a soft sea bottom, thus keeping the gape above the sediment. We consider this to be a reasonable and likely explanation of the function of the stolidium. The pedicle foramen in many species is rather small, postulating a pedicle that was thin and perhaps nonfunctional in the same species. A trend in the evolution of the genus is toward reduction of the pedicle opening, and in the most abundant species of the Word Formation (*S. renode*, new species) the pedicle beak is pressed tightly to the brachial umbonal region without any room for a pedicle in most individuals. Perhaps in earlier

species also the small size of the pedicle opening provided only for a vestigial pedicle that was not used for attachment, and the animal lay free on the sea floor (Grant, 1965a:9).

Stenosisma abbreviatum, new species

PLATE 553: FIGURES 10-27

Shell somewhat small for genus; outline transversely elliptical, greatest width near midlength; profile not strongly biconvex, pedicle valve rather flat; fold broad, low, somewhat flattened across top; costae beginning far forward, normally about 7 mm anterior to brachial beak, numbering 2 or 3 on fold in juveniles, normally 4 in adults, 2 or 3 weak costae on each flank beginning still farther forward; stolidium broad, wavy, apparently equally developed on both valves and on fold as well as on flanks, and continuous between.

Pedicle valve with sharp beak only moderately curved; foramen small, but apparently remaining open in adults; deltidial plates very small, constricting only anterior part of foramen, sporadically present; sulcus beginning far forward, but strongly depressed below flanks toward anterior, and continuing as broad tongue into fold. Brachial valve more strongly convex, both transversely as well as along crest of fold; zone of overlap of valves very short because of extensive stolidium beginning nearly as far back as hinge teeth.

Pedicle valve interior with broad, flat-bottomed spondylium on low and occasionally somewhat thick median septum; hinge teeth blunt; pallial lines weakly impressed. Brachial valve interior with small and proportionately short camarophorium; median septum very short, supporting only posterior part of camarophorium, then continuing as keel along underside; cardinal process knoblike; intercamarophorial plate somewhat thick.

MEASUREMENTS (in mm).—

	length	width	thickness
AMNH 347			
154917a	12.2	13.5	7.0
AMNH 728p			
154918a (holotype)	13.2	16.7	8.8
154918g	13.4	17.6	9.5
154918b	14.0	19.0	11.9

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Limestone Member).

LOCALITIES.—AMNH 347; USNM 728p.

DIAGNOSIS.—Small, transverse, few costae, broad continuous stolidium; interior structures short.

TYPES.—Holotype: USNM 154918a. Figured paratypes: USNM 154917a, 154918b-f. Unfigured paratype: USNM 154918g.

COMPARISON.—*Stenosisma abbreviatum* is characterized by rather small size, transverse outline of adults, few costae on fold and flanks, and broad, continuous stolidium. Internally, the short, broad spondylium and short camarophorium on a high but longitudinally abbreviated median septum are distinguishing features. It most nearly resembles *S. doricranum*, new species, from the lower part of the Cathedral Mountain Formation, differing in its wider and elliptical, rather than triangular, outline, its stronger and more numerous costae, and internally by its shorter spondylium and camarophorium. It also may be compared to the unnamed species, illustrated on figures 1-7 of plate 583, which also occurs in the Lamar Member. *Stenosisma abbreviatum*, new species, differs from that species in its 3 costae on the fold, costate flanks, and much less inflated profile, especially of the brachial valve. It resembles *S. aberrans*, new species, which occurs in the Rader Member of the Bell Canyon Formation in its very short internal structures, but differs externally in its more normally stenoscismatacean shape and its somewhat stronger but fewer costae on both fold and flanks.

Stenosisma aberrans, new species

PLATE 554: FIGURES 23-32

Medium size for genus, subrectangular to elliptical in outline; valves unequally deep, brachial valve deeper; sides strongly rounded; widest near midvalve. Anterior margin truncated. Beak very short and inconspicuous, without deltidial plates. Sides diverging at wide angle, near 140°. Surface sparsely and irregularly costate, costae of pedicle valve poorly developed, conspicuous only at front part of sulcus. Fold with 4 costae at front, produced by bifurcation of 2 farther back, costae strong and rounded and with narrow interspaces. Flanks of pedicle valve smooth or indistinctly costate, those of brachial valve with few strong costae. Stolidium vestigial.

Pedicle valve flatly convex or slightly concave in

lateral profile and nearly flat in anterior profile. Umbonal region narrowly swollen; sulcus beginning near midvalve, deepening abruptly, generally flat transversely, extended into long truncated tongue with vestigial stolidium. Flanks broad, extended laterally, slightly concave and prominent.

Brachial valve unevenly convex in lateral profile, posterior region moderately curved but anterior flattened; anterior profile broadly domed and with long steeply sloping sides. Fold prominent, originating posterior to midvalve, widening and heightening anteriorly, there strongly elevated above flanks. Anterior margin of fold strongly deflected dorsally. Flanks strongly descending and moderately swollen, forming strong contrast to flattened and elevated fold.

Pedicle valve interior with very short, wide, shallow spondylium occupying a quarter to a fifth valve length. Median septum moderately high and extending anteriorly to front of spondylium. Inner margin of tongue of sulcus with 5 prominent, conical projections or spines.

Camarophorium longer than spondylium but relatively short nevertheless, widening abruptly anteriorly and with moderately long median projection. Crura slender. Intercamarophorial plate long and slender. Inner margin with thick conical spines.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 725f					
152876a (holotype)	17.9	?	25.0	?	146
152876b	20.4	?	27.0	?	146
152876c	16.4	?	23.1	?	140
152876d	23.6	22.4	29.8	13.0	138

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Bell Canyon Formation (Hegler and Rader members).

LOCALITIES.—Getaway: USNM 728. Hegler: USNM 731. Rader: USNM 725f.

DIAGNOSIS.—*Stenosisma* with strong, unequally costated valves, rectangular to elliptical outline, and vestigial stolidium.

TYPES.—Holotype: USNM 152876a. Figured paratype: USNM 152876b. Measured paratypes: USNM 152876b–d. Unfigured paratypes: USNM 152876c, d.

COMPARISON.—The exterior form with its rec-

tangular outline and nearly flat pedicle valve is unlike that of any other *Stenosisma* described herein. The brevity of the spondylium and cardinalia for such a large shell is also a distinctive feature. The only species remotely like this one is *S. fabarium*, new species, from the upper Cathedral Mountain Formation. This has somewhat the same configuration but it is costated differently, is much smaller, and has a large stolidium as well as many minor differences of configuration.

DISCUSSION.—This species is represented by few specimens, consisting of three pedicle valves, a complete shell, and a few scraps that preserve parts of the interior of both valves. Ordinarily we would not propose a specific name for fragmentary material of this sort but this is a unique species and very rare. In spite of the meager material, all of the essentials of the interior and exterior are preserved so that an accurate picture can be given of all but the variation of the species, which is probably considerable. Two fragmentary specimens, both parts of pedicle valves indicate the same or a similar species at other localities; one is from the Hegler Limestone at USNM 731 and the other from the Cherry Canyon Formation (Getaway Member) at USNM 728.

The exterior details of this species suggest those of the Devonian *Leiorhynchus* Hall. The short beak, strong fold and sulcus and the irregularity of the ornament are all reminiscent of this similarity. *Stenosisma fabarium* is also similar in this respect and may be related to *S. aberrans*.

Stenosisma amoenum, new species

PLATE 554: FIGURES 1–14

Small for genus, subtriangular in outline, maximum width just anterior to midvalve; sides narrowly rounded; anterior margin broadly curved; apical angle about 95°; valves subequal in depth. Beak moderately long, suberect; no deltidial plates (?). Surface costate except for smooth umbones, costae fairly uniform in size on flanks, fold, and sulcus, 4 or 5 on fold with outer 2 usually depressed below median 2 or 3; costae on each flank numbering 4 or 5, outer one indistinct. Stolidium not seen.

Pedicle valve in anterior profile broadly concave but moderately convex in lateral profile; umbonal

region narrow; sulcus moderately wide, shallow, originating posterior to midvalve and forming moderately long tongue. Flank narrow, gently convex.

Brachial valve evenly and gently convex in lateral profile, fairly strongly domed in anterior profile with fold slightly protuberant medially and sides sloping steeply. Fold originating posterior to midvalve, elevating above flanks slightly in anterior direction; flanks moderately broad and gently convex.

Interior not known, except for presence of spondylium and septum seen on broken specimens.

MEASUREMENTS (in mm).—

		brachial valve		thick- ness	apical angle (°)
	length	length	width		
USNM 708q					
152271a	12.8	11.0	14.3	8.9	95
(holotype)					
152271b	11.9	10.6	12.4	8.4	89
152271c	13.3	11.3	15.6	9.2	94

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch (Decie Ranch Member).

LOCALITY.—USNM 708q.

DIAGNOSIS.—Small nearly completely costate *Stenoscisma* with strongly costate flanks.

TYPES.—Holotype: USNM 152271a. Figured paratype: USNM 152271b. Unfigured paratype: USNM 152217c.

COMPARISON.—This small *Stenoscisma* differs from all other Glass Mountains and Guadalupe Mountains species of comparable size in having the surface nearly completely costate. In this respect it suggests *S. mutabile oregonense* Cooper from the Coyote Butte Formation of central Oregon. It differs, however, in being more completely costate than that species, in having more costae on the fold, and in having less clearly defined and differently arranged intercalations and bifurcations.

DISCUSSION.—This is a very rare species; only six specimens were collected. It was not found in any of the siliceous residues but was recovered in breaking up Decie Ranch limestone.

Stenoscisma aptatum, new species

PLATE 555: FIGURES 1–50

Average size for genus; outline broadly subtriangular or subelliptical, sides diverging between 70°

and 105°, maximum width located near midlength; profile moderately strongly biconvex; commissure uniplicate, fold low to moderately high, standing increasingly high above flanks anteriorly, beginning 5–7 mm anterior to brachial beak; sulcus shallow, becoming moderately deep anteriorly, beginning 7–10 mm anterior to pedicle beak. Costae moderately strong on fold and sulcus, weaker on flanks, blunt crested, normally not bifurcating, beginning 5–7 mm anterior to beaks, numbering 3 or 4 on fold, one less in sulcus, normally 3 on each flank; stolidium well developed, better formed on brachial flanks, but on both valves at fold; growth lines fine and closely spaced, with irregularly spaced stronger laminae.

Pedicle valve moderately strongly convex transversely and longitudinally, umbonal region somewhat swollen; beak relatively short but strongly hooked and erect, not pressed against umbonal region of brachial valve; lateral pseudointerareas elongate, narrow, covered by edge of brachial valve; delthyrium triangular, normally constricted by small, disjunct deltidial plates, but entirely open in specimens with strongly hooked beaks; foramen small, slit-shaped, opening directly ventrally. Brachial valve strongly convex transversely, less convex longitudinally along crest of fold; beak bluntly pointed, slightly swollen, apex within pedicle valve, beneath deltidial plates.

Pedicle valve interior with small hinge teeth fused to sides of valve; dental plates converging just above floor to form boat-shaped spondylium, continuing to floor as low median septum. Muscle marks faint in anterior two-thirds of spondylium, set off by sharp line from posterior portion; vascula media diverging at straight angle to cross valve just anterior to median septum; gonocoel impressions posterior, lateral to spondylium.

Brachial valve interior with semicircular to crescentic hinge plate, thickened at apex of valve to form cardinal process, fibrillate for muscle attachment; hinge sockets located at lateral extremes of hinge plate, details not observed; crural bases extending forward from base of cardinal process, continuing free as slender brachial processes, outwardly bowed, ventrally bent, conforming to outline of camarophorium; intercamarophorial plate supporting hinge plate by contact with small, short crural plates between crural bases; camarophorium spoon-shaped, with broad, short anterior median projec-

tion; median septum short on valve floor, length increasing greatly with height. Muscle marks weak in camarophorium; pallial marks not observed.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 702c					
152241a	1.0	1.0	0.8	0.6	?
152241b	1.7	1.6	1.3	0.8	?
152241c	3.3	3.1	2.7	1.6	70?
152241d	4.0	3.7	3.0	1.9	72?
152241e	5.3	5.0	4.8	2.8	78
152241f	7.2	6.5	6.4	3.3	78
152241g	9.8	8.3	9.4	5.0	83
152241h	13.0	10.9	12.9	7.6	84
152241i	14.6	12.7	14.7	8.3	86
152241j	16.5	14.6	18.6	10.2	98
USNM 702					
152239	18.4	16.4	21.4	15.0	89
USNM 703bs					
152244	20.0?	18.4	25.0	15.4	99
USNM 702c					
152240 (holotype)	17.5	15.0	18.2	11.4	95

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Road Canyon Formation.

LOCALITIES.—Cathedral Mountain: USNM 702, 702un, 703b, 703bs. Road Canyon: AMNH 501; USNM 702c, 716x.

DIAGNOSIS.—Medium-sized *Stenosisma* with erect beak and moderately inflated brachial valve.

TYPES.—Holotype: USNM 152240. Figured paratypes: USNM 152239, 152241a–g. Measured paratypes: USNM 152239, 152241a–j, 152244. Unfigured paratypes: USNM 152241h–j.

COMPARISON.—*Stenosisma aptatum* is characterized by its subelliptical to broadly trigonal outline, rather weak costae with rounded crests, hooked beak, and well-developed stolidium. It most nearly resembles a large version of *S. doricranum*, new species, but differs in its larger size, more numerous costae on fold and flanks, more consistently hooked pedicle beak, and different pattern of pallial marks, at least in the pedicle valve. The pattern of development of the stolidium indicates that it probably belongs to the group of species that includes *S. venustum* (Girty) and *S. triquetrum*, new species. It differs from both of those species in its smaller size, fewer and weaker costae, less strongly triangular outline, and more strongly hooked pedicle beak with disjunct deltidial plates. Some specimens of

S. renode, new species, are similar in their blunt costation, but differ in their more triangular outlines, more numerous costae, and especially in their beaks that are pressed against the brachial umbo, eliminating the foramen.

Among foreign species *S. mutabile* (Tschernyschew 1902), also illustrated by Grabau (1931a, pl. 4), appears to have the strongest similarity to *S. aptatum*. It differs in its stronger costae and more closely hooked pedicle beak, and Tschernyschew's specimens differ additionally in their normally bifurcating costae on the fold. *Stenosisma biplicatum* (Stuckenberg) as shown by Tschernyschew (1902) also is very similar, but *S. aptatum* is not as swollen in the pedicle umbonal region, its costae begin farther forward, is not as strongly triangular, and its fold does not stand as prominently above the flanks. Stuckenberg's (1898) illustrations of *S. biplicatum* do not closely resemble *S. aptatum*. The same species illustrated by Reed (1944, pl. 24: figs. 10–10b) is much more attenuate and more strongly triangular than *S. aptatum*. Another similar species is *S. pingue* (Waagen), which differs in its narrower outline, more numerous costae, and more strongly biconvex profile.

Stenosisma bellatulum, new species

PLATE 556: FIGURES 34–54

Small for genus; outline subtrigonal, sides diverging about 100°, widest anterior to midlength; profile narrowly convex in youth, curvature of valves increasing with growth; uniplicate commissure bearing 3 costae on fold in early stages, adding 2 more by lateral branching in adults, 3 or 4 costae on each flank, beginning farther forward than costae on fold; stolidium rather narrow, apparently best developed on fold of pedicle valve and flanks of brachial valve.

Pedicle valve with moderately curved beak; foramen reduced in adults but nevertheless remaining open and without deltidial plates in all specimens; sulcus beginning about 2 mm anterior to beak. Brachial valve more strongly convex; fold broad and transversely flat across crests of costae; postero-lateral edges lapping over flattened flange of pedicle valve edges.

Pedicle valve interior with proportionately short spondylium elevated on thin median septum; hinge

teeth short, supported by central plates that converge to form spondylium; pallial trunks dichotomous, full course not observed. Brachial valve interior with proportionately small and delicate camarophorium, trough-shaped, and moderately curved ventrally; cardinal process small and narrow; pallial marks not observed.

MEASUREMENTS (in mm).—

	length	width	thick- ness	apical angle (°)
USNM 727e				
154574a	9.0	11.0	5.5	100
154574d	11.0	13.0	7.0	98
154574f	11.8	13.8	7.2	100
154574g	12.5	15.0	9.8	105
154574e (holotype)	14.4	15.6	10.9	101

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation.

LOCALITY.—USNM 727e.

DIAGNOSIS.—Small, 3 costae on fold in juveniles, 2 added by bifurcation in adults, costae of moderate strength.

TYPES.—Holotype: USNM 154574e. Figured paratypes: USNM 154574a–d.

COMPARISON.—*Stenosisma bellatulum* resembles a few of the other Wolfcampian species that are not strongly costate. It is smaller and narrower than *S. levicostum*, new species, of the Bone Spring Formation, and its costae begin farther forward, with the lateral 2 of the fold being added by bifurcation at a considerable distance from the beak. It is larger and more strongly costate than *S. myioides*, new species, of the Skinner Ranch Formation, is more highly convex, has a better developed stolidium, and its beak is more strongly curved. Its size and convexity recall *S. hueconianum* (Girty) of the Hueco Formation, but *S. bellatulum* is proportionately narrower, the pedicle valve is flatter, and its costae are fewer on both fold and flanks.

Stenosisma bonum, new species

PLATE 556: FIGURES 1–33

Small for genus, wider than long, maximum width near midvalve; subpentagonal in outline; sides narrowly rounded; beak short, strongly incurved; deltidial plates absent or vestigial; paucicostate, costae short, low, rounded, confined to anterior third or half, strongest on fold and sulcus,

2 or 3 on fold (usually 3) and one less in sulcus; flanks with 1 or 2 costae, outside one indistinct. Stolidium usually narrow, shared by both valves, tongue of pedicle valve and flanks of brachial valve.

Pedicle valve with moderately convex lateral profile, maximum curvature in umbonal region; anterior profile very gently convex; umbo and posterior moderately swollen; sulcus originating near midvalve, widening and deepening abruptly and forming short tongue. Flanks moderately broad and nearly flat.

Brachial valve evenly and moderately convex in lateral profile but strongly domed in anterior profile; sides sloping steeply to precipitously. Median region and umbo swollen. Fold originating near midvalve, steepening abruptly and moderately strongly elevated at anterior. Flanks gently swollen, sweeping strongly away from fold.

Pedicle valve interior with short, anteriorly rounded and moderately deep spondylium supported on low septum extending short distance anterior to anterior margin of spondylium. Brachial valve interior with long camarophorium, delicate intercamarophorial plate, and high median septum.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 724j					
152877a	4.1	3.7	3.8	2.2	60
152877b	4.9	4.3	4.3	2.7	66
152877c	5.9	5.2	5.2	3.2	77
152877d	6.2	5.9	6.1	3.4	77
152877e	6.7	6.0	6.7	3.8	82
152877f	8.2	7.3	8.8	4.8	92
152877g	8.2	7.3	9.7	5.6	96
152877h	9.7	8.7	10.8	5.9	104
152877i	10.0	8.7	11.9	7.0	97
152877j	8.5	7.5	9.8	6.2	100
152877s (holotype)	8.5	8.0	9.5	5.5	95

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 707e, 720d, 721j, 721o, 721t, 721y, 722e, 722g, 724a, 724b, 724j.

DIAGNOSIS.—Small, delicate, nearly nude *Stenosisma* with 3 short costae on the fold.

TYPES.—Holotype: USNM 152877s. Figured paratypes: USNM 152877j,k,m–r; 154575a. Measured and unfigured paratypes: USNM 152877a–i. Unfigured paratype: USNM 152877-l.

COMPARISON.—This species belongs to a group of semismooth stenoscismas and need be compared only to them. It is smaller than all of those named here but has other differences as well. It differs from *S. doricranum* and *peneleve*, both new, in having more subdued costae on both flanks and fold. It differs from *S. calvatum*, new species, in having a less robust brachial valve, less strong costae on the fold and sulcus, and a shorter beak. It is completely unlike *S. fabarium*, new species, which is strongly convex, variably ornamented, and, for its size, has a more prominent sulcus and shorter beak.

Stenoscisma calvatum, new species

PLATE 557: FIGURES 1-60

Small for genus, length and width nearly equal; outline subtrigonal, posterolateral margins somewhat pinched and sides narrowly rounded; greatest width just anterior to midvalve; anterior margin broadly and gently curved. Sides diverging between 75° and 100°, depending on age. Beak suberect, not pressed onto brachial umbo; deltidial plates vestigial. Surface nearly smooth except for anterior third where low rounded costae appear, 2-4, usually 3 at margin but become obsolete posteriorly in short distance; flanks with 1 or 2 costae distinct only at margin. No stolidium seen and no traces along margin.

Pedicle valve moderately convex in lateral view, not as deep as brachial valve; anterior profile varying from slightly and broadly convex to slightly and broadly concave. Umbonal region narrowly swollen. Sulcus originating abruptly at midvalve, occupying about half valve width, shallow, and developing into fairly long tongue. Flanks narrow, moderately steep, and nearly flat.

Brachial valve evenly and fairly strongly convex in lateral profile, anterior profile narrowly domed and with very steep lateral slopes. Umbonal and median regions inflated; fold originating slightly posterior to midvalve, best defined at margin, there slightly elevated. Flanks moderately depressed below the fold, convex, and inflated.

Pedicle valve interior with deep spondylium slightly less than a third valve length, wide and deep with broadly rounded anterior, attached to low median septum protruding short distance anterior to front of spondylium. Brachial valve interior

with strongly elevated camarophorium attached to short septum. Hinge plate broad and flattened, with thick striated cardinal process. Intercamarophorial plate short.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 721t					
152340a	7.4	6.4	7.3	4.1	87
152340b	8.5	7.4	8.6	5.3	85
152340c	9.5	8.1	10.0	5.4	85
152340d	11.2	9.4	12.2	8.2	83
152340e	12.3	10.3	12.5	8.2	83
152340f	11.7	10.0	13.0	8.5	87
152340g	12.4	10.6	12.6	7.8	87
152340n	10.5	10.0	13.0	8.5	96
(holotype)					
USNM 721x					
152341a	6.0	5.0	5.6	3.1	76
152341b	8.1	6.7	7.7	4.8	77
152341c	9.2	8.0	9.0	5.5	69
152341d	10.4	8.8	10.9	6.5	86
152341e	10.5	8.9	12.0	6.5	89

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Road Canyon Formation.

LOCALITIES.—Cathedral Mountain: USNM 702, 702un, 735b. Road Canyon: USNM 702c, 703a, 703c, 706f, 709c, 710u, 719x, 721t, 721x, 721y, 726z.

DIAGNOSIS.—Small, nearly smooth *Stenoscisma* with a few subdued costae.

TYPES.—Holotype: USNM 152340n. Figured paratypes: USNM 152340h-k,m-q; 152341f-h. Measured paratypes: USNM 152340a-g, 152341a-e. Unfigured paratypes: USNM 152340b-g,l; 152341a-c.

COMPARISON.—The paucicostate exterior of this species limits comparison to other paucicostate species such as *S. doricranum*, new species, and *S. bonum*, new species. *Stenoscisma calvatum* differs from the first in having less prominent costae on both valves, in being generally not so large or thick, in having a more elongated beak, and in showing no trace of a stolidium. *S. calvatum* differs from *S. bonum* in its larger size, its lack of a stolidium, and in having a more erect beak not curved over the umbo of the opposite valve and stronger costae.

Stenoscisma camurum, new species

PLATE 558: FIGURES 1-42

Shell about normal size for genus; outline trans-

versely subelliptical to subpentagonal, sides diverging between 85° and 115°, maximum width slightly anterior to midlength; profile moderately to strongly biconvex; commissure uniplicate, fold moderately high, broad, beginning 7–9 mm anterior to brachial beak; sulcus shallow, beginning 7–10 mm anterior to pedicle beak. Costae strong, blunt crested, normally not bifurcating nor intercalating, beginning 5–7 mm anterior to beaks, numbering 3–6 on fold, one less in sulcus, 4–6 on each flank, weaker on flanks; stolidium well developed on brachial flanks and pedicle sulcus; growth lines fine, with occasional stronger laminae.

Pedicle valve moderately strongly convex transversely, more strongly convex longitudinally through sulcus; umbonal region rather swollen; beak relatively short, erect to strongly hooked, usually pressed tightly against brachial umbo; lateral pseudointerareas comparatively short and wide, mostly covered by edges of brachial valve; delthyrium wide, triangular, rarely with small deltidial plates, normally completely filled by brachial beak, without external foramen. Brachial valve strongly convex transversely and longitudinally; beak bluntly pointed, with apex in pedicle valve.

Pedicle valve interior with elongate, knoblike teeth; dental plates continuous with hinge teeth, converging just above floor of valve to form large, boat-shaped spondylium, fused beneath spondylium to form low median septum reaching floor of valve. Muscle marks faint and undifferentiated in anterior two-thirds of spondylium; pallial marks moderately strongly impressed: vascular media forming troughs diverging nearly at straight angle from point just anterior to median septum, marks of gonocoels faintly visible posterior to transverse pallial troughs, on floor of valve beside spondylium. Brachial valve interior with large, laterally attenuate hinge plate, greatly thickened at apex of valve to form large, knoblike cardinal process striated for muscle attachment; hinge sockets short, relatively wide, denticulate, located at extremities of hinge plate; crural bases diverging anteriorly from near base of cardinal process, space between them filled for short distance by small crural plates attaching them to top of intercamarophorial plate; camarophorium long, spoon-shaped, widest toward anterior end, with short, wide projection at anterior median line; intercamarophorial plate short, supporting floor of camarophorium to underside of hinge plate; median

septum high, thin, length increasing with height. Muscle marks in spondylium faint; pallial marks on valve floor consisting of two thin trunks diverging from near sides of median septum, branching near midlength of valve, sending branches to anterior and lateral edges.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 707e					
152238a	12.3	11.6	15.0?	8.4	90
152238b	17.0	15.2	20.6	11.3	104
152238c	18.4	16.2	23.0	14.5	97
152238d	21.4	20.0	27.9	19.0	98
152238e	22.0	20.5	30.4	16.5	111
152238f	29.5	17.0	24.0	13.9	106
152238g	19.7	18.2	23.0	14.5	90
152878 (holotype)	17.3	15.8	19.2	13.1	99

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation; Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Road Canyon: AMNH 503; USNM 702c, 703d, 706f, 707e, 710z, 716x, 721s, 719x, 721x, 721y, 721z, 722g, 724a, 726z. Getaway: AMNH 585.

DIAGNOSIS.—Fairly large, strongly convex, and widely frilled; strongly hooked beak pressed against dorsal umbo.

TYPES.—Holotype: USNM 152878. Figured paratypes: USNM 152237a–d, 154573a–f. Measured paratypes: USNM 152238a–g.

COMPARISON.—*Stenosisma camurum* is characterized by its strong convexity, strongly hooked pedicle beak that normally presses against the brachial beak so that the foramen is nearly completely filled, moderately strong and simple costae, and its well-developed, broad and somewhat wrinkled stolidium. Its nearest relative is *S. renode*, new species, which probably is a descendant; it differs from *S. renode* in its wider outline with more strongly diverging sides, greater convexity, especially of the brachial valve, and its pedicle beak that is not as consistently pressed tightly against the brachial umbo. It is more inflated and narrower than *S. repigratum*, new species, and its beak is more strongly hooked. The hooked beak, absent deltidial plates, and the arrangement of the stolidium on the brachial flanks and pedicle sulcus distinguishes *S. camurum* from *S. venustum* (Girty) and *S. triquetrum*, new species. The only other comparable Texas species is *S.*

aptatum, new species, which is less convex, has fewer and weaker costae on fold as well as flanks, and has the stolidium better developed on the brachial valve, as in *S. triquetrum*.

Several foreign species must be compared to *S. camurum*, most notably *S. mutabile* (Tschernyschew, 1902). The Texas species differs in its somewhat less inflated brachial valve, and its simple, nonbifurcating costae. *Stenosisma purdoni* (Davidson) as shown in Waagen (1883, pl. 3) also is similar, but differs in its more numerous and stronger costae on the flanks, and its somewhat narrower outline. *Stenosisma pingue* (Waagen) has the costae beginning closer to the beaks, and also is narrower, characters that it shares with *S. biplicatum* (Stuckenberg, 1898).

Stenosisma "deloi" (R. E. King)

Camarophoria deloi R. E. King, 1931:110, pl. 34: figs. 24-27.

DISCUSSION.—As originally constituted, this species includes forms from the "Gym" (Hueco) Formation as well as from the Word Formation and from an unnamed formation in the Santa Rita Mountains of Arizona. An editor's footnote by Dunbar in R. E. King (1931:110) warns that this species is in part preempted by "*Camarophoria hueconiana* Girty (see under *Stenosisma hueconianum*). The holotype, not illustrated here, has proved to be among the specimens anticipated by the latter species, so "*deloi*" is effectively nullified. The Word specimens of King are reillustrated herein under the new species, *Stenosisma maniculum* (see Plate 565: figures 11-15) and as far as can be ascertained, the specimens identified by Stainbrook and Madera (1941, pl. 55: fig. 15-27) also belong to *S. maniculum*.

The Arizona specimens lack the internal features of *Stenosisma*, and probably represent a species of *Pontisia* (Plate 565: figures 1-10).

TYPES.—Figured specimens: YPM 12694a,b.

Stenosisma doricranum, new species

PLATE 559: FIGURES 1-55

Camarophoria thevenini R. E. King [not Kozłowski, 1914], 1931:110, pl. 34: figs. 28a-c.

Small for genus; outline subtrigonal to transversely subpentagonal, sides diverging between 75°

and 110°, most juveniles narrower than most adults, maximum width anterior to midlength; profile moderately biconvex to subtrigonal; commissure uniplicate, fold moderately high, not standing sharply above flanks, broad to narrowly arched, beginning 4-9 mm anterior to brachial beak; sulcus shallow but extended forward into brachial valve as short tongue, beginning 7-10 mm anterior to pedicle beak, no emargination of anterior. Costae low, weak, round crested, simple, beginning 5-10 mm anterior to beaks, numbering 1-3 on fold, one less in sulcus, 1 or 2 on each flank; stolidium moderately developed on both valves, normally continuous from flanks to fold.

Pedicle valve moderately convex transversely, more strongly convex longitudinally through sulcus; beak near average length for genus, erect, hooked on some specimens but not pressed against brachial valve; umbonal region moderately swollen; beak ridges short, sharp on some specimens; lateral pseudointerareas narrow, short, or absent, normally covered by edge of brachial valve; delthyrium small, triangular, constricted by small, disjunct deltidial plates. Brachial valve strongly convex transversely, with swollen umbonal area, moderately convex longitudinally along crest of fold; apex of beak within pedicle valve beneath deltidial plates.

Pedicle valve interior with small elongate teeth, parallel to and fused to sides of valve; dental plates fused just above valve floor, forming normal size, boat-shaped spondylium, supported by low, short median septum. Muscle marks faintly impressed in anterior half of spondylium; pallial trunks fine, narrowly diverging from near sides of median septum, bifurcating twice to send branches to lateral and anterior margins.

Brachial valve interior with broadly triangular hinge plate, swollen or transversely ridged at posterior apex to form cardinal process; hinge sockets short, narrow, finely denticulate, located at lateral extremes of hinge plate; crural bases diverging narrowly from anterior base of cardinal process, space between them filled by crural plates uniting them to top of intercamarophorial plate; brachial processes free, outwardly bowed and ventrally bent, conforming roughly to outline of camarophorium; median septum moderately long, length increasing with height; camarophorium elongate, spoon-shaped, with toothlike process extending anteriorly at median line; intercamarophorial plate short,

sturdy; muscle marks faint, in anterior part of camarophorium; pallial marks not completely observed: posterior parts of vascula media seen diverging anteriorly on floor of valve near median septum, anterior portions not observed.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 702a					
152287a	2.9	2.6	2.4	1.3	?
152287b	3.7	3.3	3.3	1.8	90?
152287c	4.7	4.3	4.0	2.6	80?
152287d	5.3	4.8	4.7	2.6	78
152287e	6.2	5.6	5.4	2.9	77
152287f	7.7	6.7	6.9	3.6	77
152287g	8.6	7.5	8.9	4.9	85
152287h	9.7	8.6	9.0	5.6	77
152287i	10.3	8.8	11.0	6.5	87
152287j	12.3	11.0	13.0	7.0	88
152287k	12.5	11.7	14.0	9.0	92
152287-l	14.0	12.4	15.5	10.0	90
152286h	13.0	13.5	14.0	9.0	104
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Hess Formation (Taylor Ranch Member); Skinner Ranch Formation.

LOCALITIES.—Cathedral Mountain: AMNH 500; USNM 702, 702a, 702ent, 702-low, 702un, 703b, 714w, 735b. Taylor Ranch: USNM ?702e. Skinner Ranch: USNM ?705a.

DIAGNOSIS.—Small, pauciplicate *Stenosiscisma* with long beak and small, narrow stolidium.

TYPES.—Holotype: USNM 152286h. Figured paratypes: USNM 152285; 152286a-g, i-k; 152291a. Measured paratypes: USNM 152287a-l.

COMPARISON.—*Stenosiscisma doricranum* is characterized by its small size, triangular outline, few and weak costae that begin far forward and do not bifurcate, moderately long pedicle beak with only rudimentary plates that leave a relatively large foramen, and its moderately well-developed stolidium that is equally developed on both valves and normally continuous. It is about the same average size as *S. fabarium*, new species, differing in its more triangular outline, less strongly costate fold, more consistently present stolidium, narrower divergence of sides, longer pedicle beak and spondylium, and present although disjunct deltidial plates. *S. aptatum*, new species, is most nearly similar in shape, but is about twice the size, has stronger and more numerous costae on fold and flanks, a more

strongly swollen and hooked pedicle beak, and a better developed stolidium. *S. camurum* and *S. triquetrum*, both new, and *S. venustum* (Girty) differ in most of these same characters, and also are broader in outline.

King (1931) assigned this species to *S. thevenini* (Kozłowski), but our more abundant collections show several differences from that species that are consistent and significant. *Stenosiscisma doricranum* is less elliptical in outline, has broader, lower and normally fewer costae on the fold, the costae begin farther forward, the brachial umbonal region is swollen, and the pedicle beak is longer, leaving room for a larger foramen. Among other foreign species that resemble *S. doricranum* is the type species *S. schlotheimi* (von Buch), figured by W. King (1850, pl. 7: figs. 10-21) and Grant (1965a, pl. 21: figs. 1-12). It attains a larger size than *S. doricranum*, has more and sharper costae, and its stolidium is more complete than on any known specimen of the Texas species. Juvenile shells of *S. mutabile* (Tschernyschew, 1902) also are similar to *S. doricranum* in some features; however, they are more strongly convex, more costate on the flanks, and have the beak normally pressed tightly against the brachial umbonal region.

Stenosiscisma meyeri (Ozaki, 1931) is small like *S. doricranum*, but its costae are higher, more numerous and sharper on the fold, and they begin farther back, although the flanks are nearly smooth as in *S. doricranum*. *Stenosiscisma biplicatum* (Stuckenberg) as shown not by Stuckenberg (1898) but by Tschernyschew (1902, pl. 50) and Reed (1944, pls. 22, 24) also is similar, but has the costae more numerous and beginning farther back, and that species is more convex and its pedicle umbonal area somewhat more swollen. Reed's specimens have the pedicle beak rather long and attenuate, but in Tschernyschew's it is shorter and more strongly hooked toward the brachial valve. *Stenosiscisma semiplicata* (Gemmellaro, 1899) is comparable to *S. doricranum*, but differs in its stronger, sharper, more numerous costae on fold and flanks, and its somewhat more strongly hooked pedicle beak.

Stenosiscisma exutum, new species

PLATE 560: FIGURES 1-38

Adult moderately large for genus; outline trans-

versely subelliptical, sides diverging between 75° and 135°, in most adults over 100°, maximum width of shell near midlength or slightly anterior thereto; profile strongly biconvex to subtrigonal; commissure uniplicate, fold low to moderately high, beginning 6–10 mm anterior to brachial beak; sulcus relatively shallow, beginning 10–15 mm anterior to pedicle beak. Costae fairly strong on fold and sulcus, weaker on flanks, crests sharp to slightly rounded, beginning 1–2 mm anterior to apexes of beaks, normally simple but occasionally bifurcated or intercalated, numbering 5–7 (normally 6) on fold, one less in sulcus, 6–11 (normally 7 or 8) on each flank; stolidium poorly developed, rudimentary or missing on most specimens. Fine radial ornamentation absent; growth lines fine, closely spaced, with occasional strong laminae.

Pedicle valve moderately convex transversely, strongly convex through sulcus, with somewhat inflated umbonal area; beak short to moderately long for genus, suberect or rather strongly hooked; beak ridges short, blunt; lateral pseudointerareas elongate, narrow, mostly covered by overlapping edge of brachial valve; delthyrium small, sides constricted by small and normally disjunct deltidial plates, conjunct only on large adults; foramen small, elongate oval, opening directly ventrally.

Brachial valve strongly convex transversely and longitudinally, umbonal region somewhat swollen; beak bluntly pointed, apex within pedicle valve, beneath deltidial plates.

Pedicle valve interior with 2 blunt, finely denticulate elongate teeth, fused to sides of valve, parallel to sides of valve; dental plates continuous with and supporting hinge teeth, converging just above valve floor to form boat-shaped spondylium by fusing into low median septum bracing spondylium to floor of valve; pallial troughs (vascula media) diverging nearly at straight angle from anterior end of median septum, deeply indenting floor of some valves; muscle marks faint, undifferentiated, on floor and sides of spondylium.

Brachial valve interior with broadly triangular to nearly semicircular hinge plate; cardinal process at apex of hinge plate just under apex of valve, striated radially for muscle attachment, normally knob-shaped; hinge sockets narrow, short, finely corrugate; crural bases extending forward from base of cardinal process, fused to hinge plate, fused to top of intercamarophorial plate by short crural

plates; camarophorium long, spoon-shaped, widest near anterior end, median line extended anteriorly as short, toothlike projection; intercamarophorial plate short; median septum high, thin, length increasing with height; muscle marks in camarophorium faint, anteriorly widening and diverging slightly.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 702					
152296a	4.0	3.8	3.5	2.5	85
152296b	11.0	9.6	11.0	6.5	79
152296c	12.4	10.3	12.4	8.7	78
152296d	14.4	12.6	17.8	10.8	98
152296e	16.6	14.3	20.4	13.1	101
(holotype)					
152296f	21.6	19.4	28.0	13.4	106
USNM 702b					
152298a	22.3	20.3	28.3	14.8	116
152298b	28.0?	26.4	35.7	19.0	123
USNM 703b					
152301a	22.0	20.1	26.7	15.8	94

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—USNM 702, 702b, 702-low, 703b, 727p, 731t.

DIAGNOSIS.—Subelliptical *Stenosisma* strongly and completely costate but with poorly developed stolidium.

TYPES.—Holotype: USNM 152296e. Figured paratypes: USNM 152296c,g-j; 152301a,b. Measured paratypes: USNM 152296a-d,f; 152298a,b; 152301a. Unfigured paratypes: USNM 152296a,b,d,f.

COMPARISON.—*Stenosisma exutum* is characterized by its subelliptical outline, strong convexity, rather swollen pedicle beak, numerous costae beginning near the beaks, and its absent or stunted stolidium. These features distinguish it from its nearest relatives in the Glass Mountains, *S. venustum* (Girty) and *S. triquetrum*, new species. It most nearly resembles *S. inaequale* (Girty) from the Sierra Diablo, differing in its less swollen brachial valve, stronger costae, larger maximum size, and reduced or absent stolidium. *Stenosisma renode*, new species, from the Word Formation has fewer and coarser costae and its beak is pressed against the umbonal region of the brachial valve. *Stenosisma pyraustoides*, new species, has many costae, but is much wider, strongly emarginate, and nor-

mally has a well-developed stolidium. *Stenosisma camurum*, new species, has many costae on the flanks, but fewer on the fold. Furthermore it is much less bulbous, has a well-developed stolidium, and normally has the pedicle beak pressed against the brachial umbonal region. *Stenosisma repigratum*, new species, is similar in outline, but much less convex and has fewer and coarser costae, well-developed deltidial plates, and normal stolidium.

Among European species the closest resemblance to *S. exutum* is in *S. latissimum* (Schellwien, 1892: 53, pl. 8: figs. 3a-d), the outline and costation of which are similar; however, *S. exutum* is more convex and its flanks normally have more costae; nor can its beaks and stolidium be compared, inasmuch as Schellwien's specimen is an internal mold. *Stenosisma sanctispiritus* (Schellwien, 1892) also is multicostate, but its maximum width is far posterior to the midlength, its fold and sulcus begin farther back, and its brachial valve is extremely convex longitudinally, resembling more nearly species of *Rhynchopora*.

Stenosisma applanata (Tschernyschew, 1902:87, 497, pl. 46: fig. 1) is similar in outline to *S. exutum*, but differs in its weaker and fewer costae. *Stenosisma mutabile* (Tschernyschew, 1902:81, 491: pl. 45) has some individuals that are similar in costation to *S. exutum*, but must have fewer, stronger costae, more triangular outlines, and have the beak tightly pressed against the brachial umbonal region, more like *S. renode* than *S. exutum*.

Of Salt Range species identified by Waagen (1883), only *S. purdoni* (Davidson) is sufficiently similar to *S. exutum* to warrant comparison. *S. purdoni* is narrower in outline, its costae are stronger and fewer, and its pedicle beak is shorter and closely hooked over the brachial umbonal region.

DISCUSSION.—No specimen of *Stenosisma exutum* in our collections has a well-developed stolidium; most have no stolidium. This absence is not an accident of preservation, because otherwise complete and well-preserved specimens have the stolidium lacking. Perhaps its absence in this species is a reflection of necessities of habitat, just as we have speculated for certain individuals of other species (e.g., *S. fabarium*, new species). The pedicle opening in *S. exutum* is of about normal size for the size of shell, perhaps to accommodate a functional pedicle, whereas in species with the stolidium well developed the pedicle foramen normally is small or

completely blocked (e.g., *S. renode*, new species). For a species of *Stenosisma*, *exutum* is relatively wide, and possibly the width of the shell served the same supporting function as the stolidium of other species.

Stenosisma fabarium, new species

PLATE 561: FIGURE 1-67

Small for genus; outline subelliptical to subpentagonal, sides diverging between 75° and 125°, over 100° in most adults, maximum width slightly anterior to midlength; profile biconvex, normally subtrigonal; commissure uniplicate, fold moderately high, broad, evenly arched transversely, not standing sharply above flanks, beginning approximately 5-7 mm anterior to brachial beak; sulcus broad, shallow, beginning 5-7 mm anterior to pedicle beak, extending forward as broad tongue, producing slight emargination in some shells. Costae relatively weak, low, round crested, normally not intercalating or bifurcating, beginning 3-5 mm anterior to beaks, stronger on fold and sulcus than on flanks, numbering 2-6 (normally about 3) on fold, one less in sulcus, 0-4 (normally 1 or 2) on each flank, stolidium present or absent, equally well developed on both valves, occasionally continuous from flanks to fold.

Pedicle valve moderately convex transversely, somewhat more strongly convex longitudinally through sulcus; beak very short, erect, normally strongly hooked, umbonal region somewhat swollen; lateral pseudointerareas absent; delthyrium small, triangular, without deltidial plates. Brachial valve strongly convex transversely, moderately convex along crest of fold, umbonal area swollen, strongly convex, slightly attenuate, apex of beak slightly within pedicle valve.

Pedicle valve interior with small, finely denticulate teeth, elongated parallel to sides of valve and fused to edge; dental plates converging just above valve floor, forming proportionately short, boat-shaped spondylium, supported by low to moderately high, short median septum; muscle marks in anterior half of spondylium, set off from beak portion by plainly visible dividing line; pallial marks of vascula media diverging narrowly anteriorly, each lateral trunk normally bifurcating once near valve midlength, gonadal marks on posterior floor of

valve surrounding septum and spondylium.

Brachial valve interior with small, crescentic hinge plate, greatly thickened at apex to form knoblike cardinal process, radially striated for muscle attachment; sockets short, finely corrugated, located at lateral extreme of hinge plate; crural bases diverging anteriorly from base of cardinal process, space between them filled by crural plates, one on each side, dipping to unite crura with top of intercamarophorial plate; brachial processes curved ventrally, not outwardly bowed; median septum very short on floor of valve, length greatly increasing with height; camarophorium spoon-shaped, anteriorly widening, not joined to hinge plate except by short, relatively high intercamarophorial plate, anterior midline with short, toothlike process. Muscle marks faintly impressed, undifferentiated, in anterior half of camarophorium; pallial trunks (vascula media) on floor of valve, one on each side, diverging anteriorly from forward edge of median septum, bifurcating near midlength of valve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 708u					
152234-l (holotype)	11.0	10.3	12.3	7.5	106
152235a	1.7	1.6?	1.6	0.8	?
152235b	2.6	2.4	2.4	1.2	76?
152235c	3.7	3.3	3.1	1.8	91
152235d	4.3	3.9	3.9	1.9	96
152235e	4.8	4.3	4.3	2.6	94
152235f	5.3	4.8	5.0	2.8	100
152235g	7.0	6.4	6.9	4.0	88
152235h	7.7	6.7	7.0	4.4	85
152235i	8.2	7.5	8.4	4.8	90
152235j	10.0	9.3	10.9	7.0	101
152235k	11.1	11.1	14.3	8.0	117
152235-l	13.6	13.0	17.4	8.9	113
152235m	15.7	14.9	20.0	11.4	112

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain (base).

LOCALITIES.—USNM 702, 702-low, 708u.

DIAGNOSIS.—Small, pentagonal *Stenosisma* with subdued costae, nearly smooth flanks, and unusually short beak without deltidial plates.

TYPES.—Holotype: USNM 152234-l. Figured paratypes: USNM 152233; 152234a-k, m-q. Measured paratypes: USNM 152235a-m. Unfigured paratypes: USNM 152234a-k.

COMPARISON.—*Stenosisma fabarium* is characterized by its small size, widely elliptical or pentagonal outline with widely diverging sides, low and rounded costae on the fold and in the sulcus, and nearly smooth flanks, absent lateral pseudointerareas (see discussion, below), short beak without deltidial plates, short spondylium, short brachial median septum, and its characteristic pallial markings. Among Texas species it most nearly resembles *S. doricranum*, new species, differing in its wider outline, more strongly costate fold, shorter beak, absent deltidial plates, and proportionately shorter spondylium. *Stenosisma hueconianum* (Girty) is similar in size, but is much more bulbous, more strongly costate, and more nearly triangular in outline.

Among foreign species the closest resemblance is in some specimens of *S. globulina* (Phillips) illustrated by Tschernyschew (1902, pl. 50: fig. 16). *Stenosisma fabarium* differs in its larger size, less bulbous profile, normally broader fold, and more numerous costae on the fold. *Stenosisma sella* (Kurtorga) of Schellwien (1900, pl. 15: figs. 1-4) and Ozaki (1931, pl. 13: figs. 18-18d) is similar in outline, but has no costae, only a sharp fold and groovelike sulcus. *Stenosisma tanakouense*, (Ozaki, 1931, pl. 14: figs. 13a-b) is somewhat narrower in outline, and has a low, transversely flat fold with costae that begin rather abruptly, more like a species of *Wellerella* than like *S. fabarium*. *Stenosisma superstes inornatum* (Merla, 1934, pl. 23: figs. 3-19) also is similar in outline, but differs in its lack of costation, and if Merla's illustrations are correct, also differs in its round foramen. *Stenosisma thevenini* (Kozłowski, 1914, pl. 9: figs. 71-76, pl. 10: figs. 15a-d) is similarly costate, but not as wide as *S. fabarium*, its beak is longer, pedicle umbonal area not as swollen, and its brachial processes are strongly bowed laterally.

DISCUSSION.—*Stenosisma fabarium* has a pattern of pallial markings different from typical species of the species of the genus such as *S. triquetrum*, new species. Instead of the strong and deep trunks that diverge almost at a straight angle, the marks of the vascula media of *S. fabarium* diverge more narrowly, extend forward about to midlength, there bifurcate, and disappear near the anterior and lateral margins. Some specimens have the position of the gonocoels indicated by markings on the floor of the pedicle valve near the apex. This may be a

clue to their position in species of *Stenosisma* where the marks are not visible.

The stolidium is developed on some individuals of *S. fabarium*, but absent from others. Perhaps this sporadic development is linked to the lack of deltidial plates in the foramen, which provides a relatively large opening for a functional pedicle. If the pedicle served for attachment of most individuals, a broad stolidium would have been unnecessary. *S. fabarium* lacks lateral pseudointerareas. Instead its pedicle valve has a flange around the entire margin, against which the edge of the brachial valve can bear, so that instead of meeting edge-to-edge, the valves meet in a kind of shallow tongue-and-groove joint, or in effect, overlap, thus providing more surface of contact than would be obtained by having the edges butt directly. This feature is present in other of the small species of *Stenosisma*.

Stenosisma hadrum, new species

PLATE 562, FIGURES 1-40

Camarophoria venusta [part] R. E. King [not Girty], 1931:110 pl. 34: figs. 29a, b, 30a, b, 31a, b; pl. 35: fig. 5.

Large for genus; outline broadly subtrigonal to subpentagonal, sides diverging between 70° and 120°, maximum width slightly anterior to mid-length; profile strongly biconvex; commissure uniplicate, fold moderately high, gently arched transversely, beginning 5-8 mm anterior to brachial beak; sulcus rather deep, broad, beginning 5-7 mm anterior to pedicle beak. Costae strong, rather sharp crested, added distally on fold and sulcus by bifurcation, beginning 3-5 mm anterior to beaks, numbering 3-6 (normally 5 or 6) on fold, one less in sulcus, 3-6 on each flank, becoming weaker laterally; stolidium well developed, discontinuous between fold and flanks, probably better developed on brachial valve; growth lines fine, closely spaced, with sporadic stronger laminae.

Pedicle valve flatly convex transversely, strongly convex longitudinally through sulcus; beak short, erect, but not hooked; lateral pseudointerareas elongate, covered by edge of brachial valve; delthyrium triangular, constricted by large conjunct deltidial plates, leaving small eye-shaped foramen opening ventrally. Brachial valve strongly convex transversely, moderately convex longitudinally along

crest of fold; beak blunt, now swollen nor attenuate, apex within pedicle valve.

Pedicle valve interior with teeth supported by large dental plates that fuse just above floor of valve to form boat-shaped spondylium, plates continuing to valve floor as low median septum; muscle marks not observed; pallial marks shallow, trunks of vascula media diverging nearly at straight angle, crossing valve, one on each side, beginning just anterior to median septum.

Brachial valve interior with crescentic hinge plate, greatly thickened at apex of valve to form large, striated, commonly polylobate cardinal process; hinge sockets at lateral extremes of hinge plate, details not seen; crural bases diverging slightly anteriorly, space between them filled by short crural plates joining to top of intercamarophorial plate; brachial processes continuing free into valve, outwardly bowed and ventrally bent, conforming to outline of camarophorium, spoon-shaped, with rather long median projection at anterior edge; median septum high, short on floor of valve, but length increasing with height; muscle marks not observed; intercamarophorial plate thin, low, relatively long; pallial marks on floor of valve not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 710r					
152274a	21.0?	18.6	22.5	11.7	92
152274b	21.6	20.3	25.2	15.2	88
152274c	23.6	21.2	29.0	18.5	90
152274d	27.0?	24.2	34.0?	18.2	95
152274e	27.4	25.4	40.2	22.7	101
(holotype)					
USNM 707w					
152283	32.3	27.2	44.6*	23.8	102
USNM 702e					
152267a	26.1	23.1	33.7	15.7	93
152267b	28.5	25.4	38.0	19.6	109

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch and Sullivan Peak members); Hess Formation (Taylor Ranch Member).

LOCALITIES.—Decie Ranch: USNM 715a. Sullivan Peak: USNM 707, 707b, 707d, 707v, 708e, 713d, 713m, 722h. Skinner Ranch (low): USNM 707w, 708q, 709u, 711k, 720f, 720j. Skinner Ranch (top): USNM 705r, 710r, 715v, 722m, 723h, 723-l, 723s, 724p, 726h, 729p. Skinner Ranch: USNM 705n,

727m. Taylor Ranch: USNM 702d, 702e. Hess: USNM 726n.

DIAGNOSIS.—Large *Stenosisma*, strongly costate with well-developed stolidium and short beak.

TYPES.—Holotype: USNM 152274e. Figured paratypes: USNM 152267a–c, 152272, 152274a–d, 152275, 154576a, 154577a. Measured paratypes: USNM 152267a,b; 152274a–d; 152283. Unfigured paratype: USNM 152274c.

COMPARISON.—*Stenosisma hadrum* is characterized by its large size, strong convexity, strong costae that begin near the beaks and normally bifurcate at the sides of the fold and sulcus, well-developed stolidium, and short beak. It occurs at some localities with *S. pansum*, new species, from which it differs by its less triangular outline, stronger, sharper, and more numerous costae that begin farther back, shorter beak without attenuation, proportionately greater thickness and convexity, and its greater frequency of bifurcating costae. It most nearly resembles *S. venustum*, differing primarily in its broader, less markedly triangular outline, somewhat greater convexity, fold and sulcus that start farther posteriorly, lateral costae that tend to begin farther forward on the beak, and sharper costae on fold and sulcus. It also is similar to *S. triquetrum*, new species, differing in its less swollen pedicle umbonal region, without pinched-appearing sides, normally nonbifurcating costae that begin farther from the beaks, broader and less strongly trigonal outline, and its proportionately longer pedicle beak. *Stenosisma hadrum* is more strongly and abundantly costate than *S. pansum*, and also attains larger size, is more convex, less triangular, and has shorter, less attenuate beaks on both valves. *Stenosisma exutum*, new species, also is similar in some features, but is more nearly elliptical in outline, has more numerous costae, many extending nearly to the apexes of the beaks, and it lacks a stolidium.

Several species illustrated by Tschernyschew (1902) are superficially similar to *S. hadrum*. These are *S. kutorgae* (Tschernyschew), *S. crumenum* (Martin), and *S. mutabile* (Tschernyschew), all of which are easily distinguishable by their costae that begin at or near the beaks and are strong on the flanks. Waagen (1883) illustrated specimens of *S. purdoni* (Davidson) from the Salt Range that are similar to *S. hadrum*, but differ in their more numerous lateral costae, lower brachial convexity,

stronger pedicle convexity, and more strongly hooked pedicle beak. His figured specimens of *S. humbletonense* (Howse) also differ in their stronger and more numerous lateral costae, and more strongly hooked beak, as well as in their weaker costae that begin farther forward on the fold. *Stenosisma pingue* (Waagen) is smaller than *S. hadrum*, and also narrower and more strongly convex transversely. *Stenosisma alpinum* (Schellwien, 1892) appears to be similar to *S. hadrum*, but its fold begins farther posterior and its longitudinal convexity is such that the anterior margin is nearly straight rather than somewhat emarginate as in *S. hadrum*.

Stenosisma hueconianum (Girty)

PLATE 563: FIGURES 1–54

Camarophoria hueconiana Girty 1929:412, 414, figs. 41–21.

Camarophoria deloi [part] R. E. King, 1931:110, pl. 34: fig. 24 [holotype].

Stenosisma hueconiana (Girty) Stehli, 1954:340, pl. 24: figs. 14–17.

Stenosisma hueconianum (Girty) Grant, 1965a:147, pl. 19: figs. 1–1b.

Small for genus; outline transversely subelliptical to subpentagonal or trigonal, sides diverging between 70° and 105°, maximum width located anterior to midlength; profile strongly biconvex; commissure uniplicate; fold low to moderately high, broad, beginning about 5 mm anterior to brachial beak; sulcus very shallow, beginning 5–7 mm anterior to pedicle beak. Costae strong, sharp to blunt, commonly bifurcating on fold or sulcus, beginning 3–5 mm anterior to beaks, numbering 3–5 (normally 5) on fold, one less in sulcus, 3–5 on each flank; stolidium rudimentary or absent; growth lines faint.

Pedicle valve moderately convex transversely, strongly convex longitudinally through sulcus; beak relatively long, moderately strongly hooked but not normally pressed against brachial umbonal region; lateral pseudointerareas large, covered by edge of brachial valve; delthyrium broadly triangular, normally without deltidial plates, leaving large open foramen. Brachial valve strongly convex transversely, less strongly convex longitudinally along crest of fold; beak bluntly pointed, apex within pedicle valve.

Pedicle valve interior with hinge teeth fused to

sides of valve; dental plates converging just above floor of valve to form boat-shaped spondylium, fused together beneath spondylium and forming low median septum extending slightly anterior to spondylium; apical region between spondylium and side of valve often filled with shell material. Muscle marks in anterior two-thirds of spondylium, faint and undifferentiated, set off from posterior third by sharp line; pallial marks on valve floor, vascula media diverging at straight angle from forward edge of median septum, crossing valve to sides; marks of gonocoels posterior to transverse vascula, on floor of valve beside spondylium.

Brachial valve interior with broadly triangular to crescentic hinge plate, thickened at apex to form cardinal process; hinge sockets short, located at lateral extremities of hinge plate; crural bases extending forward from base of cardinal process, space between them filled by crural plates, joining them to top of intercamarophorial plate; brachial processes continuing free beyond crural bases, outwardly bowed and ventrally bent, conforming to shape of edge of camarophorium; median septum high, thin, relatively short on floor but length increasing with height, capped by spoon-shaped camarophorium with unusually broad median projection at anterior edge; intercamarophorial plate short, buried in callus in some specimens. Muscle marks in spondylium and pallial marks on floor of valve not observed.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 712e					
142508	9.2	7.5	10.5	7.4	81
142509	10.2	8.8	12.0	9.3	84
142510	10.5	8.8	13.6	9.5	92
142511	11.1	9.9	14.7	10.7	93
142512	12.5	10.8	15.8	12.0	97
155137	11.0	9.5	15.0	9.0	90
(lectotype)					

STRATIGRAPHIC OCCURRENCE.—Alacran Mountain Formation.

LOCALITIES.—USNM 712e, 712m, 741h.

DIAGNOSIS.—Small, transverse *Stenosisma* with swollen pedicle valve umbo and wide fold and sulcus.

TYPES.—Lectotype (herein designated): USNM 155137. Figured hypotypes: USNM 152247a-d, 154578a-g.

COMPARISON.—*Stenosisma hueconianum* is characterized by its small size, bulbous shape, sharp costae, open delthyrium without deltidial plates, and its absent or rudimentary stolidium. Its nearest relative in West Texas is *S. maniculum*, new species, from the Word Formation of the Glass Mountains, but it is normally about twice as big as the latter, and attains a maximum size about three times as big. In addition its costae are stronger and sharper and begin farther back, its pedicle valve is more strongly convex, and its maximum width is located farther forward. No other Texas species is closely similar to *S. hueconianum*.

Among foreign species *S. karpinskii* (Tschernyschew, 1902, pl. 60) is most similar to *S. hueconianum*. It differs in its more globose profile, costae that begin farther back, and more numerous costae on the large specimens. *S. globosum* (Tschernyschew, 1902, pl. 46) is much more rotund, also differing in its lower and broader costae, and more nearly circular outline. *S. hueconianum* differs from *S. nuculum* (Schellwien, 1900b) also illustrated by Hamlet (1928, pl. 9), in its larger size, more numerous and stronger costae, and more strongly inflated pedicle valve. *S. meyeri* (Ozaki, 1931) is similar in outline, but differs in its less globose shape, stronger costae, and more attenuate pedicle beak. *Stenosisma acuminatum* and *S. peronae* (Gemmellaro, 1899) both are more finely costate than *S. hueconianum*, and have the pedicle beak more strongly incurved against the brachial umbonal area.

DISCUSSION.—An editor's footnote in King (1931: 110) points out that the species *Camarophoria deloi* King was partly anticipated by *C. hueconiana* Girty (1929). Unfortunately, it is the holotype from the Hueco Formation that belongs to Girty's species, thus nullifying "*deloi*" as a taxon. This is discussed further under *Stenosisma "deloi"* King (see above).

Stenosisma inaequale (Girty)

PLATE 557: FIGURES 61–67

Camarophoria inaequalis Girty, 1929:411, pl. [p. 414]: figs. 10–13.

This species from the Bone Spring Formation in North Apache Canyon in the Diablo Plateau was not recovered in our collecting nor in the work done in this region by members of the American

Museum parties. The species strongly suggests *S. kalum* Stehli in general aspect and in the costation of the fold and sulcus, but *S. kalum* has finely costate flanks unlike the coarsely costate flanks of Girty's species.

TYPES.—Holotype: USNM 155138.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITY.—USGS 4643: Apache Canyon, Sierra Diablo, Van Horn (30') quadrangle, Texas.

Stenoscisma kalum Stehli

PLATE 565: FIGURES 24–32

Stenoscisma kala Stehli, 1954:339, pl. 25: figs. 1–6.—Grant, 1965a, pl. 19: fig. 4.

This is one of the rarest species in the Sierra Diablo. Stehli figured 2 specimens and we recovered an additional 2 from the same place. The pedicle valve in the Museum collection is much larger than Stehli's and preserves its stolidium, which is confined to the tongue of the sulcus. A battery of 10 small conical spines guards the gape at the anterior of the tongue. The anterior margin of the flanks is similarly guarded. Unusually broad beveled areas over which the brachial valve laps make a shelf along the posterior margin lateral to the small teeth.

The brachial valve preserves the stolidium, which is narrow and has obscure costae corresponding to those of the flanks. The inner margin of this valve is guarded by spines that dovetail with those of the pedicle valve.

MEASUREMENTS (in mm).—From locality USNM 728f specimens 142519b and 142520b, respectively: length 18.0, (?); brachial valve length (?), 12.2; width 26.4, 19.0; thickness 8.0?, 8.3; apical angle 109°, 124°.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITIES.—AMNH 629; USNM 728f.

TYPES.—Lectotype: AMNH 27315/1:1. Figured paratypes: AMNH 27315/1:2. Figured hypotypes: USNM 142519a–d; 142520a,b.

Stenoscisma levicostum, new species

PLATE 564: FIGURES 1–41

Camarophoria venusta [part] R. E. King [not Girty], 1931: 110, pl. 35: figs. 1a–c, 4.

Average size, or slightly larger for genus; outline broadly subtrigonal to subpentagonal, sides diverging between 85° and 130°, averaging more than 90°; profile moderately biconvex; commissure uniplicate, fold moderately high, slightly arched across crest, beginning about 6 mm anterior to brachial beak; sulcus shallow to moderately deep, beginning 8–10 mm anterior to pedicle beak. Costae moderately strong on fold, crests sharp to blunt, low and weak on flanks, beginning 5–7 mm anterior to beaks, numbering 4–6 on fold, one less in sulcus, 3–5 weak and low on flanks, bifurcations occurring only rarely, at sides of fold; stolidium better developed on brachial valve, present on flanks and fold but not continuous. Growth lines weak, irregularly spaced; other ornamentation absent.

Pedicle valve flatly concave transversely, moderately convex along sulcus; umbonal region slightly swollen; beak short, moderately hooked; beak ridges blunt, short; lateral pseudointerareas elongate, flat, normally covered by edge of brachial valve; delthyrium triangular; deltidial plates small, only barely conjunct in adults, leaving narrowly elongate, oval foramen. Brachial valve rather strongly convex transversely, somewhat less longitudinally; umbonal region evenly convex, not strongly swollen or flattened; beak bluntly pointed, apex within pedicle valve, beneath deltidial plates.

Pedicle valve interior with blunt, knoblike hinge teeth; dental plates supporting hinge teeth, converging toward floor of valve; joining just above floor to form large, boat-shaped spondylium, fusing and continuing to floor as low median septum, supporting spondylium. Transverse pallial troughs shallowly impressed, diverging from anterior edge of median septum; anteriorly directed pallial marks making thin lines, diverging from near anterior edge of median septum, each trunk bifurcating toward edge of valve, making dendritic pattern; muscle marks faint striations in anterior part of spondylium.

Brachial valve interior with broadly triangular hinge plate, apex greatly thickened and roughened to form large knoblike cardinal process; sockets elongate, narrow; crura diverging from anterior of hinge plate, continuing free, bowed and bent to conform to outline of camarophorium; intercamarophorial plate thickened at posterior end, descending to merge with floor of camarophorium; median

septum high, moderately long, length slightly increasing with height, capped by large, spoon-shaped spondylium with prominent, toothlike projection at anterior midline; muscle and pallial marks not observed.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 728g					
152879a	7.2	6.4	6.5	3.6	65
152879b	8.9	8.1	8.5	4.0	75
152879c	10.8	9.6	11.0	5.2	82
152879d	12.4	10.7	13.9	6.9	87
152879e	16.6	14.6	17.0?	9.0	82
152879f	17.7	15.2	22.4	10.3	95
152879g	18.5	15.3	23.0	12.3	93
AMNH 591					
154579b (holotype)	22.3	18.9	28.4	16.1	100

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITIES.—AMNH 492, 497, 591; USNM 728g.

DIAGNOSIS.—Large, triangular *Stenosisma* with strong and prominent costae on the fold but subdued costae on the flanks and posterior.

TYPES.—Holotype: USNM 154579b. Figured paratypes: USNM 152879a,i-m; 154579a-c. Measured paratypes: USNM 152879a-g. Unfigured paratypes: USNM 152879c-g.

COMPARISON.—This species is most like *S. hadrum* and *S. aptatum*, both new. It differs from *S. hadrum* in being much smaller, in having much less prominent costae on the flanks, in having the shell more completely costate, and in having the fold originate farther anteriorly than in *S. hadrum*. The fold and sulcus of *S. aptatum* are less numerous costated than those of *S. levicostum*, the flanks are more strongly costate, it has a narrower outline, and *S. levicostum* is more spreading laterally than *S. aptatum*. It differs from *S. triquetrum*, new species, in its less inflated pedicle umbonal region, without the pinched appearance of the sides, as well as its fewer and weaker costae, wider outline, and smaller size. Its wide outline is similar to that of *S. exutum*, new species, but it is readily distinguished from that species by its fewer and weaker costae that begin far forward of the beaks.

Stenosisma maniculum, new species

PLATE 565: FIGURES 16-23

Camarophoria deloi R. E. King, 1931:110, pl. 34: figs. 25a-c [not fig. 24 = *S. hueconianum* (Girty)].—Stainbrook and Madera, 1941:378, pl. 55: figs. 15-27.

Small for genus; outline broadly subelliptical to subpentagonal, sides diverging nearly 100°, maximum width located near midlength; profile moderately strongly biconvex; commissure uniplicate, fold moderately high, transversely flat, beginning about 6 mm anterior to brachial beak; sulcus rather shallow, beginning 5-6 mm anterior to pedicle beak. Costae low, rounded, bifurcating at sides of fold, weak on flanks, numbering 5 or 6 on fold, one less in sulcus, about 5 on each flank; growth lines faint, sporadic laminae slightly stronger.

Pedicle valve moderately convex transversely, somewhat more convex longitudinally through sulcus; beak short, stubby, fairly strong, hooked but not pressed against brachial umbo; lateral pseudo-interareas narrow, short, overlapped by edge of brachial valve; delthyrium triangular, open, without deltidial plates, partly filled by brachial beak. Brachial valve moderately and evenly convex transversely and longitudinally; apex of beak within pedicle valve.

Pedicle valve interior with small hinge tooth fused to each side of valve, supported by strong dental plates that meet just above floor to form boat-shaped spondylium, continue to floor as low median septum; marks of vascula media shallow, diverging at straight angle just anterior to median septum; other pallial marks and muscle marks not observed.

Brachial valve interior with triangular hinge plate, thickened at apex to form cardinal process; hinge sockets short, located at lateral extremes of hinge plate; crural bases diverging forward from near base, continuing free as brachial processes, outwardly and ventrally bending to conform to outline of camarophorium; space between crural bases and around intercamarophorial plate filled by callus; median septum high, rather long on floor of valve, length increasing slightly with height. Muscle and pallial marks not observed.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706f					
152305a	8.6	7.3	11.4	7.0	99
(holotype)					
152305b	10.7	8.7	12.0?	9.5	85?
King 241					
YPM 12693	12.0?	?	13.8	9.5	105

LOCALITIES.—King 241; USNM 706f.

DIAGNOSIS.—Small, widely elliptical *Stenosisma*, resembling *H. hueconianum* (Girty).

TYPES.—Holotype: USNM 152305a. Figured paratype: USNM 152305b.

COMPARISON.—*Stenosisma maniculum* is characterized by its small size, broad outline, short hooked beak without deltidial plates, and its weak costae that are bifurcated only at the sides of the fold. It most nearly resembles *S. hueconianum* (Girty) from the Leonardian of the Hueco Mountains. *Stenosisma maniculum* differs in its smaller size, weaker costae, less tightly hooked beak, and much lower convexity, especially of the pedicle valve. It differs from other small species from Texas, *S. doricranum* and *S. fabarium*, both new, in its broader outline and especially by its finer and more abundant costae, especially on the flanks.

Compared to foreign species, *S. maniculum* has fewer and weaker costae than *S. acuminatum* (Gemellaro, 1899) or *S. karpinskii* (Tschernyschew, 1902), and is broader and less bulbous. It is more costate on the flanks than *S. thevenini* (Kozlowski, 1914), and also is smaller and proportionately broader.

Stenosisma multicosstum Stehli

PLATE 553: FIGURES 28–32; PLATE 565: FIGURES 33–45

Stenosisma multicossta Stehli 1954:339, pl. 25: figs. 7–9.—Grant, 1965a, 148, pl. 19: figs. 3–3a.

Large for genus, wider than long, widely trigonal outline; widest anterior to midvalve; sides narrowly rounded; divergence of sides about 100°. Beak short, straight, smooth, with vestigial deltidial plates. Foramen elongate, elliptical. Surface multicosstate, costae narrowly rounded, moderately strong, occasionally bifurcated or implanted on flanks but with several bifurcations near 10 mm anterior to beak.

Fold with 4 or 5 costae at origin but 9 or 10 at anterior margin. Lateral costae of fold or sulcus disappearing near midvalve. Flanks with 5–7 costae. Stolidium narrow.

Pedicle valve less deep than brachial valve, gently convex in lateral profile but broadly concave in anterior view. Sulcus originating about 7 mm anterior to beak, shallow to midvalve, widening rapidly and forming long moderately strongly geniculated tongue. Flanks moderately wide, gently convex, fairly strongly elevated above sulcus anteriorly.

Brachial valve strongly and evenly curved in lateral profile, broadly domed in anterior profile, with long steeply sloping sides. Umbonal and median regions swollen; fold originating about 7 mm anterior to beak, low and rounded, widening rapidly anteriorly to occupy about half valve width; flanks narrow and moderately swollen and steeply descending anterolaterally.

Pedicle valve interior 9 mm long, tapering slightly anteriorly, narrowly rounded at front, supported on short low septum slightly extended anterior to end of spondylium. Vascula media transverse, strongly impressed. Teeth small.

Brachial valve incomplete but with small hinge plate, ponderous cardinal process and short stout intercamarophorial plate. Septum high but short; camarophorium not fully preserved.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 728f					
142515a	28.4	?	37.8	?	100
142518b	?	22.4	34.0*?	12.6	100
USNM 738h					
154919a	29.6	27.0	39.0	21.3	89
USNM 728m					
152880	29.8	27.5	43.0+	20.0	107

STRATIGRAPHIC OCCURRENCE.—Cibolo Formation, Bone Spring Formation.

LOCALITIES.—Cibolo: USNM 728m, 738c, 738h, 738t. Bone Spring: AMNH 629; USNM 728f, 728h, 728e.

DIAGNOSIS.—Large, nearly completely costate *Stenosisma* with bifurcation and intercalation of costae at the inception of the fold and sulcus.

TYPES.—Lectotype (herein designated): AMNH 27316/1:3. Figured paratypes: AMNH 27316/1, 2. Figured hypotypes: USNM 142515a,b; 142518a,b; 152880; 154919a.

COMPARISON.—*Stenosisma multicostum* is most like *S. pyraustoides*, new species, in size and outline, but its costae are wider and more closely crowded, their increase is more concentrated than in the Glass Mountains species, the flanks are narrower and less strongly costate, and the lateral extremities are more flaring. This species differs from *S. problematicum*, new species, in having more numerous costae on the fold, broader flanks, and more flaring anterolateral regions. The fold and sulcus generally have more costae which are finer than those of either *S. triquetrum*, new species, or *S. venustum* (Girty).

DISCUSSION.—Stehli (1954) figured three fragmentary specimens of this species. We obtained only two specimens from the Sierra Diablo: a complete pedicle valve and a nearly complete brachial valve with parts of the stolidium preserved. The species is thus exceedingly rare and even with the additional information given herein can hardly be said to be properly described. In addition to the two specimens from the Sierra Diablo, we refer here another large, poorly preserved but nearly complete specimen from the Cibolo Formation in the Chinati Mountains. This specimen (USNM 152880) differs somewhat from the others, especially in the form and costation of the flanks; nevertheless, it is so close that we have furnished its measurements.

The peculiar development of the costae bifurcating near the initiation of the fold and sulcus is the feature that makes this species unique. This may ultimately prove to be an evanescent feature when a large series of this species is found. The specimens in the collection certainly do not constitute satisfactory comparative material. It is also possible that, when more and better material is obtained, *S. pyraustoides*, new species, will prove synonymous. At present the differences between the two species seem distinct, although there is no question as to their similar appearance and probable contemporaneity.

Stenosisma myioides, new species

PLATE 566: FIGURES 1-57

Small for genus; outline subtrigonal to subpentagonal, sides diverging between 70° and 90°, maximum width located anterior to midlength; commissure uniplicate, fold low to moderately high,

beginning 4-7 mm anterior to brachial beak, broadly to narrowly arched transversely, sulcus shallow, beginning 5-8 mm anterior to pedicle beak. Costae low, rounded, without bifurcation or intercalations, beginning 4-6 mm anterior to beaks, numbering 2-4 (averaging 3) on fold, one less in sulcus, 2 or 3 on each flank. Concentric ornament and growth lines faint; stolidium absent.

Pedicle valve moderately strongly convex transversely and longitudinally; umbonal region somewhat swollen; beak somewhat short, slightly attenuate, normally rather strongly hooked, may press against brachial umbo; beak ridges undefined; lateral pseudointerareas long, narrow, normally covered by edge of brachial valve; delthyrium triangular, wide; deltidial plates absent in individuals with strongly hooked beaks, small and disjunct in others. Brachial valve moderately strongly convex transversely, less convex along crest of fold; umbonal region slightly swollen, may be slightly attenuate; apex of beak within pedicle valve, normally covered by overhanging pedicle beak.

Pedicle valve interior with small, denticulate, knoblike teeth, dental plates large, converging just above floor to form boat-shaped spondylium, continuing to floor as low median septum. Muscle marks faintly impressed in anterior half of spondylium; troughs of vascula media diverging nearly at straight angle from anterior edge of median septum, extending across floor to sides of valve; other pallial marks thin, anteriorly diverging from edge of median septum.

Brachial valve interior with triangular hinge plate greatly thickened at apex to form cardinal process; sockets wide, rather long, corrugated, located along posterolateral edges of hinge plate; crural bases diverging from forward edge of hinge plate; brachial processes extending free, outwardly and ventrally bent, conforming to outline of camarophorium; median septum short, relatively thick, length increasing slightly with height; camarophorium short, wide, with wide, blunt, anterior marginal projection; intercamarophorial plate proportionately long, thick, low, supporting hinge plate by means of short, connecting crural plates. Muscle marks not observed: presumably in camarophorium; pallial marks on floor of valve, vascula media diverging from anterior edge of median septum, bifurcating about three times on course toward valve edge.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle
					(°)
USNM 705a					
152218a	7.6	6.4	7.4	4.1	86
152218b	9.0	7.8	10.0	5.8	89
152218c	10.0	8.4	10.0	6.4	78
152218d	10.7	8.7	12.1	7.0	92
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base).

LOCALITIES.—USNM 705a, 716q, 720e.

DIAGNOSIS.—Small, paucicostate *Stenosisma* without stolidium.

TYPES.—Holotype: USNM 152218d. Figured paratypes: USNM 152217a,b; 152218b,c; 154580a–e. Measured paratypes: USNM 152218a–c. Unfigured paratype: USNM 152218a.

COMPARISON.—*Stenosisma myioides* is characterized by its small size, rather weak costae that begin near the beaks, normally somewhat hooked pedicle beak, and absent stolidium. Among Texas species it most nearly resembles *S. doricranum*, new species, differing in its slightly smaller average size, more narrowly triangular outline, more numerous costae beginning farther back, and absence of a stolidium. *S. aptatum*, new species, also is similar in form, but is about three times as big, has a stolidium, a wider outline, proportionately shorter and more consistently hooked beak, and stronger growth lines. *Stenosisma myioides* occurs in the same beds as *S. pyraustoides*, new species, but differs from that species in its much smaller size, narrower outline, fewer costae which do not begin at the beaks and do not bifurcate, and absence of a stolidium. *Stenosisma fabarium*, new species, is another small species, although larger than *S. myioides*, and is easily distinguishable by its wide outline, bifurcating costae, very short beak, and normally well developed stolidium.

Stenosisma thevenini (Kozłowski, 1914) from the Copacabana Formation of Bolivia is similar to *S. myioides*, differing primarily in its stronger costae on the fold which begin farther back and tend to bifurcate anteriorly, weaker costae on the flanks, wider outline, and less attenuate beak. *S. biplicatum* (Stuckenberg) as figured by Reed (1944, pl. 22) also is similar, differing in its much stronger costae that begin nearly at the beaks. *Stenosisma*

biplicatum (Stuckenberg, 1898, pl. 3) is entirely dissimilar, probably more closely related to *S. renode*, new species.

Stenosisma oblisum, new species

PLATE 567: FIGURES 1–68

Average size for genus; outline subtrigonal with protruding anterior margin and attenuate beak, sides diverging between 50° and 100°, maximum width normally located slightly anterior to mid-length; profile slightly to moderately biconvex; commissure uniplicate, fold high, broad, standing high above flanks at anterior, beginning 7–10 mm anterior to brachial beak; sulcus rather shallow, broad, beginning 9–12 mm anterior to pedicle beak. Costae moderately strong, sharp to blunt crested, rarely bifurcating, beginning 6–8 mm anterior to beaks, numbering 4–7 on fold, one less in sulcus, 6–8 on each flank; stolidium present, but full extent and pattern of development not observed.

Pedicle valve nearly flat transversely, moderately convex longitudinally through sulcus; beak long and attenuate, sides pinched, umbonal area may appear swollen due to pinching of sides, apex erect, not hooked; deltidial plates not observed, but probably present; lateral pseudointerareas present, covered by edge of brachial valve, hence dimensions unknown. Brachial valve strongly convex transversely, moderately convex longitudinally along fold; beak only slightly swollen, attenuate, apex within pedicle valve.

Pedicle valve interior with boat-shaped spondylium supported above floor by low median septum; other interior details unknown. Brachial interior with thin median septum, and camarophorium; other internal details unknown.

MEASUREMENTS (in mm).—

	brachial valve			thick-	apical
	length	length	width	ness	angle
					(°)
USNM 739					
152284a	6.0	5.7	5.5	3.0	65
152284b	9.0	8.4	8.6	4.0	75
152284c	11.0	10.2	13.0?	5.3	87
152284d	19.0	17.1	18.7	12.0	78
152284e	22.0	20.0	27.0?	14.0	96
(holotype)					
USNM 740					
152264a	10.4	10.4	7.7	4.3	66

STRATIGRAPHIC OCCURRENCE.—Capitan Limestone.

LOCALITIES.—USNM 725-l, 739, 740.

DIAGNOSIS.—*Stenosisma* having low convexity and narrow pedicle valve beak.

TYPES.—Holotype: USNM 152284e. Figured paratypes: USNM 152263a,b; 152264a-c; 152284a-d. Measured paratypes: USNM 152264a, 152284a-d.

COMPARISON.—*Stenosisma obliquum* is characterized by its attenuate beak with pinched sides, relatively low convexity, numerous and normally non-bifurcating costae, and its fold that stands high at the anterior margin and causes protrusion of the anterior outline. In its numerous costae it resembles *S. trabeatum*, new species, which also occurs in the Guadalupian of the Guadalupe Mountains. It differs from that species in its normally non-bifurcating costae that begin much farther forward, pinched posterolateral outline, attenuate beaks, and normally narrower, more strongly triangular outline. It is smaller and less convex than *S. venustum* (Girty) or *S. triquetrum*, new species, has its sides more strongly pinched, and has more numerous costae on the flanks. It is much smaller and narrower than *S. pyraustoides*, new species, and its costae start much farther forward and rarely bifurcate. It differs from *S. renode*, new species, from the Word Formation of the Glass Mountains in its lower convexity, more numerous costae that start farther forward, and especially in its attenuate pedicle beak that is not hooked against the umbonal region of the brachial valve. It is smaller, more attenuate and narrower than *S. multicostum* Stehli, and its nonbifurcating costae do not begin as far back on the beaks.

Stenosisma pansum, new species

PLATE 568: FIGURES 1-42

Average size for genus; outline narrowly to broadly trigonal, sides diverging between 70° and 105°; profile flatly to moderately biconvex; commissure uniplicate; fold low to moderately high, gently arched transversely beginning 6-10 mm anterior to brachial beak; sulcus moderately deep beginning 6-12 mm anterior to pedicle beak. Costae moderately strong on fold and sulcus, weak on flanks, subangular, rarely bifurcating, beginning 6-12 mm anterior to beaks, numbering 3-5 on fold, one less in sulcus, 2-5 on each flank, becoming

weaker laterally; stolidium well developed on fold and flanks of brachial valve, presumably less strong on pedicle valve; growth lines faint, closely spaced, with irregularly spaced stronger laminae.

Pedicle valve flatly convex transversely and longitudinally; umbonal region slightly swollen, with pinched sides; lateral pseudointerareas elongate, narrow, covered by edge of brachial valve; beak moderately long, erect, slightly hooked; deltidial plates small, disjunct, leaving narrow foramen. Brachial valve moderately convex transversely, less convex longitudinally along crest of fold; beak slightly swollen, normally rather attenuate, apex within pedicle valve.

Pedicle valve interior with boat-shaped spondylium supported by low median septum; brachial interior with high median septum and camarophorium; other internal features not observed.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	length	width	
USNM 712p				
152259	18.2	15.9	23.7	11.5 103
USNM 711d				
152257a	22.0	20.0	28.4	16.0 97
152257b	25.8	23.0	31.0?	16.2 100?
152258d	17.0	15.0	24.0	11.3 114
(holotype)				

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch and Poplar Tank members); Skinner Ranch Formation (lower).

LOCALITIES.—Decie Ranch: USNM 707w. Poplar Tank: USNM 708e. Skinner Ranch (low): USNM 711d, 712p. Skinner Ranch (undifferentiated): USNM 730v.

DIAGNOSIS.—Large, sparsely costate *Stenosisma* of low convexity.

TYPES.—Holotype: USNM 152258d. Figured paratypes: USNM 152254; 152255; 152257a,b; 152258a-c. Measured paratypes: USNM 152257a,b; 152259. Unfigured paratype: USNM 152258d.

COMPARISON.—*Stenosisma pansum* is characterized by its trigonal outline, low convexity, weak costae that start far forward and may be nearly absent from the flanks, and by its rather pinched-appearing sides with attenuate pedicle and brachial beaks. It occurs at a few localities with *S. hadrum*, new species, from which it differs in its smaller maximum size, fewer costae, lower convexity, longer

and more attenuate beaks, and more distinctly trigonal outline. Among Texas species it suggests *S. venustum* (Girty) and *S. triquetrum*, new species, although the resemblance is not close. *Stenoscisma pansum* is smaller, flatter, less completely costate and has the costae beginning farther forward, leaving the umbonal region smooth. Its juveniles are similar to adults of *S. thevenini* (Kozlowski, 1914) but *S. pansum* is larger, more trigonal, less convex, and has longer more attenuate beaks.

Stenoscisma biplicatum (Stuckenberry) illustrated by Reed (1944, pl. 22: fig. 11) is somewhat similar to *S. pansum*, although its costae appear to be stronger, especially on the fold, and normally fewer, beginning farther back toward the beaks.

Stenoscisma peneleve, new species

PLATE 569: FIGURES 1-44

Medium size for genus, subtrigonal in outline, wider than long, maximum width near midvalve. Sides somewhat narrowly rounded; anterior margin broadly rounded. Divergence of sides nearly right angle. Beak short, suberect, not pressed onto umbo of opposite valve. Surface posteriorly smooth, anterior half sparsely costate, generally with 3 costae in fold, 2 in sulcus continued onto umbo and 1 indistinct costa on each flank. Stolidium present, but shape not known.

Pedicle valve fairly evenly and gently convex in lateral profile but broadly and gently concave in anterior profile. Umbonal region narrowly swollen; sulcus originating posterior to midvalve, shallow and wide, not deeply depressed; flanks narrow, slightly convex to slightly concave.

Brachial valve evenly and gently convex in lateral profile, strongly domed with steeply dipping sides in anterior profile. Median region and umbo swollen; fold originating slightly posterior to midvalve, only moderately elevated anteriorly; flanks moderately depressed but convex and swollen.

Interior unknown except for generic characters.

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation; Lenox Hills Formation.

LOCALITIES.—Neal Ranch: USNM 715b. Lenox Hills: USNM 709t.

DIAGNOSIS.—Medium-size *Stenoscisma* with smooth posterior and flanks but fold with three costae.

TYPES.—Holotype: USNM 152261a. Figured par-

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 715b					
152261a (holotype)	8.8	7.9	8.9	4.4	76
152261b	12.4	11.0	12.7	7.3	86
152261c	13.0?	11.2	14.0	8.8	92
152261d	14.0	12.3	16.6	?	86

atypes: USNM 152256a-c, 152261b. Measured paratypes: USNM 152261b-d. Unfigured paratypes: USNM 152261c,d.

COMPARISON.—The lack of costae on the posterior part and the sparseness of the costae on the anterior part of this species suggests *S. bonum*, *S. doricranum*, and *S. calvatum*, all new. *Stenoscisma peneleve* differs from the first in its larger size and much stronger costae in the adult. While *S. doricranum* attains about the same size as *S. peneleve*, it differs in having much stronger costation and deep spaces between the costae. In *S. calvatum* the costation is not uniform, there often being 3 on the fold, the flanks are more costate, and the brachial valve more strongly convex. Furthermore, in these species the costae in the sulcus do not begin as far back as the umbonal slope, as they do in *S. peneleve*.

Stenoscisma problematicum, new species

PLATE 570: FIGURES 1-44

Large for genus, widely triangular in outline with narrowly rounded sides, widest part well anterior to midvalve; anterior margin nearly straight; sides diverging about 90° in adult, less in younger specimens but slightly more in old ones. Brachial valve deeper than pedicle valve. Beak short, nearly straight; deltidial plates small. Surface costate except for smooth beaks; costae usually direct, fold with 5-9 costae, usually 6 or 7, outside costa often appearing on lateral slope; sulcus with one less; flanks with 6-9, usually 6, outside 1 or 2 indistinct. Stolidium narrow.

Pedicle valve gently convex in lateral profile but broadly concave when viewed from anterior; umbonal region narrow and flatly convex; sulcus originating near beak (5-7 mm anterior), widening rapidly, moderately geniculated with moderately long tongue. Flanks moderately elevated, narrowly rounded, slopes steep.

Brachial valve strongly and evenly convex in lateral profile, broadly domed in anterior view; fold slightly elevated, umbonal region moderately swollen; fold originating on umbonal slope about 7 mm anterior to beak, low with rounded profile and not strongly elevated, forming about 45 percent of the valve width. Flanks somewhat transverse, with swollen, steep sides.

Details of spondylium and camarophorium not known.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 727u					
154581a	11.0	10.0	11.0	5.2	74
154581b	18.0	16.8	22.6	8.8	86
154581c	23.5	21.1	27.2	?	84
154581d	21.1	18.9	27.9	16.1	82
154581e	23.4	21.1	30.7	17.0	93
154581f	c.23.0	21.2	32.6	18.3	100
154581g (holotype)	23.2	21.8	24.6	19.0	102
USNM 707a					
152197a	25.0	22.4	28.7	16.4	86
152197b	21.0	18.2	22.9	12.9	78

STRATIGRAPHIC OCCURRENCE.—Lenox Hills Formation; Cibolo Formation (Breccia Zone of Udden); Skinner Ranch Formation (Decie Ranch Member).

LOCALITIES.—Lenox Hills: USNM ?705k, ?707n. Cibolo Formation: USNM 728-l. Decie Ranch: USNM 707a, 715a, 715f, 719y, 727u, 729i. Skinner Ranch (low): USNM 720g; (upper): USNM 730r.

DIAGNOSIS.—Widely triangular *Stenosisma* usually with 6 or 7 costae on the fold and numerous costae on the flanks.

TYPES.—Holotype: USNM 154581g. Figured paratypes: USNM 152197b,c; 154581a-f; 154582. Measured paratypes: USNM 152197a,b; 154581a-f. Unfigured paratype: USNM 152197a.

COMPARISON.—This species belongs to the stock of large stenoscismas characterized by *S. venustum* (Girty) and *S. triquetrum*, new species. Consequently, resemblance is strong to a number of the larger species. It differs from *S. pansum* and *S. aptatum*, both new, in having a much larger size and more numerous costae on both flanks and on fold and sulcus.

Stenosisma problematicum differs from *S. hadrum*, new species, in its more numerous costate flanks, smooth umbonal regions, and more closely

crowded costae. It differs from *S. triquetrum* and *S. venustum* in the same respects. Its shape and costation are completely different from those of *S. exutum*, new species.

Stenosisma multicostum Stehli and *S. pyraustoides*, new species, are large forms occurring near the same level as *S. problematicum* but their much larger size, greater lateral spread, and very numerous costae make separation easy even in young forms.

DISCUSSION.—This species is fairly common in the Decie Ranch Member in the Lenox Hills area but was not seen at the same level to the east where the more numerous costate and larger stenoscismatids predominate.

We have placed a number of specimens from the Cibolo Formation of the Chinati Mountains (USNM 728-l), dated by fusulinids as Wolfcampian, with this Glass Mountains species. These Chinati specimens occur with large *Scacchinella* in an association strongly suggesting the Decie Ranch Member of the Glass Mountains. These may be a facies type adapted to biohermal conditions, or they may indicate contemporaneity.

Stenosisma pyraustoides, new species

PLATE 571: FIGURES 1-37; PLATE 572: FIGURES 1-17

Large for genus; outline broadly subelliptical to subtrigonal, sides diverging between 80° and 125°, normally over 100° in adults, maximum width near midlength, normally slightly farther toward the anterior; profile strongly biconvex to subtrigonal; commissure uniplicate, fold moderately high, standing increasingly high anteriorly, beginning 1-5 mm anterior to brachial beak; sulcus rather shallow, but dipping steeply at anterior, extending forward as broad tongue, producing emargination of anterior. Costae strong and sharp crested on fold and in sulcus, lower, broader, and rounder on flanks, beginning at beaks, frequently bifurcated, especially on fold and sulcus, numbering 6-10 on fold (normally 9), one less in sulcus, 4-9 on each flank, number not necessarily equal on both sides; stolidium better developed on brachial valve, varying from broad and fanlike to nearly absent.

Pedicle valve flatly convex transversely and from beak to flanks, strongly convex longitudinally through sulcus; beak short, only moderately thick, suberect to erect but not hooked; beak ridges gen-

tly curved, ill-defined; lateral pseudointerareas elongate, narrow, normally covered by edge of brachial valve; delthyrium moderately large, sides only slightly constricted by small, normally widely disjunct deltidial plates; foramen large for genus, nevertheless small, opening ventrally.

Brachial valve strongly convex transversely, only moderately convex along crest of fold due to anterior increase in height of fold, convexity uniform without swelling in umbonal region; beak bluntly pointed, apex only slightly inside pedicle valve.

Pedicle valve interior with small teeth, continuous with dental plates that form short, boat-shaped spondylium just above floor of valve; median septum low, extending slightly forward of spondylium; troughs of vascula media diverging from midline of valve just anterior to median septum, extending directly across floor of valve; muscle marks in spondylium faint and undifferentiated.

Brachial valve interior with short, broad hinge plate, semicircular to crescentic; cardinal process at apex of hinge plate, located just beneath apex of valve, low or rather high, knoblike, normally not polylobate, shallowly striate for muscle attachment; hinge sockets short, narrow, at lateral extremes of hinge plate, finely corrugated; crural bases slightly diverging anterior to cardinal process, space between filled by narrow crural plates dipping along center line attaching crural bases to top of intercamarophorial plate; brachial processes not observed, presumed to be normal for genus; median septum high, thin, exceptionally short, length increasing greatly with height; camarophorium narrow, relatively short, anteriorly widening; intercamarophorial plate low, thick, relatively long; muscle marks not observed.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base); Hess Formation (Taylor Ranch Member); Cibolo Formation.

LOCALITIES.—Skinner Ranch: USNM 705a, 705b, 709a, 711o, 711z, 715c, 716p, 720e, 726j, 729j. Taylor Ranch: USNM 716o. Cibolo: USNM 739-l.

DIAGNOSIS.—Exceptionally large and wide *Stenosisma* with numerous bifurcations of costae on posterior of fold and flanks.

TYPES.—Holotype: USNM 152220i. Figured paratypes: USNM 152219a-d; 152220b,c,k; 152221a,b; 152225. Measured paratypes: USNM 152220a-h,j; 152225. Unfigured paratypes: USNM 152220a,d-l,j.

COMPARISONS.—*Stenosisma pyraustoides* is char-

acterized by its exceptional width, large maximum size, numerous and frequently bifurcating costae on fold and sulcus, lower and fewer costae on flanks, short beak with small disjunct deltidial plates, relatively short spondylium and camarophorium. The only known species that is closely related to *S. pyraustoides* is *S. multicostum* Stehli (1954) from the Sierra Diablo. *Stenosisma pyraustoides* is larger, wider, and less strongly costate, especially on the flanks where the costae are lower, broader, and fewer. The species bears superficial resemblance to *S. trabeatum*, new species, which is smaller, more triangular in outline, less strongly convex, has a longer beak, and a stolidium that is continuous from flanks to fold.

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 705a					
152220a	13.0	10.7	14.5	c.6.0	95
152220b	15.0?	13.0	16.7	10.3	89
152220c	13.5	12.8	18.4	11.0	104
152220d	18.2	16.2	23.5	14.0	103
152220e	19.0	16.8	26.0+	14.0	107
152220f	23.7	22.4	28.0	16.0	93
152220g	26.0	25.2	35.9	21.3	116
152220h	28.3	26.6	45.1	22.7	104
152220i	32.5	30.5	50.0	26.6	114
(holotype)					
152220j	34.7	32.5	56.0?	21.0?	118
USNM 716o					
152225	35.5	33.5	50.5	23.2	109

acterized by its exceptional width, large maximum size, numerous and frequently bifurcating costae on fold and sulcus, lower and fewer costae on flanks, short beak with small disjunct deltidial plates, relatively short spondylium and camarophorium. The only known species that is closely related to *S. pyraustoides* is *S. multicostum* Stehli (1954) from the Sierra Diablo. *Stenosisma pyraustoides* is larger, wider, and less strongly costate, especially on the flanks where the costae are lower, broader, and fewer. The species bears superficial resemblance to *S. trabeatum*, new species, which is smaller, more triangular in outline, less strongly convex, has a longer beak, and a stolidium that is continuous from flanks to fold.

DISCUSSION.—*Stenosisma pyraustoides*, with its great width and many bifurcating costae that begin at the beaks, is the most distinctive species of the genus in the Glass Mountains. Its only close relative is *S. multicostum* Stehli, from the Sierra Diablo, and the Chinati Mountains with which it shares the characteristics of the multicostate fold and sulcus, open delthyrium with disjunct deltidial plates, and short spondylium and camarophorium. *Stenosisma pyraustoides* is rather variable, however, with respect to development of the stolidium; it is broad on some specimens and nearly absent on others. Perhaps the great width of the largest specimens reduced the need for extra surface area to be added by means of a stolidium. On the other hand, possibly the relatively large foramen, unrestricted by large deltidial plates, was present to provide for

egress of a functional pedicle, thus reducing the necessity for the supporting surface provided by a broad stolidium. In our collections it is a fact that the few specimens with well-developed stolidia have the beak unusually short and nearly pressed against the brachial umbo. Apparently the genetic potential for development of a stolidium was consistently present in this species, as in others, but the actual growth of the stolidium depended on its use to the organism; the stolidium developing if the pedicle failed to function in attachment.

Stenosisma renode, new species

PLATE 573: FIGURES 1-48; PLATE 574: FIGURES 1-22;

PLATE 575: FIGURES 1-19

Normal size for genus; outline subtrigonal, sides diverging between 50° and 100°, maximum width just posterior to anterior margin; profile moderately strongly biconvex; commissure uniplicate, fold rather low, not standing high above flanks, beginning about 7 mm anterior to brachial beak; sulcus shallow, relatively flat transversely, beginning 7-10 mm anterior to pedicle beak. Costae strong on fold and sulcus, weaker on flanks, rounded, normally not bifurcating, beginning 3-7 mm anterior to beaks, numbering 4-7 on fold (normally 5), one less in sulcus, 4-7 on each flank (normally 5 or 6); stolidium moderately broad, best developed on flanks of brachial valve and in sulcus of pedicle valve, frequently double, with two flaps on one valve rather than one flap on each valve; growth lines fine, occasional stronger laminae present.

Pedicle valve moderately strongly convex transversely and longitudinally through sulcus, somewhat swollen in umbonal region; beak strongly hooked, pressed against brachial umbo in adults; lateral pseudointerareas proportionately broad, short, partly covered by edge of brachial valve; delthyrium wide, triangular, without deltidial plates, normally completely occupied by brachial beak, with foramen visible only in juveniles. Brachial valve strongly convex transversely, moderately convex longitudinally along crest of fold; umbonal region only slightly swollen; beak bluntly pointed, entirely within pedicle valve.

Pedicle valve interior with small but prominent teeth, fused to valve, supported by strong dental plates that form relatively long, boatlike spondylium; median septum low, slightly longer than

spondylium, formed by union of dental plates beneath spondylium. Muscle marks faint in anterior two-thirds of spondylium; pallial troughs deep on floor of valve, vascula media diverging at straight angle from center line of valve just anterior to median septum. Marks of gonocoels posterior to transverse marks, on floor of valve on either side of septum and spondylium.

Brachial valve interior with large, subelliptical, laterally attenuate hinge plate, swollen at apex to form large, knoblike, frequently polylobate cardinal process, striated for muscle attachment; hinge sockets short, deep, finely denticulate, located at lateral extremities of hinge plate; crural bases extending forward from base of cardinal process, continuing anteriorly as free, outwardly bowed and ventrally bent brachial processes; crural plates between crural bases very short, attaching to top of short and rather low intercamarophorial plate; camarophorium long, spoon-shaped, widest near anterior, with only short projection on anterior median line; muscle marks faint and undifferentiated in camarophorium; median septum high, relatively long, length increasing with height.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 706b					
152210a	5.8	5.4	4.8	3.3	51
152210b	9.7	?	8.3	—	53
152210c	12.7	10.9	11.0	8.3	60
152210d	17.2	14.9	16.6	9.9	72
152210e	18.0	15.5	18.4	12.0	82
152210f	20.0	17.9	22.8	13.8	85
152210g	22.0	20.0	23.9	17.0	84
152210h	23.8	19.8	25.0	18.4	94
152210i	25.0	25.8	28.0	19.9	88
(holotype)					
152210j	26.8	23.7	29.6	18.8	91
USNM 706c					
152212	28.0	24.8	29.6	18.8	91

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, Appel Ranch members, and lens between the last two); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Word: USNM 731u. China Tank: USNM 726r, 726s, 706c. Willis Ranch: USNM 706, 706e. Appel Ranch: USNM 704, 715i, 716v, 719z. Lens: USNM 706b, 732c, 742b. Getaway: USNM 728.

DIAGNOSIS.—Robust *Stenoscisma* with pedicle valve beak pressed tightly onto the umbo of the brachial valve and with a prominent stolidium.

TYPES.—Holotype: USNM 152210i. Figured paratypes: USNM 152209a–o; 152210c,e; 152211a–d. Measured paratypes: USNM 152210a–i,j; 152212. Unfigured paratypes: USNM 152210a,b,d,f–h,j.

COMPARISON.—*Stenoscisma renode* is characterized by its triangular outline, strong but blunt costae that begin near the beaks, a stolidium that develops on the brachial flanks and pedicle sulcus, its long spondylium, camarophorium and brachial median septum, and especially by its strongly hooked pedicle beak that is pressed so tightly against the brachial umbo as to close completely the delthyrium and external opening of the foramen. In its shape and costation it resembles *S. venustum* (Girty) and *S. triquetrum*, new species, but differs in its hooked beak and arrangement of its stolidium. Its closest relative in the Glass Mountains is *S. camurum*, new species, which is wider, has more bifurcating costae, and has the pedicle beak not as tightly pressed against the brachial umbo. *S. repigratum*, new species, occurs in the same beds with *S. renode*, but is wider, less convex in profile, has the costae beginning farther back, has an erect pedicle beak with well-developed deltidial plates and rather large foramen, and rudimentary or absent stolidium. Other Texas species are easily distinguished from *S. renode* by the characters listed above.

The most common foreign species that resembles *S. renode* is *S. mutabile* (Tschernyschew) as illustrated by himself (1902, pls. 22, 23, 45, 46) and by Merla (1934, pl. 22). *Stenoscisma renode* differs in its less bulbous profile, fewer bifurcating costae, and normally narrower outline. *Stenoscisma biplacatum* (Stuckenbergh, 1898) also has the beak pressed against the brachial umbo, but it differs from *S. renode* in its more pentagonal outline, and stronger, sharper costae that begin at the apexes of the beaks. Another species with the beak strongly hooked is *S. pingue* (Waagen) of Rothpletz (1892, pl. 10), but that species, which undoubtedly differs from Waagen's (1893) species, is much wider than *S. renode*, less strongly costate, and has the costae beginning farther forward, near the midlength of the shell. Several of Waagen's (1893) species from the Salt Range, namely, *S. purdoni* (Davidson), *S. humbletonensis* (Howe), and *S. pingue* (Waagen), have the beak strongly hooked or pressed against

the brachial umbo as in *S. renode*. All three of these species differ from *S. renode* in their more numerous costae, and wider, less strongly trigonal outlines.

DISCUSSION.—*Stenoscisma renode* occurs in the Word Formation of the Glass Mountains, and represents an ultimate in the trend that we believe characterizes Texas Permian species of *Stenoscisma*. This species has the pedicle beak so tightly pressed against the brachial umbo in most individuals that a functional pedicle was impossible. The animal probably lived unattached, lying on the sea floor, supported by the added shell surface of the stolidium.

Stenoscisma repigratum, new species

PLATE 554: FIGURES 15–22

Average size for genus; outline moderately to broadly subelliptical, sides diverging between 80° and 120°, maximum width located slightly anterior to midlength; commissure uniplicate; fold low at commissure, but standing moderately high above flanks, slightly arched transversely; beginning 8–10 mm anterior to brachial beak; sulcus rather deep, broad, beginning 10–12 mm anterior to pedicle beak. Costae moderately strong, blunt to sharp, normally not bifurcating, beginning 2–5 mm anterior to beaks, numbering about 6 on fold, one less in sulcus, 5–8 on each flank; stolidium not present on observed specimens, presumably absent from species.

Pedicle valve nearly flat transversely, rather convex longitudinally along sulcus, beak short, blunt, not hooked; lateral pseudointerareas elongate, somewhat broad, overlapped by edge of brachial valve; delthyrium triangular, constricted by well-developed, conjunct or disjunct deltidial plates, leaving relatively large foramen opening ventrally. Brachial valve moderately to strongly convex transversely, flatly convex along crest of fold, with maximum convexity in umbonal region and just behind margin; beak blunt, apex within pedicle valve.

Pedicle valve interior with dental plates converging just above floor to form elongate boat-shaped spondylium, supported by low median septum. Space between spondylium and apical region partly filled by callus. Brachial valve interior with trigonal to crescent-shaped hinge plate, greatly thickened at apex of valve to form large, knoblike or

polylobate cardinal process with thickened base extending along midline of hinge plate; crural bases diverging from thickened base of cardinal process, continuing free into valve as brachial processes bending ventrally; camarophorium large, with prominent anterior median extension; intercamarophorial plate long, space around it filled with callus, obscuring any crural plates; median septum high, long, length only slightly increasing with height.

MEASUREMENTS (in mm).—From locality USNM 706c specimen 152281: length 23.2, brachial valve length 23.2, width 33.6*, thickness 21.9, apical angle 116°.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank Member); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—China Tank: USNM 706c. Getaway: 728w.

DIAGNOSIS.—Large *Stenosisma* with costate umbones but lacking a stolidium.

TYPES.—Holotype: USNM 152281.

COMPARISON.—*Stenosisma repigratum* is characterized by its many costae that begin near the beaks, its fold and sulcus that begin far from the beaks, its short beak with deltidial plates, broad outline, and flatly convex pedicle valve. It occurs with *S. renode* and *S. camurum*, both new, from which it differs in its nonhooked beak, many costae on the umbonal regions, broader outline, and absence of a stolidium. It differs from *S. venustum* (Girty) and *S. triquetrum*, new species, in the absence of a stolidium, a flatter pedicle valve, brachial umbo and anterior part of fold more swollen, and, on the flanks, more numerous costae that continue farther toward the beaks. *Stenosisma hadrum*, new species, has a thicker pedicle valve, more strongly longitudinally convex brachial valve, bifurcating costae, fewer costae on the flanks, and a fold and sulcus that begin nearer the beaks.

Among foreign species it most nearly resembles *S. sanctispiritus* (Schellwien, 1892), differing in its less widely divergent sides and fewer, nonbifurcating costae.

Stenosisma thevenini (of R. E. King)

PLATE 569: FIGURES 45–52

Camarophoria thevenini R. E. King [not Kozłowski], 1931: 110, pl. 34: figs. 28a–c.

DISCUSSION.—King identified specimens from the Wolfcamp, Gym, and Leonard Formations with Kozłowski's Bolivian species. The single illustrated specimen is a juvenile shell from the Leonard that could be referred to any one of several species. The unillustrated specimens from the Hueco Formation resemble the Bolivian species, but most likely belong to *S. hueconianum* (Girty). There is a strong resemblance between the fauna of part of the Hueco Group and that described by Kozłowski from Bolivia, but careful study normally shows specific differences.

TYPES.—Figured specimen: YPM 12695.

Stenosisma trabeatum, new species

PLATE 576: FIGURES 1–31; PLATE 577: FIGURES 9–24

Stenosisma venustum Newell et al. [not Girty], 1953, pl. 21: fig. 31.

Average size for genus; outline transversely subelliptical to subtrigonal, sides diverging between 70° and 120°, maximum width located near midlength; profile moderately strongly biconvex; commissure uniplicate, fold moderately high, broad, rather flat transversely, beginning 10–12 mm anterior to pedicle beak. Costae moderately strong, sharp crested, added anteriorly by bifurcation and intercalation, beginning 3–6 mm anterior to beaks, numbering 5–10 on fold, one less in sulcus, 5–6 on each flank; stolidium well developed on brachial valve, broad, continuous from flanks to fold, short or missing from pedicle valve.

Pedicle valve flatly concave transversely and moderately convex longitudinally; umbonal region slightly swollen; beak rather long, attenuate or with pinched sides, erect but not hooked; lateral pseudointerareas wide or narrow, spread into interior, detached from side of shell along margin, forming elongate, shallow pocket along insides of posterolateral slopes; delthyrium triangular, constricted by well-developed, conjunct deltidial plates; foramen small, eye-shaped, opening directly ventrally. Brachial valve moderately strongly convex transversely and longitudinally, with maximum convexity in umbonal region; beak somewhat attenuate, apex in pedicle valve beneath deltidial plates.

Pedicle valve interior with strong hinge teeth, one on each side, fused to side of valve or to

inwardly bowed part of lateral pseudointerareas; dental plates with forward edges sloping posteriorly, then curved strongly anteriorly to form edges of boat-shaped spondylium, plates fused beneath spondylium to form low median septum, slightly longer than spondylium. Muscle marks in anterior half of spondylium, set off from posterior half by sharp line; pallial marks distinct, troughs of vascula media beginning at edge of median septum, one crossing each side of valve, directly or slanting slightly toward posterior; gonocoel markings on floor of valve beside spondylium and behind pallial troughs.

Brachial valve interior with small, crescentic hinge plate, greatly thickened at apex of valve to form knoblike cardinal process; crural bases extending forward from near base of cardinal process, space between them filled by forward extension of process and by rather long crural plates attaching to top of intercamarophorial plate; brachial processes continuing free into living chamber, outwardly bowed and ventrally bent; camarophorium elongate, narrow, with broad projection at anterior midline giving trilobate appearance to anterior edge; median septum high, thin, short on floor but length increasing with height. Muscle marks faint in camarophorium; pallial marks plain on floor of valve: two fine trunks diverging anteriorly, one from each side of median septum (on floor of valve), bifurcating at regular intervals, finally branching near margin, producing one trunk for each costa.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	length		
USNM 737a				
152230a	10.0	9.0	8.9	4.7
152230b	12.3	11.1	10.6	6.3
(holotype)				
152230c	18.0?	15.3?	22.0	10.1
USNM 738				
152231a	20.6	18.8	26.4	13.0
152231b	23.7	21.0	31.8	14.0
152231c	22.5	19.8	28.3	14.5
USNM 750a				
152202a	24.4	21.3	29.4	15.2

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Rader and Lamar members); Capitan Formation.

LOCALITIES.—Rader: USNM 725f. Lamar: AMNH

37, 40, 347 (=L-2), 384, 430; USNM 725c, 728p, 728s, 738, 738b. Capitan: AMNH 475, 847; USNM 725p, 732q, 737a, 740-l, 740m, 740n, 750a, 750b.

DIAGNOSIS.—Broad *Stenosisma* with well-developed stolidium, bifurcating and intercalated costae that begin near the beaks.

TYPES.—Holotype: USNM 152230b. Figured paratypes: USNM 152230a,c,d; 152231a-c; 154585a; 154586; 154587; 154588. Measured paratypes: USNM 152202a; 152230a,c; 152231a-c.

COMPARISON.—*Stenosisma trabeatum* is characterized by its relatively broad outline, numerous bifurcating and intercalating costae that begin near the beaks, well-developed stolidium that is continuous, pedicle beak with conjunct deltidial plates, and its peculiar, externally opening pockets that are formed by partial detachment of the marginal portion of the lateral pseudointerareas. Externally it resembles *S. obliquum*, new species, differing in its wider outline, less attenuate and pinched beak, and its more numerous costae that frequently branch or intercalate. *S. pyraustoides*, new species, from the Wolfcamp of the Glass Mountains is similar in its costation, but *S. trabeatum* differs in its narrower outline, more numerous costae on the flanks, and its continuous stolidium and lateral pockets. *Stenosisma multicostum* Stehli also is similar, but differs in its greater convexity, discontinuous stolidium, disjunct deltidial plates, and well-developed, normal lateral pseudointerareas without pockets. No foreign species that are familiar to us have the numerous and bifurcating costae or continuous stolidium of *S. trabeatum*, therefore detailed comparisons are not necessary.

Stenosisma triquetrum, new species

PLATE 578: FIGURES 1-79; PLATE 579: FIGURES 1-32;

PLATE 580: FIGURES 1-36; PLATE 581: FIGURES 1-19;

PLATE 582: FIGURES 1-22

Camarophoria venusta R. E. King [not Girty], 1931:110, pl. 34: figs. 29a, b, 31a, b [not figs. 30a, b (= *S. hadrum*, new species)], pl. 35; figs. 3a-d, 5 [not figs. 1a-c, 4 (= *S. levicostum*, new species), fig. 2 (= ?)].

Stenosisma venusta Cooper [not Girty], 1944:315, pl. 120: figs. 38-40.

Stenosisma venustum Cooper [not Girty], 1956a:522, text fig. 1a.—Grant, 1965a:150, pl. 21; figs. 13, pl. 22: figs. 1-10, pl. 23: figs. 1-5; 1965b:H629, fig. 515:4f-i.

Adult large for genus; outline broadly subtrigo-

nal, sides diverging between 65° and 115° , averaging about 90° , divergence typically increasing with shell size; young longer than wide; length and width becoming approximately equal at about 20 mm. Profile moderately biconvex; commissure uniplicate; fold high, broad, and only gently arched over crest, beginning about 8–15 mm anterior to brachial valve beak; sulcus shallow except at anterior, beginning 12–18 mm anterior to pedicle valve beak. Costae moderately strong, blunt-crested, beginning 1–5 mm anterior to beaks, numbering 5–8, normally 5 or 6 on fold, one less in sulcus, 4–6 on flanks, becoming lower and weaker laterally, rarely 1 or 2 on fold or sulcus bifurcating anteriorly; stolidium broad, fanlike, with fine concentric ornament, beginning just behind widest part of shell, not continuous from flanks to fold, better developed on brachial valve, occasionally reduced or absent from pedicle valve. Radial and concentric ornamentation absent (except on stolidium); growth lines fine and closely spaced, with a few stronger laminae at irregular intervals.

Pedicle valve gently convex transversely and from beak to flanks, more strongly convex through sulcus; umbonal region relatively low to somewhat swollen; beak about normal length for genus, suberect to erect varying from not strongly to moderately hooked; beak ridges short, blunt; delthyrium triangular, small, constricted along sides and at anterior by conjunct deltidial plates, leaving narrow, slitlike foramen normally opening directly dorsally; lateral pseudointerareas elongate, narrow, normally covered by overlapping edge of opposite valve.

Brachial valve strongly convex transversely, moderately strongly convex along crest of fold, convexity rather uniform, valve nowhere strongly swollen or flattened; beak bluntly pointed, apex within pedicle valve, hidden by deltidial plates.

Pedicle valve interior with blunt teeth, elongate, parallel to sides of valve; dental plates continuous with teeth, slightly convergent toward floor of valve, more abruptly curved immediately above floor, joining one another to form boat-shaped spondylium supported by low median septum; space between valve floor and outside of spondylium commonly filled with callus. Relatively deep, transverse pallial troughs present in some individuals, crossing floor of valve just anterior to end of median septum; muscle marks in spondylium weak.

Brachial valve interior with broadly triangular hinge plate having apex thickened to form cardinal process, as a single small node in young individuals and becoming greatly thickened and binodose in adults, surface textured for muscle attachment; sockets elongate, narrow, finely corrugated, laterally bounding anterior third of hinge plate; crural bases fused to hinge plate, extending forward from base of cardinal process to anterior edge of plate, there continuing free as slender brachial processes, outwardly bowed and gently curved ventrally; median septum high, thin, length increasing with height; camarophorium spoon-shaped, capping septum, widest just behind anterior end, slightly produced at anterior apex; intercamarophorial plate somewhat shorter than median septum, forming support between camarophorium and hinge plate, median part of hinge plate frequently extending forward between brachial processes and dipping from sides to top of intercamarophorial plate; space between hinge plate and camarophorium commonly filled with callus, burying intercamarophorial plate. Muscle pattern not observed, presumed to lie in camarophorium.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain and Road Canyon formations.

LOCALITIES.—Cathedral Mountain: AMNH 500B, C, J, N; USNM 700-l, 700x, 702, 702a, 702b, 702ent, 702-low, 702un, 703b, 708, 708u, 711q, 713t, 713w, 721u, 723y, 724s, 726u, 726y, 727o, 727p, 729z, 731b, 735b, 737v. Road Canyon: AMNH 503, 507; USNM 702c, 703, 703a, 706f, 716x, 719x, 721o, 721s, 726z, 726za.

DIAGNOSIS.—Large *Stenosisma* with elongate young stage, few bifurcations of costae, and wide stolidium.

TYPES.—Holotype: USNM 152191u. Figured paratypes: USNM 142526; 142528; 142531; 142531-38; 142540-43; 142544; 142547; 152190a-n; 152318a-d; 152320a-c; 152334b,e-g; 154589a-c. Measured paratypes: USNM 152191a-t; 152319a-h; 152321a-f,j. Unfigured paratypes: USNM 152191a-t; 152334a,c,d.

COMPARISON.—*Stenosisma triquetrum* is characterized by its fairly large size, triangular outline with slightly indented sides just anterior to the beaks, and its usually direct and only occasionally bifurcating costae. Compared to other large stenoscismas it differs from *S. hadrum*, new species, in its less robust form of the fully grown adult, its more rounded costae, its less strong costae on the flanks,

MEASUREMENTS (in mm).—

	brachial length	valve length	width	thick- ness	apical angle (°)
USNM 702c					
152191a	1.7	1.5	1.4	0.8	67
152191b	3.5	3.1	2.9	1.6	67
152191c	4.9	4.2	3.9	2.5	74
152191d	5.5	5.0	4.7	2.8	70
152191e	6.5	5.7	5.2	3.0	68
152191f	7.3	6.5	6.2	3.5	71
152191g	7.8	7.0	6.6	3.5	79
152191h	9.2	8.2	8.4	3.8	73
152191i	10.8	10.2	10.7	5.4	79
152191j	12.0	10.6	11.3	5.8	83
152191k	14.4	12.8	13.6	6.3	73
152191-l	17.0	15.0	16.4	8.0	82
152191m	19.9	17.8	22.8	10.0	88
152191n	23.9	22.0	27.7	14.7	80
152191o	5.5	5.0	5.0	2.8	78
152191p	10.5	9.4	10.8	5.2	92
152191q	20.1	19.8	25.3	15.2	92
152191r	24.3	22.6	32.3	17.3	97
152191s	25.0	23.2	31.3	17.7	88
152191t	27.7	24.6	33.5	20.8	85
152191u	28.0	25.4	37.7	22.3	97
(holotype)					
USNM 702					
152319a	2.8	2.4	2.4	1.4	82
152319b	3.2	2.8	2.7	1.3	89
152319c	3.9	3.5	3.2	1.7	91
152319d	4.9	4.3	4.3	2.5	74
152319e	5.5	4.9	4.9	2.8	81
152319f	6.8	6.0	6.0	3.2	85
152319g	8.6	7.3	7.7	4.4	70
152319h	11.2	10.6	10.9	7.7	87
USNM 702b					
152321a	15.4	15.0	15.3	6.4	85
152321b	18.6	16.0	16.9	10.3	74
152321c	20.0	17.6	21.3	13.9	74
152321d	22.2	19.4	23.5	15.8	80
152321e	24.5	22.4	30.8	19.6	84
152321f	31.0	28.0	41.0	22.5	101
152321j	28.0	25.0	32.0	19.0	84

its sulcus not extending so far anteriorly, and its generally transverse young. *Stenoscisma levicostum*, new species, is a smaller, though coarsely costate species, which is wider and shorter than *S. triquetrum* and with the costae more spread out laterally. *Stenoscisma multicostum* Stehli is still larger than *S. triquetrum*, is much wider, and has more numerous costae. The same is true of *S. problematicum*, new species, regarding width and has more numerous costae but the two species attain nearly

the same adult size. *Stenoscisma pyraustoides*, new species, is not likely to be confused with *S. triquetrum* because it is a very large, transverse, and multicostate species. As explained under *S. venustum* (Girty) only remote similarity exists between it and *S. triquetrum*.

Among the foreign species similar enough to *S. triquetrum* externally to make comparison desirable are several species illustrated by Tschernyschew (1902); however, they all seem to differ consistently in having the ventral median septum higher and the camarophorium more strongly curved ventrally. Among them, *S. crumenum* (Martin) is most similar (see Tschernyschew, 1902:489, pl. 22: figs. 2–15), differing in its somewhat smaller size, more strongly hooked pedicle beak, less abundantly costate juveniles, and more rounded, less triangular outline. Most of Tschernyschew's illustrations show specimens that are less strongly costate and have the costae starting farther forward than in *S. triquetrum*. However, figure 10 of plate 22 is more similar to the Texas species in its costation. *Stenoscisma kutorgae* (Tschernyschew, 1902, pl. 22: figs. 16–17) is more remotely related to this species; it is more gibbous, its flanks are more strongly costate, and its costae begin at the beaks. *S. mutabile* (Tschernyschew, 1902:491, pl. 45) is comparable in size and costation, but it has the pedicle beak tightly pressed against the brachial umbo, as in the West Texas *S. renode*, new species, in contrast to the more erect beak of *S. triquetrum* which has the pedicle foramen and deltidial plates visible.

The Salt Range of Pakistan contains four species comparable to *S. triquetrum*. Waagen (1883, pl. 32) illustrated *S. purdoni* (Davidson), *S. humbletonense* (Howse), and *S. pingue* (Waagen), all of which bear superficial resemblance to the Texas species, but differ primarily in the increased longitudinal convexity of brachial valves which results in a much lower crest for the fold. These species also are not as strongly trigonal in outline, and have more strongly hooked and shorter pedicle beaks. Also from the Salt Range, Reed (1944:135, pl. 24: figs. 5–5c) illustrated a specimen of *S. cuneiforme* (Reed) that resembles the Texas species in outline and strength of costation. It differs in its more strongly hooked beak, smaller size, narrower outline, and judging by Reed's illustrations, its foramen that is completely closed by the deltidial plates

(this last feature may be a feature only of the illustrated specimen, or of the illustration itself.

The European forms of *S. humbletonense* (Howse) were described and illustrated by W. King (1850) under the name of "*Camarophoria*" *multiplcata*. King's illustrations (1850, pl. 7: figs. 26-32, pl. 8; figs. 1-7) show specimens that are similar in size and strength of costation to *S. triquetrum*. They differ from the Texas species in their more elliptical outlines, smaller and more abundant costae, possibly higher median septum in the pedicle valve, and longer intercamarophorial plate in the brachial valve. They belong to the same general group of species, but seem to resemble more closely *S. inaequale* (Girty) than *S. triquetrum*.

Another relatively similar European species is *S. affine* (Gemmellaro, 1899:128, pl. 27: figs. 1-7) which differs in its weaker costellae, especially on the flanks of the shell. Gemmellaro's specimens are internal molds which do not show the shape and attitude of the beak, so close comparison is impossible. Schellwien (1892:51, pl. 8: figs. 4-8) described *S. alpinum* from the Permian of the Carnic Alps, a species remarkably similar to *S. triquetrum*. Apparently *S. alpinum* is costate farther back on the pedicle beak, and its sulcus begins farther posteriorly. Schellwien illustrated only two adult shells, and showed both of them only from the ventral side, so that their beaks do not show. However he states in his description that the pedicle beak is strongly hooked and has a rather wide delthyrium, but makes no mention of deltidial plates. These features stand in contrast to the pedicle umbonal configurations of *S. triquetrum*.

DISCUSSION.—Juveniles of *S. triquetrum* are rather flat and very narrowly lenticular in profile as usual in the young of normally strongly biconvex rhynchonellids and stenoscismatids. Furthermore, these young are longer than wide with their sides diverging at an angle less than 90°. With approaching adulthood, length in relation to width lessens until the two are approximately equal. Costae become progressively stronger with growth, giving the impression that juvenile shells are more finely costate than the adults.

The stolidium does not appear until the shell is about half grown. It may be present, however, on some small specimens that are stunted; their maturity can be estimated from the convexity of the brachial valve. A few juveniles in the National

Museum collection are larger than some apparently fully grown adults that are complete with stolidium. Such variations in growth and attainment of adulthood have been noted in many other brachiopods (e.g., *Echinosteges*).

Most large stenoscismas in the Glass Mountains and the Guadalupe Mountains have been referred to *S. venustum* (Girty) regardless of stratigraphic level. It will be seen below that Girty's species is unlike any others described herein and that the name does not have such wide applicability.

Stenosisma venustum (Girty)

PLATE 577: FIGURES 1-8

Camarophoria venusta Girty, 1909:303, pl. 31: figs. 6-6c.

Medium size, triangular in outline, length and width about equal, maximum width anterior to midvalve; valves of unequal depth, pedicle valve shallower; posterolateral sides nearly straight; anterolateral extremities narrowly rounded; anterior margin moderately rounded, beak small, narrow, nearly straight, delthyrium visible. Surface anteriorly costate, costae numerous, narrowly rounded, interspaces broader than costae; 6 on fold, 5 or possibly 6 on each flank. Posterior half with costae much reduced or missing.

Pedicle valve gently convex in lateral profile, maximum convexity just anterior to umbo; anterior profile faintly concave. Umbonal region narrowly rounded; sulcus broad and shallow, originating just anterior to midvalve, occupying about half valve width; flanks somewhat narrowly rounded, short, slopes steep.

Brachial valve fairly strongly convex, maximum convexity at midvalve; anterior profile narrow, steep-sided dome. Median region strongly swollen; fold originating just posterior to midvalve, low and gently rounded. Flanks only moderately swollen and with steep slopes.

Interior unknown.

MEASUREMENTS (in mm).—Specimen USNM 118557 (holotype): length 18.0, brachial valve length 15.5, maximum width 18.6, thickness 11.0, apical angle 85°

STRATIGRAPHIC OCCURRENCE.—"Supposed to represent the Delaware Mountain Formation" (Girty, 1909:512).

LOCALITY.—USGS 3763 (green) (essentially an unknown locality).

DIAGNOSIS.—Medium size *Stenoscisma* with short fold and sulcus, fine costae, and nearly straight beak.

TYPES.—Holotype: USNM 118557.

COMPARISON.—All the large and transverse species of *Stenoscisma* are eliminated from comparison. Species of similar size to *S. venustum* are few and most of them are more strongly costate. *Stenoscisma aptatum*, new species, is about the same size but it is coarser ribbed and much wider. *Stenoscisma exutum*, new species, has costae of about the same size as those of *S. venustum* but the shell is rather elliptical rather than triangular, as in *S. venustum*. *Stenoscisma levicostum*, new species, is of about the same size as *S. venustum* but is very strongly costate and the costae are thick and high.

DISCUSSION.—*Stenoscisma venustum* has proved to be an enigma. We have compared it closely with all the species of the genus in the Glass Mountains and elsewhere and are unable to recognize it anywhere in the collection. The specimen is not well preserved and little is revealed on its coarsely silicified surface. No details of the interior can be ascertained, and the deltidial plates have been destroyed. The specimen is quite clearly an adult as it has a well-formed fold and sulcus, features that are usually not formed in juveniles. Furthermore the unequal depth of the valves also indicates that the specimen is adult. Valves of young specimens as a rule are nearly equal in depth. The strength of the ribs, which, although narrow, are fairly high and well formed, is another adult character. *Stenoscisma venustum* is the same type of shell as *S. triquetrum*, new species, which King and others referred to *S. venustum*. This type has prominent costae on the fold and sulcus, but those of the flanks are usually somewhat reduced and best formed only anteriorly. Compared to specimens of *S. triquetrum* having the same length as *S. venustum*, the latter proves to be much more convex, with a stronger fold and sulcus, and a much deeper brachial valve. Specimens of *S. triquetrum* of 18 mm are really still in the youthful stage and have the broad low costae and shallow valves characteristic of the young. Thus *S. venustum* appears not to be a young form of this large species.

In seeking from its stratigraphic level some clue to its relationships we are also baffled. The species

is reported from Comanche Canyon in the Glass Mountains. We have been unable to identify this canyon and thus get no help in our effort to locate the species. Species listed by Girty from USGS 3763 appear to include Leonardian as well as Word species but with a predominance of the latter. None of the Word *stenoscismas* identified and described herein even remotely suggests *S. venustum*. Furthermore, the preservation of the specimen suggests Leonardian rather than Word. The dilemma cannot be resolved by us and this rather widely used name is another that must rest on its type specimen.

Stenoscisma species 1

PLATE 583: FIGURES 22-42

Medium size for genus, wider than long, valves unequally deep, brachial valve deeper; subtrigonal to subelliptical in outline, widest just anterior to midvalve. Beak smooth, short, suberect but not pressed onto dorsal umbo. Costae strong and subangular, 5 on fold, outer two being implanted at inception of fold, and 4 or 5 on each flank. Distal 1 or 2 indistinct. Stolidium not seen.

Pedicle valve gently but unevenly convex in lateral profile; anterior profile broadly concave. Umbonal region narrow and convex; sulcus originating posterior to midvalve, 6 or 7 mm anterior to beak, deepening and widening anteriorly, flat in transverse section, produced into fairly long tongue; flanks slightly convex, narrow, and sloping fairly steeply.

Brachial valve strongly convex, somewhat more strongly curved in anterior third. Umbonal and median regions swollen; sulcus originating on umbonal slope posterior to midvalve, occupying about half valve at midwidth, nearly flat in transverse section. Flanks moderately depressed, swollen and steep.

Interior details unknown.

MEASUREMENTS (in mm).—From locality USNM 730a specimen 152279a and from USGS 9999, USNM 152280a, respectively: length 17.5, 16.1; brachial valve length 15.2, 13.2; width 21.6, 22.0; thickness 14.2, 10.7; apical angle 103°, 104°.

STRATIGRAPHIC OCCURRENCE.—Hueco Formation; Lenox Hills Formation.

LOCALITIES.—Hueco: USGS 9999; USNM 720b. Lenox Hills: USNM 730a.

DIAGNOSIS.—Fairly wide *Stenoscisma* with strong costae, five on the fold, and strongly costate flanks.

TYPES.—Figured specimens: USNM 152279a,b; 152280a,b.

COMPARISON.—The general expression of this species is that of *S. hueconianum* (Girty) but it is larger and much more robust, although the number of costae is in accordance with that of Girty's species. Other differences appear in the generally greater divergence of the sides of *Stenoscisma* species 1, and in the more strongly inflated brachial valve.

DISCUSSION.—This species is represented by a few specimens; the best preserved one was found loose but in a position that made it clear that only the upper part of the Lenox Hills Formation could have produced it. All the specimens have the general expression of *S. hueconianum*, a much smaller species that is common in the Hueco Canyon Formation.

Stenoscisma species 2

PLATE 583: FIGURES 8-21

Small, widely elliptical in outline, with widely divergent posterolateral margins and narrowly rounded sides; maximum width near midvalve. Beak short, suberect, but pressed onto dorsal umbo. Surface multicostate, 7-9 costae on fold and about 5 on each flank; costae narrow and subangular, separated by spaces of about equal width. Stolidium not seen.

Pedicle valve flatly convex in lateral profile and broadly but slightly convex in anterior profile. Umbonal region swollen; sulcus originating slightly posterior to midvalve, wide and shallow, slightly wider than midwidth. Flanks slightly elevated anteriorly, flat and with gentle slope to margins.

Brachial valve fairly strongly convex, greatest convexity in anterior third; anterior profile broadly domed and with steep lateral slopes. Median region swollen; fold originating near midvalve, wide and moderately elevated. Flanks, narrow, swollen, and steep.

Interior, except for generic characters, unknown.

MEASUREMENTS (in mm).—From locality USNM 716r specimen (USNM 152227b): length 11.5mm (but minus beak, which would add about 1.0 mm), brachial valve length 11.0, width 17.8, thickness 10.0, apical angle 118°.

STRATIGRAPHIC OCCURRENCE.—Lenox Hills Formation.

LOCALITIES.—USNM 713y, 716r.

DIAGNOSIS.—Small widely elliptical, multicostate *Stenoscisma*.

TYPES.—Figured specimens: USNM 152227a,b.

COMPARISON.—This species, like *Stenoscisma* species 1, has the general expression of *S. hueconianum* (Girty) in its elliptical outline and rounded brachial valve in lateral profile but unlike the former, is much more numerous costate than Girty's species, having 7-9 costae on the fold. Despite the numerous costae, the nearly 50 percent ratio between fold and maximum valve width is the same in all three species.

DISCUSSION.—Only a single undistorted specimen of this species was found, but it lacks the beak of the pedicle valve; the other 11 specimens are crushed in one or more directions but all reveal the multicostate character of the species. The fact that only 12 specimens were found in the upper part of the Lenox Hills Formation confirms this as a rare species. This species could be the ancestral form of *S. pyraustoides*, new species, which it immediately underlies. It could also have been ancestral to *S. kalum* and *S. multicostum*, both of Stehli (1954).

Stenoscisma species undetermined

PLATE 583: FIGURES 1-7

A single complete shell from the Lamar Limestone appears to be unique and cannot be placed in a recognized species. It is small, transverse, and essentially smooth, having but 2 costae on the fold and 2 very weak and short costae on each flank. The stolidium is not preserved, and the valve margins indicate that it had not yet developed, so perhaps the specimen is not fully adult. The closest resemblance is to two small and relatively smooth species from low in the Cathedral Mountain Formation, *S. doricranum* and *S. fabarium*, both new.

The Lamar specimen has a shorter beak than the former, a more rounded outline, and much shorter and weaker costae on fold and flanks; it differs from the latter in having fewer costae on the fold, these beginning much farther forward, and obscure costae on the flanks, and the profile of the Lamar specimen is slightly more inflated than that of the

latter, especially in the dorsal umbonal region.

MEASUREMENTS (in mm).—Specimen USNM 152317: length 12.5, width 14.9, thickness 9.3.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Limestone Member).

LOCALITY.—USNM 738.

TYPES.—Figured and measured specimen: USNM 152317.

Subfamily TORYNECHINAE Grant, 1965

Completely costate, uncinuliform *Stenosclimatis* with stolidium reduced or absent.

Genera in West Texas: *Torynechus* Cooper and Grant, 1962.

Genus *Torynechus* Cooper and Grant, 1962

Uncinuloides R. E. King, 1931:112.

Torynechus Cooper and Grant, 1962:1128.—Grant, 1965a: 152; 1965b:H631.

Large, strongly triangular in outline with broadly truncated anterior margin; valves unequally deep, brachial valve deeper. Beak short, pointed, with small disjunct deltidial plates. Surface costellate to finely costate; anterior margin slightly deflected, suggesting rudimentary or vestigial stolidium.

Pedicle valve interior with short, deep spondylium, anteriorly rounded, attached to low median septum which may be made obsolete by adventitious shell. Vascula media deeply impressed, extending laterally from anterior end of spondylium.

Brachial valve with narrow, modified hinge plate and massive bosslike cardinal process; camarophorium long and deep, extending anterior to end of spondylium; intercamarophorial plate thick. Crura long and slender as in *Stenosclisma*.

TYPE-SPECIES.—*Torynechus caelatus* Cooper and Grant (1962:1128).

DIAGNOSIS.—Internally like *Stenosclisma* but costellate and with broadly flattened anterior, the exterior like *Uncinunellina*, with only a trace of a stolidium.

COMPARISON.—The interior of this genus is exactly like that of *Stenosclisma* but the distinctive uncinuliform exterior separates it from all other *Stenosclimatidae*.

DISCUSSION.—This rare genus straddles the boundary between the Skinner Ranch and Cathedral Mountain formations. It appears first in the Dug-

out Mountain Member of the Skinner Ranch Formation, and its last known occurrence is in the Wedin Member of the Cathedral Mountain Formation. It is fairly common at a few localities in the Wedin Member, but is generally rather rare. Shells in the detrital upper part of the Skinner Ranch Formation normally are badly damaged, but well-preserved silicified shells can be obtained from the base of the Cathedral Mountain Formation. Despite the stratigraphic equivalence of the Hess Formation to parts of the Skinner Ranch and Cathedral Mountain formations, *Torynechus* has not been found in the Hess.

Cooper and Grant (1962) and Grant (1965a,b) explained the nomenclatural difficulties with the type species and the necessity for substituting a new name for King's genus *Uncinuloides*. *Torynechus* has not yet been found outside of the Glass Mountains where it occupies a very thin part of the section.

The exterior of *Torynechus* is unusual not only in the ornament but in the development of the anterior. Costellae cover the entire shell, including the umbones of both valves. Considerable bifurcation of the costellae takes place in the posterior but costellae are direct. The anterior margin is sharply geniculate to form a flat base and at this point the costellae of the base develop an impressed line. This feature is characteristic of such similar rhynchonellids as *Uncinulus* Bayle, *Hypothyridina* Buckman, and *Sphaerirhynchia* Cooper and Muir-Wood. The costella on each side of the impressed line is marked by chevron-shaped growth lines. The impressed line is produced by the hollow conical spine with which it terminates at the margin. The spines of the two valves interlock when the shells are closed, but form a sieve or screen when they gape, as explained by Schmidt (1937).

Another interesting feature, especially of adult shells, is the deflection of the anterior margin of both valves at right angles to the direction of growth. This results in an elevated ridge at the commissure. This suggests the stolidium of *Stenosclisma* but in a much aborted condition and certainly without the same function.

The interior of the pedicle valve is so like that of *Stenosclisma* that few additional remarks are necessary. The posterior is often thickened to such an extent that the septum supporting the spondylium is completely buried and appears to be sessile.

The pallial trunks are exceptionally deep in the pedicle valve of this group, a help in understanding their pattern.

The brachial valve hinge plate is much narrowed and confined, and the crural bases are squeezed close together. The camarophorium is long, fairly wide, and extends far beyond the end of the spondylium. It is supported by a strongly elevated, stout median septum. The tip of the camarophorium is drawn out into a fairly long blunt subrectangular projection.

In our experience *Torynechus* is confined to the upper part of the Skinner Ranch Formation and the basal part of the Cathedral Mountain Formation. It is found throughout the lateral extent of the Skinner Ranch Formation. It is rare in Lenox Hills but is fairly common in the hills west of Iron Mountain and on Leonard Mountain. It has a somewhat wider range in the Cathedral Mountain Formation where it is found in King's Leonard "Fifth Limestone" on Dugout Mountain, at the same level as in Leonard Mountain, and at a few places east of there in the canyon leading up to the Appel Ranch and Split Tank.

R. E. King (1931:113) reports *Uncinuloides* from the Wolfcamp (=Lenox Hills) on Dugout Mountain and from the Word Formation (=Road Canyon) southwest of Sullivan Peak. Our extensive collections have not yielded this genus from either of these horizons.

Torynechus alectorius, new species

PLATE 584: FIGURES 1-41

Uncinuloides guadalupae [part] R. E. King [not Shumard], 1931:112, pl. 35: figs. 7a-c.

Average size for genus; outline moderately to broadly subtrigonal, sides diverging between 75° and 120°, normally about 100°; profile nearly equilaterally subtrigonal; commissure uniplicate, fold standing rather high toward anterior, with lower relief posteriorly, beginning 7-10 mm anterior to brachial beak; sulcus shallow, beginning 10-12 mm anterior to pedicle beak. Costae moderately coarse to fine, beginning at beaks, sharp-crested, a few adding toward anterior by bifurcation, more rarely by intercalation, numbering 9-13 on fold, one less in sulcus, 10-12 on each flank; anterior margins abruptly bent to form flattened levigate region,

may be slightly concave, extending along sides slightly anterior to widest part of shell, each costa there deeply grooved along crest, slightly extended at margin to form interlocking serrations of commissure. Concentric ornamentation fine, closely spaced; growth laminae weak, widely spaced.

Pedicle valve moderately thick, flatly convex transversely, more strongly convex longitudinally along sulcus; beak moderately long, somewhat attenuate, slightly hooked; lateral pseudointerareas narrow, elongate, covered by edge of brachial valve; delthyrium triangular, constricted by small, disjunct deltidial plates. Brachial valve rather strongly convex transversely, nearly flat along crest of fold, except for increased convexity in beak region; beak slightly attenuate, not greatly swollen.

Pedicle interior with boat-shaped spondylium supported above floor of valve by low median septum; other internal features unknown. Brachial interior with high median septum and deep camarophorium; other internal features unknown.

MEASUREMENTS (in mm).—

	brachial valve		thick- ness	apical angle (°)
	length	length	width	
USNM 710r				
154590a	9.0?	8.4	8.9	4.2 77
154590b	11.5	10.6	13.0?	6.0 99
154590c	13.0	12.1	16.5	6.4 106
154590d	17.0	15.1	20.0	11.9 106
154590e	16.3	14.0	20.8	15.9 102
154590f	17.8	15.6	22.0	17.8 108
(holotype)				

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Dugout Mountain and Sullivan Peak members).

LOCALITIES.—Dugout Mountain: USNM 700p, 732e, 733-l. Sullivan Peak: 707b, 729p. Skinner Ranch (top): 710r, 723h, 724-l, 731o.

DIAGNOSIS.—*Torynechus* with strong, angular costellae and fairly prominent fold.

TYPES.—Holotype: USNM 154590f. Figured and measured paratypes: USNM 154590a-e.

COMPARISON.—*Torynechus alectorius* is characterized by its sharp costae that are not characteristically bifurcated or intercalated, its somewhat thick pedicle valve, brachial valve with low longitudinal convexity, and its extensive, somewhat concave levigate anterior surface. It differs from the other Texas species, *T. caelatus* Cooper and Grant (1962), in its sharper, less frequently bifurcating or inter-

calating costae, somewhat greater levigate anterior surface, less swollen brachial umbonal region, and fold that stands higher above the flanks at the anterior.

DISCUSSION.—This is an uncommon species that seems generally to come from locations west of the Split Tank area which is the locale for *T. caelatus*. The latter has not been identified in what apparently is the same horizon elsewhere. Indeed, the distribution of the genus is peculiar because it has not yet been found in some localities where *Institella* bioherms are best developed. *Torynechus alectorius* is commonest where the upper part of the Skinner Ranch Formation forms the top zone of hill 5280, and very near the top on Leonard Mountain. There it occurs in cherts just under the 40-foot calacarenite or calcirudite forming the top beds of the type section of the Skinner Ranch Formation. It also survives into this upper bed, but is less common.

Torynechus caelatus Cooper and Grant

PLATE 585: FIGURES 1–33; PLATE 586; FIGURES 15–29

Uncinuloides guadalupae [part] R. E. King [not Shumard], 1931:112, pl. 35, figs. 6a–c.—Cooper, 1944:315, pl. 120: figs. 49–51.

Torynechus caelatus Cooper and Grant 1962:1128.—Grant, 1965a:154, pl. 24: figs. 1–10; 1965b:H631, figs. 515; 1a–c.

Fairly large, attaining width about 25 mm, subtriangular to subpentagonal in outline, long sloping posterolateral margins and narrowly rounded sides; anterior margin broadly rounded to abruptly truncated. Posterolateral margins forming an angle of 69–96°. Maximum width slightly anterior to midlength. Beak moderately elongated, nearly erect but slightly incurved; foramen elongate, elliptical; deltidial plates small and narrowly disjunct. Surface costellate to finely costate, costellae low to moderately elevated, narrowly rounded and usually closely crowded, separated by spaces of about equal width; costellae numbering 9–16 on fold and usually occupying lateral slopes of fold as well as dorsal surface; flanks with 8–15, the outer third or half fine and often indistinct. Bifurcation and intercalation of costellae infrequent.

Pedicle valve unevenly and flatly convex in lateral profile, most curvature just posterior to midvalve; anterior profile broadly and fairly evenly shallow; umbonal region gently convex; sulcus

originating just posterior to midvalve, broad and shallow, not well defined because of costation of inner slopes; tongue broad and long, fairly rounded, flat or slightly concave in transverse section; flanks poorly defined, narrow, moderately convex but with steep outer posterolateral slopes.

Brachial valve much deeper than pedicle valve, gently convex in lateral profile, anterior half flattened; anterior profile broadly domed, sides precipitous. Umbonal and median regions moderately swollen; fold slightly elevated, not strongly differentiated from flanks, slopes costellate; fold originating just posterior to midvalve and occupying slightly more than half midwidth. Flanks gently swollen, but flattened and dropping off to margins at point of marginal geniculation.

Interior as described for genus.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thick- ness	apical angle (°)
USNM 702un					
154593a	14.5	12.2	14.5	11.4	75
154593b	15.3	13.1	14.4	11.2	69
154593c	16.8	14.8	18.0	10.3	78
154593d	17.0	15.0	18.2	11.9	87
154593e	17.2	14.6	19.6	15.1	85
154593f	17.2	14.7	18.7	15.0	81
154593g	16.8	14.6	18.9	13.0	90
154593h	17.4	14.9	21.0	15.4	89
154593i	18.7	17.0	23.7	15.0	92
USNM 703b					
142555	21.2	18.5	24.6	17.8	96

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (*Institella* zone).

LOCALITIES.—AMNH 500D, 504; USNM 700-1, 700x, 702, 702un, 703b, 708, 709, 712o, 721u, 724n, 724r, 724s, 730u, 735b.

DIAGNOSIS.—*Torynechus* with narrowly rounded costellae.

TYPES.—Holotype: T10167. Figured paratype (R. E. King, 1931): YPM 12582. Figured hypotypes: USNM 142553; 152594a,b; 152595a; 154591; 154593a–d,f,j–m. Measured hypotypes: USNM 142555, 154593a–i.

COMPARISON.—This species differs from its close relative in the Glass Mountains, *T. alectorius*, in having finer costellae that are narrowly rounded rather than angular as in *T. alectorius*, in having the fold less prominent, and in having more numerous costellae generally, a smaller angle of diver-

gence of the posterolateral margins, and a somewhat less levigate anterior surface.

DISCUSSION.—This species seems to be confined to the eastern part of the mountains, where it occurs in beds in the vicinity of Split Tank. There it occurs in biohermal limestone and in detrital material between bioherms. It occurs with *Institella* and the unusual *Niviconia globosa* (R. E. King).

An interesting feature observed on shells of this species is the borings that penetrate many of them. The elongate forms are evidently of a boring barnacle but the circular holes were probably produced by gastropods. These are perfectly round and have even sides, not beveled inward with diminishing diameter as in borings of Tertiary and Recent shells.

Family ATRIBONIIDAE, Grant, 1965

Subfamily PSILOCAMARINAE Grant, 1965

Atriboniidae with intercamarophorial plate absent or rudimentary, hinge plate divided or very short.

Genus *Psilocamara* Cooper, 1956

Levicamera Grabau, 1934:18 [nomen nudum, not of Sarycheva and Sokolskaya, 1952:171 (= *Camerisma* Grant, 1965a)].
Psilocamara Cooper, 1956:523.—Waterhouse, 1964:102.—Grant, 1965a:77; 1965b:H627.

Small, subglobose to subpyramidal; outline sub-trigonal to subpentagonal; anterior commissure strongly uniplicate; fold high, crest blunt to sharp, sloping evenly to flanks, normally smooth, some with few simple or bifurcating costae; sulcus shallow with weak median groove corresponding to sharp crest of fold; flanks smooth; valve edges butting except for slight overlap at extreme posterior of some shells; stolidium absent; growth lines fine, closely spaced; radial ornament absent.

Pedicle valve moderately convex transversely, strongly convex longitudinally; umbonal region swollen, flanks relatively flat; beak short, bluntly pointed, straight to suberect; beak ridges gently rounded; delthyrium small, triangular, constricted by small triangular, disjunct deltidial plates; foramen small, elongate, slitlike, partly filled by beak of brachial valve. Brachial valve strongly convex transversely, moderately convex longitudinally;

beak short, rounded, slightly attenuate, apex within pedicle valve.

Pedicle valve interior with hinge tooth on each side of delthyrium, each parallel to valve edge; dental plates large, curved toward floor, meeting to form deep, scoop-shaped spondylium, sessile in apex, anteriorly supported on low median septum duplex; septum thinner and higher toward anterior, extending about a third length of valve.

Brachial valve interior with short undivided hinge plate; crura extending from anterior edge of hinge plate, curved dorsally slightly more strongly toward anterior; median septum beginning at beak, ventral edge expanded to form spoon-shaped camarophorium, not attached to hinge plate, either directly or by intercamarophorial plate; height of septum increasing anteriorly, curving camarophorium ventrally, septum reduced to median keel on convex side of camarophorium at anterior, length about one-fourth length of valve.

TYPE-SPECIES.—*Psilocamara renfroarum* Cooper, by original designation (1956a:524, pl. 61B: figs. 20–32, text-fig. 18, nos. 4–15).

COMPARISONS.—*Psilocamara* is characterized by its smooth shell, high fold that is not distinctly set off from the flanks, lack of an intercamarophorial plate in the camarophorium of the brachial valve, and by its partly sessile spondylium and low median septum in the pedicle valve. The smooth shell distinguishes it from *Sedenticellula* Cooper, which also has a partly sessile spondylium. The edges of the camarophorium do not touch the hinge plate, distinguishing *Psilocamara* from *Camarophorinella* Licharew, which also lacks an intercamarophorial plate. *Camarophorina* Licharew lacks the intercamarophorial plate and also is smooth, but its fold is reversed, producing a sulcate rather than uniplicate commissure. The genus *Camerisma* Grant also is smooth and uniplicate, but is much larger than *Psilocamara* and has an intercamarophorial plate bracing the midline of the camarophorium to the underside of the hinge plate in the apex of the brachial valve.

Psilocamara hesperia, new species

PLATE 586: FIGURES 1–14

Small for genus, biconvex; outline heart-shaped or subpentagonal, sides diverging about 90° at

posterior; commissure strongly uniplicate, fold high at commissure but not set off distinctly from flanks, crest bluntly ridged, extending to brachial beak; sulcus shallow but with narrow median trough reflecting ridge of fold. Costae and concentric ornament absent; growth lines not observed.

Pedicle valve moderately convex transversely, more strongly curved along midline through sulcus, somewhat inflated in umbonal region anterior to beak; beak short, sharp, nearly straight; beak ridges short, blunt; delthyrium small, triangular, constricted at anterior by beak of brachial valve, at sides by very small deltidial plates; foramen slitlike. Brachial valve moderately strongly convex in profile, very strongly convex transversely; beak region inflated; beak slightly incurved, apex within pedicle valve.

Pedicle valve interior with dental plates meeting to form proportionately long spondylium, elevated toward anterior on median septum duplex extending about to midlength of valve. Brachial valve interior obscure; median septum apparent, extending anteriorly about a third length of valve; camarophorium broken or hidden on specimens available, apparently constructed as described for genus.

MEASUREMENTS (in mm).—

	brachial valve			thick- ness	apical angle (°)
	length	length	width		
USNM 701-I					
148188a	5.4	4.9	5.0	4.1	90
148188b	5.0	4.6	?	3.7	90
148188c	5.2	4.9	4.8	4.4	96
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (beds 4 and 9 of P. B. King).

LOCALITIES.—USNM 701-I, 701a³.

DIAGNOSIS.—Small, beak short, commissure not parasulcate.

TYPES.—Holotype: USNM 148188c. Figured paratypes: USNM 148188a,b; 154590a,b.

COMPARISON.—*Psilocamara hesperia* is smaller than the only other known species, *P. renfroarum* Cooper, from the Pennsylvanian of north-central Texas. In addition, its beak is shorter and straighter, and the juncture of the valves, viewed in profile, is less sinuous, with less of a dorsal bend near the anterior.

DISCUSSION.—The above description is based upon two specimens from USNM 701-I, one nearly com-

plete and the other broken so that some internal features can be seen, and six specimens from USNM 701a³. Unfortunately the camarophorium is nearly completely missing from the one from USNM 701-I, with only the extreme posterior part, and the base of the median septum preserved. Externally, the shells have the generic features of *Psilocamara*. Specimens from USNM 701a³ preserve the camarophorium well and it has no intercamarophorial plate and is thus assignable to *Psilocamara*.

Order SPIRIFERIDA Waagen, 1883

Suborder SPIRIFERIDINA Waagen, 1883

Biconvex, usually laterally extended shells having an interarea on both valves and with a delthyrium and notothyrium, the former with or without delthyrial cover. Internally a laterally directed conical spiralium supported the lophophore.

Superfamily CYRTIACEA Fredericks, 1924

Exterior and micro-ornament variable, interior with or without dental plates in the pedicle valve; brachial valve with supporting plates and nonstriate cardinal process. Impunctate.

Family AMBOCOELIIDAE George, 1931

Usually small, smooth or faintly ribbed; spines or papillae on surface; pits or plicae on inner layer. Hinge narrow, ears rounded. Jugum absent. Spire with few whorls.

Genera in West Texas: *Crurithyris* George, 1931; *Attenuatella* Stehli, 1954.

Crurithyris is inherited from the Pennsylvanian and is common in Wolfcampian rocks, rather rare in the Leonardian but well represented by species of large size in the Guadalupian. The genus is present in all West Texas areas covered in this monograph. *Attenuatella* is a long and narrow aberration of *Crurithyris* that is rare in the Sierra Diablo but also occurs in Mexico, Australia, New Zealand, New Caledonia, and Siberia.

Genus *Crurithyris* George, 1931

Crurithyris George, 1931, p. 42.—Williams et al., 1965:H672.

Small to medium size, maximum reaching 24 mm

in length, planoconvex to unequally biconvex; outline semielliptical, slightly elongate to rather strongly transverse; hinge narrower than greatest shell width, sides rounded; greatest width near or posterior to midlength; anterior margin evenly curved or slightly emarginate; commissure normally rectimarginate, sporadically folded either dorsally or ventrally in emarginate species; costae absent; some species with narrow median depression of pedicle valve simulating sulcus but normally not expressed as fold in anterior commissure; brachial valve normally not folded, occasionally depressed along midline; surface bearing fine short spines in random distribution (not along concentric or radial lines); spines seldom preserved, usually appearing as minute bumps over surface; growth lines fine, closely spaced, visible only on well-preserved surfaces; growth laminae weak, irregularly spaced.

Pedicle valve strongly convex, especially in umbonal region; beak prominent, bluntly pointed, normally erect or slightly incurved; delthyrium narrowly trigonal, open, on some specimens bounded laterally by narrow flanges (probably incipient or vestigial deltidial plates); interarea proportionately low and very wide, longitudinally rather strongly concave, tapering laterally to hinge ends.

Brachial valve less strongly convex, forming low cover on deeply cup-shaped pedicle valve; greatest convexity near beak or slightly farther forward; slight median depression of anterior in emarginate shells; interarea very low, wide, nearly flat, excavated medially by shallow, broadly trigonal notothyrium with low flanges formed by raised traces of growth of hinge sockets.

Pedicle valve interior with knoblike hinge teeth projecting anteriorly; dental ridges low, rounded, little more than thickening of inner portion of traces of hinge teeth; muscle area oval, in beak area, with elongate narrow median diductor marks extending nearly entire length of valve in some species, about half length in others; adductor marks larger, lying one on each side, separated from diductors by pair of low ridges, one ridge on each side of diductors; umbonal region lateral to muscle area with weak radial lirae fading posterior to midlength of valve.

Brachial valve interior with small, deep hinge sockets; socket walls thickened slightly; crural plates extending from underside of socket ridges to floor of valve; crura projecting anteriorly from crural

plates near valve floor, rather strong, nearly cylindrical, cemented to valve floor for short distance anteriorly in some species, gradually rising from floor, bowing distally; flattened ribbonlike spiralia attached to ends of crura, first diverging strongly, then bending medially before forming first loop on each side; axes of coiling directed slightly obliquely posteriorly toward point of greatest shell width, including about 5–7 loops on each side; cardinal process small, knoblike, deeply striate, in apex of notothyrium; muscle area elongate, between crura, extending from concavity between crural plates; pair of small depressions just anterior to muscle area located under crura, probably not muscle marks, but recesses formed where crura nearly touch floor.

TYPE-SPECIES.—*Spirifer urei* Fleming (1828:376) by original designation of George (1931:43).

DIAGNOSIS.—Strongly convex pedicle valve, nearly flat brachial valve, spinose shell surface, narrow socket ridges attached or very near floor of valve in posterior, spiralia with S-shaped flexure before first medial loop, rising from brachial valve floor and crura, and axes of coiling normally pointed somewhat posteriorly rather than directly transverse to median plane of shell.

COMPARISON.—*Crurithyris* resembles *Ambocoelia* Hall (1860), differing in its narrower hinge, knoblike and lamellate rather than elongate and bifid cardinal process, more posteriorly located muscle areas, and spinose outer surface. It differs from *Ambothyris* George (1931) in its proportionately narrower hinge, lower pedicle interarea, more strongly curved pedicle beak, and spinose surface.

The planoconvex form, wide, concave interarea, and lack of strong concentric lamellae are obvious differences from *Squamularia* Gemmellaro, *Neophricadothyris* Licharew (= *Permophricadothyris* Pavlova), *Phricodothyris* George, and *Reticularia* McCoy; the form of the crural plates and the close adherence of the crura to the brachial valve floor, with the resulting extra curve in the spiralia, are further differences. Except for the concentric lamellae, these differences also distinguish *Crurithyris* from *Martinia* McCoy and its relatives. The relatively short beak, more nearly circular outline, and fully developed spires distinguish it from *Attenuatella* Stehli, which also attains a larger maximum length.

DISCUSSION.—According to George (1931:42, pl. 5:

fig. 4), the cardinal process of *Crurithyris* is knoblike and tuberculate. Specimens in our collections with cardinal processes large enough to exhibit detail have them deeply scored longitudinally, producing in effect a closely spaced group of parallel plates in the form typical of most spiriferids. The tuberculate process of *C. magnispina* George (1931) possibly developed as a further transverse scoring of the typical spiriferid process. In that case it probably is a specific character. Possibly, however, the tuberculate condition that George illustrated resulted from the manner and perfection of preservation of the specimen. Some Texas specimens have the lamellate knoblike cardinal process incompletely preserved in such a way that the parallel plates are detached from the apex of the valve, producing a series of tiny rods, or tubercles, much like those of the British shell. These rods project posteriorly, not perpendicularly to the valve wall. This "erosion" of the cardinal process may be incomplete silicification, or may have taken place before burial of the shell.

Crurithyris guadalupensis (Girty)

PLATE 587: FIGURES 41-59

Ambocoelia planoconvexa var. *guadalupensis* Girty, 1909:370, pl. 14: fig. 12-14.

Not *Ambocoelia guadalupensis* Girty of R. E. King, 1931:119, pl. 41: figs. 1-5 [= *Crurithyris* species].

Small for genus, nearly planoconvex; outline subelliptical to nearly semielliptical, only slightly transverse in juveniles, becoming increasingly transverse with growth, greatest width near midlength, curvature of outline slightly flattened at anterior midline, rarely slightly emarginate; pedicle valve without trace of median depression except rarely at extreme anterior of large specimens; brachial valve unfolded, commissure rectimarginate; surface of many specimens rough, where short spines broke off; growth lines fine, visible on few specimens; growth laminae slightly stronger, visible on most specimens, irregularly spaced.

Pedicle valve moderately convex for genus; beak low, long, projecting well over interarea, normally incurved; interarea proportionately low, flatly concave; delthyrium narrowly triangular, open, lateral flanges low or absent. Brachial valve flatly convex, slightly swollen at beak, interarea very low; notothyrium relatively narrow.

Pedicle valve interior with small hooked hinge

teeth; dental ridges greatly reduced; short apical plates in apex of delthyrium extending down toward valve floor rather than anteriorly along delthyrial sides, thus not constricting delthyrium; muscle area in umbonal region, without median ridge or groove, individual muscle marks not differentiated.

Brachial valve interior with deep open hinge sockets with socket ridges; cardinal process forming ridge or brace between socket walls, then small lamellate thickening apically (posteriorly); hinge plates thin, short, joining crura to socket ridges; crura rodlike, rather narrowly spaced, cemented to floor for about 1 mm in posterior, bowed outward only narrowly; spiralia ribbonlike, beginning with S-shaped curve to rise above valve floor; remainder of spiralia not observed; muscle area narrow, between crura.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 738b					
152430a	2.9	2.4	3.1	2.0	1.9
152430b	3.1	2.8	3.2	2.0	1.8
152430c	3.1	2.9	3.6	2.1	1.8
152430d	3.5	2.8	3.5	2.4	2.3
152430e	3.8	3.0	4.0	3.0	2.5
152430f	4.0	3.3	3.9	2.9	2.7
152430g	4.3	3.8	4.6	3.4	3.1
152430h	5.0	4.4	5.2	3.3	3.6
152430i	5.4	4.6	6.3	5.3	3.9
152430j	5.8	4.9	6.4	4.0	3.8
152430k	6.6	5.4	7.0	4.8	3.9
152430l	6.8	5.2	6.9	5.0	4.4
152430m	7.0	6.0	7.2	4.8	4.9
152430n	7.2	6.5	9.0	6.2	5.0
152430o	7.4	6.4	7.9	5.9	4.5
152430p	8.0	6.9	9.2	6.6	4.9
152430q	8.1	6.4	8.1	5.9	5.1
152430r	8.3	6.9	9.2	5.8	5.3
152430s	10.7	7.9	11.5	8.4	5.5?
USNM 738					
152428a	7.6	6.4	8.6	6.0	4.8
152428b	8.7	7.2	9.2	6.0	5.6
152428c	9.4	7.7	9.9	7.5	5.9
USNM 737a					
152426a	7.9	6.7	7.8	4.9	4.1
152426b	8.2	6.7	8.9	6.8	5.0
USGS 2926					
118598b	8.2	6.6	9.6	6.9	5.0
118598c	8.5	7.1	8.0	5.3	5.3
118598a	9.9	7.5	10.2	7.3	5.4
(lectotype)					
AMNH 40					
189934	9.4	7.9	10.6	7.0	5.8

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Pinery, Rader, and Lamar members); Capitan Formation.

LOCALITIES.—Pinery: AMNH 398. Rader: USNM 725g. Lamar: AMNH 37, 38, 40, 347 (=L-2), 351 (=L-6), 430; USNM 725c, 728i, 728p, 738, 738b. Capitan: USGS 2926; USNM 737a.

DIAGNOSIS.—Small, transverse *Crurithyris* with wide cardinal process, low interarea, and narrowly separated crura.

TYPES.—Lectotype herein designated (Girty, 1909, pl. 14: fig. 12): USNM 118598a. Figured hypotypes: USNM 152428a,b,d-f; 152430-l,r; 154420a,b. Measured hypotypes: USNM 118598b,c; 152426a,b; 152428a-c; 152430a-s; 189934.

COMPARISON.—*Crurithyris guadalupensis* is characterized by its small to medium size, rather flat brachial valve, transverse outline in adults, comparatively low interarea, narrowly separated crura, and rather wide cardinal process. It most nearly resembles *C. tumibilis*, new species, differing in its larger size, flatter brachial valve, and more strongly curved pedicle beak, with lower interarea. It is much larger and its hinge ends not as sharp as in *C. minutalis*, new species. It lacks the high interarea and definite sulcus of *C. sulcata* Stehli; it is somewhat smaller and, in adults, wider and less strongly convex in the pedicle valve than *C. inflata* Stehli. *Crurithyris major* and *C. tholiaphor*, both new and both from the Word, are much larger.

Girty (1909) considered this species a variety of *C. planoconvexa* (Shumard), a species that it does resemble strongly. *Crurithyris guadalupensis* differs, however, in its slightly more convex brachial valve, total lack of fold or sulcus in the pedicle valve, higher interarea, and proportionately wider outline in adults.

DISCUSSION.—The above description differs in several respects from that of Girty (1909), largely because it is based on a larger collection (including Girty's illustrated specimens), mainly of silicified shells. Further differences are due to opportunity for comparison with a larger number of different species. For example, Girty says, "Area . . . strongly concave." The interarea is strongly concave only at the apex where the curvature of the beak takes its effect, nearer the hinge it is nearly flat, and it is flatter than that of most other species examined, hence the description above of the "flatly concave" interarea. The rather strong median groove shown

on the pedicle valve of figure 13 on Girty's (1909) plate 14 is not present on the illustrated specimen. No specimen of this species has a clearly defined external pedicle groove except at the extreme anterior, and it appears there only in a few specimens.

Crurithyris inflata Stehli

PLATE 587: FIGURES 60-73

Crurithyris inflata Stehli 1954:342, pl. 26: fig. 7-11.

About medium size for genus, nearly planoconvex; outline subpentagonal, length and width nearly equal, widest near midline, rarely indented; valves normally without fold or sulcus, rare pedicle valves with shallow, indistinct sulcus or median flattening; commissure rectimarginate; surface of many specimens with short spine bases, others apparently smooth; radial ornamentation weak, visible on many specimens as faint fibrous texture; growth lines and laminae weak, not visible on many specimens.

Pedicle valve strongly and evenly convex; beak short, thick, strongly incurved; interarea high, relatively narrow, concave; delthyrium narrowly triangular, open; lateral deltidial flanges short or absent. Brachial valve flatly convex; umbonal region slightly swollen, beak obtusely pointed; interarea low, relatively high for genus, flat; notothyrium deep, about equilaterally triangular.

Pedicle valve interior with small, knoblike, slightly hooked hinge teeth; dental ridges rounded, thickened, producing very short apical plate in apex; muscle area elongate, fusiform, depressed, bounded on each side by low ridge, ridges converging at anterior of area to form single ridge for short distance, posterior part of area bisected by low median ridge; faint radial pallial marks visible in posterior, lateral to muscle area.

Brachial valve interior with strong hinge sockets, socket ridges forming flange along each side of notothyrium, inoperative posterior parts of sockets bridged by thin plates; cardinal process roughly triangular, occupying wedge-shaped space in apex of notothyrium, posterior part finely lamellate, or, where partially eroded or broken, tuberculate; hinge plates thick, convergent toward midline of valve, joining crura to socket ridges; crura rodlike, distally bowed, extending just beyond midlength of valve;

spiralium flatter than crura, continuing anterior course just above valve floor for short distance, then becoming flat and broad, forming S-curve to raise spiralium above valve floor; complete spiralium not observed; muscle area between crura, narrow, weakly impressed.

MEASUREMENTS (in mm).—

	brachial		hinge	thick-
	length	valve length width		
USNM 728f				
152433a	2.5	2.0	2.3	1.9
152433b	2.6	2.1	2.8	1.9
152433c	2.8	2.4	3.2	2.3
152433d	3.2	2.9	3.4	2.2
152433e	3.3	2.8	3.6	2.5
152433f	3.4	2.9	3.6	2.5
152433g	3.7	3.1	4.1	2.7
152433h	4.1	3.3	4.3	3.4
152433i	4.1	3.9	4.8	3.0
152433j	4.6	4.3	5.4	3.6
152433k	4.9	4.4	5.5	3.9
152433l	5.1	4.7	5.6	3.7
152433m	5.3	4.6	5.4	3.8
152433n	6.2	5.0	6.2	3.9
152433o	6.5	5.7	7.1	4.5
152433p	6.6	5.6	7.0	4.9
152433q	7.5	5.9	8.4	5.9
152433r	7.7	6.6	9.3	6.4
152433s	8.0	7.0	8.9	6.3
152433t	8.9	7.3	9.0	6.0
152433u	9.0	7.5	10.1	7.9
152433v	9.7	8.0	11.1	7.9
152433w	11.1	8.8	10.9	7.9
152433x	11.8	c.9.0	11.8	8.0
152433y	12.0	9.5?	11.5?	8.5

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITIES.—AMNH 696, 697; USNM 725c, 728e, 728f.

DIAGNOSIS.—Medium size *Crurithyris* with strongly swollen pedicle valve, narrow interarea, and depressed muscle field in pedicle valve.

TYPES.—Holotype: AMNH 27323/1:1. Figured hypotypes: USNM 152433o,q,t,u,w. Measured hypotypes: USNM 152433a-y.

COMPARISON.—*Crurithyris inflata* is characterized by its moderate size, strongly convex pedicle valve, flatly convex brachial valve, comparatively narrow outline, high and narrow interarea, and pedicle muscle area that is bounded laterally by low ridges and is depressed. It most nearly resembles *C. sulcata stehli*, with which it occurs, differing in its more

strongly inflated pedicle valve that lacks a median sulcus, and has the muscle area more deeply impressed. It is much larger and not as wide as *C. tumibilis* or *C. minutalis*, both new, or *C. guadalupensis* (Girty), and somewhat smaller than the Word species *C. tholiaphor* and *C. major*, both new. It differs further from the latter two species in its proportionately higher pedicle interarea, less inflated and less strongly curved beak, and somewhat flatter brachial valve. It is not similar to the small Pennsylvanian species *C. planoconvexa* (Shumard).

Crurithyris longirostris, new species

PLATE 588: FIGURES 1-7

Medium size for genus, wider than long; outline subpentagonal to roundly subelliptical; widest at or just posterior to midvalve. Sides rounded; anterior margin broadly rounded. Anterior commissure rectimarginate. Cardinal extremities rounded. Beak elongated; interarea long, strongly apsacline. Delthyrium long and narrow. Surface with fibrous appearance and closely spaced spine bases.

Pedicle valve moderately and unevenly convex, maximum convexity between umbonal region and midvalve; anterior profile somewhat narrowly domed. Umbonal region elongated, narrowly inflated; median region inflated but anterior moderately convex to somewhat flattened; sulcus not developed. Flanks convex and steep.

Brachial valve evenly and flatly convex in lateral profile, broadly and gently convex in anterior profile. Umbonal region moderately swollen, anterior region and flanks gently convex. Posterolateral extremities slightly depressed.

Pedicle valve interior with short apical plate. Brachial valve interior with stout, ribbonlike descending branches and with strong S-curve anteriorly. Spire not seen.

MEASUREMENTS (in mm).—

	brachial		hinge	thick-
	length	valve length width		
AMNH 591				
152985a	3.7	3.3	4.3	3.8
152985b	4.5	3.8	5.2	3.9?
152985c	4.7	4.2	5.8	4.0
152985d	6.4	5.1	6.6	5.0
(holotype)				
152985e	7.4	5.6	8.0	5.7

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITY.—AMNH 591.

DIAGNOSIS.—Moderate-sized *Crurithyris* with long beak.

TYPE.—Holotype: USNM 152985d. Figured paratype: USNM 152985f. Measured paratypes: USNM 152985a–c,e.

COMPARISON.—The long beak and strongly apsacline interarea are so distinctive that detailed comparisons are unnecessary.

Crurithyris major, new species

PLATE 588: FIGURES 8–32

Large for genus, nearly planoconvex; outline subovate, normally somewhat elongate especially in large adults, greatest width near midlength, anterior outline normally evenly arcuate, less commonly flattened, rarely indented; pedicle sulcus weakly defined on some specimens, absent from most; brachial fold barely perceptible on most specimens; surface with fine radial fibers, weak growth lines and laminae, roughness possibly due to broken spine bases.

Pedicle valve strongly and relatively evenly convex; beak long, thick, strongly curved, normally incurved; interarea proportionately low, flatly concave near hinge, more deeply concave near beak; delthyrium deeply wedge-shaped, bounded laterally by pair of comparatively large deltidial flanges converging toward one another across delthyrium but not meeting. Brachial valve flatly convex, slightly swollen in umbonal region, flattened toward anterior, with slightly longitudinal median crest on some specimens; interarea wide, low, nearly flat; notothyrium broadly wedge-shaped with low flanges formed by socket walls.

Pedicle valve interior with proportionately small, knoblike hinge teeth; dental ridges low, rounded, converging to form proportionately very small apical plate of delthyrium; muscle area elongate, anteriorly widening, radially striated, median portion depressed, with median ridge in posterior, median groove in anterior.

Brachial valve interior with hinge sockets formed by strong socket ridges, bridged by thin plates; cardinal process relatively large, knoblike, filling apex of notothyrium, finely lamellate with numer-

ous closely spaced parallel plates; crural plates short, low, joining crura to socket ridges; crura strong, rod-shaped, distally bowed, cemented to valve floor for several millimeters in posterior, cemented for entire length in some specimens, remaining near floor for entire length; spiralia beginning with flattened ribbon in S-shaped loop; coiled part of spiralia narrower but still flat and ribbonlike, number of loops not observed; muscle area between crura, very weakly impressed, individual marks not distinguishable, entire area weakly striated radially.

MEASUREMENTS (in mm).—

	brachial		hinge	thick-
	length	valve length	width	ness
USNM 715i				
152437a	2.8	2.6	2.8	1.9
152437b	24.0	16.0?	22.0	15.6
152437c	26.2	19.2	21.6	16.0
(holotype)				
USNM 719z				
152439a	2.9	2.7	3.0	2.3
152439b	4.1	3.8	4.0	2.9
152439c	4.7	3.9	4.6	3.0
152439d	5.0	4.7	5.4	3.8
152439e	6.0	5.6	5.5	3.5
152439f	6.6	5.8	6.8	4.3
152439g	7.5	6.6	8.4	5.9
152439h	9.0	7.7	9.7	5.7
152439i	10.0	8.4	11.9	9.0
152439j	13.6	11.0	14.0	10.5
152439k	16.1	12.4	c.17.0	13.0
152439l	18.7	13.4	18.8	13.9
152439m	20.6	14.9	19.5	14.0
152439n	20.4	15.4	19.5	13.9
152439o	22.7	15.0?	24.5	19.0
152439p	23.0	16.3	21.5	16.0
152439q	23.2	16.0?	21.1	15.6

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member).

LOCALITIES.—USNM 715i, 719z, 722t.

DIAGNOSIS.—Large (gigantic for the genus) narrow *Crurithyris*.

TYPES.—Holotype: USNM 152437c. Figured paratypes: USNM 152439d,e,j,o,p; 154421a,b. Measured paratypes: USNM 152437a,b; 152439a–q.

COMPARISON.—*Crurithyris major* is characterized by its large size, long and thick, strongly curved pedicle beak that results in a proportionately low and concave interarea, large delthyrial flanges, depressed pedicle muscle area, and crura that remain close to valve floor, cemented to floor for their entire length in some specimens. It is the largest of the

Texas Permian species, with a median size near the maximum size of the next largest species, *C. tholia-phor*, new species. It is so much larger, and proportionately narrower, than the other species of the genus from the area, that other detailed comparisons are unnecessary.

Crurithyris minutalis, new species

PLATE 590: FIGURES 1-22

Very small for genus, nearly planoconvex; outline subquadrate to semielliptical, widest near mid-length, anterior margin slightly flattened at midline in largest specimens; commissure rectimarginate, pedicle valve with slight flattening or depression near anterior of largest specimens, not folding commissure; surface spines short, visible on few specimens; growth lines also obscured; growth laminae visible on some specimens, weak and intermittently spaced.

Pedicle valve strongly and rather evenly convex; beak thick, proportionately high for genus, slightly incurved, bluntly pointed; interarea proportionately high for genus (nevertheless much wider than high) flatly concave; delthyrium narrowly triangular, with very small lateral flanges. Brachial valve flat to flatly convex, slightly swollen at beak; interarea broadly triangular, flat; notothyrium proportionately wide, triangular, with low lateral flanges.

Pedicle valve interior with hinge teeth short, relatively broad; dental ridges rudimentary, converging at apex of delthyrium to form very small apical plate; muscle area proportionately large, ovate, without median ridge or furrow; marks weakly impressed, not individually distinguishable.

Brachial valve interior with deep, tapered hinge sockets; socket ridges thick, swelling to form small knob at anterior end; cardinal process flat to slightly convex, in apex of notothyrium, finely lamellate; crural plates proportionately thick, hardly differentiated from crura proper, fused to valve floor; crura proportionately far apart, fused to floor for short distance anteriorly, rodlike; spiralia flat, ribbonlike, rising above floor by S-shaped fold; complete spirallium not observed, hence number of loops unknown; muscle area between crura, elongate, weak, individual marks not apparent.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 703					
152415a	1.5	1.2	1.6	1.2	1.1
152415b	1.7	1.5	1.7	1.2	1.2
152415c	1.7	1.6	1.8	1.5	1.3
152415d	1.7	1.5	1.9	1.6	1.3
152415e	1.8	1.6	1.9	1.6	1.3
152415f	1.8	1.6	2.0	1.8	1.5
USNM 703c					
152416a	1.4	1.2	1.8	1.4	1.1
152416b	2.2	1.7	2.3	1.9	1.6
152416c	2.5	2.1	2.7	2.2	1.8
152416d	3.5	2.8	3.9	3.4	2.7
USNM 703d					
152417	4.1	3.4	4.4	3.4	3.2
USNM 709c					
152423a	1.2	1.1	1.4	0.9	0.9
152423b	1.9	1.7	2.1	1.6	1.4
USNM 707e					
152422	2.8	2.5	3.0	2.5	2.2
USNM 702c					
152410a	0.6	0.5	0.8	0.4	0.5
152410b	0.9	0.8	0.9	0.6	0.7
152410c	0.9	0.8	1.1	0.8	0.7
152410d	1.0	0.9	1.3	1.1	0.8
152410e	1.0	0.9	1.3	0.9	0.7
152410f	1.2	1.0	1.4	1.2	0.9
152410g	1.3	1.1	1.5	1.3	1.0
152410h	1.4	1.2	1.6	1.2	1.1
152410i	1.6	1.3	1.8	1.4	1.3
152410j	1.7	1.5	1.9	1.6	1.3
152410k	1.9	1.6	2.1	1.7	1.4
152410-l	2.0	1.7	2.3	1.9	1.5
152410m	2.1	1.8	2.2	1.7	1.6
152410n	2.2	2.0	2.4	1.9	1.6
152410o	2.4	2.1	2.5	1.8	1.9
152410p	2.6	2.1	2.6	2.1	1.9
152410q	2.7	2.2	2.6	2.4	2.0
152410r	2.7	2.4	2.7	2.1	2.0
152410s	2.9	2.4	2.8	2.5	2.2
154428b	2.5	2.0	2.5	2.2	1.9
(holotype)					

LOCALITIES.—USNM 702c, 703, 703c, 703d, 706f, 707e, 709c, 719x, 721j, 721o, 721x, 723a, 724j.

DIAGNOSIS.—Very small *Crurithyris* with long pedicle valve beak and angulated cardinal extremities.

TYPES.—Holotype: USNM 154428b. Figured paratypes: USNM 152417; 152427; 154428a,d,i,j. Measured paratypes: USNM 152410a-s, 152415a-f, 152416a-d, 152417; 152422; 152323a,b.

COMPARISON.—*Crurithyris minutalis* is characterized by its very small size, about half that of the

next smallest species, *C. tumibilis*, new species, its proportionately long pedicle beak and high pedicle interarea, and its wide hinge with ends that are sharp for the genus (nearly right angle), and resultant subquadrate outline. Its brachial valve is flatter, its interarea higher, and its hinge ends sharper than those of *C. tumibilis*, the only other species with which it need be compared. The small size might lead to the belief that the collection represents only juveniles of a larger species. The collection contains several hundred specimens, however, and the size range is small; these collections are from samples that contained large specimens of other species in other genera. A few large specimens of *Crurithyris* are known from the Skinner Ranch Formation but they are insufficient in number for description. It is highly probable that *C. minutalis* is a distinct species of small size.

Crurithyris sulcata Stehli

PLATE 588: FIGURES 33-54

Crurithyris sulcata Stehli 1954:342, pl. 26: figs. 1-6.

Medium size for genus, nearly planoconvex; outline transversely subquadrate, widest anterior to hinge, posterior to midlength, anterior margin slightly emarginate; fold absent; short depression present at anterior of most brachial valves; sulcus shallow but distinct, beginning at pedicle beak or just anterior to beak, becoming deeper anteriorly, expressed at anterior margin only by shallow indentation, not by folding of commissure; surface with short spines or low spine bases preserved on few specimens; radial fibrous effect weak; growth lines closely spaced, indistinct; growth laminae stronger, more frequent near margins.

Pedicle valve strongly convex; greatest convexity in umbonal region; beak long, strongly curved, erect to incurved; interarea high, strongly concave; delthyrium narrowly wedge-shaped, bounded laterally by pair of relatively high deltidial flanges. Brachial valve flatly convex transversely, umbonal region slightly swollen, anterior midline slightly flattened or depressed; beak sharp, short; interarea low, wide, height about average for genus; notothyrium wide, shallow to moderately deep, bounded laterally by notothyrial flanges produced by extensions of socket ridges.

Pedicle valve interior with short, knoblike,

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 728f					
152435a	1.5	1.4	1.8	1.3	1.0
152435b	1.7	1.5	2.0	1.4	1.1
152435c	1.8	1.5	1.9	1.3	1.1
152435d	1.9	1.7	2.1	1.4	1.2
152435e	2.1	1.8	2.1	1.4	1.3
152435f	2.2	1.8	2.4	1.5	1.5
152435g	2.2	1.9	2.5	1.8	1.5
152435h	2.4	2.2	2.7	1.7	1.6
152435i	2.6	2.1	2.6	1.8	1.8
152435j	2.8	2.4	2.9	2.2	2.1
152435k	3.1	2.9	3.8	2.6	2.3
152435l	3.3	3.1	3.9	2.5	2.1
152435m	3.5	3.0	3.9	2.7	2.5
152435n	3.8	3.2	4.0	2.8	2.5
152435o	4.0	3.4	4.3	3.2	2.6
152435p	4.1	3.6	4.5	3.3	2.6
152435q	4.2	3.6	4.5	3.3	2.8
152435r	4.4	3.9	5.0	3.0	2.9
152435s	4.6	3.9	5.4	3.4	3.0
152435t	4.9	3.9	5.0	3.4	3.5
152435u	5.0	4.3	5.6	3.7	3.3
152435v	5.2	4.4	5.7	3.7	3.1
152435w	5.7	4.6	5.9	4.0	3.6
152435x	5.9	4.8	6.2	4.3	3.9
152435y	6.1	5.0	6.3	4.0	4.2
152435z	6.4	5.3	6.8	4.9	4.0
152435a'	6.4	4.8	6.9	5.2	4.4
152435b'	6.6	5.5	7.9	5.6	4.0
152435c'	7.2	5.8	8.0	5.3	4.9
152435d'	7.2	6.1	8.9	6.0	4.5
152435e'	7.5	6.4	8.3	5.0	4.8
152435f'	7.8	6.0	8.0	5.0	5.0
152435g'	7.9	6.7	8.8	5.9	5.0
152435h'	10.5	8.0	11.1	8.4	6.2

slightly hooked teeth; dental ridges flat, nearly nonexistent, expanded at apex of delthyrium to form short apical plates nearly perpendicular to plane of commissure; muscle area in umbonal region, indistinct, subovate, not depressed, without median or lateral ridges.

Brachial valve interior with hinge sockets deep, bridged by thin plates, socket ridges thick; cardinal process small, wedge-shaped, filling extreme apex of notothyrium, finely lamellate longitudinally, with only few parallel plates; crural plates filling space between socket ridges and crura, slightly convergent toward floor; crura rodlike, fused to valve floor at posterior, slightly bowed distally, extending just beyond midlength of valve; spiralia not observed;

muscle area located between crura, weakly impressed, individual muscle marks not differentiable.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITIES.—AMNH 629, 631; USNM 725a, 725c, 728e, 728f, 728h, 728t.

DIAGNOSIS.—Moderately large *Crurithyris* with sulcus on pedicle valve and brachial valve and emarginate anterior.

TYPES.—Lectotype (herein designated): AMNH 27322/1:4. Figured paratypes: AMNH 27322/1:1–3. Figured hypotypes: USNM 152435d,g,h'; 154422a–d. Measured hypotypes: USNM 152435a–z, a'–h'.

COMPARISON.—*Crurithyris sulcata* is characterized by its transverse outline, consistently sulcate pedicle valve, normally sulcate brachial valve, reduced dental ridges, and weakly impressed muscle marks. It occurs with *C. inflata* Stehli, differing in its somewhat less convex, and less evenly convex pedicle valve with sulcus, normally emarginate anterior outline, and weakly impressed muscle marks. It is larger and more nearly plano-convex than *C. tumibilis*, new species, from the Neal Ranch Formation of the Glass Mountains. It is larger and more transverse than *C. guadalupensis* (Girty) from the Bell Canyon Formation (Lamar Member), in the Guadalupe Mountains. It is much larger than *C. minutalis*, new species, and much smaller than either *C. tholiaphor* or *C. major*, both new, from the Word Formation.

Crurithyris tholiaphor, new species

PLATE 589: FIGURES 1–38

Medium to large for genus, moderately biconvex to nearly planoconvex; outline subquadrate, length and width nearly equal, greatest width slightly anterior to midlength, anterior outline slightly flattened, rarely emarginate; pedicle sulcus normally absent, rarely slightly impressed at extreme anterior; fold absent; surface of some specimens with patches of fine raised lines, probably spine bases or flat-lying spines fused to shell; fine radial fibrous structure; growth lines indistinct; growth laminae weak.

Pedicle valve strongly and evenly convex; beak long, thick, strongly incurved; interarea low, strongly convex; delthyrium wedge-shaped, relatively wide, but nevertheless higher than broad; lateral flanges of delthyrium low or absent. Brachial

valve flatly convex, slightly swollen in umbonal region; interarea low, wide, flat; notothyrium broadly wedge-shaped, with low lateral flanges.

Pedicle valve interior with relatively large, knob-like, slightly hooked teeth; dental ridges thick, low, rounded, meeting at apex of delthyrium to form short apical plate; muscle area large, elongate, depressed, with short median septum in umbonal cavity; diductor marks narrow, anterior, together forming chevron; adductor marks posterior, median, elongate, depressed, separated from remainder of valve by pair of lateral ridges fusing at anterior to form low median ridge for 1–2 mm in center of valve.

Brachial valve interior with thick-walled socket ridges each bridged by thin plate; cardinal process, a low boss in apex of notothyrium, more quadrate than wedge-shaped, weakly lamellate; crural plates thick, short, joining crura to socket ridges; crura strong, rodlike, distally bowed; spiralia flat, ribbon-like, beginning with S-shaped curves, then about 5 coils with axes directed posterolaterally; muscle area weakly impressed between crura, consisting of four small quadrate impressions.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 706c					
152445a	2.8	2.8	3.2	2.4	1.7
152445b	3.9	3.6	4.3	3.1	2.3
152445c	5.9	5.2	6.2	4.4	3.4
152445d	5.9	5.2	6.2	4.1	3.6
152445e	6.5	5.6	7.0	5.0	3.9
152445f	7.4	6.4	8.0	5.8	4.7
152445g	8.7	7.3	9.0	6.5	5.0
152445h	10.0	9.0	11.2	8.5	6.3
152445i	11.3	9.0	11.7	9.1	7.0
152445j	14.4	10.5?	14.2	9.3	9.0?
152445k	15.3	11.4	15.0	11.2	9.5?
(holotype)					
152445-l	16.8	12.0	15.9	12.3	9.9
USNM 706					
152441a	3.0	2.9	3.6	2.0	1.7
152441b	3.4	2.9	3.8	2.9	2.3
152441c	4.4	3.9	5.0	3.9	2.7
152441d	4.8	4.3	5.0	3.0	3.0
152441e	10.6	8.4	10.7	7.8	6.2
152441f	10.8	8.4	11.2	8.2	6.5
USNM 706b					
152443	20.0	15.0	19.0?	14.0?	?
USNM 728					
152449a	23.7	17.0?	23.0?	17.3	?

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, and Appel Ranch members and lens between the last two). Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Word: USNM 737b. China Tank: USNM 706c, 713e, 726r, 726s. Willis Ranch: USNM 706, 706e, 719e, 723w, 724u. Appel Ranch: USNM 727j. Lens: USNM 706b. Getaway: AMNH 46, 496, 512, 600; USNM 728.

DIAGNOSIS.—Large *Crurithyris* with squarish outline, depressed muscle area bounded by anteriorly coalesced ridges.

TYPES.—Holotype: USNM 152445k. Figured paratypes: USNM 152423; 152440a–c; 152441a,b; 152445a,d,f,m,n; 152446a; 152449b,c. Measured paratypes: USNM 152441a–f; 152443; 152445a–j,l; 152449a.

COMPARISON.—*Crurithyris tholiaphor* is characterized by its relatively large size (for species from this area), nearly equal length and width, thick and strongly curved pedicle beak producing relatively low and strongly curved interarea, and its depressed pedicle muscle area bounded by low ridges that coalesce at the anterior. The only species that is comparable in size that occurs here is *C. major*, new species, from the Appel Ranch Member of the Word. *Crurithyris tholiaphor* is slightly smaller in median and maximum size, is slightly thicker shelled, has a lower interarea and shorter beak, and normally less deeply impressed and sharply bounded pedicle muscle area. The two species undoubtedly are related, with external characters of *C. tholiaphor* somewhat exaggerated in *C. major*.

This species differs from *C. sulcata* Stehli in its larger size and depressed pedicle muscle area. This latter feature is similar to that in *C. inflata* Stehli, from which *C. tholiaphor* differs in its larger size, longer and more strongly curved pedicle beak, more distinct radial fibers (possibly a function of preservation), and larger cardinal process that is more quadrate than trigonal. It is much larger and less transverse than *C. guadalupensis* (Girty).

Crurithyris tumibilis, new species

PLATE 589: FIGURES 39–58; PLATE 590: FIGURES 40–52

Ambocoelia planoconvexa R. E. King [not Shumard], 1931:120.

Small for genus, normally biconvex, less commonly nearly planoconvex; outline transversely sub-

elliptical, less commonly slightly elongate, widest between hinge and midlength, anterior normally evenly arcuate, less commonly slightly emarginate or flattened at midline; commissure rectimarginate; surface appearing smooth, rarely exhibiting irregularities of surface spines or growth lines.

Pedicle valve strongly convex, especially in umbonal region; slight median depression in some, producing anterior emargination; beak thick, bluntly pointed, strongly curved; normally erect or slightly incurved; interarea high for genus, transversely triangular, longitudinally concave; delthyrium narrowly to nearly equilaterally triangular, open, bounded laterally by pair of small (yet high for genus) deltidial flanges. Brachial valve flatly to moderately convex, with convexity rather even both longitudinally and transversely; beak slightly projecting, obtusely pointed; interarea high for genus, about a third height of pedicle interarea, flat to slightly concave; notothyrium broadly triangular, bounded by straight flanges formed by socket ridges.

Pedicle valve interior with hinge teeth short, slightly flattened and slightly hooked; dental ridges low and rounded, converging at apex of delthyrium and growing forward conjunctly for about 0.3 mm in adults, forming short apical plate; muscle marks weakly impressed in oval area in umbonal region, bisected in apex of some by short, low median ridge.

Brachial valve interior with deep, strongly constructed hinge sockets; cardinal process broad, slightly convex, finely lamellate, consisting of about 8 thin closely spaced parallel plates; hinge plates extending from socket ridges to valve floor, very short, slightly thickened; crura rodlike, cemented to valve floor for short distance in posterior by thin plates, rising slightly from floor toward anterior; spiralia attached to crural ends, flatter and more ribbonlike, broadening to make S-curve raising spiralia above valve floor, then once more narrowing to coil in about 5 loops with axes diverging posteriorly; muscle elongate, narrow, weakly impressed between crura in posterior half of valve.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Neal Ranch Formation.

LOCALITIES.—*Uddenites*: USNM 701e, 701p, 701q. Neal Ranch: USNM 701, 701a, 701a³, 701c, 701d, 701h, 701k, 701-l, 715b, 721g, 727d, 727e, 730c.

DIAGNOSIS.—Small *Crurithyris* with strongly convex brachial valve.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 701k					
152406a	1.1	0.9	1.2	0.8	0.7
152406b	1.3	1.1	1.5	0.8	1.0
152406c	1.5	1.2	1.6	1.2	1.1
152406d	1.7	1.4	1.7	1.2	1.1
152406e	1.8	1.4	2.0	1.4	1.3
152406f	2.2	1.8	2.3	1.7	1.6
152406g	2.2	1.9	2.5	1.5	1.5
152406h	2.3	1.9	2.6	1.9	1.6
152406i	2.6	2.0	2.6	1.7	1.8
152406j	2.8	2.2	2.8	2.1	1.7
152406k	2.9	2.4	3.3	1.9	1.9
152406l	3.1	2.6	3.6	2.0	2.1
152406m	3.4	2.8	3.7	2.6	2.0
152406n	3.8	3.3	4.1	3.1	2.6
152406o	3.9	3.1	3.6	2.4	2.6
152406p	4.2	3.6	4.4	3.6	3.0
152406q	5.5	4.4	5.0	3.8	2.9
152406r	5.5	4.7	5.4	3.6	3.8
152406s	5.7	5.0	6.4	4.6	3.8
152406t	5.8	4.5	5.0	4.0	3.9
152406u	6.4	5.6	6.5	4.4	4.6
152406v	6.9	6.0	7.0	4.9	4.7
152406w	6.9	5.9	7.9	5.8	4.8
152406x	7.7	6.8	7.8	5.4	5.0
152406y	7.9	6.6	8.0	6.0	5.4
152406z	8.2	6.9	8.0	5.3	5.6
152406a'	8.5	7.0	8.4	6.0	5.9
152406b'	9.7	8.2	10.1	7.1	6.5
USNM 701d					
154425a	7.0	6.7	9.0	6.0	4.7
(holotype)					

TYPES.—Holotype: USNM 154425a. Figured paratypes: USNM 154424a–c,e; 154425c; 154426a,b. Measured paratypes: USNM 152406a–z,a',b'. Unfigured paratypes: USNM 154424d, 154425b.

COMPARISON.—*Crurithyris tumibilis* is characterized by its small size, smooth appearing surface, relatively high interarea, and especially by the great number of its individuals whose brachial valve is more strongly convex than normal for the genus.

Its median size is much greater than the Leonardian *C. minutalis*, new species, and it differs further in its normally less quadrate outline and narrower, more rounded hinge ends, and in its more tumid brachial valve. *Crurithyris inflata* Stehli and *C. sulcata* Stehli from the Bone Spring Formation are much larger and are planoconvex; the Word species are still larger. *Crurithyris guadalupensis* (Girty) is similar in median size, but has a narrower and

shorter beak, less convex brachial valve, and more quadrate outline.

The species that most nearly resembles *C. tumibilis* is *C. planoconvexa* (Shumard), widespread in the Pennsylvanian (Dunbar and Condra, 1932:344). It is similar in size and outline, but differs in its less convex brachial valve and more strongly curved pedicle beak that produces a lower interarea.

Crurithyris species unidentified

Some small lots of *Crurithyris* from the Skinner Ranch Formation, which are insufficient in number to serve as a basis for species descriptions, but which should be noted are listed below.

SPECIES A.—Fairly large, transversely elliptical in outline, greatly swollen pedicle valve, gently convex brachial valve. Interarea short, apsacline beak strongly incurved. Neither valve sulcate. A complete specimen (USNM 152987a) from USNM 707a measures (in mm): length 8.2, brachial valve length 7.1, width 9.4; hinge width 7.0, thickness 5.5.

This species suggests *C. inflata* Stehli and *C. guadalupensis* (Girty) but is less inflated and has a shorter, less elongated beak region than the former, and is wider and more robust than the latter.

Specimens are from the Skinner Ranch Formation at USNM 707a and 711p.

Described specimens: USNM 152987a–d, 152988a–d.

SPECIES B.—Also moderate size, chiefly distinguished by very short beak and short interarea, but swollen umbonal region and a fairly convex brachial valve. Neither valve is sulcate. A complete specimen (USNM 152989a) from USNM 707d measures (in mm): length 6.6, brachial valve length 5.6, width 7.0, hinge width 4.7, thickness 4.0.

The shortness of its beak and interarea distinguishes this species from all others in the collection.

Specimens come from the upper part of the Skinner Ranch Formation at USNM 707d and 722-l, and from the Hess Formation (Taylor Ranch Member) at USNM 702d.

Described specimens: USNM 152989a–c; 152990a–c; 152991a,b.

SPECIES C.—We do not have enough specimens to indicate the maximum size of this species, but some incomplete fragments suggest that the size is moderate. The outline is roundly elliptical, with width slightly greater than length. The beak is moderately long, interarea moderately long, brachial valve

fairly strongly convex. The specimens are not fully enough grown to show a sulcation of the pedicle valve, but the brachial valve is anteriorly flattened but swollen posteriorly. The hinge is fairly wide but considerably narrower than the midwidth.

Measurements (in mm) are as follows:

	brachial valve			hinge width	thick- ness
	length	length	width		
USNM 702e					
152413a	1.9	1.7	2.2	1.8	1.5
152413b	3.8	3.5	4.5	3.1	2.6
152413c	4.0	3.4	4.4	3.1	2.8
152413d	4.4	3.8	4.6	3.1	3.0
152413e	4.8	4.0	5.1	3.4	3.0
152413f	5.4	4.3	6.0?	4.1	3.5?

Compared with specimens of *C. inflata* Stehli of the same size this species proves to have a much more convex pedicle valve.

Specimens come from the Hess Formation (Taylor Ranch Member) at USNM 702e.

Described and measured specimens: USNM 152413a-f.

SPECIES D (In Volume 5, Plate 745: figures 40-44).—This is a large species somewhat larger than *C. guadalupensis* (Girty) but much smaller than either *C. tholiaphor* or *C. major*, both new. It differs from the former in having a broader ventral umbo which does not protrude so far posteriorly and has somewhat narrower shoulders. It also suggests *C. sulcata* Stehli but lacks the narrow, shallow sulcus on the ventral valve of that species. This is a rare shell in the Cathedral Mountain Formation at USNM 721u.

Figured specimen: USNM 154512.

Genus *Attenuatella* Stehli, 1954

Attenuatella Stehli, 1954:343. — Cherniak in Ustritsky and Cherniak, 1963:114. — Waterhouse, 1964:108; 1967:167. — Armstrong, 1968:783.

Small, nearly planoconvex; outline narrowly elongate subovate, normally flattened or slightly indented at anterior margin, greatest width anterior to midlength; commissure rectimarginate; pedicle valve weakly sulcate; brachial valve without fold, accommodating sulcus by anterior emargination; costae absent; shell with fine radial fibers, crowded short spines or spine bases; growth lines and laminae weakly visible on some specimens, invisible on others.

Pedicle valve elongate, strongly convex; beak very long for genus, slightly attenuate, strongly curved posterior to hinge, apex normally incurved; interarea proportionately high and narrow, nearly equilaterally triangular, strongly concave; delthyrium deeply wedge-shaped, bounded laterally by low flange on each side. Brachial valve flatly convex to nearly flat; slightly swollen in beak area; beak pointed, projecting slightly beyond posterior margin; interarea proportionately very low, wide, flat; notothyrium proportionately wide and shallow.

Pedicle valve interior with large, transversely elongate, rounded hinge teeth; dental ridges, flat, scarcely identifiable as ridges, coalescing at apex of delthyrium to form very short apical plates; muscle area in umbonal region; adductor marks slightly depressed on floor of valve in posterior lateral parts of area; diductor marks raised on long narrow median ridge with low lateral flanges, ridge continuing anteriorly beyond muscle area, bisecting all but anterior fourth of valve.

Brachial valve interior with wide hinge sockets formed by thick socket ridges; cardinal process occupying apex of notothyrium, bifid in some species, proportionately thick, convex, finely lamellate; hinge plates very short, nearly parallel to valve walls, joining crura to socket ridges; crura rod-shaped, cemented to valve floor only in extreme posterior part of their length; spiralia absent (*vide* Armstrong, 1968); muscle area between crura, weakly impressed, subquadrate, individual muscle marks not distinguishable, but pattern apparently as in *Crurithyris*.

TYPE-SPECIES.—*Attenuatella texana* Stehli (1954: 343, pl. 25: figs. 31-33) (by monotypy).

DIAGNOSIS.—Elongate narrow outline, strongly incurved beak of pedicle valve, raised thickened myophragm in pedicle valve, short crural plates lying nearly against posterior walls of brachial valve, brachidia terminating without forming spires.

COMPARISON.—*Attenuatella* is longer and narrower than either *Ambocoelia* or *Crurithyris*. It differs further in its long and rather thick ventral beak and nearly flat brachial valve. Internally it is distinguished by the prominent median ridge in the pedicle valve that forms a deep groove in decorated and weathered specimens, and by its truncated brachidia that begin as in *Crurithyris* but fail to develop spiralia.

DISCUSSION.—*Attenuatella* was established on a

single pedicle valve. Since then it has been described in Permian strata of New Zealand (Waterhouse, 1964), New Caledonia (Waterhouse, 1967), and Australia (Waterhouse, 1967; Armstrong and Brown, 1968; Armstrong, 1968). In addition, it has been recognized in the literature as having been described in other guises in Mexico, Siberia, the Ural Mountains, and Novaya Zemlya (see Armstrong, 1968:787, fig. 3). Despite such wide recognition the spiralia remained undescribed, a fact usually attributed to rarity and poor preservation. Armstrong (1968) contends that the brachidia of *Attenuatella* terminate without forming the spiralia that would be expected from its obvious close relationship to *Crurithyris*. Although such abortive development could well account for the fact that no spiralia were seen in the genus, and for the elongate narrow outline of the shell, initial skepticism prompted a second look at specimens of *A. attenuata* (Cloud) from the Las Delicias area of Mexico (USNM 814). A suite of about 30 specimens was examined: many are internal molds, some retain the shell. Several specimens clearly show holes where the initial laminae of the brachidia penetrated the matrix and were weathered out. None shows any sign of a spiranium although preservation and breakage is such that one would show it if present. Therefore we accept Armstrong's conclusion that the brachidium of *Attenuatella* terminated without development of a spiranium. We agree also that other features require taxonomic placement as a close relative of *Crurithyris* despite lack of a spire, that the brachidia of *Attenuatella* are aborted spires rather than some other independent configuration.

Attenuatella attenuata (Cloud)

PLATE 590: FIGURES 32-39

Crurithyris attenuata Cloud 1944:62, pl. 17: figs. 22-25.—Waterhouse, 1964:108.

Attenuatella attenuata (Cloud) Stehli, 1954:343.—Waterhouse, 1967:171.—Armstrong, 1968:786.

DESCRIPTION.—The description and measurements by Cloud are adequate and need not be repeated.

STRATIGRAPHIC OCCURRENCE.—*Waagenoceras* zone (Word equivalent).

LOCALITY.—Palo Quemado, NW end of Las Delicias Valley, Coahuila, Mexico, USNM 814.

DIAGNOSIS.—Large *Attenuatella* with unusually

long ventral beak and nearly flat brachial valve.

TYPES.—Holotype: YPM S-2745. Figured paratypes: YPM S-2746. Figured hypotypes: USNM 154429a-c.

COMPARISON.—Stehli (1954:343) considered the possibility that additional material might prove *A. texana* to be synonymous with *A. attenuata*. New material of both species from their type localities, however, merely confirms their difference. *Attenuatella attenuata* is larger, the pedicle valve is more strongly curved, the beak is longer and thicker, and the brachial valve more nearly circular and almost perfectly flat. Many of the specimens are preserved as steinkerns, inviting comparison with the similarly preserved Australian species *A. multispinosa* Waterhouse (1967). The Mexican species does not exhibit the ventral sulcus and dorsal costae of the New South Wales species. It is much more elongate and the brachial valve more nearly plane than in *A. convexa* Armstrong (1968) from the Permian of Queensland.

Attenuatella texana Stehli

PLATE 590: FIGURES 23-31; PLATE 745: FIGURES 64-68
(in volume 5)

Attenuatella texana Stehli, 1954:343, pl. 25, figs. 31-33.

Shell smaller than medium size for genus, nearly planoconvex; outline elongate subovate with flattened anterior margin, sides subparallel, greatest width about a third distance back from anterior margin; sulcus shallow, barely perceptible on some specimens; brachial valve without fold; radial fibers fine; surface spines or spine bases apparently randomly distributed; growth lines and laminae weak.

Pedicle valve long, narrow, strongly convex in both directions; beak long, somewhat attenuate, incurved; interarea comparatively high, narrow (for genus) but wider than high, strongly concave; delthyrium deeply wedge-shaped, lateral bounding flanges low or absent. Brachial valve elongate elliptical, nearly flat, slightly swollen in beak area; interarea proportionately very low and wide; notothyrium shallow, broad, with low lateral flanges.

Pedicle valve interior with large, broad, flat, slightly hooked hinge teeth; dental ridges rudimentary; apical plate in apex of delthyrium very short; muscle area in umbonal region; adductor

marks very weak, barely discernible; diductor marks on narrow median ridge, elongate, one on each side; median ridge extending anteriorly well beyond muscle area.

Brachial valve interior known only from immature valve; hinge sockets wide, with strong socket ridges, bridged by thin plates; cardinal process filling apex of notothyrium, finely lamellate; crural plates thick, widely divergent, connecting crura to socket ridges; crura rod-shaped, rather far apart, distally bowed; muscle area between crura about a third distance anterior to beak, small, quadrate, weakly impressed.

MEASUREMENTS (in mm).—Brachial valve length, and thickness, unmeasurable.

	length	commissure length	width	hinge width
USNM 728f				
152986a	6.0	4.5	4.2	2.9
152986b	7.0	4.8	4.9	3.4
152986c	7.1	4.8	5.1	2.9
152986d	7.4	5.2	5.4	3.5
152986e	7.7	5.3	c5.5	3.1
152986f	8.0	5.8	5.9	3.7
152986g	9.0?	6.5?	6.2	4.0
152986h	9.0	6.0	6.7	4.3

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITY.—USNM 728f.

DIAGNOSIS.—Small, very narrow *Attenuatella*.

TYPES.—Holotype: AMNH 27321. Figured hypotypes: USNM 152986c,d,h-j. Measured hypotypes: USNM 152986a-h.

COMPARISON.—*Attenuatella texana* is characterized by its small size and narrow outline. It is smaller than the only other American species, *A. attenuata* (Cloud) from the Las Delicias area of Mexico, and its hinge is narrower, and brachial valve proportionately smaller. The two are difficult to compare further, because the former are silicified free valves, whereas the Mexican ones are internal casts, except for one small complete shell. The Texas specimens are narrower than the Australian species illustrated by Armstrong (1968), and much smaller than *A. incurvata* Waterhouse (1964) from the Permian of New Zealand.

Suborder ATHYRIDIDINA Boucot, Johnson and Staton, 1964

Biconvex, generally rounded shells with recti-

marginate or uniplicate commissure; interareas obsolete. Pedicle valve with rounded foramen; brachial valve with small undivided hingeplate. Spiridium with laterally directed cones. Jugum simple to complex.

Superfamily ANTHYRIDACEA McCoy, 1844

Family ATHYRIDIDAE McCoy, 1844

Brachial apparatus with complex V-shaped jugum.

Subfamily ATHYRIDINAE McCoy, 1844

Smooth, lamellose or spiny, rounded jugal process confined between primary and secondary whorls of spiral.

Genera in West Texas: *Cleiothyridina* Buckman, 1906; *Composita* Brown, 1849.

Cleiothyridina has seldom been reported in the Permian of the United States but the etching program has produced rare and mostly small specimens from many parts of the West Texas Permian. The Wolfcampian species is very small. The genus is equally rare in the Road Canyon and the Word formations. One species occurs in the Bell Canyon Formation. The rarity and small size of the genus in the United States is in strong contrast to its abundance and large size in Asia.

Composita is one of the commonest genera in all parts of the Permian of West Texas, occurring in all parts of the section.

Genus *Cleiothyridina* Buckman, 1906

Cleiothyridina Buckman, 1906:324.—Hall and Clarke 1893: 90.—Weller 1914:472.—Williams et al., 1965:H662.—Carter 1967:342.

Small to medium size, moderately strongly bi-convex to subglobose; outline subcircular to transversely subelliptical, greatest width near midlength; hinge narrow, without protruding ends; commissure rectimarginate to strongly uniplicate, less commonly weakly sulcate; in some species fold beginning near beak and remaining prominent toward anterior, in other species becoming prominent only near anterior, in some species absent; sulcus shallow, gently rounded in most species, sharply outlined in some; radial ornament absent;

concentric lamellae bearing short to moderately long, apparently solid, slender spines, density of occurrence varying with species; spines normally broken off, leaving concentric lamellae visible; growth laminae stronger, interrupting more regularly spaced lamellae.

Pedicle valve moderately to strongly convex, greatest swelling normally just anterior to umbonal region; beak short, blunt to slightly attenuate, normally suberect to erect or slightly recurved; beak ridges curved, obscure; delthyrium large, triangular, fully occupied by brachial beak; deltoidal plates absent; foramen small, subcircular, perforating apex of beak. Brachial valve slightly less strongly convex, greatest swelling in umbonal region; beak obtusely pointed, apex within pedicle valve; edges of valve slightly overlapping posterolateral edges of pedicle valves, elsewhere butting directly.

Pedicle valve interior with rather large hinge teeth, elongate parallel to sides of delthyrium; dental plates short, divergent, meeting valve walls and continuing toward floor either fused to wall or tightly pressed against it, forming small vessel-shaped smooth area in umbonal region posterior to muscle area; muscle marks located anterior to smooth apical area, extending nearly to midlength of some species, nearly to anterior margin of others; large lateral diductor marks separated by obscurely differentiated pair of mesial adductor marks; pallial trunks extending anteriorly nearly parallel to median line of shell, varying in depth with species and with individual, fading just behind valve margins, numbering about 6–8, some bifurcating at anterior extremity.

Brachial valve interior with slightly concave semielliptical hinge plate at beak, perforated at apex by small cardinal foramen with small tooth-like cardinal process projecting posteriorly within it (probably for insertion of diductor muscle tendons); hinge sockets large, posteriorly tapering, formed between valve walls and socket ridges, mesial parts of socket ridges supporting lateral edges of hinge plate; muscle area elongate elliptical, bisected in posterior half by low flat median ridge; muscle marks deepest at posterior, becoming shallower in anterior part, merging and losing distinct boundaries anteriorly; pallial grooves subparallel, slightly radial, widely spaced, similar to those in pedicle valve; crura extending anteriorly from anterolateral edges of hinge plate, directed toward floor

of valve, then anteriorly above floor; spiralia attached to crura, laterally coiled in about 9 loops, axis of coiling nearly directly transverse to median plane of shell.

TYPE-SPECIES.—*Spirifer de roissyi* Lèveillé (1835: 39=*Athyris roysii* [sic] Davidson, 1860:84, pl. 18: fig. 8) by original designation of Buckman (1906: 324).

COMPARISON.—*Cleiothyridina* is characterized by its concentric lamellae that bear short spines, its pedicle beak without interarea, its subcircular pedicle foramen that penetrates the apex of the beak, and by presence of small dental plates in the pedicle valve and an apically perforated hinge plate in the brachial valve. The surface spines and concentric lamellae resemble those on *Pemphricadothyris*, but differ in their single rather than double bases, and apparent solidity. *Cleiothyridina* differs further in its lack of interarea, its apical foramen, and possession of dental and hinge plates. The absent interarea and subcircular apical foramen resemble similar features of *Composita*, but *Cleiothyridina* is distinguished by its concentric spinose lamellae, and internally by its perforated hinge plate. This genus strongly resembles *Actinoconchus* of the Carboniferous, differing primarily in its concentric lamellae that bear slender spines.

DISCUSSION.—This is the first report of *Cleiothyridina* from the Texas Permian. It is very rare except at a few localities in the Wolfcamp Hills, and was not discovered by previous workers. Apparently, after its abundant development in the Pennsylvanian, the genus declined in the United States, becoming not only rare but very small in the Texas Permian. R. E. King (1931:41) stated, "The genera *Spirigerella* and *Cliothyridina* (sic), which are conspicuous elements of Eurasian Permian faunas, are quite absent from the Texas Permian. This is the only family in which a common Pennsylvanian genus is unrepresented, for *Cliothyridina*, an abundant fossil in places in the lower and middle Pennsylvanian, does not occur higher in this country."

Among the few species of *Cleiothyridina* in the Texas Permian there is a definite increase in strength of the anterior fold from the rectimarginate Wolfcampian *C. rectimarginata*, new species, through increasingly strongly folded *C. mulsæ*, new species, from the Late Wolfcampian and *C. nana*, new species, from the Road Canyon Formation. Despite increase in strength of folding, all these species are

very weakly folded compared to most species of the genus. The trend here in Texas culminates in the relatively (for the genus) strongly folded *C. pilularis*, new species, from the Late Guadalupian Lamar Member of the Bell Canyon Formation. This trend, while apparent in our few species, is not a general trend in the more complete history of the genus; there are Mississippian species that are nearly rectimarginate, and others well folded (Weller, 1914).

The major difference between *Cleiothyridina* and *Athyris*, whose range is earlier in the Paleozoic, is in the presence of spines instead of frills along the concentric lamellae of the shell. These spines appear to be solid rather than tubular, not only on silicified Permian specimens, but also on calcareous specimens in the National Museum collection from the Mississippian and Pennsylvanian. In order for solid spines to be formed, without an inner tube occupied by mantle as in productid spines, they must have been secreted along the mantle edge at the valve edges. Most specimens on which spines are preserved have the longest and most numerous spines at the valve edge near the commissure. From there toward the posterior the number and length of spines decreases irregularly, the decrease probably due simply to the breaking off of earlier sets of spines. If the spines were indeed formed along the valve edge, they are closely related to the frills that formed along the margins of *Athyris*, and might be considered simply as discontinuous or deeply notched frills. All other features of the two genera also are so similar that *Cleiothyridina* is undoubtedly a close phylogenetic relative of *Athyris*, and descended from that genus.

The small perforation in the apex of the dorsal hinge plate normally is described as simple and circular (e.g., Dunbar and Condra, 1932:359). In most of our specimens it is elongate elliptical, and a few exceptionally well preserved specimens show a small toothlike extension projecting posteriorly into the perforation. The hole and the little extension probably served the function of a cardinal attachment for the ends of the diductor muscles.

Cleiothyridina ciriacksi, new species

PLATE 650: FIGURES 1-18

Small for genus, outline subcircular to slightly

oval; sides and anterior margin strongly rounded; widest near midvalve. Beak and foramen small. Surface lamellose, spines numerous but length not known. Anterior commissure rectimarginate or with slight dorsad wave.

Pedicle valve slightly deeper than brachial valve, moderately but unevenly convex, greatest convexity in posterior region. Anterior profile fairly strongly and somewhat narrowly domed with long moderately steep slopes. Umbonal and median regions swollen; anterior third somewhat flattened to very faintly sulcate.

Brachial valve fairly evenly and moderately convex in lateral profile, broadly and moderately domed in anterior profile. Umbonal region slightly convex, median swollen, lateral slopes steep. Antero-median region in some specimens with faint fold.

Pedicle valve interior with short but well-defined dental plates. Teeth small. Brachial valve with small concave hinge plate without apical foramen.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 763				
154386a	5.2	4.8	5.1	3.2
154386b	7.2	6.7	6.8	4.6
154386c	8.8	8.0	9.5	5.2
154386d	9.0	8.0	8.7	5.2
154386e	9.7	8.6	9.4	5.4
154386f	9.8	9.0	9.9	5.8
154386g	9.8	10.0	10.8	6.1
154386h (holotype)	10.9	10.2	10.8	6.6

STRATIGRAPHIC OCCURRENCE.— Park City Formation (Franson Member).

LOCALITY.—USNM 763.

TYPES.—Holotype: USNM 154386h. Figured paratypes: USNM 154386g,i-k. Measured paratypes: USNM 154386a-g.

DIAGNOSIS.—Small rectimarginate *Cleiothyridina* strongly and closely lamellose with low beaks and posteriorly swollen valves.

NAME.—Named after Dr. Kenneth Ciriacks who collected the specimens.

COMPARISON.—The only North American Permian species approaching this one in size are *C. pilularis*, new species, *C. attenuata* Cooper, and *C. gerardi* (Diener). The first of these species is fairly strongly folded anteriorly and thus entirely unlike *C. ciriacksi*, which has only the faintest trace of folding. *Cleiothyridina attenuata* is distinctly oval or triangular in outline, with the posterior attenuated and

thus quite different. The last species is so much larger and more robust that no useful comparison can be made.

This species suggests the common Pennsylvanian (Desmoines) species *C. orbicularis* (McChesney) but the Permian species has a more extended beak, somewhat fuller median regions, and less tendency to plication of the commissure in late stages.

DISCUSSION.—From the accompanying descriptions of species of *Cleiothyridina* it seems evident that this hitherto rare genus is far more common than realized. The acidizing technique which is a more productive collecting procedure than most others is sure to reveal many more specimens and probably species.

Cleiothyridina malsa, new species

PLATE 650: FIGURES 19–35

Small for genus, but medium size for Texas Permian species, flatly to moderately biconvex; outline subtrigonal to oval, greatest width normally somewhat anterior to midlength; commissure rectimarginate to very weakly uniplicate; fold present on larger specimens, broad, low, expressed only at anterior, not standing above flanks; sulcus shallow, slightly depressing anterior midline of some specimens; concentric lamellae weak, closely spaced, few with spines, most with remnants of spine bases, spines preserved only near valve margins; growth laminae stronger, few, interrupting slope of shell.

Pedicle valve moderately convex, greatest swelling in umbonal region; beak short, blunt, normally suberect; beak ridges indistinct; foramen incompletely subcircular, perforating apex of beak. Brachial valve flatter; beak rounded to obtusely pointed, apex within pedicle valve.

Pedicle valve interior with proportionately large hinge teeth, elongate, parallel to sides of delthyrium; dental plates fused to sides of valve almost entirely, free only at anterior edges in a few specimens, continuing along valve walls to form smooth area in umbonal part of valve; muscle marks located anterior to smooth area, weakly impressed; individual marks not differentiated; pallial grooves shallow, invisible on some specimens.

Brachial valve interior with small elevated hinge plate, depressed medially, with small cardinal perforation at apex; sockets deep, strongly tapered

posteriorly; muscle area small, depressed in umbonal region, individual muscle marks not differentiated; crura and spiralia not observed.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 705a				
152459a	3.6	3.0	3.1	2.2
152459b	4.3	4.1	4.2	2.6
152459c	4.6	3.8	4.0	3.2
152459d	5.6	5.3	5.7	3.7
152459e	5.9	5.3	5.7	3.0
152459f	6.0	5.6	6.3	4.0
152459g	6.2	5.9	6.0	4.0
152459h	6.8	6.5	6.7	4.4
152459i (holotype)	7.1	6.7	7.0	4.2
152459j	8.6	7.9	7.8	5.0

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base).

LOCALITY.—USNM 705a.

DIAGNOSIS.—Small, weakly uniplicate *Cleiothyridina* with vestigial dental plates.

TYPES.—Holotype: USNM 152459i. Figured paratypes: USNM 152459h,k,l. Measured paratypes: USNM 152459a–h,j. Unfigured paratypes: USNM 152459a–g.

COMPARISON.—*Cleiothyridina malsa* is characterized by its small size, weak concentric lamellae with entire spines rarely preserved except at anterior, moderate biconvexity, nearly completely fused dental plates, and its weakly uniplicate anterior commissure. It is similar in size to *C. rectimarginata*, new species, from lower in the Wolfcampian, differing primarily in its lesser convexity and its uniplication. It is larger than *C. nana*, new species, from the Road Canyon Formation, and its fold is proportionately weaker. It is much smaller, less convex, and has a much lower fold than *C. pilularis*, new species, from the Lamar Member of the Bell Canyon Formation in the Guadalupe Mountains. It is smaller than species from other Permian areas, and differs from most described Carboniferous species in most of the same features that distinguish *C. rectimarginata*, (see below).

Cleiothyridina nana, new species

PLATE 650: FIGURES 36–49, 84–99

Very small for genus, flatly to moderately biconvex; outline ovate, normally slightly elongate,

greatest width near midlength; commissure weakly uniplicate; fold very low and broadly rounded; sulcus shallow, present only at commissure: not producing trough along pedicle valve; concentric lamellae closely spaced, those near margins with short but closely spaced spines, those farther posterior with fewer and lower spines and numerous spine bases; growth laminae weak and few.

Pedicle valve moderately convex; beak thick, nearly straight to suberect; foramen proportionately large for genus, incompletely subcircular, piercing apex of beak. Brachial valve slightly less convex, with obtusely pointed beak projecting into pedicle valve.

Pedicle valve interior with small hinge teeth; dental plates fused to valve walls for most of length; area proportionately large, extending anterior to midlength, beginning anterior to smooth region on floor in umbonal area; individual muscle marks not distinguished.

Brachial valve interior with triangular depression in middle, apical perforation small, round, at posterior of depressed portion, without evidence of cardinal tooth; crura extending forward from hinge plate, full extent of crura and spiralia not observed; muscle area smaller than in pedicle valve, oval, individual marks not observed.

MEASUREMENTS (in mm).—

	<i>brachial</i>			
	<i>length</i>	<i>valve length</i>	<i>width</i>	<i>thickness</i>
USNM 709c				
152456a	3.4	3.2	3.2	2.0
152456b	4.0	3.7	3.9	2.5
152456c	5.0	4.5	4.3	3.3
USNM 710u				
154387a (holotype)	4.2	3.8	3.8	2.7
154387b	4.6	4.3	4.2	2.8

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 709c, 710u, 722f, 726d.

DIAGNOSIS.—Very small *Cleiothyridina* with slightly folded anterior commissure.

TYPES.—Holotype: USNM 154387a. Figured paratypes: USNM 152456a,b; 154387b. Measured paratypes: USNM 152456a-c, 154387b.

COMPARISON.—*Cleiothyridina nana* is the smallest species of the genus known from the Texas Permian, and is smaller than any other species with which we are acquainted. It differs from the somewhat larger, but nevertheless small, Wolfcampian

species *C. rectimarginata*, new species, in its flatter convexity, narrower outline, and especially in its slightly folded anterior commissure. These features also distinguish it from the Wolfcampian species *C. mulsa*, new species. It is much smaller, narrower, and less convex than the Guadalupian species *C. pilularis*, new species, and its commissure is much less strongly folded. No foreign or Carboniferous species of *Cleiothyridina* is sufficiently similar to *C. nana* to warrant detailed comparison.

Cleiothyridina pilularis, new species

PLATE 650: FIGURES 50-83

Small for genus but large for Texas Permian, moderately to strongly biconvex; outline transversely subelliptical to subpentagonal, greatest width near midlength; commissure uniplicate; fold low, broadly rounded, beginning about 5 mm anterior to brachial beak; sulcus shallow, gently rounded, also beginning about 5 mm anterior to pedicle beak; concentric lamellae strong, regularly spaced, with intervals increasing slightly toward anterior; spine bases in single row along each lamella, but no spines observed; growth laminae strong, breaking slopes of valves, widely and irregularly spaced.

Pedicle valve moderately convex, greatest convexity located in umbonal region; beak short, thick, suberect to erect; beak ridges rounded; foramen incomplete, subcircular, perforating apex of beak. Brachial valve slightly less strongly convex longitudinally, slightly more transversely; beak obtusely pointed, apex within pedicle valve; umbonal region anterior to apex somewhat swollen.

Pedicle valve interior with rather large hinge teeth elongate parallel to sides of delthyrium; dental plates free only immediately below teeth, elsewhere tightly fused to valve walls, continuing to floor to form smooth area behind muscle field; muscle marks distinct, in large muscle area; adductor marks large, lateral, diductor marks smaller, mesial, not distinctly differentiated from one another except by midline of valve, located in posterior half of muscle area; pallial grooves deep, widely and regularly spaced, nearly parallel, radiating only slightly.

Brachial valve interior with elevated semielliptical hinge plate slightly depressed in middle, perforated near apex, perforation with small, posteriorly pointing cardinal tooth; hinge sockets wide,

deep, posteriorly tapering; crura extending forward from anterior edges of hinge plate: complete extent of crura, and spiralia, not observed; muscle area fairly large oval, lying in umbonal region, posterior half bisected by low median ridge, individual muscle marks clearly distinct from one another only at posterior border of area, there forming 2 or 4 small indentations of border; pallial grooves deep, slightly radial as in pedicle valve.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 738b				
152461a	6.8	6.5	6.2	4.5
152461b	7.2	6.7	7.4	4.3
152461c	7.4	6.8	7.0	5.1
152461d	8.1	7.7	9.0	5.0
152461e	8.6	8.4	9.0	5.7
152461f	8.9	8.0	8.9	5.7
152461g	9.0?	8.1	8.4	6.0
152461h	9.2	8.3	8.8	6.0
152461i	9.2	8.7	9.9	6.8
152461j	9.3	8.7	9.6	6.4
152461k	9.4	9.0	9.3	7.3
152461l	9.6	8.7	10.2	7.4
152461m	9.9	8.5	9.4	7.3
152461n	10.5	9.8	12.0	6.4
152461o	10.8	9.9	11.5	7.9
152461p	11.3	10.0	11.0	8.2
152461q (holotype)	10.4	9.0	10.7	8.1

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member); Capitan Formation.

LOCALITIES.—Lamar: AMNH 40; USNM 725e, 728p, 738b. Capitan: USNM 750.

DIAGNOSIS.—Fairly large *Cleiothyridina* with strong anterior folding.

TYPES.—Holotype: USNM 152461q. Figured paratypes: USNM 152461d,s,u,v; 154388a,b; 154389a,b. Measured paratypes: USNM 152461a–p. Unfigured paratypes: USNM 152461a–c,e–p,r,t.

COMPARISON.—*Cleiothyridina pilularis* is characterized by its small size and rather strong convexity, although it is the largest species of the genus in the Texas Permian. It has what appear to be spine bases along the concentric lamellae, but few spines are preserved so the length and shape of the spines could not be determined. This species differs from the abundant Wolfcampian species *C. rectimarginata*, new species, in its much larger size, well-developed fold and sulcus, more transverse outline, and lower maximum convexity. It is much larger than any of the other rare Texas species, and more

strongly folded; therefore, detailed comparisons are unnecessary.

Cleiothyridina pilularis resembles species of *Cleiothyridina* from other areas more closely than it resembles the stratigraphically remote species from nearby regions. It is larger, more convex, more strongly folded, and more transverse than either *C. attenuata* Cooper or *C. gerardi* (Diener) from the Permian of Oregon. It somewhat resembles *Athyris globulina* Waagen and *A. capillata* Waagen from the Salt Range Permian, but is not as convex as either of those species, and is more strongly folded than the former. It is much smaller than normal specimens of *C. royssii* (Léveillé) from the Salt Range and is less transverse, more pentagonal and more strongly folded than *A. acutomarginalis* Waagen. It does not greatly resemble other species described by Waagen or Reed (1944) from that region.

Cleiothyridina rara, new species

PLATE 510: FIGURES 48–55

Small for genus, slightly wider than long, outline roundly elliptical; sides and anterior margin well rounded; beak low, rounded; foramen open, no trace of deltidial plates. Anterior commissure rectimarginate. Surface with concentric rows of fine spines not well preserved.

Pedicle valve about same depth as brachial valve; evenly and moderately convex in lateral profile but anterior profile more strongly convex and forming moderately convex dome, somewhat narrowed medially, with long steeply sloping sides. Median region swollen.

Brachial valve having approximately same convexity in both profiles, strongly swollen umbo and median region. Interior not known.

MEASUREMENTS (in mm).—Holotype (USNM 154518): length 9.5, brachial valve length 8.8, width 9.6, thickness 5.5.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member).

LOCALITY.—USNM 706e.

DIAGNOSIS.—*Cleiothyridina* with valves nearly equal in depth, and length and width nearly equal.

TYPES.—Holotype: USNM 154518.

COMPARISON.—This species can be compared only with *C. pilularis* and *ciriacksi*, both new species,

which are of about the same size. The earlier species from the Wolfcampian formations are all much smaller and quite unlike. *C. rara* differs from *C. pilularis* in being rectimarginate whereas *C. pilularis* is strongly uniplicate. It differs from *C. cirracksi* in having a less deep pedicle valve, in having more distant concentric bands of spines, and a more swollen brachial valve.

This unique specimen was taken from the residues of USNM 706e from which thousands of specimens have been taken. It is thus an exceedingly rare species.

Cleiothyridina rectimarginata, new species

PLATE 651: FIGURES 1-44

Small for genus, moderately to very strongly bi-convex; outline subovate or roundly subtrigonal, length and width nearly equal, maximum width located slightly anterior to midlength; commissure normally rectimarginate, rarely flexed slightly dorsally or ventrally; valves normally not folded or indented, some specimens with slight indentation of both valves barely perceptible near extreme anterior; concentric lamellae closely spaced, those near margins bearing numerous closely crowded spines up to 1 mm in length, lamellae farther posterior with spine bases or sporadically preserved spines; growth laminae stronger, widely and irregularly spaced.

Pedicle valve moderately convex in medium size specimens, strongly convex in larger specimens; beak short but rather long for genus, normally erect or slightly incurved; foramen apical, subcircular, circle not complete; beak ridges rounded, indistinct. Brachial valve similarly convex, rarely more strongly convex; beak swollen but broadly rounded anterior to apex; apex obtusely pointed, curved into pedicle valve.

Pedicle valve interior with small, knoblike hinge teeth, slightly elongate parallel to delthyrial sides; dental plates short, narrow, meeting valve walls only short distance below hinge teeth, fused to walls for most of width of plates; valve floor between dental plates smooth; muscle area located anterior to smooth area, muscle marks weakly impressed; pallial grooves shallow, invisible in many specimens.

Brachial valve interior with small trigonal or

crescentic hinge plate, slightly concave, apex with small elongate ovate perforation with short posteriorly pointing projection in some specimens; crura extending anteriorly from edges of hinge plate, full extent not observed; hinge sockets large, open, tapering posteriorly; muscle area elongate elliptical, bisected in posterior by low median ridge, anterior and posterior adductor marks only subtly differentiated in few specimens, area extending about a third length of valve; spiralia not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	thickness
USNM 701c				
152465a	6.0	5.5	6.1	3.4
152465b	6.6	5.7	6.2	5.0
152465c	7.3	6.6	7.3	4.5
152465d	8.7	8.9	7.8	7.7
USNM 701d				
152467a	3.4	3.2	3.3	1.9
152467b	6.5	5.9	6.1	4.2
152467c	8.6	8.0	8.8	5.7
USNM 701h				
152469a	4.4	3.8	3.9	2.4
152469b	4.6	4.2	3.9	2.8
152469c	4.7	4.2	4.3	2.9
152469d	5.0	4.6	4.5	3.1
152469e	5.8	5.0	5.0	3.3
152469f	5.9	5.4	5.4	3.8
152469g	6.6	5.6	5.5	5.0
152469h	6.7	6.1	6.4	4.7
152469i	6.8	6.0	6.5	4.0
152469j	6.9	6.6	6.7	4.5
152469k	7.2	6.8	7.6	5.2
152469l	7.8	6.8	7.0	5.7
152469m	7.9	6.9	7.2	5.9
152469n	7.9	7.0	7.7	6.5
USNM 701k				
152471a	2.3	2.1	2.0	1.2
152471b	2.6	2.4	2.3	1.5
152471c	2.8	2.7	2.7	1.5
152471d	3.0	2.9	2.7	1.9
152471e	3.2	2.8	2.9	2.0
152471f	3.3	3.0	3.2	1.8
152471g	3.6	3.3	3.1	2.1
152471h	3.8	3.5	3.7	2.2
152471i	4.0	3.5	3.8	2.4
152471j	4.3	3.9	3.7	2.3
152471k	6.4	5.5	5.6	4.7
152471l	6.4	6.0	6.3	3.9
152471m	6.5	5.8	6.1	5.1
152471n	6.9	6.4	6.0	4.7
152471o (holotype)	7.3	6.4	7.7	5.0

STRATIGRAPHIC OCCURRENCE.—Moran Formation;

Coleman Junction Formation; Neal Ranch Formation; Cibolo Formation.

LOCALITIES.—Moran: USNM 709b. Coleman Junction: USNM 766. Neal Ranch: USNM 701, 701a, 701c, 701d, 701h, 701k, 701-l, 721g, 727e, 742c. Cibolo: USNM 728-l.

DIAGNOSIS.—Small, rectimarginate *Cleiothyridina*.

TYPES.—Holotype: USNM 152471o. Figured paratypes: USNM 152467a; 152469j,k,n; 152471-l; 154391a-d; 154392a,c,d. Measured paratypes: USNM 152465a-d, 152467a-c, 152469a-n, 152471a-n. Unfigured paratypes: USNM 152467b,c; 152469a-i,l,m; 152471a-k,m,n.

COMPARISON.—*Cleiothyridina rectimarginata* is characterized by its small size, rectimarginate commissure, strong to very strong convexity, subequal length and width, and its bluntly rounded beaks. It is more strongly convex and more consistently rectimarginate than *C. mulsa*, new species, which occurs somewhat higher in the section in the Glass Mountains. It is much smaller than *C. pilularis*, new species, which occurs in the Bell Canyon Formation (Lamar Member) in the Guadalupe Mountains, and lacks the strongly folded commissure of that species. It differs from the minute Road Canyon species *C. nana*, new species, in its larger size, stronger convexity, and unfolded margin.

This species is smaller and more convex than *C. attenuata* Cooper from the Permian of Oregon, and its beaks are blunter and less attenuate. The only species of *Cleiothyridina* reported by Dunbar and Condra from the Pennsylvanian of Kansas and Oklahoma is *C. orbicularis* (McChesney). *Cleiothyridina rectimarginata* differs in its smaller maximum size, greater convexity, less transverse outline, and rectimarginate commissure.

Cleiothyridina rectimarginata is smaller and more convex than most species of the genus that have been described from the Permian of other continents. These features distinguish it from *C. gerardi* (Diener) of India and Russia, and from *C. pectinifera* (Sowerby) reported by Tschernyschew (1902) and others by Netschajew (1911). Its convexity is similar to that of *C. capillata* (Waagen) from the Salt Range, but it is much smaller and has no fold. Likewise it is smaller than species called *C. royssii* by various authors, and not folded.

Species that more nearly approach the size of *C. rectimarginata* were reported by Weller (1914) from the Mississippian of the Midcontinent, but

even among these, the maximum size is somewhat greater than that of the Permian species. Most of Weller's small species also are rectimarginate or nearly so, thus resembling *C. rectimarginata*. Among them, *C. tenuilineata* (Rowley) is broader and somewhat less convex, and has more attenuate beaks; *C. hirsuta* (Hall) is considerably flatter and proportionately wider, characters that are developed even further in *C. lenticularis* Weller. Others of the numerous Mississippian species reported by Weller are much larger than *C. rectimarginata*, and also are easily distinguished by their folded commissures.

Cleiothyridina species undetermined

PLATE 651: FIGURES 73-77

A small shell from the Hueco Canyon Formation is figured because it is well preserved, retaining the characteristic spines, and to document presence of the genus in this unit.

STRATIGRAPHIC OCCURRENCE.—Hueco Canyon Formation.

LOCALITY.—USNM 499b=725z.

TYPES.—Figured specimen: USNM 154394.

COMPARISON.—This small, nearly circular, rectimarginate shell is less strongly convex than *C. rectimarginata*. It may represent a separate species, but its stratigraphic level is similar enough to suggest that it is a variant of that species.

Genus *Composita* Brown, 1849

Composita Brown, 1849:131.—Hall and Clarke, 1894:93.—Buckman, 1906:324.—Weller, 1914:484.—Dunbar and Condra, 1932:362.—Williams et al., 1965:H662.

Shell biconvex; outline subovate, subpentagonal or subtrigonal, commonly widest near midlength; commissure uniplicate, rarely rectimarginate; fold beginning far anterior, normally not standing high above flanks; sulcus shallow, beginning somewhat earlier than fold; costae absent, but some species parasulcate at anterior margin; radial ornament absent; growth lines fine, closely and regularly spaced; growth laminae stronger, more widely and randomly spaced, strength and frequency varying with species and individuals.

Pedicle valve moderately to strongly convex transversely and longitudinally, convexity rather

even, normally greatest in posterior third; beak typically thick, rounded, without well-defined beak ridges, suberect to slightly incurved, length and attenuation variable, foramen large, ovate, epithyridid to permesothyridid; delthyrium completely filled by brachial umbo, without deltidial plates.

Brachial valve most strongly convex near umbo, longitudinally rather flat along fold, strongly convex transversely; beak short, slightly attenuate with apex within pedicle valve.

Pedicle valve interior having two knoblike hinge teeth, one at anterior of each edge of delthyrium; dental plates slightly divergent from teeth to floor, continuing anteriorly along floor in some species as pair of low ridges outlining posterior part of muscle area, space between dental plates and valve wall filled by secondary shell material in many specimens of some species; floor between dental plates smooth, probably filled in life by pedicle and pedicle adjustor muscles; major muscle area ovate, in posterior third of valve; diductor muscle marks large, fusiform, anteriorly and laterally surrounding elongate, heart-shaped median adductor marks, low crest in anterior part of muscle area where diductors meet along midline; pallial marks light, radiating from margins of muscle area, consisting of numerous narrow lines without central primary trunks; floor of valve lateral and slightly anterior to muscle area thickened and pitted in large adults, pits shallowing and disappearing anteriorly and laterally, arranged in radiating rows, some continuing anteriorly as pallial lines; valve edges smooth, without traces of seats for setae, sharp in some species, slightly thickened, flattened or flanged in others; valves butting at margins except in extreme posterior, edge of brachial valve there slightly overlapping edge of pedicle valve.

Brachial valve interior with flat, nearly square hinge plate and flat, nearly square cardinal process meeting one another near right angle in apex of beak; cardinal process projecting posteroventrally along brachial beak into delthyrial area of pedicle valve, mesially concave, with light striae at seat of attachment of diductor muscles, bounded at each side by low ridge, ventral side of process cemented to apex of beak; hinge plate projecting anteroventrally, essentially constituting short web between and lateral to crura; sockets deep, one on each side of hinge plate, formed by pair of

plates continuous with lateral bounding ridges of cardinal process; crura extending anteriorly slightly beyond hinge plate, slender, fragile, slightly convergent, anterior ends attached to mesial sides of broad ribbonlike descending lamellae; lamellae proceeding directly posterior parallel to crura for short distance, then curving toward floor of brachial valve, continuing anteriorly above floor, bowing distally then converging, nearly meeting where nearest to floor, there bifurcating, one branch of each continuing anteriorly to form spiralia, other branch very short, meeting and fusing with dorsally projecting braces of jugum; spiralia tightly coiled into about 9 loops in adults, diameter decreasing rapidly toward sides, axis of coiling nearly directly transverse to shell; arms of jugum joined to descending lamellae, meeting at midline, there expanding, developing, serrated and fringed anterior edges, continuing ventrally and slightly posteriorly as single process on midline, process bifurcating near beginnings of descending lamellae (where joined to crura) each branch broadening to form ribbonlike band, parallel, distal, and following curvature of posterior part of descending lamella; muscle area narrow, elongate, sides slightly constricted about midway in length, dividing area into two distinct halves, one occupied by posterior adductor muscle marks and having low median ridge, other occupied by anterior adductor marks, without median ridge; floor around muscle area thickened and pitted in adults; pallial marks radiating from periphery of muscle area, each narrow trunk bifurcating near valve margin.

TYPE-SPECIES.—*Spirifer ambiguus* Sowerby, by original designation of Brown, T., (1849:131).

COMPARISON.—*Composita* is characterized by its biconvex streamlined shape with narrow hinge, lack of interarea or beak ridges, uniplicate commissure, and proportionately large, oval epithyridid or permesothyridid pedicle foramen. Lack of beak ridges and deltidial plates, and the position and shape of the foramen distinguish it externally from *Dielasma*. The longer more erect beak, larger foramen, more elongate outline, and lack of external surface spines distinguish it from *Cleiothyridina*. Poorly preserved specimens might be confused with *Neophricadothyris* or *Martinia*, but they can be distinguished if the oval foramen is visible; the latter two genera have trigonal

delthyria, and the apex of the beak is unperforated.

DISCUSSION.—The hinge plate and cardinal process of *Composita* are somewhat more complex than heretofore recognized. Hall and Clarke (1894:94) described the anterior face of the hinge plate as the seat of the diductor muscle marks, but instead, the hinge plate and cardinal process are distinct structures. Each is nearly square in outline, and they meet one another nearly at a right angle. The cardinal process extends postero-ventrally, with its posterior surface fused to the apex of the beak of the valve, and its interior face bearing the marks of the diductor muscles. The hinge plate extends anteriorly and slightly ventrally, and is merely a thin web supporting the posterior ends of the crura in juveniles, becoming secondarily thickened in adults. The hinge sockets are continuations of the lateral bounding ridges of the cardinal process that fit precisely between the dental plates, and extend dorsally past the sides of the hinge plate.

Species of *Composita* are highly variable, as most workers who have dealt with them have noted. Specific characters are details of shape, including form of plication, length and thickness of beak, size of foramen, strength of growth laminae, convexity, and to some extent size of shell. Internal features are consistent within the genus, with some ontogenetic variation such as that produced by shell thickening.

Composita affinis Girty

PLATE 652, FIGURES 1-44

Composita emarginata var. *affinis* Girty, 1909:389, pl. 15: figs. 6-7b.

Not *Composita emarginata affinis* Girty, R. E. King, 1931: 128, pl. 43: figs. 12-17.—Cloud, 1944:65, pl. 18: figs. 20-22. [= *C. enormis*, new species.]

About average size for genus, flatly to moderately strongly biconvex; outline ovate, slightly elongate to nearly circular, widest near mid-length; commissure rectimarginate in small and middle size shells, weakly to strongly uniplicate in middle size to large shells; fold consistently low on brachial valve, may produce high sinusosity in anterior margin, crest gently rounded to flattened, producing straight anterior outline in

some shells; sulcus shallow, normally expressed only as tongue at anterior margin of valve, extending to fill fold, not as definite trough in valve; growth laminae moderately strong, numerous; radial fibers weak; valve edges slightly flanged.

Pedicle valve moderately and rather evenly convex; beak short, slightly attenuate, suberect; foramen small, periphery entire, or slightly open dorsally. Brachial valve moderately convex, with low rounded crest along fold; beak short, blunt, slightly curved.

Pedicle valve interior with large, thick, blunt hinge teeth, slightly hooked; dental plates attached to walls at posterior, free but stout at anterior; pedicle area between plates and muscle area anterior to plates distinctly impressed; posterior of valve thickened floor with numerous shallow pits in posterior, becoming aligned and merging into radial pallial lines toward margins.

Brachial valve interior with exceptionally strong, thick hinge plate, formed between strong, trough-shaped crural bases; cardinal process short, thick, unusually distinctly bilobed, each lobe with small circular, distinct muscle scar; crura and spiralia not observed; muscle marks moderately deeply impressed in apical part of valve; posterior of valve slightly thickened, shallowly pitted, with pits aligning to form radial pallial vascula.

STRATIGRAPHIC OCCURRENCE.—Capitan Lime-stone; Bell Canyon Formation (Pinery, Rader, and Lamar members).

LOCALITIES.—Pinery: AMNH 524. Rader: AMNH 388, 410; USNM 725f, 740a, 740i, 740j. Lamar: AMNH 25, 37, 38, 39, 40, 384, 430, 528, 347, 348, 351; USNM 725e, 728i, 728p, 728q, 738, 738b. Capitan: AMNH 817, 853; USNM 725k, 725-l, 725p, 732q, 737a, 739, 750b.

DIAGNOSIS.—Outline elongate, convexity moderate, growth lines many and strong, beak short, foramen incomplete, cardinal internal structures thickened.

TYPES.—Lectotype (here designated): USNM 118609a (Girty, 1909, pl. 15: fig. 6). Figured paratypes: USNM 118609b (Girty, 1909, pl. 15: fig. 7). Figured hypotypes: USNM 153002a-k,m. Measured hypotypes: USNM 153002-l,n-z, a'-z', a''-d''.

COMPARISON.—*Composita affinis* is characterized by its moderate biconvexity, its subcircular to slightly elongate subovate outline, its numerous distinct growth laminae, its short pedicle beak

MEASUREMENTS (in mm).—

USNM 738	brachial			
	valve	valve length	width	thickness
153002-l	3.1	2.9	2.8	1.9
153002n	3.9	3.5	3.5	2.4
153002o	3.9	3.6	3.8	2.1
153002p	4.0	3.7	3.8	2.2
153002q	4.3	3.9	3.9	2.3
153002r	4.5	4.0	4.3	2.5
153002s	4.8	4.3	4.2	3.0
153002t	5.0	4.7	4.8	2.8
153002u	5.2	4.7	4.7	3.1
153002v	5.7	5.2	5.3	3.3
153002w	6.0	5.6	5.7	3.0
153002x	6.6	6.0	6.0	3.5
153002y	7.2	6.6	6.5	3.8
153002z	7.5	6.7	6.9	3.7
153002a'	7.8	7.0	7.3	4.3
153002b'	8.1	7.5	7.3	4.4
153002c'	8.9	7.9	7.4	4.5
153002d'	9.4	8.8	8.5	5.4
153002e'	9.6	8.9	9.2	5.1
153002f'	10.3	9.4	9.5	5.4
153002g'	10.7	9.9	10.0	5.6
153002h'	11.5	10.5	10.0	5.9
153002i'	12.3	11.2	11.9	5.9
153022j'	12.6	11.6	11.3	6.0
153002k'	13.0	11.8	11.4	7.2
153002-l'	14.1	12.7	12.4	7.0
153002m'	15.2	13.8	13.8	7.5
153002n'	16.4	15.1	14.7	8.3
153002o'	17.0	15.6	15.0	9.2
153002p'	17.5	15.6	16.0	8.6
153002q'	18.0	16.6	16.4	9.4
153002r'	18.8	17.6	16.0	9.6
153002s'	19.7	18.7	18.8	10.0
153002t'	20.3	18.6	17.6	10.6
153002u'	21.2	19.3	18.8	10.6
153002v'	22.1	19.8	20.6	9.3
153002w'	22.1	21.9	22.0	c.11.0
153002x'	23.0	21.3	20.8	13.0
153002y'	24.0	23.0	24.7	13.4
153002z'	24.5	22.6	23.3	12.2
153002a''	25.0	23.0	23.9	22.9
153002b''	27.0	24.7	24.0	14.4
153002c''	26.3	24.2	22.7	15.9
153002d''	28.8	25.9	25.8	c.13.0

with periphery of the foramen complete or narrowly incomplete, its somewhat thickened posterior and pitted interior of the valves, and its exceptionally strong, thickened hinge teeth, hinge plate, and cardinal process. *Composita emarginata* Girty is similar in outline, but emarginate, thicker, and more convex than *C. affinis*. Specimens that R. E. King (1931) identified as *C. affinis*

now are termed *C. enormis*, new species, from which *C. affinis* differs in its smaller maximum size, more circular outline, lower convexity, shorter pedicle beak, and stronger, more thickened internal structures.

Composita strongyle, new species, from the Wolfcampian also is flat and somewhat circular, but *C. affinis* differs in its larger size, less consistently circular outline, more numerous and distinct growth laminae, smaller and less elongate pedicle foramen, and thickened posterior, interior floors, and more robust cardinalia. It differs from *C. stalagmum*, and *C. crassa*, both new, in its somewhat smaller maximum size, less transverse outline, stronger growth laminae, lower convexity, shorter beak, and lower fold.

DISCUSSION.—Girty (1909) established *C. affinis* as a variety of *C. emarginata*. R. E. King (1931) and Cloud (1944) treated it as a trinomial, not specifying whether as a variety or as a subspecies. Clearly it is related to *C. emarginata*, but we believe that it is sufficiently distinct to warrant status as a separate species. Girty's specimens from several levels in the Capitan Formation seemed to occur with *C. emarginata*. More detailed collecting shows the two forms to be stratigraphically somewhat separated, with *C. emarginata* more prevalent in the Rader Member and its Capitan equivalents, and *C. affinis* abundant much higher, in the Lamar Member and equivalents.

Composita apheles, new species

PLATE 652: FIGURES 45-88

About average size for genus, somewhat small for Permian species, flatly to moderately strongly biconvex, outline subelliptical, widest near mid-length; commissure weakly to rather strongly uniplicate, weakly parasulcate in many specimens; fold evenly arched or slightly flattened at anterior crest, not standing prominently above flanks; sulcus shallow or not depressed, with weak median groove in many specimens; growth laminae weak to distinct, most frequent near margins, some shells nearly smooth, others with weakly regulated effect.

Pedicle valve moderately inflated in umbonal region; beak thick, blunt, suberect to erect, rarely incurved; foramen proportionately somewhat small,

typically oval, rarely circular. Brachial valve less strongly convex, with low crest from slightly inflated umbo to anterior margin.

Pedicle valve interior with short, thick, slightly curved teeth; short thin dental plates fused to walls for most of length, anterior edges free only for about half their height; muscle area shallowly to rather deeply impressed, bilobate at anterior; diductor marks large, elongate, surrounding smaller median adductor marks; posterior part of valve moderately thickened, emphasizing muscle depressions and radial pallial lines, filling space around dental plates.

Brachial valve interior with strong, slightly thickened hinge plate, deeply incised in juveniles, fused along midline in adults, there protruding slightly as small median node; crural bases forming sides of hinge plate, continuing posteriorly to produce socket ridges; cardinal process short, rather thin, bilobed, each lobe with weak subcircular diductor muscle mark on anterior surface; descending lamellae, jugum and spiralia observed only as fragments, apparently normal for genus; muscle area spatulate, moderately to rather deeply impressed, somewhat short for genus, posteriorly bisected by short, low ridge; posterior part of many valves thickened secondarily, recessing muscle area and producing pitted inner surface; pits shallow, aligned radially.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch, Poplar Tank, and Sullivan Peak members); Hess Formation.

LOCALITIES.—Decie Ranch: USNM 707a, 707g, 714t, 715c, 720g, 727u. Poplar Tank: USNM 708e. Sullivan Peak: USNM 707, 707b, 707c, 707d, 715f, 715j, 722h, 722-l, 727a. Skinner Ranch: AMNH 520; USNM 705a, 705b, 707x, 710r, 716p, 719y, 720e, 723-l, 723s, 724q, 726h, 730r. Hess: USNM 726n.

DIAGNOSIS.—Shell small, beak short and thick, fold low and evenly arched.

TYPES.—Holotype: USNM 154537f. Figured paratypes: USNM 153003a,b; 154536a; 154537a-e, g. Measured paratypes: USNM 153003a-z, a'-r'. Unfigured paratypes: USNM 154536 (many).

COMPARISON.—*Composita apheles* is characterized by its below average size for a Permian species of *Composita*, its short, thick ventral beak, low and evenly arched fold, somewhat transverse outline, moderate convexity with greatest swell-

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 705a				
153003a	2.8	2.5	2.3	1.5
153003b	4.1	3.7	3.2	2.3
153003c	4.4	4.1	3.6	2.8
153003d	4.9	4.3	3.8	2.9
153003e	5.0	4.5	4.0	3.0
153003f	5.4	5.0	5.3	3.4
153003g	5.8	5.4	5.1	3.5
153003h	6.2	5.4	5.4	3.8
153003i	6.9	6.2	6.6	4.1
153003j	7.3	6.7	6.9	4.6
153003k	7.7	7.3	6.9	4.6
153003-l	8.0	7.1	7.0	4.7
153003m	8.4	7.6	7.9	4.8
153003n	8.6	7.8	7.9	5.4
153003o	9.5	8.6	8.7	5.7
153003p	10.0	8.8	8.7	6.2
153003q	10.5	9.8	9.8	6.0
153003r	10.9	9.7	9.9	6.2
153003s	11.3	10.1	9.8	6.9
153003t	12.0	10.7	11.2	6.6
153003u	12.2	11.0	12.1	6.6
153003v	12.6	11.5	12.0	7.0
153003w	13.0	11.3	12.7	8.7
153003x	13.7	12.4	13.7	8.4
153003y	13.8	11.5	13.9	9.3
153003z	14.4	12.6	14.7	8.8
153003a'	15.1	13.0	14.4	9.3
153003b'	15.3	13.0	15.7	9.3
153003c'	16.0	14.5	16.6	9.9
153003d'	17.1	15.5	17.8	11.2
153003e'	17.8	15.9	17.4	11.3
153003f'	18.0	15.9	18.0	12.0
153003g'	19.0	16.7	20.0	12.0
153003h'	19.0	17.2	16.9	12.0
153003i'	19.9	17.7	19.5	12.8
153003j'	20.1	18.2	19.9	12.0
153003k'	20.5	18.4	19.3	13.5
153003-l'	20.7	18.5	19.0	13.1
153003m'	21.0	19.0	21.4	12.3
153003n'	21.6	19.1	20.3	14.1
153003o'	21.6	19.3	22.7	13.7
153003p'	22.5	20.1	20.2	15.4
153003q'	23.5	20.7	22.6	c.14.0
153003r'	24.6	22.1	25.7	c.14.0
USNM 720e				
154537f (holotype)	20.5	18.0	19.3	14.0

ling in the umbonal regions, and its slight secondary thickening in the posterior part of each valve. It is similar to several of the middle-sized species, notably *C. cracens*, *C. imbricata*, and *C. apsidata*, and somewhat less so to *C. stalagmum* and *C. crassa*, all new. It is wider and

has a shorter beak and somewhat stronger growth laminae than *C. cracens*; it is more convex, has a higher narrower fold, and weaker, less numerous growth laminae than *C. imbricata*, and is less convex, less strongly folded, and has weaker and fewer growth laminae than *C. apsidata*. It is smaller than *C. crassa* or *C. stalagmium*, and in addition is less convex and less strongly folded. The outline of some specimens is similar to that of *C. stalagmium*, but other features, especially the much smaller average and maximum size of *C. apheles* makes it easy to distinguish from that species. The fold of *C. apheles* is stronger, the convexity greater, and the outline less circular than in *C. affinis* Girty or *C. strongyle*, new species.

Composita apsidata, new species

PLATE 653: FIGURES 11-37

Composita mira R. E. King [not Girty, 1909], 1931:129, pl. 44: fig. 7 [not figs. 3-6, 8].

About average size for genus, moderately to strongly biconvex; outline subovate to roundly subpentagonal, widest near midlength; commissure strongly uniplicate, fold high and narrow at anterior, beginning early in growth of shell, standing above flanks only at anterior; sulcus moderately depressed, with narrow shallow median groove in most specimens; growth laminae rather strong, giving shingled effect to many shells, widely and irregularly spaced, most numerous near margins.

Pedicle valve strongly and rather evenly convex; beak thick, blunt, suberect to erect; foramen proportionately normal in size. Brachial valve somewhat less strongly convex, greatest inflation in umbonal region; profile along fold nearly flat.

Pedicle valve interior with dental plates thickened or fused to walls by secondary shell material; muscle area depressed, especially in secondarily thickened valves, extending about half length of valve; adductor marks small, median, surrounded by larger diductor marks.

Brachial valve interior with thickened hinge plate, short median lobe extending forward between crural bases; cardinal process projecting posteriorly, nearly perpendicular to hinge plate, each of two small lobes with distinct circular diductor muscle mark; crura extending forward

from crural bases at sides of hinge plate, short, tapered; descending lamellae attached weakly nearly perpendicular to crura; jugum long, with finely digitate median projection; spiralia coiled laterally with transverse axis, probably about 8 loops on each side; muscle area distinctly impressed, posterior part bisected by low rounded ridge, muscle marks shallower toward anterior of area.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 702e				
153004h	2.9	2.4	2.5	1.4
153004i	3.2	2.9	2.8	1.8
153004j	3.4	3.0	3.0	1.9
153004k	4.0	3.7	3.5	2.0
153004-l	4.3	4.0	3.8	2.7
153004m	4.8	4.4	4.4	2.6
153004n	5.2	4.7	4.6	2.5
153004o	5.7	5.2	5.1	3.4
153004p	5.9	5.3	5.7	3.2
153004q	6.8	6.2	5.7	3.7
153004r	7.0	6.3	7.0	4.3
153004s	7.6	6.7	7.0	4.3
153004t	7.7	6.9	7.4	4.5
153004u	8.4	7.6	7.8	4.8
153004v	8.7	8.0	7.8	4.8
153004w	10.4	9.2	9.7	5.8
153004x	11.8	10.6	11.4	6.8
153004y	13.2	11.7	12.0	7.8
153004z	13.9	12.4	12.3	8.0
153004a'	14.0	12.6	12.8	9.4
153004b'	14.3	12.7	13.7	8.4
153004c'	15.0	13.5	13.7	10.0
153004d'	15.8	14.4	15.0	9.1
153004e'	17.5	15.7	15.9	10.3
153004f'	17.7	15.7	16.5	11.8
153004g'	18.0	15.7	15.1	11.2
153004h'	18.1	16.1	17.5	10.5
153005i'	18.2	16.0	16.9	12.4
153004j'	19.0	16.8	17.4	12.3
153004k'	19.4	17.5	18.4	14.6
153004-l'	19.8	17.5	18.3	13.2
153004m'	20.5	18.0	17.2	14.7
153004n'	21.0	18.5	18.9	14.7
153004o'	21.0	18.5	19.7	15.2
153004p'	22.1	20.3	21.8	15.5
153004q'	23.0	19.9	21.9	15.6
153004r'	23.5	21.3	23.0	16.4
153004s'	24.0	21.4	21.6	16.1
153004d (holotype)	22.3	20.4	21.8	15.5
King 174				
YPM 12203	21.3	19.3	18.0	12.0

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member).

LOCALITIES.—USNM 702d, 702e, 716n.

DIAGNOSIS.—Shell thick and convex, fold high, growth lines few but strong.

TYPES.—Holotype: USNM 153004d. Figured paratypes: USNM 153004a-c, e-g. Measured and unfigured paratypes: USNM 153004h-z, a'-s'.

COMPARISON.—*Composita apsidata* is characterized by its thick convex shell with the fold high at the anterior, and its rather widely spaced but strong growth laminae that produce the effect of overlapping shingles. In this respect it resembles *C. imbricata*, new species, differing in its smaller maximum size, more narrowly arched and less flattened fold, and especially in its narrower outline and proportionately greater thickness. It is smaller and narrower than most specimens of *C. stalagmum* or *C. crassa*, both new, and differs further from them in its stronger and more numerous growth laminae. It is proportionately a little wider than *C. enormis*, and also differs from that species in its smaller size, stronger growth laminae, and shorter pedicle beak. *Composita affinis* Girty has somewhat similar growth laminae, but is flatter and more circular than *C. apsidata*. *Composita cracens*, new species, is similar in shape, but *C. apsidata* is thicker, and has stronger growth laminae distributed over most of the shell. It also is thicker than *C. apheles*, new species, and has stronger growth laminae, a narrower and more strongly arched fold, and commonly a proportionately narrower outline.

DISCUSSION.—This species was included by R. E. King (1931) in the group designated *C. mira* (Girty). The type of *C. mira* is a *Cleiothyridina*, as explained below under discussion of *Composita imbricata*. The form illustrated by R. E. King (1931, pl. 44: fig. 7) is distinct from that in fig. 4 on the same plate, and belongs to *C. apsidata* as presently constituted.

Composita bucculenta, new species

PLATE 654: FIGURES 1-68

Small for genus, strongly biconvex; outline transversely subpentagonal; commissure strongly parasulcate; fold beginning about 3-5 mm anterior to brachial beak, crest slightly flattened at anterior, lateral troughs deep, producing trilobation of shell longer than about 5 mm; sulcus only

at commissure, not forming depression in valve; growth laminae absent from some shells, normally two or three rather strong near valve edges.

Pedicle valve strongly inflated in umbonal region; beak short, thick, blunt, suberect to erect; foramen proportionately small, oval or elliptical, periphery incomplete at anterior; edge of valve flanged in most specimens. Brachial valve also most strongly convex near posterior; beak blunt, strongly incurved; valve edge normally flanged.

Pedicle valve interior with short thin dental plates cemented to wall in posterior, with anterior edges free; teeth short, sharp, slightly hooked; muscle area shallowly impressed, individual marks not distinguishable.

Brachial valve interior with short hinge plate anteriorly emarginate, sides formed by hinge sockets and crura; cardinal process low, broad, cemented to apex of valve; muscle area weakly impressed, apparently typical for genus; descending lamellae and jugum as described for genus; full spirillum not observed, fragments appear normal.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 702ent				
153005e (holotype)	10.0	9.6	11.7	7.9
153005g	2.9	2.7	2.6	1.7
153005h	3.4	3.2	3.3	2.2
153005i	3.7	3.4	3.6	2.4
153005j	4.0	3.8	4.1	2.8
153005k	4.3	4.0	4.3	3.0
153005l	4.5	4.2	4.8	3.1
153005m	4.9	4.7	5.0	3.9
153005n	5.1	4.7	5.6	3.9
153005o	5.6	5.1	5.6	4.0
153005p	6.2	5.6	6.1	4.7
153005q	6.3	5.7	6.5	5.1
153005r	6.4	6.0	6.6	5.7
153005s	6.9	6.4	7.3	6.0
153005t	7.0	6.5	7.2	5.2
153005u	7.4	6.9	7.8	6.2
153005v	7.8	7.3	8.3	6.5
153005w	7.9	7.3	8.9	6.1
153005x	8.0	7.5	9.0	6.6
153005y	8.8	7.9	8.9	7.3
153005z	9.0	8.6	9.2	7.3
153005a'	9.6	8.9	9.6	8.0
153005b'	9.8	8.8	10.5	7.8
153005c'	9.8	9.0	10.9	7.8
153005d'	10.3	9.6	11.8	7.9

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch

Formation (Sullivan Peak Member); Hess Formation (and Taylor Ranch Member); Cathedral Mountain Formation (Wedin Member); Road Canyon Formation.

LOCALITIES.—Sullivan Peak: USNM 707d, 722h. Taylor Ranch: USNM 702f, 702m. Hess: USNM 726n. Wedin: USNM 714w, 717e, 723v. Cathedral Mountain: AMNH 500D; USNM 702, 702b, 702ent, 702-low, 702un, 703b, 708, 721u. Road Canyon: AMNH 501; USNM 726f.

DIAGNOSIS.—Shell small, outline transverse, umbonal regions inflated, commissure parasulcate.

TYPES.—Holotype: USNM 153005e. Figured paratypes: USNM 153005a-d,f; 154548a-g. Measured paratypes: USNM 153005g-z,a'-d'.

COMPARISON.—*Composita bucculenta* is characterized by its small size among Texas Permian species, its transverse outline, strongly inflated umbonal regions of both valves, short pedicle beak and small foramen, and especially by its strong parasulcation, which actually produces an auxiliary plication on each side near the fold of many individuals. It most resembles *C. parasulcata*, new species, from the Road Canyon and Word formations, differing in its smaller size, wider outline, shorter thicker pedicle beak, and normally stronger parasulcation. It also resembles *C. pilula*, new species, but differs in its smaller size and wider outline, stronger parasulcation and shorter beak, and in its thinner shell and less strongly divided hinge plate. Other species are not closely similar to *C. bucculenta*.

Composita costata, new species

PLATE 653: FIGURES 1-10

Small for genus, strongly biconvex; outline transversely subelliptical to subpentagonal, widest near midlength or slightly posterior; commissure parasulcate, with 2 or 3 low costae on each side of some specimens; fold low, with flattened crest; sulcus not depressed below flanks; lateral parasulcations distinctly outlining fold; sporadic auxiliary costae expressed only near commissure, not plicating major portion of shell; growth laminae very weak, apparent only near margins of some shells, leaving most of shell essentially smooth.

Pedicle valve strongly inflated in umbonal region; beak short, blunt, suberect; foramen sub-

circular, proportionately somewhat small. Brachial valve strongly inflated in umbonal region, with nearly flat profile along crest of fold.

Pedicle valve interior with very small teeth; dental plates short, thin, sloping posteriorly from teeth toward floor, fused to walls for about half length; muscle area weakly impressed in thin shell, size and pattern normal for genus.

Brachial valve interior with hinge plate short, wide; cardinal process short, bilobed, somewhat concave mesially, each lobe with small diductor mark; sockets short, shallow, rather wide; muscle area shallow, details obscure; crura, lamellae, and spiralia not observed.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 725y				
153006a (holotype)	5.3	4.8	5.4	3.8
153006d	c.6.0	5.6	5.7	4.1
153006e	6.7	6.0	7.1	4.5
153006f	4.9	4.4	4.9	3.6
153006g	4.8	4.3	4.9	3.6
153006h	4.4	3.9	4.4	3.2
153006i	4.4	4.0	4.1	3.3
153006j	4.0	3.8	4.1	3.6
153006k	4.0	3.7	4.0	2.9
153006l	3.9	3.5	3.5	2.3
153006m	3.1	2.8	3.1	2.0
153006n	3.1	2.9	2.9	1.9
153006o	2.9	2.6	2.9	1.7

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITY.—USNM 725y.

DIAGNOSIS.—Shell small, outline transverse, commissure parasulcate, many specimens weakly costate.

TYPES.—Holotype: USNM 153006a. Figured paratypes: USNM 153006b,c. Measured paratypes: USNM 153006d-o.

COMPARISON.—*Composita costata* is characterized by its small size, transverse outline, parasulcate commissure, and weak costation of some shells. It clearly is related to *C. bucculenta*, new species, with many shells nearly identical in shape. It differs in its much smaller size (specimens of *C. bucculenta* the size of large *C. costata* are rectimarginate or have only the beginnings of plication) somewhat weaker parasulcation, and in the costation of some shells. No other species closely resembles this distinctive little shell, so further detailed comparisons are unnecessary.

Composita cracens, new species

PLATE 653: FIGURES 38–52

Composita emarginata affinis Stehli [not Girty, 1909], 1954: 532, pl. 27: fig. 15–18.

About average size for genus, moderately bi-convex; outline subovate, commonly elongate, less commonly equidimensional, rarely transverse; commissure uniplicate; fold standing only slightly above flanks, expressed as dull ridge along mid-line of valve, no sharp demarcation from flanks; sulcus shallow, some with weak narrow median trough; growth laminae commonly absent from most of shell, moderately strong and numerous near margins.

Pedicle valve flatly to moderately convex, strongest inflation in umbonal area; beak short, thick, suberect; foramen normal size, periphery very narrowly incomplete (rarely complete); valve edges sharp, or slightly flattened to meet opposite valve. Brachial valve somewhat less convex, beak and crest of fold slightly inflated or raised.

Pedicle valve interior with strong, blunt hinge teeth; dental plates slightly bowed distally, cemented to valve walls by secondary shell for most of length, only anterior edges free; muscle area elongate, spatulate, moderately strongly impressed, pattern normal for genus; posterior of valve thickened somewhat, with shallow pitting aligning toward anterior to produce weak radial pallial lines.

Brachial valve interior with strong hinge plate developed between stout crural bases; cardinal process bilobed, short to rather long, each lobe with distinct muscle scar; muscle area elongate, narrow, bisected in posterior by short, low ridge; posterior of valve thickened and pitted as in opposite valve; crura, descending lamellae, and spiralia not observed.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 728f				
153007a	2.1	2.0	1.9	1.3
153007b	2.3	2.1	2.0	1.5
153007c	2.4	2.1	2.0	1.3
153007d	2.7	2.4	2.3	1.6
153007e	3.2	2.9	2.9	1.9
153007f	3.3	2.9	3.0	2.0
153007g	3.7	2.4	3.6	2.1
153007h	4.0	3.7	3.4	2.4

	brachial			
	length	valve length	width	thickness
153007i	4.2	3.8	3.4	2.6
153007j	4.7	4.1	4.0	2.9
153007k	4.9	4.2	4.0	2.9
153007-l	5.5	4.8	4.8	3.2
153007m	5.8	5.3	5.5	3.5
153007n	6.3	5.9	5.5	3.6
153007o	7.3	6.6	6.5	4.1
153007p	7.7	6.9	6.5	4.5
153007q	7.7	7.0	7.5	4.4
153007r	7.8	7.2	7.3	4.7
153007s	8.9	8.0	7.9	5.3
153007t	10.0	9.1	8.7	5.8
153007u	11.0	10.0	10.0	
153007v	13.1	12.8	11.4	7.0
153007w	14.5	13.2	12.7	—
153007x	17.5	16.1	14.9	—
153007y	17.6	16.9	15.6	11.8
153007z	19.1	17.3	17.0	10.8
153007a'	20.0	18.0	18.2	—
153007b'	21.5	19.3	18.6	—
153007c'	23.2	21.7	21.1	—
153007d'	23.7	22.7	21.0	—
153007e'	23.9	21.5	23.8	—
153007f'	27.0	24.6	25.0	17.3
USNM 728g				
155122a	3.6	3.3	3.5	2.3
155122b	4.0	3.6	3.6	2.6
155122c	4.3	4.0	4.2	2.9
155122d	4.8	4.6	4.3	3.0
155122e	5.0	4.6	4.5	3.1
155122f	5.5	5.0	4.6	3.3
155122g	5.6	5.0	5.2	3.5
155122h	5.9	5.5	5.6	4.2
155122i	6.5	5.7	6.1	4.8
155122j	6.7	6.2	5.8	4.3
155122k	6.9	6.0	6.6	4.8
155122-l	7.0	6.3	6.7	4.7
155122m	7.7	6.9	7.6	5.1
155122n	8.7	7.9	7.5	5.5
155122o	9.1	8.0	8.6	5.3
155122p	9.6	8.4	8.2	5.3
155122q	10.0	9.0	10.0	6.6
155122r	10.8	9.6	10.7	6.9
155122s	11.8	10.3	c.11.0	6.9
155122t	12.2	11.0	12.3	7.3
155122u	12.7	11.0	10.4	7.9
155122v	13.0	11.6	12.0	8.0
155122w	14.7	13.0	13.1	9.0
155122x	16.2	14.7	15.7	9.6
155122y	17.0	15.0	15.0	10.1
155122z	18.7	16.3	16.7	11.4
155122a'	18.7	16.2	16.7	12.0
155122b'	19.0	17.0	17.0	11.5
155122c'	21.1	18.6	18.6	13.0
USNM 728e				
153008a (holotype)	25.5	22.8	28.5	18.0

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation; Hueco Canyon Formation.

LOCALITIES.—Bone Spring: AMNH 369, 492, 497, 591, 624, 625, 631, 632, 634, 697; USNM 728e, 728f, 728g, 728h. Hueco Canyon: USNM 712e, 719, 720a, 720b, 720c, 725b, 725z.

DIAGNOSIS.—Outline elongate, fold strong at commissure but not standing high above flanks, shell nearly smooth.

TYPES.—Holotype: USNM 153008a. Figured paratypes: USNM 153007g'–k'. Measured and unfigured paratypes: USNM 153007a–z, a'–f'; 155122a–z, a'–c'.

COMPARISON.—*Composita cracens* is characterized by its average size for a Permian species of the genus, commonly elongate ovate outline, strong fold at the commissure, a low, rounded ridge along the shell, without being distinctly set off from the flanks, and its smooth exterior except for a few strong growth laminae at the margins. It is narrower and not as large as *C. stalagmium*, new species, and *C. crassa*, new species, which have similar appearing folding. Its maximum size is much smaller than that of *C. enormis*, new species, and its outline less distinctly elongate. It also is smaller than *C. prospera*, new species, somewhat less strongly folded, and its beak is shorter and blunter. *Composita apheles*, new species, is similar, but *C. cracens* is more strongly and narrowly folded, has weaker growth laminae, is not as trigonal in outline, and has a somewhat more attenuate pedicle beak. This species is much larger, and not likely to be mistaken for such new species as *C. pilula*, *C. bucculenta*, *C. parasulcata*, and others that resemble this group.

Stehli (1954) identified this species with *C. affinis* Girty. Aside from occurring at a very different level (Bone Spring, not Capitan) this species differs from Girty's in its stronger convexity, weaker growth laminae, more elongate and less circular outline, higher fold, and longer pedicle beak with proportionately larger foramen. It differs from the most abundant Wolfcampian species of the Glass Mountains, *C. strongyle*, new species, in its greater convexity, stronger fold, and especially in its less circular outline.

DISCUSSION.—The locality where *C. cracens* is most abundant (USNM 728f = AMNH 629) is about a quarter mile south of the mouth of Victorio Canyon in the Sierra Diablo. In the

collection of several hundred valves only one large shell is articulated, and that one is held together by encrusting Bryozoa that cover the commissure on the right side (there are numerous articulated small shells). This indicates that the collection probably represents a death assemblage, so there may have been considerable sorting before burial.

This species also occurs at USNM 728e (AMNH 625) only a short distance away, at the entrance to Victorio Canyon. There and in nearby localities in the Baylor Mountains the species is not as abundant, but a few more articulated adult shells are present. These are characteristically wider than those from USNM 728f, and more nearly resemble *C. stalagmium*, new species, from the Glass Mountains. However, they seem to belong with the majority of *C. cracens*, on the basis of the shape of the fold, the typical appearance of the growth laminae at the margins, and by the presence in most shells of the shallow median groove in the sulcus that is completely absent from *C. stalagmium* or *C. crassa*, which otherwise are similar.

Composita crassa, new species

PLATE 655: FIGURES 1–39

Composita persinuata R. E. King [not Meek, 1877], 1931:130, pl. 43: figs. 18–19.

About average size for genus, moderately to strongly biconvex; outline subtrigonal to subovate, normally widest anterior to midlength; commissure moderately to strongly uniplicate; fold standing only slightly above flanks at anterior, crest broadly or narrowly arched, or slightly flattened, beginning about 10 mm anterior to brachial beak; sulcus shallow, depressed below flanks only near anterior, many with shallow median groove; lateral broad plications shallow, producing weak parasulcation on some specimens; growth laminae moderately strong near margins of most specimens, weak on some, beginning farther posterior on others; weak radial lirae visible on some.

Pedicle valve most strongly convex near midlength or in umbonal region; beak thick, long, suberect to slightly incurved; foramen proportional to size of shell, ovate, periphery narrowly incomplete at anterior; valve edges sharp or very

slightly flanged. Brachial valve inflated in umbonal region; beak short, bluntly pointed, overlapped by pedicle beak; fold arising from flanks without sharp flexure.

Pedicle valve interior with dental plates nearly parallel, anterior edges free, posterior halves cemented to valve walls; posterior not greatly thickened by secondary shell material; muscle marks shallowly impressed, pattern normal for genus; hinge teeth short, blunt, curved, supported by dental plates.

Brachial valve interior with large hinge plate distinctly divided into three elements, two crural bases at sides and thin median part projecting forward slightly; sockets, deep, formed by socket plates lateral to crural bases; full spirillum not observed, fragments indicate pattern typical for genus; muscle marks moderately impressed, normal for genus; cardinal process broad, long, perpendicular to hinge plate, cemented to apex of valve, bilobed, with distinct muscle mark on anterior surface of each lobe.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain and Road Canyon formations; possibly Cibolo Formation.

LOCALITIES.—Cathedral Mountain: AMNH 504; USNM 702a, 703a¹, 711w. Road Canyon: AMNH 503, 509; USNM 703, 703a, 703c, 703d, 706f, 707e, 709c, 710u, 710z, 716x, 716xa, 716z, 719x, 720d, 721j, 721o, 721r, 721s, 721t, 721w, 721x, 721y, 721z, 722e, 722f, 722g, 723a, 724a. Cibolo (doubtful): AMNH 703.

DIAGNOSIS.—Shell large, outline subtrigonal to subovate, umbonal regions inflated, beak long and thick, shell substance not thickened.

TYPES.—Holotype: USNM 153009g. Figured paratypes: USNM 153009a-f, h, i. Measured paratypes: USNM 153009j-z, a'-z', a''-e''.

COMPARISON.—*Composita crassa* is characterized by its relatively large size for the genus, which nevertheless is about average size for Permian representatives, its subtrigonal to subovate outline, swollen umbonal regions, thick and proportionately long ventral beak, gently arched or slightly flattened fold, and its generally nonthickened valves, unusual in a species attaining this size. It most nearly resembles *C. stalagmium*, new species, differing in its more elongate outline, and thicker ventral beak, and a shallow median goove in the sulcus of many specimens. It differs

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 719x				
153009j	2.0	1.8	1.6	1.2
153009k	2.3	2.0	2.0	1.4
153009-l	2.8	2.5	2.6	1.6
153009m	2.9	2.6	2.4	1.7
153009n	3.0	2.7	2.2	1.8
153009o	3.7	3.3	3.1	2.3
153009p	4.0	3.6	3.0	2.3
153009q	4.3	3.9	3.6	2.6
153009r	4.5	3.9	3.8	2.7
153009s	5.3	4.7	4.0	3.3
153009t	5.5	5.0	4.6	3.3
153009u	5.9	5.1	4.0	3.8
153009v	6.1	5.5	4.9	3.8
153009w	7.0	6.0	5.0	4.7
153009x	7.5	6.6	6.0	4.4
153009y	7.9	7.0	6.4	5.4
153009z	8.0	7.1	7.3	4.5
153009a'	8.9	7.7	6.8	5.7
153009b'	9.2	8.3	8.8	5.4
153009c'	9.9	8.5	8.8	7.0
153009d'	10.1	9.0	7.4	7.0
153009e'	10.4	9.3	9.0	6.6
153009f'	11.4	10.2	9.9	7.0
153009g'	12.0	10.8	10.0	7.5
153009h'	12.6	11.3	10.9	7.1
153009i'	13.0	11.7	10.3	8.3
153009j'	14.0	12.6	12.2	8.3
153009k'	14.4	13.3	13.6	8.5
153009-l'	14.7	13.2	12.9	9.3
153009m'	15.6	14.3	12.9	12.2
153009n'	15.6	14.9	15.4	10.3
153009o'	17.9	16.5	16.3	10.7
153009p'	18.4	16.3	17.3	10.5
153009q'	18.5	16.7	19.8	13.0
153009r'	19.7	18.0	19.6	14.7
153009s'	20.2	18.4	17.0	13.4
153009t'	21.5	19.2	19.6	16.0
153009u'	22.9	20.6	21.7	15.5
153009v'	23.0	21.5	22.7	17.7
153009w'	23.6	21.4	20.8	15.2
153009x'	24.9	23.0	27.9	16.9
153009y'	27.9	24.0	25.3	19.0
153009z'	28.0	25.0	26.0	18.1
153009a''	28.3	25.0	26.1	17.4
153009b''	28.4	26.4	24.0	20.8
153009c''	29.7	26.0	26.4	19.6
153009d''	31.9	28.0	30.0	20.6
153009e''	32.5	29.3	30.7	21.9
153009g (holotype)	33.0	29.3	30.5	22.2

from *C. imbricata*, new species, in the same features, and also in its less prominent growth laminae. This species is less elongate and more trigonal in outline than *C. enormis*, new species,

and does not reach as large a maximum size. It is larger than *C. strongyle*, new species, less circular in outline, more convex in profile, and has a longer beak.

This species is similar to *C. cracens*, new species, from the Bone Spring Formation, but differs in its larger maximum size, more trigonal outline, greater thickness, and longer, thicker, more strongly curved beak. The greater thickness and absence of an indented anterior margin differentiates it from *C. emarginata* Girty, which attains a similar size. *Composita prospera*, new species, from the Getaway Member becomes much larger than *C. crassa*, whereas *C. apheles*, new species, from the Bone Spring Formation at Black John Canyon is smaller, more circular, thinner and has a shorter beak.

Composita discina, new species

PLATE 656: FIGURES 1-20

Composita mexicana [part] R. E. King [not Hall, 1857], 1931: 128, pl. 43: figs. 1-3,5,8,9 [not figs. 4,6,7,10,11].

About average size for genus, flatly to moderately strongly biconvex; outline subcircular, roundly subpentagonal, or ovate; commissure uniplicate; fold low, crest evenly arched or bluntly ridged, standing distinctly above flanks only at anterior; sulcus shallow, normally with narrow median groove for most of length of shell; growth laminae weak, absent from some shells, most frequent near margins; radial fibrous ornament very weak.

Pedicle valve evenly convex; beak short, blunt, normally suberect, less commonly erect; foramen ovate, about average proportionate size for genus. Brachial valve with low median crest, beginning with inflated and somewhat elongate beak.

Pedicle valve interior with hinge teeth, dental plates and muscle area in normal arrangement; details not observed. Brachial valve interior with hinge plate formed between crural bases, inner hinge plates thinly fused at midline; cardinal process short, bilobed, cemented to valve apex; sockets deep, between hinge plate and valve walls; muscle area shallowly impressed; spiralia not observed.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Lenox

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 714p				
153010d	3.8	3.4	3.2	2.5
153010e	4.7	4.3	4.4	2.8
153010f	6.8	6.0	5.9	4.0
153010g	8.4	7.7	7.9	5.0
153010h	12.3	11.0	11.6	7.3
153010i	13.6	12.1	12.0	7.4
153010j	14.2	12.8	12.8	8.0
153010k	14.6	12.8	13.9	9.0
153010l	18.4	17.0	16.6	10.9
153010m	c.19.0	17.7	18.7	12.0
USNM 711d				
153011a	6.6	6.1	6.5	4.5
153011b	7.0	6.1	6.0	4.8
153011c	10.8	9.5	10.0	7.4
153011d	11.4	10.3	11.7	7.0
153011e	11.7	10.5	11.0	7.9
USNM 705				
153012a	16.4	14.4	14.2	9.4
USNM 708q				
153013a (holotype)	19.6	17.7	20.0	12.3
153013b	c.10.0	c.8.5	9.3	5.5
153013c	15.5	13.7	15.2	8.4
153013d	c.16.6	c.15.0	16.2	10.1
153013e	16.0	15.0	16.7	9.6
USNM 707w				
153014a	9.0	8.0	8.4	5.4
153014b	10.5	8.9	9.8	6.3
153014c	11.8	10.7	11.0	7.0
153014d	12.6	11.2	12.6	7.5
153014e	c.14.0	12.8	14.0	8.3
153014f	14.2	12.4	13.4	8.0
153014g	15.0	14.0	15.4	9.0

Hills Formation; Skinner Ranch Formation (Decie Ranch and Sullivan Peak members).

LOCALITIES.—Gaptank: USNM 708p. *Uddenites*: USNM 713a. Lenox Hills: USNM 705, 705k, 713q, 713y, 716r. Decie Ranch: USNM 707a, 707v, 707w, 715a. Skinner Ranch: USNM 708q, 711d, 711p, 711z, 712p, 714p, 716q, 720e.

DIAGNOSIS.—Outline equidimensional, beak short, dorsal umbo inflated, sulcus with shallow median groove.

TYPES.—Holotype: USNM 153013a. Figured paratypes: USNM 153010a-c. Measured and unfigured paratypes: USNM 153010d-m, 153011a-e, 153012a, 153013b-e, 153014a-g.

COMPARISON.—*Composita discina* is characterized by its moderate convexity, nearly equal length and width, short ventral beak, swollen dorsal beak, and shallow median groove in the sulcus

of most specimens. It resembles *C. strongyle*, new species, but differs in the smaller size of most specimens, and in its less uniformly circular outline, somewhat greater average convexity, and in its median groove in the sulcus. Lack of parasulcation distinguishes *C. discina* from *C. bucculenta*, *C. parasulcata*, and *C. pilula*, all new, which are in about the same size range. *C. discina* is much smaller than and quite dissimilar from *C. stalagmum*, *C. enormis*, *C. prospera*, or *C. crassa*, all new.

Composita emarginata Girty

PLATE 655: FIGURES 40–51

Composita emarginata Girty 1909:388, pl. 15: fig. 1–5a.

Large for genus, flatly to moderately strongly biconvex; outline subpentagonal with emarginate anterior; commissure rectimarginate in juveniles and some adults, uniplicate in most adults; fold low, broadly arched, not expressed as ridge or crest along shell, actually depressed in some shells, emphasizing emargination of anterior; sulcus shallow, indenting shell only at emarginate anterior and for slight distance posterior in some, with narrow median groove in many; growth laminae moderately strong, widely and randomly spaced, more frequent near margins; radial fibrous ornament weak.

Pedicle valve flatly to moderately convex; beak short, somewhat attenuate, suberect to slightly incurved; foramen normally rather small for size of shell, larger in some specimens, ovate, with periphery narrowly incomplete. Brachial valve somewhat more strongly convex; shallow median groove along flattened crest of fold of some specimens.

Pedicle valve interior with large blunt hinge teeth; dental plates slightly convergent, outlining pedicle and adjustor muscle cavity; muscle area elongate, with larger distal diductors surrounding smaller median adductor marks; posterior of valve thickened, shallowly pitted; alligned pits radiating anteriorly, becoming shallow pallial lines.

Brachial valve interior with large thickened hinge plate formed between crural bases; cardinal process extending posteriorly, about perpendicular to hinge plate, bilobed, each lobe with small circular muscle marks on anteriorly facing

surface; crura, descending lamellae, and spiralia not observed; muscle area elongate, moderately deeply impressed, pattern normal for genus, with low median ridge in posterior; shell thickened and shallowly pitted in posterior, as in pedicle valve.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 731				
153015	3.0	2.6	2.4	1.6
USNM 733				
153016a	4.9	4.4	3.9	2.7
153016b	7.9	7.4	7.9	4.4
153016c	8.8	8.0	8.3	4.5
153016d	37.3	33.9	31.9	?
USNM 740				
153017a	8.9	8.0	7.7	4.8
153017b	c.14.0	13.2	13.0	6.7
153017c	14.3	13.0	11.0	7.7
153017d	15.0	13.7	11.1	9.7
153017e	15.9	14.2	11.4	10.5
153017f	16.7	15.4	14.4	9.4
153017g	17.3	15.9	c.14.0	9.2
USNM 750a				
153018a	17.1	15.3	c.17.5	9.0
153018b	20.6	18.3	17.8	12.3
153018c	21.5	19.0	19.6	13.0
153018d	c.23.0	21.0	21.0	13.7
USNM 738a				
153019a	9.2	8.1	7.9	4.8
153019b	11.4	10.0	10.6	6.0
153019c	12.7	11.3	11.6	6.4
153019d	17.3	15.7	14.9	10.5
153019e	19.2	17.0	16.1	11.0
153019f	19.5	17.8	19.3	10.0
153019g	23.5	21.8	c.21.0	16.4
153019h	23.9	21.5	21.7	15.0
153019i	24.0	21.9	21.0	16.7
153019j	28.8	26.0	27.6	15.0
153019k	33.7	31.0	c.35.0	20.3
USGS 2926				
118608a (lectotype)	19.2	17.4	17.8	12.4
118608b	14.1	13.0	12.7	7.2
118608c	12.7	19.6	19.5	12.9
118608d	22.7	20.8	19.6	13.2

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, and Rader members); Capitan Formation.

LOCALITIES.—Capitan: AMNH 475, 803, 806; USGS 2926; USNM 725-1, 737a, 738a, 740, 740h, 740k, 740-l, 740m, 740n, 750a. Hegler: USNM 731. Pinery: AMNH 398, 401, 524, 537; USNM 733, 736, 736a. Rader: AMNH 388, 403, 410;

USNM 725g, 725n, 725o. Lamar: AMNH 37; USNM 738b.

DIAGNOSIS.—Shell large, convexity low, fold and sulcus with shallow median grooves, anterior outline emarginate.

TYPES.—Lectotype (here designated): USNM 118608a (See Girty, 1909, pl. 15; fig. 2-2c). Figured paratypes: USNM 118608b-e (Girty, 1909, pl. 15: figs. 1-1c, 3-5a). Figured hypotypes: USNM 154545a, b; 154546a. Measured hypotypes: USNM 153015, 153016a-d, 153017a-g, 153018a-d, 153019a-k.

COMPARISON.—*Composita emarginata* is characterized by its large maximum size, low biconvexity, shallow median grooves in the sulcus and along the crest of the fold in many specimens, and the shallow emargination of the anterior outline of most. Emargination may result from the meeting of the two shallow median grooves at the anterior, or in other shells it may be the result of strong indentation of the anterior tongue of the sulcus. Girty (1909) emphasized the two median grooves, but the anterior emargination seems to be present even in specimens where one or both grooves are absent, and is a more consistent character. This species most nearly resembles *C. affinis* Girty, which occurs mainly higher in the Guadalupian, but differs in its larger maximum size, stronger biconvexity, presence of a shallow median longitudinal groove in one or both valves, and especially in its slightly or strongly emarginate anterior. It is not closely similar to other species from the region.

Composita enormis, new species

PLATE 656: FIGURES 21-51

Composita emarginata affinis R. E. King [not Girty, 1909], 1931:128, pl. 43: figs. 12-17.—Cloud, 1944:65, pl. 18: figs. 20-22.

Large size for genus, profile moderately biconvex, cross section strongly biconvex; outline commonly narrow, elongate, subovate, rarely subcircular; commissure narrowly uniplicate, fold beginning about 10 mm or more anterior to pedicle beak, crest low, rounded, standing above flanks only slightly at anterior margin; sulcus shallow, depressed only at anterior where extending to fill fold; growth laminae weak, widely distributed, most frequent near margins.

Pedicle valve evenly convex in posterior two-thirds, with greatest swelling just anterior to beak; umbonal region strongly convex transversely; beak short, normally not attenuate, suberect to slightly incurved; foramen proportionately somewhat small, ovate, periphery narrowly open at anterior; edge of valve sharp or slightly flanged. Brachial valve slightly less strongly convex, greatest swelling just anterior to umbo; beak abruptly pointed, apex within pedicle valve.

Pedicle valve interior with dental plates slightly divergent toward floor, closely approximating valve walls, space between plates and walls with varying amounts of secondary shelly material, completely filled in many specimens, partly filled in others, leaving anterior edges of plates free (proportionately slightly less secondary cementation of dental plates in small shells); muscle area deeply impressed, especially in large shells with thickened posterior; adductor mark depressed slightly below surrounding diductor marks; posterior floor distinctly pitted in adults; radiating pallial marks relatively weak; valve edges slightly flattened mesially, flanged laterally.

Brachial valve interior with short strong cardinal process projecting nearly directly posteriorly, fused to apex of valve, edges slightly curled inward, areas of muscle attachment minutely corrugated; sockets deep, formed by edges of cardinal process extending lateral to hinge plate; crural bases stout, reinforced at posterior by secondary thickening of themselves and of socket plates; area between crural bases webbed over to form hinge plate; crura short, tapered anteriorly; descending lamellae and jugum, as described for genus; spiralia with 8 or 9 coils; muscle area elongate, narrow, slightly less strongly impressed than in opposite valve; posterior part of floor thickened and pitted; valve edges sharp at sides, to fit lateral flanging of opposite valve, flat on crest of fold, to fit flattened edge of pedicle valve there.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation; Word Formation (China Tank, Willis Ranch, and Appel Ranch members and lens between the last two); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Road Canyon: USNM 700v, 706f, 713, 721j, 732j, 736x. China Tank: USNM 706c, 726s. Willis Ranch: AMNH 505; USNM 706,

MEASUREMENTS (in mm).—

	brachial		width	thickness
	length	valve length		
USNM 706b				
153020a	12.0	10.6	8.9	6.9
153020b	19.3	17.5	15.2	11.2
153020c	24.0	21.8	20.0	15.9
153020d (holotype)	28.8	25.5	24.5	16.6
153020e	28.0	25.8	25.0	14.6
153020f	2.6	?	2.5	1.6
153020g	2.7	?	2.3	1.7
153020h	3.0	?	2.4	1.8
153020i	3.4	?	2.9	1.9
153020j	3.6	?	3.0	2.2
153020k	4.2	?	3.5	2.6
153020-l	4.9	4.5	3.9	3.1
153020m	5.3	4.6	4.4	3.0
153020n	6.3	5.4	5.2	3.8
153020o	6.5	5.8	5.7	3.9
153020p	6.7	5.8	5.3	4.0
153020q	7.8	6.8	6.3	4.4
153020r	8.6	7.4	6.1	5.0
153020s	9.1	8.0	7.0	6.2
153020t	9.6	8.6	7.3	5.9
153020u	9.9	8.6	8.0	6.0
153020v	11.7	10.3	9.9	6.3
153020w	12.9	11.7	10.8	7.1
153020x	13.2	11.6	10.4	7.8
153020y	14.2	12.8	11.6	7.9
153020z	15.9	14.3	11.7	9.7
153020a'	16.8	14.4	12.0	9.0
153020b'	18.5	16.4	14.0	10.9
153020c'	18.7	16.7	14.4	10.6
153020d'	19.0	17.5	14.7	12.1
153020e'	20.0	17.3	15.4	12.7
153020f'	20.0	17.8	16.3	13.0
153020g'	21.8	19.0	15.7	14.4
153020h'	23.5	21.2	17.0	13.4
153020i'	26.9	24.0	20.9	15.7
153020j'	27.0	23.9	21.7	16.1
153020k'	28.5	25.8	22.6	18.0
153020-l'	35.5	?	34.6	?
USNM 706e				
153021a	50.7	43.4	41.0	26.0
153021b	11.1	10.0	9.7	6.6
USNM 706c				
153022a	17.4	15.0	13.7	9.7
153022b	25.1	23.2	20.2	15.6
153022c	25.6	13.3	20.5	15.9
153022d	26.7	23.9	18.8	15.8

706e, 724u, 735c. Lenses: USNM 706b, 732c, 737w. Appel Ranch: USNM 704, 706d, 714o, 715i, 716v, 719z, 722t, 726t, 727j. Getaway: USNM 728, 732.

DIAGNOSIS.—Shell large, outline elongate, convexity low, beak short and blunt, fold low and narrow, posterior thickened, burying dental plates.

TYPES.—Holotype: USNM 153020d. Figured paratypes: USNM 153020a-c,e,f; 153021a; 154538a. Measured paratypes: USNM 153020a-c, e-z, a'-l'; 153021a,b; 153022a-d. Unfigured paratypes: USNM 153020g-z.

COMPARISON.—*Composita enormis* is characterized by its large maximum size, commonly elongate ovate outline, low longitudinal convexity, low and somewhat narrow fold, short blunt beak, and thickened posterior with short dental plates fused or nearly fused to sides of shell. This species was placed by R. E. King (1931:128) in *C. emarginata affinis* Girty, from which it differs in its narrower outline, weaker growth laminae, stronger convexity, and higher fold, with crest more rounded or pointed rather than somewhat flattened. It is more elongate, less convex, and has a shorter, less strongly curved beak, and its dental plates are more closely fused to the walls than in *C. crassa*, or *C. stalagmium*, both new.

This species is smaller on average than *C. prospera*, new species, although the very largest specimens of each species reach about the same size. *Composita enormis* differs further in its narrower outline, somewhat lower convexity, proportionately smaller pedicle foramen, and its lower fold. It differs from *C. parasulcata*, new species, with which it occurs, in its much larger size, more elongate outline, less globular shape, and especially in its fold that begins much farther anterior, and lacks the strong lateral sulci of that species.

Composita imbricata, new species

PLATE 658: FIGURES 1-36

Composita mira R. E. King [not Girty], 1931:129, pl. 44: fig. 4, [not pl. 44: figs. 3,5-8].

Larger than average size for genus, moderately strongly biconvex; outline subovate to subtrigonal, widest anterior to midlength; commissure broadly uniplicate, fold low at commissure, standing out slightly above flanks; sulcus shallow, growth laminae numerous, strong, producing imbricated effect, randomly spaced over most of shell, strongest and most frequent near margins.

Pedicle valve slightly inflated in umbonal region; beak short, thick, suberect; foramen ovate, size proportionately normal, periphery narrowly incomplete. Brachial valve also convex in umbonal

region, crest of fold flattened in many specimens to produce weak suggestion of divergent bounding ridges along sides.

Pedicle valve interior with dental plates thickened or cemented to walls by secondary shelly matter; pedicle area smooth on floor between anterior edges of plates and extending anteriorly about half length of valve, moderately to strongly impressed, deepest in most thickened shells, small adductor marks surrounded by larger crescentic diductor marks.

Brachial valve interior with short hinge plate formed between crural bases, secondarily thickened in some specimens; cardinal process short, distinctly bilobed, nearly perpendicular to hinge plate, each lobe with small circular diductor muscle mark; crura short, slender, projecting forward from crural bases at sides of hinge plate; descending lamellae and spiralia not observed; muscle area shallowly impressed, elongate spatulate, extending about half length of valve.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 702				
153023g	1.8	1.6	1.5	1.0
153023h	2.3	1.9	1.8	1.1
153023i	2.5	2.0	2.0	1.4
153023j	2.7	2.3	2.1	1.5
153023k	3.0	2.3	2.2	1.4
153023-l	3.0	2.7	2.5	1.7
153023m	3.2	2.8	2.5	1.8
153023n	3.3	2.9	2.5	1.8
153023o	3.6	3.1	3.0	1.8
153023p	3.9	3.3	3.3	2.0
153023q	4.1	3.6	3.0	2.3
153023r	4.4	3.9	3.8	2.3
153023s	4.6	4.0	4.0	2.5
153023t	5.0	4.2	4.2	3.0
153023u	5.2	4.6	4.8	3.3
153023v	5.6	5.0	5.1	3.3
153023w	6.0	5.5	5.3	3.6
153023x	6.9	6.1	6.3	3.9
153023y	7.2	6.5	7.0	4.7
153023z	7.9	6.8	6.6	4.4
153023a'	8.3	7.2	7.4	4.7
153023b'	8.8	7.9	8.1	5.4
153023c'	9.0	7.8	7.6	5.5
153023d'	9.2	8.1	8.7	5.8
153023f (holotype)	32.4	29.9	33.3	24.7
153023e'	9.3	8.3	8.5	6.0
153023f'	9.7	8.6	8.5	6.8
153023g'	10.0	8.6	9.5	6.5
153023h'	10.5	9.2	9.2	6.3

	brachial			
	length	valve length	width	thickness
153023i'	11.3	10.0	10.6	7.6
153023j'	11.4	10.0	9.3	6.8
153023k'	11.5	10.4	9.7	7.7
153023-l'	12.1	11.0	12.0	8.3
153023m'	12.5	11.3	11.0	7.9
153023n'	13.0	11.8	12.5	7.9
153023o'	13.2	11.6	12.9	9.8
153023p'	14.2	12.5	13.9	9.4
153023q'	15.9	14.6	14.0	10.5
153023r'	16.5	14.8	15.9	9.3
153023s'	16.9	15.0	15.8	9.0
153023t'	17.1	15.8	16.3	9.5
153923u'	18.0	16.5	17.1	10.3
153023v'	19.7	17.9	18.8	12.2
153023w'	20.1	18.1	19.0	12.8
153023x'	20.9	19.3	19.8	11.8
153023y'	21.8	20.4	19.5	14.0
153023z'	22.0	20.0	20.5	13.6
153023a''	23.5	21.8	23.0	14.6
153023b''	25.0	23.8	26.4	16.5
153023c''	25.1	22.6	24.7	14.0
153023d''	26.6	24.4	27.4	18.8
USNM 702b				
155123a	33.0	c.30.0	37.6	c.23.0
USNM 702un				
154541b	25.7	23.9	25.2	13.7
154541c	40.5	46.2	c.44.0	25.7
King 174				
YPM 12203	c.23.0	21.7	23.7	14.7

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—AMNH 500, 500B, 500D; USNM 702, 702b, 702un, 703b, 703bs, 708, 708c, 721u, 726o, 726u, 726y, 735b.

DIAGNOSIS.—Shell large, outline trigonal, fold flattened, growth laminae producing shingled effect.

TYPES.—Holotype: USNM 153023f. Figured paratypes: USNM 153023a-e, 154541a, 154541a, 154542a. Measured and unfigured paratypes: USNM 153023g-z, a'-z', a''-d''; 154541b,c; 155123a.

COMPARISON.—*Composita imbricata* is characterized by its large size (about average for Permian species), trigonal to ovate outline, flattened fold on many specimens, and by the rather strong growth laminae that produce a shingled effect over the anterior portion. Among the new Texas Permian species it most nearly resembles *C. stalagmium* and *C. crassa*, differing in its smaller maximum size, narrower outline, lower fold, and stronger growth laminae. It is larger, thicker, and more strongly folded than *C. strongyle*, and smaller and less elongate than *C. enormis*, both new.

Small to middle-sized specimens are similar to *C. apheles* in shape, but differ in their flat-crested folds and stronger growth laminae; *C. imbricata* attains a larger size than *C. apheles*. *Composita cracens* is similar in size and shape, but *C. imbricata* has stronger growth laminae, a more flattened fold, and attains a larger maximum size. It is larger than *C. apsidata*, new species, with which it was included by R. E. King (1931) under *C. mira* (Girty). In addition it is less convex, has a lower fold, lacks a median groove in the sulcus, and its growth laminae, while strong, are confined nearer the margins than in *C. apsidata*, new species.

DISCUSSION.—*Composita imbricata* is typically silicified in such a manner that a rough outer surface is produced. This may reflect an original roughened or fibrous condition of the shell, or may be a peculiarity of preservation.

R. E. King (1931) identified *C. imbricata* with *C. mira* (Girty), a name originally assigned to specimens that Meek (1877) identified as *Athyris roissii* Léveillé. Examination of Meek's specimens in the U.S. National Museum shows them to belong to a large, broad species of *Cleiothyridina*, probably more nearly related to *A. roissii* than to any species of *Composita*. The name applied to that species should be *Cleiothyridina mira* (Girty).

Composita mexicana (Hall)

PLATE 657: FIGURES 40–81

Terebratulina mexicana Hall, 1857, pl. 20: fig. 2.

Composita mexicana (Hall) Girty, 1909: p. 389 [including var. *guadalupensis*, p. 390, pl. 24: fig. 11–13b]; 1909a:68, pl. 8: fig. 1.—R. E. King, 1931:128, pl. 43: fig. 1–11.

Shell small, elongate to nearly equidimensional, moderately strongly biconvex; outline subpentagonal, widest anterior to midlength; commissure uniplicate to weakly parasulcate, fold low and flattened at commissure, crest barely raised above flanks; sulcus only a shallow and narrow trough; growth laminae very weak over most of shell, accentuated only near margins.

Pedicle valve beak long, swollen, suberect; foramen proportionately rather large, round to oval, incompletely formed. Brachial valve beak curved beneath foramen; greatest convexity farther for-

ward than in opposite valve; valve edges flanged, brachial valve edge overlapping pedicle valve edge at flanks.

Pedicle valve interior not thickened; teeth short and slight; dental plates short and thin; muscle area posteromesial, weakly impressed. Brachial valve interior with typically bilobed hinge plate; cardinal process consisting of thin flange projecting ventrally from posterior part of hinge plate; sockets deep; muscle area dual, consisting of narrow oval part median and somewhat anterior to two lateral lobes; spiralia and other brachial apparatus not observed.

MEASUREMENTS (in mm).—

USNM 725a	brachial			
	length	valve length	width	thickness
154540a	9.6	8.5	8.3	6.7
154540b	10.9	9.3	10.3	6.7
154540e	11.7	10.2	10.7	7.8
154540i	3.4	2.9	2.3	2.1
154540j	4.2	3.5	3.5	2.4
154540k	5.0	4.3	4.0	3.5
154540-l	5.4	4.8	5.0	3.4
154540m	7.2	6.2	6.7	4.8
154540n	8.0	6.9	7.4	4.9
154540p	10.4	8.9	9.0	6.7
154540q	10.9	9.4	9.6	7.7
154540r	11.9	10.5	9.8	8.0

STRATIGRAPHIC OCCURRENCE.—Hueco Formation.

LOCALITIES.—AMNH 653, 700; USNM 725a, 725b.

DIAGNOSIS.—Shell small, strongly convex, subpentagonal; growth laminae and fold strong only near commissure.

TYPES.—Holotype: figured by Hall in Emory, 1857, pl. 20: fig. 2. Figured hypotypes: USNM 154540a-i. Measured hypotypes: USNM 154540a, b, e, i-r.

COMPARISON.—*Composita mexicana* resembles several of the small species in the West Texas area. It is typically more elongate, has a longer beak and is much less strongly convex than *C. nucella*, new species, which occurs in the Cutoff Shale Member of the Bone Spring Formation. It is smaller, smoother, more elongate and more typically parasulcate than *C. apheles* from the Decie Ranch Member of the Skinner Ranch Formation. Another Bone Spring species, *C. apsidata*, new species, is larger than *C. mexicana*, not as rotund, and has a lower and broader fold and a sulcus that appears as a narrow groove.

Composita mexicana is not likely to be confused with *C. cracens*, new species, also from the Bone Spring Formation, because it is much smaller and narrower, with a longer beak and broad, flattened fold. *Composita bucculenta*, new species, from the Road Canyon Formation, which is more strongly parasulcate than *C. mexicana*, and much wider, is very distinct from the latter despite its small size, being much more strongly convex, and having the fold stand well above the flanks, especially toward the anterior margin.

DISCUSSION.—As with so many of the species that were described very early in the exploration of the West, it is difficult to decide which of those in our collection should be *Composita mexicana*. The locality for the specimen figured by Hall is obscure; it is not even certain that it came from Texas. We chose to adopt R. E. King's concept of the species rather than Girty's, however, because King's and our specimens more nearly resemble Hall's figure. Following King, therefore, the species is an early Permian form; we settled the name upon a distinctive species from the Hueco Limestone of the Baylor Mountains. Girty's species from the "Black Limestone" (i.e., the Bone Spring Formation) is not quite the same, and we have included it only tentatively in the synonymy. Thus far we have been unable to establish the identity of the Bone Spring species that Girty called *C. mexicana*.

Composita nucella, new species

PLATE 658: FIGURES 37-70

Small, moderately strongly biconvex; outline subpentagonal or subovate, elongate or equidimensional, rarely transverse, widest near or anterior to midlength; commissure nearly rectimarginate to uniplicate, most commonly weakly or strongly parasulcate; fold standing above flanks only at anterior, and only in about half of collection, crest gently arched or flattened; sulcus depressed slightly or not at all; growth laminae rather strong, especially near margins.

Pedicle valve slightly inflated in umbonal region; beak relatively long, thick, suberect to erect; foramen average size, oval, periphery incomplete; valve edges slightly thickened and flanged. Brachial valve also most strongly convex in umbonal region,

normally somewhat less strongly convex than opposite valve.

Pedicle valve interior with short hinge teeth slightly hooked inward; dental plates free for about half their length, fused to walls at posterior; muscle area elongate, spatulate, extending about half length of valve, pattern normal for genus.

Brachial valve interior with bilobate hinge plate; cardinal process also bilobed, perpendicular to hinge plate, short, with small round muscle mark on each lobe; muscle area elongate, narrow, bisected in posterior by low median ridge; descending lamellae, jugum, and spiralia not observed.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
AMNH 678				
153024c (holotype)	12.4	10.9	10.7	8.7
153024g	2.7	2.6	2.1	1.6
153024h	3.0	2.8	2.7	1.8
153024i	3.1	3.0	2.6	1.8
153024j	3.3	3.1	3.0	2.0
153024k	3.6	3.2	3.0	2.0
153024-l	3.7	3.5	3.2	2.1
153024m	4.0	3.5	3.3	2.5
153024n	4.4	4.0	3.7	2.7
153024o	4.7	4.0	3.8	2.8
153024p	4.9	4.5	4.3	3.2
153024q	5.2	4.8	4.3	3.1
153024r	5.8	5.3	5.0	3.7
153024s	6.2	5.6	5.7	4.0
153024t	6.5	5.7	5.3	3.9
153024u	7.0	6.3	6.0	4.4
153024v	7.9	7.0	6.0	4.8
153024w	8.7	7.9	7.4	5.4
153024x	8.9	8.0	7.9	5.8
153024y	9.0	8.0	7.6	5.8
153024z	9.7	8.7	7.5	6.6
153024a'	9.8	8.8	7.9	5.8
153024b'	10.0	8.9	8.9	7.0
153024c'	10.7	9.7	8.8	7.5
153024d'	11.0	10.0	9.0	7.7
153024e'	11.1	9.9	9.3	7.7
153024f'	12.0	10.9	10.0	9.0
153024g'	12.0	10.6	10.3	8.1
153024h'	12.5	11.0	10.8	8.9
153024i'	12.7	11.3	10.9	8.7
153025j'	12.8	11.2	11.8	8.5
153024k'	13.0	11.9	11.6	9.1
153024-l'	13.6	12.5	13.3	9.3

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (and Cutoff Member).

LOCALITIES.—Bone Spring: AMNH 660. Cutoff: AMNH 678. USNM 747.

DIAGNOSIS.—Shell small, elongate, commissure parasulcate, fold low, sulcus shallow, growth laminae rather strong.

TYPES.—Holotype: USNM 153024c. Figured paratypes: USNM 153024a,b,d–f. Measured and unfigured paratypes: USNM 153024g–z,a'–l'.

COMPARISON.—*Composita nucella* is characterized by its relatively small size, commonly elongate, rarely transverse outline, typically parasulcate commissure with low fold and shallow sulcus, and its moderately strong growth laminae. It is larger, narrower, and has a less distinctly defined fold than the parasulcate species *C. bucculenta* or *C. parasulcata*, both new. It most nearly resembles *C. pilula*, new species, from the Glass Mountains, differing in its less bulbous convexity, stronger and more consistent parasulcation, and longer pedicle beak. It is smaller and less strongly parasulcate than *C. pyriformis*, new species, from the Pinery Member. It is much smaller than the highly abundant and widespread species from the Glass Mountains such as *C. crassa* and *C. enormis*, both new, and the abundant Bone Spring species *C. cracens*, and *C. apheles*, both new.

Composita parasulcata, new species

PLATE 659: FIGURES 1–69

Small for genus, strongly biconvex, subglobular; outline commonly ovate, less commonly subpentagonal; commissure parasulcate, fold beginning about 5 mm anterior to pedicle valve beak, crest flatly rounded, rather prominent at anterior; sulcus depressed only at anterior of largest shells, normally expressed only as a slight flattening of valve forming a tongue extending into fold; growth laminae weak, widely spaced, absent from some specimens.

Pedicle valve strongly and evenly convex; beak suberect to slightly incurved; foramen ovate, proportionately normal in size, narrowly incomplete at anterior; edges of valve normally slightly flanged, especially at anterior. Brachial valve slightly less strongly convex; beak bluntly rounded; anterior edges slightly produced on each side of fold, increasing apparent height of fold at commissure.

Pedicle valve interior with short, subparallel dental plates, free or cemented to wall by secondary shell material; teeth short, slightly hooked; muscle area shallowly impressed, linguiform, ex-

panding slightly anteriorly from between dental plates; two shallow grooves extending anteriorly from muscle area, other pallial markings not apparent.

Brachial valve interior with short strong hinge plate extending anteriorly in plane of commissure; cardinal process projecting ventrally nearly perpendicular to hinge plate, short, fused to apex of valve; hinge sockets formed at juncture of plate and process; muscle area moderately deeply impressed, bisected for short distance at posterior by low median ridge; crura short, forming sides of hinge plate; spiralia as described for genus, about 8 coils on each side, forming two conical chambers.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 706c				
153026a	3.0	2.2	2.5	1.8
153026b	3.7	3.0	3.0	2.4
153026c	4.4	3.7	3.6	2.7
153026d	5.8	4.9	4.9	3.3
153026e	6.4	5.8	5.4	4.1
153026f	7.0	6.3	6.6	4.4
153026g	8.1	7.0	6.5	5.5
153026h	8.6	7.8	7.6	5.6
153026i	9.7	8.9	9.3	6.6
153026j	10.6	9.3	9.6	7.7
153026k	11.4	10.0	10.7	7.9
153026-l	11.9	10.6	11.1	8.3
153026m	12.9	11.2	12.4	9.2
153026n	13.9	11.7	11.7	9.5
153026o	14.1	12.7	13.9	10.1
153026p	14.9	13.3	13.3	11.7
USNM 706e				
153025a	2.7	2.3	2.4	1.7
153025b	2.9	2.4	2.7	1.7
153025c	3.0	2.7	3.1	1.6
153025d	3.5	3.0	3.6	2.2
153025e	3.7	3.3	3.9	2.3
153025g	3.8	3.5	3.6	2.2
153025h	3.9	3.6	3.7	2.4
153025i	4.1	3.6	3.8	2.3
153025j	4.6	4.2	4.6	2.9
153025k	4.9	3.5	4.6	2.9
153025-l	5.4	4.9	5.1	3.5
153025m	5.7	4.9	4.5	3.6
153025n	5.7	5.0	5.7	3.8
153025o	6.3	5.5	6.0	3.9
153025p	6.6	5.8	6.0	3.9
153025q	7.1	6.7	7.1	4.4
153025r	7.9	7.1	7.1	4.9
153025s	8.3	7.8	8.2	6.5
153025t	8.9	7.9	8.0	6.0
153025u	9.3	8.7	9.1	6.3
153025v	9.5	?	8.7	6.7

	brachial			
	length	valve length	width	thickness
153025w	10.0	8.9	8.7	6.9
153025x	10.5	9.3	9.4	7.0
153025y	10.1	9.0	8.8	7.5
153025z	10.8	9.2	10.0	7.8
153025a'	10.9	10.4	10.2	7.6
153025b'	11.4	10.5	10.7	7.4
153025c'	11.9	10.7	11.1	8.5
153025d'	12.8	12.0	12.5	9.1
153025e'	13.0	11.8	11.5	8.9
153025f'	13.3	11.0	10.4	9.3
153025g'	13.5	12.0	13.0	9.8
153025h'	14.7	13.0	13.2	10.4
153025i'	15.0	14.0	12.8	11.0
153025j'	15.4	15.0	15.6	10.8
153025k'	15.7	14.5	14.8	11.0
153025-l'	16.0	14.8	14.1	10.7
153025m'	17.0	16.3	16.8	14.8
USNM 706b				
154543e (holotype)	13.8	12.3	12.7	12.3

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation; Word Formation (China Tank, Willis Ranch, and Appel Ranch members and lens between the last two); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—Road Canyon: USNM 713. China Tank: USNM 706c, 726r, 733q. Willis Ranch: AMNH 506; USNM 706, 706e, 723t, 723w, 724u. Lens: USNM 706b. Word: USNM 737w. Appel Ranch: USNM 706d, 715i, 719z, 722t, 727j, 732c. Getaway: ANMH 512, 519, 496, 585, 600; USNM 728, 730, 732.

DIAGNOSIS.—Small for a Permian species, outline wide, profile convex, commissure consistently parasulcate.

TYPES.—Holotype: USNM 154543e. Figured paratypes: USNM 153025f,r,y,d', e',j'; 153026a,b; 154543 a-d,f,g. Measured paratypes: USNM 153025a-e, g-z, a'-m'; 153026a-p. Unfigured paratypes: USNM 153025a-e, g-p, s-v, a'-d', f'-i'; 153026a-i, k-n, p.

COMPARISON.—*Composita parasulcata* is characterized by its relatively small size among Permian species of *Composita*, broad outline, convex profile, flanged valve edges on most specimens, and especially by its parasulcate commissure. It most nearly resembles another parasulcate form *C. bucculenta*, new species, from lower in the section, differing in its larger size, proportionately somewhat narrower outline, weaker parasulcation, and longer, slightly more attenuate pedicle beak. It also resembles *C. pilula*, new species, to some extent, but differs in

its normally stronger parasulcation, flatter crest of the fold, and longer pedicle beak. The small size and parasulcation distinguish it from other species in the Glass Mountains and West Texas Permian.

Composita pilula, new species

PLATE 657: FIGURES 1-39

Small, globular; outline ovate or subpentagonal, normally slightly elongate, widest anterior to mid-length; commissure weakly parasulcate to unipli-cate; standing only slightly above flanks at anterior; sulcus expressed only in commissure, not depressed along shell; growth laminae weak and widely spaced over most of shell, stronger and crowded near margins.

Pedicle valve strongly and evenly convex; beak short, thick, suberect or erect; foramen small, periphery narrowly incomplete; edge of valve flanged or shallowly grooved in most specimens. Brachial valve somewhat less strongly convex, greatest inflation in umbonal region; edge shaped to fit flange or groove of opposite valve.

Pedicle valve interior with slender, sharp, hooked teeth; dental plates cemented to walls for all or most of length; muscle area shallowly impressed, pattern normal for genus. Brachial valve interior with small hinge plate, mesial parts not entirely fused in some specimens, leaving deep median notch; cardinal process bilobed, each lobe with small muscle scar on anterior-facing surface; muscle area elongate, narrow, low median ridge at posterior; crura, descending lamellae, and spiralia not observed.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 706f, 720d, 721y, 724d, 724j, 732j, 736x.

DIAGNOSIS.—Shell small, outline elongate, beak short, growth laminae strong near margins, fold and sulcus very weak, commissure weakly parasulcate.

TYPE.—Holotype: USNM 154539d. Figured paratypes: USNM 153027t,u,z,c'; 154539a-c,e. Measured paratypes: USNM 153027a-z, a',b'. Unfigured paratypes: USNM 153027a-s, v-y, a',b'.

COMPARISON.—*Composita pilula* is characterized by its small size, elongate ovate outline, short pedicle beak, moderately strong growth laminae,

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 720d				
153027a	3.0	2.8	2.9	1.9
153027b	3.4	3.1	3.0	2.0
153027c	4.5	3.9	3.9	2.7
153027d	4.9	4.7	4.9	2.9
153027e	5.0	4.5	4.5	3.5
153027f	5.3	4.9	4.9	3.0
153027g	5.7	5.2	5.7	3.6
153027h	6.9	6.3	5.9	4.2
153027i	7.2	6.0	6.3	4.1
153027j	9.0	7.3	6.9	4.8
153027k	8.0	7.0	7.8	5.3
153027-l	8.2	7.1	7.0	5.5
153027m	8.3	7.3	6.8	5.5
153027n	8.6	7.6	6.9	5.3
153027o	8.9	8.1	7.1	5.9
153027p	9.0	8.0	7.5	5.7
153027q	10.0	8.8	8.2	6.0
153027r	11.0	9.9	9.3	7.9
153027s	11.2	9.6	9.4	7.0
153027t	11.3	10.0	10.0	7.0
153027u	11.9	11.0	12.0	8.8
153027v	12.1	10.8	10.5	7.9
153027w	12.3	10.9	10.3	8.7
153027x	12.4	11.0	11.4	8.0
153027y	13.0	11.7	11.4	8.0
153027z	13.3	11.8	10.8	8.0
153027a'	13.3	11.4	11.7	9.8
153027b'	14.0	12.6	12.7	9.8
USNM 724j				
154539d (holotype)	17.8	15.8	16.9	13.9

especially near the margins, and its weakly parasulcate commissure, with low fold and sulcus hardly expressed except at the commissure. It is somewhat similar to other parasulcate species (e.g., *C. parasulcata* and *C. bucculenta*, both new) but is larger than either of these, has an elongate rather than transverse outline, and is not as strongly parasulcate. It is smaller than *C. crassa* or *C. stalagmum*, both new, in which there are some parasulcate individuals, and is smaller than the similarly elongate species *C. enormis*, new species. Its size averages slightly greater than that of *C. nucella*, new species, and differs further from that species in its more elongate outline, shorter pedicle beak, stronger growth lamellae, and parasulcate commissure.

DISCUSSION.—Each shell in the entire collection of several hundred specimens of *C. pilula* is covered by a rough deposit of silica. Close examination reveals that these coatings have many small circu-

lar markings, in the shape of small crinoid columnals. Apparently the shells of *C. pilula* were buried along with numerous small disassociated crinoid columnals, leaving their marks when the shells were freed by acid. Judging from the pattern of this siliceous coating, which covers the pedicle foramina of many shells, and coats the insides of disarticulated valves, but normally only one valve of complete shells, the coating did not form while the brachiopods lived, but after their burial with the columnals.

Composita prospera, new species

PLATE 660: FIGURES 32–50

Very large for genus, flatly to rather strongly biconvex; outline subovate, widest near midlength or slightly anterior; commissure strongly uniplicate; fold standing only slightly above flanks; sulcus depressed slightly at extreme anterior, extended as long tongue in many shells, producing flattened outline of anterior margin in some; growth laminae weak to moderately strong, randomly spaced over most of shell, more abundant and stronger near margins.

Pedicle valve most strongly inflated in umbonal region anterior to beak, somewhat flattened farther forward; beak short, thick, suberect to slightly incurved; foramen about proportional size for genus, more nearly circular than typical. Brachial valve more flatly convex, with low inflation of umbonal region, crest of fold flattening anteriorly.

Pedicle valve interior with short dental plates fused to walls near apex of valve, free at anterior edges, outlining posterior part of muscle area; posterior of valve thickened and lightly pitted; muscle area between and anterior to dental plates, depth of impression of muscle marks depending on amount of thickening of posterior of shell, pattern typical for genus.

Brachial valve interior with strong hinge plate formed between crural bases and sockets; cardinal process bilobed, somewhat concave anteriorly, each lobe with small circular muscle mark; muscle area elongate in posterior part of valve, bisected in posterior region by low median ridge, depth of impression of muscle marks depending on thickening of valve by secondary shell material; shallow pits weakly aligned in thickened part of valve.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
AMNH 512 = USNM 728				
153028a	2.5	2.3	2.0	1.5
153082b	2.8	2.5	2.3	1.6
153028c	3.2	2.9	2.7	1.5
153028d	3.9	3.5	3.1	2.2
153028e	4.6	4.0	4.0	2.5
153028f	4.7	4.0	3.8	2.7
153028g	5.4	4.9	4.6	2.9
153028h	6.7	5.8	6.1	4.0
153028i	7.1	6.4	6.5	4.0
153028j	7.9	7.1	7.0	4.4
153028k	9.4	8.7	7.8	5.8
153028-l	10.3	9.1	9.0	5.8
153028m	11.0	10.0	10.5	6.6
153028n	11.4	10.3	9.6	6.0
153028o	12.3	11.3	11.0	6.2
153028p	12.5	11.3	10.6	6.8
153028q	13.7	12.4	12.2	7.8
153028r	14.7	13.2	12.3	7.5
153028s	14.8	13.2	13.6	7.6
153028t	17.1	15.5	15.0	9.0
153028u	19.2	17.6	17.7	10.3
153028v	22.5	20.2	19.5	11.6
153028w	23.0	21.0	20.0	11.7
153028x (holotype)	25.0	22.9	21.7	13.7
153028y	27.1	24.7	24.4	18.2
153028z	28.5	25.7	26.7	?
153028a'	29.8	27.6	28.5	?
153028b'	31.9	28.4	27.9	?
153028c'	32.8	30.2	30.9	?
153028d'	33.1	30.6	27.7	?
153028e'	35.6	33.0	33.6	?
153029a	3.5	3.1	3.3	2.0
153029b	3.8	3.4	3.5	2.2
153029c	5.0	4.4	4.2	3.2
153029d	5.6	5.0	5.1	3.0
153029e	6.0	5.4	5.3	3.7
153029f	6.7	6.2	6.0	4.1
153029g	7.0	6.3	6.6	3.9
153029h	8.8	7.7	7.7	5.1
153029i	10.3	9.3	8.6	5.5
153029j	10.7	9.9	10.3	5.9
153029k	16.0	14.3	13.0	8.5
153029-l	17.6	16.0	15.7	9.3
153029m	26.9	25.0	25.6	15.5
153029n	27.6	25.1	24.0	16.3
153029o	30.6	27.0	27.4	?
153029p	32.6	29.0	34.7	?

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—AMNH 496, 512, 519, 585, 600; USNM 728, 730.

DIAGNOSIS.—Shell large, convexity moderate, anterior margin commonly flattened, growth laminae

moderate to strong, beak thick, short, fold high only at commissure.

TYPES.—Holotype: USNM 153028x. Figured paratypes: USNM 153028t,w,f,g'. Measured paratypes: USNM 153028a-w,y,z,a'-e'; 153029a-p.

COMPARISON.—*Composita prospera* is characterized by its large size, flatly to moderately strongly convex profile, subovate outline with flattened anterior margin in many specimens, moderate to strong growth laminae, short thick pedicle beak, and its high fold at the commissure that nevertheless does not elevate the midline of the brachial valve except at the far anterior of large shells. Small shells are somewhat elongate, but the outline becomes more nearly equidimensional with growth, some large specimens becoming slightly transverse. Among Permian species from West Texas, only *C. enormis*, new species, attains a size as great as that of *C. prospera*. However, *C. prospera* differs in its less elongate outline, especially in later stages of growth, stronger growth laminae, and much more strongly folded commissure. *Composita grandis* Cooper, from the Permian of Sonora, Mexico, surpasses *C. prospera* in size, and differs further in its greater convexity, thicker and more consistently erect pedicle beak, and less strongly folded commissure in shells of the size of *C. prospera*. *Composita prospera* is larger and not as transverse as *C. crassa* or *C. stalagmum*, both new, and has somewhat stronger growth laminae, and is more strongly folded at the commissure, but the fold stands lower above the flanks.

The larger size, stronger fold, weaker growth laminae, and greater convexity of *C. prospera* distinguish it from *C. affinis* Girty. The same features, and the lack of an emarginate anterior, differentiate it from *C. emarginata* Girty.

Composita pyriformis, new species

PLATE 660: FIGURES 1-31

Small for genus, moderately to strongly biconvex; outline typically elongate, subpentagonal, widest near or slightly anterior to midlength; commissure strongly uniplicate, or weakly parasulcate; fold high, narrow, but not standing prominently above flanks, distinctly set off from flanks by lateral troughs producing weak parasulcation of adults; sulcus only flattened, rarely depressed below flanks,

expressed as long anterior tongue projecting into fold at anterior margin; growth laminae moderately strong, but widely spaced, most frequent near margins.

Pedicle valve most strongly inflated in umbonal region; beak moderately long, thick, suberect to erect; foramen proportionately normal in size and shape. Brachial valve somewhat less convex, also with greatest inflation in umbonal region; beak slightly attenuate.

Pedicle valve interior with moderately strong, curved teeth; dental plates slightly bowed distally, not fused to walls except at posterior; muscle area lying mostly anterior to dental plates, moderately strongly impressed, spatulate, proportionately normal in size and pattern; posterior part of valve typically not thickened.

Brachial valve interior with large strong hinge plate formed between stout socket ridges that also produce deep hinge sockets; cardinal process short, consisting of two small lobes, each with small circular diductor muscle mark, connected by thinner mesial plate, extending posteriorly about perpendicular to hinge plate; muscle area narrow at posterior, there bisected by low median ridge, widening and becoming shallower anteriorly; posterior part of largest valves slightly thickened and pitted, pits aligned, radiating anteriorly, becoming shallow pallial lines.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, and Rader members).

LOCALITIES.—Hegler: AMNH 635; USNM 731, 732a. Pinery: AMNH 33, 437, 524, 537; USNM 725h, 725n. Rader: AMNH 388, 410; USNM 725g.

DIAGNOSIS.—Small for Permian species, commonly elongate, rarely transverse, commissure moderately parasulcate, beak long, growth laminae rather strong.

TYPES.—Holotype: USNM 153030x. Figured paratypes: USNM 153030w, 153031a-c. Measured paratypes: USNM 153030a-w, 153031a-e, 153032, 153033.

COMPARISON.—*Composita pyriformis* is characterized by its relatively small size for a Permian species of this genus, its elongate, or rarely transverse, subpentagonal outline produced by the typically moderate parasulcation of the commissure, its relatively long pedicle beak, and its moderately strong growth laminae on many shells. It is much smaller than, and not as consistently elongate as

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 731				
153030a	2.9	2.9	2.9	1.8
153030b	3.4	3.1	3.3	2.0
153030c	3.6	3.4	3.0	2.0
153030d	3.9	3.6	3.4	2.3
153030e	4.1	3.7	3.8	2.6
153030f	4.5	4.0	3.9	2.7
153030g	4.7	4.1	4.0	2.7
153030h	4.9	4.3	4.4	2.8
153030i	5.3	4.8	4.8	3.3
153030j	5.6	5.4	5.4	3.5
153030k	6.0	5.5	5.6	3.7
153030-l	6.7	6.1	5.7	3.8
153030m	7.3	6.6	5.9	3.8
153030n	7.4	6.8	6.9	4.2
153030o	8.3	7.7	7.0	4.9
153030p	8.5	7.6	7.9	4.9
153030q	8.7	7.7	7.4	4.9
153030r	9.0	7.9	7.9	5.8
153030s	9.9	8.9	9.0	6.4
153030t	10.0	8.6	8.0	5.8
153030u	11.4	10.4	10.2	7.1
153030v	11.8	10.9	11.3	7.3
153030w	13.3	12.0	12.7	8.6
153030x (holotype)	15.9	13.6	14.0	10.0
USNM 725h				
153031a	12.0	10.9	10.5	8.0
153031b	13.3	12.4	12.2	8.1
153031c	14.6	13.2	13.3	9.9
153031d	10.7	9.1	8.9	6.7
153031e	13.0	11.5	12.0	7.3
AMNH 437				
153032	16.8	14.5	13.3	10.7
USNM 725g				
153033	18.2	16.9	19.9	

C. enormis, new species, and differs further in its weakly parasulcate commissure. It most nearly resembles a large *C. parasulcata*, new species, although its parasulcation is not as pronounced and its outline somewhat narrower. The parasulcation might link this species to *C. bucculenta* and *C. pilula*, both new, but it is not as strong as in either of those species; *C. pyriformis*, moreover, is larger and narrower in outline. Its maximum size is slightly smaller than an average size specimen of *C. apheles* and *C. pyriformis*, both new, and differs further in its narrower outline and somewhat greater convexity. Juveniles of *C. apsidata*, new species, are similar, but *C. pyriformis* is less strongly convex, has weaker and fewer growth laminae, and lacks the narrow median groove in the

sulcus. It is larger than *C. nucella*, new species, from the Victorio Peak Member of the Bone Spring Formation, and also is narrower and less distinctly parasulcate. Most of the other species from the West Texas Permian are considerably larger than *C. pyriformis*, and unlikely to be mistaken for it.

Composita quantilla, new species

PLATE 661: FIGURES 1-21

Small, strongly biconvex; outline transversely subpentagonal, widest near midlength; commissure uniplicate; fold gently to narrowly arched, crest slightly flattened, standing above flanks only near anterior, beginning about 7 mm anterior to pedicle peak; sulcus shallow, trough also rounded or flattened, depressed for about half length of shell; growth laminae absent over most of shell, weak near margins.

Pedicle valve strongly and evenly convex; beak short, blunt, erect; foramen proportionately small, periphery widely incomplete; valve edges sharp, not flanged. Brachial valve somewhat less strongly convex, with greatest inflation in umbonal region.

Pedicle valve interior with hinge teeth small, delicate; dental plates thin, subparallel, free for most of length, cemented to walls only in extreme apex; muscle area elongate, narrow, very shallowly impressed, individual marks undifferentiated. Brachial valve interior with proportionately small, delicate hinge plate; cardinal process short, bilobed, with minute muscle marks; sockets deep; crura short, slender; descending lamellae and spiralia observed only as fragments: apparently normal for genus; muscle area narrow, nearly parallel-sided, very shallow.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 721x, 726z, 726za.

DIAGNOSIS.—Shell small, outline transverse, beak short, erect, fold strong only at commissure, uniplicate rather than parasulcate.

TYPES.—Holotype: USNM 153034z. Figured paratypes: USNM 153034v,y. Measured paratypes: USNM 153034a-y, a'.

COMPARISON.—*Composita quantilla* is characterized by its small size, transverse outline, short erect beak, strong fold at the commissure (but only slightly elevated along shell), and clear uniplica-

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 721x				
153034a	2.4	2.2	2.2	1.4
153034b	2.6	2.4	2.2	1.5
153034c	2.7	2.5	2.4	1.6
153034d	3.0	2.8	2.9	1.7
153034e	3.4	3.3	3.4	2.2
153034f	3.8	3.5	3.8	2.4
153034g	4.0	3.7	3.9	2.3
153034h	4.2	4.0	4.2	2.8
153034i	4.5	4.1	4.5	2.9
153034j	5.0	4.7	5.0	3.0
153034k	5.6	5.4	5.8	3.7
153034-l	5.8	5.3	6.0	3.8
153034m	6.1	5.7	5.8	4.0
153034n	6.7	6.2	7.2	4.6
153034o	7.4	6.7	7.4	5.2
153034p	7.5	6.8	7.9	5.4
153034q	7.7	7.2	8.1	4.8
153034r	8.5	7.8	8.5	5.7
153034s	8.6	8.0	8.9	5.8
153034t	9.0	8.2	8.9	6.1
153034u	9.3	8.6	9.3	7.0
153034v	9.6	9.0	10.2	6.9
153034w	9.6	9.0	10.0	6.7
153034x	9.7	8.9	10.2	6.7
153034y	10.0	9.3	11.0	7.0
153034z (holotype)	10.7	9.7	10.3	7.0
153034a'	10.8	9.7	10.7	7.4

tion, rather than parasulcation. It resembles some of the new parasulcate species, such as *C. parasulcata* and *C. bucculenta* in size and outline, but differs in its lack of parasulcation. It most nearly resembles a diminutive of *C. crassa* or *C. stalagmium*, both new, but differs in its much smaller size. Juveniles of those species that are the length of an average specimen of *C. quantilla* are proportionately narrower and are rectimarginate.

Composita stalagmium, new species

PLATE 661: FIGURES 22-52; PLATE 662: FIGURES 1-65

Larger than median size for genus, moderately strongly biconvex, less commonly very strongly convex; outline subpentagonal to subelliptical, juveniles elongate, adults commonly more transverse; commissure strongly uniplicate; fold beginning about 15 mm anterior to pedicle beak, forming high ridge on brachial valve only at anterior of large adults, crest broadly parabolic in cross sec-

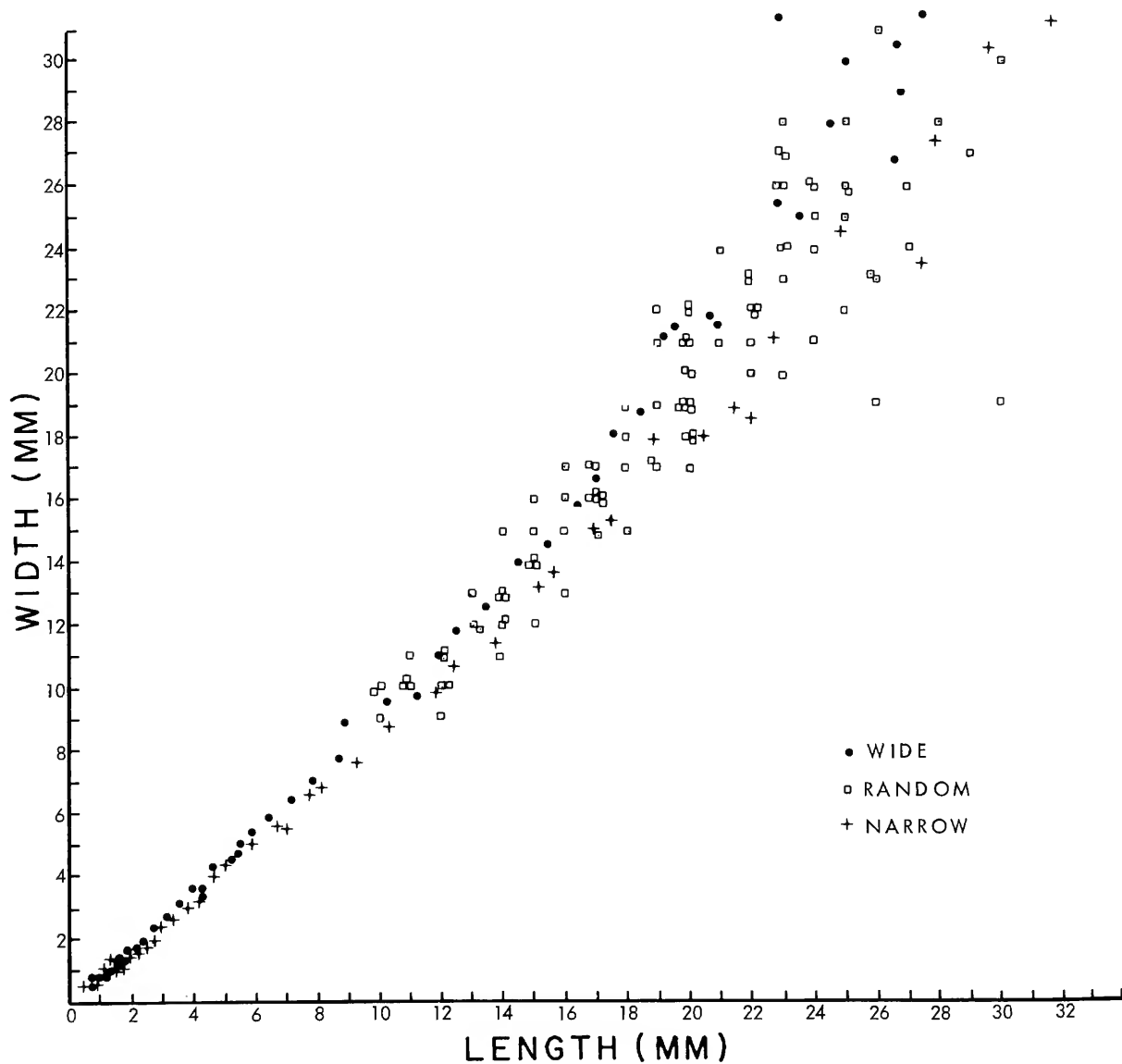


FIGURE 41.—Scatter diagram of measurements of *Composita stalagmium* from USNM locality 702c. A proportionately wide group can be segregated from a narrow group, but when specimens are selected at random the intervening area of the scatter is filled in, suggesting that all are derived from a single variable population.

tion; growth laminae infrequent, most near anterior, most of shell surface smooth.

Pedicle valve swollen in umbonal area, flattening anteriorly and laterally; beak thick, moderately long, slightly attenuate, suberect to slightly incurved; foramen large, truncated-ovate, margin closed at anterior only in some juveniles, not in adults. Brachial valve somewhat less strongly convex, except at anterior across fold, beak region swollen, beak slightly recurved in large convex adults, apex within pedicle valve.

Pedicle valve interior with parallel dental plates outlining pedicle chamber and supporting sharp, slightly hooked teeth, fused to valve wall only in apex, free for most of length, without secondary filling between plates and wall; muscle area about a third length of valve, weakly impressed; pallial lines numerous, thin, radiating from periphery of muscle area; edges of valve blunt: slightly flattened.

Brachial valve interior with stout cardinal process bearing distinct muscle marks, raised edges extending into valve to form hinge sockets; hinge plate thin, square, braced by sockets; crura short, thin; descending lamellae very broad behind jugum, width reduced by bifurcation to support arms of jugum; crest of jugum relatively narrow, with fringed anterior margin; spiralia with up to 10 coils in large shells; muscle area narrow, elongate; posterior adductor marks distinct; anterior adductor marks less distinct; weak pitting on floor around muscle area of adults, pits radiating in rows, becoming light pallial lines; edge of valve slightly beveled to fit blunt edge of pedicle valve.

MEASUREMENTS (in mm).—

	<i>brachial</i>			
	<i>length</i>	<i>valve length</i>	<i>width</i>	<i>thickness</i>
WIDE VARIETY				
USNM 702c				
153035k	0.9	0.8	0.6	0.5
153035l	0.9	0.8	0.7	0.5
153035m	1.0	0.9	0.9	0.5
153035n	1.1	1.0	0.9	0.6
153035o	1.3	1.2	1.0	0.7
153035p	1.4	1.3	1.2	0.8
153035q	1.6	1.5	1.4	0.9
153035r	1.7	1.6	1.4	0.9
153035s	1.9	1.8	1.7	1.1
153035t	2.2	2.0	1.8	1.3
153035u	2.5	2.4	1.9	1.3
153035v	2.8	2.7	2.4	1.6
153035w	3.1	3.0	2.8	1.7

	<i>brachial</i>			
	<i>length</i>	<i>valve length</i>	<i>width</i>	<i>thickness</i>
153035x	3.9	3.5	3.1	2.0
153035y	4.0	3.9	3.6	2.3
153035z	4.2	3.9	3.5	2.3
153035a'	4.5	—	3.7	2.6
153035b'	4.7	4.1	4.3	2.8
153035c'	5.1	4.7	4.5	3.0
153035d'	5.3	4.8	4.7	3.0
153035e'	5.4	—	5.0	3.4
153035f'	6.0	5.4	5.4	3.6
153035g'	6.4	5.8	5.9	3.8
153035h'	7.1	6.5	6.3	4.5
153035i'	7.9	—	7.0	4.4
153035j'	8.7	7.8	7.8	4.6
153035k'	8.9	8.0	8.0	4.9
153035l'	10.2	—	9.6	5.8
153035m'	11.1	9.8	9.8	6.0
153035n'	12.0	10.8	11.0	7.0
153035o'	12.6	11.2	11.9	7.5
153035p'	13.5	12.3	12.5	7.1
153035q'	14.4	—	14.0	7.6
153035r'	15.5	13.8	14.5	8.9
153035s'	16.3	15.3	15.9	9.8
153035t'	17.0	15.0	16.7	9.1
153035u'	17.6	—	18.1	10.7
153035v'	18.5	17.0	18.8	10.6
153035w'	19.1	17.4	21.1	12.6
153035x'	19.6	17.8	21.3	13.0
153035y'	20.7	18.7	21.9	14.9
153035z'	21.0	—	21.7	13.4
153035a''	22.7	22.4	31.5	18.1
153035b''	22.9	21.8	25.5	15.3
153035c''	23.7	21.7	25.0	14.9
153035d''	24.5	23.8	28.0	16.4
153035e''	25.7	23.7	30.0	17.3
153035f''	26.6	24.3	26.9	16.0
153035j (holotype)	26.4	23.4	28.7	17.4

NARROW VARIETY

153035g''	26.7	23.9	30.5	16.8
153035h''	26.8	—	29.0	16.6
153035i''	27.4	25.4	31.4	19.7
153035j''	29.6	27.3	30.4	20.3
153036a	10.3	9.1	8.8	6.4
153036b	15.7	13.9	13.7	10.3
153036c	18.9	17.0	17.9	11.0
153036d	22.0	18.7	17.6	12.6
153036e	27.4	24.8	23.5	16.8
153036f	31.5	27.7	31.3	21.7
153036g	0.8	0.7	0.5	0.5
153036h	0.9	0.8	0.7	0.5
153036i	1.1	1.0	1.0	0.6
153036j	1.3	1.2	1.1	0.7
153036k	1.5	1.4	1.2	0.8
153036l	1.6	1.5	1.2	0.8
153036m	1.9	1.8	1.5	1.0
153036n	2.1	2.0	1.7	1.2
153036o	2.3	2.2	1.8	1.3

	<i>brachial</i>			
	<i>length</i>	<i>valve length</i>	<i>width</i>	<i>thickness</i>
153036p	2.7	2.6	2.0	1.5
153036q	2.9	2.8	2.4	1.5
153036r	3.3	3.2	2.7	1.9
153036s	3.9	3.7	3.0	2.5
153036t	4.2	3.7	3.2	2.7
153036u	4.7	4.1	4.0	3.0
153036v	5.0	4.5	4.3	3.5
153036w	5.9	5.3	5.1	3.5
153036x	6.6	5.8	5.7	3.7
153036y	7.0	6.2	5.4	4.8
153036z	7.8	6.9	6.6	4.5
153036b'	15.1	13.5	13.2	9.0
153036e'	13.8	12.3	11.5	8.1
153036g'	17.0	15.5	15.0	10.9
153036h'	17.5	15.6	15.4	10.5
153036i'	20.5	17.8	18.0	12.5
153036j'	22.7	21.1	21.1	16.4
153036k'	24.9	24.3	24.7	18.0
153036-l'	27.9	25.0	27.5	20.4
153036m'	33.5	30.0	32.0	23.8
153036a''	8.2	7.2	6.9	5.3
153036b''	9.3	8.4	7.6	5.9
153036c''	11.8	10.4	9.9	7.3
153036d''	12.3	11.1	10.7	7.1

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Road Canyon Formation.

LOCALITIES.—Cathedral Mountain: USNM 702inst, 702-low, 712o. Road Canyon: AMNH 507; USNM 702c, 703a, 716x, 719x, 726f, 726z, 726za.

DIAGNOSIS.—Shell large, nearly smooth, outline broad, beak short, fold strong, dorsal profile nearly straight in adults.

TYPES.—Holotype: USNM 153035j. Figured paratypes: USNM 153035a-i, 153036a-f, 154544a-e, 154547. Measured paratypes: USNM 153035k-z, a'-z', a''-j''; 153036a-z, b', e', g'-m'; a''-d''. Unfigured, unmeasured paratypes: USNM 153036a', c', d', f'; 153036n'-z'.

COMPARISON.—*Composita stalagmium* is characterized by its larger average size, broad outline of many individuals, nearly smooth shell with few prominent growth laminae, strong fold that is nearly straight in profile, with slight dorsal flexure at anterior, and relatively short, commonly suberect pedicle beak.

This species most nearly resembles *C. crassa*, new species, differing in its typically broader outline, lower convexity and proportionate lesser thickness, smoother shell with fewer prominent growth

laminae, lack of a shallow median groove in the sulcus, and its shorter, less strongly curved pedicle beak. It also resembles *C. imbricata*, new species, differing in its broader outline, stronger, narrower fold, slightly more attenuate and more strongly curved beak with proportionately smaller foramen, and especially in its smoother shell with few growth laminae.

Composita stalagmium is wider than *C. enormis*, new species, more strongly folded, more convex and less circular than *C. strongyle*, new species, larger, smoother, wider, and less complexly folded than incipiently parasulcate *C. apheles*, new species. Among similar species of the Diablo Plateau and Guadalupe Mountains, it differs from *C. cracens*, new species, in its broader outline, longer beak, smoother shell surface, and dental plates that are not fused to the valve walls. It differs from *C. prospera*, new species, in its smaller maximum size, proportionately wider outline, smoother shell, and normally more strongly curved pedicle beak.

DISCUSSION.—The large sample of *C. stalagmium* from USNM 702c contains specimens that are proportionately wide and thin, and somewhat fewer that are proportionately elongate, narrow, and thick. The two forms can be separated by inspection, and measurements of specimens selected in this manner fall into two clearly separated patterns on a scatter diagram. Measurements of a random sample of 104 specimens all longer than 10 mm shows less clear division of the population into two groups. Inclusion of measurements from specimens shorter than about 8 mm also tends to obscure the dichotomy, even when these are selected by inspection.

The data seem to indicate that the sample contains but one species. Two forms are included, however, and these are most clearly separated in the intermediate size range between 8 and 30 mm length. Below 8 mm the dimensions are more uniform, and few of the wide thin forms attain a length of 30 mm. Possibly a difference in the sexes is expressed in the form of the shell of this species. The differences are obscure among small, presumably immature shells, and perhaps only one sex attained large size (greater than 30 mm length). More measurements and more sophisticated statistical treatment are necessary to test this hypothesis convincingly.

Composita strongyle, new species

PLATE 649: FIGURES 38-43; PLATE 654: FIGURES 69-88

About average size for genus, flatly biconvex; outline subcircular or rounded subpentagonal, widest near midlength; commissure rectimarginate in juveniles to moderately strongly uniplicate in adults; fold gently and evenly arched, standing only slightly above flanks at extreme anterior; sulcus shallow for most of length, moderately depressed at anterior, without longitudinal median groove; growth laminae moderately strong, irregularly spaced over shell surface, more frequent near margins; radial fibrous ornament very weak, visible on few specimens.

Pedicle valve flatly convex, greatest inflation in umbonal region anterior to beak; beak short, blunt, suberect to erect, rarely long enough to be incurved; foramen elongate ovate, cutting unusually far back into beak, periphery very narrowly incomplete at brachial valve umbo; valve edges sharp or slightly flanged. Brachial valve also most strongly inflated in umbonal region; beak protruding only slightly, covered by pedicle beak in complete shells; outline of valve nearly circular.

Pedicle valve interior with thick blunt hinge teeth, supported by short dental plates cemented to walls at posterior, but free at anterior; muscle area between dental plates, and extending anteriorly about half length of valve, not deeply impressed but distinct, pattern normal for genus. Brachial valve interior with hinge plate formed between crural bases, two inner hinge plates incompletely joined at midline of some specimens, commonly joined there but thin; cardinal process broad, bilobed, projecting posteriorly from hinge plate, anterior face of each lobe with small muscle mark; crura extending anteriorly for short distance beyond edge of hinge plate; descending lamellae and spiralia not observed: fragments appear to be typical; muscle area moderately impressed, extending anteriorly about a third length of valve, expanding anteriorly, bisected by low ridge in posterior part.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Neal Ranch Formation (beds 2-14 of P. B. King); Lenox Hills Formation; Hueco Formation.

LOCALITIES.—*Uddenites*: USNM 701e, 701q, 701x.

MEASUREMENTS (in mm).—

	brachial			
	length	valve length	width	thickness
USNM 701d				
153037a	2.9	2.6	2.4	1.8
153037b	3.1	2.9	2.7	2.0
153037c	3.4	3.1	3.0	2.0
153037d	4.4	4.1	4.4	3.1
153037e	4.7	4.3	4.4	3.0
153037f	5.1	4.7	4.6	3.3
153037g	5.8	5.2	5.3	3.9
153037h	6.8	6.2	6.3	3.8
153037i	8.3	7.2	7.4	5.0
153037j	9.3	8.7	8.6	5.9
153037k	9.7	8.7	8.7	6.2
153037-l	10.3	8.8	9.0	6.0
153037m	11.7	10.0	10.0	7.3
153037n	11.9	10.4	11.0	7.3
153037o	13.0	12.6	13.0	7.8
153037p	14.2	12.6	13.3	8.5
153037q	16.4	13.8	14.1	8.8
153037r	17.6	15.4	16.2	10.1
153037s	19.1	17.0	17.8	11.5
USNM 701k				
153038a	14.5	13.0	14.5	8.6
153038b	23.2	20.5	24.3	13.3
153038c	4.9	4.4	4.2	3.1
USNM 701-l				
153039a	11.3	10.0	10.0	6.3
153039b	21.3	19.3	22.8	11.5
153039c	c.29.0	c.26.0	29.0	15.6
USNM 701c				
153040a (holotype)	24.7	22.6	25.7	15.2
USNM 701				
153041a	20.7	18.6	20.4	13.0
153041b	7.9	7.1	7.1	4.7
153041c	17.0	15.7	16.6	9.4
USNM 727e				
154692a	23.7	21.9	27.2	15.2
154692b	26.4	23.6	30.5	28.5
154692c	12.3	11.0	11.2	7.1
154692d	18.8	16.4	18.5	10.9
154692e	21.3	19.3	21.2	12.0
154692f	25.0	22.0	26.4	16.0
154692g	25.2	22.8	28.3	15.5
154692h	28.8	26.0	34.0	20.0

Neal Ranch: USNM 701, 701a, 701a¹, 701a³, 701c, 701d, 701h, 701k, 701-l, 721g, 727d, 727e. Lenox Hills: USNM 705m, 705s?, 709t, 715b, 718y. Hueco: AMNH 700.

DIAGNOSIS.—Shell large, moderately strongly biconvex, beak short, outline subcircular, foramen large, fold high only at commissure.

TYPES.—Holotype: USNM 153040a. Figured paratypes: USNM 153038a,b; 153041a; 154692a,b. Meas-

ured paratypes: USNM 153037a-s, 153038a-c, 153039a-c, 153041a-c, 154692a-h.

COMPARISON.—*Composita strongyle* is characterized by its moderate biconvexity, short beak, and substantial width that produce a subcircular or rounded subpentagonal outline, its proportionately large pedicle foramen, and the fold that stands above the flanks only at the extreme anterior. It most nearly resembles the wide species *C. crassa* and *C. stalagmium*, both new, from higher in the section, but differs from them in its lower convexity, shorter and somewhat less prominent fold, more nearly circular outline, and shorter, less strongly curved pedicle valve beak. It also resembles *C. affinis* Girty in the outline of many specimens, but differs in its normally lower convexity, smaller median size, less prominent fold with more rounded crest, and proportionately larger pedicle foramen. It occurs near the level of another rather flat, round species, *C. discina*, new species, but differs in its larger median and average size, less prominent fold, and lack of a median groove in the sulcus.

Composita prospera, new species, from the Gateway Member is much larger than *C. strongyle* and more convex; *C. cracens*, new species, from the Bone Spring Formation is more elongate and more convex; *C. apheles*, new species, from the Skinner Ranch Formation is smaller, more elongate, more strongly convex, and has a longer, more nearly erect beak.

Family NUCLEOSPIRIDAE Davidson, 1882

Finely fimbriate to smooth, hinge plate strongly developed, elongated.

One of the surprises of the etching program is the discovery of *Nucleospira* which is generally believed to have disappeared in the Mississippian. Only minor characters separate the Permian specimens from the Mississippian ones, especially the lesser development of the median septum in the pedicle valve of the Permian species.

Genus *Nucleospira* Hall, 1859

Nucleospira Hall, 1859a:218; 1859b:23.—Hall and Clarke, 1894:142.—Weller, 1914:453.

Small, subcircular to transversely subelliptical, moderately to strongly biconvex; surface spinose

or bearing closely spaced spine bases; anterior commissure weakly uniplicate; both valves shallowly sulcate, producing slight emargination of anterior outline; costae absent; concentric lamellae conspicuous, spacing evenly decreasing toward anterior; hinge line very short, scarcely interrupting outline of shell.

Pedicle valve strongly and nearly evenly convex transversely and longitudinally; beak short, sharp, suberect to erect; interarea small, nearly equilaterally triangular, strongly concave longitudinally; delthyrium small, but appearing proportionately large in small interarea, deeply wedge-shaped, with small, concave apical plate closing the delthyrium. Brachial valve slightly more strongly convex than pedicle valve; length nearly as great; beak swollen, projecting slightly posterior to hinge; interarea very low, normally only slightly thicker than valve edge.

Pedicle valve interior with long, slender, slightly convergent and relatively strongly hooked hinge teeth, dental ridges low, rounded; no dental plates; low myophragm or median ridge on floor, bisecting valve from half to nearly entire length; muscle area subelliptical in umbonal region; adductor muscle marks small, paired, median and posterior, surrounded laterally and anteriorly by larger, paired flabelliform diductor muscle marks.

Brachial valve interior with deep, widely divergent sockets formed by fulcral plates and valve wall; hinge plate broad, long, ventrally curved, formed of three elements—paired fulcral plates and crural bases distally, and median cardinal process, thin, broad, normally bifid; crural bases extending slightly beyond cardinal process, continuing direction of process, short, tapered, extending ventrally, hooked posteriorly in some; crura long, slender, joining crural bases to spire, descending process of spire flat, broad, attached nearly perpendicularly to crura, extending toward floor of brachial valve; jugum extending nearly directly anteriorly from about midlength of broad descending process, elements from each side meeting at midline of shell, forming V, spiralia continuing anteriorly from descending processes, narrower but similarly flat, ribbonlike, coiled dorsoventrally in about 5–10 loops, with axes of coiling normally directed slightly posteriorly; muscle area in umbonal region, narrowly elliptical, normally bisected in posterior part by low median ridge.

TYPE-SPECIES.—*Spirifera ventricosa* Hall, by subsequent designation of Hall and Clarke (1894:144).

COMPARISON.—*Nucleospira* is characterized by its usually small size, subglobose shape, spinose outer surface with prominent concentric lamellae, narrow hinge with consequently narrow and proportionately high pedicle interarea, triangular delthyrium with conjunct deltidial plates in the posterior part, and its long and broad hinge plate composed of socket ridges, crural bases, and bifid cardinal process. Its spinose surface and concentric lamellae resemble those of *Neophricadothyris* Licharew, but *Nucleospira* is smaller, the two valves are nearly equal in length, the concentric lamellae are more widely spaced and are not regularly spaced but more frequent toward the anterior; internally it differs in its longer hinge teeth, conjunct deltidial plates, long hinge plate, and the crural bases located entirely differently relative to the hinge socket walls. The fine spines also recall *Crurithyris* George, but *Nucleospira* is distinguished by its strong biconvexity, strong concentric lamellae, narrow hinge and interarea, and completely different arrangement of the brachial cardinalia.

DISCUSSION.—It was a great surprise to find in the Permian a representative of this genus that was last seen in the lower part of the Mississippian. No late Mississippian, Pennsylvanian, or early Permian species have yet been found. Perhaps the small size of these remnants of a race that existed since mid-Silurian are a factor in their having been overlooked.

Nucleospira cunctata, new species

PLATE 651: FIGURES 45-72

Small for genus, strongly biconvex; outline subcircular to subpentagonal, either slightly elongate or slightly transverse, greatest width normally anterior to hinge, posterior to midlength, anterior outline flattened or slightly emarginate; pedicle valve sulcus beginning near beak, shallow, rounded in cross section; brachial valve sulcus beginning farther anterior, shallower, only slight flattening on some specimens; spine bases closely and regularly spaced over surface, not visible on all specimens; concentric lamellae distinct, logarithmically spaced; fine growth lines not observed.

Pedicle valve moderately convex; beak short, sharp, suberect; interarea small, nearly equilaterally triangular, strongly concave; delthyrium triangular, partially open in some specimens, nearly entirely closed in others by short deltidial plates growing from apex, and by long cardinal process of brachial valve, leaving small pedicle foramen. Brachial valve similarly convex, with curvature somewhat stronger in umbonal region; length only slightly less than that of pedicle valve; beak short, rounded, slightly curved; interarea merely slight thickening of valve edge along hinge.

Pedicle valve interior with elongate, anteriorly tapered and convergent, slightly hooked hinge teeth; umbonal region of floor bisected by low myophragm, anteriorly merging with rounded ridge caused by sulcus; muscle area in umbonal region, on each side of myophragm; individual muscle marks weakly impressed, not differentiated.

Brachial valve interior with open groove-like hinge sockets along posterior wall just inside interarea, bounded inside by low socket ridges; cardinal process elongate, broad, flattened, projecting ventrally and posteriorly, distally bifid; crural bases slightly longer, fused to sides of process, forming part of socket walls, hooked slightly posteriorly; crura not observed. Muscle area in umbonal region, subcircular to subelliptical, bisected by low myophragm, individual marks weakly impressed; spiralia attached to crura nearly at right angle, descending nearly to floor as broad bands, there producing V-shaped jugum pointing anteroventrally, broad bands of descending processes continuing for short distance anterior to jugum, then narrowing slightly to normal ribbon form of spiralia; axes of coiling directed from anteromedian region posteriorly toward widest part of shell; up to 5 loops observed.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (base).

LOCALITY.—USNM 708u.

DIAGNOSIS.—Small, globular *Nucleospira* with weakly developed myophragms and swollen umbones.

TYPES.—Holotype: USNM 152453z. Figured paratypes: USNM 152453g', h'; 154393a-h; 155118a. Measured paratypes: USNM 152453a-y, a'-h'. Unfigured paratype: USNM 155118b.

COMPARISON.—*Nucleospira cunctata* is the only known Permian species of the genus. It is charac-

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 708u					
152453a	1.3	1.2	1.2	0.5	0.7
152453b	1.4	1.3	1.3	0.7	0.8
152453c	1.5	1.4	1.5	0.5	0.7
152453d	1.7	1.5	1.6	0.6	0.9
152453e	1.9	1.7	1.9	0.9	1.1
152453f	2.0	1.9	1.9	0.7	1.1
152453g	2.1	1.9	2.0	0.9	1.1
152453h	2.4	2.2	2.2	0.8	1.4
152453i	2.4	2.3	2.3	1.1	1.3
152453j	2.7	2.4	2.6	1.2	1.6
152453k	2.9	2.7	2.8	1.1	1.9
152453l	3.0	2.9	3.2	1.4	2.0
152453m	3.1	2.9	3.1	1.5	2.1
152453n	3.2	3.2	3.3	1.3	2.1
152453o	3.4	3.3	3.5	1.3	2.1
152453p	3.4	3.2	3.8	1.3	2.0
152453q	3.5	3.3	3.7	1.6	2.3
152453r	3.6	3.5	3.7	1.7	2.5
152453s	3.8	3.7	4.0	1.7	2.5
152453t	3.9	3.8	3.9	1.9	2.8
152453u	3.9	3.7	4.3	1.9	2.6
152453v	4.0	4.0	4.4	1.6	3.0
152453w	4.1	4.0	4.6	1.7	3.1
152453x	4.3	4.1	4.4	1.7	3.0
152453y	4.3	4.2	4.7	2.0	3.2
152453z	4.5	4.4	5.0	2.0	3.5
(holotype)					
152453a'	4.6	4.4	5.0	1.9	3.5
152453b'	4.8	4.7	5.2	2.0	3.3
152453c'	4.8	4.7	5.0	2.0	3.6
152453d'	5.3	5.2	5.6	2.4	4.0
152453e'	5.6	5.5	6.0	2.1	4.0
152453f'	5.6	5.4	5.8	2.3	4.1
152453g'	5.7	5.6	5.8	3.1	4.6
152453h'	6.9	6.6	7.0	3.6	4.9

terized by its nearly equal length and width, strong convexity, distinct concentric lamellae, short median ridge in the pedicle valve, weakly impressed muscle marks, and long, curved hinge teeth. It most nearly resembles the several Mississippian species described by Weller (1914), differing from all in its greater convexity, especially in the umbonal region, narrower outline, normally smaller average size, and more distinct concentric lamellae on the outer surface. It is similar in external profile to *N. ventricosa* (Hall) and the other Devonian forms illustrated by Hall and Clarke in 1894 (pl. 48). Nevertheless, *N. cunctata* differs in its shorter median septum in the pedicle valve, more distinct

brachial flattening or sulcus, longer and more strongly curved hinge teeth in the pedicle valve, more posteriorly located line of greatest width, and consequently more posteriorly directed axes of coiling of the spiralia. The greatest number of loops that we have seen in the spirillum of a Permian specimen is 5, whereas both Hall and Weller report 6–10. A few of the average size specimens in our collections appear to have the spirillum unbroken, at least on one side so the lower number of loops in the coil may be a genuine difference, not a matter of preservation.

DISCUSSION.—Although some of the pedicle valves have the beak region well preserved, we were not able to ascertain exactly how the apical plate was formed. Hall and Clarke (1894:142) speak of the plate in young specimens being formed of two plates attached to the lateral margins of the delthyrium but that in old shells the plates are coalesced and appear to be a single deltidium. Weller (1914:453) speaks of this plate as a "pseudodeltidium." If this term is meant in the usual sense, it would imply a single plate growing from the apex. The smallest valves and the smallest complete specimens have the plate filling the apex and closing the delthyrium completely. No specimen showed any trace of a foramen. The apical plate may have been the seat of pedicle attachment.

XENOSARIIDAE, new family

Lenticular, smooth Athyridacea without dental plates but with foraminate inner hinge plate.

Genus in West Texas: *Xenosaria*, new genus.

An extremely rare genus known only from the Bell Canyon Formation (Hegler and Lamar members).

Xenosaria, new genus

[Greek *xenos* (stranger)]

Small, outline subcircular, profile lenticular; both valves narrowly sulcate, anterior emarginate. Anterior commissure rectimarginate. Beak small, acute, straight; interarea narrow; delthyrium open, not modified by deltidial plates. Surface smooth.

Pedicle valve interior with small narrow teeth and completely without dental plates.

Brachial valve interior with small and confined

cardinalia; socket ridges short, thick, margining wide sockets supported by broad fulcral plates; crura attached to socket ridges, short, stout, subparallel. Inner hinge plate narrow, concave, apical foramen oval. Spire consisting of broad ribbon with V-shaped jugum, number of coils not known.

TYPE-SPECIES.—*Xenosaria exotica*, new species.

DIAGNOSIS.—Small subcircular spiriferids having a concave hinge plate and a sulcus on both valves.

COMPARISON.—The only other genus resembling this one is *Nucleospira* but its interior is so different from that of *Xenosaria* that detailed comparison is hardly necessary. *Nucleospira* has a prominent long cardinal process and may have septa in both valves. *Xenosaria* has neither septa nor a cardinal process. Another earlier Paleozoic spiriferid externally like *Xenosaria* is *Glassia*, but the interior is completely different and it lacks the sulcation of *Xenosaria*.

DISCUSSION.—The general appearance of this shell suggests *Nucleospira* but as noted above many differences appear on the inside. The pedicle valves of the two genera showing the interior have few distinctive features. The absence of dental plates and poor preservation of the muscle field leave no positive characters on which to rely. The brachial valve, however, has an unusual and unique structure.

The cardinalia are inconspicuous but the socket ridges are prominent and thick, defining large sockets that are floored by broad fulcral plates. The crura are given off directly from the socket ridges and jut out approximately perpendicular to the lateral commissures. Between the crura and from their anterior surface a narrowly concave plate is suspended between the crural bases. This plate is broadly concave but has a short narrow lobe extending anteroventrally, posterior to which is a longitudinally oval foramen. This suggests the possibility that the concave hinge plate was formed by two plates that grew laterally. Unfortunately there are no very young specimens to demonstrate this. The smallest specimen, about 3 mm long, has the plate fully formed.

One opened specimen revealed traces of the spire in the form of one or two broken broad-ribboned coils and a possible jugum. The latter consists of two stout bands that meet to form a large V from whose point a long delicate process is given off on one side. This has a flattened tip. Presum-

ably the structure was symmetrical but the other side has been lost.

Xenosaria exotica, new species

PLATE 587: FIGURES 1-34

Small, nearly circular in outline with strongly rounded sides and narrowly notched anterior margin. Profile lenticular; valves subequal, brachial valve slightly deeper than opposite valve. Anterior commissure rectimarginate. Hinge narrow; beak angular; interarea narrow, apsacline. Delthyrium open. Surface smooth except for fine concentric growth lines.

Pedicle valve evenly and flatly convex in lateral profile, broadly and gently convex in anterior profile with shallow median notch. Umbonal region swollen; median region gently inflated. Sulcus originating on umbo, shallow, narrow, extending to anterior margin. Flanks bounding sulcus moderately swollen, lateral slopes gentle.

Brachial valve evenly and moderately convex, more so than opposite valve in lateral profile; anterior profile moderately convex and medially notched. Umbonal and median regions swollen; anterior slope moderately steep, slightly flattened. Sulcus originating on umbo, extending to anterior margin, there meeting sulcus of opposite valve. Flanks bounding sulcus moderately swollen and with moderately steep slopes.

Interior as described for genus.

MEASUREMENTS (in mm).—

	brachial valve length	width	thick- ness	apical angle (°)
USNM 731				
153459e	8.2	7.3	8.6	4.3
(holotype)				100
USNM 732a				
153460a	5.8	5.3	6.0	3.0
153460b	8.4	7.5	8.7	5.0
				116

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler and Lamar members).

LOCALITIES.—Hegler: USNM 731, 732a, 740c. Lamar: USNM 728p.

DIAGNOSIS.—Moderately convex and slightly anteriorly notched *Xenosaria*.

TYPES.—Holotype: USNM 153459e. Figured paratypes: USNM 153459c,g,h; 153460a-c. Measured

paratypes: USNM 153460a,b. Unfigured paratypes: USNM 153459a,b,d,f.

COMPARISON.—No other species of this genus is known to which this one may be compared.

DISCUSSION.—This species is extremely rare, the entire collection consisting of four specimens from USNM 731 and three from USNM 732a. No specimen shows a complete spire but remains of this structure appear in specimen USNM 153460b.

Superfamily SPIRIFERACEA King, 1846

Variable, usually transverse with uniplicate anterior commissure, fold and sulcus with or without ornament, with or without dental plates; cardinal process lamellate. Socket ridges with or without supports. Impunctate.

Family SPIRIFERIDAE King, 1846

Subfamily NEOSPIRIFERINAE Waterhouse, 1968

Transverse, multicostate to fascicostate Spiriferacea with fine concentric lamellae.

Genera in West Texas: *Neospirifer* Fredericks, 1924c; *Lepidospirifer* Cooper and Grant, 1969; *Spiriferinaella* Fredericks, 1926b; *Gypsospirifer*, new genus; *Cartorhium*, new genus.

Neospirifer and its aberrations, *Cartorhium* and *Lepidospirifer*, are fairly common in the Glass Mountains but less common in the Sierra Diablo and Guadalupe Mountains. The larger spiriferoids are rare in the Capitan Formation. *Gypsospirifer* is sporadic in the Hueco Group but is well known in the Copacabana Formation in Bolivia. It is common in the Hueco Canyon Formation at one locality in the Hueco Mountains and also occurs in the Graham Formation (Wayland Shale) of the Cisco Group of north-central Texas.

Genus *Neospirifer* Fredericks, 1924

Neospirifer Fredericks, 1924c:311.

Shell large, biconvex, spiriferid, with straight hinge, widest at hinge region or anterior thereto; commissure uniplicate, with fold normally well expressed at anterior; fastigium present, height

varying among species; sulcus shallow to deep, extending anteriorly as a tongue filling notch of fold. Costae usually strong, numerous, beginning at beaks, bifurcating asymmetrically to form fascicles with number of costae increasing anteriorly, mesial fascicles normally plicating shell gently, amplitude decreasing laterally, but some species laterally unplicated; costal patterns of fold and sulcus somewhat different from those of lateral fascicles. Fine radial ornamentation absent; growth lines fine, closely spaced; growth laminae stronger, irregularly spaced, most frequent near margins, may be somewhat raised near margins, but without prominent scaly effect.

Pedicle valve with prominent beak, weakly to strongly hooked; delthyrium triangular, open except at apex, where filled by small pseudodeltidium or thick apical callosity, laterally bounded by grooves formed by traces of growth of hinge teeth; interarea smooth, wide, slightly concave longitudinally, wedging out laterally or terminating bluntly at lateral extremes of alate shells, anterior edge bearing numerous small, anteriorly pointing denticles that insert in corresponding shallow pits in face of brachial interarea, serving as fulcra in valve movement. Brachial valve shorter, normally somewhat less convex; beak short; brachial interarea short, low, slightly concave, bisected by broadly wedge-shaped notothyrium with apex occupied by thick cardinal process, a finely lamellate callosity.

Pedicle valve interior with two strong, anteriorly divergent hinge teeth, dental ridges extending along underside of hinge teeth, more or less convergent toward midline, forming sloping platform on each side of delthyrium; dental plates short, continuous with posterior part of dental ridges, slightly or greatly divergent to valve floor, meeting floor lateral to muscle area; apical cones and dental plates buried by callous thickening of posterior of valve in adults of some species. Muscle area elongate ovate, bisected by thin low median ridge and normally by rounded ridge formed by trough of sulcus; adductor muscle marks narrow, elongate, mesial, one on each side of median ridge, normally lightly lirate longitudinally; diductor muscle marks wider, semioval to slightly crescentic, irregularly radially lirate, lying lateral to adductors; pedicle adjustor muscle marks in extreme posterior of muscle area, one on each side of median ridge, normally under lip of apical callosity, Floor of poste-

rior part of thickened valves shallowly pitted in irregularly radial pattern, pits fading toward margins, coalescing to form faintly impressed pallial troughs.

Brachial valve interior with widely divergent, thick-walled hinge sockets, one on each side of notothyrium, nonfunctional apical part of sockets roofed by thin plate in most species. Helicophores (see New Morphological Terms, below) originating from outer mesial walls of socket ridges, there thin, extended along most of length of socket ridge, abruptly narrowing anteriorly, forming thin ribbon, gently flexed and twisted about 90°, slightly converging but not meeting; spiralia attached to anterior ends of helicophores by flat lateral joint, each one with short ventrally pointing jugal process near joint, main portion of spiralia ribbonlike, coiled dorsoventrally in oval loops of laterally decreasing diameter. Small, elaborate buccal plate located between spiralia, inside loops, on median line of shell, braced against spiralia and jugal spurs, strongly cupped, normally trilobate, perforated by several small holes with lacy rims, fringed around edges, oriented with concave side ventral, convex side dorsal, lobate end posterior, winglike extensions anterior. Muscle area elongate, anteriorly widening, normally occupying part of depression formed by crest of fastigium, bisected for part of length by low, thin median ridge, beginning anterior to beak, attaining maximum length early, hence occupying greater proportion of length of younger shells; two strongly impressed antero-medial adductor marks in trough of fastigium, anteriorly widening, faintly lirate in irregular pattern; two smaller posterolateral adductor muscle marks lying outside trough, one on each side, faintly lobate, lirate in irregularly radial pattern. Floor of valve near hinge somewhat thickened in large individuals of some species; thickened portions faintly pitted; plications and costae more strongly reflected internally than in pedicle valve.

DIAGNOSIS.—Spiriferidae with fasciculate costae, without scaly, raised growth laminae, and with fine radial ornamentation weak or absent.

TYPE-SPECIES.—*Spirifer fasciger* Keyserling (1846: 231, pl.8: figs. 3–3b) by original designation of Fredericks (1924c:311). Lectotype of *S. fasciger* herein designated (Keyserling, 1846, pl.8: fig. 3b [not figs. 3,3a, species unknown]).

COMPARISON.—*Neospirifer* is distinguished from

Spirifer Sowerby by its asymmetrically bifurcating costae that form distinct fascicles on the mesial portions of the shell, and normally plicate the shell lateral to the fold. Costae in *Spirifer* bifurcate symmetrically, and most bifurcation is in early stages of growth, whereas in *Neospirifer* bifurcation tends to recur at intervals throughout the life of the shell. Strongly fasciculate costae distinguish *Neospirifer* from *Choristites* Fisher; the costae of *Neospirifer* also tend to be higher, and the sides plicated. *Choristites* has larger dental ridges that nearly join to close the delthyrium, and its dental plates are much longer, extending into the more anteriorly located muscle area, rather than meeting the floor of the valve at the sides of the muscle area. *Munella* Fredericks and *Purdonella* Reed are now considered synonyms of *Choristites* (for evidence see Dunbar, 1955) and need not be compared to *Neospirifer*. *Tangshanella* Chao and *Choristitella* Ivanov and Ivanova have narrow triangular interareas like *Cartorhium latum* (King), but differ in their symmetrically bifurcating costae that do not form strong fascicles and do not plicate the side of the shell. *Brachythyryna* Fredericks is simply costate, normally unplicated laterally.

The only other distinctly fascicostate spiriferoid is *Lepidospirifer* Cooper and Grant (1969) which differs from *Neospirifer* by its fine and weakly fasciculate costellae, raised growth laminae that give the crest of the costae the appearance of a tiled roof, and in its straighter beak and more open delthyrium.

NEW MORPHOLOGICAL TERMS.—Difficulties were encountered in the course of describing the *Neospirifer* group, necessitating the coining of two new terms. The term *fold* traditionally has served dually: it can mean the flexure of the anterior commissure, with all the various kinds distinguished by Thomson (1927), or it can mean the ridge along the valve that is produced by this anterior flexure, the crest that corresponds to the trough (sulcus) of the opposite valve. Many brachiopods have strong anterior flexures that produce hardly any crest. In some groups this is unimportant, but in the spiriferids the distinction needs to be made, resulting in descriptions that say the fold is high, but nevertheless it is low. We propose and use the term “fastigium” (Latin for the gable top, or ridge, of a roof) for the crest along the midline of the brachial valve that is produced by the anterior flexure of

the commissure known in its restricted sense as the "fold."

Internally, there seems to be no satisfactory term for the structures that join the spires to the socket ridges. These two short processes have been called crura or brachiophores, but neither term seems applicable in the *Neospirifer*inae. Crura normally have the distal ends free, and brachiophores produce or contribute to the formation of the socket. The structures in *Neospirifer* that support the spiralia, proximal to the descending (or primary) lamellae and projecting from the socket ridges, are here termed the "helicophores" (Greek *helix*, a spire, + *phor*, to bear).

DISCUSSION.—The genus *Neospirifer* was based by Fredericks (1924c) on *Spirifer fasciger* Keyserling, but the reference cited was to Tschernyschew (1902:141) rather than to the original description by Keyserling (1846). Ivanov and Ivanova (1937:19), studying Keyserling's illustrated specimens, arrived at the opinion that they are three different "forms" (presumably, three species), and suggested that inasmuch as none of Keyserling's three specimens show all the characteristics of the genus, *Spirifer tegulatus* Trautschold be chosen as the type species. This procedure clearly is contrary to the rules of zoological nomenclature; Fredericks' unambiguous designation of *S. fasciger* as the type species leaves no ground for choice of another. Despite his reference to descriptions and illustrations by Tschernyschew rather than to those of Keyserling, the type species must remain as defined by Keyserling. Judging from Keyserling's (1846, pl.8: figs. 3–3b) illustrations, the Ivanovs are correct in their opinion that more than one species are involved; therefore, one of the three figured specimens must be fixed as the holotype of *S. fasciger*. We believe that figure 3b best shows the fasciculate costation that characterizes species of *Neospirifer*, and hereby choose the specimen represented by that figure to be the lectotype. Figure 3b shows no scaly, or tile-roof, effect in the concentric ornamentation, and therefore conforms to the customary concept of *Neospirifer*. *Spirifer tegulatus* Trautschold and *S. moosakhailensis* Davidson, which has been identified with *N. fasciger* (e.g. Tschernyschew, 1902), have the raised scaly laminae and may belong to the genus *Lepidospirifer* Cooper and Grant (1969, q.v., below) which has *L. angulatus* Cooper and Grant as type.

A significant new structure in the interior of *Neospirifer* has been discovered by the technique of acid etching. Many of the complete specimens each contained a small, irregularly shaped and strongly cupped plate; similar plates were found in insoluble residues accompanying specimens of *Neospirifer*, *Lepidospirifer*, and *Cartorhium*. The plate has been found in its correct position only in one specimen of *N. bakeri*. There, it is on the midline of the shell, braced against the ends of the two spiralia and against the short jugal processes near the juncture of the spiralia with the helicophores. The function of the plate is not known, but from its median position between the descending branches of the spiralia it appears to be near where the mouth must have been, and may have been a supporting apparatus for the mouth or a structure near the mouth. Therefore we have termed it the "buccal plate," a name which expresses our opinion as to its probable position near the mouth, without implying a particular function.

In order to describe the various types of buccal plates associated with the different species, it has been necessary to name the parts. The posterior normally is lobate, the "lobes" are considered to be on the convex side, the "troughs" between them forming similar lobes on the concave side. The lobes are perforated, the troughs are not. In some the perforations have coalesced, producing deep indentations of the lobes. Many perforations have raised "rims" of various heights, most with fringed edges, some with rims so high that they are tubes rather than mere rims. The anterior end has three projections; the two lateral projections are mirror images of one another, and spread stretched out like small "wings", fringed or feathered at the edges. The median projection is digitate, with great variety in shape and size: we have termed it the "anterior median comb." The edges of the buccal plate are fringed; in some species there are a few small perforations in the sides, between the lobes and the wings.

The buccal plate is characteristic for each species, although within any species it is too variable to be the sole basis for certain specific identification. Its manner of growth is not known in detail. Plates from juvenile shells are miniatures of adult plates, except that the lobes are shorter and have few or not any perforations. The perforations appear as

the plate enlarges, they are not results of later resorption.

The form of the buccal plate of *Neospirifer* and its relatives *Lepidospirifer* and *Cartorhium* exhibits an evolution, with plates from Word species consistently and characteristically different from those in Leonard or Wolfcamp species. The trend is for the normal three lobes to become four by sublobation of the median lobe. This is first seen in the Cathedral Mountain Formation species *Cartorhium latum* King. In the Word species the median lobe is more strongly subdivided, and may have two rows of perforations as in *C. orbiculatum* and *C. chelomatum*, both new. The rims around the perforations tend to become higher or more tubular in the younger species, and there is a strong tendency for the perforations of the lateral two lobes to coalesce, producing deep, high-rimmed indentations along the lobal crests in place of the series of perforations that is normal in species from lower in the section.

Neospirifer amphigyus, new species

PLATE 592: FIGURE 11; PLATE 593: FIGURES 1-15;
PLATE 594: FIGURES 1-11

Shell large, rather strongly biconvex; outline transverse, irregularly semielliptical, widest at hinge, alate, many specimens with hinge greatly extended; commissure uniplicate, rather strongly plicated laterally; fastigium normally low, broadly or narrowly arched transversely and rather strongly plicated; sulcus shallow, broad, sharply bounded by crests of coarse costae, one on each side. Costae strongly fasciculate, 3 or 4 fascicles on each side of fastigium or sulcus forming plications, becoming lower laterally, each with high primary costa forming crest of plication, height slightly increasing anteriorly, costae numbering 3-7 per fascicle, 15-30 per side of valve, 6-16 on fastigium or sulcus; median costa of fastigium splitting equally near beak, each branch increasing in height and breadth anteriorly and splitting laterally, not medially, but diverging sufficiently not to produce prominent dual crest to fastigium; median costa of sulcus normally (but not invariably) beginning at beak, remaining undivided, with great increase in size anteriorly, or bifurcating within 10-30 mm of beak and continuing forward as twin, without further divi-

sions. Fine radial ornament absent; fine concentric ornament consisting of closely spaced growth lines, interrupted by irregularly spaced coarser growth laminae becoming more frequent anteriorly.

Pedicle valve moderately to greatly thickened just anterior to hinge; moderately convex transversely and longitudinally; beak short, somewhat hooked; delthyrium widely wedge-shaped, bounded laterally by groove formed by trace of growth of hinge teeth; pseudodeltidium short, convex, normally missing or buried by apical callosity; interarea high, concave, wide, extending to tips of alations; hinge line with numerous small, anteriorly pointing denticles beginning 5-10 mm lateral to hinge teeth, not present on alate portion of hinge. Brachial valve somewhat more strongly convex, profile of crest of fastigium continuously convex, not flattened; brachial interarea short, concave; notothyrium wide, short, apex with broad, brushlike cardinal callosity, finely fimbriate for muscle attachment.

Pedicle valve interior with strong, knoblike hinge teeth, bending slightly toward median line, supported by strong, ventrally and posteriorly convergent dental ridges, continuous near apex of valve with thin dental plates diverging toward floor of valve, meeting floor at edges of muscle area; apical cones normally filled by callus in adults, partly or wholly burying dental plates. Muscle area elongate oval, posterior part excavated, anterior part elevated; adductor marks median, elongate, longitudinally striated, separated by low median ridge; diductor marks lateral, surrounding adductor marks, irregularly radially striated; adjustor marks small, one on each side of median line in extreme posterior of muscle area. Floor of posterior part of valve outside muscle area marked by small pits and bumps, irregularly radially oriented, channeling into several radiating stripes reaching margins of valve.

Brachial valve interior with widely divergent, thick-walled hinge sockets, nonfunctional part of socket trough roofed by thin, elongate plate. Helicophores attached to undersides of socket ridges by thin, triangular plates, convergent toward floor of valve; full form of helicophores, spiralia, and buccal plate not observed. Muscle area elongate, narrow, spatulate, anteriorly widening, bisected by low, sharp median ridge; each adductor mark faintly striated longitudinally; floor of valve lateral

to posterior end of muscle area bearing pair of short, low, anteriorly divergent, S-shaped ridges, one on each side; costae and plications strongly reflected in interior of valve.

MEASUREMENTS (in mm).—

	brachial				thick- ness
	length	valve length	hinge width	midwidth	
USNM 706					
152893a	5.2	4.3	4.0	5.0	3.9
152893b	?	6.1	7.3	7.7	?
152893c	25.0	?	60.0?	39.5	?
152893d	38.9	?	78.7	48.0	?
USNM 706c					
152894a	6.9	6.0	8.0	8.8	5.4
152894b	8.3	6.9	10.0	10.0	5.9
152894c	9.8	8.8	11.8	12.4	7.9
152894d	12.6	11.0	14.5	16.7	10.0
152894e	14.6	13.2	22.8	21.0	11.3
152894f	20.2	16.9	35.3	28.8	17.0
152894g	21.9	18.6	33.0	28.6	c.18.0
152894h	c.36.0	?	63.3	c.50.0	?
152894i	51.5	?	89.0	62.0	?
152894j	?	5.6	5.7	7.3	?
152894k	?	6.4	7.8	9.4	?
152894l	9.0	?	8.6	10.0	?
152894m	11.0	9.3	11.5	12.9	7.4
152894n	11.0	?	14.6	15.1	?
152894o	12.2	?	14.5	15.1	?
152894p	13.5	11.4	17.9	17.5	18.9
152894q	17.8	?	25.7	22.5	?
152894r	21.0	?	65.0	31.2	?
152894s	22.4	?	32.0	28.6	?
152894t	26.1	?	52.0?	38.4	?
152894u	31.3	?	50.0?	c.36.0	?
152894v	?	33.7	c.64.0	c.56.0	?
152894w	42.0?	?	c.84.0	60.0?	?
152894x	48.3	?	69.5	68.0	?
152894y	48.8	41.6	75.0+	63.0	35.0
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, and Appel Ranch members and lens between the Willis Ranch and Appel Ranch members).

LOCALITIES.—Word: USNM 731m, 741p. China Tank: 706c, 713, 726r, 726s. Willis Ranch: AMNH 506; USNM 706, 706e, 724u. Lens: USNM 706b. Appel Ranch: USNM 716v.

DIAGNOSIS.—Large, mucronate *Neospirifer* with undivided costa in sulcus.

TYPES.—Holotype: USNM 152894y. Figured paratypes: USNM 152893c, e; 152894b,e,i,x; 154596a-c; 154597. Measured paratypes: USNM 152893a-d, 152894a-x.

COMPARISON.—*Neospirifer amphigyus* is characterized by its mucronate hinge extremities, strong costae that are grouped into definite fascicles, each fascicle producing a relatively strong plication of the shell, the split median costa of the fastigium, giving the fastigium a rather evenly arched transverse profile, and its undivided or evenly bifurcated median costa of the sulcus, which increases in height anteriorly. Its high and strongly fasciculate costae distinguish it from all other species in the Glass Mountains. Only *N. thescelus*, new species, is as strongly plicated, but its costae are weaker, its outline not as transverse, hinge not as extended, and the crest of the fastigium is prominent, formed by two strong costae.

Among related foreign species, only *Spirifer interplicatus* var. *baschkirica* Tschernyschew (1902, pl. 6) has comparably strong costation. *Neospirifer amphigyus* is much larger, more transverse and mucronate, its plications are stronger, and it has prominent costae in the sulcus. Species belonging to the genus *Spiriferella* Tschernyschew (1902) also are similarly strongly costate, but *N. amphigyus* is more transverse and alate than any of them, its costae are more definitely fasciculate, its fold and sulcus strongly costate, and it lacks the narrow interarea, pustulose ornamentation, and well-developed pseudodeltidium of many species of *Spiriferella*.

Neospirifer apothescelus, new species

PLATE 595, FIGURES 1-20

Average size for genus, moderately strongly bi-convex; outline transverse, normally widest at hinge, some specimens weakly alate; commissure uniplicate, fastigium rather low, crest narrow but blunt, standing moderately high above flanks; sulcus moderately deep, broadly V-shaped. Costae strong, round crested, fasciculate, with fascicles producing 4 low plications on flanks, numbering 3-5 costae per fascicle, aggregating 13-21 per side on mature individuals, 6-12 on fastigium and sulcus; median costa of fastigium bifurcating at beak, forming double crest, may have a third costa intercalated; median costa of sulcus beginning about 5 mm anterior to beak, continuing forward singly, or narrowly bifurcating about 15 mm anterior to beak. Fine radial ornamentation absent; growth

lines fine, closely spaced; growth laminae somewhat stronger, irregularly spaced, most frequent near margins.

Pedicle valve flatly convex transversely and longitudinally; beak strongly curved, reducing height of wedge-shaped delthyrium; pseudodeltidium short, convex or flat, supported by apical callosity; interarea low, wide, bluntly terminated at lateral extremities of hinge; normally longitudinally scored by shallow, irregularly spaced grooves, anterior edge with numerous fine but strong denticles beginning adjacent to hinge teeth. Brachial valve moderately convex transversely and longitudinally, maximum convexity near beak; brachial interarea low, wide, slightly concave, bisected by wide, wedge-shaped notothyrium with finely lamellate cardinal callosity (process) at apex.

Pedicle valve interior with strong divergent hinge teeth; dental ridges moderately deep, only slightly convergent toward floor, dental plates apically continuous and short, diverging toward floor, meeting floor on each side of muscle area; posterior part of valve normally thickened, partly filling apical cones, producing thick apical callosity. Muscle area subcircular to elongate subovate; posterior part bisected by obscure median ridge; adductor muscle marks elongate, narrow, one on each side of median line, longitudinally striated; diductor marks wider, slightly shorter, lying lateral to adductors, striations diverging anteriorly. Floor of valve lightly pitted, in radial pattern, pits becoming shallower and more elongate toward margins.

Brachial valve interior with widely divergent, thick-walled sockets, normally open, without cover over nonfunctional part. Helicophores attached to sockets ridges, narrowing, slightly converging and slightly twisting anteriorly, attached to spiralia by flat lateral joint; spiralia with short ventrally pointing jugal spur near juncture with helicophores, remainder ribbonlike, coiling dorsoventrally in loops of decreasing size laterally. Buccal plate not observed. Muscle area elongate, narrow, anteriorly widening, lying in trough formed by fastigium, bisected by low, thin median ridge; adductor muscle marks faintly, irregularly radially lirate.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Neal Ranch Formation; Lenox Hills Formation.

LOCALITIES.—*Uddenites*: USNM 701f, 701t, 701x,

MEASUREMENTS (in mm).—

		brachial valve length	hinge width	width	thick- ness
USNM 701d					
152899a	2.5	2.4	2.1	2.7	1.7
152899b	3.6	3.1	2.9	3.8	2.7
152899c	4.9	4.6	5.3	5.8	3.7
152899d	5.6	5.1	4.3	6.3	4.4
152899e	6.9	6.5	8.5	9.6	5.0
152899f	9.8	8.4	13.5	13.6	6.8
152899g	11.9	10.6	17.3	16.0	7.8
152899h	12.8	11.0	19.6	16.0	8.5
152899i	12.6	11.4	20.9	20.9	9.0
152899j	17.9	14.4	44.0?	30.0?	11.4
USNM 701					
152900a	5.8	5.2	5.2	6.7	4.2
152900b	6.4	5.4	5.0	6.8	4.6
152900c	17.5	14.4	17.8	20.0	11.4
152900d	?	28.0?	52.0	42.5	?
USNM 701c					
152901a	16.6	13.5	25.3	22.6	c.11.0
USNM 701t					
152902a	21.5?	19.6	35.0?	27.6	15.2
USNM 701x					
152903a	c.25.0	21.5	50.0?	45.0	?
USNM 727e					
154599a (holotype)	39.0	32.5	72.0	61.0	28.0

702n, 703-l, 705h. Neal Ranch Formation: USNM 701, 701c, 701d, 701k, 701-l, 713h, 715b, 721g, 722x, 727e. Lenox Hills: USNM 715.

DIAGNOSIS.—Small, coarsely costate *Neospirifer* with median costa of sulcus originating anterior to beak.

TYPES.—Holotype: USNM 154599a. Figured paratypes: USNM 152900c,d; 154599b; 154600a; 154601a. Measured paratypes: USNM 152899a-j, 152900a-d, 152901a, 152902a, 152903a. Unfigured paratypes: USNM 152900a,b; 154600b; 154601b.

COMPARISON.—*Neospirifer apothescelus* is characterized by its small size, relatively strong lateral plications, low fastigium, low interarea, and open hinge sockets. It most nearly resembles *N. thescelus*, new species, differing in its smaller size, less alate hinge, lower interarea, fewer costae per fascicle and per side, and median costa of the sulcus that begins anterior to the beak. Its resemblance to *N. thescelus* makes it unnecessary to compare it to species from other regions or of other ages. For this, see the discussion of comparisons under *N. thescelus*.

Neospirifer bakeri R. E. King

Spirifer (*Neospirifer*) *bakeri* R. E. King, 1931:113, pl. 37: figs. 4-6.

Spirifer (*Neospirifer*) *pseudocameratus* [part] R. E. King [not Girty], 1931:116, pl. 38: figs. 5a-b [only].

COMMENT.—The following description relates only to the holotype of R. E. King's species *Neospirifer bakeri*. Specimens in the National Museum collection from the Glass Mountains appear to belong to two geographic subspecies of that species. Each of these is discussed in detail under its proper subheading. Illustrations of each subspecies are cited under the respective heading.

DESCRIPTION OF KING HOLOTYPE.—The holotype of *N. bakeri* (YPM 12500a), is an imperfect specimen having both valves in contact, missing most of one half, and with the ornamentation of the brachial valve mostly worn away and that of the pedicle valve mostly decorticated. A paratype consists of a young pedicle valve with the exterior badly exfoliated. Another paratype from locality 58 has no number. It is also an exfoliated pedicle valve but the costae are fairly well preserved.

The holotype is 43.7 mm long and 66.4 mm wide, based on the half measure, but the lateral extremities are broken and the measure is lacking at least 10 mm. The thickness is approximately 25 mm but the fold of the brachial valve is broken away and the measure not accurate.

Pedicle valve of holotype moderately and evenly convex but with the umbo narrowly rounded and the beak narrow and incurved. Anterior profile with flanks depressed below side of fold and flattened. Sulcus originating on the beak, widening anteriorly and becoming moderately deep; fold bounding sulcus prominent and subcarinate, elevated above flanks. Interarea long, curved, gently apsacline; delthyrium covered by convex pseudodeltidium.

Brachial valve with gently convex lateral profile and depressed anterior profile, the flanks being flattened and (probably) depressed below the fastigium, which is not preserved.

Ornamentation with 3 fascicles and the lateral slopes widening anteriorly and diminishing anteriorly. Lateral extremities not fasciculate.

Neospirifer bakeri bakeri R. E. King

PLATE 596: FIGURES 1-47; PLATE 597: FIGURES 1-14;

PLATE 601: FIGURES 1-5

Spirifer (*Neospirifer*) *bakeri* R. E. King, 1931:113, pl. 37: figs. 4-6.

Spirifer (*Neospirifer*) *pseudocameratus* [part] R. E. King [not Girty], 1931:116, pl. 38: figs. 5a-b only.

Large, moderately to strongly biconvex; outline transversely trapezoidal, widest at hinge, normally alate to mucronate, interareas extending to lateral extremities; commissure uniplicate, laterally straight or slightly plicated; fastigium moderately high, expanding moderately anteriorly, sharply bounded by intercostal troughs on each side; sulcus shallow to moderately deep, bounded on each side by one prominent costa. Costae fasciculate, 2 or 3 fascicles immediately lateral to fold and sulcus usually produce low plications; each fascicle with a primary costa and weaker lateral costae, totaling 3-6 on adults, aggregating 25-50 costae on each side of fastigium and sulcus, average about 30; median costa of fastigium splitting at beak, continuing forward as double crest, each costa splitting only distally, not medially, number of costae on fastigium 12-22, normally about 15; median costa of sulcus beginning at beak, becoming wider and lower anteriorly, without bifurcating. Fine radial ornament absent; concentric ornament consisting of fine, closely spaced growth lines, with irregularly spaced, coarser growth laminae becoming increasingly frequent toward margin.

Pedicle valve of some adults somewhat thickened anterior to hinge; convexity strong near beak, flattened anteriorly; transverse convexity moderate; delthyrium high, triangular; pseudodeltidium small, flat to slightly convex, normally missing or fused to callosity in apical part of delthyrium; interarea smooth, slightly concave, marked only by fine transverse growth lines, forward edge with numerous, small, anteriorly pointing denticles, beginning about 3 mm lateral to delthyrium and extending laterally to edge of valve, but not onto alate or mucronate extremities of hinge. Brachial valve moderately strongly convex transversely and longitudinally, profile of fastigium flattening anteriorly, only slightly broadened and flattened transversely; beak short, not prominent; interarea short, slightly concave, interrupted by wide, wedge-shaped

notothyrium; apex of notothyrium occupied by brushlike cardinal callosity, lamellate for muscle attachment.

Pedicle valve interior with strong hinge teeth, pointing slightly toward median line at ends, their growth trace forming groove along edge of delthyrium; teeth supported by strong, deep, dental ridges tending to converge toward floor of valve, giving rise posteriorly to dental plates diverging toward floor, reaching it at sides of muscle area, dental plates partly buried by callus in largest shells. Muscle area elongate oval, slightly excavated at posterior, elevated at anterior; adductor marks elongate, narrow, median, longitudinally striated, separated by low median ridge; diductor marks large, semioval, lying lateral to adductors, marked by irregularly radiating lirae; adjustor marks in extreme posterior of muscle area, small, one on each side of median line, adjustor lirae similar to but discordant with those of diductors. Floor of valve lateral and slightly anterior to muscle area, marked by faint pits and bumps in irregular radial pattern, fading anteriorly and laterally into faint pallial sinuses.

Brachial valve interior with widely divergent, anteriorly expanding hinge sockets, all but functional anterior portion covered by thin elongate plate. Helicophores attached to anterior or underside of sockets by thin triangular plate, gently curving to meet end of spirulum, thin, ventrally projecting spur or jugal process near joint with helicophore; spirulum in oval loops, decreasing in size laterally; cross section of ribbonlike spirulum somewhat thickened in center, tapered to feather edges. Buccal plate on median line, with concave side ventral; structure of plate trilobed, with moderately wide and divergent anterior wings, each lobe, wings, and sides much perforated, giving delicate lacy appearance, perforations on lobes rounded, with low, digitate rims, those on sides elongate slits without rims. Muscle area spatulate, anteriorly expanding and rounded, bisected by low median ridge, each adductor scar marked by weak longitudinal striations; valve floor behind muscle area marked by faint striations and pair of short, simply arcuate, low ridges, one on each side, diverging anteriorly; remainder of floor with rib pattern reflecting costae of exterior.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

MEASUREMENTS (in mm).—

	length	brachial		thick- ness
		valve length	hinge width midwidth	
USNM 707e				
152904a	2.2	2.0	1.5	2.3
152904b	2.8	2.4	2.4	3.2
152904c	3.7	3.3	3.9	4.1
152904d	4.1	3.6	4.0	4.7
152904e	5.4	4.5	4.4	5.6
152904f	5.6	4.7	5.7	6.8
152904g	6.0	5.7	7.1	7.8
152904h	7.0	6.2	12.5	9.0
152904i	7.9	6.6	12.6	9.0
152904j	8.3	7.2	9.8	11.4
152904k	8.8	7.0	13.3	10.5
152904l	9.0	7.9	19.8	13.3
152904m	10.4	8.8	23.0+	14.9
152904n	12.3	11.0	25.6	15.0
152904o	12.6	10.2	34.9	18.0
152904p	17.8	14.1	35.0	25.0
152904q	18.0	14.2	44.5	27.5
152904r	22.0?	19.8	57.7	30.5
152904s	24.7	22.4	c.63.0	40.0
152904t	26.3	24.0	75.5	43.0
152904u	29.5	27.6	74.0+	46.0
152904v	35.5	30.6	c.73.0	51.0
152904w	39.0+	32.8	74.0	51.0
152904x	39.0	34.7	72.4	50.0
152904y	43.0	?	91.0	59.0
152904z	47.5	41.8	84.0	63.0
152904a'	43.5	32.3	103.0+	61.5

LOCALITIES.—AMNH 503, 509; King 46, 58; USNM 703, 703a, 703c, 706f, 707e, 710u, 710z, 716x, 716xa, 719x, 720d, 721j, 721r, 721w, 721y, 722g, 723x, 724a, 724b, 726d, 726z, 726za, 732j, 735a, 736x.

DIAGNOSIS.—Large, moderately strongly costate *Neospirifer* with alate to mucronate hinge.

TYPES.—Holotype: YPM 12500. Figured paratypes: YPM 12500 (sic) (R. E. King, 1931, plate 37: figs. 5a,b, specimens unnumbered). Figured hypotypes: USNM 152904e,g,i,l,q,r,z,a; 154613ak. Measured hypotypes: USNM 152904a-z,a'.

COMPARISON.—*Neospirifer bakeri* is characterized by its large thick shell which is transverse and strongly alate in youth, becoming longer and only slightly produced at the hinge extremities in maturity, its weak to moderately strong costae, low lateral plication, low to moderately high fold with rounded crest, shallow sulcus with a strong costa bounding it on each side, and its strongly hooked beak. It differs from *N. thescelus* and *N. apothese-*

celus, both new, in its weaker costae and weaker plications, much more strongly transverse and alate juveniles and neanic individuals, and normally larger mature adults. It is nearly the same size as *N. notialis*, new species, but more transverse and alate at all stages of growth, and more strongly plicated. It is larger, and more alate than *N. mansuetus*, new species, has weaker costae and, although its lateral plications are about the same strength, they are fewer.

Large foreign species that are comparable include *Spirifer siculus* Gemmellaro (1899, pl. 36) and *S. fritschi* Schellwien (1892, pl. 5), but these lack lateral plications and are not extended at the hinge extremities. The species most similar in shape is *S. marcoui* Waagen (1883, pl. 47) from the Lower *Productus* Limestone of the Salt Range; but *N. bakeri* is more strongly alate, its fold is lower and more rounded, sulcus shallower and more gently troughed, and the costae more definitely fasciculate, with the proximal fascicles plicating the shell.

The subspecies *N. b. bakeri* is characterized by its large shell, with strong costae and fairly strong and distinct plications formed by the proximal fascicles and its narrow and moderately high fold. The strong costae and higher fold distinguish it from *N. bakeri columbarius* which occurs mainly at USNM 703d, farther east in the Glass Mountains, but at the same horizon.

Neospirifer bakeri columbarius, new subspecies

PLATE 598: FIGURES 1-26; PLATE 599: FIGURES 1-14;
PLATE 600: FIGURES 1-11

Large, moderately strongly biconvex; outline trapezoidal, normally widest at hinge, usually somewhat alate, interareas maintaining breadth to lateral extremities; commissure broadly uniplicate, slightly plicated laterally; fastigium low, crest blunt near beak, becoming broadly arched anteriorly, rather sharply bounded on each side by intercostal troughs; sulcus shallow, more broadly troughed anteriorly, reflecting fastigium, sharply bounded on each side by crest of high costa. Costae fasciculate; 3 or 4 fascicles on each side of fastigium producing low plications, becoming lower anteriorly; median costa on fold bifurcating immediately anterior to beak, continuing forward as prom-

inent dual ridge along crest of fold, some shells with one secondary costa intercalated 10-20 mm anterior to beak; lateral costae splitting off from major crestal costae about 5 mm anterior to beak, somewhat weaker, themselves splitting anteriorly to produce one fascicle on each side of fold; number of costae on fastigium normally even, 10-16; lateral costae forming fascicles, each with primary costa beginning at beak, others added anteriorly by incipient bifurcation, producing about 5-7 costae per fascicle normally, as many as 9 near anterior of large shells, total number of costae 20-30 on each side of mature shells; fasciculation absent at lateral extremes; median costa of sulcus beginning at beak, bifurcating evenly 10-20 mm anterior to beak, may split again farther forward.

Fine radial ornament absent; fine concentric ornament consisting of closely spaced growth lines, interrupted by stronger, irregularly spaced growth laminae becoming stronger and more frequent near margins.

Pedicle valve of adults greatly thickened in posterior; moderately convex transversely, strongly convex longitudinally, maximum convexity slightly anterior to strongly hooked beak; delthyrium high, triangular, apical part closed by slightly convex, inset pseudodeltidium with posteriorly curved edge, thickened by callus in adults; interarea nearly smooth, marked by fine, transverse growth lines, laterally tapering, longitudinally somewhat concave, extending to extreme points of alations, forward edge with numerous small, anteriorly pointing denticles. Brachial valve moderately convex transversely and longitudinally, greatest convexity in umbonal region; fastigium nearly straight longitudinally anterior to umbonal region, may have slight dorsal flexure near anterior margin in mature shells; apex of beak not prominent; brachial interarea short, concave, length nearly uniform, slightly decreasing near lateral extremes; notothyrium broadly wedge-shaped, apex occupied by bilobed cardinal callosity (process), finely and deeply lamellate for muscle attachment.

Pedicle valve interior with strong, divergent hinge teeth, projecting anteriorly, leaving trace along edge of delthyrium, supported by strong, deep, wedge-shaped dental ridges; dental plates short, near apex of valve, continuous with dental ridges, slightly divergent toward valve floor, slanting posteriorly, normally buried by apical thicken-

ing of shell material; apex of valve beneath pseudodeltidium filled by callus. Muscle area excavated, elongate oval; adductor marks narrow, elongate, lying on each side of median line, separated from one another by slightly raised ridge along median line, beginning just anterior to adjustor marks in apical part of muscle area, extending about four-fifths of total length, expanding slightly anteriorly, lightly striated longitudinally; diductor muscle marks large, surrounding adductors anteriorly and laterally, each semioval, strongly marked by fine, irregularly radiating lirae; adjustor marks in apical part of area normally trilobate, lirae; posterior half to two-thirds of floor marked by shallow pits and bumps in vaguely radial pattern, becoming stronger toward hinge line, fading anteriorly and laterally, giving way to faintly impressed rather widely spaced, radiating pallial markings, some reaching margin of valve.

Brachial valve interior with strong, widely divergent hinge sockets along sides of notothyrium, trough of sockets behind functional portion covered by thin plate. Helicophores, triangular plates from socket ridges, doubly flexed, first dorsally, then ventrally, converging but not meeting, slightly twisted, joining end of spiral brachidium in scarf-like joint; end of spirallium produced to form short ventrally projecting jugal spur at juncture with helicophore; spirallium ribbonlike, in oval loops decreasing in size laterally, coiled dorsoventrally. Buccal plate elaborate, lacy, strongly trilobed, with prominent divergent anterior wings, fringed sides, each lateral lobe pierced by 2 or 3 holes, median lobe by as many as 6, each hole with low irregular, ventrally projecting fringe; buccal plate located on median line, braced against helicophores and spiralia, with convex side dorsal, concave side ventral, lobate end posterior, wings and median comb anterior. Muscle area spatulate, slightly widening anteriorly, beginning about a fifth length of valve anterior to beak, bisected by low median ridge; each adductor scar marked by faint lirae in irregular herringbone pattern. Floor of valve behind muscle area with low, narrow median ridge, pair of short, sinuous ridges diverging from median ridge, one on each side near posterior end, also miscellaneous lirae in somewhat radial pattern; floor of valve along hinge and for short distance anteriorly marked by faint pits, much less distinct than on floor of pedicle valve; plications of shell more

strongly reflected inside than on inside of pedicle valve.

MEASUREMENTS (in mm).—

	brachial				thick- ness
	length	valve length	hinge width	midwidth	
USNM 703d					
152905a	2.4	2.4	2.5	2.7	1.8
152905b	3.7	3.3	3.6	4.0	2.6
152905c	4.4	3.7	4.7	4.9	3.3
152905d	5.1	4.5	5.3	5.7	3.9
152905e	6.0	5.3	5.9	7.1	3.7
152905f	8.2	7.0	9.0	8.9	7.5
152905g	11.7	9.6	18.6	13.7	8.0
152905h	27.6	22.3	53.0	32.0	17.2
152905i	39.0	33.8	91.0	56.0	25.5
152905j	42.5	35.9	75.8	53.0	27.3
152905k	42.8	31.7	63.0	56.5	26.6
152905-l	48.3	40.0	57.4	60.0	29.2
152905m	47.6	35.4	85.0	64.5	30.9
152905n	50.0	40.1	85.0+	66.0	32.0
152905o	54.3	42.4	105.0+	72.5	38.4
152905p (holotype)	56.0	44.8	99.4*	75.0	36.9

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—USNM 703d, 724a.

DIAGNOSIS.—Large, robust *Neospirifer*, fasciculate but the fascicles forming only low plications and broad fold.

TYPES.—Holotype: USNM 152905p. Figured paratypes: USNM 152905e,g,h,m; 154602a-i; 154603a-c. Measured paratypes: USNM 152905a-o.

COMPARISON.—*Neospirifer bakeri columbarius* is characterized by its large and robust shell, and its low and rounded costae, which, although strongly fasciculate, form only low plications near the middle of the flanks. The fastigium is low and gently rounded, and the sulcus shallow, but rather strongly bounded by a prominent costa on each side. It differs from the subspecies from farther west in the Glass Mountains, *N. bakeri bakeri* R. E. King, primarily by its lower and broader fold, weaker costae, and weaker lateral plications.

DISCUSSION.—Most specimens of *N. bakeri columbarius* are widest at the hinge, although in juveniles shorter than 1 cm, the hinge width and midwidth are nearly equal, and alation is rare. One well preserved mature adult (USNM 152905-l) is slightly wider at midlength than at the hinge, but even on that specimen growth lines show that it

was widest at the hinge when the shell was between 15 and 30 mm long.

The pedicle valve of most adults is greatly thickened at the posterior. The thickening becomes noticeable in shells longer than about 25 mm, apparently being accomplished by addition of callus on the inside along the hinge. The callus not only thickens the valve, but also buries the dental plates, fuses with or partly buries the pseudodeltidium, and allows the muscle area to become deeply excavated by building up around it. Few brachial valves show any thickening, and in them it is confined to the immediate area of the beak. Unthickened juveniles show that, in the pedicle valve, the dental plates diverge toward the floor, and are continuous with the dental ridges which converge toward the floor. The pseudodeltidium in adults also appears to be continuous with the dental ridges, but in juveniles it is obvious that it is a separate structure, forming as a small ridge, continuous around the edge of the apex of the delthyrium, in individuals about 2.5 mm long. As the shell becomes larger the apical part of the pseudodeltidium fills in by addition to its forward edge, and the lateral parts continue to be carried forward with growth of the shell, remaining like elongated horns of a crescent.

Neospirifer formulosus, new species

PLATE 602: FIGURES 1-14

About medium size for genus, wider than long, hinge usually mucronate; sides sloping medially; anterior margin slightly reentrant medially. Interarea short, curved, strongly apsacline; beak narrowly incurved. Surface multicostate, costae low and rounded, fasciculate in young stages becoming low anteriorly, not forming marginal plications. Fascicles usually with 3 costae, fastigium with 8-10 costae, flanks with 18 or 20.

Pedicle valve moderately and evenly convex in lateral profile, umbo narrowly curved; anterior profile broadly angular, median region depressed by fastigium but sides sloping evenly and moderately. Umbonal and median regions fairly strongly swollen. Sulcus originating at beak, widening moderately but not deep. Sulcus with costae intercalated on sides about 5 mm anterior to beak. Sulcus strongly demarcated from beak to midvalve, but

less so anteriorly. Flanks flattened, moderately sloping laterally but with gentle anterior slopes.

Brachial valve fairly strongly convex in lateral profile, moderately domed in anterior profile and with steeper lateral slopes than opposite valve. Median region fairly strongly swollen. Fold originating in single costa extending to anterior margin, against which additional costae intercalate about 4 or 5 mm anterior to beak. Median costa bounded by costae of equal strength but diverging, fastigium low, subcarinate posteriorly and medially but rounded anteriorly. Flanks somewhat swollen, with fairly steep slopes laterally but flattening before reaching cardinal extremities.

Pedicle valve interior not greatly thickened; apical plate short, reentrant, and excavated. Dental plates anteriorly divergent, defining narrow delthyrial cavity. Muscle field lanceolate, muscle scars divided by low myophragm. Dental ridges delicate, not shelflike.

Brachial valve interior with elongate sockets, proximal parts covered by thin plate; notothyrium narrow; cardinal process small; crural bases somewhat spatulate. Buccal plate delicate, deeply concave, with 2 anterior and 2 posterior serrate projections, and 2 lateral projections broader than others, 3 medial perforations, posterior one smaller.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—AMNH 503; USNM 720d, 721j, 721z, 723a, 724c, 724d, 726d, 726e, 732i.

DIAGNOSIS.—Medium-sized, variable, with shallow sulcus but sharp tongue, deep pedicle valve, and small delicate buccal plate.

TYPES.—Holotype: USNM 152906f. Figured paratypes: USNM 152906e,g,j; 152907; 152908a,b.

COMPARISON.—The only other species in the Glass Mountains that can be confused with this one is *N. bakeri*, particularly among the young, but the costae of *N. bakeri* are much coarser than those of *N. formulosus*. This is true also of the wide adults when compared with *N. bakeri*.

DISCUSSION.—This species is distinctive but highly variable. Variation is apparent not only in the adults but the same types of variations occur in the young. Many of the young have the lateral extremities rounded, a few have them drawn into long points, but the details of the ornament of the two types appear to be the same. Some adults are wide and have mucronate extensions, others are

MEASUREMENTS (in mm).—

Neospirifer huecoensis (R. E. King)

PLATE 624: FIGURES 17-21

Spirifer (*Neospirifer*) *huecoensis*, R. E. King, 1931:116, pl. 38: figs. 2, 3.

Large, transversely subrectangular in outline; wider than long, widest near middle; sides gently rounded; anterior margin subtruncate; surface costellate, costellae low, narrowly rounded in posterior half, wider and flattened in anterior region; bundling of costae uncommon but short bundles appearing in posterior, especially umbonal regions of both valves.

Pedicle valve evenly and gently convex in lateral profile with maximum convexity in median region; anterior profile broadly convex but depressed medially by the sulcus. Interarea curved and moderately long; beak incurved; umbonal region somewhat swollen, swelling passing into general convexity of valve at middle; sulcus originating on beak, extending to anterior margin; tongue short, broadly rounded; sulcus becoming shallower and broader anteriorly, radial costellae becoming broader and flatter (surface at anterior appears almost smooth); flanks bounding sulcus gently inflated with moderate slopes to margins; umbonal slopes steep; cardinal extremities obtuse to pointed, with small angular projections, as shown by growth lines.

Brachial valve equal in depth to pedicle valve, moderately convex in lateral profile, broadly convex in anterior profile; umbonal region gently swollen; fold originating on beak, defined only by crowding or bundling of costellae, elevating slightly but widening anteriorly, where occupying about a third of shell width; fold at anterior broad, gently rounded; fastigium only slightly elevated above flanks; fold surface marked by low costellae; flanks gently inflated, slightly depressed below the fold at anterior, slopes gentle to margins.

MEASUREMENTS (in mm).—Holotype YPM 12441: length 40.3, brachial valve length 38.5, hinge width 57.4, midwidth 60.2, thickness 28.3.

TYPES.—Holotype: YPM 12441. Paratype: YPM 12442 (pedicle interior).

STRATIGRAPHIC OCCURRENCE.—Gym Formation = Hueco Formation (ridge east of Juan Peak).

LOCALITY.—King 389.

DIAGNOSIS.—Large *Neospirifer* with rectangular outline and low fold.

	brachial				
	length	valve length	hinge width	width	thickness
USNM 723a					
152906a	4.7	3.8	5.5	5.5	3.5
152906b	11.0	9.3	24.7+	16.5	8.1
152906c	12.2	10.1	21.9+	17.9	9.1
152906d	16.0	13.7	39.6+	28.2	12.4
152906e	19.4	16.7	60.0*	31.6	15.0
152906f	27.0	23.3	71.0*+	40.0	20.2
(holotype)					
152906g	26.3	?	35.2	37.8	?
USNM 724c					
152907	16.0	14.1	26.6	23.8	12.4
USNM 720d					
152908a	3.6	?	3.7	4.2	2.0
152908b	4.6	?	4.1	5.4	?
152908c	4.8	4.3	4.3	5.5	3.4
152908d	6.4	5.5	7.0	9.0	4.6
152908e	7.1	6.4	9.4	10.8	5.5
152908f	8.1	?	15.8	11.2	?
152908g	8.2	?	10.2	11.9	?
152908h	9.2	8.3	10.7	12.4	?
152908i	11.5	?	15.4	18.2	?
152908j	13.2	?	19.4	18.8	?
152908k	14.6	?	21.0	20.9	?
152908l	16.4	?	33.3	27.3	?
152908m	16.5	?	21.2	22.7	?
152908n	17.2	?	27.6	24.6	?
152908o	18.2	?	28.7	28.4	?
152908p	21.7	?	33.4	30.2	?
152908q	25.4	?	39.9	37.4	?
152908r	27.6	?	53.3	41.3	?
152909a	?	4.3	4.1	5.8	?
152909b	?	4.7	5.5	6.5	?
152909c	?	5.2	6.6	7.6	?
152909d	?	5.7	6.7	7.5	?
152909e	?	6.5	10.4	10.6	?
152909f	?	8.0	11.5	13.1	?
152909g	?	8.7	14.6	13.6	?
152909h	?	10.4	17.9	16.4	?
152909i	?	11.2	17.3	19.0	?
152909j	?	11.4	17.3	21.0	?
152909k	?	12.8	24.7	22.4	?
152909l	?	13.2	24.7*	23.3	?
152909m	?	13.6	32.2*	26.6	?
152909n	?	14.0	34.3	25.0	?
152909o	?	14.2	38.0*	25.0	?
152909p	?	14.6	23.6	23.7	?
152909q	?	16.3	32.3	27.9	?
152909r	?	16.7	34.6	31.0	?
152909s	?	19.3	51.6*	30.5	?
152909t	?	8.8	31.6*	16.7	?
152909u	?	15.6	49.6	31.4	?

more compact, but have auriculations and retain the same ornament.

DISCUSSION.—For comparison with its nearest related species see *Neospirifer notialis*.

Neospirifer mansuetus, new species

PLATE 603: FIGURES 1–29; PLATE 604: FIGURES 1–27;
PLATE 605: FIGURES 1–9

Spirifer (*Neospirifer*) *pseudocameratus* R. E. King [not Girty], 1931:116, pl. 39: figs. 2, 3a–c.

Large, moderately to strongly biconvex; outline normally transverse, becoming more elongate in full grown adults, widest at hinge, but not alate; commissure uniplicate, slightly plicated laterally; fold high at commissure, but fastigium not standing high above flanks; sulcus shallow, broad, strongly bounded laterally only in posterior half. Costae moderately strong, height decreasing anteriorly, fasciculate, producing up to 4 low plications, numbering 3–5 costae per fascicle, aggregating 15–30 per side on adults; median costa of fastigium bifurcating about 5 mm anterior to beak, each branch incipiently bifurcating laterally, additional single median costa added by insertion in some specimens, costae numbering 10–16 on fastigium and sulcus; median costa of sulcus beginning at beak, remaining single or less commonly bifurcating 15–30 mm anterior to beak. Fine radial ornamentation absent; concentric ornamentation consisting of fine growth lines interrupted by irregularly spaced growth laminae becoming more frequent near margins.

Pedicle valve moderately convex transversely, more convex longitudinally; beak hooked over open wedge-shaped delthyrium; pseudodeltidium short, flatly convex, set deep in apex of delthyrium, often thickened or buried by callus; interarea concave, tapering near hinge ends but not pinching out, edge bearing small, anteriorly pointing denticles beginning immediately adjacent to hinge teeth. Brachial valve only moderately convex transversely and longitudinally; interarea short, concave; notothyrium broadly wedge-shaped, apex occupied by finely lamellate, strongly anteriorly projecting cardinal callosity.

Pedicle valve interior with strong hinge teeth, supported by deep, anterior and ventrally convergent dental ridges; dental plates very short, diverging to meet floor of valve lateral to muscle area, continuous with apical portion of dental ridges;

valve somewhat thickened in posterior along hinge, partly burying dental plates, filling apical cones, building up around posterior part of muscle area, leaving anterior part slightly elevated; adductor muscle marks elongate, longitudinally striated, lying along low median ridge; diductor marks larger, lateral, irregularly radially striated, adjustor marks small, located in apical part of muscle area, markings similar to diductors. Posterior floor of valve moderately to strongly pitted in irregular radial pattern, fading toward margins, channeling into shallow pallial trunks.

Brachial valve interior with widely divergent, thick-walled hinge sockets, normally open, rarely covered by thin, elongate plate. Helicophores joining socket ridges as thin, triangular plates, tapering anteriorly and converging but not meeting, joined to spiralia by flat scarf joint; spiralia ribbonlike, spiraling laterally in ovals of decreasing size; jugal process small. Buccal plate strongly trilobed, each lobe sparsely perforated by somewhat elongate holes, each hole with high, lacy or tubelike rim, anterior wings fairly strongly divergent, anterior median comb incompletely tubular, lacy. Muscle area elongate, bisected by low median ridge, flanked at posterior by short, slightly raised, divergent ridges.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Bone Spring Formation.

LOCALITIES.—Cathedral Mountain: AMNH 500C, 520; USNM 702, 702a, 702a¹, 702b, 702ent, 702inst, 702–low, 702un, 703b, 703bs, 707q, 711q, 714w, 721r, 721u, 723u, 724i, 724m, 724s, 726o, 726u, 726x, 726y, 727o, 729r, 732u, 735b. Bone Spring: AMNH 663.

DIAGNOSIS.—Transverse but not alate *Neospirifer* with gentle plications and shallow sulcus.

TYPES.—Holotype: USNM 152913e. Figured paratypes: USNM 152912a,d,g,j; 152913c,d,e; 154606a–e; 154607a,b; 154615a–e. Measured paratypes: USNM 152912a–g, 152913a–d, 152914a–r. Unfigured paratypes: USNM 152912b,c,e,f,h.

COMPARISON.—*Neospirifer mansuetus* is characterized by its transverse outline with the hinge the widest part, but not alate, its gently plicated shell, shallow sulcus, elaborate buccal plate with rimmed perforations, and its normally completely open hinge sockets. Many specimens resemble individuals of *N. thescelus*, new species, but differ in their lower lateral plications, more rounded costae

MEASUREMENTS (in mm).—

	brachial		hinge	width	thick- ness
	length	valve length			
USNM 702a					
152914a	1.3	1.3	1.3	1.7	0.8
152914b	1.7	1.6	1.7	2.0	1.0
152914c	1.9	1.8	1.9	2.2	1.3
152914d	2.6	2.4	2.0	2.8	1.7
152914e	3.8	3.3	2.8	3.8	2.9
152914f	4.0	3.5	3.6	4.6	3.1
152914g	4.7	4.2	3.7	5.4	3.4
152914h	5.1	4.6	5.6	6.6	4.0
152914i	5.8	5.1	5.0	6.2	4.4
152914j	6.0	5.3	6.0	7.4	4.3
152914k	6.6	6.0	7.1	8.3	5.3
152914l	7.9	7.0	6.6	8.7	6.2
152914m	9.6	8.5	7.9	10.7	6.4
152914n	9.6	8.5	11.0	12.5	7.8
152914o	10.0	9.0	10.7	12.6	7.9
152914p	13.4	10.0	12.9	16.0	9.0
152914q	25.9	23.4	31.5	32.3	17.4
152914r	30.0	26.3	43.0	c.40.0	23.7
USNM 702					
152913a	11.3	9.7	11.0	14.0	8.0
152913b	26.9	25.3	44.0	38.8	21.0
152913c	42.0	35.5	52.0	50.0	30.0
152913d	50.0	44.8	65.0	70.7	41.3
152913e	51.5	41.6	75.5+	62.3	35.3
(holotype)					
USNM 702un					
152912a	16.0	14.4	19.0	20.4	11.9
152912b	17.0	15.7	c.23.0	23.0	12.7
152912c	18.9	16.5	24.6	27.9	13.5
152912d	21.5	18.0	36.0	28.4	15.7
152912e	30.4	28.4	43.0	47.5	25.4
152912f	33.0	28.4	49.0	45.2	24.4
152912g	38.5	32.0	66.8	56.6	27.0

that do not set off sharply the edges of the sulcus and the crest of the fold, normally rounded hinge ends without alations, and elaborate buccal plates with rimmed perforations. *Neospirifer notialis*, new species, has similarly rounded and nonalate hinge terminations, but *N. mansuetus* is more transverse in outline, with the hinge normally the widest part of the shell, and its dorsal interarea slants dorsally, separating the beaks of the two valves a distance more typical of the genus. The buccal plate of *Cartorhium coristum*, new species, has tubelike rims around the perforations as in *N. mansuetus*, but the shell differs greatly in its sharp-crested fold, strong costae, hinge that is narrower than the midwidth, and weak scaly ornamentation. Some large specimens resemble average-

sized specimens of *N. bakeri* R. E. King, but differ in their rounded posterolateral margins, gentle plications, stronger costae, and broadly rounded fold.

Neospirifer mansuetus is the Glass Mountains species that most nearly resembles typical Pennsylvanian species such as *N. dunbari* R. H. King. It differs from that species (formerly *N. triplicatus* (Hall) in its nonalate hinge, less transverse outline, somewhat lower fold, and more wedge-shaped profile. It is distinguished from *N. cameratus* (Morton) as illustrated by Dunbar and Condra (1932, pl. 39) in its more transverse outline, less sharp posterolateral margins, somewhat more pronounced lateral plications, and more strongly fasciculate costae.

Among foreign species, *Spirifer cameratus* Morton of Tschernyschew (1902:138, pls. 5,6,11,40) is similar but *N. mansuetus* differs in its more rounded posterolateral margins, somewhat stronger lateral plications, and more definitely fasciculate costae, with more costae per fascicle. The costae of the Russian specimens appear to bifurcate more nearly symmetrically, producing "fascicles" of two, more as in typical *Spirifer* than in *Neospirifer*. A large specimen of *Neospirifer ravana* var. *plicatifer* Reed (1944, pl. 29) resembles the largest of our specimens of *N. mansuetus* in outline and general aspect. Normal specimens of *N. mansuetus* are easily distinguishable; the large one differs from the Salt Range species primarily in its broader and fewer costae and more gently rounded crest of the fold. *Neospirifer marcoui* var. *undata* Reed (1944, pl. 25) also is similar to *N. mansuetus*, differing in its broader lateral plications, sharper costae, and in the more transverse outline of the large specimens. *Spirifer poststriatus* Nikitin (1890, pl. 2) is similar in outline at maturity, but its younger specimens are more transverse and sharply alate. In addition, the costae of *N. mansuetus* are more strongly fasciculate, and the fold broader and blunter.

Neospirifer neali, new species

PLATE 605: FIGURES 10-17; PLATE 606: FIGURES 1-10

Large, transversely elliptical outline, maximum width slightly posterior to midwidth; sides narrowly rounded; hinge narrower than maximum width;

cardinal extremities slightly auriculate. Anterior margin broadly rounded. Anterior commissure strongly uniplicate. Interarea long, wide, slightly curved, and strongly apsacline. Beak prominent, strongly incurved. No pseudodeltidium seen. Surface fasciculate, fascicles numbering 3, forming plications in posterior half but dying out anteriorly, not affecting lateral commissure. Costae numbering about 23–25 on flanks and 16–18 on fastigium.

Pedicle valve evenly and moderately convex in lateral profile, broadly and moderately convex in anterior profile, outside halves of flanks descending somewhat abruptly. Umbonal region full, median region somewhat swollen. Sulcus originating at beak, without median costa; first costae intercalated inside bounding costa at 7 mm anterior to beak. Median costa originating about 10 mm anterior to beak. Sulcus narrow and moderately deep in posterior half, widening but shallow anteriorly, producing long broadly rounded tongue. Flanks with steep posterolateral but gentle anterior slopes.

Brachial valve fairly evenly and moderately convex in lateral profile, broadly angular in anterior profile, sides flattened and moderately sloping, but median region forming rounded angle. Umbonal and median regions moderately swollen. Fastigium originating at beak as single costa producing broad fascicle anteriorly. Fastigium low throughout its extent, broadly rounded in section and poorly differentiated from flanks, which are slightly swollen proximally and have moderately steep slopes anteriorly and laterally.

Interior not well known, but buccal plate present.

MEASUREMENTS (in mm).—

	brachial				thick-
	length	valve length	hinge width	midwidth	ness
USNM 702d					
152915a	54.5	45.5	79.2*	86.0*	35.3?
152915b	46.5	39.0	66.5	73.0	30.0
(holotype)					
152915c	35.7	30.1	33.7	48.0	21.8
152915d	12.7	10.3	8.8	13.5	7.7
152915e	7.3	6.4	6.5	9.3	5.3
152915f	6.0	?	4.8	6.9	?
152915g	?	4.7	5.4	6.6	?

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member); Bone Spring Formation.

DIAGNOSIS.—Large, elliptical *Neospirifer* with

strong fasciculation in the posterior half and strongly apsacline, long interarea.

LOCALITIES.—Taylor Ranch: USNM 702d. Bone Spring: AMNH 591.

TYPES.—Holotype: USNM 152915b. Figured paratypes: USNM 152915a,c; 154608a,b. Measured paratypes: USNM 152915a,c-g.

COMPARISON.—Characterized by its very transverse outline and large size, this species is unlike any other in the Glass Mountains. It is quite unlike *N. notialis*, new species, which occurs at the same stratigraphic level but not in direct association. *Neospirifer neali* is shorter and wider than *N. notialis*, and much wider than *Cartorhium latum* (R. E. King) which has similar ornamentation. Species of *Neospirifer* and related genera in the Word Formation are too dissimilar from *N. neali* to require detailed comparison.

DISCUSSION.—This species is confined to a single locality in the Glass Mountains, the sponge bioherms at USNM 702d, but also has been identified as a rare constituent of the Bone Spring Formation in the Sierra Diablo. Such a peculiar distribution suggests that the species was dependent upon a rather narrow set of living conditions.

Neospirifer notialis, new species

PLATE 607: FIGURES 1–14; PLATE 608: FIGURES 1–13

Spirifer (*Neospirifer*) *huecoensis* [part] R. E. King, 1931:116, pl. 38: figs. 3a, b [not figs. 2a–c = *N. huecoensis* King].

Large, moderately strongly convex; outline subquadrate, normally widest near midlength, hinge rarely extended; commissure strongly uniplicate, normally not plicated laterally; fold highly arched, somewhat parabolic, greatly increasing in height anteriorly; sulcus shallow, gently troughed, only slightly deepening anteriorly, indistinctly bounded laterally. Costae weakly fasciculate, most bifurcation taking place in posterior half of shell, fascicles not producing plications, costae numbering 3–6 per fascicle, normally 3, totaling 16–28 per side exclusive of fastigium or sulcus, about 16 on fastigium and sulcus; median costa bifurcating at or near beak, continuing forward as dual crest of fastigium, each incipiently bifurcating distally, occasionally third median costa added by insertion 10–20 mm anterior to beak; median costa of sulcus beginning at beak, continuing singly or evenly bifurcating 10–20 mm anterior to beak, normally

without further bifurcation. Fine radial ornamentation apparently absent (detail destroyed by silicification); fine concentric ornament consisting of closely spaced growth lines, interrupted by stronger growth laminae becoming more frequent near margins.

Pedicle valve flatly convex transversely, slightly more convex longitudinally; beak short, relatively strongly hooked, apex approaching rather near to brachial beak; shell greatly thickened along hinge; delthyrium high, wedge-shaped; pseudodeltidium small, slightly convex, normally cemented to or buried in larger apical callosity; interarea short, concave, normally terminated abruptly at ends of hinge; edge of hinge bearing minute denticles, beginning 2 or 3 mm lateral to hinge teeth. Brachial valve more strongly convex transversely, only moderately convex along fastigium owing to increase in height of fastigium anteriorly; brachial interarea short, concave, slanting ventrally toward posterior, bringing beak near to apex of pedicle beak; notothyrium broadly wedge-shaped, apex occupied by rather large, ventrally projecting cardinal process, finely lamellate for muscle attachment.

Pedicle valve interior with strong divergent hinge teeth, supported by thick, deep dental ridges tending to converge toward floor of valve, continuous farther toward beak with short dental plates, diverging to intersect floor beside muscle area; apical cones partly or wholly filled by callus, burying dental plates of largest specimens. Muscle area elongate oval, posterior end excavated, anterior end slightly elevated; adductor marks elongate, lying along median line, separated by low median ridge; diductor marks lateral, irregularly radially striated; adjustor muscle marks in apical part of area under edge of apical callosity, one on each side, textured like diductors but with striae fanning posteriorly; floor of valve pitted in vaguely radial pattern, presumably channeling into pallial trunks as in other species.

Brachial valve interior with widely divergent hinge sockets, thick-walled, normally completely open, without covering plate. Helicophores beginning as thin plates, along socket ridges, spiralia ribbonlike, number of coils not observed; buccal plate not observed. Muscle area elongate, spatulate, anteriorly slightly widening, bisected by low median ridge; details of adductor marks not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	midwidth	thick- ness
USNM 702e					
152910a	30.2	27.3	44.8	46.0	19.9
152910b	46.0	37.8	60.0*	68.0?	31.9
(holotype)					
152910c	46.6	39.4	54.0	63.2	27.5
152910d	50.3	41.9	57.4	66.1	32.5
152910e	55.2	45.5	68.2*	75.0	38.6

STRATIGRAPHIC OCCURRENCE.—Hess Formation (Taylor Ranch Member).

LOCALITIES.—USNM 702d, 702e.

DIAGNOSIS.—Large *Neospirifer* with hinge narrower than midwidth and high fastigium, low costae with indistinct fasciculation.

TYPES.—Holotype: USNM 152910b. Figured paratypes: USNM 152910a,f,j; 154604a. Measured paratypes: USNM 152910a, c-e. Unfigured paratypes: USNM 152910c-e.

COMPARISON.—*Neospirifer notialis* is characterized by its quadrate outline, large maximum size, thickened valves, weakly fasciculate costae that do not form plications, high fastigium but shallow sulcus, hinge that is narrower than widest part of shell and normally not alate, and its ventrally slanting brachial interarea that brings the two beaks near together. Its nearest relative is *N. huecoensis* R. E. King (1931:116) from the Hueco Canyon Formation in the Hueco Mountains. That species shares the characteristic of closely opposed beaks, quadrate outline, weak fasciculation, low interarea, and has a similar pattern of costation on the fastigium and sulcus. The Glass Mountain species differs in its greater thickness, and especially in its higher fastigium with nearly flat profile at the anterior which is filled at the commissure by an exaggeratedly large fold of the commissure.

Few species in the Glass Mountains attain a size as great as that of *N. notialis*. One that does is *N. bakeri* R. E. King, from which *N. notialis* differs in its lack of alate hinge extremities, lack of lateral plications, coarser and fewer costae, shallower and less distinctly bounded sulcus, and beaks that are nearer together. Some of the largest specimens of *N. mansuetus*, new species, also may be compared with *N. notialis*, which is distinguished by its lack of plications, lower pedicle interarea, lower fastigium, and less convex profile.

Several foreign species may be compared to *N. notialis*. Most similar is *Spirifer fritschi* Schellwien (1892), from which the Texas species differs in its more definitely fasciculate costae, greater convexity in profile, and more prominent brachial beak. *Spirifer musakheylensis* Davidson of Rothpletz (1892, pl. 9) is similar in its outline, costation, and size, but differs in its greater convexity and much higher and sharper fold and deeper sulcus. Normally *S. musakheylensis* has the raised scaly growth laminae that characterize species of *Lepidospirifer* Cooper and Grant (1969), but Rothpletz' drawings do not show that ornament. *Spirifer siculus* Gemmellaro (1899, pl. 36) is superficially similar to *N. notialis*, but differs in its more widely separated beaks and its higher, triangular interarea.

Only two of the Salt Range species illustrated by Waagen (1883) are comparable to *N. notialis*. The specimens he called *Spirifer striatus* Martin (pl. 44) differ in their normally proportionately narrower hinge lines and higher ventral beaks with necessarily higher interareas. *Spirifer oldhamianus* Waagen (pl. 46) is more nearly elliptical in outline, has the fold higher, sulcus deeper, and is more strongly convex.

Neospirifer placidus, new species

PLATE 609: FIGURES 1-29

About medium size for genus, wider than long, hinge equal to or narrower than midwidth; cardinal extremities at nearly right angle or slightly obtuse. Ears minute, set off by faint indentation just anterior to hinge ends; sides gently rounded; anterior margin broadly rounded. Anterior commissure uniplicate. Surface multicostate, 4 primary costae at beaks, additional costae implanted 5-10 mm anterior to beaks and third generation near midvalve to form 3 indistinct fascicles. Costae narrowly rounded to subangular and crossed by fine concentric lines. No fine radial ornament noted.

Pedicle valve evenly and moderately convex in lateral profile, broadly and moderately convex in anterior profile, median region humped, with slight median depression, sides flattened and moderately steeply sloping. Sulcus originating at beak, narrow, with 2 costae implanted on sides about 7 mm anterior to beak; anterior to beak sulcus widening rapidly but not becoming much deeper

than at midvalve, terminating in broad rounded tongue; sulcus occupied by about 5 broad, low, rounded costae on tongue. Flanks moderately swollen.

Brachial valve evenly and gently convex in lateral profile, most convex medially; anterior profile forming low dome with slight median elevation. Fastigium low, widening anteriorly but not strongly elevated. Fastigium beginning as single costa splitting and developing slight depression near beak, deepening and widening anteriorly, and continuing to margin. Two costae implanted on each side of fold. Flanks, swollen slightly, gently depressed below fastigium.

Pedicle valve interior with delicate, short, flaring dental plates and moderately long apical plate. Brachial valve interior with delicate socket ridges and broad inner hinge plate; sockets narrow, partly covered by roofing plates. Cardinal process small.

MEASUREMENTS (in mm).—

	length	brachial		width	thick- ness
		valve length	hinge width		
USNM 727e					
153276a	2.8	2.5	2.1	2.9	1.9
153276b	4.0	3.7	2.8	4.6	3.1
153276c	5.0	4.3	3.6	5.5	3.4
153276d	8.0	6.8	5.8	8.8	5.8
153276e	14.5	12.3	13.2	17.3	9.2
153276f	16.8	13.8	14.0	19.4	11.3
153276g	19.5	17.0	17.3	22.6	12.4
153276h	23.3	20.5	25.0	30.7	15.0
153276i	28.9	26.5	40.9	40.9	20.5
153276j	27.1	25.0	38.9	40.4	20.0
(holotype)					
153276k	37.8	31.0	48.5	52.0?	22.4

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (bed 4).

LOCALITIES.—USNM 701-1, 727e.

DIAGNOSIS.—Medium-sized *Neospirifer* with sparsely bundled, low rounded costae, and cardinal extremities without prominent ears.

TYPES.—Holotype: USNM 153276j. Figured paratypes: USNM 153276e,g,l-o,q. Measured paratypes: USNM 153276a-i,k.

COMPARISON.—This species suggests *Neospirifer cameratus* (Morton) which has the same soft contours and nonextended hinge. It differs, however, in its smaller size, fewer costae than *N. cameratus*, and the lower fastigium, and shallower sulcus. The two other Neal Ranch species are more numerous costate and more strongly fasciculate.

Neospirifer thescelus, new species

PLATE 609: FIGURES 30–48; PLATE 610: FIGURES 1–38;
 PLATE 611: FIGURES 1–12; PLATE 612: FIGURES 1–12

Large, rather strongly biconvex; outline irregularly semielliptical to subpentagonal or trapezoidal, normally widest at hinge but only slightly alate; commissure uniplicate medially, slightly undulating laterally; fastigium somewhat narrow, attaining considerable height at anterior of large shells; sulcus deep, cross section broadly V-shaped, sharply bounded laterally by prominent costa on each side. Costae strongly fasciculate, fascicles form up to 4 plications on each side of shell, progressively weaker laterally, normally with prominent primary costa beginning at beak, giving rise to others anteriorly by bifurcation, numbering 3–8 per fascicle, highest number on proximal fascicles, aggregating 15–30 per side on mature shells; median costa of fastigium symmetrically bifurcating near beak, continuing forward as dual crest of fold, each bifurcating laterally, rarely proximally, totaling 10–20 on mature shells, greatest number on largest shells; median costa of sulcus beginning at beak, normally bifurcating 10–20 mm anterior to beak, continuing to anterior margin without further splitting, other costae in sulcus produced by bifurcation from lateral bounding costae. Fine radial ornament absent; concentric ornament consisting of fine, closely spaced growth lines, interrupted by stronger, irregularly spaced growth laminae becoming more frequent toward margins.

Pedicle valve rather strongly convex transversely and longitudinally, greatest convexity in beak region; shell somewhat thickened along hinge in large individuals; beak strongly hooked, overhanging open, wedge-shaped delthyrium; pseudodeltidium short, flatly convex, located in apex of delthyrium, fused to larger, thicker apical callosity; interarea concave, fairly smooth, extending to ends of lateral extensions of hinge; edge of hinge bearing numerous short, sharp denticulations, beginning about 3 mm lateral to hinge teeth. Brachial valve less convex transversely and along fastigium; dorsal interarea short, concave; notothyrium wide, short, apex occupied by brushlike cardinal callosity, finely fimbriate for muscle attachment.

Pedicle valve interior with strong, knoblike teeth diverging anteriorly, supported by thick, deep dental ridges tending to converge toward

floor of valve; dental plates continuous with dental ridges in apical region, diverging to intersect floor on each side of muscle area, partly buried in callus in largest shells, apical cones partly filled with callus. Muscle area elongate oval, apical portion excavated, anterior portion slightly elevated in large thickened shells, adductor marks elongate, narrow, longitudinally lightly striated, lying along each side of low, thin median ridge; diductor marks large, lateral to adductors, marked by moderately strong, irregularly radiating striae; pedicle adjustor muscle marks small, one on each side, located in extreme apical portion of muscle area, marked by posteriorly diverging striae similar to those of diductors. Floor of valve along hinge pitted and pustulose in irregularly radiating pattern fading anteriorly and channeling into several irregular pallial marks reaching margins.

Brachial valve interior with widely divergent, thick-walled hinge sockets, nonfunctional part roofed by thin plates. Helicophores thin, triangular, extending nearly length of socket ridges, narrowing to form thin, slightly sinuous, anteriorly converging arms attached to ends of spirallium by parallel scarf joint; spiralia with short jugal process near attachment to helicophores, remainder ribbonlike, spiraling dorsoventrally. Buccal plate lacy, trilobed, two deep narrow grooves separating lobes, each lobe perforated by two or three large or small holes, sides and anterior wings fringed, anterior median comb fringed or perforated. Muscle area elongate spatulate, bisected by low, sharp median ridge, flanked at posterior by pair of low, nearly straight, anteriorly slightly divergent ridges on floor of many valves; plications and other irregularities of exterior strongly reflected internally.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—AMNH 507. USNM 702c, 703a, 709c, 716x, 719w, 719x, 721o, 721r, 721s, 721t, 721x, 721y, 724j.

DIAGNOSIS.—Large, thick *Neospirifer* having strong costae and strong fascicles producing plications, wide hinge but short alae, and a deep sulcus but low fastigium.

TYPES.—Holotype: USNM 152916y. Figured paratypes: USNM 152916–l,o,s,u,y,za; 152917b; 152918a,b; 154610a–j; 154611a; 154612a. Measured paratypes: USNM 152916a–x,z,za; 152917a,b; 152918a. Unfigured paratypes: USNM 152918c,d.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	midwidth	thick- ness
USNM 702c					
152916a	0.7	?	0.4	0.8	0.5
152916b	1.1	?	0.7	1.3	0.8
152916c	1.7	1.5	1.2	1.8	1.0
152916d	2.0	1.8	1.5	2.1	1.2
152916e	2.5	2.4	2.1	3.1	1.7
152916f	3.0	2.6	2.5	3.5	2.0
152916g	4.3	3.9	4.4	4.9	3.3
152916h	4.9	4.2	4.4	5.4	3.0
152916i	5.3	4.6	4.7	5.5	3.5
152916j	6.3	5.1	5.8	7.5	4.6
152916k	8.0	7.0	8.4	9.5	5.4
152916-l	11.0	8.9	12.0	12.0	7.9
152916m	12.8	10.4	9.7	13.7	8.8
152916n	14.7	12.4	18.4	16.2	9.3
152916o	15.9	12.8	16.3	17.0	10.8
152916p	18.0	15.2	22.1	20.7	13.0
152916q	19.0	15.5	28.3	21.5	12.9
152816r	20.2	16.6	29.5	25.6	14.5
152916s	20.3	17.4	35.0	24.1	13.9
152916t	25.5	21.8	35.5	32.0	18.8
152816u	27.6	23.6	41.2	32.3	19.0
152916v	30.7	26.7	65.6	45.0	23.5
152916w	35.8	29.8?	60.0	43.2	27.2
152916x	40.0	32.1	64.1	52.0	27.7
152916y (holotype)	44.0	37.8	81.0	58.5	30.5
152916z	50.8	42.8	83.9	62.0	39.0
152916za	59.6	51.0	75.0	70.0	37.3
USNM 719x					
152917a	46.4	36.0	60.6	50.8	32.7
152917b	36.0	30.0	65.5	48.3	26.2
USNM 721y					
152918a	54.0	45.5	76.7	73.5	36.0

COMPARISON.—*Neospirifer thescelus* is characterized by its relatively long shell with short lateral extensions of the hinge, strong lateral plications, fascicles with up to 8 strong costae, dual crest of fastigium, median costa in sulcus that begins at the beak and normally bifurcates anterior to the beak, comparatively narrow fastigium and sulcus, with the latter bounded by a strong high costa on each side, and by its multitudinously perforated buccal plate without collars or digitate rims around the holes, and with deep narrow grooves separating the three lobes.

Among Glass Mountains species *N. thescelus* most nearly resembles *N. mansuetus*, new species. The costae, plications, and fold of *N. thescelus* are stronger and sharper, and its hinge extremities

are sharp, normally alate, in contrast to the blunt hinge ends of *N. mansuetus*. Half-grown specimens of *N. bakeri* R. E. King from the Road Canyon Formation also might be considered similar, but they have finer, more numerous costae, and greatly produced hinge extremities. The adults of *N. bakeri* are easily distinguished from *N. thescelus* by their low costae, low plications, more broadly rounded fold, and their generally weaker surface features. The nearest similar species probably is *N. apothescelus*, new species, from the Wolfcampian, but *N. thescelus* differs in its larger size, more produced hinge extremities, more numerous costae, and median costa of the sulcus which normally begins at the beak. *Neospirifer amphigyus*, new species, from the Word is similarly strongly plicated but *N. thescelus* has lower, sharper costae, shorter hinge alations, and its fastigium has two strong costae, the branches of the median costa.

R. E. King (1931) assigned this species and *N. mansuetus* to *N. pseudocameratus* (Girty, 1920, pl. 56); however, study of Girty's type lot of specimens and comparison with King's illustrated specimens indicates that they are not conspecific. *Neospirifer thescelus* differs from *N. pseudocameratus* in its larger size, stronger costae and plications, higher fastigium, deeper sulcus, more transverse outline, alate hinge line, and median costa of the sulcus which bifurcates far anterior to the beak. Among other domestic species, *N. thescelus* may be compared to *N. triplicatus* (Hall) as described by Dunbar and Condra (1932, pls. 38,39), and later ascribed by R. H. King, (1933:441) to *N. dunbari*. *Neospirifer thescelus* is more strongly plicate, costate, and alate, and has the characteristic dual crest to the fastigium. *Neospirifer latus* Dunbar and Condra (1932, pl. 40) also is rather strongly plicate, but *N. thescelus* is more transverse, more alate, has sharper costae, and a broader, shallower sulcus.

Among foreign species *Spirifer ambiensis* Waagen (1883, pl. 48) most nearly resembles *N. thescelus* in its strong plication, but differs in its broader fastigium with single sharp crest, its less produced hinge extremities, and especially in its low inter-area which brings the beaks of the two valves close together. *Spirifer poststriatus* Nikitin (1890, pl. 2) also is similar, but *N. thescelus* has higher, sharper costae, stronger plications and normally is less transverse, although more strongly alate.

Cartorhium, new genus

[Greek *carto* (shortened) + *rhion* (beak)]

Small to moderately large, biconvex; outline subcircular to transversely subelliptical, widest anterior to hinge, rarely slightly auriculate at hinge extremities; commissure uniplicate, laterally not plicated or with low plications that diminish anteriorly; fold low, broadly rounded to bluntly peaked; fastigium low, barely expressed in some species, height increasing anteriorly; sulcus shallow, beginning at beak, depth increasing anteriorly, extending forward as short tongue into fold. Costae strong and round-crested near posterior, becoming lower, flatter, and broader toward anterior, arranged in distinct fascicles, with most of the asymmetrical bifurcation taking place in posterior 20–30 mm. Radial ornamentation fine, rarely preserved; fine concentric ornament making minute grid pattern with radial striae; growth laminae weak, irregularly spaced.

Pedicle valve with prominent, moderately curved beak; delthyrium wedge-shaped, open except at apex, there filled by small, deep-set pseudodeltidium or apical callosity, laterally bounded by traces of growth of hinge teeth; interarea triangular, pinching out at sides, moderately high, gently concave, anterior edge bearing small, anteriorly pointing denticles to insert in corresponding shallow pits in face of dorsal interarea, serving as fulcrum for shell movement. Brachial valve shorter, normally less convex; beak short, blunt; interarea low, broadly triangular, slightly concave, bisected by widely wedge-shaped notothyrium bounded by grooves of hinge sockets; apex of notothyrium occupied by thick, lamellate cardinal callosity.

Pedicle valve interior with strong, anteriorly divergent hinge teeth; dental ridges deep, bladelike, running along undersides of hinge teeth, converging apically and toward floor, but not joining, continuous with divergent dental plates that meet floor on each side of muscle area; posterior part of valve somewhat thickened, partly burying dental plates and partly filling apical cones. Muscle area elongate, narrow, bisected by low median ridge in some specimens; adductor muscle marks narrow, straight, one on each side of median ridge, normally striated longitudinally; diductor muscle marks larger, lying distal to adductors, with lateral

borders bowing outward, lightly striated in irregularly radial pattern.

Brachial valve interior with widely divergent, thick-walled sockets, nonfunctional part roofed by thin plate. Helicophores attached to socket ridges, flexed and converging anteriorly but not meeting, spiralia coiling dorsoventrally on oval loops of laterally decreasing size. Buccal plate elaborate, strongly trilobed, some with incipient bilobation of median lobe, perforations and indentations with lacy rims. Muscle area elongate, narrow, lying in trough of fastigium, anteriorly widening accordingly, bisected by low median ridge; adductor muscle marks lightly striated longitudinally. Pallial markings not observed.

TYPE-SPECIES.—*Cartorhium retusum*, new species.

DIAGNOSIS.—Hinge narrow, interarea triangular, fastigium and fold low, costae coarse, asymmetrically fasciculate, rounded.

COMPARISON.—*Cartorhium* is characterized by its narrow hinge, triangular pedicle interarea, round posterolateral margins, low fold, shallow sulcus, and its moderately coarse to coarse costae that branch asymmetrically to form fascicles. It includes the species that Reed (1944:218–22) assigned to his subgenus *Purdonella*, but does not include species that had been assigned to "*Munella*" Fredericks (1924c), for which Reed introduced the name *Purdonella* as a substitute.

Authors other than Reed, notably Fredericks (1924c), Licharew (1934b), Miloradovitch (1936b), and Dunbar (1955) have considered *Munella* or *Purdonella* to be an offshoot of the genus *Choristites* Fisher. Our opinion is in accord with that of Dunbar (1955, pl. 159) that the species assigned by Reed to *Purdonella* are not closely related to species of *Choristites*. We believe that the narrow-hinged, coarsely fascicostate spiriferids with narrow triangular interareas belong to a genus different from *Munella* and more closely related to *Neospirifer* Fredericks than to *Choristites*.

Cartorhium differs from *Choristites* Fischer de Waldheim (1825), and its synonym *Munella*, by its higher, narrower, fasciculate costae. These same features show its relationship to *Neospirifer*, but its distinctions from *Neospirifer* are its rounded flanks, normally subelliptical outline which rarely is strongly transverse, its consistently triangular pedicle interarea, and its bifurcations, which take place only in the posterior 20–30 mm. Its low fold

and strong fasciculate costae distinguish it from *Spirifer* Sowerby, and from other impunctate spiriferids.

Reed (1944) was somewhat ambiguous in his proposal of the name *Purdonella*, introducing it under the heading of a new subgenus, not simply as a new name. In subsequent text he first (p. 218) stated that it "seems to correspond to Fredericks' name *Munella* (1919) for which *Spirifer nikitini* Tschernyschew was chosen as the type. But the name *Munella* was pre-occupied by Bonnier 1896." Further on, under his discussion of *Purdonella lunwalensis* (p. 219), he made the more positive statement that, "as above mentioned that name is pre-occupied and we may suggest the name *Purdonella*."

Miloradovitch (1936b:52-53) discussed the problem of the distinction of *Munella* from *Choristites*. He showed clearly that no clear separation is possible; that the "euseptoid" supposedly absent in *Munella* but present in *Choristites* is an artifact of secondary thickening of the posterior shell wall and of the dental plates. Thickened specimens have a thin suture between the calcite crystals around each of the two dental plates; this shows as a line in thin-sections or on polished surfaces, and it causes a plane of weakness along which specimens may break. It is not a septum in any normal sense of the word. Miloradovitch illustrated by a diagram (p. 17, fig. 4) how a single unthickened youthful specimen of *Munella* could change to a mature specimen of *Choristites* by addition of secondary calcite around the dental plates. His logical conclusion is that *Munella* is a synonym of *Choristites*. If Reed intended *Purdonella* as a direct nominal substitute for *Munella*, it, too, is suppressed in favor of *Choristites*.

It is clear that the name *Purdonella* must be rejected, on two grounds. First, if it is a replacement for the name *Munella*, it becomes a synonym of *Choristites*. Secondly, if Reed intended it as a new subgenus (which may be construed on the basis of his uncertain equation of his new name with *Munella*) then no type species was established and the name is invalid, according to Article 13b of the International Code of Zoological Nomenclature. We believe, however, that a generic category is warranted for reception of species like *Neospirifer latus* King and new species described below; and that this category includes all of Reed's

species of "*Purdonella*." For this we offer the new genus *Cartorhium*.

Cartorhium chelomatium, new species

PLATE 613: FIGURES 1-35

About average size for genus; moderately strongly biconvex; outline transverse, normally emarginate, widest near midlength, hinge minutely auriculate; commissure uniplicate, fold at commissure high, sharply arched, but not expressed along length of shell; fastigium nearly flat; sulcus moderately deep near posterior, becoming deeper anteriorly, wrapping around anterior, forming sharp projection into deep notch of brachial valve. Costae moderately strong, arranged in indistinct fascicles without plication of shell, numbering 3-8 per fascicle (number increasing with size of shell), totaling 20-40 per side, exclusive of fold or sulcus, on medium to mature shells; median costa of fastigium bifurcating 5-10 mm anterior to beak, each branch asymmetrically bifurcating laterally, some shells with single costa intercalated on median line, costae numbering 10-25 on fastigium and sulcus; median costa of sulcus beginning 2-5 mm anterior to beak, remaining single or symmetrically bifurcating once near midlength of shell. Radial striae fine, rarely preserved; concentric growth lines fine, closely spaced, interrupted at irregular intervals by stronger growth laminae, these becoming more closely spaced toward margins.

Pedicle valve moderately convex transversely, more strongly convex longitudinally through deep sulcus, ending anteriorly in sharp point at median line of sulcus; beak slightly attenuate, somewhat bent but not hooked; delthyrium high, open, laterally bounded by grooves formed by traces of growth of hinge teeth; apical plates short, deep-set, may be incipiently bisected, giving effect of incomplete development; interarea triangular, pinching out at sides, slightly concave, edge with short, anteriorly pointing denticles beginning near hinge teeth. Brachial valve somewhat more strongly convex transversely and toward anterolateral margins, nearly flat along crest of fold; interarea slightly convex, slanting ventrally; notothyrium broadly wedge-shaped, apex with thick triangular cardinal callosity, finely lamellate for muscle insertion.

Pedicle valve interior with strong hinge teeth,

anteriorly divergent, slightly swollen to form small knobs at anterior ends; dental ridges deep, shelf-like, tapering anteriorly, slanting ventrally toward median line; dental plates continuous with dental ridges, short, divergent, meeting floor of valve lateral to muscle area; posterior part of valve normally only slightly thickened, leaving apical cones open and dental plates exposed. Muscle area narrow, elongate oval, bisected by weak median ridge and larger ridge formed by trough of sulcus; adductor muscle marks narrow, elongate, median, lightly striated longitudinally; diductor muscle marks larger, lateral, irregularly radially striate; pedicle adjustor muscle marks small, in extreme posterior of area, normally slightly beneath edge of the apical plates. Floor of thickened valves lightly pitted, with pits arranged in irregularly radial pattern.

Brachial valve interior with widely divergent, thick-walled sockets, partly covered by thin, elongate concave plate. Helicophores flattened into thin plate where attached to socket ridges, gently flexed, twisted, and convergent toward ends of spiralia, joined to them by flat lateral joint; spiralia ribbonlike, coiled dorsoventrally, bearing short blunt jugal processes. Buccal plate strongly convex, primarily trilobed, with median lobe dual, bearing two rows of perforations becoming smaller and attaining high, tubular rims anteriorly, each lateral lobe with row of perforations all connected, cutting lobe in half, rim on each side becoming higher anteriorly, then becoming discrete tubular rims around individual perforations; anterior wings diverging more than 90°; anterior median comb extended into elongate tube, and several lateral digits; sides of plate only slightly fringed, essentially simple. Muscle area anteriorly widening, following edges of fold, bounded by low ridges for part of length, bisected by thin, low median ridge, anterior boundary faint, striations not apparent, mostly obscured by strong internal reflections of costae.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank, Willis Ranch, and Appel Ranch Members, and lens between Willis Ranch and Appel Ranch members).

LOCALITIES.—China Tank: USNM 706c, 706z, 713, 723t, 733q. Willis Ranch: USNM 706, 724u. Lens: USNM 706b, 732c. Appel Ranch: USNM 719z.

DIAGNOSIS.—Transverse outline, rather narrow but slightly auriculate hinge, slightly curved beak,

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	width	thick- ness
USNM 706b					
151840a	5.7	?	4.8	6.1	?
151840b	8.8	?	7.9	10.4	?
151840c	9.0	8.2	9.9	11.6	6.3
151840d	11.4	?	11.0	15.3	?
151840e	13.2	11.5	15.9	18.8	9.9
151840f	14.1	14.0	15.2	22.8	10.0
151840g	14.9	?	19.8	26.0	?
151840h	20.7	18.0	20.2	27.3	11.7
151840i	21.0	?	24.9	31.6	?
151840j	23.1	?	20.8	33.7	?
151840k	24.2	?	22.4	35.0	?
151840-l	27.8	?	36.7	42.0	?
151840m	34.2	29.4	37.6	50.0	23.0
(holotype)					

short and poorly developed apical plates, indistinctly separated fascicles of costae which do not plicate the shell, and low fold but deep sulcus, producing a deep notch in the anterior margin of the shell and a deeper notch in the brachial valve.

TYPES.—Holotype: USNM 151840m. Figured paratypes: USNM 151839a-e; 151840b,f,h; 154617a. Measured paratypes: USNM 151840a-l.

COMPARISON.—In the notched anterior margin this species resembles *C. retusum*, new species, from the Cherry Canyon Formation (Getaway Member) in the Guadalupe Mountains. It is distinguished from that species by its finer, somewhat sharper, and less distinctly fasciculate costae, proportionately narrower hinge and its more V-shaped sulcus with resultant sharper anterior notch in the pedicle margin. *Cartorhium chelomatium* is similar to *C. mexicanum* (Shumard) from the Guadalupe Mountains with its low fold and notched anterior margin. The Glass Mountain species is more transverse, proportionately thinner, and attains much larger size. *Cartorhium orbiculatum*, new species, also belongs to the group with low folds, but *C. chelomatium* is wider, normally less coarsely costate, and has a deeper sulcus and sharper anterior notch in contrast to the rounded sulcus and fold of *C. orbiculatum*.

Cartorhium coristum, new species

PLATE 613: FIGURES 36-39; PLATE 614: FIGURES 1-25

Moderately large, strongly convex ventrally, less

convex dorsally; outline transverse, anteromedially emarginate, somewhat bilobate, normally widest near midlength, hinge not extended; commissure uniplicate, without lateral plications; fold high at anterior, normally sharply pointed; sulcus deep, V-shaped, extending forward as long tongue into fold, edges indistinctly bounded. Costae prominent and rounded near posterior, becoming lower and somewhat flatter anteriorly, fasciculate, numbering 3–6 per fascicle, aggregating 15–30 per side on mature shells, normally about 20, median costa on fastigium bifurcating at or near beak, branches remaining closely parallel toward anterior, fusing again near anterior margin of some specimens, bifurcating laterally once or twice, most costae of fastigium consisting of branches from lateral costae, total number on fastigium 14–20, median costa of sulcus normally beginning weakly about 5 mm anterior to beak, normally not bifurcating, number of costae in sulcus about as on fold. Concentric ornament consisting of fine growth lines, intermittent growth laminae becoming stronger and more frequent anteriorly, in some specimens obliterating costae near margins and scaly raised laminae sporadic, becoming consistent near anterior margin of large specimens.

Pedicle valve moderately convex transversely, strongly convex longitudinally, especially near beak and anterior margin; beak moderately strongly hooked; delthyrium open; apical plate short, thin, flat, set deep inside delthyrium; interarea gently concave, broadly triangular, pinching out at ends of hinge, orthocline to moderately apsacline, edge bearing short denticles beginning adjacent to hinge teeth. Brachial valve moderately convex transversely, nearly flat along crest of roof-like fastigium, or slightly reflexed near anterior margin; interarea short, slightly concave, tapering out at edges, notothyrium wide, apex occupied by finely lamellate, ventrally projecting cardinal callosity.

Pedicle valve interior with strong, knoblike hinge teeth, diverging anteriorly; dental ridges converging anteriorly; dental ridge converging toward apex and floor of valve, posteriorly continuous with short dental plates slightly diverging to intersect floor of valve on both sides of muscle area; posterior part of valve free of callus. Muscle area elongate oval, bisected by rather strong median ridge; adductor marks elongate, narrow, longitu-

dinally striated, lying along median ridge; diductor marks large, irregularly stippled, filling remainder of area lateral to adductors; adjustor marks in posterior part of area, extending beneath apical plate, floor of valve with large, irregularly radial troughs and ridges in posterior, fading and disappearing anteriorly.

Brachial valve interior with widely divergent, thick-walled hinge sockets, partly covered by thin elongate plate. Helicophores thin triangular plates, tapering and converging anteriorly to meet ends of spiralia and flexing slightly; spiralia ribbonlike, joined by tapered flat joint, bearing short, ventrally pointing jugal spur near joint, coiling dorso-ventrally in laterally diminishing ovals.

Buccal plate rather short and broad, outline roughly square, indistinctly trilobed, center lobe deeply excavated instead of perforated posteriorly, lateral lobes and anterior part of center lobe with small perforations, rims built into high projecting tubes, with ends closed in some specimens; anterior wings widely divergent, nearly at straight angle, anterior median comb reduced to few fringes with variable orientation. Muscle area vaguely impressed in trough of fastigium, elongate, anteriorly widening slightly, without median ridge; pattern of adductor marks not observed; other internal markings on floor of valve masked by costae and intertroughs.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation (Wedin Member).

LOCALITIES.—Wedin: USNM 700–l, 700x, 714w, 717e, 723v, 727p. Cathedral Mountain: USNM 708, 723u, 727q.

DIAGNOSIS.—Elliptical *Cartorhium* with low, angular, fold.

TYPES.—Holotype: USNM 152920a. Figured paratypes: USNM 152919–l,n,o; 152921a; 154618 a,b. Measured paratypes: USNM 152919a–p; 152921a,b.

COMPARISON.—*Cartorhium coristum* is characterized by its moderate size, transverse outline, peaked-roof-like fastigium, V-shaped sulcus, strong costae. The median costa of the fold bifurcates early and that of the sulcus normally begins anterior to the beak. The interarea tapers out at the ends of the hinge, is not alate, and rarely is the widest part of the shell. The buccal plate has high, tubelike rims around the perforations and widely

MEASUREMENTS (in mm).—

	brachial		hinge	midwidth	thick- ness
	length	valve length	width		
USNM 714w					
152919a	3.3	2.9	2.2	3.1	2.1
152919b	5.3	4.6	4.2	5.5	3.9
152919c	7.4	6.0	6.0	7.8	c.5.0
152919d	8.2	6.6	7.9	9.4	5.6
152919e	9.5	8.6	9.6	12.0	7.4
152919f	9.7	8.2	11.0	13.0	6.0
152919g	10.9	9.1	12.3	15.9	7.5
152919h	14.5	12.0	17.8	20.4	9.9
152919i	15.7	12.9	18.0	20.6	9.5
152919j	15.7	13.4	19.6	c.25.0	10.0
152919k	21.9	17.2	26.4	29.3	13.5
152919-l	24.0	18.3	27.0	32.0	15.5
152919m	25.5	20.3	37.0	39.6	16.4
152919n	30.0	22.4	38.3	42.4	20.0
152919o	38.8	23.0	39.0	46.0	20.0
152919p	35.4	25.6	42.8*	48.0*	24.5
USNM 708					
152920a	37.0	28.4	47.7	53.9	27.8
(holotype)					
USNM 727p					
152921a	24.6	19.6	30.6	36.0	16.4
152921b	25.9	20.4	38.2	40.8	15.8

divergent anterior wings that give the plate a nearly square appearance.

Cartorhium coristum differs strongly from *C. latum* (King) in being much smaller, in having an angular fold, and in having an entirely different shape. The Cathedral Mountain species suggests *Neospirifer formulosus*, new species, of the Road Canyon Formation in size and general appearance. The two are quite different, however, because *N. formulosus* is generally wide-hinged whereas *C. coristum* is always narrow-hinged and has well-rounded lateral extremities.

Among Glass Mountains species of *Lepidospirifer*, only *L. angulatus* Cooper and Grant (1969) need be compared. *Cartorhium coristum* is smaller, narrower, less variable, has a fastigium with nearly a straight ridge, and has scaly concentric ornamentation only sparingly present, near the extreme anterior of the largest specimens.

This species is similar in some respects to several foreign species. Its high fastigium is similar to that of *Spirifer marcoui* Waagen (1883, pl. 47) also illustrated by Tschernyschew (1902, pl. 6), but it differs in its smaller size, its lower convexity, its straighter ridged fastigium, and possibly in its pos-

session of scaly ornamentation. Its fold is somewhat lower, considerably lower than that of the specimens illustrated by Waagen. Specimens of *S. musakheylensis* Davidson illustrated by Waagen (1883, pl. 45) are wider, larger, and more convex than *C. coristum*. *Choristitella internatus* Reed (1944, pl. 25) is similar in outline, but lacks the sharp fastigium and also the strongly fasciculate costae of *C. coristum*.

Cartorhium latum (R. E. King)

PLATE 615: FIGURES 1-33; PLATE 616: FIGURES 1-23;

PLATE 624: FIGURES 1-10

Spirifer (*Neospirifer*) *mexicanus latus* R. E. King, 1931:116, pl. 37: fig. 7, pl. 38: fig. 1.

Not *Neospirifer latus* Dunbar and Condra, 1932:336, pl. 40: figs. 1-5 [= *N. dunbari* R. H. King].

About average to large for genus, moderately biconvex; outline rounded, subcircular to transversely subelliptical, widest near midlength; hinge narrow, rarely with slight auriculation; commissure uniplicate, not plicated laterally; fold moderately high at commissure, fastigium broadly rounded or somewhat gabled, standing only slightly above flanks through most of length; sulcus shallow, sharply or gently bounded laterally. Costae moderately strong near posterior, becoming lower and wider anteriorly, arranged in distinct fascicles producing low plications near posterior, not plicating commissure, numbering 5-8 per fascicle on mature shells, aggregating 16-30 per side; median costa of fastigium bifurcating at or immediately anterior to beak, diverging rather widely, adding costae between primary branches by bifurcation, also adding costae laterally in same manner, total number on fold and sulcus 10-15; median costa of sulcus very weak near beak, becoming stronger anteriorly, normally bifurcating symmetrically about 20 mm anterior to beak. Radial ornamentation fine, may be destroyed by silicification; fine concentric growth lines forming minute grid pattern with radial lines; coarser growth laminae weak, irregularly spaced, most frequent near margins.

Pedicle valve moderately convex transversely and longitudinally; beak normally slightly hooked; delthyrium open, wedge-shaped; apical plate small, nearly flat, deep set, normally not thickened; interarea narrow, relatively long, concave, pinching

out at sides, edge bearing small denticles beginning near hinge teeth. Brachial valve moderately convex, crest of fold similar in contour to flanks; inter-area short, narrow, interrupted by wide, wedge-shaped notothyrium; cardinal callosity in apex of notothyrium, finely lamellate for muscle attachment, relatively short, projecting only slightly ventrally.

Pedicle valve interior with strong, anteriorly diverging hinge teeth, supported by deep, bladelike dental ridges, convergent toward floor of valve, continuous posteriorly with short dental plates, narrowly diverging to intersect floor of valve lateral to muscle area; posterior part of valve normally not thickened, leaving dental plates exposed and apical cones open. Muscle area elongate, narrow, bisected by low median ridge; adductor muscle marks narrow, straight-sided, lying along median ridge, separated from diductor marks by low lateral ridges in some specimens, one on each side; diductor muscle marks larger, lateral, lightly striated longitudinally or in slightly radial pattern; adjustor marks not distinctly separate, probably located in apical part of muscle area. Floor of valve unmarked except for internal reflections of costae.

Brachial valve interior with widely divergent, thick-walled hinge sockets, partly covered by thin plate. Helicophores beginning as thin, broad triangular plates, attached to socket ridges, narrowing and converging anteriorly, not meeting, attached to spiralia by flat, distal, scarf joints; each spirallium with short jugal process near juncture with helicophore; spirallium ribbonlike, coiled dorso-ventrally in oval loops decreasing in size laterally. Buccal plate elaborate, strongly trilobate, with median lobe weakly divided in some, each lobe perforated by large holes, or deeply indented, holes and indentations with incomplete lacy rims, anterior wings moderately divergent, anterior median comb incomplete, consisting of few long digits. Muscle area narrow, elongate, lying in trough of fastigium, bisected by low, narrow, median ridge, muscle marks lightly striated longitudinally, bounded laterally by low, anteriorly divergent ridges in mature shells, flanked at posterior by short, low, arcuate ridges, more strongly divergent than lateral bounding ridges; floor of valve reflecting external costation.

STRATIGRAPHIC OCCURRENCE.—Cathedral Moun-

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	width	thick- ness
USNM 702a					
152922a	1.5	?	0.9	1.6	0.9
152922b	2.0	1.9	1.4	1.9	1.2
152922c	3.5	3.1	2.6	3.4	2.3
152922d	3.7	3.4	2.9	3.9	2.8
152922e	4.1	3.6	3.2	4.0	2.9
152922f	5.4	5.0	4.4	5.6	3.9
152922g	5.8	5.3	5.8	6.7	4.2
152922h	6.2	5.8	5.3	7.4	4.6
152922i	7.4	6.9	6.7	8.6	5.6
152922j	8.5	7.2	7.5	9.8	5.8
152922k	9.9	8.7	8.3	12.0	7.4
152922l	9.9	9.3	9.9	13.5	7.5
152922m	11.7	10.2	11.0	14.6	8.2
152922n	15.4	13.7	12.8	20.0	10.7
152922o	17.8	15.3	17.6	24.7	11.9
152922p	19.0	16.9	21.6	27.8	14.2
152922q	42.8	37.5	42.6	55.5	28.8
USNM 702un					
152923a	14.5	12.0	12.8	18.3	8.6
152923b	24.0	19.7	20.0	28.6	15.3
USNM 703b					
152924	45.3	39.0	55.7	62.2	39.2
USNM 703a ¹					
152925a	27.0	23.2	24.9	32.8	17.5
152925b	28.0	25.6	23.8	34.4	19.7
USNM 702					
152926a	2.8	2.5	2.2	2.9	1.9
152926b	3.0	2.7	2.0	3.0	1.9
152926c	4.6	4.2	3.7	4.8	3.4
152926d	35.0	31.4	31.3	48.5	25.5
YPM 123					
YPM 12504 (holotype)	27.1 +	22.5	20.0	34.1	18.2

tain Formation (Wedin Member); Bone Spring Formation.

LOCALITIES.—Cathedral Mountain (lower): USNM 702inst, 735b; YPM 123. Wedin: AMNH 500A, 500B, 500C, 500D, 500F, 500G, 500H, 500J, 500L, 500M, 500N, 500Q, 500X, 504; USNM 702, 702a, 702a¹, 702b, 702ent, 702un, 703a¹, 703b, 703bs, 709, 711q, 712o, 717e. Bone Spring: AMNH 591, 661.

DIAGNOSIS.—Fairly large *Cartorhium* with swollen valves in the adult, rounded contours, and low, rounded fastigium.

TYPES.—Holotype: YPM 12504. Figured paratypes: YPM 12505. Figured hypotypes: USNM 152922i,l,o,q,r; 152923b-d; 152924a; 152925c;

152926d-i. Measured hypotypes: USNM 152922a-q; 152923a,b; 152924; 152925a,b; 152926a-d.

COMPARISON.—*Cartorhium latum* is characterized by its rounded outline with hinge narrower than midwidth, its fasciculate costae forming weak plications that fade anteriorly, its low fold and shallow sulcus, median costa of the fastigium that bifurcates near the beak with branches diverging anteriorly and giving rise to further branches both proximally and distally, its narrowly divergent dental plates, and its narrow pedicle muscle area with longitudinal or slightly divergent striations. Among Texas Permian species of *Neospirifer* only juveniles are similar to *C. latum*. From most of these it is distinguished by rather low costae, low and normally gently arched fold, absent or obscure lateral plications, and bifurcating median pedicle valve costae. It most nearly resembles juveniles of species of *Lepidospirifer* Cooper and Grant (1969), differing in its more gently arched fold, lower costae without granular ornamentation, and its complete lack of scaly ornament, even on largest individuals.

Among foreign species, Reed's (1944:218–222) species of *Purdonella* (now included with *Cartorhium*) differ from *C. latum* only in details of costation, primarily in their consistent possession of a strong median costa on the fastigium and a corresponding median trough in the sulcus. *Spirifer wynnei* Waagen (1883:517, pl. 44), also figured by Diener (1897a:44, pl. 7) and Schellwien (1900b:75, pl. 10) is similar in outline but apparently lacks the fasciculate costae of *C. latum* and of other species of *Cartorhium*. *Spirifer nikitini* Tschernyschew (1902, pl. 10), which is the species selected by Fredericks (1924c) for his *Munella*, differs from *C. latum* in its higher and asymmetrically bifurcating, fasciculate costae, and its proportionately longer brachial valve.

DISCUSSION.—The measurements of the holotype, a young specimen with strong costae and fasciculation, are not exact because the entire shell has been exfoliated, except for a thin skin in the umbonal regions that obscures the interior details.

A paratype (YPM 12505) in the type lot of *N. mexicanus latus* is a poorly preserved specimen with silicified shell. Fasciculation is indistinct but the fold is low and the sulcus shallow. Indications point to a hinge wider than that of the holotype and an interarea broader and less curved. The beak is not preserved, but indications from the slope of

the interarea are that it was not so strongly incurved as in the holotype. The paratype is an older specimen and thus wider, with the fasciculation flattening anteriorly. It is in complete accordance with the larger forms referred to this species.

King (1931:116) considered this species to be but a variety of *Spirifer mexicanus* Shumard (1859:292). We have studied Girty's (1909, pl. 13) topotype specimens from the Guadalupe Mountains and conclude that King's species is distinctly different from *S. mexicanus* as interpreted by Girty and by us, and occurs at an entirely different stratigraphic level. *Cartorhium latum* is not only typically wider, as observed by King, but also is more coarsely costate, has a well-defined although low fastigium (lacking in *S. mexicanus*), more distinctly fasciculate costae, low lateral plications in the posterior part of the shell, and has, instead of a median groove in the sulcus, a median costa that begins at or near the beak. The costae of *S. mexicanus* are only indistinctly fasciculate, with only one set of asymmetrical bifurcations, and that taking place in the posterior 5–10 mm. Bifurcation that takes place farther forward is symmetrical. The oval outline, flatly convex brachial valve with low fold and absent fastigium, the more strongly convex brachial valve with prominent beak, and the indistinctly fasciculate costae of Girty's species bespeak a possible closer relationship to *Choristites* Fischer than to *Neospirifer*.

Cartorhium mexicanum (Shumard)

PLATE 619: FIGURES 10–20

Spirifer mexicanus Shumard 1859:292; 1860:390, pl. 11: figs. 4a, 4b. [Not of Girty, 1909:360.]

Medium size for genus, outline subcircular to subpentagonal, sides broadly rounded, maximum width near midlength. Anterior margin broadly rounded to moderately emarginate. Interarea narrow, long, beak slightly incurved; interarea apscaline. Surface multicostate, costae moderately strong, narrowly rounded, posterior fasciculated, about 3 distinct fascicles, disappearing anteriorly, not producing plications. Flanks with 15 to 20 costae and fold with 10 or 12, often indistinct anteriorly.

Pedicle valve fairly strongly convex in lateral profile, moderately convex in anterior profile, median region with deep depression formed by sulcus,

flanks fairly steep. Umbonal and median regions strongly swollen; sulcus originating at beak, costae intercalated on sides about 10 mm anterior to beak; sulcus widening and deepening anteriorly to form broad rounded tongue anteriorly. Flanks fairly well differentiated, moderately swollen, and with steep slopes.

Brachial valve gently convex in lateral profile, less convex than opposite valve; anterior profile forming moderately convex dome. Umbonal and median regions strongly inflated. Fastigium originating at beak in single costa flanked by bounding costa. Fold poorly defined, only slightly elevated anteriorly, but in some specimens scarcely elevated, producing anterior emargination. Flanks moderately swollen and moderately steeply sloping.

Interior of pedicle valve with strong divergent dental plates and short apical plate. Other details of the pedicle valve and interior of brachial valve not known.

MEASUREMENTS (in mm).—

	length	brachial	hinge	midwidth	thick- ness
		valve length	width		
AMNH 475					
152927a	34.7	30.3	18.7	39.3	24.2
152927b	38.0	34.9	25.4	41.7	26.2
152927c	37.3	33.5	27.8	48.2	29.2
152927d	45.0	36.2	24.1	43.4	23.0
152927e	44.2	38.3	25.0*	47.6	27.8
USNM 738a					
152928a	10.3	8.9	9.9	4.4	6.9
152928b	12.8	10.0	12.0	6.8	7.5
152928c	13.5	10.8	13.2	5.8	8.0
152928d	17.2	13.9	17.1	6.8	10.3
152928e	23.0	19.8	24.0	10.4	13.5
USGS 2926					
118588d	14.0+	11.5+	14.3	8.7	8.5
118588b	11.4	10.0	11.0	5.6	6.6

STRATIGRAPHIC OCCURRENCE.—Captain Formation.

LOCALITIES.—AMNH 475; USGS 2926; USNM 725m, 732q, 738a.

DIAGNOSIS.—*Cartorhium* of medium size having strongly rounded outline, obscure fold, and poor fasciculation of the costae.

TYPES.—Holotype: See Shumard, 1860, pl. 11: fig. 4 (actual specimen lost). Topotypical hypotypes figured: USNM 152927b,c,e. Measured hypotypes: USNM 118588b,d; 152927a-c; 152928a-e.

COMPARISON.—The only species like this one is *C. latum* (R. E. King) but the two are very distinct, *C. latum* being wider, with a shallower sulcus but

stronger fold, finer costae, and a wider hinge. Other species of the genus are much more transverse and not comparable.

DISCUSSION.—In our interpretation of this species, we differ from Girty (1909:360, pl. 13:figs. 1-6a), who figured a small species, the largest individual of which is 20 mm long by 22 mm wide. But Shumard gives the dimensions of his largest specimen as length and width about 1.34 inches. This equals 38 mm, a fairly large brachiopod. Shumard's figures (1860, pl. 11: figs. 4a, and 4b) do not accord with his stated measurement because they are about 20 mm long by 19 mm wide, in accordance with Girty's interpretation. Shumard gives no clue as to the enlargement of his figures. On the other hand a further statement of his shows that he had larger specimens than his figures indicate. In his brief note under this species (1859:390) he states: "This species bears considerable resemblance to *S. duplicicostata*, Phillips, [undoubtedly=*S. duplicicostata*] as figured by Mr. Davidson [1858, pl. 3: figs. 7-10] in his excellent monograph on the British Carb. Brachiopoda. Our shell is, however, much more gibbous and attains a much greater size." The largest specimen figured by Davidson is 42 mm long by 55 mm wide, much larger than any we have. Although Shumard is emphatic about his specimens being more gibbous and having a much greater size than Phillips' species, he is undoubtedly referring to his figures 8-10 which are similar in size and appearance to ours and probably to Shumard's. The specimens we figure are in accordance with Shumard's statement and measurements. We believe, therefore, that our specimens represent his conception of the species in spite of the inconsistencies noted.

Cartorhium orbiculatum, new species

PLATE 617: FIGURES 1-20

Large for genus, flatly to moderately biconvex; outline subcircular to somewhat transverse, widest near midlength, hinge narrow, slightly auriculate, some specimens anteriorly emarginate; commissure uniplicate, fold moderately high at commissure, but with fastigium along valve nearly flat; sulcus shallow to moderately deep, depth increasing anteriorly, extending forward at margin as a tongue to fill notch of fold. Costae strong, round crested,

arranged in distinct fascicles, numbering 3–6 per fascicle, aggregating 15–25 per side exclusive of fold or sulcus, numbering 9–18 on fold and sulcus; median costa of fastigium splitting symmetrically 5–10 mm anterior to beak, third median costa may be added by insertion between branches, lateral costae added by asymmetrical bifurcation; median costa of sulcus beginning 3–12 mm anterior to beak, normally bifurcating symmetrically farther toward anterior. Radial ornamentation not observed; growth lines fine, closely spaced; growth laminae moderately strong, irregularly spaced, more frequent toward margins.

Pedicle valve moderately convex transversely and longitudinally; beak gently to rather strongly hooked; delthyrium high, wedge-shaped, bounded laterally by traces of growth of hinge teeth; apical plates short, deep set; interarea triangular, wedging out laterally; moderately strongly concave, anterior edge with small, anteriorly pointing denticles beginning adjacent to hinge teeth. Brachial valve flatly to moderately convex transversely, nearly flat longitudinally along fastigium; brachial interarea slightly concave, slanting dorsally; notothyrium wedge-shaped, apex with finely lamellate cardinal callosity.

Pedicle valve interior with strong anteriorly divergent teeth; dental ridges deep, tapering posteriorly, converging strongly toward midline, forming sloping shelf on each side of delthyrium; dental plates short, divergent, meeting floor of valve on each side of muscle area; posterior part of valve not thickened, leaving dental plates free and apical cones open. Muscle area elongate, widening anteriorly, bluntly terminated in front, bisected by ridge formed by sulcus and by thin, low median ridge; adductor muscle marks elongate, median; diductor muscle marks larger, surrounding adductors; adjustor marks in extreme posterior of muscle area. Floor of posterior part of the valve lightly pitted and scored in irregularly radial pattern, fading toward margins.

Brachial valve interior with thick-walled hinge sockets strongly divergent; small plate covering part. Helicophores flattened into broad plates where attached to socket ridges, stretching forward without twisting, joined to ends of spiralia by flat lateral joints; spiralia ribbonlike, coiled dorso-ventrally, with short jugal process. Buccal plate deeply cupped, trilobed; median lobe with two

rows of perforations, low rims at posterior, progressively higher rims anteriorly, culminating in high tubular rim at anterior where two rows converge; lateral lobes with perforations coalescing at posterior, making deep incision in lobe, anterior perforations separate and rimmed; anterior wings diverging nearby 90°; anterior median comb digitate, low, relatively simple; sides of plate simple, with short fringe around edges; small incipient lateral lobes, one on each side, with minute, low-rimmed perforations. Muscle area weakly impressed, anteriorly widening, bisected by very low median ridge; adductor muscle marks longitudinally striated; pallial markings on floor of valve mostly obscured by costation.

MEASUREMENTS (in mm).—

		brachial valve length	hinge width	width	thick- ness
USNM 706d					
152885a	2.8	?	2.0	2.5	?
152885b	2.8	?	2.0	3.1	?
152885c	3.0	?	2.8	3.5	?
152885d	3.8	?	3.2	4.0	2.9
152885e	3.9	?	3.6	4.2	?
152885f	4.5	4.0	5.4	5.6	3.3
152885g	6.0	?	5.8	7.1	?
152885h	7.5	?	8.4	9.3	?
152885i	9.3	8.5	9.9	11.4	4.9
152885j	11.3	8.9	11.7	13.6	6.8
152885k	12.7	?	11.1	15.5	?
152885l	13.6	?	14.1	17.0	?
152885m	15.6	?	16.8	21.1	?
152885n	15.9	?	18.4	20.1	?
152885o	17.0	17.0	19.9	23.6	?
152885p	34.0	27.9	33.4	44.4	15.0+
USNM 714o					
152886a	33.3	27.6	29.0	36.0+	19.7
152886b	36.2	30.2	32.7	41.1	22.0
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member and lens below it).

LOCALITIES.—Appel Ranch: USNM 706d, 714o, 715i, 726t, 727j. Lens: USNM 742b.

DIAGNOSIS.—Large, elliptical *Cartorhium* with low fastigium, strong costae, and without grid pattern on surface.

TYPES.—Holotype: USNM 152886b. Figured paratypes: USNM 152885j,m,p,q; 152886c. Measured paratypes: USNM 152885a-p, 152886a.

COMPARISON.—*Cartorhium orbiculatum* is characterized by its larger elliptical outline, strong

costae, auriculate hinge, shallowly notched fold, distinct but low fastigium, somewhat deeper sulcus, and high, rather strongly curved beak. Its low fold and resulting notched anterior margin put it in the same group with *C. mexicanum* (Shumard), from which it differs in its larger size, more transverse outline, wider hinge, stronger costae, and is proportionately thinner. It is more transverse than *C. chelomatum* or *C. retusum*, both new, and not as deeply notched at the anterior margin. Its costae are stronger and fewer than in *C. chelomatum*, and it lacks the fine, gridlike ornament of *C. retusum*.

Cartorhium retusum, new species

PLATE 617: FIGURES 21–26; PLATE 618: FIGURES 1–29

Large for genus; moderately strongly biconvex; outline transversely subelliptical, slightly to sharply emarginate, widest near midlength, hinge only slightly less than maximum width, normally slightly auriculate; commissure uniplicate, normally without lateral plications; fold rather high at commissure; fastigium standing only little above sides posteriorly, crest fairly sharp or gently rounded; sulcus moderately deep to deep, in many wrapping around anterior margin to project deeply into notched pedicle margin. Costae strong, round-crested, arranged in distinct fascicles but with only slight plication of shell in a few specimens, numbering 3–7 per fascicle, on mature shells aggregating 15–20 per side, exclusive of fold or sulcus, and 7–14 on fold and sulcus; median costa of fold bifurcating at beak or as much as 10 mm anterior to beak, each branch splitting laterally by asymmetrical bifurcation; median costa of sulcus beginning 3–5 mm anterior to beak, normally remaining single, but bifurcating symmetrically once in some specimens. Radial striae fine, crossing fine concentric growth lines to produce faint grid pattern of ornamentation; growth laminae irregular in strength and spacing, normally more closely crowded near margins.

Pedicle valve flatly convex transversely, more strongly convex longitudinally through trough of sulcus; beak only slightly bent; delthyrium high, wedge-shaped, open, laterally bounded by traces of growth of hinge teeth; apical plates short, poorly developed, deep set; interarea triangular, wedging out at sides, slightly concave, forward edge with

small, anteriorly pointing denticles beginning 3–7 mm from hinge teeth. Brachial valve flatly to moderately convex transversely, nearly flat along low fastigium; brachial interarea slightly convex, slanting slightly dorsally, nearly paralleling plane of commissure; notothyrium broadly wedge-shaped, apex with thick triangular, lamellate cardinal callosity.

Pedicle valve interior with strong, divergent teeth; dental ridges deep, converging anteriorly and toward midline, running along distal part of underside of hinge teeth, with consequent shallow groove formed by juncture of teeth with ridges; dental plates short, divergent, meeting floor of valve on each side of muscle area; posterior part of larger valves somewhat thickened but apical cones partly open, and anterior edges of dental plates free. Muscle area narrow, elongate ovate, bisected by ridge formed by trough of sulcus and by additional low, thin median ridge; adductor muscle marks elongate, narrow, median; diductor muscle marks larger, crescentic, lateral, irregularly radially striated; pedicle adjustor muscle marks small, located in posterior part of muscle area beneath lip of apical plate. Floor of valve faintly scored by irregularly radial pallial marks, fading out toward margins.

Brachial valve interior with widely divergent, thick-walled sockets partly covered by thin, concave plates. Helicophores attached to socket ridges as thin plates along proximal sides; anterior course of helicophores not observed; spiralia ribbonlike, coiled dorsoventrally in loops of decreasing size laterally. Buccal plate not observed. Muscle area elongate, narrow, anteriorly widening, bisected by low, thin median ridge; adductor muscle marks faintly impressed; pallial marks on floor of valve lateral to muscle area, faint, irregularly radial, fading toward margins.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Word Formation (Appel Ranch Member and lens below it).

LOCALITIES.—Getaway: AMNH 21, 496, 512, 519, 585, 600; USNM 728, 730, 732. Appel Ranch: USNM 714o, 715i, 719z, 722t, 726t. Lens: USNM 737w.

DIAGNOSIS.—Transverse, costae coarse, fold low, anterior margin emarginate, ornament reticulate.

TYPES.—Holotype: USNM 152929w. Figured paratypes: USNM 152929d,h,k,o,p,r,u,v,x,y; 152930b;

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	width	thick- ness
USNM 728					
152929a	5.5	?	4.0	5.7	?
152929b	7.6	?	8.9	9.3	?
152929c	8.8	?	11.7	12.9	?
152929d	9.0	7.8	6.9	9.8	6.2
152929e	10.0	?	11.6	13.4	?
152929f	10.8	?	11.4	14.3	?
152929g	11.4	?	14.9	15.3	?
152929h	11.7	10.0	11.6	15.7	7.4
152929i	13.5	?	15.7	17.9	?
152929j	14.5	?	15.8	19.5	?
152929k	15.2	12.2	18.3	19.0	8.5
152929-l	18.5	?	18.2	21.8	8.5
152929m	19.2	?	c.17.5	25.7	?
152929n	c.19.0	?	29.0	29.9	?
152929o	?	21.5	31.0	34.3	?
152929p	24.0	?	27.4	32.7	?
152929q	?	23.0	34.0	40.3	?
152929r	26.5	?	39.8	42.5	?
152929s	36.6	?	39.0	49.0	?
152929t	42.0	36.0	39.4	60.0	24.6
152929u	45.3	?	49.2	63.0	?
152929w	34.0	?	41.0	44.0	?
(holotype)					
USNM 719z					
152930a	44.3	?	60.0*	72.0*	?
152930b	?	42.0	66.4	75.9	?
USNM 726t					
152931	35.0	28.7	55.4	60.6	15.8

154620a. Measured paratypes: USNM 152929a-u; 152930a,b; 152931. Unfigured paratype: USNM 152930a.

COMPARISON.—*Cartorhium retusum* is characterized by its transverse outline, coarse costae, slightly bent beak, shallowly or deeply notched anterior margin, low fastigium, proportionately deeper sulcus, and reticulate ornament formed by growth lines and radial striae. Specimens with the deeper anterior notch resemble in that feature typical specimens of *C. chelomatum*, new species, but are more coarsely costate, with fewer costae, have a somewhat higher fastigium, and normally are less transverse. *Cartorhium retusum* differs from *C. orbiculatum*, new species from the high Word in the Glass Mountains, in its more deeply notched anterior margin, deeper sulcus, and shorter, less strongly hooked pedicle beak and from *C. mexicanum* (Shumard) in its coarser, more distinctly fasciculate costae, larger size, more transverse out-

line, proportionately wider hinge and wider interarea, and less prominent pedicle beak.

Cartorhium vidriense, new species

PLATE 619: FIGURES 1-9

About medium size for genus, outline strongly elliptical, widest near midlength; hinge minutely auriculate. Sides narrowly rounded; anterior margin deeply and angularly reentrant. Interarea curved, strongly apsacline; beak narrow, slightly incurved. Surface multicostate, costae fine, poorly fasciculate, not producing plications; fastigium consisting of median costae beside which others intercalate to produce about 22 costae; sulcus originating at beak, bounded by 2 prominent costae, others appearing by intercalation and bifurcation. Flanks marked by 28-30 costae sparsely bifurcated in posterior region, but bifurcations becoming numerous just posterior to midvalve.

Pedicle valve gently convex in lateral profile, broadly but gently convex in anterior profile. Umbonal region narrowly convex; median region gently convex. Sulcus narrow, originating at beak, deepening rapidly anteriorly, there occupying a third of width; sulcus deeply V-shaped, strongly convex longitudinally, producing long angular tongue. Sides of sulcus rounded, fading into gently sloping and nearly flat flanks.

Brachial valve flatly but unevenly convex in lateral profile, umbonal region strongly incurved to overhang interarea; anterior profile forming a broad, narrowly rounded V. Interarea moderately long, strongly curved, moderately apsacline. Fastigium low, poorly defined, scarcely differentiated from flanks except by gentle elevation; fold strongly angular at commissure. Flanks steep anteriorly, less so laterally, gently swollen.

Pedicle valve interior with diamond-shaped muscle region divided by low median ridge formed by sulcus, but internally thickened. Apical plate thick but short and strongly excavated below; dental plates short. Brachial valve interior not known.

MEASUREMENTS (in mm).—From locality USNM 706c, specimen 154626a (holotype): length 32.3, brachial valve length 29.5, hinge width 47.9, midwidth 59.6, thickness 22.4.

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank and Willis Ranch members).

LOCALITIES.—China Tank: USNM 706c. Willis Ranch: USNM 706.

DIAGNOSIS.—Widely transverse, elliptical *Cartorhium* with fine costae and very deep, angular sulcus.

TYPES.—Holotype: USNM 154626a. Figured paratypes: USNM 154626b, 154627.

COMPARISON.—This species differs from *C. latum* (R. E. King) in its widely elliptical outline and the deep angularity of its sulcus. It is distinguished from *C. chelomatum* and *orbiculatum*, both new, by its finer costae and the exaggerated angularity of its sulcus. These features also serve to separate it from *C. retusum*, new species.

DISCUSSION.—This is a very rare species; only 3 specimens have been found.

Cartorhium zoyei, new species

PLATE 620: FIGURES 1-25

Large, narrowly elliptical in outline, hinge 0.6 to 0.8 of width; sides somewhat narrowly rounded, maximum width at midlength. Anterior margin broadly rounded; anterior commissure with strong median fold in the adult, narrow and gentle in young. Interarea long, curved, strongly apsacline. Beak moderately incurved. Surface multicostate, fascicles weakly developed, strongest in the young and young stages of the adults, dying out anteriorly and not producing plications. Costae fairly strong, narrowly rounded, numbering 18 to 25 on flanks and about 12 on fastigium; median costa of fastigium bifurcating about 5-7 mm anterior to beak, each branch immediately dividing to form median fascicle forming fastigium. Intercalations appearing on each side of sulcus 10 mm anterior to beak.

Pedicle valve gently convex in lateral profile, broadly and gently convex in anterior profile, with median depression formed by sulcus; umbonal region slightly swollen. Sulcus originating at beak, widening and deepening anteriorly, forming narrowly rounded tongue anteriorly, fairly strongly geniculated in old specimens. Sulcus poorly defined laterally; flanks broad, moderately steep and flattened.

Brachial valve evenly and gently convex in lateral profile, broadly and unevenly arched in anterior profile. Umbonal and median regions moderately swollen; fastigium originating at beak, with

median costa bounded by costa on each side, low and scarcely defined in young and early adult stages, abruptly defined at anterior in old specimens; fold strong at commissure. Flanks gently swollen, with steep anterior slopes.

Adult interior not known.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	midwidth	thick- ness
USNM 714t					
151851a	13.1	11.3	11.0	15.5	9.3
151851b	24.8	20.3	23.0	34.9	15.4
151851c	25.4	20.0	25.3	33.6	18.0
151851d	32.0	27.3	35.9	49.0	21.5
151851e	31.9	28.4	43.8	52.0	22.2
151851f	38.7	33.3	28.8*	55.5?	24.0
151851g	26.5	21.9	20.7	28.6	17.3
USNM 707a					
151847a	40.6	32.0	44.2	62.8	26.0
151847b	35.6	27.9	36.0	50.4	23.7
151847c	32.9	26.6	31.1	44.7	20.6
151847d	37.7	31.7	42.3	61.0	26.5
151847e	50.5	36.5	71.6	75.0	31.0
151847f	34.6	29.4	35.7	48.3	22.8
USNM 727h					
152933	41.9?	34.5	51.8	67.0	29.6
USNM 727u					
152932a	21.8	17.6	18.6	31.2	13.3
152932b	40.4	36.0	53.0?	77.3	28.8
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (Decie Ranch and Sullivan Peak members); Bone Spring Formation.

LOCALITIES.—Decie Ranch: USNM 707a, 714t, 727u. Sullivan Peak: USNM 707, 707d, 707-l, 708e, 715j, 722h, 722-l. Skinner Ranch (base): USNM 707w, 709u, 711d, 712p, 720g. Skinner Ranch (top): USNM 710r. Skinner Ranch : USNM 715n, 716p, 720j, 722m, 726j, 727h. Bone Spring: AMNH 625; USNM 728e.

DIAGNOSIS.—Large, transverse *Cartorhium* with deep sulcus and broadly rounded anterior fold.

TYPES.—Holotype: USNM 152932b. Figured paratypes: USNM 151851a-d. Measured paratypes: USNM 151847a-f, 151851a-g, 152932a, 152933.

NAME.—Named for Zoye Decie who welcomed us cordially to his ranch, and gave us access to all localities there.

COMPARISON.—*Cartorhium zoyei* differs from *C. chelomatum*, new species, in being wider, having a less angular anterior commissure, and a more

prominent fold. It differs from *C. latum* (R. E. King) in its much greater width and stronger anterior fold, and it is much wider than *C. orbiculatum*, new species. It differs from *C. vidriensis*, new species, in having stronger costae and stronger posterior fasciculation in the young stages. From *C. retusum*, new species, it differs in shape, larger size, less prominent and more angular anterior commissure, and the sharper tongue.

Cartorhium species unidentified

As with many other genera, a few specimens from various localities cannot be placed with described species. Most of these represent new species for which we have insufficient material for formal description. We list them below by the formation in which they occur.

ROAD CANYON FORMATION.—Several specimens indicate two probable species from this formation. One is represented by only four brachial valves. These have obscure fasciculation and the costae are sparsely scattered. One specimen has no fasciculation and most of the costae are direct, with only a few intercalations at the margins. The specimens measure 20 mm long by 30 mm at midwidth. The fastigium is scarcely defined at any part of the shell from beak to anterior margin, but produces a slight anterior emargination. The specimens (USNM 152934) are from USNM 703d.

A pedicle valve (USNM 152935) from USNM 720d is quite the opposite of the preceding in having fine, closely crowded costae or costellae, a poorly defined sulcus, and a short anterior tongue. Inside, the dental plates are subparallel and the apical plate is short and not well formed. The length is 20 mm and the width at the widest part is 31.4 mm.

CHERRY CANYON FORMATION (Getaway Member).—A small circular to roundly elliptical species occurs in the Getaway Member at USNM 728 and is represented by 8 specimens (USNM 152936), 5 of them young. The pedicle valve is incomplete, but measures 20 mm in length by 30* mm in width. The brachial valve is 18 mm long by 25 mm in width. The costellae are narrow and fairly distant. The fold and sulcus are not conspicuous. The median costella of the sulcus is variable, in one specimen appearing near the beak but in others at a considerable distance from it. The two young

specimens are nearly circular. The dental plates are strongly receding.

BELL CANYON FORMATION.—Small circular outline and posterior inflation are the chief characters of three brachial valves from this formation. The largest specimen is 13.8 mm long by 15.5 mm wide. The costae are slender, the fastigium scarcely defined and fasciculation not well defined except for the median fascicle that forms the fastigium. Specimens are from USNM 725g (USNM 152939), USNM 731 (USNM 152938), and AMNH 410 (USNM 152937).

Genus *Lepidospirifer* Cooper and Grant, 1969

Lepidospirifer Cooper and Grant, 1969:14.

Biconvex spiriferid, attaining fairly large size; outline transverse to subovate, widest anterior to hinge, normally posterior to midlength; hinge straight, normally only slightly narrower than widest part of shell; commissure uniplicate, fastigium low to high, crest sharp to rounded; sulcus correspondingly variable, producing tongue at anterior to insert in notch of fold. Costae normally strong, numerous, crests rounded, beginning at beaks, bifurcating asymmetrically to form fascicles, number increasing anteriorly; mesial fascicles gently plicating shell of some species. Fine radial ornamentation rather strong, producing rows of tiny granules in some species; growth lines fine, closely spaced, making grid pattern with radial striae; growth laminae strong, irregularly spaced near beaks, becoming stronger and more crowded toward margins, raised on crests of costae to produce a characteristic scaly or tiled-roof appearance.

Pedicle valve with prominent beak, only slightly bent, not hooked; delthyrium open, wedge-shaped, bounded laterally by traces of growth of hinge teeth, apex only slightly obstructed by small apical callosity normally fused to floor of valve rather than extending forward as platform; interarea high, slightly concave, usually apsacline, wedge-shaped or terminating bluntly at sides, anterior edge of hinge with small denticles for insertion in shallow pits in face of brachial interarea. Brachial valve shorter, normally less convex; beak short, blunt; brachial interarea low, slightly concave; notothyrium broadly wedge-shaped, apex occupied by large cardinal callosity, finely lamellate for attachment of diductor muscles.

Pedicle valve interior with strong, anteriorly divergent hinge teeth; dental ridges deep, convergent toward midline, forming inwardly sloping platform along sides of delthyrium, tapering toward beak; dental plates short, moderately divergent to intersect valve floor at edge of muscle area; apical plate short, posterior part of valve thickened in some species, burying or partly burying dental plates and filling apical cones. Muscle area elongate ovate, bisected by ridge formed by trough of sulcus, and by thin, low myophragm; adductor muscle marks narrow, elongate, mesial, lightly striated longitudinally; diductor muscle marks larger, semioval or crescentic, lying lateral to adductors, irregularly lirate in radial or fan-shaped patterns; pedicle adductor muscle marks in extreme posterior of area, one on each side, just anterior to smooth apical callosity. Floor of thickened valves marked by faint radiating pallial troughs, fading toward margins.

Brachial valve interior with widely divergent, thick-walled hinge sockets with part roofed by thin plate. Helicophores originating from socket ridges as long, thin plates, abruptly narrowing to thin ribbons, slightly converging and twisted about 90°; spiralia ribbonlike, attached to helicophores by flat lateral joints, with short, ventrally pointing jugal process near junction, main body coiled dorsoventrally in oval loops of laterally decreasing size. Buccal plate normally rather lacy, trilobed, deeply cupped, each lobe deeply indented or perforated by holes with fringed rims, divergent winglike appendages at anterior, with median digitate comb on midline; margins of plate fringed; no plates observed in place, presumably located on midline between spiralia, braced against short jugal processes with convex side dorsal, lobate end posterior, as in *Neospirifer*. Muscle area elongate, mostly within trough formed by fold, slightly widening anteriorly, posterior part bisected by low, thin median ridge in some species, large mesial adductor muscle marks, one on each side of median line; posterolateral marks smaller, also elongate, faintly impressed just outside trough of fold. Floor of posterior part of valve marked by light lirae and striae in radial pattern, fading toward margins.

TYPE-SPECIES.—*Lepidospirifer angulatus* Cooper and Grant (1969:15, pl. 4: figs. 22–25).

DIAGNOSIS.—Finely costellate, weakly fasciculate, with concentric scallops and fine radial lines on the costae and costellae.

COMPARISON.—*Lepidospirifer* is characterized by its fine, posteriorly fasciculate costae, rather straight and open beak, and by the raised growth laminae that stand high on the crests of the costae, giving the shell a scaly or tiled-roof appearance. The raised laminae cover most of the shell in some species but in others begin farther forward so that juveniles lack them, and adults have them only in a broad stripe around the margins. It most nearly resembles *Neospirifer* Fredericks but has weaker fasciculation, finer costae, scaly ornamentation, and straighter beak with the apical plate small and low, normally fused to the floor. Its asymmetrically bifurcating costae with scaly laminae distinguish it from *Spirifer* Sowerby, *Tangshanella* Chao, and *Choristitella* Ivanov and Ivanova. These features plus its normally more transverse outline distinguish it from *Choristites* Fischer de Waldheim. It is distinguished from *Cartorhynchus* by its ornament consisting of fine radial lines and concentric scales, relatively high myophragm, and small apical plates inside the pedicle valve.

Lepidospirifer angulatus Cooper and Grant

PLATE 621: FIGURES 1–14; PLATE 622: FIGURES 7, 10

Spirifer (*Neospirifer*) *costella* [part] R. E. King, 1931:115, pl. 37: figs. 1?, 2.

Lepidospirifer angulatus Cooper and Grant, 1969:15, pl. 4: figs. 22–25.

Widely elliptical to depressed pentagonal in outline; both valves deep; sides narrowly rounded; lateral margins strongly sloping medially; anterior margin narrowly truncated. Hinge not quite equaling maximum width which is just anterior to hinge. Beak long and narrowly angular; interarea strongly curved, apsacline. Surface costellate, costellae crowded, about 7 in 5 mm, about 25–30 on flanks and 20 or more on fastigium. Posterior with 4 or 5 primary costae producing obscure fascicles that disappear within a third the length from beak, thus not producing plications; costellae in old specimens becoming flattened and obscure; costellae with numerous convex scales about 3 per mm in adults.

Pedicle valve fairly strongly convex in lateral profile with strong curvature at beak and anterior end of tongue; anterior profile strongly and broadly convex, with median notch representing sulcus.

Median region strongly swollen. Sulcus beginning at beak as narrow slit, expanding and deepening anteriorly and forming elongated angular tongue and strong (90°) dorsad geniculation at anterior. Fold and flanks fairly well differentiated by bounding plications. Flanks narrowly swollen transversely but flattened in profile.

Brachial valve evenly but gently convex in lateral profile, broadly and moderately convex in anterior profile with angular medial hump. Umbonal region swollen; median region transversely swollen. Fastigium originating at beak as single costa, with 2 implanted on each side in first 2 mm. Median costa maintaining to about midvalve, there breaking into several costellae, fastigium thus constituting essentially one fascicle. Fold fairly high anteriorly, strongly angular and steep-sided. Flanks with a 90° ventrad geniculation to form precipitous anterior slopes.

Pedicle valve interior with small teeth and broad, shelflike dental ridges supported by short, somewhat receding dental plates. Myophragm moderately strong, extending to about midvalve; apical plate small, deeply reentrant. Muscle field subcordate, not strongly impressed.

Brachial valve interior with deep sockets proximally covered by thin plate; socket ridges strong; hinge plate concave and broad. Cardinal process small.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	width	thick- ness
USNM 702 152940a (holotype)	32.8	26.5	56.6	61.6	27.4
USNM 702a 152943a	26.0	22.0	34.2	44.4	16.0
USNM 702un 152942a	32.4	25.6	55.0	58.3	23.0
USNM 703a ¹ 152941a	5.2	4.4	5.2	5.5	4.0
152941b	6.2	5.9	6.7	7.0	3.8
152941c	7.3	6.4	7.9	8.8	5.4
152941d	10.4	8.6	9.7	12.7	7.0
152941e	14.0	11.6	16.0	19.3	9.0?
152941f	21.4	17.4	23.6	31.7	13.5
152941g	26.9	21.8	34.9	43.0	17.5?
152941h	33.7	25.4	46.9	51.0	25.5

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—AMNH 500A; USNM 702, 702a, 702-low, 702un, 703a¹, 703b, 723y, 726y.

DIAGNOSIS.—Wide, thick *Lepidospirifer* with strongly angular fold.

TYPES.—Holotype: USNM 152940a. Figured hypotypes: USNM 151942a; 152940b; 152941i; 154629a; 154630a,b. Measured hypotypes: USNM 152941a-h, 152942a, 152943a.

COMPARISON.—This species differs from *L. costellus* (R. E. King) in its greater lateral extension, geniculated anterior tongue and anterior of brachial valve flanks, and lack of strong plications on the flanks. It differs from *L. demissus*, new species, in its transverse form, greater depth, more extended lateral areas, finer and more crowded costellae, and strongly angular fastigium. *Lepidospirifer inferus*, new species, is very wide but it has a low and rounded fold, more broadly rounded lateral regions, and more distant costellae.

Lepidospirifer costellus (R. E. King)

PLATE 621: FIGURES 15–21; PLATE 624: FIGURES 11–16

Spirifer (*Neospirifer*) *costella* R. E. King, 1931:115, pl. 37: figs. 3a–d [only].

Type lot consists of 3 specimens. The holotype is a large but very imperfect specimen lacking both lateral margins and cardinal extremities and is very coarsely silicified. Paratype YPM 12439 is a fragment of a pedicle valve with well preserved exterior. A third specimen without number was not seen. According to the figures this is not complete.

Large, transversely elliptical in outline, maximum width probably at midlength; anterior margin subtruncate. Surface distinctively marked by costellae bundled into 3 or 4 broad wrinkles on each side of fold and sulcus; costellae numbering 5–7 in 5 mm and having 6–10 per fascicle; fascicles forming plications continuous to anterior margin.

Pedicle valve gently and evenly convex in lateral profile, broadly and fairly strongly convex in anterior profile; beak elongated and only slightly incurved; interarea long and gently concave, moderately apsacline; umbo narrowly swollen; median region strongly swollen; sulcus originating at beak, deepening and widening moderately to front margin; costae intercalated on each side of sulcus 2 mm anterior to beak; flank with 32 costellae, fastigium

with about 20; flanks flattened to faintly concave and sloping moderately to margins; delthyrium wide; sloping face of dorsal part of dental ridges broad.

Brachial valve gently convex in lateral profile, most convex in posterior half; anterior profile broadly and flatly convex; fold originating at beak, low but carinate, widening anteriorly to occupy about a third of width; flanks bounding fold gently convex and with gentle slopes to margins.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	midwidth	thick- ness
King 174					
YPM 12437	39.5	32.9	?	50.4	23.6
(holotype)					
USNM 703b					
151832a	32.4	26.3	38.2	47.6	16.9
151832b	35.0	28.3	47.0	51.8	23.6

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—King 174; USNM 703b.

DIAGNOSIS.—Large compressed *Lepidospirifer* with fascicles forming strong plications.

TYPES.—Holotype: YPM 12437. Figured hypotypes: USNM 151832a,b.

COMPARISON.—This species is distinguished from all others of the genus by its compressed form, low but angular fastigium, and especially by the strength of the plications produced by the lateral fascicles of the flanks.

DISCUSSION.—The type specimen of King's species is the only one known to us that has such strong plications on the flanks. These extend to the margins and are so strong that they are impressed on the matrix filling the shell. Furthermore the shell is compressed in form rather than becoming thickened as in *L. demissus* and *L. angulatus*. Other peculiarities of the type are the shallow and broad fold resulting in a very short tongue for such a large specimen and the broadly angulated fastigium. Two specimens from USNM 703b accord with most of the features of *L. costellus* and are assigned to it, but they do not have as strong plications as the type specimen. Possibly the type is a freak in respect to its plications, but it may be rather a localized form of which many are known in the Glass Mountains.

Another difficulty with the type specimen is the

poor preservation of its exterior surface. This is so strongly beekitized that it is impossible clearly to observe any of the scalloped lamellae so characteristic of the genus. Were it not for the fine and closely crowded costellae that cover the entire shell it would not be possible to assign the species to *Lepidospirifer*.

Lepidospirifer demissus, new species

PLATE 622: FIGURE 8; PLATE 623: FIGURES 1–29

About average size for genus; shape highly variable, moderately to strongly biconvex; transversely semiovalate to subpentagonal; normally widest anterior to hinge, not alate; commissure uniplicate, laterally only slightly plicate; fold low in juveniles, moderately high in adults, fastigium standing moderately high above flanks, crest gently rounded; sulcus shallow throughout length, but extending far forward at commissure of some specimens, wrapping around anterior of shell, trough broadly V-shaped posteriorly, becoming broadly U-shaped anteriorly, gently rounded laterally. Costae strong, crests rounded, becoming lower and flatter anteriorly, posteriorly bundled into fascicles by asymmetrical bifurcation, producing in some shells 3 or 4 low, indistinct plications on each flank, numbering 4–9 per fascicle, aggregating 25–35 per side on mature shells; median costa of fastigium remaining as single ridge in some specimens, bifurcating in others about 10–15 mm anterior to beak, with further splitting anteriorly; median costa of sulcus beginning 10–20 mm anterior to beak, or absent, normally not bifurcating. Radial ornament consisting of fine lines and minute granules along sides of costae; growth lines fine near posterior, becoming stronger anteriorly, producing raised crescentic roof-tile-like laminae over crests of costae, increasing in frequency anteriorly, closely crowded near margins of mature shells.

Pedicle valve moderately convex transversely, moderately to strongly convex longitudinally, convexity fairly even; beak normally not strongly curved or hooked; delthyrium wedge-shaped, open; apical plate short, deep-set, normally parallel to floor of valve rather than to interarea, slightly thickened or unthickened; interarea triangular, only slightly concave, apsacline, bearing small, sharp, denticles along inner edge, beginning about

3 mm lateral to hinge teeth. Brachial valve moderately convex transversely and along fastigium, flanks more strongly convex longitudinally; inter-area short, slightly concave, slanting ventrally, interrupted medially by wide, wedge-shaped noto-
thyrium with lamellate cardinal callosity at apex.

Pedicle valve interior with strong hinge teeth; dental ridges broad, strongly convergent toward midline, forming sloping platform in each side of delthyrium; dental plates short, continuous with posterior part of dental ridges, slightly divergent, meeting valve floor lateral to muscle area; callus material normally absent, leaving apical cones open and dental plates unthickened. Muscle area elongate oval, bisected by ridge formed by axis of sulcus and by low thin median ridge; adductor muscle marks elongate, narrow, lying along median ridge, lightly striated longitudinally; diductor muscle marks larger, lateral, striations slightly divergent anteriorly; pedicle adjustor located in extreme posterior of area. Floor of valve marked by shallow troughs in irregularly radial pattern.

Brachial valve interior with strong, thick-walled, widely divergent hinge sockets, nonfunctional part open or covered by thin, elongate plate. Helicophores attached to socket ridges as flat triangular plates, tapering anteriorly, attached to ends of spiralia by short side-joints; spiralia coiled dorso-ventrally. Buccal plate relatively simple, trilobed, with median lobe faintly bilobate and bearing 2 rows of 3 holes each, separated by short elongate slit on median line, rows uniting in single median hole on median line near anterior, lateral lobes of plate each with 2 holes, all holes with low fringed rims becoming higher around smaller anterior holes; anterior wings diverging somewhat more than 90°; anterior median comb large, digitate, forming open trough, not closed cylinder; lateral edges rather solid, not elaborately fringed. Muscle area narrow, elongate, in trough of fastigium, weakly striated longitudinally, bisected by low, short, straight, narrowly diverging, ridges; floor of valve marked by faint radial lirae and striae.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation; Road Canyon Formation.

LOCALITIES.—Cathedral Mountain: AMNH 500c, 504; USNM 700-l, 702, 702a, 702-low, 702un, 703b, 708, 708u; 721u; 726o, 726u, 726y, 731b, 732u, 733m, 735b. Road Canyon: USNM 702c.

DIAGNOSIS.—Costae strong, with tegulate orna-

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	width	thick- ness
USNM 702a					
151824a	1.7	1.5	2.2	2.2	1.3
151824b	2.3	1.9	2.6	2.7	1.8
151824c	3.1	2.5	2.8	3.5	2.3
151824d	4.7	4.6	6.7	6.8	4.3
151824e	5.9	5.3	7.0	7.9	4.3
151824f	7.9	7.4	9.0	10.9	6.0
151824g	12.3	10.7	15.9	18.7	8.2
USNM 702					
151822a	6.7	5.2	7.8	8.2	4.5
151822b	10.5	10.0	12.7	15.8	7.6
151822c	14.4	12.2	15.9	17.9	9.0
151822d	15.6	14.1	16.7	22.0	11.5
151822e	29.6	22.4	46.2	48.9	20.0
151822f	29.6	24.0	39.8	42.0	19.0
USNM 702un					
151828a	25.3	21.4	37.8	42.6	16.8
151828c	40.0	32.8	56.9	59.4	22.5
151827b (holotype)	44.3	35.3	66.3	62.7	37.0

ment beginning far back, outline variable (often asymmetrical), fold rounded, lateral plications indistinct, ventral beak unusually straight.

TYPES.—Holotype: USNM 151827b. Figured paratypes: USNM 151821a-f; 151827c,d; 154631a. Measured paratypes: USNM 151822a-f; 151824a-g; 151828a,c. Unfigured paratype: 151827a, 151828a.

COMPARISON.—*Lepidospirifer demissus* is characterized by its greatly variable shape, its strong costae with scaly ornament beginning 5–15 mm anterior to beaks, a hinge that normally is narrower than the widest part, its usually rounded fastigium, a shallow sulcus that wraps far around anterior at commissure, indistinct to absent lateral plications, median costa of fastigium that remains single or bifurcates far anterior to the beak, median costa of the sulcus which begins at the beak, and its only slightly concave interarea without hooked beak and with nearly completely open delthyrium. It differs from *L. inferus*, new species, also from the Cathedral Mountain Formation, in its compact outline, higher fastigium, and stronger scaly ornament which begins farther back. It is larger and less wide than *L. angulatus* Cooper and Grant, the type species of *Lepidospirifer*, and differs also in its straighter fastigium, and much more extensive and distinct scaly ornamentation. *Lepidospirifer demissus* differs from *L. costellus* (R. E. King)

in its lesser development of lateral plications which do not meet the margins and in its rounded fold.

Lepidospirifer demissus is so variable that it must be compared with many of the Asian and Russian species that have scaly ornamentation. One of the most widespread and well known of these is *Spirifer moosakhailensis* Davidson (1862, pl. 2; 1866, pl. 2) from the Salt Range, which has been identified by many subsequent authors, with several variations in the spelling of the specific name.

Lepidospirifer demissus differs in its shorter, more transverse outline, narrower, somewhat more sharply ridged fastigium, indistinct or absent lateral plications, and especially in its scaly ornament which does not begin at the beaks as in Davidson's species, but begins anterior to the beak, normally about 15 mm forward. *L. musakheylensis* (sic) Davidson of Waagen (1883, pl. 45), Reed (1944, pl. 25), Diener (1897b, pls. 4,5), and Stepanov (1937, pl. 7) also are much more strongly plicate than *L. demissus*, and apparently all have the scaly ornamentation beginning farther posterior.

Some authors have considered *Spirifer moosakhailensis* Davidson to be synonymous with *Spirifer fasciger* Keyserling, largely on the basis of rather strong lateral plications. Therefore, many synonyms include the two names, and specimens with scaly ornament and strong lateral plications have been identified as *S. fasciger*. The same features that distinguish *L. costellus* from *L. moosakhailensis* distinguish it from the specimens identified as "*S. fasciger*" by Tschernyschew (1889, pl. 5; 1902, pls. 38,49), Frebold (1950, pl. 4), Schellwien (1892, pl. 5; 1900b, pl. 10), Tschernyschew and Stepanov (1916, pl. 9), and Chao (1929, pls. 1,2).

Another widely identified species with scaly ornament is *Spirifer tegulatus* Trautschold, which Ivanov and Ivanova (1937:17, 30, pls. 2,3) attempted to establish as the type species of *Neospirifer*. That species differs from *L. demissus* in its stronger scaly ornament, which begins at the beaks, and also in its shorter, more strongly curved pedicle beak and heavier apical apparatus in the pedicle valve.

Lepidospirifer inferus, new species

PLATE 622: FIGURES 1-6, 9

About average size for genus, moderately strongly

biconvex; outline transverse, subovate to subpentagonal, greatest width normally anterior to hinge but some individuals widest at hinge, normally slightly auriculate; commissure uniplicate, fold gently arched; fastigium very low to moderately high, standing slightly above flanks, becoming higher anteriorly, rarely unelevated; sulcus shallow, sharply bounded posteriorly, bounding costae becoming lower, and less distinct anteriorly. Costae strong, narrow near beaks, becoming lower, wider, flatter, anteriorly arranged in fascicles of 3-5, not producing lateral plications of shell, numbering 30-50 per side exclusive of fastigium; median costa of fastigium bifurcating 5-10 mm anterior to beak, further bifurcation and insertion toward anterior, total number on fastigium or in sulcus 10-20; median costa of sulcus weak, beginning 5-10 mm anterior to pedicle beak, may bifurcate symmetrically farther forward. Radial ornamentation absent or not preserved; concentric ornament consisting of fine growth lines closely spaced, stronger growth laminae irregularly spaced, becoming scaly over tops of costae near anterior of larger shells, giving characteristic tile-roof effect.

Pedicle valve moderately convex transversely and longitudinally; beak slightly curved, not hooked at apex; delthyrium open, wedge-shaped; apical plate small, located in apex of delthyrium, may be fused to floor of valve; interarea triangular, pinching out at sides, slightly concave, anterior edge with small pointed denticles beginning 2 or 3 mm lateral to hinge teeth. Brachial valve moderately convex longitudinally and transversely, convexity depending on height of fastigium; interarea short, rather narrow to wide depending on width of hinge, slightly concave, interrupted at midline by wide, wedge-shaped notothyrium with large, finely lamellate cardinal callosity in apex.

Pedicle valve interior with strong, divergent hinge teeth, free anterior end of each slightly bent mesially; dental ridges broad, strongly convergent toward midline of valve, forming sloping platform on each side of delthyrium; dental plates short, continuous with dental ridges, slightly divergent to intersect valve floor lateral to muscle area; posterior of valve normally not thickened, leaving dental plates exposed and apical cones open; where thickened, callus is pitted. Muscle area narrow, elongate, spindle-shaped, anterior may be slightly raised, bisected by low median ridge; adductor

muscle marks narrow, lying along median ridge; diductor muscle marks larger, lateral to adductors; pedicle adjustor muscle marks in apical part of area, small, on slightly raised platform in some specimens. Floor of valve with faint radiating pallial marks, fading anteriorly, there masked by internal reflections of costae.

Brachial valve interior with widely divergent, thick-walled hinge sockets, partly covered by thin, elongate concave plate. Helicophores attached to socket ridges as broad plates; spiralia not observed. Buccal plate trilobed, each lobe perforate, anterior wings nearly parallel to one another, anterior median comb small, digitate (single specimen not preserved well enough for detailed description). Muscle area elongate, located in trough of fastigium, anteriorly expanding, bounded laterally by low ridges, bisected by low, anteriorly divergent ridges; floor of valve with weakly impressed irregularly radial pattern of pallial troughs, fading toward margins.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	width	thick- ness
USNM 702b					
151846a	2.1	?	1.8	2.7	?
151846b	3.0	?	2.4	3.1	?
151846c	3.5	?	3.2	3.9	?
151846d	4.9	4.5	4.9	5.6	3.9
151846e	5.1	?	6.3	6.6	?
151846f	6.9	7.0	7.0	8.0	?
151846g	7.5	?	8.2	8.9	?
151846h	8.2	?	7.9	9.5	?
151846i	10.3	?	10.5	11.7	?
151846j	11.9	?	10.9	14.3	?
151846k	12.2	?	11.8	15.8	?
151846-l	14.8	?	11.0	16.0	?
151846m	16.8	?	15.0	21.0	?
151846n	17.5	?	19.0	25.6	?
151846o	21.9	?	20.6	30.0	?
151846p	?	25.7	43.3	50.6	?
151846q	22.6	?	35.1	36.9	?
151846r	24.0	?	37.9	42.0	?
151846s	?	30.0	61.9	61.9	?
151846t	30.7	?	47.0	50.3	?
154632	27.0	24.0	30.0	37.0	17.0
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—AMNH 500; USNM 702b, 721u, 726o.

DIAGNOSIS.—*Lepidospirifer* with narrow hinge and low fold.

TYPES.—Holotype: USNM 154632. Figured paratypes: USNM 151846p,t,u. Measured paratypes: USNM 151846a-t.

COMPARISON.—*Lepidospirifer inferus* is characterized by its normally transverse outline with hinge narrower than the widest part of the shell, low, evenly arched rather than sharp crested fastigium, scaly ornamentation that begins rather far forward, and its relatively low costae that tend to flatten anteriorly. It differs from *L. demissus*, new species, in its lower costae, lower and gently arched fold, median costa of the fold which splits early, absent lateral plications, slightly more strongly curved pedicle beak, and its scaly ornament that begins farther anteriorly. Its low and blunt crested fold and fastigium, and low costae distinguish it from *L. angulatus* Cooper and Grant. It is readily distinguished from *L. costellus* (R. E. King) by its lack of lateral plications and broadly rounded fastigium.

DISCUSSION.—*Lepidospirifer inferus* varies in its proportionate width, height of fastigium, and hinge width. In other features, mainly thickness and convexity, it is not nearly as variable as *L. demissus*. Most specimens in the National Museum collection are disarticulated valves without their counterparts, making comparison with complete specimens of other species difficult.

Gypospirifer, new genus

[Greek *gypos* (vulture)]

Large, transverse, strongly biconvex; commissure uniplicate, approaching "parasulcate"; fold high, crest rounded; fastigium distinct, anteriorly broadening, semicircular to parabolic in cross section. Costae fine, bifurcating, subtly fasciculate in posterior regions, rather evenly spaced near anterior, numbering 6–10 in 10 mm of width, crests rounded to bluntly pointed, raised growth laminae producing tegulate ornament in anterior regions of some shells; growth laminae crowded and imbricated along commissures of adults, increasing thickness of shell with little or no increase in length; greatest width at hinge or immediately anterior thereto.

Pedicle valve evenly convex, beak hooked but not strongly incurved; delthyrium large, completely

covered on well-preserved specimens by stegidium composed of imbricating plates or only partially constricted by one or more pairs of such plates, leaving delthyrium largely open. Interarea high, nearly smooth, marked only by weak transverse growth lines and longitudinal traces of denticles. Brachial valve somewhat less strongly convex along fold, but more strongly curved laterally; interarea very low, smoother in lacking denticle marks; notothyrium wide, shallow.

Pedicle valve interior with strong divergent hinge teeth, deep dental ridges; dental plates and much of dental ridges buried in apical callosity; muscle area median, ovate, bisected by narrow median adductor scar and low median ridge, diductor marks broad, with slightly pitted floor of myotest.

Brachial valve interior with hinge sockets thick-walled and open; cardinal process low, lamellate as in *Neospirifer*. Spiral brachidia beginning as slightly convergent primary lamellae descending toward floor of brachial valve; short jugal processes at point of closest convergence, but apparently no complete jugum; spiralia forming rather evenly tapered cones with axes diverging posterolaterally toward hinge extremities.

TYPE-SPECIES.—*Gypospirifer nelsoni*, new species.

DIAGNOSIS.—Large, transverse, thick Spiriferidae with many fine costae that bifurcate or fasciculate only in the umbonal regions and have rounded or pointed (not flat) crests, and do not produce plications of the shell. The fold and sulcus are rounded in cross section, the interarea is high, the hinge denticulate, the delthyrium has stegidial plates (may be entirely closed by them), dental plates are short and normally buried in callus, and the axes of the spires are directed posterolaterally.

COMPARISONS.—Species now referred to *Gypospirifer* have been referred variously to *Spirifer* Sowerby and *Neospirifer* Fredericks. It differs from *Spirifer*, a Carboniferous and primarily Mississippian genus, in its transverse outline with greatest width at the hinge rather than at midlength, its sharper costae that tend to bifurcate and form weak fascicles in the posterior regions but become simple a short distance forward, its stronger concentric growth lines that may produce a tegulate ornamentation, and internally by its shorter dental plates and posteriorly directed spiral axes. It differs from *Neospirifer* in its more numerous and finer costae that are not distinctly fasciculate, many

more costae on fastigium and sulcus, and by total absence of true plication of the shell (aside from the median fold).

Gypospirifer differs from *Brachythyryna* Fredericks in its sharper, finer, bifurcating and much more numerous costae, its larger size, higher interarea, and imbricating stegidial plates. The fine and numerous costae that are rounded or sharp distinguish it readily from the genera with flat-crested costae such as *Choristites* Fischer de Waldheim, *Choristitella* Ivanov and Ivanova, or *Tangshanella* Chao. Two species referred to *Tangshanella* by Cherniak (1963:113, pl. 41), however, appear to belong more properly to *Gypospirifer*, judging by the contrast of the costae of *T. taimyrica* (Einor) and *T. byrangi* Cherniak with those of the type species of *T. kaipingensis* Chao (1929, pl. 7: figs. 12–14).

Gypospirifer differs from *Lepidospirifer* Cooper and Grant in its much larger size, coarser and less consistently tegulate costae that bifurcate only occasionally at the rear. The large size and transverse outline distinguish it from the new genus *Cartorhium* Cooper and Grant (above), as well as its sparsely bifurcating and essentially non fasciculate costae. The posteriorly directed spiral axes also differentiates *Gypospirifer* from both of these more nearly "neospiriferid" genera.

DISCUSSION.—The description of the interior of this genus was derived from the illustrations of *G. condor* (d'Orbigny) presented by Kozłowski (1914:68, fig. 16, pl. 1: fig. 1, an excellent stereophotograph), supplemented by observations on *G. anancites* and *G. nelsoni*, both new species.

Gypospirifer anancites, new species

PLATE 593: FIGURES 16–25

Spirifer condor R. E. King [not d'Orbigny], 1931:113, pl. 35: figs. 8, 9?, 10?, pl. 36: figs. 1a, b.

Small for genus, moderately strongly biconvex; outline transverse, normally widest at hinge or slightly anterior, but not alate; commissure uniplicate; fold low at anterior; fastigium moderately high, crest narrowly rounded; sulcus proportionately somewhat deeper, broadly V-shaped; without lateral plications. Costae low but well defined, round crested, weakly fasciculate, most bifurcation posterior to midlength of mature shells, numbering

3–5 per fascicle, usually 3, 18–25 per side exclusive of fastigium, 9–16 on fastigium or sulcus; median costa of fastigium bifurcating near beak, branches remaining closely continuous toward anterior; median costa of sulcus beginning at beak, remaining single or symmetrically bifurcating about 20 mm anterior to beak. Fine radial ornamentation absent; fine concentric growth lines closely spaced, interrupted by numerous stronger growth laminae giving costae somewhat rugose surface.

Pedicle valve moderately convex transversely, more strongly convex longitudinally; beak rather strongly curved; delthyrium wedge-shaped, forming angle of 60°, with thick apical callosity and deeply reentrant pseudodeltidium rarely preserved; inter-area long, wide, gently curved, anterior edge with numerous small, anteriorly pointing denticles. Brachial valve only slightly convex along fastigium, somewhat more strongly convex transversely; inter-area short, wide, slightly concave, bisected by wide, wedge-shaped notothyrium with thick, lamellate cardinal callosity in apex.

Pedicle valve interior with strong, anteriorly divergent teeth; dental ridges deep, converging gently; dental plates and most of dental ridges buried by apical callosity, apical cones nearly filled. Muscle area elongate, ovate, bisected by crest of sulcus and by low median ridge; adductor muscle marks narrow, elongate, one on each side of median ridge; diductor muscle marks larger, lying laterally. Valve thickened near posterior, floor of thickened part rather strongly pitted, with pits arranged in irregularly radial pattern.

Brachial valve interior with thick-walled, strongly divergent hinge sockets, open, without cover, muscle area lying in trough formed by fastigium. Spiral cones oblique; no buccal plate observed.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Lenox Hills Formation; Hueco Canyon Formation.

LOCALITIES.—*Uddenites*: USNM 701e, 701p, 702q, 703p. Lenox Hills: USNM 716r. Hueco Canyon: King Tmm; USNM 725z=499b.

DIAGNOSIS.—Large costa, narrow, poorly fasciculate and nonplicate *Neospirifer* with low, narrowly rounded fold.

TYPES.—Holotype: USNM 152895c. Figured paratypes: USNM 152895f, 154598. Measured paratypes: USNM 152895a,b,d,f; 152896a,b; 152897; 152898a,b.

MEASUREMENTS (in mm).—

	brachial		hinge		thick-
	length	valve length	width	width	ness
USNM 701p					
152898a	15.0	?	24.2	24.2	?
152898b	19.7	?	32.8	32.8	?
USNM 702q					
152897	28.8	24.6	55.0?	55.0?	18.5
USNM 701c					
152896a	29.9	23.5	48.4*?	43.4*?	19.4
152896b	38.9	?	65.0*?	53.8	?
USNM 499b					
152895a	13.6	11.4	29.1+	25.6	9.7
152895b	33.0	26.0	43.2+	40.8	22.0
152895c	25.7	27.6	48.0*+	47.8	23.4
(holotype)					
152895d	36.4	34.6	53.6+	54.0	25.0
152895e	45.0	33.5	81.4*	84.0	34.0
152895f	34.9	27.1	52.0*	49.0	21.0

COMPARISON.—*Gypospirifer anancites* is characterized by its strong narrow costae and strong growth laminae which give the shell a rugose surface, its weak fasciculation and lack of lateral plications, and its transverse outline widest at the hinge but without alation.

DISCUSSION.—This is the species that has commonly been identified with *Spirifer*, now *Gypospirifer condor* (d'Orbigny) but it differs from the South American species in being smaller, having a less incurved beak, narrower fold and sulcus, and more pronounced fasciculation of the costae even though fasciculation is not well developed in the Texas species.

Gypospirifer condor (d'Orbigny)

PLATE 592: FIGURES 1–10

Spirifer condor d'Orbigny, 1842:46, pl. 5: figs. 11–14.—Kozłowski, 1914:67, pl. 1: fig. 1, pl. 7: figs. 10–14.

Neospirifer condor (d'Orbigny) Chronic, 1953:60, pl. 10, figs. 10a–12e.

Figures of *Gypospirifer condor* (d'Orbigny) are introduced for comparison with *G. anancites*, new species, and *G. nelsoni*, new species, both of which have been mistaken for the Bolivian species.

Gypospirifer gryphus, new species

PLATE 591: FIGURES 1–5

Large, strongly biconvex, outline irregularly sub-

elliptical, widest at hinge; hinge ends rounded or slightly produced, acuminate in juveniles; commissure strongly and broadly uniplicate (not parasulcate); fold semicircular in section; fastigium rather low but distinctly set above flanks; sulcus correspondingly shallow; costae fine, bifurcating in umbonal regions and occasionally farther forward, crests rounded on both valves but slightly sharper on brachial valve, numbering 8 or 9 in 10 mm, with about 15–20 on fastigium and sulcus; concentric growth lines fine, crowded, ends not raised sufficiently to produce tegulate ornament and not crowded at commissure to thicken shell.

Pedicle valve profile an evenly expanding spiral; sulcus beginning at tip of beak; interarea proportionately very high for genus, smoothly concave, lightly marked by growth laminae and traces of denticles. Delthyrium relatively narrow, entirely closed by imbricated series of stegidial plates. Brachial valve similarly convex; interarea high for genus; notothyrium broadly arcuate in outline to accommodate last stegidial plate.

Pedicle valve interior greatly thickened in umbonal region; dental plates buried in callus; muscle area deeply impressed in thickened region; other internal features of this valve and brachial valve not observed.

MEASUREMENTS (in mm).—Specimens 154615a (holotype) and b, respectively: length 51.0, c. 45.0; width 75.0, 70.0; thickness 45.0, 41.0.

STRATIGRAPHIC OCCURRENCE.—Graham Formation (Wayland Shale Member).

LOCALITY.—USNM 728x.

DIAGNOSIS.—Convex shell with rotund outline, fastigium low and broad, costae rounded on both valves but slightly sharper on brachial valve, delthyrium completely covered.

TYPES.—Holotype: USNM 154615a. Unfigured measured paratype: USNM 154615b.

COMPARISONS.—*Gypospirifer gryphus* resembles *G. condor* (d'Orbigny) and *G. nelsoni*, new species, in its large size, but differs from both in its more rounded outline. Its costae are intermediate; those on the brachial valve are sharper than those of *G. condor*, but not as sharp as those of *G. nelsoni*. Its low fold resembles that of *G. nelsoni*, although it is proportionately broader, and it is much lower than in *G. condor*. It is much larger than *G. anancites*, new species, and also differs in its costal pattern and other features that are imme-

diately apparent in the illustrations on Plates 591–593.

DISCUSSION.—This is a rare species not closely related to the species described from these strata by Dunbar and Condra (1932) which belong to *Neospirifer*. The closest of their species is *N. cameratus* (Morton) which has the bifurcated and bundled costae typical of *Neospirifer*, although the fascicles of costae are not plicated as in many species of that genus.

Gypospirifer infraplicus (R. E. King)

PLATE 601: FIGURES 6–18; PLATE 602: FIGURES 15–19

Spirifer marconi infraplica R. E. King, 1931:114, pl. 36: figs. 3–4 [not fig. 2].

Very large, relatively flat; outline broadly semi-elliptical, normally widest at hinge, slightly alate; commissure uniplicate, normally not plicate laterally; fastigium moderately high, increasing in height anteriorly; sulcus shallow, extended as broad tongue into fold at commissure, not sharply bounded at sides. Costae fasciculate, but rarely producing low plications that fade anteriorly, numbering 3–9 per fascicle typically more than 7, aggregating 25–40 per side on mature shells, and 15–18 on fold and sulcus; median costa of fastigium bifurcating at beak, each branch dividing laterally but not medially in anterior course, all costae attaining nearly equal size, without prominent primary members; median costa of sulcus beginning at beak, continuing forward without splitting, in some specimens bifurcating evenly about 15 mm anterior to beak. Fine radial ornamentation absent; fine concentric ornament consisting of closely spaced growth lines, interrupted by coarser growth laminae becoming increasingly frequent anteriorly.

Pedicle valve rather flat to moderately convex transversely and longitudinally; beak short, not strongly hooked; delthyrium large, wedge-shaped; pseudodeltidium occupying about half length of delthyrium, flatly convex, deep set; interarea long, flatly concave, extending to tips of extensions of hinge, inner edge bearing numerous small, anteriorly pointing denticles, beginning immediately lateral to hinge teeth. Brachial valve somewhat more convex, profile of fastigium moderately convex near beak, flattening anteriorly, producing increase in height anteriorly; brachial interarea

rather short, but length nearly constant laterally, decreasing only on extensions of hinge; notothyrium shallow, broadly wedge-shaped, apex occupied by wide, brushlike cardinal callosity projecting only slightly away from valve wall, finely lamellate for muscle attachment.

Pedicle valve interior with large hinge teeth, normally divergent, but ends bent slightly inward in some specimens, supported by deep, thick dental ridges, slightly convergent toward floor of valve, giving rise apically to very short, divergent dental plates reaching floor along side extreme posterior part of muscle area; shell without callus or other thickening, leaving apical cones open and dental plates unburied. Muscle area elongate oval, occupying a quarter to a third valve length, neither excavated nor elevated, bisected by low median ridge; adductor marks elongate, proximal, set off from lateral diductor marks by low ridges in largest shells, both sets of marks longitudinally striated; adjustor muscle marks in extreme posterior part of muscle area, beneath pseudodeltidium, light striations fanning posteriorly; floor of valve unmarked except by crests and troughs of costae.

Brachial valve interior with widely divergent, moderately thick-walled hinge sockets, nonfunctional part roofed by thin plate; helicophores attached by thin triangular plates to socket ridges: spiralia and buccal plate not observed. Muscle area elongate, anteriorly widening slightly, set in internal trough produced by crest of fold, bisected by low median ridge; each adductor mark lightly striated longitudinally; posterior portion flanked by low, short, straight, slightly divergent ridges, so close to muscle area as to appear to define its edges in some specimens; costae plainly visible on floor of valve outside muscle area.

MEASUREMENTS (in mm).—Thickness unmeasurable.

	length	brachial valve length	hinge width	midwidth
USNM 705a				
152911a	12.0	—	11.5	17.3
152911b	—	13.8	18.9	24.4
152911c	20.4	—	35.7	5.0
152911d	32.9	—	56.3	54.0
152911e	—	40.0	96.6	73.8
152911f	—	49.6	87.1	82.0?
152911g	65.5	—	132.8*	100.0?
King Tg				
T10043b	47.0?	—	72.0?	69.0?
(lectotype)				

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation (base); Bone Spring Formation. Cibolo Formation (Breccia Zone of Udden).

LOCALITIES.—Skinner Ranch: USNM 705a, 720e. Bone Spring: AMNH 492; USNM 728e. Cibolo: 738c, 738r.

DIAGNOSIS.—Large, finely costate *Neospirifer* with valves of low convexity, and low rounded fold and sulcus.

TYPES.—Lectotype (herein designated): T 10043b. Figured paratypes: T 10043a, YPM 12402; Figured hypotypes: USNM 152911e-h. Measured hypotypes: USNM 152911a-g.

COMPARISON.—*Gypospirifer infraplicus* is characterized by its large size and rather flat valves that tend to bend or twist slightly during growth or later, its long pedicle interarea, deep-set apical plates unthickened by callus, and by its numerous rather fine costae of nearly uniform strength, without strong primary costae. R. E. King (1931) identified this species as a variety of *Spirifer marcoui* Waagen, stating that the costae are not fasciculate. The costae are not obviously fasciculate because they do not produce definite plications of the shell, however, they are fasciculate on our specimens as well as on King's. Fasciculation, much flatter valves, less hooked pedicle beak, shallower sulcus and lower, less sharply crested fastigium, and fewer costae on fastigium and sulcus are features that contrast with those of Waagen's species from the Salt Range. Waagen (1883:510) based his species on specimens collected in Texas by Marcou (1858, pl. 7: figs. 2, 2a). To judge from Marcou's illustrations, *G. infraplicus* differs in its fasciculate costae, shallower sulcus, lower and less sharp crested fastigium, and in its normally slightly extended hinge line.

DISCUSSION.—The type lot consists of three cotypes. YPM 12402 is a fragmentary specimen having both valves in place but very poorly preserved, and is from the Sierra Diablo. Two Texas Bureau of Economic Geology specimens, T 10043a, a pedicle valve from Shafter, and T 10043b, a brachial valve from the same place, are specifically different from the Yale specimen from the Sierra Diablo. The large brachial valve T 10043b is the best specimen and is here selected as type of the species. The Yale specimen has a longer interarea that is strongly apsacline, and a different ornament as well as shape, and is very different from the Shafter specimens.

Gypospirifer nelsoni, new species

PLATE 591: FIGURES 6-9

Outline transversely diamond-shaped, widest at hinge; commissure strongly uniplicate with slight ventral flexure on each side producing pattern called parasulcate; fastigium not greatly raised above flanks, crest gently rounded; costae fine, bifurcating only in umbonal regions, thereafter remaining simple, crests rounded on pedicle valve, sharp on brachial valve, numbering 7 or 8 in 10 mm, continuous over fastigium and sulcus (14 or 15 costae in fastigium and sulcus); concentric growth lines distinct, crowded, slightly raised to give tegulate appearance especially in anterior regions, growth laminae piled up along commissure, producing foliated effect and greatly thickening shell without adding to length.

Pedicle valve moderately convex; beak short, hooked, not swollen; sulcus shallow but produced at margin to form broad tongue into fold; interarea high, slightly concave longitudinally nearly perfectly straight transversely, posterior outline jagged, reflecting major growth laminae on shell, but these greatly mitigated on surface of interarea. Delthyrium bounded by only one pair of narrow deltidial (or stegidial) plates, otherwise remaining open on observed specimens. Brachial valve beak curved into delthyrium; interarea very low; notothyrium broad and shallow.

Internal features essentially as described for genus except for strong posterior direction of spiral axes, a distinctive feature of the species.

MEASUREMENTS (in mm).—Specimens 111919a (holotype) and b, respectively: length 49.0, 55.0; width 89.5, 86.0; thickness 42.0, 40.0.

STRATIGRAPHIC OCCURRENCE.—Hueco Formation (near base).

LOCALITY.—USNM 728y.

DIAGNOSIS.—Large, thick, strongly alate, costae tegulate, sharp on brachial valve, rounded on pedicle valve, fold low (and sulcus shallow) with broad semicircular cross section.

TYPES.—Holotype: USNM 111919a. Unfigured paratype: USNM 111919b.

COMPARISON.—*Gypospirifer nelsoni* most nearly resembles *G. condor* (d'Orbigny) which was described and illustrated in detail by Kozlowski (1914). Main differences are the somewhat larger

size and greater thickness of *G. nelsoni*, much lower fold and shallower sulcus, fewer costae per 10 mm, lack of bifurcation of costae except in posterior regions, and sharp crests of the costae on the brachial valve. Internally, the axes of the spires are directed rather strongly toward the posterior, as reflected in the alate outline and rather great length of the shell. This species is much larger than *G. anancites*, new species, and more alate, the fold is lower, and the costae simpler and less obviously grouped.

DISCUSSION.—This rare species is based on specimens collected and donated to the National Museum by Prof. Lloyd A. Nelson, late of the University of Texas, El Paso. Internal features were noted in a specimen retained in the El Paso campus collections, although the direction of the spire axis can be inferred from the external shape of the shell.

Genus *Spiriferinaella* Fredericks, 1926

Spiriferinaella Fredericks, 1926b:407.

About average size for a spiriferid, strongly bi-convex, usually strongly transverse, hinge ends alate, slender, normally produced far beyond main part of shell; commissure uniplicate, fold moderately high, gently arched, separated by costae; fastigium low, broad, with rounded median plication; sulcus broad, shallow to moderately deep, normally with shallow median trough. Costae low, rounded, numerous, beginning at beaks or hinge, lateral costae normally simple, rarely bifurcating, height and distinctness decreasing laterally, normally absent from extended hinge ends; costae of fastigium and sulcus bifurcating, normally branching from lateral bounding costae in sulcus and from median costa of fastigium. Growth lines distinct, closely spaced, covering shell, constituting characteristic ornamentation; stronger growth laminae few, widely spaced; radial striae fine, closely spaced, may serrate edges of slightly raised growth lines.

Pedicle valve strongly convex longitudinally, flatly convex transversely; beak rather prominent, strongly hooked over interarea; delthyrium narrow, wedge-shaped, apical part filled by internal callosity, anterior part nearly covered by pseudodeltidium, leaving small opening near apex of brachial beak; interarea longitudinally concave, maximum convexity toward beak, surface striated trans-

versely by light growth lines, longitudinally by traces of growth of denticles, anterior edge with numerous short, sharp, anteriorly pointing denticles, fitting into corresponding shallow pits in brachial valve interarea. Brachial valve nearly equally convex, interarea low, slightly concave, bisected by broadly wedge-shaped notothyrium; beak short, blunt, rather strongly bent over notothyrium; apex of notothyrium with thick cardinal process, finely lamellate for attachment of diductor muscles.

Pedicle valve interior with slender hinge teeth knobbed on the ends; dental ridges thin, continuous in straight line with dental plates; dental plates in apical part of valve, widely divergent to floor, normally nearly completely buried in callus; apical callosity thick, occupying space between dental plates, filling apical part of delthyrium, lateral callosities nearly filling apical cones in adults. Muscle area tear-shaped, bisected by low, distinct, ridge, posterior part covered by apical callosity in adults; individual muscle marks not distinctly separate, hence relative sizes unknown; anterior margin of area serrate, indistinct. Thickened posterior part of valve with shallow pits in irregularly radial rows, fading toward margins, pits not only on floor of valve but also on underside of interarea, where thickened.

Brachial valve interior with widely divergent, thick-walled sockets, apical part of each roofed by thin plate, each socket ridge with small knob at anterior; cardinal process broad, longitudinally lamellate; helicophores originating from socket ridges, ascending dorsally, curving and narrowing anteriorly; junction of helicophores and spiralia somewhat thickened, producing sharp, ventrally pointing jugal processes; spiralia ribbonlike, coiled dorsoventrally in oval loops, size decreasing laterally. Muscle area elongate, spatulate, bisected by low, sharp median ridge; individual muscle marks not visibly differentiated; posterior part of valve slightly thickened in some adults, floor of thickened part pitted in radial rows fading out toward margins.

TYPE-SPECIES.—*Spirifer artiensis* Stuckenberg, (1898:266, pl. 5:figs. 6a-b) by original designation of Fredericks (1926b:407).

COMPARISON.—*Spiriferinaella* is characterized by its rather short, very wide, alate shell with distinct, slightly raised, closely spaced growth lines, low fold, shallow sulcus, normally nonbifurcating

lateral costae but bifurcating mesial costae, and its very wide, denticulate interarea with longitudinal striation produced by tracks of growth of denticles. Traditionally this genus has been compared with punctate spiriferids, in the belief that it is punctate. It is not punctate, as explained below, and should be compared with impunctate genera.

Its nonfasciculate costae distinguish it from *Neospirifer* Fredericks and related genera, and its alate form and concentric ornamentation are obvious differences from *Choristites* Fischer de Waldheim. Its nearest relatives appear to be the spiriferids that have the sulcus and fastigium costate, i.e., *Spirifer* Sowerby *sensu stricto*. Obvious differences in *Spiriferinaella* are the very alate shape, normally fewer and broader costae, the strength of the concentric ornamentation, and the presence of paired deltidial plates in contrast to the open delthyrium of *Spirifer*. The denticulate hinge of *Odontospirifer* Dunbar (1955) is similar, but *Spiriferinaella* lacks the coarse plication and the ventral median septum of that genus, and is further distinguished by its wider outline, costate fold and sulcus, and deltidial plates. The costate fastigium and lack of a ventral median septum are salient distinctions from *Paeckelmanella* Licharew.

DISCUSSION.—*Spiriferinaella* bears external resemblance to genera of the punctate spiriferids and formerly was considered to be punctate (e.g., Stehli, 1954; Campbell, 1959a). Fredericks (1926b:407) established it as a *forma conjuncta* under *Spiriferella*, which is punctate, with the type species *Spiriferina artiensis* Stuckenberg as identified by Tschernyschew (1902), who placed it among punctate forms. Pitrat (1965) placed *Spiriferinaella* in the Spiriferinidae, a mixture of punctate and impunctate genera, but compared it to impunctate *Odontospirifer* Dunbar (1955). We have not examined types and so are prepared to be contradicted by direct evidence, but many factors lead us to concur with Pitrat's conclusion that *Spiriferinaella* is impunctate.

Neither Stuckenberg (1898) nor Tschernyschew (1902) mention that the shell of *S. artiensis* is punctate, a feature that Tschernyschew, at least, normally included in descriptions of punctate shells. Tschernyschew (1902:129, 529) placed *S. artiensis* in *Spiriferella*, an impunctate group, but then ambiguously (for the sake of this argument)

considered *Spiriferella* a subgenus of *Spiriferina* which now contains only punctate species.

Campbell (1959a:351) pointed out that the denticulate hinge of *Spiriferinaella* distinguishes it from most other punctate spiriferids. A denticulate hinge is a consistent feature of impunctate Spiriferacea. Another feature of punctate Spiriferinidae that is absent from *Spiriferinaella* is the median septum of the pedicle valve.

The ornamentation of *Spiriferinaella* consists of fine and very even concentric lamellae, very much as in *Pterospirifer* Dunbar (1955), which is impunctate. As a final (although certainly not clinching) argument that *Spiriferinaella* is impunctate, we cite evidence from specimens in our collections. These resemble *S. artiensis* sufficiently, in our opinion, to be congeneric. They are impunctate. Unfortunately, this line of evidence is somewhat weakened by age differences; the Russian species is Artinskian, whereas in West Texas the range of the genus begins at the very top of the Leonard Series, in the Road Canyon Formation. All things considered, however, we classify *Spiriferinaella* among the impunctate spiriferids.

Spiriferinaella limata, new species

PLATE 625: FIGURES 1-10

About average size for genus, moderately strongly biconvex; outline broadly transverse, width of juveniles about 3 times length, width of adults up to 5 times length, widest at hinge, normally alate; commissure uniplicate, with broad low fold; fastigium beginning at beak, swollen in umbonal region, becoming broader and lower toward anterior; sulcus broad, shallow, bounded by a strong costa on each side; costae numerous, fastigium with median costa, and others totaling up to 7, added anteriorly by bifurcation; sulcus with median costa or trough, also up to 7 costa, number of costa on each side of juveniles about 5, up to 18 counted on adults, number not necessarily equal on each side, lateral costae rarely bifurcating. Growth lines fine, weak, closely spaced, edges not raised, producing essentially smooth surface; stronger growth laminae widely and irregularly spaced.

Pedicle valve moderately strongly convex, greatest convexity in umbonal region; beak prominent but not elongate, strongly hooked over delthyrium,

apex bluntly pointed, interarea wide, short, flatly concave, longitudinally striated by traces of growth of denticles; numerous fine denticles along entire anterior edge of hinge; delthyrium relatively broadly wedge-shaped, apical half filled by internal callosity, posterior half partly covered by pseudodeltidium, anteriorly leaving small triangular opening for incursion of brachial beak during shell opening, and for pedicle. Brachial valve more strongly convex, umbonal region of fastigium somewhat swollen; interarea low, wide, concave, anterior edge of hinge with single row of small pits to accommodate denticles of pedicle hinge; notothyrium broadly wedge-shaped; apex with large, knoblike, lamellate cardinal process.

Pedicle valve interior with rather small, knoblike teeth; dental ridges weak, rounded; dental plates divergent, short, visible only in apical part of juveniles, buried by shell thickening in adults. Muscle area rather broad, bisected by low ridge, posterior part of area progressively covered by thickening posterior of valve; thickened posterior part of valve with irregularly radial rows of shallow pits, fading toward margins.

Brachial valve interior with strong, widely divergent hinge sockets; socket ridges strong, each with low knob on anterior edge; hinge plates extending from socket ridges, rather small; helicophores tapering anteriorly, slightly bowed outwardly; entire spirallium not observed. Muscle area large, broadly expanding anteriorly, bisected by low ridge, weakly lirate longitudinally, occupying most of trough formed by fastigium.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	midwidth
USNM 706c				
152943a	6.0?	?	24.0?	?
152943b	8.0?	?	32.0?	8.0
152943c	?	7.4	29.0?	?
152943d	?	13.0?	40.0?	?
152943e (holotype)	?	16.4	80.0?	?

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank and Willis Ranch members).

LOCALITIES.—China Tank: USNM 706c, 726r. Willis Ranch: USNM 723w.

DIAGNOSIS.—*Spiriferinaella* of moderate size with weak ornament.

TYPES.—Holotype: USNM 152943e. Figured par-

atypes: USNM 152943b-d,f,g. Measured paratypes: USNM 152943a-d.

COMPARISON.—*Spiriferinaella limata* is characterized by its moderate size, alate but not strongly produced hinge ends, numerous fine costae, and relatively smooth surface with growth lines fine and weak. Its weak ornamentation distinguishes it from *S. scalpata*, new species, although it also is smaller, and from *S. artiensis* (Stuckenberg) and *S. medialis*, new species, both of which are similar to it in size.

Spiriferinaella medialis, new species

PLATE 626: FIGURES 1-5

About average size for genus, moderately strongly biconvex; outline broadly transverse, width about 4 times length; widest at hinge, ends alate but not strongly produced; commissure uniplicate, with fold broad, low; fastigium rather low, crest rounded, with median costa and 2 or 3 costa on each side added by bifurcation; sulcus shallow, broad, bounded by a strong costa on each side, other costae added by bifurcation from bounding costa, median line with shallow trough; costae numbering up to 7 on fastigium and sulcus, up to 10 on each side, those on sides normally simple. Growth lines closely spaced, edges slightly raised to give distinct ornamentation; slightly stronger growth laminae widely and irregularly spaced.

Pedicle valve moderately convex; beak prominent but not elongate, strongly hooked; interarea low, wide, longitudinally striated by traces of growth of denticles; anterior edge of hinge with numerous small, anteriorly pointing denticles; delthyrium narrowly wedge-shaped, nearly filled by pseudodeltidium, leaving small triangular foramen at anterior to accommodate brachial beak and pedicle. Brachial valve more strongly convex, beak scarcely protruding, umbonal region somewhat swollen; interarea low, wide, concave; notothyrium broadly wedge-shaped, apex with rather large knob or wedge-shaped, lamellate cardinal process.

Pedicle valve interior with strong, pointed teeth, dental ridges scarcely expressed, rounded; dental plates buried by shell thickening in adults (no juveniles observed). Muscle area subcircular or subelliptical, posterior part covered by thickening of valve with growth; bisected by low median ridge; thickened posterior part of valve with irregularly

radial rows of shallow pits, fading toward margins.

Brachial valve interior with strong, widely divergent hinge sockets; socket ridges each with small knob at anterior edge; helicophores small, extending dorsally from socket ridges; spiralia not observed. Muscle area weakly impressed in shallow depression that swells umbonal part of fastigium; median line with low, thin ridge.

MEASUREMENTS (in mm).—Holotype USNM 152944a: length 14.4, brachial valve length 13.4, hinge width about 47.0, thickness 14.0.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—USNM 728.

DIAGNOSIS.—*Spiriferinaella* of moderate size and with strong concentric ornament.

TYPES.—Holotype: USNM 152944a. Unfigured paratypes: USNM 152944b,c.

COMPARISON.—*Spiriferinaella medialis* is characterized by its rather small size, its outline relatively somewhat narrow for the genus but nevertheless broadly transverse, its distinct ornamentation by growth lines, and its relatively few lateral costae. It is similar to the type species, *S. artiensis* (Stuckenberg) as illustrated by Tschernyschew, (1902) in its size and ornamentation, but it is proportionately wider, its pedicle valve is shallower, with lower interarea, and it has more numerous and distinct costae. Its ornamentation is similar to that of *S. scalpata*, new species, but it is smaller, proportionately not as wide, and its costae are fewer and lower. The distinct concentric ornamentation distinguishes this species from *S. limata*, new species.

Spiriferinaella scalpata, new species

PLATE 625: FIGURES 11-28

Large, biconvex; outline extremely transverse, width up to 6 times length in large adults, about 3 times length of juveniles; hinge ends extended, alate; commissure uniplicate, with fold broad, low; fastigium with up to 7 costae, number increasing toward anterior by lateral bifurcation from median costa; sulcus shallow, with equal number of costae also bifurcating; lateral costae low, numbering 3 or 4 in small juveniles, 8-15 in adults, amplitude decreasing laterally, alations of hinge ends not costate. Growth lines relatively coarse, closely and

rather regularly spaced, strongest near margins, stronger growth laminae widely and irregularly spaced.

Pedicle valve strongly convex longitudinally; flatly convex transversely; beak prominent, strongly hooked, apex increasing toward beak, strongly ornamented longitudinally by traces of growth of denticles, anterior edge with numerous small, anteriorly pointing denticles along entire edge from hinge teeth to extreme tip, including alate portion; delthyrium narrowly wedge-shaped, apical half filled by internal callosity, anterior half partly covered by pseudodeltidium, leaving slight opening to accommodate brachial beak, apparently little or none for pedicle. Brachial valve similarly convex, umbonal region somewhat swollen; interarea low, concave, with row of pits near anterior edge to accommodate denticles of pedicle interarea; notothyrium broadly wedge-shaped, apex with large, knoblike, finely lamellate cardinal process.

Pedicle valve interior with small, knoblike teeth; dental ridges thin; dental plates small, divergent, reaching floor of apex of valve, exposed in juveniles, buried by shell thickening in posterior of adults. Muscle area elongate ovate, rather deeply recessed, bisected by low ridge, posterior progressively covered by thickening of valve with growth. Thickened posterior of valve with shallow pit in irregularly radial rows, fading toward margins.

Brachial valve interior with wide, divergent hinge sockets, posterior part roofed by thin plate; socket ridges thick, with low knob on anterior edge of each; helicophores beginning as triangular plates, extending dorsally from socket ridges, becoming slender, extending forward, each with short, jugal process near juncture with spiralium, not convergent toward one another; spiralia coiled dorsoventrally in loops of laterally decreasing size, about 7 loops observed in incomplete spiralium. Muscle area in umbonal region, bisected by low, thin ridge, extending forward about a half to two-thirds length of valve.

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch, Appel Ranch Member, and lenses between the two).

LOCALITIES.—Willis Ranch: USNM 706. Appel Ranch: USNM 706d, 715i, 727j. Lenses: USNM 706b, 732c, 742b.

DIAGNOSIS.—Extremely wide *Spiriferinaella* with fine but slightly raised growth laminae.

MEASUREMENTS (in mm).—

	length	brachial valve length	hinge width	thickness
USNM 715i				
152945a	6.3	?	19.3	?
152945b	?	17.7	56.0	?
152945c	?	18.0	91.0	?
152945d	20.5	?	110.0?	?
USNM 706d				
152946b	17.0	13.3	70.0*	14.6
152946d	?	15.0	70.0?	15.0
USNM 706b				
152947a (holotype)	15.8	14.0	66.0*	16.0

TYPES.—Holotype: USNM 152947a. Figured paratypes: USNM 152945b-d; 152946a,b; 152947b. Measured paratypes: USNM 152945a-d; 152946b, d. Unfigured paratypes: USNM 152945a; 152946c,d.

COMPARISON.—*Spiriferinaella scalpata* is characterized by its large size, extremely transverse outline with extended hinge ends, and especially by its fine but distinct, closely spaced, slightly raised growth laminae that produce a rasplike external surface. It is larger and more transverse than *S. artiensis* (Stuckenberg) (see Tschernyschew, 1902, pl. 37), and more strongly and completely costate. It differs from *S. limata*, new species which occurs somewhat lower in the Word Formation, by its larger size, coarser costae, and especially by its stronger ornamentation by growth laminae. It is larger and more transverse than *S. medialis*, new species, from the Cherry Canyon Formation, although its ornament is similar but somewhat stronger.

Spiriferinaella species undetermined

PLATE 626: FIGURES 6–9

Two specimens from separate localities in the Word Formation are illustrated. In addition, a few valves referable to *Spiriferinaella*, found in the Road Canyon Formation at USNM 720d and 726d, are too poor to figure, but they are mentioned to establish the earliest occurrence of the genus in the Glass Mountains.

Figured specimens: USNM 154549, 154550.

Family BRACHYTHYRIDIDAE Fredericks, 1924

Biconvex, usually narrow hinged, strongly rostrate Spiriferacea, uniplicate, multicostate, micro-

ornament variable, dental plates usually present but no ventral septum; brachial valve with or without socket ridge supports. Impunctate.

Genera in West Texas: *Eridmatius* Branson (1966), *Spiriferella* Tschernyschew (1902), *Elivina* Fredericks (1924c), *Eliva* Fredericks (1924c).

Eridmatius strongly resembles *Spiriferella* and is confined to the *Uddenites*-bearing Shale Member of the Gaptank Formation of Permian rocks but is fairly common in Pennsylvanian formations.

Spiriferella appears first in the Road Canyon Formation where it is very rare. It is commoner in the Word members but is rare in the Cherry Canyon and Bell Canyon formations in the Guadalupe Mountains. *Eliva* and *Elivina* occur in the Capitan and Bell Canyon formations and are common locally.

Genus *Eridmatius* Branson, 1966

Eridmatius Branson, 1966:74.

Small to medium, biconvex, narrowly spiriferid, adults normally somewhat longer than wide, greatest width at hinge or anterior to midlength; hinge narrow, ends normally truncated, only slightly auriculate; commissure strongly uniplicate with high, inverted, V-shaped fold, lateral plications low; fastigium high, standing increasingly high above flanks toward anterior, nearly straight in profile, crest normally with two costae separated by shallow, narrow trough; sulcus beginning at beak, greatly deepening anteriorly, cross section V-shaped, median line with trough or low costa, anteriorly extended to fill fold. Costae fairly strong, crests rounded, arranged in fascicles with splitting taking place near posterior, proximal 1 or 2 fascicles with 3 costae each, distal fascicles each with 2, zone of splitting located farther posterior in distal fascicles, each fascicle normally with only 1 zone of splitting, without further branching of costae toward anterior; each fascicle making low plication in shell, plications fading anteriorly, absent at margins of large specimens. Radial ornamentation moderately strong, most clearly visible in troughs between costae; concentric growth lines fine, crowded; growth laminae stronger, irregularly spaced, normally strongest and most frequent near margins; surface bearing numerous small pustules, most following growth lines, some apparently lin-

ing up along fine radial ornamentation, best preserved near margins and in troughs near beaks.

Pedicle valve elongate, strongly convex; beak thick, rather short, strongly hooked; interarea normally pentagonal in outline, with truncated sides, strongly concave near beak, becoming nearly flat at hinge without denticles along anterior edge; delthyrium triangular, nearly equilateral; pseudodeltidium short, thick, strongly arched, located in apex of delthyrium, with lateral projections forward along sides. Brachial valve strongly convex transversely, less so longitudinally; outline semicircular to subquadrate, shield-shaped; beak short, barely projecting; notothyrium wide, wedge-shaped, apex with large, finely lamellate callosity for attachment of diductor muscles; interarea low, slightly concave.

Pedicle valve interior with strong, thick, fairly short hinge teeth; dental ridges continuous with thick dental plates and reaching nearly to ends of hinge teeth, strongly bowed inward, reaching floor of valve beside posterior part of muscle area, normally not extending forward along floor of valve. Muscle area elongate, fusiform, many with posterior part overrun by callus, midline with low, threadlike ridge; adductor muscle marks median, narrow, elongate, one on each side of median ridge; diductor muscle marks larger, lying lateral, lightly striated longitudinally. Posterior part of valve greatly thickened, filling or partly filling apical cones, nearly burying dental plates, encroaching forward onto muscle area; floor of thickened part marked by shallow pits arranged in irregular radial rows, fading anteriorly.

Brachial valve interior with thick-walled hinge sockets, helicophores extending dorsally, then anteriorly from socket ridges; spiralia ribbonlike, coiled dorsoventrally in about twelve loops decreasing in size laterally. Muscle area, and floor of valve not observed.

TYPE-SPECIES.—*Spirifer* (*Trigonotreta*?) *texana* Meek (1871:179).

COMPARISON.—*Eridmatius* is characterized by its elongate outline, relatively narrow hinge with truncated ends, strong but rounded costae arranged in definite fascicles which plicate the shell near the beaks, fairly strong radial ornamentation, high fastigium and deep sulcus, both sharply V-shaped, greatly thickened pedicle valve, short dental plates that nevertheless extend nearly to the ends of the

hinge teeth and then descend nearly straight to the valve floor, and especially by its external surface pustules. The narrow outline, surface pustules, and the costae that split only near the beaks, without further splitting anteriorly, distinguish this genus from *Neospirifer*, to which its species have heretofore been assigned—e.g., *Neospirifer texanus* (Meek) in Dunbar and Condra (1932:338). Its pustules and median groove on the brachial valve are links to *Spiriferella*, but *Eridmatus* differs in its higher, wider fastigium, deeper, wider sulcus, sharper costae, fascicles that plicate the shells only near the posterior and are produced by only one splitting of costae, hinge without denticles on the anterior edge, somewhat stronger radial ornamentation, and more widely spaced surface pustules. *Eridmatus* also is similar to *Eliva* and *Elivina*, but differs in its wider hinge with truncated ends, giving a pentagonal rather than triangular interarea, its coarse and strongly fasciculate costae, thickened pedicle valve, and especially by its high fastigium, deep sulcus, and pustulose surface.

DISCUSSION.—The best known species of *Eridmatus* is the type species, *E. texana*, formerly assigned to *Neospirifer*. That species needs study, and probably specimens that have been assigned to it will be seen to belong to more than one species.

We believe that *Eridmatus* occupies a phylogenetic position between *Neospirifer* and *Spiriferella*. The narrowly spiriferid outline, coarsely fasciculate costae, and high fastigium link it to *Neospirifer*, from which it probably descended at some time in the Mid-Pennsylvanian. On the other hand, the truncate pentagonal interarea, pustulose surface, and the dual crest with median groove on the fastigium are characteristics of *Spiriferella* which may have descended from *Eridmatus* or one of its relatives in the late Pennsylvanian or Early Permian.

Eridmatus marathonensis, new species

PLATE 626: FIGURES 10–20

Average size, outline subpentagonal, slightly elongate to nearly equidimensional, widest at hinge or slightly anterior; hinge ends tapering, abruptly truncated only in largest specimens, slightly auriculate; commissure uniplicate with fold moderately high, sides slightly curved, lateral plications mod-

erately strong but reduced or absent in large specimens; fastigium moderately high, profile somewhat curved thus reducing amount of increase in anterior height, crest dual, with costae nearly fused and median groove shallow to nearly obliterated; sulcus shallow to moderately deep, rather broad, beginning at beak, wrapping around anterior to fill fold, median line with low costa or trough. Costae low, rounded, distinct, beginning at beaks, splitting once within 5–8 mm of beaks to form strong fascicles with 3 costae in each mesially, 2 distally, without further splitting anteriorly, numbering 9–12 per side, 8–10 on fastigium and in sulcus; each fascicle making distinct plication of shell in beak regions, fading anteriorly, not plicating commissure of larger specimens. Surface pustules weak, sparse; radial ornamentation fine, weak, visible only in troughs between costae; concentric growth lines also weak, crowded; growth laminae irregularly spaced, somewhat more frequent near margins.

Pedicle valve strongly and evenly convex longitudinally, strongly convex transversely; beak short, thick, strongly curved; interarea broad, concave, somewhat extended laterally, nearly tapering to ends but there slightly truncate; delthyrium high, wedge-shaped; pseudodeltidium not observed. Brachial valve flatter; outline elongate to transversely elongate to transversely subquadrate to subelliptical; beak rather prominent; interarea low, slightly convex; notothyrium wide, wedge-shaped; apical muscle attachment not observed.

Pedicle valve interior with strong, anteriorly divergent hinge teeth; dental ridges thick, supported by thick short dental plates reaching floor of valve at edges of muscle area; posterior part of valve greatly thickened, partly filling apical cones, partly burying dental plates, forming thick shelf of callus in delthyrium beneath position of pseudodeltidium. Muscle area elongate fusiform, posterior partly covered by forward growing callus; adductor muscle marks narrow, elongate, median, one on each side of low median ridge; diductor muscle marks larger, lateral, longitudinally striated; thickened part of valve with shallow pits arranged in roughly radial rows, fading anteriorly.

Brachial valve interior with helicophores leading forward from thick socket ridges; spiralia coiled dorsoventrally in about 12 loops (in mature specimen) decreasing in size laterally; other internal features not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	midwidth	hinge width	thick- ness
USNM 701v					
152977a	15.7	12.6	15.0?	8.0?	10.6
152977b	17.5	14.0	13.5?	c.13.0	11.0?
(holotype)					
152977c	19.5	14.9	18.9	18.6	13.2
152977d	21.0	17.8	20.0	20.5?	14.9
152977e	23.0	17.2	19.5?	19.5	16.5
152977f	25.0?	20.0?	24.0	22.8	16.8
152977g	31.7	25.6	28.4	27.5	23.2
152977h	32.5?	26.5	26.2	28.0?	26.9
USNM 701e					
152978	34.0	25.5?	26.4	24.0	26.0

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (Uddenites-bearing Shale Member); Wolfcampian.

LOCALITIES.—Gaptank: USNM 700f, 700g, 705ca. Uddenites: USNM 701e, 701p, 701q, 701r, 701t, 701v, 703o. Wolfcampian: USNM 708b.

DIAGNOSIS.—Narrow, widest near hinge, fastigium low and slightly rounded with very shallow median groove.

TYPES.—Holotype: USNM 152977b. Figured paratypes: USNM 152977a,c. Measured paratypes: USNM 152977a,c-h; 152978.

COMPARISON.—*Eridmatius marathonsensis* is characterized by its subpentagonal outline with greatest width normally at hinge line or just anterior to hinge line, relatively low, somewhat rounded fastigium and shallow sulcus, nearly fused dual crest of fastigium with very shallow median groove, weak radial and concentric ornamentation, and sparse surface pustules. It differs from *E. texana* (Meek) in its somewhat narrower outline with greatest width located much farther posterior, sharper costae in more distinct fascicles, lower and more rounded fastigium, shallower sulcus, and weaker surface ornamentation.

An unnamed species of *Eridmatius* occurs in the Carnic Alps, as evidenced by specimens in the National Museum (USNM 63155). *Eridmatius marathonsensis* appears to be larger, has its greatest width farther back, has a deeper sulcus and higher fastigium, and fewer costae on the fastigium, with a different pattern of their arrangement (repeated splitting anteriorly in the European species). *E. marathonsensis* differs from *Spiriferella editiata* Einor (in Licharew and Einor, 1939:152, pl. 26: figs. 1-4), which probably is a species of *Eridmatius*, in

its broader outline, less prominent pedicle beak, slightly protruding hinge ends, and lower longitudinal convexity, especially of the crest of the fastigium.

Genus *Spiriferella* Tschernyschew, 1902

Spiriferina (*Spiriferella*) Tschernyschew, 1902:121, 522.

Small to moderately large, biconvex, spiriferid; outline subcircular to elongate subelliptical or ovate, normally longer than wide; hinge straight, width normally about equal to midwidth of shell, normally auriculate, rarely somewhat mucronate; commissure uniplicate, with low, evenly arched fold; fastigium low or absent, with sharp narrow groove along median line. Costae strong, broad, gently rounded, beginning at beaks, forming low fascicles by one stage of asymmetrical bifurcation near beaks, sporadic bifurcations farther forward, fascicles producing several plications on each side of fold and sulcus. Fine radial ornamentation normally present, in some species only near beaks or in troughs between costae; concentric growth lines fine, producing fine cancellate pattern with radial striae; growth laminae stronger, irregularly spaced; surface of shell densely or sparsely covered by small pustules arranged roughly along growth lines but not in radial rows.

Pedicle valve elongate, rather strongly convex; beak thick, prominent, normally rather strongly curved; delthyrium large, triangular, apical half covered by large, flatly convex pseudodeltidium with long lateral projections extending forward along edges of delthyrium; interarea high, moderately to strongly concave, normally subpentagonal with lateral extremities abruptly truncated, anterior edge with numerous small denticles pointing forward, inserting in shallow pits in brachial interarea, serving as fulcra for valve movement. Brachial valve much flatter, more nearly equidimensional; beak short, blunt; interarea low, only slightly concave; notothyrium broadly wedge-shaped, large cardinal callosity in apex finely lamellate for attachment of diductor muscles.

Pedicle valve interior with strong anteriorly diverging hinge teeth, trace of growth leaving shallow groove along each side for insertion of edges of pseudodeltidium; dental ridges fairly deep, slightly convergent ventrally; dental plates

continuing from dental ridges, diverging toward valve floor, meeting floor on each side of muscle area; apical callosity normally thick, partly burying mesial sides of dental ridges and teeth. Muscle area elongate ovate, bisected by low median ridge, posterior part progressively covered by forward growth of apical callosity; adductor muscle marks median, forming midline of middle lobe of somewhat trilobed anterior margin of muscle area, longitudinally striated; diductor muscle marks lateral, each larger than adductors, also longitudinally striated. Floor of thickened part of valve with small, fairly deep pits arranged in irregularly radial rows, becoming shallower anteriorly, giving way toward margins to shallow radiating pallial troughs.

Brachial valve interior with widely divergent, thick-walled sockets, proximal part roofed by thin plate. Helicophores originating from mesial walls of socket ridges, starting thin, broad, becoming thicker and narrower anteriorly, outwardly bowed and slightly flexed, attached to ends of spiralia by flat lateral joint; spiralia ribbonlike, coiling dorso-ventrally along oblique axes in large oval loops, becoming smaller and elliptical, then subcircular laterally; jugal processes near junction, each spreading into small handlike plate with digitate or serrate edges, converging toward midline of shell, meeting opposite plate in mature specimens but not fusing. Muscle area weakly impressed, elongate spatulate, widening anteriorly, bisected by low median ridge; adductor muscle marks forming two elongate lobes, one on each side of median ridge, shorter posterolateral lobe on each side just below apical callosity. Posterior part of valve only slightly thickened in some species, normally unthickened; floor of valve faintly marked by shallow pits in posterior, irregular radial striae farther forward, largely masked by internal reflections of costae.

TYPE-SPECIES.—*Spirifer saranae* Verneuil (1845: 169, pl. 6: figs. 15a,b) by original designation of Tschernyschew, (1902:111, 121).

DIAGNOSIS.—*Spiriferella* is characterized by its normally elongate outline, thickened pedicle valve, broad, low costae that split asymmetrically to form weak fascicles, auriculate hinge with truncate ends, its well-developed pseudodeltidium, median groove along the crest of the very low fastigium, and by its pustulose ornamentation.

COMPARISON.—Traditionally *Spiriferella* has been

confused with *Elivina* Fredericks (e.g., Dunbar, 1955; Pitrat, 1965), from which it differs in its wider, somewhat auriculate hinge, pentagonal interarea, nearly nonexistent fastigium, shallower sulcus, broader lower costae, well-developed pseudodeltidium, and pustulose ornamentation. Species now assigned to *Eridmatus* Branson resemble *Spiriferella* in their auriculate hinges and pustulose ornamentation. They differ in their sharper, more strongly fasciculate costae, sharp and high fastigia, lack of lateral plications, and normally more quadrate, elongate outline.

DISCUSSION.—Weller (1914) used the name *Spiriferella* for a group of Mississippian spiriferids with punctate shells. This was based upon misinterpretation of the pustules for punctae, as pointed out by Dunbar (1955:139), and possibly upon a mistranslation of Tschernyschew's (1902: 514) use of the words "punktirte Structur", which means "dotted," not necessarily "punctate" structure.

Dunbar (1955:138) agrees with Miloradovitch (1936a:72) that Tschernyschew mistook the line separating the calcareous thickenings of the two dental plates for the trace of a high median septum, viewed in section. A silicified topotype specimen of *S. saranae* (USNM 63205a) in the National Museum collection from the Indiga River region of Timan has a low median septum that is thickened and heightened by calcareous additions, as are the dental plates. However, the interior of *S. saranae* figured by Tschernyschew (1902:524–525, figs. 41–46b) show no such septum. Therefore we believe that whereas Tschernyschew probably was not entirely mistaken about the possibility of the presence of a median septum, one is not invariably present, consequently that feature cannot be considered taxonomically significant.

Spiriferella does not have a buccal plate such as that in *Neospirifer* and *Lepidospirifer*. However, the function of that plate probably was served by the little hand-shaped expansions at the ends of the jugal processes near the junction of the spiralia with the helicophores. In genera that do have the buccal plate, it is braced against the jugal processes and against the trunk of the first loop of the spiralia. The maniculiform expansions in *Spiriferella* occupy a similar position, and their serrate or digitate edges are reminiscent of the form of the

buccal plate. We speculate that the buccal plate supported some part of the mouth apparatus, and believe that the expanded jugal processes in *Spiriferella* are analogous. They have been observed only in juvenile and immature adult specimens. They are obviously separated from one another in the youngest specimens, but grow toward the midline of the shell. They are touching but not fused in the largest specimen in which they were observed. Probably they become nearly as large as a normal buccal plate in mature adults, and may fuse along the median line.

The pseudodeltidium begins in the apex of the delthyrium by the deposition of a small crescent of shell material. It grows anteriorly by addition of shelly matter of varying thickness at the anterior edge, producing a rugose, flatly convex upper surface. It is held in place by insertion into a shallow longitudinal groove along the mesial side of each hinge tooth or dental ridge. When the pseudodeltidium is about 0.5 mm long a pair of deltidial plates begins to grow at its edges, one on each side. These insert into shallow grooves, between the edges of the interarea and the traces of growth of the hinge teeth, just lateral to the edges of the delthyrium. The deltidial plates converge dorsally, but are widely disjunct, forming small semiellipses that wedge out posteriorly and anteriorly.

The pseudodeltidium and deltidial plates are well preserved on a few specimens. On many they are incomplete, showing evidence of having been broken. They are completely absent from many specimens. On some there is evidence in the grooves along the edges of the delthyrium that they once were present, whereas on others there is no such evidence. There are two classes of shells in which there is no evidence of their presence. The first is juveniles: we have not seen any trace of these plates on specimens shorter than 8 mm. Normally the plate begins when the shell has attained a length between 8 and 15 mm. The second group in which the pseudodeltidium is lacking includes the lighter shells in which the pedicle valve is only slightly thickened and the apical callosity poorly developed. No species has been found in which all specimens are lightly constructed and the pseudodeltidium absent; lighter specimens occur in several species, as individual variants.

We consider it likely that growth of the pseudo-

deltidium and deltidial plates reflected the size and function of the pedicle at different stages in the life of the individual animal. In juveniles shorter than 8–15 mm the proportionate size of the pedicle opening is greater than at any subsequent stage of growth. In them the apical callosity is rudimentary, and the delthyrium nearly entirely open. As the apical callosity grew, the pedicle opening became constricted, at the same time the shell was becoming larger and the pedicle valve normally much heavier by thickening along the hinge and the beak area. The pseudodeltidium probably grew to cover and protect the apical portion that no longer was occupied by the pedicle, and was therefore left otherwise exposed as the apical callosity pushed the pedicle forward, accompanying its retardation in growth. We believe that at some stage in life most of the normally thickened individuals released their peduncular attachment to the substrate and lay free in the floor of the sea. Those in which thickening did not take place remained attached by the pedicle. In them the pedicle opening is proportionately much larger and the weight that the pedicle supported, considerably less. Most of the thickened shells have only part of the delthyrium covered by the pseudodeltidium, leaving a small opening to accommodate the beak of the brachial valve as the shell opened, and probably also the remainder of the somewhat atrophied pedicle.

We have one complete shell in which the delthyrium is entirely closed by the pseudodeltidium which has grown tightly against the brachial beak. Obviously the pedicle had become nonfunctional in this shell, so that it could be shed, entirely, but this points to the likelihood that it became useless in other individuals as well, after they broke loose from their moorings and lay on the sea floor. Also, it may indicate that the rugosity and rather platy construction of the pseudodeltidium was for the purpose of providing it with slight mobility. Unless the pseudodeltidium of the shell in which the delthyrium is entirely closed was a little flexible, the valves could not have opened. Unless the valves were able to open, the animal could not have remained alive to continue adding shell material to the anterior of the pseudodeltidium, therefore it cannot be argued that this individual was killed by its own structural inability to open the valves.

The great thickening of the posterior part of the pedicle valve provides a center of gravity so that

an unattached shell lies on its pedicle valve with the anterior slanting obliquely upward. This position would keep a shell that is on the sea floor in the optimum position for unobstructed opening of the valves. If these free lying shells were disturbed by currents, they would regain their positions on the pedicle valves as they settled. When they died, however, the brachial valves were detached and swept away, and the pedicle valves concentrated into heaps, with much breakage of the marginal, fragile, unthickened portions. This is just the way they are found, in pockets where broken thick pedicle valves abound but complete shells, brachial valves, and unthickened pedicle valves are rare.

One might expect that shells lying on the sea floor would show some evidence of abrasion. We consider this unlikely. Shells that live in crowded conditions, perhaps attached by short pedicles, might be unable to avoid abrading their neighbors. But shells that lay on the sea floor, without attachment for the currents to bear against, would be gently moved by the currents and would be loosely packed if they fell together in heaps. These would not develop flat places from repeated abrasion of one spot. Most specimens of *Spiriferella* are bilaterally symmetrical and undistorted except by breakage, indicating that they did not live crowded together. Most likely they needed an unusually thick or tough periostracum to provide against diffuse abrasion by sand particles or shell fragments. Perhaps the pustules that cover the surface of the shell, arranged in rows corresponding to growth lines, were related in life to a thick periostracum, possibly providing its anchorage and determining its thickness.

DISTRIBUTION.—Species of *Spiriferella* appear to have been rather strongly isolated during life. Each locality has its own distinct species, and only rarely is there mixing. The shells became attached to the substrate fairly early in life, judging from the large pedicle opening in the smallest shells, but it is unknown how soon the larvae settled. Adults probably became detached from their moorings and settled to the sea floor (see discussion of pseudodeltidium). One might expect that the free-living adults could have achieved fairly wide distribution and consequent mixing of both genotypes and phenotypes, but this does not seem to have happened.

Two species are mixed in the sample from USNM

706b, although the more abundant species there (*S. gravis*, new species), makes up 95 percent of the sample. The preservation of the shells indicates that the assemblage is a thanatocoenose, which might mean that a few shells drifted in from the habitat of a species that lived contemporaneously or nearby. However, possibly the larvae did the drifting, and the two species lived together, the displaced few from another locality managing to survive where they settled. At USNM 715i also there are shells from two species, but with a great difference in the preservation of the two kinds of shells. The dominant species is *S. clypeata*, new species, of which several are complete shells, and although the single valves have undergone only surface silicification, and therefore are rather fragile, they are not badly broken. A few thick, heavy, completely silicified shells of *S. gravis*, new species, on the other hand, are rounded nearly to pebble shapes. *S. gravis* normally occurs at a slightly lower horizon, and probably a patch of dead shells of that species was excavated by currents and a few deposited along with locally growing *S. clypeata*, new species.

Spiriferella calcarata, new species

PLATE 626: FIGURES 21–36

Average size for genus, biconvex; outline elongate subovate, widest at hinge or anterior to midlength; hinge weakly to strongly auriculate, terminating in sharp points in some specimens; commissure uniplicate, gently plicated laterally; fold low, rather sharply arched, producing shallow notch at anterior midline; fastigium low, barely standing above flanks, bisected by shallow median groove between primary costae; sulcus fairly deep, with median trough V-shaped in cross section, extending forward as short tongue into notch of fold. Costae strong, broadly rounded, beginning at beaks, each normally bifurcating asymmetrically, once on each side, producing fascicles of three, each fascicle making low plication of shell; costae numbering 6–10 per side on submature or mature shells, excluding fastigium or sulcus, numbering 4–6 on fastigium and sulcus. Surface densely to rather sparsely covered with small pustules roughly arranged in rows along growth lines; fine radial ornament normally preserved only in troughs be-

tween costae near beaks; growth lines fine, crowded; growth laminae stronger, sporadic, more frequent toward margins.

Pedicle valve rather strongly convex transversely and longitudinally, beak short to moderately long, fairly strongly hooked near end; interarea moderately high, concave, rapidly widening anteriorly to produce auricularia, anterior edge with numerous small denticles pointing forward; delthyrium high, narrowly wedge-shaped, apical portion in some broken specimens covered by small incipient pseudodeltidium, other specimens with it somewhat better developed, only complete shells with it well developed, these also with rather large, disjunct deltidial plates. Brachial valve flatly to moderately convex; outline elongate to transversely semielliptical; beak short, blunt; interarea low, wide, slightly concave; notothyrium broadly wedge-shaped, apex with strong, finely lamellate cardinal callosity.

Pedicle valve interior with strong, knoblike hinge teeth; dental ridges deep, slightly convergent toward midline; dental plates short, continuous with dental ridges, slightly divergent, meeting floor on each side of muscle area; posterior of valve moderately to greatly thickened, partly or completely filling umbonal cavities and burying dental plates; apical callosity fairly well developed, encroaching on muscle area by forward growth. Muscle area elongate subovate to subcircular, bisected by low median ridge; adductor marks elongate, longitudinally striate, lying along each side of median ridge, diductor marks larger, lying lateral, also longitudinally striate; floor of thickened part of valve with few shallow pits in radiating rows, coalescing to form shallow pallial striae, fading considerably behind margins.

Brachial valve interior with large, thick-walled hinge sockets, partly roofed by thin plates. Helicophores growing from socket ridges, beginning thin, broad, narrowing anteriorly, somewhat flexed and outwardly bowed, attaching to spiralia by flat lateral joint; spiralia ribbonlike, coiled dorsoventrally in elliptical loops becoming smaller and more circular laterally; short ventrally pointing jugal processes bearing small, flat frondlike plate with serrated edges, both growing toward midline of valve, but not meeting to fuse. Muscle area elongate spatulate; median adductor marks elongate, lying one on each side of low median ridge;

smaller, lateral adductor marks shorter, lying in posterolateral part of area.

MEASUREMENTS (in mm).—

	brachial				
	length	valve length	width	hinge width	thickness
USNM 706e					
152948a	3.0	2.8	3.0	1.7	2.0
152948b	3.9	3.5?	4.1	2.4	?
152948c	5.0	4.3?	5.0	3.0	?
152948d	7.6	6.8	7.8	3.9	5.6
152948e	9.0	7.5?	9.6	5.8	?
152948f	12.4	9.8?	12.8	7.1	?
152948g	15.5	11.7?	15.3	13.0	?
152948h	17.7	14.3	17.2	11.3	11.6
152948i	18.0	14.3?	17.9	13.4	?
152948j	18.4	14.0?	18.7	14.0	?
152948k	22.0	16.4?	21.0	16.4	?
152948l	22.4	16.4?	22.1	19.9	?
152948m	22.9	16.4?	22.2	20.9	?
152948n	25.0	19.5?	23.0?	24.0	?
152948o	27.5	22.0	27.9	22.7	21.0?
152948p	30.0	22.5?	27.0	23.7	?
152948q	42.5	31.0?	41.8	26.2	26.0?
152948s	29.5	23.0	27.0	20.5	14.5
(holotype)					
USNM 706					
152949	?	38.3	46.4	38.0	15.6

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank and Willis Ranch members); Cherry Canyon Formation (Getaway Member).

LOCALITIES.—China Tank: USNM 706c, 706z. Willis Ranch: AMNH 505; USNM 706, 706e, 724u. Getaway: AMNH 600.

DIAGNOSIS.—Large *Spiriferella* with moderately thickened pedicle valve and wide auriculate hinge.

TYPES.—Holotype: USNM 152948s. Figured paratypes: USNM 152948j, l, m, q, r, t, u, v. Measured paratypes: USNM 152948a-q, 152949.

COMPARISON.—*Spiriferella calcarata* is characterized by its somewhat elongate outline, moderately thickened pedicle valve, normally wide hinge with auriculate ends, and its rapidly widening interarea that is tapered at the sides in all but the largest specimens, and in them, truncated. Most specimens are preserved by a thin surface silicification which leaves them very fragile, especially in the thickened part of the pedicle interior. Many of these valves have the posterior inner floor broken or missing, but enough is present on a sufficient number of specimens to show the amount of thickening and the configuration of the dental plates and the muscle marks. This species most nearly resembles

S. gravis, new species; some of the largest and oldest shells are not easy to distinguish. Youthful shells and normal mature adults differ from *S. gravis* in their more auriculate hinges, laterally more tapered interareas, shorter pedicle beaks, and less elongate outlines. When the shell reaches a certain maturity, apparently the hinge ceases to become wider, but the interarea continues to grow anteriorly. This produces the truncate hinge ends that are so characteristic of *S. gravis*, and also reduces the width of the hinge relative to the length and width of the rest of the shell. These large shells can be distinguished from *S. gravis* primarily by their shorter pedicle beaks. The short beak and the rapid anterior expansion of the interarea puts the beginning of the truncate part of the interarea much closer to the apex of the beak in *S. calcarata* than in *S. gravis*.

Spiriferella calcarata is distinguished from *S. embrithes*, new species, by its more elongate outline, less thickened pedicle valve, and smaller average size. It differs from *S. clypeata*, new species, also in its smaller size and narrower outline, and in its somewhat higher and sharper costae. Both of these have the pseudodeltidium well developed and strong enough to be preserved on single pedicle valves, whereas in *S. calcarata* it is well preserved only on complete shells, and only remnants are present in single valves, either in the apex or along the sides of the delthyrium. This species also is similar in some features to *S. levis*, new species, but differs in its normally more thickened pedicle valve, more elongate outline, stronger auriculation, and larger average and maximum size.

Spiriferella sulcifer (Shumard) is smaller and thinner shelled than *S. calcarata* and *S. propria*, new species, is longer, not as auriculate, and has a more attenuate, hooked beak. Comparable foreign species can be compared on the same basis as with *S. gravis*.

Spiriferella clypeata, new species

PLATE 627: FIGURES 1–22; PLATE 628: FIGURE 37

Spirifer (*Elivina*) *sulcifer* R. E. King [not Shumard], 1931: 118, pl. 39: figs. 6a–c; pl. 40: figs. 2a–b, 3 (?) 5a,b [not figs. 1 and 4].

Average to large for genus, biconvex; outline elongate subovate to transversely subelliptical, normally

widest slightly anterior to midlength; hinge normally somewhat auriculate, with ends truncate; commissure uniplicate, gently plicated laterally; fold low, gently arched, producing slight emargination of anterior; fastigium low, barely standing above flanks; sulcus deep, beginning at pedicle beak, deepening anteriorly, with rather broad, U-shaped median trough rarely with median costa. Costae strong, broad, rounded, beginning at beaks, bifurcating asymmetrically 10–15 mm anterior to beaks, producing fascicles of three, normally without further bifurcation, numbering 6–9 on each side exclusive of sulcus and fastigium, normally about 6 in sulcus and fastigium, with median groove between primary costae of fastigium. Surface covered with small pustules, roughly following growth lines; fine radial ornament in troughs between costae, strongest near beaks; growth lines fine, closely spaced; growth laminae stronger, widely spaced, becoming crowded and stronger near margins. Pustules fine, widely spaced.

Pedicle valve moderately to strongly convex; beak prominent, normally strongly hooked; interarea moderately high, concave, narrow at beak, rapidly widening, anterior edge with numerous small, anteriorly pointing denticles; delthyrium high, apical half covered by flatly convex to concave, rugose pseudodeltidium with lateral projections running forward along sides nearly to anterior limit. Brachial valve flatly convex except near beak, there rather strongly convex; outline transversely to longitudinally subelliptical; beak short, blunt; interarea low, slightly concave; notothyrium broadly wedge-shaped, bound laterally by socket ridges, apex with thick, lamellate cardinal callosity.

Pedicle valve interior with strong, knoblike hinge teeth diverging anteriorly; dental ridges with mesial sides somewhat concave for reception of edges of pseudodeltidium, slightly convergent toward valve floor; dental plates short, divergent, reaching valve floor at edges of muscle area, normally partly buried by thickening of posterior part of valve, mesial sides partly buried by apical callosity. Muscle area elongate ovate, bisected by thin, low median ridge, posterior progressively covered by forward growth of apical callosity; adductor muscle marks narrow, elongate, median; diductor muscle marks larger, semioval, longitudinally to irregularly radially striate, surrounding adductor marks laterally and anteriorly. Posterior part of valve

greatly thickened, partly or completely filling umbonal cavities; floor of thickened portion marked by shallow, elongate pits in irregularly radiating rows, becoming shallower and coalescing anteriorly into pallial striae, fading toward margins.

Brachial valve interior with widely divergent, thick-walled hinge sockets, partly roofed in thin, short plate. Helicophores attached to socket ridges, beginning thin and broad, becoming narrower and somewhat thicker anteriorly, outwardly bowed and dorsally flexed; spiralia attached by flat lateral joint, coiling dorsoventrally; jugal processes pointing ventrally, ends spread into small maniculiform plates with serrate edges, converging toward one another but not meeting to fuse. Muscle area elongate, anteriorly widening; two adductor muscle marks along midline, occupying most of muscle area, two small lateral adductor marks at posterior lateral flanks of area, diverging slightly toward anterior, extending about a fourth length of area; floor of valve outside muscle area unmarked except by costae.

MEASUREMENTS (in mm).—

	brachial valve			hinge	thick- ness
	length	length	width	width	
USNM 715i					
152950a	2.9	2.2?	2.8	2.2	?
152950b	3.6	2.9?	3.5	2.2	?
152950c	4.2	3.6?	4.8	2.8	?
152950d	6.6	5.5	6.2	4.5	4.8
152950e	8.8	6.7?	8.8	5.0	?
152950f	10.0	7.9?	11.5	8.0	?
152950g	13.3	10.4?	15.4	9.5	?
152950h	17.5	14.1?	19.7	17.0	?
152950i	26.0	22.8	28.3	23.9	16.0?
152950j	30.0	24.6	32.0	31.3	16.3
152950k	33.3	25.3	35.0	26.5	?
152950-l	41.0?	34.2	42.2	32.5	24.4
152950m	41.0	32.0	38.6	27.0	22.0?
152950n	41.5	33.0	34.6	25.2	28.6
152950o	48.6	39.0	46.0	29.3	22.0?
(holotype)					
YPM 12414	51.7	37.1	47.8	33.7	24.0+

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member and lenses below it).

LOCALITIES.—Appel Ranch: USNM 715i, 719z, 722t, 727j, 731z. Lenses: 732c, 742b.

DIAGNOSIS.—Large, transverse, auriculate *Spiriferella* with broad, low costae.

TYPES.—Holotype: USNM 152950o. Figured par-

atypes: USNM 152950d,m,n, p-t; 154551a; 154552a. Measured paratypes: USNM 152950a-n. Unfigured paratypes: USNM 152950a-c,e-l; 154551 (many).

COMPARISON.—*Spiriferella clypeata* is characterized by its relatively large size, normally transverse outline, auriculate hinge, low lateral extremities of interarea, low, broad costae, convex pedicle valve, and its dental plates that normally are short, but nonetheless long enough not to be completely buried by thickening of the posterior part of the pedicle valve. It differs from *S. embrithes*, new species, in its greater convexity, its lower, laterally more tapered interarea, shorter auriculations, smaller and more widely spaced pustules, stronger growth laminae, and its more exposed dental plates. It is distinguished from *S. gravis*, new species, by its more transverse outline, lower and more auriculate interarea, and weaker costae. It is larger, more transverse, and more definitely fascicostate than *S. sulcifer* (Shumard). It is more convex, normally wider, and has broader costae than *S. propria*, new species, and its beak is blunter and not as strongly hooked nor as attenuate.

Some specimens of *S. clypeata* resemble specimens in the National Museum collection from the Permian of Timor that have been identified as *S. rajah* (Salter). *Spiriferella clypeata* is smaller, more auriculate, has lower and broader costae, and lacks the sharp median costa of the fold which characterizes *S. rajah*. It differs from Davidson's (1866) specimens of *S. rajah* from Kashmir in its wider outline, fewer and lower costae, and also by lack of the median costa of the sulcus. *Spiriferella clypeata* is wider and more auriculate than foreign species that are closely related to *S. saranae* (Verneuil). Its broad outline and well-developed pustules are similar to those features in *S. keilhavii* (von Buch), as identified by Dunbar (1955) from the Permian of Greenland. However *S. clypeata* differs in its more auriculate hinge, broader and less distinct costae, normally more deeply grooved sulcus, without median costa or costae, and its more attenuate pedicle beak. There seems to be nearly the same range in variation of outline in the two species. The species identified as *S. keilhavii* by Tschernyschew and Stepanov (1916) from Spitzbergen is narrower than *S. clypeata*, and has narrower, sharper costae, a median costa in the sulcus, and less auriculate hinge. The one identified as *S. keilhavii* by Tschernyschew (1902) has a trans-

verse outline, but differs in its sharp costae and especially in its wide sulcus with many costae.

Spiriferella embrithes, new species

PLATE 628: FIGURES 1-19

Average size for genus, biconvex; outline subquadrate, length and width nearly equal, widest at hinge normally auriculate, with truncated ends; commissure gently uniplicate, moderately plicated laterally; fold low, bluntly peaked to gently arched transversely, producing slight emargination at anterior of some shells; fastigium low, standing little or not at all above flanks, bisected by shallow narrow median groove between two primary costae; sulcus moderately deep, with shallow median trough, no median costa, extending from apex of beak to notch of fold. Costae fairly strong, blunt crested, beginning at beaks, bifurcating asymmetrically about 10-15 mm anterior to beaks, producing fascicles of three, each fascicle forming low plication of shell, number of costae 6-16 on each side of neanic to mature shells, (exclusive of sulcus or fastigium) fewer on juveniles, 4-8 in sulcus, 2 primary costae on fastigium, each branching laterally once, each branch also branching laterally in larger shells. Surface densely covered by tiny rounded pustules, roughly following growth lines; fine radial ornamentation rather weak, strongest in troughs between costae near beaks; growth lines closely crowded; growth laminae somewhat stronger, normally present near margins of large shells.

Pedicle valve moderately convex longitudinally and transversely, beak relatively short, strongly hooked, terminating in blunt point; interarea rather low, height only gradually decreasing toward sides, slightly concave, pentagonal, with sides auriculate, truncated, anterior edge with numerous small denticles; delthyrium narrowly wedge-shaped, apical half covered by flatly arched pseudodeltidium with lateral projections running to anterior edges of delthyrium. Brachial valve transversely semicircular to semielliptical, moderately to flatly convex; beak blunt, projecting slightly; interarea low, slightly concave; notothyrium broadly wedge-shaped bounded laterally by socket ridges, apex with flat to knoblike cardinal callosity, deeply lamellate for attachment of diductor muscles.

Pedicle valve interior with strong divergent hinge

teeth; dental ridges thick, slightly convergent toward floor of valve, with shallow groove for reception of pseudodeltidium; dental plates divergent, short, meeting floor at sides of muscle area, partly or completely buried by thickening of valve and by apical callosity in all but youngest specimens. Muscle area elongate subovate, bisected by low median ridge, apical part progressively covered by forward growth of apical callosity; adductor muscle marks elongate, median, surrounded by larger, wider diductor marks all lightly striated longitudinally. Posterior part of valve greatly thickened, leaving muscle area deeply excavated; floor of thickened part of valve marked by shallow elongate pits arranged in radial pattern, coalescing anteriorly to form shallow pallial striae, fading toward margins.

Brachial valve interior with widely divergent, thick-walled hinge sockets, apical part roofed by thin plate. Helicophores beginning as thin plates attached to socket ridges, becoming thicker, narrower anteriorly, attached to spiralia by flat lateral joints; spiralia coiled dorsoventrally in elliptical loops; short jugal processes at ends of spiralia, near junction with helicophores, each spreading into maniculiform plate, converging toward one another, meeting at midline of large specimens but not fusing. Muscle area faintly impressed, elongate, anteriorly widening, bisected by internal crest of median trough of fastigium; adductor muscle marks faintly striated longitudinally. Floor of posterior faintly pitted, pits fading anteriorly.

MEASUREMENTS (in mm).—

	brachial		hinge	thick-
	length	valve length	width	ness
USNM 706c				
152951a	6.4	4.9	5.7	3.0 ?
152951b	?	8.4	9.8	8.6 ?
152951c	9.1	8.0	11.1	9.2 6.8
152951d	13.0?	10.0	13.4	11.7 ?
152951e	16.6	11.4	13.5	10.0 10.0
152951f	20.0?	17.0?	24.0	26.5 ?
152951g	27.8	21.0	27.0	24.2 17.7
152951h	29.3	21.4	28.5	25.0? 18.8
152951i	31.0?	23.0?	33.6	30.3 ?
152951j	39.8	30.4	42.4	43.4 21.0
(holotype)				

STRATIGRAPHIC OCCURRENCE.—Word Formation (China Tank Member).

LOCALITIES.—USNM 706c, 726s.

DIAGNOSIS.—Subquadrate, large *Spiriferella* with

short beak, greatly thickened pedicle valve, low costae, and small pustules.

TYPES.—Holotype: USNM 152951j. Figured paratypes USNM 152951d,g,h,j,k. Measured paratypes: USNM 152951a-i.

COMPARISON.—*Spiriferella embrithes* is characterized by its transverse, subquadrate outline, greatly thickened pedicle valve with relatively short beak, low but wide interarea, auriculate and abruptly truncate hinge ends, rather low costae, and small surface pustules. It differs from *S. gravis*, new species, which also has a heavy pedicle valve, in its greater width, proportionately less thickness and convexity, much wider and somewhat lower, more auriculate interarea, shorter pedicle beak, and smaller pustules. It differs from *S. clypeata*, new species, also thickened in the pedicle valve, by its less convex pedicle valve, wider outline, wider interarea which remains higher toward the sides (although its maximum height is about the same), its more auriculate hinge, weaker growth laminae, and larger surface pustules. *Spiriferella calcarata*, new species, is normally smaller than *S. embrithes*, and its outline is narrower, hinge ends more strongly auriculate and sharply pointed, interarea proportionately lower, and its pedicle valve is not as greatly thickened.

The only foreign species that is similar enough to *S. embrithes* to warrant detailed comparison is *S. keilhavii* (von Buch), from the Permian of Bear Island, Greenland (Dunbar, 1955), and the Urals (Tschernyschew, 1902). *Spiriferella embrithes* is smaller, less convex, has a more definitely pentagonal interarea with truncated ends, auriculate hinge ends, thicker pedicle valve, its pedicle muscle area is shorter and not as attenuate at the anterior midline, and instead of a median costa in the sulcus, it has only a trough.

Spiriferella gloverae, new species

PLATE 629: FIGURES 1-21

Average size for genus, biconvex; outline elongate subovate, widest anterior to midlength, hinge nonauriculate to slightly auriculate; commissure uniplicate, fold low, lateral plications gentle; fastigium barely standing above flanks; sulcus deeper, gently rounded trough extending anteriorly into shallow notch of fold. Costae low, gently

rounded, beginning at beaks, each normally bifurcating asymmetrically on each side, producing fascicles of three, each fascicle a low plication of shell; costae numbering 6-10 on each side lateral to fold or sulcus, 2-4 on fastigium or in sulcus, no median costa in sulcus, moderately deep, narrow median groove along fastigium. Surface somewhat sparsely covered by small sharp pustules arranged along growth lines; fine radial ornament in troughs between costae, normally strongest near beaks; growth lines fine, closely spaced; growth laminae stronger, more widely spaced, more crowded and stronger toward margins.

Pedicle valve moderately convex; beak rather short, slightly hooked; interarea high, narrow, slightly concave, anterior edge normally somewhat thickened, burying anteriorly pointing denticles; delthyrium high, narrow, apex with short rudimentary pseudodeltidium in some specimens, lacking it in most. Brachial valve moderately strongly convex; outline shield-shaped; beak short, blunt; interarea low, slightly concave; notothyrium broadly wedge-shaped, apex with small, finely lamellate cardinal callosity.

Pedicle valve interior with short, blunt, divergent hinge teeth; dental ridges concave, convergent toward midline of valve, meeting at apex of delthyrium; dental plates short, diverging to meet floor on each side of muscle area, extending short distance forward along floor in some specimens, partly buried by callus in few specimens. Muscle area elongate subovate, bisected by relatively strong median ridge; adductor muscle marks elongate, narrow, lying adjacent to median ridge, one on each side; diductor muscle marks larger, semiovate, rather deeply striated longitudinally, lateral to adductors. Posterior part of some valves thickened, floor with small, deep pits roughly arranged in radiating rows, fading toward margins, lacking in unthickened valves.

Brachial valve interior with thick-walled, anteriorly divergent hinge sockets, partly roofed by thin plates. Helicophores attached to socket ridges, extending anteriorly and dorsally, slightly converging; full course of helicophores and spiralia not observed. Muscle area narrow, elongate, tear-shaped, with two long median adductor muscle marks widening anteriorly, filling main part of area, two small, short adductor marks flanking posterior part

of area, all faintly impressed, faintly striated longitudinally.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 728					
152952a	5.5	4.2?	5.9	4.0	?
152952b	6.6	5.3?	6.2	4.1	?
152952c	7.2	6.0	6.9	4.6	4.9
152952d	7.8	6.1?	7.4	6.2	?
152952e	8.2	6.0?	6.8	5.4	?
152952f	9.0	7.0?	9.5	7.5	?
152952g	9.5	7.6?	9.2	8.7	?
152952h	10.0	8.1?	10.1	6.9	?
152952i	10.2	c.8.5	11.2	8.0	?
152952j	13.0	11.8	13.0	8.4	9.7
152952k	14.0	11.5?	13.0	9.2	?
152952l	15.0	12.0?	14.3	10.0	?
152952m	21.4	17.0?	20.9	15.6	?
152952n	19.6	13.0?	16.0	10.6	?
152952o	22.5	18.5?	19.5?	13.9	?
152952p	24.0	19.5?	22.1	15.3	?
152952q	?	21.0	23.2	17.5	?
152952r	32.4	?	26.3	20.5	?
152952x	41.5	33.5	35.0	24.0	32.5
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—AMNH 512, 600; USNM 728.

DIAGNOSIS.—Long, slender *Spiriferella* of medium size with low costae, widely spaced pustules, and a median ridge in pedicle valve.

TYPES.—Holotype: USNM 152952x. Figured paratypes: USNM 152952q-w. Measured paratypes: USNM 152952a-r.

COMPARISON.—*Spiriferella gloverae* is characterized by its relatively thin and normally somewhat small shell, widest anterior to the midlength and without auriculate hinge ends, its low costae, rather widely spaced surface pustules, short dental plates, its rather high median ridge in the pedicle valve. It most nearly resembles *S. sulcifer* (Shumard) in its small size and thin shell, but differs in its narrower outline without auriculate hinge, longer but less hooked beak, less frequent thickening of the pedicle valve, and its higher median ridge. Its somewhat elongate outline recalls that of *S. gravis*, new species, but *S. gloverae* is much smaller, thinner-shelled, with shorter beak, higher median pedicle ridge, normally shorter beak, and more triangular than pentagonal interarea.

Named for Mrs. Walter Glover of Pine Spring Camp, under the shadow of Guadalupe Peak, who housed and fed our several parties.

Spiriferella gravis, new species

PLATE 630: FIGURES 1-40

Spirifer (Elivina) sulcifer [part] R. E. King [not Shumard], 1931:118, pl. 40: fig. 4 [not figs. 1-3,5].

Small to about average size for genus, biconvex; outline elongate, subovate, normally widest anterior to midlength, some widest at hinge; hinge auriculate, normally abruptly truncated at ends; commissure uniplicate, moderately plicated laterally; fold low to moderately high, gently to sharply arched, normally producing shallow notch in anterior margin; fastigium low, normally producing little or no change in transverse convexity of brachial valve, with sharp median trough; sulcus rather deep, normally sharply troughed, with no median costa, extending forward as short tongue filling notch of fold. Costae distinct, rather broadly rounded, beginning at beaks, each one normally branching asymmetrically on both sides, producing fascicles of three, numbering 6-15 on each side of neanic to mature shell (exclusive of fastigium or sulcus), fewer in juveniles, normally an even number (4-10) in sulcus; 2 primary costae on fastigium, beginning at beaks, with sharp trough between, each bifurcating laterally once, each branch also bifurcating once on largest shells, producing maximum of 6 costae on fastigium. Surface densely covered by small sharp pustules arranged in wavy lines more or less corresponding with growth lines; fine radial ornamentation weak, rarely visible; growth lines fine, closely crowded; growth laminae stronger, irregularly spaced, more frequent and stronger near margins.

Pedicle valve elongate, moderately convex longitudinally, somewhat more convex transversely; beak prominent, thick, moderately to strongly curved, terminating in blunt point; interarea high, moderately concave, normally subpentagonal, with abruptly truncated aurications, approaching triangularity in some specimens, anterior edge with numerous denticles; delthyrium elongate, covered about half of length by flatly convex pseudodeltidium with forward projecting lateral extensions running along edges of delthyrium. Brachial valve

also longer than wide, but more nearly circular, moderately to flatly convex transversely and longitudinally, beak somewhat swollen, apex bluntly rounded; interarea low, wide, slightly concave; notothyrium broadly wedge-shaped, bounded by socket ridges, apex occupied by small to rather large, single or bilobed cardinal callosity finely lamellate longitudinally for attachment of diductor muscles.

Pedicle valve interior with short, blunt, hinge teeth, supported by deep, rather thick dental ridges; dental plates short, continuous with dental ridges only near apex of valve, diverging toward floor of valve, there continuing for short distance forward along sides of muscle area; dental plates and ridges partly or completely buried, laterally by thickening of posterior part of valve, medially by large apical callosity. Muscle area elongate subovate, bisected by low median ridge, posterior part covered in some specimens by anterior growth of apical callosity, in most specimens muscle field deeply excavated into shell thickening; adductor muscle marks elongate, narrow, one on each side of median ridge, longitudinally striate; diductor muscle marks larger, lying lateral, semiovate, each striated longitudinally or slightly radially. Floor of thickened part with moderately deep to shallow elongate pits arranged in irregularly radial rows, becoming shallower anteriorly, coalescing into light striations, fading toward margins.

Brachial valve interior with widely divergent, thick-walled hinge sockets, apical part roofed by thin plate. Helicophores attached to socket ridges, thin, wide, rapidly narrowing and slightly thickening anteriorly, outwardly bowed, slightly flexed, attaching to ends of spiralia by flat lateral joint; spiralia ribbonlike, coiled dorsoventrally in large, rather eye-shaped loops, becoming smaller and more elliptical laterally, ending as small circles; small, ventrally pointing jugal processes near junction with helicophores, end of each spreading into small handlike plate with serrate or digitate edges, converging toward one another, not seen to meet but probably meeting in large specimens. Muscle area weakly impressed, elongate, anteriorly widening, bisected by low median ridge partly formed by crest of external median trough; adductor muscle marks elongate, median, with one small sublobe on each side at posterior just below cardinal callosity. Posterior part of valve slightly thickened in largest

specimens; floor faintly marked by shallow pits or striae, fading toward margins.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 706b					
152953a	3.0	2.7	2.0	3.2	2.4
152953b	3.8	3.6	2.5	3.9	3.1
152953c	4.9	4.8	2.8	5.6	3.2
152953d	6.3	5.3	3.5	6.5	4.5
152953e	8.7	7.7	4.7	9.1	6.0
152953f	9.0	8.0	5.6	9.9	5.8
152953g	10.8	8.5	5.8	10.0	6.4
152953h	11.6	9.0	6.5	11.0	7.5
152953i	13.8	10.6	8.0	13.4	8.2
152953j	19.5	14.5	11.0	16.4	11.4
152953k	20.0	14.0	13.0	17.9	11.3
152953l	20.5	14.6	12.4	16.6	11.9
152953m	23.8	17.6	14.3	20.5	14.0
152953n	24.6	17.8	14.0	20.7	14.9
152953o	25.8	19.7	16.9	22.2	15.2
152953p	26.9	18.0	13.2	21.0	16.4
152953q	29.0	20.4	20.0	23.3	16.6
152953r	20.6	22.3	15.0	23.7	17.7
(holotype)					
152953s	33.6	23.3	17.8	25.5	18.6
152953t	33.7	?	20.1	30.0?	?
152953u	35.6	?	19.0	31.3	?
152953v	45.0?	?	27.5	37.8	?
152953w	47.0?	?	24.7	39.0	?
152953x	48.0?	?	32.0?	46.0	?

STRATIGRAPHIC OCCURRENCE.—Word Formation (Willis Ranch Member, Appel Ranch Member, and lenses between the two).

LOCALITIES.—Willis Ranch: USNM 706e. Lenses: USNM 706b, 723t, 735c. Appel Ranch: USNM 715i.

DIAGNOSIS.—Long, slender *Spiriferella*, anteriorly notched, strongly pustulose, coarsely costate, and with very thick pedicle valves.

TYPES.—Holotype: USNM 152953r. Figured paratypes: USNM 152953g,k,m,s,y,z,a'-g'. Measured paratypes: USNM 152953a-q, s-x. Figured specimen: YPM 12414.

COMPARISON.—*Spiriferella gravis* is characterized by its elongate shell with prominent beak, normally thickened pedicle valve but unthickened brachial valve, auriculate hinge with truncated ends producing pentagonal interarea, and its normally dense pustulation and rather coarse costation. It differs from *S. clypeata*, new species, which occurs somewhat higher in the Word Formation, in its smaller

average and maximum size, elongate rather than subcircular outline, thicker pedicle valve, shorter dental plates which normally are buried by shell thickening, and its somewhat larger pustules and notably stronger costae. It is distinguished from *S. sulcifer* (Shumard) from the Capitan and Bell Canyon formations by its larger size, more elongate, less quadrate outline, less widely diverging costae, especially on the brachial valve, normally truncated rather than rounded hinge ends, denser and larger pustules, and its weaker, rarely preserved radial striae.

Among foreign species it most nearly resembles the type species of the genus, *S. saranae* (Verneuil, 1845) which Tschernyschew (1902:526) reports from the *Schwagerina* and *Productus cora* beds of the Urals and Timan. *Spiriferella gravis* differs in its more strongly fasciculate costae, less strongly hooked pedicle beak, broader shallower sulcus, shorter and less convex pseudodeltidium, and its much stronger surface pustules. *Spiriferella salteri* Tschernyschew (1902) also is comparable, especially in its fasciculation, but *S. gravis* can be distinguished by its normally less complete pseudodeltidium and by the median trough in the sulcus, whereas *S. salteri* has a single costa. Unfortunately Tschernyschew did not obtain many unequivocal or undistorted brachial valves, so comparison of the important features of the fastigium and median groove cannot be made. We doubt that the brachial valve shown on Tschernyschew's (1902) plate 40: figure 7, belongs to a species of *Spiriferella*, because of its simple, non-fasciculate costae and absent median groove. Verneuil (1845, pl. 6: fig. 15b) illustrated part of the brachial valve on the broken holotype, and it clearly has the median costa divided at the brachial beak as in all other species of *Spiriferella*.

Spiriferella keilhavii (von Buch) is a rather well known species that, without doubt, belongs to *Spiriferella* (see especially Tschernyschew, 1902, pl. 40; Dunbar, 1955, pls. 25–26). Possibly the Russian specimens of Tschernyschew and the Greenland specimens of Dunbar are not conspecific, but they are similar enough to differ in the same features from the Texas species. *Spiriferella gravis* is narrower, has lower and less strongly fasciculate costae, thicker pedicle valve, and higher surface pustules that normally are more crowded. *Spiriferella rajah* (Salter) is much larger and

thicker than *S. gravis* and has a shorter beak with lower and much narrower interarea, its pseudodeltidium is less developed, and it has a median costa in the sulcus.

DISCUSSION.—Pedicle valves of *Spiriferella gravis* have been found in great abundance at USNM 706b, along with about 100 brachial valves and about 75 valves of *S. levis*. We believe that the two species most likely lived in separate assemblages, perhaps on separate bioherms or banks, or at different depths, and that currents swept together dead valves from each. The pedicle valves of *S. gravis* are much thicker and heavier than those of *S. levis*, but the brachial valves are light and thin. The currents that concentrated the valves in depressions or into heaps on the sea bottom probably segregated them according to their weight, with the lighter pedicle and brachial valves of *S. levis* and brachial valves of *S. gravis* being winnowed out and carried away, leaving nearly the same number of each at USNM 706b.

Spiriferella gravis has been found at several localities. The specimens at USNM 706e and 715i are badly worn, and even appear to be weathered. They occur with more numerous specimens of *S. calcarata* and *S. clypeata*, new species, and it is likely that the few *S. gravis* were transported a great distance, or may even have been buried and exhumed before being carried to these localities. Their broken extremities and spongy texture indicate that they were not buried while fresh.

Spiriferella levis, new species

PLATE 631: FIGURES 16–21

Small for genus, biconvex; outline transversely subelliptical, widest at midlength or at hinge, normally somewhat auriculate, hinge tips blunt; commissure uniplicate, laterally plicated; fold low, rather sharply arched, forming shallow notch at anterior; fastigium scarcely expressed on brachial valve bearing narrow groove along midline; sulcus fairly deep, broad, and wide, U-shaped median trough beginning at beak, extending forward into notch of fold, few broad costae on sides. Costae strong, round-crested, beginning at beaks, bifurcating asymmetrically once or twice on each side forming fascicles of 3–5, each fascicle plicating shell, total number of costae per side exclusive of fasti-

gium or sulcus 8–13 on submature to mature shells, normally 4–8 in fastigium and sulcus. Surface densely covered with low rounded to pointed pustules arranged in rows along lines of growth, fine radial ornament normally seen only in troughs between costae near beaks; growth lines fine, crowded; growth laminae strong, irregularly spaced, more frequent near margins.

Pedicle valve moderately strongly convex transversely and longitudinally; beak moderately long, fairly strongly hooked; interarea low to moderately high, rapidly widening anteriorly, concave, terminating laterally in blunt auricularia, anterior edge with numerous small anteriorly pointing denticles; delthyrium high, rather narrow, normally without laterally bounding grooves; pseudodeltidium normally not present, when present a rudimentary single layer of shell material in apex of delthyrium. Brachial valve flatly convex; outline semielliptical; beak short; interarea low, flatly concave, notothyrium broadly wedge-shaped, apex with strong, thick, finely lamellate cardinal callosity.

Pedicle valve interior with strong, blunt or knob-like hinge teeth; dental ridges forming deep grooves, nearly vertical to slightly convergent toward midline of valve; dental plates short, continuous with dental ridges, diverging slightly, meeting floor of valve on each side of muscle area; posterior of valve only slightly thickened; not filling umbonal chambers, leaving anterior part of dental plates free; apical callosity only slightly to moderately developed, normally not encroaching on muscle area nor covering inner sides of dental plates. Muscle area elongate to transverse, subovate, bisected by low median ridge; adductor muscle marks elongate, narrow, median, diductor muscle marks larger, lateral, longitudinally striated; posterior part of valve floor with shallow pits coalescing anteriorly to form shallow radial pallial canals, fading toward margins.

Brachial valve interior with strong, widely divergent, thick-walled hinge sockets, apical part roofed by thin plate. Helicophores growing from socket ridges, beginning thin, broad, narrowing to flattened rod-shape; spiralia, and maniculiform jugal processes not observed. Muscle area elongate, spatulate, bisected by low median ridge; elongate median adductor muscle marks faintly impressed, posterior flanking pair not observed.

MEASUREMENTS (in mm).—Pedicle valves only.

USNM 706b	length	brachial valve		hinge width
		length (est.)	midwidth	
152954a	4.1	3.4	4.0	2.8
152954b	5.4	4.2	5.7	3.9
152954c	6.3	5.0	6.6	3.9
152954d	7.4	6.3	8.1	3.8
152954e	9.5?	7.0	10.1	7.6
152954f	11.7	10.3	13.4	9.1
152954g	14.3	11.3	15.9	11.5
152954h	17.0?	12.3	16.8	12.0
152954i	17.0?	13.0	19.0	15.6
152954j	20.0?	14.0	20.0	19.4
152954k	23.8	16.9	24.2	16.6
(holotype)				
152954-l	25.0?	18.5	26.6	25.7
152954m	30.0?	23.0	30.0?	24.3

STRATIGRAPHIC OCCURRENCE.—Word Formation (lens between Willis Ranch and Appel Ranch members).

LOCALITY.—USNM 706b.

DIAGNOSIS.—Medium-sized, thin-shelled *Spiriferella* with poorly developed apical callosity and transverse outline.

TYPES.—Holotype: USNM 152954k. Figured paratypes: USNM 152954h,n. Measured paratypes: USNM 152954a-j,l,m.

COMPARISON.—*Spiriferella levis* is characterized by its transverse outline, auriculate hinge, rather short pedicle beak, unthickened or only slightly thickened pedicle valve, poorly developed apical callosity, and normal absence of a pseudodeltidium. It occurs with *S. gravis*, new species, differing in its wider outline, lighter shell, shorter pedicle beak, more auriculate hinge, broader median trough in the sulcus, laterally more tapered interarea, its small apical callosity, and normally absent, rarely rudimentary, pseudodeltidium. It resembles *S. embrithes* and *S. clypeata*, both new, in its transverse outline and auriculate hinge, but differs in its smaller size, lighter pedicle valve with dental plates normally exposed, more tapered interarea, and lack of a pseudodeltidium. It is somewhat larger, heavier, more convex, and lacks a pseudodeltidium. It is somewhat larger, heavier, more convex and more strongly costate than *S. sulcifer* (Shumard), and normally its hinge is not as extended. Its transverse outline and unthickened pedicle valve distinguish it from *S. propria* and *S. calcarata*, both new.

It is smaller than most of the well known

European and Asiatic species. It differs from *S. keilhavii* (von Buch) from Bear Island and Greenland (Dunbar, 1955) in its smaller size, less thickened pedicle valve, and proportionately larger and fewer costae.

DISCUSSION.—*Spiriferella levis* occurs at the same locality as *S. gravis*, although much less abundantly. This led us to consider the possibility that it might be a rare variant making up about 5 percent of the population of *S. gravis* at USNM 706b, or that it was a dimorph of that species. However, *S. levis* differs so markedly from *S. gravis*, in characters considered to be specific in other species, that we suggest another explanation of their occurrence together. We believe that *S. levis* probably lived apart from *S. gravis*, at a locality other than USNM 706b. As animals of the two species died, currents caught them and concentrated them into heaps or in depressions. The scarcity of brachial valves of both species, and the number of pedicle valves with broken or abraded edges are evidence that the shells are preserved in a death assemblage and have undergone some transportation and abrasion. The shells of *S. levis* are lighter, and probably more easily transported with somewhat less damage. Their scarcity may indicate that they were not abundant, or that their place of growth was farther from the place of deposition than was the place of growth of *S. gravis*; or that the currents were strong enough only to sweep away the light shells without removing the heavier ones.

Spiriferella propria, new species

PLATE 631: FIGURES 1-15

Average size for genus, strongly biconvex; outline elongate subquadrate to subovate; widest near midlength; hinge normally slightly auriculate with truncated tips, nearly as wide as widest part of shell; commissure uniplicate, with low arched fold making shallow notch at anterior; fastigium low, rarely expressed, with deep narrow median groove between two primary costae; sulcus shallow to moderately deep, rather narrow, bearing U-shaped median groove without costae, few broad costae on sides. Costae rather narrow, sharp, distinct, beginning at beaks, bifurcating asymmetrically on each side to form fascicles of three, each fascicle producing low plication of shell, numbering 6-9 costae

per side exclusive of fastigium and sulcus; 2 primary costae on fastigium, each bifurcating only laterally; up to 6 relatively low costae in sulcus. Surface sparsely to densely covered with small rounded pustules, arranged along growth lines, becoming higher and more crowded toward postero-lateral margins; fine radial ornamentation normally seen only in troughs between costae near beaks; concentric growth lines crowded, fine; growth laminae stronger, irregularly spaced, stronger and more closely crowded toward margins.

Pedicle valve moderately convex longitudinally, more strongly convex transversely; beak attenuate, strongly hooked, ending in sharp point; interarea high, rapidly widening anteriorly, strongly concave near apex, bluntly terminated at side; delthyrium high, narrow, wedge-shaped; pseudodeltidium not observed. Brachial valve rather strongly convex near beak, flatter farther forward; beak blunt, slightly projecting; interarea low, concave; notothyrium broadly wedge-shaped, bounded by walls of hinge sockets, apex with broad, flattish cardinal callosity, finely lamellate for attachment of diductor muscles.

Pedicle valve interior with hinge teeth stubby or knoblike; dental ridges deep, slightly converging toward floor; dental plates short, divergent, continuous with dental ridges, meeting floor on each side of muscle area; posterior part of valve unthickened or slightly thickened, apical callosity poorly developed, dental plates buried by callus only in extreme apex of valve. Muscle area elongate-ovate, normally bisected by relatively high median ridge; adductor muscle marks elongate, narrow, median, longitudinally striate; diductor muscle marks larger, lateral, also longitudinally striate. Posterior parts of valve floor, especially those more thickened, marked by shallow elongate pits in irregularly radial rows, fading and coalescing anteriorly to form shallow pallial striae, becoming fainter toward margins.

Brachial interior with strong, widely divergent, thick-walled sockets, extreme apical part of each socket roofed by short, thin plate. Helicophores beginning as thin plates emanating from socket ridges, forward course not observed; spiralia seen only as fragments, apparently coiled as in other species of genus. Muscle area elongate spatulate, bisected by low median ridge, too faintly impressed for observation of individual muscle marks.

MEASUREMENTS (in mm).—

	length	brachial	width	hinge	thick-
		valve length			ness
USNM 706d					
152955a	?	4.3	4.5	2.6	?
152955b	5.7	5.4?	7.2	5.0	?
152955c	?	10.5	12.5	8.6	?
152955d	10.4	8.7	10.4	6.9	5.3
152955e	19.4	15.7	19.5	14.3	10.8
152955f	20.0?	17.5?	19.4	15.9	11.0?
152955g	28.9	24.5?	29.0?	24.0?	?
152955h	29.2	34.0	32.0	27.6	26.0?
USNM 719z					
152956a	52.0	41.4	52.0?	36.0*	28.8
(holotype)					

STRATIGRAPHIC OCCURRENCE.—Word Formation (Appel Ranch Member).

LOCALITIES.—USNM 706d, 719z, 716v, 726t.

DIAGNOSIS.—Rounded *Spiriferella*, slightly thickened pedicle valve, with strongly defined costae, and a sharp median ridge in the muscle region of the pedicle valve.

TYPES.—Holotype: USNM 152956a. Figured paratypes: USNM 152955d,e. Measured paratypes: USNM 152955a-h. Unfigured paratypes: USNM 152956b.

COMPARISON.—*Spiriferella propria* is characterized by its elongate outline, sharp costae, attenuate and strongly hooked beak, comparatively slightly thickened pedicle valve, and rather sharp median ridge in the pedicle muscle area. It resembles a few abnormally elongate specimens of *S. clypeata*, new species, but differs from them in its longer more pointed beak, sharper and higher costae, less thickened pedicle valve, and its somewhat stronger pustules that increase in strength and density toward the posterolateral margins. It is clearly distinguishable from normal specimens of *S. clypeata*, new species, by these features and also its narrow outline and shorter hinge. Its elongate rather than transverse outline is a similarity with *S. gravis*, new species, but it differs in its less thickened pedicle valve, sharper costae, more attenuate and hooked pedicle beak, and more quadrate than ovate outline. It is narrower, more sharply costate, and its pedicle valve is less thickened than that of *S. embrithes*, new species; and it is longer, more attenuate, and somewhat larger than *S. levis*, new species.

Spiriferella sulcifer (Shumard)

PLATE 628: FIGURES 20–36; PLATE 631: FIGURES 22–26

Spirifer sulcifer Shumard, 1859:293; 1860:391, pl. 11: figs. 3a-c.—Girty, 1909:363, pl. 13: figs. 10–10b. [Not of R. E. King, 1931:118.]

Small for genus, biconvex; outline subquadrate, slightly elongate to slightly transverse, normally widest at hinge, rarely near midlength; hinge auriculate, somewhat acuminate in some specimens; commissure uniplicate, gently plicated laterally; fold low, gently arched, producing slight anterior notch in some specimens; fastigium low, standing only slightly or not at all above flanks, shallow median trough between primary costae becoming shallower and broader anteriorly; sulcus shallow, broad, with shallow, U-shaped (in cross section) median trough beginning at beak. Costae prominent, rather broad, gently rounded, beginning at beaks, each normally with one asymmetrical bifurcation on each side, producing fascicles of three; fascicles gently plicating shell; primary costae of fastigium remaining subparallel, branching only laterally, normally producing total of 4 costae, sulcus normally with 4–6, each flank with 4–8. Surface with small rounded pustules, moderately dense to sparse, arranged in rows along growth lines; fine radial ornamentation fairly obvious in troughs between costae, especially toward posterior; growth lines fine, crowded; growth laminae coarser, irregularly spaced, normally more frequent toward margins.

Pedicle valve flatly convex; beak short, somewhat swollen, strongly hooked; interarea low, rather strongly concave, especially toward apex, rapidly widening anteriorly, wedging out at ends of auriculations, anterior edge with numerous denticles pointing forward, beginning about 2 mm lateral to hinge teeth; delthyrium low, wedge-shaped, normally about half covered by small, flatly convex pseudodeltidium with lateral projections running farther forward along sides. Brachial valve moderately to flatly convex; beak region slightly to moderately swollen, blunt; interarea wide, low, slightly concave, with shallow transverse groove for reception of pedicle valve denticles; notothyrium broadly wedge-shaped to U-shaped; cardinal process wide, rather flat, longitudinally lamellate for attachment of diductor muscles.

Pedicle valve interior with strong, somewhat flattened, knoblike hinge teeth diverging anteriorly; dental ridges low, flattened; dental plates very short, slightly diverging, meeting valve floor on each side of muscle area somewhat thickened in some specimens; posterior part of valve normally not thickened, or only slightly thickened, leaving umbonal cavities open; apical callosity variably developed, normally weak. Muscle area rather narrow, elongate ovate, bisected by low median ridge; adductor muscle marks elongate, narrow, lying along median ridge; diductor muscle marks larger, lying laterally, all longitudinally striate. Floor of valve, especially those slightly thickened, with shallow pits in irregularly radiating rows, becoming light striae, fading toward margins.

Brachial valve interior with widely divergent, thick-walled hinge sockets, apical part of each roofed by thin plate. Helicophores attached to socket ridges, beginning as broad thin plates, narrowing anteriorly; course of spiralia, size and shape of jugal processes not observed. Muscle area faintly impressed, elongate spatulate, slightly widening anteriorly, bisected by low median ridge; form of individual muscle marks indistinct.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Hegler: AMNH 635; USNM 731, 732a, 740c, 740d. Pinery: AMNH 537, 398, USNM 725n, 733, 736, 748. Rader: AMNH 397, 403, 404, 410; USNM 725f, 725g, 725o, 740a, 740i, 740j. Lamar: USNM 728q.

DIAGNOSIS.—Small, slightly elongate, auriculate *Spiriferella* with slightly thickened pedicle valves and few primary costae.

TYPES.—Shumard (1860, pl. 11: figs. 3a-c) specimen lost; neotype herein selected: USNM 152958a. Figured hypotypes: USNM 152957o,q, 152959a-c. Measured hypotypes: USNM 152957a-u, 152959d.

COMPARISON.—*Spiriferella sulcifer* is characterized by its small size, subquadrate outline, auriculate, pointed hinge ends, few, broad, rounded costae, shallow and relatively wide median groove in the fastigium, unthickened or only slightly thickened pedicle valve, low interarea, and strongly hooked pedicle beak. The pustules on the surface are rather sparsely distributed, but become more crowded toward the anterior.

This species is smaller and more delicate than

MEASUREMENTS (in mm).—

	length	brachial valve length	mid- width	hinge width	thick- ness
USNM 731					
152957a	2.7	2.3?	2.4	1.4	?
152957b	3.6	3.0?	3.5	2.5	?
152957c	4.7	3.9	4.8	3.4	3.3
152957d	5.0	4.3?	4.6	2.5	?
152957e	5.1	4.5?	5.7	3.8	?
152957f	7.8	6.6	6.3	8.5	5.0
152957g	8.2	?	8.2	6.7	?
152957h	10.7	8.8?	9.8	7.3	?
152957i	11.3	?	12.3	11.5	?
152957j	11.3	8.7?	10.7	8.1	?
152957k	12.0	?	11.4	9.3	?
152957-l	12.0	9.8?	13.1	11.4	?
152957m	12.2	?	12.4	12.5	?
152957n	16.2	?	14.3	13.3	?
152957o	15.8	12.6?	14.2?	13.4	?
152957p	16.7	?	14.6	19.6	?
152957q	?	13.6	9.6	15.7	?
152957r	?	14.6?	13.2	16.2	?
152957s	18.9	?	12.8	18.5	?
152957t	19.4	?	19.6	14.6	?
152957u	26.3	?	18.6	26.5	?
USNM 725f					
152959d	14.4	12.3	13.0	13.8	9.5
USNM 725g					
152958a (neotype)	15.0	12.5	11.6	13.8	9.5
Shumards fig. 3a-c	16.6	11.6	13.5	13.8	10.6

any of the species from the Word Formation in the Glass Mountains. It is most comparable to *S. levis* and *S. calcarata*, both new, but differs from them in its smaller size, less thickened pedicle valve, shorter pedicle beak with more strongly hooked end, and consequently lower and more concave interarea. It is smaller than *S. gloverae*, new species, from the Cherry Canyon Formation in the Guadalupes, and also differs in its less elongate outline, more prominent and more definitely fasciculate costae, shorter, more strongly hooked pedicle valve, and normally more auriculate hinge ends.

DISCUSSION.—We have assigned the specimens described herein to Shumard's species *Spirifer sulcifer* in spite of the fact that the type was lost in a fire and never was well illustrated. Girty (1909: 363) had no specimens of this species and we did not obtain any from the Capitan Limestone which is the formation from which Shumard obtained his specimen. Careful comparison of Shumard's de-

scription and figures places his species well within the variation of the specimens we believe to be a single species. The specimen in Shumard's figures, assuming the proportions are fairly faithfully depicted, has a length of either 16.1 or 16.6 mm. Girty's figures 10 and 10a on his Plate 13 (copied from Shumard) are, respectively, ventral and dorsal views of a complete specimen, and this difference, which has no significance in our argument, may result from careless posing of the specimen by the original artist. Shumard's figures compare very favorably with our measured hypotype USNM 152957n, the length, midwidth, and hinge of which are nearly identical to those measurements of Shumard's figures. Inasmuch as this close agreement exists and Shumard's description fairly well describes our specimens, we have adopted his name. The assignment is also in accordance with the stratigraphy because the Bell Canyon Formation is a lateral equivalent of the Capitan Limestone.

Specimens from the Hegler Member are nearest Shumard's description. Some of the specimens from the Rader Member seem to be dorsally more convex and to have somewhat more numerous intercalations or bifurcations of the main costae. Specimens from the localities vary strongly in the dimensions of the hinge and the presence of auricularia. A few specimens are mucronate, but in others the hinge is considerably less than the maximum width. The outline is variable within narrow limits. Most of the specimens tend to be subquadrate with the length and maximum width about equal. Most tend to be longer than wide but a few are slightly wider than long but have length-width indexes above 0.9.

In view of these considerations, we have elected to establish a neotype for *S. sulcifer* in order to conserve what we believe to be a valid and identifiable species. This specimen (USNM 152958a, Plate 628; figures 24–28) is a complete shell from the Rader Member of the Bell Canyon Formation, chosen because it is well preserved and complete, despite the minor differences noted above from the dimensions of Shumard's illustrated specimen.

We have not been able to identify the specimens that R. E. King (1931, pls. 39,40) called *S. sulcifer*, but we are fairly certain that these specimens from the Word Formation in the Glass Mountains are not conspecific with Shumard's species from the Capitan Limestone and its lateral equivalents in the Guadalupe Mountains. We have refigured

King's shells (Plate 631: figures 22–26) for comparison.

Spiriferella species

PLATE 745: FIGURES 45, 46 (in volume 5)

Worn fragments of the pedicle valve of a species of *Spiriferella* occur rarely in the debris from solution of blocks from USNM 732j. Only the thickened posterior is preserved but it indicates a medium-sized species with 8 rounded costae at the posterior. The illustrated specimen preserves the pseudodeltidium.

Figured specimen: USNM 154517.

Genus *Eliva* Fredericks, 1924

Eliva Fredericks, 1924c:319.—Ivanova, in Sarycheva, 1960: 270.—Pitrat, in Williams et al., 1965:H708.

Small, biconvex, elongate, normally oval with greatest width near midlength; hinge narrow, straight, ends normally not protruding beyond the midwidth; commissure uniplicate, lateral plications weak, small crenulations at ends of costae; fold low to moderately high, rounded to peaked, producing shallow notch at anterior margin; fastigium low or absent, rarely breaking contour of transverse profile of brachial valve; sulcus beginning at beak, deepening anteriorly, extending forward as angular tongue to fill notch of fold at anterior margin, median line with trough or costa. Costae beginning at beaks, normally bifurcating, some splitting several times forming fascicles of 2–5 costae, only rarely producing lateral plications, normally stronger and more numerous on pedicle valve. Surface without pustules; fine radial ornament normally weak, confined to troughs between costae, stronger on brachial valve, some species with low secondary costae in trough; concentric growth lines fine, crowded; growth laminae weak, irregularly spaced, strongest and most crowded near margins.

Pedicle valve strongly convex, normally elongate; beak prominent, curved; interarea triangular, long to equilateral, concave; delthyrium long, wedge-shaped; pseudodeltidium not observed. Brachial valve less convex than pedicle valve; outline subelliptical; beak short, blunt; interarea low, slightly concave; notothyrium shallow, broadly wedge-

shaped; apical diductor muscle attachment not observed.

Pedicle valve interior with anteriorly divergent hinge teeth supported by dental ridges; dental plates parallel or slightly bowed outward, anteriorly divergent, rather short; muscle area with low, sharp myophragm. Brachial valve interior with hinge sockets and spiralia; details and other features not observed.

TYPE-SPECIES.—By original designation of Fredericks (1924c:319) *Spirifer lyra* Kutorga (1844:92–93, pl. 9: fig. 7).

DIAGNOSIS.—Elongate oval Spiriferida, fasciculate but seldom plicate, nonpustulose, fastigium consisting of one fascicle only and without a median groove.

COMPARISON.—*Eliva* is characterized by its rather small size, elongate-oval outline, short hinge, emarginate anterior, fasciculate costae that normally do not produce lateral plications, low fastigium formed by a single fascicle of costae, nonpustulose surface, and shallow to moderately deep sulcus. It most nearly resembled *Elivina* Fredericks (1924c), differing in its normally deeper sulcus, somewhat narrower hinge, costae that branch several times producing fascicles of as many as 5 costae but scarcely plicating shell, and its fastigium composed of one fascicle of costae without median groove. It differs from *Spiriferella* Tschernyschew (1902) in its usually smaller size, nonpustulose surface, narrow hinge, triangular interarea, and low fastigium without median groove. The narrow hinge, low fastigium, weak fascicles, and absence of surface pustules and plications distinguish it from *Eridmatos* Branson. It differs from *Cartorhium*, new genus, mainly in its smaller size, narrower outline, much weaker costae, lower lateral plications, lower fastigium, and proportionately deeper sulcus. Some species of *Cartorhium* have individuals with interareas that are not triangular, but as far as we know all specimens belonging to species of *Eliva* have the interarea triangular.

DISCUSSION.—Fredericks (1924c) established the genus *Eliva*, designating as the type species *Spirifer lyra* Kutorga. He considered the primary difference between *Eliva* and *Elivina* Fredericks to be in the abbreviated dental plates of *Eliva*. Dunbar (1955: 137) cast suspicion upon this distinction, and cited a letter from Fredericks to Schuchert which shows that Fredericks himself was not entirely convinced

of its validity. Our studies bring us to the same conclusion: we have not found that length of dental plates is reliable as a taxonomic character among the Spiriferidae. One collection of silicified specimens of *Elivina detecta*, new species, from the Guadalupe Mountains contains individuals with very abbreviated, rudimentary dental plates in association with specimens in which the dental plates extend forward nearly a third the valve length. This is evidence that length of dental plates is valueless in distinguishing genera in this group of spiriferids, as we have found it to be in most others. However, we have been able to distinguish *Eliva* from *Elivina* on the basis of external shape, costation, and fine ornament. Upon close investigation we have concluded that they not only are distinct, but probably are descended from separate stocks.

Eliva is fasciculocostate, and its fascicles rarely make weak plications in the shell. *Elivina*, on the other hand, has costae that bifurcate symmetrically and only rarely produce bundles with three costae at the anterior. The primary clue to the ancestry of the two genera is in the form of the fastigium. *Eliva* has the fastigium formed by one fascicle, normally containing 4 costae. There is one primary costa at the beak, but this bifurcates early, making 2 major costae. The major costae diverge from one another, and each branches laterally, making the usual total of 4. In some specimens the lateral branches of the major costae also split laterally, making a fascicle of as many as 5 or 6. The trough between the two major costae is shallow and widens anteriorly. At the anterior margin, the 4–6 costae of the fastigium are all about the same strength and form a low, even arch. This type of fastigium is similar to that of *Cartorhium*, new genus, which is most abundant in the Cathedral Mountain Formation. *Elivina* has a narrow groove along the midline of the brachial valve, similar to that in species of *Spiriferella*, and one species has sparsely distributed pustules on the surface which link it to *Spiriferella*. Our conclusion is that *Eliva*, with its fasciculate costae and evenly arched fasciculate fastigium is related to *Cartorhium*, whereas *Elivina* with the broad, more symmetrically bifurcating costae, median brachial groove, and occasional pustules is derived from the stock of *Spiriferella*. We feel more confident of the ancestry of *Elivina*, however, because of uncertainty of relationship of

spiriferids like *Choristites* Fischer de Waldheim to *Neospirifer*, *Cartorhium*, or to *Eliva*.

Eliva inflata, new species

PLATE 633: FIGURES 39-53

Spirifer mexicanus Girty [not Shumard], 1909:360, pl. 13: figs. 3-3a [not figs. 1-2, 4-6 (= *E. shumardi*, new species)]

Large for genus, rather strongly biconvex; outline subovate, normally slightly elongate, widest anterior to midlength; hinge narrow, ends rarely interrupting curve of lateral margins; commissure uniplicate with low fold, lateral plications normally absent, fine serrations where costae meet margins; anterior margin with shallow angular notch; fastigium low, flattened, rarely breaking transverse contour of brachial valve; sulcus moderately deep, with median trough beginning at beak, deepening anteriorly, slightly extended at margin to fill notch of fold. Costae moderately strong, rounded, fine and numerous, normally bifurcating symmetrically to form fascicles of two, less commonly bifurcating asymmetrically to form fascicles of three, numbering 8-10 in sulcus, normally 9, 12-18 on each side lateral to sulcus, normally about 15, fastigium with median costa bifurcating symmetrically once near beak, each branch splitting laterally once, producing total of 4. Surface without pustules; radial ornamentation weak, normally in troughs between costae; concentric growth lines fine, crowded; growth laminae weak, widely spaced, slightly stronger, and more frequent near margins.

Pedicle valve elongate subtriangular, strongly convex; beak thick, elongate, rather strongly curved, end bluntly rounded; interarea narrow, triangular, nearly equilateral, fairly strongly concave, strongly apsacline; delthyrium high narrow, bounded by shallow lateral grooves formed by anterior growth of hinge teeth; pseudodeltidium not observed. Brachial valve moderately strongly convex, consistently flatter than pedicle valve but moderately inflated medially; outline subcircular to heart-shaped; beak short, blunt; interarea low, slightly concave; notothyrium wide; apical callosity not observed.

Pedicle valve interior with divergent hinge teeth; dental plates slightly bowed laterally, slightly divergent anteriorly, extending forward about a quarter to a third length of shell. Brachial valve

with spiralia coiled normally; other internal features not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	mid- width	hinge width	thick- ness
USNM 750a					
152887a	14.1	11.8	15.0	6.3	8.8
152887b	14.6	12.3	13.4	6.7	9.5
152887c	17.4	14.9	17.0	7.0	10.7
152887d	17.9	15.4	18.0	6.0	12.7
152887e	18.6	15.4	18.8	7.5	12.9
152887f	19.9	17.3	19.6	8.5	12.7
152887g	20.2	17.6	18.2	8.9	16.0
152887h	22.0+	18.0+	21.3	9.0?	17.0
152887i	23.5	19.7	22.0+	10.5	14.7
152887j	26.4	21.0	25.4	11.5	20.8
(holotype)					
152887k	31.0+	25.0+	29.5?	12.5	28.0?
USGS 2926					
118588e	15.0?	13.5	15.9	6.9	10.2

STRATIGRAPHIC OCCURRENCE.—Capitan Limestone and Bell Canyon formations.

LOCALITIES.—Capitan: AMNH 830, 847; USGS 2926; USNM 725-l, 725p, 738a, 740k, 740-l, 740n, 740o, 750a. Bell Canyon: USNM 728p, 728q, 740g, 740h.

DIAGNOSIS.—*Eliva* with rotund outline and strong convexity.

TYPES.—Holotype: USNM 152887j. Figured paratypes: USNM 118588e; 152887c,f. Measured paratypes: USNM 152887a-i, k; 118588e.

COMPARISON.—*Eliva inflata* is characterized by its rotund outline, strong convexity of both valves, rather high but fine costae that split early and are only weakly fasciculate, with the troughs between fascicles indistinct at posterior and no deeper than ordinary troughs at anterior. Among American species it most nearly resembles *E. shumardi*, new species, and occurs sparingly with it. *Eliva inflata* attains larger size, is much more convex, especially in the brachial valve, has a narrower outline, and its costae are less distinctly fasciculate and do not plicate the shell. It is even more strongly swollen in contrast to *Cartorhium mexicanum* (Shumard) and its costae are higher, less strongly fasciculate, with fewer per fascicle, and its outline is not as transverse.

This species is distinguished from the type species, *Eliva lyra* (Kutorga) by its rounder outline, more bulbous shape, higher but less obviously

fasciculate costae, and its deeper anterior marginal notch. *Eliva inflata* more closely resembles *E. lyra* (Kutorga) than the other American species of the genus.

Eliva shumardi, new species

PLATE 632: FIGURES 1-54

Spirifer mexicanus [part] Girty [not Shumard], 1909:360, pl. 13: figs. 1-2, 4-6 [not fig. 3 (= *E. inflata*, new species)].

Not *Spirifer* (*Neospirifer*) *mexicanus latus* R. E. King, 1931: 116, pl. 37: fig. 7, pl. 38: fig. 1.

Not *Eliva lyra mexicana* Fredericks, 1932a:167, pl. 1: figs. 13a-c.

Average size for genus, biconvex; outline slightly elongate to transversely suboval, widest near mid-length; hinge proportionately wide for genus, not protruding at ends; commissure uniplicate, fold low, gentle or absent lateral plications, fine serrations at ends of costae; fastigium low or absent, rarely breaking transverse profile; sulcus moderately deep, beginning at beak, slightly extended at anterior to fill notch of fold, producing shallow emargination, median line with trough. Costae low, rounded, bifurcating asymmetrically to form weak fascicles of three costae, producing little or no plication of shell, costae numbering 12-15 on each side lateral to fastigium or sulcus, 6-9 in sulcus, 4-6 on fastigium. Surface not pustulate; radial ornamentation very fine, visible only in troughs; concentric growth lines fine, crowded; growth laminae weak, sporadically spaced, somewhat more frequent near margins.

Pedicle valve rather strongly convex, outline heart-shaped; beak thick, prominent, rather strongly curved, apex blunt; interarea triangular, nearly equilateral, concave; delthyrium high; pseudodeltidium not observed. Brachial valve flatly convex, proportionate convexity increasing with growth of shell; outline transversely subelliptical to subcircular; beak short, slightly curved; interarea low, bisected by wide notothyrium; apical callosity finely lamellate for attachment of diductor muscles.

Pedicle valve interior with divergent hinge teeth supported by deep dental ridges; dental plates slightly divergent anteriorly, meeting floor on each side of muscle area, extending forward as much as one third length of shell; muscle area with low median ridge; other internal features not observed.

Brachial valve interior with divergent, thick-walled hinge sockets; helicophores leading off from socket ridges; spiralia present, coiled normally, details not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	mid- width	hinge width	thick- ness
USGS 2926					
118588a	9.0	8.4	9.0	4.8	5.9
118588c	11.8	10.0	11.0	5.1	6.7
118588f	22.0	18.3	23.9	13.4	15.4
USNM 739					
152960a	10.3	8.5	10.6	5.5	6.7
USNM 740					
152961a	14.4	11.6	13.3	6.6	9.3
152961b	15.1	12.0	13.8	7.5	9.7
152961c	18.0?	14.0	16.6	11.0	11.9
152961d	19.0	16.7	18.0+	8.9	12.7
154567b (holotype)	23.7	18.7	21.0	10.0	17.0

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Rader, and Lamar members); Capitan Formation.

LOCALITIES.—Hegler: USNM 731. Rader: AMNH 410; USNM 725f, 740i. Lamar: USNM 725e, 728p, 738. Capitan: USGS 2926; USNM 725i, 725k, 725-l, 739, 740, 740n.

DIAGNOSIS.—Hinge proportionately wide, brachial valve transversely subelliptical and flatly convex, costae low, in fascicles of two or three that produce low plications of the shell.

TYPES.—Holotype: USNM 154567b. Figured paratypes: USNM 118588a-d,f,g; 154567a; 154568a-h; 154569a-c. Measured paratypes: USNM 118588a,c,f; 152960a; 152961a-d. Unfigured paratype: USNM 154569d.

COMPARISON.—*Eliva shumardi* is flatter, wider, more strongly fasciculate and plicate than *E. inflata*, new species, and its maximum size is somewhat less. It is distinguished from *Cartorhium mexicanum* (Shumard) by its smaller size, generally elongate appearance, greater convexity, fewer costae per fascicle, less pronounced lateral plications, and deeper sulcus. It differs from *E. lyra* (Kutorga), the type species, in its more transverse outline, lower convexity of the brachial valve, fascicles with normally three instead of two costae, lack of a median costa in the sulcus, and lack of tiny secondary costae in the troughs between major costae.

Genus *Elivina* Fredericks, 1924

Elivina Fredericks, 1924c:314, 315.

Small, biconvex; outline rounded, normally elongate elliptical to subovate; hinge narrow, straight, ends not auriculate; maximum width near mid-length, normally slightly anterior; commissure weakly to moderately uniplicate, laterally crenulated but without strong lateral folds; median fold low, bluntly to sharply arched, normally producing shallow notch in anterior margin; fastigium low or absent, median line with narrow groove between two major costae; sulcus beginning at beak, trough or low costa medially, deepening and widening anteriorly, extending forward as short angular tongue into notch in anterior margin of brachial valve. Costae beginning at or near beaks, narrow, low, crests rounded, most not bifurcating, few splitting asymmetrically, normally only on one side, not producing fascicles or strong plications of shell, some species with low, sharp, secondary costae in trough between major costae. Fine radial ornamentation normally present, strongest near beaks, in troughs between costae; concentric growth lines fine, closely spaced; growth laminae stronger, irregularly spaced, more crowded near margins; surface normally without pustules.

Pedicle valve elongate subovate, rather strongly convex; beak long, narrow, normally fairly strongly hooked, apex blunt; interarea triangular, concave, moderately long; delthyrium narrow; pseudodeltidium not observed, probably present in life, as evidenced by shallow grooves along sides of delthyrium; denticles along hinge edge weak or absent. Brachial valve fairly strongly convex but flatter than pedicle valve; outline subcircular to subtrigonal; beak short, blunt; interarea low, short, slightly concave; notothyrium shallow, apex occupied by finely lamellate cardinal process.

Pedicle valve interior with short, blunt, anteriorly divergent hinge teeth supported by deep, posteriorly diminishing dental ridges, slightly convergent toward midline; dental plates short, slightly divergent, meeting valve floor on each side of muscle area, continuing anteriorly along edges of muscle area for short distance in some species; posterior part of valve only slightly thickened or not thickened; apical callosity slight, forming thin shelf. Muscle area narrow, elongate, beginning

rather far forward, only slightly anterior to ends of dental plates, bisected by low, sharp or blunt myophragm; adductor muscle marks very narrow, occupying slopes of median ridge; diductor muscle marks larger, fusiform, occupying most of muscle area lateral to adductors. Floor of valve pitted only where thickened, with shallow pits arranged in roughly radial rows, fading toward margins to form faint pallial lines.

Brachial valve interior with thick-walled, widely divergent hinge sockets, partly roofed by thin plates. Helicophores beginning as broad thin plates growing from socket ridges; spiralia not observed. Muscle area faintly impressed; median adductor muscle marks elongate, longitudinally striated; posterior adductor muscle marks short, flanking median marks, somewhat radially striated.

TYPE-SPECIES.—By original designation of Fredericks (1924c:315) *Spirifer tibetanus* Diener (1897a: 45, pl. 6: figs. 1–7).

COMPARISON.—*Elivina* is characterized by its small size, rather strong convexity, ovate outline, short hinge, low to absent fastigium, normally nonfasciculate costae, typically nonpustulose surface, emarginate anterior, comparatively deep sulcus, and its ventral muscle area which begins rather far forward despite lack of shell thickening. The narrow hinge, nonfasciculate costae, lack of lateral plications, lack of surface pustules, and more bulbous shape distinguish it from *Spiriferella* Tschernyschew (1902). These same features plus the normally low or absent fastigium, distinguish this genus from *Eridmatus* Branson. It differs from *Choristites* Fischer de Waldheim (1825) and *Choristitella* Ivanov and Ivanova (1937) in its narrow, elongate rather than transverse outline, its thin valves, elongate rather than subcircular pedicle muscle area, divergent dental plates, and in its fastigium with a median groove rather than a prominent median costa. Its dental plates are short and lie at the edges of the muscle area as in *Choristitella*, rather than long and intersecting the muscle area as in *Choristites*. It is similar to *Cartorhium*, new genus, in its low fastigium and narrow hinge, but differs in its elongate outline and only occasionally bifurcating, essentially nonfasciculate costae.

DISCUSSION.—*Elivina* is strikingly similar in shape and size to *Eliva* Fredericks (1924c). Fredericks originally attempted to distinguish these genera

on the basis of the degree of development of their dental plates. We have found length of dental plates to be generally unreliable as a taxonomic character in the Spiriferidae, and particularly so in *Elivina*. Our best collection of silicified specimens of *Elivina detecta*, new species, has individuals with dental plates ranging in length from barely visible rudiments to nearly one third the length of the shell.

Elivina can be distinguished from *Eliva* by the nature of its costation and form of its fastigium. Fredericks (1924c:319) described the costae of *Eliva* as "strongly dichotomous" and those of *Elivina* (1924c:315) as "radial," not particularly meaningful distinctions. In his description of *Spirifer lyra* (type species of *Eliva*) Kutorga (1844:93) mentioned that many of the costae bifurcate, and a few trifurcate. In describing *S. tibetanus* (designated by Fredericks as type species of *Elivina*) Diener (1897a:47) says that the costae are typically bifurcating, in contrast to *S. rajah* Salter in which they are triplicate. We have relied on Diener's (1897a, pl. 6) and Tschernyschew's (1902, pl. 7) illustrations of *E. tibetanus*. Kutorga's (1844, pl. 9) illustrations of *E. lyra* are inadequate, but fortunately we have a topotype specimen from the Ural Mountains to study along with Tschernyschew's (1902, pls. 6-8) accurate illustrations.

We have attempted to trace the phylogeny of *Elivina* and *Eliva*. Our conclusion is that they are not only distinct genera, but that they may be descended from separate lines within the Spiriferidae (see discussion of *Eliva* for evidence). The similarity in shape probably is a matter of convergence, and due to at least two factors. One is the similarity of the ancestors, a second is a trend toward narrowing of the shell outline in the high Guadalupian. If *Elivina* descended from *Spiriferella*, as we consider possible, and *Eliva* descended either from *Choristites* (a possibility) or from *Cartorhium*, new genus (in our opinion more probably), they must necessarily be somewhat similar in outline, differing primarily in costation and fasciculation. A trend toward narrowness is evident among spiriferids of the Guadalupian (see species of *Cartorhium*), and seems to produce a similar shape and outline in several groups. The heart-shaped outline is characteristic of Guadalupian species of *Elivina*, *Eliva*, *Spiriferella*, and the emarginate species *Cartorhium retusum* and *orbi-*

culatum, both new, and *C. mexicanum* (Shumard). Similarity is further enhanced by the low fastigium of the ancestors, accompanied by trends in the several genera toward continued reduction of the fastigium.

These trends and their resulting convergence of gross form in several genera may be the effects of factors in the reefy environment so widespread in the Guadalupian, but they also are genetic, inasmuch as they appear to have begun earlier. In *Neospirifer* the trend is noticeable in the Leonardian; in *Choristites* it began in the Pennsylvanian; in the *Spiriferella* lineage it began feebly in the Pennsylvanian and was well established in the earlier Guadalupian (e.g., Word Formation).

Elivina? annectens, new species

PLATE 633: FIGURES 21-37

About average size for genus, unequally biconvex; outline elongate subovate, widest near midlength, slightly posterior to midlength of brachial valve; hinge narrow, ends slightly protruding in large specimens; commissure uniplicate, low fold producing slight notch at anterior margin in some specimens, no notch in others; fastigium absent, its place marked by 2 parallel costae with narrow groove between; sulcus shallow, beginning at beak, median line with low costa or shallow trough. Costae broad, rounded, in distinct and large fascicles of three, each fascicle making low plication in shell; costae numbering about 10 on each side, 4-8 in sulcus, normally 4 over fastigium. Surface with small, sparsely distributed pustules arranged along growth lines, normally most frequent near margins; radial ornamentation fine, confined to troughs between costae, normally slightly stronger on brachial valve; growth lines fine, crowded; growth laminae weak, sporadically spaced, somewhat more frequent near margins.

Pedicle valve elongate subovate, moderately convex; beak short, blunt, moderately curved; interarea triangular, nearly equilateral; delthyrium long, apex with small shelflike callosity and shallow grooves for pseudodeltidium (not preserved) Brachial valve flatly convex, outline subelliptical, normally slightly transverse, beak short; interarea low, slightly concave; notothyrium short and wide,

apex with small callosity, finely lamellate for attachment of diductor muscles.

Pedicle valve interior with strong, anteriorly divergent hinge teeth, ends blunt, somewhat knob-like; dental ridges deep, slightly convergent toward midline; dental plates short, diverging anteriorly, meeting floor at edges of muscle area, extending short distance forward; posterior part of valve normally not thickened. Muscle area elongate, rather narrow, bisected by low myophragm; adductor muscle marks larger, lying lateral, occupying most of area, lightly striated longitudinally.

Brachial valve interior with strong, thick-walled sockets partly roofed by thin plates. Helicophores broadly attached to socket ridges, narrowing, pointing dorsally, then anteriorly; spiralia not observed. Muscle area short, rather round, bisected by low median ridge; anterior pair of adductor muscle marks median, posterior pair lateral, flanking median pair.

MEASUREMENTS (in mm).—

	length	brachial valve length (est.)	mid- width	hinge width	thick- ness
USNM 736					
152962a	4.0	c.3.5	4.6	2.5	?
152962b	4.3	3.7	4.6	2.3	?
152962c	6.8	6.0?	7.6	4.0	?
USNM 731					
152963a	7.1	6.5	7.9	4.7	4.9
152963b (holotype)	13.5	12.0	15.4	7.3	9.8
USNM 733					
152964a	10.7	8.7?	10.5?	5.4	?
152964b	17.6	15.0?	18.5	8.4	?
USNM 736a					
152965	23.6	18.0?	23.0?	12.0?	?

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, Rader, and Lamar members).

LOCALITIES.—Hegler: AMNH 635; USNM 731, 740c, 740d. Pinery: AMNH 398, 437, 524; USNM 725h, 725n, 733, 736, 736a, 748. Rader: AMNH 403, 410; USNM 725f, 725g, 725o, 740a, 740j. Lamar: USNM 738b.

DIAGNOSIS.—*Elivina* having broad, distinctly fasciculate costae and shallow sulcus.

TYPES.—Holotype: USNM 152963b. Figured paratypes: USNM 154563a; 154564a,b. Measured paratypes: USNM 152962a-c; 152963a; 152964a,b; 152965.

COMPARISON.—*Elivina? annectens* is characterized by its broad, low costae in wide, distinct fascicles, shallow sulcus, shallow or nonexistent anterior marginal notch, and by its small, sharp pustules on the exterior surface. It differs from *E. detecta*, new species, in its fewer, broader costae and more definite fasciculation, shallower sulcus, and by the presence of pustules. It is distinguished from *E. compacta*, new species, by its lower convexity, wider outline, more distinct fascicles and stronger costae, and its surface pustules. It differs from the type species, *E. tibetanus* (Diener) in its broader costae, larger fascicles, lower convexity of the brachial valve, and by its external pustules.

DISCUSSION.—As is implied in its name, we consider this sparsely pustulose species of *Elivina* to be a morphologic intermediate with *Spiriferella*. Its stratigraphic position precludes its being ancestral to the *Elivina* stock, but probably it remained morphologically near to the ancestral form, and retained the external pustules of *Spiriferella* while assuming the shape, outline, costation, fasciculation, and plication of *Elivina*.

Elivina compacta (Girty)

PLATE 633: FIGURES 1-20

Spirifer mexicanus var. *compactus* Girty, 1909:361, pl. 13: figs. 7-9.

Small for genus, strongly biconvex; outline elongate subtrigonal, tear-shaped, widest anterior to midlength of brachial valve; hinge narrow, but normally with ends slightly protruding; commissure uniplicate with fairly high wedge-shaped fold producing moderately deep notch in anterior margin, lateral plications low, only as high as costae; fastigium low, gently rounded, with 2 low costae divided by median groove, only standing above flanks near anterior; sulcus deep, with median trough beginning at beak, deepening anteriorly, wrapping around anterior to fill notch of fold. Costae broad, low, rounded, not fasciculate, some bifurcating, somewhat sharper and more widely separated on brachial valve, numbering 6-8 on each side lateral to fastigium or sulcus, 2 on fastigium, 4-6 in sulcus. Surface without pustules; fine radial ornamentation in troughs between costae; concentric growth lines fine, crowded;

growth laminae fairly weak, widely-spaced, most frequent near margins.

Pedicle valve strongly convex, elongate; beak narrow, thick, prominent, rather strongly curved, apex blunt; interarea triangular, equilateral to slightly higher than wide, concave; delthyrium narrow; pseudodeltidium not observed. Brachial valve strongly convex but less so than pedicle valve; outline heart-shaped; beak rather prominent; interarea relatively high, slightly concave, bisected by wide notothyrium.

Pedicle valve interior with short dental plates slightly diverging anteriorly and toward floor of valve, extending forward normally less than a quarter length of valve. Spiralia coiled normally, details obscured by calcification. Other internal features not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	mid- width	hinge width	thick- ness
USNM 750b					
152967a	11.0	10.8	10.9	4.7	7.6
USNM 737a					
152966a	14.3	12.6	13.7	5.5?	10.1
152966b	15.1	13.0	14.6	6.3	11.0
152966c	17.2	14.0	13.0?	6.5	14.3
152966d	17.4	14.7	15.7	7.3	13.8
152966e	18.0	16.5	17.6	7.0	12.9
152966f	20.7	18.4	19.0	7.0	16.7
USGS 2926					
118589 (holotype)	20.0	17.0	17.3	7.3	17.4

STRATIGRAPHIC OCCURRENCE.—Capitan Formation.

LOCALITIES.—USGS 2926; USNM 737a, 739, 740, 740o, 750b.

DIAGNOSIS.—Elongate, cordate *Elivina* with rarely bifurcating, non-pustulose costae, strongly convex brachial valve, and greatest width anterior to midvalve.

TYPES.—Holotype: USNM 118589. Figured hypotypes: USNM 152966b-d. Measured hypotypes: USNM 152966a-f, 152967a.

COMPARISON.—*Elivina compacta* is characterized by its heart-shaped outline with greatest width anterior to midline of brachial valve, well-defined median groove on the brachial valve, broad, rounded pedicle valve, costae which only rarely bifurcate and do not trifurcate, its low, narrower, sharper brachial costae with wide troughs between, rather prominent brachial beak, and its deep

sulcus with median trough. It differs from *E. detecta*, new species, in its smaller size, greater convexity, costae which are fewer, broader, less frequently bifurcating, and its deeper sulcus and deeper anterior median notch. It differs from *E. tibetana* (Diener), the type species, in its smaller size, broader and less frequently bifurcating costae, and its median trough in the sulcus rather than a median costa. It is distinguished from the species which Tschernyschew (1902, pl. 7: figs. 2-7) identified as *Spirifer tibetanus* Diener by its fewer, broader and normally nonbifurcating costae, more anterior location of its maximum width, its median trough in the sulcus, and especially by its very low, nearly absent fastigium. Tschernyschew's specimens from the Urals differ from Diener's Himalayan species by possession of the high fastigium. In the Himalayan species the fastigium is more similar to that of *E. compacta*.

Elivina detecta, new species

PLATE 634: FIGURES 1-49

Average size for genus, moderately biconvex; outline slightly elongate, subovate, widest near midlength; hinge rather wide for genus, ends protruding in many specimens; commissure uniplicate with low to moderately high fold producing slight notch at anterior margin, lateral plication absent, fine serrations at marginal ends of costae; fastigium absent; sulcus beginning at beak moderately deep, with low median costa in most specimens, median trough in few. Costae fine, crowded, crests rounded, normally splitting dichotomously, rarely into three branches, normally not forming fascicles, numbering 12-15 on each side of pedicle valve lateral to sulcus, about 8 in sulcus, 8-10 on each side of brachial valve, with median two separated by shallow median groove. Surface without pustules; fine radial ornamentation present on brachial valve where troughs are broader, normally absent from pedicle valve; concentric growth lines fine, crowded; growth laminae weak, irregularly spaced, more frequent near margins.

Pedicle valve rather strongly convex, elongate to subcircular; beak rather short, blunt, not strongly curved; interarea triangular, high to broad, moderately concave; delthyrium narrow, wedge-shaped, apex with small recessed shelf; pseudodeltidium

not observed, probably present but small in life, as evidenced by short grooves along sides of delthyrium. Brachial valve flatly convex; outline sub-circular, beak short, blunt; interarea low, slightly concave; notothyrium wide, rather deep, wedge-shaped, apex with very small, finely lamellate diductor callosity.

Pedicle valve interior with small, rather sharp hinge teeth; dental ridges deep, slightly convergent toward midline of valve; dental plates fused to dental ridges near apex of valve, diverging slightly to floor of valve, intersecting floor on each side of muscle area, plates very short, rudimentary in some specimens, extending forward nearly a third length of valve in others, normally extending about to midlength or only slightly thickened, leaving dental plates free; floor of thickened valves with irregularly radial rows of shallow pits, fading anteriorly. Muscle area elongate, fusiform, located rather far forward, bisected by prominent median ridge; adductor muscle marks long, narrow, lying on sides of median ridge; diductor muscle marks larger, lateral, wedging out posteriorly, slightly widening anteriorly, striated longitudinally.

Brachial valve interior with widely divergent hinge sockets, partly roofed by thin plate. Helicophores extending from socket ridges, proceeding dorsally, then anteriorly; spiralia not observed. Muscle area elongate subelliptical, faintly impressed; adductor muscle marks in two pairs, median pair elongate, posterior pair shorter, flanking median pair.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member).

LOCALITIES.—AMNH 37, 40, 401, 347; USNM 725e, 728i, 728r, 738, 738b.

DIAGNOSIS.—Fairly large *Elivina* with short ventral beak, fine, crowded costae, and lack of a fastigium.

TYPES.—Holotype: USNM 152968f. Figured paratypes: USNM 152968c,e,h,j; 152969k,n,s-u; 154565a-d; 154565a-d; 154566. Measured paratypes: USNM 152939a-r, 152968a-e. Unfigured paratypes: USNM 152968a,b,d,g,i; 152969a-j,l,m,o-r.

COMPARISON.—*Elivina detecta* is characterized by its pedicle valve with rather short beak, shallow sulcus, and numerous, fine, crowded, nonfasciculate costae; brachial valve with lower, fewer, more widely spaced costae, absent fastigium, and well-

MEASUREMENTS (in mm).—

	length	brachial valve length	mid- width	hinge width	thick- ness
USNM 738					
152939a	4.1	3.7*	4.0	2.0	?
152939b	5.3	4.7*	5.6	2.9	?
152939c	8.0	6.8*	7.8	4.1	?
152939d	8.5	7.0*	9.5	5.5?	?
152939e	9.4	7.9*	10.0	6.3	?
152939f	10.2	8.3*	12.0	6.0	?
152939g	11.1	9.7*	13.0	7.6	?
152939h	13.3	10.7*	14.9	8.9	?
152939i	16.6	12.2*	14.3	8.5	?
152939j	17.4	14.3*	17.5?	12.0?	?
152939k	18.5	13.9*	19.8	13.0	?
152939-l	19.5	15.3*	20.0?	14.0	?
152939m	25.8	20.5*	27.0?	17.0?	?
152939n	?	14.6	16.2	7.8?	?
152939o	?	13.3	15.4	8.0	?
152939p	?	8.5	9.5	5.7	?
152939q	?	5.8	6.6	3.3	?
152939r	?	5.0	5.0	2.7	?
USNM 738b					
152968a	3.9	3.4	3.7	2.6	2.5
152968b	5.2	4.8	5.5	2.8	3.1
152968c	10.5	9.7	10.1	5.3	5.4
152968d	10.9	10.0	11.3	6.0?	5.8
152968e	14.2	12.8	13.8	7.3	9.6
152968f	15.1	13.4	16.4	9.5	9.0
(holotype)					

marked median groove. It is the only undoubted species of *Elivina* in our collections preserved by silicification so that the internal features are visible. The only other species in the Guadalupe Mountains is *E. compacta*, new species, from which *E. detecta* differs in its smaller size, less convexity (especially of the brachial valve) shallower sulcus, absent fastigium, and especially in its finer and more numerous costae on the pedicle valve. *Elivina detecta* differs from the type species, *E. tibetanus* (Diener) from the Himalaya Mountains, in its flatter brachial valve, finer and more numerous ribs that normally bifurcate earlier and do not form such definite fascicles, and by its median trough or very low median costa in the sulcus. Tschernyschew's (1902, pl. 7: figs. 2-6) species from the Ural Mountains, identified as *Spirifer tibetanus* Diener, differs from Diener's species and from *E. detecta* by possession of a high fastigium, and further differs from *E. detecta* in its fewer, coarser, more fasciculate costae.

Superfamily RETICULARIACEA Waagen, 1883

Biconvex with rounded contours and narrow hinge; exterior smooth to plicate often with concentric lamellae bearing fringe of spines. Pedicle valve with or without dental plates.

Family ELYTHIDAE Fredericks, 1924

Neophricadothyris is common in Wolfcampian and Leonardian sediments. *Astegosia* occurs in swarms in the upper part of the Capitan Formation and in the Lamar Member of the Bell Canyon Formation.

Permophricadothyris Pavlova (1965) probably supersedes *Neophricadothyris*. We employ the earlier names because we decided that a new name really was necessary for the largely Permian form, and have not seen evidence that synonymizes *Neophricadothyris* with *Phricadothyris*, although we do agree with Pavlova.

Genus *Neophricadothyris* Licharew, 1934

Neophricadothyris Licharew, 1934d:175.

Small to large for spiriferid, moderately to strongly biconvex; outline subelliptical or subovate to subpentagonal, elongate or transverse, greatest width near midlength or more commonly posterior to midlength, near posterior margin of brachial valve; commissure rectimarginate to moderately strongly uniplicate; fold normally low at anterior, rarely moderately high, producing consistently low fastigium beginning far forward; sulcus correspondingly shallow, beginning near pedicle valve beak, extended at anterior commissure to fill fold; costae and other radial ornamentation entirely absent; evenly spaced concentric laminae bearing short to long double-barreled spikes, each with lateral pairs of thornlike spicules at regular intervals of 0.2 to 0.4 mm, each spicule splitting into 2 or 3 tiny, sharp, widely divergent barbs.

Pedicle valve normally more strongly convex than brachial valve, greatest convexity in umbonal region; beak thick, blunt at end, normally strongly curved, erect or slightly recurved; interarea small, rounded, and ill-defined to distinct, flat, wide, outlined by distinct beak ridges, entirely free of surface spines; delthyrium trigonal, large, open, bounded

on each side by thin deltidial flange, flanges converging at apex of delthyrium, height variable, attached to shell along juncture of interarea with hinge tooth. Brachial valve less strongly and more evenly convex, beak short, suberect to erect, blunt, projecting slightly over open delthyrium, notothyrium broad, shallow, bounded by pair of lower notothyrial flanges; interarea low, flat or slightly concave, tapering laterally.

Pedicle valve interior with strong blunt hinge teeth; dental ridges low to very high, remaining completely separate from one another or joining at apex of delthyrium to form apical platform; dental plates absent; muscle area narrow, elongate, fusiform, normally distinct; adductor muscle marks occupying most of muscle area, one on each side of midline, together making heart-shaped impression; diductor muscle marks narrower, meeting one another at anterior, extending diagonally posteriorly along anterior edges of adductor marks, shape of chevron; posterior part of fusiform area consisting of traces of former attachment, abandoned by forward migration of muscle marks with growth of shell.

Brachial valve interior with deep hinge sockets formed by curved socket ridges, proximal walls slightly enlarged to form denticles; posterior part of sockets bridged; apical attachment for diductor muscles roughened or lamellate, flat or swollen into small, knoblike cardinal process; helicophores projecting anteriorly and slightly dorsally, somewhat divergent at posterior, converging slightly near midlength of shell, continuing nearly full length of shell interior, diverging again at anterior, there giving rise to spiralia; short jugal processes pointing posteriorly, arising about two-thirds distance toward anterior; spiralia ribbonlike, axis of coiling from anteromedian to posterolateral, coils numbering about 10, diameter of coils remaining nearly constant for most of length of spiralia, gently decreasing in distal fifth, producing blunt, thimblelike shape for each spirallium; short spines projecting from peripheral edges of spiral ribbons, fairly widely spaced, pointing either in direction of coiling or in opposite direction, apparently at random; muscle area elongate, narrow; posterior adductor muscle marks short, narrow, flanking larger anterior marks that lie along midline, muscle marks separated along midline by low narrow ridge or by broad low ridge with narrow

median trough extending anteriorly beyond muscle area; posterior part of valve floor lateral to muscle area somewhat thickened and pitted in large adult shells, pits becoming shallower and more nearly arranged in radial rows toward anterior, disappearing near midlength of valve.

TYPE-SPECIES.—*Squamularia asiatica* Chao (1929: 91, pl. 11: figs. 12–14), by original designation of Licharew, (1934a:211, 213).

DIAGNOSIS.—Spiriferacea having biramous spines in concentric rows and the spiral axes coiled posterolaterally.

The type-species, *Neophricadothyris asiatica* (Chao) is rectimarginate, whereas most Texas Permian species are gently uniplicate, at least in adult stages. Specimens in our collections show a subtle but unmistakable correlation between shell outline and strength of folding. The more transverse species have the most pronounced median folds, and the more transverse individual adults of any species are most strongly folded. Examples are the transverse Wolfcampian species *N. transversa*, new species, and *N. catatona*, new species, and in the normally globose *N. bullata*, new species, a few large and transverse specimens are more strongly folded than is typical for that species.

The exceptional preservation of the Glass Mountains specimens permits description and illustration of morphological parts hitherto not fully understood. These are the deltidial structures of the pedicle valve and the cardinalia of the brachial valve. The development of the deltidial structures is very variable, not only between species but in the same species. Furthermore, obviously young specimens in some cases develop old age characters at an early growth stage whereas some large adults may retain youthful characters to a late stage.

COMPARISON.—*Neophricadothyris* is characterized by its rectimarginate to weakly uniplicate anterior commissure, closely spaced and rather weak concentric sculpture, concentric rows of long spiculate spines with biramous bases, complete absence of dental plates or median septa, and its narrowly coiled spiralia whose axes of coiling diverge posterolaterally. It differs from *Squamularia* Gemmellaro (1899) in its biramous spine bases, posterolaterally directed and much narrower spiralia with more numerous coils, and apparently also in its more evenly concentric ornamentation. Gemmellaro's (1899, pls. 33,34) drawings show a fringed or scal-

loped kind of edging to the concentric laminae of the type species, *Squamularia rotundata* Gemmellaro. Specimens from the Sosio Limestone in the national collection show a similar kind of irregular ornamentation, but others that probably are a different species have the more evenly scored concentric lines that characterize the Texas specimens. We prefer to emphasize the great differences in the form and direction of coiling of the spiralia rather than the subtle differences in concentric ornamentation, although these undoubtedly are significant, and were emphasized by Licharew (1934a) as generic characters.

Neophricadothyris differs from *Phricadothyris* George (1932) in its more closely spaced and less prominent concentric ornament, but more importantly, as noted by Licharew (1934a), in the different form of the spiralia. In *Phricadothyris* the spiralia are proportionately shorter, have larger loops, and their direction of coiling is more nearly transverse to the shell.

Numerous genera of "reticulate" and *Martinia*-like spiriferids have been proposed by several authors. The major differences are in presence or absence of internal plates, the shape and direction of coiling of the spiralia, and the single or double bases of the external spines. *Neophricadothyris* differs from *Reticularia* McCoy (1844) in its complete absence of internal plates or septa. It differs from *Martiniopsis* Waagen (1883) in its lack of internal plates and in its posterolaterally directed spiralia. Its narrower hinge, weaker fold, spinose-lamellose concentric ornament, and posterolaterally directed axes of coiling of the spiralia distinguish it from *Martinia* McCoy (1844).

Minato (1953) proposed several genera and subgenera of reticulariids, some of which were placed in various synonymies by Maxwell (1961). Among those with biramous spine bases but having dental plates or median septa, Maxwell (1961: 97) noted that *Martinothyris* and *Nebenothyris* are invalid on nomenclatural grounds, and *Condraothyris* is essentially the same as *Phricadothyris*, a synonym on morphological grounds. *Neophricadothyris* may be considered a *Phricadothyris* with posterolaterally directed spiral axes as noted above.

Pavlova (1965) undertook a study of *Squamularia asiatica* Chao, the type species of *Neophricadothyris*, and concluded that it is not generically distinct from species of *Phricadothyris*. She intro-

duced the new genus *Permophricadothyris*, with type species *P. ovata* Pavlova, for the group in which the spiral axes point posterolaterally. We have had some doubts about *Neophricadothyris*, and perhaps could subscribe to Pavlova's view. We retain the name *Neophricadothyris*, however, because our original study convinced us that *Neophricadothyris* is a valid generic concept, and we are unsure of the relationship of *P. ovata* to the shells in the Texas fauna.

DISCUSSION.—The shape of the shell of *Neophricadothyris* accommodates the posterolaterally directed spiral axes: the greatest width normally is posterior to midlength, and the sides converge toward the anterior. Genera in which the spiralia are transverse normally are widest near midlength, and the sides converge both posteriorly and anteriorly. Despite the scarcity of specimens with completely preserved and exposed spiralia, both in our collections and in the literature, it is possible to determine the direction of the axes of coiling of the spiralia by close observation of the external shape of the shell, once the relationship is known.

The direction of coiling of the spiralia in *Neophricadothyris* is dorsoventral, the normal direction in spiriferids, and contrary to the direction of coiling in atrypids (Rudwick, 1960). The flow of currents during feeding in this genus therefore probably was not fundamentally different from that in other spiriferids, except that the water entered the shell somewhat farther to the posterior. However, from the standpoint of taxonomy this modification seems to us more important than previous authors (excepting Licharew, 1934a) have admitted. For example, George (1932:531) states that the posterolateral direction of coiling in *Reticularia* is "perhaps significant," but observes that if its only function was in directing the exhalent water currents, then it "would seem to be of trivial functional importance, and its 'meaning' is by no means apparent." It is a consistent feature of *Neophricadothyris* and *Reticularia*, however, and therefore is significant and useful taxonomically.

Neophricadothyris bullata, new species

PLATE 635: FIGURES 1–64; PLATE 649: FIGURES 20–24

Squamularia guadalupensis [part] (Shumard) R. E. King,

1931:118, pl. 40: figs. 6–7 [not fig. 8 (= *N. conara*, new species)].

Somewhat small for genus, rare individuals attaining large size, strongly biconvex; outline subelliptical to subpentagonal, moderately to strongly transverse, rarely elongate except as large adults, greatest width normally posterior to midlength of brachial valve; commissure weakly uniplicate, with fold gently and evenly rounded; fold not elevating brachial valve; sulcus slightly depressing pedicle valve, normally beginning farther than 10 mm anterior to beak; concentric lamellae numbering about 5–10 per 5 mm, each with 1 or 2 rows of double-barreled, thorny spines.

Pedicle valve strongly convex; beak thick, blunt, strongly curved; interarea poorly defined, somewhat rounded, small; delthyrium bounded by low deltidial flange on each side, space of delthyrium partly occupied by dorsal beak. Brachial valve less strongly and more evenly convex; beak short, rather strongly curved, with sharp apex; interarea very low, narrow; notothyrium broad, shallow.

Pedicle valve interior with short and rather sharp teeth, slightly hooked in some specimens; dental ridges low, somewhat flattened, not forming apical plates or other deposit in apex of delthyrium; muscle area distinct but weakly impressed, bisected by very low thin ridge; adductor muscle marks forming ellipse; diductor muscle marks flanking adductors only slightly, lying mostly anterior, shaped like broad chevron with curved sides.

Brachial valve interior with deep sockets, proximal socket ridges slightly swollen and raised simulating hinge teeth; cardinal process small, knoblike to gently convex, finely lamellate; hinge plates widening from apex to ends of sockets, tapering anteriorly from there to form slender helicophores, oriented subparallel to valve floor; helicophores very long, converging, then diverging anteriorly; small, sharp jugal processes projecting mesially and posteriorly near anterior of valve; spiralia delicate, with about 10 coils, axis of coiling divergent from anterior median to posterior lateral, diameter of coils constant nearly to ends decreasing in last two or three loops; muscle marks weakly impressed, sides of muscle area nearly straight, slightly divergent anteriorly, area bisected by low thin ridge, most of area occupied by large pair of anterior adductor marks, posterior adduc-

tor marks diverging anteriorly, flanking anterior marks; floor of valve not thickened or pitted, with weak radial striae in posterior half of adults.

MEASUREMENTS (in mm).—

	brachial				
	length	valve length	width	hinge width	thick-ness
USNM 702c					
152486a	0.6	?	0.6	0.3	0.4
152486b	0.7	?	0.7	0.3	0.4
152486c	0.9	?	1.0	0.5	0.6
152486d	1.2	?	1.3	0.7	0.8
152486e	1.4	?	1.4	0.9	1.0
152486f	1.5	?	1.7	0.9	1.0
152486g	1.8	?	1.8	1.3	1.2
152486h	2.0	?	1.9	1.2	1.2
152486i	2.2	?	2.5	1.4	1.6
152486j	2.5	?	2.3	1.4	1.8
152486k	2.7	?	3.0	1.8	1.9
152486-l	3.0	2.7	3.0	2.2	2.0
152486m	3.1	2.8	3.2	1.9	2.0
152486n	3.3	3.0	3.7	2.4	2.3
152486o	3.8	3.3	4.0	2.4	2.4
152486p	3.9	3.5	4.4	3.1	2.7
152486q	4.4	3.7	4.4	2.6	3.0
152486r	4.6	4.0	5.0	3.0	3.3
152486s	4.8	4.3	5.3	3.6	3.2
152486t	5.1	4.6	5.8	3.9	3.5
152486u	5.8	5.4	7.0	3.4	4.0
152486v	6.4	6.0	7.4	4.9	4.1
152486w	6.9	6.0	7.8	5.0	5.0
152486x	7.5	7.1	8.9	5.4	5.5
152486y	7.8	7.1	8.6	4.9	5.6
152486z	8.8	7.6	8.9	4.2	6.5
152486a'	8.5	7.9	9.8	5.1	6.1
152486b'	9.4	8.1	9.7	4.7	7.1
152486c'	8.8	8.1	9.7	5.6	6.3
152486d'	10.1	8.8	11.0	5.5	6.8
152486e'	10.1	9.2	11.3	5.0	7.0
152486f'	10.2	8.8	10.9	4.8	7.8
152486g'	10.7	9.7	11.0	4.8	7.4
152486h'	10.7	9.8	12.9	7.1	7.8
152486i'	11.4	10.0	11.5	5.8	8.3
152486j'	11.2	10.1	13.8	8.0	7.7
152486k'	11.9	10.6	12.1	7.6	9.0
152486-l'	12.7	11.0	13.8	7.4	9.6
152486m'	12.8	11.5	15.3	8.6	10.0
152486n'	13.9	12.3	15.0	8.6	10.0
152486o'	14.5	12.2	14.6	7.4	11.2
152486p'	14.9	13.2	14.4	6.2	11.6
152486q'	15.1	13.3	16.9	8.2	11.3
152486r'	15.3	13.8	17.5	10.7	11.3
152486s'	15.9	14.0	16.6	7.7	11.7
152486t'	16.4	14.0	16.8	8.9	12.6
152486u'	17.0	14.2	16.8	7.4	12.9
152486v'	17.5	15.0	18.0	8.7	12.6
152486w'	18.0	15.1	18.4	9.4	12.9

	brachial		hinge width	thick-ness
	length	valve length		
152486x'	19.0	16.6	19.9	11.0
152486y'	19.0	16.9	19.6	8.9
152486z'	19.4	17.3	19.6	10.3
152486a ¹	23.0	17.4	21.0	11.2
152486b ²	22.0	19.4	20.6	9.4
152486c ²	22.4	19.2	22.6	11.9
152486d ²	22.6	18.5	20.3	11.6
152486e ²	23.3	20.4	22.0	10.3
152486f ²	26.2	22.2	26.4	?
152486g ²	29.4	24.0	25.4	21.7
(holotype)				
USNM 703a				
152492	33.0	26.5?	30.6	15.0?

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation; Hess Formation; Cathedral Mountain Formation (Wedin Member); Road Canyon Formation.

LOCALITIES.—Bone Spring: AMNH 591. Hess: USNM 702d. Cathedral Mountain: AMNH 500, 500D, 500F, 500H, 500J, 500K, 500L, 500M, 500N, 500X, 504, 520; USNM 702, 702a, 702b, 702ent, 702-low, 702un, 703a¹, 703b, 703bs, 707q, 708, 708c, 708u, 712o, 713t, 721u, 724t, 726o, 726u, 726x, 727p, 729r, 731b. Wedin: USNM 700-l, 700x, 714w, 717e, 723v, 727p. Road Canyon: AMNH 503, 507; USNM 702c, 703, 703a, 719x, 721o, 724j, 726f, 726z, 726za.

DIAGNOSIS.—Rotund, strongly convex *Neophricadothyris* with weakly folded anterior commissure.

TYPES.—Holotype: USNM 152486g². Figured paratypes: USNM 152483; 152485a-s; 152486v,d', l',v'; 152490a,b; 154956; YPM 12370. Measured paratypes: USNM 152486a-f², 152492.

COMPARISON.—*Neophricadothyris bullata* is characterized by its rotund shape, with normally sub-elliptical outline and strong convexity, rounded beak ridges and interarea, strongly curved pedicle beak, by its weak muscle impressions, its low fold that affects only the anterior commissure, its shallow sulcus, and its small cardinal process. A few individuals attain large size, but most are below the average size of the majority of West Texas species of the genus. It most nearly resembles *N. crassibacca*, new species, differing only in its larger average and maximum size, and its lower convexity of both valves evident mainly in the lesser swelling of the two beak regions. It also resembles *N. cordata*, new species, of the Road Canyon

Formation, differing in its greater convexity, normally elliptical rather than subpentagonal outline, less distinct interarea, and less prominent concentric lamellae. It is smaller than *N. transversa* or *N. catatona*, both new, of the Wolfcampian, or *N. guadalupensis* (Shumard) of the Guadalupian. Its rounded interarea resembles that of *N. conara*, new species, from the Word Formation, but *N. bullata* is more strongly inflated, has a smaller, flatter cardinal process, weaker muscle marks, lower dental ridges, and a longer, more strongly curved pedicle beak.

In its greater convexity, larger average size, normally less transverse outline, and longer, thicker, more curved pedicle beak *N. bullata* resembles the South American Permian species that Kozłowski (1914) called *Reticularia lineata* Martin var. *perplexa* McChesney, and that Chronic (1953) called *Phricodothyris guadalupensis peruensis* Chronic. Absence of internal plates and septum distinguishes it from *P. septata* Chronic.

Neophricadothyris catatona, new species

PLATE 636: FIGURES 1-28

Large for genus, moderately strongly biconvex; outline moderately to strongly transverse, greatest width posterior to midlength; commissure rectimarginate in juveniles, very slightly uniplicate in adults; fold producing little or no elevation of brachial valve; sulcus beginning about 10 mm anterior to beak, flattening or slightly depressing midline of pedicle valve; concentric lamellae distinct, numbering about 10-15 per 5 mm near middle of either valve; each lamella bearing single row of fine, short, anteriorly slanted spines, apparently with double bases; growth laminae widely and irregularly spaced.

Pedicle valve moderately strongly convex, greatest swelling in umbonal region; beak moderately long, suberect to erect or slightly incurved; beak ridges blunt but distinct, outlining relatively distinct interarea; delthyrium high, wide, bounded on each side by low deltidial flanges on some specimens, no flange on many. Brachial valve less strongly and more evenly convex; beak short, curved, obstructing delthyrium only slightly; interarea rather low, flat or concave; notothyrium wide, moderately deep.

Pedicle valve interior with short, blunt, slightly hooked hinge teeth; dental ridges deep, slightly concave mesially, converging at apex of delthyrium, forming small obstruction in some specimens; muscle area fusiform, bisected by low ridge; adductor marks occupying most of area; diductor marks forming posteriorly open chevron at anterior of muscle area; floor of posterior of valve weakly striated radially.

Brachial valve interior with deep sockets, non-functional parts bridged or open, anterior ends of socket ridges swollen into small knobs; cardinal process large prominent knob, finely lamellate; helicophores attached along length of socket ridges, nearly parallel to valve floor, tapering at anterior; unbroken spiralia not observed; muscle area elliptical, bisected by low, broad ridge with shallow median groove; individual muscle marks not differentiated.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 720e					
152532a	5.3	?	5.5	2.7	?
152532b	7.0	6.4	8.5	6.0	5.7
152532c	9.0	?	11.4	6.3	?
152532d	11.7	?	16.0	10.0	?
152532e	15.0	?	19.5	9.2	?
152532f	19.1	?	20.8	11.0	?
152532g	22.0?	19.7	24.4	15.0?	15.0
152532h	22.3	18.8	25.8	18.5	13.6
152532i	24.0	20.2?	25.8	15.8	15.8
152532j	31.0?	26.3	35.9	25.2	19.7
152532k	29.0	?	36.4	17.9	?
152532l	30.0?	28.5?	39.0	24.0?	22.5
152532m	40.0?	?	53.0	31.0	?
152532n	42.2	?	56.0	32.3	?
USNM 705a					
152527a	7.8	?	8.7	4.6	?
152527b	15.0	?	17.0	9.7	?
152527c	36.1	?	46.8	31.9	?
USNM 711o					
152994a (holotype)	37.7	32.6	43.2	25.5?	24.7

STRATIGRAPHIC OCCURRENCE.—Lenox Hills Formation; Hueco Canyon Formation; Bone Spring Formation; Skinner Ranch Formation (Decie Ranch and Sullivan Peak members).

LOCALITIES.—Lenox Hills: USNM 709t. Hueco Canyon: USNM 725b. Bone Spring: AMNH 624, 632, 634, 696; USNM 725c, 728f. Decie Ranch: USNM 715c. Sullivan Peak: USNM 707d, 730k.

Skinner Ranch: USNM 705a, 711o, 716p, 720e, 726h, 739-l.

DIAGNOSIS.—Large, outline transverse, spines short, fine.

TYPES.—Holotype: USNM 152994a. Figured paratypes: USNM 152531a,b; 152532k,m; 154558a,b; 154559a. Measured paratypes: USNM 152527a-c; 152532a-n.

COMPARISON.—*Neophricadothyris catatona* is characterized by its large size and transverse outline. The only similar species in the Texas Permian is the Wolfcampian *N. transversa*, new species, from which *N. catatona* is distinguished by its larger maximum size, weaker uniplication, coarser and more widely spaced surface spines, and its normally more distinct pedicle interarea and beak ridges. Other species from the area are smaller and more elongate.

DISCUSSION.—The spine bases of this species are double, but the spines themselves are short and relatively fine, similar to those of *N. transversa*. Apparently the development of spines in this species is intermediate between the earlier fine spines of *N. transversa* and the longer spines, definitely double-barreled for most of their length, of later species such as Leonardian *N. bullata*, new species.

Neophricadothyris conara, new species

PLATE 638: FIGURES 34–54

Squamularia guadalupensis R. E. King [not Shumard], 1931: 118, pl. 40, fig. 8a–b [not others].

Somewhat small for genus, moderately strongly biconvex; outline subelliptical to indistinctly subpentagonal, widest near or posterior to midlength, length and width nearly equal; commissure rectimarginate in early stages, developing low, broadly rounded fold in adults; fold normally not elevating midline of brachial valve; sulcus flattening or depressing pedicle valve slightly for most of length; concentric lamellae moderately strong, numbering 5–10 per 5 mm near center of either valve, each bearing two rows of double-barreled, thorny spines near midline, one row distally; growth laminae weak, widely spaced.

Pedicle valve moderately strongly convex; beak bluntly pointed, moderately long, strongly curved, erect to slightly incurved, no apical plate; inter-

area indistinct, bounded by rounded beak ridges; delthyrium long, wedge-shaped, flanked by low to moderately high flanges, slanting medially in some specimens to constrict delthyrium slightly at apex, normally nearly perpendicular to interarea and providing no constriction. Brachial valve less strongly convex, greatest swelling in umbonal region; beak rather long, bluntly pointed, curved, extending well into delthyrium; interarea moderately high, flat to slightly concave, divided by wide, deep notothyrium.

Pedicle valve interior with slender, sharp, slightly hooked hinge teeth; dental ridges moderately deep, rounded, not forming obstruction at apex of delthyrium; muscle area narrow, elongate, normally bisected by low, flat or sharp ridge; adductor muscle marks narrow, fusiform, median; diductor marks forming long, posteriorly open chevron against anterior sides of adductor area; posterior part of floor of valve weakly striated radially.

Brachial valve interior with deep narrow sockets; socket ridges slightly swollen at anterior to form denticles; cardinal process unusually large for genus, forming hemispherical lamellate knob in apex of notothyrium; helicophore plates joined to socket ridges, nearly parallel to sides of valve, thus converging slightly dorsally, becoming long, slender, slightly convergent to near center of shell cavity, then slightly divergent farther to anterior; spiralia not observed; shell shape and orientation of helicophores indicate posteriorly divergent axes of coiling; muscle area irregularly elliptical with indistinct anterior termination, bisected by low, broad in some specimens, ridge; posterior adductor muscle marks small, subelliptical, one on each side of midline; anterior adductor muscle marks less deeply impressed, somewhat larger; posterior part of valve floor weakly striated radially.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member); Word Formation (China Tank, Willis Ranch, Appel Ranch members, and lens between the last two).

LOCALITIES.—Getaway: AMNH 496, 600; USNM 728, 730, 732. China Tank: USNM 706c, 726r, 733q. Willis Ranch: USNM 706. Lens: USNM 706b. Appel Ranch: USNM 715i, 719z, 722t, 726t, 731z.

DIAGNOSIS.—Relatively small *Neophricadothyris* with narrow pedicle valve muscle field.

TYPES.—Holotype: USNM 152534p. Figured

MEASUREMENTS (in mm).—

	brachial valve			hinge	thick-
	length	length	width	width	ness
USNM 706b					
152534a	3.3	2.9	3.3	2.3	2.3
152534b	3.6	3.3	3.6	2.6	3.0
152534c	4.2	?	4.8	2.7	?
152534d	6.2	5.6	6.9	4.0	4.6
152534e	6.7	6.0	6.7	4.4	4.2
152534f	6.8	5.8	6.5	3.4	4.5
152534g	8.5	?	8.9	5.7	?
152534h	9.3	?	9.8	5.9	?
152534i	10.5	?	11.0?	5.9	?
152534j	11.8	?	12.5	8.2	?
152534k	14.0	?	15.0	9.0	?
152534l	14.6	?	15.5?	8.8	?
152534m	16.7	?	17.6	9.2	?
152534n	18.2	?	19.4	9.8	?
152534o	20.5	?	20.5	10.5	?
152534p (holotype)	21.4	19.0	21.3	11.0	15.7
152534q	24.5	?	21.2?	10.0	?
152534r	25.7	?	27.0?	12.0?	?
152534s	?	3.5	4.0	2.5?	?
152534t	?	4.6	5.5	3.4?	?
152534u	?	6.9	7.4	4.4	?
152534v	?	8.5	9.1	5.4	?
152534w	?	8.5	10.0	6.0	?
152534x	?	13.7	16.0	8.9	?
152534y	?	16.4	18.4	10.3	?
152534z	?	19.8	23.3	15.2	?
152534a'	?	20.3	24.0	15.7	?

paratypes: USNM 152534d,o,q,r,y,z; 154562a. Measured paratypes: USNM 152534a-o, q-a'. Unfigured paratypes: USNM 154562b.

COMPARISON.—*Neophricadothyris conara* is characterized by its rather small size, moderate biconvexity, low anterior fold that is not expressed as a fastigium on the brachial valve, relatively widely spaced concentric lamellae, and internally by its narrow pedicle muscle area and its large, knoblike cardinal process. It differs from *N. cordata*, new species, in its less pronouncedly pentagonal outline, lower convexity, lower fold, larger cardinal process, and less distinct concentric lamellae. It is distinguished from *N. crassibacca*, new species, which also occurs stratigraphically near it, in its less strong convexity, especially in the pedicle beak region, less strongly curved pedicle beak, more widely spaced concentric lamellae, and its larger cardinal process. It is much smaller than *N. guadalupensis* (Shumard), and much less transverse than

N. transversa, new species, or *N. catatona*, new species. It is somewhat similar to the Leonardian species *N. bullata*, new species, but is less strongly convex, attains a smaller size, has a shorter and less curved pedicle beak, deeper dental ridges, and a more prominent cardinal process.

Neophricadothyris cordata, new species

PLATE 637: FIGURES 1–48; PLATE 649: FIGURES 27–30

Average size for genus, moderately to strongly biconvex; outline subpentagonal, length and width nearly equal, greatest width near posterior of brachial valve; commissure weakly uniplicate, with low rounded fold expressed on brachial valve as low fastigium or as slight sinuosity of concentric lamellae; sulcus shallow, beginning near pedicle beak, producing slight emargination at anterior of most specimens; concentric lamellae distinct, numbering about 5 per 5 mm near middle of either valve of adult, each with 1 or 2 rows of double barreled, thorny spines.

Pedicle valve moderately to strongly convex; beak broad, rather thick on many specimens, strongly curved but rather short; interarea slightly rounded, bounded by blunt, indistinct beak ridges; delthyrium open, broadly wedge-shaped, bounded on each side by low deltidial flange. Brachial valve less strongly convex longitudinally, somewhat more strongly convex transversely; beak short, blunt, moderately curved, extending into space of delthyrium; interarea low, flat, bisected by broadly wedge-shaped notothyrium.

Pedicle valve interior with short, rather sharp teeth; dental ridges moderately deep, thick, meeting at apex of delthyrium to form small platform in some specimens; muscle area deeply impressed in posterior, shallow at anterior; adductor marks each semielliptical, divided at posterior by low rounded ridge, at anterior by broad shallow depression; diductor marks narrow, converging anteriorly to form broad chevron just anterior to adductor marks, but not meeting one another, separated by continuation of median shallow depression.

Brachial valve interior with deep hinge sockets; cardinal process flat to slightly swollen, finely and vertically lamellate; helicophores broad, slightly concave, nearly parallel to median plane of shell, becoming slender, long, each with short, posteriorly-

pointing jugal process near juncture with spirillum; spiralia coiled dorsoventrally, with axes diverging toward posterior, each with at least 9 coils in adults; muscle area narrow, elongate, with narrowly divergent sides; posterior adductor marks small, anteriorly divergent; anterior adductor marks larger, one on each side of median line, some specimens with indistinct median depression or elevation; posterior part of valve floor lateral to muscle area weakly striated radially, striae fading anteriorly.

MEASUREMENTS (in mm).—

	brachial valve			hinge	thick-
	length	length	width	width	ness
USNM 707e					
152507a	2.6	2.2	2.6	1.6	1.7
152507b	3.5	3.2	3.5	2.4	2.1
152507c	4.8	4.7	6.0	3.9	3.5
152507d	6.0	5.6	7.0	3.4	4.1
152507e	12.0	11.0	12.7	5.5	8.4
152507f	18.1	15.5	18.4	10.6	10.7
152507g	25.6	22.0	26.9	11.0	19.0
USNM 703d					
152505a	5.2	4.9	5.9	3.1	3.7
152505b	9.4	8.5	7.8	4.2	5.6
152505c	13.1	12.0	12.6	5.9	8.7
152505d	16.5	15.5	17.6	8.9	11.6
152505e	18.9	16.4	18.0	7.0	13.0
152505f	20.6	17.8	21.1	12.6	13.7
152505g	22.5	20.0	19.6	11.3	15.1
152505h	22.4	19.0	22.4	11.8	15.1
152505i	23.8	19.8	22.4	13.3	16.9
152505j	24.7	19.8	24.5	12.8	17.7
(holotype)					
152505k	26.6	22.6	26.8	14.0	17.5

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation; Cibolo Formation.

LOCALITIES.—Road Canyon: USNM 703d, 707e, 710u, 721r, 721z, 732j, 736x. Cibolo: 738g, 738-l.

DIAGNOSIS.—Subpentagonal *Neophricadothyris* with low but definite fold on dorsal valve and strongly thickened dental ridges.

TYPES.—Holotype: USNM 152505j. Figured paratypes: USNM 152505a,b,i-k,m-r; 152506a-e; 154959. Measured paratypes: USNM 152505a-i,k; 152507a-g.

COMPARISON.—*Neophricadothyris cordata* is characterized by its moderately strong convexity, low but definite fastigium, normally subpentagonal outline, rather widely spaced concentric lamellae, thickened dental ridges, and crural plates nearly

parallel to median plane of shell. It most nearly resembles *N. bullata*, new species, from the Leonardian, and *N. crassibacca*, new species, from the Road Canyon Formation, differing in its more pronouncedly pentagonal outline, shorter and less inflated pedicle beak, stronger and more widely spaced concentric lamellae, deeper and more thickened dental ridges, and higher fastigium. It is narrower and less strongly folded than the Wolfcampian species *N. transversa* and *N. catatona*, both new, and is smaller, more strongly folded, less ovate, and has a more curved pedicle beak than the Guadalupian *N. guadalupensis* (Shumard). It differs from the Word species *N. conara*, new species, in its pentagonal outline, somewhat more strongly convex pedicle valve, higher fold, and thicker dental ridges.

Neophricadothyris crassibacca, new species

PLATE 638: FIGURES 1-33

Smaller than normal for genus, strongly biconvex; outline subpentagonal to subelliptical, slightly elongate to slightly transverse, greatest width near midlength; commissure very weakly uniplicate; anterior fold producing low fastigium beginning 8-12 mm anterior to beak; sulcus shallow, normally visible beginning about 5 mm anterior to beak; concentric lamellae moderately strong, numbering 10-15 per 5 mm, each normally with 1 row of double-barreled spines of unknown length and shape; growth laminae irregularly spaced, producing local crowding of concentric lamellae.

Pedicle valve strongly convex, greatest swelling in umbonal region; beak very thick, blunt, strongly curved, erect to slightly incurved; interarea curved, narrow, poorly outlined by indistinct beak ridges; delthyrium nearly equilaterally wedge-shaped, bounded laterally by low deltidial flanges, leaving delthyrium entirely open. Brachial valve strongly convex for genus, less over delthyrium, partly blocking it in some specimens; interarea moderately high, interrupted by deep broad notothyrium, flat to slightly concave; each side of notothyrium bounded by low flange.

Pedicle valve interior with short, pointed, slightly hooked teeth; dental ridges very low, meeting posterior to apex of delthyrium, not forming obstruction there; muscle area weakly impressed,

elongate subelliptical, bisected by low ridge; adductor marks occupying most of area, one semi-ellipse on each side of midline; diductor marks weaker, forming posteriorly open chevron around anterior edges of adductor marks.

Brachial valve interior with large hinge sockets, socket ridges with toothlike swellings at anterior; cardinal process small, knoblike, finely lamellate; helicophores broad, nearly parallel to floor of valve, apically convergent, anterior course long, slender, giving rise to spiralia with up to 12 coils; axes of coiling divergent toward posterior; muscle area narrow, elongate, sides slightly divergent, bisected by low ridge; impressions too weak to differentiate separate muscle marks.

STRATIGRAPHIC OCCURRENCE.—Road Canyon Formation.

LOCALITIES.—AMNH 503; USNM 703a, 703c, 706f, 710z, 716x, 716xa, 716z, 719x, 720d, 721j, 721o, 721r, 721s, 721t, 721x, 722e, 724a, 724b, 724c, 724j, 726d.

DIAGNOSIS.—Small, strongly biconvex, *Neophricadothyris* with crowded concentric lamellae, each with one row of spines.

TYPES.—Holotype: USNM 152995z. Figured paratypes: USNM 152541a-f; 152995g,n,t; 154561a. Measured paratypes: USNM 152542a-k, 152995a-y.

COMPARISON.—*Neophricadothyris crassibacca* is characterized by its relatively small size, curved but recognizably pentagonal or elliptical outline, crowded concentric lamellae each normally with only one row of spines throughout, and especially by its great biconvexity that gives the shell a globose shape and produces a very thick pedicle beak and beak region. It most nearly resembles *N. bullata*, new species, and indeed might be considered a subspecies of it except that the thickened pedicle beak and more convex brachial valve are consistent features that distinguish all individuals. It differs from *N. bullata* in both these characters and in its smaller average and maximum size, and its somewhat more closely crowded concentric lamellae. It also resembles the subpentagonal species *N. cordata*, new species, but differs in its smaller size, less definitely pentagonal outline, more closely spaced concentric lamellae, its thicker, more convex pedicle beak, and its more convex brachial valve. It is much smaller than *N. guadalupensis* (Shumard), and has a thicker, more strongly curved pedicle beak, more convex bra-

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 719x					
152542a	2.1	1.9	2.2	1.5	1.5
152542b	11.9	10.6	12.9	7.9	8.3
152542c	11.9	10.8	12.3	5.9	8.9
152542d	12.6	11.2	14.5	7.1	8.7
152542e	12.8	11.3	14.2	7.4	9.3
152542f	13.7	11.8	14.3	7.2	9.8
152542g	14.5	12.7	15.9	7.8	11.6
152542h	17.7	15.5	16.3	8.1	12.9
152542i	20.4	17.2	20.0	9.5	15.6
152542j	23.7	21.0	21.7	10.6	17.2
152542k	25.0	?	24.6	12.2	?
USNM 721o					
152995a	2.8	2.6	3.0	1.6	1.8
152995b	2.9	2.7	3.2	2.4	2.5
152995c	3.7	3.7	4.6	2.5	2.8
152995d	4.9	4.6	6.3	3.4	3.7
152995e	5.8	5.3	6.5	3.0	4.2
152995f	6.1	5.6	7.4	4.2	4.6
152995g	6.6	6.0	7.5	4.0	4.7
152995h	7.0	6.1	7.6	5.2	5.4
152995i	8.0	7.0	8.2	4.9	5.5
152995j	8.5	7.9	8.8	5.0	6.8
152995k	8.0	7.7	9.5	5.6	5.9
152995-l	8.7	8.1	9.9	5.4	7.0
152995m	9.1	8.0	10.4	5.9	6.9
152995n	9.4	8.5	10.3	5.9	7.4
152995o	10.4	8.6	9.9	5.9	6.9
152995p	11.7	10.5	11.5	6.5	8.6
152995q	11.7	10.8	14.0	7.7	8.9
152995r	12.7	10.7	13.8	7.5	9.8
152995s	13.5	11.4	13.3	7.4	10.9
152995t	14.2	12.6	15.0	8.5	11.0
152995u	14.1	12.1	15.0	7.9	11.7
152995v	15.2	12.6	14.5	8.6	10.8
152995w	14.8	12.5	15.4	7.5	11.6
152995x	15.2	13.5	15.9	7.8	12.0
152995y	16.5	14.4	17.2	7.8	13.3
152995z	17.9	15.0	17.0	9.0	14.4
(holotype)					

chial valve, lower deltidial flanges, and much lower dental ridges. This species is fairly close stratigraphically to *N. conara*, new species, of the Word Formation, and attains about the same maximum size. It differs from *N. conara* in its greater convexity with thick and more strongly curved pedicle beak, its more closely spaced concentric ornamentation, lower deltidial flanges, and, internally, in its much lower dental ridges. It is not sufficiently similar to the large transverse Wolfcampian species

N. transversa or *N. catatona*, both new, to require close comparison.

***Neophricadothyris transversa*, new species**

PLATE 639: FIGURES 1-28

Large for genus, moderately to strongly biconvex; outline moderately to strongly transverse, widest near midlength or posterior to midlength of brachial valve; commissure rectimarginate in juveniles, becoming uniplicate with growth; fold producing definite fastigium; sulcus broad, shallow, becoming rather deep for genus at anterior of some larger specimens; concentric lamellae distinct but not prominent, numbering about 5-10 per 5 mm near middle of either valve, each bearing at edge one row of short, anteriorly pointing spines, apparently biramous; growth laminae producing crowding of concentric ornament, widely and irregularly spaced.

Pedicle valve moderately convex transversely and longitudinally; beak bluntly pointed, rather thick, curved, erect or slightly incurved; beak ridges rounded; interarea poorly defined; delthyrium large, wedge-shaped, bounded on each side by low flange, each nearly perpendicular to shell surface. Brachial valve slightly less strongly convex; beak broad, blunt, extending into or over delthyrial opening and about half blocking it; interarea low, relatively narrow, bisected by wide, deep notothyrium.

Pedicle valve interior with short sharp teeth; dental ridges moderately deep, somewhat thickened in some specimens; muscle area elongate subelliptical, bisected by low thin myophragm, individual muscle marks not observed.

Brachial valve interior with large deep hinge sockets, socket ridges with knobs at anterior ends; cardinal process large, with several small lobes, finely lamellate; helicophores broad, slightly concave, roughly parallel to shell wall, tapering anteriorly to form long, slender lamellae; spiralia ribbonlike, with about 12 coils, axes of coiling diverging posteriorly; muscle area narrow, with straight, slightly diverging sides, low thin median ridge; individual muscle marks not observed.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites*-bearing Shale Member); Neal Ranch Formation; Lenox Hills Formation.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 701a ³					
152511a	1.5	?	1.8	1.0	?
152511b	3.4	3.3	3.9	2.1	2.4
152511c	4.2	4.0	4.0	2.7	3.3
152511d	6.0	5.7	7.4	4.6	4.2
152511e	7.5	6.2	7.6	4.0	4.7
152511f	9.0	7.7	9.7	4.6	5.6
152511g	10.8	9.8	12.0	5.8	7.0
USNM 701					
152515	5.8	5.5	6.0	3.5	4.0
USNM 701c					
152513a	6.8	6.0	7.4	3.3	4.6
152513b	7.0	6.4	7.5	5.2	4.9
152513c	8.7	8.9	9.0	4.8	5.7
152513d	12.7	11.3	13.8	8.7	8.1
152513e	13.4	12.7	18.4	8.0	9.6
152513f	14.5	12.1	14.5	7.0	9.0
152513g	17.8	16.3	20.4	11.0	13.2
152513h	18.7	16.4	20.5	11.3	12.9
152513i	19.8	17.2	20.4	10.5	14.3
152513j	28.6	26.4	33.3	17.0?	17.2
152513k	33.6	28.4	41.3	21.6	22.8
(holotype)					
USNM 701a					
152545a	12.0	10.5	13.7	7.4	7.5
152545b	14.7	13.0?	15.0	8.0	9.5
152545c	23.0	20.3	20.6	12.7	18.6
152545d	25.3	20.0	26.7	12.7	16.7

LOCALITIES.—*Uddenites*: USNM 701e, 701f, 701p, 701q, 701x. Neal Ranch: USNM 701, 701a, 701a³, 701c, 701d, 701h, 701k, 701-l, 712z, 715b, 721g, 727e. Lenox Hills: USNM 707m, 715, 723d, 737u.

DIAGNOSIS.—Large, transverse *Neophricadothyris* with strong anterior uniplication and widely spaced lamellae.

TYPES.—Holotype: USNM 152513k. Figured paratypes: USNM 152509a,b; 152513c,h,i; 152514a,b. Measured paratypes: USNM 152511a-g, 152513a-j, 152515, 152545a-d.

COMPARISON.—*Neophricadothyris transversa* is characterized by its large size, transverse outline, strong uniplication of the anterior of large specimens, rather widely spaced concentric lamellae, and its numerous fine, short surface spines that point anteriorly. It most nearly resembles *N. catatona*, new species, in size and outline, differing in its smaller maximum size, strong fold and sulcus, and finer surface spines. Its transverse outline distinguishes it from most other Texas Permian

species including *N. guadalupensis* (Shumard), and its large size distinguishes it also from the new species *N. bullata*, *N. cordata*, *N. conara*, and *N. crassibecca*.

DISCUSSION.—Our material does not display the structure of the surface spines of this species in sufficient detail to determine whether they are single- or double-based. Their similarity to the double-based spines of *N. catatona* suggests that they probably also are double. The anterior orientation and fineness of the spines of *N. catatona* and *N. transversa* distinguish them from the coarser and longer spines of all subsequent species in the area. There also is no evidence that spines of these two species bear tiny barbs along their sides. But preservation of the barbs is rare in any species; they occur only on about a half-dozen specimens in the very abundant *N. bullata*, new species.

Neophricadothyris species 1

PLATE 638: FIGURES 55–59

This is one of two large but quite different specimens of *Neophricadothyris* from the Cathedral Mountain Formation at USNM 702. The specimen is very large and robust with a fairly convex pedicle valve but a swollen brachial valve with a fairly well developed fold at the anterior. The sulcus of the opposite valve is fairly deep but produces a prominent tongue on the anterior. The umbonal and median regions of the brachial valve are longitudinally swollen to produce a fastigium. The beak is long and the delthyrium is margined by prominent vertical lateral plates.

MEASUREMENTS (in mm).—Figured specimen USNM 153473: length 36.2, brachial valve length 29.3, hinge width 25.3, maximum width at midvalve 39.0, thickness 25.2.

DISCUSSION.—No specimens of *N. bullata*, new species, appear to attain the size of this species. *Neophricadothyris catatona*, new species, is large, but it is wider and does not have the strong fold and sulcus of *N. species 1*. The specimen is unique but might be a gigantic specimen of *N. bullata*.

Neophricadothyris species 2

PLATE 639: FIGURES 29–34

Large, transversely elliptical, with narrowly

rounded sides and a low narrow fold and fastigium on the brachial valve and a short but deep sulcus on the pedicle valve. Tongue fairly long and narrow. Interarea long and strongly apsacline.

MEASUREMENTS (in mm).—Figured specimen 153474 from USNM 702: length 28.2, brachial valve length 26.1, hinge width 30.3, maximum width at midvalve 42.0, thickness 29.5?

DISCUSSION.—Although this specimen occurs with the preceding, the two are entirely unlike in outline and profile. Furthermore this specimen is unlike *N. catatona*, new species, which also is large and wide, because it is more narrowly elliptical and that species does not have the narrow fold of the Cathedral Mountain form.

Neophricadothyris? species undetermined

PLATE 636: FIGURES 29–45

Four separate valves (USNM 154560a-d) from the Cathedral Mountain Formation at USNM 721u may belong to a species of *Neophricadothyris*. They cannot be identified certainly, but are illustrated to record presence of a flat species that differs from *N. bullata* which is the common form at this locality.

Genus *Astegosia* Cooper and Grant, 1969

Astegosia Cooper and Grant, 1969:16.

Large, subcircular, subpentagonal to roundly elliptical in outline; strongly inequivalved, pedicle valve much deeper. Hinge narrower than maximum width. Anterior commissure rectimarginate in young but broadly uniplicate in old forms; fold not well developed but shallow sulcus present in many specimens. Umbonal region swollen. Interarea narrow, divided by wide delthyrium; not restricted by pseudodeltidium. Beak small, incurved, hooked over delthyrium. No deltidial flanges. Surface with fine lamellae bearing small single-barrelled spines.

Pedicle valve interior with small teeth bearing laterally directed hook at free end; dental ridges crescentic in section, concave inward and extending to apex. Apical plate growing anteriorly along lower free side of dental ridges, forming shelf well below delthyrial edges. Muscle field elongate, rhomboidal in outline, diductor scars elongate,

semicrescent in shape, anteriorly surrounding small adductor scars. No distinct pallial marks.

Brachial valve with shallow sockets formed by flattish fulcral plate and strong but narrow socket ridges; proximal disused part of socket covered by thin roofing plates. Helicophore plates broad, nearly horizontal, supporting spire coiling posterolaterally toward the cardinal extremities. Adductor scars elongate, separated by low myophragm (often double). Pallial marks radial when preserved. Cardinal process longitudinally roughened boss in apex.

TYPE-SPECIES.—*Squamularia guadalupensis subquadrata* Girty (1909, pl. 14: figs. 2,3).

DIAGNOSTIC COMPARISON.—Differs from *Neophricadothyris* in not having a pseudodeltidium but having in its place a shelflike apical plate. It differs from *Anomaloria* in having a cardinal process and in not possessing the notothyrial flanges characteristic of that genus.

DISCUSSION.—The most interesting and significant detail of this genus centers about the delthyrial region of the pedicle valve. The apical plate starts at the apex as a triangular callosity which is concentrically marked. There it is sessile, but as it grows forward it is attached to the free edge of the dental ridges. Medially it is united and in old shells forms a fairly long shelf. This is somewhat like the apical plate in *Hemithiris*, which serves as a sort of pedicle collar. No scar of pedicle attachment is present and it is possible that this callosity is the seat of its attachment.

The apical plate is variable in its growth, some specimens of small size having the plate well advanced but others of huge proportions having it only in an incipient stage. Normally it is largest in the largest specimens. The muscle field of the pedicle valve is quite variable and occupies different positions in the valve as it migrates anteriorly with advancing age and size. In the young it is in the umbonal cavity but it migrates forward and in old shells is near midvalve. The anteriorly advancing growth track is covered posteriorly by callus that obliterates all details. The diductors form a posteriorly truncated crescent and partially surround the adductor scars which are posterior in position and heart-shaped in outline. They are divided posteriorly by a low ridge of callus.

The cardinalia of the brachial valve are like those of *Neophricadothyris* with narrow socket

ridges defining sockets that are floored by a fulcral plate and roofed by cover plates in the proximal disused part. The hinge plate is different in the fact that it is attached almost horizontally to the dorsad edge of the socket ridge. The spires extend strongly obliquely toward the cardinal extremity.

Inasmuch as it is clear that two genera occur in Shumard's species and especially in Girty's interpretation of it, some decision had to be made concerning Shumard's name. We cannot accept Girty's interpretation of the species, because he has two genera mixed in his illustrated lots, as indicated in our synonymy. Some points in Shumard's description make clear what he had in mind. He states that his species is large, "ovate," and that the pedicle beak is "prolonged, rather acute." The elongation of the beak is a feature of most of the specimens that have no pseudodeltidium and clearly belong to *Astegosia*. Girty's varieties *Squamularia guadalupensis ovalis* and *subquadrata*, in having elongate beaks, ovate form, and large size, accord with these details. We believe that his variety *ovalis* is synonymous with *A. subquadrata*. The median depression in the pedicle valves of the specimens of his variety *subquadrata* is of fairly common occurrence on the large specimens. We have selected as lectotype for Girty's species an elongate specimen, with long beak and without a sulcus on the pedicle valve. This leaves Shumard's species unplaced but, in view of the fact that it never was illustrated and the specimens were lost even before Girty had a chance to study them, we see no way that it can be recognized.

Two forms are conspicuous among our specimens. One of these is large but has the beak fairly strongly incurved, to about the same degree as that of *Anomaloria*. This makes separation of the two difficult. With unsilicified specimens the beaks have to be needled free to see whether cover plates are present or absent. The specimens with strongly incurved beaks are anteriorly flattened but not markedly sulcate. The other group with elongate more erect beaks can be divided into two kinds: one transverse or with length and width approximately equal; the other definitely elongate. In adults and old specimens both these types are slightly to fairly strongly sulcate. Nonsulcate types with elongated beaks are distinctly rare. We believe, that they are closely allied, however, to the sulcate forms.

Astegosia subquadrata (Girty)

PLATE 641: FIGURES 1-57; PLATE 642: FIGURES 1-20;

PLATE 649: FIGURES 25-26

Squamularia guadalupensis (Shumard) var. *subquadrata* Girty, 1909:369, pl. 14: figs. 2-3a.*Squamularia guadalupensis* (Shumard) var. *ovalis* Girty, 1909:369, pl. 14: figs. 1-1a.*Astegosia subquadrata* (Girty) Cooper and Grant, 1969:16.Not *Spirifer guadalupensis* Shumard, 1860:391.Not *Squamularia guadalupensis* (Shumard) of Girty, 1909:367, pl. 14: figs. 4-11a [= *Anomaloria anomala* Cooper and Grant, 1969]; not of R. E. King, 1931:118, pl. 40: figs. 6-8 [fig. 6, 7 = *Neophricadothyris bullata*, new species; fig. 8 = *N. conara*, new species]; not of McKee, 1938:252, pl. 48: figs. 1-3.Not *Reticularia guadalupensis* (Shumard) of Tschernyschew and Stepanov, 1916:45, pl. 9: fig. 8.Not *Phricadothyris guadalupensis peruensis* Chronic, 1953:63, pl. 10: fig. 1a-6.

Shell attaining large size, moderately strongly biconvex; outline elliptical to subovate, elongate or transverse, greatest width near midlength; commissure rectimarginate to weakly uniplicate; fold not producing plica in brachial valve; sulcus producing slight flattening or depression in pedicle valve; concentric lamellae distinct, rather closely spaced, numbering about 10-15 per 5 mm near middle of adult valves, each lamella bearing 1 or 2 rows of very thin, double-barreled spines of unknown length.

Pedicle valve moderately convex transversely and longitudinally; beak proportionately rather short for genus, moderately to strongly curved, normally erect but rarely recurved; interarea flat, bounded by distinct but not sharp beak ridges; delthyrium deeply wedge-shaped, open. Brachial valve slightly less strongly convex, convexity rather even; beak short, blunt, curved, extending into lower part of delthyrium; interarea rather high for genus, gently concave, narrow; notothyrium deep for genus, broad, with slightly bowed sides.

Pedicle valve interior with proportionately short broad teeth, some slightly hooked at end; dental ridges deep, somewhat thickened immediately under interarea, thinning toward valve floor, converging to form V-shaped platform in apex of delthyrium; muscle area elongate, fusiform, rather deeply impressed, bisected by low ridge or shallow groove; adductor marks large, semielliptical; diductor marks narrow, elongate, lying anterior,

bounding adductors as posteriorly divergent chevron; posterior part of valve thickened and weakly striated radially.

Brachial valve interior with large deep hinge sockets; cardinal process flatly convex, finely lamellate, rather broad; hinge plates narrow and strongly concave for genus, parts forming socket ridges nearly perpendicular to valve floor, dorsal edges nearly parallel to valve floor; helicophores extending anteriorly from socket ridges; spiralia with axes diverging posteriorly, with as many as 17 coils in adults; muscle area bisected by low broad median ridge, with shallow groove along crest in some specimens; posterior adductor muscle marks elongate, one on each side of median ridge; anterior adductor marks bounding them in shape of posteriorly open chevron; median ridge and groove continuing nearly to anterior margin of some valves.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USGS 2926 (green)					
118595a	5.9	5.4	5.7	2.7	4.5
118595b	8.7	7.8	8.8	3.5	6.0
118595c	10.0	9.3	11.0	4.5	7.2
118595d	10.9	9.6	11.0	5.1	8.0
118595e	16.1	14.8	16.7	7.8	10.8
118595f	21.5	19.8	21.9	10.9	15.7
118595g	24.5	21.7	25.4	11.6	18.1
118596a	27.8	23.0	28.3	13.2	19.5
(lectotype)					
118596b	30.1	25.0	27.6	12.9	22.4
118597	39.6	32.9	36.0?	20.0	28.5?
USNM 750					
152481a	6.4	6.2	5.8	2.9	4.4
152481b	7.3	6.9	7.2	3.8	4.9
152481c	7.8	7.5	8.9	c.4	5.1
152481d	8.3	8.0	8.7	c.4	6.5
152481e	8.8?	?	10.2	4.6	5.9
152481f	9.6	7.8?	9.0	4.1	5.9
152481g	9.5?	9.0	10.4	5.4	6.4
152481h	9.8?	9.0	9.4	6.0	6.5
152481i	11.4	10.6	11.3	6.9	7.6
152481j	12.5?	11.7	12.5?	6.5	8.1
152481k	13.0?	12.3	14.6	7.1	8.6
152481-l	15.5?	14.7	15.0	9.1	9.9
152481m	16.0	14.2	14.6	7.0	10.3
152481n	16.4	15.5	17.0?	9.0	10.1
152481o	17.0	16.4	16.3	9.8	13.0
152481p	17.1	15.7	16.6	7.9	11.4
152481q	17.6	16.0	16.0	7.8	11.0
152481r	18.0	16.5	19.0	10.5	11.4

	<i>brachial</i>						<i>brachial</i>				
	<i>length</i>	<i>valve length</i>	<i>width</i>	<i>hinge width</i>	<i>thickness</i>		<i>length</i>	<i>valve length</i>	<i>width</i>	<i>hinge width</i>	<i>thickness</i>
152481s	19.6	18.0	18.4	9.8	13.7	152996q	13.5	12.4	15.4	7.9	8.1
152481t	19.0	17.8	20.0	11.7	13.5	152996r	13.5	11.5	14.6	7.6	8.7
152481u	20.6	18.3	21.4	11.8	16.6	152996s	15.2	13.4	17.4	7.7	9.1
152481v	22.5	21.0?	22.6	12.0?	16.3	152996t	15.3	13.5	14.9	7.0	9.7
152481w	25.0	21.9	23.5	11.0?	18.7	152996u	16.8	15.7	18.0	10.0	11.5
152481x	26.2	23.2	24.9	11.4	19.0	152996v	16.3	14.5	18.1	8.0	8.4
152481y	27.5?	?	23.6	8.5?	19.9	152996w	18.1	16.2	17.1	10.0	11.1
152481z	28.5	24.0	25.6	11.7	20.0	152996x	18.3?	16.5	20.1	9.9	12.4
152481a'	29.3	27.3	27.9	14.3	20.1	152996y	18.4	15.8	20.6	9.8*	13.0
152481b'	31.5?	?	29.7	16.7	22.0?	152996z	19.4	16.5	19.4	9.9	11.9
152481c'	37.9	33.9	34.0	17.4	26.4	152996a'	22.3	21.0	23.0	12.0	14.4
USNM 737a						152996b'	23.6	21.3	25.0	11.5	15.5
152480a	6.0	5.9	7.4	4.0	4.8	152996c'	25.4	?	26.5	11.6	?
152480b	8.2	7.8	9.9	4.7	5.6	152996d'	25.0	22.0	24.4	13.6	14.4
152480c	9.0	8.2	9.9	5.7	6.3	152996e'	25.4	?	26.5	15.0	?
152480d	10.0	9.4	10.5	4.5	6.6	152996f'	25.4	22.3	25.2	11.2	16.0
152480e	11.2	10.2	11.3	6.3	7.3	152996g'	26.1	?	23.5	13.3	?
152480f	11.4	10.3	11.9	5.5	7.7	152996h'	29.3	?	28.8	16.4	?
152480g	11.5	10.7	13.1	6.3	8.0	152996i'	31.0	?	28.3	c.16.0	?
152480h	12.3	11.1	13.7	5.7	8.7	152996j'	30.4	?	31.9	17.2	?
152480i	12.6	12.0	14.5	6.7	7.8	152996k'	32.2	?	29.4	17.0	?
152480j	15.5	14.5	17.5	7.8	10.5	152996l'	33.7?	?	32.2	17.5	?
152480k	16.3	15.0	17.4	9.6	9.6	152996m'	34.6	?	31.9	18.4	?
152480l	17.7	15.9	19.3	7.5	12.4	152996n'	36.0	?	36.0	15.8	?
152480m	18.7	16.9	20.0	10.0	13.3	152996o'	38.0	?	35.9	20.5	?
152480n	22.8	20.4	22.9	11.0	17.6	152996p'	?	13.0	14.6	8.8	?
152480o	24.4	21.9	22.3	9.8	15.0	152996q'	?	20.6	29.0	15.8	?
152480p	25.5?	24.1?	26.9	12.9	18.2	152996r'	?	21.8	24.5	12.3	?
152480q	26.2	21.2	27.5?	12.0	15.4	152996s'	?	24.6	28.4	16.4	?
152480r	26.6	25.5	26.4	11.9	16.7	152996t'	?	27.7	30.8	16.6	?
152480s	27.0?	24.0?	26.9	14.6	18.3	USNM 738					
152480t	29.1	27.5?	30.0	15.0	19.5	152475a	5.9	5.4	6.3	3.0	3.9
152480u	29.0	27.4	27.0	10.9	17.2	152475b	6.9	6.0	7.0	3.7	4.5
152480v	29.4	26.7	25.4	13.0	19.6	152475c	7.4	?	9.0	4.5	?
152480w	30.4	25.0	33.5	c.16.0	21.8	152475d	8.8	8.2	10.5	4.4	6.0
152480x	31.0	28.8?	32.4	14.0	20.0	152475e	9.7	8.8	10.8	5.1	6.1
152480y	32.4	30.4	29.0?	14.5	21.5	152475f	10.5	?	13.0	8.6	?
152480z	33.0	?	31.0	18.8	22.7	152475g	11.6?	?	13.7	7.6	8.3
USNM 738b						152475h	12.4	?	12.9	7.7	?
152996a	1.6	?	1.8	1.1	1.3	152475i	13.0	?	13.3	9.0	7.6
152996b	3.7	3.5	4.6	3.0	2.5	152475j	12.6	?	14.6	8.9	?
152996c	6.8	6.0	5.6	3.7	4.3	152475k	14.0	?	16.9	10.5	?
152996d	6.2	6.1	7.0	4.0	4.3	152475l	14.4	?	16.7	9.3	?
152996e	7.0	6.6	7.6	5.0	4.5	152475m	17.6	15.5	16.0	11.0	10.9
152996f	7.6	7.0	7.8	4.3	4.6	152475n	18.5	?	17.9	11.6	?
152996g	7.8	6.7	7.3	5.6	4.8	152475o	19.0	?	19.0	10.9	?
152996h	7.1	7.0	8.3	4.6	5.1	152475p	21.2	?	20.0	12.8	?
152996i	7.9	?	8.8	5.6	?	152475q	24.3	?	23.7	13.9	?
152996j	9.4	9.0	11.2	6.5	6.5	152475r	24.1	?	24.5	11.6	?
152996k	10.6	10.0	11.2?	6.4	7.0	152475s	26.0	?	23.1	12.0	?
152996l	11.4	10.4	12.5	7.2	7.9	152475t	24.0	23.3	26.9	12.8	13.9
152996m	11.6	?	12.4	5.7	?	152475u	25.6	?	26.0	16.4	?
152996n	11.7	10.6	12.9	6.6	7.5	152475v	26.3?	24.2?	27.4	16.6	16.5
152996o	13.3	?	14.3	7.7	?	152475w	29.6	?	26.0	17.2	?
152996p	13.3	12.2	14.6	8.4	9.0	152475x	30.5	?	30.3	19.4	?

		brachial valve		hinge	thick-
	length	length	width	width	ness
152475y	33.8	?	32.2	18.7	?
152475z	34.5	?	34.3	17.5	?
152475a'	35.0	?	38.7	20.9	?
152475b'	37.6	?	38.7	16.3	?
152475c'	40.0	?	38.4	20.0	?
152475d'	?	17.8	21.9	11.2	?
152475e'	?	24.7	25.6	14.8	?
152475f'	?	29.2	31.4	15.1	?
152475g'	?	29.4	32.5	17.0	?
152475h'	?	32.3	35.2	21.0	?

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Rader and Lamar members); Capitan Formation.

LOCALITIES.—Rader: AMNH 388. Lamar: AMNH 37, 38, 39, 40, 347 (=L-2), 348 (=L-3), 351 (=L-6), 384, 389, 430; USNM 725e, 728i, 728p, 728s, 738, 738b. Capitan: AMNH 725, 817, 830, 840, 843; USGS 2926; USNM 725p, 737a, 740k, 740m, 740n, 740o, 750, 750b, 750f.

DIAGNOSIS.—Large maximum size, strong convexity, long and thick beak with apical plate.

TYPES.—Lectotype (herein designated): USNM 118596a, (Girty, 1909, pl. 14, fig. 3-3b). Figured paratype: USNM 118596b, (Girty, 1909, pl. 14, fig. 2-2b). Figured hypotypes: USNM 152474a,b; 152476a-c; 152480q'; 152481b,i; 152996h,l,r,u,y,z; 154570a-h; 154571a-f; 154572a-d; 154960. Measured hypotypes: USNM 118595a-g, 118597, 152475a'-h', 152480a-z, 152481a-c', 152996a-t'. Measured paratype: USNM 118596b.

ANOMALORIIDAE, new family

Biconvex, with swollen valves having concentric rows of fine spines, pedicle valve with convex pseudodeltidium, brachial valve with elaborate socket ridges.

Genus in West Texas: *Anomaloria* Cooper and Grant, 1969.

This is a rare genus and is only known from the Lamar Member of the Bell Canyon Formation, in which it is common.

Genus *Anomaloria* Cooper and Grant, 1969

Anomaloria Cooper and Grant, 1969:16.

Medium to large, unequally biconvex, pedicle valve deeper; hinge narrower than maximum

width; anterior commissure rectimarginate. Umbonal region of pedicle valve swollen; beak small, incurved, hanging over delthyrium; interarea narrow, defined by strongly marked beak ridges. Pseudodeltidium covering part or all of delthyrium and laterally extended as elevated deltidial flanges in some species. Surface lamellae covered by row of fine spines.

Teeth small, with small hooklike knob facing medial part of valve; dental ridges narrow, extending to apex, usually with shallow grooves, along inner surfaces; muscle field posteromedian, heart-shaped in outline with point anterior; diductor scars crescentic; adductors posteromedian, surrounded by diductors. Pallial marks not clearly defined.

Brachial valve with small sockets defined by fulcral plate, proximal part covered by thin roofing plates. Socket ridges narrow, without attached hinge plates; socket ridges extended posteriorly along notothyrial edge as low ridges, but leaving narrow gap medially into which beak protrudes. Cardinal process a pit under beak. Adductor scars elongate and often separated by low ridge or double ridge. Pallial marks not clearly defined.

TYPE-SPECIES.—*Anomaloria anomala* Cooper and Grant (1969:16, pl. 3: figs. 8-13).

DIAGNOSIS.—Like *Neophricadothyris* but with narrow socket ridges, no hinge plates, and notothyrial flanges.

COMPARISON.—This genus has its closest affinities with *Condathyrus* Minato and *Neophricadothyris* Licharew, which are probably congeneric, and *Astegosia* Cooper and Grant in external form and general configuration. Its shell is lamellose like that of the others and has similar spines. It differs, however, in the cardinalia of the brachial valve in having notothyrial flanges that margin the edge of the notothyrium and extend posteriorly from the socket ridges. The helicophores that carry the spire attach to the socket ridges near the valve floor but their course anteriorly is now unknown and the spire has not been seen. The distinction is thus based on the crurithyridid aspect of the cardinalia.

DISCUSSION.—We have been unable to find evidence to indicate that the delthyrial structures of this genus are formed by coalescence of deltidial plates as has been stated for *Crurithyrus*, which has essentially the same structure. The smallest speci-

mens in the collection have the same structure as the adults, i.e., a short convex pseudospondylium with anterior flangelike extensions along the delthyrial edge. The convex cover is buttressed on the delthyrial edge and appears to extend from the edge of the dental ridges. Variation in the development consists chiefly in the length of the convex cover and the extension of the flanges; the basic form is the same in all specimens. No trace of a median suture was seen, reinforcing the identification of the cover as a pseudodeltidium. Deposition of adventitious shell in the apex of the pseudodeltidium welds the cover to the dental ridges giving, in some specimens, the appearance of a solid callosity in the apex. We have not detected any adventitious thickening of the dental ridges to produce an interior plate such as that of *Astegosia*.

The muscle field is heart-shaped or in the form of a rounded arrowhead with the point anterior. In adults the muscle field is located just posterior to midvalve but well forward of the delthyrial cavity. The strong callus thickening in the posterior umbonal region indicates a considerable anterior migration of the muscles. Individual scars are not easily discerned but the diductor scars are posteriorly truncated crescents, concave toward midvalve and surround the adductor scars. Vague radial marks indicate a system of pallial channels similar to those of *Martinia*.

The brachial valve is the distinctive part of this genus and the development of its cardinalia is unlike that of other similar appearing forms. The sockets are formed by moderately broad and flatish fulcral plates bounded by strong and narrow (in an anterior-posterior direction) socket ridges. Only the anterior, distal part of the socket is functional and the proximal portion is covered by the notothyrial flanges. These grow obliquely across the distal ventrad edge of the socket ridge and the proximal roofing plates of the socket, but do not meet at midvalve, where they surround the adductor pit just under the beak and leave this region free for attachment of the thin diductor muscles. The notothyrial flanges are welded by adventitious shell which also strengthens the umbonal region with a moderate callosity.

Our collection unfortunately offers scant information on the spires and their attachment to the socket ridges. Remnants of the helicophores were seen in several specimens and these indicate that

the attachment was fairly broad, but that it was given off close to the valve floor. Anterior to this, the descending lamellae of the spire must have been slender or delicate because no traces of the spire were seen except occasional lengths of spiral ribbon left inside the shell.

This genus is a rare relative of *Astegosia*, with which it occurs and to which it is externally similar, in the Lamar Member of the Bell Canyon Formation. The proportion is at least ten of *Astegosia* to one of *Anomaloria*. Separation of the two genera is readily accomplished by comparison of the beak regions and of the dorsal cardinalia.

Anomaloria anomala Cooper and Grant

PLATE 640: FIGURES 1-49

Anomaloria anomala Cooper and Grant, 1969:16, pl. 3: fig. 8-13.

Squamularia guadalupensis Girty [not Shumard], 1909:367, pl. 14: fig. 4-11a.

Not *Squamularia guadalupensis subquadrata* or *S. guadalupensis ovalis* Girty, 1909 [= *Astegosia subquadrata* (Girty)].

Medium to large, subcircular to rounded sub-pentagonal in outline; sides and anterior regularly rounded; maximum width near midlength; interarea about half maximum width. Anterior commissure rectimarginate at all ages. Beak short, strongly incurved, not extended strongly posterior to posterior margin of opposite valve. Delthyrium covered by moderately strong and long pseudodeltidium with lateral flanges extending anteriorly in some specimens. Interarea flat and bounded by moderately strong beak ridges. Surface smoothly lamellose in most specimens which were decorticated before deposition. Spines numerous, delicate but not usually seen.

Pedicle valve strongly but unevenly convex in lateral profile, maximum curvature in posterior half, anterior half slightly flattened. Anterior profile broadly domed, sides moderately steep, the dome narrowly rounded on top. Umbonal region narrowly inflated; median region swollen. No trace of sulcus. Lateral slopes steep and slightly convex.

Brachial valve about half as deep as opposite one, strongly and fairly evenly convex in lateral profile; anterior profile only moderately but broadly domed, with gently sloping sides. Umbonal region not prominent, swollen, swelling continuing to

midvalve. Anterior slope moderately steep; no distinct median folding detected. Flanks gently convex and moderately steep.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member); Capitan Formation.

LOCALITIES.—Lamar: AMNH 40, 347 (=L-2), 384, 430; USNM 725e, 728p, 738, 738b. Capitan: USGS 2926; USNM 737a, 750.

DIAGNOSIS.—Fairly large *Anomaloria* with sub-circular valves.

COMPARISON.—These cannot be confused with *Astegosia*, with which they occur, if the distinctive character of the pseudodeltidium and the cardinalia are preserved and can be examined.

TYPES.—Holotype: USNM 153197a. Figured paratypes: USNM 153197b-d. Figured hypotypes: USNM 152998i-k, m-p; 152999b,e,g-j; 153000f; 153001d; 153197e-g. Measured hypotypes: USNM 118595b,h; 152997b,i,j; 152998a-j; 152999a-f; 153000a-f; 153001a-p. Unfigured paratypes: USNM 153197.

DISCUSSION.—Examination of Girty's type specimens of *Squamularia guadalupensis* (Shumard) shows them to be conspecific with *Anomaloria anomala*. Unfortunately there is no way to determine that they are conspecific with Shumard's (1860) unillustrated and now lost specimens of *S. guadalupensis*. Therefore we have adopted the expedient of confining Shumard's name to the lost specimens, and have established *A. anomala* for Girty's and our specimens, based on abundant and well documented material. This name does not apply to the two varieties named by Girty (1909, p. 369). The variety *Squamularia guadalupensis subquadrata* has been elevated to species rank and made the type species of the genus *Astegosia* Cooper and Grant (1969:16). The second variety, *S. guadalupensis ovalis* Girty also belongs to *Astegosia subquadrata* (Girty).

Several species have been assigned to "*Squamularia*" *guadalupensis* (see synonymies of *Anomaloria anomala* and *Astegosia subquadrata*). Those from the Glass Mountains and other West Texas localities are compared under these specific headings. The species from the Kaibab, called *Squamularia guadalupensis* by McKee (1938), differs from *A. anomala* from the Capitan in its smaller size, stronger biconvexity with greatest swelling farther forward, and more prominent dorsal beak.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 738b					
152998a	4.6	4.4	5.2	2.8	3.9
152998b	6.2	5.7	6.0	3.3	4.6
152998c	6.8	6.3	6.6	3.7	4.9
152998d	7.0	6.5	7.3	3.9	5.0
152998e	8.2	7.9	9.0	4.4	5.8
152998f	10.5	9.6	10.6	5.6	7.4
152998g	11.0	10.3	11.6	5.7?	6.0
152998h	11.3	10.7	12.1	5.6	7.8
152998i	17.9	16.0	15.8	10.4	13.1
152998j	18.9	18.2	20.2	9.7	12.4
USNM 725e					
152999a	8.4	7.7	8.7	5.2	6.0
152999b	9.4	8.8	10.8	5.3	5.8
152999c	10.2	9.6	11.3	6.0	6.6
152999d	14.3	13.0	16.0	7.8	8.8
152999e	15.5	14.3	15.6	7.5	10.6
152999f	16.9?	14.3	17.1	8.0	12.8?
USNM 738					
152997b	?	17.1	21.4	11.3	?
152997i	23.9	?	22.5	10.4	?
152997j	28.0+	?	35.9	18.9	?
USGS 2926					
118595b	7.5	7.0	8.6	3.3	5.2
118595h	24.5	21.7	25.4	11.6	18.1
USNM 750					
153000a	15.5	14.0	16.0	8.7	10.0
153000b	15.4	14.4	16.0	9.5	11.6
153000c	19.0	18.0	19.2	11.0	13.4
153000d	21.0	19.2	21.5	10.7	14.3
153000e	21.0?	?	21.9	11.8	15.3
153000f	24.9	22.8	26.6	12.4	17.9
USNM 737a					
153001a	8.7	7.9	9.9	4.7	5.6
153001b	9.8	9.5	11.7	5.7	6.9
153001c	10.0	9.3	11.9	4.6	7.0
153001d	12.6	11.7	13.4	6.0	9.0
153001e	13.0	12.5	16.3	7.5	9.5
153001f	13.0	12.3	14.0	7.4	9.0
153001g	14.0	13.4	15.3	8.4	9.0
153001h	15.7	14.6	16.4	8.4	11.0
153001i	16.5?	15.3	18.6	9.5	11.9
153001j	17.4	16.1	19.5	8.9	12.3
153001k	17.5	16.0	17.5	7.5	12.4
153001l	17.7	16.4	20.8	8.8	12.6
153001m	19.3	18.3	22.0	10.9	13.6
153001n	20.3?	18.5	20.2	10.0	15.0
153001o	21.9	19.6?	24.4	12.9	17.0
153001p	23.5	21.3	24.6	11.9	17.2
USNM 728p					
153197a (holotype)	22.0	20.2	23.2	10.5	15.6

Chronic (1949, 1953) identified a subspecies, *Phricodothyris guadalupensis peruensis*, from the Permian of Peru. The Capitan species is much larger, more elongate, and has a flattened or shallowly depressed sulcus along the midline of the pedicle valve. The Peruvian form is completely rectimarginate except at anterior of largest specimens. The greatest length given by Chronic (1953, p. 64) for the Peruvian form is 17 mm, and he mentions gerontic individuals in his collection. Specimens of *Anomaloria anomala* shorter than 20 mm are below average or median size.

Tschernyschew and Stepanov (1916) assigned specimens from Big Bear Cape, King Oscar's Land (Ellesmere Island) to this species under the name *Reticularia guadalupensis* (Shumard). These arctic specimens differ from the Capitan species in their smaller size, more convex pedicle valve with greatest convexity farther anterior, complete lack of sulcus, and more strongly curved pedicle beak. Apparently the Ellesmere specimens belong to *Neophricadothyris* because they lack internal plates or septa, but the assignment remains doubtful because the direction of the axes of coiling of the spiralia is unknown.

Family MARTINIIDAE Waagen, 1883

Contours rounded, surface usually smooth or faintly costate. Inner layer with fine radii. Ovarian pits near the muscle field. Jugum absent.

Genera in West Texas: *Heteraria*, new genus; *Martinia* McCoy, 1844; *Rallacosta*, new genus.

Martinia is very rare in the Pennsylvanian of North America but becomes common in the Permian. It is generally rare in the Wolfcampian and Leonardian of the Glass Mountains and has not been seen in the Word Formation. In the Sierra Diablo it is rare in the Bone Spring Formation. In the Guadalupe Mountains it is abundant in the Bell Canyon and Capitan formations, often occurring with *Astegosia* and *Anomaloria*. It is also common in the members of the Bell Canyon Formation in the Delaware Mountains.

Heteraria is extremely rare, but ranges from Wolfcamp to Guadalupe; *Rallacosta* is somewhat more abundant, and extends through nearly the same range.

Genus *Martinia* McCoy, 1844

Martinia McCoy, 1844:139.

Pseudomartinia Leidhold, 1928:82-83.—Cooper, 1953:59.

Shell moderately to strongly biconvex; outline subelliptical, subovate or subpentagonal, normally elongate, less commonly transverse, normally widest near or slightly anterior to midlength of brachial valve; hinge ends slightly protruding on many; commissure uniplicate; fold low to very high at anterior, rarely producing high fastigium except at anterior of large adults or on laterally compressed specimens: fold normally producing low, rounded fastigium; sulcus shallow for length of pedicle valve, greatly extended at anterior of some specimens forming long tongue to fill fold; costae absent; radial ornament only in secondary shell layer, visible on exfoliated or abraded shells as fine, closely spaced lines or fibers; growth lamellae weak, irregularly spaced; each beak with median line where shell fibers meet, fading anteriorly.

Pedicle valve normally strongly convex, greatest swelling in umbonal region; beak short, blunt, somewhat inflated, erect to slightly incurved; interarea narrow, high, transversely flat, longitudinally concave, distinctly bounded by sharp edges; delthyrium large, wedge-shaped, open, and unobstructed. Brachial valve less convex longitudinally, rather strongly convex transversely, especially where fold is high; beak bluntly pointed, curved but too short to obstruct delthyrium; notothyrium wide, shallow; interarea narrow, moderately high, slightly concave.

Pedicle valve interior with short blunt hinge teeth; dental ridges deep, slightly convergent toward midline, converging apically, meeting one another beneath beak without forming platform or other obstruction of delthyrium; dental plates absent; muscle area small, deeply impressed, irregularly elliptical, normally bisected by shallow or deep narrow groove; adductor muscle marks posterior, occupying much of area; diductor marks anterior and mesial, then dividing toward posterior in shape of Y along adductor marks; posterior part of valve floor deeply marked by narrow radial grooves, bifurcating toward anterior, becoming shallower, barely perceptible or absent at anterior margins of valve.

Brachial valve interior with deep, elongate, pos-

teriorly narrowing hinge sockets, open in some species, bridged in others, formed between valve wall and socket ridges; anterior edge of each socket ridge swollen to form small knob simulating hinge tooth of opposite valve; cardinal process small, wider than long or high, coarsely lamellate; helicophores extending along dorsal edges of socket ridges, narrow to very wide, in various attitudes, tapering to form elongate slender lamellae, each with short posteriorly pointing jugal process; helicophores diverging at anterior, giving rise to spiralia nearly transverse, each coiled in nearly symmetrical cone; muscle area small, narrowly flabellate, in posterior of valve, bisected by sharp but fine groove, two halves of area contiguous in some specimens, disjunct in others; floor of valve radially striated, striae bifurcating toward anterior margin.

TYPE-SPECIES.—*Spirifer glaber* Sowerby, by subsequent designation of Muir-Wood, (1951:109), validated under Opinions 420–421 of the International Commission of Zoological Nomenclature (*Bulletin of Zoological Nomenclature*, 14 (4–5): 132, 171, 1956).

The complex nomenclatural histories of *Martinia* and its type species are summarized by Muir-Wood (1951) and Muir-Wood and Stubblefield (1951).

COMPARISON.—*Martinia* is characterized by its subovate to subpentagonal outline, either transverse or elongate, its weak or absent radial ornamentation, absent concentric ornamentation (except for growth lines, and laminae), complete absence of dental plates or septa inside, its relatively strong, normally bifurcating pallial lines, its oblique shell fibers in the posterior that cause a zone of weakness along the midlines of the beaks which is visible in many shells, and its spiralia with axes of coiling nearly perpendicular to the plane of symmetry of the shell. It is easily distinguished from *Squamularia* Gemmellaro, *Phricodothyris* George, and *Neophricadothyris* Licharew by its normally stronger uniplication, its lack of regular concentric ornamentation, and lack of surface spines. It differs from *Reticularia* McCoy and *Martiniopsis* Waagen in its lack of dental plates and septa, and from *Notospirifer* Harrington and *Ingelarella* Campbell in the lack of internal plates and lack of costation. The uncostate shell and lack of dental plates and septa also distinguish it from *Ella* Fredericks, *Kitakamithyris* Minato, and *Fredricksia* Paeckelmann.

DISCUSSION.—Leidhold (1928) established the "temporary" genus *Pseudomartinia* for martiniids without dental plates, then rejected it on the following page in favor of broad use of the name *Spirifer*. He argued that the groups known as *Martinia*, *Martiniopsis*, and *Pseudomartinia* all were united by possession of "chagrin sculpture" (i.e., a finely pitted surface like that of "chagrin" leather, according to Waagen, 1883:529; correctly interpreted by Dunbar, 1955:152, to mean "shagreen"). Dunbar concluded that *Pseudomartinia* is a synonym of *Martinia*. Action by the International Commission on Zoological Nomenclature (1956) at the request of Muir-Wood and Stubblefield (1951) established as the type of *Martinia* the form which Muir-Wood (1951) says has no dental plates. Therefore, *Pseudomartinia* and *Martinia* have the same defining characteristics: Leidhold (1928:83) defined *Pseudomartinia* as "like *Martinia*, but without dental plates."

The surface shagreen noted by Waagen, and deemed so important by Leidhold, is rarely preserved. We have not noted it on any of our specimens from Texas, either silicified or calcareous, although it is visible on some well preserved specimens in the collection from the Sosio Limestone of Sicily, and *Productus* Limestone of the Salt Range. Waagen emphasized its scarcity; Leidhold noted its general occurrence among spiriferids. Therefore, although we have observed it only rarely, we consider it most probably a matter of preservation of the outer shell layer of the fibrous smooth spiriferids.

A feature of the Permian species of *Martinia* that is preserved on most calcitic (and many silicified) specimens is oblique orientation of the shell fibers on each side of the median line of each valve in the beak area. The fibers of each side meet at an angle, forming a chevron or herringbone pattern along the median line, with the apex pointing anteriorly, the divergence posterior. This produces a line of weakness in the shell along which it tends to break, or weather. The angle of meeting becomes progressively less acute toward the anterior, and the visible zone of weakness normally fades out about a third the distance forward from the beak.

The median line is visible on many silicified specimens, even though the orientation of the original shell fibers is destroyed. It is expressed also as

a median groove in the interior of each valve, bisecting the muscle areas and normally continuing, although becoming very shallow, nearly to the anterior margin. This feature is not visible in Muir-Wood's illustrations (1951, pl. 3) of the lectotype of *M. glabra* (Sowerby), but it is present in closely similar specimens that are labeled Carboniferous of Derbyshire, England, and "Mountain limestone," Derbyshire, in the National Museum collection. Similarly, it is present in Carboniferous specimens from the United States, (including Alaska) and Permian specimens from Timor, Sicily, and Pakistan. Apparently it is a generic character.

Martinia causaria, new species

PLATE 631: FIGURES 43-45

Average size for genus, moderately strongly bi-convex; outline subelliptical, normally slightly elongate, widest near or slightly posterior to mid-length, many shells distorted; fold becoming high in adults; fastigium standing only slightly above flanks; sulcus shallow for entire length, but extended at anterior to form long tongue extending into deep notch of fold; growth lines weak, rarely observed; growth laminae moderately strong, some wrinkling of shell.

Pedicle valve irregularly convex; beak short, thick; normally slightly incurved; interarea high or wide, split by large triangular delthyrium; hinge ends protruding slightly. Brachial valve less strongly convex; fold producing ridgelike crest; beak short, bluntly pointed; interarea wide, low, excavated by wide triangular notothyrium.

Pedicle valve interior with hinge teeth small and sharp in juveniles, becoming blunt in large adults; dental ridges moderately deep, sickleshaped, joining just behind apex of delthyrium; muscle area elongate, fusiform, lying in umbonal region of greatest valve convexity, bisected by low median ridge or groove; diductor muscle marks narrow, elongate, lying along median line in anterior part of area, flanked by larger, more posteriorly lying adductor marks; pallial grooves shallow, radiating toward margins, bifurcating, fading toward margins, lying outside of visceral area in posterior part of valve.

Brachial valve interior with small lamellate car-

dinal process in apex of notothyrium; hinge sockets wide where functional, becoming narrow and slitlike posteriorly but not closed or bridged; heliophores broad, extending from socket ridges, paralleling valve sides, becoming slender, tapering anteriorly; full extent of primary lamellae and spiralia not observed; muscle area in umbonal region, rather broad, anteriorly widening, longitudinally striated, individual muscle marks not differentiated, bisected by shallow median groove; pallial troughs beginning around edges of visceral area, radiating and bifurcating toward valve margins.

MEASUREMENTS (in mm).—Maximum length not necessarily measured in plane of commissure. Measurements in brackets are actual dimensions of broken shells. Brachial valve length unmeasurable.

	length	maximum length	width	hinge width
USNM 732				
152397a	4.9	5.8	[5.0]	3.7
152397b	8.1	8.3	7.6	3.4
152397c	12.9	13.0	10.5	6.4
152397d	13.0	?	11.7	8.2
152397e	14.5	?	[11.7]	[16.0]
152397f	15.4	16.0	[14.3]	10.2
152397g	17.6	?	[14.0]	9.0
152397h	15.7	?	[15.0]	10.2
152397i	16.4	?	17.4	9.6
152397j	15.5	?	[20.2]	11.9
152397k	15.6	?	[18.8]	12.3
152397-l	23.5	27.3	27.3	18.2
(holotype)				
152397m	?	20.7	21.0	11.3

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITIES.—USNM 728, 732.

DIAGNOSIS.—Distorted *Martinia* with long beak and short tongue.

TYPES.—Holotype: USNM 152397-l. Figured paratypes: USNM 152395, 152397m. Measured paratypes: USNM 152397a-k,m.

COMPARISON.—*Martinia causaria* is characterized by its moderately convex, normally elongate, distorted shell with short beak and long anterior tongue on the pedicle valve. Most specimens in the collection are somewhat wrinkled by their growth lines, and many are pitted, showing action of ectoparasites of some kind (Schlaudt and Young, 1960). It most nearly resembles *M. rhomboidalis* Girty from the Capitan and Bell Canyon formations, dif-

fering in its smaller size, flatter convexity, shorter beak, sharper fold, and slightly more strongly protruding hinge ends. It bears little resemblance to the other Texas Permian species, being much smaller, rougher, more distorted, and having a higher fold and longer anterior tongue than *M. miranda*, new species. It is larger, more elongate, rougher, has a longer anterior tongue, and is more distorted than *M. fucina*, new species. It differs from *M. martinezi* (Cooper) from the Permian of Mexico in its larger size, more elongate outline, shorter and less acute brachial beak, more protruding hinge ends, stronger growth lines, and absent or indistinct radial striation. Our sample of this species is too small to warrant detailed comparisons with species of other areas; in general, the differences that distinguish *M. rhomboidalis* also apply to *M. causaria*.

Martinia cruenta, new species

PLATE 644: FIGURES 54–57

Moderately large for genus, transversely rectangular in outline, maximum width just anterior to midvalve; hinge wide, about two-thirds maximum width. Sides broadly rounded; anterior margin truncated. Ventral beak short and scarcely protruding beyond dorsal beak. Interarea short, strong, apsacline to procline. Surface marked by growth lines only.

Pedicle valve moderately convex in lateral profile, most convex in posterior half; anterior profile broadly and moderately convex, sides fairly strongly sloping. Region just anterior to umbo strongly swollen. Sulcus originating just posterior to midvalve, shallow throughout its length, only moderately depressed at anterior. Areas bounding sulcus narrowly rounded; flanks flattened and steep.

Brachial valve gently convex in lateral profile, posterior third somewhat more convex than anterior; anterior profile broadly domed, greatest convexity medial, sides dipping moderately steeply. Umbonal and median regions narrowly swollen longitudinally; fastigium originating just posterior to midvalve, variable, low to moderately high, spreading moderately anteriorly but not strongly elevated above flanks except at anterior of old specimens. Flanks flattened but steep.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 719q					
152376a	25.0	23.3	31.4	18.5	17.4+
(holotype)					
152376b	31.8	30.4	42.5	23.0	24.4
152376c	24.1	23.1	30.2	17.3	18.4
152376d	25.0	22.4	28.3	17.1	17.5

STRATIGRAPHIC OCCURRENCE.—Hess Formation (?) uncertain (see “Discussion”).

LOCALITY.—USNM 719q.

DIAGNOSIS.—Wide *Martinia* with short ventral beak.

TYPES.—Holotype: USNM 152376a.

COMPARISON.—The shortness of the beak, the wide hinge, and transverse, subrectangular outline distinguish this species from all other named species of the Glass Mountains. The specimens are most like two imperfect separated valves from USNM 716p.

DISCUSSION.—The lot on which the foregoing description is based consists of 28 specimens, which come from a loose boulder found on the upper part of the Neal Ranch Formation in the center of the Wolfcamp Hills. The specimens occur with a few productids such as *Cancrinella*, *Fimbrinia*, and *Antiquatonia*. The matrix is red limestone of smooth texture, like much of the biohermal rock found in the Skinner Ranch Formation. The boulder was obviously not derived from the Neal Ranch Formation but lies in the front of the Hess escarpment facing the Wolfcamp Hills. It is almost certain that it must have been derived from the Hess Formation.

The specimens compare favorably with poorly preserved *Martinia* from USNM 716p of the Skinner Ranch Formation. We believe it likely that our specimens were derived from biohermal beds in the Hess even though none have been seen on the outcrop.

Martinia exigua, new species

PLATE 644: FIGURES 24–44

Small for genus, wider than long, outline broadly elliptical; hinge narrower than midwidth; pedicle valve deeper than brachial valve; greatest width at midvalve; sides strongly rounded; anterior margin

gently convex; anterior commissure broadly uniplicate; beak elevated, incurved; interarea narrow, apsacline. Surface smooth.

Pedicle valve moderately convex in lateral profile, fairly strongly arched in anterior profile, flanks sloping steeply. Sulcus broad and shallow, not strongly demarcated, anterolateral extremities well rounded.

Brachial valve evenly and gently convex in lateral profile, bluntly angulated in anterior profile, middle of valve slightly keeled, sides sloping fairly steeply. Fold low, with gentle slopes to flanks, originating slightly posterior to midvalve. Anterolateral extremities moderately depressed, rounded.

Pedicle valve interior with small teeth, slightly developed lateral plates just ventrad of delthyrial edge. Pallial marks fairly well developed, about 6.

Brachial valve interior with delicate cardinalia; sockets very narrow, roofed distally by thin plates. No septa, muscle scars only weakly impressed.

MEASUREMENTS (in mm).—

		brachial valve		hinge	thick- ness
	length	length	width	width	
USNM 727c					
153344a	13.2	10.7	14.1	7.5	8.3
153344b	11.0	10.0	13.3	7.0	7.1
153344c	12.3	11.2	11.8	6.8	8.0
153344d	10.4	9.3	12.0	6.7	7.2
153344e	10.5	9.4	12.0	5.5?	6.7
(holotype)					
153344f	10.0	?	12.0	6.4	3.5

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation (bed 4).

LOCALITY.—USNM 727e.

DIAGNOSIS.—Very small *Martinia* with shallow sulcus and low fold.

TYPES.—Holotype: 153344e. Figured paratypes: USNM 153344a,f,h. Measured paratypes: USNM 153344a-d,f.

COMPARISON.—This small species is readily distinguished from all others in the Texas Permian except perhaps *M. fucina*, new species (see below), of the Bone Spring Formation. It is more circular in outline than that species, its fold is lower, and its convexity (and consequently the thickness dimension) is lower.

Martinia fucina, new species

PLATE 631: FIGURES 27–42

About average size for genus, moderately strongly biconvex; outline transversely subelliptical, widest near midlength; anterior commissure with low rounded fold, rarely with fold high and somewhat angular; sulcus shallow, normally broadly rounded but some specimens with narrower median trough, anterior margin extended to form short, rounded tongue into fold; radial costae absent; radial color bands visible on most specimens, alternating dark and light, anteriorly expanding, spacing and width of bands irregular; concentric fine growth lines normally not visible; growth laminae weak.

Pedicle valve moderately strongly convex; beak short, rather thick, strongly curved, normally somewhat incurved; interarea wider than high, bisected by wide open delthyrium; hinge protruding only slightly at extremities. Brachial valve less strongly convex, greatest convexity about a third distance forward from beak; interarea very low, wide, bisected by wide notothyrium; beak short, sharp, erect.

Pedicle valve interior with short sharp hinge teeth; low dental ridges meeting at apex of delthyrium; muscle area in region of maximum convexity anterior to beak, elongate elliptical, weakly impressed, bisected by low median ridge; individual muscle marks not distinguishable.

Brachial valve interior with small lamellate thickening in apex of notothyrium forming cardinal process; hinge sockets small, only functional portion open, remainder bridged by thin plate; helicophores extending dorsally from socket ridges, paralleling sides of valve, converging toward floor, curving anteriorly; full extent of spiralia, not observed; muscle area weakly impressed in region just below beak, small, anteriorly widening.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation.

LOCALITY.—AMNH 634; USNM 728f.

DIAGNOSIS.—*Martinia* of average size, having smooth, rounded contours, short tongue, and gentle sulcus in the pedicle valve, and broad, rounded fold.

TYPES.—Holotype: USNM 154553b. Figured paratypes: USNM 152394f,g,k,m; 154553a. Meas-

MEASUREMENTS (in mm).—Maximum length not necessarily measured in plane of commissure.

	brachial			width	hinge width
	length	valve length	maximum length		
USNM 728f					
152394a	5.7	?	5.7	6.9	2.6
152394b	7.8	?	7.8	8.3	4.8
152394c	11.4	?	11.4	14.3	6.5
152394d	13.0	?	14.6	16.0?	8.9
152394e	14.8	?	?	19.0	10.0
152394f	15.0	?	16.3	18.2	10.0
152394g	15.3	?	17.6	18.6	12.2
152394h	18.6	?	?	20.0?	11.9
152394i	?	?	24.4	?	20.0?
152394j	?	11.2	?	14.0	8.6
152394k	?	16.4	?	21.6	12.4
AMNH 634					
154553b	19.5	16.8	?	20.0?	12.3
(holotype)					

ured paratypes: USNM 152394a-k. Unfigured paratypes: USNM 154553c,d.

COMPARISON.—*Martinia fucina* is characterized by its average size, transverse outline, low fold, and its normally preserved color bands. It is smaller than either of the two abundant species in West Texas: *M. rhomboidalis* Girty and *M. miranda*, new species. Also it is smoother and less distorted than either *M. rhomboidalis* Girty or *M. causaria*, new species.

This species is similar in outline and size to *M. corculum* (Kutorga) of Tschernyschew (1902), but it is less convex, especially in the pedicle valve, and its sulcus is more sharply indented. It also is similar to *M. semiglobosa* Tschernyschew and the Russian specimens of *M. orbicularis* Gemmellaro, differing from the latter in its lower convexity and higher fold; differing from the former in its lesser convexity, the more anterior position of its greatest width, and its fastigium that is higher along the crest of the valve, although about the same height at the anterior commissure.

Among species of the Sosio Limestone *M. rupicola* Gemmellaro and small specimens of *M. triquetra* Gemmellaro resemble *M. fucina* most closely. The Texas species is smaller than either, however, and differs further in its proportionately wider outline that is more elliptical than pentagonal, lesser convexity, and less strongly curved pedicle beak.

Productus Limestone species that most nearly

resemble *M. fucina* are *M. buriensis* Reed, *M. warthi* Waagen, *M. chidruensis* Waagen and *M. cf. M. glabra* (Martin). It differs from *M. buriensis* in its less pentagonal outline, narrower fold, and greatest width farther anterior; from *M. warthi* and *M. chidruensis* in its less transverse outline and lower fold without subsidiary lateral costae; and from *M. cf. M. glabra* in its smoother, less convex shell.

DISCUSSION.—This is a rare species and is unusual for preservation of color bands. Traces of color are not often seen in impunctate brachiopods but were reported in *Meristella* by Reimann (1945) and in *Pugnax* (now *Pugnoides*) by Richter (1919). We have seen them also in occasional specimens of *Neophricadothyris* and *Composita*. The banding is similar to that of *Dielasma* but is usually straight. The true color of the bands is not known but it was probably pink or red.

Martinia miranda, new species

PLATE 643: FIGURES 1–39

Martinia rhomboidalis [part] R. E. King [not Girty], 1931:120, pl. 41: figs. 7,9 [not figs. 6,8,10 (= *M. rhomboidalis*?)].

Large for genus, moderately to strongly biconvex; outline subtrigonal to rounded subpentagonal, juveniles elongate, proportionate width increasing with length, greatest width at or somewhat anterior to midlength; commissure unipligate; fold at anterior commissure low to moderately high, broadly rounded; fastigium standing above flanks beginning at point about 20 mm from beak; sulcus shallow, broadly rounded, beginning about 20 mm from beak, anterior extended as broadly rounded tongue into recess of fold; fine radial structure of secondary shell layer visible on exterior of many specimens; growth lines fine, closely spaced, destroyed by silicification on many specimens; growth laminae stronger, widely and irregularly spaced.

Pedicle valve strongly and rather evenly convex, beak slightly swollen, normally slightly incurved; interarea about equilaterally triangular protruding slightly at extremities of hinge; delthyrium narrowly triangular, occupying most of interarea. Brachial valve flatly convex longitudinally along fastigium, most curvature located in beak region; transverse convexity increasing slightly toward an-

terior; beak short, obtusely sharp, erect to slightly incurved; interarea wide, low, mostly occupied by wide notothyrium.

Pedicle valve interior with short, sharp or knob-like hinge teeth, dental ridges deep, sickle-shaped, converging toward apex of delthyrium, there meeting to form continuous ridge around delthyrium, also slightly convergent toward midline of valve; muscle area located in beak region, slightly anterior to beak, moderately deeply impressed, sub-ovate with apical end deeper and more gently curved, bisected by very low myophragm; adductor muscle marks occupying most of area, lying posterior; diductor marks on each side of median line in anterior part of area, elongate, narrow, extending slightly farther forward; visceral area of floor weakly pitted; pallial markings radiating from edge of visceral area, weakly impressed, bifurcating, becoming weaker toward margins.

Brachial valve interior small, knoblike cardinal process in apex, composed of several parallel laminae; hinge sockets formed between valve walls and socket ridges, wide at functional end, constricted apically but not bridged; helicophores broad, descending toward floor, nearly parallel to side walls of valve, continuing dorsally, then proceeding anteriorly; spiralia coiled dorsoventrally from ends of primary lamellae, in irregularly elliptical coils, with axis nearly transverse to shell; muscle area weakly impressed in umbonal region, small, anteriorly widening, weakly striated radially, individual muscle marks not discernible.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—AMNH 500B, 500D, 500F, 504; USNM 702, 702a, 702b, 702-low, 702un, 703a¹, 703b, 708u, 726x, 735b.

DIAGNOSIS.—Very large *Martinia* with pentagonal outline, symmetrical form, and low fastigium.

TYPES.—Holotype: USNM 152381a. Figured paratypes: USNM 152380, 152382a, 152383a-g, 152384r, 152387c, 152391. Measured paratypes: USNM 152380, 152382, 152384a-s, 152387a-g, 152389a-c, 152391a. Unfigured paratypes: USNM 152380, 152391.

COMPARISON.—*Martinia miranda* is characterized by its large size, rounded trigonal or pentagonal outline, thick and recurved beak, smooth and undistorted shape, its low fastigium that stands only slightly above the flanks along the brachial valve,

MEASUREMENTS (in mm).—

	brachial		hinge	thick-
	length	valve length	width	ness
USNM 702b				
152384a	2.8	?	3.1	1.5 ?
152384b	3.8	?	4.0	2.6 ?
152384c	4.4	4.0	4.2	2.8 3.1
152384d	5.1	4.8	5.7	3.3 3.7
152384e	6.1	?	5.9	4.2 ?
152384f	7.2	6.7	7.0	4.2 4.6
152384g	8.9	?	8.4	5.5 ?
152384h	9.6	?	10.0	6.6 ?
152384i	10.6	?	9.5	7.3 ?
152384j	22.4	?	23.0	13.4 ?
152384k	23.4	22.0	24.0	11.3 14.0
152384-l	26.4	?	27.0	13.2 ?
152384m	29.4	?	23.9	10.9 ?
152384n	27.7	?	25.4	12.9 ?
152384o	29.6	?	28.5	13.6 ?
152384p	32.0	?	30.5	15.2 ?
152384q	33.0	?	35.5	15.3 ?
152384r	33.7	29.5	32.5	14.6 22.0?
152384s	43.2	?	48.0?	27.0 ?
USNM 702-low				
152387a	5.0	4.6	5.0	3.7 3.5
152387b	8.9	8.0	9.0	5.7 5.5
152387c	15.0	14.3	16.6	9.6 9.3
152387d	17.7	15.7	16.7	9.6 12.0
152387e	17.9	16.2	18.0	11.6 10.8
152387f	19.8	17.0	19.5?	12.8 12.6
152387g	21.3	18.6	21.4	13.7 12.4
USNM 702a				
152381a	38.0	36.4	41.9	20.5 30.7
(holotype)				
152382	9.6	8.3	9.7	7.2 6.8
USNM 702un				
152389a	12.4	11.4	12.5	8.3 9.0
152389b	13.4	11.9	12.4	8.8 9.0
152389c	24.0	21.4	24.7	12.7 19.0
USNM 703b				
152391a	18.3	17.2	18.9	9.7 11.7
USNM 702				
152380	27.0	22.2	27.5	14.6 19.1

and fold that is broadly rounded at the anterior, producing only a short broad tongue from the pedicle valve. It gets somewhat larger and thicker than *M. rhomboidalis* Girty, and also differs in its smoother, undistorted shell, higher, thicker, and slightly more strongly curved ventral beak, and its much lower fold at the anterior, producing a shorter anterior tongue. From *M. fucina*, new species, a fairly regular and smooth shell from the Bone Spring Formation, *M. miranda* differs in its larger size, less transverse outline, lower and

rounder fastigium, longer, thicker beak, and narrower hinge. It is larger, smoother, proportionately narrower, and has a lower fold and shorter anterior tongue than *M. causaria*, new species; it is larger, wider, and has a broader fold than *M. martinezi* Cooper from Mexico.

Among foreign species of the genus, *M. miranda* most nearly resembles *M. elegans* Diener (1897a) from the Permian of Chitichun, but differs in its less pronounced pentagonal outline, less swollen brachial valve, and narrower proportionate width. The species that Diener (1897a, pl. 9) identified with *M. contracta* Meek & Worthen also is similar, but *M. miranda* is less strongly convex, and, viewed from the side, has a less sinuous line of commissure. The only species of Waagen (1883) that is comparable in size to *M. miranda* is *M. indica*, which, however, has a subcircular outline and prominent concentric growth lines. Species identified by Reed (1944) from the Productus Limestone all are smaller and more transverse than *M. miranda*.

The species from the Sosio Limestone described by Gemmellaro (1899) all are smaller than *M. miranda*, and many are wider and distorted; they are not closely comparable. The same is true of most species described by Tschernyschew (1902), which are smaller and wider. Only *M. triquetra* Gemmellaro and *M. uralica* Tschernyschew attain the size of *M. miranda*. The former has a wide outline, sharp sulcus and bifid fold; the latter is more strongly convex and has a more circular outline.

Martinia nealranchensis, new species

PLATE 649: FIGURES 1-14

Near average size for genus; outline transverse, subelliptical to weakly subpentagonal, widest near midlength; hinge about half shell width; commissure uniplicate, with low rounded fold, fastigium not standing above flanks except at extreme anterior of adults; growth lines numerous, low, with few at intervals somewhat higher; very weak radial undulations visible in low incident light, other radial ornament absent.

Pedicle valve with short beak strongly curved; interarea longitudinally curved, consisting of a platform on each side of relatively narrow delthyrium; delthyrial plates or flanges absent. Bra-

chial valve only slightly less strongly convex than pedicle valve, with nearly equal convexity transversely and longitudinally; beak short, slightly pointed; interarea low, bisected by wide notothyrium.

Pedicle valve interior with sharp dental ridges but no plates or septa; muscle areas not observed. Brachial valve interior with short trifid cardinal process; hinge sockets narrow, open; helicophores beginning broad, produced anteriorly to form primary lamellae of spiralia; details of spiralia not observed; muscle area short, with drop-shaped median part surrounded by equally large lateral pair of adductor marks.

MEASUREMENTS (in mm).—

		brachial valve		hinge	thick- ness
	length	length	midwidth	width	
USNM 727e					
154957a	11.0	10.8	12.8	5.9	7.9
154957b	17.0	15.6	19.0	9.5	12.0
154957c	21.8	21.4	27.0	14.5	17.0
(holotype)					
154957d	26.8	23.7	27.0	14.0	19.0

STRATIGRAPHIC OCCURRENCE.—Neal Ranch Formation.

LOCALITY.—USNM 727e.

DIAGNOSIS.—Outline transverse, beak short, shell smooth, fold low, sulcus shallow.

TYPES.—Holotype: USNM 154957c. Figured paratypes: USNM 154957a,b. Measured paratypes: USNM 154957a,b,d.

COMPARISON.—This species is much larger than *M. exigua*, new species, with which it occurs. Its beak is proportionately shorter and much less thickened, and the fold lower and less distinct. The transverse and subelliptical outline and the short beak and low fold are obvious distinctions from *M. wolcampensis* R. E. King and *M. renfroae*, new species, which also occur in strata of similar age. It resembles *M. cruenta*, new species (see Plate 644: figures 54-57), but differs in its lower fold and especially in its proportionately narrower hinge.

Martinia renfroae, new species

PLATE 644: FIGURES 45-49

Medium size for genus, strongly pentagonal in outline with long straight posterolateral slopes and rounded sides. Anterior margin truncated. Ante-

rior commissure strongly and narrowly uniplicate; beak long and narrow, strongly incurved; hinge narrow, equal in width to about half maximum valve width (which is at midvalve). Interarea small, approximately orthocline. Surface marked by strong growth interruptions, crowded on sides and anterior.

Pedicle valve moderately convex in lateral profile, greatest convexity in umbonal and beak regions. Anterior profile broadly domed, top flattened, sides short and steeply sloping. Umbonal and median regions strongly swollen. Sulcus originating posterior to midvalve about 15 mm (measured on surface) anterior to beak; sulcus shallow, widening gradually anteriorly to occupy about half of midwidth; sulcus anteriorly bounded by short subangular plications; anteromedian part of sulcus occupied by low, narrow costa, distinct but low. Flanks short, narrow, steep.

Brachial valve slightly convex in lateral profile, broadly and gently convex in anterior profile, sides moderately sloping. Median region gently swollen; fastigium originating just posterior to midvalve, widening and steepening anteriorly where narrowly rounded and moderately elevated above flanks. Median part of fastigium marked by obscure narrow depression corresponding to median costa of opposite valve. Flanks slightly inflated, depressed adjacent to fastigium.

Interior not known.

MEASUREMENTS (in mm).—Holotype USNM 152378: length 23.8, brachial valve length 17.0?, width 23.8, hinge width 11.6, thickness 15.0.

STRATIGRAPHIC OCCURRENCE.—Graham Formation (Jacksboro Member).

LOCALITY.—USNM 510g = Renfro locality 43.

DIAGNOSIS.—Medium-sized *Martinia* with narrow fold but shallow sulcus bearing a low median costa.

TYPES.—Holotype: USNM 152378.

COMPARISON.—This species is about the same size as *M. wolfcampensis* R. E. King but has a narrow fold, a definite sulcus having a median costa, and a more elongated beak that gives the species a distinctly pentagonal outline.

DISCUSSION.—This is the first species and only specimen of *Martinia* to be described from the north-central Texas region of the Pennsylvanian. It is from the same shale that produced *Waagenoconcha prophetica*, new species, and suggests the Permian affinities of this part of the Pennsylvanian.

Martinia rhomboidalis Girty

PLATE 644: FIGURES 1–23; PLATE 645: FIGURES 1–39;
PLATE 649: FIGURES 31–37

Martinia rhomboidalis Girty, 1909:634, pl. 13: fig. 11–14c.—
R. E. King, 1931:120, pl. 41: fig. 8a–c, 10? [not fig. 6,7,9].
[Not of Grabau, 1931a:197, pl. 18: fig. 6a–f.]
Martinia shumardiana Girty, 1909:365, pl. 13: fig. 15.

Large for genus, moderately to strongly biconvex; outline subelliptical to subpentagonal, normally slightly elongate, less commonly slightly transverse, greatest width near midlength; commissure uniplicate; fold low to rather high at anterior, broadly to sharply arched, rarely flat at crest, forming low ridge along midline of valve, beginning narrow and sharply arched at beak, becoming wider and more gently arched anteriorly; sulcus shallow, beginning 5–10 mm anterior to beak, in some specimens not depressed, expressed only as elongation of anterior edge of valve to fit into arch of fold (some exfoliated shells showing shallow median linear depression); costae absent, fine radial lirae on inner shell layers, visible on many specimens, concentric and irregularly spaced, most strong and frequent near margins.

Pedicle valve strongly convex in posterior half, lowering somewhat anteriorly; beak short but thick, strongly curved (suberect to slightly incurved); interarea high and narrow, nearly equilaterally triangular, longitudinally concave, lateral extremities slightly protruding at hinge line of some specimens; delthyrium narrowly triangular, open, without flanges or delthyrial plates. Brachial valve more strongly convex, especially swollen in umbonal area; beak narrow, somewhat attenuate, curved; interarea wide, low, bisected by broadly triangular notothyrium.

Pedicle valve interior with short blunt hinge teeth; dental ridges deep, curved, shaped like sickle-blades, slightly convergent toward midline, convergent posteriorly, meeting at apex; muscle area small, fusiform, normally deeply impressed, located in extreme posterior of valve; adductor muscle marks posterior, widening anteriorly; diductor muscle marks narrow, slightly widening anteriorly, lying along midline, extending slightly farther forward than adductor marks; pallial troughs distinct, radial, intercalating and bifurcating anteriorly, fading toward valve margins; poste-

rior part of adult valves thickened, some with floor shallowly pitted.

Brachial valve interior with large, deep, open hinge sockets, bridged by thin plates only in apical portions; cardinal process slightly elongate, lying along posterior of valve for most of length, protruding only slightly, with few coarse lamellae for muscle attachment; helicophores widening anteriorly, lying along mesial walls of socket ridges, forming deeply divided platform between sockets, crura slender, elongate, supporting spiralia, details not observed; spiralia coiled around transverse axis, with at least 7 coils, in symmetrical conical shape; muscle area bifid, with rounded median ridge depressed at crest by narrow median trough; muscle marks on floor lateral to median ridge.

MEASUREMENTS (in mm).—

	<i>brachial</i>		<i>hinge</i>	<i>thick-</i>		<i>brachial</i>		<i>hinge</i>	<i>thick-</i>
	<i>length</i>	<i>valve</i>				<i>length</i>	<i>valve</i>		
USNM 737a									
152348a	8.3	8.2	8.2	3.9	5.8	152349p	13.6	?	10.4
152348b	8.5	8.4	8.7	4.5	6.5	152349q	14.2	?	13.2
152348c	8.9	8.7	9.7	4.9	5.9	152349r	15.2	?	13.8
152348d	11.3	11.0	9.4	4.0?	8.0	152349s	15.0	?	15.3
152348e	12.9	11.6	11.6	5.7	8.7	152349t	16.4	?	13.6
152348f	12.3	11.4	13.0	5.8	8.6	152349u	17.2	?	17.0
152348g	13.8	12.4	13.4	6.4	9.6	152349v	17.9	?	16.6
152348h	14.4	13.5	13.4	6.6	10.4	152349w	19.8	?	16.9
152348i	15.4	14.1	14.8	6.9	9.4	152349x	19.6	?	17.5
152348j	16.6	?	15.3	6.0?	9.8	152349y	19.4	?	17.7
152348k	16.3	14.8	15.7	7.0	9.6	152349z	20.0	?	17.5
152348-l	18.7	16.6	17.1	7.0?	13.3?	152349a'	19.5	?	20.2
152348m	20.0	18.6	18.4	9.0	13.4	152349b'	19.9	?	17.9
152348n	19.7	18.0	20.4	9.2	13.1	152349c'	21.4	?	20.3
152348o	21.4	19.3	20.5	10.0	14.1	152349d'	23.7	?	20.9
152348p	21.3	18.8	21.9	9.9	14.6	152349c'	21.4	?	20.2
152348q	21.1	18.9	20.0	8.3	15.0	152349f'	22.4	?	21.6
152348r	22.2	21.2	23.6	11.0	17.0	152349g'	23.7	?	22.1
USNM 738						152349h'	22.7	?	20.6
152349a	4.0	?	4.1	2.1	?	152349i'	26.2	?	22.6
152349b	4.8	?	4.7	2.3	?	152349j'	29.8	?	23.9
152349c	5.2	?	5.5	3.0	?	152349k'	35.9	?	27.8
152349d	5.8	?	4.9	2.4	?	152349-l'	27.5	?	25.0
152349e	6.0	?	6.0	3.2	?	152349m'	27.3	?	28.0
152349f	6.6	?	5.6	3.5	?	152349n'	31.2	?	26.6
152349g	7.0	?	6.2	3.3	?	152349o'	29.1	?	25.3
152349h	8.3	?	8.4	3.8	?	152349p'	30.7	?	28.5
152349i	9.3	?	8.3	4.1	?	152349q'	32.8	?	28.9
152349j	10.7	?	9.8	5.8	?	152349r'	30.9	?	28.0
152349k	10.0	?	8.9	5.1	?	USNM 750			
152349-l	10.5	?	10.4	5.0	?	152353a	6.8	6.4	5.9
152349m	10.6	?	9.5	4.9	?	152353b	6.9	6.4	6.6
152349n	10.9	?	11.0	6.0	?	152353c	7.8	7.5	7.1
152349o	12.4	?	10.3	5.0	?	152353d	8.4	7.9	7.8
						152353e	9.0	8.9	7.9
						152353f	9.8	9.5	8.9
						152353g	10.5	9.6	9.9
						152353h	11.8	10.9	10.5?
						152353i	12.8	11.8	12.1
						152353j	16.7	14.2	15.5
						152353k	16.3	14.8	14.4
						152353-l	16.5	14.8	16.4
						152353m	16.7	15.0	14.2
						152353n	17.8	15.6	16.9
						152353o	20.0	16.9	18.9
						152353p	20.0	16.9	18.8
						152353q	22.8	19.3	18.5
						152353r	26.0	22.8	23.3
						USNM 738			
						152350a	3.2	2.7	3.0
						152350b	4.1	3.7	3.4
						152350c	4.4	3.7	3.7
						152350d	4.8	4.6	5.0
						152350e	7.6	6.9	7.0
						152350f	21.5	19.2	18.7

each narrowly wedge-shaped and with greatest width anterior, longitudinally striated weakly.

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Lamar Member); Capitan Formation.

LOCALITIES.—Lamar: AMNH 25, 37, 38, 39, 40, 347, 348, 351, 384, 389, 430; USNM 725e, 728i, 728p, 728q, 728r, 738, 738b. Capitan: AMNH 725, 817, 820, 840, 847; USNM 725p, 737a, 740k, 740m, 750, 750b, 750e.

DIAGNOSIS.—Large, usually misshapen *Martinia* with long slender tongue on the ventral valve.

TYPES.—Lectotype (herein designated): USNM 118593a, figured by Girty (1909, pl. 13: fig. 11–11d). Figured paratypes: USNM 118593b–d, figured by Girty (1909, pl. 13, fig. 12–14c). Figured hypotypes: USNM 108551a,b; 152349q,t,v; 152350f; 154554a–e; 154555a–d; 154556a–j; 154557a; 154961a–c.

COMPARISON.—*Martinia rhomboidalis* is characterized by its large size, normally somewhat irregular or distorted shape, high fold that produces a long tongue on the pedicle valve but only a shallow notch in the brachial valve, thick and strongly curved pedicle beak, and relatively low pedicle interarea. It is larger than *M. martinezi* (Cooper) from the Permian of Mexico, and normally is proportionately wider, has a longer beak and higher interarea, is more strongly convex, and has a broader fold. It differs from *M. causaria*, new species, from the Getaway Member in its greater convexity, lower and more broadly arched fold, and narrower hinge with less prominent lateral protrusions. In addition, *M. causaria* typically is more distorted and the shells are pitted by ectoparasites. *Martinia rhomboidalis* differs from the rare Bone Spring new species, *M. fucina*, in its larger size, less transverse outline, stronger growth lines, thicker, more robust shell, and much higher fold, producing a much longer anterior tongue on the pedicle valve. The only other abundant species from Texas with which it may be compared is *M. miranda*, new species, from the Cathedral Mountain Formation in the Glass Mountains, from which *M. rhomboidalis* differs in its slightly smaller maximum size, less symmetrical shape, stronger growth lines, shorter beak, weaker radial ornament (confined to inner shell layers), and its higher fold and consequent longer anterior pedicle tongue.

Martinia rhomboidalis is larger than any of the species of the genus that Gemmellaro (1899) de-

scribed from the Sosio Limestone of Sicily, excepting only his *M. triquetra*. Its outline is not as distinctly pentagonal as in his *M. semiramis* or *M. aviformis*, and the fold is not as high or as abrupt as in *M. variabilis* or *M. polymorpha*. It most nearly resembles specimens of *M. rupicola*, differing primarily in its normally higher and narrower fastigium, with longer pedicle tongue; it is much larger than *M. distefanoi* and, although the width of the fold is similar, its height is much greater. Finally, its shallow sulcus and high fastigium are in strong contrast to the sharp sulcus and shallow trough along the crest of the fastigium of his *M. bisinuata* and *M. triquetra*.

All the species from the Salt Range described by Waagen (1883) are proportionately wider than *M. rhomboidalis*, and none has the high anterior fold that produces the long tongue on the pedicle valve. If Waagen's illustrated specimens are representative, the Salt Range species are smaller than *M. rhomboidalis* (specimens from the Salt Range in the National Museum collection are similar in size to Waagen's).

Martinia rhomboidalis has a more strongly curved pedicle beak than *M. osborni* Grabau (1931a), and also differs in its higher fold, long forward-extending tongue in the pedicle valve, and less depressed sulcus. It differs similarly from *M. mongolica* Grabau, whose fold is even lower. *Martinia sinensis* Grabau is much more strongly biconvex than *M. rhomboidalis*, and *M. rectangularis* Grabau is more quadrate, with wider hinge and very low fold. All the Mongolian species are smaller than *M. rhomboidalis*.

Among the Carboniferous and Permian species that Chao (1929) assigned to *Martinia*, *M. semiconvexa* Chao differs from *M. rhomboidalis* in its wide hinge and radial costae, and *M. undatifera* Chao differs in its strong concentric ornament. These two species probably belong to genera other than *Martinia*, and do not appear to be congeneric with one another. *Martinia changchiakouensis* Chao appears to be a *Martinia*; it is more strongly biconvex than *M. rhomboidalis*, and has a deeper sulcus and low fold without long lingual extension. *Martinia lopingensis* Grabau of Chao (1929, pl. 10) has a high fold, but rather than extending anteriorly as in *M. rhomboidalis*, it is nearly perpendicular to the plane of commissure, producing a much deeper sulcus and a slightly higher ridge

along the brachial valve. *Martinia remota* Chao is small and proportionately wide, and Chao's *M. semiglobosa* Tschernyschew is strongly convex, small, and wide.

The little species from the *Schwagerina* limestone that Tschernyschew called *M. corculum* (Kutorga) is similar to many specimens of *M. rhomboidalis*. The Texas species, however, attains larger size, normally is proportionately narrower, and is typically less symmetrical, most specimens being somewhat distorted. Tschernyschew's specimens of *M. triquetra* Gemmellaro attain a size somewhat larger than that of *M. rhomboidalis*, and differ further in their deeper sulci, flatter brachial valves, and normal presence of a shallow median trough along the crest of the fold, and in their more regularly elliptical rather than subpentagonal outlines. His *M. orbicularis* Gemmellaro differs from *M. rhomboidalis* as its name implies, being more circular in outline and more strongly biconvex. In addition, *M. orbicularis* is small and nearly rectimarginate. *Martinia timanica* Tschernyschew is large and has a strongly convex pedicle valve; its convexity, width of hinge, and the depth of its sulcus distinguish it from *M. rhomboidalis*. *Martinia semiglobosa* Tschernyschew is similar to *M. rhomboidalis*, but the Texas species attains larger size, has a higher fold, typically is more distorted, and has a narrower hinge line. *Martinia uralica* Tschernyschew is a large and convex species that differs from *M. rhomboidalis* in those features as well as in its greater proportionate width and lower fold. The pedicle valves of *M. semiplana* Waagen that Tschernyschew (1902, pl. 40) illustrated are small, and lack the tongue of the fold that single pedicle valves of *M. rhomboidalis* normally have. Tschernyschew's *M. incerta*, *M. parvula*, and *M. applanata* are small species that retain juvenile characters like rectimargination and subcircular outline of the brachial valve; his *M. simensis* is radially costate and has a deeper sulcus than *M. rhomboidalis*; and his *M. gemmellaroi* is weakly costate and nearly rectimarginate, in strong contrast to *M. rhomboidalis*.

DISCUSSION.—*Martinia rhomboidalis* is highly variable due to distortion of many of the shells during their growth, distortion of some after burial, and also due to preservation of some specimens as single silicified valves and of others as complete calcareous shells in various stages of exfoliation.

The average size of the calcareous shells is smaller than that of the silicified ones, but no other characters are sufficiently consistent to warrant recognition of more than one species. The collections of calcareous specimens from USNM 750 in the Capitan Limestone contain individuals that are narrower and have higher and sharper folds than the calcareous specimens from USNM 737a in the Lamar Member of the Bell Canyon Formation, but most specimens from the two localities are similar to one another, and the narrow specimens may be compressed because they were somewhat more crowded during growth.

Silicified specimens from USNM 738 in the Lamar Member attain a much larger size than calcareous specimens from USNM 737a elsewhere in the same member. No specific differences are apparent, however, and specimens of similar size are closely comparable. The difference in size may be the result of sorting, or perhaps of differences in available nutrients or living space in the Permian environments occupied by the two groups.

Girty recognized a second species from USGS 2926, naming it *M. shumardiana*. He stated that he expected to find intermediates between the holotype of this species and *M. rhomboidalis*. The *M. shumardiana* form differs in its supposedly more quadrate fold (i.e., flattened at crest), but the crest of the fastigium of the holotype is broken so as to produce a flat top. A few silicified pedicle valves from USNM 738b in the Lamar Member have the fastigium somewhat flattened, but these are distorted, as are so many examples of the species, and just happen to be distorted so that the fastigium is flattened. These specimens and Girty's specimen of *M. "shumardiana"* are variants within a variable population and, in fact, are not as far from the norm as are some others in our collections.

Martiania wolfcampensis R. E. King

PLATE 649: FIGURES 15–19

Martinia wolfcampensis R. E. King, 1931:121, pl. 40: figs. 9, 11–13 [not fig. 10].

Shell about medium size for genus, slightly wider than long; hinge narrow, equal to about half width; widest in middle; sides narrowly rounded; anterior margin somewhat nasute; anterior commissure strongly uniplicate; surface smooth.

Pedicle valve with moderately convex lateral profile, most convex on umbo; anterior profile broadly and moderately convex; umbo narrowly swollen, extended considerably beyond posterior margin; median region swollen; flanks inflated, slopes moderately steep. Sulcus not well defined; tongue long, with squarish front; tongue moderately convex, not concave as usual in most species of this genus; beak strongly incurved; interarea moderately long.

Brachial valve very gently convex in lateral profile; anterior profile somewhat narrowly convex with lateral slopes long and moderately steep. Umbonal and median region somewhat narrowly swollen, swelling continued anteriorly as flattened fastigium, well-defined only in front half; flanks bounding fold flattened and sloping moderately to margins. Umbonal slopes short.

MEASUREMENTS (in mm).—Holotype YPM 12295: length 24.3, brachial valve length 20.1, midwidth 24.4, hinge width 13.0, thickness 15.0.

STRATIGRAPHIC OCCURRENCE.—Gaptank Formation (*Uddenites* zone), Neal Ranch Formation (?).

LOCALITY.—King locality 88s.

DIAGNOSIS.—*Martinia* with a well-marked fold but with nearly obsolete sulcus.

TYPES.—Holotype: YPM 12295; Plaster replica of holotype: USNM 152377.

COMPARISON.—This species has a more prominent fold but less developed sulcus than *M. miranda*, new species. The transversely rounded tongue of *M. wolfcampensis* is very distinctive and sets the species off from any other Glass Mountains or Guadalupe species. It shares this feature with *M. martinezi* (Cooper) but that species does not have so strongly folded a brachial valve as that of *M. wolfcampensis*. This species is unlike any of those figured by Tschernyschew (1902), Grabau (1936), and Waagen (1884) from the Salt Range. It is most like *M. renfroae*, new species, from the Jacksboro Shale Member of north-central Texas.

DISCUSSION.—This is evidently a rare species, because we were unable to find any specimens of it in the careful search we made of the *Uddenites* zone and the Neal Ranch Formation. King (1931: 121) cites some variation in his specimens, noting that those from his localities 75 and 87 have a well-developed median depression, which is certainly not true of the type specimen. We have a specimen from USNM 706x = 715e, about bed 12–14 of the

Neal Ranch Formation, which is larger than *M. wolfcampensis* and has a narrow sulcus extending from near the beak to the anterior margin. This specimen suggests *M. triquetra* Tschernyschew (1902, pl. 56; not Gemmellaro 1899, pl. 32). The type specimen of *M. wolfcampensis* is most unlike *M. triquetra*. We believe that King was dealing with more than one species in his collections, and that his specimens from the Neal Ranch Formation are unlike the type from the *Uddenites* zone.

Martinia species 1

PLATE 644: FIGURES 50–53

This species is represented by 10 specimens of various sizes from USNM 711d and another poorly preserved one from USNM 708q. The species represented was very large, attaining a length of 33 mm from USNM 711d and the one from USNM 708q measuring almost 40 mm in length. The pedicle valve has a well-marked but shallow sulcus and the brachial valve has a gentle but poorly defined fold. The species is somewhat reminiscent of *M. miranda*, new species, but the sulcus of the pedicle valve is stronger than that of *M. miranda* and the brachial valve is not posteriorly narrowed as in *M. miranda*.

MEASUREMENTS (in mm).—From locality USNM 711d specimens 152521a and b, respectively: length 33.7, (?); brachial valve length (?), 29.0; width 33.6, 34.6; hinge width 16.2?, 16.0?; thickness 11.0?, 7.0.

STRATIGRAPHIC OCCURRENCE.—Skinner Ranch Formation.

LOCALITIES.—USNM 708q, 711d.

TYPES.—Figured specimens: USNM 152521a,b.

Martinia species 2

A pedicle valve (USNM 152993) from USNM 705a and two (USNM 152992) from USNM 720e indicate a second species different from all others described herein. The shells are narrowly and transversely elliptical with a long tongue and scarcely any sulcus.

Heteraria, new genus

[Greek *heteros* (different)]

About medium size, resembling *Martinia* exter-

nally; hinge narrow; interarea narrow but well formed; anterior commissure uniplicate; delthyrium open; surface without other ornament than fine lines of growth, and fine concentric undulations and growth varices. Color bands narrow, radial.

Pedicle valve with narrow but deep delthyrial cavity; teeth small; dental plates short and receding; delthyrium restricted on each side by thin horizontal plate under delthyrial edge and attached to dental ridge and dental plate. Muscle area narrow and extended slightly anterior to delthyrial cavity.

Brachial valve interior with small bosslike cardinal process and long tubular sockets; socket ridges stout; distal ends of sockets covered by thin plates; helicophore bases broadly triangular and directed in dorsad direction. No median ridge or axial thickening of any sort.

TYPE-SPECIES.—*Heteraria blakemorei*, new species.

DIAGNOSIS.—A martiniid brachiopod having dental plates but no other septa in either valve.

COMPARISON.—*Heteraria*, as shown by its brachial valve, is clearly a martiniid differing from *Martinia*, sensu stricto, in the presence of strong dental lamellae. Possession of dental lamellae links *Heteraria* to other septate martiniids such as *Fredericksia* Paeckelmann, *Martiniella* Grabau and Tien, *Martiniopsis* Waagen, *Mentzelia* Quenstedt, *Merospirifer* Reed, *Notospirifer* Harrington, and *Tomiopsis* Benedictova. The last three of this list are weakly or strongly costate or plicate, and thus differ from the smooth *Heteraria*. *Fredericksia* and *Mentzelia* have dental plates but in addition they are provided with a median septum, no trace of which appears in *Heteraria*. *Moumina* Fredericks and *Martiniella* have dental plates but no median septum, and are thus like *Heteraria*, but the former is capillate and has surficial pits on the exterior while the latter is only capillate. *Eomartiniopsis* and *Martiniopsis* have, respectively, short and long crural plates but such plates do not occur in *Heteraria*.

DISCUSSION.—This genus is one of the rarest in the Glass Mountains. It is known from 14 valves taken from the blocks at USNM 721u, and 3 other valves, 2 from the Guadalupes and 1 from the Sierra Diablo.

Features of interest in this genus are the color bands, fold and sulcus, the lateral plates in the delthyrial cavity, and the formation of the sockets in the brachial valve. One specimen has traces of color which consist of a posteriorly tapering streak like those of *Neophricadothyris* and *Composita* noted and illustrated elsewhere in this monograph. The actual color of the band is a pale brown and this leads to the suggestion that the true color was red as it is in Recent color-banded brachiopods, such as *Laqueus rubellus* (Sowerby) and *Argyrotheca barrettiana* (Davidson). Some Devonian terebratulids have been found with red color bands (Cloud, 1942).

The fold and sulcus of *Heteraria* are characteristically martiniid, especially the sulcus, which has a fairly strongly impressed narrow median depression.

A feature well developed and shared with *Martinia* of the Permian involves the lateral plates of the delthyrial cavity. In *Heteraria* these are almost horizontal to slightly shelving toward midvalve; in the oldest adult they narrow the delthyrium considerably and thus act in a manner similar to deltidial plates, differing from the latter in being dorsal to the delthyrial edge rather than flush with it.

These lateral plates are welded to the dental ridge, to the prolongation of the tooth in a distal direction, and to the dental plates where they buttress the interarea. No apical plate was seen in the pedicle valves of this genus.

The brachial valve interior of *Heteraria* is like that of other martiniids and also like that of some reticulariids such as *Neophricadothyris* and *Astegosia*. The long slitlike sockets are covered distally by thin plates that make the socket into a long proximally expanding tube. The socket ridge is thus a narrowly curved plate attached to the side of the valve. The base of the helicophore is attached to the side of the socket ridge facing the inside of the valve. This base is broadly triangular and tapers proximally.

The stratigraphic range of this genus is from Wolfcampian into the Guadalupian. *Heteraria blakemorei* occurs in the lower Cathedral Mountain (early Leonardian) on the Iron Mountain Ranch.

Heteraria blakemorei, new species

PLATE 646: FIGURES 10-34

About medium size, subrectangular in outline, broadly rounded sides, and somewhat truncated anterior margin. Hinge narrower than maximum width (at about midvalve). Anterior commissure broadly to deeply and narrowly uniplicate. Interarea narrow, strongly apsacline; beak ridges moderately strongly defined. Delthyrium wide, open, not modified externally. Surface without pits or capillae but marked by closely spaced narrow undulations, fine lines of growth and varices of growth.

Pedicle valve exterior with broad, shallow fold, deepening anteriorly and marked medially by narrow depression. Sulcus originating at beak, forming short to moderately long, gently rounded to truncated tongue at anterior. Lateral profile gently convex; anterior profile broadly convex, median region flattened to narrowly concave. Lateral slopes steep. Beak suberect.

Brachial valve unevenly convex, anterior half in lateral profile flattened, posterior half curved to beak. Anterior profile broadly to moderately convex with lateral slopes moderately steep. Fastigium low to moderately strong, originating near midvalve or somewhat posterior to that point; fold broadly to narrowly rounded at anterior. Antero-lateral extremities narrowly rounded to pointed. Umbonal region somewhat inflated.

Pedicle valve interior with deep delthyrial cavity restricted just beneath margin by strong marginal plates. Muscle area short, protruding beyond anterior end of delthyrial cavity, rhomboidal in outline. No septa, but slight median ridge formed by exterior sulcus. No pallial marks preserved.

Brachial valve interior as described under genus; no septa; muscle scars slightly impressed; cardinal process small.

MEASUREMENTS (in mm).—

	brachial valve		hinge	thick-
	length	length	width	ness
USNM 721u				
153190a (holotype)	21.0	?	25.0	12.4
153190b	?	20.4	25.7	11.2
153190c	19.8	?	21.2	11.8
153190e	?	19.7	25.6	13.3

STRATIGRAPHIC OCCURRENCE.—Lower Cathedral Mountain Formation.

LOCALITY.—USNM 721u.

DIAGNOSIS.—Subrectangular *Heteraria* having numerous varices of growth and strong lateral plates in the delthyrium.

TYPES.—Holotype: USNM 153190a. Figured paratypes: USNM 153190b-f. Unfigured paratypes: USNM 153190g-n. Measured paratypes: USNM 153190b,c,e.

COMPARISON.—The presence of dental plates in this genus makes its differentiation from other martiniids easy. The only other species that are similar belong to the genus *Rallacosta* and occur in the Guadalupe Mountains. These appear to have been larger, more elliptical, less inflated in both valves, and with less pronounced fold and sulcus.

Rallacosta, new genus[Latin *ralla* (thin) + *costa* (rib)]

Moderate size spiriferid, biconvex, transverse; greatest width near midlength, hinge slightly narrower in adults; greatest width at or just anterior to hinge in some small juveniles; commissure uniplicate, fold weak in juveniles, stronger in large adults; fastigium standing only slightly above flanks, normally rather broad, gently arched or bluntly and gently crested; sulcus shallow, beginning nearly at beak, projected anteriorly as tongue fitting into arch of fold; costae low, blunt, single or weakly fasciculate, occupying fold and sulcus as well as flanks; growth laminae fine and obscure in some species, distinct and rather regularly spaced in others.

Pedicle valve moderately to somewhat strongly convex, greatest convexity near beak, or at anterior of sulcus, convexity elsewhere rather even; beak short, bluntly pointed, moderately curved, with apex suberect to erect; interarea low, broadly trigonal, narrowly tapered distally, moderately to strongly concave longitudinally; delthyrium nearly equilaterally triangular, open, occupying median third of interarea. Brachial valve less strongly and more evenly convex; beak short, blunt; interarea absent or reduced to very narrow flat surface, located just posterior to bearing-surface of articulation for edge of opposite valve; notothyrium very

broadly wedge-shaped, occupying median third of hinge width.

Pedicle valve interior with short, sharply wedge-shaped hinge teeth, projecting dorsally in plane of interarea; dental ridges broad, slanting medially, converging toward apex of delthyrium, fusing to form short internal delthyrial plate at extreme apex; dental plates very short, moderately high, mesially bowed, continuous with dental ridges and meeting floor of valve, defining small, wedge-shaped delthyrial chamber, and two semiconical umbonal chambers in posterior; muscle area weakly impressed, occupying region between dental plates and extending anteriorly about a third valve length; adductor muscle marks narrow, elongate, median; diductor marks larger, anterior and lateral to diductors; pedicle adjustor marks not clearly differentiated, probably lying in area between dental plates.

Brachial valve interior with deep hinge sockets, smooth or weakly denticulate, bridged by thin plate except where occupied by teeth of opposite valve; cardinal process small, incised into several small parallel plates; socket ridges projected slightly just above functional socket; bases of helicophores extending from socket plates, broad, flat, but rapidly tapering to become narrow, ribbonlike; descending processes giving rise to jugal processes; spiralia ribbonlike, coiled dorsoventrally; muscle area lightly impressed, spatulate in shape, paired adductor muscle marks only indistinctly differentiated.

TYPE-SPECIES.—*Rallacosta imporcata*, new species.

DIAGNOSIS.—Outline transversely elliptical, widest anterior to hinge, beak short, interarea low, costae few, low, single or weakly fasciculate, cardinal process very small, made of several parallel plates, dental plates present but short.

COMPARISON.—All specimens in the collection are preserved by silicification which is not fine enough to preserve a possible surface shagreen. The weakly fasciculate form of the costation, the length of the hinge, and the transverse outline suggest relationship of this genus to the major group of impunctate spiriferids which lack fine pitting of the outer shell surface, rather than to the subfamily Ingellarellinae of Campbell, which includes *Martiniopsis* Waagen and its relatives.

This genus resembles some specimens of "*Elina*" *rectangula* (Kutorga) illustrated by Tschernyschew

(1902, pl. 8: fig. 1) but differs in its narrower and lower costae, lower fold, and especially in its narrower hinge. Specimens of *E. rectangula* on Plate 41 of Tschernyschew (1902), cited as examples of the genus *Elina* by Fredericks (1924c:322) clearly indicate that genus belongs to the wide-hinged spiriferids, remote from *Rallacosta* (for status of *Elina*, see Williams et al., 1965:H704).

The outline of *Fredericksia simensis* (Tschernyschew, 1902, pl. 6: fig. 10) is similar to that of certain species of *Rallacosta*, but other features are dissimilar. *Fredericksia* Paeckelmann is strongly biconvex, and noncostate, whereas *Rallacosta* is ornamented by radial costae, concentric lamellae, or both. *Rallacosta* has much finer and lower costae than the narrow-hinged *Cartorhium*, new genus, and differs further in its reduced dental plates and very small cardinal process. It differs similarly from *Spirifer nikitini* Tschernyschew, the type species of Fredericks' preoccupied genus "*Munella*" for which Reed (1944) substituted the name *Purdonella*. As explained in the discussion of *Cartorhium*, Reed's *Purdonella* appears to represent a group different from "*Munella*." *Rallacosta* is more similar to *Purdonella*, differing in its much finer, weaker and fewer costae, higher anterior fold, stronger growth laminae, and probably also by its small thin dental plates and tiny cardinal process.

Rallacosta actina, new species

PLATE 647: FIGURES 1-37

Average size for genus; outline moderately transverse in juveniles, becoming broadly transverse in adults, widest near midlength or slightly posterior to it; commissure flatly uniplicate; fold low, rounded, producing slight emargination of brachial valve; sulcus shallow, beginning at beak, with shallow median trough in some specimens, projecting anteriorly to fill fold and reduce extent of emargination of shell; costae weak, fine, incipiently fasciculate, alternately coarser and finer on some specimens, with finer costae being added later, by intercalation or bifurcation; growth lines obscure or prominent, closely spaced; growth laminae absent or infrequent and widely spaced at irregular intervals.

Pedicle valve moderately convex, with greatest

swelling just anterior to beak; beak sharp, nearly erect, slightly attenuate in some individuals; interarea trigonal, concave, bisected by wedge-shaped delthyrium with traces of growth of teeth along each side. Brachial valve somewhat less strongly convex; beak short, but somewhat extended for genus in some specimens; interarea just a flattening of edge of valve, with broadly wedge-shaped notothyrium open.

Pedicle valve interior with short wedge-shaped hinge teeth; dental ridges moderately deep, tapered both at anterior and posterior ends; dental plates short, thin, divergent; muscle impressions weak, lying between dental plates and extending anteriorly about one-third valve length.

Brachial valve interior with deep, very weakly denticulate sockets bridged by thin plate over non-functional part; cardinal process somewhat long and broad for genus (nevertheless, very small) composed of several small platelets; bases of helicophores broad, tapering from socket plates, converging toward midline, narrowing to ribbons; descending lamellae with short jugal processes; spiralia ribbon-like; number of coils and direction of axis of coiling not observed.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 702b					
152970a	2.7	?	3.8	3.4	?
152970b	3.9	?	5.4	4.8	?
152970c	4.1	?	5.1	4.0	?
152970d	?	4.1	5.5	4.5	?
152970e	4.8	?	6.6	5.4	?
152970f	5.3	?	7.0	6.2	?
152970g	?	6.1	8.6	7.5	?
152970h	6.5	?	10.4	9.9	?
152970i	7.9	?	11.0	c.9.0	?
152970j	?	10.8	14.7	10.2	?
152970k	?	13.2	17.8	13.0	?
152970-l	19.9	?	30.6	24.9	?
USNM 702					
152971a	?	14.0	17.7	14.5	?
152971b	?	14.4	22.0?	16.0?	?
152971c	16.8	14.6	18.8	13.0?	10.8
152971d	19.0	?	30.6	24.9	?
(holotype)					
USNM 702inst.					
152972	?	15.4	21.6	14.2	?

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITIES.—AMNH 500B, 500F; USNM 702, 702b, 702inst, 702un, 712o.

DIAGNOSIS.—Weakly costate *Rallacosta* with irregularly spaced growth laminae, and low fold and sulcus.

TYPES.—Holotype: USNM 152971d. Figured paratypes: USNM 152970k-p; 152971c,e; 152972. Measured paratypes: USNM 152970a-l, 152971a-c, 152972. Unfigured paratypes: USNM 152970a-j.

COMPARISON.—*Rallacosta actina* is characterized by its weak costae, infrequent and irregularly spaced growth laminae, low fold, and shallow sulcus. Its lack of strong or regular growth laminae distinguish it from *R. xystica*, and *R. laminata*, both new. It most nearly resembles *R. importata*, new species, but differs in its weaker and less obviously fasciculate costae, somewhat lower convexity, more transverse outline, and possibly also by larger maximum size (one specimen in the small collection is larger than the largest specimen of the more numerous *R. importata*).

Rallacosta importata, new species

PLATE 648: FIGURES 1-48

Small for genus, rather strongly biconvex; outline transversely but roundly subelliptical, greatest width near midlength, less commonly posterior to midlength, rarely anterior to midlength; commissure strongly uniplicate; fastigium low, sharply or evenly arched, beginning at beak; fold producing notable emargination at anterior; sulcus shallow, with shallow rounded median trough in most specimens; costae strong for genus, some sharp, some rounded, simple or weakly fasciculate, adding anteriorly by intercalation or dichotomy, occurring on fastigium and sulcus as well as on flanks; growth lines weak, barely visible except near margins of most specimens; growth laminae absent.

Pedicle valve moderately strongly convex, with greatest swelling in umbonal region; beak short, blunt, somewhat bulbous in some specimens; interarea low, rather strongly concave longitudinally; delthyrium broad, open. Brachial valve less strongly and more evenly convex, also with greatest convexity near posterior; interarea very short, hardly more than thickness of valve edge in some; notothyrial cavity wide, shallow.

Pedicle valve interior with short sharp teeth; dental ridges slender, nearly uniform in depth throughout length; dental plates thin, subparallel or slightly divergent, short; muscle area weakly impressed between plates and anterior, details of pattern apparently normal.

Brachial valve interior with small cardinal process composed of several tiny platelets; sockets deep, partly covered by thin plate, denticulation not observed, apparently smooth; bases of helicophores broad, slightly convergent, tapering to narrow ribbons; short jugal process observed but remainder of brachial apparatus not seen; muscle area shallowly impressed in umbonal region, pattern of individual muscle marks not observed.

MEASUREMENTS (in mm).—

	length	brachial length	width	hinge width
USNM 725f				
152973a	5.5	?	7.1	4.4
152973b	5.8	?	7.7	5.8
152973c	8.3	?	10.0	7.4
152973d	?	8.4	11.2	6.1
152973e	8.8	?	11.7	6.4
152973f	9.5	?	13.1	8.2
152973g	9.3	?	13.8	8.4
152973h	10.0	?	13.0	7.9
152973i	10.0	?	14.7	11.7
152973j	?	10.9	13.7	11.4
152973k	11.4	?	15.0	11.0
152973l	?	12.2	18.3	10.4
152973m	12.8	?	17.7	15.0
152973n (holotype)	13.6	?	18.0	10.0
152973o	13.3	?	18.3	11.8
152973p	?	14.0	20.0	12.1
152973q	?	14.6	21.0	15.0
152973r	14.8	?	19.8	15.0
152973s	16.0	?	22.0?	19.5?
152973t	16.5	?	24.6	21.4

STRATIGRAPHIC OCCURRENCE.—Bell Canyon Formation (Hegler, Pinery, and Rader members).

LOCALITIES.—Hegler: USNM 731, 732a, 740c, 740d. Pinery: AMNH 524; USNM 733, 736, 725n. Rader: 725f, 725g, 740a, 740i, 740j.

DIAGNOSIS.—Small, convex, strongly costate *Rallacosta*.

TYPES.—Holotype: USNM 152973n. Figured paratypes: USNM 152973j,q,t-y. Measured paratypes: USNM 152973a-m, o-t.

COMPARISON.—*Rallacosta imporcata* is characterized by its small size, relatively strong convexity, slightly swollen beaks, and for this genus, its strong

costae. It is smaller than any other of the known species, and differs from small specimens of the other species primarily by its stronger costae, weak growth lines, and absent growth laminae.

Rallacosta laminata, new species

PLATE 648: FIGURES 49-77

Large for genus, moderately to rather strongly biconvex; outline transversely subelliptical, widest anterior to hinge and posterior to midlength; commissure weakly uniplicate in juveniles, moderately uniplicate in adults; fastigium beginning at apex of beak, low, gently arched, weakly costate; sulcus shallow, beginning at beak, rather sharply defined in some specimens by a low costa along each edge; costae low, fine, best defined and somewhat fasciculated in juveniles, becoming lower and broader, less obviously fasciculate on adult parts of shell; growth lines fine, closely spaced, several occurring concurrently at rather regular intervals, forming stronger growth laminae, producing distinctive concentric ornament over most of shell surface.

Pedicle valve rather evenly convex transversely and longitudinally; beak short, bluntly pointed, suberect; interarea transversely flat, moderately concave longitudinally, with closely spaced growth lines slightly wavy over trace of growth of hinge teeth; delthyrium open. Brachial valve arched toward crest of fold, greatest longitudinal convexity near beak; interarea very low, nearly completely excavated by broad shallow notothyrial wedge.

Pedicle valve interior with short, blunt teeth; crescentic dental ridges, short, slightly divergent dental plates meeting near apex to form small, deep-set delthyrial platform in adults; muscle area weakly impressed, but distinct for genus, with pattern as described for genus.

Brachial valve interior with deep sockets, weakly denticulate and bridged by thin plate over non-functional part; cardinal process small, parallel plates producing bilobed or trilobed appearance, relative size increasing slightly with growth; helicophore bases broad, extending from socket ridges, tapering rapidly to narrow ribbons; remainder of brachial apparatus not observed; muscle area very shallowly impressed.

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

MEASUREMENTS (in mm).—

	length	brachial valve length	width	hinge width	thick- ness
USNM 708u					
152974a	1.6	?	1.8	1.4	?
152974b	?	1.8	2.0	1.2	?
152974c	1.9	1.9	2.6	2.0	1.4
152974d	2.2	2.2	2.7	1.9	1.5
152974e	2.8	?	3.0	2.0	?
152974f	3.3	?	4.1	3.4	?
152974g	?	4.0	5.2	4.8	?
152974h	4.8	?	4.7	3.7	?
152974i	?	5.4	7.0	5.6	?
152974j	5.4	5.4	6.0	5.3	3.9
152974k	5.8	?	6.8	4.6	?
152974l	?	6.0	8.0	7.0	?
152974m	6.4	?	8.0	5.6	?
152974n	?	7.1	9.6	7.4	?
152974o	7.8	?	10.3	8.6	?
152974p	?	8.3	11.7	10.4	?
152974q	8.8	?	10.9	9.1	?
152974r	8.9	?	11.6	8.2	?
152974s	?	10.0	13.8	11.8	?
152974t	10.2	?	14.1	12.2	?
152974u	?	12.0	14.5	10.6	?
152974v	11.1	?	15.7	12.3	?
152974w	12.4	?	16.1	12.2	?
152974x	?	14.0	17.5	11.1	?
152974y	14.5	?	17.9	12.5	?
152974z	?	14.7	20.0	15.8	?
152975a	?	17.0	23.6	17.9	?
152975b	17.3	?	23.0	16.4	?
152975c	18.7	?	23.0	16.0	?
152975d	?	19.8	29.5	20.8	?
152975e	10.8	?	27.3	20.0	?
152975f	21.0	?	29.6	21.8	?
152975g	?	24.0	34.1	22.4	?
(holotype)					
152975h	24.2?	?	31.2	c.22.0	?

LOCALITY.—USNM 708u.

DIAGNOSIS.—Large *Rallacosta* with weak costae but strong concentric laminae.

TYPES.—Holotype: USNM 152975g. Figured paratypes: USNM 152974u,y; 152975b,c,d,i. Measured paratypes: USNM 152974a-z; 152975a-f,h.

COMPARISON.—*Rallacosta laminata* is characterized by its relatively large size for the genus, its weak costae that are strongest on juveniles (or the posterior parts of adults) and along the edges of the sulcus, and especially by its strong growth laminae that occur at rather regular intervals, producing a laminated effect in some specimens and a reticulate effect in others that have relatively

strong costae. Its size is approached by that of *R. actina* and *R. xystica*, both new, although neither of those species contains specimens as large as the largest *R. laminata* known. *Rallacosta xystica* also is laminated, but has much stronger costae, a higher fold, a median groove in the sulcus, and the laminae produce a rougher surface and seem to be more widely and less regularly spaced than in *R. laminata*.

This species differs from *R. actina* in its stronger laminae and weaker costae, and from *R. imporcata*, new species, in its larger size, weaker costae, stronger laminae, and lower fold.

Rallacosta xystica, new species

PLATE 647: FIGURES 38–54

Average size for genus, moderately to rather strongly biconvex; outline transversely sub- or semi-elliptical, widest near midlength or slightly anterior; commissure strongly uniplicate; fastigium low, only slightly elevated above flanks, evenly rounded; fold producing shallow emargination at anterior edge; sulcus shallow, some with shallow rounded median trough; costae weak to moderately strong, bifurcating or trifurcating, weakly fasciculate in some specimens, crests rounded; growth lines fine and closely spaced; growth laminae very strong for genus, with slightly raised edges producing rasp-like surface by crossing costae and fascicules of costae.

Pedicle valve rather strongly convex; short, sharp, suberect to erect; interarea slightly narrow for genus, strongly concave longitudinally. Brachial valve less strongly convex; beak short, rounded; interarea forming only slight flattening of valve edge along hinge; notothyrium very broad, shallowly wedge-shaped.

Pedicle valve interior with short blunt hinge teeth; dental ridges very deep, crescentic, strongly convergent toward midline, meeting at apex: area between dental plates obstructed for short distance anterior to beak by small platform of secondary shell material; dental plates thin, very short, rather strongly divergent; muscle area elongate, spatulate, individual muscle marks not discerned.

Brachial valve interior with thick socket ridges; deep sockets partly bridged by thin plates; cardinal process large for genus, triangular, with mesial

part composed of several thin platelets; spiralia and attachments not preserved; muscle area obscure, apparently normal for genus.

MEASUREMENTS (in mm).—Thickness unmeasurable.

		brachial valve		hinge
	length	length	width	width
USNM 703b				
152976a	?	7.6	10.7	8.8
152976b	?	8.4	11.1	8.9
152976c	?	10.6	15.4	12.0?
152976d	?	14.2	21.7	15.0
152976e (holotype)	?	15.7	23.0	15.6
152976f	17.0	?	22.4	18.5
152976g	21.0	?	30.4	23.0

STRATIGRAPHIC OCCURRENCE.—Cathedral Mountain Formation.

LOCALITY.—USNM 703b.

DIAGNOSIS.—Large, laminated *Rallacosta* with laminae interrupted by costae to produce a rough surface.

TYPES.—Holotype: USNM 152976e. Figured paratypes: USNM 152976d,g. Measured paratypes: USNM 152976a-d,f,g.

COMPARISON.—*Rallacosta xystica* is characterized by its rather large size (for the genus) and strong convexity, and especially by its rounded costae that are crossed by strong growth laminae to produce a coarse rasplike surface. It most nearly resembles *R. laminata*, new species, in its size and ornamentation, differing in its somewhat thicker shell, deeper dental ridges, stronger and more widely spaced growth laminae, and its stronger and more rounded costae. The rough external surface distinguishes this species from *R. actina* and *R. importata*, both new; in addition, it is much larger than *R. importata*.

Rallacosta species 1

PLATE 646: FIGURES 1–6

Large for genus, wider than long, outline broadly elliptical; hinge narrower than maximum width at midvalve. Anterior commissure broadly uniplicate; interarea narrow and strongly apsaline; surface mostly smooth but growth lines and varices concentrated on anterior parts of valves.

Pedicle valve with very gently convex lateral profile and very broadly convex anterior profile; flanks moderately steep; sulcus shallow, originating at

beak as narrow depression extending to anterior margin but forming center of broadly shallow sulcus. Beak small; umbonal region narrowly swollen. Tongue short, bluntly pointed.

Brachial valve with gently convex lateral profile, most convex somewhat posterior to midvalve; fastigium low and poorly formed originating at midvalve; flanks sloping gently.

Interior of pedicle valve with short receding dental plates; lateral plates below delthyrial margin narrow; muscle area elongate diamond-shape and anterior extending to about midvalve. No septa but slight thickening anterior to muscle field probably produced by sulcus.

Brachial valve interior with short, shallow socket ridges, sockets partly covered by plates; cardinal process small. Other features not clearly visible.

MEASUREMENTS (in mm).—Specimens 153191a and b, respectively: length 27.3, (?); brachial valve length (?), 21.7; maximum width 31.9, 26.8; hinge width 21.4 *, 14.6; thickness 8.3, 5.5.

STRATIGRAPHIC OCCURRENCE.—Cherry Canyon Formation (Getaway Member).

LOCALITY.—USNM 728.

DIAGNOSIS.—Broadly elliptical *Rallacosta* of large size having poorly developed fold and sulcus, slightly developed lateral plates in the pedicle valve, and small socket ridges in the brachial valve.

TYPES.—Figured specimens: USNM 153191a,b.

Rallacosta species 2

PLATE 633: FIGURE 38; PLATE 646: FIGURES 7–9

A single fragmentary pedicle valve indicates a species larger than the preceding. It has a prominent impressed line running the length of the very shallow sulcus. The line is so strongly impressed that it makes an elevated ridge on the inside of the valve. The dental plates are not so strongly receding as in the previous two species but no lateral plates are developed below the margin of the delthyrium. The shell is too thin to record details of the muscle field. The dimensions are estimated to have been about 27 mm long and 36 mm wide.

STRATIGRAPHIC OCCURRENCE.—Bone Spring Formation (lower).

LOCALITY.—AMNH 629.

TYPES.—Figured specimen: USNM 153192.

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