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SMITHSONIAN MISCELLANEOUS COLLECTIONS
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Charles D. and Mary Vaux Walcott Research Fund

CENOZOIC AND CRETACEOUS ECHINOIDS FROM TRINIDAD AND VENEZUELA

(With 14 Plates)

By
C. WYTHE COOKE
Research Associate
Smithsonian Institution

(Publication 4459)

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SOURCES OF INFORMATION

Most of the fossils described herein were received by the United States National Museum in 1959 and 1960 from Richard L. Casanova as an exchange with the Paleontological Research Laboratory at Statesville, N. C. The Museum also contains a large collection of West Indian echinoids obtained many years ago from R. J. L. Guppy. This includes not only Guppy's own specimens from Trinidad but also the Cleve collection, chiefly from St. Bartholomew and Anguilla, which was reported on by G. H. Cotteau (1875) and was restudied by Jackson (1922). Other types from the Caribbean region in the National Museum are those of Jackson (1917, 1918, 1937) from the Canal Zone and Costa Rica and from Mexico. Most of my own types from Venezuela (Cooke, 1941a), Colombia (Cooke, 1955), Guatemala (Cooke, 1949b), Peru (Cooke, 1949a), and Panama (Cooke, 1948) are in the National Museum, as well as the large collections from the Cretaceous and Cenozoic formations of the United States (Cooke, 1941b, 1942, 1946, 1953, 1959), including the types of W. B. Clark and Twitchell's (1915) monograph.

The echinoid faunas of much of the West Indian region are well known. The most comprehensive papers are by Cotteau (1875) on St. Bartholomew and Anguilla, Jackson (1922) on the West Indies, Egozcue y Cía (1897) and Sanchez Roig (1923, 1926, 1949) on Cuba, and Arnold and H. L. Clark (1927, 1934) on Jamaica.

Little has been published about the echinoids of Trinidad and Venezuela. The first publication is the description by Guppy (1866) of *Echinolampas ovum-serpentis,* later called *Haimea,* from Trinidad. Jackson (1922) added one new species, *Peronella mirabilis,* here referred to *Weisbordella,* also from Trinidad. Seventeen species, for the most part from Venezuela, were described as new by Jeannet

(1928) from collections made in Trinidad by H. G. Kugler and in Venezuela by Kugler, Wiedenmayer, and Vonderschmitt. These collections evidently were not exhaustive, for several of the species are represented by a single fragment. One late-Eocene species, *Oligopygus nancei* Cooke (1941a) was later obtained from Venezuela, and Anisgard (1954) figures an unnamed species of *Plagiobrissus* from a deep well in Venezuela.

The geology of Trinidad is discussed by Suter (1960) and by Kugler (1956). The stratigraphy of Venezuela is also well known because of the many years of research by petroleum geologists. Their results are summarized in a "Léxico estratigráfico de Venezuela" (Schwarck Anglade, 1956), a book of 729 pages containing signed articles on each geologic formation and ending with a bibliography of several hundred titles of works on Venezuela, Trinidad, the West Indies, and some of broader interest.

The geologic names and the stratigraphic horizons assigned to the species from Venezuela in the present report agree, for the most part, with those found in the "Léxico." Because of my unfamiliarity with the region I have had to depend chiefly on the formation names and ages designated on the labels accompanying the fossils, without the ability to evaluate them. As some of the fossils were collected many years ago, it is quite likely that the stratigraphic data need revision.

SPECIES OF EARLY CRETACEOUS AGE

Seven species of Early Cretaceous age, six from some part of the Albian, one from the Aptian, are here recorded from Venezuela. Four of the genera and two of the species occur also in Colombia, where Cooke (1955, p. 87) reports eight species believed to be of late Albian age. Several species from both Venezuela and Colombia occur also in the Comanche series of Texas (Cooke, 1946) or are represented there by very closely related forms. The species from Venezuela are as follows:

Tetragramma sp.
Holectypus (*Caenholectypus*) *planatus aponensis* Cooke, n. subsp.
Phyllobrissus zulianus Cooke, n. sp.
Enallaster (*Washitaster*) *bravoensis* Böse?
Pseudananchys sp. indet.
Hemiaster sp.
Epiaster whitei Clark

SPECIES OF PALEOCENE AGE

The only echinoid thus far recognized as of Paleocene age in this region is *Phymosoma trinitensis* Cooke, n. sp. As the name indicates,

it was found in Trinidad. Its affinities appear to be with Cretaceous rather than Eocene species. This is in accordance with the Paleocene fauna of the United States, which includes more genera reminiscent of the Cretaceous than of the Eocene (Cooke, 1959, p. 2).

SPECIES OF MIDDLE EOCENE AGE

One species, *Fibularia farallonensis* Cooke, n. sp., was collected by J. A. Bullbrook on Farallon Rock, near San Fernando, Trinidad. According to W. P. Woodring (oral communication), H. G. Kugler regards this rock as representing a reef facies of the Navet formation of middle Eocene age. This correlation seems to be supported by the echinoid, which is similar to *Fibularia texana* (Twitchell) from the middle Eocene Weches greensand member of the Mount Selman formation of Texas.

SPECIES OF LATE EOCENE AGE

Seven species of echinoids from Trinidad or Venezuela are referred to the late Eocene. None are new. Their names are as follows:

Oligopygus wetherbyi kugleri Jeannet (from Trinidad)
Oligopygus haldemani costuliformis Jeannet (from Trinidad)
Oligopygus rotundus Cooke (from Trinidad and Venezuela)
Oligopygus nancei Cooke (from Venezuela)
Haimea ovum-serpentis (Guppy) (from Trinidad)
Weisbordella mirabilis (Jackson) (from Trinidad)
Eupatagus clevei (Cotteau) (from Venezuela)

Of these seven species, typical *Oligopygus wetherbyi* de Loriol and typical *Oligopygus haldemani* (Conrad) are restricted to the Ocala limestone (Crystal River limestone of Puri), the youngest formation of late Eocene age in Florida. Both subspecies are known only from the San Fernando formation of Trinidad. *Oligopygus rotundus,* described originally from the Moodys Branch (?) formation of Alabama, occurs also in the San Fernando formation and in the Tinajitas formation of Venezuela. *Oligopygus nancei* is known only from the Tinajitas formation of Venezuela. *Haimea ovum-serpentis,* typically from the San Fernando formation, occurs also in the St. Bartholomew limestone of the British West Indies. *Weisbordella mirabilis* has been found only in the San Fernando formation, but it is closely related to, possibly only a variant of, *Weisbordella johnsoni* (Twitchell), a species abundant in the Ocala limestone. *Eupatagus clevei,* typically from the St. Bartholomew limestone, occurs also in the Inglis limestone of Florida (Cooke, 1959, p. 89) and in the Gatuncilla formation of Panama (Cooke, 1948; Woodring, 1957, p. 22). The formations

containing *Eupatagus clevei* in Venezuela and in Jamaica (Arnold and Clark, 1934) are not specified.

The Inglis limestone and the Moodys Branch formation are contemporaneous, both of late Eocene age but older than the Crystal River limestone. The St. Bartholomew limestone contains several species of mollusks (Cooke, 1919, p. 106) and echinoids (Jackson, 1922, p. 8) of late Eocene age, though it is sometimes classified as middle Eocene (Woodring, 1957, p. 22) on the evidence of the Foraminifera.

The evidence of the echinoids indicates that the St. Bartholomew limestone is of late Eocene age. Jackson (1922, p. 8) lists 17 named species of echinoids from the St. Bartholomew and referred the formation to the late Eocene. The following revised list shows also the nearest relative in the United States and the geologic range if known. The evidence for a late Eocene age is apparent.

Echinoids from the St. Bartholomew limestone

Name used by Jackson	Revised name or affinity	Eocene Middle	Eocene Late
Cidaris loveni Cotteau	=*Phyllacanthus mortoni* (Conrad)	x	x
Sismondia antillarum Cotteau	*Neolaganum antillarum* (Cotteau)		
	Aff. *Neolaganum dalli* (Twitchell)	x	?
Parapygus antillarum (Cotteau)			
Echinolampas antillarum Cotteau			
Echinolampas ovumserpentis Guppy	*Haimea ovum-serpentis* (Guppy)		x
Echinolampas clevei Cotteau			
Asterostoma cubense Cotteau			
Agassizia inflata Jackson	=*Agassizia floridana* de Loriol		x
Prenaster loveni Cotteau			
Paraster antillarum (Cotteau)	=*Ditremaster subcylindricus* (Cotteau)		
	Aff. *Ditremaster beckeri* (Cooke)		x
Paraster subcylindricus (Cotteau)	*Ditremaster subcylindricus* (Cotteau)		
Periaster elongatus Cotteau			
Plagiobrissus loveni (Cotteau)			
Macropneustes antillarum (Cotteau)	*Schizobrissus jacksoni* Lambert		
Eupatagus grandiflorus (Cotteau)	=*Eupatagus clevei* (Cotteau)		
Eupatagus clevei (Cotteau)			x
Eupatagus antillarum (Cotteau)			x

SPECIES OF MIOCENE AGE

The species indicated as probably occurring in beds of Miocene age, though some persist to the Recent, are as follows:

Encope secoensis Cooke, n. sp.
Encope michelini Agassiz
Encope kugleri Jeannet
Encope (*Melitella*) *falconensis* Cooke, n. sp.
Clypeaster rosaceus (Linnaeus)
Echinolampas lycopersicus Guppy
Cassidulus falconensis (Jeannet)
Brissopsis antillarum Cotteau
Antillaster lamberti Jeannet
Pericosmus stehlini Jeannet
Brissus unicolor (Leske)
Plagiobrissus grandis (Gmelin)?
Rhynobrissus rostratus Cooke, n. sp.
Lovenia cf. *L. dumblei* Kew

At least two horizons of Miocene age are represented in this list. The older is that of the Anguilla limestone of the British West Indies, which seems to be coeval with the Chipola formation of Florida. Its occurrence in Trinidad and Venezuela is indicated by *Echinolampas lycopersicus,* described originally from Anguilla and believed to be restricted to that horizon. Another species described from Anguilla is *Brissopsis antillarum.* This, however, is less dependable, for it may have a longer range. Several species from the "couches d'Ojo de Agua" were referred to the middle Miocene by Jeannet (1928). The name Ojo de Agua, according to the "Léxico" (Schwarck Anglade, 1956, p. 460), has been used for two formations, one of middle Miocene age, the other predominantly upper Miocene.

The younger horizon includes the Springvale formation of Trinidad and the Chiguaje and La Vela formations of Venezuela, which are classified as late Miocene and presumably are about the age of the Duplin marl of the Carolinas and Florida. Among the species from these late Miocene formations may be mentioned *Encope falconensis* and *Rhynobrissus rostratus,* but both of these species may have a longer range.

SPECIES OF PLIOCENE AGE

The species attributed to the San Gregorio formation include *Lytechinus variegatus* (Leske), *Encope secoensis* Cooke, n. sp., *Encope* (*Melitella*) *falconensis* Cooke, n. sp., *Moira atropos* (Lamarck), and *Agassizia scrobiculata* Valenciennes. The *Lytechinus* and the *Moira* are still living in Atlantic waters, but *Agassizia scrobiculata*

is extinct there, though it now lives in the Gulf of California and in the Pacific Ocean.

DESCRIPTIONS OF SPECIES

MESOZOIC SPECIES

TETRAGRAMMA sp.

Two fragments resembling *Tetragramma streeruwitzi* (Cragin) (Cooke, 1946, p. 208, pl. 31, fig. 23) in all recognizable features are too poorly preserved for specific identification. The apical system is wanting. The poriferous zones are biserial on the upper part of the test, uniserial below. There are two rows of large perforated, crenulated tubercles in each ambulacrum, six in each interambulacral area. The median part of the latter contains only granules.

Occurrence.—Venezuela: El Pao, "Ojo de Agua," Cojedes (Mene Grande Petroleum Co. B-2454).

Geologic horizon.—No data. Early Cretaceous, presumably late Albian.

HOLECTYPUS (CAENHOLECTYPUS) PLANATUS APONENSIS Cooke, n. subsp.

Pl. 2, figs. 4-5

This subspecies, represented by only one individual, whose upper surface is defective, differs from the typical *Holectypus planatus* Roemer (Cooke, 1946, p. 217, pl. 32, fig. 13; 1955, p. 94, pl. 21, figs. 1-3) in its lesser height and more acute margin. This shape appears to be original, not caused by compression. The typical form is abundant in the Trinity and Fredericksburg groups of Texas, of early and middle Albian ages. It has been recorded also from the late Albian of Colombia (Cooke, 1955, pp. 87, 94).

Occurrence.—Venezuela: Río Apón, Zulia (Creole Petroleum Co. 50878).

Geologic horizon.—Early Cretaceous: Capacho formation, of middle Albian to Vraconian age.

Holotype.—USNM 131169.

PHYLLOBRISSUS ZULIANUS Cooke, n. sp.

Pl. 1, figs. 10-12

Test subquadrate, rounded in front, truncated behind, sides nearly parallel. Upper surface slightly inflated, highest point at the apical system, sloping more steeply in front, less steeply behind; lower sur-

face concave around the peristome; margin rounded. Apical system monobasal, slightly anterior, four genital pores; madreporite star shaped, central. Petals alike, extending nearly to the margin; poriferous zones very slightly arched, separated at the distal ends; inner pores circular, outer pores elongated, pores conjugate; interporiferous zones wider than the poriferous. Peristome defective; slightly anterior, more nearly central than the apical system. Periproct supramarginal, about one-third the way from the posterior margin to the apical system, twice as long as wide, flush, at the upper end of a shallow depression that indents the margin. Tubercles scrobiculate, more numerous and larger on the lower surface than elsewhere.

Length 46 mm.; width 42 mm.; height 18 mm.

Occurrence.—Venezuela: Roas Island, Zulia.

Geologic horizon.—Early Cretaceous: Apón formation, of Aptian age.

Holotype.—USNM 131167.

Comparisons.—The holotype, a unique specimen, is nearly twice as long and wide but proportionately lower than *Phyllobrissus gresslyi* (Agassiz), the type species of the genus, as figured by Orbigny (1854-1860, p. 425, pl. 966, figs. 1-6) under the genus *Clypeopygus* but referred to *Phyllobrissus* by Cotteau (Orbigny, 1854-1860, p. 553). The periproct is proportionately longer and narrower, and it is farther forward.

ENALLASTER (WASHITASTER) BRAVOENSIS Böse

Pl. 1, figs. 1-4

Enallaster bravoensis Böse, 1910, Inst. Geol. México Bol. 25, p. 168, pl. 41, figs. 5-10; pl. 42, figs. 2-12; pl. 43, figs. 1-2, 6-7.

Enallaster (*Washitaster*) *bravoensis* Böse. Cooke, 1955, U. S. Geol. Surv. Prof. Pap. 264-E, p. 106, pl. 27, figs. 5-12. Includes additional synonymy.

The single *Enallaster* here tentatively referred to *E. bravoensis* has the shape and lies within the size range of that species. It retains traces of a broad granular band surrounding the petals, on which band can be detected obscure narrow streaks of granules or fascioles like those characterizing *Washitaster*.

Occurrence.—Venezuela: Río Socuy, Zulia (Creole Petroleum Co. 50878).

Geologic horizon.—Early Cretaceous: Cogollo limestone, probably of late Albian age. The type of *Enallaster bravoensis* came from Cerro Muleros in Mexico near El Paso, Tex., and the species is abundant in the Ranchería Valley of Colombia (Cooke, 1955). In

all these places it occupies beds of late Albian age. The label accompanying the specimen from Venezuela specifies "Cenomanian, Cogollo limestone." As the Cogollo ranges in age from Aptian to Cenomanian (Wolf Maync in Schwarck Anglade, 1956, p. 172), and as *Enallaster* is not known to occur in the Cenomanian of Texas, this specimen is probably of Albian, not Cenomanian, age.

Occurrence.—Venezuela: Río Socuy, Zulia (Creole Petroleum Co. 64769). Another *Enallaster,* too poorly preserved for specific identification but resembling *E. bravoensis,* comes from Río Apón, Zulia (Creole Petroleum Co. 50878).

Figured specimen.—USNM 131170.

PSEUDANANCHYS sp. indet.

Several fragments of a species of *Pseudananchys* are embedded in hard calcareous rock. One of them retains the disjunct apical system, and all show the characteristic elongated ambulacral pores. The anterior petal is like the others.

Occurrence.—Venezuela: Island of Chimana Grande, off Puerto La Cruz, District of Bolívar, Anzoátegui (Mene Grande Petroleum Co. B-1615).

Geologic horizon.—Early Cretaceous: Chimana formation, of early to middle Albian age.

HEMIASTER sp.

Pl. 1, figs. 5-9

Weakly cordate, with a shallow depression in front and a narrow truncation behind; upper surface moderately inflated, highest point in front of the apical system; posterior end sloping downward and backward at an angle of about 45°. Apical system slightly anterior; four genital pores rather far apart, equally spaced. Anterior ambulacrum somewhat sunken; pores of petaliferous part short, circumflexed. Paired petals moderately sunken; the anterior pair slightly the longer, extending about two-thirds the way to the margin; pores elongated, widely spaced; poriferous zones open distally; interporiferous zones equal in width to the poriferous zones. Peristome far forward. Periproct oval, near the top of the posterior sloping truncation. Faint traces of a peripetalous fasciole.

Length 41 mm.; original width about 32 mm.; height about 23 mm.

Occurrence.—Venezuela: Location unknown, Monagas (Creole Petroleum Co. 19838).

Geologic horizon.—Early Cretaceous.

Figured specimen.—USNM 131168.

Comparison.—*Hemiaster* sp., known only from two specimens, one very much corroded, is most closely related to *Hemiaster calvini* Clark (Cooke, 1946, p. 225, pl. 32, fig. 5) from the Washita group of Texas; but it is lower, its petals are shallower, and its posterior truncation slopes less steeply.

EPIASTER WHITEI Clark

Pl. 2, figs. 6-9

Epiaster whitei Clark, 1891, Johns Hopkins Univ. Circ., vol. 10, No. 87, p. 77.
Epiaster whitei Clark. Clark, 1893, U. S. Geol. Surv. Bull. 97, p. 82, pl. 43, figs. 2a-d; pl. 44, figs. 1a-g.
Hemiaster whitei (Clark) (part). Clark, 1915, U. S. Geol. Surv. Monogr. 54, p. 89, pl. 43, figs. 2a-c; pl. 44, figs. 1a-h. Not pl. 45, figs. 1a-c (type of *Macraster washita* Lambert).
Hemiaster whitei (Clark). Cooke, 1946, Journ. Paleont., vol. 20, No. 3, p. 224, pl. 32, figs. 16-17. Includes additional synonymy.
Epiaster whitei Clark. Cooke, 1955, U. S. Geol. Surv. Prof. Pap. 264-E, p. 108.

Cordate, with a shallow depression in front and a narrow vertical truncation behind; moderately inflated, margin rounded; highest point at the apical system, evenly rounded in front, gently sloping behind to the truncation; widest at the anterior third; sides evenly rounded to the anterior depression, straighter behind. Apical system slightly anterior; ethmophractic, the two posterior genital plates touching, the madreporite not protruding between them; four genital pores, nearly equally spaced. Anterior ambulacrum depressed; pores short, outer pores transverse, inner pores diagonal except near the apical system, where they are transverse. Paired petals depressed, moderately long, the anterior pair the longer; pores elongated, parallel; interporiferous zones nearly as wide as the poriferous. Peristome far forward, subpentagonal, small. Periproct small, higher than wide, near the top of the vertical truncation, barely visible from above. Tubercles widely scattered, larger on the under side.

Length of holotype 40 mm.; width 35 mm.; height 23 mm.

Well-preserved specimens show a fine granulation, which is particularly noticeable in a broad band surrounding the ends of the petals, but there is no fasciole. This granulation is not preserved on the holotype (the locality of which is unknown), but it shows traces of a narrow smooth area suggestive of a peripetalous fasciole.

The preceding description is based on the holotype and other, better-preserved specimens from Texas. The figured specimen from Venezuela is more compressed posteriorly and is somewhat shorter

than the type, but these features can be matched by specimens from the Fredericksburg group of Texas. Three other individuals from Venezuela resemble the holotype in shape but are not well preserved.

Occurrence.—Venezuela: Río Caripe, Monagas (Creole Petroleum Co. 51381).

Geologic horizon.—Early Cretaceous. In Texas the species is abundant in the Goodland limestone, of Albian age.

Figured specimen.—USNM 131171.

CENOZOIC SPECIES

LYTECHINUS VARIEGATUS (Leske)

Pl. 5, figs. 1-2

This common Recent species, which now ranges from North Carolina to Santos, Brazil, is represented by the two fragments figured.

Occurrence.—Venezuela: Río Seco area, Falcon (Creole Petroleum Co. 72466, 72479).

Geologic horizon.—Pliocene: San Gregorio formation.

Figured specimens.—USNM 638624a, b.

PHYMOSOMA TRINITENSIS Cooke, n. sp.

Pl. 2, figs. 1-3

Horizontal outline circular; upper surface slightly inflated; lower surface slightly concave; margin rounded. Apical system wanting; outline pentagonal, the posterior point elongated, the sides weakly fluted. Ambulacra widening regularly to the margin; the first few zygopores uniserial, the later zygopores staggered or biserial to the peristome. Peristome occupying about one-third of the diameter; weakly notched. Primary tubercles smooth, imperforate; two rows in each area. Secondary tubercles scattered over all areas except the median parts of the interambulacral areas near the apex, which are bare.

Diameter of holotype 24 mm.; height 8.7 mm.; diameter of peristome 8.7 mm.

Occurrence.—Trinidad: Marac quarry, M. C. Cater, collector.

Geologic horizon.—Paleocene.

Types.—Holotype, USNM 638643a. Paratype, USNM 638643b.

Comparisons.—This species, which is represented by the holotype and one paratype, closely resembles *Phymosoma hilli* (Clark) (Cooke, 1953, p. 9, pl. 3, figs. 6-7), from which it differs chiefly in the arrange-

ment of the zygopores, which are biserial or staggered throughout in *P. hilli,* uniserial near the apex in *Phymosoma trinitensis.*

OLIGOPYGUS WETHERBYI KUGLERI Jeannet

Pl. 3, figs. 9-11

Oligopygus kugleri Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, pl. 1, figs. 1-7.

Oligopygus kugleri is here treated as a subspecies of *O. wetherbyi* de Loriol (Cooke, 1959, p. 28, figs. 9-12) because all the specimens from Trinidad, 9 entire individuals and several fragments, though variable in proportions, are oval, strongly inflated, and have a smaller peristomial depression than the typical form from Florida. The usual shape of *O. wetherbyi,* as shown by Cooke's figures, is rather low and subpentagonal, though some are regularly oval. All of the rather large suite in the U.S. National Museum are fairly large, and all have a large peristomial depression.

In Cuba, *Oligopygus wetherbyi* tends to be larger than in Florida and even more variable. One long, narrow, very plump variety was described under the name *Oligopygus pinguis* Palmer (MS.) by Sanchez Roig (1949, p. 165, pl. 28, figs. 2-3). A shorter, nearly circular variety from Jamaica has been named *Oligopygus hypselus* Arnold and Clark (1927, p. 29, pl. 4, figs. 9-11). Both of these varieties from Cuba and Jamaica have large peristomial depressions like the typical form from Florida.

Occurrence.—Trinidad: Soldado Rock, Gulf of Paria (Trinidad Petroleum Co. K-903).

Geologic horizon.—Late Eocene: San Fernando formation.

Holotype.—Naturhistorisches Museum, Basel, Switzerland.

Figured specimen.—USNM 638627, a topotype.

OLIGOPYGUS HALDEMANI COSTULIFORMIS Jeannet

Pl. 3, figs. 1-3

Oligopygus cf. *costulatus* (Desor). Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 8, pl. 1, figs. 10-12.

Oligopygus costuliformis Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 9, pl. 1, figs. 13-15.

This subspecies differs from typical *Oligopygus haldemani* (Conrad) as described and figured by Cooke (1959, p. 29, pl. 8, figs. 6-8) in its smaller peristomial depression, which, though deep, is not as conspicuously elongated as that of the typical form from Florida. The only specimen of the subspecies at hand measures 25 mm. in length,

22 mm. in width, and 15 mm. in height. These dimensions fall within the range in size of the typical form, of which a large series is available.

Specimens from Cuba at first identified by Lambert as *Oligopygus wetherbyi* de Loriol and figured under that name by Sanchez Roig (1926, p. 82, pl. 13, figs. 10-11) were later renamed *Oligopygus cubensis* Lambert (1931, Soc. Géol. France Bull., ser. 5, vol. 1, p. 292). This name appears to be a synonym of typical *Oligopygus haldemani* (Conrad).

The most conspicuous difference between *Oligopygus wetherbyi,* the type species of *Oligopygus,* and *O. haldemani* is the location of the periproct. In *O. wetherbyi* it lies midway between the margin and the peristomial depression, in *O. haldemani* closer to the margin. *O. haldemani* is usually the smaller.

Occurrence.—Trinidad: Bella Vista quarry (Mene Grande Oil Co. 19059).

Geologic horizon.—Late Eocene: San Fernando formation.

Holotype.—Naturhistorisches Museum, Basel, Switzerland.

Figured specimen.—USNM 638626, a topotype.

OLIGOPYGUS ROTUNDUS Cooke

Pl. 3, figs. 4-6

?*Oligopygus christi* Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 10, pl. 1, fig. 19; pl. 6, fig. 2. Not pl. 1, figs. 16-18.

Oligopygus rotundus Cooke, 1942, Journ. Paleont., vol. 16, No. 1, p. 9, pl. 2, figs. 1-3.

Oligopygus rotundus Cooke. Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 29, pl. 8, figs. 1-5.

Horizontal outline nearly circular; upper surface inflated; lower surface flatter; margin broadly rounded. Apical system central, tumid, monobasal; four genital pores. Petals tumid; paired petals extending more than halfway to the margin, odd petal somewhat longer; poriferous zones narrow, regularly expanding, open distally; pores circular, conjugate. Peristome central, oval, at the bottom of a deep, straight-walled transverse depression occupying less than one-third of the total diameter of the test. Periproct small, round, flush, near the posterior third of the lower side. Tubercles rather large, sunken; intermediate spaces granulated.

Length of holotype 22 mm.; width 20.7 mm.; height 11.2 mm.

Occurrence.—Alabama: Koons Mill on Cripple Creek, Geneva County (holotype).

Trinidad: Bella Vista Road, Mount Moriah, San Fernando (USGS 8879, 9201, J. A. Bullbrook). Point Bontour (Trinidad Oil Co., W. Barr).

Venezuela: Alta Casa Nueva, north of Altagracia de Orituco, Guárico. Bolívar district, Zulia (Creole Petroleum Co. 151007).

Geologic horizon.—Late Eocene: San Fernando formation, Trinidad; Tinajitas formation, Venezuela.

Holotype.—USNM 498991.

Figured specimen.—USNM 638625.

Remarks.—The circular outline of *Oligopygus rotundus* suggests *Oligopygus nancei* Cooke, which has proportionately longer petals, smaller peristomial depression, and more acute margin. *O. nancei* is much larger.

Oligopygus christi Jeannet is based on one corroded, ovate individual from Río Calderas, near Los Baños, Zamoras, Venezuela (the holotype) and one nearly circular fragment from Soldado Rock, Trinidad, which probably represents *Oligopygus rotundus*. The figures do not clearly show the diagnostic features of either specimen. Both are in the Naturhistorisches Museum, Basel, Switzerland.

OLIGOPYGUS NANCEI Cooke

Pl. 2, figs. 10-11

Oligopygus nancei Cooke, 1941, Journ. Paleont., vol. 15, No. 3, p. 305, 3 text figs.
?*Oligopygus circularis* Sanchez Roig, 1949, Los equinodermos fósiles de Cuba, Paleontologia Cubaana, vol. 1, p. 159, pl. 29, figs. 2-3.

Test moderately large; outline subpentagonal to subcircular, widest at the anterior paired ambulacra; about half as high as long; upper surface regularly convex; lower surface nearly flat. Apical system central; four genital pores, widely separated. Petals long, not quite reaching the ambitus, the anterior somewhat longer than the paired petals, straight, open at the distal ends; poriferous zones nearly as wide as the interporiferous zones, slightly curved inward at the tip; pore pairs conjugate; inner pores nearly circular, outer pores elongated; pores at the ends of the plates. Extrapetalous pores in diagonal pairs becoming linear near the peristome. Peristome central, rather small, deeply sunken in a steep-walled, transversely elliptical pit. Periproct round, flush, about one-third the way from the margin to the peristome. Tubercles fairly large, about the same size on top and bottom sides; interscrobicular spaces densely papillated.

Dimensions of holotype and figured paratype: Length 51 and

56 mm.; width 49 and 55 mm.; height (somewhat crushed) 19 and 21 mm.

Occurrence.—Venezuela: Holotype and paratypes from near the headwaters of Río Amana, Anzoátegui, approximately 5 km. southwest of Mundo Nuevo, Monagas (Standard Oil Co. of Venezuela 30123). Río Amana, 3¼ km. southwest of Mundo Nuevo, Monagas (Mene Grande Oil Co. A-445). Río Amana, Monagas (Mene Grande Oil Co. A-7532).

Geologic horizon.—Late Eocene: Tinajitas formation.

Holotype and paratype.—USNM 498964.

Remarks.—No authentic specimens of *Oligopygus circularis* are available for comparison, but the description and figures tally with those of *O. nancei.*

HAIMEA OVUM-SERPENTIS (Guppy)

Pl. 4, figs. 7-11

?*Haimea caillaudi* Michelin, 1851, Rev. et Mag. Zool., ser. 2, vol. 3, p. 92, fig. 2. (Locality unknown.)

Echinolampas ovum-serpentis Guppy, 1866, Geol. Soc. London Quart. Journ., vol. 22, p. 300, pl. 19, figs. 4a-b, 5. Not fig. 6.

Echinolampas ovum-serpentis Guppy. Cotteau, 1875, K. Vetensk.-Akad. Handl., N.F., vol. 13, No. 6, p. 20, pl. 3, figs. 13-21.

Echinolampas ovum-serpentis Guppy. Egozcue y Cía, 1897, Com. Mapa Geol. España Bol., vol. 22, p. 62, pl. 16, figs. 5-9.

Echinolampas ovumserpentis Guppy. Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 60, pl. 10, figs. 4-5.

"Echinolampas" ovumserpentis Guppy. Hawkins, 1924, Geol. Mag., vol. 61, p. 318.

?*Pauropygus elevatus* Arnold and Clark, 1927, Harvard Coll. Mus. Comp. Zool. Mem., vol. 50, No. 1, p. 35, figs. 1-3.

Pauropygus ovumserpentis (Guppy). Arnold and Clark, 1927, Harvard Coll. Mus. Comp. Zool. Mem., vol. 50, No. 1, p. 36, pl. 5, figs. 7-12.

?*Haimea caillaudi* Michelin. Arnold and Clark, 1934, Harvard Coll. Mus. Comp. Zool. Mem., vol. 54, No. 2, p. 143.

Haimea ovumserpentis (Guppy). Arnold and Clark, 1934, Harvard Coll. Mus. Comp. Zool. Mem., vol. 54, No. 2, p. 143.

Haimea ovum-serpentis (Guppy). Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 1, p. 259.

?*Haimea caillaudi* Michelin. Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 1, p. 258, text figs. 248a-d (after Michelin).

Haimea ovumserpentis (Guppy). Durham and Melville, 1957, Journ. Paleont., vol. 31, No. 1, p. 257, text fig. 2.

Proportions of test variable; horizontal outline usually oval to subpentagonal; upper surface evenly inflated or subconical, highest at the apical center; lower surface much flatter, deeply depressed around

the peristome; margin evenly rounded. Apical system central; four genital pores, the anterior pair closer together than the posterior pair; madreporite central. Petals long, extending nearly to the margin, sides straight, wide open at the distal ends; poriferous zones much narrower than the interporiferous; pores circular or oval, conjugate. Extrapetaliferous pores nearly linear except in the peristomial depression, where the two zones are adjacent and the pore pairs are nearly transverse. Peristome central, subquadrate, with shallow notches at the paired ambulacra and a very shallow notch at the anterior ambulacrum. Periproct small, transversely oval or round, flush; near the posterior third of the radius. Tubercles sunken, covering the entire surface except the poriferous zones.

Length of holotype 42 mm.; width 33 mm.; height 18 mm.

Occurrence.—Trinidad: San Fernando (USNM 115389, 115409, R. J. L. Guppy). Bella Vista Road, Mount Moriah, San Fernando (USGS 8878, 9201, J. A. Bullbrook).

Geologic horizon.—Late Eocene: San Fernando formation.

Holotype.—USNM 115392a.

Figured specimens.—USNM 115392a, 115392b, 638628.

Remarks.—Guppy published four figures ostensibly representing *Echinolampas ovum-serpentis.* The original of his figures 4a and 4b, now USNM 115389a, was figured by Jackson (1922, pl. 10, fig. 4) as a cotype. This specimen was selected by H. L. Clark (Arnold and Clark, 1927, p. 36) as the holotype of *Echinolampas ovum-serpentis,* which became the type species of their new genus *Pauropygus.* Guppy's figure 5 is not recognizable. The original of his figure 6 (USNM 115409a, now broken) appears to represent *Oligopygus rotundus* Cooke.

Arnold and Clark (1934, p. 143) reported that their *Pauropygus elevatus* is a synonym of *Haimea caillaudi* Michelin. This identification is open to question because the periproct of *H. caillaudi* is shown in Michelin's drawing (Mortensen, 1948, text fig. 248b) as nearer the peristome, farther from the margin than that of Arnold and Clark's photograph of *Haimea elevata,* which probably is an unusually plump variety of *Haimea ovum-serpentis.* If *Haimea elevata* really is a synonym of *H. caillaudi* and if it represents the same species as *Haimea ovum-serpentis,* then the name *Haimea caillaudi* takes precedence over both.

Haimea ovum-serpentis is abundant in St. Bartholomew and in Jamaica. Egozcue y Cía (1897) and Sanchez Roig (1949, p. 167) report it also from Cuba. Jeannet (1928, p. 12) describes a fragment

of an unidentified species of *Pauropygus* from Ramytrace, Trinidad, and he mentions another from Venezuela.

FIBULARIA FARALLONENSIS Cooke, n. sp.

Pl. 4, figs. 1-6

Horizontal outline subcircular, slightly produced behind. Upper surface hemispherical; lower surface flattened, depressed around the peristome; margin broadly rounded. Apical system obscure. Petals long, straight; poriferous zones diverging; pores circular. Peristome large, central, circular. Periproct smaller, circular; near the posterior third of the radius.

Length of holotype 4.5 mm.; width 4.2 mm.; height 2.9 mm. Length of paratype 5.1 mm.; width 4.8 mm.; height 3.7 mm.

Occurrence.—Trinidad: Farallon Rock, San Fernando (USGS 9199, J. A. Bullbrook).

Geologic horizon.—Middle Eocene: A reef facies of the Navet formation.

Types.—Holotype, USNM 638629a (the smaller specimen); paratype, USNM 638629b.

Comparisons.—*Fibularia farallonensis* is nearly circular in horizontal outline, like *F. texana* (Twitchell) (Cooke, 1959, p. 30, pl. 9, figs. 15-19), and its petals seem to be similar; but its lower surface is flatter and its periproct is nearer the margin. These differences also hold for *Fibularia vaughani* (Twitchell) (Cooke, 1959, p. 30, pl. 9, figs. 23-27) and for *F. alabamensis* (Twitchell) (Cooke, 1959, p. 31, pl. 9, figs. 20-22), both of which, moreover, are conspicuously ovate.

CLYPEASTER ROSACEUS (Linnaeus)

Pl. 5, fig. 3

Echinus rosaceus Linnaeus, 1758, Systema naturae, ed. 10, p. 665.

?*Clypeaster cubensis* Cotteau. Egozcue y Cía, 1897, Com. Mapa Geol. España Bol., vol. 22, p. 33, pl. 6, figs. 1-5.

Clypeaster kugleri Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 19, pl. 2, figs. 4-6.

Clypeaster rosaceus (Linnaeus). Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 40, pl. 1, figs. 2-4; pl. 64, figs. 1-5. Includes additional synonymy.

Clypeaster rosaceus (Linnaeus). Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 34, pl. 10, figs. 1-3.

Individuals of this common Recent species vary considerably in size and shape and in the width of the opening between the tips of the poriferous zones of the anterior petal. Many are broadly truncated

behind, others are elliptical in horizontal outline, like the type of *Clypeaster kugleri,* which agrees well in such other features as can be determined from the figures. There is some variation also in the degree of swelling of the interporiferous zones. The wide petals with strongly incurved tips are characteristic.

Occurrence.—Venezuela: Goajira Peninsula, Zulia (Creole Petroleum Co. 13418). Near Castilletes, Goajira Peninsula (Creole Petroleum Co. 81046). Quebrado Cojoro, Goajira Peninsula, Paez district, Zulia (B-2305). Punta Carnero, Isla Margarita (Creole Petroleum Co. 79055). Río Motoruco, La Vela de Coro, Falcon (B-2771). Río Coro, Falcon (Creole Petroleum Co. 56929). Near southwest edge of Cumarebo field, Falcon (Creole Petroleum Co. 59953).

Geologic horizon.—Miocene to Recent.

Figured specimen.—USNM 638630 (Creole Petroleum Co. 13418).

ENCOPE MICHELINI Agassiz

Pl. 6, figs. 5-6; pl. 7, fig. 5

Encope michelini Agassiz, 1841, Monographies d'échinodermes, Monogr. 2, p. 58, pl. 6a, figs. 9-10.

?*Encope platytata* Jackson, 1917, Proc. U. S. Nat. Mus., vol. 53, No. 2218, pl. 67, figs. 1-2, text fig. 2.

Encope wiedenmayeri Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 20, pl. 3, figs. 1-4, text fig. 3.

Encope michelini Agassiz. Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 49, pl. 18, figs. 2-3.

This common Recent species is variable in many features, notably the height of the posterior part, which ranges from slightly higher than the apical system to a protruding hump; the depth of the ambulacral emarginations; the size and shape of the posterior lunule, which ranges from circular to much elongated; and the shape of the petals, which in young individuals are more convex than when full grown.

A single fragment from the Gatun formation of the Canal Zone, the holotype of *Encope platytata* Jackson, has convex poriferous zones of the anterior paired petals much like those of the small Recent specimen figured by Cooke (1959), but the discovery of topotypes may show it to be different.

There seems to be no doubt that the many Encopes in the collections from Venezuela here studied represent the same species as the two fragments named *Encope wiedenmayeri* by Jeannet. Most of them fall within the range of variation of *Encope michelini,* but some of the fossils are larger than the living form. One fossil from

near Cumaná, Sucre (Creole Petroleum Co. 8270), is nearly twice as large as the one from Sucre figured here. All are somewhat higher behind the apical system than in front; a few are conspicuously higher.

Occurrence.—Venezuela: Boca de Güeque, Falcon (*E. wiedenmayeri* Jeannet, *fide* Jeannet). Güeque area, Falcon (Creole Petroleum Co. 11050). Sucre (Creole Petroleum Co. 8286, 8298). Near Cumaná, Sucre (Creole Petroleum Co. 8270).

Geologic horizon.—Miocene to Recent: "Couches d'Ojo de Agua," of middle Miocene age (*fide* Jeannet). San Gregorio formation, of Pliocene age.

Figured specimen.—USNM 638631, from the San Gregorio formation.

ENCOPE KUGLERI Jeannet

Pl. 10, fig. 1

Encope kugleri Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 23, pl. 3, figs. 5-6; text figs. 4-6.

This species, represented by several fragments, seems to be nearly equidimensional in horizontal directions. It has five fairly deep ambulacral notches. The posterior petals are somewhat longer than the others. The posterior lunule in the figured specimen is narrower than that shown in Jeannet's type, and its rim is raised. It lies between the tips of the petals and extends nearly halfway to the center.

Occurrence.—Venezuela: La Jovita de Candado, near Mirimire, Falcon (type, *fide* Jeannet). Río Seco area, Falcon (Creole Petroleum Co. 72709, 72716, 72912).

Geologic horizon.—Miocene: Capadare limestone, of middle Miocene age (*fide* Jeannet). Chiguaje formation, of late Miocene age.

Figured specimen.—USNM 638632.

ENCOPE SECOENSIS Cooke, n. sp.

Pl. 8, fig. 1; pl. 9, figs. 1-2

Horizontal outline ovate, very slightly longer than wide, widest point behind the middle, flattened behind; highest point anterior; margin thin. Five ambulacral notches showing a tendency to close. Posterior lunule elongated, narrow; extending anterior to the distal tips of the adjacent petals; rim very slightly raised. Apical system slightly anterior, star shaped, with five genital pores. Posterior petals the longest, anterior paired petals the shortest; all petals open distally; poriferous zones curved, those of the anterior paired petals

evenly curved, those of the other petals incurved near the distal tips. Peristome under the apical system. Periproct elongated, closer to the lunule than to the peristome.

Length of holotype 109 mm.; width 105 mm.; height 12 mm.

Occurrence.—Venezuela: Río Seco area, Falcon (Creole Petroleum Co. V-2635, 72466 (holotype), 72468 (paratypes), 72480, 72482).

Geologic horizon.—Pliocene: San Gregorio formation. One lot from the Miranda district is referred by the label to the Codore formation, another to the Chiguaje formation, both of late Miocene age.

Comparisons.—The petals of *Encope secoensis* resemble those of *Encope micropora* Agassiz (1841, p. 50, pl. 10a, figs. 4-8; pl. 19a, fig. 7), but its ambulacral notches are usually open, like those of *Encope emarginata* (Leske) (Cooke, 1959, p. 49, pl. 17, fig. 5; pl. 18, fig. 1), which, however, is highest behind. *Encope secoensis* appears to be closely related to *E. sverdrupi* Durham (1950, p. 48, pl. 37, fig. 6; pl. 39, figs. 4, 6), from the lower Pliocene of Santa Inez Bay, Baja California, but the petals of the holotype of that species are less broadly rounded. This may be an individual feature, for there is some variation in the curvature of *E. secoensis,* some of whose petals approximate the shape of *E. sverdrupi.*

ENCOPE (MELITELLA) FALCONENSIS Cooke, n. sp.

Pl. 8, figs. 2-4

Horizontal outline subcircular, truncated behind. Highest point central. Apical system central, star shaped, rather large; five genital pores. Petals short, nearly equal in length, extending halfway to the margin; half as wide as long; poriferous zones evenly rounded; inner pores circular, outer pores elongated, diagonal. Ambulacral notches closed in the type, open in smaller individuals. Posterior lunule oval, near the margin. Peristome small, central, pentagonal. Periproct elongated, midway between the peristome and the margin. Ambulacral grooves conspicuous.

Length of holotype 61 mm.; width 63 mm.; height 9 mm.

Occurrence.—Venezuela: Río Seco area, Falcon (Creole Petroleum Co. V-2651, 72465, 72473, 72715 (holotype)).

Geologic horizon.—Miocene and Pliocene: Chiguaje formation, of late Miocene age (type). San Gregorio formation, of Pliocene age.

Holotype.—USNM 638633.

Comparison.—This species appears to resemble *Encope* (*Melitella*) *stokesii* Agassiz (1841, p. 59, pl. 6a, figs. 1-8), living off the Galápagos and along the west coast of tropical America, and may prove to be the

same. No authentic specimens of *E. stokesii* are available for comparison. Agassiz's figures are similar, but according to Mortensen (1928-1951, vol. 4, pt. 2, p. 449) "the apical system and the vertex are posterior as in *Dendraster excentricus*" though less so, and the posterior petals are correspondingly shorter. The apical star of *Encope falconensis* seems to be larger than that of *E. stokesii*.

WEISBORDELLA MIRABILIS (Jackson)

Pl. 3, figs. 7-8

Horizontal outline subpentagonal; lateral profile straight below, arched centrally above; upper surface tumid medially; lower surface very slightly concave; margin acutely rounded. Apical system nearly central; four widely spaced small genital pores, the anterior pair closer together than the posterior pair; a few scattered hydropores. Petals extending about two-thirds the way to the margin, the anterior pair somewhat shorter than the others; poriferous zones of nearly even width, narrower than the widest part of the interporiferous zones, plainly open apically, nearly closed distally, inner pores circular, outer pores slightly elongated; interporiferous zones lanceolate. Peristome central, small, pentagonal. Periproct small, circular, near the posterior fourth of the radius. Small tubercles and granules cover all the test except the poriferous zones; two large sunken tubercles between the lateral petals and one in each anterior interambulacral area.

Ocurrence.—Trinidad: Bella Vista Road, Mount Moriah, San Fernando (USGS 8878, J. A. Bullbrook).

Geologic horizon.—Late Eocene: San Fernando formation.

Types.—Holotype, USNM 328247; paratype, USNM 328248.

Remarks.—*Weisbordella mirabilis* closely resembles *W. johnsoni* (Twitchell) (Cooke, 1959, p. 54, pl. 20, figs. 5-7), from which it differs in having six large tubercles and in the location of its periproct, which is somewhat nearer the margin than is customary in *Weisbordella johnsoni*. The occurrence of large tubercles may be a variable feature, as in *Weisbordella cubae* (Weisbord) (Cooke, 1959, p. 53, pl. 20, figs. 1-4), and the distance of the periproct from the margin may vary with the shape of the test. As the types are the only representatives thus far discovered, the range of variability is unknown.

CASSIDULUS (CASSIDULUS) FALCONENSIS (Jeannet)

Pl. 14, figs. 5-8

Eurhodia falconensis Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 32, pl. 4, figs. 2-7; pl. 6, fig. 7; text fig. 10.

Four specimens of this species from the Naturhistorisches Museum of Basel have been available for study. The species is not an *Eurhodia* as interpreted by Cooke (1959, p. 63), for its peristome is transversely elongated and its periproct is flush.

Like most species of *Cassidulus, C. falconensis* varies considerably in proportions. These specimens are low, and their margins are acute, as in *Cassidulus gouldii* (Bouvé) (Cooke, 1959, p. 57, pl. 24, figs. 5-12), a species common in Oligocene deposits of the United States, but its petals are longer. The petals are similar to those of *Cassidulus sabistonensis* Kellum (Cooke, 1959, p. 57, pl. 23, figs. 6-14) from the late Miocene of Florida and the Carolinas, but its test is much lower and its margin much more acute.

Occurrence.—Venezuela: Punta Gavilan, Falcon.

Geologic horizon.—Middle Miocene: Upper part of the "couches d'Ojo de Agua" (*fide* Jeannet).

Holotype.—Naturhistorisches Museum, Basel, Switzerland.

Figured specimen.—USNM 638635.

ECHINOLAMPAS LYCOPERSICUS Guppy

Pl. 9, figs. 3-5

Echinolampas lycopersicus Guppy, 1866, Geol. Soc. London Quart. Journ., vol. 22, p. 300, pl. 19, fig. 8.

Echinolampas lycopersicus Guppy. Cotteau, 1875, K. Svenska Vetensk.-Akad. Handl., vol. 13, No. 6, p. 21, pl. 3, figs. 22-26.

Echinolampas anguillae Cotteau, 1875, K. Svenska Vetensk.-Akad. Handl., N.F., vol. 13, No. 6, p. 24, pl. 4, figs. 5-8.

Echinolampas lycopersicus Guppy. Cotteau, 1881, Soc. Géol. Belgique Ann., vol. 9, p. 20.

Echinolampas lycopersicus Guppy. Egozcue y Cía, 1897, Com. Mapa Geol. España Bol., vol. 22, p. 59, pl. 19, figs. 1-3 (after Cotteau).

Echinolampas lycopersicus Guppy. Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 64, pl. 11, figs. 3-6.

Echinolampas anguillae Cotteau. Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 66, pl. 11, figs. 7-9.

Echinolampas lycopersicus Guppy. Arnold and Clark, 1927, Harvard Coll. Mus. Comp. Zool. Mem., vol. 50, No. 1, p. 50.

?*Echinolampas* sp. Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 35, text fig. 11.

Horizontal outline ovate; upper surface variably inflated; lower surface flattish, slightly depressed around the peristome; margin broadly rounded. Apical system small; four genital pores; slightly anterior. Petals extending nearly to the margin, open distally, posterior pair the longest; poriferous zones curved, narrow, posterior zone of anterior pair longer than the others; pores conjugate, inner pores circular, outer pores elongated; interporiferous zones much wider than the poriferous. Peristome directly beneath the apical system, large, pentagonal, transversely elongated; floscelle distinct; bourrelets swollen. Periproct submarginal, not visible from above, transversely elongated. Tubercles small, depressed, closely covering the entire test except the poriferous zones.

Length of figured specimen 53.7 mm.; width 47.6 mm.; height 24 mm.

Occurrence.—Trinidad: Morne Diablo quarry (Creole Petroleum Co. 19070).

Venezuela: Bejuco, Araurima Valley, Acosta district, Falcon.

Geologic horizon.—Middle Miocene: The species was described from the Anguilla formation of Anguilla, B.W.I.

Cotypes.—Six specimens, USNM 115388, one of which was figured by Guppy. Holotype of *Echinolampas anguillae* USNM 115372.

Figured specimen.—USNM 115387a, one of three collected by Guppy but probably not in his original lot. This specimen was figured also by Jackson, another by Cotteau.

Remarks.—*Echinolampas lycopersicus* has been found also in Puerto Rico, Cuba, and Jamaica. It varies considerably in size and degree of inflation, but the shape of the petals is relatively constant. The specimens from Trinidad and Venezuela are much more highly inflated than the one figured from Anguilla, but others from Anguilla are equally inflated.

The holotype of *Echinolampas anguillae* is a unique specimen which has been compressed laterally, making it proportionally narrower and subconical, and giving a specious concavity to its lower surface. Guppy (1879, p. 196), too, regarded it as an unusual form of *Echinolampas lycopersicus.*

MOIRA ATROPOS (Lamarck)

Pl. 6, figs. 1-4

Spatangus atropos Lamarck, 1816, Histoire naturelle des animaux sans vertèbres, vol. 3, p. 32.

Moira atropos (Lamarck). Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 73, pl. 30, figs. 1-4.

Three large, imperfect specimens certainly represent the genus *Moira* and probably this species, which is widely distributed in the Atlantic Ocean and in the Gulf of Mexico. The largest measures 55 mm. in length, 45 mm. in width, and 29 mm. in height.

Occurrence.—Venezuela: Río Seco area, Falcon (Creole Petroleum Co. V-2677, 72537).

Geologic horizon.—Pliocene: San Gregorio formation. Also Recent.

Figured specimen.—USNM 638637.

AGASSIZIA SCROBICULATA Valenciennes

Pl. 5, figs. 4-7

Agassizia scrobiculata Valenciennes, 1846, Voyage de la Frégate *Venus*, pl. 1, fig. 2.

Agassizia scrobiculata Valenciennes. A. Agassiz, 1872-1874, Harvard Coll. Mus. Comp. Zool. Mem., vol. 3, pp. 85, 594, pl. 19a, figs. 1-3; pl. 19b. figs. 1-3.

Agassizia scrobiculata Valenciennes. Grant and Hertlein, 1938, California Univ. (Los Angeles) Publ. in Math. Phys. Sci., vol. 2, p. 114, pl. 29, figs. 2-3; pl. 30, fig. 12; text fig. 10 (after Valenciennes).

Agassizia scrobiculata Valenciennes. Mortensen, 1951, Monograph of the Echinoidea, vol. 5, pt. 2, p. 342, pl. 19, figs. 4, 10, 11; pl. 55, figs. 1-4, 7, 10, 13, 15. Includes additional synonymy.

Test subglobular; horizontal outline steeply sloping in front of the apex, more openly curved behind. Apical system anteriorly eccentric, ethmolytic; four genital pores when mature. Petals widely spreading; anterior pair longer than the posterior, pores of anterior row very small and inconspicuous; posterior pair fairly long, well developed. Peristome at the anterior third. Periproct transversely oval; near the top of a posterior truncation, which curves forward near the bottom. Marginal fasciole extending downward in a V-shaped projection below the periproct. Lateral fascioles uniting behind the posterior petals.

Occurrence.—Venezuela: Río Seco area, Falcon (Creole Petroleum Co. 2630, 2632, 72479 (figured)).

Geologic horizon.—Pliocene: San Gregorio formation. Also Recent.

Figured specimen.—USNM 638636.

Remarks.—There are no apparent differences between these Pliocene forms from Venezuela and Recent specimens from the Gulf of California, with which they have been compared. Grant and Hertlein

(1938) record the species also from the Pliocene at Santa Inez Point on the east coast of Baja California.

ANTILLASTER LAMBERTI Jeannet

Pl. 11, figs. 1-2

Antillaster lamberti Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 36, pl. 4, figs. 14-15.

Horizontal outline cordate, widest in front of the center; lateral profile strongly inflated above, nearly flat beneath, anterior slope the steeper; transverse profile nearly semicircular. Apical system somewhat anterior, at the highest point; three genital pores, the right anterior pore not developed. Anterior ambulacrum not petaloid, narrow, in a shallow depression, which is deepest at the margin. Anterior paired petals widely diverging, slightly curved forward, open distally, extending more than halfway down the lateral slopes; pores conjugate, outer pores elongated, inner pores circular; interporiferous zones much wider than the poriferous. Posterior petals somewhat longer than the anterior pair, straight. Peristome surrounded by a floscelle, wider than long, strongly lipped, at the anterior fifth, in a deep transverse depression, which covers more than half the width of the test. Periproct submarginal, not visible from above; on a concave truncation, which slopes downward and forward. Tubercles perforated, larger on the bottom, evenly scattered. No fascioles visible.

Length of largest of four specimens 103 mm.; width 99 mm.; height 75 mm.

Occurrence.—Venezuela: Sabanas Altas, Falcon (type, *fide* Jeannet). La Vigía, 10 km. southwest (southeast?) of Pueblo Nuevo, Paraguaná district, Falcon (Creole Petroleum Co. 7824). Cerro La Luz near Quebrada Larga, 3 km. west of Pueblo Nuevo (Mene Grande Petroleum Co. B-6295).

Geologic horizon.—Miocene: Upper part of the "couches d'Ojo de Agua" (type, *fide* Jeannet). La Vela formation, of late Miocene age.

Figured specimen.—USNM 638639, from La Vigía.

Remarks.—*Antillaster lamberti* shows considerable variation in the degree of inflation and in the depth of the anterior emargination. The periproct of the figured specimen is somewhat distorted; it may originally have been pear shaped.

PERICOSMUS STEHLINI Jeannet

Pl. 13, figs. 3-6

Pericosmus stehlini Jeannet, 1928, Soc. Paléont. Suisse Mém., vol. 48, p. 43, pl. 4, figs. 21-24.

Horizontal outline subovate, emarginate in front, truncated behind; upper surface inflated; lateral profile highest near the front, steeply curved downward in front, more gently behind, nearly straight below. Apical system slightly anterior; three genital pores, the right anterior pore wanting; ethmolytic. Anterior ambulacrum not at all petaloid; moderately depressed, the depression extending the full length, weakest near the peristome. Paired petals deeply sunken, widely spreading, the anterior pair the longest, extending nearly to the margin; poriferous zones wider than the interporiferous; inner pores circular, outer pores somewhat elongated; pores conjugate. Peristome near the anterior fifth, semilunate, weakly lipped. Periproct broadly oval, transverse; at the top of the posterior truncation; slightly overhanging. Peripetalous fasciole deeply indented in the posterior and interambulacral areas. Marginal fasciole slightly undulate, curved down under the periproct. Tubercles of medium size, somewhat smaller on the top.

Length of figured specimen 56 mm.; width 54.5 mm.; height 37 mm. Another specimen measures 66 by 60 by 41 mm.

Occurrence.—Venezuela: Coro, Falcon (type, *fide* Jeannet). La Vigía, 10 km. southwest (southeast?) of Pueblo Nuevo, Paraguaná district, Falcon (Creole Petroleum Co. 7824).

Geologic horizon.—Miocene: Probably "Damsite series," of middle (?) Miocene age (type, *fide* Jeannet). Le Vela formation, of late Miocene age.

Holotype.—Naturhistorisches Museum, Basel, Switzerland.

Figured specimen.—USNM 638638. From La Vigía.

LOVENIA cf. L. DUMBLEI Kew

Pl. 13, fig. 2

Cf. *Lovenia dumblei* Kew, 1917, California Acad. Sci. Proc., ser. 4, vol. 7, No. 5, p. 136, pl. 17, figs. 2a-c.

One defective *Lovenia* should be compared with *Lovenia dumblei* Kew from the Miocene (?) of Mexico at Rancho Nuevo, 35 km. northwest of Tuxpan. It is proportionately longer and narrower than the holotype as figured by Kew (fig. 2a) and differs further in that

the proximal end of the anterior poriferous zone of the anterior paired petals is straight, not curved forward. This may be an individual variation, for the zone of the paratype (Kew's figure 2b) appears to be straight.

The distribution of the tubercles is similar to that of *Lovenia dumblei* but differs from that of *Lovenia alabamensis* Cooke (1959, p. 77, pl. 32, figs. 14-17) from the Chickasawhay limestone of Alabama in that its tubercles extend farther back. The shape of the poriferous zones is like that of *L. alabamensis*.

Occurrence.—Venezuela: Punta Gavilan, Falcon.

Geologic horizon.—Miocene.

Figured specimen.—Naturhistorisches Museum, Basel, Switzerland.

EUPATAGUS CLEVEI (Cotteau)

Pl. 10, figs. 2-5

Euspatangus clevei Cotteau, 1875, K. Svenska Vetensk.-Akad. Handl., N.F., vol. 13, No. 6, p. 44, pl. 8, figs. 1-4.

Euspatangus grandiflorus Cotteau, 1875, K. Svenska Vetensk.-Akad. Handl., N.F., vol. 13, No. 6, p. 45, pl. 8, figs. 5-6.

Eupatagus clevei (Cotteau). Guppy, 1879, Sci. Assoc. Trinidad Proc., vol. 2, pt. 12, p. 109.

Eupatagus grandiflorus (Cotteau). Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 89, pl. 15, figs. 5-6.

Eupatagus clevei (Cotteau). Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 90, pl. 16, figs. 1-2.

Eupatagus grandiflorus (Cotteau). Molengraaff, 1929, Geologie en geohydrologie het eiland Curaçao, p. 72, pl. 24, figs. 1-2; pl. 25, fig. 1.

Eupatagus grandiflorus (Cotteau). Arnold and Clark, 1934, Harvard Coll. Mus. Comp. Zool. Mem., vol. 54, No. 2, p. 156.

Eupatagus clevei (Cotteau). Cooke, 1948, Journ. Paleont., vol. 22, No. 1, pl. 22, fig. 9.

Eupatagus clevei (Cotteau). Fischer, 1951, Florida Geol. Surv. Bull. 34, pt. 2, p. 83, pl. 7, figs. 1-3; text fig. 18.

Eupatagus clevei (Cotteau). Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 89, pl. 41, figs. 6-8.

This large swollen *Eupatagus* is represented in the collections from Venezuela by one slightly crushed individual whose lower surface is covered by hard matrix and whose upper surface is badly corroded. It measures 64 mm. in length by about 53 mm. in width.

The types of *Eupatagus clevei* (refigured here) and *E. grandiflorus* (a synonym) were found in the Eocene of St. Bartholomew. The species later came to light in Curaçao, Jamaica, Panama, and Florida.

Occurrence.—Venezuela: San Mateo, Lara (Creole Petroleum Co. 99004).

Geologic horizon.—Late Eocene.

Holotype.—USNM 115379.

BRISSUS UNICOLOR (Leske)

Pl. 7, figs. 1-4

Spatangus brissus var. *unicolor* Leske, 1778, Klein's Naturalis dispositio echinodermatum, p. 248, pl. 26, figs. B-C.

Brissus exiguus Cotteau, 1875, K. Svenska Vetensk.-Akad. Handl., N.F. vol. 13, No. 6, p. 35, pl. 6, figs. 16-18.

Brissus exiguus Cotteau. Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 87, pl. 15, figs. 2-4.

Brissus unicolor (Leske). Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 81, pl. 36, figs. 1-4.

This well-known Recent species is represented by one fairly well preserved specimen and one fragment. They are remarkably similar to Recent specimens of the same size from Haiti, from which they differ in the apparently farther forward location of the apical system, which has been foreshortened by slight crushing, which also has deepened the anterior paired petals. The apical system and the lower margin of the peristome are wanting. The peripetalous and subanal fascioles are like those of the Recent species.

Brissus exiguus Cotteau, from the Miocene of Anguilla, seems to be this same species. The holotype (USNM 115396) is a juvenile with only three genital pores. Its left side and base have been crushed.

Occurrence.—Trinidad: Savanetta, near Gran Couva (Trinidad Oil Co. 254677).

Geologic horizon.—Late Miocene: Springvale formation.

Figured specimen.—USNM 638641.

BRISSOPSIS ANTILLARUM Cotteau

Pl. 12, figs. 1-4

Brissopsis antillarum Cotteau, 1875, K. Svenska Vetensk.-Akad. Handl., N.F., vol. 13, No. 6, p. 37, pl. 6, figs. 19-25.

Brissopsis antillarum Cotteau. Jackson, 1922, Carnegie Inst. Washington Publ. 306, p. 82, pl. 14, figs. 3-4.

Horizontal outline subovate, notched in front, truncated behind. Apical system slightly anterior; four genital pores; ethmolytic. Anterior ambulacrum strongly depressed on upper surface, slightly notching the margin, almost flat on lower surface; paired pores sepa-

rated by a bead. Anterior paired petals depressed, widely spreading, extending three-fourths of the way to the margin, wide; anterior pores much reduced near the apical system. Posterior petals depressed, longer than the anterior pair, adjacent and confluent near the apical system, spreading apart distally; pores large, oval. Peristome near the anterior quarter, strongly lipped. Periproct vertically elongated, near the top of a posterior truncation. Peripetalous fasciole deeply indented except in front; subanal fasciole reniform.

Length of largest cotype (from Antigua) 47 mm.; width 38 mm.; height about 18 mm. Length of figured specimen (from Venezuela) 62 mm.; width 47 mm.; height 23 mm.

Occurrence.—Venezuela: Paraguaná Peninsula 10 km. southeast of Pueblo Nuevo, Falcon (Creole Petroleum Co. 7824).

Geologic horizon.—Miocene: La Vela formation, of late Miocene age. The types are from the Anguilla formation, of middle Miocene age.

Cotypes.—USNM 115406.

Figured specimen.—USNM 638640.

PLAGIOBRISSUS GRANDIS (Gmelin)?

Pl. 13, fig. 1

Echinus grandis Gmelin, 1791, Linné, Systema naturae, vol. 1, pt. 6, p. 3200.
Plagiobrissus grandis (Gmelin). Mortensen, 1951, Monograph of the Echinoidea, vol. 5, pt. 2, p. 496, pls. 40-41; pl. 63, figs. 13, 16.
Plagiobrissus grandis (Gmelin). Cooke, 1959, U. S. Geol. Surv. Prof. Pap. 321, p. 86, pl. 39, figs. 1-2; pl. 40, fig. 6.

One fragment showing most of the right posterior quadrant of the upper surface, most of the escutcheon and subanal fasciole, and part of the lateral lower surface agrees in all recognizable features with the Recent *Plagiobrissus grandis* of the West Indian region. The escutcheon is semicircular in front, like the Recent species, differing in this respect from *Plagiobrissus lamberti* Jeannet (1928, p. 38, pl. 5, figs. 1-2; pl. 6, figs. 13-14; text fig. 12) from the "couches d'Ojo de Agua" on the road from Guaidima to Riecito (Falcon) as figured by Jeannet, which is pointed.

Occurrence.—Venezuela: Paraguaná Peninsula 10 km. southeast of Pueblo Nuevo, Falcon (Creole Petroleum Co. 7824).

Geologic horizon.—Miocene?

Figured specimen.—USNM 638642.

RHYNOBRISSUS ROSTRATUS Cooke, n. sp.

Pl. 14, figs. 1-4

Horizontal outline pointed ovate, strongly rostrate behind; lateral profile narrowly wedge shaped, highest behind; posterior end sloping downward and forward at an angle approximating 45°. Apical system somewhat anterior, not preserved (the genus has four genital pores, the posterior pair separated by the protruding madreporite). Anterior ambulacrum flush, not at all petaloid. Petals depressed; anterior pair forming a straight line, extending about three-fourths the way to the margin, the anterior half much reduced in width near the apical system; posterior petals longer, straight, not widely diverging; pores oval. Peristome anterior, strongly lipped. Periproct bilunate, transversely elongated, high on the rostrate end. Peripetalous fasciole strongly depressed; slightly reentrant between the lateral petals. Subanal and circumanal fascioles connected, forming a figure 8. Tubercles small, close set and granular on the upper surface, larger and farther apart on the lower surface.

Length 51.4 mm.; width 37.3 mm.; height 24.5 mm.

Occurrence.—Venezuela: Punta Gavilan, Falcon.

Geologic horizon.—Miocene?: Probably from the La Vela formation, of late Miocene age.

Holotype.—Naturhistorisches Museum, Basel, Switzerland.

Comparison.—The unique type of this species is somewhat distorted by crushing. It most closely resembles *Rhynobrissus cuneus* Cooke (1959, p. 88, pl. 36, figs. 7-11), living off the coast of North Carolina. It differs from *R. cuneus* as follows: Its anterior petals are more widely diverging. Its posterior end is narrower, more rostrate, more strongly overhanging. Its plastron is more protruding and less nearly elliptical. Its periproct is nearer the junction of the anal and circumanal fascioles, and its peripetalous fasciole is somewhat indented. Some of these differences may be the result of distortion, the others possibly are individual variations. If so, this species will fall into the synonymy of *Rhynobrissus cuneus*.

BIBLIOGRAPHY

AGASSIZ, LOUIS.
1841. Des scutelles. Monographies d'échinodermes vivans et fossiles, Monogr. 2, 151 pp., 27 pls.

ANISGARD, HARRY W.
1954 (1955). An echinoid from the Eocene of western Venezuela. Journ. Paleont., vol. 28, No. 6, pp. 830-835, 5 text figs.

Arnold, B. W., and Clark, H. L.

1927. Jamaica fossil echini; with descriptions of new species of Cainozoic Echinoidea by Herbert L. Hawkins. Harvard Coll. Mus. Comp. Zool. Mem., vol. 50, No. 1, 84 pp., 3 figs., 22 pls.

1934. Some additional fossil echini from Jamaica. Harvard Coll. Mus. Comp. Zool. Mem., vol. 54, No. 2, pp. 139-156, pls. 1-5.

Clark, W. B., and Twitchell, M. W.

1915. The Mesozoic and Cenozoic Echinodermata of the United States. U. S. Geol. Surv. Monogr. 54, 341 pp., 108 pls.

Cooke, C. Wythe.

1919. Tertiary mollusks from the Leeward Islands and Cuba. Carnegie Inst. Washington Publ. 291, pp. 103-156.

1941a. *Oligopygus nancei,* a new echinoid from Venezuela. Journ. Paleont., vol. 15, No. 3, pp. 305-306, 3 text figs.

1941b. Cenozoic regular echinoids of eastern United States. Journ. Paleont., vol. 15, No. 1, pp. 1-20, pls. 1-4.

1942. Cenozoic irregular echinoids of eastern United States. Journ. Paleont., vol. 16, No. 1, pp. 1-62, pls. 1-8.

1946. Comanche echinoids. Journ. Paleont., vol. 20, No. 3, pp. 193-237, pls. 31-34.

1948. Eocene echinoids from Panama. Journ. Paleont., vol. 22, No. 1, pp. 91-93, pl. 22.

1949a. Two Cretaceous echinoids [*Orthopsis titicacana,* n. sp., *Hemiaster* (*Macraster*) *cascajalensis,* n. sp.] from Peru. Journ. Paleont., vol. 23, No. 1, pp. 84-86, pl. 22.

1949b. *Pygurostoma pasionensis,* a Cretaceous echinoid from Guatemala. Amer. Mus. Nat. Hist. Nov., No. 1422, 3 pp., 1 fig.

1953. American Upper Cretaceous Echinoidea. U. S. Geol. Surv. Prof. Pap. 254-A, pp. 1-44, pls. 1-16.

1955. Some Cretaceous echinoids from the Americas. U. S. Geol. Surv. Prof. Pap. 264-E, pp. 87-112, pls. 18-29.

1957. *Rhynobrissus cuneus,* a new echinoid from North Carolina. Proc. U. S. Nat. Mus., vol. 107, No. 3379, pp. 9-12, pl. 1.

1958. Cretaceous Echinoidea of New Jersey and adjacent regions. New Jersey Geol. Surv., Cretaceous fossils, pt. 1, pp. 45-54, pls. 6, 7.

1959. Cenozoic echinoids of eastern United States. U. S. Geol. Surv. Prof. Pap. 321, 106 pp., 43 pls.

Cotteau, G. R.

1875. Description des échinides tertiaires des îles St. Barthélemy et Anguilla. K. Svenska Vetensk.-Akad. Handl., N. F., vol. 13, No. 6, 47 pp., 8 pls.

Durham, J. Wyatt.

1950. 1940 E. W. Scripps cruise to the Gulf of California, pt. 2, Megascopic paleontology and marine stratigraphy. Geol. Soc. Amer. Mem. 43, 216 pp., 48 pls.

Egozcue y Cía, Justo.

1897. Adiciones á la descripción de los equinoides fósiles de la isla de Cuba por M. G. Gotteau. Com. Mapa Geol. España Bol., vol. 22, pp. 1-99, pls. 1-20.

GRANT, U. S. IV, and HERTLEIN, L. G.
1938. The West American Cenozoic Echinoidea. California Univ. (Los Angeles) Publ. in Math. Phys. Sci., vol. 2, 225 pp., 30 pls.

GUPPY, R. J. L.
1866. On Tertiary echinoderms from the West Indies. Geol. Soc. London Quart. Journ., vol. 22, pp. 297-301, illus.
1879. On the fossil Echinodermata of the West Indies. Sci. Assoc. Trinidad Proc., vol. 2, pp. 193-199. Rep. 1921, Bull. Amer. Paleont., No. 35, pp. 103-109.

HEDBERG, H. D.
1956. Handbook of South American geology; Northeastern Venezuela. Geol. Soc. Amer. Mem. 65, pp. 337-340.

JACKSON, R. T.
1917. Fossil echini of the Panama Canal Zone and Costa Rica. Proc. U. S. Nat. Mus., vol. 53, No. 2218, pp. 489-501, pls. 62-68.
1918. Fossil echini of the Panama Canal Zone and Costa Rica. U. S. Nat. Mus. Bull. 103, pp. 103-116, pls. 46-52. Essentially a reprint of Jackson 1917.
1922. Fossil echini of the West Indies. Carnegie Inst. Washington Publ. 306, 103 pp., 18 pls.
1937. Mexican fossil echini. Proc. U. S. Nat. Mus., vol. 84, No. 3015, pp. 227-237, 4 pls.

JEANNET, ALPHONSE.
1928. Contribution á l'étude des échinides tertiaires de la Trinité et du Venezuela. Soc. Paléont. Suisse Mém., vol. 48, 49 pp., 6 pls.

KEHRER, LOUIS.
1956. Handbook of South American geology; Western Venezuela. Geol. Soc. Amer. Mem. 65, pp. 341-349.

KUGLER, H. G.
1956. Handbook of South American geology; Trinidad. Geol. Soc. Amer. Mem. 65, pp. 353-365.

LAMBERT, JULES.
1931. Note sur le groupe des *Oligopygus*, la nouvelle famaille des Haimeidae, et sur quelques échinides fossiles de Cuba. Soc. Géol. France Bull., ser. 5, vol. 1, fasc. 3-4, pp. 289-304, 3 figs., 1 pl.

MORTENSEN, TH.
1928-1951. A monograph of the Echinoidea. 5 vols. and index.

ORBIGNY, ALCIDE D'.
1854-1860. Échinoides irregulieres. Paléontologie française, Terrain crétacé, ser. 1, vol. 6, 596 pp., pls. 801-1006. Completed by G. Cotteau.

SANCHEZ ROIG, MARIO.
1923. Revision de los equínidos fósiles cubanos. Soc. Cubana Historia Nat. "Felipe Poey" Mem., vol. 5, No. 1, pp. 6-92 (reprint 1924, pp. 3-68), pls. 1-13.
1926. Los equinodermos fósiles de Cuba. Cuba, Dir. Montes y Minas Bol. Minas, No. 10, pp. 1-179, 43 pls.
1949. Los equinodermos fósiles de Cuba. Paleontologia Cubana, vol. 1, 302 pp., 50 pls.

Schwarck Anglade, Armando (Editor).
1956. Léxico estratigráfico de Venezuela. Venezuela, Dir. Geología, Bull. de Geología Publ. Especial No. 1, 729 pp.

Suter, H. H.
1960. The general and economic geology of Trinidad, B.W.I. 2d ed., with revisionary appendix by G. E. Higgins. 145 pp. London, Colonial Geol. Surv. Min. Res. Div.

Woodring, W. P.
1957. Geology and paleontology of Canal Zone and adjoining parts of Panamá. U. S. Geol. Surv. Prof. Pap. 306-A, 145 pp., 23 pls.

EXPLANATION OF PLATES

Plate 1

Figs. 1-4. *Enallaster bravoensis* Böse (p. 7).
Top, posterior-end, bottom, and right-side views × 1 of USNM 131170. From the Cogollo limestone, of Early Cretaceous age, at Río Socuy, Zulia, Venezuela.

Figs. 5-9. *Hemiaster* sp. (p. 8).
Top, right-side, left-side, posterior-end, and bottom views × 1 of USNM 131168. From beds of Early Cretaceous age in the State of Monagas, Venezuela.

Figs. 10-12. *Phyllobrissus zulianus* Cooke, n. sp. (p. 6).
Top, right-side, and bottom views × 1 of holotype, USNM 131167. From the Apón formation, of Aptian age, at Roas Island, Zulia, Venezuela.

Plate 2

Figs. 1-3. *Phymosoma trinitensis* Cooke, n. sp. (p. 10).
Top view × 2 and bottom and left-side views × 1 of holotype, USNM 638643a. From the Marac formation, of Paleocene age, in the Marac quarry, southern Trinidad.

Figs. 4-5. *Holectypus planatus aponensis* Cooke, n. subsp. (p. 6).
Top and left-side views × 1 of holotype, USNM 131169. From the Capacho formation, of Early Cretaceous age, at Río Apón, Zulia, Venezuela.

Figs. 6-9. *Epiaster whitei* Clark (p. 9).
Top, posterior-end, left-side, and bottom views × 1 of USNM 131171. From rocks of Early Cretaceous age on Río Caripe, Monagas, Venezuela.

Figs. 10-11. *Oligopygus nancei* Cooke (p. 13).
Top view of holotype and bottom view × 1 of paratype, USNM 498964. From the Tinajitas formation, of late Eocene age, near the headwaters of Río Amana, Anzoátegui, Venezuela, approximately 5 km. southwest of Mundo Nuevo, Monagas.

Plate 3

Figs. 1-3. *Oligopygus haldemani costuliformis* Jeannet (p. 11).
Top view × 1½ and bottom and right-side views × 1 of USNM 638626. From the San Fernando formation, of late Eocene age, at the Bella Vista quarry, Trinidad.

Figs. 4-6. *Oligopygus rotundus* Cooke (p. 12).
Top and bottom views × 2 and right-side view × 1 of USNM 638625. From the Tinajitas formation, of late Eocene age, at Alta Casa Nueva, north of Altagracia de Orituco, Guárico, Venezuela.

Figs. 7-8. *Weisbordella mirabilis* (Jackson) (p. 20).
Top view × 2 and bottom view × 1 of holotype, USNM 328247. From the San Fernando formation, of late Eocene age, on the Bella Vista Road, Mount Moriah, San Fernando, Trinidad (USGS 8878).

Figs. 9-11. *Oligopygus wetherbyi kugleri* Jeannet (p. 11).
Top view × 1½ and bottom and left-side views × 1 of USNM 638627. From the San Fernando formation, of late Eocene age, at Soldado Rock, Trinidad.

Plate 4

Figs. 1-6. *Fibularia farallonensis* Cooke, n. sp. (p. 16).
1-3, Top, left-side, and bottom views × 5 of holotype, USNM 638629a.
4-6, Top, left-side, and bottom views × 5 of paratype, USNM 638629b.
From a reef facies of the Navet formation, of middle Eocene age, on Farallon Rock, near San Fernando, Trinidad (USGS 9199).

Figs. 7-11. *Haimea ovum-serpentis* (Guppy) (p. 14).
7, Top view × 1 of USNM 115392a.
8, Bottom view × 1 of USNM 115392b.
From the St. Bartholomew limestone, of late (?) Eocene age, on St. Bartholomew, B.W.I.
9-11, Top and bottom views × 1½ and right-side view × 1 of USNM 638628.
From the San Fernando formation, of late Eocene age, on Bella Vista Road at Mount Moriah, near San Fernando, Trinidad (USGS 8878).

Plate 5

Figs. 1-2. *Lytechinus variegatus* (Leske) (p. 10).
1, Bottom view × 1 of USNM 638624a.
2, Top view × 1 of USNM 638624b.
From the San Gregorio formation, of Pliocene age, in the Río Seco area, Falcon, Venezuela.

Fig. 3. *Clypeaster rosaceus* (Linnaeus) (p. 16).
Top view × 1 of USNM 638630. From beds of Miocene age in the Goajira Peninsula, Zulia, Venezuela.

Figs. 4-7. *Agassizia scrobiculata* Valenciennes (p. 23).
Top, bottom, left-side, and posterior-end views × 1 of USNM 638636. From the San Gregorio formation, of Pliocene age, in the Río Seco area, Falcon, Venezuela.

PLATE 6

Figs. 1-4. *Moira atropos* (Lamarck) (p. 22).
Top, anterior-end, posterior-end, and bottom views × 1 of USNM 638637. From the San Gregorio formation, of Pliocene age, in the Río Seco area, Falcon, Venezuela.

Figs. 5-6. *Encope michelini* Agassiz (p. 17).
Top and right-side views of USNM 638631. Probably from the San Gregorio formation, of Pliocene age, in Sucre, Venezuela.

PLATE 7

Figs. 1-4. *Brissus unicolor* (Leske) (p. 27).
Top, right-side, posterior-end, and bottom views × 1 of USNM 638641. From the Springvale formation, of late Miocene age, of Savanetta, near Gran Couva, Trinidad.

Fig. 5. *Encope michelini* Agassiz (p. 17).
Bottom view × 1 of USNM 638631. Probably from the San Gregorio formation, of Pliocene age, in Sucre, Venezuela.

PLATE 8

Fig. 1. *Encope secoensis* Cooke, n. sp. (p. 18).
Top view × 1 of holotype, USNM 638634. From the San Gregorio formation, of Pliocene age, in the Río Seco area, Falcon, Venezuela.

Figs. 2-4. *Encope* (*Melitella*) *falconensis* Cooke, n. sp. (p. 19).
Top, bottom, and right-side views × 1 of holotype, USNM 638633. From the Chiguaje formation, of late Miocene age, in the Río Seco area, Falcon, Venezuela.

PLATE 9

Figs. 1-2. *Encope secoensis* Cooke, n. sp. (p. 18).
Bottom and right-side views × 1 of holotype, USNM 638634. From the San Gregorio formation, of Pliocene age, in the Río Seco area, Falcon, Venezuela.

Figs. 3-5. *Echinolampas lycopersicus* Guppy (p. 21).
Top, left-side, and bottom views × 1 of USNM 11587a. From the Anguilla limestone, of middle Miocene age, in Anguilla, B.W.I. Figured also by Jackson (1922, pl. 11, figs. 3-5).

PLATE 10

Fig. 1. *Encope kugleri* Jeannet (p. 18).
Top view × 1 of USNM 638632. From the Chiguaje formation, of late Miocene age, in the Río Seco area, Falcon, Venezuela.

Figs. 2-5. *Eupatagus clevei* (Cotteau) (p. 26).
Top, bottom, right-side, and posterior-end views × 1 of holotype, USNM 115379. From the St. Bartholomew limestone, of late (?) Eocene age, in St. Bartholomew, B.W.I.

PLATE 11

Figs. 1-2. *Antillaster lamberti* Jeannet (p. 24).
Posterior-end and top views × 1 of USNM 638639. From the La Vela formation, of late Miocene age, at La Vigía, 10 km. southwest (southeast?) of Pueblo Nuevo, Paraguaná district, Falcon, Venezuela.

PLATE 12

Figs. 1-4. *Brissopsis antillarum* Cotteau (p. 27).
Top, posterior-end, bottom, and right-side views × 1 of USNM 638640. From the La Vela formation, of late Miocene age, on the Paraguaná Peninsula 10 km. southeast of Pueblo Nuevo, Falcon, Venezuela.

Fig. 5. *Antillaster lamberti* Jeannet (p. 24).
Bottom view × 1 of USNM 638639. From the La Vela formation, of late Miocene age, at La Vigía, 10 km. southwest (southeast?) of Pueblo Nuevo, Paraguaná district, Falcon, Venezuela.

PLATE 13

Fig. 1. *Plagiobrissus grandis* (Gmelin)? (p. 28).
Top view × 1 of fragment, USNM 638642. From beds of Miocene (?) age on the Paraguaná Peninsula 10 km. southeast of Pueblo Nuevo, Falcon, Venezuela.

Fig. 2. *Lovenia* cf. *L. dumblei* Kew (p. 25).
Top view × 1. Naturhistorisches Museum, Basel, Switzerland. From beds of Miocene age at Punta Gavilan, Falcon, Venezuela.

Figs. 3-6. *Pericosmus stehlini* Jeannet (p. 25).
Posterior-end, right-side, top, and bottom views × 1 of USNM 638638. From the La Vela formation, of late Miocene age, at La Vigía, 10 km. southwest (southeast?) of Pueblo Nuevo, Paraguaná district, Falcon, Venezuela.

PLATE 14

Figs. 1-4. *Rhynobrissus rostratus* Cooke, n. sp. (p. 29).
Top, left-side, and bottom views × 1 of holotype. Naturhistorisches Museum, Basel, Switzerland. Probably from the La Vela formation, of late Miocene age at Punta Gavilan, Falcon, Venezuela.

Figs. 5-8. *Cassidulus falconensis* (Jeannet) (p. 21).
Top, right-side, posterior-end, and bottom views × 1 of USNM 638635. From beds of middle Miocene age at Punta Gavilan, Falcon, Venezuela.

PLATES


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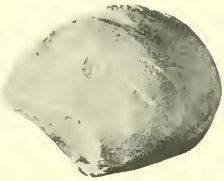
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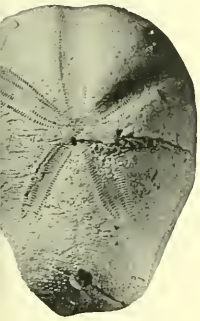
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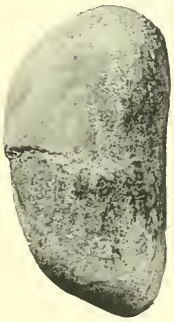
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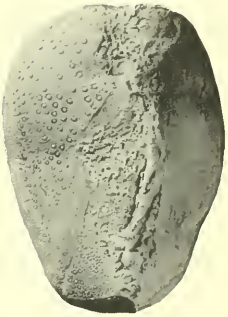
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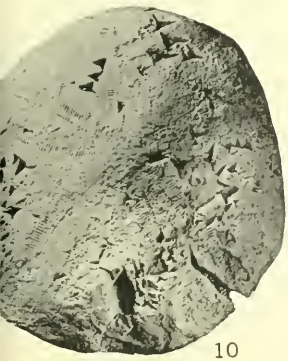
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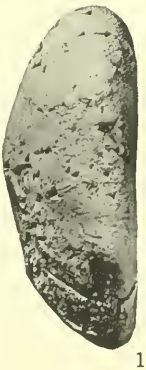
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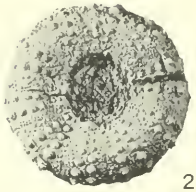

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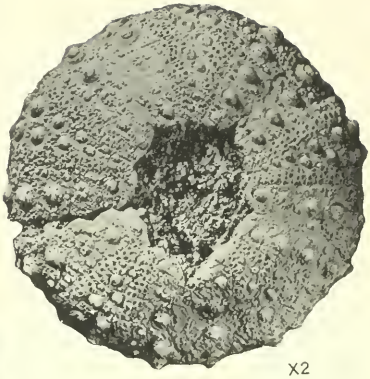

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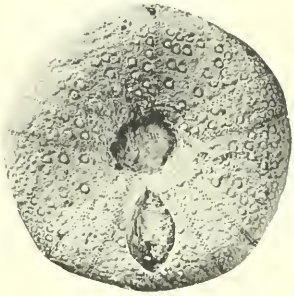

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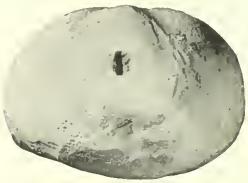

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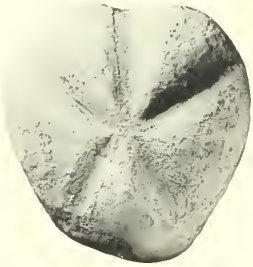

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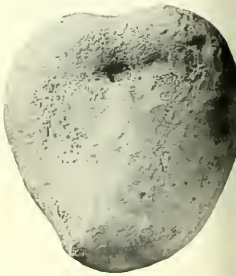

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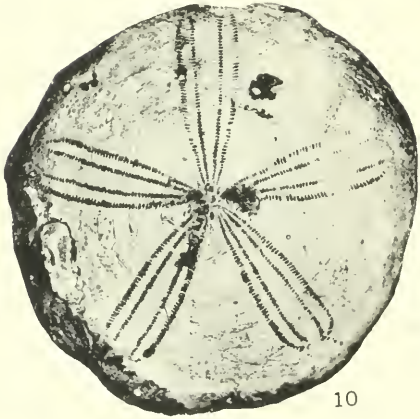

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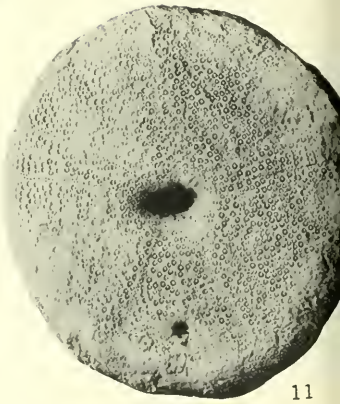

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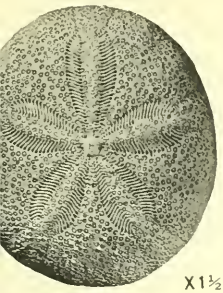

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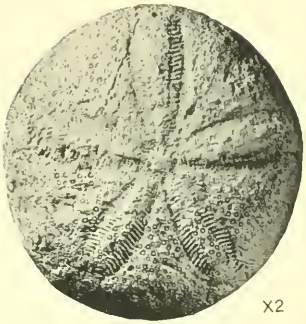

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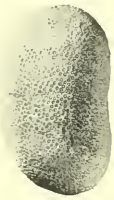

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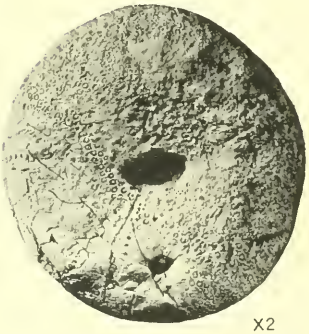

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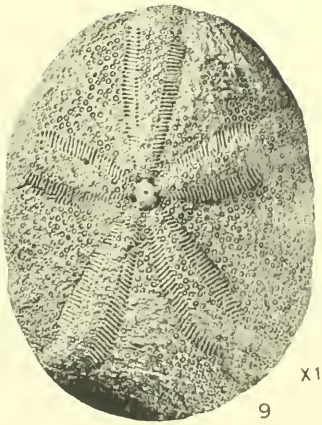

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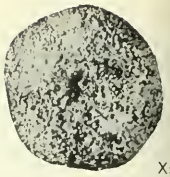
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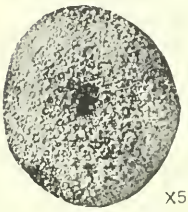
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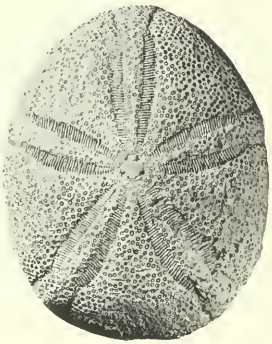
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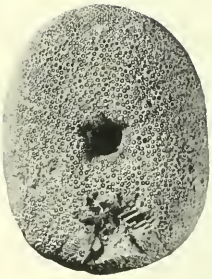
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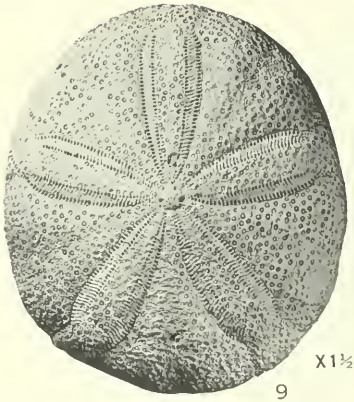
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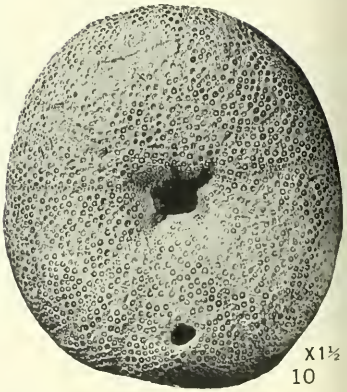
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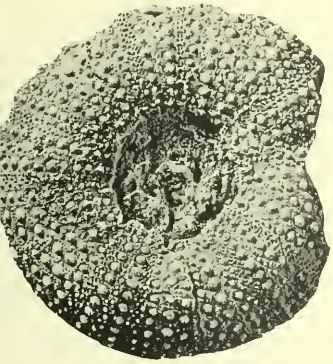

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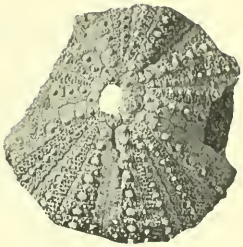

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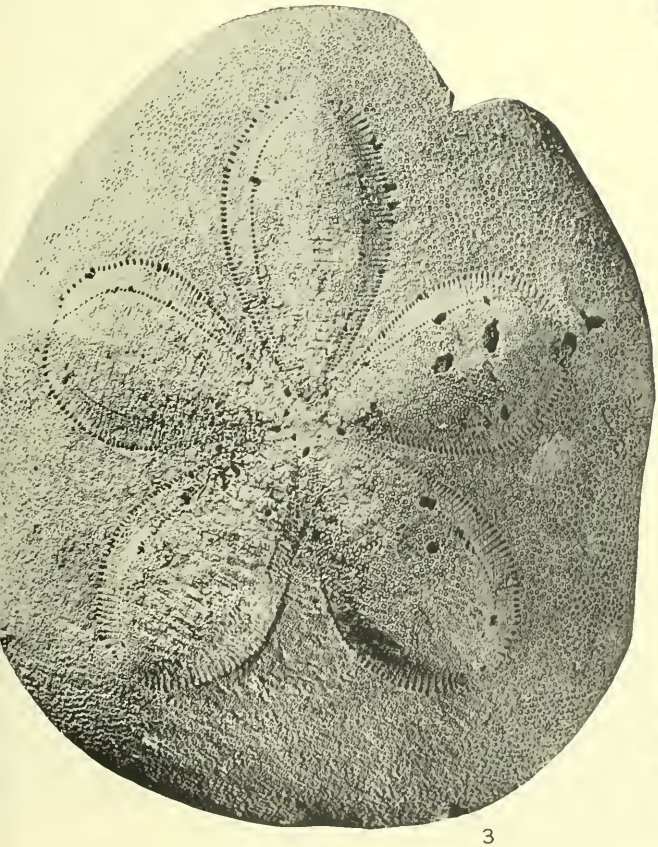

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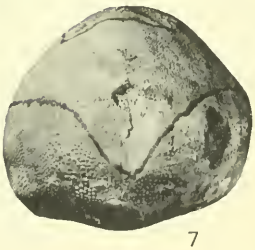

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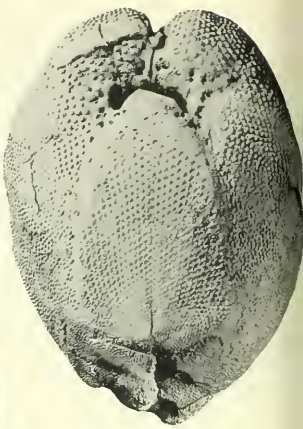

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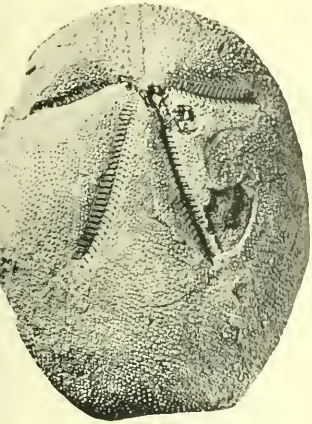

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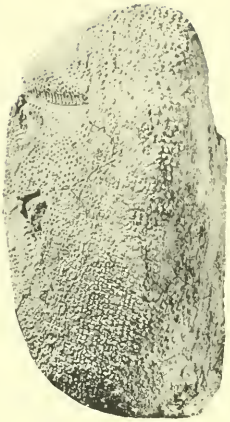

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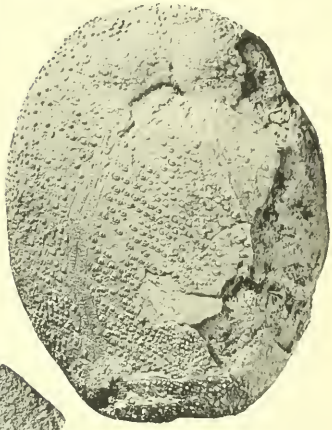

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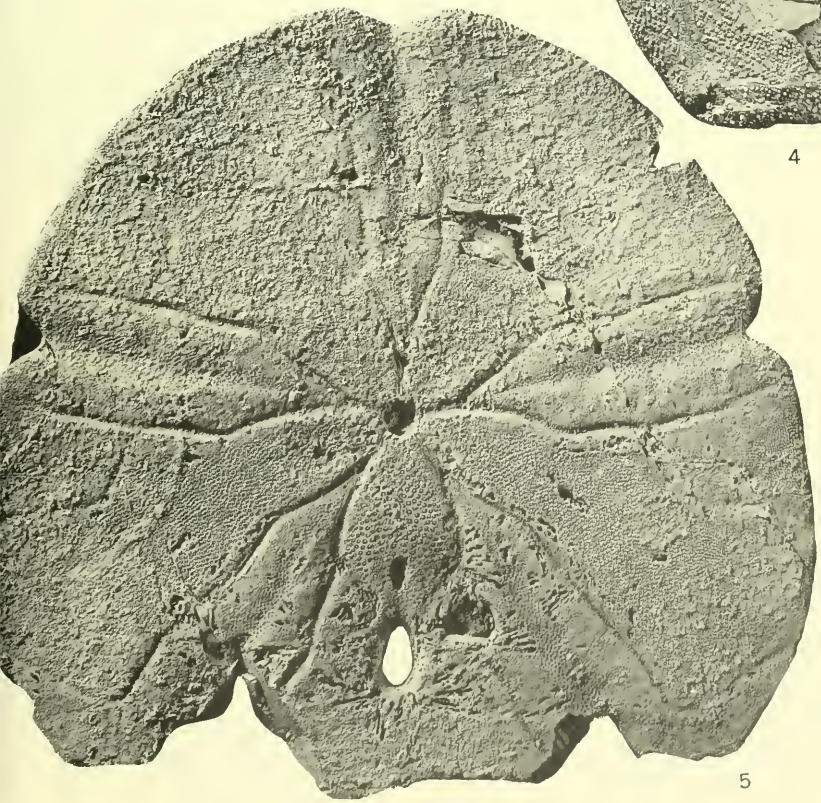

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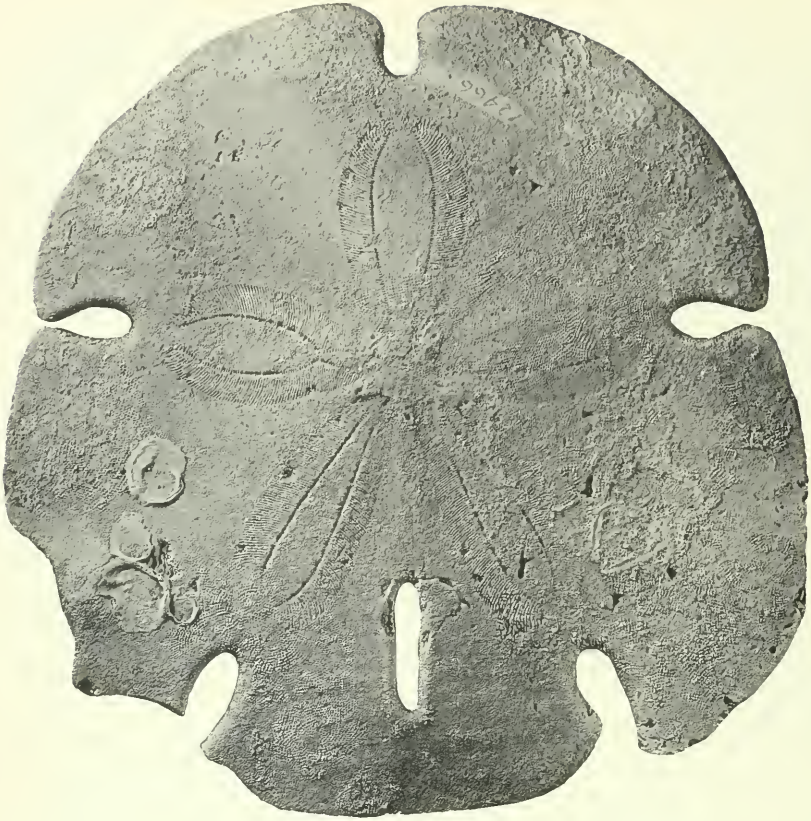

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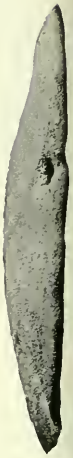

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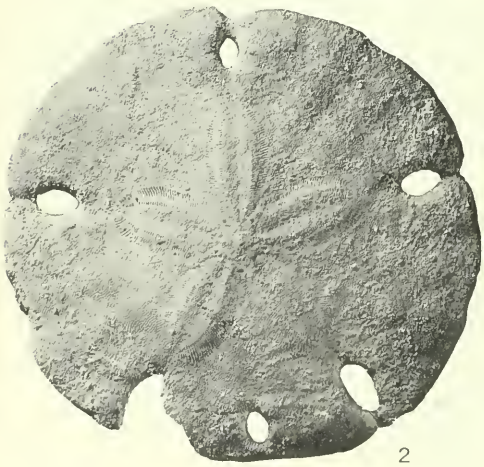

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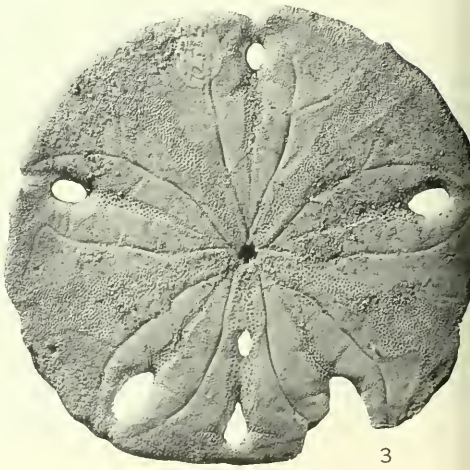

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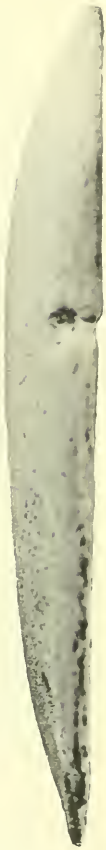

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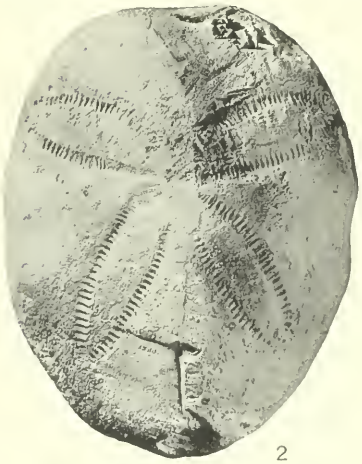

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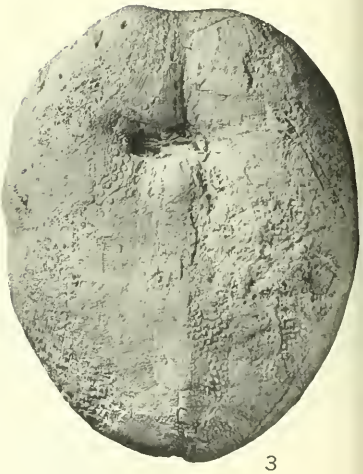

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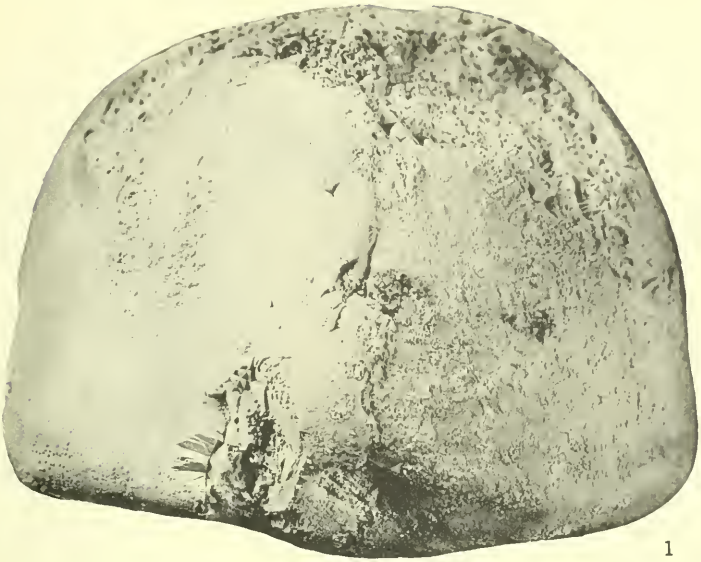

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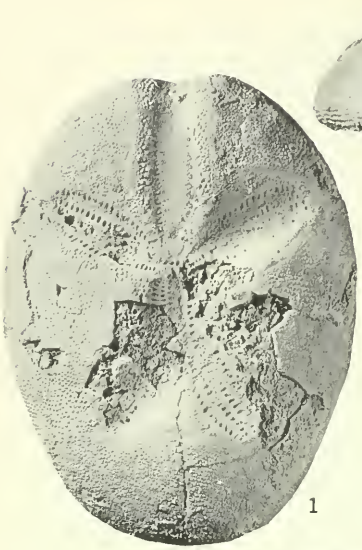

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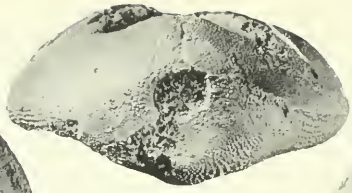

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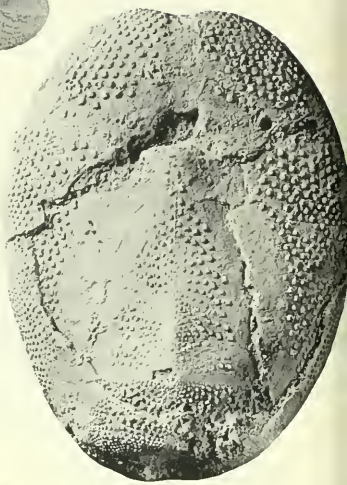

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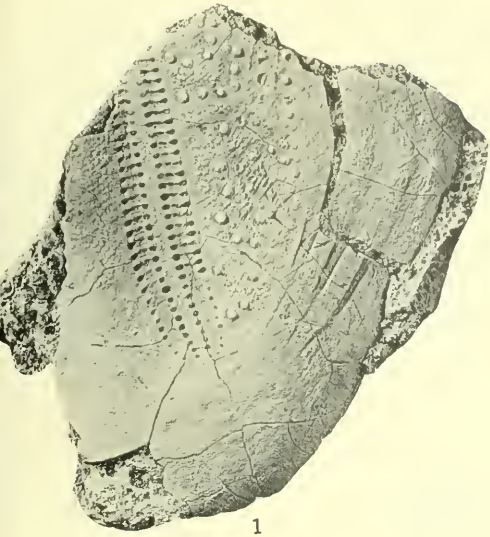
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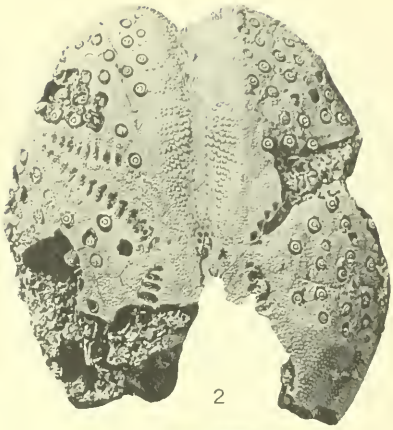
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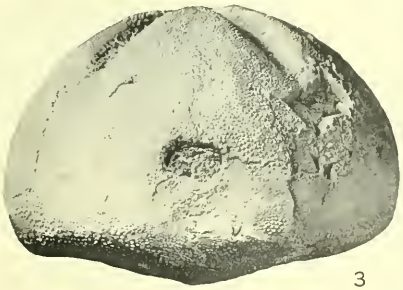
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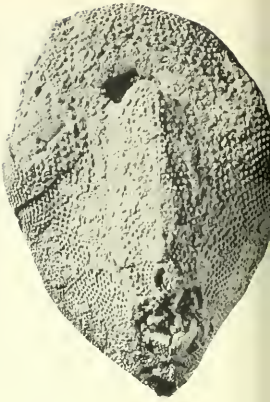

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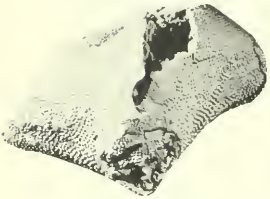

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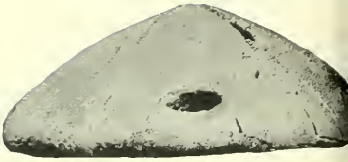

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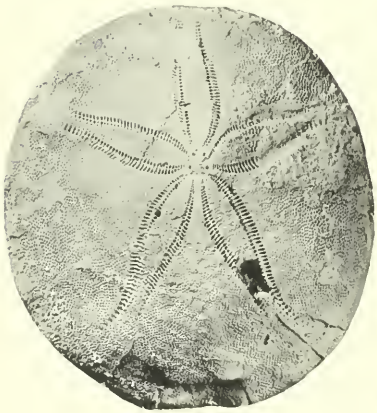

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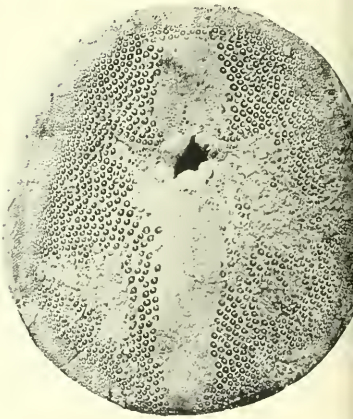

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