SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 145, NUMBER 5

TERTIARY ECHINOIDS FROM THE CALOOSAHATCHEE AND TAMIAMI FORMATIONS OF FLORIDA

(With 18 Plates)

By
PORTER M. KIER
Associate Curator, Division of Invertebrate Paleontology and Paleobotany
United States National Museum
Smithsonian Institution

(Publication 4543)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
AUGUST 2, 1963

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 145, NUMBER 5

Charles D. and Mary Vaux Walcott Research Fund

TERTIARY ECHINOIDS FROM THE CALOOSAHATCHEE AND TAMIAMI FORMATIONS OF FLORIDA

(With 18 Plates)

By

PORTER M. KIER

Associate Curator, Division of Invertebrate Paleontology and Paleobotany
United States National Museum
Smithsonian Institution

(Publication 4543)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
AUGUST 2, 1963

PORT CITY PRESS, INC.
BALTIMORE, MD., U. S. A.

Charles D. and Mary Vaux Walcott Research Fund

TERTIARY ECHINOIDS FROM THE CALOOSAHATCHEE AND TAMIAMI FORMATIONS OF FLORIDA

BY PORTER M. KIER

Associate Curator, Division of Invertebrate Paleontology and Paleobotany, United States National Museum Smithsonian Institution

(With 18 Plates)

Echinoids in the Caloosahatchee and Tamiami formations are abundant and well preserved. There are seven species in the Caloosahatchee and nine in the Tamiami, with two of the subspecies occurring in both formations. Five species and two subspecies are new. These echinoids are of particular interest because many of the species are very similar to species now living in the Caribbean. This similarity makes it possible to suggest several phylogenetic lineages. Furthermore, most of the species are represented by many specimens, thus permitting a biometric study of their variation and ontogeny.

The living *Clypeaster prostratus* (Ravenel) is redescribed to facilitate easy comparison with its fossil relative *Clypeaster crassus* Kier, new species, in the Tamiami formation. An extraordinary hexamerous variant of this species is figured and described.

ACKNOWLEDGMENTS

I thank Druid Wilson, of the U.S. Geological Survey, who not only collected many of the specimens described herein but also took me to the localities where most of them were collected. His knowledge of the stratigraphy and molluscan faunas of the Caloosahatchee and Tamiami formations made it possible to determine the relationships of the echinoid faunas. John Ayres presented me with many specimens and guided Mr. Wilson and me to a Caloosahatchee locality near Denaud where we collected many well preserved echinoids. Thomas Phelan, John Reynolds, and Wesley Stark kindly sent me

many echinoids. Drs. Norman F. Sohl and Richard S. Boardman critically read the manuscript and made valuable suggestions. I thank F. Stearns MacNeil for his opinions on the stratigraphy of the Late Tertiary of Florida and Dr. J. Wyatt Durham and Mrs. Carol Wagner for their opinions on several of the clypeasteroids. The graphs, map, and the text-figure of the tubercles of *Lytechinus variegatus plurituberculatus* Kier, new subspecies, were drawn by Lawrence B. Isham, scientific illustrator, Department of Geology, U. S. National Museum.

The cost of the publication of the plates was covered by part of a grant from the National Science Foundation.

PREVIOUS WORK

Very little work has been done on the echinoid faunas of the Caloosahatchee and Tamiami formations. Twitchell (in Clark and Twitchell, 1915, p. 218) described one species from the Caloosahatchee, *Diplothecanthus dalli,* and referred another specimen to *Diplothecanthus rosaceus* (Linnaeus). These specimens were referred by Cooke (1942, p. 11; 1959, p. 34) and DuBar (1958, p. 209) to *Clypeaster rosaceus* (Linnaeus) and are herein considered as a subspecies, *C. rosaceus dalli.* Clark and Twitchell (1915, p. 209) referred some specimens from what is now considered the Tamiami formation to *Encope macrophora* (Ravenel). Mansfield (1932, p. 48) erected a new subspecies *Encope macrophora tamiamiensis,* which Cooke (1942, p. 20) considered as a separate species referring Clark and Twitchell's specimens to it. Mansfield, in the same paper, described a new cassiduloid, *Cassidulus* (*Rhynchopygus* ?) *evergladensis,* a species herein referred to *Rhyncholampas.* Finally, DuBar (1958, p. 61) stated that a large echinoid fauna, including several regular forms and cassiduloids, occurred in his Bee Branch member of the Caloosahatchee formation.

ECHINOIDS FROM THE CALOOSAHATCHEE FORMATION

The echinoid fauna of the Caloosahatchee formation comprises seven species, including one new species and two new subspecies:

Lytechinus variegatus plurituberculatus Kier, new subspecies
Echinometra lucunter (Linnaeus)
Encope michelini imperforata Kier, new subspecies
Clypeaster subdepressus (Gray)
Clypeaster rosaceus dalli (Twitchell)
Rhyncholampas ayresi Kier, new species
Agassizia porifera (Ravenel)

The Caloosahatchee formation is described in detail by DuBar (1958, 1962). It consists of tan, sandy or silty, extremely fossiliferous marl that uncomformably overlies the Tamiami formation.

Many workers have considered the Caloosahatchee to be Pliocene (Heilprin, 1887; Dall and Harris, 1892; Mansfield, 1939; Olsson and Harbison, 1953; Bergendahl, 1956). However, DuBar (1958, 1962) and MacNeil (1962, personal communication) place it in the Pleistocene. Unfortunately, the echinoids are of little assistance in determining its age. There are no well-dated Pleistocene or Pliocene echinoid faunas known in the Western Hemisphere to compare with the Caloosahatchee echinoids, and the fauna is distinct from any of the European faunas. Furthermore, the relationship of the fauna to the Recent Caribbean fauna likewise gives no significant clues as to the age of the formation. Five of the species are still living, but three of them are subspecifically differentiated from Recent forms. The two extinct species, *Agassizia porifera* (Ravenel) and *Rhyncholampas ayresi* Kier, new species, are distinct from any echinoids now living in the Caribbean. These similarities and differences are of little use in determining the age of the fauna until more is known of the rate of speciation in Late Tertiary echinoids.

ECHINOIDS FROM THE TAMIAMI FORMATION

The Tamiami echinoid fauna consists of nine species, including four new species and two new subspecies:

Arbacia crenulata Kier, new species
Lytechinus variegatus plurituberculatus Kier, new subspecies
Clypeaster crassus Kier, new species
Clypeaster sunnilandensis Kier, new species
Encope tamiamiensis Mansfield
Encope michelini imperforata Kier, new subspecies
Mellita aclinensis Kier, new species
Rhyncholampas evergladensis (Mansfield)
Echinocardium gothicum (Ravenel)?

As redefined by Parker (1951) and DuBar (1958), the Tamiami formation is represented by several facies. At Sunniland (fig. 2, p. 8) it is a soft gray limestone with abundant echinoids and mollusks. At Buckingham it is a phosphatic, argillaceous, fossiliferous marl, and in the subsurface along the Caloosahatchee River it consists of beds of clay and sand, most of which are almost devoid of megafossils. It has been described in detail by DuBar (1958, 1962).

Most workers consider the Tamiami formation as Late Miocene. The echinoids are of little use in determining the age of the Tamiami

because so many of the species are confined to the Tamiami or found elsewhere in poorly dated beds. Five of the species are confined to the Tamiami; two of the subspecies to the Tamiami and Caloosahatchee. *Clypeaster crassus* Kier, new species, has been found in South Carolina in deposits considered by Cooke (1959, p. 36) to be Pleistocene, but Wilson (1962 personal communication) suggests that these deposits may be Late Miocene.

EVOLUTION

Many of the taxa in the two formations and those living today in the Caribbean are so similar that it is reasonable to suggest several phylogenetic lineages (fig. 1). *Clypeaster subdepressus,* a species known from the Caloosahatchee and the Recent, appears to be descended from the Tamiami *Clypeaster sunnilandensis.* The two species are alike in all characters except petal III, which is open in *C. sunnilandensis* and closed in *C. subdepressus. Clypeaster rosaceus dalli* is distinguished from *Clypeaster rosaceus rosaceus* only by its broader test. *Clypeaster prostratus,* a living species, can be distinguished from the Tamiami *Clypeaster crassus* only by its thinner margin; it is probably descended from it.

Encope michelini imperforata from the Tamiami and Caloosahatchee is probably the ancestor of *Encope michelini michelini,* known only from the Pleistocene-Recent. The two subspecies are very similar, differing only in the development of the posterior lunule. *Lytechinus variegatus pluritubercularatus,* also from the Tamiami and Caloosahatchee, is similar in all respects to *Lytechinus variegatus variegatus* except for the number of tubercles in the ambulacra. *Rhyncholampas ayresi* from the Caloosahatchee is similar to *Rhyncholampas evergladensis* from the Tamiami and probably is descended from it.

ECOLOGY

Echinoids of both the Tamiami and Caloosahatchee formations evidently lived in shallow water. Five out of the seven species found in the Caloosahatchee formation are still living: *Lytechinus variegatus, Echinometra lucunter, Clypeaster rosaceus, Clypeaster subdepressus,* and *Encope michelini.* These species occur today in shallow water. H. L. Clark (1933) included all of them in his report on the littoral echinoderms of Puerto Rico. According to Clark (op. cit., p. 74), "the littoral sea urchins are so well known and the line between them and the deep water forms is so easy to draw that there

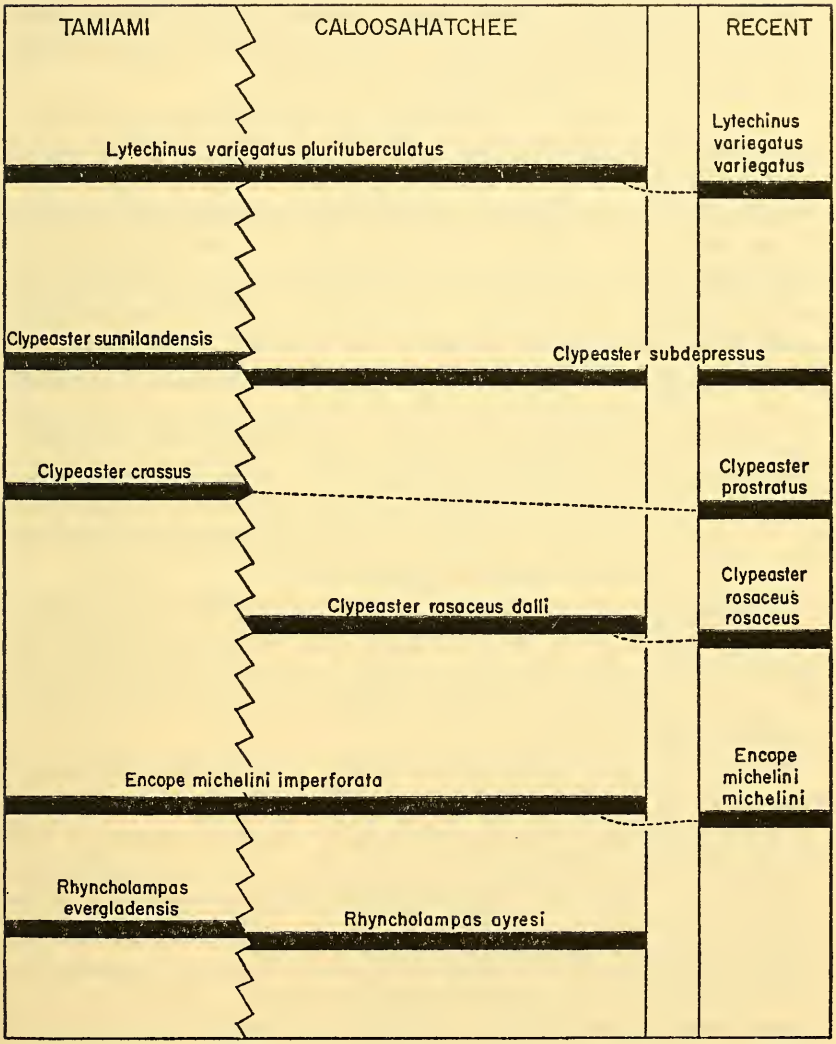


FIG. 1.—Suggested lineages of some of the species.

is little room for difference of opinion as to what species should be included in this report." In his description of the echinoids of the Barbados-Antigua expedition, Clark (1921, p. 103-104) considered *Lytechinus variegatus, Echinometra lucunter,* and *Clypeaster rosaceus* as "strictly littoral" and as "those species which occur along shore, or on reefs easily accessible at low tide."

According to Sharp and Gray (1962, p. 313), *Lytechinus variegatus* off North Carolina is most common in shallow water on sandy bottoms where there is material for protective covering and where wave action is at a minimum. They found the small adhesive discs of the tube-feet of this species inadequate for withstanding even moderately heavy wave action. Clark (1933, p. 81) reported that off Puerto Rico *L. variegatus* is most often found on a rather firm sandy bottom that is covered with short eelgrass or turtle grass.

I have observed *Clypeaster rosaceus* and *L. variegatus* in great numbers off the northeast tip of Key Biscayne, Fla. Here the water is sheltered and less than 3 feet deep. The echinoids live on a sandy grassy floor, and individuals of both species cover themselves with fragments of shells and echinoid tests. Sharp and Gray (op. cit., p. 313) have shown that in *L. variegatus* this covering of the test serves as a protection against intense light.

The other two clypeasteroids, *Clypeaster subdepressus* and *Encope michelini,* are found in sandy bottoms, but *Echinometra lucunter* is usually found on rock or coral, suggesting that, although the sea floor was probably predominately sandy, there may have been some areas of hard sea floor.

The two extinct Caloosahatchee species, the cassiduloid *Rhyncholampas ayresi* and the spatangoid *Agassiza porifera,* are little help in making paleoecological interpretations. Little is known of the ecology of the cassiduloids (Kier, 1962, p. 21). *Rhyncholampas pacificus* (A. Agassiz), which resembles *R. ayresi,* is known from depths of 5 to 60 feet, but nothing is known of its living habits. Of the two living species of *Agassizia,* one of them, *A. scrobiculata* Valenciennes, is, according to Mortensen (1951, p. 345), "an eminently littoral form," but the other, *A. excentrica* A. Agassiz, occurs in depths from 45 to 900 meters.

Two of the living littoral species, *L. variegatus* and *Encope michelini,* also occur in the Tamiami formation. Four of the extinct Tamiami species, *Clypeaster crassus, Clypeaster sunnilandensis, Encope tamiamiensis,* and *Mellita aclinensis,* are clypeasteroids. Species of this order generally occur in the littoral zone (Hyman, 1955,

p. 579) or littoral-sublittoral zone (Mortensen, 1948, p. 17). Two of the three extinct nonclypeasteroids, *Rhyncholampas evergladensis* and *Echinocardium gothicum* ?, belong to genera which occur today in both shallow and deep water. The third species, *Arbacia crenulata,* is a member of a genus that almost always is littoral.

FLORIDA LOCALITIES (FIG. 2)

UNNAMED POST-CALOOSAHATCHEE PRE-FORT THOMPSON UNIT

According to Druid Wilson (1962, personal communication), this unnamed unit contains the beds referred by Mansfield (1939, p. 34) to the upper Pliocene; DuBar's unit 6 (1958, p. 80) at Ortona Lock, and DuBar's unit F (1962), p. 14) at Shell Creek, which, he observed, contained a molluscan fauna considerably different from the underlying Caloosahatchee bed. Both units are included by DuBar in the Caloosahatchee formation.

Locality No.	*U.S.G.S. No.*	*Description*
1	22704	Float from road metal pit on south side of Florida route 80 southwest of town of Belle Glade, Palm Beach County.
		CALOOSAHATCHEE FORMATION (BEE BRANCH MEMBER OF DUBAR IN CALOOSAHATCHEE RIVER AREA).
2	23082	Float from north bank of Caloosahatchee River and from road metal ("La Belle") pits on north bank in SE ¼ sec. 12, T. 43 S., R. 28 E., Sears quad., Hendry County.
3	23083	Outcrops along north bank of Caloosahatchee River and in road metal ("La Belle") pits on north bank in SE ¼ sec. 12, T. 43 S., R. 28 E., Sears quad., Hendry County.
4	23085	Float from north bank of Caloosahatchee River west of Three Way Rock Co. pits, in SW ¼ sec. 6, T. 43 S., R. 29 E., La Belle quad., Hendry County.
5	23084	Float from Three Way Rock Co. pits on north bank of Caloosahatchee River in SW ¼ sec. 6, T. 43 S., R. 29 E., La Belle quad., Hendry County.
6	22373	Float in Denaud pits, in NW ¼ sec. 14, T. 43 S., R. 28 E., Sears quad., Hendry County.
7	22387	Caloosahatchee Canal (south bank), 1 mile east of bridge at La Belle, Hendry County.
8	22914	2-3 feet of outcrop above 5 feet (approx.) greenish-gray clay in west bank of canal in SE ¼ sec. 18 and NE ¼ sec. 19 (over distance of approx. 0.3 mi.), T. 40 S., R. 22 E., El Jobean quad., float and in place.

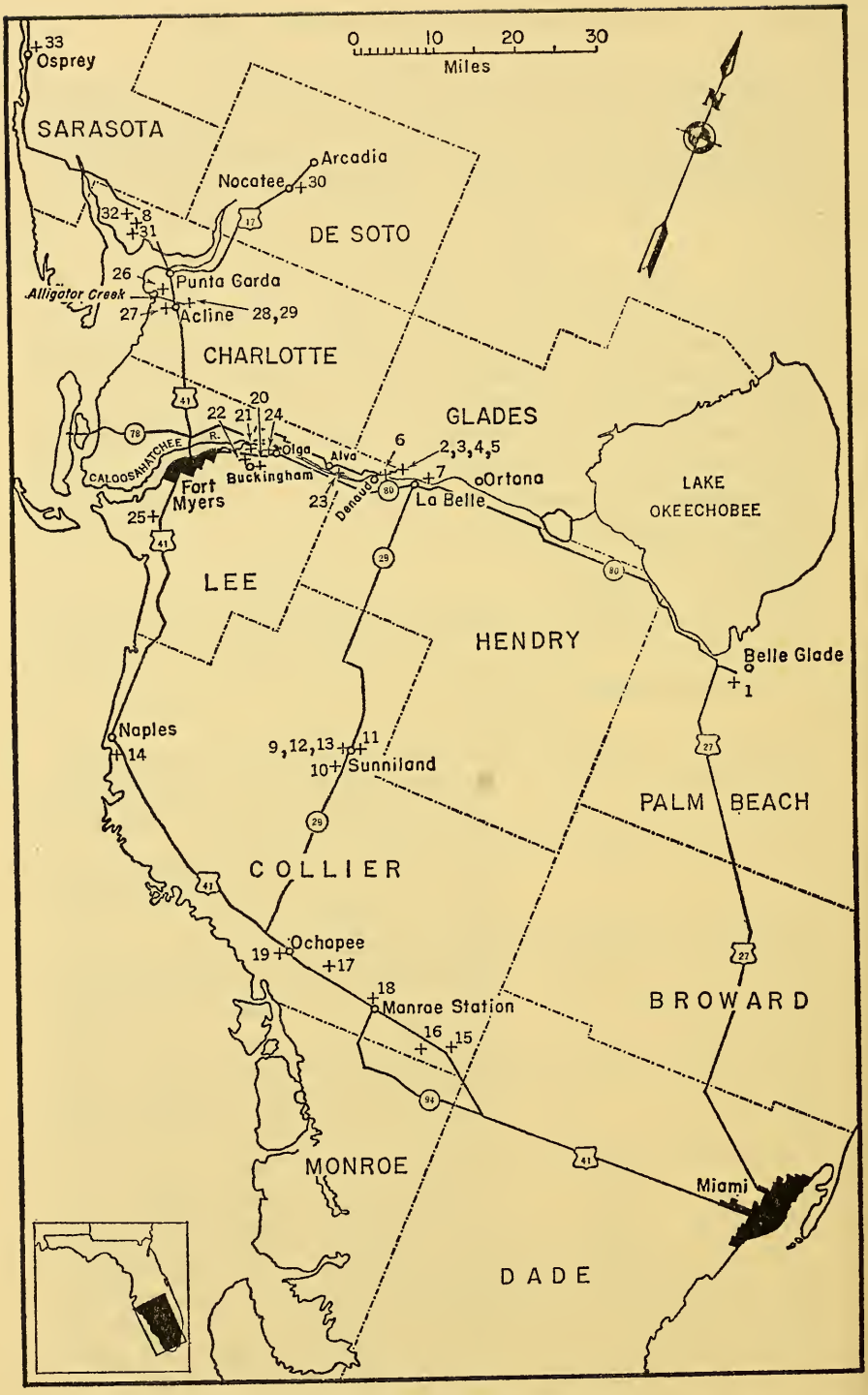


FIG. 2.—Sketch map of echinoid localities.

Locality No.	*U.S.G.S. No.*	*Description*
		TAMIAMI FORMATION (TYPICAL)
9	22587 21067	Sunniland Rock Co. pits west side of Florida route 29, Sunniland, Collier County, in NW ¼ sec. 29, T. 48 S., R. 30 E.
10	22879	Float from pits west side of Florida route 29 about 1.3 miles south of Sunniland.
11	22880	Float from pits 0.3 mile east of Florida route 29 at Sunniland, Collier County, in SE ¼ sec. 29, T. 48 S., R. 30 E.
12	22881	Float from pits about 0.5 mile west of Florida route 29 near Sunniland, Collier County, in SW¼ sec. 29, T. 48 S., R. 30 E.
13	22882	Float from pit in Sunniland Rock Co. property about 0.1 mile south of pits 0.5 mile west of Florida route 29 near Sunniland, Collier County, in SW ¼ sec. 29, T. 48 S., R. 30 E.
14	21263	Golden Shores, Naples, just south of U.S. route 41 and east of Naples Bay, NW ¼ sec. 10, T. 50 S., R. 25 E.
15	21262	North of Tamiami Trail (U.S. route 41) at point 11.7 miles east of Monroe Station.
16	21260	South side of Tamiami Trail (U.S. route 41) at a point 7.1 miles east of western intersection of U.S. route 41 and Florida route 94.
17	21091	1 mile north of Tamiami Trail (U.S. route 41) at a point 4.7 miles east of Ochopee post office.
18	21044	From pits of Sunniland Rock Co. at Monroe Station just north of Tamiami Trail (U.S. route 41).
19	22792	Float from canal in subdivision on south side of Tamiami Trail (U.S. route 41) about 0.8 mile west of Ochopee post office.
		TAMIAMI FORMATION ("BUCKINGHAM" FACIES)
20	22604 22597	Type locality of "Buckingham limestone," Buckingham, Lee County, in SW ¼ sec. 5, T. 44 S., R. 26 E.
21	21169	Spoil banks of canals at end and between Tropic Avenue and Ponciana Boulevard 10 miles east of Fort Myers at Fort Myers Shores, in NW ¼ sec. 29, T. 43 S., R. 26 E., Lee County.
22	21128	Spoil bank of pit in Baucom Ranch, south of Florida route 80 and Fort Myers Shores, in SE ¼ sec. 31, T. 43 S., R. 26 E., Lee County.
23	21066	Float from pits on east side of "County marl pits" (east side of Spanish Creek) about 1.3 miles east of Alva, just south of Florida route 78 in NW ¼ NW ¼ sec. 23, T. 43 S., R. 27 E., Lee County.

Locality No.	*U.S.G.S. No.*	*Description*
24	23086	Float from north spoil bank of canal about 0.2 mile southwest of bridge over Caloosahatchee River at Olga, Lee County, NE ¼ NE ¼ sec. 21, T. 43 S., R. 26 E., Olga quad.
25	21015	West Coast Rock Co. pits 0.3 mile west of U.S. route 41 about 8.0 miles south of Fort Myers in SW ¼ sec. 26, T. 45 S., R. 24 E., Fort Myers SW quad.
	TAMIAMI FORMATION (BARNACLE–ECHINOID–OYSTER FACIES)	
26	22454	Float from spoil banks of canals and north bank of North Fork (of Alligator Creek) west of U.S. route 41, in NE ¼ NW ¼ sec. 20, R. 23 E., T. 41 S., Punta Gorda, Sea Lanes subdivision, Punta Gorda quad.
27	21257 22315 22318	Spoil banks from group of pits in sec. 29, T. 41 S., R. 23 E., about 1 miles southwest of Acline, Charlotte County.
28	22592	Outcrop in west bank of Alligator Creek (South Prong), about 2.5 miles east of U.S. route 41 and just south of bridge on paved road in NE ¼ sec. 26, T. 41 S., R. 23 E., Cleveland quad., Charlotte County.
29	22742	From bed and banks of Alligator Creek (South Prong) northwest of bridge in NE ¼ sec. 26, T. 40 S., R. 23 E., Cleveland quad., Charlotte County.
30	21258	Spoil from borrow pit along Florida route 760, 1.6 miles east of junction of U.S. route 17 and Florida route 760 at Nocatee, in NW ¼ SE ¼ sec. 24, T. 38 S., R. 24 E. (Bergendahl, 1956, p. 74).
31	22911	Float from spoil on west side of canal in Port Charlotte area, Charlotte County, in SW ¼ sec. 20, T. 40 S., R. 22 E., El Jobean quad.; locality directly opposite eastward turn in canal.
32	22916	Float from east side of "Sam Knight" canal crossing with U.S. route 41 about 2.4 miles west of "Murdock" Station (Port Charlotte), Murdock quad., in SW ¼ sec. 2, T. 40 S., R. 21 E., Charlottee County.
	UNNAMED LATE MIOCENE FORMATION	
33	22584	Osprey, Sarasota County, float from road metal pit some distance east of U.S. route 41 just north of North Creek.

SYSTEMATICS

ARBACIA CRENULATA Kier, new species

Plate 1, figures 1-5; text figures 3-7

Diagnosis.—Species characterized by crenulated ornamentation on plates.

Material.—Thirty-one specimens most of which are extremely well preserved with all the ornamentation visible.

Shape.—Medium size, varying from a horizontal diameter of 11.8 to 42.0 mm; moderately high, with height 40 to 50 percent of diameter, height-diameter ratio constant throughout growth (text fig. 3).

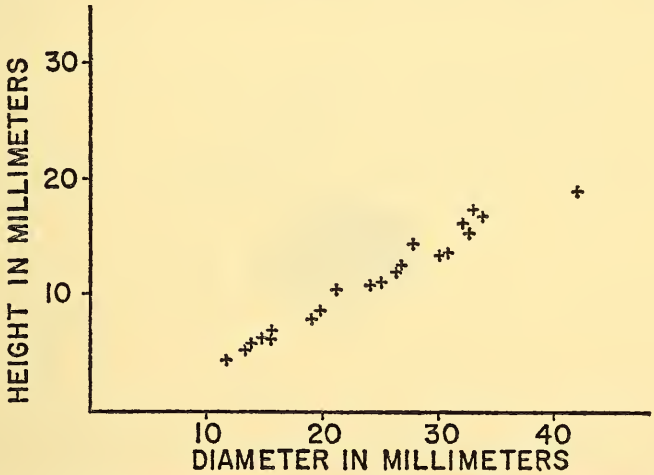


FIG. 3.—*Arbacia crenulata* Kier, new species. Height of the test relative to the diameter.

Apical system.—Preserved in 21 specimens; all oculars exsert in all specimens (text fig. 4); oculars generally pentagonal, small usually without tubercles; genital plates large with genital pore in center of each plate; periproct elongate diagonally from interambulacra 3 to 1, at greatest width between 13 to 17 percent of horizontal diameter of test.

Ambulacra.—At ambitus one-half width of interambulacra; poriferous zones straight from apical system to near margin, arcuate around large tubercles at margin, greatly widened adorally; adorally tubercles so large that pore pairs perforate bosses; ambulacral plates compound, trigeminate; in each poriferous zone 35 pore-pairs in specimen 13.8 mm in diameter, 42 in specimen 19.7 mm in diameter,

56 in specimen 30 mm in diameter; the number of primary tubercles in each ambulacrum varies from 7 in a specimen 11.8 mm in diameter to 20 in a specimen 33 mm in diameter; one large pit in each ambulacrum near peristome (pl. 1, fig. 4); primary tubercles very large adorally, but greatly reduced in size and number to ambitus.

Interambulacra.—Plates low, 22 in interambulacrum of specimen 13.8 mm in diameter, 24 in specimen 19.7 mm in diameter, 28 in specimen 30 mm in diameter; primary tubercles very small in area extending from apical system to slightly above ambitus, no tubercles in median region, one tubercle on each plate near adradial suture, in some specimens tubercles smaller on every other plate in some series; tubercles very large in area from slightly above ambitus to peristome; usually two tubercles on each plate.

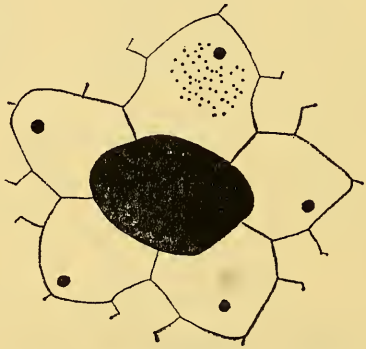


FIG. 4.—*Arbacia crenulata* Kier, new species: Apical system of holotype, U.S.N.M. 648133, from the "Buckingham facies" of the Tamiami formation, from loc. 20, × 4.

Peristome.—Very large, one-half as wide as horizontal diameter of test, pentagonal, relative size of peristome constant throughout adult growth (text fig. 5); gill slits wide, continuing considerable distance on surface of test (pl. 1, fig. 4); auricles high, slender, not joined.

Periproct.—Opening elongated along line passing through interambulacra 1 and 3; size constant throughout growth (text fig. 6).

Tuberculation.—All primary tubercles imperforate, smooth, on highly inflated bosses; surface of all plates, where tubercles do not occur, crenulated with series of narrow grooves and ridges running from apical system to peristome (pl. 1, fig. 5). Number of tubercles relative to size constant throughout growth (text fig. 7).

Comparison with other species.—This species is very similar to

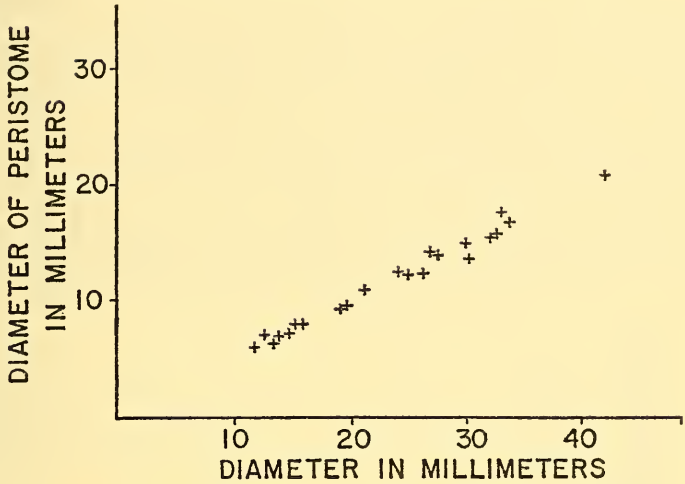


FIG. 5.—*Arbacia crenulata* Kier, new species. Diameter of the peristome relative to the diameter of the test.

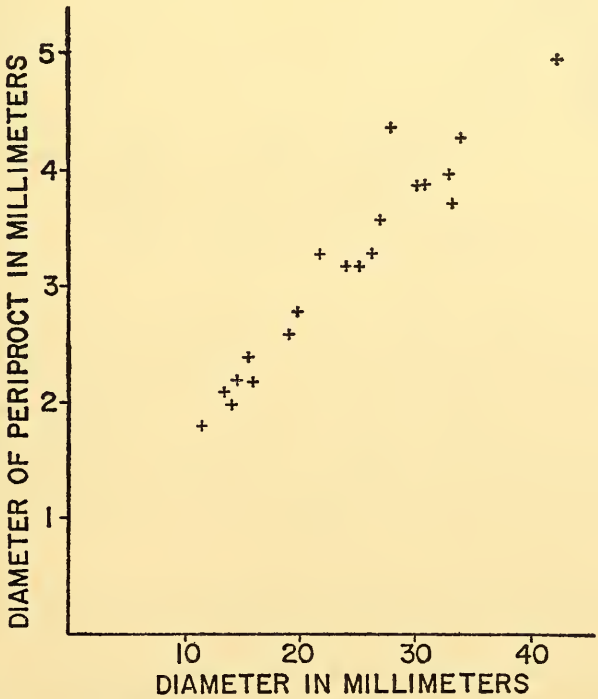


FIG. 6.—*Arbacia crenulata* Kier, new species. Diameter of the periproct relative to the diameter of the test.

Arbacia improcera (Conrad) from the upper part of the Yorktown formation (Late Miocene). Both species have the same shape, same number of tubercles in the ambulacra and interambulacra, and same number of ambulacral and interambulacral plates. *A. crenulata* differs in the surface ornamentation of the plates. In *A. crenulata* the ornamentation consists of fine crenulations (pl. 1, fig. 5) that extend adorally, whereas in *A. improcera* there are granules (pl. 1, fig. 6). Furthermore, in *A. crenulata* the naked areas in the ambulacra and interambulacra extend farther adorally than in *A. impro-*

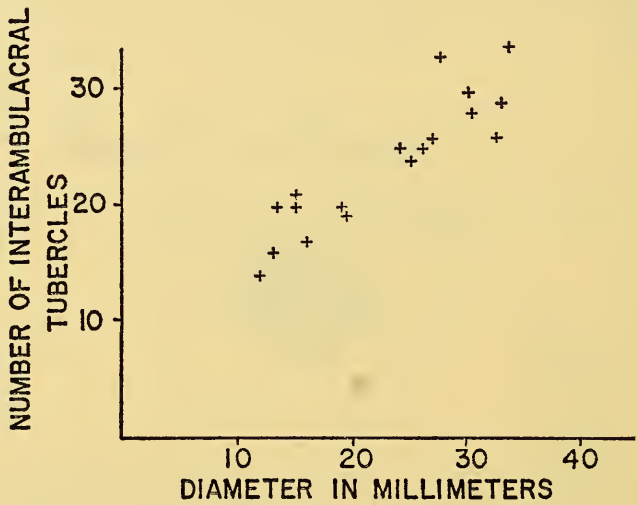


FIG. 7.—*Arbacia crenulata* Kier, new species. Number of interambulacral tubercles relative to the diameter of the test.

cera. A. crenulata is easily distinguished from *Arbacia waccamaw* Cooke by its much more ventral ambitus, lower interambulacral plates, and smaller adapical tubercles. It is distinguished from *Arbacia rivuli* Cooke in having fewer tubercles in the adapical interambulacra. *A. crenulata* is similar to *Arbacia sloani* (Clark) from the Late Miocene (Duplin marl) but unfortunately no well preserved specimens are known of *A. sloani,* and it is not possible to make a detailed comparison of the two species.

Occurrence.—This species is most common in the "Buckingham" facies and the barnacle–echinoid–oyster facies of the Tamiami formation. Very few specimens were collected from the typical Tamiami.

Tamiami formation: Typical Tamiami: Loc. 12, 14.

Tamiami formation, "Buckingham" facies: Loc. 20, 21, 22, 23, 24, 25.

Tamiami formation, barnacle–echinoid–oyster facies: Loc. 26, 29, 30.

Unnamed late Miocene formation: Loc. 33.

Type.—Holotype, U.S.N.M. 648133, loc. 20.

LYTECHINUS VARIEGATUS VARIEGATUS (Leske)

Plate 2, figure 3

Cidaris variegata (part) Leske, 1778, Klein's Naturalis dispositio Echinodermatum, p. 149, pl. 10, figs. B, C.

Lytechinus variegatus (Lamarck). Mortensen, 1943, Monograph of the Echinoidea, vol. 3, pt. 2, p. 437, pl. 24, figs. 1-9; pl. 25, figs. 1-12, pl. 53, figs. 1, 6, 7, 11, 13.

Lytechinus variegatus (Leske). Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, p. 15, pl. 2, figs. 12, 13.

Lytechinus variegatus (Leske). Cooke, 1961, Smithsonian Misc. Coll., vol. 142, No. 4, p. 10, pl. 5, figs. 1-2.

A detailed description and synonymy are given by Mortensen (1943, pp. 437-446). This species occurs today in the West Indies, extending as far north as North Carolina and as far south as Brazil. It was previously known as a fossil from the Pliocene San Gregorio formation in Venezuela (Cooke, 1961, p. 10). The San Gregorio specimens appear to be slightly different and may not belong to this subspecies. Cooke reports this subspecies from deposits in South Carolina which he considers to be Pleistocene.

Type.—Figured specimen, U.S.N.M. 648151.

LYTECHINUS VARIEGATUS PLURITUBERCULATUS Kier, new subspecies

Plate 2, figures 1, 2; Plate 3, figure 1; Plate 4, figure 4; text figures 8-11

Diagnosis.—Distinguished from nominate subspecies by more numerous tubercles in ambulacra.

Material.—Two specimens from the Tamiami formation; 13 from the Caloosahatchee.

Shape.—Size moderate, varying from 48 to 56 mm in horizontal diameter, height varying from 55 to 60 percent (average 57) of the diameter; marginal outline circular to subpentagonal; peristome depressed.

Apical system.—Partially preserved on only one specimen (text fig. 8), genital plates of different size, genital 5 smaller than others; ocular plates I and V broadly insert, other oculars exsert.

Ambulacra.—Ambulacra moderately broad, approximately 60 percent width of interambulacra, in specimen 54 mm in diameter 36

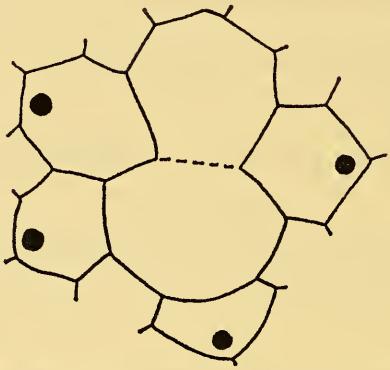


FIG. 8.—*Lytechinus variegatus plurituberculatus* Kier, new subspecies: Apical system of U.S.N.M. 648150, from the Caloosahatchee formation, loc. 6, × 4. Genital 2 absent on specimen.

plates in each series; two regular series of secondary tubercles parallel to primary series in each ambulacrum; this series extending from midway between apical system and margin to near peristome, in specimen 54 mm long from 25 to 31 secondary tubercles in each area.

Interambulacra.—Secondary tubercles well developed (text fig. 9), of approximately same size as primary; at margin in specimen 48 mm in diameter one secondary tubercle adradial to primary, two admedial; in specimen 56 mm in diameter two tubercles adradial, three admedial, number of secondary tubercles variable in different interambulacra

FIG. 9.—*Lytechinus variegatus plurituberculatus* Kier, new subspecies: Side view at ambitus showing tuberculation in U.S.N.M. 648149, from the Caloosahatchee formation, loc. 6, × 4.

in same specimen; in larger specimens doubling of adradial secondary tubercles usually in alternate plates.

Peristome.—Larger, varying from 31 to 34 percent (average 32) of diameter of test; gill slits well developed, curving toward medial line of interambulacra.

Comparison with the nominate subspecies.—This subspecies is identical in all its characters with the nominate subspecies except in the number and arrangement of the secondary tubercles in the ambulacra and the lateral distance between the primary ambulacral

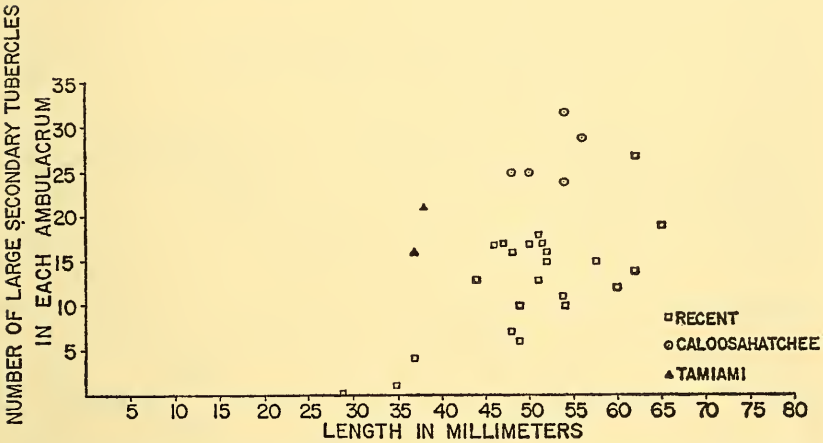


FIG. 10—*Lytechinus variegatus* (Leske). Number of large secondary tubercles in each ambulacrum relative to the length of the specimens in the Recent *L. variegatus variegatus* (Leske) and in the Caloosahatchee and Tamiami *L. variegatus pluituberculatus* Kier, new subspecies.

tubercles. In the nominate subspecies the secondary tubercles are usually irregularly arranged, alternating from either side of the median suture (pl. 2, fig. 3). In *L. variegatus pluituberculatus,* however, the secondary tubercles are in two regular series (text fig. 8; pl. 2, fig. 2). Furthermore, they are much more numerous (see scatter diagram, text fig. 10) than in the nominate subspecies. I have found only one specimen out of 59 studied of the nominate subspecies that had a double series of tubercles. Mortensen (1943, p. 440) reports that specimens with a double series of secondary tubercles are rare.

The lateral distance between the primary tubercles of the same ambulacrum is usually greater in *L. variegatus pluituberculatus* than in the nominate subspecies. In the five Caloosahatchee specimens in

which this area can be seen this distance averaged 13.1 percent of the length, with a standard deviation of 0.29. In the nominate subspecies (using 59 specimens) this distance averages 11.2 percent of the length, with a standard deviation of 0.69. Even though there are so few fossil specimens the difference between this distance between the primary ambulacral tubercles is highly significant as shown in a scatter diagram (text fig. 11) and by biometric analysis. Using the

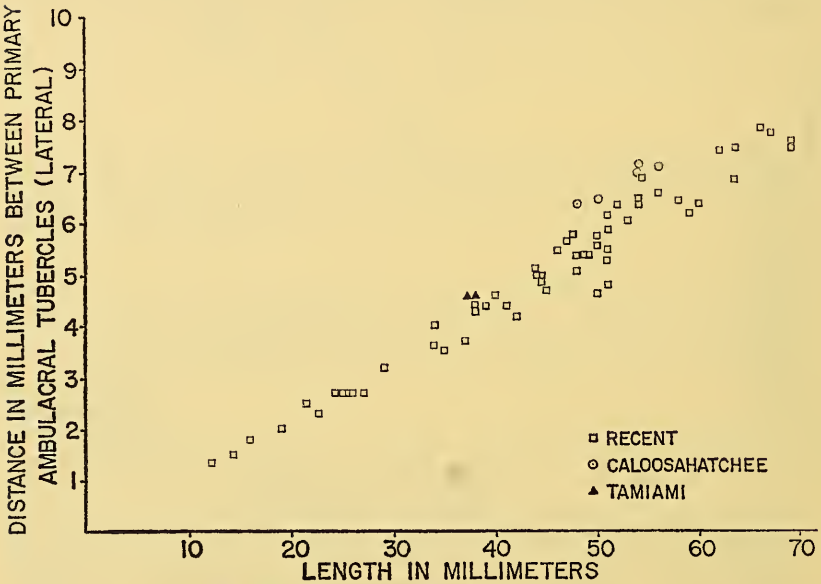


FIG. 11.—*Lytechinus variegatus* (Leske). Distance between primary ambulacral tubercles relative to length of test in specimens of *L. variegatus variegatus* (Leske) from the Recent and specimens of *L. variegatus plurituberculatus* Kier, new species, from the Caloosahatchee and Tamiami formations.

procedure recommended by Burma (1948, p. 731) and followed by Kier (1957, p. 86) a value of 12.6 was found for the difference in the means of the distance between the primary ambulacral tubercles in the two populations. Since a result of 3 or more is almost certainly significant, with the degree of probability increasing greatly with the increase of this number, it is evident that these populations are significantly different in this character. In the two Tamiami specimens the distance between the primary tubercles is less than that in the Caloosahatchee specimens but more than in the nominate subspecies, with an average of 12.15 percent of the length and a standard deviation of 0.07.

Although these differences in the number and arrangement of the

tubercles are significant, there is some overlap, and some of the specimens are intermediate between the two taxa. It is for this reason, together with the great similarity between the taxa in all their other features, that these taxa are herein subspecifically rather than specifically distinguished from each other.

Occurrence.—Caloosahatchee formation, loc. 2, 6. Tamiami formation ("Buckingham" facies), loc. 20.

Types.—Holotype, U.S.N.M. 648149, loc. 6; figured specimen U.S.N.M. 648150, loc. 6.

ECHINOMETRA LUCUNTER (Linnaeus)

Plate 3, figure 2; Plate 4, figures 1-3

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

Echinometra lucunter (Linnaeus). Mortensen, 1943, Monograph of the Echinoidea, vol. 3, pt. 3, p. 357. (See this work for the pre-1943 references to this species.)

Echinometra lucunter (Linnaeus). Caso, 1948, Inst. Biol. México, vol. 19, p. 199, figs. 10-11.

Echinometra lucunter (Linnaeus). Dartevelle, 1953, Ann. Mus. Congo Belge, vol. 13, p. 38, figs. 7-8, pl. A, fig. 5, pl. i, figs. 4-6.

Echinometra lucunter (Linnaeus). Clark, 1954, Bull. U.S. Fish Comm., vol. 55, p. 374.

Echinometra lucunter (Linnaeus). Clark, 1955, Journ. West Afr. Sci. Assoc., vol. 1, p. 52.

Echinometra lucunter (Linnaeus). Bernasconi, 1955, Biol. Inst. Oceanogr. São Paulo, vol. 6, p. 62, pl. 2, figs. 1, 5.

Echinometra lucunter (Linnaeus). Tommasi, 1957, Pap. Dep. Zool. Sec. Agric. São Paulo, vol. 13, p. 29, figs. 16, 20, pl. 1, figs. 4, 6.

Remarks.—There are seven specimens which can be referred to this species. Although the fossil specimens are only slightly elongated, whereas in most of the Recent specimens the test is greatly elongated, this difference is not considered significant. According to Clark (1954, p. 374, footnote), Recent specimens are commonly circular in outline in the western part of the Gulf of Mexico.

Ecology.—This species is usually found living on rocks in the littoral zone.

Distribution.—This species is found living today in the West Indies from Florida to Brazil and off the west coast of Africa. Arnold and Clark (1934, p. 140) report it as a fossil from Jamaica, and Dartevelle (1953, p. 38) found it in the Pleistocene of Angola.

Fossil occurrence in Florida.—Caloosahatchee formation, loc. 6.

Types.—Figured specimens, U.S.N.M. 648152-3, loc. 6.

CLYPEASTER PROSTRATUS (Ravenel)

Plate 5, figures 2, 3; Plate 6, figures 1, 2; Plate 7, figures 1-4; text figures 12-17

Scutella gibbosa Ravenel, 1845, Proc. Acad. Nat. Sci. Philadelphia, vol. 2, p. 253 (not *Scutella gibbosa* Risso, 1825).

Clypeaster prostratus Ravenel. Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 118, pl. 16, fig. 1; pl. 24, fig. 1; pl. 25, figs. 1, 2; pl. 26, fig. 5. (See this work for the pre-1948 references to this species.)

Clypeaster prostratus Ravenel. Cooke, 1959. U.S. Geol. Surv. Prof. Paper 321, p. 36.

Before Mortensen (1948, p. 118) this species had never been adequately described. Although Mortensen's description is thorough, it is based on only two specimens. Since 38 specimens are now available, a redescription is warranted.

Diagnosis.—Species characterized by thin pentagonal test with thick margin, flat area between end of petals and margin, and closed paired petals.

Material.—Thirty-eight specimens, all dried.

Shape.—Smallest specimen 37 mm long, largest 91, average 70 mm; wide, average width 91 percent of length; length-width ratio with little variation (text fig. 12); test pentagonal with truncated posterior margin, pointed anterior with greatest width anterior to center, in some specimens slight indentation at margin in interambulacra 4 and 1; margin thick, 6.5 mm thick in specimens 91 mm long, area between margin and ends of petals very slightly sloping, horizontal, or slightly depressed; petaloid area inflated; test low, average height 17 percent of length (text fig. 13); adoral surface flat.

Apical system.—Central (pl. 7 fig. 4), small, madreporite large, button shaped, five genital pores; ocular plates small.

Ambulacra.—Petals broad, short, extending three-fifths distance from apical system to margin; anterior petal (III) slightly longer than others, in specimen 91 mm long anterior paired petals (II, IV) shortest, approximately 9 percent shorter (25 mm long in holotype) than petal III; posterior paired petals intermediate (27.2 mm in specimen 91 mm long), 6-8 percent shorter than petal III; paired petals closed, anterior petal (III) open; interporiferous zone approximately twice width poriferous zone; number of pore-pairs varying with size, in smallest specimen (37 mm long) 37 pore-pairs in petal III, in largest (91 mm long) 61; as evident from text fig. 14, rate of addition of new pore-pairs decreasing in larger specimens; in specimen 91 mm long 59 pore-pairs in petals II or IV, 65 in petals I or V.

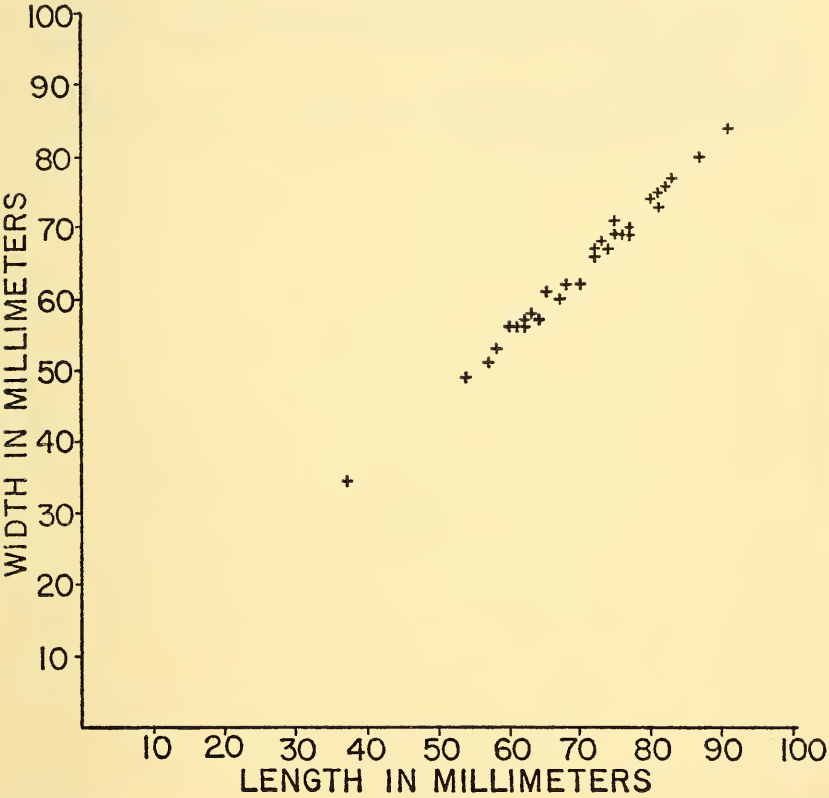


FIG. 12.—*Clypeaster prostratus* (Ravenel). Width relative to length of test.

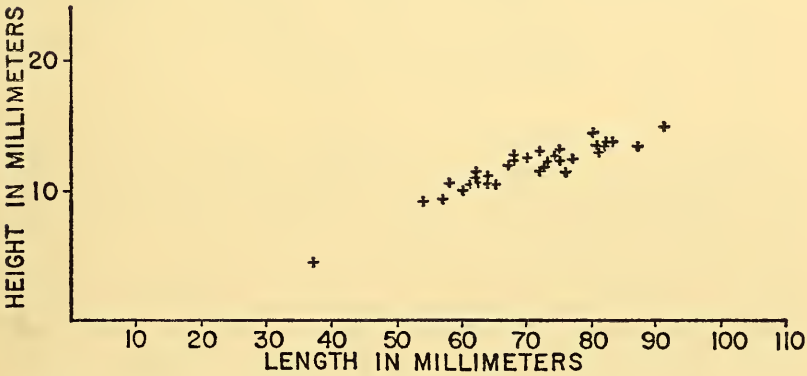


FIG. 13.—*Clypeaster prostratus* (Ravenel). Height relative to length of test.

Periproct.—Inframarginal, located near posterior margin; on holotype 3.5 mm from margin, opening irregular in shape, usually elongated transversely.

Peristome.—Central to slightly posterior, pentagonal, pointed anteriorly, truncated posteriorly.

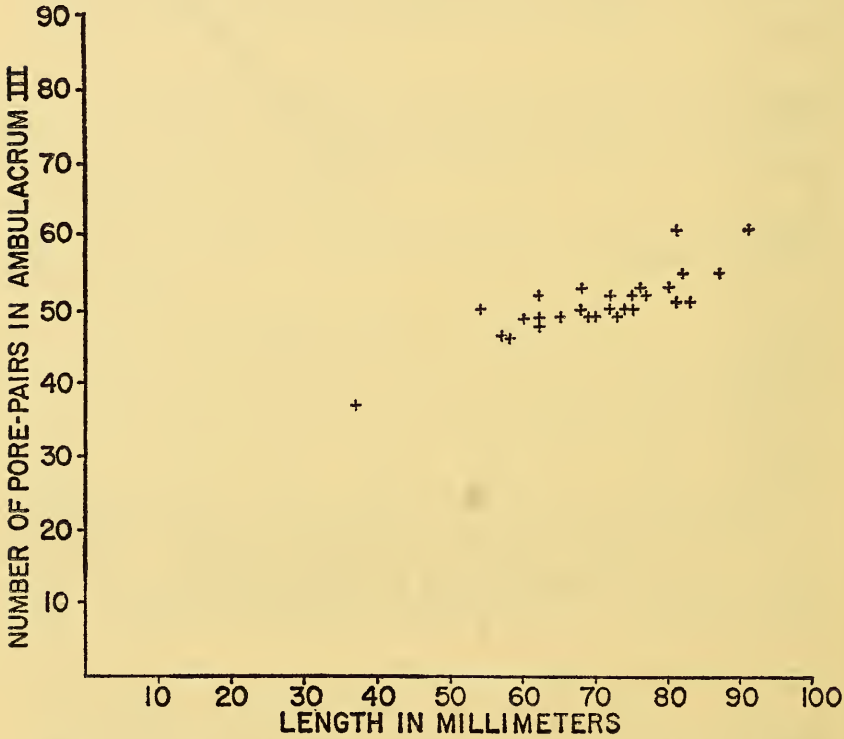
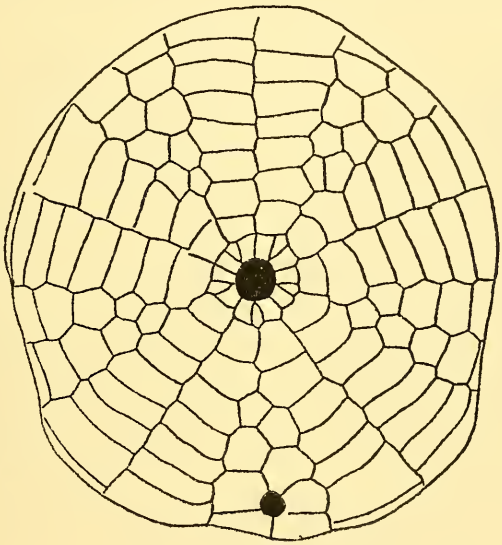


FIG. 14.—*Clypeaster prostratus* (Ravenel). Number of pore-pairs in ambulacrum III relative to length of test.

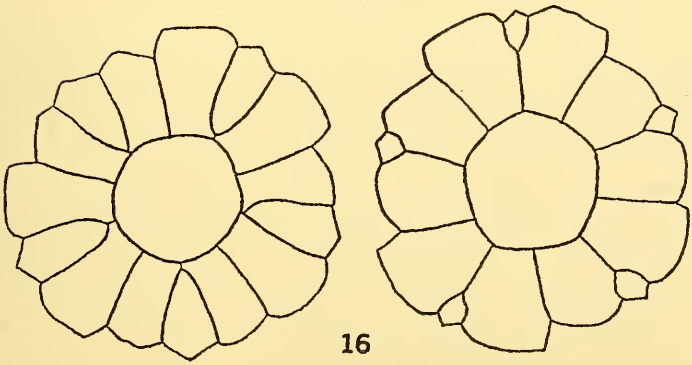
Adoral plate arrangement.—Primordial interambulacral plates much smaller than ambulacral plates, difficult to see because of extension of ambulacral plates over suture, on inside of test (text fig. 16) interambulacral plates only visible near outer edge of basicoronal plates, on outside of test (text fig. 16) plates more exposed, extending almost to peristome; basicoronal interambulacral plates separated from postbasicoronal plates by two pairs of ambulacral plates (text fig. 15); 6 to 7 ambulacral, 4 or 5 interambulacral postbasicoronal plates in each series on adoral surface.

Color.—Yellow-brown except for five brown specimens.

Comparison with other species.—This species is most similar to *Clypeaster subdepressus.* It differs in having a thicker margin, a less elongate and less inflated test, and a flatter area between the ends of the petals and the margin. Petal III in *C. prostratus* is more open and shorter relative to the other petals, and the paired petals are more constricted distally. The basicoronal interambulacral plates do not



15



16

FIGS. 15, 16.—*Clypeaster prostratus* (Ravenel): 15, Adoral view of U.S.N.M. 648176, from the Recent, Gulf of Mexico, lat. 29° 10′ N., long. 85° 31′ W., *Albatross* station 2375, × 1; 16, exterior and interior views of basicoronal plates of U.S.N.M. 648173 from same locality as above, × 3.

extend to the peristome in *C. prostratus*. Apparently this species is smaller than *C. subdepressus*, although it is possible that no fully grown adults have been collected. *C. prostratus* resembles in its marginal outline and thick margin *Clypeaster ravenelii* (A. Agassiz). However, in *C. ravenelii* the petals are widely open.

Aberrant specimen.—One specimen is a perfect hexamerous variant belonging to Jackson's (1929, p. 541) group 18. There are six genital pores, six petals (pl. 6, fig. 1), six ambulacral grooves (pl.

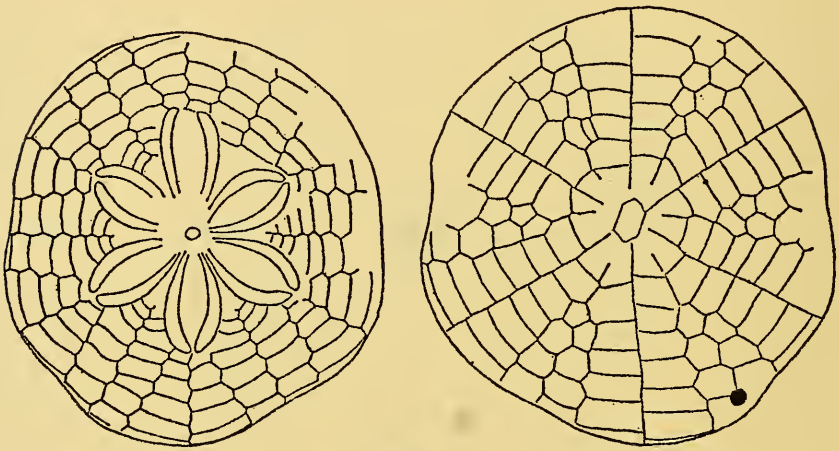


FIG. 17.—*Clypeaster prostratus* (Ravenel): Adapical and adoral views of hexamerous variant, U.S.N.M. 648174, from the Recent, Gulf of Mexico, lat. 29° 10′N., long. 35° 31′ W., *Albatross* station 2375, × 1.

6, fig. 2), and six pyramids and teeth (pl. 5, fig. 3). The plate arrangement is completely normal (text fig. 17) except that there are two extra ambulacral and two extra interambulacral series. The shape of the test is not regular and the test is not bilaterally or radially symmetrical. The anterior petal (III) can be identified because it is more open than the others. Because of the location of the periproct the petals between it and petal III on the left side of the test are normal. The extra petal is one of those lying between petals V and III on the right side of the test (as viewed adapically). There seems to have been no disruption in the production of plates, for the petals have the same number of pore pairs found in a normal specimen of this size. This aberrant form was evidently not produced by any pathological accident since all the test is hexamerous. It is probably the result of a mutation.

Occurrence.—Living off South Carolina and Georgia and in the Gulf of Mexico with a bathymetrical distribution of 25-55 meters.

Types.—Figured specimens, U.S.N.M. 648173-5.

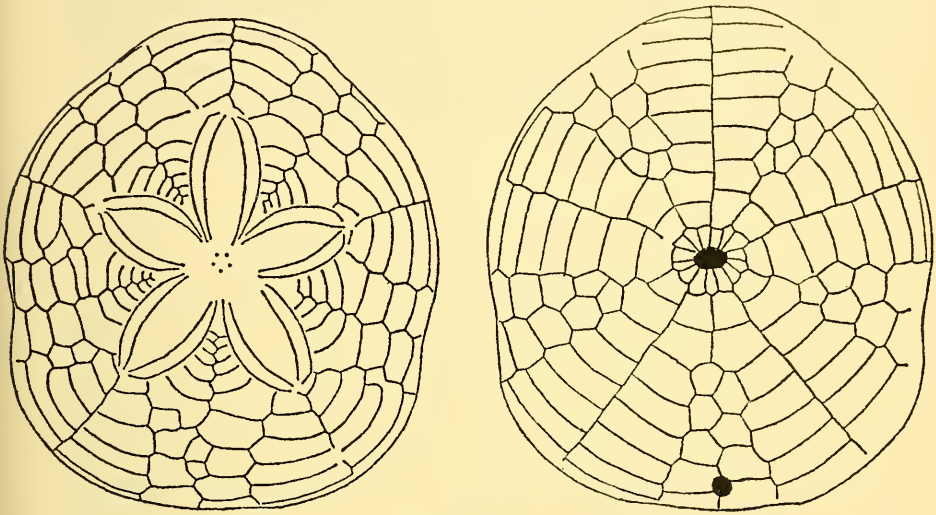


FIG. 18.—*Clypeaster subdepressus* (Gray): Adapical and adoral views of U.S.N.M. 648177, from the Recent, Gulf of Mexico, off Galveston, Tex., × ½.

CLYPEASTER SUBDEPRESSUS (Gray)

Plates 8, 9; text figure 18

Echinanthus subdepressa Gray, 1825, Ann. Philos., ser. 2, vol. 26, p. 427.

Clypeaster (*Stolonoclypus*) *subdepressus* (Gray). Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 112, pl. 23, figs. 1-3; pl. 24, fig. 3; pl. 25, fig. 6; pl. 26, figs. 1-6, pl. 27, fig. 4; pl. 45, figs. 4, 11, 14, 15. (See this reference for the pre-1948 citations of this species.)

Clypeaster subdepressus (Gray). Sanchez Roig, 1949, Paleont. Cubana, vol. 1, p. 82.

Stolonoclypus subdepressus (Gray). Sanchez Roig, 1952, Revision de los Clypeasteridos Cubanos, p. 17.

Clypeaster subdepressus (Gray). Breder, 1955, Bull. Amer. Mus. Nat. Hist., vol. 106, no. 3, pl. 1, fig. 3.

Clypeaster subdepressus loculatus Bernasconi, 1956, Neotropica, vol. 2, p. 35, fig.

Clypeaster (*Stolonclypus*) *subdepressus* (Gray). Krau, 1956, Mem. Inst. Oswaldo Cruz, vol. 54, p. 415-416, figs. 5-10, 13, 15, 17, 19.

Clypeaster (*Stolonclypus*) *subdepressus* (Gray). Tommasi, 1957, Pap. Dept. Zool. Sec. Agr. São Paulo, vol. 13, p. 30-31, figs. 22-24, pl. 2, figs. 3, 4.

Clypeaster subdepressus lobulatus Bernasconi, 1958, Bol. Inst. Oceanogr. São Paulo, vol. 7, p. 122, pl. 1, figs. 4a-c.

Clypeaster subdepressus (Gray). Cooke, 1959, U.S. Geol. Surv. Prof. Paper 321, p. 36, pl. 11, figs. 2-4.

Material.—Seven specimens.

Remarks.—There is little doubt that these specimens belong to this living species. They are identical in all characters. The species is known all over the West Indies from Florida to Brazil. Sanchez Roig (1949, p. 82) reported it as fossil from the Pleistocene of Cuba. The specimens which Cooke (1959, p. 36) referred to this species are herein referred to *Clypeaster crassus* Kier, new species.

Fossil occurrence.—Caloosahatchee formation, loc. 3, 4, 6.

Types.—Figured specimen, U.S.N.M. 648162 (fossil), loc. 3; U.S.N.M. 648177 (Recent).

CLYPEASTER ROSACEUS (Linnaeus)

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

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. (See this work for a list of the pre-1948 references to this species.)

Clypeaster rosaceus (Linnaeus). Sanchez Roig, 1949, Paleont. Cubana, vol. 1, p. 78.

Clypeaster rosaceus (Linnaeus). Sanchez Roig, 1952, Revisión de los Clypeasteridos Cubanos, p. 9.

Clypeaster rosaceus (Linnaeus). Durham, 1955, Univ. California Publ. Geol. Sci., vol. 31, no. 4, text figs. 15a, 25a.

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

Clypeaster rosaceus (Linnaeus). Cooke, 1961, Smithsonian Misc. Coll., vol. 142, No. 4, p. 16, pl. 5, fig. 3.

CLYPEASTER ROSACEUS ROSACEUS (Linnaeus)

This subspecies has been recorded as fossil from the Miocene of Venezuela (Cooke, 1961, p. 16) and the Pleistocene of Cuba (Sanchez Roig, 1949, p. 78). It was not found in the Tamiami or Caloosahatchee formations.

Ecology.—I have observed this species off Key Biscayne, Fla., in 3 feet of water living on top of the sand sea floor. They had covered the top of their tests with sea shells and portions of the dead tests of other echinoids.

CLYPEASTER ROSACEUS DALLI (Twitchell)

Plate 10; text figures 19-23

Diplothecanthus rosaceus (Lamarck). Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 219, pl. 102, figs. 1a, b; pl. 103, figs. 1a, b.

Diplothecanthus dalli Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 218, pl. 99, figs. 2a, b; pl. 100, figs. 1a, b.

Clypeaster dalli (Twitchell). Jackson, 1922, Carnegie Inst. Washington Publ.. 306, p. 37, pl. 4, fig. 1.

Clypeaster rosaceus (Linnaeus). Cooke (part), 1942, Journ. Paleont., vol. 16, p. 11.

Clypeaster rosaceus (Linnaeus). DuBar, 1958, Florida Geol. Surv. Bull. 40, p. 209, pl. 12, fig. 17.

Clypeaster rosaceus (Linnaeus). Cooke (part), 1959, U.S. Geol. Surv. Prof. Paper 321, p. 34.

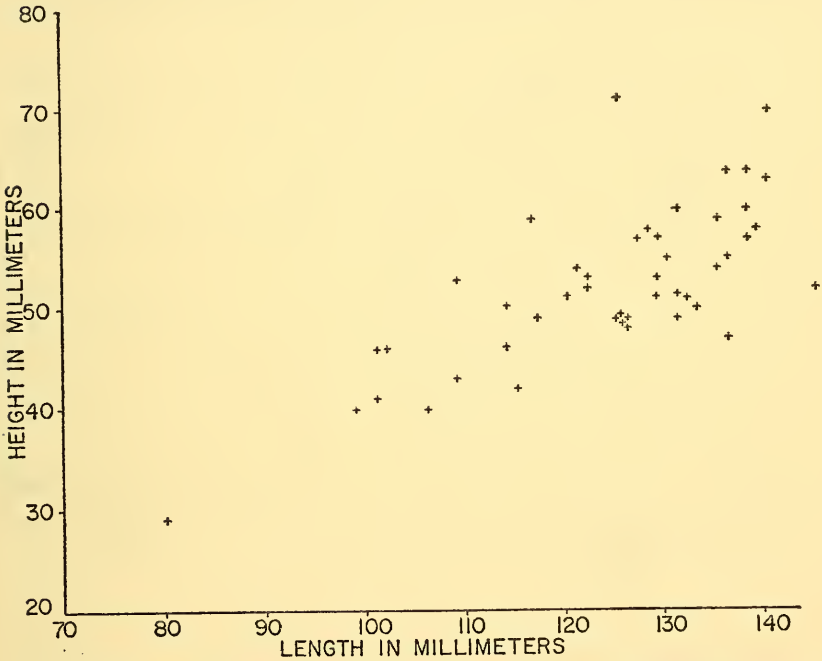


FIG. 19.—*Clypeaster rosaceus dalli* (Twitchell). Height relative to length of test.

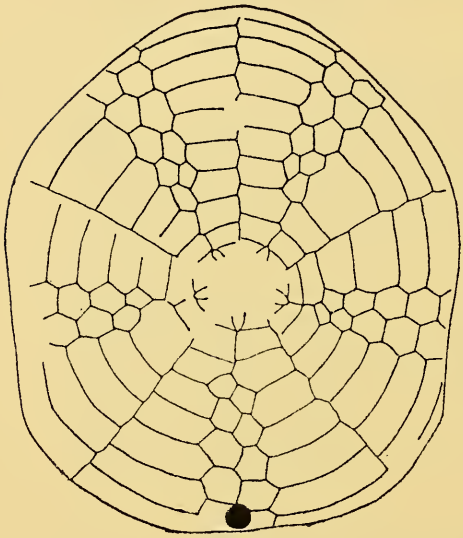
Diagnosis.—Subspecies characterized by broad test.

Material.—Sixty-nine specimens.

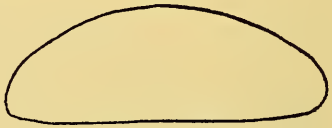
Shape.—Large, largest specimen 145 mm long, smallest 70 mm; elongate with width varying from 79 to 90 percent of the length; height very variable (text figs. 19, 21, 22), varying from 36 to 57 percent of the length; marginal outline variable, angularly pentagonal in some specimens, smoothly pentagonal in others; anterior margin pointed, posterior truncated, sides indented slightly in all but three specimens; petals strongly inflated in some specimens, slightly inflated in other, adorally test greatly depressed in area immediately around peristome.

Apical system.—Central, monobasal, madreporite pentagonal, genital pores small, five, varying in position from adjacent to madreporite, or far distant, occurring in interambulacra.

Ambulacra.—Petals all similar, broad, closed, long petals II, III, IV extending almost to margin, petals V, I over two-thirds distance to margin; number of pore-pairs in each poriferous zone variable; pore-pairs near apical system extremely small, difficult to see; poriferous zones only slightly depressed relative to interambulacra.



20



21

22

FIGS. 20-22.—*Clypeaster rosaceus dalli* (Twitchell): 20, Adoral view of U.S.N.M. 648164; 21, right side of U.S.N.M. 648165; 22, right side of U.S.N.M. 648166. All from the Caloosahatchee formation, loc. 6. All × ½.

Periproct.—Small, inframarginal, situated within 1 or 2 mm of posterior margin, at junction between fourth and fifth postbasicoronal interambulacral plates.

Adoral interambulacra.—Primiordinal interambulacral plates much smaller than ambulacral plates (text fig. 20), separated from postbasicoronal plates by two pairs of ambulacral plates; 9 or 10 postbasicornal plates in each interambulacrum adorally; 16-20 plates in each ambulacrum.

Peristome.—Central to slightly posterior, deeply depressed, circular to slightly pentagonal, opening 10 mm wide on specimen 100 mm long.

Variation.—This subspecies, as is also true of the nominate subspecies, is very variable in many of its features. The test varies in shape, from low to highly inflated, with angular to rounded marginal outline. The petals may be highly inflated or only slightly inflated. In the apical system, all the genital pores may be widely separated from the madreporite, or any number of them may be in contact with the madreporite. The characters which do not vary are the outline of the petals, the position and size of the periproct, and the extent of the depressed area around the peristome.

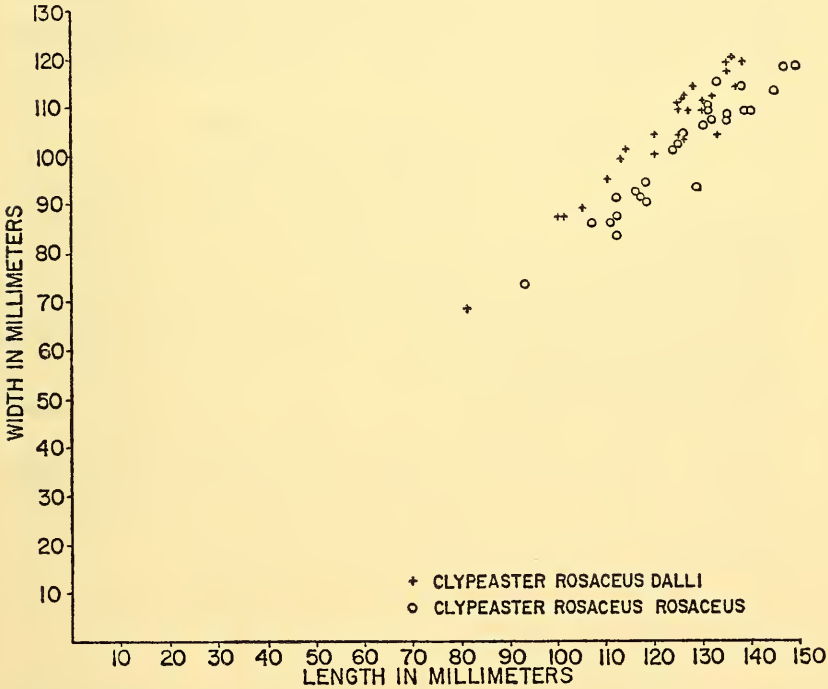


FIG. 23.—*Clypeaster rosaceus* (Linnaeus). Width of the test relative to length.

Comparison with other species.—This subspecies is distinguished from the nominate subspecies by its wider test. In all other features these specimens are indistinguishable from the nominate subspecies. Although there are some specimens of *C. rosaceus rosaceus* that are as wide as specimens of *C. rosaceus dalli,* most of them are narrower (see graph in text fig. 23). I have examined the specimen that Jackson referred to *Clypeaster dalli* and it can not be distinguished from the Caloosahatchee specimens. Jackson states that his specimen came

from the Miocene or Pliocene of the Dominican Republic, but evidently this age determination is based only on the fact that the same species occurs in the Caloosahatchee.

Occurrence.—Post-Caloosahatchee, pre-Fort Thompson loc. 1. Caloosahatchee formation loc. 2, 3, 6.

Cooke (1959, p. 34) suggested that all the Florida specimens of this species came from the Pleistocene Fort Thompson formation. However, neither DuBar nor Wilson and I have ever collected any specimens of *C. rosaceus dalli* from the Fort Thompson. Wilson and I have collected several specimens of this subspecies in place in the Caloosahatchee formation (DuBar's Bee Branch member).

Types.—Holotype, U.S.N.M. 164670; figured specimens, U.S.N.M. 648163-6.

CLYPEASTER CRASSUS Kier, new species

Plate 11, figs. 1-3; text figure 24; table 1

Clypeaster subdepressus Cooke, 1942 (not Gray), Journ. Paleont., vol. 16, p. 11; pl. 4, fig. 5.

Clypeaster subdepressus Cooke (not Gray), 1959, U.S. Geol. Surv. Prof. Paper 321, p. 36, pl. 11, figs. 2-4.

Diagnosis.—Species characterized by thick margin and marginally indented interambulacra.

Material.—Three specimens from Florida; 10 from South Carolina, three well preserved.

Shape.—Smallest specimen 91 mm long, largest 126; average width 90 percent of length, average height 19 percent; test pentagonal with truncated posterior margin, pointed anterior with greatest width anterior to center; strong indentations in interambulacra 4, 5, 1; margin thick, 10 percent of length, area between margin and ends of petals flat or slightly depressed; petaloid area inflated; adoral surface flat.

Apical system.—Slightly posterior to center, five genital pores, small ocular plates, madreporite star-shaped.

Ambulacra.—Petals broad, short, extending three-fifths distance from apical system to margin; anterior petal (III) slightly longer than others (see table 1), anterior paired petals (II, IV) shortest, posterior paired petals (V, I) intermediate; interporiferous zone approximately twice width poriferous zone; approximately 60 pore-pairs in each poriferous zone (see table 1).

Periproct.—Inframarginal, located near posterior margin; on holotype (91 mm long) opening 5.5 mm from margin, opening irregular in outline, elongated transversely.

TABLE 1.—*Dimensions of 6 specimens of* Clypeaster crassus *Kier, new species*

	Length	Width	Height	Thickness of margin	Number of pore-pairs Petal III	II	I	Length of petal III	II	I
Florida	91	85	15	8.3	60	58	55	26.3	24.9	24.8
	121	108	20	9.8	..	..	..	38.5	32.5	33.3
	141	121	..	12.0	71	64	69	45.0	35.7	38.5
South Carolina	101	89	18	8.2	67	63	62	32.5	29.0	29.0
	110	101	21	10.1	67	57	60	34.5	29.6	30.3
	126	115	27	11.5	64	61	65	41.0	37.7	39.0

Peristome.—Central to slightly posterior, pentagonal, pointed anteriorly, truncated posteriorly.

Adoral plate arrangement.—Plate sutures of basicoronal plates not visible on all plates; basicoronal interambulacral plates separated from postbasicoronal plates by two pairs of ambulacral plates (text fig. 24); 7 to 8 ambulacral, 3 to 5 interambulacral postbasicoronal plates in each series on adoral surface.

Comparison with other species.—*C. crassus* is very similar to the living species *Clypeaster prostratus* and is probably an ancestor of it. It is similar in shape, size, petal arrangement, plate arrangement, and position of apical system, periproct, and peristome. It differs mainly in having a thicker margin. In *C. crassus* the margin is 10 percent of the length, whereas in the average specimen of *C. prostratus* it is 7.2 percent of the length. In *C. crassus* the interambulacra are much more strongly indented at the margin in areas 4, 5, 1, and the poriferous zones are slightly wider.

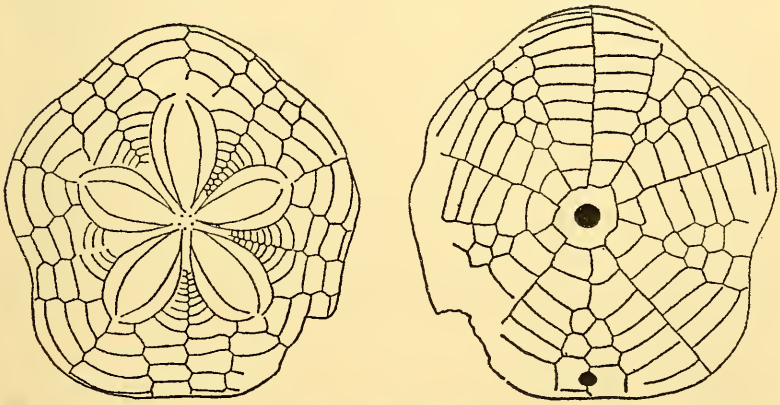


FIG. 24.—*Clypeaster crassus* Kier, new species: Adapical and adoral views of U.S.N.M. 648176, from Intracoastal Waterway Canal about 5 miles southwest of Little River, Horry County, S. C., × ½. Basicoronal plate sutures not visible.

Cooke (1959, p. 36) referred his specimens of this species from South Carolina to *Clypeaster subdepressus* Gray. However, *C. crassus* has a much thicker margin and the area between its margin and the ends of its petals is flat or depressed whereas it slopes marginally in *C. subdepressus*. In *C. crassus* petal III is more widely open and not as long relative to the other petals, and the test is less elongate and smaller.

Occurrence.—Florida, Tamiami formation, loc. 9, 10. South Carolina, U.S.G.S. 18759, Intracoastal Waterway canal 1.5 miles southwest of highway bridge near Nixons Crossroads, about 15 miles northeast of Myrtle Beach.

Types.—Holotype U.S.N.M. 648142, loc. 9; figured specimens, U.S.N.M. 648143, loc. 9, 648176, U.S.G.S. 18759.

CLYPEASTER SUNNILANDENSIS Kier, new species

Plate 3, figure 3; plates 12, 13

Diagnosis.—Species characterized by large, low, elongate test with petal III open distally.

Material.—Fourteen specimens.

Shape.—Large, largest specimen 157 mm long, smallest 119 mm, average 140 mm; test elongate, average width 85 percent of length; marginal outline pentagonal, anterior pointed, posterior truncated, interambulacra 4, 1 slightly indented at margin; area between margin and ends of petals sloping marginally; test low, average height 20 percent of length; margin thin, thickness approximately 7 percent of length; petaloid area inflated, adoral surface slightly depressed.

Apical system.—Central to slightly anterior, five genital pores, small ocular plates, madreporite star-shaped.

Ambulacra.—Petals broad, of unequal length, anterior petal (III) longest, 20 percent longer than anterior paired petals (II, IV); posterior paired petals intermediate in length; anterior petal open, gap at distal end of petal averaging 6.2 mm in width or 4.4 percent of length, posterior petals open in some specimens; interporiferous zone approximately twice width of poriferous zone; in specimen 139 mm long 75 pore-pairs in poriferous zone of petal III, 64 in petal II, 69 in petal I, in specimen 119 mm long, 68 pore-pairs in zone of petal II, 57 in petal IV.

Periproct.—Inframarginal, located near posterior margin, on specimen 130 mm long, 4.1 mm from posterior margin, opening irregular in outline, elongated transversely.

Peristome.—Central, shape not preserved on any specimen.

Adoral plate arrangement.—Plate sutures not visible on any specimen.

Comparison with other species.—*C. sunnilandensis* is identical in all characters to *C. subdepressus* except that its anterior petal (III) is open whereas in *C. subdepressus* it is closed. I examined 35 specimens of *C. subdepressus,* and in all these specimens the anterior petal was closed, whereas in all the 12 specimens of *C. sunnilandensis* in which this area was exposed the petal was open.

Occurrence.—Tamiami limestone, loc. 9, 10.

Types.—Holotype, U.S.N.M. 648135, loc. 9; figured specimen, U.S.N.M. 648134, loc. 9.

ENCOPE MICHELINI L. Agassiz

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

Encope michelini L. Agassiz. Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 441, pl. 70, fig. 23. (See this reference for the pre-1948 references to this species.)

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

Encope michelini L. Agassiz. Cooke, 1961, Smithsonian Misc. Coll., vol. 142, No. 4, p. 17, pl. 6, figs. 5-6; pl. 7, fig. 5.

ENCOPE MICHELINI IMPERFORATA Kier, new subspecies

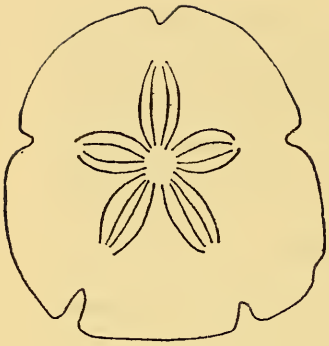
Plate 5, figure 1; Plate 6, figures 3, 4; text figures 25-30; table 2

Diagnosis.—Subspecies distinguished from nominate subspecies by absence of posterior interambulacral lunule in many specimens.

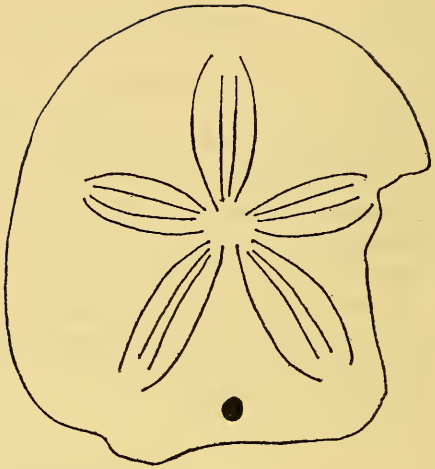
Material.—Sixteen specimens.

Shape.—From 82 to 140 mm long. Broad with width varying from 94 to 101 percent (average 96) of length; test very low varying from 7 to 12 percent (average 9) of length; greatest width posterior to center, anterior margin rounded, posterior sharply truncated; greatest height posterior to center; ambulacral notches well developed on some specimens (text figs. 25, 30), absent on others; posterior closed interambulacral lunule present in six of twelve specimens preserving area where it would occur, irregularly developed, in some specimens opening very small (text fig. 26), in others quite large (text fig. 28), usually irregular in shape, unsymmetrical; in one specimen opening in adapical surface but none in adoral; in six specimens no lunule (text figs. 25, 29, 30); adoral surface flat to slightly depressed except for slight elevation between peristome and periproct; margin sharp.

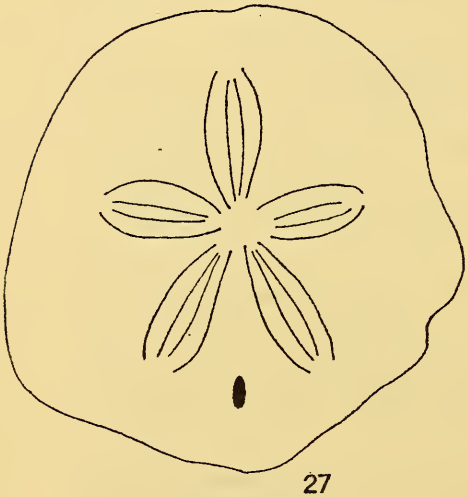
Apical system.—Slightly anterior, madreporite large, star shaped,



25



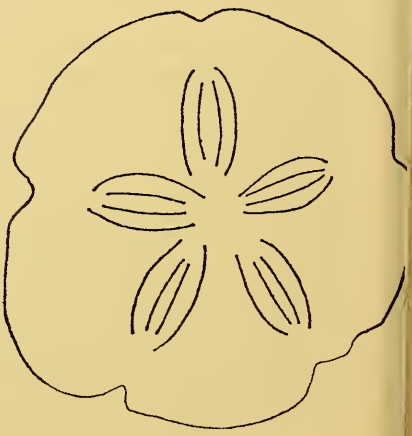
26



27

28

29



30

FIGS. 25-30.—(See opposite page for legend.)

five genital pores, genital pore 5 eccentric to right on most specimens.

Ambulacra.—Petals broad, closing distally, interporiferous zone wider in petal III than in other petals; anterior petal III, posterior paired petals (V and I) of approximately same length (see table 2); anterior paired petals shorter than others, in most specimens petal II shorter than petal IV; in smallest specimen 76 pore pairs in petal III, 59 in II, 61 in IV, 82 in V or I; in larger specimen 100 mm long 92 pore pairs in petal III, 70 in II, 81 in IV, 118 in V or I.

TABLE 2.—*Encope michelini imperforata* Kier, new subspecies

	Length of petal				
Length of test	III	II	IV	V	I
109	39	..	31	41	41
100	32.5	27.3	29.2	36	..
106	33	25.1	25.1	..	..
115	36	27.2	29.4	36	36.5
122	38	32.3	32.5	39.5	39
82	23	17.1	18.4	22.3	22.4
90	32.5	16.8	17.8	22.8	..

Adoral plate arrangement.—Sutures not visible on specimens.

Periproct.—Opening longitudinal, located one-third distance from peristome to posterior margin.

Peristome.—Central, circular.

Comparison with nominate subspecies.—This subspecies is similar in all respects to the nominate subspecies except that its posterior closed lunule is quite small or entirely absent. In one-half of the specimens of *Encope michelini imperforata* the lunule is absent whereas in the nominate subspecies it is apparently always present. I examined 186 specimens of the nominate subspecies, and in all of them this lunule was present.

Remarks.—This subspecies, as with the nominate subspecies, is very variable in the shape of the test. The ambulacral notches are very well developed in many of the specimens but completely absent in others.

Occurrence.—Post-Caloosahatchee, pre-Fort Thompson, loc. 1. Caloosahatchee formation, loc. 4, 6, 7. Tamiami ("Buckingham" facies) formation, loc. 23.

Types—Holotype, U.S.N.M. 648167, loc. 2; figured specimens,

FIGS. 25-30.—*Encope michelini imperforata* Kier, new species: 25, U.S.N.M. 648169, loc. 7; 26, U.S.N.M. 648167, loc. 2; 27, U.S.N.M. 648170, loc. 4; 28, U.S.N.M. 648168, loc. 6; 29, U.S.N.M. 648171, loc. 4; 30, U.S.N.M. 648172, loc. 4. All approximately × ½.

U.S.N.M. 648169, loc. 7; U.S.N.M. 648170, 648171, 648172, loc. 4; U.S.N.M. 648168, loc. 6.

ENCOPE TAMIAMIENSIS Mansfield

Plate 14, figures 1-6; text figures 31-35

Encope macrophora (Ravenel) (part), Clark and Twitchell, 1915, U. S. Geol. Surv. Mon. 54, p. 206, pl. 94, figs. 1a-f.

Encope macrophora tamiamiensis Mansfield, 1932, U. S. Geol. Surv. Prof. Paper 170-D, p. 48, pl. 17, fig. 8.

Encope michelini Agassiz. Barry, 1941, Proc. U.S. Nat. Mus., vol. 90, pl. 65, fig. 4.

Encope tamiamiensis Mansfield. Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 20

Encope tamiamiensis Mansfield. Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, p. 48, pl. 17, figs. 3, 4.

Diagnosis.—Species characterized by thin margin, smaller lunule, and more posterior apical system.

Material.—More than 1,000 specimens.

Shape.—Length varying from 7.6 to 122 mm; width varying from slightly wider than high to 80 percent of length, with average specimen slightly narrower than long (text fig. 31); marginal outline subcircular, truncated posteriorly; five ambulacral notches; anterior notch slight, posterior notches deep; on smallest specimens no notches; posterior notch well developed, present on all specimens, elongate, irregular in shape and size; test low, height varying from 10 to 20 percent with an average of 14 percent of the length (text fig. 32), greatest height posterior of center at anterior edge of lunule; margin very sharp with test thin at margin; adoral surface evenly concave.

Apical system.—Anterior (text fig. 33) distance from anterior margin to apical system approximately 40 percent of length of test; large central star-shaped madreporite with five genital pores, genital pore 5 usually eccentric to right (pl. 14, fig. 5).

Ambulacra.—Anterior petals II, III, IV lanceolate, straight, of approximately equal length, with interporiferous zones wider, equal to or narrower than poriferous zones; posterior petals V and I longer, curving posteriorly, interporiferous zones narower than poriferous. In specimen 75 mm long 70 pore-pairs in each poriferous zone in petal III; 62 in petals II or IV; 80 in petals V or I; rate of introduction of new pore-pairs decreases with growth (text fig. 34.).

Periproct.—Opening small, elongate, located at anterior edge of lunule at inner margin of first pair of postbasicoronal plates in most specimens, in several not in lunule but anterior to it.

Peristome.—Anterior, small opening, subcircular; food grooves bifurcating near peristome, one or two lateral branches to each groove.

Adoral plate arrangement.—Basicoronal plates small (text fig. 35), interambulacral plates larger than ambulacral, posterior interambulacral plate considerably larger than others; paired interambulacra

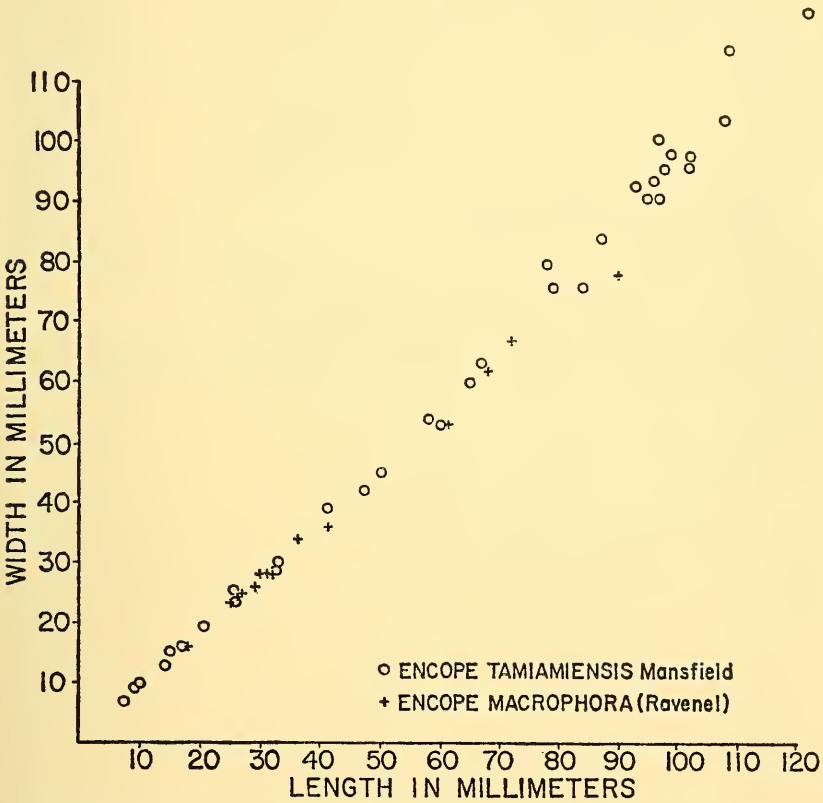


FIG. 31.—*Encope tamiamiensis* Mansfield, *Encope macrophora* (Ravenel). Width of test relative to length of test.

separated from basicoronal plates by first pair of postbasicoronal ambulacral plates; posterior interambulacrum in contact with basicoronal plate; interambulacra with 3 or 4 postbasicoronal plates in each column; ambulacra with 6 or 7 postbasicoronal plates to each column.

Growth.—On the smallest specimen, 7.6 mm long, the posterior notches are very slightly developed and there are no anterior notches. The posterior lunule is very small. The first anterior notches occur in a specimen 14.2 mm long, where they are only slightly developed.

The posterior petals are straight in all the smaller specimens (pl. 14, fig. 1), but curve posteriorly in all the specimens over 17 mm long. There are no genital pores in any of the specimens less than 20 mm long.

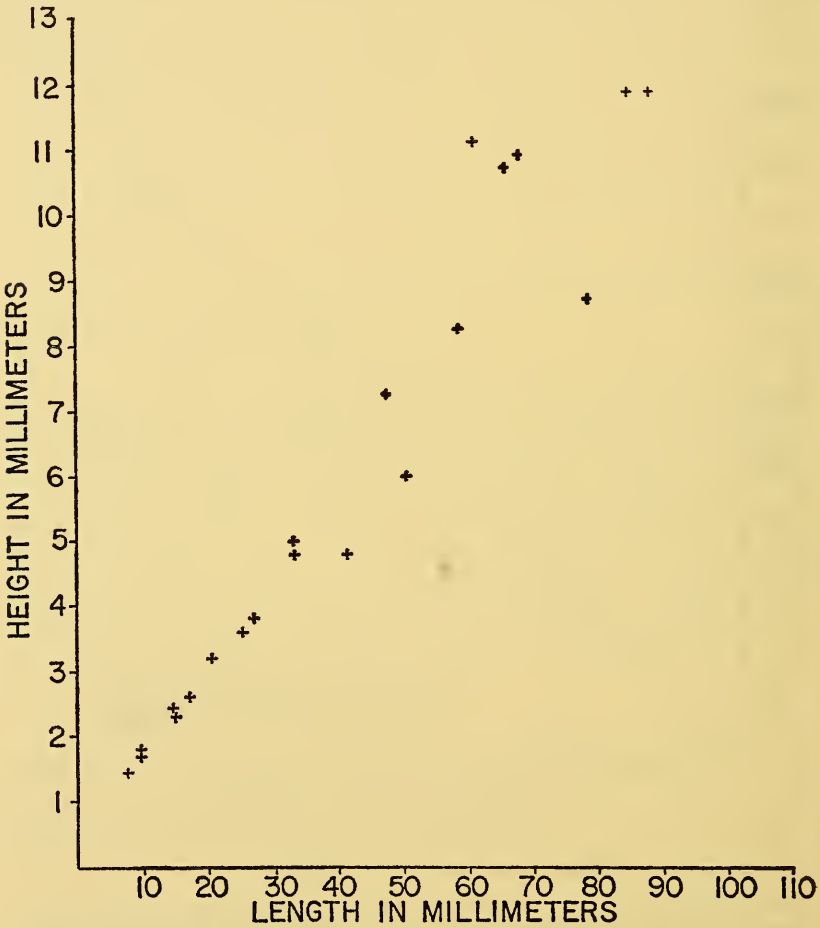


FIG. 32.—*Encope tamiamiensis* Mansfield. Height of test relative to length of test.

Variation.—The posterior lunule is very variable in its outline and size. In many of the specimens it is not symmetrical. Genital pore 5 is eccentric to the right in most of the specimens. In a population of 25, 23 of the specimens had an eccentric pore and in only two was the pore not eccentric.

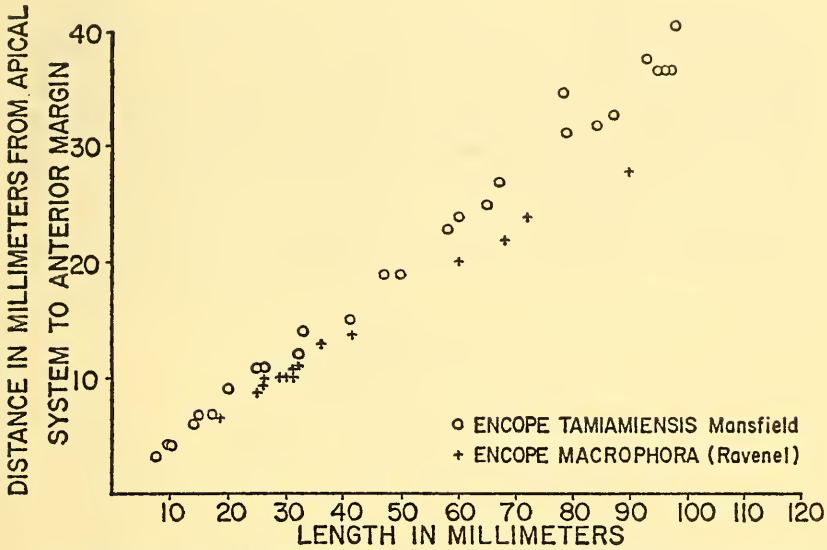


FIG. 33.—*Encope tamiamiensis* Mansfield, *Encope macrophora* (Ravenel). Distance of apical system from anterior margin relative to the length of the test.

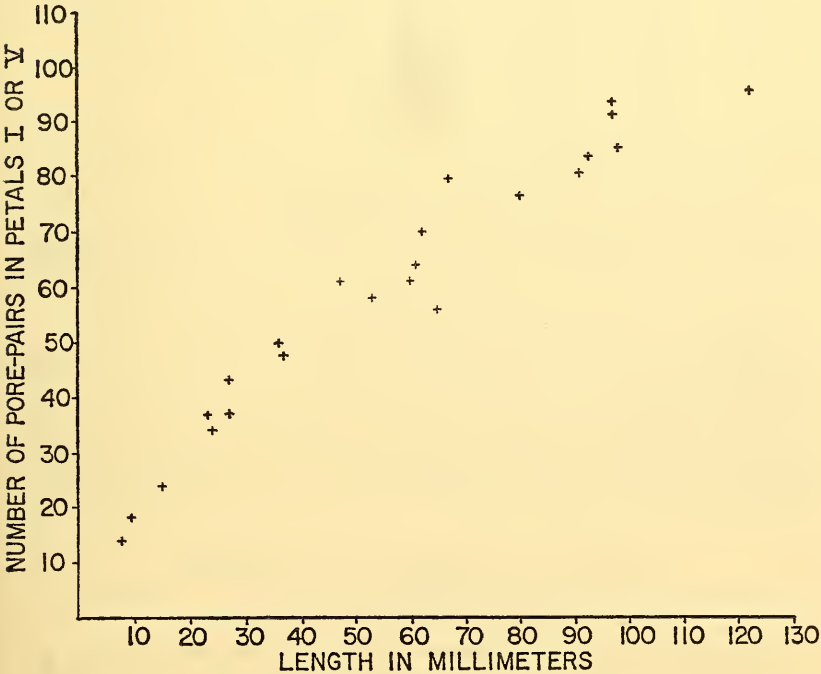


FIG. 34.—*Encope tamiamiensis* Mansfield. Number of pore-pairs in petals I or V relative to length of test.

Comparison with other species.—*E. tamiamiensis* is similar to *Encope macrophora* (Ravenel) from the Late Miocene of South Carolina. However, in *E. tamiamiensis* the margin is thinner, the lunule is smaller, and the apical system is less anterior (text fig. 33). Furthermore, in *E. tamiamiensis* the anterior paired petals (II and IV) are less curved posteriorly. Both species have the same length-width ratio (text fig. 31).

Occurrence.—Tamiami formation (typical), loc. 9, 10, 11, 14, 15, 17, 18, 19.

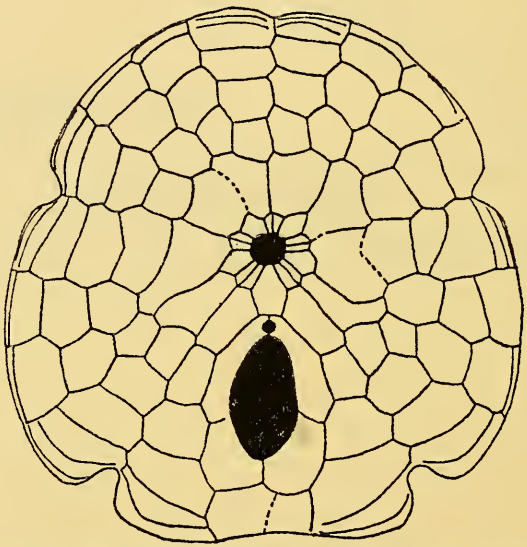


FIG. 35.—*Encope tamiamiensis* Mansfield: Adoral view of U.S.N.M. 648141, from the Tamiami formation, loc. 31, × 1.

Tamiami formation ("Buckingham" facies), loc. 20.

Tamiami formation (barnacle-echinoid-oyster facies), loc. 26, 27, 28, 29, 31, 32.

Types.—Figured specimens, U.S.N.M. 648137, loc. 27; U.S.N.M. 648138, loc. 26; U.S.N.M. 648139; loc. 11; U.S.N.M. 648140-1, loc. 31.

MELLITA ACLINENSIS Kier, new species

Plate 15, figures 1-3; text figures 36-41; tables 3, 4

Diagnosis.—Species characterized by five ambulacral lunules.

Material.—Eleven nearly complete specimens and many fragments.

Shape.—Smallest specimen 16.5 mm long, largest 73 mm (see table 3 for dimensions); margin subcircular except for truncated posterior margin on some specimens; width approximately equal to length; test very low with thin sharp margin; adoral surface flat to slightly concave; 5 elongate ambulacral lunules in large specimens, lunule in ambulacrum III smaller than others; lunule in posterior interambulacrum very elongate, extending far between petals.

Apical system.—Slightly anterior, distance from anterior margin to apical system approximately 45 percent of length of test; large madreporite; four genital pores.

TABLE 3.—*Dimensions of 11 specimens of* Mellita aclinensis *Kier, new species*

Length	Width	Height	Length of petal III	II	I
mm	mm	mm	mm	mm	mm
16.5	16.3	2.4	4.0	3.8	4.3
21.8	22.5	2.7	...	4.4	6.1
22.7	23.0	3.1	5.7	5.0	6.3
24.0	23.6	3.2	5.9	5.4	6.4
25.7	25.5	3.3	6.0	5.5	...
30.0	32.7	4.0	7.9	7.4	9.1
31.7	31.4	4.1	8.5	8.3	8.9
35.0	37.0	5.0	9.2	7.7	9.8
44.0	...	...	10.5	10.0	12.1
...	56.0	5.6	11.2	11.3	15.3
73.0	...	...	...	...	...

Ambulacra.—Anterior petals II, III, IV lanceolate, straight, petal III longer, extending almost two-thirds distance from apical system to anterior margin, petals II and IV only halfway to margin; posterior petals V and I longer than anterior petals, not straight but curving posteriorly; in all petals poriferous zone equal in width to interporiferous; petals almost closed; in specimen 35 mm long, 34 pore pairs in single poriferous zone of petals II, III, IV, 47 in petals V or I. Adorally, five pairs of food grooves extending from peristome to near margin (pl. 15, fig. 3); area circumscribed by pair of grooves expanding distally with greatest width near lunule, constricted distal to lunule; area broad between adjacent pairs of grooves. Secondary pores difficult to see in most specimens, apparently confined to area circumscribed by food grooves.

Periproct.—Opening small, elongate, located at anterior edge of lunule.

Peristome.—Anterior, small, subcircular to pentagonal, food grooves bifurcating near peristome.

Adoral plate arrangement.—Basicoronal plates small (text fig. 36); adoral-most plate of interambulacrum 5 considerably larger than other basicoronal plates; paired interambulacra separated from basicoronal plates by one pair of ambulacral plates, three postbasicoronal plates in each column on adoral surface; first pair of postbasicoronal interambulacral plates elongate; posterior interambulacrum in contact with basicoronal plates; half of periproct within basicoronal interambulacral plate; first postbasicoronal plate of posterior interambulacrum extending length of lunule.

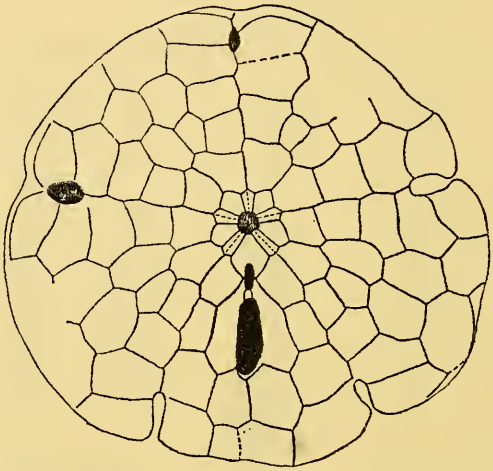


FIG. 36.—*Mellita aclinensis* Kier, new species: adoral view of U.S.N.M. 648192, from the Tamiami formation, loc. 27. × 2.

Aberrant specimen.—In one of the specimens the anterior ambulacrum (III) is not fully developed (text fig. 37). The plate arrangement is normal adoral to the tip of the petal, but there are no ambulacral plates between the apical system and the tip of this petal. Evidently production of ambulacral plates ceased after the first few petaloid plates had been formed and the resulting gap was filled by the prolongation of the interambulacral plates which would normally be adjacent to this ambulacrum.

Ontogeny.—The ambulacral lunules are not present in the smallest specimen, 16.5 mm long (text fig. 38), but there are slight marginal notches in ambulacra II and IV and more developed notches in V and I. In a specimen 21.8 mm. long (text fig. 39) there are deep notches in the paired ambulacra, with the notches in ambulacra II and IV almost closed, and in a specimen 24.0 mm long (text fig. 40)

there are lunules in all the paired ambulacra. A lunule in ambulacrum III is present in a specimen 35.0 mm long (text fig. 41).

Comparison with other species.—This species is distinguished from all the other species of the genus in having in adult specimens five instead of four ambulacral lunules.

Remarks.—Previously all species of the Mellitidae having four genital pores and five ambulacral lunules have been referred to *Leodia.* Although this species has five ambulacral lunules, it has all

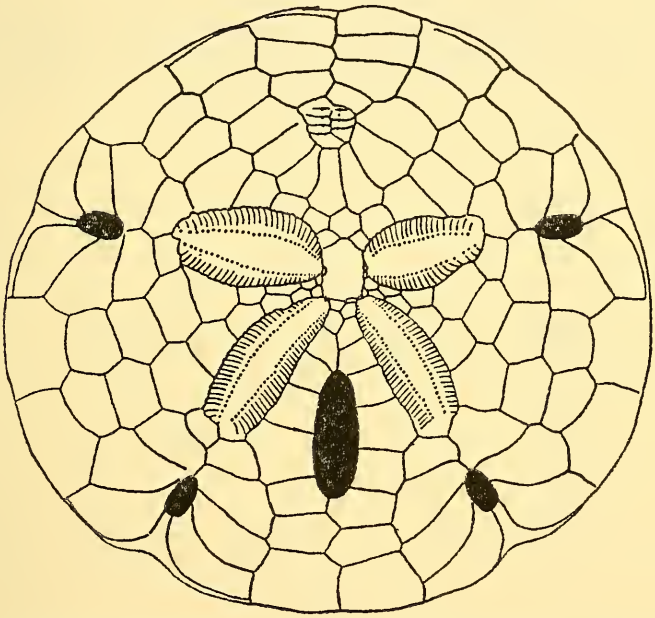


FIG. 37.—*Mellita aclinensis* Kier, new species: Adapical view of abnormal specimen U.S.N.M. 648193, from the Tamiami formation, loc. 27, × 3.

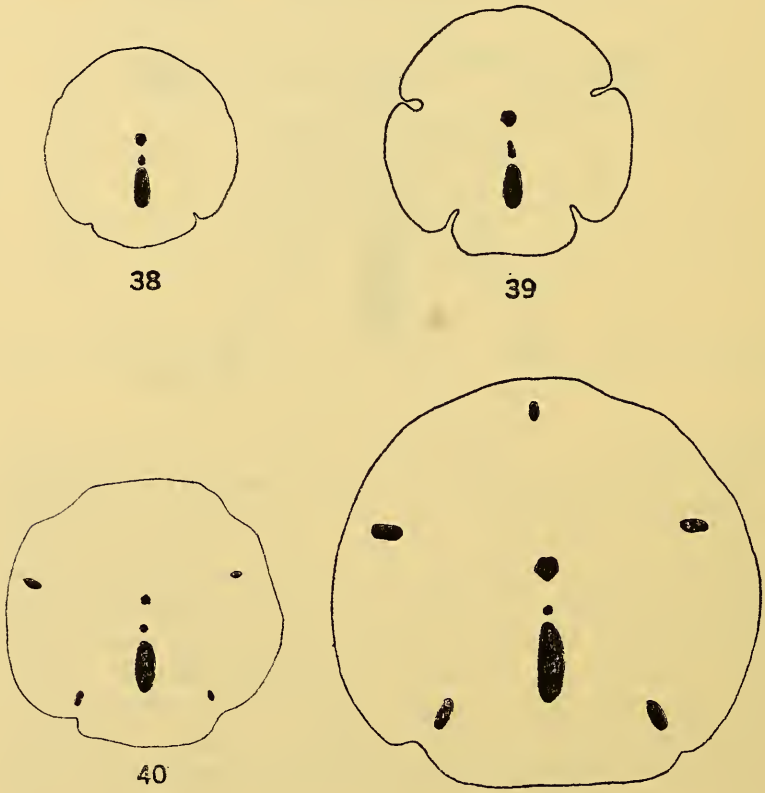
the other characters of *Mellita* that distinguish this genus from *Leodia* (see table 4). Therefore it seems reasonable to consider this a species of *Mellita,* and to broaden the generic concept of the genus to include species having five ambulacral lunules.

Durham (1961, p. 3) predicted that *Mellita* would be found in the Miocene and Pliocene of the Neotropical region: "In view of its occurrence only in the tropical and warm temperate areas of the western Atlantic and eastern Pacific, it is evident that *Mellita* must have a fossil record extending back to at least the upper Miocene when the Central American seaways were open (Durham and Alli-

TABLE 4.—*Characters distinguishing* Mellita *from* Leodia

Mellita	Leodia
Four ambulacral lunules	*Five ambulacral lunules
*Posterior lunule extending far anteriorly between posterior petals	Posterior lunule not extending far anteriorly between posterior petals
*Paired interambulacra separated from basicoronal row by one pair of ambulacral plates	Paired interambulacra separated from basicoronal row by two pairs of ambulacral plates
*Periproct partly within basicoronal interambulacral plate	Periproct outside basicoronal plate
*First pair of post-basicoronal plates in paired interambulacra elongate	First pair of postbasicoronal plates in paired interambulacra short
*Lunules formed by closing of marginal notches	Lunules formed by resorption of test

The characters marked with an asterisk occur in *Mellita aclinensis.*



FIGS. 38-41.—*Mellita aclinensis* Kier, new species: Growth series showing development of lunules: 38, U.S.N.M. 648189; 39, U.S.N.M. 648190; 40, U.S.N.M. 648191; 41, U.S.N.M. 648136. From the Tamiami formation, loc. 27, all × 1½.

son, 1960 pp. 66–67), permitting migration from the Panamic to the Caribbean area or vice versa."

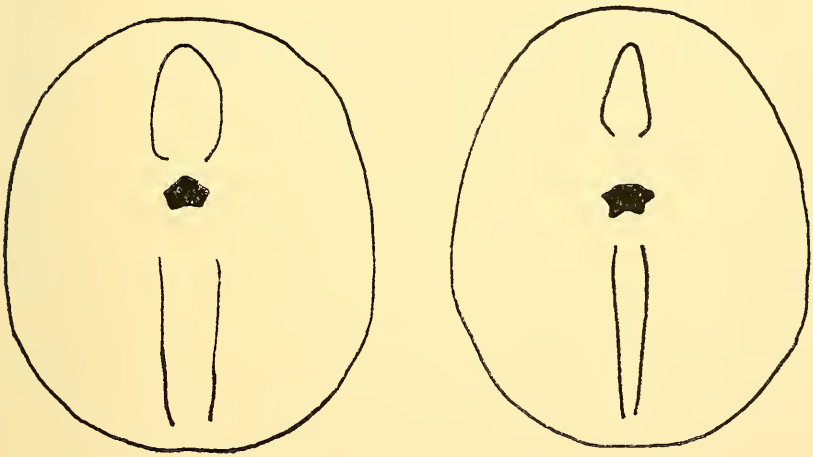
Occurrence.—Tamiami formation (barnacle-echinoid-oyster facies), loc. 27.

Types.—Holotype, U.S.N.M. 648136; figured specimens, U.S.N.M. 648189-648193.

RHYNCHOLAMPAS AYRESI Kier, new species

Plate 16, figures 3-6; text figures 43-46

Diagnosis.—Species characterized by highly inflated adapical surface, steep sides, smooth marginal outline, narrow naked zone in interambulacrum 5, narrow phyllode III.



42 43

FIGS. 42, 43.—*Rhyncholampas evergladensis* (Mansfield): 42, Adoral view of U.S.N.M. 648148, from the Tamiami formation, loc. 9; 43, *Rhyncholampas ayresi* Kier, new species: Adoral view of U.S.N.M. 648160, from the Caloosahatchee formation, loc. 6. These two drawings show the difference in the width of the naked zones in ambulacrum III and interambulacrum 5.

Material.—Twenty-seven specimens.

Shape.—Varying in length from 54 to 65 mm, average 63 mm, in smaller specimens width approximately 85 percent of length, in larger 90 percent of length (text fig. 44) with greatest width posterior to center (text fig. 43); adapical surface highly inflated with steeply sloping sides, height averaging 55 percent of length (text fig. 45); adoral surface flat or in few specimens slightly depressed around peristome.

Apical system.—Anterior, four genital pores, compact.

Ambulacra.—Petals well developed, broad, lanceolate, with greatest width one-third distance from apical system to end of petal, all petals of approximately equal length, petals II, IV wider than others, petal III narrower, 43 to 45 pore-pairs in posterior zones of petal II or IV in specimens 54 to 60 mm long; poriferous zones of unequal

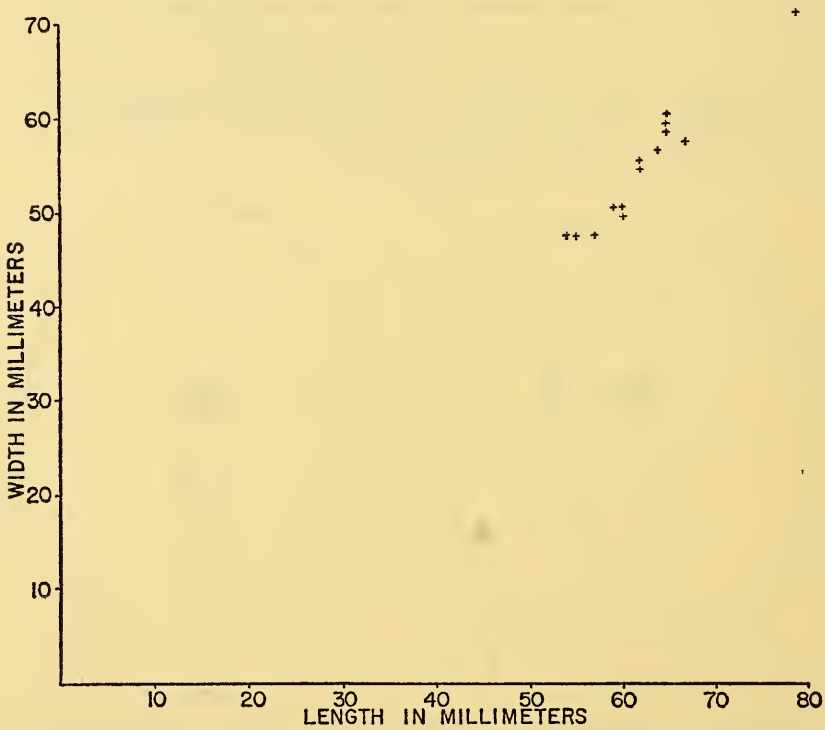


FIG. 44.—*Rhyncholampas ayresi* Kier, new species. Width relative to length of test.

length with one to three more pore-pairs in right poriferous zone of petal II, posterior zones of petals II, IV, and anterior poriferous zones of petals V, I; single pores in ambulacral plates beyond petals.

Periproct.—Supramarginal, wider than high, with slight groove extending from opening to posterior margin.

Peristome.—Anterior, pentagonal, depressed, wider than high.

Floscelle.—Phyllodes well developed, broad (text fig. 46), approximately 30 pores in each phyllode, with 10 in each outer series, 4-6

irregularly arranged in each inner. Buccal pores present. Bourrelets very prominent (pl. 16, fig. 6), pointed.

Tuberculation.—Tubercles adorally much larger than adapically, narrow naked granular zone (text fig. 43) in median area of interambulacrum 5 and ambulacrum III adorally.

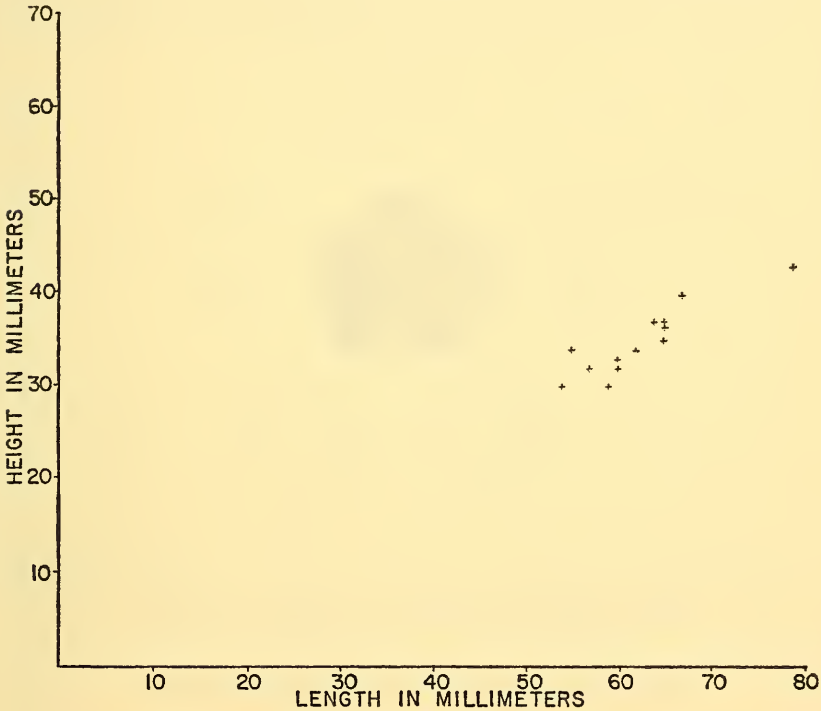


FIG. 45.—*Rhyncholampas ayresi* Kier, new species. Height relative to length of test.

Comparison.—This species is distinguished from *Rhyncholampas evergladensis* by having more of its adapical surface inflated, by its steeper sloping sides, less pointed adapical surface, and less angular marginal outline. The adoral surface in *R. ayresi* is less depressed, the naked zone in interambulacrum 5 is narrower (text fig. 43), and phyllode III is narrower.

Remarks.—The specimens from South Carolina that Cooke (1959, pl. 23, figs. 8-14) referred to *Cassidulus sabistonensis* Kellum seem to be intermediate between *R. ayresi* and *R. evergladensis.* Further study is necessary before these specimens can be definitely assigned.

Occurrence.—Caloosahatchee formation, loc. 2, 3, 4, 6.

Types.—Holotype, U.S.N.M. 648160, loc. 6; figured specimen, U.S.N.M. 648161, loc. 6.

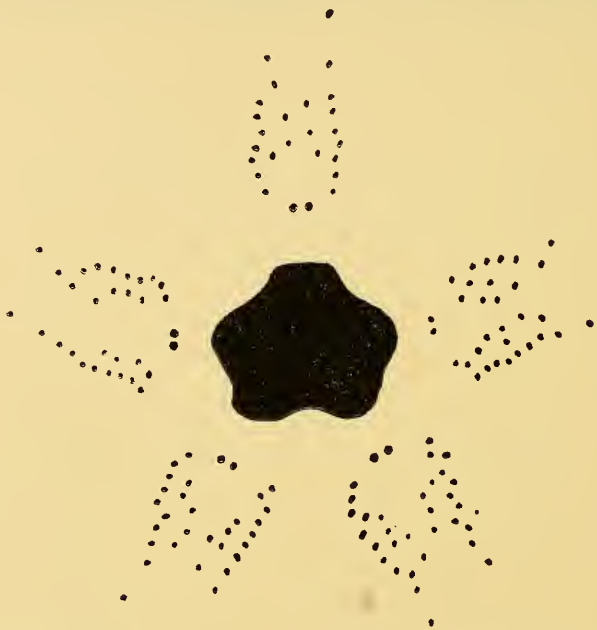


FIG. 46.—*Rhyncholampas ayresi* Kier, new species: Floscelle of U.S.N.M. 648161, from the Caloosahatchee formation, loc. 6, × 5.

RHYNCHOLAMPAS EVERGLADENSIS (Mansfield)

Plate 17, figures 1-5; text figures 42, 47-50

Cassidulus (*Rhynchopygus ?*) evergladensis Mansfield, 1932, U. S. Geol. Surv. Prof. Paper 170, p. 48, pl. 18, figs. 1-10.

Cassidulus (*Cassidulus*) *evergladensis* Mansfield. Cooke, 1942, Journ. Paleont. vol. 16, no. 1, p. 30, pl. 8, figs. 5, 6.

Cassidulus sabistonensis Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, p. 57 (in part); not *Cassidulus sabistonensis* Kellum.

Diagnosis.—Species characterized by angular marginal outline, gently sloping sides, depressed adoral surface, wide naked zone in interambulacrum 5, and wide phyllode III.

Material.—One hundred and one specimens.

Shape.—Large, varying from 35 to 97 mm in length; width fairly constant, usually approximately 83 per cent of length (text fig. 47);

greatest width at midlength or posterior to midlength; margin usually slightly angular but in some specimens smooth, anterior, posterior slightly truncated; heights variable, some specimens considerably higher than others with height varying from 44 to 58 percent of the height, larger specimens usually slightly lower than smaller (text fig. 48); greatest height central to slightly anterior, usually at apical system; sides gently curving, in some specimens curving sharply at margin; adoral surface concave.

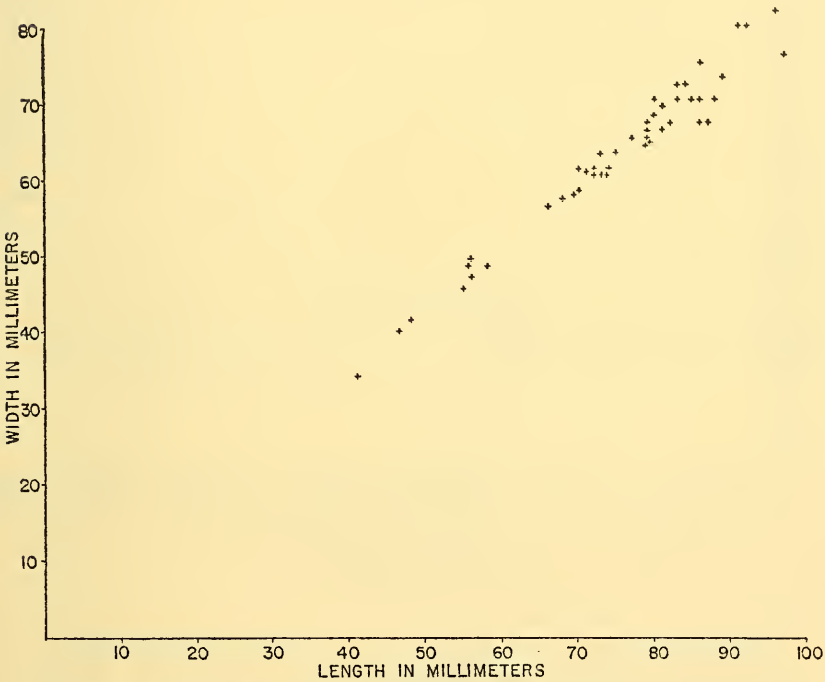


FIG. 47.—*Rhyncholampas evergladensis* (Mansfield). Width of the test relative to the length.

Apical system.—Anterior, four genital pores, compact (pl. 17, fig. 3).

Ambulacra.—Petals well developed, broad, with greatest width one-third distance from apical system to end of petal, petals of approximately equal length, petals II, IV wider than other petals, petal III narrower; poriferous zones of unequal length, one to three more pore-pairs in right poriferous zones of petal III, posterior poriferous zones of petals II, IV, anterior poriferous zones of petals V, I; num-

ber of pores variable, specimens 80 mm long having from 44 to 53 pore-pairs in posterior poriferous zone of petal II or IV; fewer pores in smaller specimens with 37 pore-pairs in posterior poriferous zone of petal II of specimen 35 mm long, very few pore-pairs added in specimens over 70 mm long (text fig. 49); single pores in ambulacral plates beyond petals.

Periproct.—Supermarginal, wider than high, shallow grove extending from opening to posterior margin.

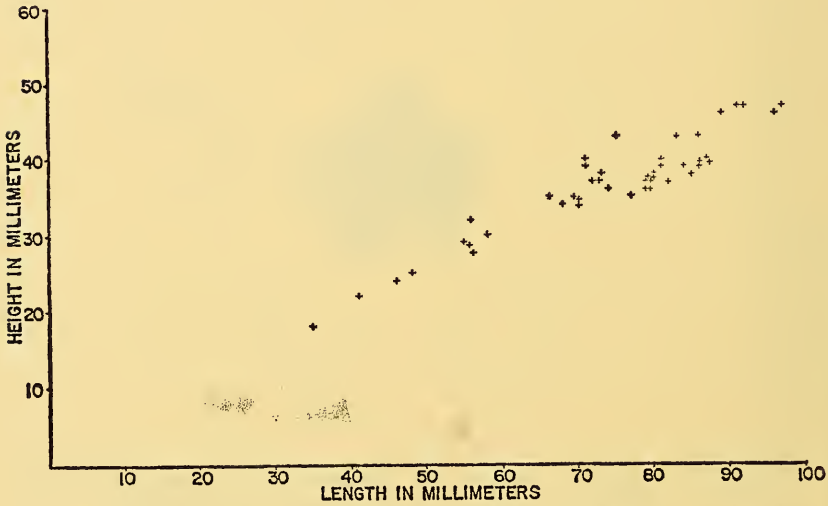


FIG. 48.—*Rhyncholampas evergladensis* (Mansfield). Height of the test relative to the length.

Peristome.—Anterior, pentagonal, depressed, wider than high.

Floscelle.—Phyllodes well developed, broad (text fig. 50), approximately 34-37 pores in each phyllode, 11 or 12 in each outer series, 5-7 irregularly arranged in each inner series; approximately same number in smallest specimen preserving phyllode (40 mm long) as in largest (90 mm long). Buccal pores present. Bourrelets very prominent, pointed.

Tuberculation.—Tubercles adorally much larger than adapically, naked granular zone in median area of interambulacrum V and ambulacrum III adorally.

Comparison with other species.—This species is distinguished from *R. ayresi* Kier by its more pointed adapical surface, more gently sloping sides, and more angular marginal outline. Its adoral surface

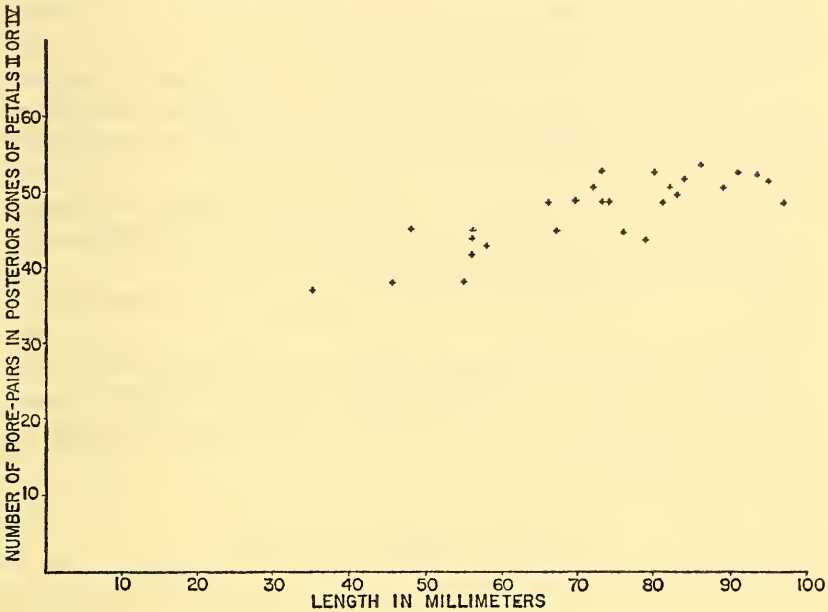


FIG. 49.—*Rhyncholampas evergladensis* (Mansfield). Number of pore-pairs in posterior zones of petals II or IV relative to length of test.

FIG. 50.—*Rhyncholampas evergladensis* (Mansfield): Floscelle of U.S.N.M. 648148, from the Tamiami formation, loc. 9, × 5.

is more depressed, the naked zone in interambulacrum 5 is wider (text fig. 42), and phyllode III is wider.

R. evergladensis is similar in many of its characters to *R. pacificus* (A. Agassiz), a species living off the west coast of the United States, but is distinguished by its wider petals and more steeply sloping posterior margin.

R. evergladensis is distinguished from *Rhyncholampas sabistonensis* (Kellum) by its higher and narrower test. Cooke (1959, p. 57) considered the two species synonyms.

Occurrence.—Tamiami formation (typical), loc. 9, 11, 13, 15, 16, 18, 19.

Tamiami formation (barnacle-echinoid-oyster facies), loc. 26, 27.

Types.—Lectotype, herein designated, U.S.N.M. 37329 (Mansfield, 1932, pl. 18, figs. 1-3), U.S.G.S. 11177; figured specimens, U.S.N.M. 648145-9, loc. 9.

AGASSIZIA PORIFERA (Ravenel)

Plate 16, figures 1-2; Plate 18, figures 1-5; text figures 51-58

Brissopsis poriferus Ravenel, 1848, Echinidae, Recent and fossil, of South Carolina, p. 4, figs. 5, 6.

Agassizia porifera (Ravenel). McCrady, in Tuomey and Holmes, 1857, Pleiocene fossils of South Carolina, p. 5, pl. 1, figs. 5-5b; pl. 2, figs. 4, 4a.

Agassizia porifera (Ravenel). Cooke, 1942, Journ. Paleont., v. 16, no. 1, p. 45.

Agassizia porifera (Ravenel). Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, pp. 74-75, pl. 31, figs. 1-8.

Diagnosis.—Species characterized by large inflated test.

Material.—Thirty-seven specimens.

Shape.—Large, largest specimen 79 mm long, 76 mm wide, 64 mm high; broad (text fig. 57), with greatest width at center or slightly posterior; moderately to highly inflated, height varying from 69 to 90 percent of length (text fig. 58), with highest point anterior of center slightly posterior of apical system; marginal outline angular with slight anterior, posterior truncation; adoral surface moderately inflated, in some specimens keel developed in midline of interambulacrum 5.

Apical system.—Anterior, ethmolytic (text fig. 56), madreporite extending posteriorly, sutures between genital plates not visible.

Ambulacra.—Ambulacrum III not petaloid, in very slight groove not extending to margin; anterior paired petals, II, IV, narrow, depressed in groove, long, when viewed from above extending almost to margin, when viewed from side extending midway from top to

bottom of specimen; anterior poriferous zones slightly developed, (pl. 18, fig. 5; text fig. 54) pore-pairs minute, 34 in posterior poriferous zone of specimen 79 mm long, 31 in specimen 49 mm long; petal straight, or curved anteriorly or posteriorly distally; posterior petals V, I depressed in groove, short, extending slightly more than half distance to margin, interporiferous zones very narrow, pores strongly conjugate, 23 pore-pairs in poriferous zone of specimen 49 mm long, 30 in specimen 79 mm long.

Periproct.—Transverse, situated high on posterior truncation.

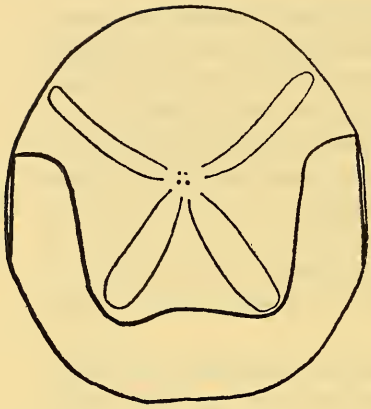
Peristome.—Very eccentric anteriorly, transverse, with well-developed lip.

Fascioles.—Peripetalous fasciole at anterior very low, below margin, not visible adapically, passing around petals II, IV below ends of petals, curving adapically very abruptly posterior to these petals, extending toward apical system, then abruptly turning posteriorly (text figs. 51-53), passing around end of petals V, I, then curving anteriorly forming pronounced lobe, convex toward apical system, in some specimens. Lateroanal fasciole originates from peripetalous fasciole just posterior to petals II, IV, extending posteriorly slightly adapical to margin in interambulacra 4, 1, passing adorally near periproct, then forming distinct deep sulcus immediately adoral to periproct; this sulcus a consistent character in species, occurring in all 23 specimens in which this area visible.

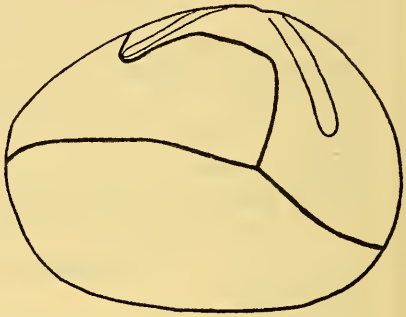
Phyllodes.—Phyllodes well developed, broad (text fig. 55), 4 or 5 pores in phyllode III, 7 or 8 in phyllodes II or IV, 5 or 6 in phyllodes V or I; numbers and position of pores quite consistent in all specimens.

Remarks.—The Florida specimens are clearly conspecific with those described and illustrated by Cooke (1959, p. 74, pl. 31, figs. 1-8) from South Carolina. On first impression they do not appear to be conspectific with Ravenel's holotype as figured by McCrady (in Tuomey and Holmes, 1857, pl. 1, figs. 5-5b). Most of the Florida specimens are larger and more inflated, but one specimen (pl. 18, figs. 3, 4) is approximately the same size as the holotype and can not be distinguished specifically. As shown in a height to length graph (text fig. 58), there is a disproportionate increase in height relative to length in the larger specimens.

The specimen figured by Clark and Twitchell (1915, pl. 97, figs. la-d) does not appear to belong to this species. I have studied this specimen from the American Museum of Natural History. As it is slightly crushed, its original shape is not certain, but it appears to have been considerably higher than *A. porifera.*

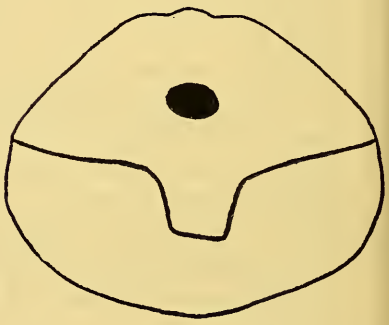


51



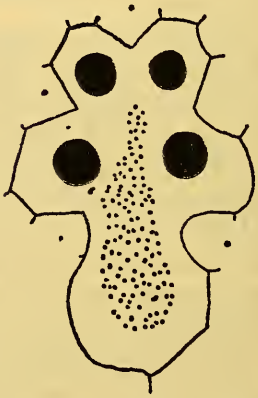
52

54



53

55



56

FIGS. 51-56.—(See opposite page for legend.)

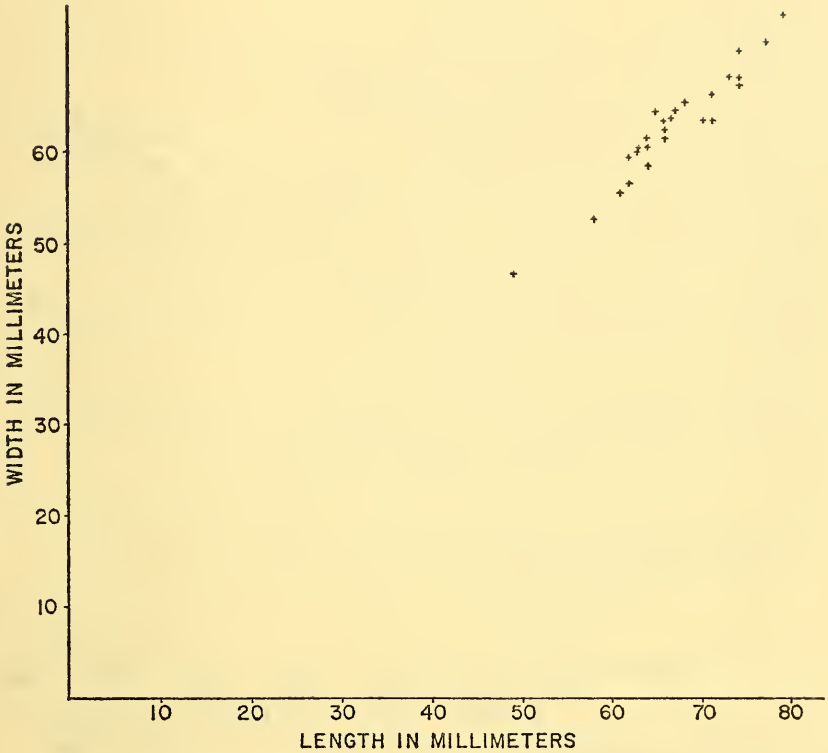


FIG. 57.—*Agassizia porifera* (Ravenel). Width of test relative to length.

Occurrence.—Florida, Caloosahatchee formation, loc. 2, 6. South Carolina, The Grove, Cooper River; U.S.G.S. 18759, Intracoastal Waterway canal in Horry County 1 to 1½ miles southwest of the bridge on U.S. Highway 17 near Nixons Crossroads, about 5 miles southwest of Little River.

Types.—Location of holotype not known; figured specimens, U.S.N.M. 562462, U.S.G.S. 18759, 648154-9, loc. 6.

FIGS. 51-56.—*Agassizia porifera* (Ravenel): 51-53, Adapical, right side, posterior of U.S.N.M. 648157, from the Caloosahatchee formation, loc. 6, showing position of fascioles, × 0.6; 54, portion of ambulacrum IV of U.S.N.M. 648154, from the Caloosahatchee formation, loc. 6, showing the slightly developed anterior poriferous zone, × 13; 55, peristomal region of U.S.N.M. 648158, from the Caloosahatchee formation, loc. 6, × 2; 56, apical system of U.S.N.M. 648159, from the Caloosahatchee formation, loc. 6, × 11.

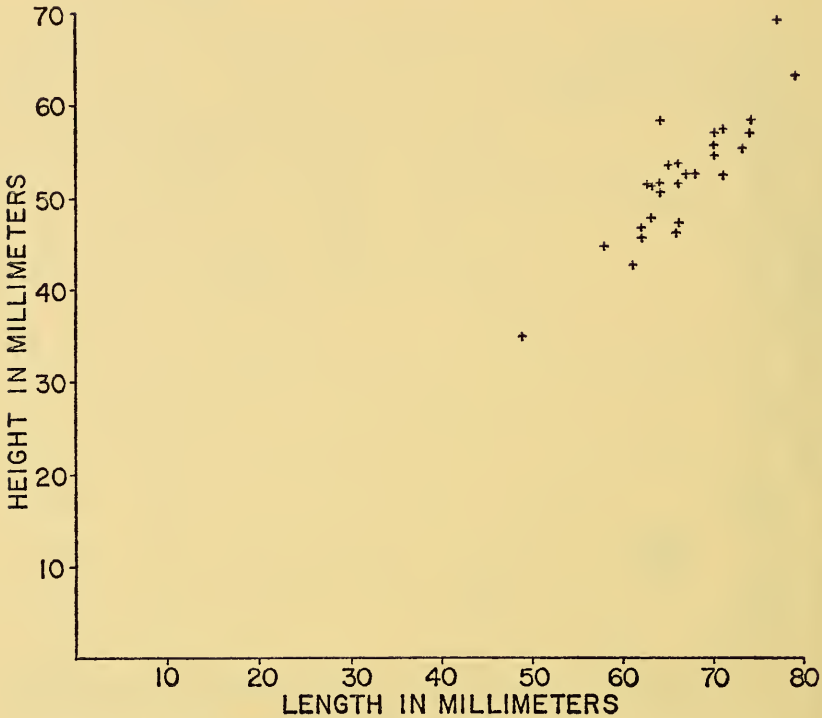


FIG. 58.—*Agassizia porifera* (Ravenel). Height of test relative to length.

ECHINOCARDIUM GOTHICUM (Ravenel) ?

Plate 11, figure 4

Remarks.—There are 29 fragments that appear to belong to this species of Ravenel (1848, p. 4). The petal arrangement and fascioles are identical to Cooke's (1959, pl. 33, figs. 7-10) figured specimens. Without having any complete specimens it is not possible to know the shape of the test, and these fragments can be referred only provisionally to this species.

Occurrence.—Tamiami formation (barnacle-echinoid-oyster facies), loc. 26, 32.

Figured specimen.—U.S.N.M. 648144, loc. 32.

LITERATURE CITED

Agassiz, Louis.

1841. Des scutelles: Monographie d'échinodermes vivans et fossiles, Mon. 2, pt. 6, 151 pp., 27 pls.

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

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

Bergendahl, M. H.

1956. Stratigraphy of parts of De Sota and Hardee Counties, Florida. U.S. Geol. Surv. Bull. 1030-B, pp. iv, 65-98, illus. incl. geol. map.

Bernasconi, I.

1955. Equinoideos y asteroideos de la colección del Instituto Oceanográfico de la Universidad de San Pablo. Segunda contribución. Bol. Inst. Oceanogr. São Paulo, vol. 6, pp. 51-91, 7 pls.

1956. Dos nuevos equinodermos de la costa del Brazil. Neotropica, vol. 2, pp. 33-36, 2 figs.

1958. Equinoideos y asteroideos de la colección del Instituto Oceanográfico de la Universidad de San Pablo. Segunda contribución. Bol. Inst. Oceanogr. São Paulo, vol. 7, pp. 119-149, 4 pls.

Berry, E. W.

1941. Pamlico fossil echinoids. Proc. U. S. Nat. Mus., vol. 90, p. 443-445, 3 pls.

Breder, C. M., Jr.

1955. Observations on the occurrence and attributes of pentagonal symmetry. Bull. Amer. Mus. Nat. Hist., vol. 106, pp. 173-220, 2 pls., 33 figs.

Burma, B. H.

1948. Studies in quantitative paleontology: 1. Some aspects of the theory and practice of quantitative invertebrate paleontology: Journ. Paleont., vol. 22, p. 725-761, 23 text-figs.

Caso, M. E.

1948. Contribución al conocimiento de los equinoideos de México. II, Algunas especes de equinoideos litorales. An. Inst. Biol. México, vol. 19, p. 183-231, 24 figs.

Clark, A. H.

1954. Echinoderms (other than holothurians) of the Gulf of Mexico. Bull. U. S. Fish Comm., vol. 55, pp. 373-379.

1955. Echinodermata of the Gold Coast. Journ. West Afr. Sci. Assoc., vol. 1, No. 2, pp. 16-56, 23 text figs., pl. 2.

Clark, H. L.

1921. Report on the Echinoidea collected by the Barbados-Antigua Expedition. Univ. Iowa Stud. Nat. Hist., vol. 9, pp. 103-121, 2 pls.

1933. A handbook of the littoral echinoderms of Porto Rico and the other West Indian islands. Scientific Survey of Porto Rico and the Virgin Islands, New York Acad. Sci., vol. 16, pt. 1, 147 pp., 7 pls.

CLARK, W. R., 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. W.
1942. Cenozoic irregular echinoids of eastern United States. Journ. Paleont., vol. 16, No. 1, pp. 1-62, pls. 1-8.
1959. Cenozoic echinoids of eastern United States. U. S. Geol. Surv. Prof. Paper, 321, 106 pp., 43 pls.
1961. Cenozoic and Cretaceous echinoids from Trinidad and Venezuela. Smithsonian Misc. Coll., vol. 142, No. 4, 35 pp., 14 pls.

DALL, W. H., and HARRIS, G. D.
1892. Correlation papers; Neocene. U. S. Geol. Surv. Bull. 84, 349 pp., maps.

DARTEVELLE, E.
1953. Echinides fossiles du Congo et de l'Angola. 2e partie. Description systématique des echinides fossiles du Congo et de l'Angola. Ann. Mus. Congo Belge, vol. 13, pp. 1-240, 1 table, 56 pls.

DUBAR, J. R.
1958. Stratigraphy and paleontology of the late Neogene strata of the Caloosahatchee River area of southern Florida. Florida Geol. Surv. Bull., vol. 40, 267 pp., 12 pls., 49 figs.
1962. Neogene biostratigraphy of the Charlotte Harbor area in southwestern Florida. Florida Geol. Surv. Bull., vol. 43, 83 pp., 8 text figs., 2 pls.

DURHAM, J. W.
1955. Classification of clypeastroid echinoids: Univ. California Publ. Geol. Sci., vol. 31, No. 4, pp. 73-198, frontis. + 2 pls., 38 text figs.
1961. The echinoid *Mellita* in the Pacific coast Cenozoic. Los Angeles County Museum Contr. Sci., No. 48, 12 pp., 2 pls., 1 text fig.

DURHAM, J. W., and ALLISON, E. C.
1960. The geologic history of Baja California and its marine faunas. Syst. Zool., vol. 9, No. 2, p. 47-91. 7 figs., 9 tables.

GRAY, J. E.
1825. An attempt to divide the Echinoida, or sea eggs, into natural families. Ann. Philos., ser. 2, vol. 26, pp. 423-431.

HEILPRIN, A.
1887. Explorations of the west coast of Florida. Trans. Wagner Free Inst. Sci., vol. 1, 134 pp., 21 pls.

HYMAN, L. H .
1955. The invertebrates, vol. 4: Echinodermata. The Coelomate Bilateria, 763 pp., 280 figs.

JACKSON, R. T.
1922. Fossil Echini of the West Indies. Carnegie Inst. Washington Publ. 306, 103 pp., 18 pls.
1929. Studies of *Arbacia punctulata* and allies and of nonpentamerous Echini. Mem. Boston Soc. Nat. Hist., vol. 8, pp. 433-565.

KIER, P. M.
1957. Tertiary Echinoidea from British Somaliland. Journ. Paleont., vol. 31, No. 5, pp. 839-902, pls. 103-107, 20 text figs.
1962. Revision of the cassiduloid echinoids. Smithsonian Misc. Coll., vol. 144, No. 3, 262 pp., 181 text figs., 44 pls.

KRAU, L.
1956. A existência de *Clypeaster latissimus* (Lamarck) no Brazil e considerações sobre *Clypeaster subdepressus* (Gray). Mem. Inst. Oswaldo Cruz, vol. 54, pp. 413-427, 6 pls.

LESKE, N. G.
1778. Iacobi Theodri Klein Naturalis dispositio Echinodermatum: 278 p., 54 pls.

LINNAEUS, CAROLUS
1758. Systema naturae, ed. 10, 823 pp.

MANSFIELD, W. C.
1932. Pliocene fossils from limestone in southern Florida. U. S. Geol. Surv. Prof. Paper 170-D, pp. 42-49, pls. 14-18.
1939. Notes on the upper Tertiary and Pleistocene mollusks of peninsular Florida. Florida Geol. Surv. Bull., vol. 18, 75 pp., 4 pls.

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

OLSSON, A. A., and HARBISON, A.
1953. Pliocene Mollusca of southern Florida. Acad. Nat. Sci. Philadelphia Monogr. 8, 457 pp., 65 pls.

PARKER, G. G.
1951. Geologic and hydrologic factors in the perennial yield of the Biscayne aquifer. Amer. Water Works Assoc., vol. 43, pp. 817-834, 7 figs.

RAVENEL, E.
1845. Description of a new Recent species of *Scutella*. Proc. Acad. Nat. Sci. Philadelphia, vol. 2, p. 253.
1848. Echinidae, Recent and fossil, of South Carolina, 4 pl., 10 figs.

SANCHEZ ROIG, M.
1949. Los equinodermos fosiles de Cuba. Paleontologia Cubana, vol. 1, 302 pp., 50 pls.
1952. Revision de los Clypeasteridos Cubanos. Rev. Agric., Habana, for 1952, 24 pp., 16 pls.

SHARP, D. T., and GRAY, I. E.
1962. Studies on factors affecting the local distribution of two sea urchins, *Arbacia punctulata* and *Lytechinus variegatus*. Ecology, vol. 43, No. 2, pp. 309-313, 2 figs., 1 table.

TOMMASI, L. R.
1957. Os equinodermes do litoral de São Paulo. I. Echinoidea, Crinoidea e Holothuridea do bentos costeiro. Pap. Dept. Zool. Sec. Agr. São Paulo, vol. 13, pp. 19-44.

TUOMEY, M., and HOLMES, F. S.
1857. Pleiocene fossils of South Carolina, 152 pp., 30 pls. Pages 1-30 published 1855; 31-152, 1856 (Silliman's Journal, 1855-1857).

EXPLANATION OF PLATES

Plate 1

Page

Arbacia crenulata Kier, new species..... 11

1, 2, 3, Adapical, adoral, and side view of holotype, U.S.N.M. 648133, from the "Buckingham facies" of the Tamiami formation, loc. 20.

4, Enlarged view of portion of peristome of same specimen, × 2.

5, Enlarged view showing ornamentation in interambulacrum of same specimen, × 2.

Arbacia improcera (Conrad)..... 14

6, Enlarged view showing ornamentation in interambulacrum of U.S.N.M. 166487 from the Yorktown formation on Smith Creek ½ mile below Suffolk, Va., waterworks dam, × 2.

Plate 2

Lytechinus variegatus plurituberculatus Kier, new subspecies..... 15

1, Adapical view of holotype, U.S.N.M. 648149, from the Caloosahatchee formation, loc. 6, × 1½. Adoral view of same specimen on pl. 9, fig. 1, side view pl. 10, fig. 4.

2, View of ambulacrum at ambitus of same specimen figured in pl. 1, fig. 1, × 4.

Lytechinus variegatus variegatus (Leske)..... 15

3, View of ambulacrum at ambitus of U.S.N.M. 648151 from the Recent at Boca Inlet, Fla., × 4.

Plate 3

Lytechinus variegatus plurituberculatus Kier, new subspecies..... 15

1, Adoral view of holotype figured in pl. 8, fig. 1, × 1½.

Echinometra lucunter (Linnaeus)..... 19

2, View of a fragment, U.S.N.M. 648152, from the Caloosahatchee formation, loc. 6, × 2.3.

Clypeaster sunnilandensis Kier, new species..... 32

3, Right side view of U.S.N.M. 648134 from the Tamiami formation, loc. 9, × 1. Adoral view of same specimen pl. 3.

Plate 4

Echinometra lucunter (Linnaeus)..... 19

1, 2, 3, Adoral, adapical, and side view of U.S.N.M. 648153 from the Caloosahatchee formation, loc. 6, × 1½.

Lytechinus variegatus plurituberculatus Kier, new subspecies.....

4, Side of holotype figured on pl. 8, fig. 1, 2; pl. 2, fig. 1, × 1½.

PLATE 5

Page

Encope michelini imperforata Kier, new subspecies..... 33

1, Adapical view of holotype, U.S.N.M. 648167, from the Caloosahatchee formation, loc. 2, × 1.

Clypeaster prostratus (Ravenel)..... 20

2, Interior view of basicoronal plates (U.S.N.M. 648173) from the Recent specimen from the Gulf of Mexico, lat. 29° 10′N., long. 85° 31′W., *Albatross* station 2375, × 4.

3, Lantern from hexamerous variant from same locality, × 2.

PLATE 6

Clypeaster prostratus (Ravenel)..... 20

1, 2, Adapical, adoral view of hexamerous variant (U.S.N.M. 648174) from the Recent from the Gulf of Mexico, lat. 29° 10′N., long. 85° 31′W., *Albatross* station 2375, × 1.

Encope michelini imperforata Kier, new subspecies..... 33

3, 4, Adoral and left side of U.S.N.M. 648168 from the Caloosahatchee formation, loc. 6, × 1.

PLATE 7

Clypeaster prostratus (Ravenel)..... 20

1, 2, 3, Adapical, right side, adoral views of U.S.N.M. 648175 from the Recent specimen from the Gulf of Mexico, lat. 29° 10′N., long. 85° 31′W., *Albatross* station 2375, × 1.

4, Apical system of same specimen, × 10.

PLATE 8

Clypeaster subdepressus (Gray)..... 25

Adapical view of U.S.N.M. 648162 from the Caloosahatchee formation, loc. 3, slightly reduced. Adoral view on pl. 14.

PLATE 9

Clypeaster subdepressus (Gray)..... 25

Adoral view of same specimen in pl. 8.

PLATE 10

Clypeaster rosaceus dalli (Twitchell)..... 26

Adapical view of U.S.N.M. 648163 from post-Caloosahatchee but pre-Fort Thompson beds at loc. 1, × 1.

PLATE 11

Clypeaster crassus Kier, new species..... 30

1, 2, Adapical, right side of holotype, U.S.N.M. 648142, from the Tamiami formation, loc. 9, × 1.

3, Adoral view of U.S.N.M. 648143 from the Tamiami formation, loc. 9, × ½.

PLATE 17

Page

Rhyncholampas evergladensis (Mansfield) 48

1, Adapical view of U.S.N.M. 648145 from the Tamiami formation, loc. 9, × 1.

2, Right side view of U.S.N.M. 648146 from the Tamiami formation, loc. 9, × 1.

3, Apical system of U.S.N.M. 648147 from the Tamiami formation, loc. 9, × 7.

4, Floscelle of U.S.N.M. 648148 from the Tamiami formation, loc. 9, × 4.

5, Adoral view of same specimen in fig. 4, × 1.

PLATE 18

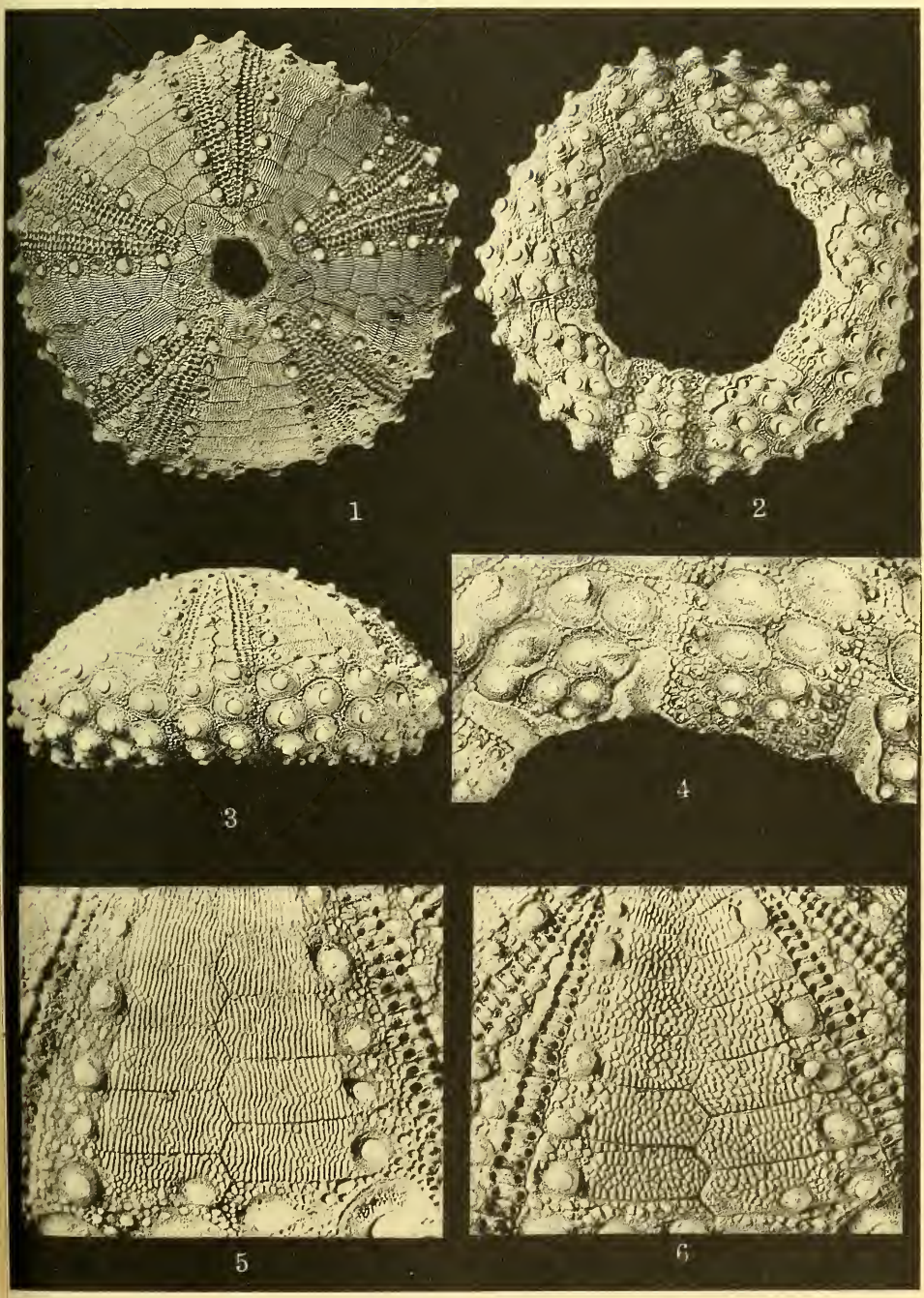
Agassizia porifera (Ravenel) 52

1, 2, Adapical, adoral view of U.S.N.M. 648154 from the Caloosahatchee formation, loc. 6, × 1.

3, 4, Adapical, left side of U.S.N.M. 648155 from the Caloosahatchee formation, loc. 6, × 1. Posterior view of same specimen on pl. 12, fig. 2.

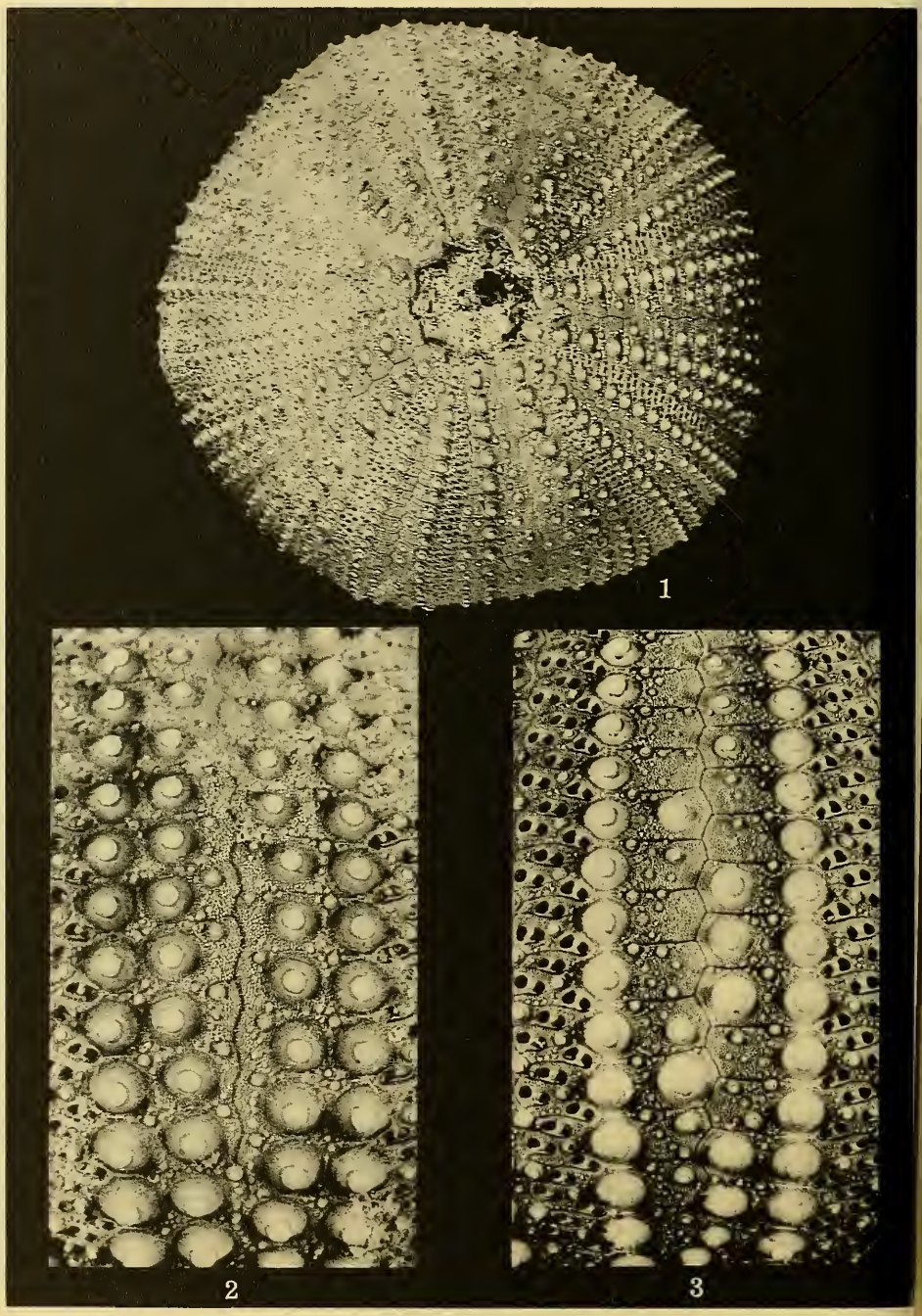
5, View of petal IV of same specimen in fig. 1, × 5.

PLATES



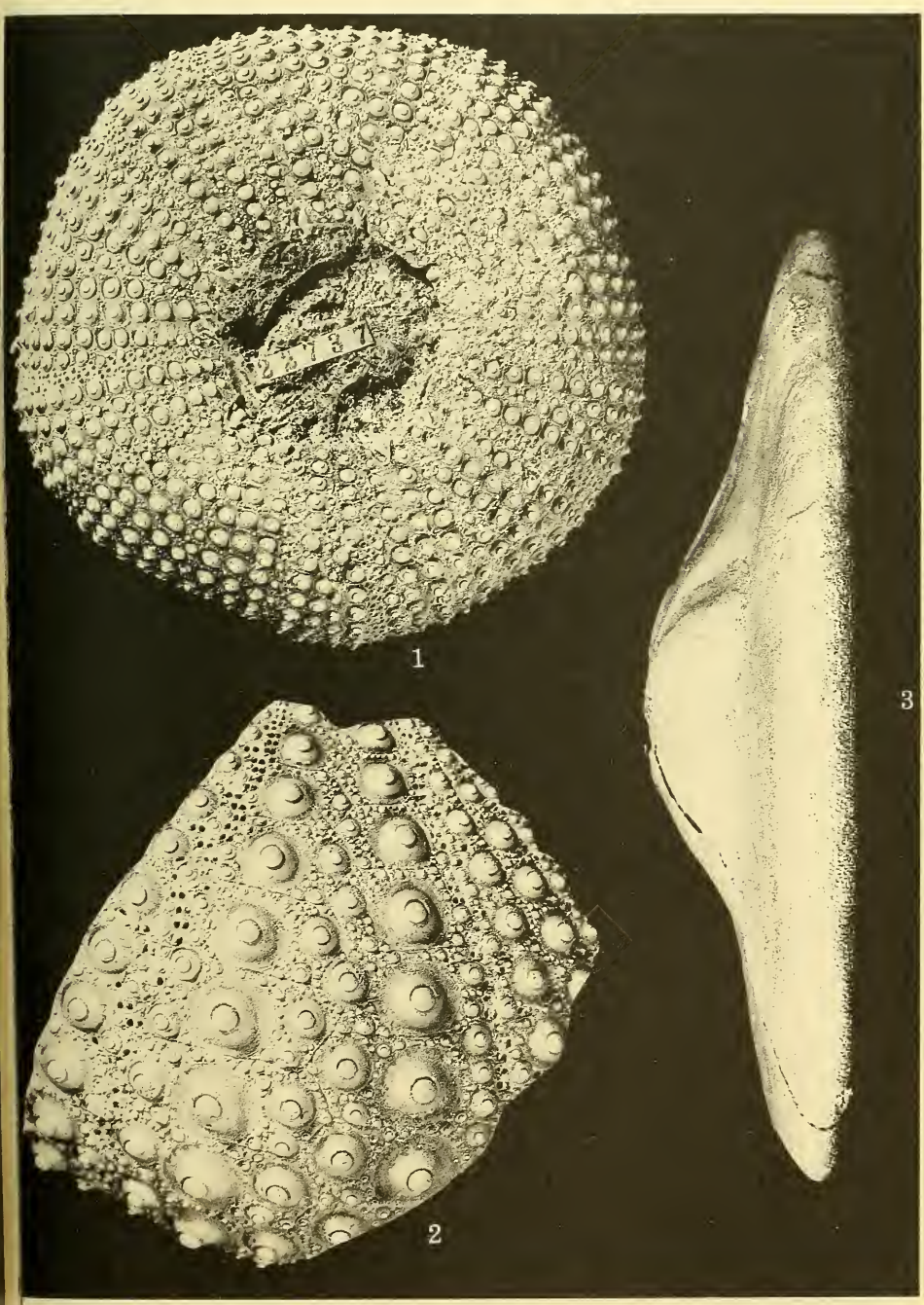
1-5, ARBACIA CRENULATA KIER, NEW SPECIES; 6, ARBACIA IMPROCERA (CONRAD)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



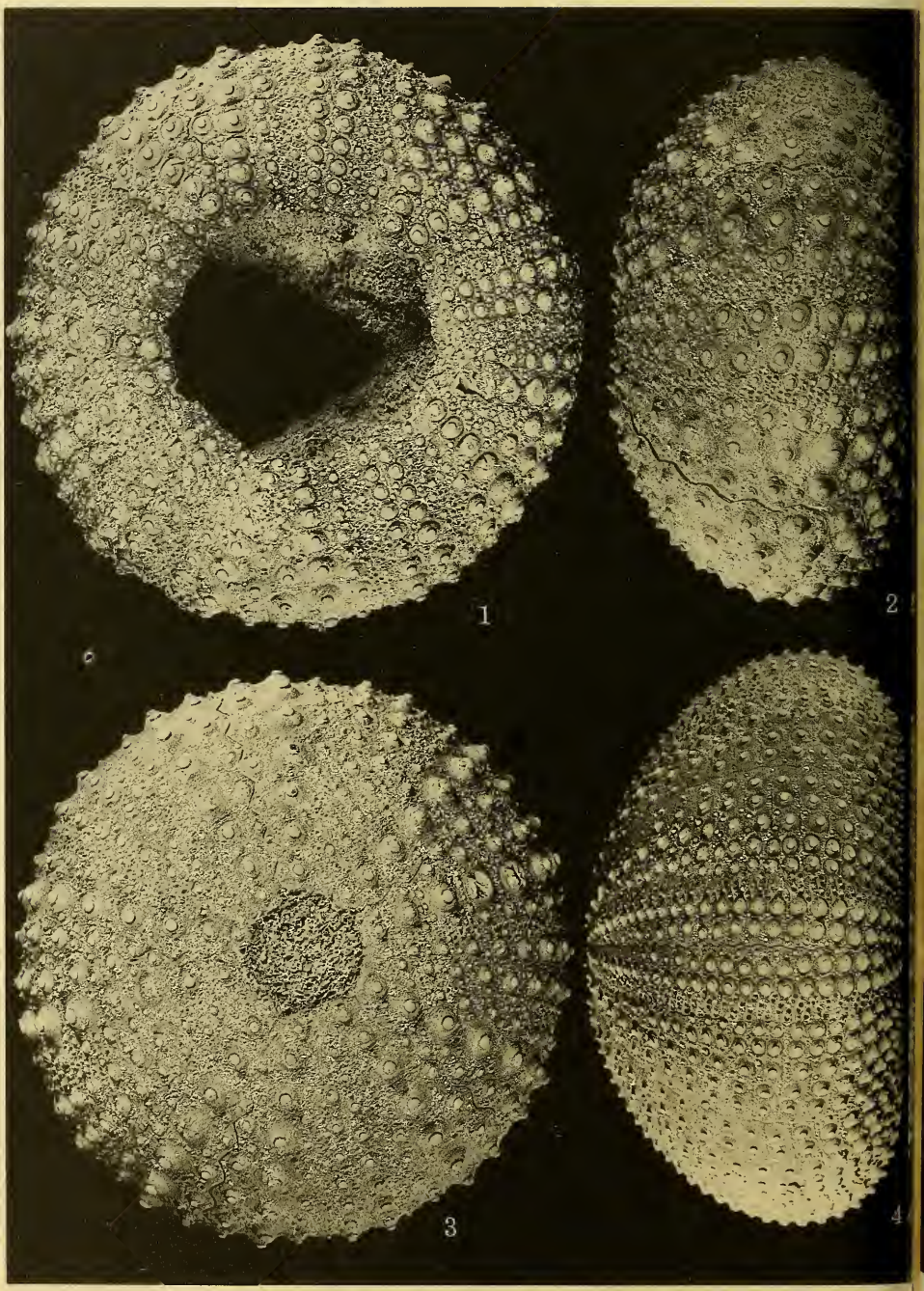
1-2, LYTECHINUS VARIEGATUS PLURITUBERCULATUS KIER, NEW SUBSPECIES;
3, LYTECHINUS VARIEGATUS VARIEGATUS (LESKE)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



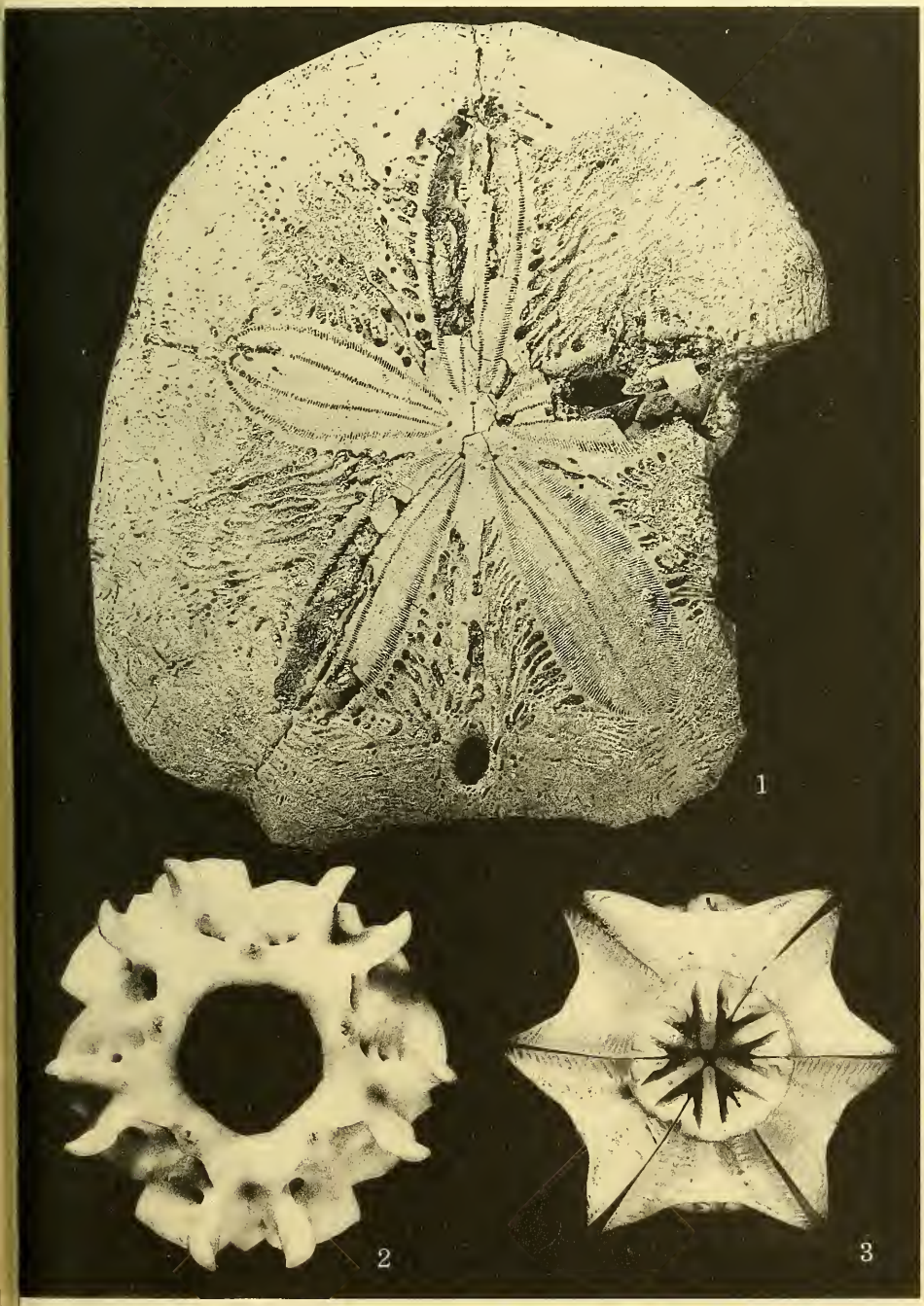
1, LYTECHINUS VARIEGATUS PLURITUBERCULATUS KIER, NEW SPECIES; 2, ECHINOMETRA LUCUNTER (LINNAEUS); 3, CLYPEASTER SUNNILANDENSIS KIER, NEW SPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



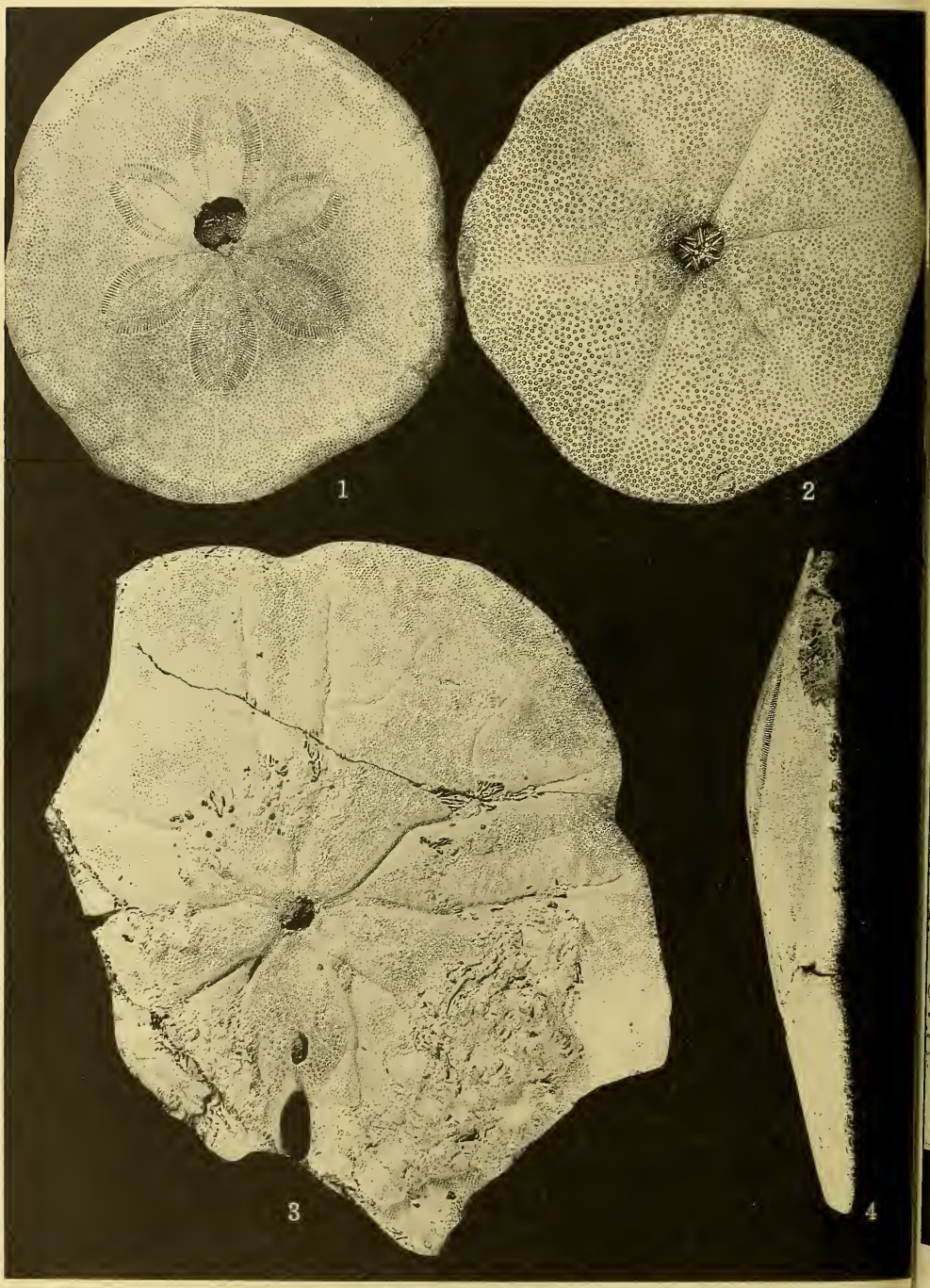
1-3. ECHINOMETRA LUCUNTER (LINNAEUS); 4, LYTECHINUS VARIEGATUS PLURITUBERCULATUS KIER, NEW SUBSPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



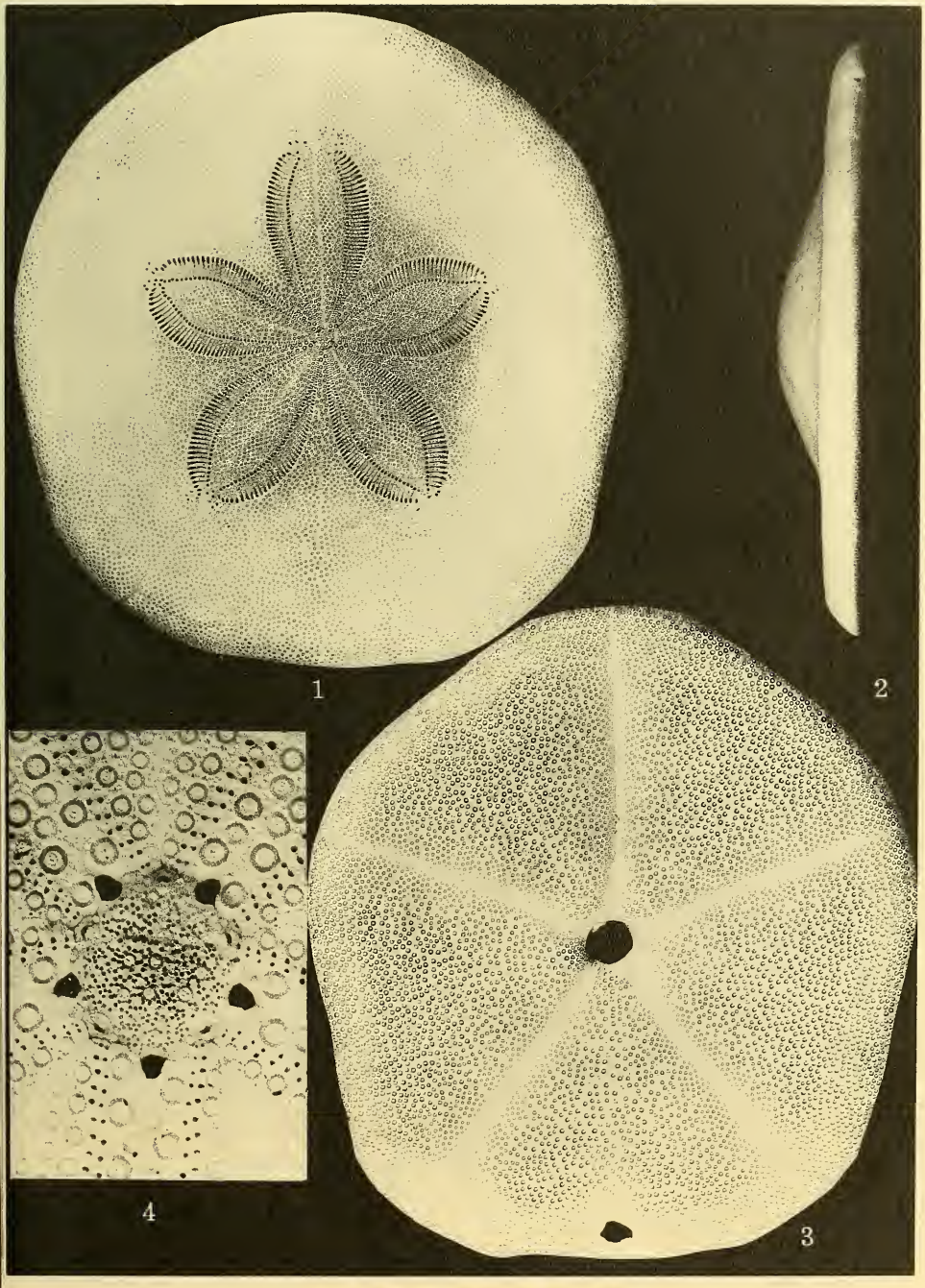
1, ENCOPE MICHELINI IMPERFORATA KIER, NEW SUBSPECIES; 2-3, CLYPEASTER PROSTRATUS (RAVENEL)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



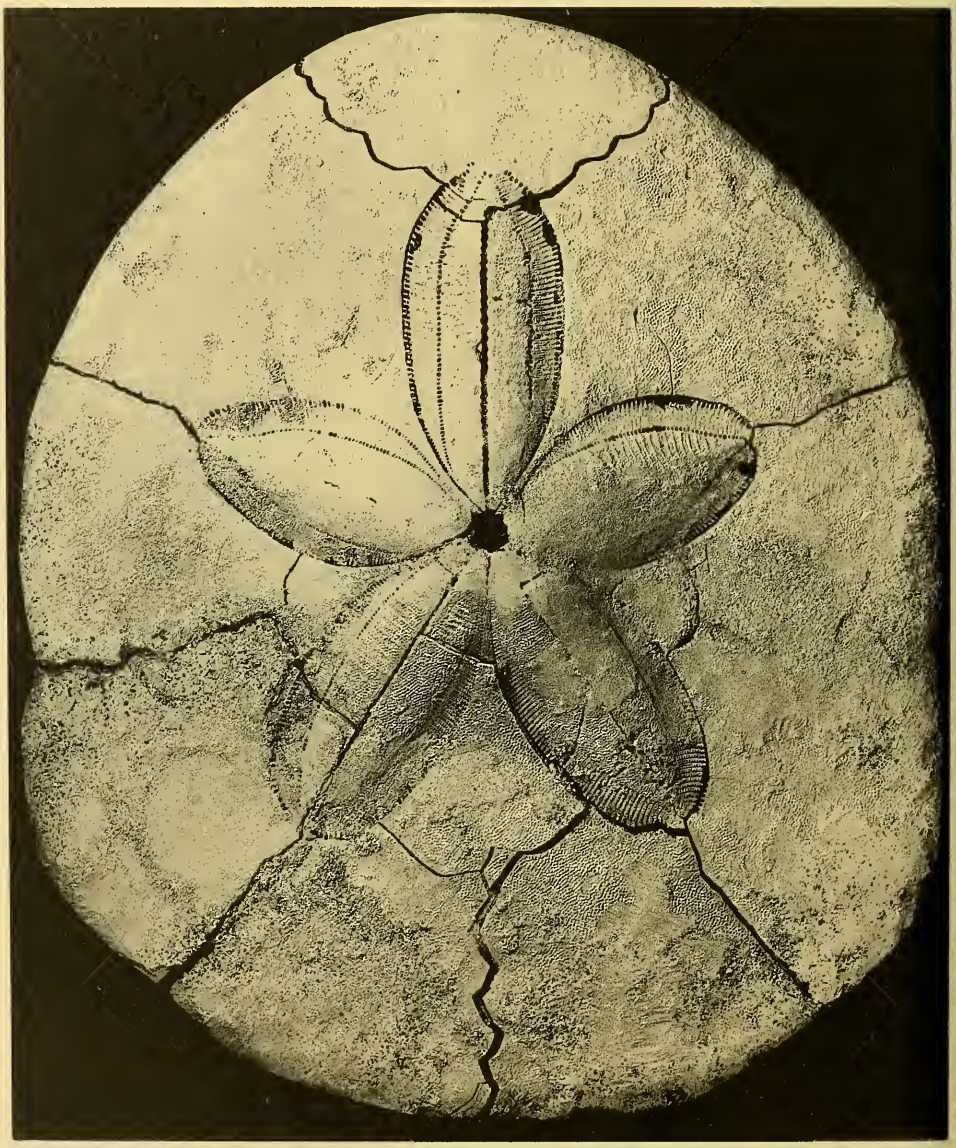
1-2, CLYPEASTER PROSTRATUS (RAVENEL); 3-4, ENCOPE MICHELINI IMPERFORATA KIER, NEW SUBSPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



CLYPEASTER PROSTRATUS (RAVENEL)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

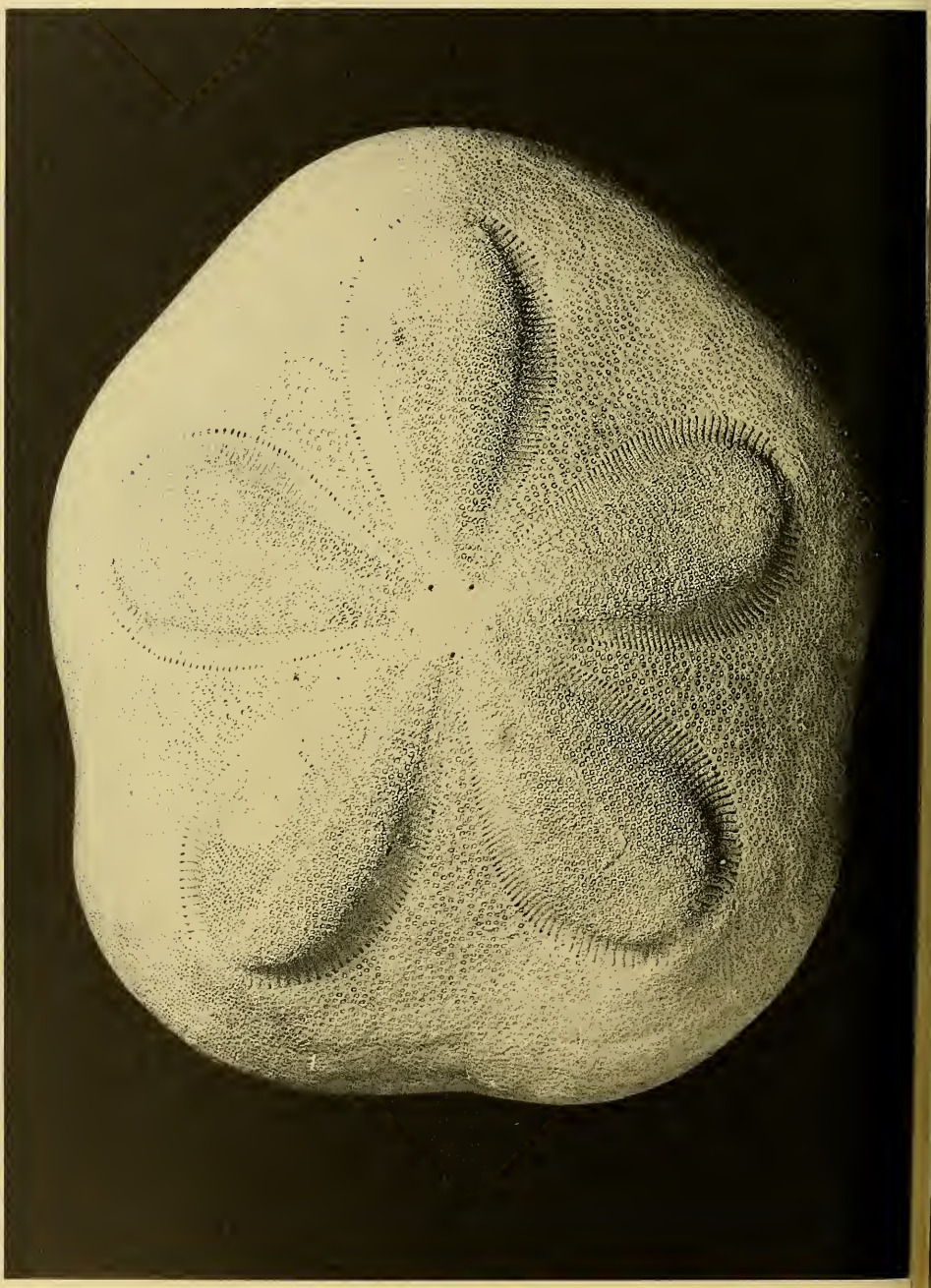


CLYPEASTER SUBDEPRESSUS (GRAY)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

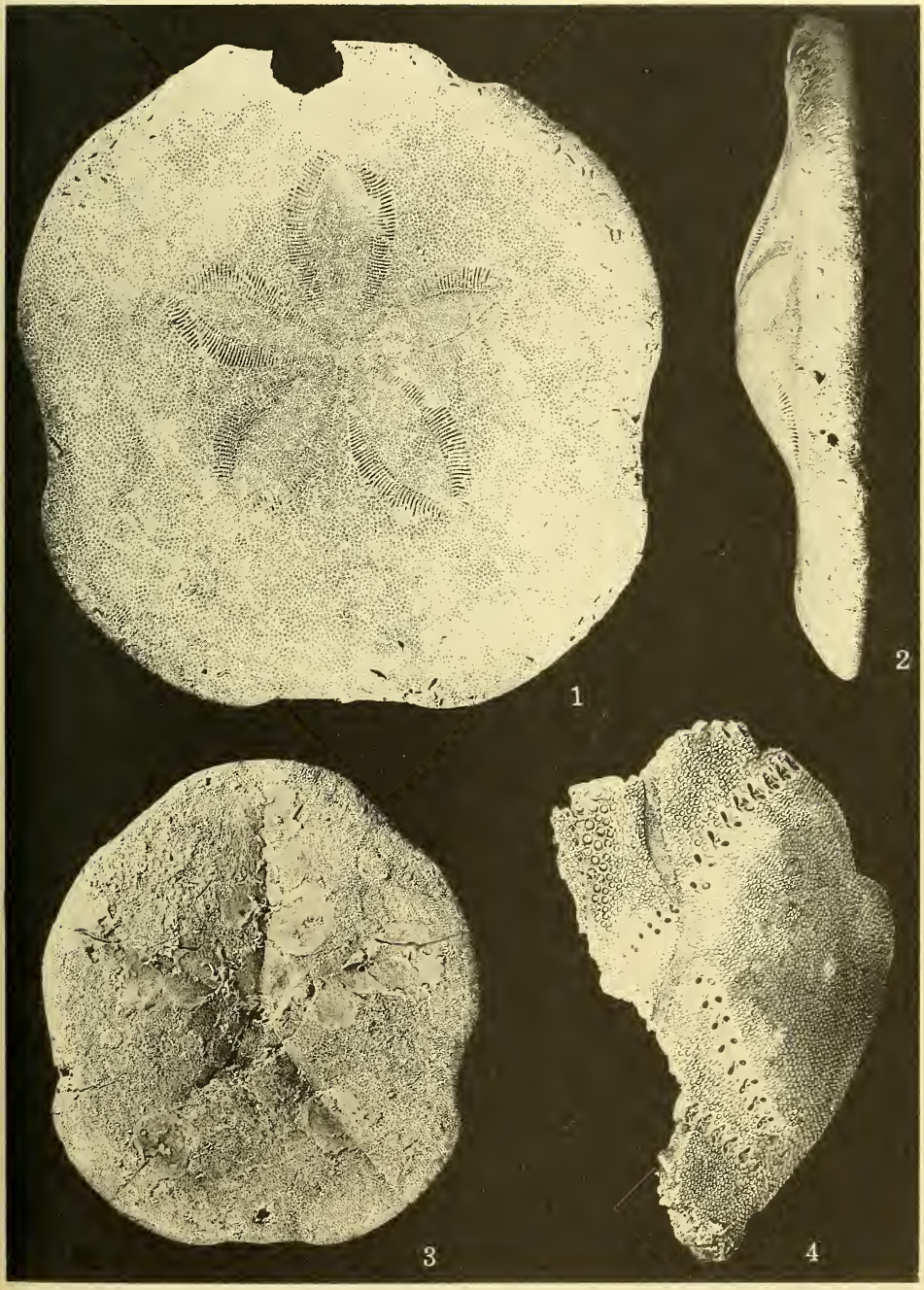
CLYPEASTER SUBDEPRESSUS (GRAY)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



CLYPEASTER ROSACEUS DALLI (TWITCHELL)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

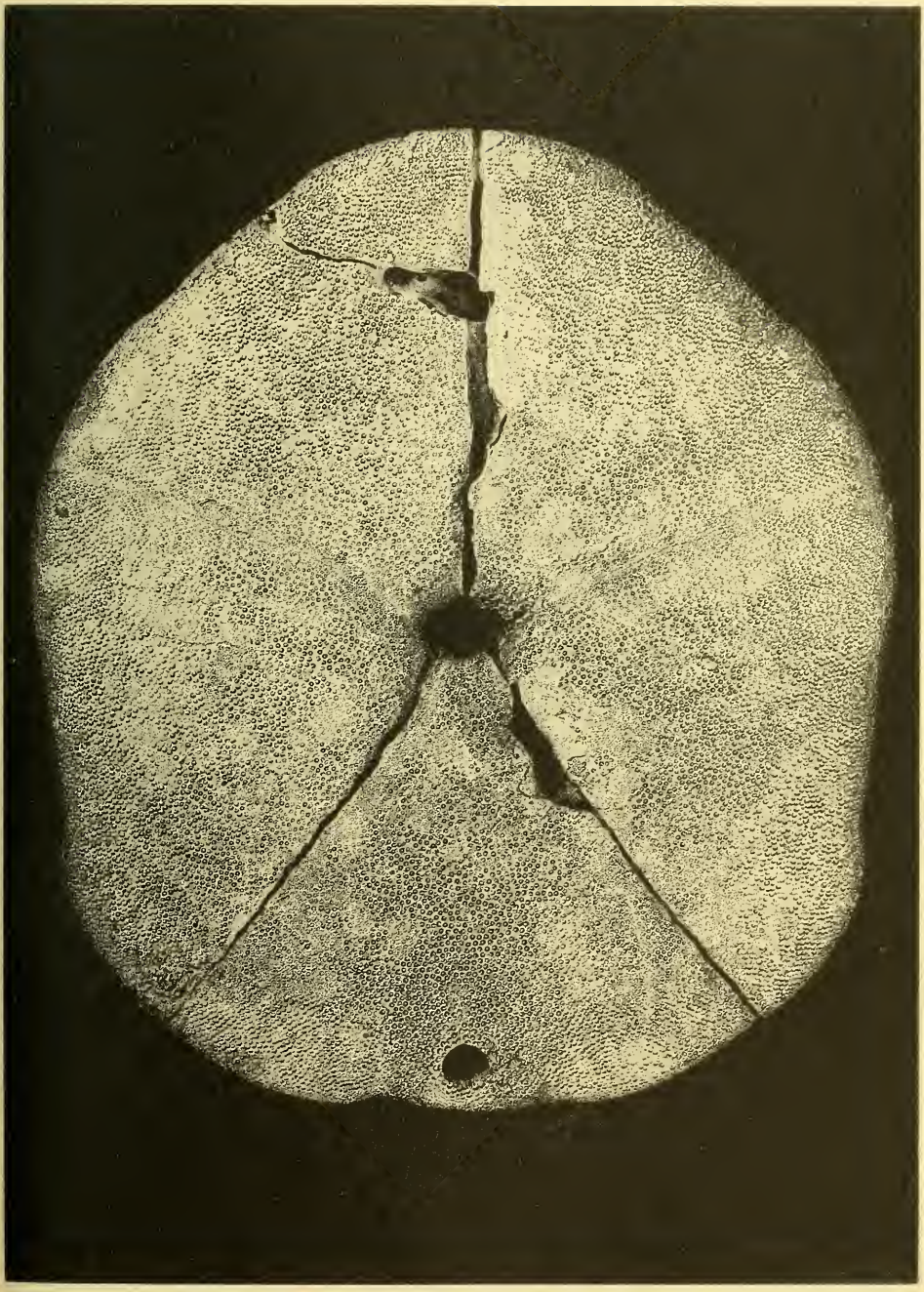


1-3, CLYPEASTER CRASSUS KIER, NEW SPECIES; 4, ECHINOCARDIUM GOTHICUM (RAVENEL)?

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

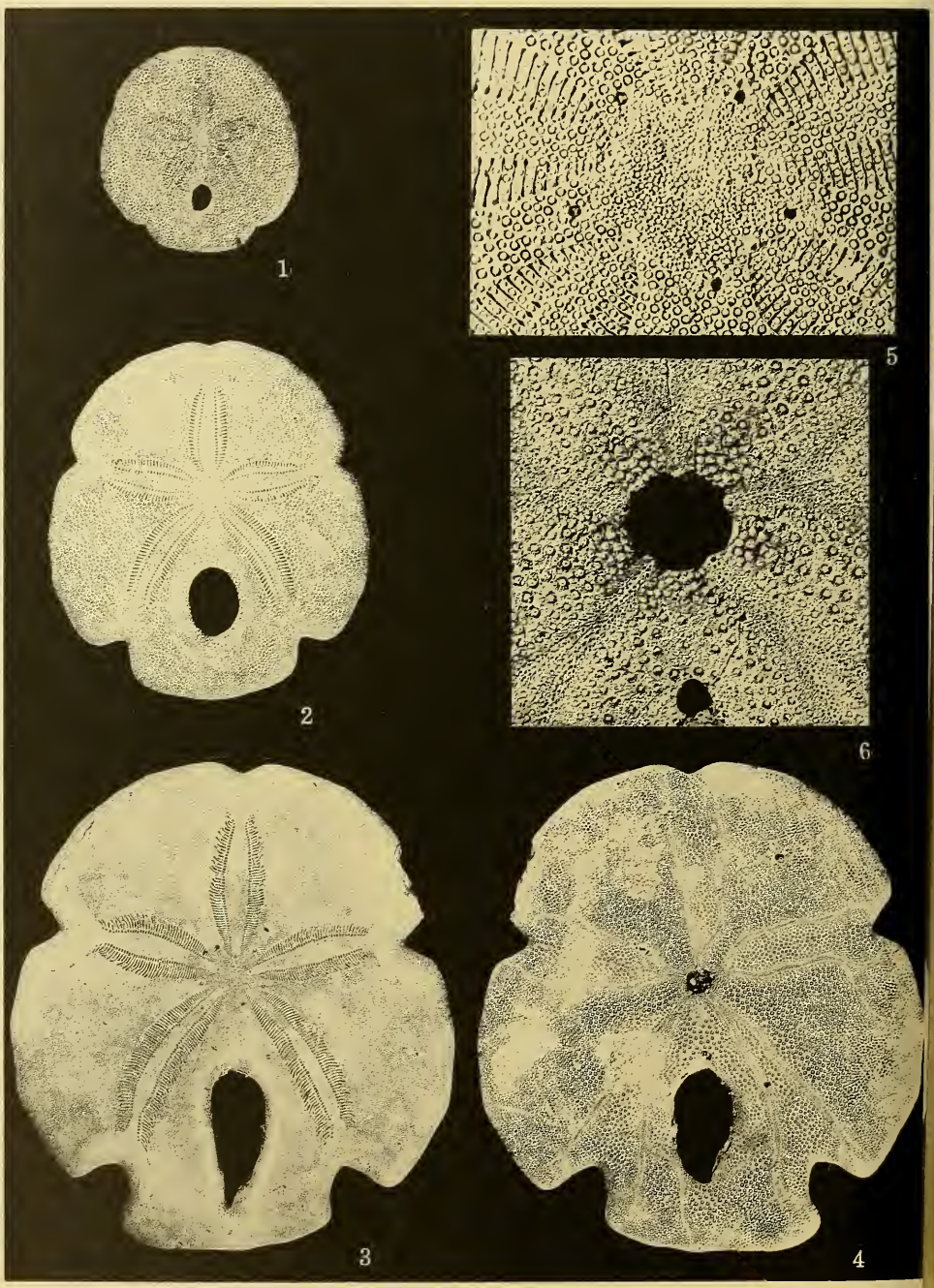
CLYPEASTER SUNNILANDENSIS KIER, NEW SPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



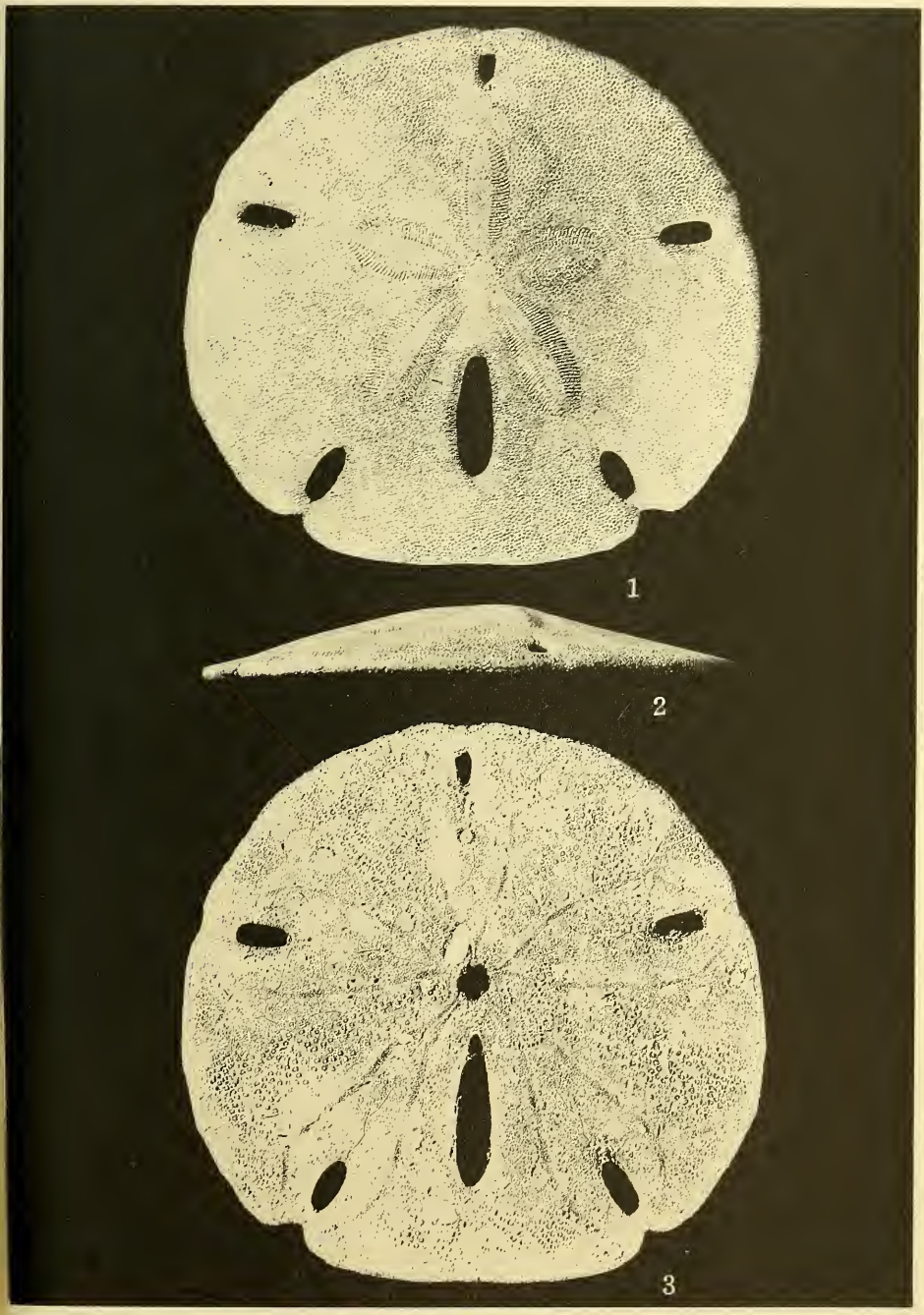
CLYPEASTER SUNNILANDENSIS KIER, NEW SPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



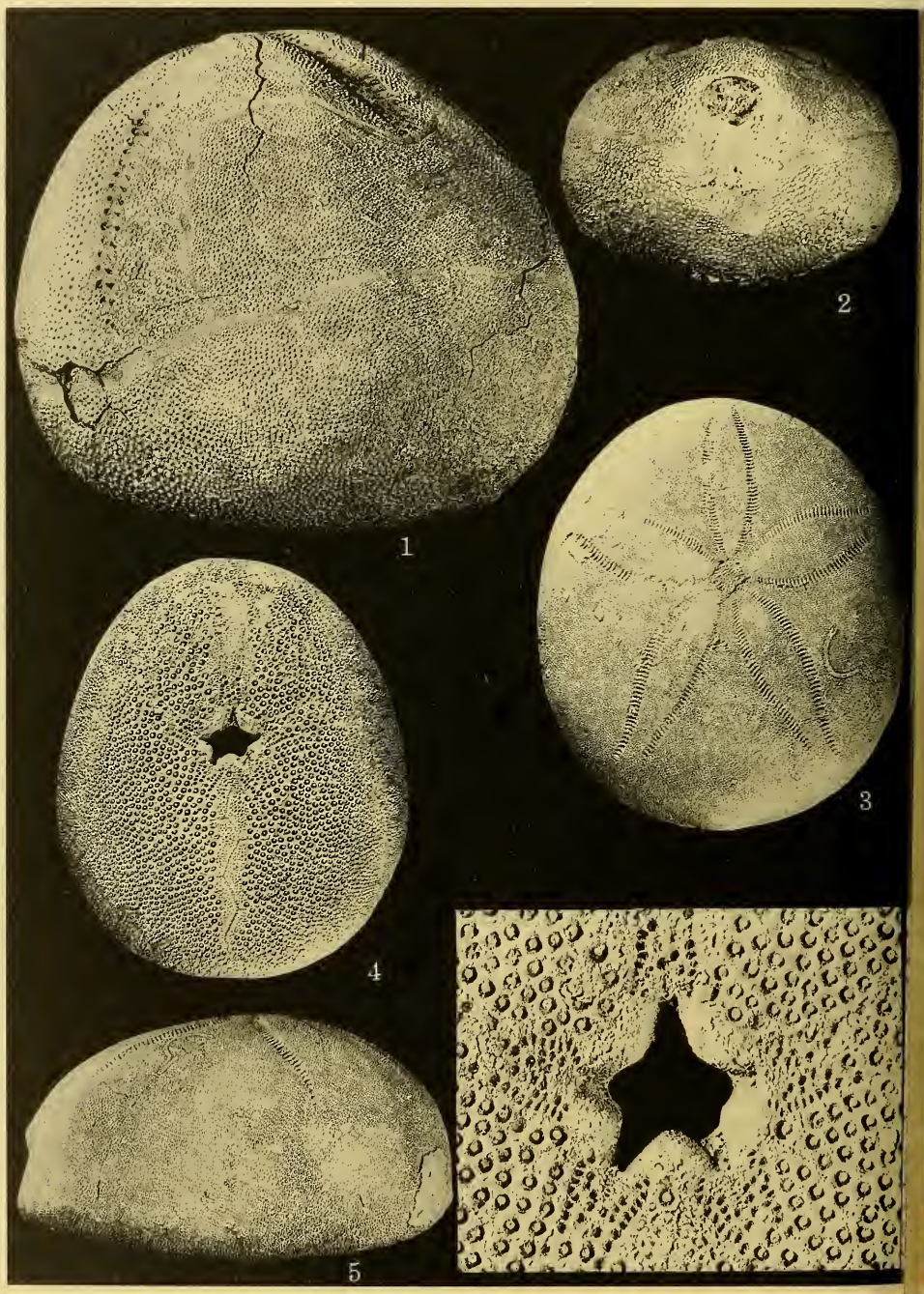
ENCOPE TAMIAMIENSIS MANSFIELD

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



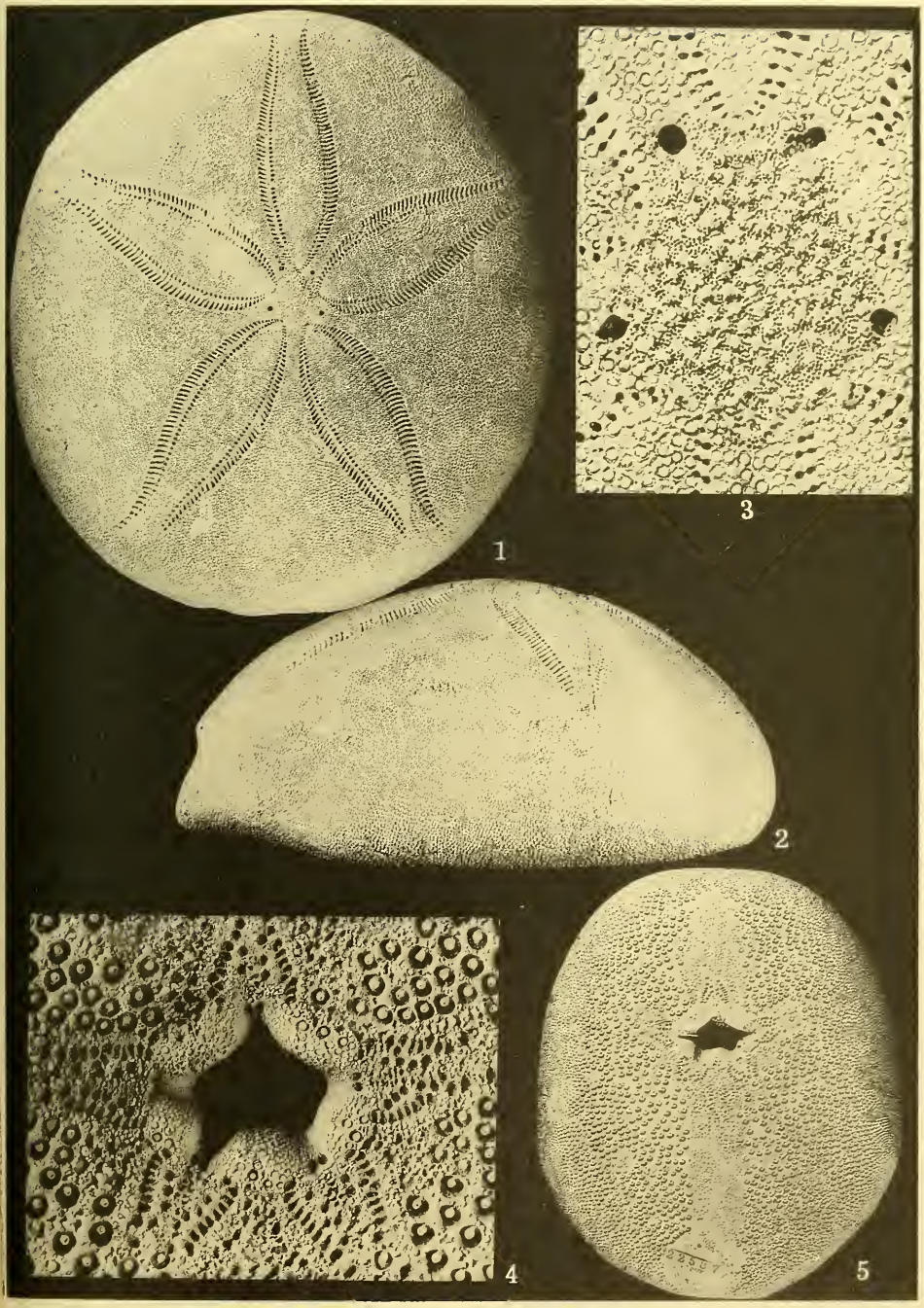
MELLITA ACLINENSIS KIER, NEW SPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



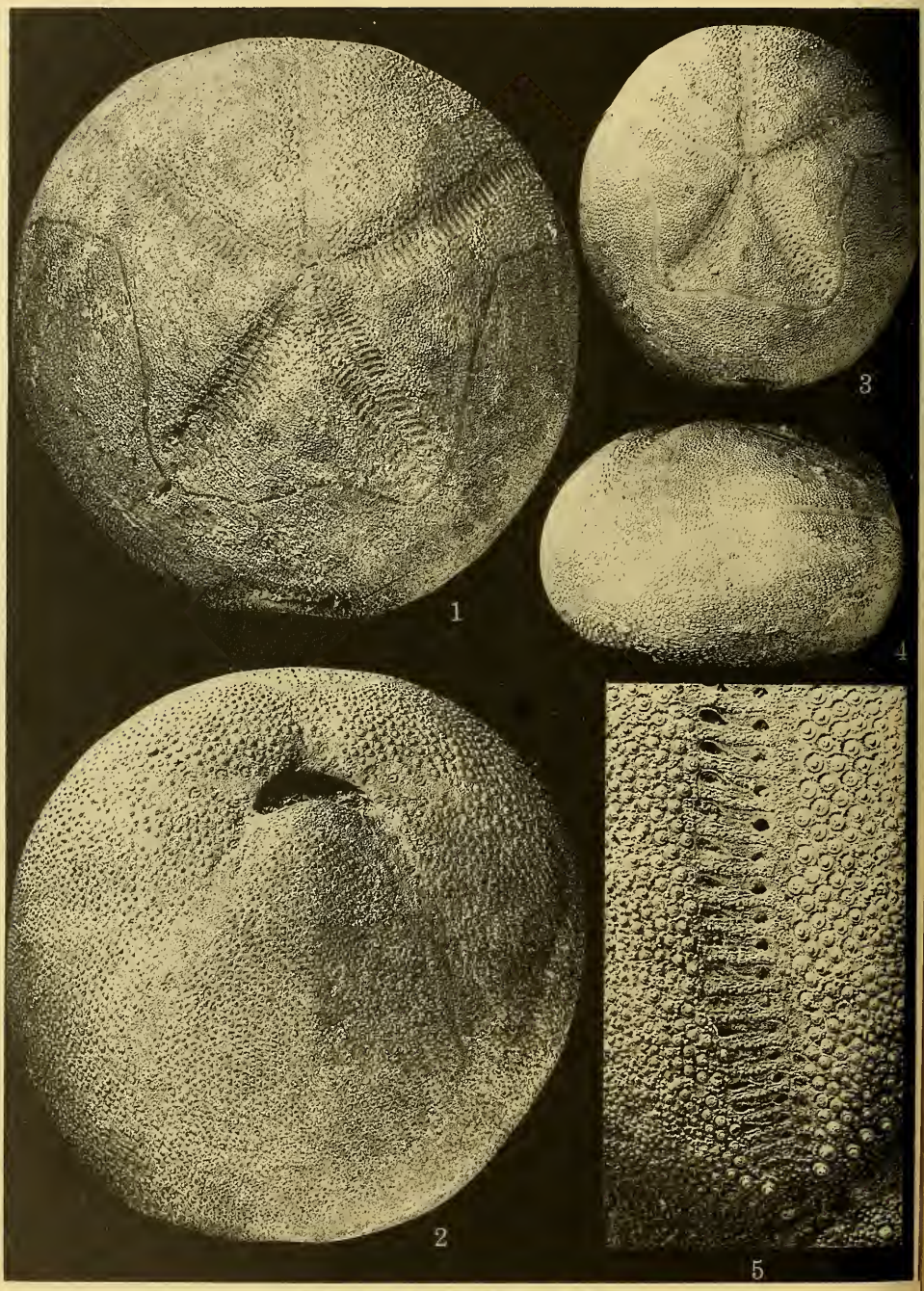
1-2, Agassizia porifera (Ravenel); 3-6, Rhyncholampas ayresi Kier, New Species

(see explanation of plates at end of text.)



RHYNCHOLAMPAS EVERGLADENSIS (MANSFIELD)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



AGASSIZIA PORIFERA (RAVENEL)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)