

GONIASTERIDAE (ECHINODERMATA: ASTEROIDEA)  
OF THE STRAITS OF FLORIDA<sup>1</sup>

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ABSTRACT

Eleven species of goniasterid sea stars collected by the R/V GERDA during a biological survey of the Straits of Florida were studied. Each is fully described and illustrated. A key to all the goniasterid genera in the tropical western Atlantic is provided.

Wide variations occur within many of the species, and as a result, many invalid nominal species have been described. Thus, a good deal of taxonomic revision is made. *Ceramaster affinis* is made a junior synonym of *C. grenadensis*. The genus *Peltaster* is delimited and *placenta* placed in it. *Peltaster planus* is made a junior synonym of *P. placenta*. *Plinthaster perrieri*, *P. nitidus*, and *P. comptus* are made junior synonyms of *P. dentatus*. *Lydiaster* is made a junior synonym of *Circeaster*, and *Circeaster occidentalis* is made a junior synonym of *C. americanus*.

INTRODUCTION

The family Goniasteridae is one of the largest families of sea stars, containing about 40 genera. Goniasterids are found in all seas from the sublittoral zone to depths of over 5000 meters. They are well represented in the Straits of Florida and are an important component of its sea-star fauna.

A large number of goniasterids were collected by the R/V GERDA during an extensive biological survey of the Straits of Florida. The present study is a systematic treatment of these sea stars and provides a basis for the identification of goniasterids from the Straits of Florida.

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Several individuals have been of help. Miss Johanne Kjennerud of the University of Bergen Zoological Museum loaned me specimens of *Peltaster nidarosiensis* from Norway. Helpful information was provided by Dr. F. Jensenius Madsen of the Zoological Museum, Copenhagen; Dr. Gustave Cherbonnier of the Museum National d'Histoire Naturelle, Paris; Dr. Irene

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#### MATERIALS

The primary material used in this study was collected by R/V GERDA of the University of Miami, Rosenstiel School of Marine and Atmospheric Sciences, during a biological survey of the Straits of Florida begun in 1962. Only those species collected by R/V GERDA are treated; however, to help solve systematic problems and delimit infraspecific variations, much additional material was used.

Members of the scientific parties on board the R/V JOHN ELLIOTT PILLSBURY, of the University of Miami Rosenstiel School of Marine and Atmospheric Sciences, collected West Indian goniasterids on the Bermuda cruise in 1965, and the Panama cruises of 1966 and 1967. Important specimens of amphi-Atlantic species were obtained in the eastern Atlantic during the cruises of the PILLSBURY to the Gulf of Guinea in 1964 and 1965.

I examined a number of sea stars collected by the Bureau of Commercial Fisheries vessels, M/V OREGON, M/V SILVER BAY, and M/V COMBAT. These sea stars were taken over a wide area, from the northern Gulf of Mexico and North Carolina to Brazil.

I have also examined the collections of the United States National Museum and the Museum of Comparative Zoology at Harvard, which house most of the types of West Indian goniasterids.

#### TERMINOLOGY

The abbreviations UMML, MCZ, and USNM refer to the museum of the University of Miami Rosenstiel School of Marine and Atmospheric Sciences (University of Miami Marine Laboratory), the Museum of Comparative Zoology at Harvard, and the United States National Museum, respectively.

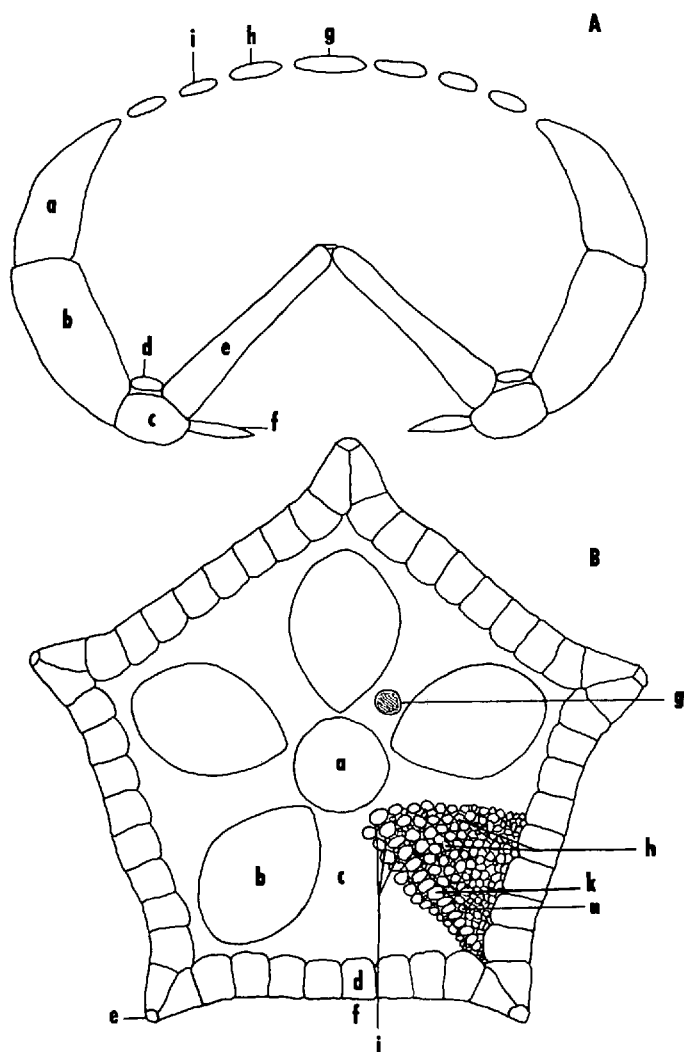


FIGURE 1. Diagram of a generalized goniasterid sea star: A, cross-section through an arm (a, superomarginal plate; b, inferomarginal plate; c, ambulacral plate; d, superambulacral ossicle; e, ambulacral ossicle; f, adambulacral furrow spine; g, carinal plate; h, adradial plate; i, dorsolateral plate); B, dorsal view (a, center of disk; b, radial area; c, interradian area; d, superomarginal plate; e, terminal plate; f, interbrachial arc; g, madreporite; h, dorsolateral primary plates; i, secondary plates; k, carinal plate; n, adradial plate).

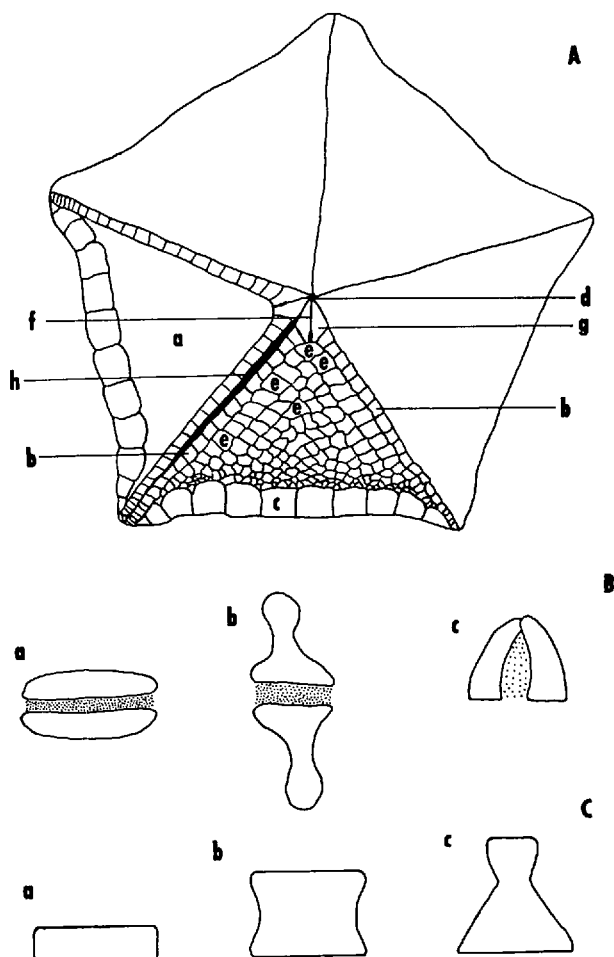


FIGURE 2. Diagram of a generalized goniasterid sea star: A, ventral view (a, actinal intermediate area; b, adambulacral plates; c, inferomarginal plate; d, mouth; e, actinal plates; f, suture; g, mouth plate; h, ambulacral groove); B, pedicellariae (a, bivalved, open; b, excavate sugar-tong, open; c, spatulate, lateral view, closed); C, abactinal plates, lateral view (a, flat; b, tabulate; c, paxilliform).

The terms in the following glossary are defined in reference to the Goniasteridae only, and may not be valid for other groups of sea stars.

**Abactinal plates:** the round or polygonal plates comprising the area inside the superomarginals. These plates may be flat, tabular, or paxilliform. Figure 2,C (a, b, c).



- Actinal intermediate area:** the triangular area between the adambulacral and inferomarginal plates. Figure 2,A (a).
- Actinal plates:** the plates covering the actinal intermediate areas. Plates never paxilliform; may be carinate or convex. Figure 2,A (e).
- Adambulacral armature:** the spines covering the adambulacral plates. Spines divided into two series; furrow spines (Fig. 1,A [f]) strong and movable, covering ambulacral furrow; subambulacral spines covering rest of adambulacral plate. When the rows of spines are numbered, the numbering begins with the row adjacent to the furrow spines and proceeds toward the actinal plates.
- Adambulacral plates:** the plates forming the ventrolateral borders of the ambulacral furrow. Figures 2,A (b) and 1,A (c).
- Adradial plates:** those plates in the rows adjacent to the carinal row. Figure 1,A (h) and 1,B (n).
- Ambulacral furrow:** a V-shaped groove, running from the tip of the arm to the mouth; contains the tube feet. Figure 2,A (h).
- Ambulacral ossicles:** the ossicles forming the roof of the ambulacral furrow. Figure 1,A (e).
- Ampullae:** the bulbous, dorsal parts of the tube feet which are located above the ambulacral ossicles. They help regulate the hydrostatic pressure in the tube feet. In goniasterids there are always two ampullae for each tube foot.
- Apophyses:** the angular projections of the adambulacral plates which project over the furrow.
- Arms:** the radial prolongations from the disk; not distinct from disk. Since it is impossible to ascertain precisely where the disk ends and the arms begin, unfortunately a subjective concept is involved.
- Carinals:** the row of abactinal plates along midline of arm. This term is commonly used only for forcipulate and spinulosan sea stars; these are usually called the radial plates in phanerozonians. I see no reason why the term should not be uniform among sea stars. Furthermore, the term "radial plates" can be confused with the plates of the radial areas. Figure 1,A (g); 1,B (k).
- Center of disk:** the circular area in center of disk. When the center of disk bears papulae, it is defined by the tops of the interradial, where no papulae are found. When the center of disk bears no papulae it is defined by the most proximal radial areas, where papulae are found. Figure 1,B (a).
- Disk:** the central area, encompassing entire body, except arms; usually very large in goniasterids. The disk is divided into three regions: the center, the radial areas, and the interradial areas.
- Dorsolateral plates:** the abactinal plates other than the carinals and adradials. Figure 1,A (i) and 1,B (h).
- Furrow margin:** the edge of the adambulacral plates that faces the ambulacral groove and bears the furrow spines.
- Inferomarginal plates:** the ventral series of marginal plates. Figures 1,A (b) and 2,A (c).
- Interbrachial arc:** the arc between two adjacent arms. Figure 1,B (f).
- Interbrachial septum:** an internal partition along the mid-interradial line; usually membranous in goniasterids.
- Internal radiating ossicles:** the small ossicles located between the bases of the abactinal radial plates on the internal side, helping to connect them. They are found only in the more primitive goniasterids. Figure 5,E.
- Interradial areas:** the areas between the radial areas; papulae are never present. Figure 1,B (c).

**Madreporite:** the grooved plate located in an interradius of the abactinal area.

It is the external opening of the water vascular system. Figure 1,B (g).

**Marginal fascioles:** the grooves between the marginal plates, usually bordered by specialized spinelets. They are reduced in the more primitive goniasterids and absent in the rest.

**Marginal plates:** the prominent, fairly rigid plates which form the sides of the body. The number of marginal plates represents those from the tip of one arm to the tip of an adjacent arm.

**Mouth plates:** the two modified adambulacral plates at the apex of each triangular actinal intermediate area. These two plates are joined by connective tissue, forming a mouth-plate pair. The apex of each plate bears a large spine; the two spines are called median spines. These may be fused, forming an unpaired median spine at the apex of the mouth-plate pair. When the furrow spines are numbered, the numbering begins with the spine next to the adjacent adambulacral plate and proceeds toward the median spine. Figure 2,A (g).

**Papular pores:** the openings in the abactinal surface, between abactinal plates, through which papulae extend.

**Papulae:** the small, vermiform outpocketings of the coelom, used for respiration.

There may be one or several papulae within each papular pore.

**Pedicellariae:** the modified spines which perform a pincer-like function.

The following types are present in goniasterids:

1. **Bivalved:** the two jaws or valves are thick, long and narrow, and very low, resembling a pair of human lips.
2. **Excavate:** the jaws are usually higher than wide, resembling sugar tongs, but in some forms they are wide and low; they are never as low and thick as the bivalved type. When pedicellaria is relaxed the jaws lie back flat against the plate, usually in a specialized depression.
3. **Spatulate:** the jaws are simple, movable, apposed spines. When the pedicellaria is relaxed the jaws gape only slightly. There are usually two jaws, but three and four are not uncommon.

These types are not clearly demarcated and grade into one another. They are all alveolar, i.e., the jaws are sunken into an endoskeletal depression or alveolus. Figure 2,B (a, b, c).

4. **Pectinate:** this consists of two rows of apposing spines, each borne on an adjacent plate, and meeting over the suture. It is sessile, i.e., is attached directly to the skeleton by connective tissue and muscle and is not sunken into it. This is only found in the more primitive goniasterids, viz., the *Pseudarchasterinae*.

**Primary plates:** the major plates of an area, usually the abactinal. See secondary plates. Figure 1,B (h).

**Polian vesicles:** the muscular sacs in the interradii that probably maintain turgor in the water-vascular system.

**R, or major radius:** the distance from the center of the disk to the tip of the arm.

**r, or minor radius:** the distance from the center of the disk to the middle of the interbranchial arc.

**Radial areas:** the areas from the bases of the arms to the center of the disk, which bear papulae. They may extend down the arms. Figure 1,B (b).

**Radial plates:** the plates of the radial areas; taller and more loosely connected than interradii plates.

Secondary plates: the small plates which occupy the spaces left by the very much larger primary plates. Figure 1,B (i).

Subambulacral spines: the spines or granules covering the adambulacral plates. See adambulacral armature.

Superambulacral ossicles: the small internal ossicles connecting the ambulacral ossicles with the inferomarginal plates; found only in the more primitive goniasterids. Figure 1,A (d).

Superomarginal plates: the dorsal series of marginal plates. Figure 1,A (a); 1,B (d).

Suture: the seam formed by the joining of two adjacent plates; usually referring to the two mouth plates of a mouth-plate pair.

Terminal plate: the unpaired plate at the tip of the arm. Figure 1,B (e).

Tube feet: the short, tubular, external projections of the coelom, located in ambulacral furrow. Their primary function is locomotion, but they are also important in respiration and feeding. In goniasterids they are arranged in two rows, and the tips are flattened to form suckers.

#### KEY TO THE GENERA OF THE GONIASTERIDAE OF THE TROPICAL WESTERN ATLANTIC

The following key is intended to be used only for the Caribbean species of the genera included in it. All the genera likely to be found in the Straits of Florida are included, even if not yet collected there.

1. Large, prominent spines on dorsal surface ..... *Goniaster*  
No spines on dorsal surface ..... 2
2. Entire body covered by a skin, obscuring the plates in adults .....  
..... *Anthenoides*  
Body not covered by a skin ..... 3
3. Superomarginal plates in contact medially throughout length of arm ..... 4  
Superomarginal plates in contact medially for half the length of arm or less ..... 6
4. Abactinal plates naked centrally; surrounded by a single row of granules ..... *Astroceramus*  
Abactinal plates completely covered by granules ..... 5
5. Abactinal plates strongly tabulate; adambulacral plates lack apophyses, furrow margins not strongly angular; gonads serial; internal radiating ossicles present ..... *Rosaster*  
Abactinal plates low-tabulate; adambulacral plates with strongly angular furrow margin, becoming apophyses distally; gonads in a single tuft; internal radiating ossicles lacking ..... *Nymphaster*
6. Each adambulacral plate bearing one to three very large, heavy furrow spines ..... 7  
Each adambulacral plate bearing four or more moderately narrow furrow spines ..... 8
7. Secondary abactinal plates present ..... *Hippasteria*  
No secondary abactinal plates ..... *Cladaster*

8. Secondary abactinal plates present ..... 9  
     No secondary abactinal plates ..... 11
9. Abactinal plates of arms abruptly larger than those of disk .....  
     ..... *Circeaster*  
     Abactinal plates of arms not larger than those of disk ..... 10
10. Abactinal plates naked centrally; surrounded by a single row of  
     granules ..... *Plinthaster*  
     Abactinal plates completely covered by granules ..... *Peltaster*
11. An unpaired median tooth common to each mouth-plate pair .....  
     ..... 12  
     Mouth-plate pair bearing pair of median teeth ..... 13
12. Several rows of abactinal plates separating superomarginal plates  
     of arm ..... *Pseudarchaster*  
     Only a single row of abactinal plates separating superomarginal  
     plates of arm ..... *Paragonaster*
13. Abactinal plates flat, very thin ..... *Litonotaster*  
     Abactinal plates tabulate ..... 14
14. Actinal plates covered by spinules; radial abactinal plates con-  
     nected by internal radiating ossicles; superambulacral ossicles  
     present ..... *Mediaster*  
     Actinal plates covered by rounded granules; no internal radiating  
     ossicles; no superambulacral ossicles ..... 15
15. R/r less than two; furrow margin of adambulacral plates not  
     strongly angular, no apophyses ..... *Ceramaster*  
     R/r about four; furrow margin of adambulacral plates strongly  
     angular, becoming apophyses distally ..... *Tessellaster*

#### Family GONIASTERIDAE Forbes, 1841

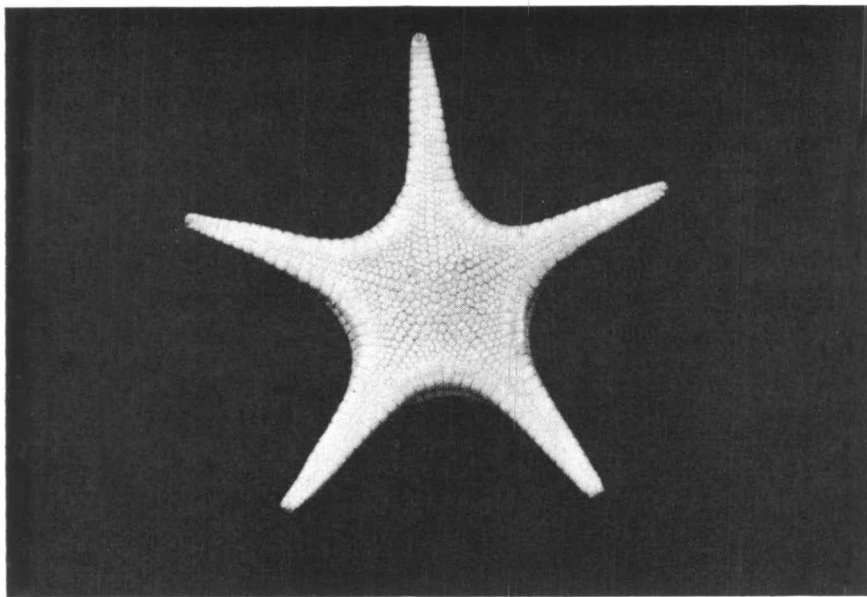
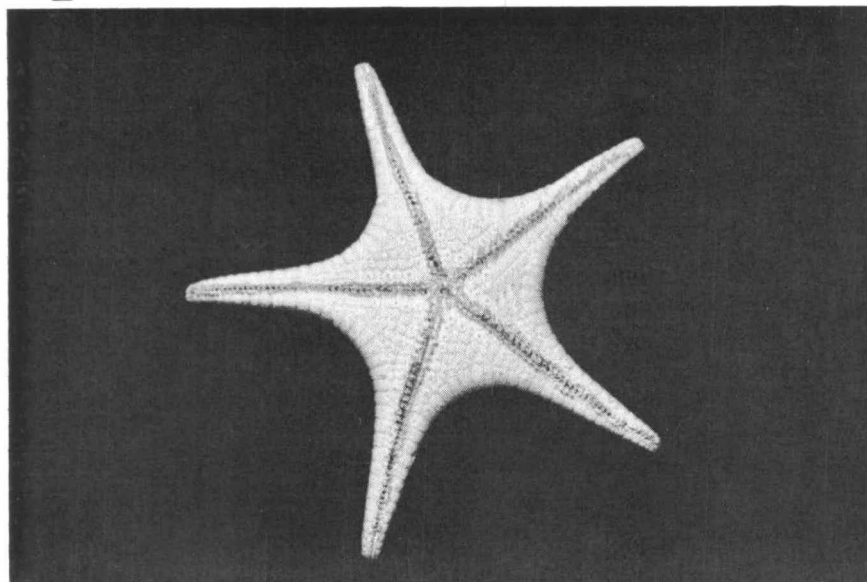
Phanerozonia with thick and massive marginal plates, large disk, and usually tessellate abactinal and actinal plates. Papulae confined to dorsal surface; usually restricted to radial areas. Actinal intermediate areas usually large. Tube feet with large sucking disks. Interbrachial septum usually membranous.

#### Subfamily Goniasterinae Verrill, 1899

No membrane or skin covering body. Secondary abactinal plates, when present, not forming reticulated skeleton. No intermarginal papulae. Mouth-plate pair bearing no unpaired median tooth.

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FIGURE 3. *Mediaster pedicellaris* (Perrier): A, specimen from GERDA sta. G-232; 0.9 ×; B, specimen from GERDA sta. G-232; actual size.

**A****B**

Genus *Mediaster* Stimpson, 1857

*Mediaster* Stimpson, 1857: 530.—Sladen, 1889: 263.—Perrier, 1894: 377; 1896: 45-46.—Verrill, 1899: 178-179.—Fisher, 1911: 196-197.—Verrill, 1914: 295-296; 1915: 108-109.—Fisher, 1919: 255-256.—Macan, 1938: 369.—H. L. Clark, 1946: 83.—Bernasconi, 1963: 11; 1964: 253-254.  
*Isaster* Verrill, 1894: 257-258.

*Diagnosis*.—Abactinal plates tabulate; internal radiating ossicles connecting bases. No intermarginal papulae. Superomarginal plates not contiguous throughout arm. No supplementary internal actinal intermediate plates. No unpaired median mouth spine. Rudimentary superambulacral ossicles present. Interbrachial septa membranous.

*Type-Species*.—*Mediaster aequalis* Stimpson (by monotypy).

*Mediaster pedicellaris* (Perrier, 1881)

Figs. 3-5

*Goniodiscus pedicellaris* Perrier, 1881a: 23; 1884: 173, 174, 175, 177, 185, 245-246, pl. 4, fig. 3.—Sladen, 1889: 756.—Perrier, 1894: 37, 38.

*Pentagonaster pedicellaris* Perrier, 1884: 168.

*Mediaster agassizii* Verrill, 1899: 181-182.

*Mediaster pedicellaris*: Verrill, 1899: 182-183.—Fisher, 1911: 97.—Verrill, 1915: 109-110.—H. L. Clark, 1941: 34-36.—A. H. Clark, 1954: 375.

*Mediaster trinadensis* Bernasconi, 1957a: 33-34, fig. 1; 1957b: 133-135, pl. 3, figs. 3, 6, 7; 1963: 11-13, pl. 5, figs. 3-5.

*Material Studied*.—HOLOTYPE: R = 59 mm, r = 18 mm, R = 3.3r; off Barbados, 329 m, BLAKE sta. 295, 1878-79, MCZ 470.

OTHER MATERIAL: 27°22'N, 79°27'W, 503 m, R/V GERDA sta. G-261, 7 February 1964, UMML 40.118, 4 spec.—27°08'N, 79°21'W, 567 m, R/V GERDA sta. G-247, 5 February 1964, UMML 40.98, 1 spec.—26°00'N, 79°19'W, 439-458 m, R/V GERDA sta. G-633, 30 June 1965, UMML 40.156, 2 spec.—25°43'N, 79°22'W, 452-474 m, R/V GERDA sta. G-234, 30 January 1964, UMML 40.155, 7 spec.—25°40'N, 79°22'W, 412 m, R/V GERDA sta. G-233, 30 January 1964, UMML 40.105, 2 spec.—25°38'N, 79°21'W, 430 m, R/V GERDA sta. G-232, 29 January 1964, UMML 40.85, 2 spec.—24°30'N, 80°51'W, 205 m, R/V GERDA sta. G-482, 26 January 1965, UMML 40.97, 1 spec.—24°23'N, 81°59'W, 210-220 m, M/V SILVER BAY sta. 2426, 29 October 1960, 1 spec.—00°18'N, 44°17'W, 275 m, M/V OREGON sta. 4226, 9 March 1963, 9 spec.

*Diagnosis*.—Abactinal surface of distal half of arm confined to carinal and adradial plates. Only four internal radiating ossicles to a plate. Each papular pore containing a single papula. Excavate sugartong pedicellariae present. Furrow spines long, thin; each mouth plate bearing seven to nine.

*Description*.—Five arms. R = 45 mm; r = 13 mm; R/r = 3.5.

The general form is stellate, with a broad, flat disk and long, narrow, evenly tapered arms. The interbrachial arcs are wide and rounded.

The abactinal plates are arranged in a regular series parallel to the carinals, the proximal carinal plates and some disk plates being the largest. The abactinal surface is very narrow on the distal half of the arms and is restricted to the carinal and adradial plates. The abactinal plates are tabulate and irregularly round, except for the carinals, which are elongated transversely.

The bases of the abactinal plates are six-lobed in the papular areas, the lateral lobes being connected by internal radiating ossicles. There are only four ossicles to a plate; there are no ossicles in the distoproximal axis. Each plate bears one to three blunt, vertical spinules in its center and ten to 14 lanceolate, finely serrate, laterally directed spinules around its periphery. The larger number of spinules is found on the larger plates, most plates having only one spinule. Some of the plates have excavate sugar-tong pedicellariae with convex, strongly toothed jaws. These pedicellariae are about one and one-half to two times as high as the central spinules. The papular area is extensive. Papulae are absent only in the narrow inter-radial areas. There are six papular pores surrounding each plate, each pore containing a single papula.

The superomarginal and inferomarginal plates correspond. There are 44 plates in each series. Narrow marginal fascioles are present. The superomarginal plates are rectangular (about one and one-half times as wide as long) in the interbrachial arc, square in the middle of the arm, and become about one and one-half times as wide again distally. Five or six pairs of superomarginals are contiguous medially. The superomarginal plates are covered by regularly spaced spinules that are similar to, but slightly smaller than, those on the abactinals. Some plates have pedicellariae similar to those on the abactinals. The superomarginals slope downward so that they are fairly inconspicuous. The terminal plate is slightly larger than the adjacent superomarginals. It is naked and heart-shaped; the distal end is notched, the proximal end truncate. The inferomarginal plates are smaller than the superomarginals, especially distally. The inferomarginals are wider than long in the interbrachial arc, becoming square, and finally longer than wide distally. The granulation and pedicellariae are similar to those of the superomarginals.

The actinal intermediate area is large, extending about one-quarter the length of the arm. The actinal plates are irregularly round and convex. Those plates adjacent to the adambulacrals on the disk are about two times larger than the other actinal plates. Most of these large plates have excavate sugar-tong pedicellariae similar to those on the abactinals. None of the other actinals have pedicellariae. The actinal plates are covered by

regularly spaced, prismatic spinules that are slightly taller than those on the marginals.

The adambulacral plates are about half as large as the adjacent actinals. They are rectangular (slightly wider than long) proximally, square distally. The furrow margin is angular and extended dorsally, so that it forms a "shelf" which supports a furrow armature of four to six long, thin, blunt spines. The subambulacral spines are in two rows. The first row consists of three or four blunt, compressed spines which are slightly longer than, and about twice as thick as, the furrow spines. The second row is irregular and has four to six spinules like those found on the actinals.

The mouth plates are convex. Each plate bears seven to nine furrow spines which are similar to the furrow spines of the adambulacrals, except for the median spine. The median spine is slightly taller than the other furrow spines, and about twice as broad; it is strongly compressed. The rest of the mouth plate is covered by two irregular rows of five or six spines. Some of the spines are high and broad; some are spinules similar to those on the actinals. The median suture is barely distinct.

The anus is small, inconspicuous, and surrounded by spinules. The madreporite is small, square, and partially hidden by the plates surrounding it. It is located at one-third the distance from the center of the disk to the middle of the interbrachial arc. Irregularly round, flat, rudimentary superambulacral ossicles are present. The gonads are arranged in a series extending along the arm. The dorsal surface is pale orange, the ventral surface cream-colored in living specimens.

*Type*.—Museum of Comparative Zoology, cat. no. 470.

*Type-Locality*.—Off Barbados, 329 m, BLAKE sta. 295.

*Distribution*.—This species is known from the Straits of Florida, Cuba, the Windward Islands, and Brazil. It is probably found throughout the tropical western Atlantic. The bathymetric range is 205-576 m.

*Discussion*.—The smallest specimen examined ( $R = 19$  mm;  $r = 7$  mm;  $R/r = 2.7$ ) had fully developed adult characters.

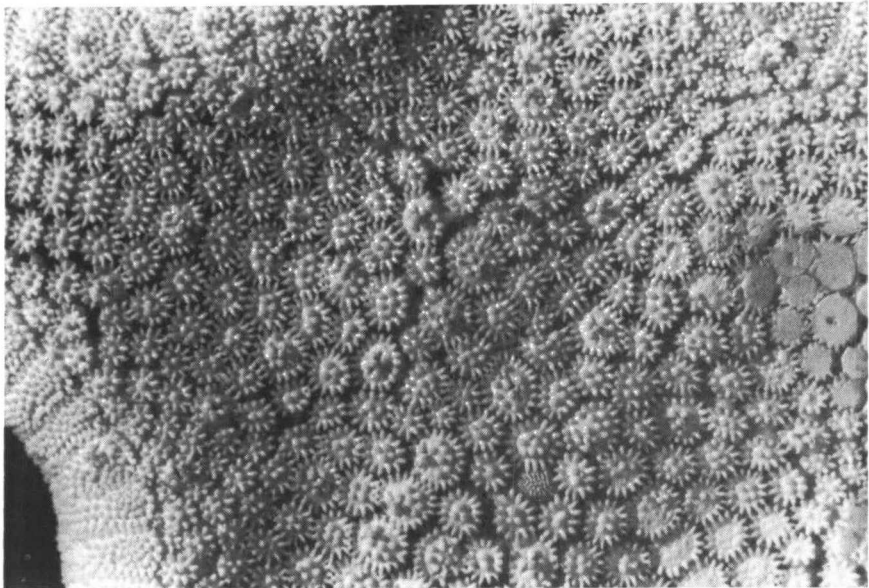
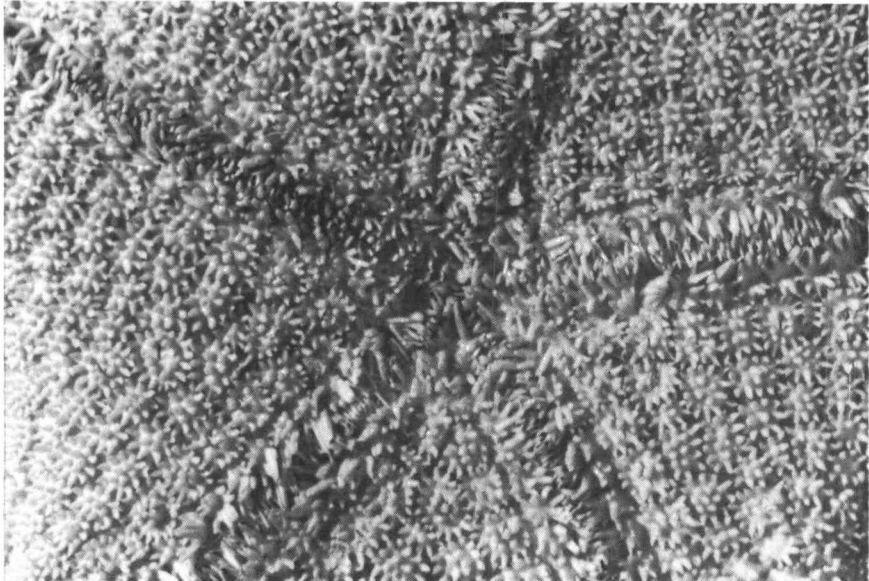
Most of the specimens examined bear excavate sugar-tong pedicellariae with convex, strongly toothed jaws on the large actinal plates adjacent to the adambulacrals. Many have no pedicellariae on any other actinal plates.

Many specimens lack pedicellariae on the abactinal surface; in those with abactinal pedicellariae, the pedicellariae are never abundant, and often

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FIGURE 4. *Mediaster pedicellaris* (Perrier): A, specimen from GERDA sta. G-482; 3.5 ×; B, specimen from GERDA sta. G-482; 3.5 ×.



**A****B**

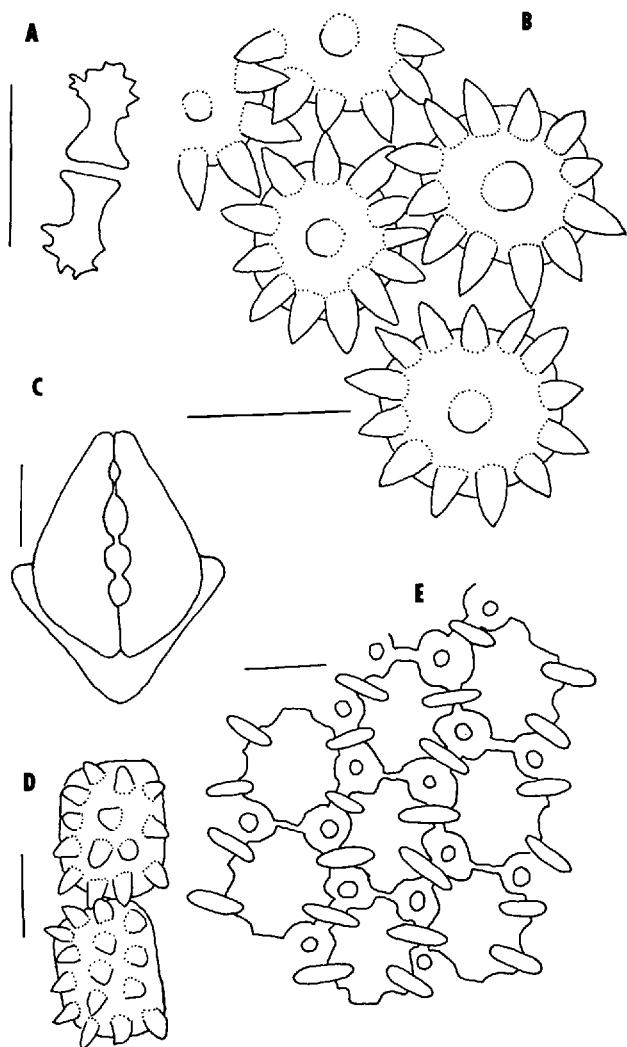


FIGURE 5. *Medaster pedicellaris* (Perrier): A, excavate sugar-tong pedicellaria, open; B, abactinal plates; C, mouth-plate pair, denuded of granules; D, actinal plates; E, under surface of radial abactinal plates, showing internal connecting ossicles.

limited to just one or two on the whole abactinal surface. Many specimens bear pedicellariae on the superomarginal and inferomarginal plates.

One, normal in all other respects, is aberrant in having smooth-jawed, spatulate pedicellariae on the mouth plates.

The number of superomarginals in contact varies from zero to seven and is usually five. No specimen from the Straits of Florida has less than three superomarginals in contact.

*Remarks.*—*Mediaster pedicellaris* is closely allied to *M. trinadensis* (to the south) and *M. bairdi* (to the north).

The separation of *Mediaster trinadensis* from *M. pedicellaris* is questionable. Bernasconi (1957a: 34) separates it as follows (translated from the Spanish): "It is distinguished by the superomarginal plates being very wide and not contiguous except for the last five. In *M. pedicellaris*, the plates are contiguous for the last third of the arm; they are also distinguished by the adambulacral armature."

Bernasconi gives no measurements, but the superomarginal plates do not appear exceptionally wider in the accompanying photograph. The number of superomarginals in contact is the same as in *Mediaster pedicellaris*.

I have examined nine specimens of *Mediaster* from one station off the coast of Brazil, near the equator, at a depth of 275 m. The number of superomarginals in contact medially is variable. In five of the Brazilian specimens it falls within the range of *M. pedicellaris*, but in the other four specimens it is zero to two.

In the type of *M. trinadensis* there is sometimes a thick bivalved pedicellaria (0.6 mm long) between the furrow spines and the first row of subambulacral spines of the adambulacral plates.

The type of *M. trinadensis* has seven furrow spines. *M. pedicellaris* has four to six and the Brazilian specimens have four to seven.

The number of central granules on the abactinal plates differ. In three of the Brazilian specimens it falls within the range of *M. pedicellaris*, but in the other six and in *M. trinadensis* it is greater.

All the differences that have been discussed are in variable characters. There is considerable overlapping, and these differences are probably clinal in nature.

The adambulacral pedicellariae in the type of *Mediaster trinadensis* may be aberrant, as are the pedicellariae on the mouth plates of one specimen of *M. pedicellaris*.

I consider the Brazilian specimens to be *Mediaster pedicellaris* and suggest that this is also true of *M. trinadensis*.

*Mediaster pedicellaris* and *M. bairdi* are distinct species. In the former, the abactinal surface is narrow and confined to the carinals and adradials on the distal half of the arm. In the latter, the abactinal surface of the distal half of the arm is wide, consisting of numerous small plates. In *M. bairdi* the abactinal surface always extends to the terminal plate, and the pedicellariae are spatulate, massive, and tend to be wider than high.

The type of *Mediaster agassizi* Verrill, 1899, apparently is lost, but

judging from Verrill's description (1899: 181-182) this is a junior synonym of *Mediaster pedicellaris* (Perrier).

Genus *Rosaster* Perrier, 1894

*Rosaster* Perrier, 1894: 386.—Fisher, 1911: 164.—Verrill, 1915: 110-111.—

Fisher, 1913: 629; 1919: 240-244.—Macan, 1938: 364-365.

*Nereidaster* Verrill, 1899: 186.

not *Nereidaster* Fisher, 1911: 170.

**Diagnosis.**—Abactinal plates strongly tabulate; internal radiating ossicles connecting bases of abactinal plates. Superomarginal plates contiguous throughout most of arm (if separated, then only by single series of small plates). Adambulacral plates with straight or slightly curved furrow margin. No superambulacral ossicles present. Gonads arranged in series extending along arms.

**Type-Species.**—*Pentagonaster alexandri* Perrier (by monotypy).

*Rosaster alexandri* (Perrier, 1881)

Figs. 6, 7

*Pentagonaster alexandri* Perrier, 1881a: 22-23; 1884: 168, 169, 170, 172, 177, 178, 183, 238-242, pl. 6, figs. 3-8.—Sladen, 1889: 256, 267, 295, 296, 748.—Perrier, 1894: 37, 335.

*Rosaster alexandri* Perrier, 1894: 36, 38, 39, 40, 387.—Verrill, 1899: 197; 1915: 111-113, pl. 11, figs. 3-3b, pl. 17, fig. 2.—Fisher, 1919: 240, 241, 242, 243, 247, 255.—H. L. Clark, 1941: 41.—Madsen, 1951: 89.—A. H. Clark, 1954: 375.

**Material Studied.**—HOLOTYPE: R = 9 mm, r = 4.5 mm, R = 2.0r; off Barbados, 183 m, HASSLER sta. 4, 1871, MCZ 450.

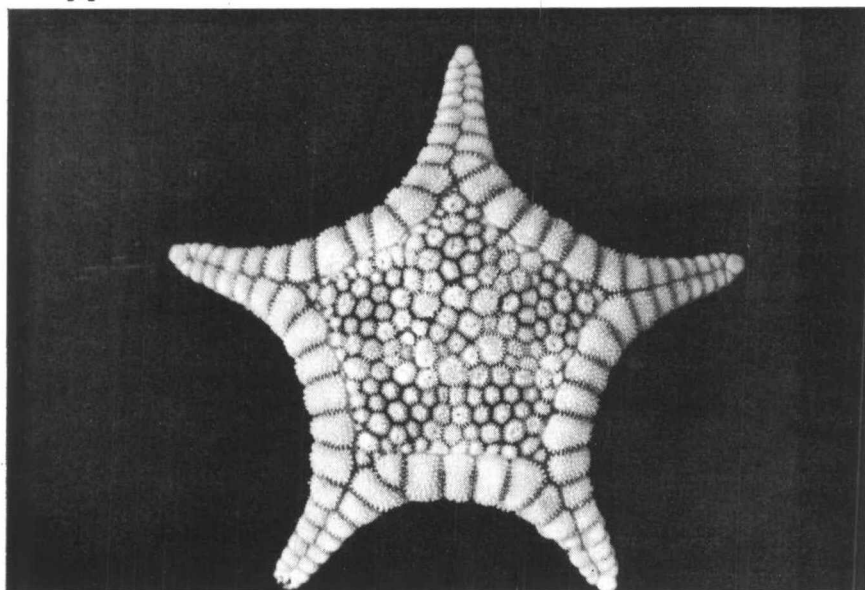
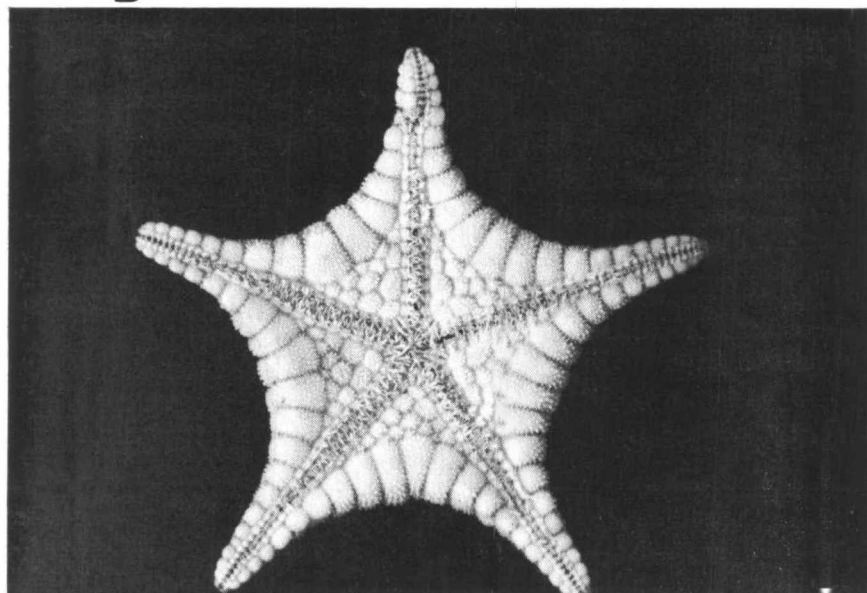
OTHER MATERIAL: 24°42'N, 80°32'W, 137 m, R/V GERDA sta. G-596, 15 April 1965, UMML 40.122, 2 spec.—21°10'N, 86°21'W, 242-320 m, R/V GERDA sta. G-893, 10 September 1967, 2 spec.—20°59'N, 86°24'W, 210-293 m, R/V GERDA sta. G-897, 10 September 1967, 1 spec.—00°18'N, 44°23'W, 183 m, M/V OREGON sta. 4225, 9 March 1963, 5 spec.

**Diagnosis.**—R/r less than three. Abactinal plates rounded. Central and peripheral granules of abactinal plates approximately same size. Superomarginal plates contiguous medially throughout length of arm. Four or five adambulacral furrow spines; furrow spines long, slender.

**Description.**—Five arms. R = 20 mm; r = 10 mm; R/r = 2.0.

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FIGURE 6. *Rosaster alexandri* (Perrier): A, specimen from GERDA sta. G-596; 2.1 ×; B, specimen from GERDA sta. G-596; 2.0 ×.

**A****B**

The general form is stellate. The disk is flat and the arms are moderately short and strongly tapered.

The abactinal surface is restricted to the disk. The abactinal plates are tabulate and irregularly round. The bases of the abactinal plates are six-lobed in the papular area, the lobes being connected by internal radiating ossicles. Each plate bears two to eight short, blunt, vertical spinules in its center and 12 to 20 truncate, pectinate, laterally directed spinules around its periphery. The central and peripheral spinules are about the same size. Many of the plates have excavate sugar-tong pedicellariae. The papular areas are conspicuous but small, being restricted to the radial areas at the bases of the arms. Each plate is surrounded by six papular pores, each pore bearing a single papula.

The superomarginal and inferomarginal plates correspond in the interbrachial arc and proximal half of the arm, but alternate distally. Narrow marginal fascioles are present. There are 18 superomarginal plates. They are wider than long and rounded at their free edge. These plates are contiguous medially throughout the length of the arm; there are seven pairs in contact. The superomarginals are covered by regularly spaced, short, blunt spinules which are taller at the free edge. Some plates have excavate sugar-tong pedicellariae similar to those found on the abactinal plates. The terminal plate is slightly larger than the superomarginals adjacent to it. It is naked and heart-shaped, with its distal end notched and its proximal end truncate. There are 20 inferomarginal plates. They are wider than long in the interbrachial arc, but become longer than wide distally. Their granulation is similar to the superomarginals.

The actinal intermediate area is small, being restricted to the disk. The actinal plates are large and convex. These plates are covered by nine to 22 regularly spaced, conical spinules. Some of the plates have excavate sugar-tong pedicellariae similar to those of the abactinals.

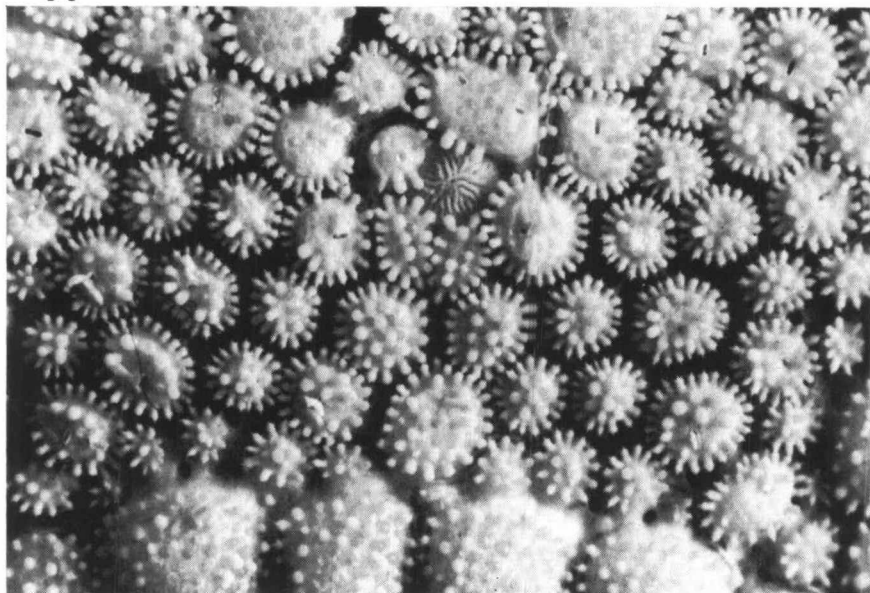
The adambulacral plates are about half as large as the actinal plates adjacent to them. They are rectangular proximally (about one and one-half times as wide as long), but become square distally. They bear four or five long, thin, blunt furrow spines. The first subambulacral row consists of two or three spines that are slightly shorter than the furrow spines and about twice as thick. The rest of the subambulacral spines are in one or two irregular rows of spinules similar to those of the actinals.

The mouth plates are thin and small. Each plate bears six compressed furrow spines. The first spine is slightly larger than the adambulacral furrow spines and the spines gradually increase in size proximally, so that

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FIGURE 7. *Rosaster alexandri* (Perrier): A, specimen from GERDA sta. G-596; 10.0  $\times$ ; B, specimen from GERDA sta. G-596; 10.0  $\times$ .

**A****B**

the median spine is largest. Immediately behind and parallel to the furrow spines is a row of three spines that are slightly larger. There are three or four regularly spaced spinules, similar to those of the actinals, covering the rest of the plate.

The madreporite is small, irregularly square, and partly hidden by the plates surrounding it. It is located at one-third the distance from the center of the disk to the middle of the interbranchial arc. The anus is small, sub-central, and surrounded by spinules. The ambulacral plates are pectinate. No superomarginal ossicles are present. The gonads are arranged in a series extending along the arms. The color of the living specimen is pale orange on the dorsal surface and cream-colored on the ventral surface.

*Type*.—Museum of Comparative Zoology, cat. no. 450.

*Type-Locality*.—Off Barbados, 183 m, HASSLER sta. 4.

*Distribution*.—This species is known from the Straits of Florida, the southern Gulf of Mexico, Cuba, Barbados, and Brazil. It is probably found throughout the tropical western Atlantic. The bathymetric range is 68-443 m, with records from 3530 m and 1793 m of questionable validity. Sladen (1889: 748) questioned the record from 3530 m.

*Discussion*.—The number of pedicellariae is variable. The type, all the Brazilian specimens, and two of the specimens from Yucatan have none; one specimen from Yucatan has abactinal pedicellariae. One of the specimens from the Straits of Florida has pedicellariae on the abactinal and actinal plates; the other has pedicellariae on the abactinal plates only.

The Brazilian specimens differ from those of the Caribbean area in having the same number of marginal plates in each series; these correspond throughout the arm.

The smallest specimen examined has  $R = 9$ ,  $r = 4.5$ ; the largest,  $R = 27$ ,  $r = 11$ . No growth differences were discernible.  $R/r$  ranges from 1.9 to 2.8.

#### Genus *Ceramaster* Verrill, 1899

*Ceramaster* Verrill (Sec. C of *Tosia*), 1899: 161.—Fisher (subgenus), 1906: 1054; 1911: 204-205.—Verrill, 1914: 289-290.—Koehler, 1924: 173-174.—Mortensen, 1927: 80.—Tortonese, 1937: 59.—Tortonese & A. M. Clark, 1956: 348, 349, 351.—Bernasconi, 1963: 7-8; 1964: 254.

*Philonaster* Koehler (subgenus), 1909b: 74.

*Diagnosis*.—Abactinal plates completely covered by granules. Radial abactinal plates tabulate; peripheral granules distinct from central. Usually no secondary abactinal plates; when secondary abactinal plates present, confined to disk. No superambulacral ossicles. No internal radiating ossicles.

*Type-Species*.—*Asterias granularis* Retzius (by subsequent designation: Fisher, 1906: 1054).



*Ceramaster grenadensis* (Perrier, 1881)

Figs. 8, 9

*Pentagonaster grenadensis* Perrier, 1881a: 19-20; 1884: 168, 181, 186, 232-233, pl. 8, fig. 2.—Sladen, 1889: 265, 266, 744.—Perrier, 1894: 39, 390.

*Pentagonaster affinis* Perrier, 1884: 168, 183, 186, 243, pl. 8, fig. 4.—Sladen, 1889: 265, 267, 744.—Perrier, 1894: 40, 390.

*Tosia affinis* Perrier, 1884: 183.

*Tosia grenadensis*: Verrill, 1899: 162.

*Pyrenaster affinis*: Verrill, 1899: 168; 1915: 222.

*Ceramaster affinis*: Fisher, 1911: 165.

*Ceramaster grenadensis*: Verrill, 1915: 222.—H. L. Clark, 1941: 38-39.—A. H. Clark, 1954: 375.

*Material Studied*.—HOLOTYPE: R = 26 mm, r = 17 mm, R = 1.5r; off Grenada, 1054 m, BLAKE sta. 265, 1878-79, MCZ 416.

OTHER MATERIAL: 27°49'N, 78°45'W, 824 m, R/V GERDA sta. G-403, 20 September 1964, UMML 40.176, 3 spec.—25°08'N, 79°25'W, 841 m, R/V GERDA sta. G-293, 4 April 1964, UMML 40.179, 1 spec.—23°55'N, 81°16'W, 1153-1190 m, R/V GERDA sta. G-375, 17 September 1964, UMML 40.180, 1 spec.—23°26'N, 84°02'W, 2421 m, BLAKE sta. 40, 1877-78, MCZ 404 (paratype of *Pentagonaster affinis* Perrier), 1 spec.—23°26'N, 80°33'W, 1016 m, ATLANTIS sta. 2992, 15 March 1938, MCZ 3944, 1 spec.—23°24'N, 81°01'W, 677-1107 m, ATLANTIS sta. 2995, 16 March 1938, MCZ 3945, 1 spec.—23°21'N, 79°58'W, 576 m, ATLANTIS sta. 2987D, 13 March 1938, MCZ 3942, 2 spec.—23°21'N, 79°57'W, 715 m, ATLANTIS sta. 3449, 3 May 1939, MCZ 3949, 2 spec.—23°18'N, 80°46'W, 897 m, ATLANTIS sta. 3474, 10 May 1939, MCZ 3950, 1 spec.—23°15'N, 79°57'W, 695 m, ATLANTIS sta. 2988, 14 March 1938, MCZ 3943, 1 spec.—21°01'N, 86°25'W, 210 m, R/V GERDA sta. G-879, 9 September 1967, 1 spec.—20°51'N, 75°21'W, 1025 m, ATLANTIS sta. 3377, 20 April 1939, MCZ 3948, 1 spec.—20°49'N, 74°56'W, 1519 m, ATLANTIS sta. 3363, 19 April 1939, MCZ 3947, 1 spec.—19°07'N, 74°52'W, 2196 m, BLAKE sta. 111, 1878-79, MCZ 404 (paratypes of *Pentagonaster affinis* Perrier), 2 spec.—Off Dominica, 2070 m, BLAKE sta. 182, 1878-79, MCZ 403 (holotype of *Pentagonaster affinis* Perrier; R = 25 mm, r = 15 mm, R = 1.7r).—09°24'N, 76°34'W, 924-950 m, R/V PILLSBURY sta. 364, 13 July 1966, 1 spec.—00°18'N, 44°17'W, 275 m, M/V OREGON sta. 4226, 9 March 1963, UMML 40.177, 2 spec.

*Diagnosis*.—General form pentagonal to arcuate pentagonal. Abactinal plates low-tabulate; bases irregularly round, not lobate; no secondary plates. Papular area restricted to moderately small radial areas; each papular pore bearing one papula. Pedicellariae, when present, small, excavate sugar-tong. Five to seven adambulacral furrow spines.

*Description*.—Five arms. R = 21 mm; r = 16 mm; R/r = 1.3.

The general form is pentagonal to arcuate pentagonal. The disk is large and flat.

The abactinal plates are arranged in a regular series parallel to the carinals. The largest plates are at the tops of the interradii. The abactinals are low-tabulate and irregularly round. Each carinal plate has 15 to 25 rounded granules in its center and 10 to 20 flattened, rectangular granules that are slightly longer than wide around its periphery. All the other abactinal plates are covered only by closely crowded, rounded granules like those on the center of the carinals. Some of the plates have small, excavate sugar-tong pedicellariae. The bases of the plates are irregularly round and not lobate. The papular area is restricted to the moderately narrow radial areas. There are six papular pores surrounding each plate, each pore containing a single papula. The interradiial areas are large and triangular.

The superomarginal and inferomarginal plates correspond. There are 12 massive plates in each series. The superomarginal plates are rectangular (about twice as wide as long). There are one or two pairs in contact medially. The superomarginals are covered by closely crowded, rounded granules like those covering the interradiial abactinals. Some of the plates have small, excavate sugar-tong pedicellariae like those on the abactinals. The terminal plate is small (about one-third the size of the adjacent superomarginals), naked and heart-shaped. Its distal end is notched, proximal end truncate. The inferomarginal plates are rectangular (one and one-half to two times as wide as long). They are covered by closely crowded, rounded granules like those on the superomarginals.

The actinal plates are moderately small, swollen, and rhombic. Some of them have small, excavate sugar-tong pedicellariae like those on the abactinals. The actinals are covered by large, closely crowded granules like those on the inferomarginals.

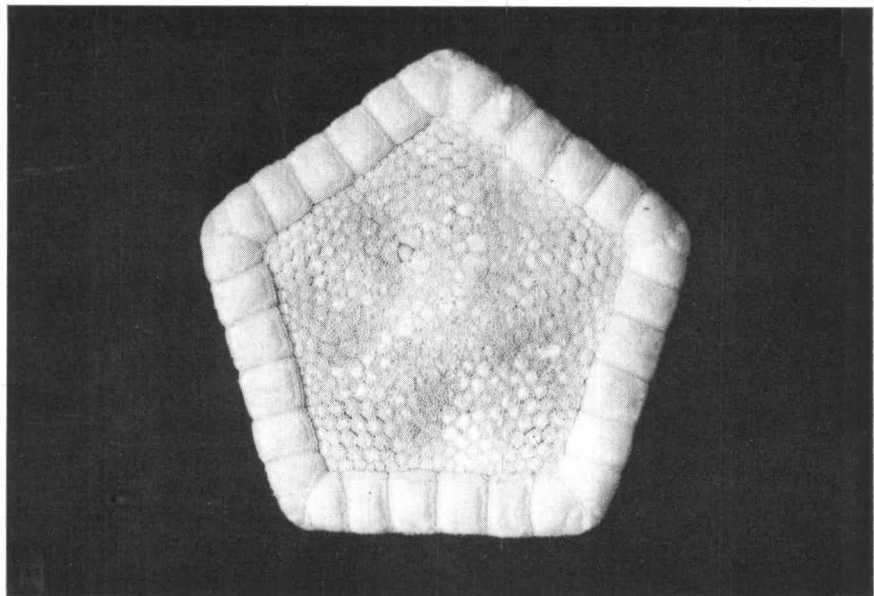
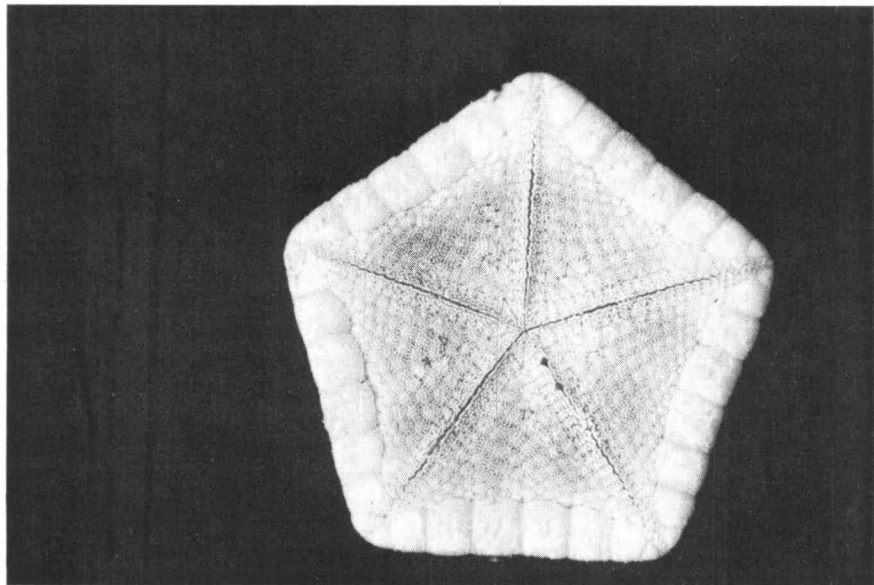
The adambulacral plates are rectangular (slightly wider than long). They are about half the size of the adjacent actinals. The furrow margin is slightly curved. It bears five or six subequal, short, compressed furrow spines with rounded tips. The subambulacral spines are in three or four irregular rows of large, rounded granules like those on the actinal plates. The first row is often slightly enlarged. Many of the plates bear small, excavate sugar-tong pedicellariae like those on the abactinals.

The mouth plates are long and triangular. Each plate bears nine furrow spines. The first eight spines are subequal and like the adambulacral furrow spines. The median spine is about one and one-half times as large as the

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FIGURE 8. *Ceramaster grenadensis* (Perrier): A, specimen from GERDA sta. G-897; 2.0 ×; B, specimen from GERDA sta. G-897; 2.0 ×.

**A****B**

other eight spines. There are three large, compressed, subequal spines distal to the median spine in a row along the suture. These three spines are about the same size as the median spine. The rest of the plate is covered by six or seven prismatic to rounded granules, about the same size as the actinal granules.

The anus is small, subcentral, and surrounded by spinules. The madreporite is rhombic, small, and about half the size of the adjacent abactinal plates. It is located approximately one-third the distance from the center of the disk to the middle of the interbranchial arc. The gonads are serial. They are in thick, triangular tufts on each side of the interbranchial septum. The color of the living specimen is pale orange on the dorsal surface and cream-colored on the ventral surface.

*Type*.—Museum of Comparative Zoology, cat. no. 416.

*Type-Locality*.—Off Grenada, 1054 m, BLAKE sta. 265.

*Distribution*.—This species is known from as far north as east of Fort Pierce, Florida, and as far south as off Brazil, just north of the equator. It is known from the following localities in the Caribbean: Straits of Florida, northern and southern coasts of Cuba, Windward Passage between Cuba and Haiti, off Dominica, off Grenada, and off Isla Fuerte, Colombia. It is probably found throughout the tropical western Atlantic. The bathymetric range in the Caribbean is 576-2421 m. Off Yucatan and Brazil it was found in only 210 m and 275 m, respectively.

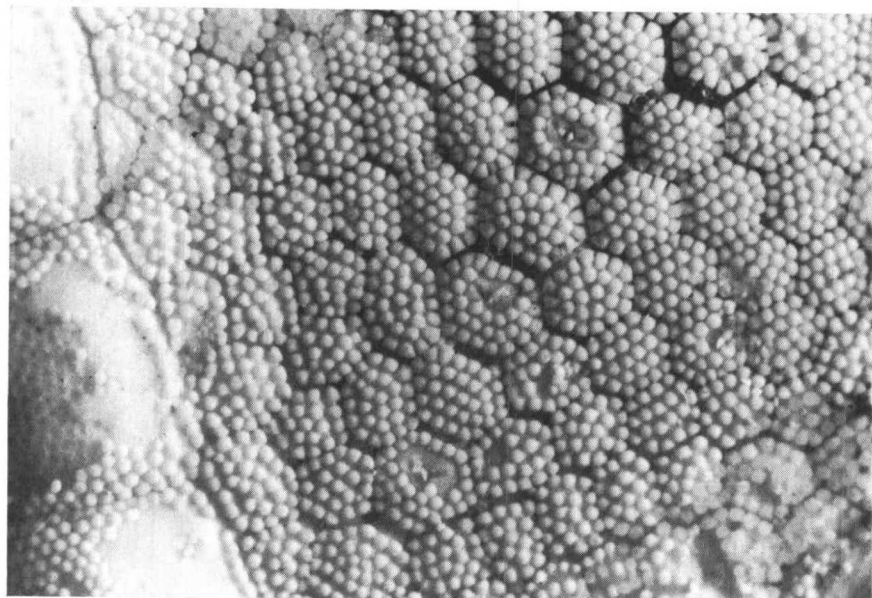
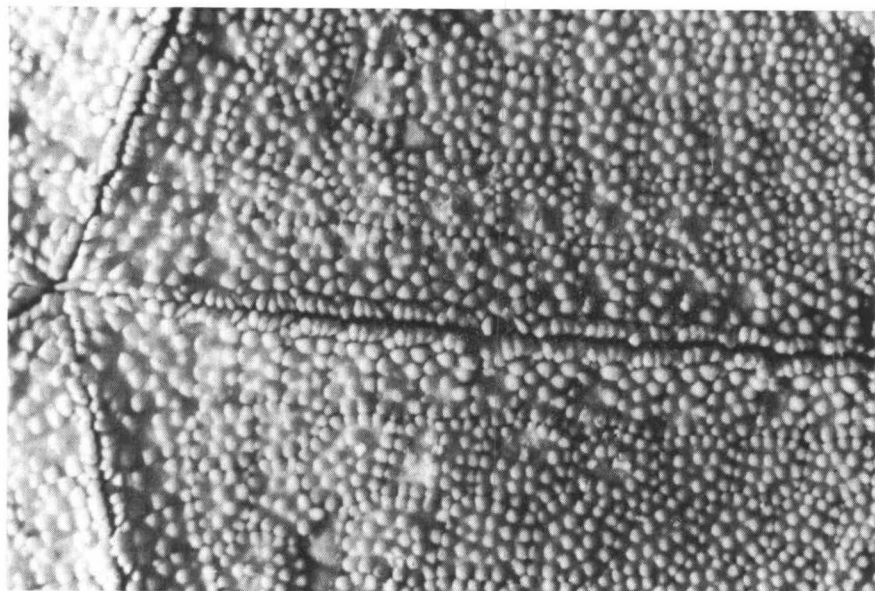
*Discussion*.—The R/r ratio ranges from 1.3 to 1.9. The pedicellariae are variable; they are absent in some specimens, while others have them on the abactinal, actinal, adambulacral, superomarginal and/or inferomarginal plates. The number of superomarginals in contact varies from one to four.

The general body form is variable. There are three basic forms; they are the same as are found in *Plinthaster dentatus*, but the variation is not as great (see Discussion and Remarks under *Plinthaster dentatus*).

The only difference between the types of *Ceramaster grenadensis* and *C. affinis* is the granulation of the radial plates. In *C. affinis* the peripheral granules are elongate, in *C. grenadensis* they are square. The holotype of *C. affinis* appears very distinctive. This is due to the aberrant, malformed superomarginal plates, probably from an earlier injury. The paratypes have normal superomarginal plates. The peripheral granules of the radial plates in the specimens I have examined range from square to twice as long as

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FIGURE 9. *Ceramaster grenadensis* (Perrier): A, specimen from OREGON sta. 4226; 10.0 ×; B, specimen from GERDA sta. G-897; 9.4 ×.

**A****B**

wide, with a complete spectrum of intermediate forms. There is a tendency toward elongation of the peripheral granules with an increase in depth. The state of relaxation or contraction of the specimen is also important in the appearance of the radial plates. Taking these factors into consideration, I have concluded that *Ceramaster grenadensis* and *C. affinis* are one species.

Genus *Tessellaster* H. L. Clark, 1941

*Tessellaster* H. L. Clark, 1941: 36.

**Diagnosis.**—General form stellate with long arms. Abactinal plates completely covered by granules; radial abactinal plates tabulate. No secondary abactinal plates. Furrow margins of adambulacral plates strongly angular, becoming apophyses distally. No internal radiating ossicles. No superambulacral ossicles.

**Type-Species.**—*Tessellaster notabilis* H. L. Clark (by original designation: H. L. Clark, 1941: 36).

*Tessellaster notabilis* H. L. Clark, 1941

Figs. 10, 11

*Tessellaster notabilis* H. L. Clark, 1941: 36-38, pl. 5, fig. 1.—A. H. Clark, 1954: 375.

**Material Studied.**—HOLOTYPE: R = 95 mm, r = 28 mm, R = 3.8r; 22° 33'N, 78°09'W, 467 m, ATLANTIS sta. 3388, 26 April 1939, MCZ 3817.

OTHER MATERIAL: 27°48'N, 79°01'W, 536 m, R/V GERDA sta. G-405, 21 September 1964, UMML 40.129, 1 spec.—27°47'N, 79°14'W, 549-567 m, R/V GERDA sta. G-260, 7 February 1964, UMML 40.157, 1 spec.—26°28'N, 78°40'W, 554-575 m, R/V GERDA sta. G-695, 22 July 1965, UMML 40.158, 1 spec.—22°48'N, 78°48'W, 412 m, ATLANTIS sta. 2981, 10 March 1938, MCZ 3941 (paratype), 1 spec.—17°39'N, 62°16'W, M/V OREGON sta. 6699, 19 May 1967, 1 spec.

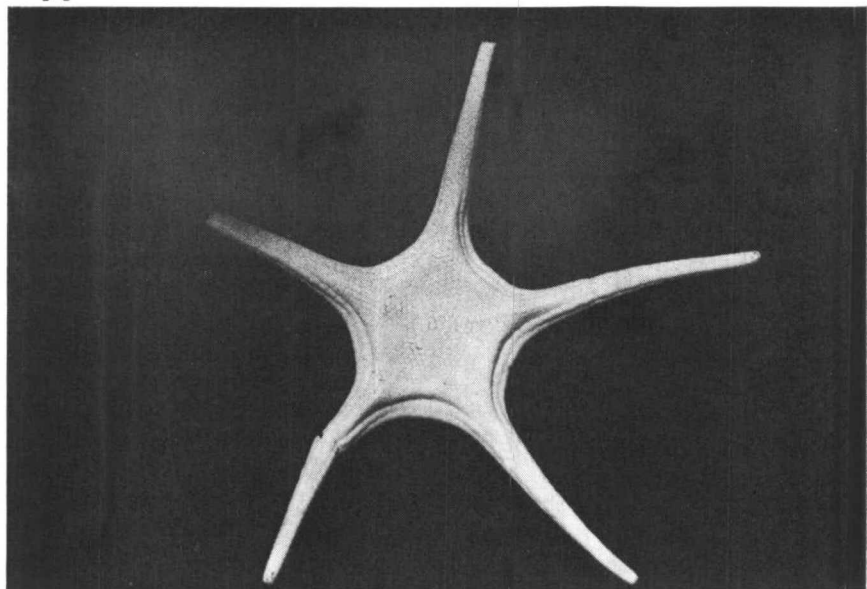
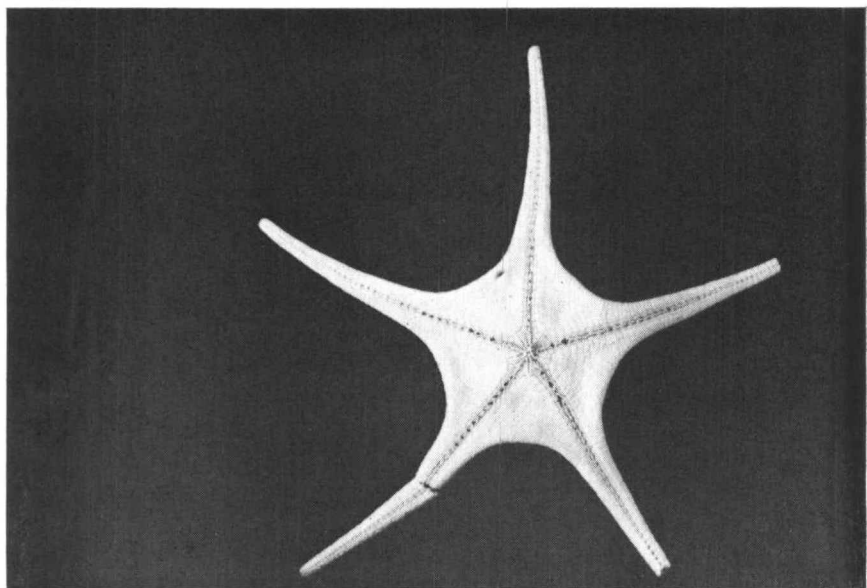
**Diagnosis.**—Arms long, narrow; R/r about four. Abactinal surface extending about half way down arm. Carinal plates low-tabulate; bases with six prominent lobes. Furrow margin of adambulacral plates strongly angular; apophysis appearing at about ninth plate.

**Description.**—Five arms. R = 74 mm; r = 19 mm; R/r = 3.9.

The general form is stellate. The disk is large and inflated, and the arms are very long and narrow.

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FIGURE 10. *Tessellaster notabilis* H. L. Clark: A, specimen from GERDA sta. G-405; 0.6 ×; B, specimen from GERDA sta. G-405; 0.6 ×.

**A****B**

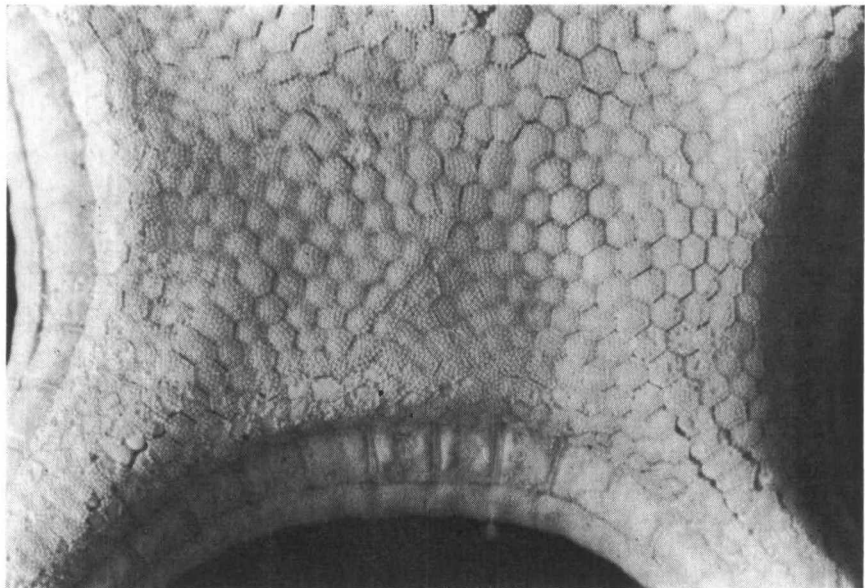
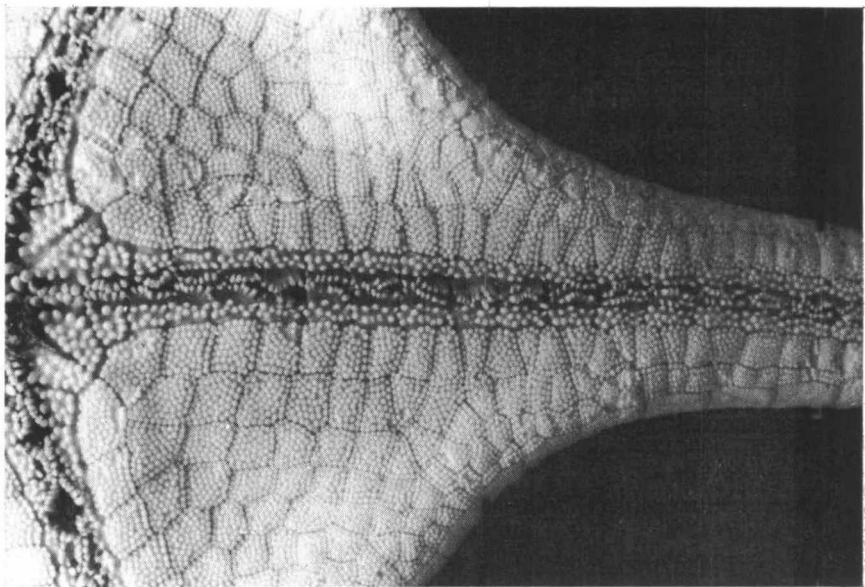
The abactinal plates are arranged in a regular series parallel to the carinals. The abactinal surface extends slightly more than half way down the arm and is limited to the carinals and adradials on the arm. The abactinal plates are small and numerous. The plates of the radial areas are low-tabulate and hexagonal. They are covered by 20 to 35 rounded granules in the center and 15 to 25 flattened, irregularly rectangular (slightly longer than wide) marginal granules. The interradian areas are large and triangular. The plates are flat and covered by rounded granules like those found in the center of the radial plates. They have no specialized marginal granules. The bases of the radial plates have six prominent, swollen, truncate lobes. These lobes are absent in the plates of the interradian areas and of the center of the disk, whose bases are irregularly round. The papular areas are oval and moderately small. They extend from the bases of the arms to the center of the disk. There are six papular pores surrounding each plate, each pore containing a single papula. The center of the disk is small and devoid of papulae.

The marginal plates correspond in the interbrachial arc and on the proximal half of the arm, but alternate on the distal half of the arm. There are 56 small, thin, superomarginal plates. The lateral angle of the plates is depressed, so that the plates are flattened and inconspicuous. They become more angular distally. The superomarginals are wider than long in the interbrachial arc, slightly longer than wide in the proximal half of the arm, and again become slightly wider than long in the distal half of the arm. There are 15 to 17 plates in contact medially. There is a single row of small, rounded granules along the margin of each plate. The plates in the middle of the interbrachial arc have an indentation in their center, which occupies about half the plate. This indentation bears about 60 small, rounded granules similar to those along the margin of the plate. The rest of the plate is naked. This indented, granulated area becomes smaller distally until, about half way down the arm, it disappears and the plates are completely naked except for the marginal granules. Even these marginal granules disappear in the last seven plates. The small terminal plate is oval and about the same size as the adjacent superomarginals. There are 62 inferomarginal plates. They are small and largely confined to the lateral surface. The plates are slightly wider than long in the interbrachial arc, becoming about one and one-half times as long as wide in the proximal half of the arm and approximately square in the distal half. They are completely covered by small, rounded granules like those found on the

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FIGURE 11. *Tessellaster notabilis* H. L. Clark: A, specimen from GERDA sta. G-405; 3.3 ×; B, specimen from GERDA sta. G-405; 3.3 ×.



**A****B**

superomarginals, except for the last eight, which have only one row of marginal granules.

The actinal plates are moderately large, rhombic to polygonal, and covered by about 40 granules that are slightly larger than those of the inferomarginals.

The adambulacral plates are about one and one-half times as long as wide and about half the size of the adjacent actinals. The furrow margin is strongly angular, an apophysis appearing at about the ninth plate. There are seven subequal, moderately short, stout, compressed furrow spines with rounded tips. A wide channel separates the furrow spines from the subambulacral spines. The subambulacral spines are in two or three irregular rows of four to six large, coarsely round granules about twice as large as the actinal granules.

The mouth plates are moderately prominent. Each plate bears eight or nine furrow spines. The first four or five spines are subequal; they are slightly higher and thicker than the adambulacral furrow spines. The next three spines are about one and one-half times as high as the first four or five; the median spine is about twice as high and thick as the first four or five spines. There is one short, stout spine behind the median spine. It is about one-third as high as the median spine. The rest of the plate is covered by about 30 coarse, closely crowded granules, slightly larger than the subambulacral granules of the adambulacral plates.

The irregularly round madreporite is three to four times as large as the adjacent abactinals. It is located about one-third the distance from the center of the disk to the middle of the interbrachial arc. The anus is small, subcentral, and surrounded by small, conical spinules. The gonads are in single tufts on each side of the interbrachial septum. There are no pedicellariae, superambulacral ossicles, or internal radiating ossicles.

*Type*.—Museum of Comparative Zoology, cat. no. 3817.

*Type-Locality*.—Old Bahama Channel, Camaguey Province, Cuba, 22° 33'N, 78°09'W, 467 m, ATLANTIS sta. 3388.

*Distribution*.—This species is known from the northern Straits of Florida from Delray Beach to Vero Beach, 536-575 m; in Old Bahama Channel, off the northern coast of Cuba, 412-467 m; and off Barbuda, 329-339 m.

*Discussion*.—All specimens examined have  $R/r = 3.8$ .  $R$  ranged from 65 mm to 95 mm. The peripheral granules of the radial abactinal plates ranged from square to one and one-half times as long as wide.

#### Genus *Nymphaster* Sladen, 1885

*Nymphaster* Sladen, 1885: 612; 1889: 294-295.—Fisher, 1917: 167-168; 1919: 261-263.—Macan, 1938: 373-374.

*Dorigona* Perrier (not Gray), 1885a: 39; 1894: 365.—Koehler, 1909b: 54.

*Diagnosis*.—Arms long; R/r greater than three. Superomarginals contiguous medially throughout length of arm. Abactinal plates low-tabulate. Adambulacral plates with strongly angular furrow margins, becoming apophyses distally. Gonads in a single tuft; no internal radiating ossicles.

*Type-Species*.—*Nymphaster protentus* Sladen (= *Pentagonaster arenatus* Perrier) (by subsequent designation: Fisher, 1917: 168).

*Remarks*.—The genus *Nymphaster* is widespread and common in the Atlantic Ocean, but presents a difficult taxonomic problem. I have concluded that there are only two valid species in the Atlantic.

#### KEY TO THE ATLANTIC SPECIES OF THE GENUS *Nymphaster*

1. Actinal plates covered by short, stout, conical spines ..... *subspinosus*
2. Actinal plates covered by rounded granules ..... *arenatus*

#### *Nymphaster arenatus* (Perrier, 1881)

Fig. 28, B

*Pentagonaster arenatus* Perrier, 1881a: 21; 1884: 168, 176, 178, 179, 181, 182, 186, 236-238, pl. 7, figs. 3, 4; 1894: 39.

*Pentagonaster ternalis* Perrier, 1881a: 20; 1884: 168, 180, 181, 186, 233-234, pl. 1, fig. 1.—A. Agassiz, 1888: fig. 377.

*Dorigona arenata* Perrier, 1885a: 39, 40; 1885b: 884; 1894: 31, 32, 33, 34, 38, 39, 40, 379-382, pl. 21, fig. 5, pl. 22, fig. 6, pl. 24, figs. 5, 6.—Koehler, 1895: 15; 1896: 57-58, 124-125; 1909a: 83, pl. 3, fig. 7.—Grieg, 1921: 19-20, pl. 4, figs. 5-8.

*Dorigona prehensilis* Perrier, 1885a: 39-40; 1894: 31, 32, 33.

*Dorigona ternalis* Perrier, 1885a: 39, 40; 1894: 39, 371-375.

not *Dorigona ternalis*: Koehler, 1909b: 54-58, pl. 8, fig. 5, 6.

*Nymphaster protentus* Sladen, 1889: 295, 296, 300, 303-306, 307, 309, 651, 693, 705, 752, pl. 50, figs. 3, 4, pl. 53, figs. 9, 10.—Bell, 1889: 434-435.—Bourne, 1890: 326-327.—Sladen, 1891: 694.—Verrill, 1899: 186.—Farran, 1913: 12.

*Nymphaster albidus* Sladen, 1889: 295, 296, 306-308, 309, 655, 694, 750, pl. 51, figs. 1, 2, pl. 53, figs. 5, 6.—Verrill, 1899: 186.

*Nymphaster basilicus* Sladen, 1889: 295, 296, 306, 308-310, 655, 693, 709, 752, pl. 57, figs. 8, 9.—Verrill, 1899: 186.

*Nymphaster arenatus*: Sladen, 1889: 752.—Verrill, 1899: 186.—Farran, 1913: 11-12.—Fisher, 1919: 277.—Koehler, 1924: 182.—Mortensen, 1927: 84-85, fig. 48.—H. L. Clark, 1941: 39-40.—A. H. Clark, 1954: 375.—Dilwyn-John & A. M. Clark, 1954: 139.

*Nymphaster prehensilis*: Sladen, 1889: 752.

*Nymphaster ternalis*: Sladen, 1889: 752.—Verrill, 1899: 185, pl. 26, fig. 7.—Fisher, 1919: 264, 266, 268, 276, 278, 282.—A. H. Clark, 1954: 375.

*Pentagonaster subspinosus*: Bourne, 1890: 327.

*Nymphaster subspinosus*: Bell, 1892: 75-76.—Nichols, 1903: 249.—Kemp, 1905: 189.

*Dorigona jacqueti* Perrier, 1894: 31, 383-386, pl. 21, fig. 4, pl. 22, fig. 5.—Koehler, 1895: 15.

*Nymphaster jacqueti*: Koehler, 1924: 182.

*Material Studied.*—LECTOTYPE: R = (31) mm, r = 8 mm, R = 3.9r; off Barbados, 382 m, BLAKE sta. 274, 1878-79, MCZ 437.

PARALECTOTYPE: R = 19 mm, r = 4.5 mm, R = 4.2r; off Barbados, 527 m, BLAKE sta. 281, 1878-79, MCZ 438.

PARALECTOTYPE: R = (43) mm, r = 10.5 m, R = 4.1r; off Grenada, 300 m, BLAKE sta. 254, 1878-79, MCZ 439.

OTHER MATERIAL: SW of Ireland, 458-992 m, collector and date unknown, MCZ 2176, 1 spec.—34°44'N, 07°10'W, 407-636 m, TRAVAILLEUR, station and date unknown, MCZ 482, 1 spec.—28°53'N, 87°47'W, 1739-2022 m, M/V OREGON sta. 2814, 13 July 1960, 5 spec.—28°23'N, 88°22'W, 1830 m, M/V OREGON sta. 2820, 15 July 1960, 8 spec.—27°48'N, 94°55'W, 458 m, M/V OREGON sta. 1505, 6 May 1956, 4 spec.—26°44'N, 79°23'W, 690 m, R/V GERDA sta. G-302, 5 April 1964, UMML 40.206, 1 spec.—26°23'N, 79°32'W, 549 m, R/V GERDA sta. G-154, 25 June 1963, UMML 40.204, 2 spec.—25°57'N, 78°07'W, 733-897 m, R/V GERDA sta. G-190, 4 July 1963, UMML 40.203, 1 spec.—25°42'N, 79°58'W, 332-338 m, R/V GERDA sta. G-266, 29 March 1964, UMML 40.202, 1 spec.—24°19'N, 80°26'W, 897-915 m, R/V GERDA sta. G-223, 23 January 1964, UMML 40.208, 3 spec.—24°16'N, 82°58'W, 549-567 m, R/V GERDA sta. G-472, 25 January 1965, UMML 40.205, 2 spec.—24°14'N, 82°57'W, 641-686 m, R/V GERDA sta. G-112, 18 June 1963, UMML 40.201, 1 spec.—24°14'N, 82°54'W, 576 m, R/V GERDA sta. G-474, 25 January 1965, UMML 40.213, 1 spec.—24°14'N, 82°37'W, 550 m, R/V GERDA sta. G-475, 26 January 1965, UMML 40.253, 2 spec.—24°14'N, 82°26'W, 566-584 m, R/V GERDA sta. G-439, 29 November 1964, UMML 40.209, 2 spec.—24°14'N, 82°23'W, 549-567 m, R/V GERDA sta. G-440, 29 November 1964, UMML 40.207, 2 spec.—24°05'N, 82°29'W, 742-753 m, R/V GERDA sta. G-442, 29 November 1964, UMML 40.217, 1 spec.—24°04'N, 82°20'W, 792-829 m, R/V GERDA sta. G-443, 29 November 1964, UMML 40.211, 1 spec.—23°55'N, 82°02'W, 1373-1428 m, R/V GERDA sta. G-449, 1 December 1964, UMML 40.212, 1 spec.—23°30'N, 82°35'W, 1683-1739 m, R/V PILLSBURY sta. 586, 24 May 1967, UMML 40.230, 5 spec.—21°02'N, 86°29'W, 567-571 m, R/V PILLSBURY sta. 585, 23 May 1967, 1 spec.—16°54'N, 81°18'W, 458 m, M/V OREGON sta. 1885, 23 August 1957, 1 spec.—16°42'N, 82°36'W, 550 m, M/V OREGON sta. 1946, 16 September 1957, 1 spec.—Off Guadeloupe, 1343 m, BLAKE sta. 173, 1878-79, MCZ 483 (syntype of *Pentagonaster ternalis* Perrier).—13°31'N, 81°54'W, 550 m, M/V OREGON sta. 1920, 12 September 1957, 2 spec.—Off Barbados, 399 m, BLAKE sta. 275, 1878-79, MCZ 448, 1 spec.—12°31'N, 82°21'W, 366 m, M/V OREGON sta. 3574, 23 May 1962, 1 spec.—11°35'N, 62°37'W, 403-421 m, M/V OREGON sta. 2775, 19 April 1960, 2 spec.—11°33'N, 62°09'W, 576-597 m, R/V PILLSBURY sta. 478, 2 August 1966, UMML 40.228, 4 spec.—10°13'N, 76°05'W, 814-1050 m, R/V

PILLSBURY sta. 388, 15 July 1966, 1 spec.—10°05'N, 76°28'W, 1222-1748 m, R/V PILLSBURY sta. 391, 16 July 1966, UMML 40.214, 1 spec.—09°58'N, 78°31'W, 1803-1815 m, R/V PILLSBURY sta. 338, 9 July 1966, UMML 40.225, 5 spec.—09°52'N, 79°36'W, 1656-1774 m, R/V PILLSBURY sta. 325, 7 July 1966, UMML 40.229, 2 spec.—09°31'N, 76°34'W, 924-950 m, R/V PILLSBURY sta. 364, 13 July 1966, UMML 40.227, 4 spec.—09°00'N, 76°55'W, 952-1267 m, R/V PILLSBURY sta. 413, 18 July 1966, UMML 40.215, 4 spec.—07°46'N, 54°17'W, 640 m, M/V OREGON sta. 4297, 22 March 1963, 2 spec.—07°46'N, 54°00'W, 733 m, M/V OREGON sta. 4299, 23 March 1963, 1 spec.—07°44'N, 54°19'W, 549 m, M/V OREGON sta. 4300, 23 March 1963, 1 spec.—07°34'N, 54°13'W, 366 m, M/V OREGON sta. 4301, 24 March 1963, 2 spec.—07°21'N, 53°15'W, 550 m, M/V OREGON sta. 4294, 21 March 1963, 15 spec.—07°14'N, 52°55'W, 733 m, M/V OREGON sta. 4293, 21 March 1963, 1 spec.

*Diagnosis.*—Abactinal granules never mucronate. Actinals covered by rounded granules; granules sometimes elongated, but never spinose. Eight to 12 furrow spines on adambulacrals with fully developed apophyses; first row of subambulacral spines usually less than half as tall as furrow spines. Each mouth plate bearing eight to 11 furrow spines.

*Description.*—Five arms.  $R = 96$  mm,  $r = 23$  mm,  $R = 4.2r$ .

The general form is stellate with a broad disk and very long arms.

The abactinal surface is restricted to the disk. The plates are low-tabulate, irregularly round and completely covered by regularly spaced, rounded granules. The bases of the radial plates have six prominent, long, sub-cylindrical lobes. Some plates bear small, excavate sugar-tong pedicellariae. The papular area includes the center of the disk. The interradial areas are large and triangular. Six papular pores surround each plate; each pore contains a single papula.

The marginal plates correspond in the interbrachial arc and on the proximal half of the arm. There are 64 plates in each series. The superomarginals are in contact medially throughout the length of the arm. The superomarginal plates are about two and one-half times as wide as long in the interbrachial arc, becoming square at about the middle of the arm, and about twice as long as wide at about the middle of the distal half of the arm; they become square again distal to this. The superomarginals are completely covered by large, regularly spaced, rounded granules. The granules of the marginal row are only about two-thirds as large as the other granules. The terminal plate is oval, and about twice as large as the adjacent superomarginals. The inferomarginal plates are about twice as wide as long in the interbrachial arc and become elongated distally, so that they are square at about the middle of the arm, and about twice as long as wide in the distal part of the arm. The granulation of the inferomarginals is similar

to that of the superomarginals. Some of the plates bear small, excavate sugar-tong pedicellariae.

The actinal plates are rhombic to polygonal. The plates adjacent to the adambulacrals are largest. The actinal plates are covered by regularly spaced, large, rounded granules slightly larger than those on the marginals. Some plates bear excavate sugar-tong pedicellariae almost twice as large as the abactinal pedicellariae.

The adambulacral plates are about one and one-half times as long as wide, and are about half the size of the actinal plates adjacent to them. The furrow margin is strongly angular; an apophysis appears at the third or fourth plate and is fully developed by the eighth plate. There are six to seven furrow spines on each of the first three or four plates; when the apophysis first appears, the number of furrow spines increases until the apophysis is fully developed, whence each plate bears ten or 11 spines. The furrow spines are compressed, moderately long and have rounded tips. The subambulacral spines are in three or four irregular rows of four to five large, rounded granules which are slightly taller than the actinal granules. Some of the granules of the first row are elongated. Some plates bear two, three, or four jawed spatulate pedicellariae.

The mouth plates are long and triangular. Each plate bears ten or 11 furrow spines similar to those of the adambulacral plates; the median spine is slightly taller and more compressed than the others. A row of moderately tall, rounded spines lines the median suture; the rest of the plate is covered by scattered granules similar to those on the actinals.

The anus is subcentral and surrounded by small, conical spinules. The madreporite is irregularly square and about one and one-half times as large as the abactinal plates adjacent to it. It is located approximately one-fifth the distance from the center of the disk to the middle of the interbrachial arc. The gonads are in single tufts on each side of the interbrachial septum. In living material, the dorsal surface is orange and the ventral surface is cream colored.

*Type*.—Museum of Comparative Zoology, cat. no. 437 (lectotype).

*Type-Locality*.—Off Barbados, 382 m, BLAKE sta. 274.

*Distribution*.—This widely distributed species is amphi-Atlantic.

In the western Atlantic it is known from throughout the Caribbean and Gulf of Mexico and the northeastern coast of South America. The northernmost records are the northern Gulf of Mexico (28°53'N), north of the Little Bahama Bank (27°20'N), and off Palm Beach, Florida. It is known from as far south as Brazil (10°46'S). The bathymetric range is 275-3000 m.

Although apparently limited to tropical waters in the western Atlantic, in the eastern Atlantic it is found in temperate and subtropical seas. It is

known from the west coast of Ireland, 381-1332 m; the Bay of Biscay, 400-1410 m; off Morocco and southwestern Spain, 458-1635 m; the Canary Islands, 1098-1300 m; and southwest of the Canary Islands (25°45'N, 20°14'W), 2791 m. There is one questionable record from off the Cape Verde Islands (Sladen, 1889: 308).

*Discussion.*—The arms of most specimens are broken. Many are in various stages of regeneration, indicating mutilation during life; others have been broken in the trawl.

The abactinal plates vary from irregularly round to hexagonal. Their granules also vary and may all be subequal, or one to five of the central granules on a plate may be twice as large as the others. These variations sometimes occur within a single specimen and were documented as infra-specific by Macan (1938: 373-382) for *Nymphaster moebii*. The number of abactinal pedicellariae is variable, ranging from abundant to absent.

The marginal plates range from flat to tumid, exhibiting a complete intermediate spectrum. This variability was also discussed by Macan. Sugar-tong excavate pedicellariae, like those found on the abactinals, are sometimes found on the superomarginal and/or inferomarginal plates. Spines may be present on the superomarginal and/or inferomarginal plates. Perrier (1894: 382) reported specimens bearing marginal spines from the eastern Atlantic, and furthermore, he did not consider these spines as a reliable character for *Nymphaster subspinosus* (1884: 236).

The subambulacral spines of the adambulacral and mouth plates are usually less than half as tall as the furrow spines, but may be almost as tall. They also vary in number and are irregularly arranged, so that there may be two to four rows. Macan discussed the variability of the subambulacral spines in *N. moebii* (1938: 379). In adults there are eight to 12 furrow spines on adambulacral with fully developed apophyses. An adult mouth plate bears eight to 11 furrow spines. The actinal and adambulacral pedicellariae range from abundant to absent.

*Remarks.*—I have synonymized *Nymphaster ternalis* with *N. arenatus* for the following reasons: Perrier states that the apophysis of *N. ternalis* begins at the twenty-fourth adambulacral plate. I have examined the type and have found this to be an error. The apophysis begins at the third or fourth adambulacral plate. I suspect that "2-4" became "24" in an early transcription of Perrier's notes and he mistakenly propagated it. Perrier's major reason for separating *N. ternalis* from *N. arenatus* was that it has pedicellariae on the abactinal, actinal, and adambulacral plates, while the types of *N. arenatus* have no pedicellariae. A large series of specimens shows that the pedicellariae are variable and may be present on only some of these plates, in any combination. Perrier also mentions that the superomarginal plates of *N. ternalis* are more tumid, but when a large number of specimens

are examined many intermediate forms are found. This variation has also been demonstrated for *N. moebii* (Macan, 1938: 380). Perrier himself apparently became confused about these species. A specimen at the Museum of Comparative Zoology at Harvard, MCZ 448, was listed by Perrier (1884: 178, 238) as *N. arenatus*, but the label, in Perrier's own handwriting, identifies it as *N. ternalis*.

Perrier later examined specimens of *Nymphaster* with pedicellariae on the abactinal and actinal plates, but none on the adambulacrals. In a preliminary report (1885a: 39-40), he named this "intermediate" form *prehensilis*. In the final report (1894), he called this species *prehensilis* in one place, but elsewhere he referred to it as *jacqueti*. Naturally, *prehensilis* is the proper name, but his species was separated on the basis of pedicellariae, a variable and unreliable character, and is a synonym of *N. arenatus*. Mortensen (1927: 84) synonymized *prehensilis* with *arenatus*.

Sladen described three new species of *Nymphaster* in his "Challenger Report" (1889). *Nymphaster albicus* and *N. basilicus* are very close and are separated on the basis of the shape and pedicellariae of the abactinal plates. The differences in shape are slight, and well within the range of individual variation. These two species are separated from *N. protentus* because the subambulacral granules of the adambulacrals are slightly taller. This, too, is within the normal range of variation. Farran (1913: 12) sent specimens of *N. protentus* to H. L. Clark and Koehler, both of whom found it identical to *N. arenatus*. Mortensen (1927: 84) also synonymized *protentus* with *arenatus*.

I designate the specimen collected at BLAKE station 274 the lectotype and the type-locality is restricted to off Barbados, at a depth of 382 m. The specimens collected by the BLAKE at stations 254 and 281 are designated paralectotypes.

*Nymphaster subspinosus* (Perrier, 1881)

Figs. 12, 13

*Pentagonaster subspinosus* Perrier, 1881a: 21, 1884: 168, 176, 177, 178, 185, 234-236, pl. 6, fig. 1; 1894: 39.

*Dorigona subspinosus* Perrier, 1885a: 39, 40; 1894: 38, 39, 375-379.—Koehler, 1895: 453; 1896: 59-60, 124-125.

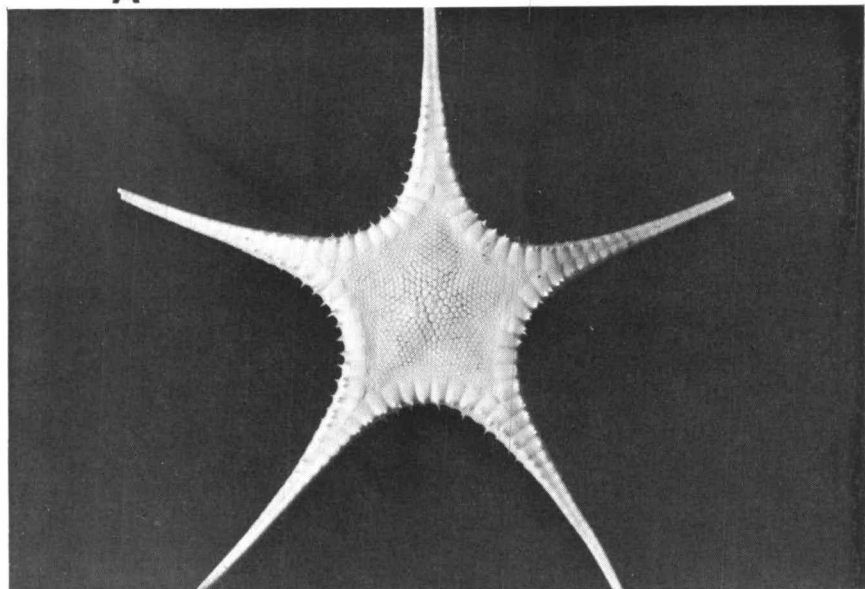
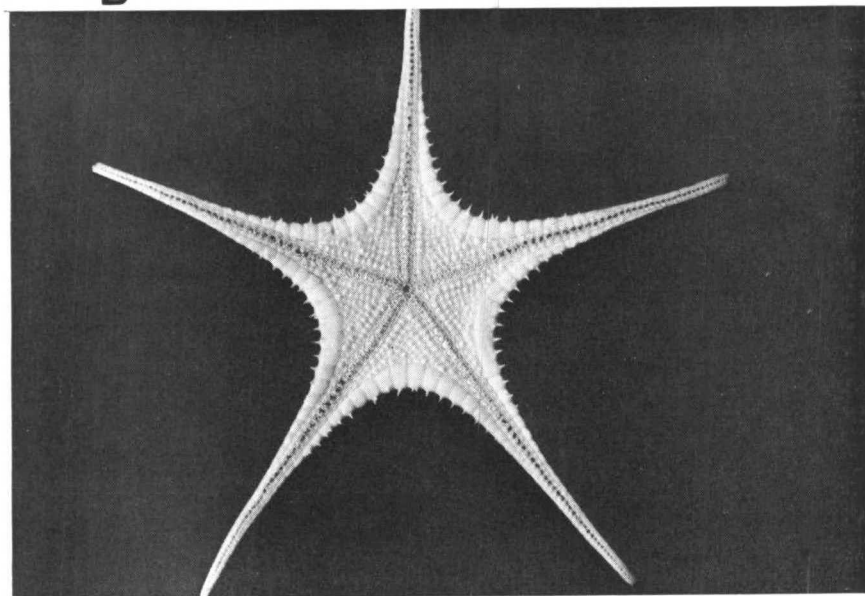
*Nymphaster subspinosus*: Sladen, 1889: 752.—Verrill, 1899: 185.—Koehler, 1924: 182.—H. L. Clark, 1941: 40.—A. H. Clark, 1954: 375.

*Material Studied*.—LECTOTYPE: R = (103) mm, r = 27 mm, R/r = 3.8; off Barbados, 382 m, BLAKE sta. 274, 1878-79, MCZ 445.

→

FIGURE 12. *Nymphaster subspinosus* (Perrier): A, specimen from GERDA sta. G-635; 0.6 ×; B, specimen from GERDA sta. G-635; 0.6 ×.



**A****B**

PARALECTOTYPE:  $R = (43)$  mm,  $r = 10.5$  mm,  $R/r = 4.1$ ; off Grenada, 300 m, BLAKE sta. 254, 1878-79, MCZ 446.

OTHER MATERIAL: 27°50'N, 79°15'W, 522 m, R/V GERDA sta. G-666, 17 July 1965, 1 spec.—27°46'N, 79°12'W, 549-567 m, R/V GERDA sta. G-179, 1 July 1963, UMML 40.261, 6 spec.—27°22'N, 79°27'W, 494-512 m, R/V GERDA sta. G-261, 7 February 1964, UMML 40.252, 1 spec.—26°44'N, 79°23'W, 690 m, R/V GERDA sta. G-302, 5 April 1964, 1 spec.—26°33'N, 79°24'W, 622-648 m, R/V GERDA sta. G-301, 5 April 1964, UMML 40.253, 2 spec.—26°26'N, 78°40'W, 724 m, R/V GERDA sta. G-709, 22 July 1965, UMML 40.251, 2 spec.—26°05'N, 79°20'W, 458-480 m, R/V GERDA sta. G-635, 30 June 1965, UMML 40.254, 3 spec.—25°45'N, 79°22'W, 531 m, R/V GERDA sta. G-235, 30 January 1964, UMML 40.259, 2 spec.—24°15'N, 80°02'W, 540-549 m, R/V GERDA sta. G-142, 22 June 1963, 1 spec.

*Diagnosis*.—Abactinal granules never mucronate. Actinals covered by short, stout, conical spines. Eight to 12 furrow spines on adambulacra with fully developed apophyses; first row of subambulacral spines usually about as tall as furrow spines. Each mouth plate bearing eight to 11 furrow spines.

*Description*.—Five arms.  $R = 78$  mm,  $r = 20$  mm,  $R/r = 3.9$ .

The general form is stellate with a broad disk and very long arms.

The abactinal surface is restricted to the disk. The plates are low-tabulate and irregularly round. In the center of each plate are two to four large, rounded granules, surrounded by 12 to 15 rounded granules about half as large. The bases of the radial plates have six prominent, long, subcylindrical lobes. Some plates bear small, excavate sugar-tong pedicellariae. The papular area includes the center of the disk. The interradian areas are large and triangular. Six papular pores surround each plate; each pore contains a single papula.

The marginal plates correspond. There are 64 plates in each series. The plates of both marginal series are about one and one-half times as wide as long in the interbrachial arc, becoming square in the proximal half of the arm and about twice as long as wide in the distal half; the last five to six pairs of each series become square again. The superomarginals are completely covered by large, rounded granules. The granules of the marginal row are only about two-thirds as large as the other granules. Each plate in the interbrachial arc bears one to three short, stout, conical spines. These tend to diminish distally, so that there are no spines on the distal half of the arm. The terminal plate is oval, and about twice as large as the adjacent superomarginals. The inferomarginals are completely covered by stout, very short, conical spinules. Each plate bears one or two large, conical spines one and one-half to two times as tall as those on the superomarginals.

These tend to disappear distally, so that there are no spines on the distal half of the arm.

The actinal plates are moderately large, and are rhombic to polygonal in shape. The plates adjacent to the adambulacrals are largest. In the center of each actinal plate are one to four short, stout, conical spines. These are surrounded by eight to 15 stout, very short, conical spinules similar to, but slightly larger than, those covering the inferomarginals.

The adambulacral plates are about one and one-half times as long as wide; they are about half the size of the actinal plates adjacent to them. The furrow margin is strongly angular; an apophysis appears at the second or third plate and is fully developed by the sixth plate. There are six or seven furrow spines on each of the first two or three plates; when the apophysis first appears, the number of furrow spines increases until it is fully developed, whence each plate bears ten or 11 spines. The furrow spines are compressed, moderately long, and have rounded tips. The subambulacral spines are in two to three irregular rows of three to five spines each. The spines of the first subambulacral row are stout, conical, and about as tall as the furrow spines. The other one or two rows grade into the actinal spinules. Some plates bear two, three, or four jawed spatulate pedicellariae.

The mouth plates are long and triangular. Each plate bears ten to 11 furrow spines similar to those of the adambulacral plates; the median spine is slightly taller and more compressed than the others. The first two rows of subambulacral spines are conical and slightly taller than the furrow spines; the rest grade into the actinal spinules.

The anus is subcentral and surrounded by small conical spinules. The madreporite is irregularly square and about one and one-half times as large as the abactinal plates adjacent to it. It is located approximately one-fifth the distance from the center of the disk to the middle of the interbrachial arc. The gonads are in single tufts on each side of the interbrachial septum. In living material, the dorsal surface is orange and the ventral surface cream colored.

*Type*.—Museum of Comparative Zoology, cat. no. 445 (lectotype).

*Type-Locality*.—Off Barbados, 382 m, BLAKE sta. 274.

*Distribution*.—There is only one record of this species from the eastern Atlantic (Koehler, 1895: 453), from the Bay of Biscay, 400-500 m. Perrier (1885a: 39) reported specimens of *Nymphaster* with marginal spines, but considered them to be *arenatus*. Because of the confused taxonomic state of the group, whether this species is found in the eastern Atlantic remains an open question.

In the western Atlantic, it is known from as far north as off Florida (27°50'N) to as far south as off Brazil (00°18'N). It is known from the

Straits of Florida, Cuba, Panama, Barbados, Grenada, and Curaçao, and is probably distributed throughout the tropical western Atlantic. The bathymetric range is 275-724 m.

*Discussion.*—The arms are often broken, as in *Nymphaster arenatus*. The variations in the shape and granulation of the abactinal plates, the thickness of the marginals, and the pedicellariae are similar to those in *N. arenatus*.

Spines are usually present on both the superomarginal and inferomarginal plates, but may be absent from one or both series.

The subambulacral spines are conical and range from about half as tall as the furrow spines to slightly taller than them. The numbers of ambulacral and mouth furrow spines both range from eight to 11.

*Remarks.*—I designate the specimen collected at BLAKE station 274 the lectotype, and the type-locality is restricted to off Barbados, at a depth of 382 m. The specimen collected by the BLAKE at station 254 is designated the paralectotype.

*Nymphaster arenatus* × *Nymphaster subspinosus*

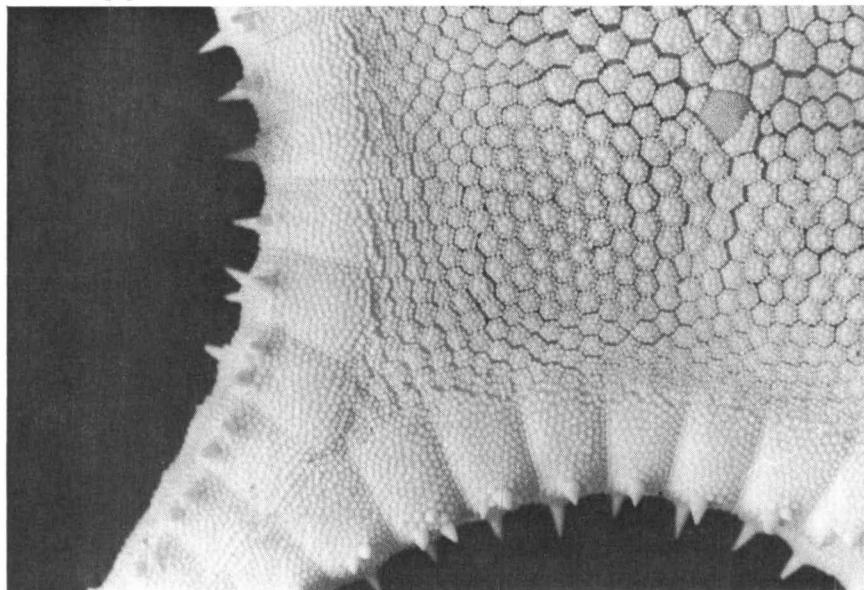
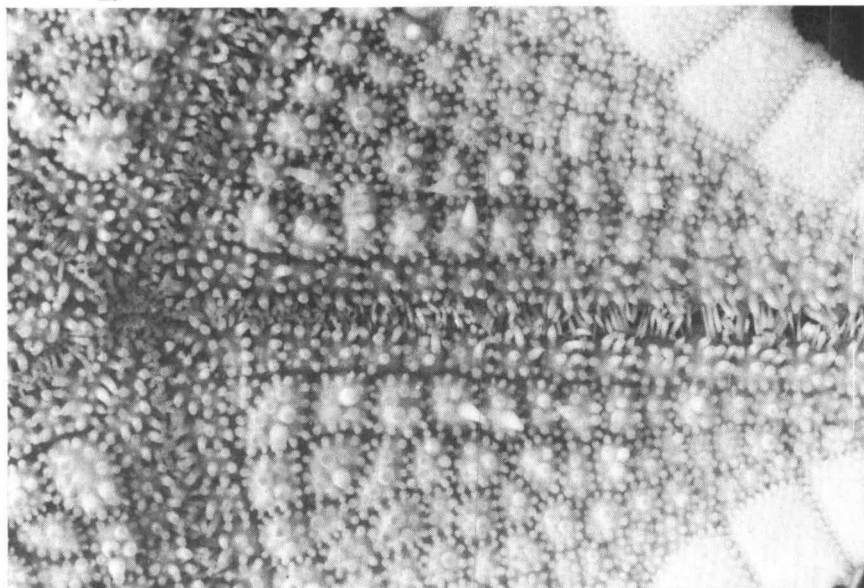
*Material Studied.*—27°20'N, 78°19'W, 458-622 m, M/V SILVER BAY sta. 3472, 25 October 1961, 1 spec.—26°19'N, 78°42'W, 513-715 m, R/V GERDA sta. G-524, 3 March 1965, 2 spec.—26°04'N, 79°24'W, 512-549 m, R/V GERDA sta. G-715, 2 August 1965, 3 spec.—24°37'N, 80°45'W, 575 m, R/V GERDA sta. G-786, 16 August 1966, 2 spec.—23°59'N, 79°43'W, 640 m, M/V COMBAT sta. 450, 25 July 1957, 4 spec.—23°59'N, 79°17'W, 530-550 m, M/V SILVER BAY sta. 2469, 7 November 1960, 1 spec.—23°30'N, 79°27'W, 549 m, M/V SILVER BAY sta. 3514, 8 November 1961, 7 spec.—23°06'N, 79°37'W, 435 m, ATLANTIS sta. 3438, 2 May 1939, 2 spec.—16°35'N, 80°10'W, 576 m, M/V OREGON sta. 3560, 16 May 1962, 3 spec.—11°35'N, 62°41'W, 388-458 m, M/V OREGON sta. 2353, 23 September 1958, 7 spec.—09°28'N, 76°28'W, 416-634 m, R/V PILLSBURY sta. 394, 16 July 1966, 9 spec.—07°34'N, 54°50'W, 366 m, M/V OREGON sta. 2005, 6 November 1957, 1 spec.—00°18'N, 44°17'W, 275 m, M/V OREGON sta. 4226, 9 March 1963, 5 spec.

*Discussion.*—Many specimens of *Nymphaster* are intermediate between *N. arenatus* and *N. subspinosus*. Because these two species are usually separable on the basis of the actinal granulation and all specimens below 750 m are "typical" *arenatus*, I consider them to be distinct.

The probable explanation for the many "intermediate" forms is that

→

FIGURE 13. *Nymphaster subspinosus* (Perrier): A, specimen from GERDA sta. G-635; 3.5 ×; B, specimen from GERDA sta. G-235; 3.2 ×.

**A****B**

this is a case of an introgressing hybrid swarm. There apparently is a complete breakdown of isolating mechanisms between sympatric populations of *Nymphaster arenatus* and *N. subspinosus*.

### Genus *Peltaster* Verrill, 1899

*Peltaster* Verrill, 1899: 168-169.—Tortonese & A. M. Clark, 1956: 348-349.

**Diagnosis.**—General form pentagonal to arcuate pentagonal. Abactinal plates flat, completely covered by granules; secondary plates present throughout radial areas. Adambulacral furrow spines stout, moderately short; subambulacral series graduated in size, grading from furrow spines to granules of actinal intermediate plates. Adambulacral granulation very crowded.

**Discussion.**—The genus *Peltaster*, as characterized above, contains the following species: *Peltaster nidarosiensis*, *P. placenta* (= *P. planus*) and *P. cycoplax*.

Fisher (1911: 205) suggested that *Tosia* (*Ceramaster*) *micropelta* Fisher, 1906, might belong in *Peltaster*. However, the adambulacral granulation of this species is considerably different than in *Peltaster*.

Tortonese & A. M. Clark (1956) separated *Peltaster planus* and *P. placenta* from *P. nidarosiensis* (the type-species) on the basis of the differences of the pedicellariae. They placed them in the genus *Sphaerodiscus* Fisher, 1910. This genus is characterized by enlarged penultimate or antepenultimate superomarginal plates; these are not always found in *Peltaster placenta*.

Tortonese & A. M. Clark (1956: 348) admitted that the use of pedicellariae as a diagnostic character of genera is controversial. I contend it is wholly unwarranted in this case. The only major difference between *Peltaster placenta* and *P. nidarosiensis* is the pedicellariae. The genus is better characterized by the more stable features of the abactinal skeleton and adambulacral granulation.

The validity of the genus *Sphaerodiscus* is questionable. *Sphaerodiscus scotocryptus* Fisher, 1919 and *S. ammophilus* Fisher, 1906 belong in the genus *Ceramaster* (personal observation). The penultimate or antepenultimate superomarginal plates are always enlarged in *Sphaerodiscus bourgeti* (Perrier), the type-species. However, it is doubtful that this character warrants its separation into a new genus. Madsen (1958: 93) observes, "There can be no doubt that *placenta* and *bourgeti* ought to be placed in the same genus."

**Type-Species.**—*Peltaster hebes* Verrill (= *Goniaster nidarosiensis* Storm) (by original designation: Verrill, 1899: 168).

KEY TO THE ATLANTIC SPECIES OF *Peltaster*

1. Many of the actinal plates adjacent to the adambulacrals bearing large, bivalved pedicellariae ..... *nidarosiensis*
2. When pedicellariae present, small, excavate sugar-tong type only ..... *placenta*

*Peltaster nidarosiensis* (Storm, 1881)

## Fig. 14

*Goniaster nidarosiensis* Storm, 1881: 90-91.

*Pentagonaster nidarosiensis* Storm, 1888: 61; 1901: 12.

*Goniaster acutus* Lütken, 1890: 359.

not *Goniaster acutus*: Heller, 1863: 419, pl. 1, figs. 1-4.

*Pentagonaster placenta* (in part): Ludwig, 1897: 157.

*Peltaster hebes* Verrill, 1899: 169-170, pl. 28, fig. 4.—Fisher, 1911: 162.—

H. L. Clark, 1941: 41-42.—A. H. Clark, 1954: 375.

*Hippasteria phrygiana* (in part): Ludwig, 1900: 457-458.

*Peltaster nidarosiensis*: Grieg, 1905a: 3-13, figs. 1-5.—Fisher, 1911: 162.—

Verrill, 1915: pl. 28, figs. 4, 4a.—Mortensen, 1924: 20.—Grieg, 1913: 114;

1927: 131.—Tortonese & A. M. Clark, 1956: 348, 350, 351, figs. 1A, 2A.

*Material Studied*.—Trondhjemsfjord (depth, date, collector unknown), Bergens Museum No. 14451, 1 spec.—59°44'N, 05°34'E, 96-120 m, J. Kjennerud, 4 June 1959, 1 spec.—30°59'N, 79°39'W, 538 m, ALBATROSS sta. 2668, 5 May 1886, USNM 18442 (holotype of *Peltaster hebes* Verrill). —26°42'N, 79°22'W, 692 m, R/V GERDA sta. G-302, 5 April 1964, UMMML 40.80, 1 spec.

*Diagnosis*.—Almost every actinal plate adjacent to adambulacrals bearing large, bivalved pedicellariae; such pedicellariae also found on other actinals, especially near inferomarginals. Smaller bivalved pedicellariae usually present on primary abactinal plates. Each papular pore bearing one to three papulae.

*Description*.—Five arms.  $R = 54$  mm,  $r = 43$  mm,  $R = 1.3r$ .

The general form is pentagonal to arcuate pentagonal. The disk is very large and flat.

The abactinal plates are arranged in a fairly regular series parallel to the carinals. The abactinal surface extends to the terminal plate. The primary abactinal plates are flat and irregularly round. They are covered by moderately large, rounded, closely crowded granules. There are 30 to 35 peripheral, and 20 to 25 central, granules on the larger plates. The secondary abactinal plates are present in the radial areas and the small center of the disk. They are covered by granules similar to those on the primary abactinals. The larger secondary plates bear about one central and ten peripheral granules. The secondary plates do not form a reticulated skeleton with the primary plates. The papular areas are very extensive.

There are papulae in the center of the disk and in the large radial areas. Only the narrow, triangular interradiar areas have no papulae. Six papular pores surround each primary plate; each pore contains one to three papulae.

The marginal plates correspond, except at the most distal part of the arms. The 18 massive, rectangular superomarginal plates are about twice as wide as long. They are covered by rounded granules like those covering the abactinal plates. The terminal plate is small and roundly triangular. There are no pedicellariae on the dorsal surface. There are 22 large, rectangular inferomarginal plates, about twice as wide as long. They are completely covered by rounded granules like those of the superomarginals.

The actinal plates are large, rhombic, and covered by large, rounded, closely crowded granules slightly larger than those of the marginals. Almost every actinal plate adjacent to the adambulacrals bears a large, bivalved pedicellaria; such pedicellariae are also found on other actinals scattered about the actinal intermediate area, especially near the inferomarginals.

The adambulacral plates are rectangular (approximately twice as wide as long) and slightly smaller than the adjacent actinals. The furrow margin is very slightly curved, bearing four to six thick, compressed, moderately short, subequal furrow spines with rounded tips. The first subambulacral row has three prismatic spines, approximately half as tall and slightly thicker than the furrow spines. The rest of the subambulacral spines are in three irregular rows of three or four spines, similar to the first row, but becoming smaller actinally so that the spines of the last row are reduced to granules like those on the actinal plates.

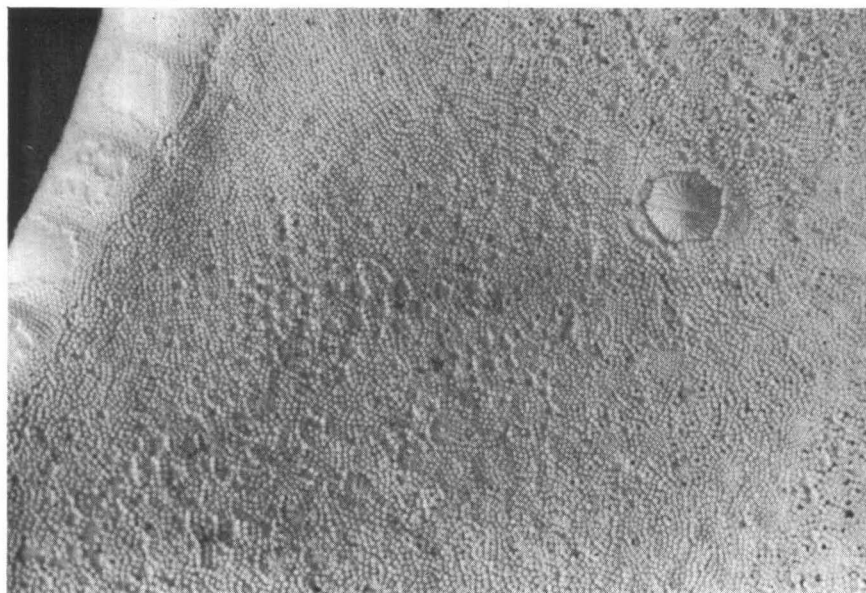
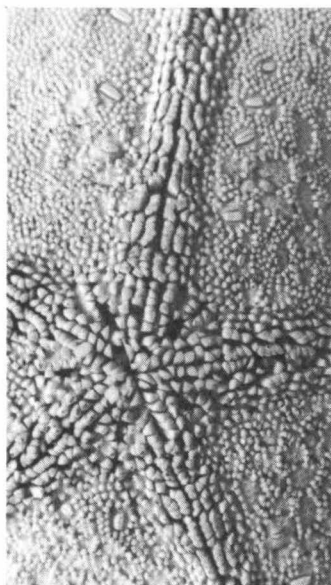
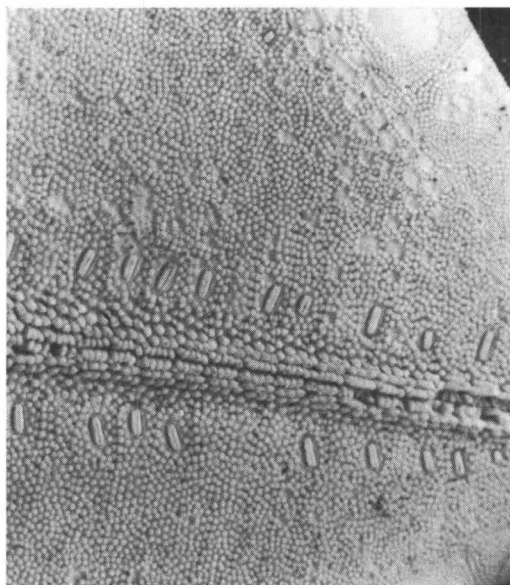
The mouth plates are moderately large; each plate bears seven to nine furrow spines, similar to the adambulacral furrow spines, but more strongly compressed. The median spine is the most compressed; it is slightly enlarged. There are five spines parallel to, and slightly thicker and shorter than, the furrow spines. Seven scattered spines, grading actinally into granules like those of the actinals, cover the rest of the plate.

The anus is prominent, subcentral, and surrounded by large, flat spinules. The round madreporite is slightly more than three times as large as the adjacent primary abactinal plates. It is located approximately half the distance from the center of the disk to the middle of the interbrachial arc. The gonads are in large, thick, triangular tufts on each side of the inter-

→

FIGURE 14. *Peltaster nidarosiensis* (Storm): A, specimen from GERDA sta. G-302; 3.3 ×; B, specimen from GERDA sta. G-302; 3.4 ×; C, specimen from GERDA sta. G-302; 3.5 ×.



**A****B****C**

brachial septum. The dorsal surface is orange, the ventral surface cream colored when alive.

*Type*.—Not traced.

*Type-Locality*.—Trondhjemsfjord, 470 m.

*Distribution*.—This species is known from the western coast of Norway in Trondhjemsfjord, Hardangerfjord, and Sognefjord, 96-1000 m; from the southern coast of Iceland, 957 m; and from the Lousy Bank, northwest of Scotland.

In the western Atlantic, it is known from off Brunswick, Georgia, 538 m; from the northern Straits of Florida, 692 m; and from the northern and southern coasts of Cuba, 329-1107 m.

*Discussion*.—The ratio  $R/r$  ranges from 1.3 to 1.7.

The dorsal pedicellariae are variable in abundance. The type of *Peltaster hebes* has no dorsal pedicellariae. All the other specimens I have examined have numerous bivalved pedicellariae which are smaller than those on the actinals. The specimen taken from the southern coast of Cuba ( $R = 45$  mm) "has very few dorsal pedicellariae" (H. L. Clark, 1941: 41).

The specimen from Florida has the peripheral granules of the abactinal plates enlarged, so that they are fewer in number than normally, and are about twice as large as the central granules.

In the Norwegian specimens that I have examined, the inferomarginal plates are largely confined to the lateral surface. This is probably due to growth (both specimens have  $R$  greater than 100 mm).

The color of the dorsal surface can be yellow, pale pink, orange, or light brown; the ventral surface is cream colored.

*Peltaster placenta* (Müller & Troschel, 1842)

Figs. 15, 16

*Goniodiscus placenta* Müller & Troschel, 1842: 59.—Dujardin & Hupé, 1862: 402.

*Goniodiscus placentaeformis* Heller, 1863: 419-420, pl. 1, figs. 1-2; 1868: 54.—Gasco, 1876: 11-12, fig. 11.

*Goniodiscus acutus* Heller, 1863: 420-421, pl. 1, figs. 3-4; 1868: 54.

*Goniaster placenta*: von Marenzeller, 1875: 361.—Stossich, 1883: 189.

*Goniaster acutus*: von Marenzeller, 1875: 362.—Stossich, 1883: 189.

*Pentagonaster mirabilis* Perrier, 1876a: 40-41; 1878: 21, 84.—Ludwig, 1879: 540.—Carus, 1885: 88.—Sladen, 1889: 265, 746.—Perrier, 1894: 390.

*Pentagonaster placenta*: Perrier, 1878: 21, 84.—Ludwig, 1879: 540.—Carus, 1885: 87.—Colombo, 1888: 68.—Sladen, 1889: 265, 266, 748.—Perrier, 1894: 390.—von Marenzeller, 1895: 11, 23.—Koehler, 1895: 454-455; 1896: 66-67.—Ludwig, 1897: 157-179, pl. 5, figs. 1, 2, 10, pl. 7, figs. 24-42.—Grieg, 1905a: 4.—Mangold, 1909: 134.—Lo Bianco, 1909: 561.

*Pentagonaster acutus*: Perrier, 1878: 21, 84.—Carus, 1885: 87.

*Pentagonaster minor* Koehler, 1895: 451-453, fig. 1; 1896: 61-62, pl. 2, figs. 5-7.

*Pentagonaster planus* Verrill, 1895: 135-136.

*Tosia placenta*: Verrill, 1899: 161.

*Peltaster planus* Verrill, 1899: 170-171, pl. 28, figs. 3, 3a.—H. L. Clark, 1941: 42.

*Ceramaster placenta*: Koehler, 1921a: 42, fig. 31; 1924: 174.—Mortensen, 1927: 80, 81.—Koehler, 1929: 2 unnumbered pages, one plate.—Tortonese, 1937: 60.—Kolosvary, 1937: 447, pl. 32, fig. 19.—Cuénot, 1948: 238.—Tortonese 1952: 187, fig. 3.—Wilson, 1955: fig. 3.—Forest, 1955: pl. 40a.—Cherbonnier, 1956: 10.—Vevers, 1956: 485.—Cherbonnier, 1958: 15.—Buchsbaum & Milne, 1960: pl. 130.—Strenger, 1963: 446, pl. 164.

*Peltaster placenta*: Dilwyn-John & A. M. Clark, 1954: 149.

*Sphaerodiscus placenta*: Tortonese & A. M. Clark, 1956: 347-352, figs. 1B, 2B.—Madsen, 1958: 90-94, fig. 2.—Tortonese, 1965: 157-159, figs. 72-74.

*Material Studied*.—39°53'N, 69°43'W, 285 m, FISH HAWK sta. 1098, 11 August 1881, USNM 13362 (holotype of *Pentagonaster planus* Verrill;  $R = 50$  mm,  $r = 35$  mm,  $R = 1.4r$ ).—Off Montauk Point, New York, about 100 miles out, 31 m or more, Roy Latham, date unknown, USNM E7777, 1 spec.—26°28'N, 78°41'W, 622-695 m, R/V GERDA sta. G-694, 21 July 1965, UMML 40.249, 1 spec.—25°58'N, 79°20'W, 412 m, R/V GERDA sta. G-798, 12 September 1966, 1 spec.—24°39'N, 80°40'W, 205-210 m, R/V GERDA sta. G-785, 16 August 1966, UMML 40.244, 1 spec.—24°23'N, 81°59'W, 210-220 m, M/V SILVER BAY sta. 2426, 29 October 1960, 1 spec.—24°18'N, 81°29'W, 229 m, M/V SILVER BAY sta. 2416, 28 October 1960, 6 spec.—20°52'N, 73°41'W, 366-412 m, M/V SILVER BAY sta. 3498, 4 November 1961, 1 spec.—17°39'N, 62°16'W, 329-339 m, M/V OREGON sta. 6699, 19 May 1967, 1 spec.—00°39'N, 09°20'W, 311-366 m, R/V PILLSBURY sta. 73, 4 June 1964, 2 spec.

*Diagnosis*.—Pedicellariae of excavate sugar-tong type; usually present on scattered actinal plates, but never in such great abundance so as to be present on almost every actinal plate. Each papular pore bearing one to five papulae.

*Description*.—Five arms.  $R = 51$  mm,  $r = 36$  mm,  $R = 1.4r$ .

The general form is pentagonal to arcuate pentagonal, with a very large, flat disk.

The abactinal plates are arranged in a regular series parallel to the carinals. The abactinal surface extends to the terminal plate. The primary abactinal plates are flat, irregularly round, and covered by rounded, closely crowded granules. There are 25 to 30 peripheral and 40 to 50 central granules on the larger plates. Many primary plates bear excavate sugar-tong pedicellariae. The secondary abactinal plates are present in the radial areas and the small center of the disk. They are covered by rounded granules like those of the primary abactinals. The larger secondary plates

bear about ten peripheral and four central granules. The secondary plates do not form a reticulated skeleton with the primary plates. The interradi al areas are narrow and triangular; the interradi al plates are large and polygonal. The papular areas are very extensive. There are papulae in the center of the disk and the large radi al areas; only the narrow interradi al areas have no papulae. Six papular pores surround each primary plate, each pore containing one to five papulae.

The marginal plates correspond in the interbrachial arcs, but not on the arms. The 12 massive superomarginal plates are square or slightly longer than wide proximally, and wider than long distally. In the center of each plate is a raised area bearing a few scattered, large, hemispherical granules. This raised, mostly naked area ranges from very small to large, sometimes occupying most of the plate. The rest of the plate is covered by large, closely crowded, hemispherical granules. Some plates bear small, excavate sugar-tong pedicellariae. The terminal plate is small, heart-shaped and naked; the distal end is notched, the proximal end truncate. The 16 inferomarginal plates are about one and one-half times as wide proximally and slightly wider than long distally. Their granulation is similar to the superomarginals except that the raised, mostly naked area in the center tends to be small; it is sometimes absent, so that the entire plate is covered by granules. Some plates bear small, excavate sugar-tong pedicellariae.

The actinal plates are small, thick, and rhombic; some bear small, excavate sugar-tong pedicellariae. The actinals are covered by closely crowded, large, hemispherical granules slightly larger than those on the marginals. The peripheral granules are flattened externally, so that they fit flush against the marginal granules of the adjacent plates.

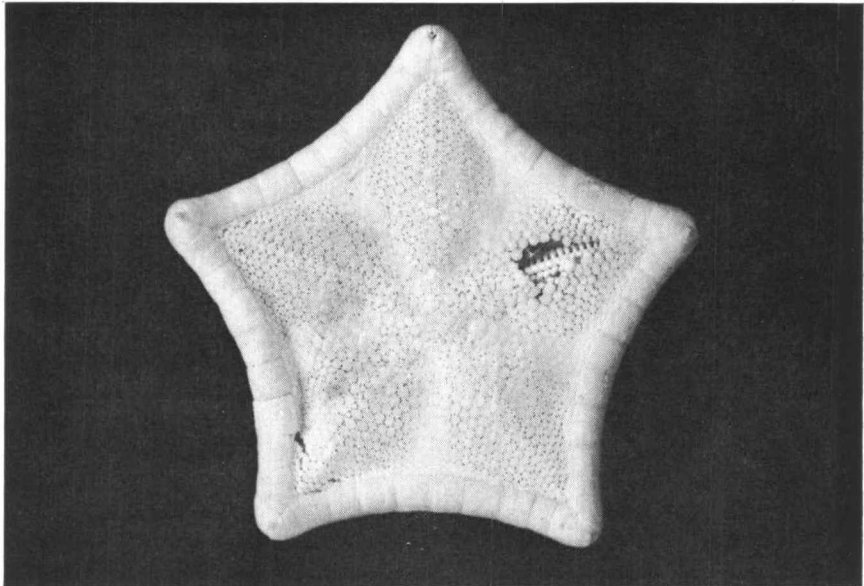
The adambulacral plates are rectangular, (approximately two times as wide as long) and slightly smaller than the adjacent actinals. The furrow margin is very slightly curved, bearing four to six thick, compressed, moderately short, subequal furrow spines with rounded tips. The first subambulacral row has three prismatic spines, approximately half as tall and slightly thicker than the furrow spines. The rest of the subambulacral spines consist of three irregular rows of three or four spines, similar to the first row, but becoming smaller actinally so that the spines of the last row are reduced to granules like those of the actinal plates.

Each mouth plate bears seven to nine furrow spines similar to the adambulacral furrow spines, but more strongly compressed. The median spine is most compressed and slightly enlarged. There are five spines parallel to, and slightly thicker and shorter than, the furrow spines. Seven scattered

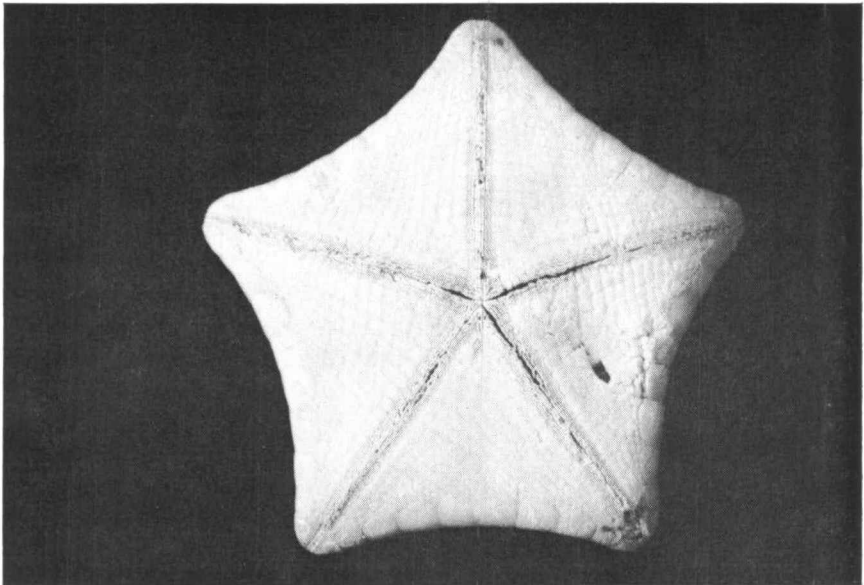
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FIGURE 15. *Peltaster placenta* (Müller & Troschel): A, specimen from GERDA sta. G-785; 0.8 ×; B, specimen from GERDA sta. G-785; 0.8 ×.

A



B



spines grading actinally into granules like those on the actinals cover the rest of plate.

The anus is subcentral, moderately prominent and surrounded by large, pentagonal plates. The large, round madreporite is four to five times as large as the adjacent abactinals. It is located approximately one-quarter the distance from the center of the disk to the middle of the interbranchial arc. The gonads are in large, thick, triangular tufts on each side of the membranous interbranchial septum. The dorsal surface is pale orange, the ventral surface cream colored in live material.

*Type*.—Not traced.

*Type-Locality*.—The type-locality is listed as unknown in the original description (Müller & Troschel, 1842: 59). However, the type-locality must certainly be the Mediterranean Sea.

*Distribution*.—This species is found on both sides of the Atlantic Ocean.

In the eastern Atlantic, it is found in the Bay of Biscay and along the northern coast of West Africa, as far south as the equator, in 200-600 m; and throughout the Mediterranean Sea, in 10-200 m.

In the western Atlantic, it is found along the eastern coast of North America, from Martha's Vineyard, Massachusetts, to Key West, Florida, in 205-695 m; and throughout the Caribbean, in 329-604 m.

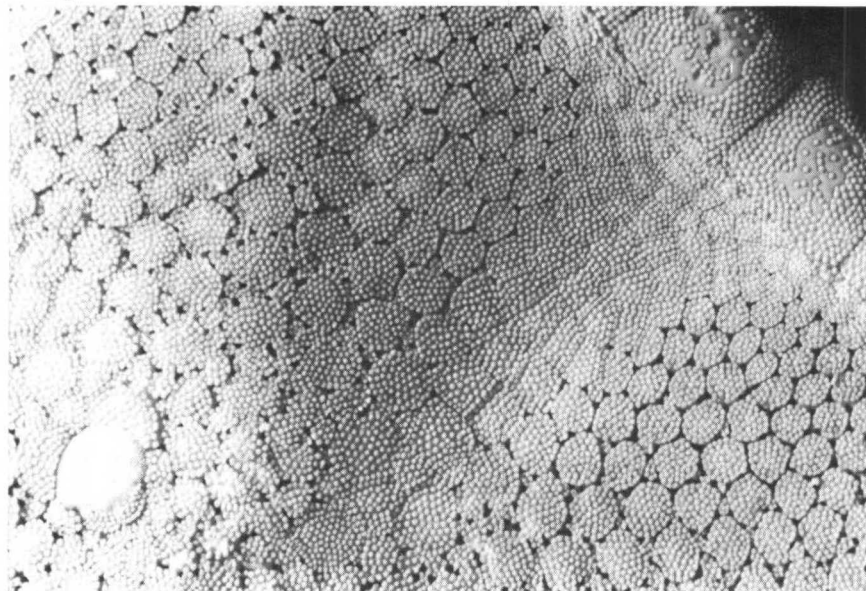
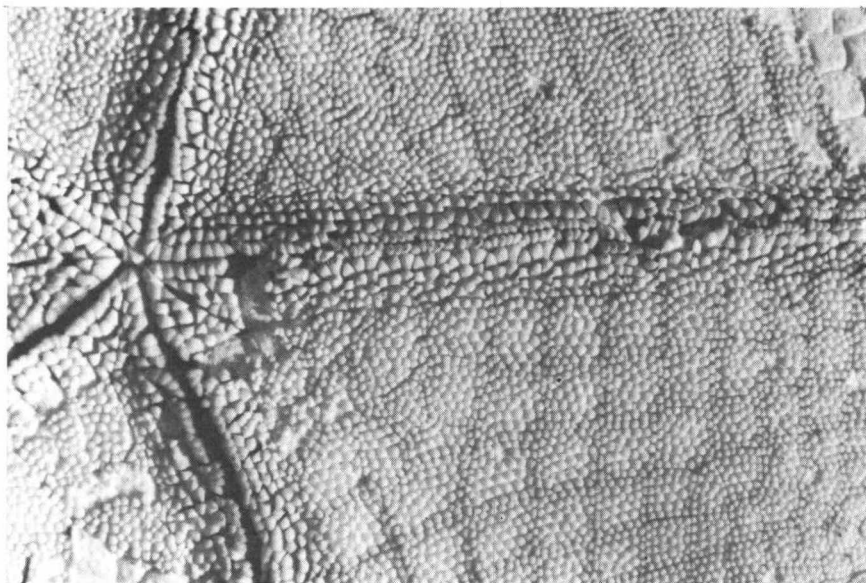
*Discussion*.—The general body form is variable, ranging from pentagonal to arcuate pentagonal. The R/r ratio ranges from 1.3 to 1.8. Tortonese (1965: 159) discussed this variability. The pedicellariae are also variable, ranging from absent to abundant. On one specimen the actinal pedicellariae are not of the usual small, sugar-tong type, but are large and almost as wide as high; the abactinal pedicellariae are normal. The number of superomarginal plates in contact medially ranges from zero to three.

*Remarks*.—The type of *Peltaster planus*, from off Cape Cod, has no pedicellariae. All of the specimens collected in the Caribbean have pedicellariae. It has been suggested that this may "warrant separating a northern and West Indian species" (H. L. Clark, 1941: 42).

Only two specimens are known from north of North Carolina. The specimen recorded as *Peltaster planus* from off Newfoundland by Boone (1933: pl. 43) is a young *Ceramaster granularis*. One specimen, the type of *Peltaster planus*, has no pedicellariae. The other, from off Montauk Point, Long Island, has only one small, excavate sugar-tong pedicellaria

→

FIGURE 16. *Peltaster placenta* (Müller & Troschel): A, specimen from GERDA sta. G-785; 4.0 ×; B, specimen from GERDA sta. G-785; 4.0 ×.

**A****B**

on a primary abactinal plate. Many of the Caribbean specimens have abundant pedicellariae, but they are scarce in some. One specimen (UMML 40.244) has only two small, excavate sugar-tong pedicellariae; one on a primary abactinal plate, and one on an actinal plate. The northern and Caribbean specimens are similar in every other respect and thus represent a single species.

Tortonese & A. M. Clark (1956: 350) and Madsen (1958: 93) suggested that the western Atlantic *Peltaster planus* and the eastern Atlantic *Peltaster placenta* may be conspecific. I completely agree, and I have synonymized the two species.

#### Genus *Plinthaster* Verrill, 1899

*Plinthaster* Verrill (Sec. B. of *Tosia*), 1899: 161.—Fisher (subgenus), 1906: 1052; 1911: 165.—Mortensen, 1927: 83.

*Pyrenaster* Verrill, 1899: 166-167.—Fisher, 1911: 165.

*Eugoniaster* Verrill, 1899: 172-173.—Macan, 1938: 382.

**Diagnosis.**—General form pentagonal to stellate with short arms; R/r two or less. Abactinal plates naked except for single row of marginal granules; naked area in center of plates roughened by numerous very small, glassy protuberances or bosses, not smooth; some secondary abactinal plates present.

**Discussion.**—Macan (1938: 385) observed: "The genus *Eugoniaster*, founded by Verrill in 1899 for the reception of the single species *Pentagonaster investigatoris* Alcock, is separated from related genera by remarkably insignificant characters." It differs from *Plinthaster* in the character of the pedicellariae, which are actually quite similar, and in the number of superomarginal plates in contact medially, the difference being no greater than the variability within a single species. I have therefore synonymized *Eugoniaster* with *Plinthaster*.

**Type-Species.**—*Pentagonaster perrieri* Sladen (= *Pentagonaster grandis* Perrier [not Gray]) (by subsequent designation: Fisher, 1910: 172).

#### *Plinthaster dentatus* (Perrier, 1884)

Figs. 17-19

*Pentagonaster dentatus* Perrier, 1884: 168, 170, 179, 180, 185, 242-243, pl. 3, fig. 8; 1894: 36, 39, 40.—Sladen, 1889: 265, 267, 744.—Farran, 1913: 10-11.—Grieg, 1921: 21-23.

*Pentagonaster grandis* Perrier, 1885a: 35; 1885b: 886; 1894: 32.

*Pentagonaster perrieri* Sladen, 1889: 265, 267, 746.—Perrier, 1894: 31, 34, 391, pl. 25, figs. 1a, 1b.—Koehler, 1895: 15; 1896: 60-61, 124-125; 1909a: 85-86, pl. 2, fig. 7; 1924: 182.

*Pentagonaster concinnus* Sladen, 1891: 690, pl. 26, figs. 1-5.

*Tosia* (*Plinthaster*) *perrieri*: Verrill, 1899: 161.—Fisher, 1906: 1054.



*Tosia (Plinthaster) compta* Verrill, 1899: 161, 163-165, pl. 27, fig. 2.—Fisher, 1906: 1054.

*Tosia (Plinthaster) nitida* Verrill, 1899: 161, 165-166, pl. 27, figs. 1, 1a, 1b.—Fisher, 1906: 1054.

*Pyrenaster dentatus*: Verrill, 1899: 167, pl. 27, figs. 3, 3a, 3b.

*Plinthaster dentatus*: Fisher, 1910: 172; 1911: 165.—Verrill, 1915: 107.—H. L. Clark, 1941: 42-43.—A. H. Clark, 1954: 375.

*Plinthaster perrieri*: Fisher, 1910: 172; 1911: 165.—Koehler, 1921b: 2; 1924: 182.—Mortensen, 1927: 83-84, figs. 46, 47.

*Goniaster africanus* Koehler, 1914: 169-170, pl. 7, figs. 1-4.

**Material Studied.**—LECTOTYPE: R = 34 mm, r = 22 mm, R = 1.5r; off Grenada, 762 m, BLAKE sta. 264, 1878-79, MCZ 408.

OTHER MATERIAL: SW of Ireland, 1007-1080 m (collector and date unknown), MCZ 2175, 1 spec.—34°10'N, 79°59'W, 384 m, M/V COMBAT sta. 364, 15 June 1957, 2 spec.—Off Morocco, 830-1440 m, TALISMAN, 1883, MCZ 418 (syntype of *Pentagonaster grandis* Perrier).—E of St. Augustine, Florida, 311-329 m, M/V COMBAT (date unknown), 6 spec.—29°08'N, 88°04'W, 668-724 m, M/V OREGON sta. 2824, 17 July 1960, 1 spec.—28°34'N, 86°48'W, 613 m, ALBATROSS sta. 2396, 13 March 1885, USNM 18449 (holotype of *Tosia nitida* Verrill).—28°31'N, 79°51'W, 329 m, M/V SILVER BAY sta. 3072, 28 April 1961, 1 spec.—28°25'N, 79°50'W, 403 m, R/V PILLSBURY sta. 89, 25 July 1964, UMML 40.188, 1 spec.—27°53'N, 79°03'W, 796 m, R/V GERDA sta. G-672, 18 July 1965, UMML 40.189, 1 spec.—27°49'N, 78°45'W, 824 m, R/V GERDA sta. G-403, 20 September 1964, UMML 40.32, 3 spec.—27°40'N, 95°35'W, 366 m, M/V OREGON sta. 1508, 7 May 1956, 1 spec.—26°39'N, 79°45'W, 452-476 m, R/V GERDA sta. G-650, 16 July 1965, UMML, 40.194, 1 spec.—26°25'N, 79°01'W, 549 m, M/V SILVER BAY sta. 2483, 9 November 1960, 1 spec.—Off Hillsboro Light, Florida, 275 m, L. Burry, 1949, UMML 40.63, 2 spec.—26°04'N, 79°24'W, 512-549 m, R/V GERDA sta. G-715, 2 August 1965, UMML 40.191, 2 spec.—25°40'N, 79°31'W, 805-830 m, R/V GERDA sta. G-354, 2 August 1964, UMML 40.196, 1 spec.—25°31'N, 79°58'W, 329-339 m, R/V GERDA sta. G-77, 28 September 1962, UMML 40.187, 1 spec.—24°48'N, 80°12'W, 366 m, M/V SILVER BAY sta. 3517, 9 November 1961, 2 spec.—24°18'N, 82°58'W, 357-370 m, R/V GERDA sta. G-464, 25 January 1965, UMML 40.192, 1 spec.—24°17'N, 82°23'W, 401 m, R/V GERDA sta. G-435, 28 November 1964, UMML 40.184, 4 spec.—24°17'N, 82°16'W, 362-384 m, R/V GERDA sta. G-437, 28 November 1964, UMML 40.132, 1 spec.—24°16'N, 82°58'W, 549-567 m, R/V GERDA sta. G-472, 25 January 1965, UMML 40.190, 3 spec.—24°15'N, 80°02'W, 540-549 m, R/V GERDA sta. G-142, 22 June 1963, UMML 40.195, 1 spec.—24°14'N, 82°23'W, 549-567 m, R/V GERDA sta. G-440, 29 November 1964, UMML 40.128, 6 spec.—24°14'N, 82°21'W, 512-549 m, R/V GERDA sta. G-476, 26 January 1965, UMML 40.185, 1 spec.—

24°13'N, 81°28'W, 594-604 m, R/V GERDA sta. G-289, 3 April 1964, UMML 40.183, 3 spec.—24°13'N, 81°24'W, 595 m, M/V SILVER BAY sta. 2421, 28 October 1960, 2 spec.—24°12'N, 81°13'W, 679-709 m, R/V GERDA sta. G-366, 15 September 1964, UMML 40.198, 1 spec.—24°11'N, 81°39'W, 540-595 m, R/V GERDA sta. G-288, 3 April 1964, UMML 40.200, 1 spec.—24°10'N, 81°40'W, 631 m, R/V GERDA sta. G-362, 15 September 1964, UMML 40.199, 1 spec.—24°07'N, 82°00'W, 686-715 m, R/V GERDA sta. G-122, 19 June 1963, UMML 40.193, 2 spec.—24°05'N, 82°29'W, 742-753 m, R/V GERDA sta. 442, 29 November 1964, UMML 40.197, 1 spec.—24°04'N, 82°20'W, 792-829 m, R/V GERDA sta. G-443, 29 November 1964, UMML 40.174, 4 spec.—23°59'N, 79°43'W, 640 m, M/V COMBAT sta. 450, 24 July 1957, 2 spec.—Off French W. Africa, 1477 m, PRINCESSE-ALICE sta. 1209, 1901, MCZ 2716, 1 spec.—16°35'N, 80°04'W, 733 m, M/V OREGON sta. 3561, 18 May 1962, 1 spec.—15°25'N, 63°32'W, 1250 m, ALBATROSS sta. 2117, 27 January 1884, USNM 7053 (holotype of *Tosia compta* Verrill).—14°18'N, 81°44'W, 751-770 m, M/V OREGON sta. 3573, 22 May 1962, 1 spec.—11°40'N, 62°27'W, 403 m, M/V OREGON sta. 2771, 15 April 1960, 2 spec.—11°36'N, 62°42'W, 430 m, M/V OREGON sta. 2776, 19 April 1960, 2 spec.—11°35'N, 62°41'W, 388-458 m, M/V OREGON sta. 2353, 23 September 1958, 1 spec.—11°35'N, 62°37'W, 403-421 m, M/V OREGON sta. 2775, 19 April 1960, 1 spec.—11°33'N, 62°09'W, 586-608, R/V PILLSBURY sta. 478, 2 August 1966, UMML 40.186, 6 spec.—09°53'N, 59°53'W, 229 m, M/V OREGON sta. 1983, 2 November 1957, 1 spec.—09°07'N, 81°10'W, 733 m, M/V OREGON sta. 3601, 31 May 1962, 1 spec.—04°25'N, 09°24'W, 641-733 m, R/V PILLSBURY sta. 74, 4 June 1964, UMML 40.106, 3 spec.—00°18'N, 44°17'W, 275 m, M/V OREGON sta. 4226, 9 March 1963, 1 spec.

*Diagnosis.*—Inferomarginal plates reduced in size distally; not corresponding with, and more numerous than, superomarginals. Adambulacra bearing five to eight furrow spines; each mouth plate bearing eight to 12 furrow spines.

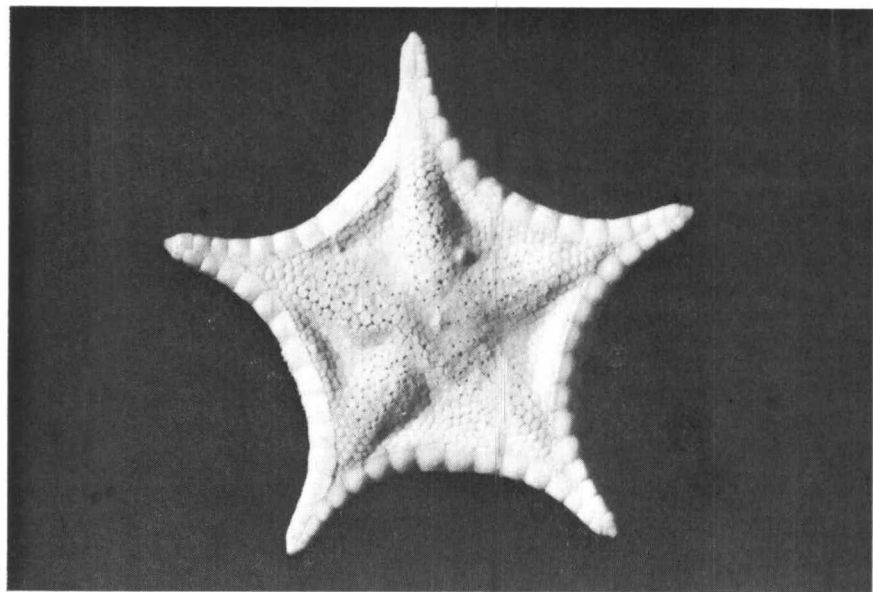
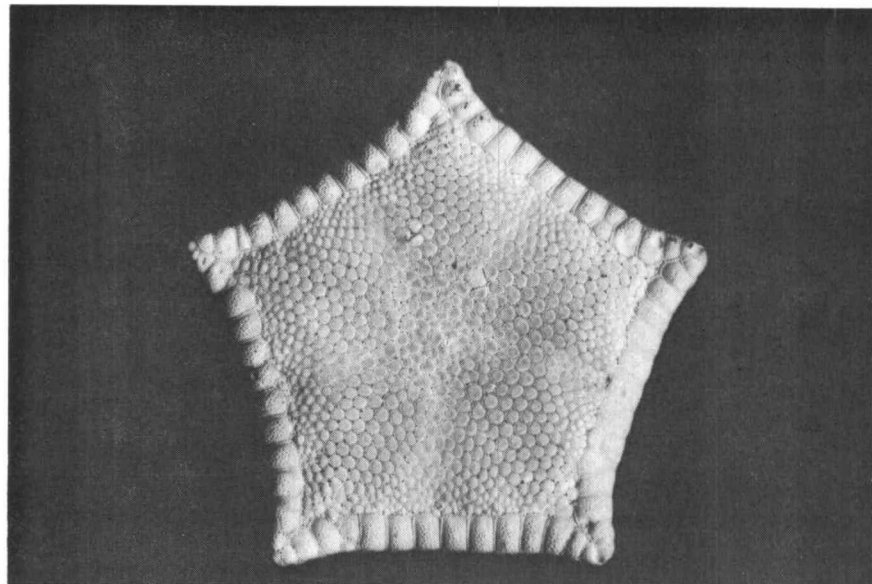
*Description.*—Five arms.  $R = 45$  mm,  $r = 35$  mm,  $R/r = 1.3$ .

The general form is pentagonal to arcuate pentagonal, the disk being large and flat.

The abactinal plates are flat, thin, and round. They are naked except for a single row of small, flattened granules surrounding each plate; the central naked area is roughened by numerous, minute, glassy, circular to elliptical bosses. Many plates bear small, excavate sugar-tong pedicellariae. Several

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FIGURE 17. *Plinthaster dentatus* (Perrier): A, specimen from OREGON sta. 2353; 1.8 ×; B, specimen from SILVER BAY sta. 3072; 0.9 ×.

**A****B**

scattered secondary plates are in the center of the disk and the proximal radial areas. Their granulation is similar to that of the primary abactinal plates. The large papular area includes the entire abactinal surface except for the narrow, triangular interradian areas. There are six papular pores surrounding each primary plate, each pore containing a single papula.

The marginal plates correspond, except at the most distal parts of the arms, where the inferomarginals are greatly reduced in size and more numerous. There are ten massive, thick, superomarginal plates. The distal pair is enlarged. The superomarginals are rectangular (about one and one-half times as wide as long), except for the most distal plate, which is triangular and longer than wide. The superomarginals are surrounded by a marginal row of small, flat, irregularly square granules. The center of each plate bears rounded, regularly spaced granules. The terminal plate is small and heart-shaped; the distal end is notched, the proximal end truncate. The 16 inferomarginal plates are about one and one-half times as wide as long. They are covered by small, spaced granules like those of the superomarginals.

The actinal plates are large, flat, rhombic, and completely covered by coarse, rounded, spaced granules, one and one-half to two times as large as the marginal granules. Only one actinal plate bears a small, excavate sugar-tong pedicellaria.

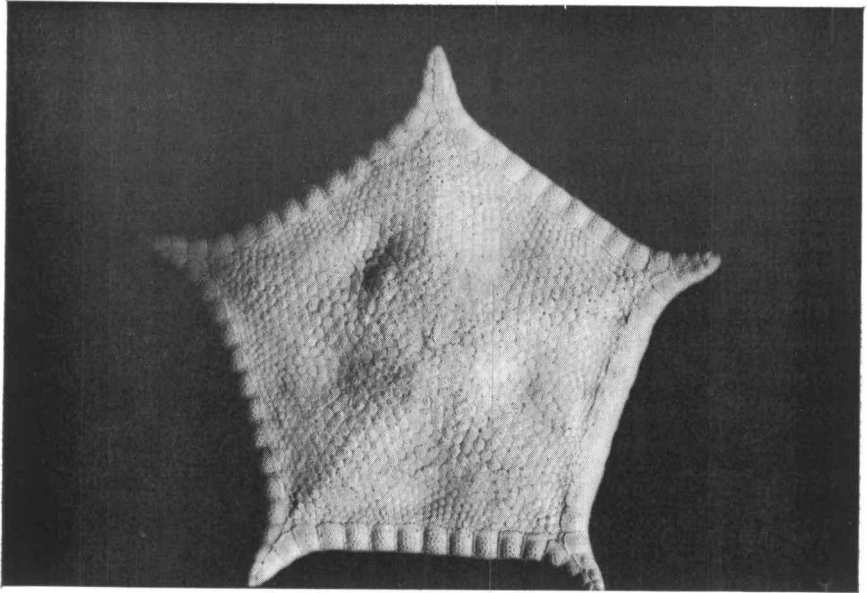
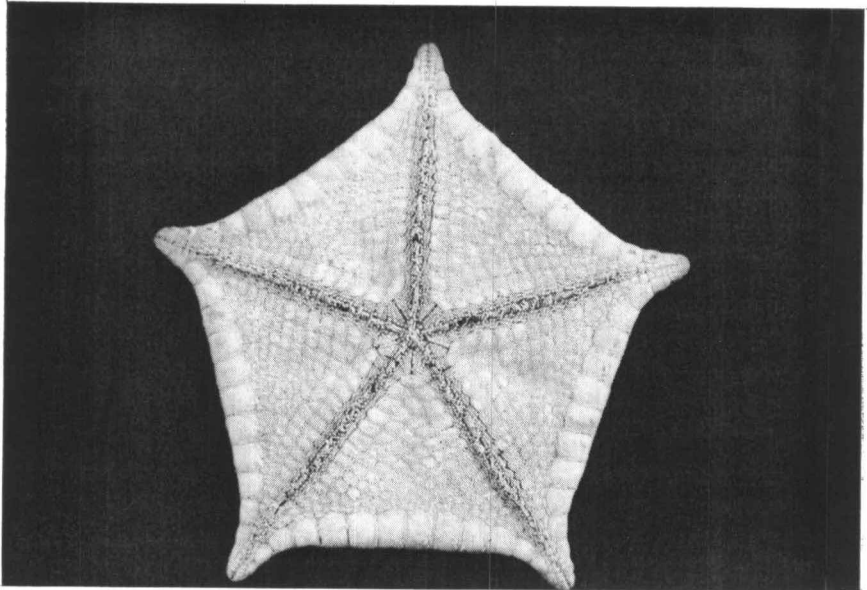
The adambulacral plates have a straight furrow margin. Each bears six to eight subequal, stout, moderately short, slightly compressed furrow spines with blunt, rounded tips. There are two or three irregular rows of four to six very short, blunt, subambulacral spinules slightly taller than the granules of the actinal plates. Some adambulacral plates bear sugar-tong pedicellariae.

The mouth plates are large, long, and triangular. Each plate bears nine or ten furrow spines, the spines increasing in size toward the mouth. The first eight or nine spines are similar to the adambulacral furrow spines, but are slightly longer and thicker. The median spine is largest and triangular in cross section. The rest of the plate is covered by 16 to 18 large, rounded granules, about twice as large as the granules of the actinal plates.

The anus is prominent and subcentral. The madreporite is irregularly square and about the same size as the adjacent abactinal plates. It is located approximately one-third the distance from the center of the disk to the middle of the interbrachial arc. The dorsal surface is orange, the ventral surface cream colored in living material.

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FIGURE 18. *Plinthaster dentatus* (Perrier): A, specimen from OREGON sta. 1983; actual size; B, specimen from OREGON sta. 1983; actual size.

**A****B**

*Type*.—Museum of Comparative Zoology, cat. no. 408.

*Type-Locality*.—Off Grenada, 762 m, BLAKE sta. 264.

*Distribution*.—This species is known from both sides of the Atlantic Ocean.

In the eastern Atlantic, it is known from the southern and western coasts of Ireland, 600-1800 m; Bay of Biscay, 950-960 m; off the western coast of Africa, from northern Morocco (35°34'N) to off Liberia (04°25'N), including the Canary Islands and the Cape Verde Islands, 641-1615 m.

It is known from the Azores, in 1095-1804 m.

In the western Atlantic, it is known from the southeastern coast of the United States from North Carolina (34°10'N) to Key West, Florida, 275-830 m; throughout the Gulf of Mexico, 366-829 m; off the eastern coast of Central America, from Honduras (16°35'N, 80°04'W) to Panama (09°07'N, 81°10'W), 733-770 m; off the northern and western coasts of Cuba, 439-1217 m; Aves Ridge, off Dominica, 2117 m; off Grenada, 403-762 m; off Trinidad, 586-606 m; off the eastern coast of South America, from Venezuela (09°53'N) to Brazil, near the equator off São Luís, 229-275 m.

*Discussion*.—The general body form is variable. There are three basic forms. In one form, the body is pentagonal, with a straight or slightly curved interbranchial arc; R/r ranges from 1.2 to 1.6; the superomarginal plates are massive, one pair being in contact medially; the body is thicker than in other forms (Fig. 17,B). In another form, the body is also pentagonal with R/r ranging from 1.4 to 1.7, but the distal part of each arm abruptly juts out at an angle; the superomarginal plates are smaller than in the other forms, and the distal pair are in contact medially and extend the length of that part of the arm that juts out (Fig. 18). In the third form, the body is stellate, with broadly curved interbranchial arcs, R/r ranging from 1.6 to 1.9; there are three to four pairs of superomarginal plates in contact medially (Fig. 17,A). I have described the three most extreme forms. There is complete intergradation in all the characters discussed.

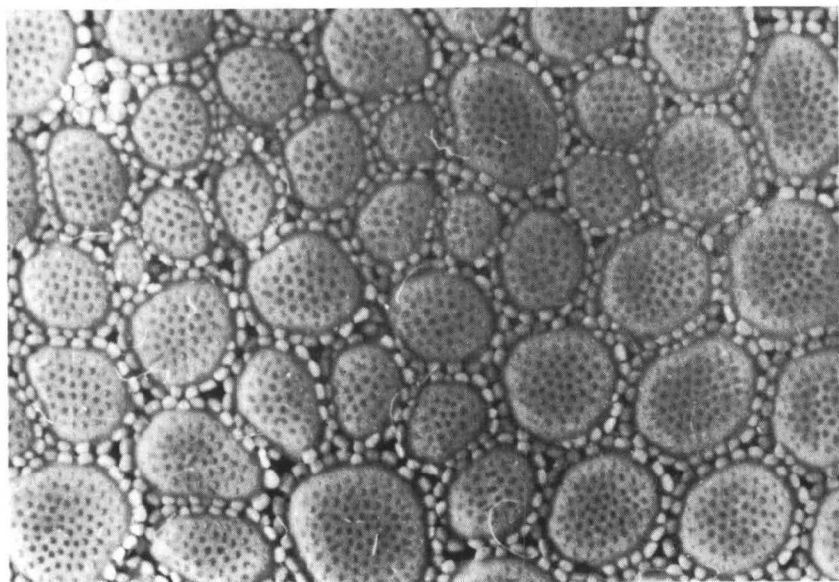
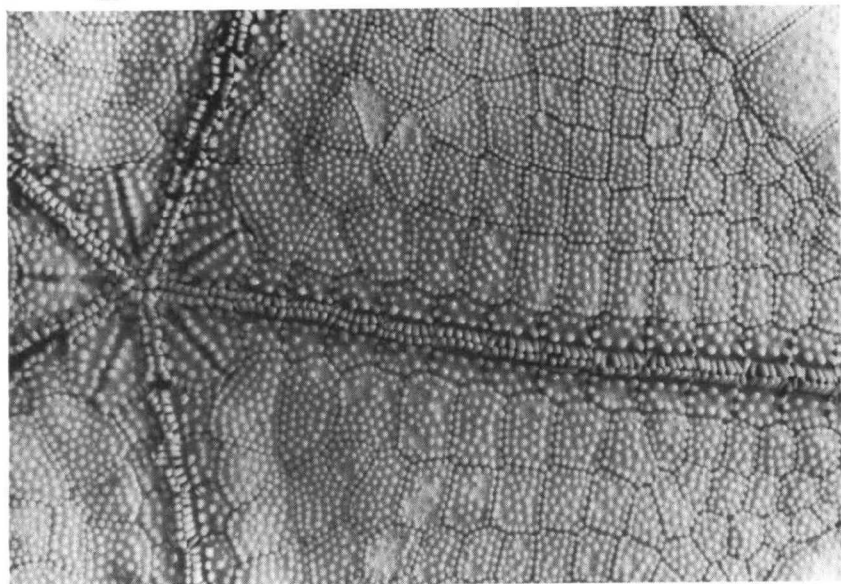
The number of pedicellariae is variable, ranging from none to many. Pedicellariae may be present on the dorsal or ventral surface only. The pedicellariae of the adambulacral plates vary from excavate sugar-tong to two, three, or four valved spatulate, sometimes within a single specimen.

The number of superomarginal plates in contact medially varies from one to five pairs.

The number of adambulacral furrow spines is usually five to seven. One large specimen had seven to eight. The number of furrow spines on a mouth plate ranges from eight to 12.

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FIGURE 19. *Plinthaster dentatus* (Perrier): A, specimen from GERDA sta. G-440; 8.0 ×; B, specimen from OREGON sta. 2824; 4.0 ×.

**A****B**

Verrill (1899: 165) described *P. nitidus* as being "closely allied to *P. comptus* in form and most of the details of structure." The holotypes of these species are very similar. Verrill exaggerated the differences in the characters he used for separating them. Furthermore, the differences that do exist are attributable to growth. These specimens are basically like the stellate form described above. The type of *P. dentatus*, though arcuate pentagonal, is closest to the first pentagonal form described above. The type of *P. perrieri* is basically like the stellate form.

The specimens from the eastern Atlantic show the same type and range of variation as those from the western Atlantic. Farran (1913: 10) and Grieg (1921: 23) have already characterized *P. dentatus* as an amphiatlantic species, synonymizing the eastern Atlantic species *P. perrieri* with it.

*Remarks.*—H. L. Clark (1941: 43) discussed the variations in the Cuban specimens of *Plinthaster dentatus*. He was astonished, as I am, by the great difference in appearance between the extremes of the different forms. However, he concluded that "the intergradation seems too complete to justify any separation."

I designate the specimen collected at BLAKE station 264 the lectotype and the type-locality is restricted to off Grenada, in 762 m.

#### Genus *Litonotaster* Verrill, 1899

*Litonotaster* Verrill, 1899: 171-172.—Fisher, 1911: 165-166.—Halpern, 1969: 129-130.

*Diagnosis.*—Abactinal plates flat, very thin; not completely covered by granules, but bearing more than single marginal row. No secondary abactinal plates. Papular areas narrow. No superambulacral ossicles. No internal radiating ossicles.

*Type-Species.*—*Pentagonaster intermedius* Perrier (by original designation: Verrill, 1899: 171).

#### *Litonotaster rotundigranulum* Halpern, 1969

Figs. 20-22

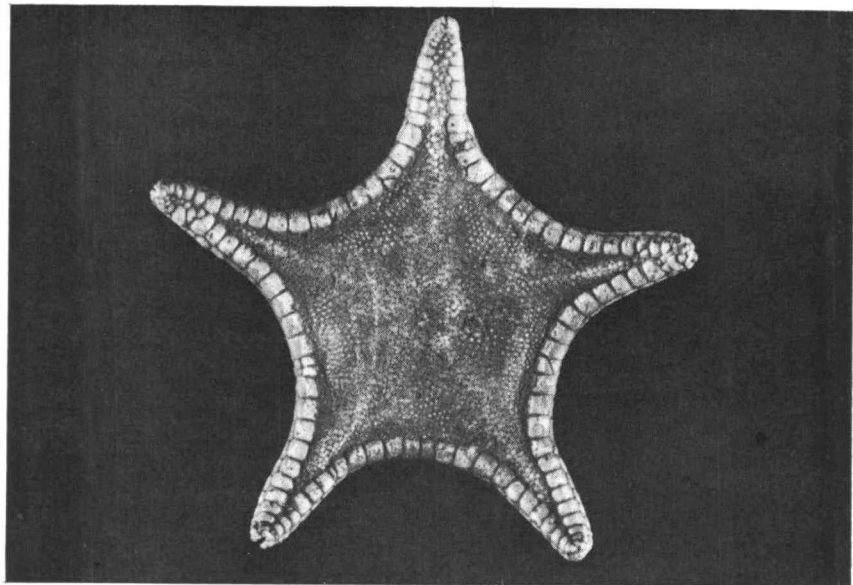
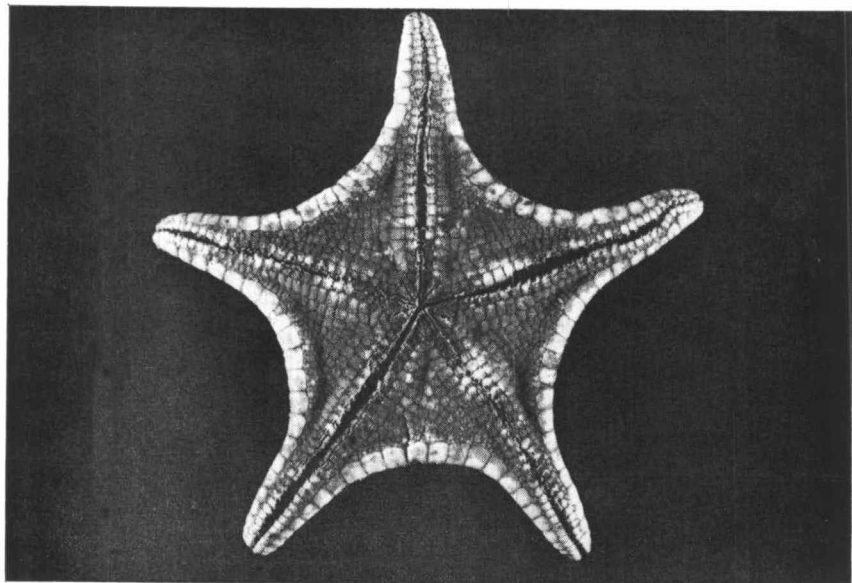
*Litonotaster rotundigranulum* Halpern, 1969: 139-142, figs. 1A, 6, 7.

*Material Studied.*—HOLOTYPE: R = 60 mm, r = 29 mm, R = 2r; 23°54'N, 82°19'W, 1135-1184, R/V GERDA sta. G-448, 1 December 1964, USNM E10862.

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FIGURE 20. *Litonotaster rotundigranulum* Halpern: A, holotype from GERDA sta. G-448; 0.7 ×; B, holotype from GERDA sta. G-448; 0.7 ×.



**A****B**

*Diagnosis.*—Disk large. Superomarginal plates prominent. Actinals covered by large, hemispherical granules. Seven to eight furrow spines in proximal half of ambulacral furrow, five to six distally. No pedicellariae.

*Description.*—Five arms.  $R = 60$  mm;  $r = 29$  mm;  $R/r = 2$ .

The general form is stellate, with arms that taper regularly to a bluntly pointed tip and broadly curved interbrachial arcs. The large disk is slightly inflated, the abactinal surface being very thin and flexible.

The small, flat, irregularly round, very thin abactinal plates are closely crowded. They are covered by small, rounded granules. A small central area may be bare or have one to four scattered granules. There are no secondary plates. The interrachial areas are large. The papular areas are small and inconspicuous, being restricted to narrow bands running from the arms to the center of the disk. The papular pores are small. Six papular pores surround each plate, each pore containing a single papula.

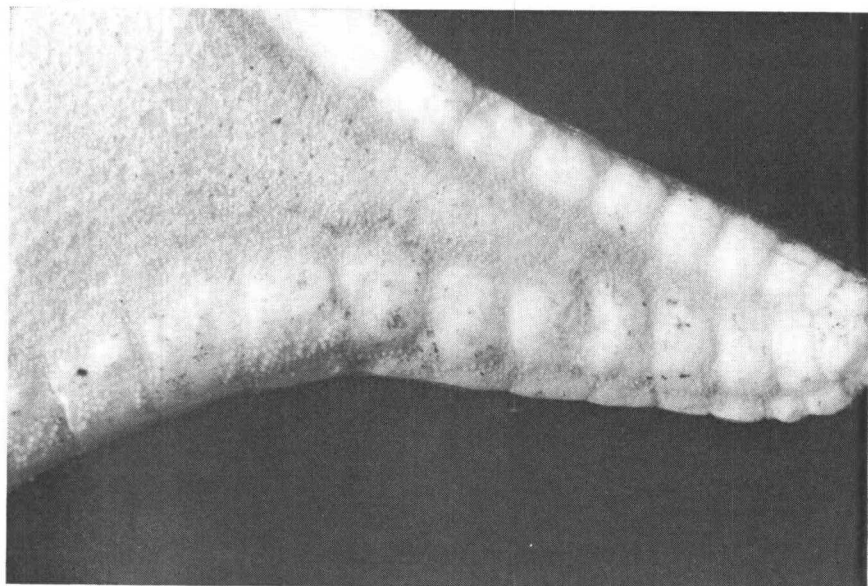
There are 24 to 28 large superomarginal plates. They correspond with the inferomarginals in the interbrachial arc, but are irregular in shape, number, and correspondence in the distal parts of the arms. The plates are square in the interbrachial arc, becoming wider than long distally. There are one to four pairs in contact medially. The lower half of each plate is completely covered by hemispherical granules. The upper half is bordered by a row of granules, with the center bare or having scattered granules. In the interbrachial arc, the lateral angle of the superomarginals is depressed so that each plate is flattened and moderately thin. They become more angular distally. The terminal plate is moderately large, naked, swollen, and heart shaped; the distal end is notched, the proximal end truncate. There are 26 to 30 inferomarginal plates, always two more than in the superomarginal series. The inferomarginals are completely covered by hemispherical granules similar to those of the superomarginals.

The actinal intermediate area is large. The plates are large and rhombic, except near the marginals, where they are small and irregular. The actinals are flat, well defined, and completely covered by closely crowded, large hemispherical granules.

The adambulacral plates are square or sometimes pentagonal. They correspond with the adjacent actinals, which are twice as wide. The furrow margin is straight. There are six or seven furrow spines in the proximal half of the ambulacral furrow, five or six distally. The spines are short, blunt, compressed, and subequal. The first subambulacral row consists of five or six very short, blunt spines. There are three more irregular sub-

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FIGURE 21. *Litonotaster rotundigranulum* Halpern: A, holotype from GERDA sta. G-448; 3.2 ×; B, holotype from GERDA sta. G-448; 3.1 ×.

**A****B**

ambulacral rows of five to six large, hemispherical granules like those of the actinals.

The mouth plates are very large and have a long furrow margin. Each plate has ten short, blunt furrow spines. The first nine spines are subequal and like the adambulacral furrow spines. The median spine is only slightly larger. The rest of the plate is covered by large hemispherical granules like those of the actinals, except for short, blunt spines at the suture. The suture is broad and prominent.

The madreporite is deeply furrowed, rhombic, and about four times larger than the surrounding plates. It is at one-third the distance from the center of the disk to the middle of the interbranchial arc. There are no pedicellariae, no internal radiating ossicles, and no superambulacral ossicles. The anus is small and subcentral.

*Type*.—United States National Museum, cat. no. E10862.

*Type-Locality*.—Straits of Florida, on Pourtales Plateau, south of Key West; 23°54'W, 82°19'W, 1135-1184 m, R/V GERDA sta. G-448.

*Distribution*.—This species is known only from the type-locality.

Genus *Goniaster* L. Agassiz, 1835

*Goniaster* L. Agassiz, 1835a: 143; 1835b: 191.—Gray, 1840: 280; 1866: 10.—von Martens, 1866: 86.—Verrill, 1899: 150-151.—Koehler, 1909a: 87.—Fisher, 1911: 167-168.—Verrill, 1915: 103-104.—Tortonese, 1937: 55.

*Phaneraster* Perrier, 1894: 387-388.

*Diagnosis*.—Many large, prominent, conical spines on dorsal surface; secondary abactinal and marginal plates. No large actinal or adambulacral spines; adambulacral armature grading into actinal granulation.

*Type-Species*.—*Asterias tessellata* Lamarck (by subsequent designation: L. Agassiz, 1835a: 143).

*Goniaster tessellatus* (Lamarck, 1816)

Figs. 23-25

*Pentagonaster semilunatus* Linck, 1733: 21, pl. 23, no. 37, pl. 24, no. 39, pl. 27, no. 45.

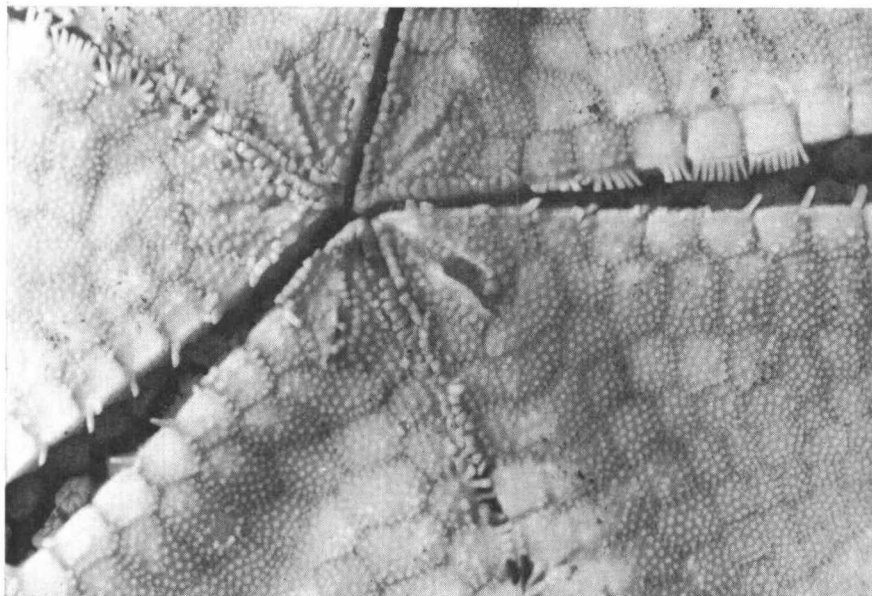
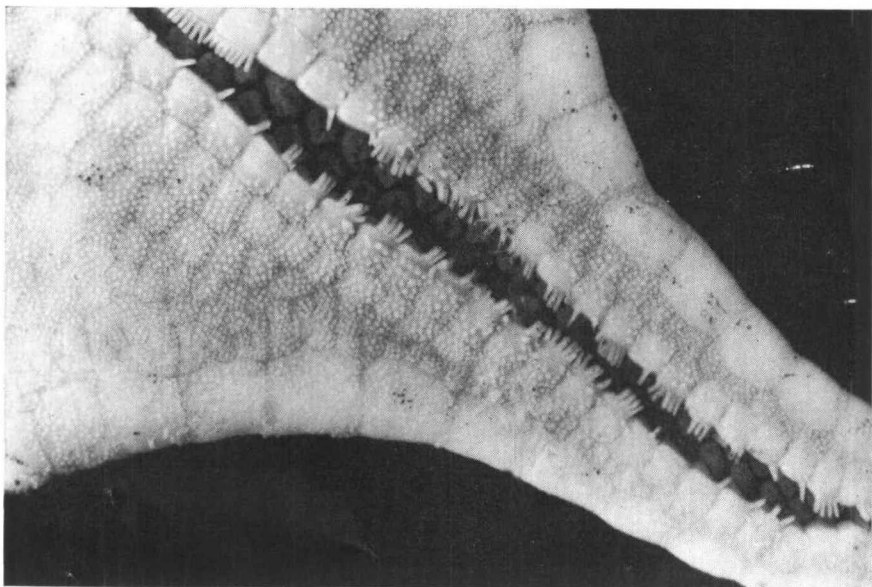
*Artocreatis tertia species* Seba, 1761: 11, pl. 6, figs 9-10.

*Asterias granularis* (in part) Gmelin, 1791: 3164.

*Asterias tessellata* (Var. C & D) Lamarck, 1816: 552.

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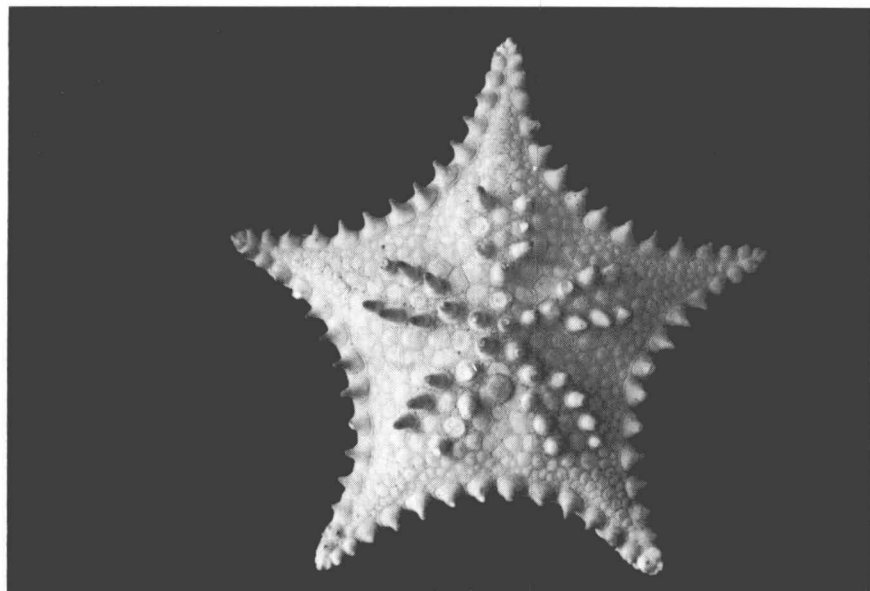
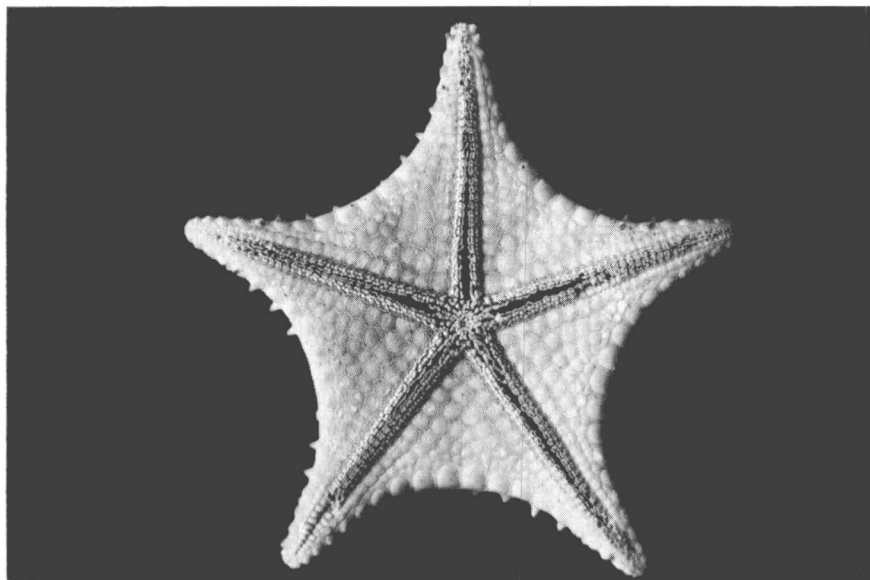
FIGURE 22. *Litonotaster rotundigranulum* Halpern: A, holotype from GERDA sta. G-448; 3.1 ×; B, holotype from GERDA sta. G-448; 3.0 ×.

**A****B**

- Asterias tessellata*: de Blainville, 1834: pl. 23, fig. 4.
- Goniaster tessellatus*: L. Agassiz, 1835a: 143; 1835b: 191.—H. L. Clark, 1909: 110.—Fisher, 1910: 172; 1911: 167-168.—Verrill, 1914: 286.—H. L. Clark, 1946: 81.
- Goniaster cuspidatus* Gray, 1840: 280; 1866: 10.—Tortonese, 1937: 31-34, pl. 2, fig. 6, pl. 6, figs. 25-31.—Madsen, 1950: 209-211.—Dilwyn-John & A. M. Clark, 1954: 139.—A. H. Clark, 1954: 375.—A. M. Clark, 1955: 18, 22.—Engel *et al.*, 1960: 12.
- Astrogonium cuspidatum*: Müller & Troschel, 1842: 56.—Dujardin & Hupé, 1862: 394.—Perrier, 1869: 85; 1876c: 67.
- Goniaster semilunatus*: von Martens, 1866: 86.—Koehler, 1909a: 87, pl. 5, fig. 5.
- Astrogonium dubium* Perrier, 1869: 85.
- Goniaster americanus* Verrill, 1871: 130-131.—Perrier, 1875: 1273; 1876b: 261; 1876c: pl. 67.—Verrill, 1899: 151-156, pl. 24a, figs. 1-2, pl. 26, figs. 1-6; 1915: 104-107, pl. 13, figs. 5, 5a.—Bernasconi, 1958: 13-15, pl. 1, figs. 1-2.—Cherbonnier, 1959: 107-108.
- Goniaster africanus* Verrill, 1871: 131-132.—Perrier, 1875: 1273; 1876b: 261; 1876c: 67.—Verrill, 1899: 156-157, pl. 25, figs. 1-2.
- Pentagonaster semilunatus*: Perrier, 1876a: 24-28; 1876c: 64, 67.—Rathbun, 1879: 148-149.—Sladen, 1889: 265, 266, 267-268, 655, 694, 748-749.—Ludwig, 1899: 539.
- Astrogonium semilunatum*: Perrier, 1885a: 37.
- Phaneraster semilunatus*: Perrier, 1894: 388-390.
- Material Studied.**—34°11'N, 76°42'W, 35 m, M/V SILVER BAY sta. 2945, 15 March 1961, 1 spec.—29°37'N, 85°03'W, 22 m, (collector and date unknown), 1 spec.—29°30'N, 80°15'W, 73 m, M/V SILVER BAY sta. 3171, 10 March 1961, 1 spec.—29°19'N, 85°09'W, 24 m, M/V SILVER BAY sta. 41, 15 July 1957, 1 spec.—28°13'N, 80°02'W, 66 m, M/V SILVER BAY sta. 2008, 25 April 1960, 1 spec.—27°46'N, 84°06'W, 57 m, M/V OREGON sta. 4086, 4 December 1962, 6 spec.—25°52'N, 79°45'W, 430 m, M/V PELICAN sta. 11, 11 March 1956, UMML 40.64, 1 spec.—24°50'N, 80°35'W, 92 m, W. Starck, 22 August 1961, 1 spec.—24°48'N, 80°34'W, 73 m, D. de Sylva, 20 August 1961, 2 spec.—24°21'N, 82°36'W, 59 m, R/V GERDA sta. G-574, 13 April 1965, UMML 40.120, 7 spec.—24°21'N, 82°34'W, 64 m, R/V GERDA sta. G-575, 13 April 1965, UMML 40.119, 3 spec.—08°00'N, 58°05'W, 55 m, M/V OREGON sta. 4164, 18 February 1963, 2 spec.—04°56'N, 00°49'W, 36 m, R/V PILLSBURY sta. 24, 28 May 1964, UMML 40.153, 2 spec.—Zanzibar, (depth, collector, and date unknown), MCZ 119, 1 spec.
- Diagnosis.**—Four to six adambulacral furrow spines. Six to nine mouth furrow spines.

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FIGURE 23. *Goniaster tessellatus* (Lamarck): A, specimen from northern Gulf of Mexico, UMML 40.61; 0.8 ×; B, specimen from northern Gulf of Mexico, UMML 40.61; 0.8 ×.

**A****B**

*Description.*—Five arms.  $R = 75$  mm;  $r = 42$  mm;  $R = 1.8r$ .

The general form is stellate, with a large disk and short arms. The abactinal surface is slightly convex, the interbranchial arcs wide and rounded, and the arms are broad and gradually tapered.

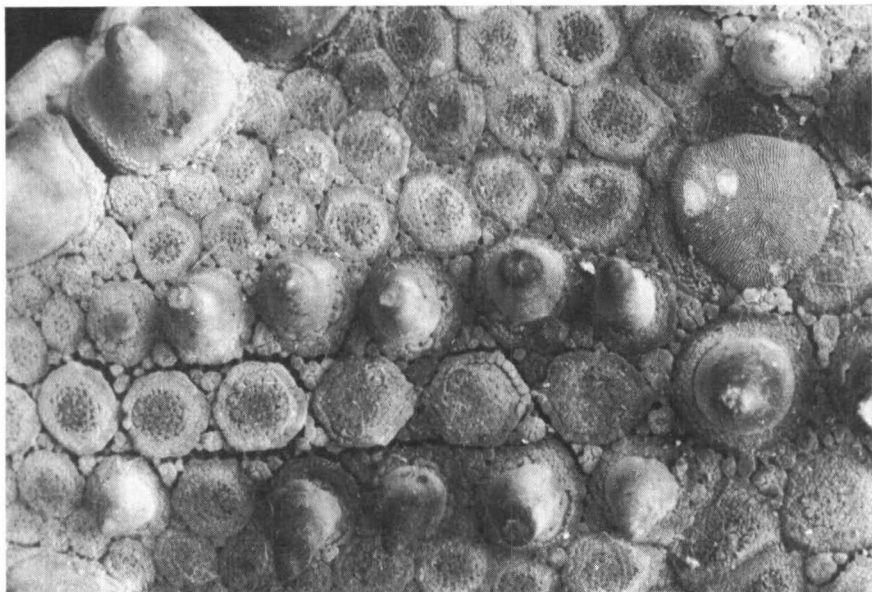
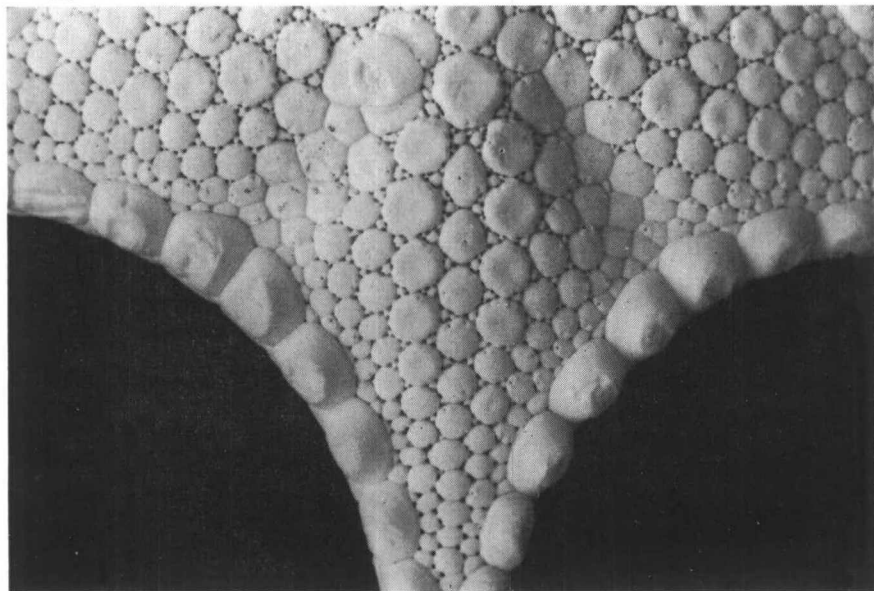
The abactinal surface is characterized by a number of large, prominent conical spines. These spines are found only on the primary plates in the radial areas and the center of the disk, and are distributed as follows: on the central abactinal plate; on the first two carinal plates only, continuing distally in a double row on the adradial plates. This pattern is constant. Other spines are often found on various dorsolateral plates of the radial area. The spines are attached by connective tissue to the abactinal plates and are often broken off. The primary abactinal plates are flat and irregularly round. They are covered by flat, polygonal, closely crowded granules. The margin bears one row of larger, irregularly rectangular, flat granules. Small, excavate sugar-tong pedicellariae are present (often as many as four on a plate) on the primary plates, including those bearing spines. The bases of the radial plates have six prominent, truncate lobes. Secondary plates are present in the radial areas and the center of the disk. They are covered by granules and a marginal row similar to those of the primary plates. The secondary plates do not form a reticulated skeleton with the primary plates. The papular area is extensive. It is made conspicuous by the secondary plates. Six papular pores surround each primary plate, each pore containing one to four papulae.

The marginal plates are massive and slightly wider than long in the interbranchial arc. The superomarginals (except for the distal pair) are larger than the inferomarginals. There are four to six more inferomarginals than superomarginals. A ridge on the bottom of the superomarginals fits into a groove on top of the inferomarginals. There are 15 to 17 superomarginals. Each bears a large, conical, blunt spine which is part of the plate (not attached by connective tissue). Along the margin of each plate is a row of granules similar to those surrounding the abactinals. The rest of the plate is bare. Some plates bear small, excavate sugar-tong pedicellariae at the base of the spine. The distal pair of superomarginals is greatly reduced in size; the pair proximal to these is enlarged. These last two pairs are contiguous medially. The lateral edges of the superomarginals are rounded. Roundly triangular secondary marginal plates fill the two spaces formed by two adjacent plates. These secondary plates are covered by flat, polygonal, closely crowded granules and a marginal row of larger, irregularly rectangular granules. The terminal plate is small and conical. There are

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FIGURE 24. *Goniaster tessellatus* (Lamarck): A, specimen from GERDA sta. G-574; 3.5  $\times$ ; B, denuded specimen from PELICAN sta. 11; 4.0  $\times$ .



**A****B**

20 to 22 high, convex inferomarginal plates. Along the margin of each plate is one or two rows of large, irregularly rectangular, flat granules, similar to those surrounding the actinals. The rest of the plate is usually bare, but some plates have one to seven small, excavate sugar-tong pedicellariae. The lateral edges of the plates are rounded, so that adjacent plates form spaces; the spaces formed on the ventral side are filled by irregular actinals. Secondary marginal plates fill the spaces formed on the dorsal side. These secondary plates are roundly triangular and convex, with granulation similar to the secondary superomarginals. The inferomarginal and superomarginal secondary plates may correspond or alternate.

The most distal two to four pairs of inferomarginal plates bear short, conical spines attached by connective tissue to flattened areas of the plates.

The actinal intermediate area is large. Each plate is flat, large, polygonal and completely covered by coarse, rounded granules. The marginal row of granules is slightly enlarged. Many actinal plates bear one to four excavate sugar-tong pedicellariae.

The adambulacral plates are rectangular, being twice as wide as long. They are as wide as the adjacent actinal plates and half as long. The proximal adambulacrals bear two-jawed spatulate pedicellariae. The surface of the plates is tuberculate. The furrow margin is straight and bears four to six long, compressed, subequal furrow spines with truncate or rounded tips. The subambulacral spines are closely crowded. The first row has three or four large, compressed, blunt spines; the second row has two to four similar spines, except that every second or third spine is almost twice as wide and clavate. The third row is similar to the second, except that the spines are about half as high. Two irregular rows of four or five polygonal granules, slightly larger than the marginal granules of the actinals, cover the rest of the plate.

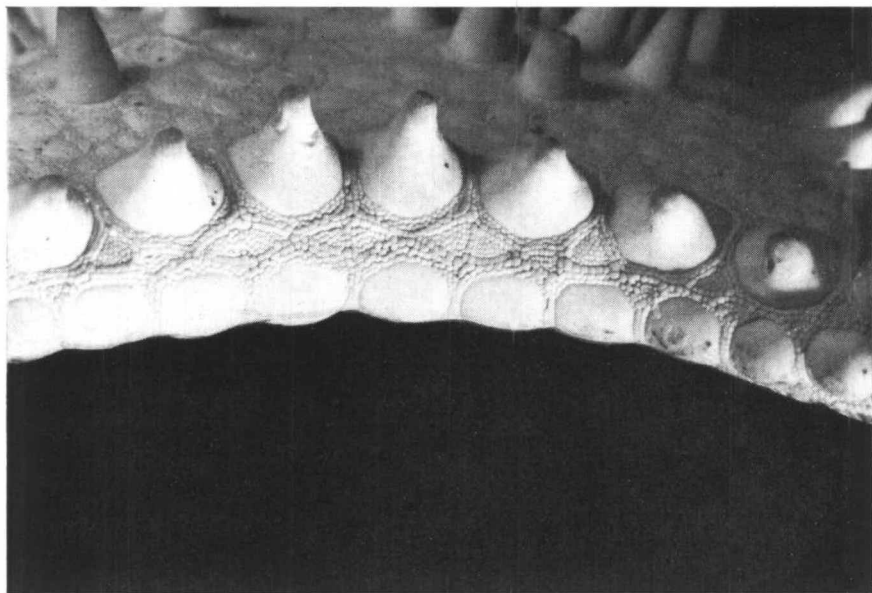
The mouth plates are small, narrow and slightly convex. Each plate bears seven to eight subequal, strongly compressed, truncate furrow spines, similar to, but thicker than, the adambulacral furrow spines. The median spine is not enlarged. Each plate is completely covered by large, thick, clavate or compressed-terete spines. They are arranged in two irregular rows, parallel to the furrow, of four to six spines. There are two smaller spines, slightly less than half as large, in the distal corner.

The anus is adjacent to the abactinal plate bearing the central spine. It is surrounded by a row of spinules. The madreporite is roundly triangular and about three times as large as the adjacent abactinal plates. It is at

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FIGURE 25. *Goniaster tessellatus* (Lamarck): A, specimen from northern Gulf of Mexico, UMML 40.61; 3.8  $\times$ ; B, specimen from northern Gulf of Mexico, UMML 40.61; 3.6  $\times$ .

**A****B**

the top of an interradius, close to the center of the disk. The gonads are serial. They are large, thick, triangular tufts on each side of the inter-brachial septum. The hepatic caecae are long, extending more than two-thirds the length of R. The polian vesicles are large and ovoid.

*Type*.—Not traced.

*Type-Locality*.—Lamarck (1816: 552) stated that *Asterias tessellata* lives in the seas of Europe, America, and the "Grandes-Indes." The first two localities probably refer to the section on *Ceramaster granularis*. The "Grandes-Indes" are probably the East Indies.

*Distribution*.—This species is known from the Atlantic Ocean and Indo-Pacific, in 22-430 m.

In the western Atlantic, it is known from North Carolina to Brazil, including the West Indies and Gulf of Mexico. There is one doubtful record from Buenos Aires (cf., Bernasconi, 1958: 15).

In the eastern Atlantic, it is known from Morocco to Gabon, including the Cape Verde Islands.

In the Indo-West Pacific, it is known from Zanzibar, the Celebes, Viet Nam, and China.

*Discussion*.—This species is quite variable. The number of spines on the dorsolateral plates varies, though there is a tendency for it to increase with age; the spines also vary in shape, but are usually conical or subconical. The superomarginal spines can be nipple-shaped, conical, subconical, or broad and truncate. One to three superomarginal plates are in contact medially. The distal pair of superomarginals may be greatly reduced or swollen and enlarged. The number of pedicellariae is quite variable, ranging from abundant to absent. They may be present on only the dorsal or ventral surface. Discussion of the variability of this species may be found in Perrier (1876a) and Tortonese (1937).

Six specimens collected by M/V OREGON (sta. 4086) in the Gulf of Mexico are noteworthy. One specimen has the normal arrangement of abactinal spines; two are lacking several spines. One specimen has seven spines and another only two; the other specimen has no abactinal spines. All these specimens are normal in every other respect and are obviously *Goniaster tessellatus*.

*Remarks*.—Most modern authors have referred to this species as *Goniaster cuspidatus* Gray, 1840; only Fisher (1910: 172; 1911: 167-168) and H. L. Clark (1909: 110; 1946: 81) have called it *G. tessellatus*. I consider *G. cuspidatus* Gray a junior synonym of *G. tessellatus* (Lamarck, 1816).

*Asterias tessellata* Lamarck, 1816, is a composite species. Varieties C and D are definitely referable to the same species as Gray's *cuspidatus*. Variety A refers to a figure by O. F. Müller (1789: pl. 92), which has

been identified by Mortensen (see Anker, 1950) as *Ceramaster granularis*, and various figures of Linck and Seba which are also of *Ceramaster granularis*. Thus, *tessellatus* cannot be employed for variety A, for it has already been given the name *granularis* (Retzius, 1783). This would leave *tessellatus* available for varieties C and D; however, Lamarck gave no identifiable references for variety B.

When Louis Agassiz established the genus *Goniaster*, he specifically named *Asterias tessellata* Lamarck as "le type du genre" (1835a: 143). Furthermore, by his characterization of the genus, there is no doubt that Agassiz had varieties C and D in mind. Thus, as the first reviser, Agassiz established *tessellatus* Lamarck as a valid name, referable to one species. This makes *cuspidatus* Gray, 1840, a junior synonym.

#### Genus *Circeaster* Koehler, 1909

*Circeaster* Koehler, 1909b: 83.

*Lydiaster* Koehler, 1909b: 91-92.

*Diagnosis*.—Abactinal plates of arms polygonal, conspicuously larger than those of disk. No spines on marginal plates. Disk large, arms long. Actinal plates bearing bivalved, excavate, or spatulate pedicellariae.

*Discussion*.—Koehler (1909b: 91) erected a monotypic genus, *Lydiaster*. He separated it from the closely related genus *Circeaster* because of its excavate abactinal pedicellariae and because the increase in size of its abactinal arm plates is gradual, not abrupt.

I do not consider these differences to be of generic importance. The Caribbean representative of this goniasterid section is intermediate between *Circeaster* and *Lydiaster*. The dorsal pedicellariae are characteristic of *Lydiaster*, but the ventral pedicellariae are more like those of *Circeaster*. When all four species of this section are examined, the increase in size of the arm plates ranges from abrupt to gradual in the following order: *Circeaster marcelli* (most abrupt), *C. magdalenae*, *C. americanus*, and *C. johannae* (least abrupt).

*Type-Species*.—*Circeaster marcelli* Koehler, 1909b (here designated).

#### *Circeaster americanus* (A. H. Clark, 1916)

Figs. 26; 27; 28, A

*Lydiaster americanus* A. H. Clark, 1916: 141-144; 1954: 376.

*Circeaster occidentalis* H. L. Clark, 1941: 46-49, pl. 4, fig. 2.—A. H. Clark, 1954: 376.

*Material Studied*.—HOLOTYPE: R = 100 mm, r = 35 mm, R = 2.9r; 28°26'N, 86°50'W, 635 m, ALBATROSS sta. 2395, 13 March 1885, USNM 10872.

OTHER MATERIAL: 24°15'N, 80°02'W, 545 m, R/V GERDA sta. G-142,

22 June 1963, UMML 40.216, 1 spec.—23°18'N, 80°46'W, 897 m, ATLANTIS sta. 3474, 10 May 1939, MCZ 3985 (paratype of *Circeaster occidentalis* H. L. Clark).—23°17'N, 80°12'W, 760 m, ATLANTIS sta. 2990B, 14 March 1938, MCZ 3819 (holotype of *Circeaster occidentalis* H. L. Clark).—23°06'N, 82°35'W, 604 m, ATLANTIS sta. 3305, 23 March 1938, MCZ 3984 (paratype of *Circeaster occidentalis* H. L. Clark).—18°21'N, 87°17'W, 1098 m, BLAKE sta. XVIII, 1880, MCZ 502 (paratype of *Circeaster occidentalis* H. L. Clark).—16°35'N, 80°10'W, 576 m, M/V OREGON sta. 3560, 18 May 1962, 1 spec.—13°33'N, 81°55'W, 503 m, M/V OREGON sta. 1921, 13 September 1957, USNM E9963, 1 spec.—11°54'N, 69°18'W, 915 m, M/V OREGON sta. 4416, 4 October 1963, 1 spec.—11°33'N, 62°09'W, 598-576 m, R/V PILLSBURY sta. 478, 2 August 1966, 1 spec.—10°13'N, 76°06'W, 814-1050 m, R/V PILLSBURY sta. 388, 15 July 1966, UMML 40.231, 1 spec.

**Diagnosis.**—Many abactinal and superomarginal plates bearing large, excavate pedicellariae, about as high as wide, with denticulate jaws. Very large, spatulate pedicellariae with denticulate or smooth jaws on ventral surface; pedicellariae about one to two times as wide as high on actinals and inferomarginals and about two to three times as wide as high on adambulacrals. Three to five pairs of superomarginals in contact medially.

**Description.**—Five arms.  $R = 75$  mm,  $r = 24$  mm,  $R = 3.1r$ .

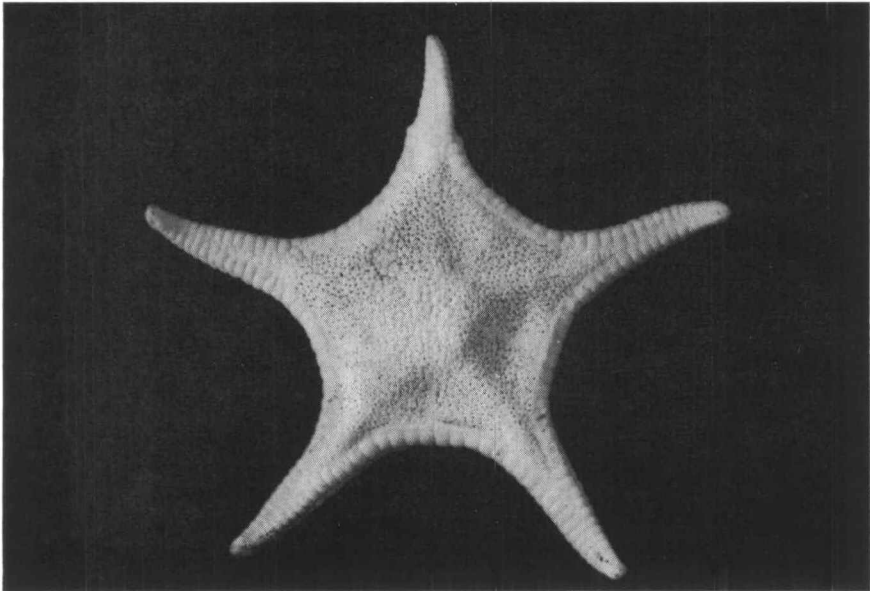
The general form is stellate with a large disk. The interbranchial arcs are wide and rounded.

The abactinal plates are slightly swollen, but not tabulate. They are irregularly round to polygonal and surrounded by flattened, irregularly square granules. The abactinal plates of the arms are conspicuously larger than those of the disk. The center of some plates is naked; in others it bears one to ten round granules. No plates bear pedicellariae. The primary abactinal plates on the disk are bordered by about 15 to 25 flattened granules. The center of many plates is naked and smooth; others bear one or two large, excavate pedicellariae and/or one to five rounded granules. The pedicellariae are about as high as wide and have denticulate jaws. Each granule is inserted in a small pit. The secondary abactinal plates on the disk are present in the papular area only; they are bordered by about four to ten granules. Two of the larger secondary plates bear pedicellariae like those on the primary plates. The secondary plates do not form a reticulated skeleton with the primary plates. The papular area is extensive; papulae are found throughout the disk to the bases of the arms, except for

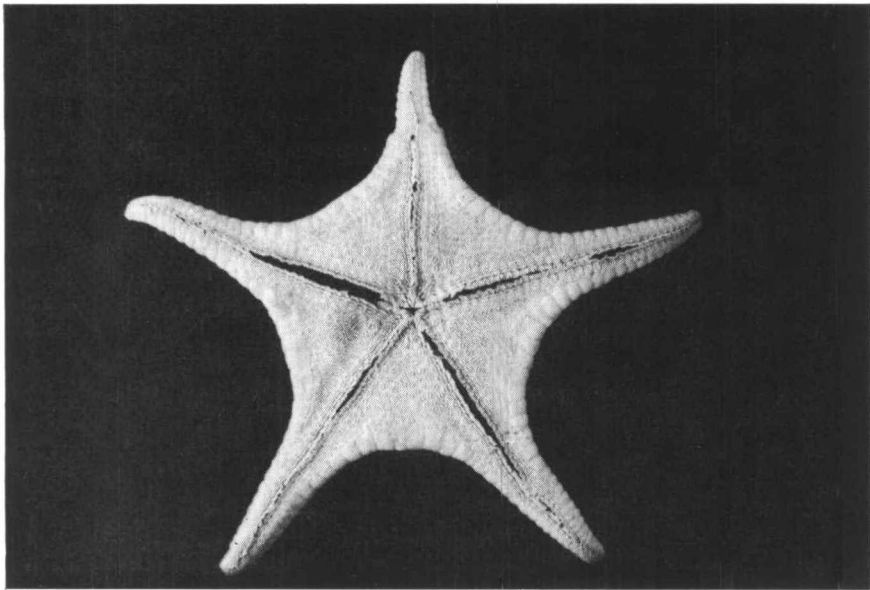
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FIGURE 26. *Circeaster americanus* (A. H. Clark): A, specimen from GERDA sta. G-142; 0.6 ×; B, specimen from GERDA sta. G-142; 0.6 ×.

**A**



**B**



the narrow, triangular interradial areas. Six papular pores surround each primary plate, each pore containing one papula.

The 44 marginal plates in each series correspond throughout.

The superomarginal plates are approximately square in the interbrachial arc, becoming about twice as wide as long in the distal part of the arm. They are surrounded by granules similar to those surrounding the abactinals. Fifteen to 25 scattered round granules are in the center of each plate. Some plates bear pedicellariae of the same type as those on the abactinals. Three to five superomarginals are in contact medially. The terminal plate is large, about three times the size of the adjacent superomarginals, and oval; the proximal end is rounded, the distal end roundly truncate. The terminal plate bears three large, truncate spines distally; the median spine is dorsal to the two lateral spines. The inferomarginal plates are slightly wider than long in the interbrachial arc, becoming slightly longer than wide on the proximal half of the arm and slightly wider than long again on the distal half of the arm. The inferomarginals are surrounded by flattened granules of the same type surrounding the superomarginals. Forty to 50 regularly spaced granules, like those on the superomarginals but slightly larger, cover the center of the plate. Some plates bear pedicellariae similar to those on the actinals. Pedicellariae are more common on the inferomarginals than on the superomarginals.

The actinal intermediate area is large. Almost every actinal plate bears a spatulate pedicellaria in its center. The pedicellariae usually have two valves, but some have three. The pedicellariae are about twice as large as the abactinal pedicellariae. They are about two times as wide as high, giving a bivalved appearance, but are higher than, and not as thick as, true bivalved pedicellariae; they are about as wide as high on the smaller plates. The actinal plates are surrounded by flattened granules slightly larger than, but similar to, those surrounding the abactinals. On the larger plates, one to four large, prismatic granules surround the pedicellaria; one to six such granules are on the plates without pedicellariae.

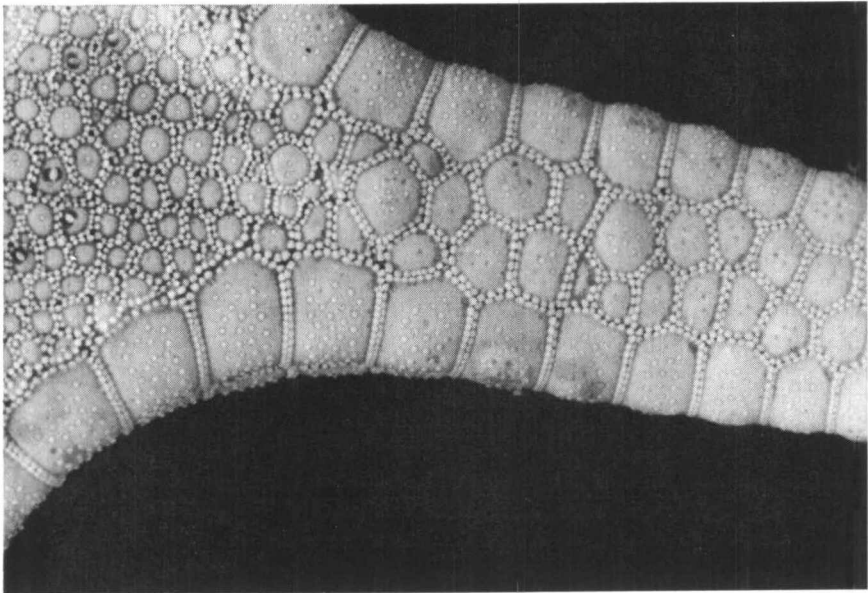
The adambulacral plates are rectangular (approximately one and one-half times as wide as long) and slightly larger than the adjacent actinals. The slightly angular furrow margin bears four to six (usually five) short, stout, prismatic, truncate, subequal spines. At the tip of each spine is a groove, parallel to the furrow. The first subambulacral row consists of three to five prismatic granules; the granules are about as high as wide and about half as high as the furrow spines. The second row has two to four granules like those of the first row. The third and last subambulacral row

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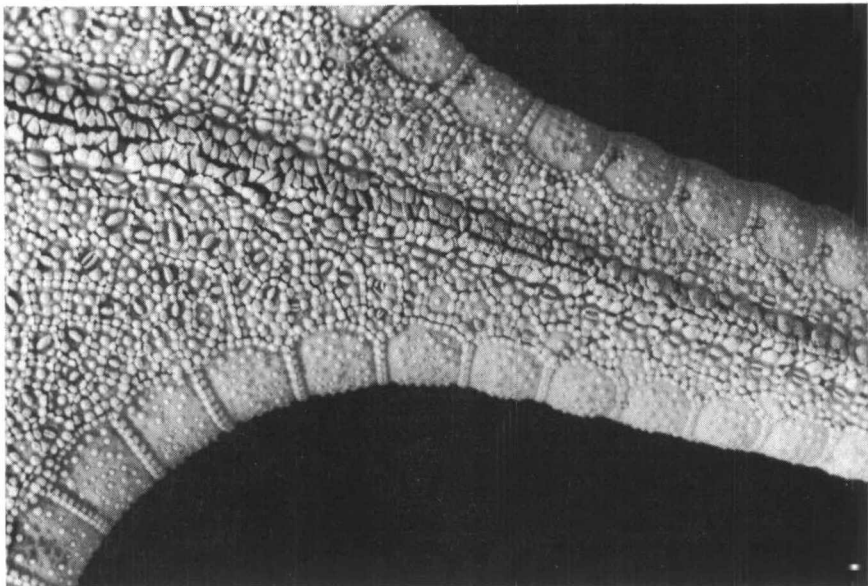
FIGURE 27. *Circeaster americanus* (A. H. Clark): A, specimen from PILLSBURY sta. 388; 3.0 ×; B, specimen from PILLSBURY sta. 388; 3.0 ×.



**A**



**B**



has five flattened granules similar to those surrounding the actinals and slightly smaller than the second actinal row.

The mouth plates are long and narrow. Each plate is about three times as long as wide and bears six furrow spines similar to the adambulacral furrow spines, but they are stouter, slightly longer, and compressed. The median spine is the longest and most compressed. The first subambulacral row has four prismatic spines that are slightly thicker and shorter than the furrow spines. The rest of the plate is covered by eight to ten prismatic granules, about as high as wide, and slightly larger than the granules of the actinals. There is a wide median suture between the plates of a mouth-plate pair.

The madreporite is irregularly round and about three times as large as the adjacent abactinals; it is slightly closer to the center of the disk than to the middle of the interbranchial arc. The anus is subcentral, small, and inconspicuous. The gonads are serial. They are in large, thick, triangular tufts on each side of the interbranchial septa.

*Type*.—U.S.N.M., cat. no. 10872.

*Type-Locality*.—28°36'N, 86°50'W, 635 m, ALBATROSS sta. 2395.

*Distribution*.—This species is found in the Gulf of Mexico, the Straits of Florida, northern Cuba, west of Yucatan, north of Trinidad, and off Cartagena, Colombia. The bathymetric range is 503-1098 m.

*Discussion*.—The general body form is variable. R/r ranges from 2.7 to 3.4. The interbranchial arc ranges from angular to rounded. These differences can give various specimens very different appearances (cf., Fig. 26; also H. L. Clark, 1941: pl. 4, fig. 2). The marginals do not always correspond in the distal half of the arms, but there is always the same number in each series.

A specimen collected by M/V OREGON (sta. 4416) off Curaçao has few enlarged abactinal plates on the arms. On one arm, there are none. This specimen has eight to 14 superomarginals in contact medially.

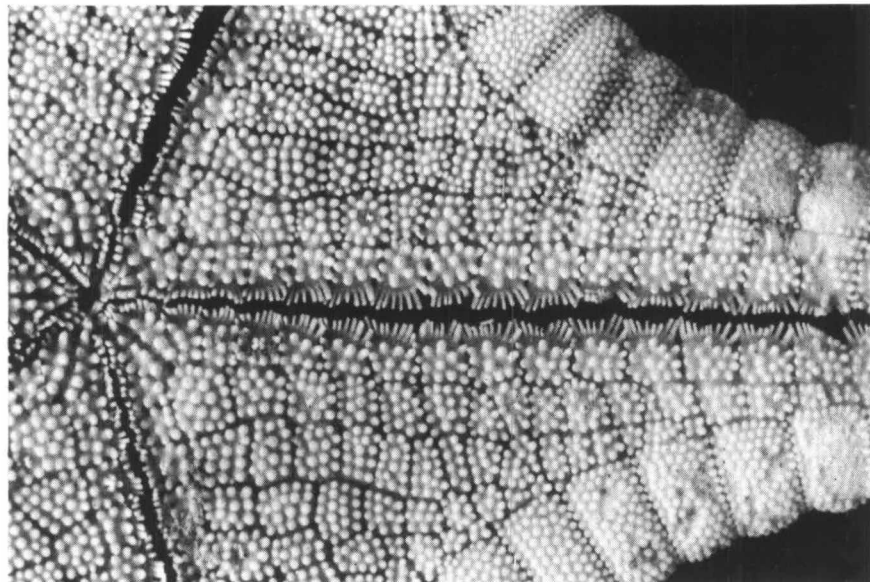
There are no major differences between the types of *Lydiaster americanus* A. H. Clark and *Circeaster occidentalis* H. L. Clark. Apparently H. L. Clark never examined the type of *Lydiaster americanus*.

#### Subfamily Anthenoidinae Perrier, 1894

Body covered by membrane, usually obscuring outlines of underlying

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FIGURE 28. A, *Circeaster americanus* (A. H. Clark), specimen from PILLSBURY sta. 388; 3.3 ×; B, *Nymphaster arenatus* (Perrier), specimen from GERDA sta. G-475; 3.3 ×.

**A****B**

plates. Abactinal skeleton not reticulate; no spines on abactinal surface. Actinal intermediate areas large.

Genus *Anthenoides* Perrier, 1881

*Anthenoides* Perrier, 1881a: 23; 1884: 246-247.—Verrill, 1915: 113.—Fisher, 1919: 328.—Bernasconi, 1963: 20; 1964: 254-255.

*Leptogonaster* Sladen, 1889: 326.—Fisher, 1911: 169, 173.

*Antheniaster* Verrill, 1899: 173.—Fisher, 1906: 1067; 1911: 169, 173.

*Diagnosis*.—Entire body covered by skin of moderate thickness which obscured plates below it. Granules, when present, beneath skin. Numerous secondary abactinal plates, extending along arms; secondary plates increasing in number with age.

*Type-Species*.—*Anthenoides peircei* Perrier, 1881 (by monotypy).

*Anthenoides peircei* Perrier, 1881

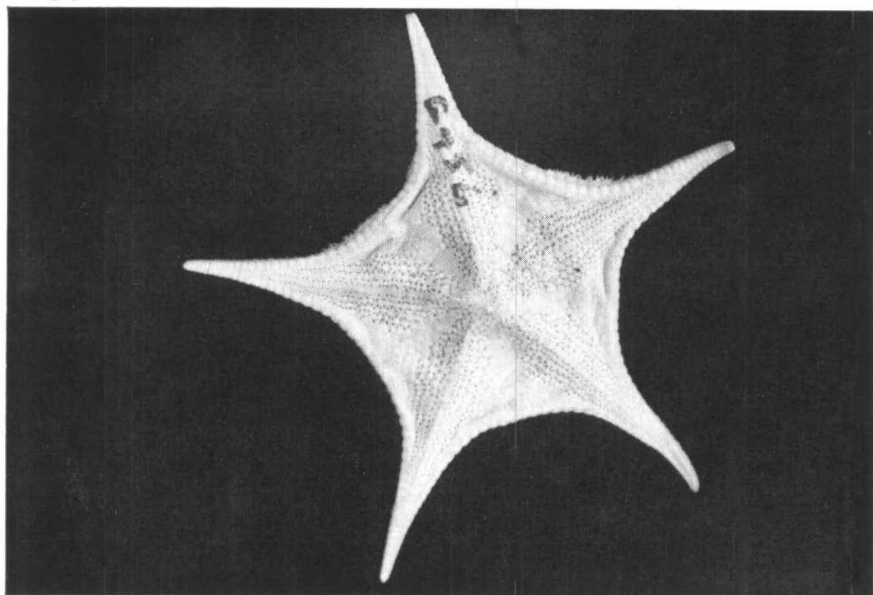
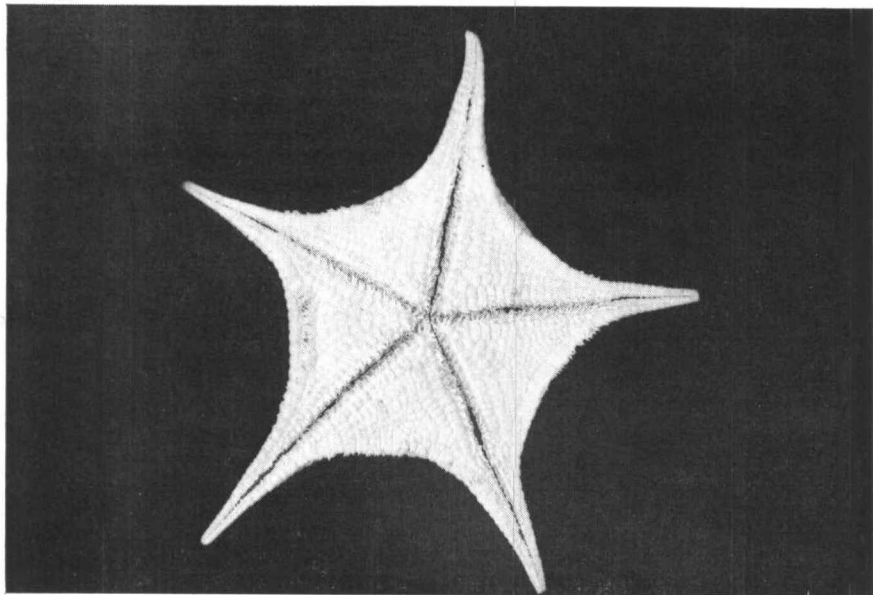
Figs. 29, 30

*Anthenoides peircei* Perrier, 1881a: 23-24; 1884: 168, 170, 184, 247-248, pl. 8, fig. 1.—A. Agassiz, 1888: fig 379.—Sladen, 1889: 326, 756.—Perrier, 1894: 38.—Verrill, 1915: 113-115, pl. 3, fig. 2, pl. 10, figs. 1-1b, 2-2f.—Fisher, 1919: 328, 331, 332.—H. L. Clark, 1941: 49.—Dilwyn-John & A. M. Clark, 1954: 139.—A. H. Clark, 1954: 375.

*Material Studied*.—34°34'N, 75°40'W, 165 m, M/V SILVER BAY sta. 2932, 13 March 1961, 1 spec.—33°03'N, 77°33'W, 183 m, M/V SILVER BAY sta. 2539, 5 December 1960, 3 spec.—28°22'N, 80°06'W, 46 m, M/V SILVER BAY sta. 4308, 2 September 1962, 1 spec.—27°45'N, 95°46'W, 73 m, M/V SILVER BAY sta. 281, 2 February 1958, 1 spec.—27°45'N, 79°15'W, 229-256 m, R/V PILLSBURY sta. 198, 11 August 1964, UMML 40.146, 1 spec.—27°45'N, 79°15'W, 311-329 m, R/V PILLSBURY sta. 199, 11 August 1964, UMML 40.145, 1 spec.—27°22'N, 79°11'W, 225 m, R/V GERDA sta. G-395, 19 September 1964, UMML 40.92, 1 spec.—26°35'N, 78°19'W, 494-503 m, R/V GERDA sta. G-690, 21 July 1965, UMML 40.143, 1 spec.—26°08'N, 79°11'W, 311-392 m, R/V GERDA sta. G-509, 2 March 1965, UMML 40.151, 1 spec.—26°08'N, 79°09'W, 311-329 m, R/V GERDA sta. G-510, 2 March 1965, UMML 40.152, 2 spec.—26°06'N, 79°10'W, 223-229 m, M/V SILVER BAY sta. 2480, 9 November 1960, 1 spec.—25°58'N, 79°20'W, 458 m, R/V GERDA sta. G-798, 12 September 1966, UMML 40.247, 1 spec.—25°37'N, 80°04'W, 119 m, R/V GERDA sta. G-280, 1 April 1964, UMML 40.83, 2 spec.—5 miles east of Alligator Light, Florida, 92 m, Starck, Emerson and Herrid, 22 August

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FIGURE 29. *Anthenoides peircei* Perrier: A, specimen from GERDA sta. G-456; 0.4 ×; B, specimen from GERDA sta. G-456; 0.4 ×.

**A****B**

1961, 5 spec.—24°44'N, 80°40'W, 110 m, M/V SILVER BAY sta. 2384, 26 October 1960, 1 spec.—24°41'N, 80°45'W, 112 m, R/V GERDA sta. G-591, 14 April 1965, UMML 40.91, 1 spec.—24°40'N, 80°46'W, 150 m, R/V GERDA sta. G-589, 14 April 1965, UMML 40.144, 1 spec.—24°39'N, 80°47'W, 132 m, R/V GERDA sta. G-456, 23 January 1965, UMML 40.93, 2 spec.—Off Sombbrero Light, Florida, 110-146 m, McGinty, June 1951, UMML 40.21, 1 spec.—24°08'N, 80°08'W, 253 m, M/V SILVER BAY sta. 2445, 3 November 1960, 2 spec.—Off west coast of Barbados, 220 m, John B. Lewis, 1962, 1 spec.—Off west coast of Barbados, 280-300 m, John B. Lewis, 1962, 1 spec.

*Diagnosis*.—Entire animal covered by moderately thick membrane or skin; inferomarginal plates beveled so that angular ventral edge bears four to eight blunt, depressed spines; most actinal plates bearing large, bivalved pedicellariae.

*Description*.—Five arms.  $R = 97$  mm,  $r = 46$  mm,  $R = 2.1r$ .

The general form is stellate, with a large disk and relatively short arms. The disk is slightly inflated. The interbranchial arcs are very wide and slightly angular. The arms are broad and strongly tapered.

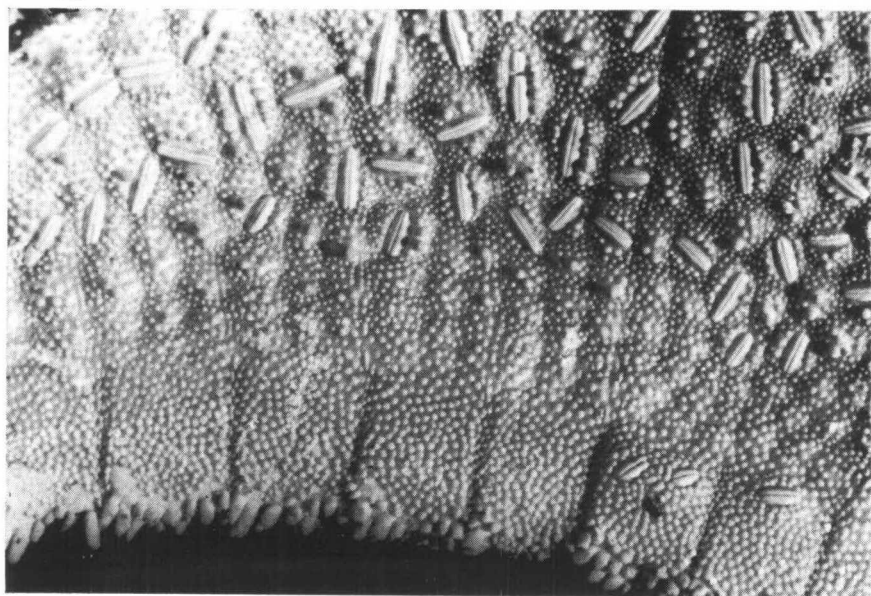
The entire animal is covered by a moderately thick membrane that obscures the outline of most of the plates in living and alcoholic specimens; the abactinal plates are visible in dried specimens, due to membrane shrinkage. The entire dorsal surface is covered by widely scattered, fine, round papillae, which are visible in dried specimens only. The papular areas are large and conspicuous. Six papular pores surround each plate, each pore containing a single papula.

The abactinal plates are flat and irregularly polygonal. Bivalved pedicellariae, similar to, but smaller than, the actinal pedicellariae, are scattered throughout the radial areas. The secondary plates are in two rows between the carinals and the adradial plates on the arms, and are found throughout the radial areas of the disk.

The inferomarginal and superomarginal plates correspond proximally, but tend to alternate distally. There are usually one or two more plates in the superomarginal series, but sometimes the two series have an equal number of plates or the inferomarginals are more numerous. The 46 to 49 small superomarginal plates are square to slightly wider than long. Nine to ten pairs are contiguous medially. The terminal plates are small and clavate. The 47 to 49 large inferomarginal plates are twice as wide as long in the interbranchial arc, becoming square distally. They are covered by hemi-

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FIGURE 30. *Anthenoides peircei* Perrier: A, specimen from GERDA sta. G-456; 3.0 ×; B, specimen from GERDA sta. G-510; 3.6 ×.

**A****B**

spherical granules similar to those on the periphery of the actinals. Many plates bear bivalved pedicellariae. The edges of the inferomarginals are beveled and crowded with spines. These spines are usually rounded and depressed, but are quite variable, some being almost conical. They are arranged in rows of four to eight, one to three rows usually encroaching on the lateral surface and sometimes extending along the margins of the ventral surface of the plates.

The actinal intermediate area is large, extending to the ninth inferomarginal. Each plate is distinctly tumid. There are three to 12 very large, unequal granules in the center, ranging from hemispherical granules to conical spines. The rest of each plate is covered by much smaller, closely crowded, hemispherical granules. Large, bivalved pedicellariae are on almost every actinal plate except for the small area adjacent to the inferomarginals, where only a scattered few occur.

The adambulacral plates are slightly longer than wide and moderately small. They bear no pedicellariae. Each plate is extended dorsally, forming a "shelf" which supports four to seven (usually six or seven) slightly divergent, long, slender, bluntly pointed, cylindrical furrow spines. There is one subambulacral row of two to four (usually three) large, compressed, broad, clavate spines.

The mouth plates are large and convex actinally. Each mouth-plate pair is two to three times as large as the adjacent actinals. Each mouth plate bears seven to ten furrow spines; all but the last two are similar in size and shape to the adambulacral furrow spines. The last regular furrow spine is similar to the others, but enlarged. The median spine is greatly enlarged; it is subterete at its base, but much flattened beyond the middle and chisel shaped at its tip. It forms a prominent pair with the median spine of the adjacent mouth plate. There is a similar pair of spines immediately distal to the median spines, which are part of a single subambulacral row which parallels the furrow spines and is similar to them. Hemispherical granules, similar to those on the periphery of the actinals, cover the rest of the plate.

The anus is subcentral and prominent; it is surrounded by two or three large, specialized granules. The madreporite is round and about four times as large as the adjacent abactinal plates. It is located approximately one-quarter the distance from the center of the disk to the middle of the interbranchial arc. The gonads are in a series on each side of, and parallel to, the membranous interbranchial septa. The dorsal surface is pale orange and the ventral surface cream colored in the living specimen.

*Type*.—No type-material could be found at the Museum of Comparative Zoology or the Museum National d'Histoire Naturelle, and it is presumed lost.



*Type-Locality*.—Barbados, 154 m, BLAKE sta. 296.

*Distribution*.—This species is known from North Carolina to British Guiana, 20-844 m. The distribution from North Carolina to Key West is well known. It has been collected from Cuba, Barbados, Guadeloupe, St. Lucia, and Grenada, and is probably found throughout the West Indies. It is also found in the northern Gulf of Mexico. There are two records from off the coast of South America, the most southern being 07°11'N.

*Discussion*.—The general body form can vary considerably. The inter-brachial arc ranges from angular to rounded. The ratio  $R/r$  varies from 1.9 to 3.3, usually ranging from 2.2 to 2.7. Either marginal series may overlap the other, depending upon the state the animal was in at preservation.

The number of abactinal pedicellariae is variable, and ranges from very numerous to completely absent. The actinal pedicellariae are always present in abundance.

The superomarginal plates occasionally bear bivalved pedicellariae. The granulation of the inferomarginal plates is variable. It is usually similar to the granulation of the periphery of the actinal plates, but the granules are sometimes much larger, like those in the center of the actinal plates.

The color of the dorsal surface is variable. It can be pale orange, bright orange, orange red, bright red, reddish brown, or purple in living material.

In a young specimen ( $r = 13$  mm), the skin is very thin, the abactinal plates being readily visible; the superomarginal plates are also more distinct. There are no secondary abactinal plates. The actinal surface bears no granules or spines (except the furrow spines), and the terminal plate is very large. The following changes occur during growth.

1. At about  $R = 20$  mm, papilliform granules appear on the actinal surface; they are scattered on the actinal plates, dense on the adambulacrals.

2. At about  $R = 30$  mm, the subambulacral spines of the adambulacral plates are developed.

3. At about  $R = 40$  mm, the dorsal surface is moderately obscure, the actinal surface is granulated, and some actinal plates bear large central granules and bivalved pedicellariae.

4. At about  $R = 50$  mm, the animal has all the adult characters, except that the terminal plates are still slightly enlarged.

The largest specimen (UMML 40.152) had unusually long arms ( $R = 194$  mm,  $r = 58$  mm,  $R/r = 3.3$ ). It may be that at a certain size, growth is sharply curtailed in the disk while continuing unabated in the arms. Most likely, however, this is an aberrant specimen.

The next largest specimen ( $R = 88$  mm,  $r = 40$  mm) had an  $R/r$  ratio of only 2.2.

The specimens I examined range in size from  $R = 13$  mm to  $R = 194$  mm.

*Remarks.*—This is one of the commonest species of sea stars in the Straits of Florida. It is interesting that, as recently as 1941, H. L. Clark referred to it as a "rare sea star."

#### GENERAL DISCUSSION

A large range of variation has been demonstrated in certain species of sea stars: *Ceramaster granularis* (Grieg, 1905b, 1907; Dilwyn-John & A. M. Clark, 1954; Tortonese, 1955); *Nymphaster moebii* (Macan, 1938); *Hyphalaster inermis* (Madsen, 1961); and *Leptasterias hexactis* (Chia, 1966).

*Oreaster reticulatus* and *Luidia senegalensis*, two fairly common shallow-water species whose validity is not questioned, also exhibit a wide range of variation (unpublished observations; also, Ummels, 1963).

Thus, ranges of variation just as wide as those that I have proposed for *Nymphaster arenatus* and *Plinthaster dentatus* have been shown in other species. Furthermore, in this paper, every species in which enough specimens were examined also showed much variation. The reason that these two species include so many nominal species is because such large numbers have been collected and because of their wide geographic and bathymetric distribution.

The present state of deep-sea sampling in the tropical Atlantic precludes any comprehensive zoogeographical study of the Goniasteridae. Four valid species are known from only one specimen each. Nevertheless, some general zoogeographical considerations can be made.

The West Indian goniasterids represent a relict Tethyan fauna whose center of distribution was the Indo-West Pacific. The genera *Anthenoides*, *Rosaster*, *Circeaster*, *Astroceramus*, *Tosia*, and *Paragonaster* have many species in the Indo-West Pacific, but are represented by only a single species in the Atlantic. *Paragonaster* extends into the temperate region in the Atlantic.

*Pseudarchaster*, *Nymphaster*, and *Mediaster* are circumtropical and best represented in the Pacific. Some of their species are temperate.

The genus *Ceramaster* has a worldwide distribution, including the polar seas. *Peltaster*, *Plinthaster*, *Cladaster*, and *Litonotaster* are equally represented in the Pacific and Atlantic. *Tessellaster* is apparently endemic to the Caribbean.

#### SUMARIO

##### GONIASTERIDAE (ECHINODERMATA, ASTEROIDEA) DEL ESTRECHO DE LA FLORIDA

Se estudiaron once especies de estrellas de mar goniasteridas colectadas por el barco de investigación GERDA durante un reconocimiento biológico del Estrecho de la Florida. Cada una es totalmente descrita e ilustrada. Se

provee una clave para todo el género goniasterido en el Atlántico Occidental tropical.

Se presentan grandes variaciones en muchas de las especies y, como resultado de ello, muchas especies nominales inválidas se han descrito. Por ello, se hizo una gran revisión taxonómica. *Ceramaster affinis* es hecho sinónimo de *C. grenadensis*. Se delimita el género *Peltaster* y se sitúa en él a *placenta*. *Peltaster planus* es hecho sinónimo de *P. placenta*. *Plinthaster perrieri*, *P. nitidus* y *P. comptus* son hechos sinónimos de *P. dentatus*. *Lydiaster* es hecho sinónimo de *Circeaster* y *Circeaster occidentalis* es hecho sinónimo de *C. americanus*.

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