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A REVISION OF THE SEA-STARS OF
THE GENUS TETHYASTER

(WITH 12 PLATES)

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British Museum (Natural History)

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The interrelationships of the sea-stars that we regard as constituting the genus *Tethyaster* have never been satisfactorily worked out. All the species are rare—at least few specimens have been collected—and no one museum has been able to secure a fully representative series either of the included species or of the growth stages of any single species. The growth stages in this genus are especially important, for the young may present an aspect quite different from that of fully developed individuals, and the adult characters are often late in making their appearance.

In the preparation of this revision we have studied all the specimens in the U. S. National Museum, in the British Museum (Natural History), and in the Museum of Comparative Zoology at Cambridge, Mass., for the loan of which we are greatly indebted to our friend Dr. Elisabeth Deichmann.

Two of the species (*canaliculatus* and *vestitus*) have not previously been figured, the type specimen of another (*magnificus*) has not been figured, and of one (*grandis*) only a few details have been illustrated. Of the others, two (*subinermis* and *aulophora*) have been illustrated in satisfactory detail, and the last (*pacei*) has been figured sufficiently for purposes of identification.

Thomas Say in 1825 (p. 143) described a very large sea-star from New Jersey under the name of *Asterias vestita*, as follows:

5. *A. vestita*. Disk broad, surface reticulated, covered by cylindrical prominences, margin articulated; rays depressed.

The whole surface is covered by cylindrical prominences, which are placed near each other, truncated at their summits, and each summit crowned by from ten to eighteen small, equal, cylindrical fimbriae; wart-like tubercle [madre-

porite] large, radiated, very conspicuous; *margin* articulated; each articulation with about four very much compressed, subquadrate, truncated spines or moveable processes, which are vertically adpressed to the surface of the segment, and are imbricated with respect to each other.

Diameter 1 foot 2 inches.

The locality was given as Cape May, N. J. Say said that it is "Allied to *A. aranciaca* Linn., but distinct by many characters, and particularly by the form and number of the lateral spines. It is very rare on this coast." The type and only known specimen disappeared, and the species has since remained an enigma.

Dr. A. Philippi in 1837 (p. 193) briefly described *Asterias subinermis* from a specimen 14 inches in diameter from the coast of Sicily. This well-known but rare species has been recorded from both coasts of the Mediterranean as far east as Rhodes and from the Bay of Biscay southward to the Gulf of Guinea. It has never been confused with any other species and has no synonyms, but it has been assigned to various genera—*Astropecten* (Müller and Troschel, 1842), *Archaster* (Perrier, 1875), *Goniopecten* (Perrier, 1885), *Plutonaster* (*Tethyaster*) (Sladen, 1889), and *Tethyaster* (Perrier, 1894), almost all these dispositions being followed by other authors. A detailed account of this species, under the name *Plutonaster subinermis*, with figures and bibliographic references, was given by Ludwig in 1897 (p. 105).

Say's *Asterias vestita* was listed, without description, as *Astropecten vestitus* by Lütken in 1859 (pp. 27, 54). Verrill in 1866 (p. 339) under *Astropecten vestitus* Lütken said "Say's specimen was from Cape May, collected by Mr. J. Robbins. I am not aware of any other being found."

In 1882 (p. 440) Prof. F. Jeffrey Bell described *Archaster magnificus* from two specimens with $R=207$ and 138 mm., and $r=50$ and 37 mm., which had been presented to the British Museum some years before by J. C. Melliss who had obtained them at St. Helena.

W. Percy Sladen in 1889 established, under *Plutonaster*, the subgenus *Tethyaster* (p. 101) in which he placed Philippi's *Asterias subinermis* and Düben and Koren's *Astropecten parelii*. He also (p. 192) diagnosed the genus *Moiraster* for the reception of *Archaster magnificus* Bell.

In 1895 Verrill (p. 133) listed *Astropecten vestitus* Lütken and said "B. range, shallow water. Cape May (Say). It is not uncommon farther south."¹ In 1899 Verrill (p. 210) proposed the new genus *Sideriaster*, based upon a new species, *S. grandis*, from Albatross station 2378. The description was brief, but he figured the actinal side

¹ Possibly here confused by Verrill with *Astropecten cingulatus* Sladen.

of a part of the middle of a ray, an adambulacral plate, and an abactinal paxilla.

In 1908 Dr. René Koehler described in detail and figured a small specimen of *Moiraster magnificus* with $R = 62$ mm. from Pointe Pyramid, Ascension, in 40 fathoms.

In 1914 (p. 21) Verrill discussed *Sideriaster*(?) *vestitus* (Say). He said that the type of *Sideriaster*, *S. grandis*, does not agree sufficiently well with *vestitus* to be identified as the same species, but it seems almost certain that it is congeneric. He added that when more specimens can be obtained it may prove to be the same species.

In 1915 (p. 191) Verrill republished his diagnosis of *Sideriaster* and (p. 192) his description of *S. grandis*, also republishing the figures of details previously given. He also discussed (pp. 193-195) *Sideriaster* (?) *vestitus* (Say) Verrill at considerable length. He noted that "Probably the type is lost. It is probably not an *Astropecten*. In having a large disk, and especially in having four appressed spines in a transverse row on the inferomarginal plates, the *Sideriaster grandis* V. agrees, perhaps, with Say's species. But he gives too little, as to other characters, to enable me to say whether they are related."

In 1916 (p. 52) A. H. Clark described in detail, but did not figure, *Sideriaster canaliculata* from *Albatross* station 2998, Gulf of California, in 40 fathoms.

Dr. Walter K. Fisher in 1911 (p. 417) published a diagnosis of a new genus, *Anthosticte*, based upon a new species, *A. aulophora*, described from a single specimen from *Albatross* station 5420 in the Philippines. In 1919 (p. 140) he republished the diagnosis of *Anthosticte*, redescribed and figured *A. aulophora*, and discussed the relationships of the new genus.

Dr. Th. Mortensen in 1925 (b, p. 147) described and figured *Anthosticte pacei* from South Africa. He wrote that "from the type species *A. aulophora*, the only species hitherto known of the genus *Anthosticte*, the present species is easily distinguished through the lower paxillae and the complete lack of pedicellariae." In 1933 (p. 422) Mortensen recorded three specimens of *Moiraster magnificus* that he dredged off Egg Island, St. Helena. In these $R = 160-179$ mm. He gave various details of the specimens.

In 1947 Señorita María Elena Caso described and figured *Moiraster gigas* from a very large specimen with $R = 205-245$ mm. from Santa Rosalia, Baja California, on the western shore of the Gulf of California.

In 1950 (p. 302) A. H. Clark recorded under the name of *Moiraster magnificus* a specimen with $R = 168$ mm. from off the western coast

of Puerto Rico. This specimen we now consider as representing *vestitus*.

As for the interrelationships of these genera, they were discussed in some detail by Fisher in 1919 (p. 143). He said that *Moiraster*, *Tethyaster*, *Sideriaster*, and *Anthosticte* agree in having unarmed supermarginals, inferomarginals with a few small enlarged spines, naked madreporite, large actinal interradiial areas, and intermediate plates far along the ray, marginal and actinal fascioles, true paxillae, stellate abactinal plates, an astropectinid adambulacral armature, and probably also in having the single papulae uninterrupted all over the dorsal surface. He said that the first two seem to be a little more closely related than either is to the last two, while *Sideriaster* and *Anthosticte* are possibly also nearly related. He noted that unfortunately there is but one species in each genus, and it is difficult to ascertain what characters are of generic importance. He remarked that, according to the standards used in other larger genera, *Anthosticte* differs from *Tethyaster* chiefly in having very deep marginal fascioles, gonads to the end of the ray, and no midradial series of enlarged paxillae. *Anthosticte* has taller and more delicate paxillae, but this may not be of generic importance. Its special points of agreement in addition to the characters listed are the deposits in the tube feet (not recorded for *Moiraster* and *Sideriaster*) and shallow interambulacral fascioles, and an incipient interradiial series of actinal intermediate plates, less prominent and regular than in *Tethyaster*.

He said that *Anthosticte* differs from *Sideriaster* in having very deep marginal fascioles and no distally enlarged subambulacral spines. Neither the deposits in the tube feet nor the gonads of *Sideriaster* are described. He considered that the fascioles between the adambulacral plates which he examined in the type specimen of *Sideriaster grandis* form one of the most striking features of the genus. They are densely lined with small, delicate spinelets, and are therefore similar to marginal fascioles. Such is not the case, he said, in *Anthosticte*, *Tethyaster*, or *Moiraster*.

Mortensen in 1933 (p. 424) also discussed these four genera. He wrote that the knowledge now acquired of the characters of *Moiraster* (from his three specimens from St. Helena) makes it clear that the four genera are even more closely related than Fisher thought them to be—so closely, indeed, that it seems scarcely possible to maintain them all. He said that *Tethyaster* is well characterized by its midradial row of enlarged paxillae, the shallow marginal fascioles, and the low paxillae, so it may justly be maintained as a separate genus. He noted that Fisher's statement that its gonads do not extend to the

ends of the rays is a curious mistake, "in flat contradiction to the description given by Ludwig." As for *Anthosticte*, he said that it is now seen that the only character by which it differs from *Moiraster* is the absence of enlarged spines on the ventrolateral plates. In regard to fascioles between the adambulacral plates he said there seems to be a very gradual passage from *Anthosticte* to *Moiraster* and *Sideriaster*. He noted that *Sideriaster*, which is still imperfectly known, would likewise seem to differ from *Moiraster* only in lacking enlarged spines on the ventrolateral plates. He said that it is, of course, a matter of taste whether this character, the presence or absence of enlarged spines on the ventrolateral plates, affords sufficient reason for generic distinction. But, he added, this is all the difference there is.

In 1950 the question of the identity of a specimen taken by the M.V. *Rosaura* off the mouth of the Orinoco in 75 meters was raised between the two present authors. Dr. Dilwyn John has provisionally attributed the specimen to *Sideriaster*, but investigation seemed to show that it also had some affinity with Bell's *Moiraster magnificus* from St. Helena. At about the same time the M.V. *Oregon* dredged 10 specimens of *Sideriaster grandis* off Corpus Christi, Tex., another was dredged by the yacht *Triton* off Sombrero Key, Fla., and still another was received by the U. S. National Museum from off the coast of Tamaulipas, Mexico. Furthermore, the Museum acquired a very large sea-star from the coast of North Carolina that agrees completely with the meager description of Say's *Asterias vestita*, but is slightly larger. There seems to be no doubt that it represents Say's long-lost species.

With this additional material available it has seemed advisable to review the status of *Tethyaster*, *Moiraster*, *Sideriaster*, and *Anthosticte*. We have personally examined specimens of all the species described in these genera except *Anthosticte pacei*, which was briefly, though sufficiently, described and figured by Mortensen.

We can see no valid reason for not considering all these species congeneric and we therefore unite them all in the genus *Tethyaster*, of which we regard *Moiraster*, *Sideriaster*, and *Anthosticte* as synonyms.

Genus TETHYASTER Sladen

Asterias (part) SAY, 1825, p. 143.—PHILIPPI, 1837, p. 193.

Astropecten (part) MÜLLER and TROSCHEL, 1842, p. 74, following authors.

Archaster (part) PERRIER, 1875, p. 369, and following authors.

Goniopecten (part) PERRIER, 1885, p. 71.

Plutonaster (subgenus *Tethyaster*) (part) SLADEN, 1889, p. 101 (diagnosis; genotype *Asterias subinermis* Philippi).

- Moiraster* SLADEN, 1889, p. 192 (diagnosis; genotype *Archaster magnificus* Bell).
—FISHER, 1919, pp. 143, 144 (discussion).—MORTENSEN, 1933, p. 424 (discussion).
- Tethyaster* PERRIER, 1894, p. 322; 1896, p. 50.—KOEHLER, 1896a, pp. 56, 57; 1896b, pp. 450, 451.—GREGORY, 1900, p. 251.—FISHER, 1919, p. 143.—KOEHLER, 1921, p. 53; 1924, p. 199.—RIVERA, 1930, p. 105.—MORTENSEN, 1933, p. 424.
- Plutonaster* (part) LUDWIG, 1897, p. 105.—CUÉNOT, 1927, p. 295.—NOBRE, 1931, figs. 42, 43.
- Sideriaster* VERRILL, 1899, p. 210 (diagnosis; genotype *Sideriaster grandis*, sp. nov.); 1914, p. 21; 1915, p. 191.—FISHER, 1919, p. 143.—MORTENSEN, 1933, p. 424.
- Anthosticte* FISHER, 1911, p. 417 (diagnosis; genotype *Anthosticte aulophora*, sp. nov.).—MORTENSEN, 1933, p. 424.
- Thetyaster* NOBRE, 1931, p. 62.
- Thethyaster* NOBRE, 1931, p. 176.

Diagnosis.—A genus of Astropectinidae with both series of marginal plates large and conspicuous, equally developed, the supermarginals granulated or with numerous short spinelets, the inferomarginals with a median row of usually about five enlarged and flattened appressed spines; actinal intermediate areas large with numerous intermediate plates arranged in definite series with an incomplete unpaired median row; the inferomarginals separated from the adambulacrals by a series of actinal intermediate plates for most of the ray; fascioles between the marginals, adambulacrals, and actinal intermediate plates; madreporite large and bare; adambulacral armature astropectinid; abactinal plates with paxillae having high columns; gonads extending far along ray.

Geographical range.—From New Jersey south to the mouth of the Orinoco; Gulf of Mexico; St. Helena and Ascension; Bay of Biscay south to the Gulf of Guinea; Mediterranean east to the Aegean Sea; South Africa; Philippines; Gulf of California.

Bathymetrical range.—From 44 to about 1,400 (?1,425) meters.

Remarks.—Presumably the most specialized species of *Tethyaster* are those with the spines on the inferomarginal and actinal intermediate plates wide, rectangular, and broadly truncated, as these depart most widely from the generalized astropectinid type. Although our knowledge of this genus is admittedly meager, these species appear to be primarily American, ranging from New Jersey to Venezuela (*vestitus*), occurring at St. Helena and Ascension (*magnificus*), and found also in the Gulf of California (*canaliculatus*). This group in its distribution would parallel roughly the genera *Encope*, *Mellita*, and *Leodia* among the echinoids, the *Marginatus* group of *Astropecten*, and *Astrocaneum* in the Gorgonocephalidae. It should be noted that

the crinoid genus *Crinometra* so very characteristic of the Caribbean area is also represented at St. Helena.

A more generalized type with less strongly modified spines on the inferomarginals, which only very rarely extend on to the actinal intermediate plates, is widely distributed, occurring in the Gulf of Mexico (*grandis*), in the Mediterranean and east Atlantic from the Bay of Biscay to the Gulf of Guinea (*subinermis*), off South Africa (*pacei*), and in the Philippines (*aulophora*). At the same time *aulophora* is distinguished from the other members of this group by the relatively tall and slender dorsal paxillar columns, such as are found also in *vestitus* and *magnificus*. However, this character is probably less fundamental than the shape of the inferomarginal spines.

Other differences between the species are shown in the key.

KEY TO THE SPECIES OF TETHYASTER

(This key is adapted for fully developed specimens with R = 100 mm. or more.)

- a*¹. Actinal intermediate plates each with an enlarged, broad, flattened, and broadly truncated procumbent spine directed outward (if these are undeveloped the inferomarginal spines are broadly truncated); enlarged and flattened spines on the inferomarginals broad, usually approximately rectangular or scoop-shaped with broadly truncated ends, rarely tapering; R = 200-250 mm. in fully grown individuals.
- b*¹. Enlarged spines on actinal intermediate plates fan-shaped or scoop-shaped with divergent sides and broadly truncated ends; spines on the inferomarginals similar (may be tapering in young individuals: pl. 3; fig. 1, *c*) (Gulf of California) *canaliculatus*
- b*². Enlarged spines on actinal intermediate and inferomarginal plates rectangular, rarely scoop-shaped.
- c*¹. Enlarged and flattened spines in fully grown individuals 6-7 mm. long, first appearing when R = about 70 mm. (pl. 10) (St. Helena and Ascension) *magnificus*
- c*². Enlarged and flattened spines in fully grown individuals reaching only 4 mm., first appearing when R = about 150 mm. (pl. 6; fig. 1, *d*) (New Jersey south to off the Orinoco River) *vestitus*
- a*². Actinal intermediate plates without a central enlarged spine (there may be a very few pointed spines in some specimens of *grandis*); enlarged and flattened spines on inferomarginals sharp-pointed.
- b*¹. Columns of paxillae slender, high, about 4 times as high as thick; most of paxillae with a pedicellaria of 2-4 valves (Philippines) *aulophora*
- b*². Columns of paxillae stout, low, not over twice as high as thick; no abactinal pedicellariae, so far as known.

- c*¹. Marginals short, 68-85 in number; rays fairly broad, width of rays at base = *r*; paxillae of median row on rays sometimes larger than others (Bay of Biscay to Gulf of Guinea and most of Mediterranean)..... *subinermis*
- c*². Marginals longer, up to 65 in number; rays narrow, width at base less than *r*; paxillae of median row on rays not larger than others.
- d*¹. Rays very narrow, $R = 4.3 r$; first series of actinal intermediate plates reaching to about outer third of ray, second only in proximal third; intermarginal fascioles deep, extending inward for about two-thirds the proximal and distal sides of marginals (South Africa)..... *pacci*
- d*². Rays broader basally, $R = 3.2$ to $3.5 r$; first series of actinal intermediate plates reaching to about outer fourth of ray, second to well beyond middle; intermarginal fascioles shallow, extending inward for less than one-third the proximal and distal sides of marginals (pls. 11, 12) (Gulf of Mexico)*grandis*

TETHYASTER CANALICULATUS (A. H. Clark)

Plates 1-4; text figure 1, *c*

Sideriaster canaliculata A. H. CLARK, 1916, p. 52 (description; *Albatross* station 2998).—ZIESENHENNE, 1937, p. 212 (notes; *Zaca* stations 136, D-19; 142, D-3; 146, D-1; 147, D-2; 150, D-9).—CASO, 1947, p. 225 (listed).

Moiraster canaliculata CASO, 1947, p. 225 (listed).

Moiraster gigas CASO, 1947, p. 225, fig. 1, p. 226, fig. 2, p. 227, fig. 3, p. 228, fig. 4, p. 229 (description; Santa Rosalia, Baja California).

Diagnosis.—Enlarged spines on the inferomarginals and actinal intermediate plates scoop-shaped with divergent and convex sides, broadly truncate, the outer portion commonly with a broad, shallow groove and the distal end slightly notched; size large, *R* up to 250 mm.

Type.—In the U. S. National Museum (No. 36951).

Type locality.—*Albatross* station 2998, Gulf of California west of Culiacán, Sinaloa (lat. $24^{\circ}51'00''$ N., long. $110^{\circ}39'00''$ W.); 73 meters; bottom temperature 64° F.; March 16, 1889.

Additional localities.—Santa Rosalia, Baja California (Caso, 1947).

Zaca station 136, D-14; Arena Bank, Gulf of California (lat. $23^{\circ}29'30''$ N., long. $109^{\circ}25'$ W.); 82 meters; April 20, 1936 (Ziesenhenné, 1937).

Zaca station 142, D-3; Santa Inez Bay, Gulf of California (lat. $27^{\circ}04'$ N., long. $111^{\circ}53'$ W.); 73 meters; April 11, 1936 (Ziesenhenné, 1937).

Zaca station 146, D-1; Santa Inez Bay (lat. $26^{\circ}52'$ N., long. $111^{\circ}53'$ W.); 64 meters; April 16, 1936 (Ziesenhenné, 1937).

Zaca station 147, D-2; Santa Inez Bay ($26^{\circ}57'30''$ N., long. $111^{\circ}48'30''$ W.); 110 meters; April 17, 1936 (Ziesenhenné, 1937).

Zaca station 150, D-9; Gorda Banks, Gulf of California (lat. $23^{\circ}04'$ N., long. $109^{\circ}30'30''$ W.); 91-109 meters; April 22, 1936 (Ziesenhenné, 1937).

Geographical range.—Central and southern part of the Gulf of California.

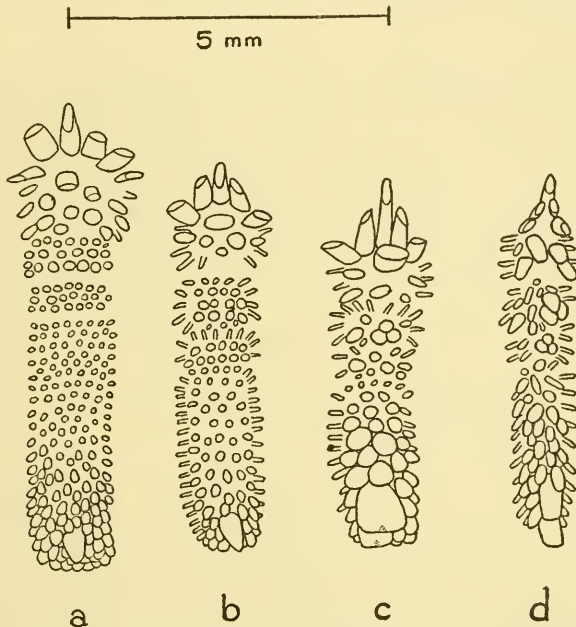


FIG. 1.—Adambulacrals, intermediate plates, and inferomarginals of *a*, *Tethyaster subinermis* ($R = 86$ mm.); *b*, *T. grandis* ($R = 59$ mm.); *c*, *T. canaliculatus* ($R = 64$ mm.); *d*, *T. vestitus* ($R = 70$ mm.). The adambulacral plate is at the top in each case and is about the tenth, while the inferomarginal corresponding is about the seventh.

Bathymetrical range.—From 64 to 110 meters.

Remarks.—Our reasons for considering Señorita Caso's *Moiraster gigas* a synonym of the previously described but much smaller *Sideraster canaliculatus* are the following. The supermarginals of the type of *canaliculatus* ($R = 64$ mm.) number 45, those of the type of *gigas* ($R = 205-245$ mm.) 58-62. Considering the discrepancy in size this difference is negligible. In *canaliculatus* $R:r = 3.4:1$, in *gigas* (average) $3.6:1$. This difference is not significant.

The paxillae on the rays in *canaliculatus* are in three regular alternating rows in the midradial region, and from these central rows diago-

nal rows run out at an angle of 45° to the superomarginals. Judging from Señorita Caso's figure (fig. 3) there is the same arrangement in *gigas*, though here the lateral rows make a larger angle with the median.

In *canaliculatus* the enlarged and flattened spines in the inferomarginals are broad, broadly truncate, about half as broad as long, or even shorter, with convex sides, the outer half commonly deepened in the middle or broadly grooved. In *gigas* these spines are "espatuladas, truncadas, aplanadas, ligeramente henidas en sus extremos libres."

In the type of *canaliculatus* most of the actinal intermediate plates carry one or two enlarged tubercles somewhat swollen in the outer half and frequently somewhat flattened. These resemble the less-developed of the corresponding spines on the actinal intermediate plates in the young specimen of *vestitus* from Puerto Rico.

In the type of *canaliculatus* all the plates bordering the adambulacrals and mouth plates, and a few of the other actinal intermediate plates, bear pedicellariae with three or four valves. In *gigas* also "Todas las placas que limitan a las placas adambulacrales y las placas bucales y alguna que otra placa intermediaria, están provistas de pedicelarios espiniformis, trivalvados, de forma irregular; en general, unos son pequeños y otros grandes."

In the largest specimen collected by the *Zaca* (M.C.Z. No. 36232; pl. 3) $R = 95$ mm., $r = 26$ mm.; $R:r = 3.6:1$. The paxillae have cylindrical columns which are about half again as high as thick and rather slender. The crown consists of 8-10 subcapitate peripheral spinelets, mostly about twice as high as thick at the base, with one or two usually much more slender than the others, and most frequently a single central spinelet which resembles the larger peripheral.

There are 54-58 marginals. The superomarginals resemble those of the smaller type specimen ($R = 64$ mm., $r = 19$ mm.). The inferomarginals have usually two flattened, tapering, and pointed spines which at the base of the rays are 3-4 mm. long and about 0.75 mm. broad at the base.

Each actinal intermediate plate carries in the middle a strongly flattened wedge-shaped or narrowly fan-shaped spine with straight sides and a gently convex tip which is usually about twice as broad as the base. These flattened spines, which are mostly 1-1.5 mm. long, lie parallel with the surface of the plate, directed toward the inferomarginals. In addition to these central spines the plates bear a few much smaller subcapitate spines and numerous fine lateral spinelets.

The enlarged spines on the actinal surface of the adambulacrals

plates are somewhat flaring, abruptly truncated, and broadly grooved or chisel-shaped.

A number of the plates in the inner part of the interradial areas, especially those adjoining the adambulacrals, bear pedicellariae of three, sometimes four, valves which resemble stout subcapitate spines, one of which is commonly smaller than the others.

This specimen is intermediate between the smaller type specimen and Señorita Caso's much larger type of *gigas*, resembling the latter in having enlarged and flattened spines on all the actinal intermediate plates. So far as can be judged from the published figure, these spines resemble those of *gigas*. The spines on the inferomarginals, however, are tapered and pointed and resemble those of *grandis* more nearly than those of the type of *gigas*.

In a specimen from Arena Bank in 40 fathoms (M.C.Z. No. 3447; pl. 4, upper) with $R = 41$ mm., $r = 15$ mm., $R:r = 2.7:1$, the paxillae are very low, the thick columns being about as high as broad. The crown consists of 6-7 peripheral granules and one central elongated capitate granule, all similar.

There are 39 marginals. The inferomarginals are mostly on the actinal surface, the outer ends curving upward to meet the superomarginals. In lateral view they are at the arm bases about half as high as the superomarginals, but the height of the superomarginals decreases so that in the outer half of the ray the two series are, in lateral view, of about the same height.

The marginals and the actinal intermediate plates have a similar covering of granules with swollen tips which are not higher than thick, largest and lowest in the center of the plates, becoming more slender along the edges. The spines on the adambulacral plates resemble those of the larger specimen. The very few pedicellariae are in the inner part of the interradial areas.

A specimen from Santa Inez Bay in 35 fathoms (M.C.Z. No. 3448; pl. 4, lower) with $R = 32$ mm., $r = 11$ mm., $R:r = 2.9:1$, and 34 marginals, resembles the preceding, but there are no pedicellariae and the adambulacral spines, though similar, are not so stout.

A specimen (M.C.Z. No. 36251) with $R = 30$ mm., $r = 11$ mm., $R:r = 2.7:1$, and 30 marginals, resembles the preceding, as does another (M.C.Z. No. 36251) with $R = 18$ mm., $r = 7$ mm., $R:r = 2.6:1$, and 27 marginals.

In five small specimens from Gorda Bank (M.C.Z. No. 3449) $R = 7-10$ mm., $r = 3.5-4.5$ mm. The spines on the adambulacral plates are slender, cylindrical or slightly swollen in the outer part, and little if at all flattened; they bear numerous fine serrations. All the granules on

both surfaces are more slender, relatively higher, and less crowded than in the larger specimens, and bear very numerous fine serrations.

In a specimen from Santa Inez Bay (M.C.Z. No. 3450) with $R = 4$ mm., $r = 2.7$ mm., there are 8 marginals. The terminal plate is very large. All the spines and the slender elongate granules are spinulose.

With decrease in size the madreporite decreases in relative size and in the smaller specimens cannot be distinguished.

In nearly all the specimens we have seen the rays differ somewhat in length, as was the case in Señorita Caso's type of *gigas*.

Specimens examined.—All known specimens except the type of *gigas*.

TETHYASTER VESTITUS (Say)

Plates 5-8; text figure 1, d

Asterias vestita SAY, 1825, p. 143 (description; Cape May, N. J.).

Astropecten vestitus LÜTKEN, 1859, pp. 27, 54 (listed).—VERRILL, 1866, p. 339

(Say's record); 1895, p. 133 (Say's record; "not uncommon farther south.")

Sideriaster (?) *vestitus* VERRILL, 1914, p. 21 (identity of Say's species); 1915, pp. 193-195 (discussion).

Moiraster magnificus A. H. CLARK, 1950, p. 302 (off Puerto Rico) (not *magnificus* Bell, 1882).

Diagnosis.—Enlarged spines on the inferomarginal and actinal intermediate plates rectangular, sometimes tapering distally, broadly truncate, in fully grown individuals up to 4 mm. long, first appearing when R is about 150 mm.; size large, R up to 250 mm.

Description.—The paxillae are compact and in contact, with a slender tall pedicel 3-4 mm. high and four or five times as high as broad, crowned by a floriform group of usually 20-30 peripheral and 5-15 or more central, terete, slightly tapering, blunt spinelets 0.5 to 1 mm. long and 3-5 times as long as broad at the base. On the disk and arms they are arranged in rows at an angle of approximately 75° to the midradial line; in the middle of the interradial areas of the disk there are 4 or 5 usually irregular rows that do not reach the interradial border. The paxillae are largest on the disk, slowly and gradually becoming slightly smaller with more slender, more pointed, and relatively longer spinules toward the interradial margins and on the rays. The madreporite is very large, 17 by 16 mm., slightly sunken below the summits of the surrounding paxillae, slightly concave with very numerous and fine, regularly radiating striae.

The marginal plates correspond throughout the ray. They are high and narrow with very deep fasciolar channels between them, the chan-

nels being roughly twice as deep as the width of the summits of the marginals or even deeper. The superomarginals, 78 in number, are in the interradial arcs flat and 13 mm. high, decreasing in height to 6 mm. and becoming slightly convex on about the sixth, then remaining similar to near the arm tips. They bear about four rows of elongated granules or short spinelets. The two outer rows are regular and are composed of slightly tapering spinelets, resembling those of the paxillae in the center of the disk, and about three times as long as broad at the base; the two median rows are irregular and are composed of shorter and stouter spinelets. On the high, narrow superomarginals in the interradial arcs there are only two rows of spinelets, or an irregular single row, these spinelets resembling those of the outer rows of the outer superomarginals. The inner rows first appear on about the eighth supermarginal. The superomarginals are bordered on each side by an irregular double row of from 30 to 40 slender tapering spinelets which just meet those of the neighboring superomarginals. The lower end of the superomarginals is bordered by a row of about 6 stout spinelets directed diagonally outward.

The inferomarginals are about the same size as the superomarginals in the interradial angles but, being more uniform in size, are slightly larger elsewhere. In the interradial arcs they are flat and make a considerable angle with the superomarginals, but they soon become convex, continuing the curve of the superomarginals to the flat actinal surface. They bear a median row of usually four broad, flat, truncated, appressed spines 3 to 4 mm. long and 1.25 to 1.50 mm. wide, which overlap the bases of those succeeding. These are flanked by much smaller flattened and truncated spines mixed with more or less terete spinelets. The plates are bordered laterally by very numerous fine, laterally directed spinules resembling those bordering the superomarginals. Toward the ends of the rays the enlarged spines become very short, not much longer than broad.

The terminal plate is rather large, swollen, heart-shaped, with the distal end deeply notched and the proximal end broadly truncated. It overlies about 4 superomarginals.

The actinal intermediate areas are large. One series of plates extends to within about 20 mm. of the end of the ray, a second to within about 40 mm., and a third to about the middle. An incomplete and usually irregular row extends from a pair just beyond the mouth plates to about one-third the distance to the inferomarginals. Between the first inferomarginal and the second adambulacral the series contains 9 or 10 plates. Deep channels lead from the marginal fascioles to the fascioles between the adambulacrals, these being separated by single

regular rows of actinal intermediate plates. Each of these intermediate plates bears a tall, stout, laterally compressed column somewhat broadened at the summit, which bears a large, flattened, truncated spine 4 mm. long and about 1.3 mm. broad resembling the large spines on the inferomarginals. This spine lies parallel with the surface of the plate and is directed toward the inferomarginals. Occasional plates may carry two or even three of these spines. The median spine is accompanied by a few much smaller, flattened spines or stout spinelets, and the border of the summit of the plate carries a large number of fine, laterally directed slender spinelets directed laterally and arranged in an irregular double row. In a single interradius seven of the actinal intermediate plates carry a fine, somewhat scattered granulation instead of the large flattened spine and the accompanying smaller ones. Many of the actinal intermediate plates adjoining the adambulacrals carry spiniform pedicellariae with usually two, sometimes three, blades.

The adambulacral plates are broader than long. The inner half forms an acute angle of roughly 60° and the outer half has parallel sides. At the apex of the furrow angle there is a stout, sharp, prismatic, slightly recurved spine which in the basal part of the ray is 7 or 8 mm. long. On the sides of the angle are two, sometimes three, similar but much flattened sharp spines of about the same dimensions. The actinal surface of the plate carries usually 4 or 5 spines as stout as the marginal spines but slightly shorter, flattened, broadly truncate, and fluted in the outer half. Each adambulacral plate therefore carries a more or less compact group of usually 9 or 10 generally similar conspicuously large and stout spines. The plates are bordered laterally by an irregular double row of fine spinules similar to those on the actinal intermediate plates.

The mouth plates are densely covered with spines, larger on the inner third (toward the mouth) than elsewhere. There are about 6 enlarged and strongly flattened marginal spines which are placed far down on the side of the plate, with a second series parallel with them along the edge of the plate. Beyond the marginal spines the mouth plates carry along their border very numerous, very fine, laterally directed spinules arranged in about three rows.

Type.—Lost; the specimen described above, from the coast of North Carolina, may be regarded as a neotype.

Type locality.—Cape May, N. J.; the type was collected by J. Robbins.

Additional localities.—Twelve miles west-southwest of Diamond Shoal, N. C.; 44 meters; February 6, 1951 (U.S.N.M. No. E.8000).

Caroline station 35; off the west coast of Puerto Rico (lat. $18^{\circ}24'45''$ N., long. $67^{\circ}14'15''$ W.); 146-329 meters; 1933 (U.S.N.M. No. E.3963).

Rosaura station 35; off the mouth of the Orinoco River; 86 meters (B.M. No. 1949.1.19.18).

Geographical range.—From New Jersey south to the mouth of the Orinoco River.

Bathymetrical range.—From 44 to 146 (?329) meters.

Remarks.—We have no hesitation in identifying the specimen from North Carolina with Say's *Asterias vestita* for the following reasons. The distinctive features in Say's brief description are (1) the paxillae on the abactinal surface; (2) the large and very conspicuous madreporite; (3) the occurrence of about four very much compressed, subquadrate, truncated, and imbricated spines on the marginals; (4) the size; and (5) the comparison with [*Astropecten*] *aranciaca*. All these features are equally distinctive of the specimen from North Carolina, but of no other species known from the western Atlantic. The only species that might be considered in this connection is Verill's *Sideriaster grandis*, but this is smaller and the spines on the marginals are tapering and pointed, not subquadrate and truncated.

In the specimen from Puerto Rico (pls. 7, 8) $R = 160$ mm., $r = 45$ mm.; $R = 3.6 r$ ($R = 3.9 r$ in the large specimen from North Carolina). The abactinal paxillae have short, stout, cylindrical columns 1.25 mm. high and 0.75 mm. in diameter.

The marginals are 75 in number. The superomarginals are densely covered with low, somewhat flattened granules, largest in the middle, and resemble those near the tip of the rays in the large specimen in which, however, the granules are higher. The enlarged spines on the inferomarginals are small, mostly 1.5 to 2 mm. long by 1 mm. wide.

Many of the actinal intermediate plates, in some interradii more than half, in others fewer, show the enlarged and flattened spines in various stages of development; most of them are about two-thirds the size of those on the inferomarginals and of the same shape.

A few scattered paxillae on the disk and arm bases carry pedicellariae with usually 3, occasionally 2 or 4, blades which are scarcely more than slightly modified spines. A number of the actinal intermediate plates of the inner row, especially in the second fourth of the ray, carry a pedicellaria, sometimes two, consisting of scarcely modified spines.

The specimen taken by the *Rosaura* has $R = 75$ mm. It has not yet developed the enlarged spines on the actinal intermediate plates, but the inferomarginal spines (see text fig. 1, *d*) are broadly truncated

or spatulate in shape. There are some actinal pedicellariae. The columns of the midradial proximal dorsal paxillae are about 0.35 mm. in maximum thickness, measuring 0.75 mm. in height, or 1-2 mm. including the basal part. The paxillar spinelets are about 0.45 mm. long. The marginals are 52 in number.

Specimens examined.—All those known.

TETHYASTER MAGNIFICUS (Bell)

Plates 9, 10; text figure 2, *e-g*

Archaster magnificus BELL, 1882, p. 440 (description; St. Helena).

Moiraster magnificus SLADEN, 1889, p. 193 (reassignment of Bell's species).—

KOEHLER, 1908, p. 630, pl. 12, figs. 107-110 (Ascension; notes).—MORTENSEN, 1933, p. 422, text figure 6, pl. 21, figs. 1, 2, pl. 22, fig. 1 (Egg Island, St. Helena; notes).—CASO, 1947, p. 225 (listed).

Diagnosis.—Enlarged spines on the inferomarginal and actinal intermediate plates rectangular or even with divergent sides, rarely somewhat tapering distally, broadly truncate, in fully grown individuals 6-7 mm. long, first appearing when R = about 70 mm.; size large, R up to 220 mm. at least.

Types (2).—In the British Museum (Nos. 68.6.15.1 and 68.6.15.2).

Type locality.—St. Helena, collected by J. C. Melliss; no further details.

Additional localities.—St. Helena, Egg Island; about 73 meters (Mortensen, 1933). Ascension, Pyramid Point; 73 meters (Koehler, 1908).

Geographical range.—St. Helena and Ascension.

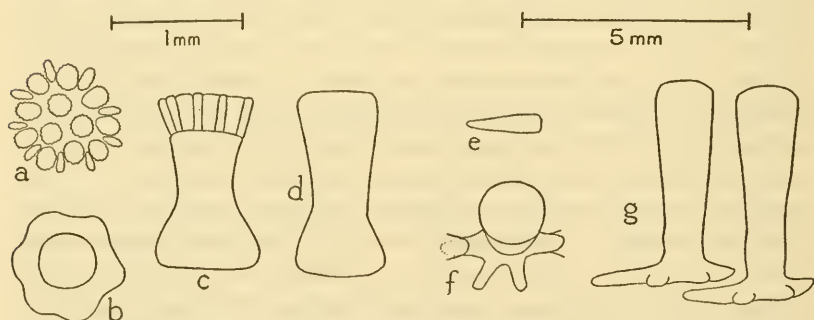


FIG. 2.—*a-d*, *Tethyaster subinermis*. *a-c*, specimen from Naples with R = 55 mm.; *a* and *b*, dorsal views of proximal midradial paxillae with and without spinelets; *c*, side view of a complete paxilla; *d*, side view of a paxilla without spinelets from a specimen from Senegambia with R = 72 mm.

e-g, *Tethyaster magnificus*, alcoholic specimen from St. Helena with R = 215 mm. *e*, paxillar spinelet; *f*, dorsolateral view of a paxilla without spinelets, and single lobes of two adjacent ones; *g*, lateral view of two adjacent paxillae without spinelets, showing their position in the skin. Drawings by A. M. Clark.

Bathymetrical range.—The only definite records are 73 meters.

Remarks.—There are three specimens of this species in the British Museum, all collected at St. Helena by J. C. Melliss, although Bell mentioned only two. The third (B.M. No. 67.12.30.1) is preserved in alcohol but possibly spent some time in formalin since it is in a very flaccid state. The two types are both dry.

The larger of the types has $R = 215, 213, 222,$ and 214 mm. on the four entire arms (Bell gives 207 mm.). In the alcoholic specimen $R =$ about 215 mm.

Mortensen and Koehler have added considerably to Bell's original description and the only further points to be made here concern the paxillae and the relative size of the actinal intermediate spines.

A strip of the dorsal skin with paxillae from the midradial base of a ray of the alcoholic specimen shows considerable overlapping of the bases of consecutive dorsal plates, although this may have been exaggerated by the contraction under preservation. In dorsal view the bases of the plates are seen to have much more prolonged lobes than in *T. subinermis*. The height of the columns relative to their minimum width (4 or 5:1) is also greater than in *T. subinermis*, but comparable to the proportions found in *T. vestitus*.

The smaller type, with $R = 138$ mm., has the paxillar columns only two-and-a-half times as high as wide. Its actinal intermediate spines are already large and overlapping, averaging 3.5 mm. in length. The two larger specimens have these spines 5 to 7 mm. long. In Koehler's specimen from Ascension and Mortensen's from St. Helena with R about 65 mm. the spines are just beginning to make their appearance but do not much, if at all, exceed their breadth in length.

It therefore seems that in *T. magnificus* the development of the actinal intermediate spines is accelerated so that they first appear when R is about 60 mm., whereas in *T. vestitus* they begin to develop only when R is about 150 mm.

Specimens examined.—The type and paratype and a third specimen also collected by J. C. Melliss at St. Helena.

TETHYASTER GRANDIS (Verrill)

Plates 11, 12; text figure 1, b

Sideriaster grandis VERRILL, 1899, p. 220, pl. 30, figs. 8, 8a, 8b (description; Albatross station 2378); 1914, p. 21 (discussion); 1915, p. 192, pl. 12, figs. 5-5b (redescription, with the original figures republished).

Diagnosis.—Enlarged spines on the inferomarginals narrow and sharp-pointed, in some specimens a few also on the actinal inter-

mediate plates; columns of the paxillae low, not over twice as high as thick; no abactinal pedicellariae (on any of the specimens examined); rays broad at the base, tapering, the width at base equal to, or greater than, r ; first series of actinal intermediate plates reaching to outer fourth of the ray, second to about the middle; superomarginals up to 65 in number; paxillae with coarse, elongated granules; granulation of actinal intermediate plates coarse, coarsest in the center; conspicuous fascioles present; R up to 160 mm.

Description.—The paxillae are compact and in contact, with a low, stout pedicel about 1.5 mm. high, less than twice as high as thick, having a rather strongly concave profile, crowned by a group of slightly elongated, well-separated granules, usually 15-20 peripheral which are about twice as long as thick, cylindrical with broadly rounded tips, and usually 7 stouter and shorter central granules, one in the middle surrounded by 6 others. The paxillae are largest on the disk, gradually decreasing in size and with fewer and smaller central granules outwardly along the rays and toward the superomarginals. In the central part of the rays they are arranged in regular longitudinal rows, on the sides in rows at right angles to the superomarginals, three rows to each two superomarginals. The median row on the rays is sometimes slightly larger than the others.

The madreporic body is large, approximately circular, 10 mm. in diameter, wholly exposed, flat, with numerous fine prominent radiating ridges. It is situated somewhat nearer the interradial border than the center of the disk.

The marginal plates correspond throughout the ray. They are high and narrow with shallow fasciolar channels between them which at the base are about half as deep as the exterior face of the plates, becoming shallower distally. The superomarginals, 65 in the specimen described, are high and narrow in the interradial arcs, 6 mm. high and 1.5 mm. wide, but gradually become wider, after the tenth being 6 mm. high and 2.5 mm. wide, the relation of height to width then remaining essentially the same to the arm tips. The superomarginals in the interradial angles bear about 5 irregular columns of granules, those in the middle of the plate the largest, the lateral about half as large; on succeeding superomarginals the granules become smaller and usually more uniform, in 6-8 irregular columns, though often the central granules are enlarged. The superomarginals are bordered on each side by a somewhat irregular row of very fine, closely set spinelets extending laterally over the fasciolar grooves.

The inferomarginals are confined to the actinal surface. They are

everywhere of about the same size and shape as the superomarginals. They bear a dorsoventrally median row of usually 4, sometimes 5, tapering, pointed, and flattened spines about 4 mm. long which increase slightly in length from the lowest to the uppermost and are appressed to the surface of the plate, each overlapping the base of the one next above. On either side of this median row of spines, and also between them, there are numerous much shorter, more or less flattened, truncated spinules. The outer edges of the inferomarginals, like those of the superomarginals, are bordered with an irregular row of very fine, closely set spinules extending outward over the fascioles.

The terminal plate is of moderate size, heart-shaped, with the distal end deeply notched and the proximal end slightly truncated.

The actinal intermediate areas are large. The innermost series of plates extends to about the outer fourth of the ray (to about 25 mm. from the tip), the second to well beyond the middle (to about 45 mm. from the tip), and the third to about the tenth inferomarginal. Between the first inferomarginal and the second adambulacral the series contains about 10 plates. In each interradius there is a median unpaired row of 1-5, commonly 3, plates. The actinal intermediate plates bear 6-12 well-spaced, coarse, elongated granules, which are cylindrical with broadly rounded ends, not over twice as high as thick, and are bordered with an irregular row of fine spinules extending laterally over the rather deep fascioles. On the interradiial areas the elongated granules are irregularly arranged, but on the rays they become aligned in two or three irregular rows parallel to the axis of the ray. In some specimens some of the actinal intermediate plates in the outer part of the interradiial areas may bear an enlarged, flattened, outwardly directed appressed spine similar to those on the inferomarginals but smaller.

The adambulacrals are at first broader than long, later becoming squarish or even slightly longer than broad; the inner end forms an obtuse angle; in the middle of the inner edge there is a broad, strongly flattened, recurved spine with a broadly rounded tip; on each side of this, on the edge of the plate, are two flattened but straight and slightly smaller spines. Behind these, on the actinal surface of the plate, there is a row of usually 3 similar spines, and behind these two more, slightly smaller. In the outer part of the ray the median spine in the row of three gradually enlarges, and toward the tip of the ray the median spine becomes long, stout, and conspicuous. The adambulacrals are bordered with numerous fine spinules extending laterally.

Each mouth plate bears about a dozen short, stout, somewhat flattened spines resembling those on the adambulacrals which they adjoin;

on the border abutting on the adambulacrals the mouth plates are bordered with numerous very fine spinules.

The gonads extend almost to the tips of the rays.

The occurrence of pedicellariae in this species is very erratic. None of the specimens have any pedicellariae on the abactinal surface, and some have no pedicellariae at all. The one described has a few pedicellariae consisting of three blades of slightly modified spines situated on some of the interactinal plates from about the tenth adambulacral to about the middle of the ray.

Type.—Presumably in the Yale University Museum.

Type locality.—*Albatross* station 2378, off Mobile, Ala. (lat. $29^{\circ}14'30''$ N., long. $88^{\circ}09'30''$ W.); 124 meters; gray mud; February 11, 1885.

Additional localities.—Off Sombbrero Light, Fla.; 110-128 meters; yacht *Triton*, 1951 (1 specimen).

M.V. *Pelican*, between Pensacola and Mobile; March 1, 1939 (1 specimen).

M.V. *Oregon*, southeast of Corpus Christi, Texas (lat. $27^{\circ}25'$ N., long. $96^{\circ}13'$ W.); 139 meters; bottom temperature 60.5° F.; November 27, 1950 (10 specimens).

Off Tamaulipas, Mexico (lat. $24^{\circ}10'$ N.); 64-67 meters; Hildebrand, March 1951 (1 specimen).

Geographical range.—Known only from the Gulf of Mexico.

Bathymetrical range.—From 67 (?64) to 139 meters.

Remarks.—In a specimen with $R = 145$ mm. some of the superomarginals in the second quarter of the rays carry small pedicellariae at one or both of the lower angles. The inferomarginals from about the fifth outward carry mostly two pedicellariae, one at each upper angle, occasionally three or only one. The intermediate plates of the inner row from about the eleventh to about the middle of the ray carry usually two pedicellariae, one at each outer angle, occasionally only one. The pedicellariae have usually three, rarely two or four, subequal valves which resemble short spines with a swollen tip.

A small specimen from off Tamaulipas, Mexico, with $R = 58$ mm. and $r = 18$ mm., is in general similar to the one described. The enlarged spines on the inferomarginals are apparently just beginning to appear. They are mostly about twice as high as the maximum diameter, which is usually halfway to the tip, and are stumpy, subconical, slightly flattened, with a subacute tip; a few have acute tips; some are circular in cross section, and some are simply much enlarged granules. There are no pedicellariae.

Specimens examined.—All known specimens except the type.

TETHYASTER SUBINERMIS (Philippi)

Text figures 1, a, 2, a-c

- Asterias subinermis* PHILIPPI, 1837, p. 193 (description; Sicily).—LAMARCK, 1840, p. 258 (from Philippi).—MÜLLER and TROSCHER, 1840, p. 324 (listed).—PREYER, 1886, p. 32 (Naples; rare in about 100 fathoms).
- Astropecten subinermis* MÜLLER and TROSCHER, 1842, pp. 74-75 (Sicily).—SARS, 1859, p. 48 (Messina; 100 fathoms).—DUJARDIN and HUPÉ, 1862, p. 425 (coasts of Sicily).—PERRIER, 1875, p. 369; 1876, p. 289 (Nice; Algeria; Mediterranean).—STUDER, 1884, p. 46 (off Liberia, lat. 4°40' N., long. 9°10'06" W., 59 fathoms).—CARUS, 1885, pp. 90-91 (summary of localities).—PREYER, 1886, p. 32 (Naples; rare in about 100 fathoms).—CUÉNOT, 1888, p. 134 (Banyuls).—COLOMBO, 1888, pp. 47, 66 (Naples).—STUDER, 1889, p. 28 (lat. 4°40.1' N., long. 9°10.6' W., 108 meters).—VON MARENZELLER, 1895, pp. 125, 127, 145 (Adriatic Sea, east of Pelagosa, lat. 42°23'00" N., long. 16°21'59" E., 131 meters, sand and mud).—NOBRE, 1903, p. 155 (Setubal); 1904, p. 133 (Setubal).
- Astropecten crenaster* (part) DUJARDIN and HUPÉ, 1862, p. 414 (according to Cuénot, 1912).—?FISCHER, 1869, p. 364.
- Astropecten aranciaca* FISCHER, 1869, p. 363 (not of Linné = *subinermis* according to Cuénot, 1912) (Bassin d'Arcachon).
- Archaster subinermis* PERRIER, 1878, pp. 33, 57, 88 (Mediterranean).
- Goniopecten subinermis* PERRIER, 1885, p. 71.
- Plutonaster (Tethyaster) subinermis* SLADEN, 1889, pp. 82, 83, 101, 102, 722.
- Tethyaster subinermis* PERRIER, 1894, p. 323; (*Talisman* station 5, Baie de Cadix, lat. 36°26' N., long. 8°47' W., 60 meters, mud and shells; station 15, coast of Morocco, lat. 33°57' N., long. 10°47' W., 1,283-1,425 meters, mud, coral; station 66, off Cape Bojador, Morocco, lat. 26°13' N., long. 17°10' W., 175 meters, mud, coral).—KOEHLER, 1896b, pp. 450, 451 (*Caudan*, lat. 45°18' N., long. 5°23' W., 180 meters; lat. 45°52' N., long. 6°03' W., 250 meters; lat. 46°40' N., long. 6°30' W., 300 meters; *Talisman*, Baie de Cadix and coast of Morocco, 60-1,425 meters); 1896a, pp. 56, 124 (*Caudan* station 17, lat. 45°18' N., long. 5°23' W., 180 meters, gravel and sand; station 20, lat. 45°52' N., long. 6°03' W., 250 meters, mud; station 27, lat. 46°40' N., long. 6°30' W., 300 meters, mud).—PERRIER, 1896, p. 50 (Bay of Biscay, station 44, 166 meters; station 46, 155 meters).—KOEHLER, 1921, p. 54, fig. 40 (range); 1924, p. 200, pl. 7, fig. 4 (range).—MORTENSEN, 1925a, p. 178 (Atlantic coast of Morocco).—CUÉNOT, 1927, p. 295 (from Cuénot, 1912).—KOEHLER, 1930, figs. 1-3 (principally Mediterranean; Portugal; Cadix; coasts of Morocco and Liberia).—RIVERA, 1930, p. 105, fig. 4, p. 106 (Cádiz).—CUMANO, 1934, p. 138 (north of Berlengas).—NOBRE, 1938, p. 55 (Leixões, Bacia do Tejo, Sezimbra), pl. 30 (apparently from Ludwig, 1897), p. 195 (west of Sezimbra); TORTONESE, 1947a, p. 18 (Rodi [Rhodes]).—MADSEN, 1950, p. 186 (*Atlantide* station 120, lat. 2°09' N., long. 9°27' E., 650-260 meters; station 163, lat. 13°43' N., long. 17°23' W., 65-89 meters; about lat. 30°30' N., long. 10° W., 100 to 120-500 meters).
- Plutonaster subinermis* LUDWIG, 1897, pp. 105-118, pl. 1, figs. 1, 2, pl. 6, figs. 10-24 (detailed description; range).—Lo BIANCO, 1899, p. 473 (Gulf of Naples, very rare, on muddy bottoms, rarely on bottoms of other types).—KOEHLER, 1909a, p. 7; 1909b, p. 22 (*Princesse-Alice* station 1447, lat. 45°21' N., long.

2°39' W., 130 meters, fine sand, July 23, 1903).—CUÉNOT, 1912, pp. 28, 109 (range).—GOTO, 1914, p. 359.—CUÉNOT, 1927, p. 295.—NOBRE, 1931, figs. 42, 43, p. 62 (probably from Ludwig).

Thetyaster subinermis NOBRE, 1931, p. 62 (west coast of Portugal).

Tethyaster Tortonese, 1947b, p. 888 (Rhodes).

Diagnosis.—Enlarged spines on the inferomarginals narrow and sharp-pointed, none on the actinal intermediate plates; columns of the paxillae low, not over twice as high as thick; no abactinal pedicellariae; rays broad at the base, tapering, width at base equal to, or greater than, r ; first series of actinal intermediate plates to outer fourth of ray, second to about the middle; superomarginals short, 68-85 in fully developed individuals; granulation of superomarginals and actinal intermediate plates fine, uniform, and crowded; size large, R up to 275 mm.

Description.—This species was described and figured in detail by Ludwig (1897, p. 105).

Type.—We have no information regarding the type.

Type locality.—Sicily.

Geographical range.—From the Bay of Biscay (lat. 46°40' N.) south to the Gulf of Guinea, off Spanish Guinea (lat. 2°09' N., long. 9°27' E.); Mediterranean, east to Rhodes in the Aegean Sea.

Bathymetrical range.—From about 50 to about 1,400 (possibly 1,425) meters.

Remarks.—In a specimen from Algiers (B.M. No. 1947.6.24.1) with R = 110 mm. there are 73 superomarginals. In a specimen from Naples (U.S.N.M. No. E.8001) with R = 86 mm., r = 21 mm., there are 72 superomarginals; in this specimen the mouth plates are followed by 1 pair of plates in three interradii, and by 2 pairs in two; these are followed by a midinterradial unpaired row of 5 plates in three interradii, of 4 in two, that reach to the suture between the interradial pair of inferomarginals. In Ludwig's figure this unpaired median row consists of 5 plates, but reaches only to about two-thirds the distance to the inferomarginals.

In a specimen from off Gambia (*Atlantide* station 163, lat. 13°43' N., long. 17°23' W., 69-89 meters) (B.M. No. 1950.3.18) with R = 72 mm. there are 62 superomarginals. In a specimen from off Spanish Guinea (*Atlantide* station 120, lat. 2°09' N., long. 9°27' E., 650-260 meters) (B.M. No. 1950.7.3.26) with R = 71 mm. there are 68 superomarginals. In a specimen from Naples (B.M. No. 98.5.3.105-6) with R = 50-57 mm. there are 48 superomarginals.

In individuals of this species the rays may be of slightly different lengths.

In some specimens from Naples the paxillae of the midradial row on the rays gradually become enlarged in the outer part of the ray, but this does not seem to be the case in specimens from Algiers or from the Atlantic.

Specimens examined.—Five, listed above.

TETHYASTER PACEI (Mortensen)

Anthosticte pacei MORTENSEN, 1925b, p. 147, fig. 1, p. 148, pl. 8, fig. 3 (description; "Off South African Coast").

Diagnosis.—Enlarged spines on the inferomarginals narrow and sharp-pointed, none on the actinal intermediate plates; columns of the paxillae low, not over twice as high as thick; no abactinal pedicellariae (in the single known specimen); rays narrow, width at base markedly less than r ; first series of actinal intermediate plates to about the outer third of the ray, second only in the proximal third; $R = 120$ mm.

Type.—In the Zoological Museum, Copenhagen, Denmark.

Type locality.—"Off South African Coast."

Remarks.—This species is known only from the type specimen, which we have not seen.

TETHYASTER AULOPHORA (Fisher)

Anthosticte aulophora FISHER, 1911, p. 417 (description; *Albatross* station 5420); 1919, p. 140, pl. 17, fig. 1, pl. 18, fig. 2, pl. 19, fig. 2, pl. 38, fig. 3, pl. 39, figs. 1, 1a-d (redescription).—MORTENSEN, 1925b, p. 148 (comparison with *A. pacei*).

Diagnosis.—Enlarged spines on the inferomarginals narrow and sharp-pointed, none on the actinal intermediate plates; columns of the paxillae slender, high, about four times as high as thick; most of the paxillae with a pedicellaria of 2-4 valves; $R = 162$ mm.

Type.—In the U. S. National Museum (No. 28656).

Type locality.—*Albatross* station 5420, between Cebu and Bohol, Philippines (lat. $9^{\circ}49'35''$ N., long. $123^{\circ}45'00''$ E.); 232 meters; bottom temperature 59° F.; March 25, 1909.

Remarks.—This species is known only from the type specimen which we have examined.

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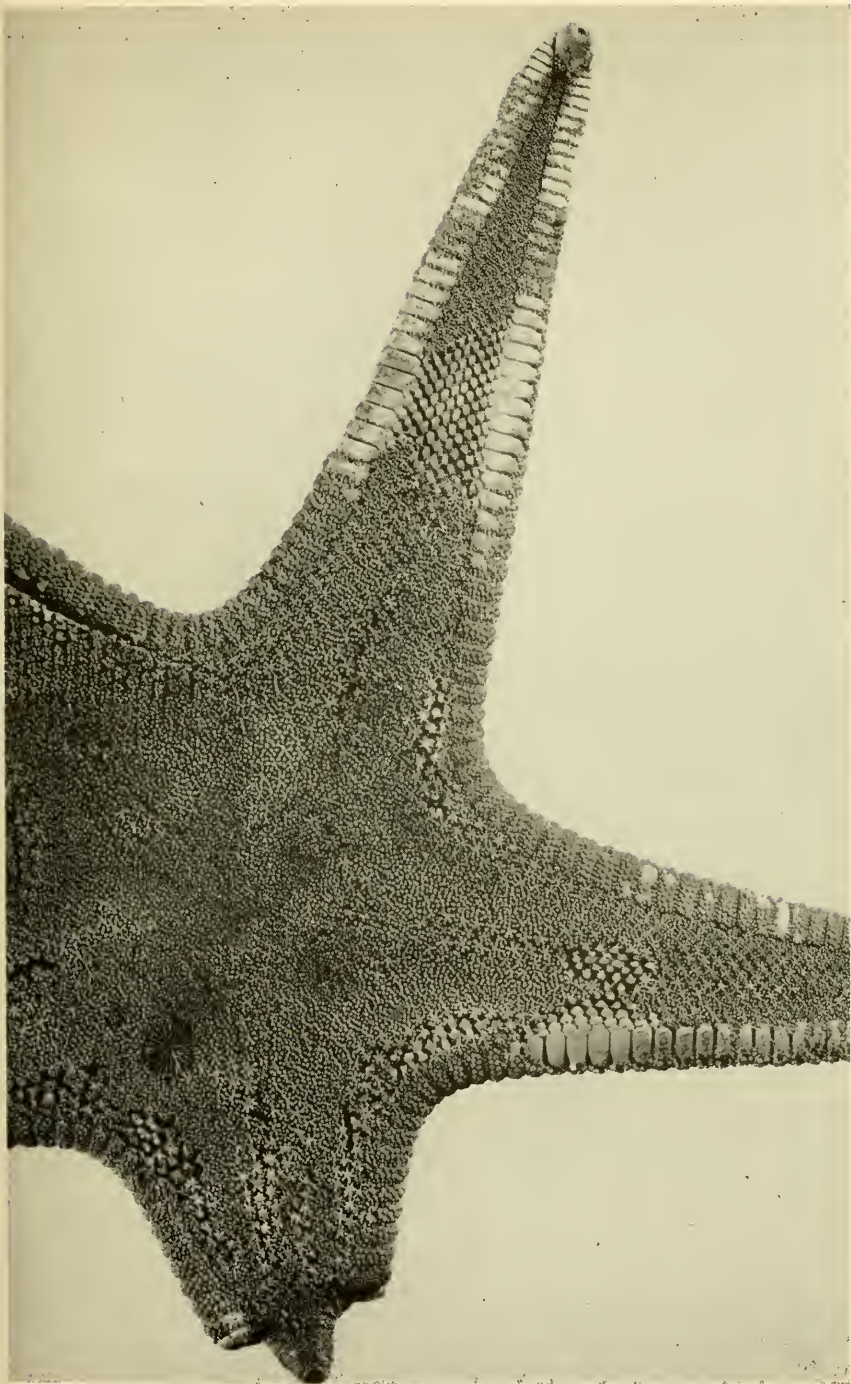
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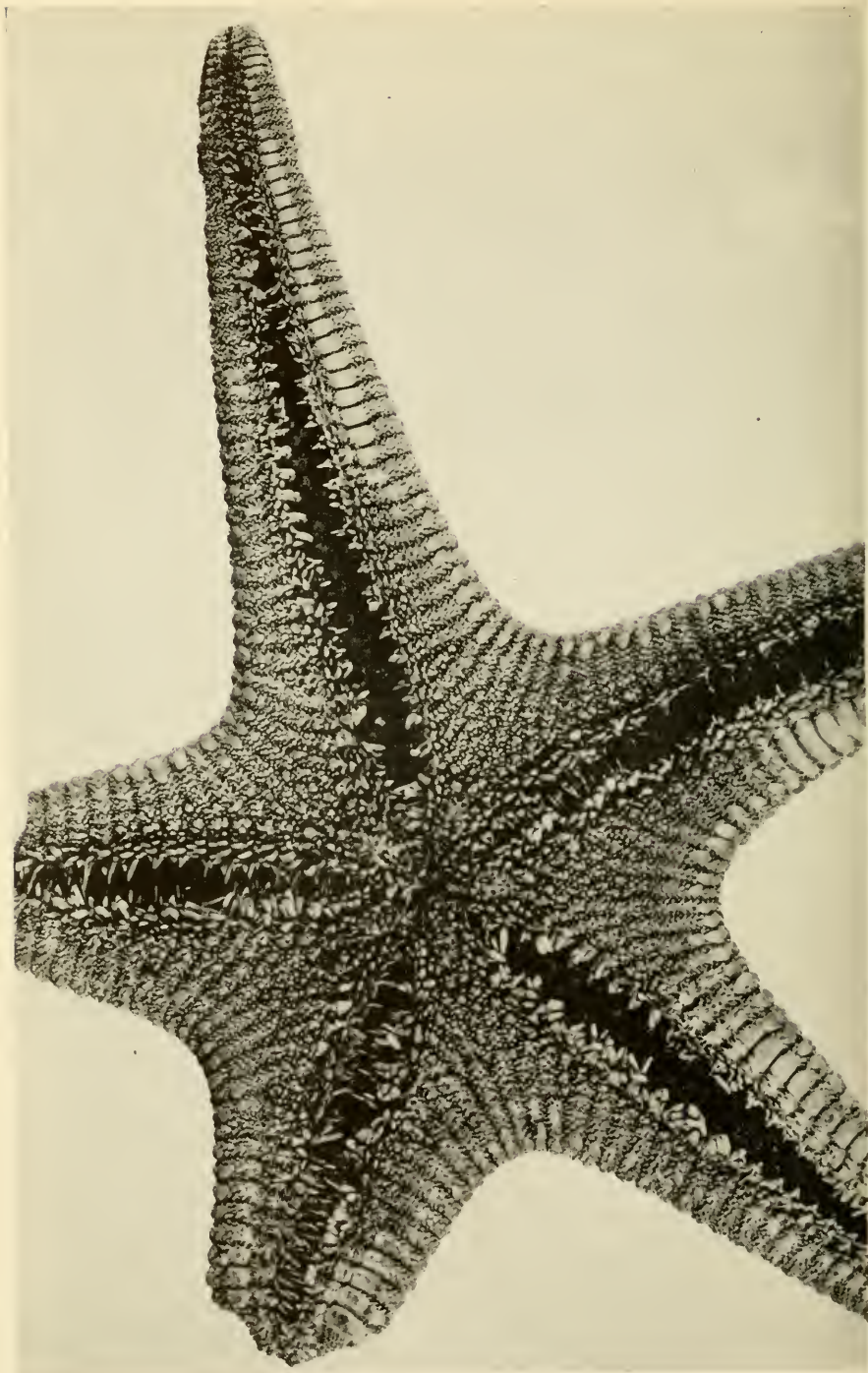
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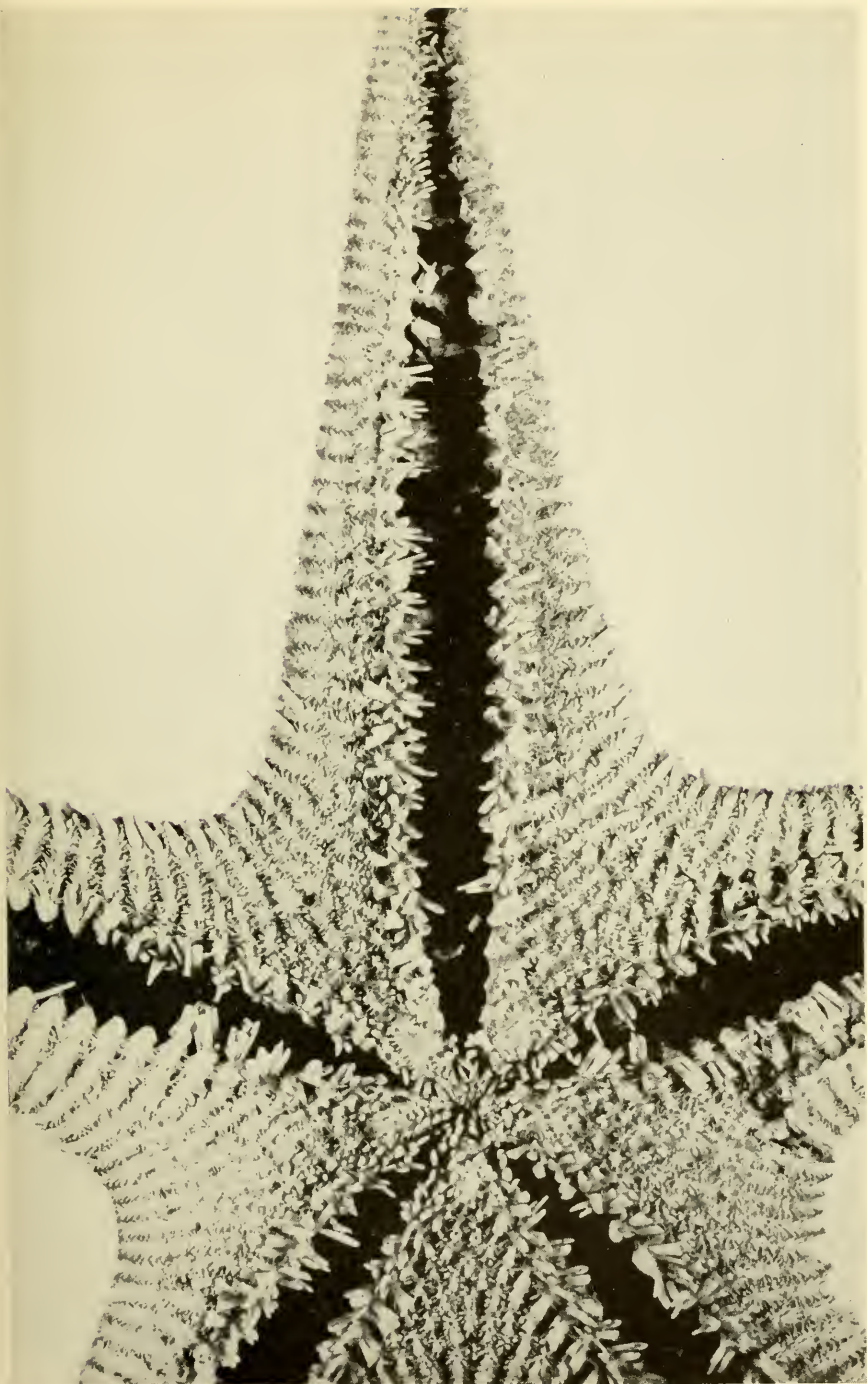
PLATES



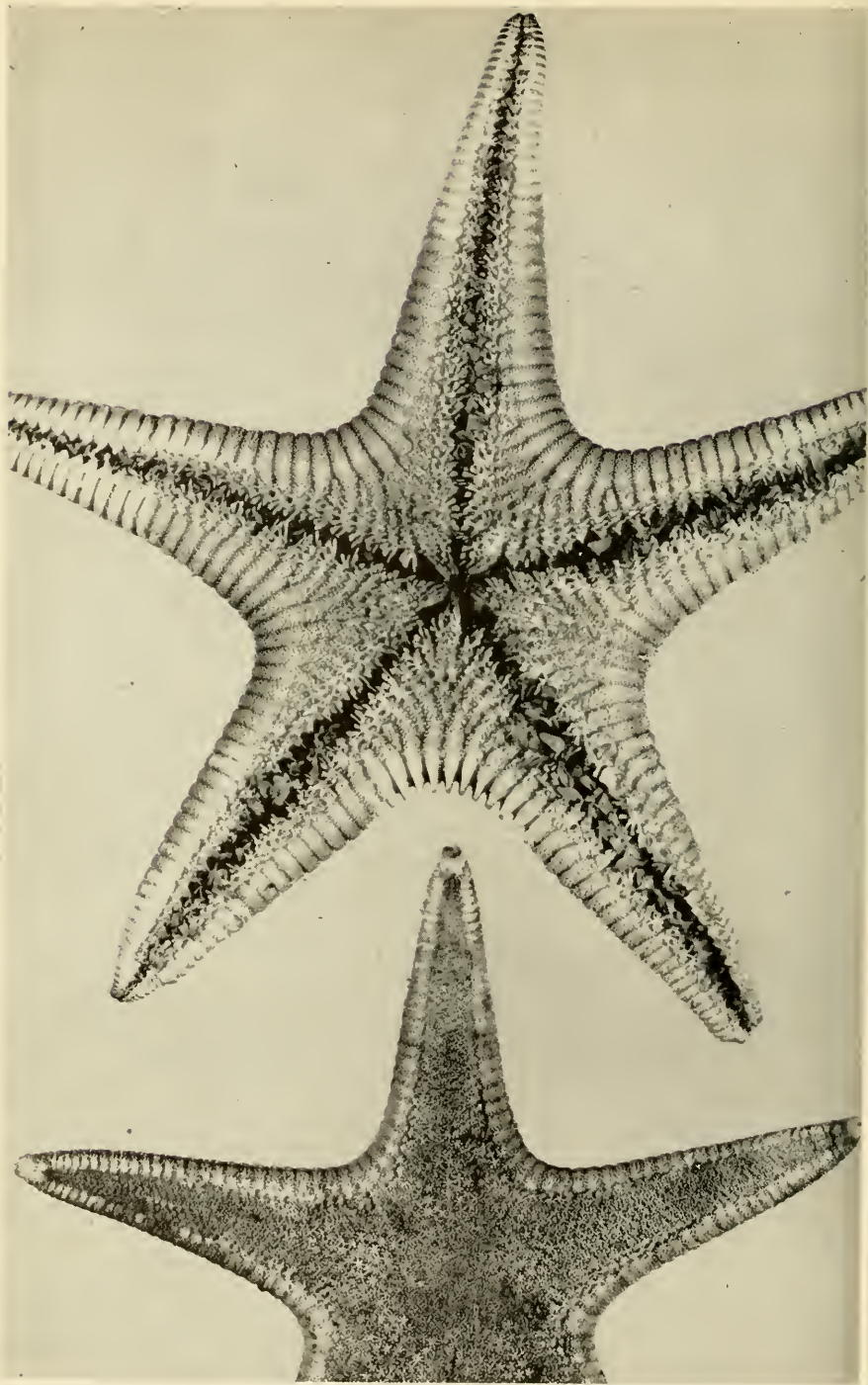
Tethyaster canaliculatus (A. H. Clark), the type specimen from *Albatross* station 2998, Gulf of California, in 73 meters; abactinal view, $\times 2$. (U.S.N.M. No. 36951.)



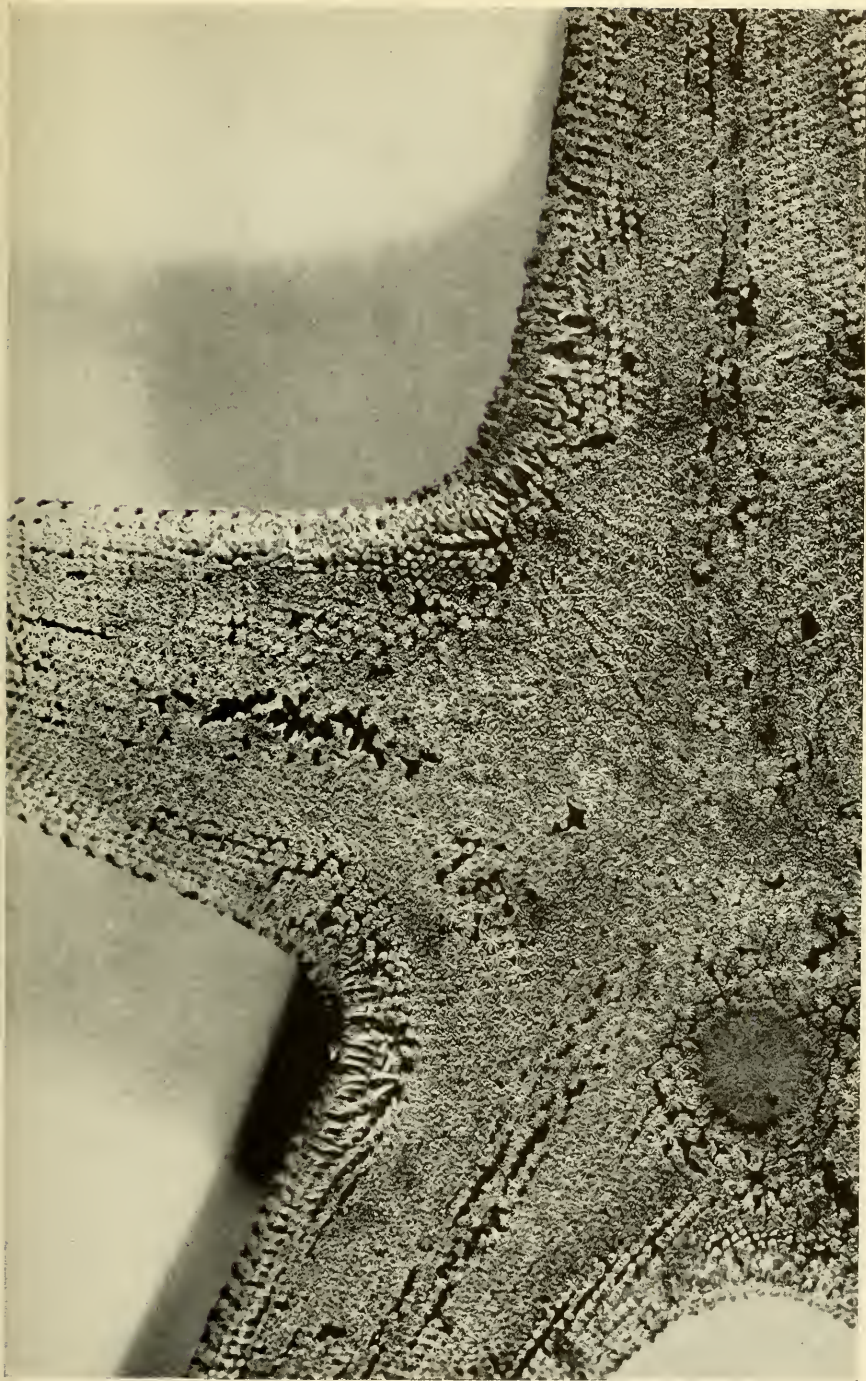
Tethyaster canaliculatus (A. H. Clark), the type specimen from *Albatross* station 2998, Gulf of California, in 73 meters; actinal view, $\times 2$. (U.S.N.M. No. 36951.)



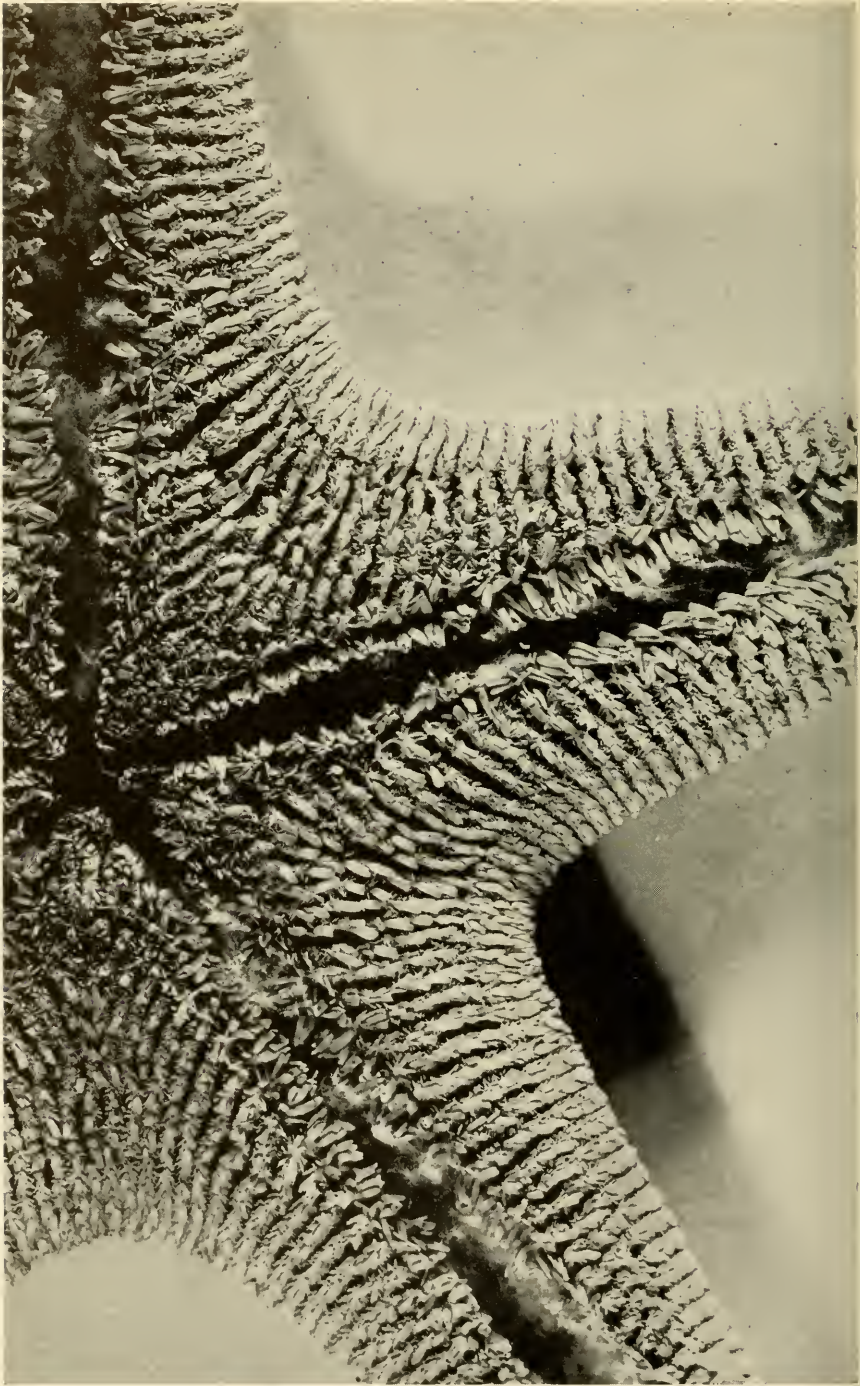
Tethyaster canaliculatus (A. H. Clark), the specimen with $R = 95$ mm. from Zaca station 142, D-3, Santa Inez Bay, Gulf of California, in 73 meters; actinal view, $\times 2$. (M.C.Z. No. 36232.)



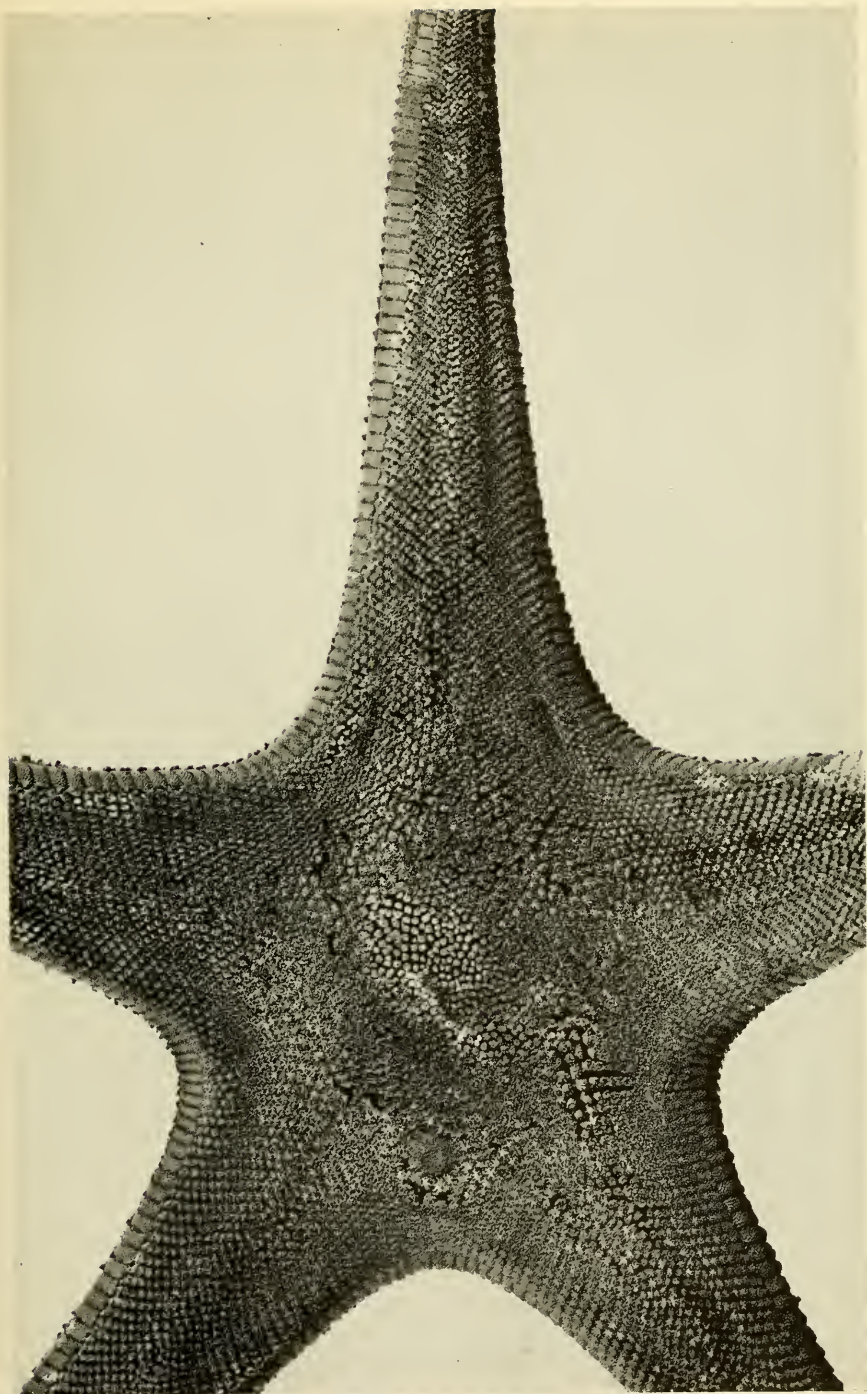
Tethyaster canaliculatus (A. H. Clark): *Upper*, the specimen with $R = 41$ mm. from Zaca station 136, D-14, Arena Bank, Gulf of California, in 82 meters; actinal view. (M.C.Z. No. 3447.) *Lower*, the specimen from Zaca station 146, D-1, Santa Inez Bay, Gulf of California, in 73 meters; abactinal view. (M.C.Z. No. 3448.) Both figures $\times 2$.



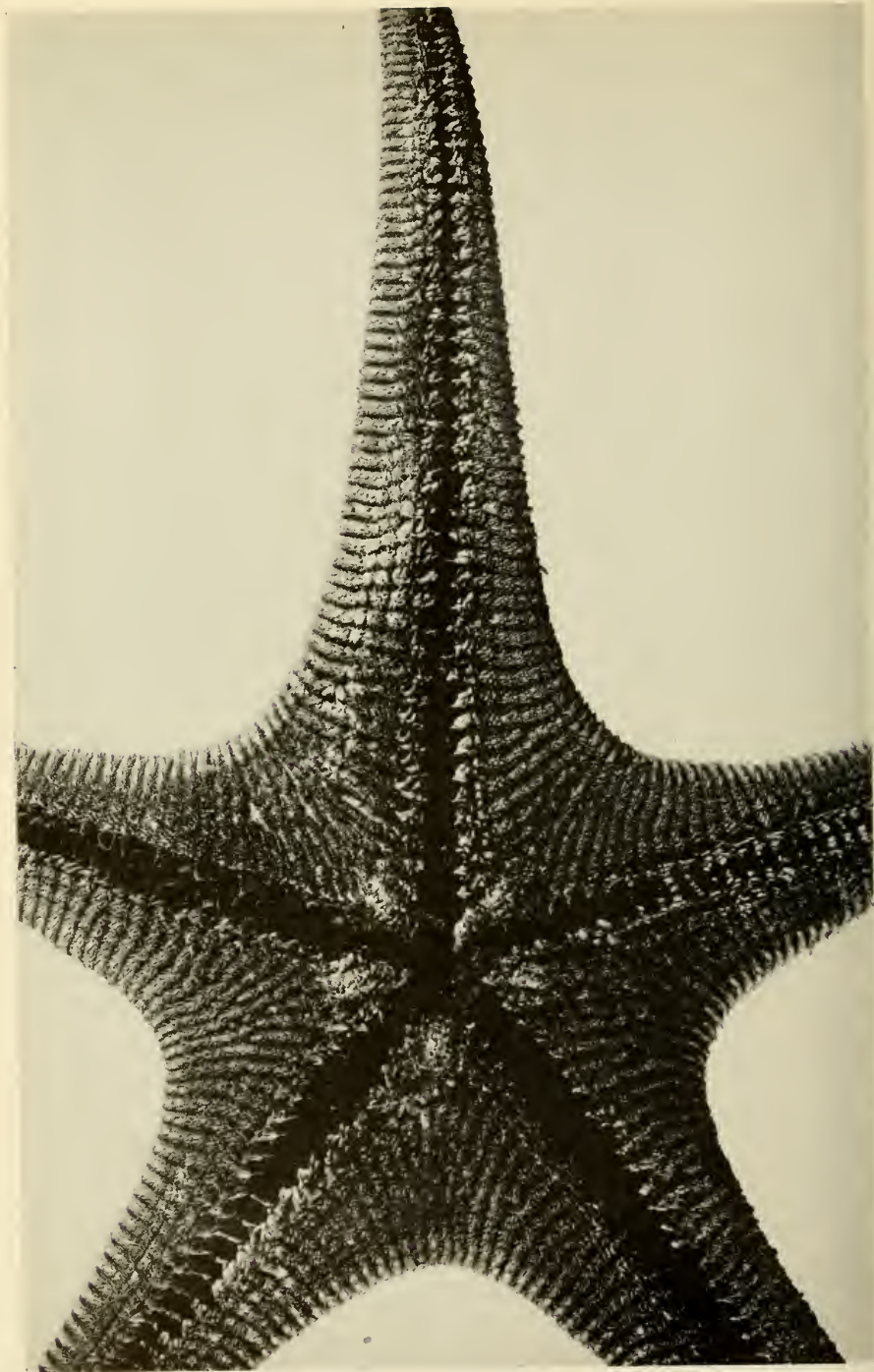
Tethyaster vestitus (Say), specimen from off Diamond Shoal, North Carolina, in 44 meters; abactinal view, natural size. (U.S.N.M. No. E.8000.)



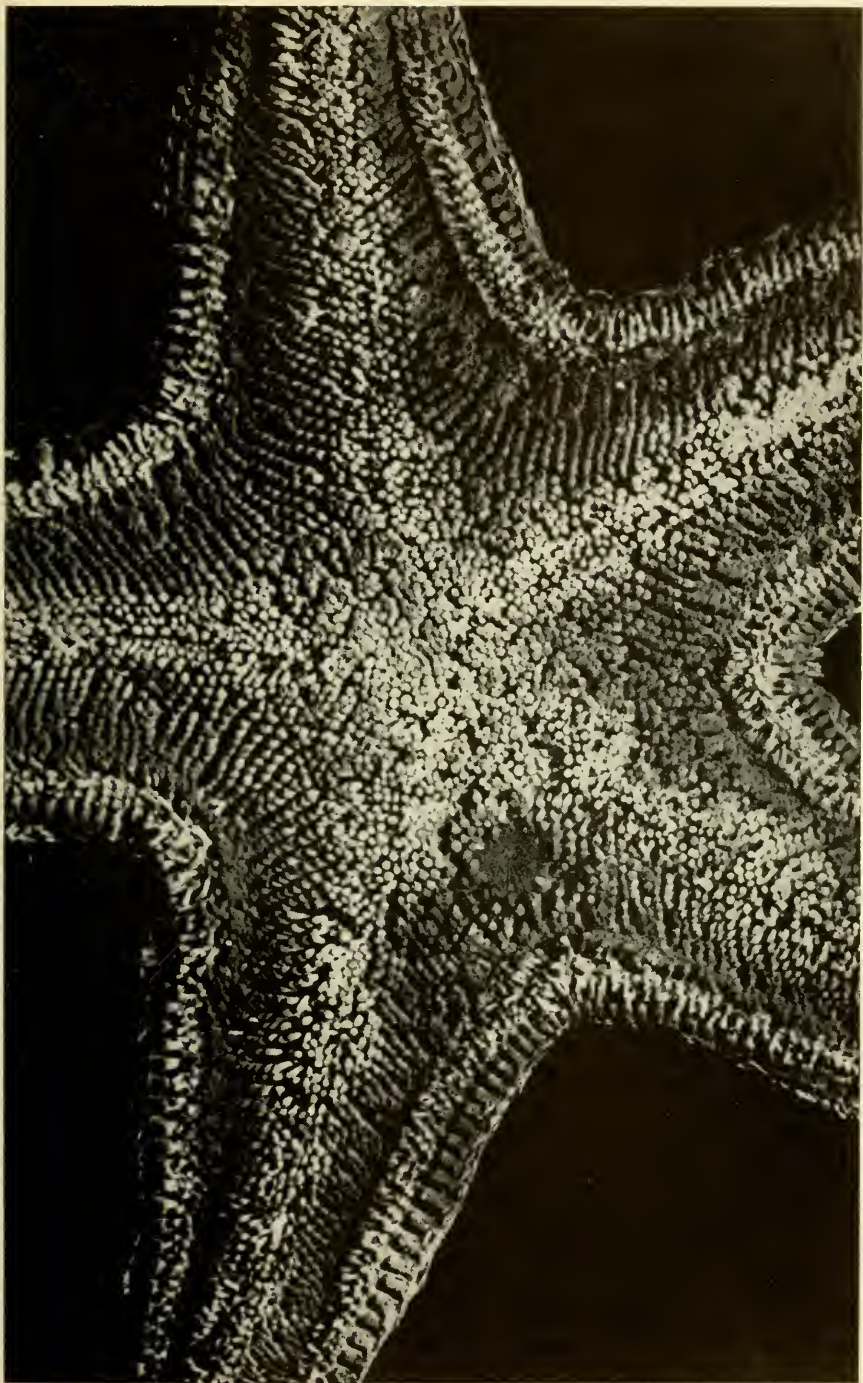
Tethyaster vestitus (Say), specimen from off Diamond Shoal, North Carolina, in 44 meters; actinal view, natural size. (U.S.N.M. No. E.8000.)



Tethyaster vestitus (Say), specimen from off Puerto Rico in 146-329 meters; abactinal view, natural size. (U.S.N.M. No. E.3963.)



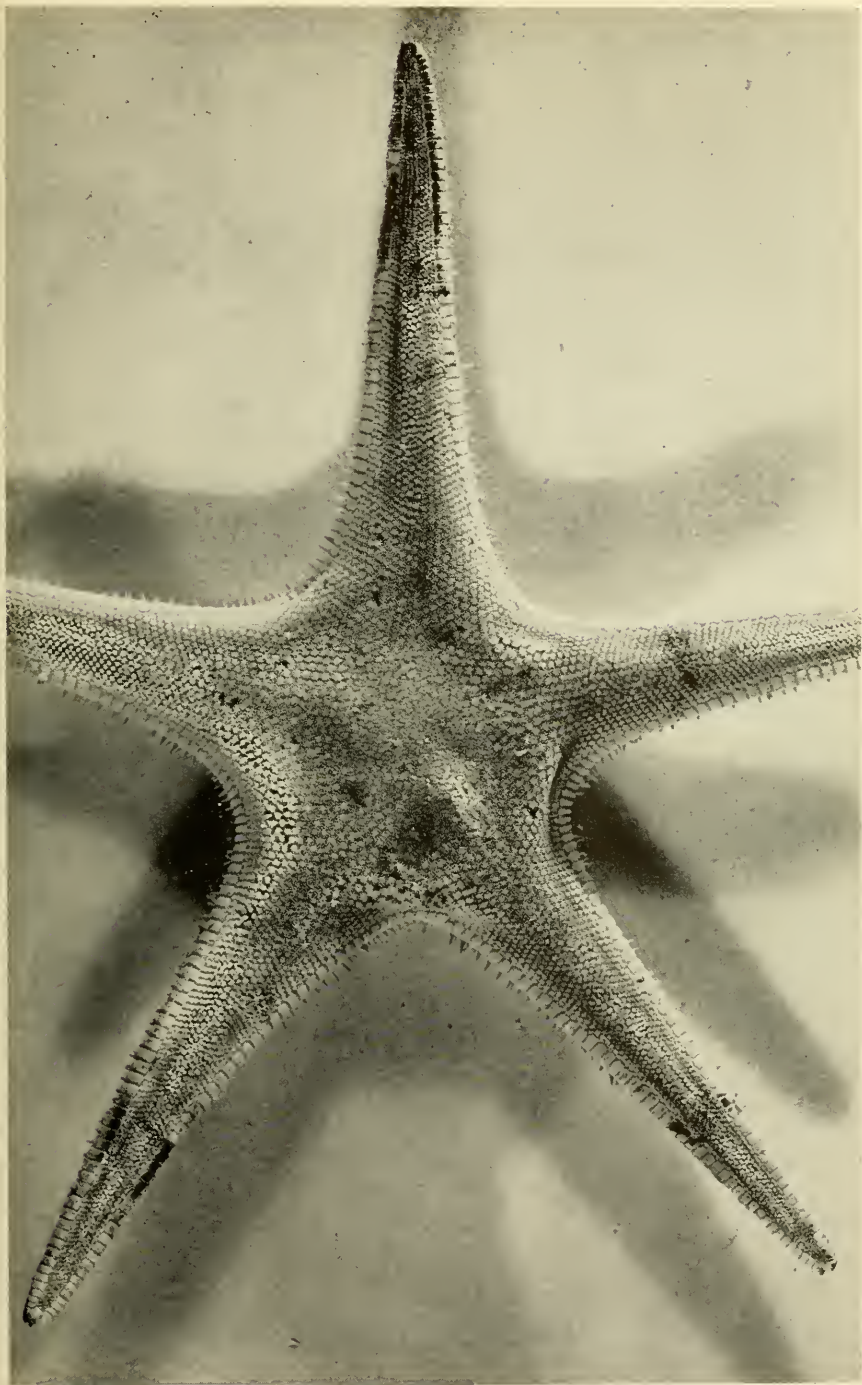
Tethyaster vestitus (Say), specimen from off Puerto Rico in 146-329 meters; actinal view, natural size. (U.S.N.M. No. E.3963.)



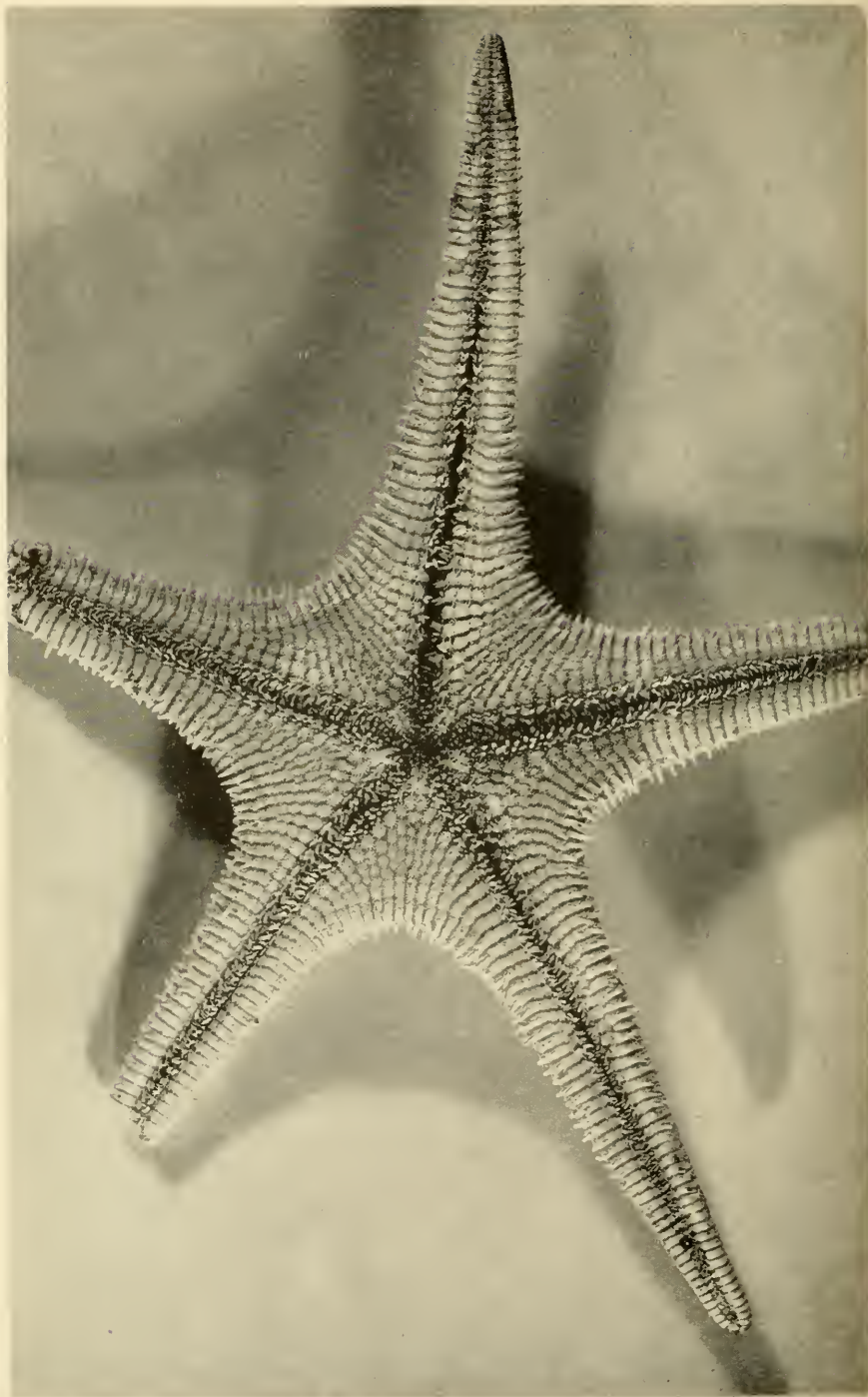
Tethyaster magnificus (Bell), the larger cotype from St. Helena; abactinal view, natural size. (B.M. No. 68.6.15.1.)



Tethyaster magnificus (Bell), the larger cotype from St. Helena; actinal view, natural size. (B.M. No. 68.6.15.1.)



Tecthyaster grandis (Verrill), from off Corpus Christi, Tex., in 139 meters;
abactinal view, natural size. (U.S.N.M.)



Tethyaster grandis (Verrill), from off Corpus Christi, Tex., in 139 meters;
actinal view, natural size. (U.S.N.M.)

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