(74)

MEMOIRS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT

HARVARD COLLEGE.

VOL. XXXIV.

146078
20/5/18

CAMBRIDGE, MASS., U. S. A.
Printed for the Museum.
1907–1912.

CONTENTS.

HAWAIIAN AND OTHER PACIFIC ECHINI.

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXXIV. No. 1.

HAWAIIAN AND OTHER PACIFIC ECHINI.

THE CIDARIDÆ.

BY
ALEXANDER AGASSIZ AND HUBERT LYMAN CLARK.

WITH FORTY-FOUR PLATES.

[Published by Permission of George M. Bowers, U. S. Commissioner of Fish and Fisheries.]

CAMBRIDGE, U. S. A.:
Printed for the Museum.
February, 1907.

CONTENTS.

CONTENTS.

* Hawaiian species.

NOTICE.

The following account of the Cidaridæ of the Hawaiian Echini collected in the spring of 1902 by the United States Fish Commission Steamer "Albatross," Commander Chauncey Thomas, U. S. N., commanding, is the first part of the description of a large collection of Sea-urchins intrusted to us for examination by the Hon. George M. Bowers, United States Fish Commissioner. A few other Echini collected by the "Albatross" in different parts of the Pacific have been incorporated in our Report, and special reference has been made to some Deep Sea Panamic Cidaridæ collected by the "Albatross" in 1891, for the sake of having a connected account of the pedicellariæ of the Pacific Cidaridæ. This part of the Report has been prepared by Mr. Clark, and he has, as far as practicable, analyzed the statements of Mortensen, Döderlein, and de Meijere regarding their systematic value. Mr. Agassiz has in his Panamic Deep Sea Echini given his views of the new classification of Echinoids proposed by Mortensen and de Meijere. As regards the position taken by Döderlein regarding Mortensen's system, in his Echini of the "Valdivia," which has recently been published, it is difficult to follow him. His statements are often most guarded; next they may be enthusiastic in favor of a classification based upon pedicellariæ, and again are radically opposed to such a course. The numerous illustrations of pedicellariæ given by Döderlein are unfortunately somewhat indistinct, and it is often very difficult to distinguish their characteristic features.

The succeeding parts of this monograph on the Hawaiian Echini will be published as rapidly as the preparation of the plates will allow. In the meantime a preliminary list of the species included in the collection will shortly be printed. For the positions indicated in the Stations, see U. S. Hydrographic Chart, No. 1368.

ALEXANDER AGASSIZ.
HUBERT LYMAN CLARK.

Museum of Comparative Zoölogy.
Cambridge, Mass., February, 1907.

HAWAIIAN AND OTHER PACIFIC ECHINI.

COLLECTED BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," COMMANDER CHAUNCEY THOMAS, U. S. N., COMMANDING.

CIDARIDÆ Müller.

PEDICELLARIÆ are present in considerable numbers among the secondary and miliary spines of the Cidaridæ and show the greatest diversity in their size, form, and relative abundance. We can distinguish in this family three sorts of pedicellariæ, differing from one another in structure, as well as in size, and for convenience these have been designated as "tridentate," "large globiferous," and "small globiferous." The three kinds are not, however, sharply distinct from one another, for intermediate forms are common, often on one and the same individual. Covered with their epidermal tissue the pedicellariæ are difficult to study, but when the organic matter has been cleaned off with caustic potash, or much better with hypochlorite of soda, their calcareous parts show many interesting features. In what follows, reference is made to these calcareous parts only.

The tridentate pedicellariæ have the valves elongated, and either flat or contracted rather abruptly into a slender blade, which may terminate in a rounded, more or less smooth end, or in a conspicuous hook or "end-tooth." Each valve is practically solid and does not contain any interior cavity, but it is often more or less perforated, near the base and along the sides, with small holes. A tridentate pedicellaria is usually made up of three valves, of equal size, connected with each other at the base by muscles, and freely movable on the end of a stalk of variable length. But similar pedicellariæ with only two valves occur regularly in *Porocidaris purpurata,* and rarely in *P. variabilis,* while in the latter species such pedicellariæ with four valves are also occasionally found. When closed, the valves may meet for their entire length (and this is always so in pedicellariæ having two or four valves) or, as in many of those with three valves, these meet only at the tip or for a fraction of their length, and are more or less widely separated above their basal union. In size, the valves show a wide range, from less than half a millimeter to over half a centimeter long, the width being from .10 to .70 of the length. In small examples the stalk, which is a simple, straight rod, is often as long as the valves, but in large ones the valves are much the longer. Tridentate pedicellariæ occur mainly around the primary spines, especially on the actinal half of the test, but they may occur abactinally and are sometimes conspicuous on the abactinal system. They may be entirely wanting not merely in individual cases but in whole groups of species.

The large globiferous pedicellariæ are always three-valved. They take their name from the fact that when the valves, which are large and hollow, are closed in their normal position, the whole head appears more or less globular. The cavity of each valve opens on the inner side near the tip, or the opening may be terminal. The size of the opening is very variable, but the three valves of any one pedicellaria are all alike. When the opening is not at the end, the tip of the valve may be blunt and rounded or it may terminate in a more or less conspicuous "end-tooth." When the opening is large the edges are usually irregularly serrate, and more or less of the entire length of the margin of the valve may be provided with small teeth. The lower edge of the opening is usually sharply indicated by a horizontal, outwardly curved "lip," but this is frequently imperfect or entirely wanting. The lower part and back of the valve is more or less perforated with holes of variable size and shape. True large globiferous pedicellariæ show relatively little diversity in size, the valves ranging only from one-half to a little more than one millimeter in length. The stalk is usually about as long as the valves, but is often less, while on the other hand it may be twice as long. Usually it is a simple, straight, calcareous rod, but in some species there are frequently, if not always, projecting, slender spicules which form a circle near the distal end of the stalk; this is referred to as the "limb." Large globiferous pedicellariæ occur chiefly on the abactinal half of the test and most commonly between the primary spines, though they are often frequent on the abactinal system. They seldom occur on the ambulacra or near the actinostome and they are often entirely wanting, not merely in individual cases, but even in whole groups of species. In individuals on which they are abundant, there may not uncommonly be found large globiferous pedicellariæ in which the valves have become elongated and narrow, without a lip, and the opening larger and longer than usual, and the transition into tridentate pedicellariæ can be traced step by step through a series of such intermediate forms. More commonly a series may be found in which, by a gradual reduction in size, the large globiferous intergrade with the small globiferous pedicellariæ.

The small globiferous pedicellariæ are very similar to the large ones in all essentials of structure, but the valves are more slender and the stalk is much longer, and rarely, if ever has a limb. Often the valves differ in some way very clearly from those of the large globiferous pedicellariæ of the same individual; thus, if the latter have an "end-tooth" most of the small ones may lack it, or vice versa. But they vary greatly, and in the same individual may be found small pedicellariæ the valves of which have no end-tooth, and others in which it is conspicuous. And in some species, moreover, the small globiferous pedicellariæ are just like the large ones and intergrade with them completely. The valves of the small ones range from .15 mm. upwards in length, while the stalk is often two or three times as much and in some cases is five or six times as long as the valves. Small globiferous pedicellariæ may occur anywhere on the test except within the areolæ and the poriferous zones. They are particularly abundant on the actinostome and on the actinal part of the ambulacra, but they may be equally common on the abactinal system. Those with the shortest stalks occur on the ambulacra, while those with the longest stalks are found among the secondary spines of the scrobicular circles. They are never entirely wanting except in the genus *Porocidaris,* where they are replaced by very small tridentates.

GONIOCIDARIDÆ Haeck.

Cidaris Klein.

Cidaris tribuloides Agass.

Cidarites tribuloides Lamarck, 1816, Anim. s. Vert. III, p. 56.
Cidaris tribuloides Agassiz, 1835, Prodrome, p. 188.

Plate 2, figs. *1–4*.

All three kinds of pedicellariæ are present in most individuals, but occasionally the tridentate are wholly wanting, and now and then only two or three large globiferous ones will be found, even on large specimens.

The large globiferous pedicellariæ (Pl. 2, fig. *1*) have the opening large, terminal, with a well-developed lip and the margins conspicuously toothed.

The blade is somewhat curved, so that it has been described as "projecting in a snout-like way." This is the type of pedicellaria which Mortensen regards as characteristic of the genus *Cidaris;* as a matter of fact, however, it occurs in several other genera. The valves are .60–.70 mm. in length; the stalks (Pl. 2, fig. *2*) are .60–1.50 mm. long and have no limb. They occur chiefly on the interambulacra and most commonly on the abactinal surface.

The tridentate pedicellariæ (Pl. 2, fig. *4*) are not specially peculiar. The valves are narrow and somewhat compressed, usually .50 mm. long or less, often much less, but sometimes are nearly or quite 1 mm.; the stalks are shorter than the valves. They occur almost wholly on the actinal side of the test and are most abundant on the interambulacra.

The small globiferous pedicellariæ (Pl. 2. fig. *3*) have a conspicuous end-tooth on each valve; the opening is not terminal nor is the blade curved, so that the general appearance is quite different from the large ones. The valves are .20–.50 mm. in length, while the stalk is from one to three times as long. They occur everywhere on the actinostome, ambulacra, interambulacra and abactinal system.

Cidaris Thouarsii Val.

Cidaris Thouarsii Val. Agassiz et Desor. 1846, Cat. Rais. Ann. Sci. Nat. (3) VI, p. 326.

Plate 1, figs. *1*, *2*.

All three kinds of pedicellariæ are commonly present, but in specimens from the Galapagos Islands and occasionally in those from Panama, the tridentate are wholly wanting. The large globiferous are also often reduced in numbers so that only two or three are to be found.

The large globiferous pedicellariæ are like those of *C. tribuloides* in form, but are generally larger, often with valves nearly 1 mm. long. The stalk about equals the head and may have a well-developed limb, but this is more commonly lacking (Pl. 1, fig. *1*). These pedicellariæ occur mainly on the abactinal interambulacra.

The tridentate pedicellariæ are similar to those of *tribuloides*, but are somewhat larger. They occur mainly on the actinal surface.

The small globiferous pedicellariæ (Pl. 1, fig. *2*) are like those of *tribuloides*, but are larger, sometimes .75–.80 mm. in length of valves, though they are usually under .50 mm.; the stalk is one to three times as long as the valves. They occur abundantly everywhere.

In October and November of 1904, this species was collected by the "Albatross" at the following localities:

Perico Island Panama, one fathom; three specimens.

Toboquilla Island, Panama, shore; one specimen.

Chatham Island, Galapagos, shore; eight specimens.

Cidaris metularia Bl.

Cidarites metularia Lamarck, 1816, Anim. s. Vert. III, p. 56.
Cidaris metularia Blainville, 1830, Zoophytes: Dict. Sci. Nat., LX, p. 212.

Plate 1, figs. *3–7*.

All three kinds of pedicellariæ are present, usually in considerable numbers.

The large globiferous pedicellariæ (Pl. 1, fig. *6*) are like those of *C. tribuloides*, but are a trifle smaller. The stalks are one or two times as long as the valves and are provided with a conspicuous limb (Pl. 1, fig. *3*), which seems to be always present. They occur on the interambulacra, chiefly abactinally.

The tridentate pedicellariæ (Pl. 1, fig. *7*) are similar to those of *tribuloides*. The valves are about .80 mm. in length and the stalks are about equal to them. These pedicellariæ are common everywhere except on the abactinal system.

The small globiferous pedicellariæ (Pl. 1, figs. *4–5*) are like those of *tribuloides*, but a little smaller, the valves usually about .35 mm. long.; the stalks are one to three times as long as the valves. They occur everywhere on the test and are very common.

None of the two hundred and ninety-six specimens of this widely distributed Indo-Pacific species show any notable peculiarities, and they differ from Zanzibar examples only in their brighter color. They were taken by the "Albatross" at the following stations.

Station 3838. Off S. coast of Molokai. Bott. temp. 67°. 92–212 fathoms. Fne. gy. br. s.

Station 3847. Off S. coast of Molokai. 23–24 fathoms. S. st.

Station 3849. Off S. coast of Molokai. Bott. temp. 67.6°. 43–73 fathoms. Crs. s. brk. sh. co.

Station 3861. Paiíolo Channel, and N. E. approach. 30–52 fathoms. Fne. s. sm. p. co.

Station 3871. Auau Channel, between Maui and Lanai. 13–43 fathoms. Fne. wh. s.

Station 3872. Auau Channel, between Maui and Lanai. Bott. temp. 74.6°. 32–43 fathoms. Yl. s. p. co.

Station 3874. Auau Channel, between Maui and Lanai. Bott. temp. 75.3°. 21–28 fathoms. S. p. sh.

Station 3876. Auau Channel, between Maui and Lanai. Bott. temp. 74°. 28–43 fathoms. S. g.

Station 3955. Vicinity of Laysan. Bott. temp. 74°. 20–30 fathoms. Co. r. alg.

Station 3962. Vicinity of Laysan. 16 fathoms. Wh. s. co.

Station 3968. French Frigate Shoal. $14\frac{1}{2}$–$16\frac{1}{2}$ fathoms. Crs. s. co.

Station 3970. French Frigate Shoal. 17–$17\frac{1}{2}$ fathoms. Crs. s. sh. co.

Station 3971. French Frigate Shoal. 17 fathoms. Crs. s. sh. co.

Station 3978. Vicinity of Modu Manu. 32–46 fathoms. Co. s. for. r.

Station 4027. Vicinity of Kauai. Bott. temp. 42.8°. 319 fathoms. Fne. gy. s. r.

Station 4032. Penguin Bank, S. coast of Oahu. 27–29 fathoms. Fne. co. s. for.

Station 4033. Penguin Bank, S. coast of Oahu. 28–29 fathoms. Fne. co. s. for.

Station 4034. Penguin Bank, S. coast of Oahu. 14–28 fathoms. Fne. co. s. for.

Station 4046. Off W. coast of Hawaii. Bott. temp. 59°. 71–147 fathoms. Co. s. for.

Station 4146. Vicinity of Modu Manu. Bott. temp. 78.7°. 23–26 fathoms. Crs. co. s. for.

Station 4147. Vicinity of Modu Manu. Bott. temp. 77.9°. 26 fathoms. Co. corln.

Station 4148. Vicinity of Modu Manu. Bott. temp. 77.9°. 26–33 fathoms. Co. s. for.

Station 4149. Vicinity of Modu Manu. Bott. temp. 77.7°. 33–71 fathoms. Co. corln.

Station 4150. Vicinity of Modu Manu. Bott. temp. 74°. 71–160 fathoms. Co.

Station 4158. Vicinity of Modu Manu. Bott. temp. 78.6°. 20–30 fathoms. Co. corln.

Station 4159. Vicinity of Modu Manu. Bott. temp. 78.3°. 30–31 fathoms. Crs. co. s. brk. sh. for.

Station 4160. Vicinity of Modu Manu. Bott. temp. 78°. 31–39 fathoms. Co. corln.

Station 4161. Vicinity of Modu Manu. Bott. temp. 77.9°. 39–183 fathoms. Co. corln.

Station 4162. Vicinity of Modu Manu. 21–24 fathoms. Co.

Station 4167. Vicinity of Modu Manu. 18–20 fathoms. Co. s.

Station 4169. Vicinity of Modu Manu. Bott. temp. 78.6°. 21–22 fathoms. Co.

Bathymetrical range, 13–319 fathoms. Extremes of temperature, 78.7°–67°.

Dorocidaris A. Ag.

Dorocidaris abyssicola A. Ag.

Dorocidaris abyssicola A. Ag., 1869. Bull. M. C. Z., I, 9, p. 253; Rev. Ech. Pl. I, figs. 1–4.

Plate 12ᵃ, figs. *1–5*.

Further examination of a large series of Dorocidaris from the West Indies and Florida, comparisons being carefully made with a considerable number of European specimens of *D. papillata*, makes it evident that *abyssicola* can be constantly distinguished from that species. Mortensen's[1] suggestion that the small pedicellariæ might be a distinguishing character is however not a happy one, for the pedicellariæ in *abyssicola* are very variable. The large globiferous ones show remarkable diversity even in a single individual, as is well shown in the figures here given, so that it would be unwise to lay any stress on their form as a systematic character. In general it may be said that the pedicellariæ agree closely (as would naturally be supposed) with those of *papillata*. The smooth, white spines afford the most obvious character by which *abyssicola* may be recognized.

[1] Ingolf Exped. Echinoidea, 1903, Pt. I, p. 34.

Dorocidaris affinis A. Ag.

Cidaris affinis Philippi, 1845. Arch. f. Naturg. Eilfter Jahrg. Bd. I, p. 351.
Dorocidaris affinis A. Ag., 1869. Bull. M. C. Z., I, pp. 17 and 254; Rev. Ech. Pl. I, fig. 5.

Plate 12[b], figs. *1–3*.

Mortensen[1] has pointed out the characteristics distinguishing this species from *papillata*, but he fails to realize the diversity which the pedicellariæ may show. It is true that the large globiferous pedicellariæ are ordinarily like those of *Cidaris* (Pl. 12[b], fig. *3*), but occasionally they are scarcely distinguishable from those of *Dorocidaris* (Pl. 12[b], fig. *1*), while not infrequently they are somewhat intermediate as the opening is not quite terminal (Pl. 12[b], fig. *2*.).

Dorocidaris Bartletti A. Ag.

Dorocidaris Bartletti A. Ag., 1880. Bull. M. C. Z., VIII, 2, p. 69.

Plate 12[a], figs. *6–13*.

Of all the Cidaridæ which we have examined, none exhibit more remarkable diversity in the form of the large globiferous pedicellariæ than does this interesting and handsome West Indian species. Although the most common form (Pl. 12[a], fig. *10*) is that which Mortensen[2] gives as the distinguishing feature of his proposed genus *Tretocidaris*, others (Pl. 12[a], fig. *7*) are quite frequent which ought to distinguish a true Cidaris, while others (Pl. 12[a], figs. *6* and *9*) are quite unlike either. The pedicellaria shown in Pl. 12[a], fig. *6*, may possibly be a stage of growth of the one shown in Pl. 12[a], fig. *7*, but this hardly seems probable. If one were to attempt to determine the generic position of this species by the pedicellariæ, it is obvious that serious difficulties would arise, nor would the presence of a "limb" on the stalk be of assistance, for it is also a very variable character (Pl. 12[a], figs. *12* and *13*). This great diversity in the pedicellariæ is of special interest because the primary spines of *Bartletti* show a greater variety of form than those of any other member of the genus, and according to Mortensen's view[3] the pedicellariæ ought to afford more constant characters.

[1] Ingolf Exped. Echinoidea, 1903, Pt. I, pp. 35–37.
[2] Loc. cit., p. 16.
[3] Loc. cit., p. 15.

Dorocidaris Blakei A. Ag.

Dorocidaris Blakei A. Ag., 1878. Bull. M. C. Z., V, 9, p. 185. Pl. IV; "Blake" Ech. Pl. I.

Plate 12^b, figs. *4–6*

Although the large globiferous pedicellariæ of this species are much less variable than those of *Bartletti*, nevertheless they show sufficient diversity to prevent assigning them all to a single type. The opening at the tip may be broadly triangular with a well-defined lip (Pl. 12^b, fig. *4*), but it is commonly more elongated (Pl. 12^b, fig. *5*), and may be so narrow (Pl. 12^b, fig. *6*) as to approach the form which Mortensen[1] assigns to "*Schizocidaris*." The valves are, however, much broader than in that group, and none were found which would indicate any other genus than Dorocidaris.

Dorocidaris panamensis A. Ag.

Dorocidaris panamensis A. Ag., 1898. Bull. M. C. Z., XXXII, 5, p. 73. Pls. I and II, fig. 1; Pan. Deep Sea Ech. Pl. 1.

Plate 2, figs. *5–8*.

Only two kinds of pedicellariæ are present in the specimens of this species which are at hand, as the tridentate are entirely wanting.

The large globiferous pedicellariæ (Pl. 2, fig. *5*) are much like those in *Cidaris*. The valves are .90–.95 mm. in length and the stalk is about the same or a little shorter; it has no limb. These pedicellariæ are not very common, but occur between the primary spines on the interambulacra.

The small globiferous pedicellariæ (Pl. 2, figs. *6–8*) are quite different from the large ones and sometimes have a large end-tooth (Pl. 2, fig. *8*) as in *Cidaris*. The valves are only .30–.60 mm. in length, while the stalk varies from .30 to 2.50 mm. They are common on all parts of the test.

Dorocidaris bracteata A. Ag.

Dorocidaris bracteata A. Ag., 1879. Proc. Am. Acad., XIV, p. 197.

Plate 3, figs. *15–28*.

Three small specimens of a *Cidaris* were collected at Station 3746, May 19, 1900, off Suno Saki, Sagami Bay, Japan, in 49 fathoms, gy. s. p., the largest of which has a test 15 mm. in diameter, and the smallest only 8 mm. We take

[1] Ingolf Exped. Echinoidea, 1903, Pt. I, p. 25.

them to be the young of *Dorocidaris bracteata*, although the serrations of the radioles (Pl. 3, fig. *24*) are sharper and more prominent than the blunt ones forming the ridge of the fluting of larger specimens. The color of the bands of the radioles is light greenish brown; the small spines are of a lighter color, yellowish gray, while the older specimens of *D. bracteata* collected by the "Challenger" were of a reddish-brown tint. Coming from so near the spot, where the adults of *D. Reini* Döderlein (referred to beyond) were taken, it would be natural to regard these small specimens as the young of that species; but the form and coloration of the spines leave no doubt that they belong rather to *bracteata.* In these specimens, all three kinds of pedicellariæ are present. They resemble quite closely those of *D. Reini*, but are somewhat smaller.

The large globiferous pedicellariæ (Pl. 3, fig. *15*) are more common and the limb (Pl. 3, fig. *23*) curves outward more than in *Reini* and its branches are sometimes provided with additional projections. In addition to these, other large pedicellariæ (Pl. 3, fig. *16*) are found which have the opening of the valves on the inner surface, very large and with no lip, somewhat like those which Mortensen considers characteristic of *Stereocidaris*. There are also tridentate pedicellariæ with strongly curved valves (Pl. 3, figs. *19, 20*), which are quite peculiar. The small globiferous pedicellariæ (Pl. 3, figs. *17, 18*) often lack the end-tooth.

Mortensen, on the strength of a large pedicellaria like Pl. 3, fig. *17*, places this species in *Stephanocidaris*, while the presence of pedicellariæ like Pl. 3, fig. *15* surely fixes its place, according to his scheme, in *Cidaris!* On the other hand, Pl. 3, fig. *16* would seem to show that it is nearer to *Stereocidaris!* What are we to do in the face of such disorderly pedicellariæ?

Dorocidaris Reini Död.

Cidaris (Dorocidaris) Reini Döderlein, 1887. Jap. Seeigel., p. 7, Taf. IV, figs. 1–7 and Taf. VIII, fig. 4 a-d.

Plate 3, figs. *1–14*.

Five specimens of this species were collected off Honshu Island, Japan, which agree well with the specimen figured by Döderlein. They range in size from 22 mm. to 30 mm. in diam. The primary radioles (Pl. 3, fig. *9*) are very uniform in appearance and structure, in one of the specimens, however, the radioles are somewhat more slender and proportionally longer in comparison to the diameter of the test than in the specimen figured by Döderlein.

There seems to be some variation in the coloring of the secondary spines; in some specimens they are yellowish green and in other light reddish brown.

All three kinds of pedicellariæ occur in some specimens, but in others only the tridentate and small globiferous are present.

The large globiferous pedicellariæ (Pl. 3, fig. *1*) are of the form found in *Cidaris*, with valves .75–.80 mm. in length. The stalks have a well developed limb (Pl. 3, fig. *8*) and are from .80 to 1.50 mm. long. The few examples of this sort of pedicellaria which were found were between the primary spines on the interambulacra.

The tridentate pedicellariæ (Pl. 3, figs. *4–7*) show much variety of form, the valves in some being short and broad and in others long and narrow. Many were only partially developed. The valves measure from .65 to 1.25 mm. and the stalks vary greatly, sometimes shorter than, sometimes equal to, and sometimes twice as long as the valves. These pedicellariæ are common on the actinal portion of the interambulacra.

The small globiferous pedicellariæ (Pl. 3, figs. *2*, *3*) are remarkable for their great diversity of size, some of them being longer than the large globiferous form. The end-tooth on the valves is often wanting. The valves are .27–.87 mm. long and the stalk is 1–3 times that length. They are common everywhere.

This species was collected at the following stations:

Station 3749. Off Suno Saki, Sagami Bay, Japan. 83–158 fms. Bk. s. sh. Three specimens.

Station 3751. Off Suno Saki, Sagami Bay, Japan. 140–148 fms. Gn. m. vol. s. Two specimens.

Bathymetrical range, 83–158 fathoms.

Dorocidaris calacantha A. Ag. and Clark.

Plates 4, figs. *1–12*; 13; 14; 34; 35.

The specimens collected of this species vary in diameter from 40 mm. (Pls. 34, 35) to 12 mm. (Pl. 14; figs. *5–8*). The primary radioles taper very gradually from the slight swelling above the milled ring.

The longest radioles of the largest specimen collected are 78 mm. in length (Pls. 34, 35); they are delicately fluted (Pl. 4, fig. *4*), the ridges formed of low serrations closely packed. The primary radioles are of a violet gray tint, often banded with rings of a darker color than the shaft. The small primary radioles of the actinal side (Pl. 4, fig. *8*) are somewhat club-shaped and fluted at the extremity.

The secondary interambulacral spines are spathiform, slightly grooved on the upper surface, and delicately fluted. They are of a yellowish gray tint, with a greenish stripe extending from the tip towards the base of the spine. The ambulacral spines are similar to the interambulacral, only much narrower, longer, and more slender.

In a specimen 34 mm. in diameter (Pls. 13, figs. *1, 2*; 14, figs. *1, 2*) there are five and six interambulacral plates. In the larger plates the scrobicular area is surrounded by a ring of large secondaries, which occupy the whole of the plate both in the median row and along the outer edge of the poriferous zone (Pl. 14, figs. *1, 2*). In the smaller interambulacral plates towards the actinal system the median zone is formed of three or four rows of small secondaries, and larger secondaries flank the poriferous zone (Pl. 13, fig. *2*). The median ambulacral zone is formed by two vertical rows of small secondaries. The abactinal system is 17 mm. in diameter. The anal system is pentagonal, with an outer row of larger plates inclosing two irregular rows of smaller plates (Pl. 13, fig. *2*); when dry the anal system and the genital plates are of a light-green color. The ocular plates are heart-shaped, with few small secondaries; the genital plates are covered near the anal system by a cluster of small tubercles; these carry short, sharp, flattened, minute miliaries. The actinal system is 14 mm. in diameter, and shows twelve narrow ambulacral plates, with a small secondary on each side of the poriferous zone. There is only a single row of five interambulacral plates occupying the space between the actinal ambulacral plates; on the edge of the interambulacral plates are very minute miliaries. The central part of the madreporic genital is riddled with the madreporitic openings.

In a specimen 29 mm. in diameter (Pls. 13, figs. *3, 4*; 14, figs. *3, 4*) the abactinal system measures 15 mm., and the actinal 12 mm. in diameter. There are five and five primary interambulacral tubercles. There are no important differences in the test of this smaller specimen as compared with that of the larger one. The principal difference to be noticed is the absence of miliaries and secondaries on the abactinal system. The genital and ocular plates are nearly bare; a few miliaries only are scattered on the proximal part of the genital plates.

In the smallest specimen collected, measuring 12 mm. in diameter (Pl. 14, figs. *5–8*), the abactinal system was 7 mm. and the actinal 6 mm. There are no differences in the abactinal system, except those due to size, and there are four and five primary tubercles. The secondaries occupy nearly the whole of the interambulacral plates outside of the scrobicular area. There are only four actinal interambulacral plates.

In this smallest specimen the primary spines are stouter and less tapering in proportion to the diameter of the test (Pl. 14, figs. *1, 5, 6*) than in older specimens.

Only two kinds of pedicellariæ occur in this species, as the large globiferous seem to be wholly wanting.

The tridentate pedicellariæ (Pl. 4, fig. *3*) have the valves very long and slender, and quite abruptly expanded near the base, while the narrow portion is much compressed. The valves are about 1.20 mm. long, and the stalks are of about the same length. These pedicellariæ are found mainly on the actinal part of the test.

The small globiferous pedicellariæ (Pl. 4, figs. *1, 2*) are like those of *Reini* and *bracteata*; the end-tooth is usually very marked. The valves are from .20–.87 mm. long, while the stalks are one to three times as long. They occur everywhere, but the largest ones, on the longest stalks, occur in the scrobicular circles.

This species we have named *calacantha,* from the regular and graceful shape of the primary radioles. It was collected by the "Albatross" at the following localities.

Station 3859. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 60.2°. 138–140 fathoms. Fne. s. m.

Station 3863. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 60°. 127–154 fathoms. Brk. co. crs. g. r.

Station 3882. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 63.5°. 136 fathoms. S. co. r.

Station 3885. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 64.8°. 136–148 fathoms. S. p.

Station 3886. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 65°. 148 fathoms. P. r.

Station 4045. West coast of Hawaii. Bott. temp. 49°. 147–198 fathoms. Co. s. for.

Station 4100. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 61°. 130–151 fathoms. Co. s. sh. for.

Bathymetrical range, 127–198 fathoms. Extremes of temperature, 65°–49°.

Twenty-eight specimens.

Chondrocidaris A. Ag.

Chondrocidaris gigantea A. Ag.

Chondrocidaris gigantea, A. Ag. 1863. Bull. M. C. Z., I, 2, p. 18. Rev. Ech. Pl. I *a*.

Plate 4, figs. *13–19*.

At the time a specimen of this species was first obtained from the Hawaiian Islands, it was separated from the other Cidaridæ as a new genus; subsequently it was assigned to the genus Phyllacanthus. An examination of two additional specimens collected by the "Albatross" from Station 4050 off Kealakekua Light House, W. coast of Hawaii, as well as of other Cidaridæ, inclines us to revert to the first determination and to recognize again the genus Chondrocidaris, not merely upon the nature of the pedicellariæ as has been done by Mortensen,[1] but also owing to the uniform granulation of the test and of the abactinal system. This is composed of very small tubercles of nearly uniform size, carrying minute, triangular, miliary spinelets.

The abactinal system is circular. There is only a single ring of secondary tubercles round the scrobicular area.

In a specimen of 83 mm. diameter there are nine and nine primary interambulacral plates. The abactinal system is 31 mm. in diameter; the greatest width of the anal pentagon is 15 mm.; the actinal system is 19 mm. When dry the secondary spines are at the tip, of a dark chocolate color, and the primary radioles are of the same color from the milled ring to the base of the tip of the radiole. The rest of the spine is of a lighter color.

The mammary boss of the primaries is perforate, but not crenulated.

No large globiferous pedicellariæ are present in any available specimens, so that it has not been possible to determine the accuracy of Mortensen's figures.

The tridentate pedicellariæ (Pl. 4, figs. *14*, *17–19*) have the valves very slender and in contact for practically their entire length. They are about 1.65 mm. long, while the stalk is somewhat shorter. They are rather infrequent, occurring chiefly between the actinal primary spines.

The small globiferous pedicellariæ (Pl. 4, figs. *13*, *15*, *16*) are very characteristic. The valves are short and wide with a large opening, well-defined lip and prominent end-tooth. They are only .40 mm. in length, and

[1] Ingolf Echinoidea, 1903, Pt. I, p. 29.

the stalk on which they are borne is even less. These pedicellariæ are abundant everywhere among the numerous miliary spines so characteristic of this species.

Station 4050. Off Kealakekua Light, W. coast of Hawaii. 14–215 fathoms. Frag. cor. r. Two specimens.

PHYLLACANTHUS Brandt.

Phyllacanthus annulifera A. Ag.

Cidarites annulifera Lamarck, 1816. Anim. s. Vert. III, p. 57.
Phyllacanthus annulifera A. Ag. 1872. Rev. Ech. Pt. I, p. 150. de Loriol's Trois Esp. Ech. Pl. IV.

Plate 12^b, figs. *14, 15*.

It has seemed worth while to figure the actinal primary spines of this species to show the contrast between them and those of *Stephanocidaris bispinosa*, with which this species appears to have often been confused.

Phyllacanthus baculosa A. Ag.

Cidarites baculosa Lamarck, 1816. Anim. s. Vert. III, p. 55.
Phyllacanthus baculosa A. Ag. 1872. Rev. Ech. Pt. I, p. 150. Pl. I *f, 4–5*.

Plate 12^b, figs. *16, 17*.

The actinal primary spines of this species are also figured to emphasize the contrast between Stephanocidaris and Phyllacanthus in this particular.

Phyllacanthus Thomasii A. Ag. and Clark.

Plates 5, figs. *1–17*; 26, figs. *5–8*; 27–30.

The specimens collected of this species vary in size from 70 mm. to 30 mm. in diameter. In a specimen of 70 mm., with nine and nine primary interambulacral tubercles (Pls. 27–30), the abactinal system measures 33 mm., the anal system 18 mm., and the actinal 26 mm. in diameter. The longest primary radiole is 101 mm.

In a specimen 40 mm. in diameter (Pl. 26, figs. *5–8*), with six and seven primary interambulacral tubercles, the abactinal system measures 20 mm., the anal 11 mm., and the actinal 20 mm. in diameter, and the longest primary radioles, 70 mm.

In a specimen 35 mm. in diameter, with six and seven primary interambulacral plates, the abactinal system measures 16 mm., the anal 10 mm., the actinal 17 mm.

The longest primary radiole of a specimen 30 mm. in diameter, with six and six primary tubercles, measures 73 mm.

The primary radioles (Pl. 5, fig. *7*) are somewhat swollen near the base, and taper very gradually toward the tip (Pls. 27–30). The radioles are of a grayish pink tint faintly banded transversely with darker, alternating with lighter, colored patches. The shaft is covered with longitudinal rows of low, blunt serrations. The base of the shaft above the milled ring is of a dark chocolate color. The same coloring extends to the secondary and miliary spines. There is but little difference in the shape and proportion of the primary radioles in the specimens collected. The radioles of the smaller specimens are proportionally more slender (Pl. 30). The small actinal primary radioles are fluted and somewhat club-shaped (Pls. 27, 30, fig. *1*). In large specimens the general aspect of the regular secondary and miliary tuberculation of the test (Pls. 27–30) greatly resembles that of Chondrocidaris, though the contrast between the secondaries of the scrobicular area and of the rest of the interambulacral plates is not as marked as in that genus, and is perhaps more as we find it in the test of Stereocidaris. In smaller specimens (Pl. 26, figs. *5–8*) the tubercles of the interambulacral plates outside of the scrobicular circles are less uniform in size and less regularly arranged and carry small miliary spinelets.

The median ambulacral space is filled by two irregular vertical rows of small secondaries (Pls. 27, 28, 29, fig. *1*). In smaller specimens the median vertical rows are well separated and run close to the outer rows of secondaries (Pl. 26, fig. *8*).

The abactinal system of large specimens (Pl. 28) is very uniformly covered with secondaries. These are less prominent in smaller specimens (Pl. 26, fig. *5*).

The outer row of plates of the pentagonal anal system is made up of large, irregularly shaped plates, the next and following rows of which there are four or five, of smaller polygonal plates, which become smaller towards the anal opening.

In the actinal system there is but a single row of narrow interambulacral plates (Pl. 26, fig. *6*). In larger specimens they are split into three or four rows (Pl. 27.)

Only the tridentate and small globiferous pedicellariæ are present in this species, no large globiferous ones occurring in any of the numerous specimens examined.

The tridentate pedicellariæ (Pl. 5, figs. *2, 5, 6*) have the valves very slender and generally about 1.5 mm. long; in some specimens, however, where these pedicellariæ are very abundant, they vary greatly in size and sometimes the valves are only .30 or .40 mm. in length. Usually the stalks are as long as the valves or a little longer, but often they are shorter. These pedicellariæ are generally fairly common around the primary spines; when very abundant they occur on the ambulacra also.

The small globiferous pedicellariæ (Pl. 5, figs. *1, 3, 4*) are not peculiar; they have rather narrow valves and a well-developed end-tooth. The valves are from .18 to .80 mm. long, and the stalks are from one to three times as long. These pedicellariæ are usually abundant everywhere, but in specimens with an exceptionally large number of tridentate pedicellariæ, they are much less frequent and occur chiefly among the secondaries of the scrobicular circles.

Station 3823. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 69°. 78–222 fathoms. Fne. s. p.

Station 3838. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 67°. 92–212 fathoms. Fne. gr. br. s.

Station 3863. Pailolo Channel, between Molokai and Maui. Bott. temp. 61°. 127–154 fathoms. Brk. co. crs. g. r.

Station 4046. Off Kawaihae Light, W. coast of Hawaii. Bott. temp. 59°. 71–147 fathoms. Co. s. for.

Station 4062. Off Kauhola Light, N. E. coast of Hawaii. 83–113 fathoms. Co. vol. s. sh. for.

Station 4096. N. E. approach to Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Bathymetrical range, 71–286 fathoms. Extremes of temperature, 69°–45.3°. Nineteen specimens.

Stephanocidaris A. Ag.

The discovery of a cidarid among the Hawaiian Islands which shows clearly the characters of this genus emphasized by the senior author in 1873, is interesting, for specimens of *S. bispinosa* seem to be remarkably rare, and recent writers have been disposed to ignore the genus altogether. This tendency has been increased by confusing *Phyllacanthus annulifera* with *S. bispinosa*, and as the former does not have a specially peculiar abactinal system, it is not strange that the characteristic feature of Stephanocidaris has been misunderstood. The Hawaiian specimens not only show clearly the remarkable abactinal system, but enable us to call attention to another feature of the genus, found in the peculiar "capping" of the actinal primary radioles (Pl. 12^b, figs. *10–13*), a character we have observed in no other cidarid except *Acanthocidaris hastigera* (q. v.).

Stephanocidaris bispinosa A. Ag.

Cidarites bispinosa Lamarck, 1816, Anim. s. Vert. III, p. 57.
Stephanocidaris bispinosa A. Ag. 1872, Rev. Ech., Pt. I, p. 160. Pl. I *f*, *1*.

Plate 12^b, figs. *10, 11*.

The peculiar "capping" of the actinal primary spines is a striking character of this handsome species, and is clearly shown in the figures given. It will also be noticed that the abactinal side of these spines is marked with roundish white spots, and it is interesting to see that the same feature is present to an even greater degree in the new species from Hawaii (Pl. 12^b, fig. *12*). We have been unable to find any large globiferous pedicellariæ in the single available specimen of this species, but it is safe to say that the figure given by Mortensen[1] is not that of a Stephanocidaris pedicellaria, if, indeed, it represents the valve of a *large* globiferous pedicellaria at all; it appears to be a large example of a *small* globiferous pedicellaria of a Phyllacanthus, and probably *P. annulifera*.

Stephanocidaris hawaiiensis A. Ag. and Clark.

Plates 4, figs. *20–23*; 12^b, figs. *12, 13*; 24; 25; 26, figs. *1–4*.

A large series of this species was collected by the "Albatross," varying in size from 41 mm. to 6 mm. in diameter. In a specimen of 41 mm. diameter the abactinal system measures 20 mm., the anal 11 mm., and the actinal 18 mm., and the longest primary radioles are 87 mm. long; there are eight and eight large interambulacral tubercles. In a specimen 33 mm. in

[1] Ingolf Echinoidea, 1903. Pt. I. Pl. X. fig. 17.

diameter, the largest radioles are 83 mm. long, with six and six primary interambulacral tubercles. In a specimen 20 mm. in diameter with six and six primary tubercles, the longest radiole measures 56 mm. In a specimen 32 mm. in diameter with six and seven primary tubercles, the abactinal system is 15 mm., the anal system 10 mm., and the actinal 13 mm. in diameter. In a specimen 31 mm. in diameter, the longest radiole measures 73 mm. In a specimen 14 mm. in diameter with five and five primary tubercles, the longest radiole is 34 mm., and the abactinal as well as the actinal system, 6 mm.

In a small specimen 9 mm. in diameter, with five and four primary interambulacral plates, the abactinal system measures 4 mm., the anal system 2.5 mm., and the longest radiole 16 mm.

In this small specimen the genitals are in contact at the proximal angles; the ocular plates do not as yet separate them as they do in larger specimens (Pl. 26, fig. *1*) where the ocular and genital plates form a continuous ring in contact with the distal row of large anal plates. The anal plates form four or five irregular rows of large plates diminishing in size towards the anal opening. The primary radioles are flattened on the lower side (Pl. 24), rounded above (Pl. 25); they vary greatly in color. Most of them are transversely banded with brick-red and yellowish or white, from the tip of the radiole to the dark, chocolate-colored band above the milled ring. In some young specimens the prevailing shade is yellowish-green, in place of the red. In others again, the radioles are of a uniform brick-red color towards the base of the spine, and are only banded near the tip. Others are of a uniform dull brick-red, with serrations of darker color, while still others, usually those round the abactinal system, are of a uniform dark-violet color. Seen from the lower side the primaries, as well as the secondaries are of a uniform, dull, light-yellowish red, the latter being somewhat darker. The larger and longer serrations on the edge of the primary radioles are usually white; the serrations of the upper side are usually of a brick-red color, somewhat darker than the color of the transverse bands. In the smaller specimens the banding of the radioles towards the tip is very marked.

The interambulacral secondary spines are long, slender, flattened, and sharply pointed (Pls. 24, 25), of a dirty, greenish-brown color. The ambulacral are more slender and pointed than the interambulacral secondaries, but are of the same greenish-brown color as the median intermbulacral spines and are carried upon tubercles which might truly be called miliaries. The secondary tubercles form a ring of a single row round the scrobicular area; the rest of the interambulacral plates is occupied by miliaries both in the median interambulacral space and in the space adjoining the poriferous zone. This granulation resembles somewhat that of *Chondrocidaris gigantea.* The median ambulacral space carries only very small miliaries forming irregular, interrupted, vertical rows between the two vertical rows of larger ambulacral secondaries.

This arrangement is only well developed in the larger specimens; it is only apparent in specimens as large as those figured in Pl. 26, figs. *1–4*, and fully developed in larger specimens.

There is only a single vertical row of narrow, elongate actinal interambulacral plates.

Besides the radical differences in color, this species may be distinguished from *S. bispinosa* by the much longer and more slender primary radioles and the large actinal system, which is but little, if at all, smaller than the abactinal.

The large globiferous pedicellariæ seem to be entirely wanting, and in young individuals the tridentate are also quite infrequent.

The tridentate pedicellariæ (Pl. 4, figs. *22–23*) have valves long and slender, as much as 1.5 mm. in length, while the stalks are more or less nearly equal to them. They occur chiefly on the interambulacra about the primary spines, and are quite common in large individuals.

The small globiferous pedicellariæ (Pl. 4, figs. *20–21*) are not peculiar, but the valves have a prominent end-tooth. The valves are about .50 mm. in length and are borne on stalks from one to six times as long. These pedicellariæ are common, especially on the abactinal system of the young and the interambulacra of the adults.

This species was collected by the "Albatross" at the following localities.

Station 3845. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71°. 60–64 fathoms. Crs. s. p. sh.

Station 3846. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71.5°. 60–64 fathoms. Crs. br. s. sh. g.

Station 3849. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 67.6°. 43–73 fathoms. Crs. s. br. sh. co.

Station 3861. Pailolo Channel and N. E. approach. 30–52 fathoms. Fne. s. sm. p. co.

Station 3863. Pailolo Channel and N. E. approach. Bott. temp. 61.° 127–154 fathoms. Brk. co. crs. g. r.

Station 3872. Auau Channel between Maui and Lanai. Bott. temp. 74.6°. 32–43 fathoms. Yl. s. p. co.

Station 3876. Auau Channel between Maui and Lanai. Bott. temp. 74°. 28–43 fathoms. S. g.

Station 3906. Off Mokapu Islet, N. coast of Molokai. Bott. temp. 72°. 66–96 fathoms. Gy. s. sh. p.

Station 3936. Vicinity of Laysan. Bott. temp. 68°. 79–130 fathoms. Sml. brk. sh. corln.

Station 3955. Vicinity of Laysan. Bott. temp. 74°. 20–30 fathoms. Co. r. alg.

Station 3987. Vicinity of Kauai. Bott. temp. 73°. 50–55 fathoms. Crs. co. s. co. frag.

Station 3991. Vicinity of Kauai. Bott. temp. 43.7°. 272–296 fathoms. Fne. s. r.

Station 4027. Vicinity of Kauai. Bott. temp. 42.8°. 319 fathoms. Fne. gy. s. r.

Station 4046. W. coast of Hawaii. Bott. temp. 59°. 71–147 fathoms. Co. s. for.

Station 4054. N. E. coast of Hawaii. 26–50 fathoms. Crs. co. s. corln.

Station 4057. N. E. coast of Hawaii. 75–77 fathoms. Fne. gy. s. sh.

Station 4064. N. E. coast of Hawaii. Bott. temp. 69°. 63–107 fathoms. Vol. s. for. co.

Station 4066. Between Maui and Hawaii. Bott. temp. 52.5°. 49–176 fathoms. Rky.

Station 4073. N. E. and N. coast of Maui. Bott. temp. 71.9°. 69–78 fathoms. Crs. co. s. for.

Station 4077. N. E. and N. coast of Maui. Bott. temp. 70°. 99–106 fathoms. Fne. co. s. for.

Station 4128. Vicinity of Kauai. Bott. temp. 47.8°. 68–253 fathoms. Crs. br. co. s. for.

Station 4160. Vicinity of Modu Manu. Bott. temp. 78°. 31–39 fathoms. Co. corln.

Station 4161. Vicinity of Modu Manu. Bott. temp. 77.9°. 39–183 fathoms. Co. corln.

Bathymetrical range, 20–319 fms. Extremes of temperature, 78°–42.8°.

One hundred and five specimens.

Stereocidaris Pomel.

Stereocidaris grandis Död.

Stereocidaris grandis Död., 1887. Jap. Seeigel, p. 3. Pls. I; II, figs. 1–11; VIII, fig. 2.

Plates 5, figs. *18–20*; 33 and 36.

The "Albatross" collected *Stereocidaris grandis* both in Japan and in the Hawaiian Islands. In the Japanese specimens the primary radioles are more slender and comparatively longer than in the Hawaiian specimens, and are slightly pointed. The lateral serrations of the flattened actinal primary radioles are also marked in some cases, while in the Hawaiian specimens the actinal radioles are cylindrical and blunt.

A note by the collector with the specimens from Station 4044 states that "the test is pale olive gray, the long spines a still paler muddy gray and the secondary spines at the base of the primary radioles pale green." The specimens collected vary from 8 mm. to 39 mm. in diameter. All of the different kinds of pedicellariæ are present in this species and quite common.

The large globiferous pedicellariæ (Pl. 5, fig. *18*) have the valves short and stout with a large opening and no end-tooth; they measure about .75 mm. in length, while the stalks are usually shorter and have no limb. These pedicellariæ are frequent on the interambulacra and are often found singly at the inner angles of the coronal plates.

The tridentate pedicellariæ (Pl. 5, fig. *20*) generally have the valves unusually broad and widely separated at the base, only meeting near the tip; sometimes, however, they are narrow and compressed and only slightly separated near the base. The valves are about 1.25 mm. in length, while the stalk is somewhat shorter. They are found almost wholly on the actinal side of the test.

The small globiferous pedicellariæ (Pl. 5, fig. *19*) are much like the large ones, but the margins are straighter. The valves are only about .40 mm. in length while the stalk is from one to three times as long. They are abundant everywhere.

This species was taken at the following localities.

Station 3749. Off Suno Saki, Sagami Bay, Japan. 83–158 fathoms. Bk. s. sh.

Station 3831. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 45.1°. 178–261 fathoms. Br. m. co. s. r. co.

Station 3919. Off Diamond Head, Oahu. Bott. temp. 45.6°. 220–257 fathoms. Gy. s.

Station 4044. Off Kawaihae Light, W. coast of Hawaii. Bott. temp. 47°. 198–233 fathoms. Fne. gy. s.

Station 4096. Off Mokuhooniki Islet, approach to Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Bathymetrical range, 83–286 fathoms. Extremes of temperature, 47°–45.1°. Fifteen specimens.

Stereocidaris leucacantha A. Ag. and Clark.

Plates 6 ; 15 ; 32.

The specimens collected vary in diameter from 52 mm. (Pl. 32, figs. *1–4*) to 26 mm. They are notable for their long, slender primary radioles. In a specimen measuring 28 mm. in diameter, the longest radioles are 67 mm. In a larger specimen, 37 mm. in diameter, the longest radioles measure 87 mm.; they vary in color from light violet-gray to white, with the band above the milled ring more or less distinctly purple. This species is closely allied to *S. grandis*, but the radioles (Pl. 6, fig. *8*) differ from those of that species in being more slender and more cylindrical (Pls. 15, figs. *1, 2;* 32, figs. *5, 6*). The fluted extremity often expands somewhat.

The serrations of the radioles of *leucacantha* are smaller and less distinct than those of *grandis.* The secondary spines both in the ambulacral and interambulacral areas are shorter and smaller than those of *grandis.* The granulation of the abactinal system and of the test is much closer and smaller in this species than in *grandis.* (Compare Pls. 15 and 32 with Pls. 33 and 36). The plates on the angles of the anal pentagon are much larger than the corresponding plates of *grandis.* With increasing size the ocular plates become more elongate (compare fig. *5,* Pl. 32, with fig. *1,* Pl. 32). The large specimen figured on Pl. 32, figs. *1–4* shows an extraordinary splitting of the upper interambulacral plate (Pl. 32, fig. *1*) so that the abactinal circle of interambulacral plates consists of fifteen plates instead of ten, a structure we have not noticed in any other Cidarid. In another specimen, from Station 3992, the abactinal edges of the plates which are split have been pushed out by the genital and ocular plates, forming a steep wall round the abactinal system, which thus bulges as much as 10 mm. well up beyond the general outline of the test. This specimen measures 40 mm. in diameter, the abactinal system 27, showing a proportionally far larger abactinal system than in the smaller specimens measured.

The median ambulacral zone consists of two outer vertical series of large secondaries with irregularly arranged miliaries, forming two or three indistinct vertical rows. In *grandis*, there is only one irregular median vertical row of miliaries.

In a specimen measuring 52 mm. in diameter (Pl. 32, fig. *1*) there are six and six interambulacral plates; the abactinal system measures 25 mm.; the genital plates are more rectangular than those of *grandis;* the actinal system measures 18 mm.

In a specimen of 38 mm. there are five and five interambulacral plates; the abactinal system measures 19 mm. and the actinal system 18 mm.

In a smaller specimen, 31 mm. in diameter (Pl. 32, figs. *5*, *6*) the abactinal system measures 15 mm. and the actinal 12 mm. There are five and five interambulacral plates.

These measurements clearly show that the proportionate increase in height of the test is mainly due to the greater vertical height of the abactinal interambulacral plates in larger specimens than in the smaller ones.

All of the different kinds of pedicellariæ occur in considerable numbers and very closely resemble those of *grandis*.

The large globiferous pedicellariæ (Pl. 6, figs. *3* and *6*) are a trifle smaller than in *grandis* and usually have the stalk shorter, but these differences are not at all constant. These pedicellariæ occur on the abactinal surface, but usually not within the abactinal system.

The tridentate pedicellariæ (Pl. 6, figs. *1*, *2*, and *5*) are smaller than in *grandis*, the valves usually under a millimeter in length, and the stalks still less. They are almost wholly actinal.

The small globiferous pedicellariæ (Pl. 6, fig. *4*) are usually only about .25 mm. long, though the stalk may be three times that. They are abundant everywhere.

This species was collected by the "Albatross" at the following localities.

Station 3828. Off Lae-o Ka Laau Light, Molokai. Bott. temp. 43.8°. 281–319 fathoms. Brk. sh. g.

Station 3835. Off Lae-o Ka Laau Light, Molokai. Bott. temp. 55°. 169–182 fathoms. Fne. br. s. m.

Station 3839. Off Lae-o Ka Laau Light, Molokai. Bott. temp. 46.3°. 259–266 fathoms. Lt. br. m. s.

Station 3865. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 45°. 256–283 fathoms. Fne. vol. s. r.

Station 3866. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 43.8°. 283–284 fathoms. Gy. m. fne. s.

Station 3867. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 44°. 284–290 fathoms. Fne. s. m.

Station 3893. Off Lae-o Ka Laau Light, Kaiwi Channel. Bott. temp. 47°. 220–346 fathoms. Fne. wh. s. r.

Station 3909. Off Diamond Head, Oahu. Bott. temp. 43.5°. 308–322 fathoms. Fne. wh. s. m.

Station 3912. Off Diamond Head, Oahu. Bott. temp. 43°. 310-334 fathoms. Fne. gy. s. m.

Station 3917. Off Diamond Head, Oahu. Bott. temp. 44°. 294–330 fathoms. Gy. s. m.

Station 3918. Off Diamond Head, Oahu. Bott. temp. 44.5°. 257–294 fathoms. Wh. s. m.

Station 3992. Off Mokuaeae Islet, Kauai. Bott. temp. 39.6°. 528 fathoms. Fne. gy. s. m.

Station 4096. Off Mokuhooniki Islet, N. E. approach to Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4097. Off Mokuhooniki Islet, N. E. approach to Pailolo Channel. Bott. temp. 44.2°. 286 fathoms. Fne. gy. s.

Station 4116. Off Kahuku Pt., N. W. coast of Oahu. Bott. temp. 48.8°. 241–282 fathoms. Cor. s. for.

Station 4117. Off Kahuku Pt., N. W. coast of Oahu. Bott. temp. 45.6°. 253–282 fathoms. Cor. s. for.

Bathymetrical range, 169–528 fms. Extremes of temperature, 55°–39.6°. Forty-one specimens.

Goniocidaris Des.

Goniocidaris biserialis Död.

Stephanocidaris biserialis Död., 1885. Arch. f. Naturg. 51 Jahrg. Bd. I, p. 79.
Goniocidaris biserialis Död., 1887. Jap. Seeigel, p. 10. Pls. V and VIII, fig. 8.

Plate 10, figs. *22–25*.

Specimens of *G. biserialis* Döderlein from 17 to 30 mm. in diameter were collected at the stations given below. They agree well with the figures given by Döderlein on Plate V of his Memoir. There are no tridentate pedicellariæ to be found, but both sorts of globiferous pedicellariæ occur.

The large globiferous pedicellariæ (Pl. 10, figs. *22, 23*) are short and broad, with a large terminal opening much as in Cidaris. The valves are somewhat curved and are about .55 mm. in length, while the stalk is even shorter. These pedicellariæ are found only on the interambulacra and are rather rare.

The small globiferous pedicellariæ (Pl. 10, figs. *24, 25*) have the valves straighter, narrower, and with an evident end-tooth, and only .27–.45 mm. in length. The stalk may be shorter or longer, sometimes twice as long. These pedicellariæ are abundant everywhere.

Station 3700. Off Seno Umi, Suruga Gulf, Japan. 63 fathoms. Vol. m. s.

Station 3707. Off Ose Zaki, Suruga Gulf, Japan. 63–75 fathoms. Vol. s. a. g.

Station 3718. Off Ose Zaki, Suruga Gulf, Japan. 65 fathoms. Vol. s. sh. r.

Bathymetrical range, 63–75 fathoms. Seven specimens.

Goniocidaris clypeata Död.

Goniocidaris clypeata Död., 1885. Arch. f. Naturg. 51 Jahrg. Bd. I, p. 82; 1887, Jap. Seeigel, p. 13. Pls. VI and VIII, fig. 7.

Plate 10, figs. *27–31*.

A number of specimens of this species were collected by the "Albatross" in Japan at the stations given below. They range in size from 6 mm. in diameter to 18 mm. Three of the larger specimens showed the large disks figured by Döderlein at the extremity of the primary abactinal spines. The test is much flattened in young specimens, gradually increasing in height with age. The number of primary interambulacral plates is proportionately larger in young specimens than in other Goniocidaridæ. In a specimen 13 mm. in diameter there are seven and seven plates; in a specimen of 18 mm. there are only seven and eight plates. In a specimen only 8 mm. in diameter there are already five and five plates. With the exception of the variation in the radioles and the absence of the cup-bearing radioles, there are but slight differences to be noted in the structure of the test, the sunken median ambulacral and interambulacral areas, the shape of the abactinal system and of the anal system, between the smaller and larger specimens examined. The smaller specimens usually carry only the serrated radioles. Usually a specimen 12 mm. in diameter carries a few disk-bearing radioles; though in the largest specimens collected all the radioles, actinal as well as abactinal, belong to the serrated type.

The series of specimens before us leaves little doubt that Döderlein's *Porocidaris gracilis*[1] was based on a young specimen of this species, in which the expanded radioles were not developed.

There are only two kinds of pedicellariæ present in *clypeata*, as the tridentate seem to be wholly wanting.

The large globiferous pedicellariæ (Pl. 10, figs. *27–29*) show considerable diversity in the shape of the valves; normally (Pl. 10, fig. *29*) they are like those of *G. biserialis* but sometimes they are much longer and narrower, with a large terminal opening (Pl. 10, fig. *28*) or still narrower, slightly curved and with an end-tooth (Pl. 10, fig. *27*). They measure from .50 to .90 mm. with the stalk somewhat shorter. These pedicellariæ are somewhat rare and occur only on the interambulacra.

The small globiferous pedicellariæ have a strong end-tooth on the valves; sometimes (Pl. 10, fig. *30*) they are like those of *G. mikado*, while others (Pl. 10, fig. *31*) are like those of *biserialis*. The valves are .25–.50 mm. in length, while the stalks are shorter, longer, or twice as long. They are abundant everywhere.

Station 3748. Off Suno Saki, Sagami Bay, Japan. 73–200 fathoms. Yl. s. rot. co.

Station 3749. Off Suno Saki, Sagami Bay, Japan. 83–158 fathoms. Bl. s. sh.

Station 3751. Off Suno Saki, Sagami Bay, Japan. 140–148 fathoms. Gn. m. vol. s.

[1] Dorocidaris (?) gracilis, 1885. Arch. f. Naturg. 51 Jahrg. Bd. 1, p. 78.
Porocidaris gracilis, 1887. Jap. Seeigel, p. 8. Pls. IV, figs. 8–20; VIII, fig. 5.

Station 3752. Off Suno Saki, Sagami Bay, Japan. 54–100 fathoms. Gy. s. g.

Bathymetrical range, 54–200 fathoms. Fifteen specimens.

Goniocidaris mikado Död.

Discocidaris (Cidaris) mikado Död., 1885. Arch. f. Naturg., 51 Jahrg., Bd. I, p. 80.
Goniocidaris mikado Död., 1887. Jap. Seeigel, p. 15. Pls. VII and VIII, figs. 6 and 9–18.

Plate 10, fig. *26*.

Two specimens of this species were collected by the "Albatross" in Sagami Bay. As has been stated by Döderlein, it is one of the most beautiful and elegant of the Cidaridae, and the peculiar structure of its primary ambulacral spines is without parallel in the family. The remarkable cupuliform expansion of the shaft occurs immediately above the milled ring, while in *G. tubaria* the great expansion of the shaft takes place at its extremity; in *G. mikado,* moreover, there are rudimentary cupular expansions along the shaft, often merely flattened serrations. The distal part of the shaft carries smaller serrations. Döderlein has given a number of figures showing the great variation found among the primary radioles of this species in Pls. VII and VIII of his Memoir on Japanese Sea Urchins, though even the best lithographic figures can scarcely do justice to the great delicacy of the structure of the primary radioles.

This species is notable for the absence of both large globiferous and tridentate pedicellariæ. The small globiferous pedicellariæ (Pl. 10, fig. *26*) have a very large end-tooth with the opening some distance beneath it. The valves are very small, only .20–.30 mm. in length, while the stalk is even shorter. They occur abundantly everywhere on the test.

Station 3755. Off Suno Saki, Sagami Bay, Japan. 52–77 fathoms. Gy. s. co.

Station 3759. Off Suno Saki, Sagami Bay, Japan. 52–60 fathoms. Gy. s. fne. g. brk. sh. r.

CENTROCIDARIS A. Ag.

Centrocidaris Doederleini A. Ag.

Goniocidaris Doederleini, A. Ag., 1898. Bull. M. C. Z., XXXII, 5, p. 73, Pl. III. fig. 1.
Centrocidaris Doederleini, A. Ag., 1904. Mem. M. C. Z., XXXI, p. 33, Pls. 5, 14, figs. 1–2.

Plates 10, figs. *1–9* ; 12ᵇ, figs. *7–9*.

In this species there are at least four very distinct sorts of pedicellariæ present, of which two may be regarded as large globiferous pedicellariæ.

The normal large globiferous pedicellariæ (Pl. 12ᵇ, fig. *7*) are of great interest because they are intermediate in character between those which Mortensen considers characteristic of *Cidaris,* and those which he assigns to *Dorocidaris ;* thus they are curved and have a large, nearly terminal opening as in the former, but have a powerful end-tooth as in the latter. The valves are about .70 mm. long, and the stalks are about the same length or a little longer. These pedicellariæ are found on the abactinal surface, but are not very common. In addition to them, peculiar large pedicellariæ (Pl. 12ᵇ fig. *8*) with flat, wide valves, having an inner cavity and a terminal opening, but no end-tooth and no lip, also occur; the valves are about .52 mm. long and nearly .20 wide; these pedicellariæ are found on the actinal surface, especially on the actinostome.

The tridentate pedicellariæ (Pl. 12ᵇ, fig. *9*) have the valves long (1.15 mm.) and slender, considerably separated at the base. They are found mainly on the abactinal surface and appear to be very rare.

The small globiferous pedicellariæ (Pl. 10, figs. *1, 2*) are not peculiar, but have an end-tooth as in Cidaris. The valves are from .19 to .75 mm. in length and their stalks, one or two times as long. They occur everywhere, but are not very common.

This handsome and very interesting species was collected by the "Albatross" during her trip to the Eastern Pacific, in 1904, at the following stations.

Station 4642. Off southern side of Hood Island, Galapagos. Lat. 1° 30.5′ S.; Long. 89° 35′ W. Bott. temp. 48.6°. 300 fathoms. Brk. sh. glob.

Station 4643. Off southern side of Hood Island, Galapagos. Lat. 1° 28.7′ S.; Long. 89° 48.5′ W. Bott. temp. 67.2°. 100 fathoms. Brk. sh. glob.

Bathymetrical range, 100–300 fathoms. Extremes of temperature, 67.2°–47.6°. Twelve specimens.

Anomocidaris A. Ag. and Clark.

This genus is established for a specimen we take to be *Cidaris tenuispina* Yoshiwara[1] (Pl. 31, figs. *5–8*). It can at once be distinguished from all other Cidaridæ by the sharp, deep sutures separating the plates of the abactinal system, and of the interambulacral areas, and the deep median vertical suture of the ambulacral area. Towards the actinal system the sutures tend to imitate, at the angles of both the ambulacral and interambulacral plates, those of some species of Goniocidaris. When seen from above the general aspect of the test resembles somewhat that of the Arbaciadæ, the upper interambulacral plates having no well developed primary tubercles, much as in Cœlopleurus, and among the Cidaridæ in Diplocidaris and to a lesser degree, in some species of Stereocidaris. The primary tubercles begin only at the equatorial zone and extend from there to the actinal system. The primary radioles (Plate 12, fig. *19*) resemble a combination of those of Dorocidaris and of Porocidaris. Anomocidaris is notable for its conical test and the presence of rudimentary abactinal primary tubercles.

Anomocidaris tenuispina A. Ag. and Clark.

Cidaris (Stereocidaris) tenuispina Yoshiwara, 1898. Annot. Zool. Jap., II, p. 57.

Plates 11, figs. *6–12;* 12, figs. *18–30;* 31, figs. *5–8*.

The only specimen of this species collected measures 29 mm. in diameter; the abactinal system is circular, 14 mm. in diameter, the actinal system is pentagonal and 10 mm. across.

The genital plates are large, irregularly heptagonal. The anal system is sharply pentagonal, included by the genital plates. The genital pores are large; the ocular plates are small, elongated triangular, deeply cut into by the ambulacral system; the ocular pores are prominent; the whole abactinal system is covered with irregularly arranged, distant, small secondaries and interspersed miliaries. A similar granulation extends over the interambulacral plates above the equatorial belt and surrounds an ill-defined scrobicular area with a rudimentary low, imperforate tubercle. Below the equatorial belt, there are five or six primary tubercles, usually two large ones at the ambitus, gradually diminishing in size. The scrobicular areas are well defined, somewhat sunken, edged by a large ring of

[1] Annot. Zool. Jap., 1898, Vol. II, p. 57.

secondaries; these with the scrobicular area occupy nearly the whole of each interambulacral plate; along the median interambulacral line, some of the larger scrobicular areas below the equatorial belt are flanked by half-circles of secondaries and irregular rows of minute miliaries. On the interambulacral plates below the equatorial belt, the mammary boss is high, the tubercles are small and perforate. On both sides of the sharply cut median line of suture of the ambulacral plates runs a vertical line of secondaries with an inner row of irregularly placed miliaries. Unfortunately the actinal system is wanting; it is pentagonal and 10 mm. in greatest width.

The primary radioles (Pl. 12, fig. *19*) are slender, gradually tapering, with lines of blunt serrations. The shorter primary radioles are slightly flattened at the extremity and indistinctly fluted. The longest equatorial radiole is 37 mm. in length. Others of the shorter radioles taper rapidly to a point above the equatorial belt. The secondary and miliary spines are slender and pointed; a few of the secondaries round the scrobicular areas are stouter at the base. The larger interambulacral spines round the scrobicular areas on the equatorial and actinal side are narrow and flattened, with rounded tips. The ambulacral spines are blunt, somewhat cylindrical or flattened. Only a single kind of pedicellaria is found, as the tridentate and large globiferous are both wanting. The small globiferous ones are very numerous everywhere and very variable in size and form. The valves are elongated and rather slender, and the lip and end-tooth may both be present, or either or both be wanting. In length they range from .28 to .91 mm., while the opening varies in size from .15 to .32 of the length. The stalk is shorter than the valves, or as long, or even twice as long.

Station 3709. Off Spithead, Shimizu Harbor, Honshu Island, Japan. 173–260 fathoms. Sft. bl. vol. m. r.

Porocidaris Desor.

Porocidaris Cobosi A. Ag.

Porocidaris Cobosi A. Ag. 1898. Bull. M. C. Z., XXXII, 5, p. 74. Pl. III, figs. 2–5.

Plate 7.

Only tridentate pedicellariæ are present in this beautiful species, even the small globiferous pedicellariæ being entirely wanting.

The tridentate pedicellariæ have the valves very broad, thick, and flat. They vary enormously in size, ranging from .50 to 5.5 mm. in length; the small ones have the stalk about equal to the valves, but in the large ones it is much less. The small ones are abundant everywhere; the larger ones are on the interambulacra, while the largest are mainly above the ambitus and often near the abactinal system. The largest are 20 to 30 in number, more or less, though they may be much fewer; their valves are always tapering and more or less distinctly pointed.

Porocidaris variabilis A. Ag. and Clark.

Plates 8, 16–22, and 23, figs. *1–4*.

An excellent series of specimens of this species was collected by the "Albatross" from thirteen localities, in 202 to 346 fathoms, varying in size from 77 mm. in diameter to 22 mm. (Pls. 16–22; 23, figs. *1–4*). In the smaller specimens the primary radioles are much longer in proportion to the diameter than in larger specimens. In the small specimen (Plate 22) of 22 mm. there are several of the primary radioles more than 76 mm. in length. In a specimen 35 mm. in diameter, the longest radioles are 122 mm. long (Pls. 20, 21). In a specimen 40 mm. in diameter (Pl. 23, figs. *1–4*) the longest radioles are only 74 mm. long. In the largest specimen examined (Pls. 16, 17) the longest radioles have a length of only 71 mm. The general appearance of the large primary radioles varies greatly (Pl. 8, figs. *12–20*); in the smaller specimens the majority are pointed, the shaft is very delicately striated with minute serrations. The shaft is a porcelain white, but towards the extremity it becomes yellowish-brown, slightly fluted. The base of the spine above the milled ring is a delicate salmon color. In older specimens there are but few white primary radioles. The shaft of the radioles is of a light-brown color with only a small part white; the base of the spine is of a darker color. The shaft of the radioles is also more deeply fluted, the serrations larger and more blunt than in smaller specimens. The fluting becomes very marked and quite deep towards the tip of the radioles, and many of the shorter and stouter primary radioles spread somewhat at the tip (Pls. 16, 17; 23, figs. *1–4*). The actinal primary radioles (Pl. 8, figs. *19* and *20*) are short, slightly curved, deeply fluted, with large blunt serrations; the smaller radioles are flattened; the lower part of the shaft of the larger radioles is porcelain white, in marked contrast to the dark-brown color of the base of the radiole above the milled ring and with the brown of the heavily fluted tip of the radiole. The large radioles are frequently infested with numerous specimens of a small species of Scalpellum (Pls. 16–21). The secondary spines (Pl. 8, figs. *21–24*) are slender, pointed, flattened or rounded or slightly dished, and finely fluted.

Seen from above (Pls. 17, 21) the test is a dark violet or chocolate-brown; the abactinal system is the darkest and towards the equatorial region of the test the color of the ambulacral and interambulacral spines becomes somewhat lighter, of a greenish tinge at the tip. From these stand out prominently the yellowish or brownish or whitish primary spines.

The specimens figured on Pl. 23, figs. *1–4* and on Pl. 22 are of a much lighter color. In the specimen of Pl. 22 the ambulacral and interambulacral spines are of a light yellowish-brown color, and those of the specimen figured on Pl. 23, figs. *1–4* are of a still lighter color. On the whole, judging from the specimens at our disposal, the color increases in depth with size.

In a specimen 72 mm. in diameter (Pls. 18, 19) and 50 mm. in height, there are eight and nine interambulacral plates. The primary tubercles are perforate, but irregularly crenulated (Pl. 19). The scrobicular area is surrounded with secondaries only slightly larger than those of the median interambulacral space and filling the angles of the interambulacral plates next to the poriferous zone (Pl. 19, fig. *2*). The scrobicular areas below the equatorial zone are slightly confluent. The median ambulacral zone is slightly broader than the poriferous zone. It is undulating, separated from the poriferous zone by an outer vertical row of secondaries, the median belt carrying miliaries forming irregular vertical rows. The inner row of pores is somewhat larger than the outer row (Pl. 19, fig. *1*). The abactinal system (Pl. 18, fig. *2*) is circular, 31 mm. in diameter. The madreporic genital is far larger than the others; they all are irregularly heptagonal; the ocular plates are small, heart-shaped, and are all excluded from the anal system. The anal system is sharply pentagonal, with a large outer row of anal plates; there is a second row of smaller plates adjoining the irregularly arranged minute plates which surround the anal opening. The miliaries on the genital plates are limited in their distribution; they are small, comparatively few in number, and irregularly arranged round the genital pores. On the oculars they occur on the median belt of the plate. The larger anal plates carry from one to three secondaries, with a few miliaries on the plates forming the angles of the pentagonal anal system. The proximal part of the madreporic genital is riddled with pores. The genital openings are large (a female Pl. 18,. fig. *1*) and placed near the distal edge of the genital plates. The actinal system (Pl. 18, fig. *2*) is pentagonal, 25 mm. in diameter, with eight rows of ambulacral plates, and not more than four or five small interambulacral plates. The latter are bare or carry one indistinct miliary. The ambulacral plates carry minute secondaries on the actinal edge of the plates.

In a specimen 36 mm. in diameter (Pl. 23, figs. *1–4*) and 26 mm. in height, there are six and seven interambulacral plates. The abactinal system is circular, 16 mm. in diameter (Pl. 23, fig. *1*); it differs only in size from the structure of the abactinal system of the larger specimen described (Pl. 18, fig. *1*), and being that of a male it has small genital openings. A comparison of the interambulacral plates of the specimens figured on Plate 18 with those of Pl. 23, figs *3*, *4*, shows that the equatorial increase of the test takes place more rapidly than the increase in width of the median interambulacral zone covered by secondaries and miliaries. In the smaller specimen there is only one circle of secondaries round the scrobicular area, with a few irregularly arranged large miliaries filling the angles of the interambulacral plates along the median line. The actinal system is pentagonal (Pl. 23, fig. *2*) 14 mm. in diameter. There are but five rows of ambulacral plates with three or four small elongated plates in the small interambulacral space, four of the rows of ambulacral plates being in contact along the interambulacral line, and leaving but a small angle for the interambulacral actinal plates.

In the specimen 22 mm. in diameter and 14 mm. in height, there are six interambulacral plates. In the smallest specimen, 4.5 mm. in diameter and 3 mm. in height, there are already four and five interambulacral plates. The longest primary radiole is 14 mm. The secondaries are few in number and are more or less cylindrical or club-shaped. The abactinal system is very large, 2.5 mm. in diameter, and each genital plate carries a conspicuous perforate tubercle. The actinostome is less than 2 mm. in diameter and is practically covered by the ten buccal plates, a pair in each ambulacrum. The pedicellariæ are already conspicuous, and, like the primary radioles, are strikingly similar to those of the adult. In specimens of *P. Cobosi* slightly larger, the structure of the abactinal system is very similar to that of this young individual.

The general aspect of *P. variabilis* (Pl. 17) is much like that of *P. Sharreri* (Pl. 3, "Blake" Echini, Mem. M. C. Z., X, No. 1). It differs from *P. Sharreri* in having the genital plates united as in *P. Cobosi* (Panamic Deep Sea Echini, Pl. 11, figs. *5*, *6*), while they are separated by the anal plates in *P. Sharreri* (Pl. 4, fig. *2* "Blake" Echini). In the latter the secondary tubercles round the scrobicular circle are larger and the secondaries and miliaries are arranged in rows parallel to the horizontal suture of the median interambulacral zone (Pl. 4, fig. *1* "Blake" Echini), while they are of more uniform size and more irregularly arranged in *P. variabilis* (Pl. 19).

The general aspect of the smaller specimens of *P. variabilis* (Pl. 22) is more like that of *P. elegans* ("Challenger" Echini, Pl. 3, fig. *1*). It is difficult to determine to just how great an extent *variabilis* differs from Yoshiwara's *P. misakiensis*, but if we may rely on de Meijere's[1] figures of the latter, *variabilis* has a much smaller abactinal system, and smoother and more slender primaries.

Although this species resembles *Cobosi* in the entire absence of globiferous pedicellariæ, the tridentate show some peculiarities. They are very variable (Pl. 8, figs. *1–11*), occasionally having only two valves, sometimes four. The valves are broader and less tapering than in *Cobosi*, and the tip is rounded or little pointed. They vary in length from .50 up to 4.00 mm. and the stalk is always shorter, sometimes only half as long. The largest occur actinally as well as above the ambitus, but are often present in numbers on the abactinal system.

Specimens of *Porocidaris variabilis* were collected at the following stations:

Station 3865. Off Mokuhooniki Islet, Pailolo Channel. Bott. temp. 44.8°–45°. 256–283 fathoms. Fne. vol. s. r.

Station 3866. Off Mokuhooniki Islet, Pailolo Channel. Bott. temp. 43.8°. 283–284 fathoms. Gy. m. fne. s.

Station 3883. Off Mokuhooniki Islet, Pailolo Channel. Bott. temp. 45.2°. 277–284 fathoms. Glob. oz.

Station 3893. Off Lae-o Ka Laau Light, Kaiwi Channel. Bott. temp. 47°. 220–346 fathoms. Fne. wh. s. r.

Station 3918. Off Diamond Head, Oahu. Bott. temp. 44.5°. 257–294 fathoms. Wh. s. m.

Station 4081. Off Puniawa Point, Maui. Bott. temp. 51.7°. 202–220 fathoms. Gy. s. for.

[1] Die Echinoidea der Siboga-Expedition, 1904. Pl. II, figs. 15, 16.

Station 4083. Off Puniawa Point, Maui. 238–253 fathoms. Gy. s.

Station 4085. Off Puniawa Point, Maui. 267–283 fathoms. S. sh.

Station 4090. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 43.8°. 304–308 fathoms. Fne. gy. s.

Station 4096. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4097. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 44.2°. 286 fathoms. Fne. gy. s.

Station 4116. Off Kahuku Point, N. W. coast of Oahu. Bott. temp. 48.8°. 241–282 fathoms. Cor. s. for.

Station 4117. Off Kahuku Point, N. W. coast of Oahu. Bott. temp. 45.6°. 253–282 fathoms. Cor. s. for.

Bathymetrical range, 202–346 fathoms. Extremes of temperature, 51.7°–43.8°.

Twenty-seven specimens.

Aporocidaris A. Ag. and Clark.

The discovery of a cidaroid in deep water off Kamchatka very similar to *Porocidaris Milleri* A. Ag. calls attention with new emphasis to the peculiarities of that form, and makes it seem desirable to establish a genus for the reception of the two species, in order to make more clear the features in which they differ from Porocidaris. The extraordinary size of the abactinal system, which is from .60 to .70 of the horizontal diameter of the test; the small number of ambulacral plates, which are usually fewer than 30 and only in the largest specimens exceed that number; the fact that the poriferous zones are scarcely sunken at all; the very slender but rough primary radioles; the nearly cylindrical or even club-shaped secondaries and miliaries; and the absence of any sort of tridentate pedicellariæ, combine to make the line between these species and the other Cidaridæ remarkably distinct. They are small and rather delicate echinoids, apparently confined to very deep water.

Aporocidaris Milleri A. Ag. and Clark.

Porocidaris Milleri A. Ag. 1898. Bull. M. C. Z., XXXII, 5, p. 74. Pl. IV.

Plate 9.

Neither tridentate nor large globiferous pedicellariæ occur in this species, but small globiferous ones of very diverse sizes are abundant all over the test. They have the valves short and wide though the proportions vary, from those having the width .38 of the length to those in which it is .75. The opening is very irregular, either with or without a lip, and there may or may not be an end-tooth. The valves range in length from .32 to .87 mm. and the stalks are one or two times as long.

The great variability of the primary radioles referred to in the previously published description is remarkably illustrated by two specimens, each 10 mm. in diameter, one from St. 3399, off Cocos Id., the other from St. 4717. In the former, all the radioles are very slender and almost perfectly smooth, while in the latter many are much stouter and are provided with longitudinal series of stout, hooked prickles, as long as one-half the diameter of the spine.

This species was collected by the "Albatross," during her trip to the Eastern Pacific, in 1904, at the following stations.

Station 4647. 4°33′ S.–87°42.5′ W. Bott. temp. 35.5°. 2005 fathoms. Very lt. gy. glob. oz.

Station 4717. 5°10′ S.–98°56′ W. Bott. temp. 35.2°. 2153 fathoms. Red br. glob. oz. diat.

Aporocidaris fragilis A. Ag. and Clark.

Plates 10, figs. *10–21*; 23, figs. *5–8*.

Of this species two specimens were collected at Station 3783. It is closely allied to *P. Milleri*. It is more flattened (Pl. 23, figs. *7*, *8*) than that species, but like it in that the miliaries and secondaries are distant and the smaller spines are of uniform size, and very slender and elongate. In a specimen of 20 mm. diameter there are five and five interambulacral plates; the longest radioles (Pl. 10, fig. *14*) are 35 mm. and are comparatively stouter than in *P. Milleri*. They are of a whitish tint, and are covered with sharp, prominent serrations. The actinal primary radioles (Pl. 10, fig. *15*) are curved, flattened, with longer teeth on the edges. The color of the secondary spines and papillæ is light yellowish-brown.

In a specimen measuring 15 mm. in diameter and 9 mm. in height there are four and five interambulacral plates. The abactinal system measures 9 mm. across, the actinal system 8 mm. The median ambulacral zone consists of two vertical rows of secondary tubercles about equal in size to those surrounding the scrobicular area. In the younger specimens of *Milleri* and *fragilis* the genital pores are frequently not developed (Pl. 23, fig. *5*), and the actinal interambulacral plates are limited to a very small area between the ambulacral plates (Pl. 23, fig. *6*).

Neither tridentate nor large globiferous pedicellariæ are to be found. The small globiferous ones occur everywhere, but are not specially abundant. They are very variable, but the valves are somewhat more slender than in *Milleri;* the lip is generally present, but the end-tooth is usually wanting. The valves range in length from .40 to 1.00 mm., and the stalk is about equal to them, or may be as much as twice as long.

Station No. 3783. Off Kamchatka; S. E. Cape, Copper Id. 1567 fathoms. Gy. v. s. gn. m.

Acanthocidaris Mort.

It is not surprising that Mortensen[1] should have established this genus without any further examination than the superficial one he was able to make of the specimens in the British Museum and in the Jardin des Plantes and of the pedicellariæ he figured of *Cidaris curvatispinis* Bell.[2] For this cidarid is indeed a most striking Echinoid and is remarkable for its huge curved primary spines resembling those of Cœlopleurus, though they are not smooth, and end in a shallow grooved socket and not in a point as in that genus. The base of the primary spines above the milled ring is smooth, with fine striation, and indistinct, undulating ribs or ridges extend to the base of the shoe, which is sharply fluted or longitudinally ribbed. The primaries are curved near the extremity and are also often flattened there. The shaft of the spine is not more than one third the length of the shoe. The longest radioles are on the abactinal interambulacral plates (Pls. 37, 38). The radioles of the actinal part of the test (Pls. 12[b], figs. *18*, *19*; 37; 39, fig. *1*) are much flattened, slightly dished, and have the shaft tipped with a conspicuous, short, curved shoe or cap, as in Stephanocidaris. The larger primary spines are somewhat triangular in section, the curved abactinal side of the radiole being wider than the side

[1] Ingolf Exped. Echinoidea I, p. 21.

[2] Trans. Zool. Soc. London, XIII, 1893, p. 303. Pl. XXXVIII.

faces of the spines. The younger primary spines adjoining the abactinal system are not tipped with shoes. They are irregularly triangular, smooth, and pointed (Pls. 38; 39; 40; 41, fig. *2*; 42, fig. *5*). The abactinal system is pentagonal. The actinal system is smaller than the abactinal.

Acanthocidaris hastigera A. Ag. and Clark.

Plates 11, figs. *1–5;* 12, figs. *1–17;* 12[b], figs. *18, 19;* 37–42.

In a specimen 50 mm. in diameter and 40 mm. in height, the longest abactinal spines measure three times the diameter of the test, the smooth part of the shaft being nearly one quarter the length of the radiole seen from above, and the spines taper very gradually towards the extremity (Pl. 38). The extent of the curvature is well shown on two of the longest spines of Pls. 37 and 38, and in Pl. 12, fig. *4*. The secondary spines (Pl. 12, figs. *11–14*) are slender, elongated, flattened, and striated; they hardly extend beyond the milled ring of the radioles. The miliary spines (Pl. 12, fig. *17*) resemble the secondaries in every point except in size, though they appear on the whole as more pointed. The pentagonal abactinal system measures 25 mm. in greatest diameter (Pl. 39, fig. *2*), while the actinal system does not measure more than 18 mm. (Pl. 39, fig. *1*). There are seven and eight primary tubercles in each vertical interambulacral row; these tubercles are perforate and crenulate. The scrobicular circle is surrounded by a single row of large secondaries. The small secondaries and miliaries in two or three irregular rows cover the sides of the interambulacral plates, forming a broad, median belt along the suture of the interambulacral plates (Pl. 40, figs. *1, 2*). The scrobicular areas of the small interambulacral plates, near the actinal system, unite on the horizontal line of suture (Pl. 39, fig. *1*).

The poriferous zone of the ambulacral area is slightly undulating. The area itself is divided into three belts of equal width; the two poriferous zones and the median ambulacral belt which is defined by a vertical line of small secondaries flanking the poriferous zones (Pl. 40, fig. *1*), with a line of minute miliaries on the median angle of each ambulacral plate. The larger ambulacral tubercles carry comparatively long, slender, sharp-pointed spines. The miliary spines are slender and minute. The outer line of pores is composed of larger pores than the inner line; the pores are slightly confluent.

The genital plates are irregularly hexagonal with rounded angles, the distal sides being the smallest (Pl. 39, fig. *2*). The genital pores are near the distal edge; the specimen figured in Pl. 39, fig. *2*, is probably a male. The genital plates are covered with well-separated secondary tubercles, all more or less comma-shaped, especially in the area adjoining the anal system. The madreporic genital is riddled with pores, and is covered with small globular tubercles closely packed together (Pl. 39, fig. *2*). The ocular plates are heart-shaped, irregularly triangular, with rounded sides, and with the exception of the right anterior one, come in contact with a large intergenital anal plate. The anal system is pointedly pentagonal, with an outer ring of large, irregularly shaped plates, an inner ring of irregularly shaped smaller plates, and the smallest plates immediately round the anal opening. The plates of the anal system carry a few tubercles similar to those of the genital and ocular plates.

The ambulacral plates of the actinal system are very narrow; they are edged with three small miliaries on each side of the central line of pores. To the thirteen ambulacral plates in each vertical row only six interambulacral plates correspond.

In a smaller specimen measuring 24 mm. in diameter the ratio of the diameter of the test to the length of the longest primary spine is somewhat less than in the larger specimen. In this specimen the longest primary spines are 65 mm. only, and the basal part of the radiole is fully one third the length of the whole spine. Although the test is proportionately much flatter, only 12 mm. in height, there are already five and six interambulacral plates. With diminishing size the flattening of the test also rapidly increases. In a specimen 18 mm. in diameter, the height is 8 mm. (Pl. 42, figs. *1–4*), the longest primary spine is 48 mm., and there are five and six primary tubercles. In a specimen 9 mm. in diameter, the height is 4 mm., the longest spine is 14 mm. (Pl. 42, figs. *7–10*), and there are four and five primary tubercles. In the smallest specimen examined, with three and four primary tubercles, the diameter was 5 mm., and the height 2.25 mm. The longest spines measure 12 and 14 mm.; the basal part of the spine being nearly one-half the length of the radiole. In small specimens the abactinal system is smaller than the actinal. In the specimen figured in Pl. 42, figs. *1*, *2*, the abactinal system measures 6.5 mm. and the actinal 7 mm. across. In the specimen Pl. 42, figs. *7*, *8*, the abactinal system measures 3.5 mm., and the actinal 4 mm. In the smallest specimen, 5 mm. in diameter, the abactinal and actinal system each measure 3 mm.

When dried the secondary and miliary spines are of a uniform brown, chocolate color. The primary spines are of a lighter color with a pinkish tinge, the basal part of the spine yellowish, or sometimes porcelain white in smaller specimens.

Although the tridentate and small globiferous pedicellariæ are present always, the large globiferous may be wholly wanting in large specimens.

The large globiferous pedicellariæ (Pl. 11, fig. *1*) are not essentially different from the small ones, but often have the lip incomplete and the end-tooth is wanting. There are numerous calcareous ridges and elevations on the inner face of the valve, which measures about .80 mm. in length. The stalk (Pl. 12, fig. *1*) is about as long and has a well-developed limb. These pedicellariæ are infrequent and apparently most common in young specimens.

The tridentate pedicellariæ (Pl. 11, figs. *4*, *5*) have long stout valves, with longitudinal ridges on the inner face. The valves are as much as 1.55 mm. in length and the stalk is about the same. They occur mainly on the actinal surface.

The small globiferous pedicellariæ (Pl. 11, figs. *2*, *3*) have straight sides and a well-developed end-tooth, which is less conspicuous in large valves. They range in size from .20 mm. upwards, in length of valve, with stalks 1–3 times as long, and intergrade with the large globiferous ones, so that it is hard to draw any line between the two. They are abundant everywhere.

Although similar in its general appearance to Bell's species (*Cidaris curvatispinis*) from Mauritius, *hastigera* differs so strikingly in color, as well as in the form of the basal half of the primaries, that the two cannot be identical.

This species has been collected at the following stations in the Hawaiian Islands.

Station 3823. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 69°. 78–222 fathoms. Fne. s. p.

Station 3838. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 67°. 92–212 fathoms. Fne. gy. br. s.

Station 3845. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71°. 60–64 fathoms. Crs. s. p. sh.

Station 3846. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71.5°. 60–64 fathoms. Crs. br. s. sh. g.

Station 3847. Off Lae-o Ka Laau Light, S. coast of Molokai. 23–24 fathoms. S. st.

Station 3848. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71.1°. 44–73 fathoms. S. g.

Station 3861. Off Mokuhooniki Islet, Pailolo Channel. 30–52 fathoms. Fne. s. sm. p. co.

Station 3906. Off Mokapu Islet, N. coast of Molokai. Bott. temp. 72°. 66–96 fathoms. Gy. s. sh. p.

Station 4061. Off Kauhola Light, N. E. coast of Hawaii. 24–83 fathoms. Co. s. corln. nod. for.

Station 4062. Off Kauhola Light, N. E. coast of Hawaii. 83–113 fathoms. Co. vol. s. sh. for.

Station 4064. Off Kauhola Light, N. E. coast of Hawaii. Bott. temp. 69°. 63–107 fathoms. Vol. s. for. co.

Station 4066. Off Ka Lae-o Ka Ilio Point, Maui. Bott. temp. 52.5°. 49–176 fathoms. Rky.

Station 4077. Off Puniawa Point, Maui. Bott. temp. 70°. 99–106 fathoms. Fne. co. s. for.

Bathymetrical range, 23–222 fathoms. Extremes of temperature, 72–52.5°. Fifty specimens.

EXPLANATION OF THE PLATES.

PLATE 1.

Plate 1.

1–2. Cidaris Thouarsii Val.

1. Upper end of stalk of globiferous pedicellaria, showing entire absence of limb. × 156.
2. Valve of small globiferous pedicellaria. × 156.

3–7. Cidaris metularia Bl.

3. Upper end of stalk of globiferous pedicellaria, showing presence of limb. × 156.
4. Valve of small globiferous pedicellaria. × 156.
5. Tip of valve of another small globiferous pedicellaria. × 156.
6. Valve of globiferous pedicellaria. × 156.
7. Valve of tridentate pedicellaria. × 156.

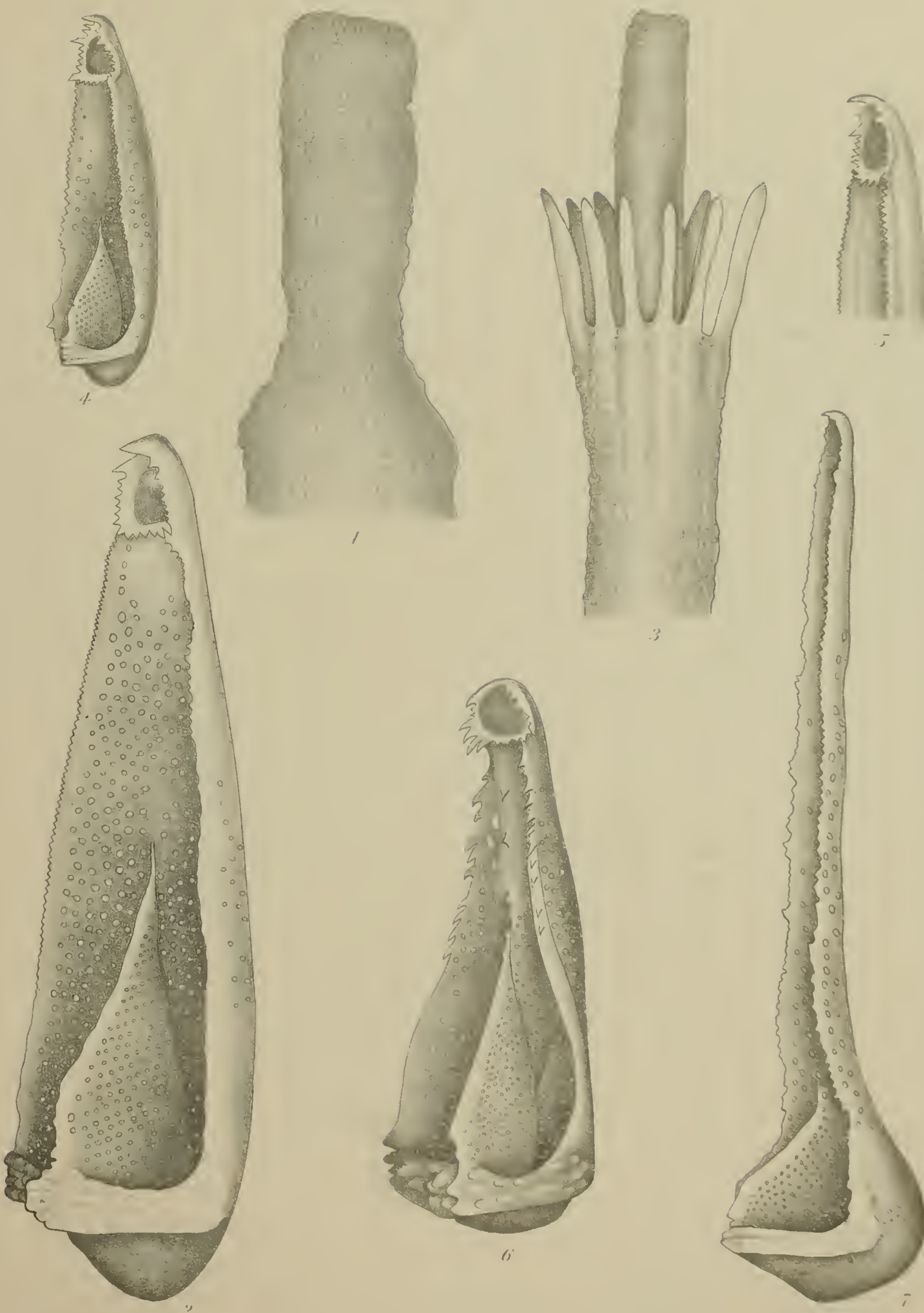

4
1
3
5
2
6
7

PLATE 2.

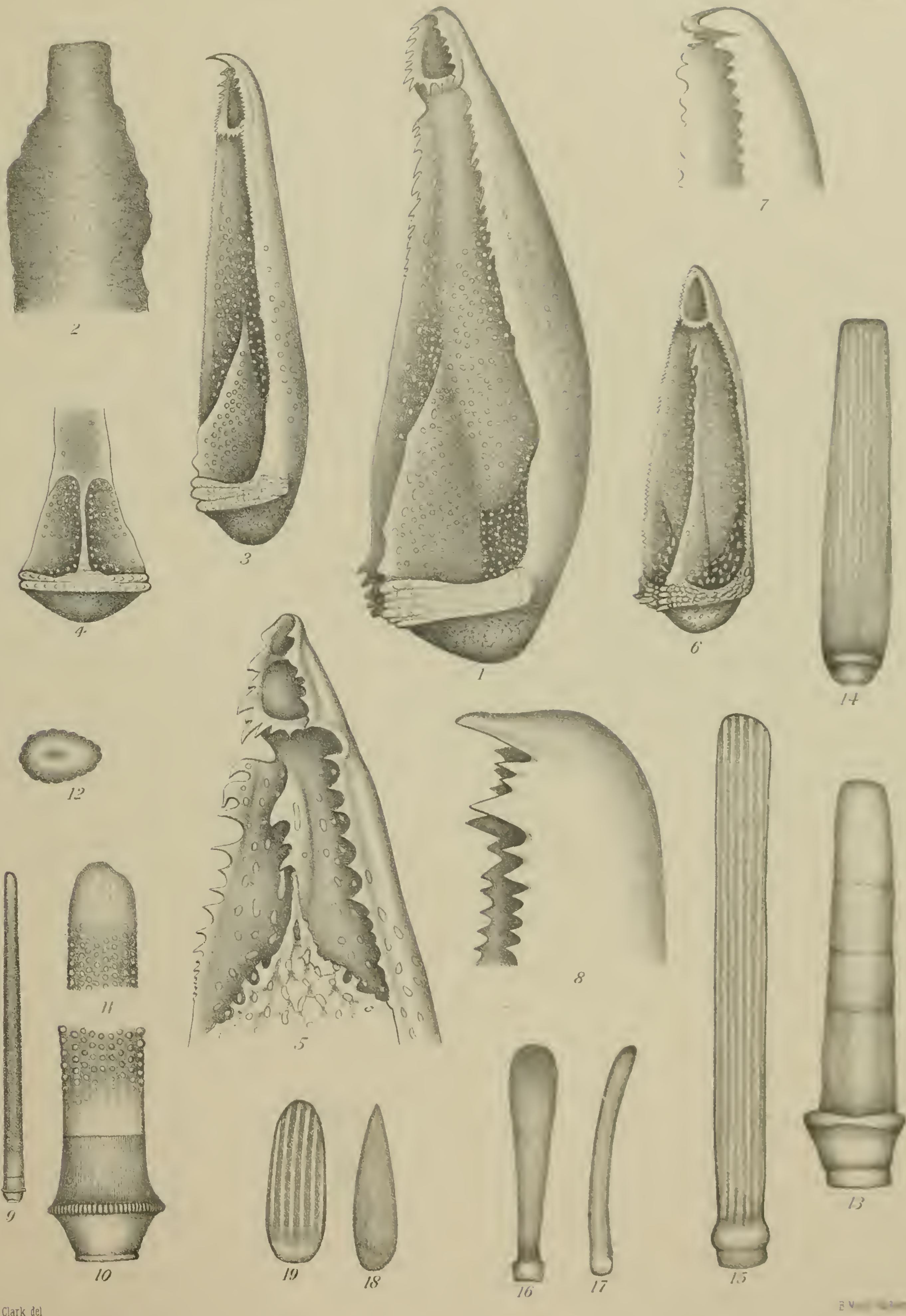
Plate 2.

1–4. **Cidaris tribuloides** Ag.

1. Valve of globiferous pedicellaria. × 156.
2. Upper end of stalk of globiferous pedicellaria, showing absence of limb. × 156.
3. Valve of small globiferous pedicellaria. × 156.
4. Interior view of base of valve of tridentate pedicellaria. × 156.

5–19. **Dorocidaris panamensis** A. Ag.

5. Tip of valve of globiferous pedicellaria. × 156.
6. Valve of small globiferous pedicellaria. × 156.
7. Tip of valve of another small globiferous pedicellaria, without end-tooth. × 617.
8. Tip of valve of another small globiferous pedicellaria, with end-tooth. × 617.
9. Ambital primary spine. Nat. size.
10. Base of same spine. × 5.
11. Tip of same spine. × 5.
12. End view of same tip. × 5.
13. Small actinal primary spine. × 11.
14. Abactinal interambulacral secondary spine. × 11.
15. Actinal ambulacral secondary spine. × 23.
16. Actinostomal miliary. × 23.
17. Same miliary from side. × 23.
18. Most common form of miliary. × 23.
19. Less common form of miliary. × 23.



H. L. Clark del

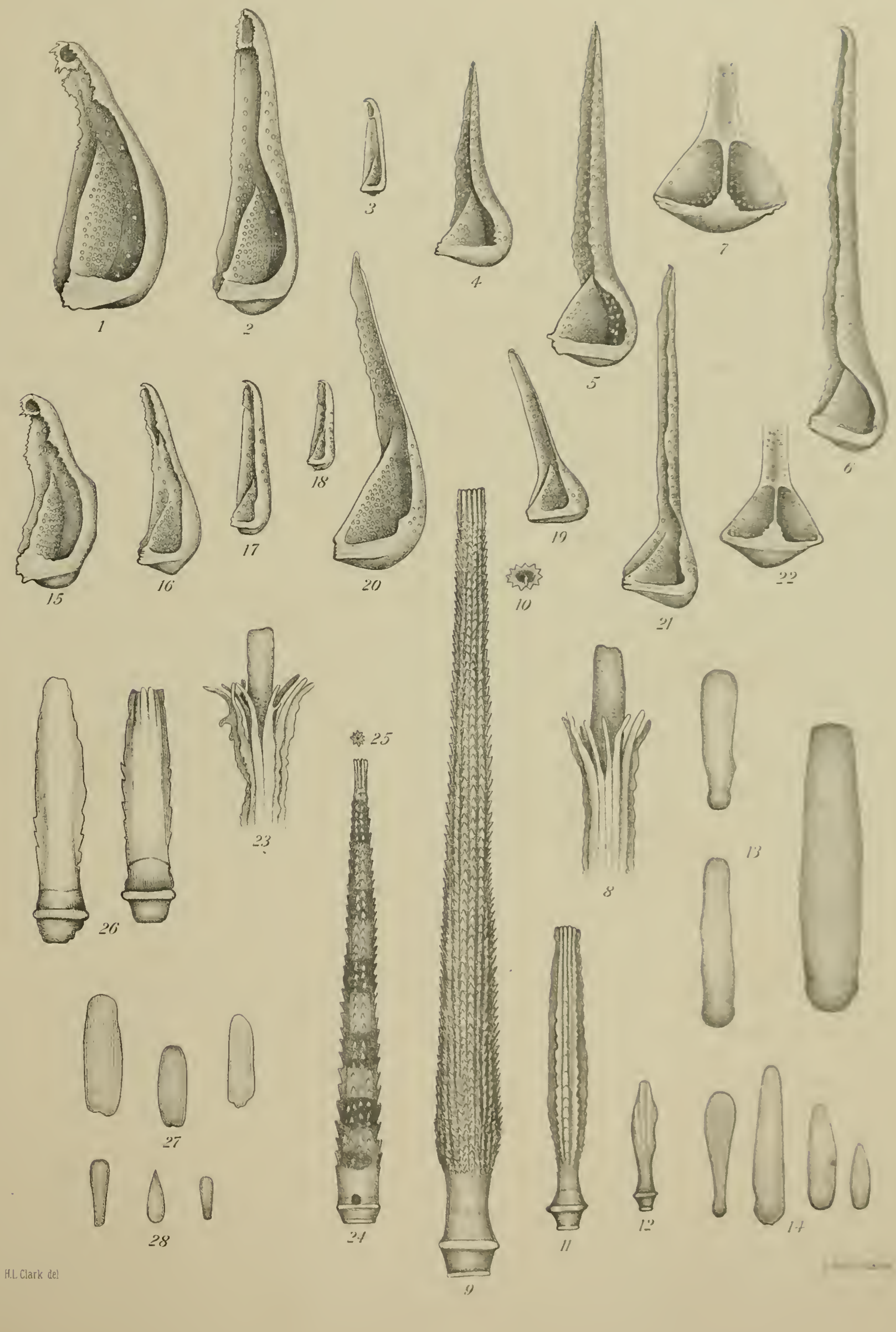
Plate 3.

1–14. **Dorocidaris Reini** Död.

1. Valve of globiferous pedicellaria. × 55.
2. Valve of small globiferous pedicellaria. × 55.
3. Valve of another small globiferous pedicellaria. × 55.
4. Developmental stage of valve of tridentate pedicellaria. × 55.
5. Later developmental stage of valve of tridentate pedicellaria. × 55.
6. Valve of tridentate pedicellaria. × 55.
7. Interior view of base of valve of tridentate pedicellaria. × 55.
8. Upper end of stalk of globiferous pedicellaria. × 55.
9. Ambital primary spine. × 3.
10. End view of tip of same spine. × 3.
11. Actinal primary spine. × 3.
12. Primary spine nearest actinostome. × 3.
13. Secondary spines. × 11.
14. Miliaries. × 11.

15–28. **Dorocidaris bracteata** A. Ag.

15. Valve of globiferous pedicellaria. × 55.
16. Valve of small globiferous pedicellaria. × 55.
17. Valve of another small globiferous pedicellaria. × 55.
18. Valve of another small globiferous pedicellaria. × 55
19. Developmental stage of valve of tridentate pedicellaria. × 55.
20. Later developmental stage of valve of tridentate pedicellaria. × 55.
21. Valve of tridentate pedicellaria. × 55.
22. Interior view of base of valve of tridentate pedicellaria. × 55.
23. Upper end of stalk of globiferous pedicellaria. × 55.
24. Ambital primary spine. × 3.
25. End view of tip of same spine. × 3.
26. Actinal primary spines. × 11.
27. Secondary spines. × 11.
28. Miliaries. × 11.



H.L. Clark del.

Plate 4.

Plate 4.

1–12. **Dorocidaris calacantha** A. Ag. and Clark.

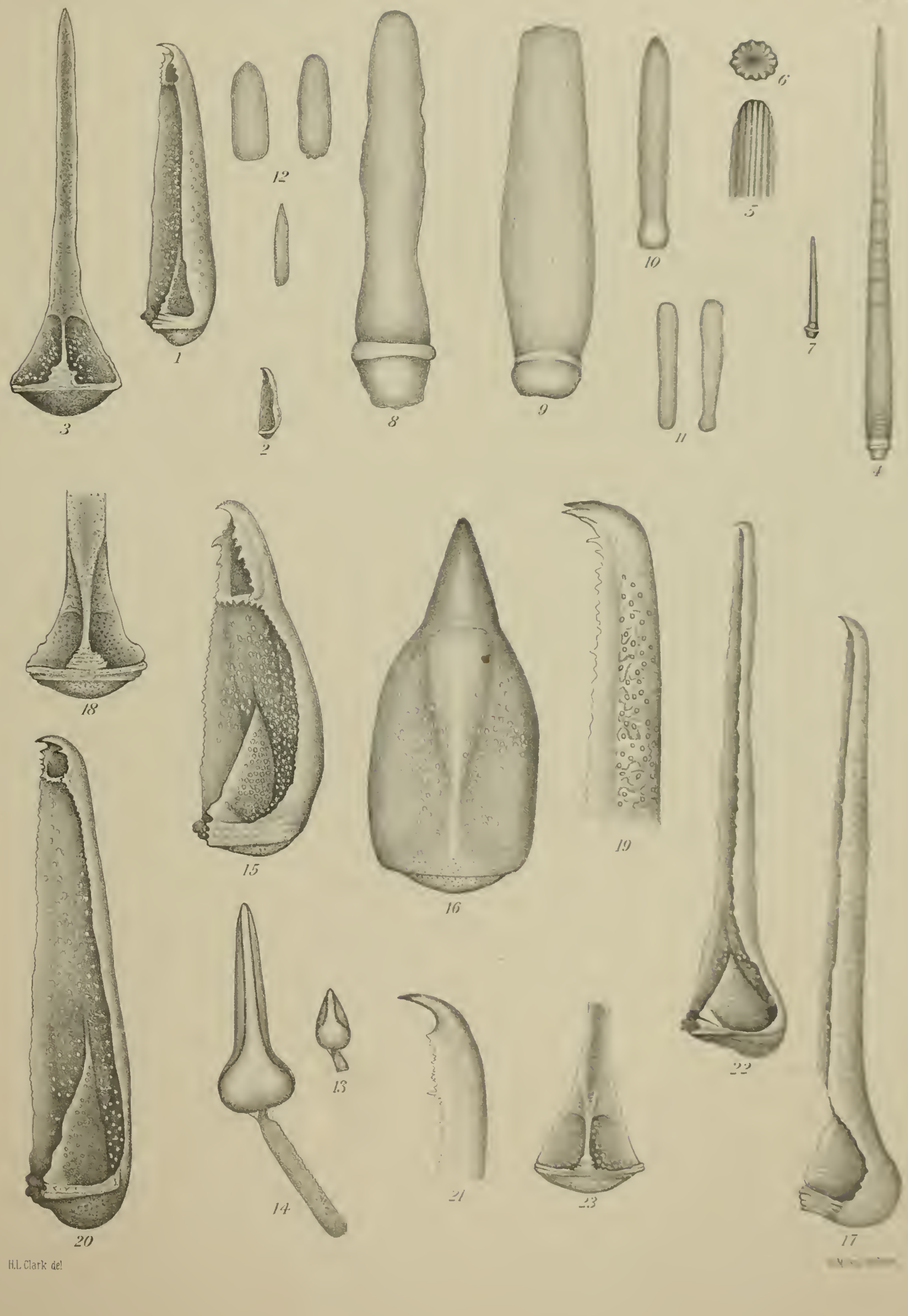
1. Valve of small globiferous pedicellaria. × 55.
2. Valve of another small globiferous pedicellaria. × 55
3. Valve of tridentate pedicellaria. × 55.
4. Ambital primary spine. Nat. size.
5. Tip of same spine seen from side. × 5.
6. End view of same tip. × 5.
7. Abactinal primary spine. Nat. size.
8. Actinal primary spine. × 11.
9. Interambulacral secondary spine. × 11.
10. Ambulacral secondary spine. × 11.
11. Actinostomal miliaries. × 11.
12. Other miliaries. × 11.

13–19. **Chondrocidaris gigantea** A. Ag.

13. Small globiferous pedicellaria. × 23.
14. Tridentate pedicellaria. × 23.
15. Valve of small globiferous pedicellaria. × 156.
16. Exterior view of same valve. × 156.
17. Valve of tridentate pedicellaria. × 55.
18. Interior view of base of valve of tridentate pedicellaria. × 55.
19. Side view of tip of valve of tridentate pedicellaria. × 156.

20–23. **Stephanocidaris hawaiiensis** A. Ag. and Clark.

20. Valve of small globiferous pedicellaria. × 156.
21. Tip of valve of small globiferous pedicellaria. × 156.
22. Valve of tridentate pedicellaria. × 55.
23. Interior view of base of valve of tridentate pedicellaria. × 55.



H. L. Clark del.

PLATE 5.

Plate 5.

1–17. **Phyllacanthus Thomasii** A. Ag. and Clark.

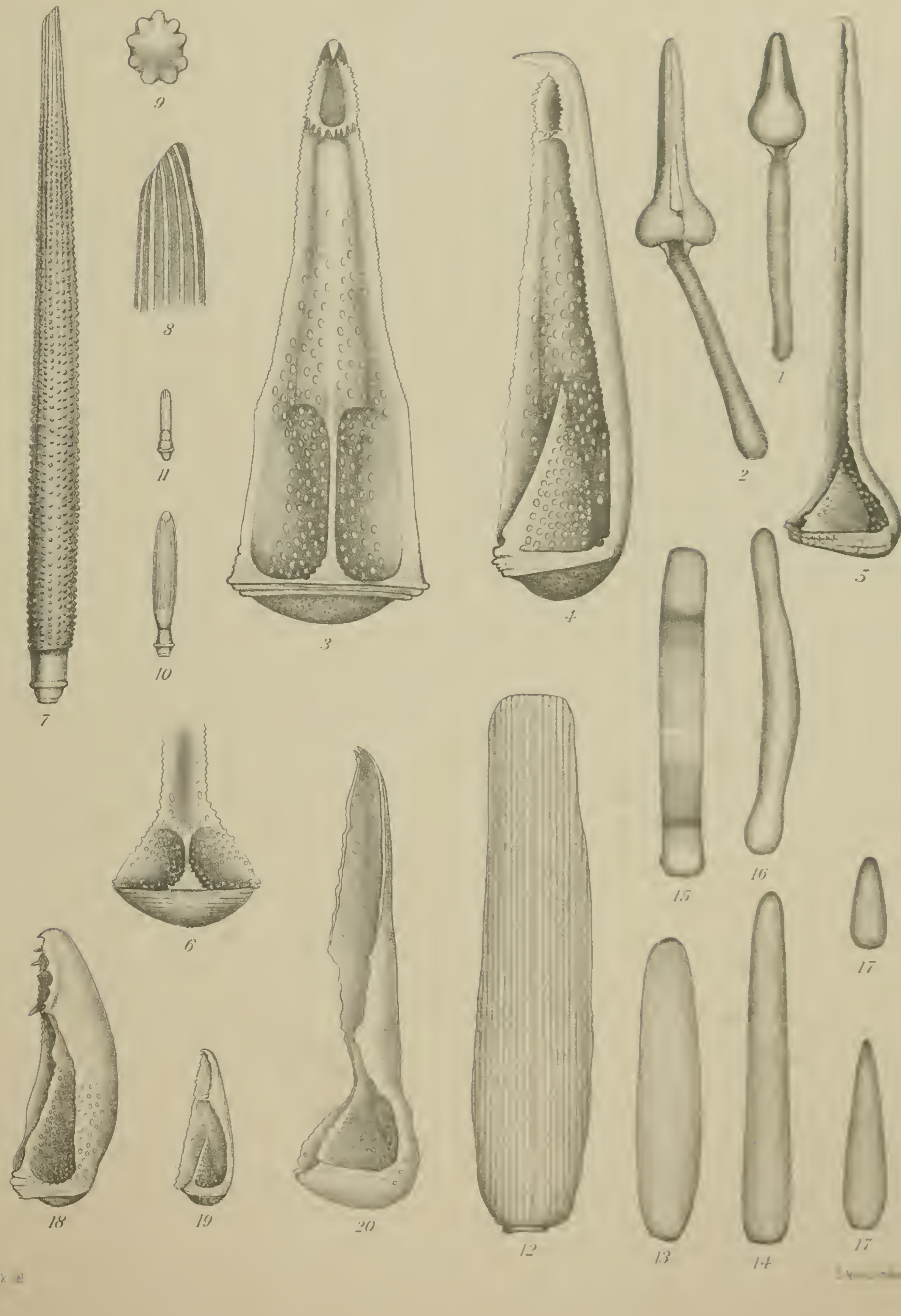
1. Small globiferous pedicellaria. × 23.
2. Tridentate pedicellaria. × 23.
3. Valve of small globiferous pedicellaria. × 156.
4. Small valve, from side. × 156.
5. Valve of tridentate pedicellaria. × 55.
6. Interior view of base of valve of tridentate pedicellaria. × 55.
7. Ambital primary spine. Nat. size.
8. Tip of same spine. × 5.
9. End view of same tip. × 5.
10. Actinal primary spine. Nat. size.
11. Primary spine nearest actinostome. Nat. size.

12, 13. Interambulacral secondary spines. × 11.

14. Ambulacral secondary spine. × 11.
15. Actinal secondary spine. × 11.
16. Side view of same spine. × 11.
17. Miliaries. × 11.

18–20. **Stereocidaris grandis** Död.

18. Valve of globiferous pedicellaria. × 55.
19. Valve of small globiferous pedicellaria. × 55.
20. Valve of tridentate pedicellaria. × 55.



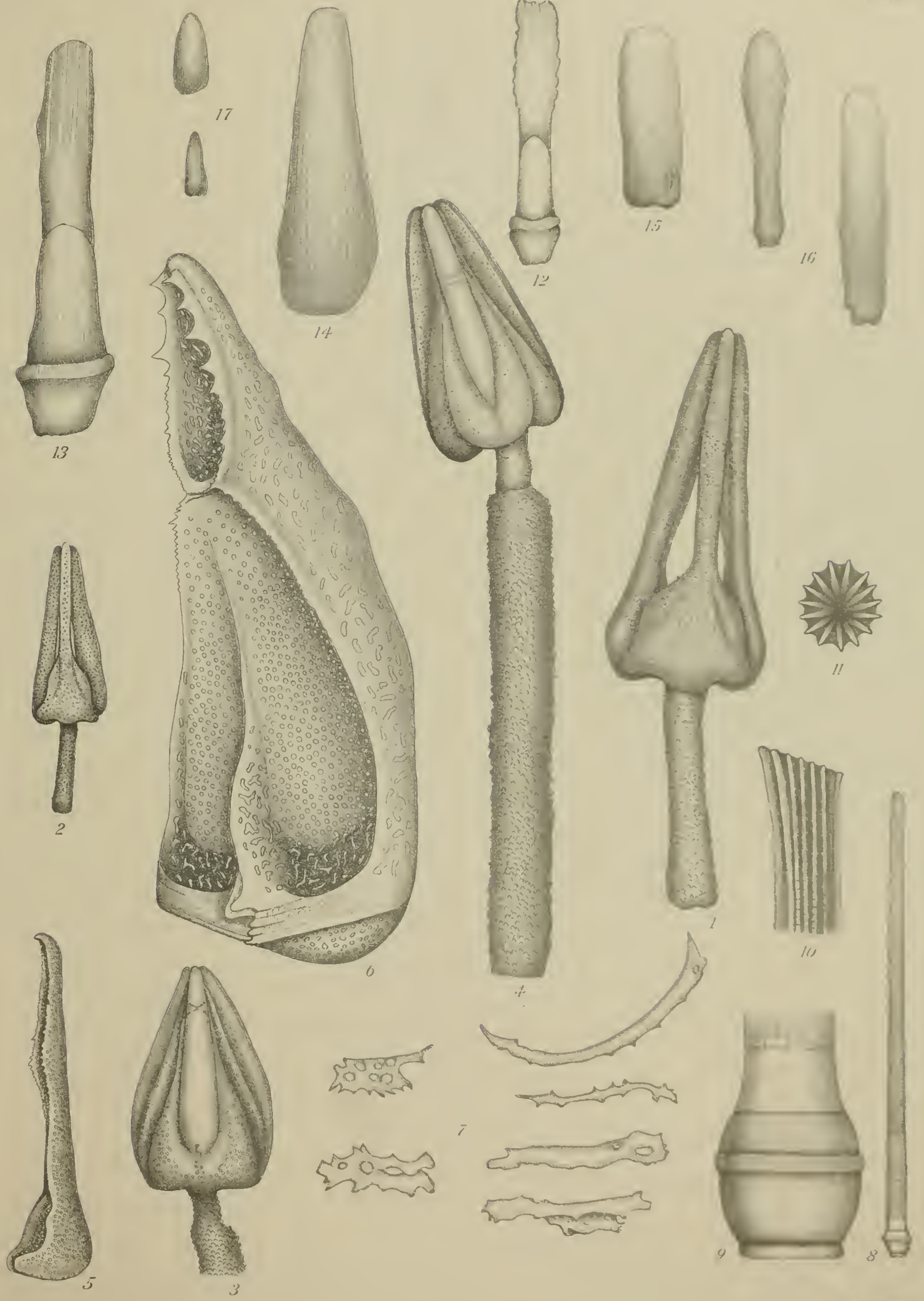
Clark del.

Plate 6.

Plate 6.

1–17. **Stereocidaris leucacantha** A. Ag. and Clark.

1. Tridentate pedicellaria. × 55.
2. Smaller tridentate pedicellaria. × 55.
3. Globiferous pedicellaria. × 55.
4. Small globiferous pedicellaria. × 156.
5. Valve of tridentate pedicellaria. × 55.
6. Valve of globiferous pedicellaria. × 156.
7. Calcareous particles from pedicels. × 156.
8. Ambital primary spine. Nat. size.
9. Base of same spine. × 5.
10. Tip of same spine. × 5.
11. End view of same tip. × 5.
12. Actinal primary spine. × 5.
13. Smallest actinal primary spine. × 11.
14. Interambulacral secondary spine. × 11.
15. Ambulacral secondary spine. × 23.
16. Actinal secondaries. × 23.
17. Miliaries. × 23.



H. L. Clark del.

PLATE 7.

Plate 7.

1–24. **Porocidaris Cobosi** A. Ag.

1. Tridentate pedicellaria. × 11.
2. Smaller tridentate pedicellaria. × 11.
3. Developmental stage of tridentate pedicellaria. × 11.
4. Very small tridentate pedicellaria. × 55.
5. Valve of large tridentate pedicellaria. × 30.
6. Interior view of base of valve of small tridentate pedicellaria. × 55.
7. Calcareous particles from pedicels. × 156.
8. Abactinal primary spine. Nat. size.
9. Ambital primary spine. Nat. size.
10. Base of same spine. × 5.
11. Tip of same spine. × 5.
12. End view of same tip. × 5.
13. Ambital primary spine of small individual. × 3.
14. Actinal primary spine. × 5.
15. Side view of same spine. × 5.
16. Smaller actinal primary spine. × 5.
17. Smallest actinal primary spine. × 5.
18. Young abactinal primary spine. × 5.
19. Somewhat younger abactinal primary spine. × 5.
20. Youngest abactinal primary spine. × 5.
21. Interambulacral secondary spine. × 11.
22. Another interambulacral secondary spine. × 11.
23. Ambulacral secondary spine. × 11.
24. Actinal miliaries. × 11.

H.L. Clark del.

PLATE 8.

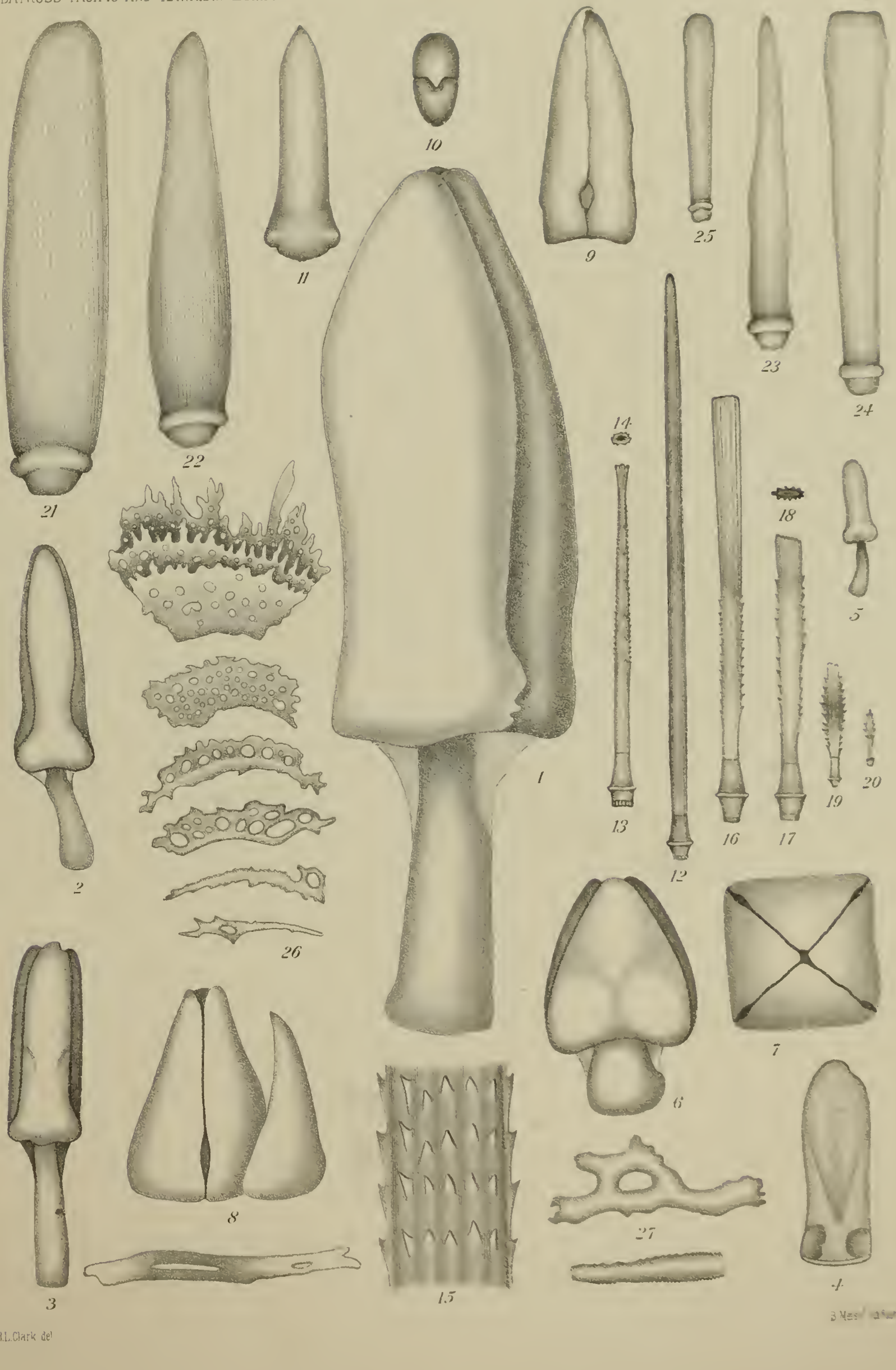
Plate 8.

1–27. **Porocidaris variabilis** A. Ag. and Clark

1. Large pedicellaria. × 23.
2. Another pedicellaria. × 23.
3. Another large pedicellaria. × 8.
4. Interior view of valve of pedicellaria. × 8.
5. Very small pedicellaria. × 23.
6. Side view of normal four-valved pedicellaria. × 23.
7. End view of same. × 23.
8. Abnormal four-valved pedicellaria. × 23.
9. Side view of two-valved pedicellaria. × 11.
10. End view of same. × 11.
11. Rear view of same. × 11.
12. Abactinal primary spine. Nat. size.
13. Ambital primary spine. Nat. size.
14. End view of same spine. Nat. size.
15. Small piece of primary spine, near middle. × 10.
16. Subambital primary spine. Nat. size.
17. Subambital primary spine. Nat. size.
18. End view of same spine. Nat. size.
19. Actinal primary spine. Nat. size.
20. Smallest actinal primary spine. Nat. size.

21, 22. Interambulacral secondary spines. × 11.

23. Ambulacral secondary spine. × 11.
24. Actinal secondary spine. × 11.
25. Actinostomal miliary. × 11.
26. Calcareous particles from pedicels. × 156.
27. Calcareous particles from pedicels of another individual. × 300.



H.L. Clark del.

B Meis[illegible]

PLATE 9.

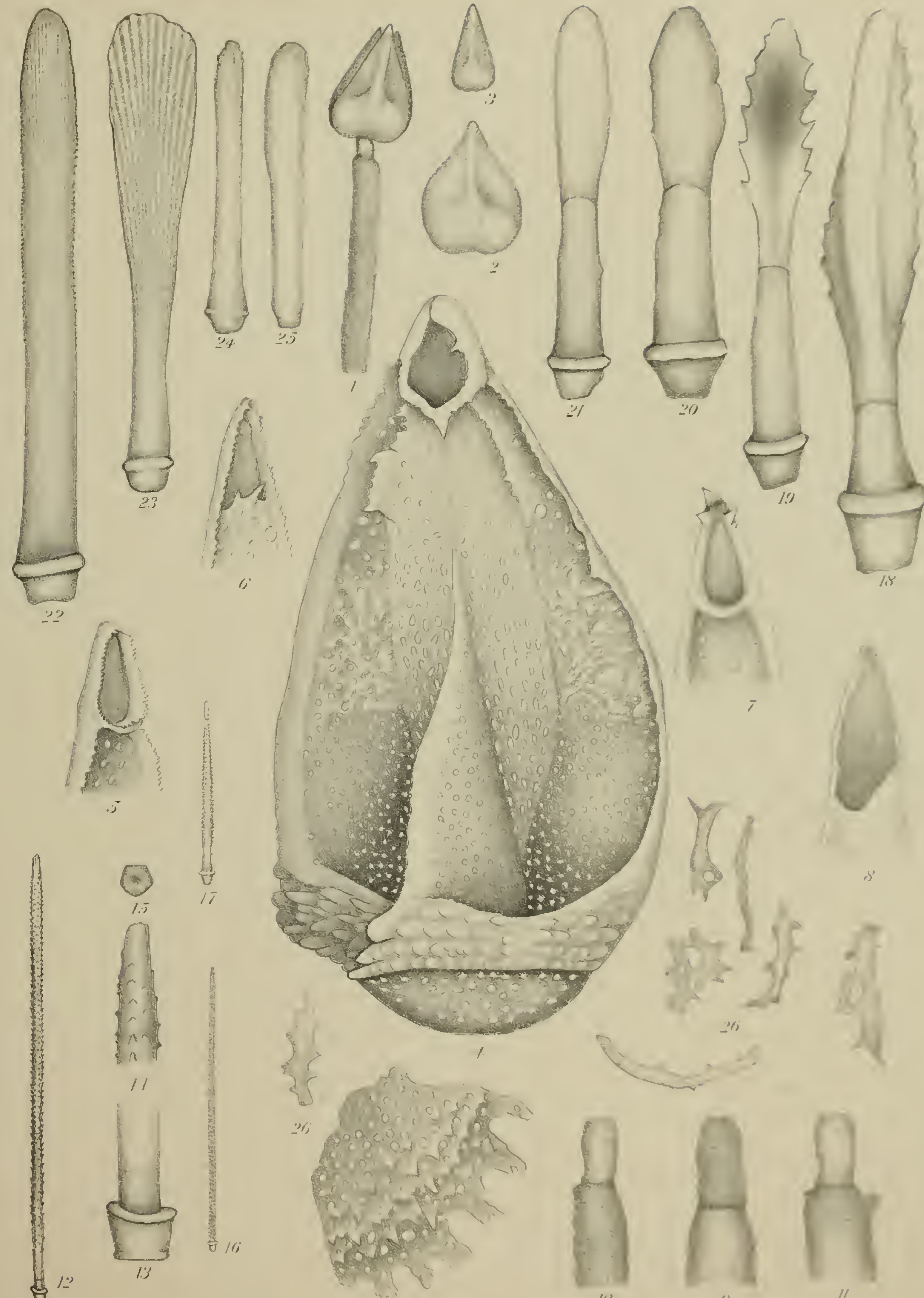
Plate 9.

1-26. **Aporocidaris Milleri** A. Ag. and Clark.

1. Typical pedicellaria, with stalk. × 23.
2. Valve of broader pedicellaria. × 23.
3. Valve of narrower pedicellaria. × 23.
4. Interior view of valve of pedicellaria. × 156.
5. Tip of pedicellaria, showing well formed lip. × 156.
6. Tip of pedicellaria, showing absence of lip; same individual. × 156.
7. Tip of pedicellaria, showing presence of end-tooth and lip. × 156.
8. Tip of pedicellaria, showing absence of end-tooth and lip; same individual. × 156.
9. Upper end of pedicellaria-stalk, showing absence of limb. × 55.
10. Upper end of pedicellaria-stalk, showing indication of limb. × 55.
11. Upper end of pedicellaria-stalk, showing rudimentary limb. × 55.
12. Primary spine. Nat. size.
13. Base of same spine. × 5.
14. Tip of same spine. × 5.
15. End view of same tip. × 5.
16. Primary spine from another individual. Nat. size.
17. Subambital primary spine. Nat. size.
18. Actinal primary spine; abactinal surface. × 11.
19. Actinal primary spine; actinal surface. × 11.
20. Very small actinal primary spine. × 11.
21. Smallest actinal primary spine. × 11.
22. Interambulacral secondary spine. × 23.
23. Actinal secondary spine. × 23.

24, 25. Ambulacral secondary spines. × 23.

26. Calcareous particles from pedicels. × 156.



H. L. Clark del.

Plate 10.

Plate 10.

1–9. **Centrocidaris Doederleini** A. Ag.

1. Small globiferous pedicellaria. × 55.
2. Interior view of valve of same pedicellaria. × 120.
3. Primary spine. Nat. size.
4. Base of same spine. × 5.
5. Tip of same spine. × 5.
6. End view of same tip. × 5.
7. Actinal primary spine. × 16.
8. Interambulacral secondary spine. × 23.
9. Ambulacral secondary spine. × 23.

10–21. **Aporocidaris fragilis** A. Ag. and Clark.

10. Interior view of valve of pedicellaria. × 55.
11. Side view of similar valve. × 55.
12. Interior view of valve of pedicellaria. × 55.
13. Side view of similar valve. × 55.
14. Primary spine. × 5.
15. Actinal primary spine. × 5.
16. Side view of smallest actinal primary spine. × 11.
17. Abactinal view of same spine. × 11.
18. Secondary spine. × 11.
19. Actinostomal miliary. × 11.
20. Side view of actinostomal miliary. × 11.
21. Abactinal miliary. × 11.

22–25. **Goniocidaris biserialis** Död.

22. Interior view of valve of globiferous pedicellaria. × 55.
23. Side view of similar valve. × 55.

24, 25. Valves of small pedicellariæ. × 55.

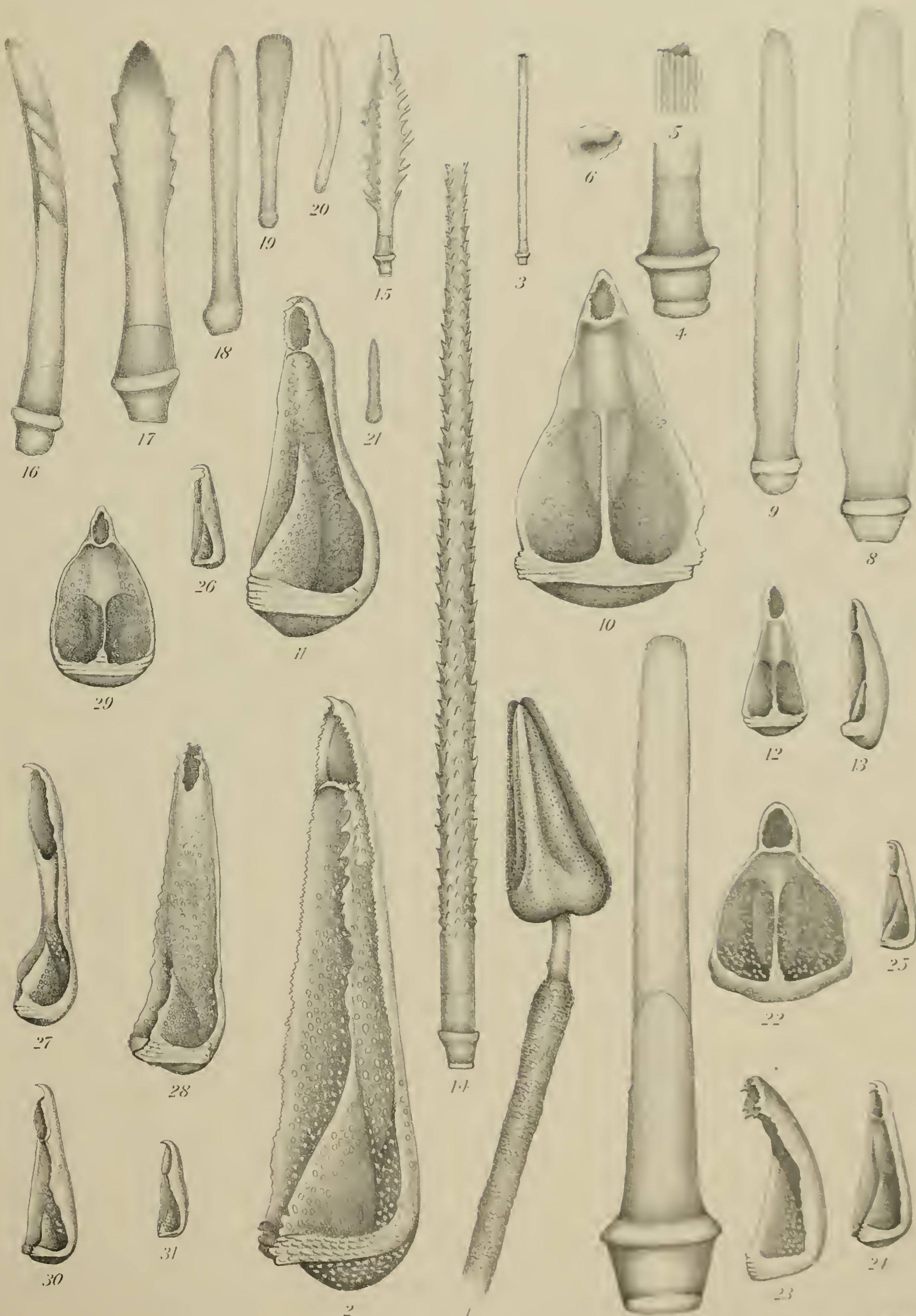
26. **Goniocidaris mikado** Död.

26. Valve of small pedicellaria. × 55.

27–31. **Goniocidaris clypeata** Död.

27. Valve of peculiar globiferous pedicellaria. × 55.
28. Valve of peculiar globiferous pedicellaria. × 55.
29. Valve of normal globiferous pedicellaria. × 55.

30, 31. Valves of small pedicellariæ. × 55.


16
17
18
19
20
15
3
6
5
4
9
8
21
26
11
10
29
12
13
27
28
2
14
1
7
22
25
30
31
23
24

H.L. Clark del.

Plate 11.

Plate 11.

1–5. **Acanthocidaris hastigera** A. Ag. and Clark.

1. Valve of globiferous pedicellaria. × 156.
2. Valve of small globiferous pedicellaria. × 156.
3. Valve of another small globiferous pedicellaria. × 156.
4. Valve of tridentate pedicellaria. × 55.
5. Exterior view of base of valve of tridentate pedicellaria. × 55.

6–12. **Anomocidaris tenuispina** A. Ag. and Clark.

6–10. Valves of small globiferous pedicellariæ, showing the great diversity in form and size. × 55.

11. Tip of valve of small globiferous pedicellaria, showing absence of end-tooth. × 156.
12. Tip of valve of small globiferous pedicellaria, showing presence of end-tooth. × 156.

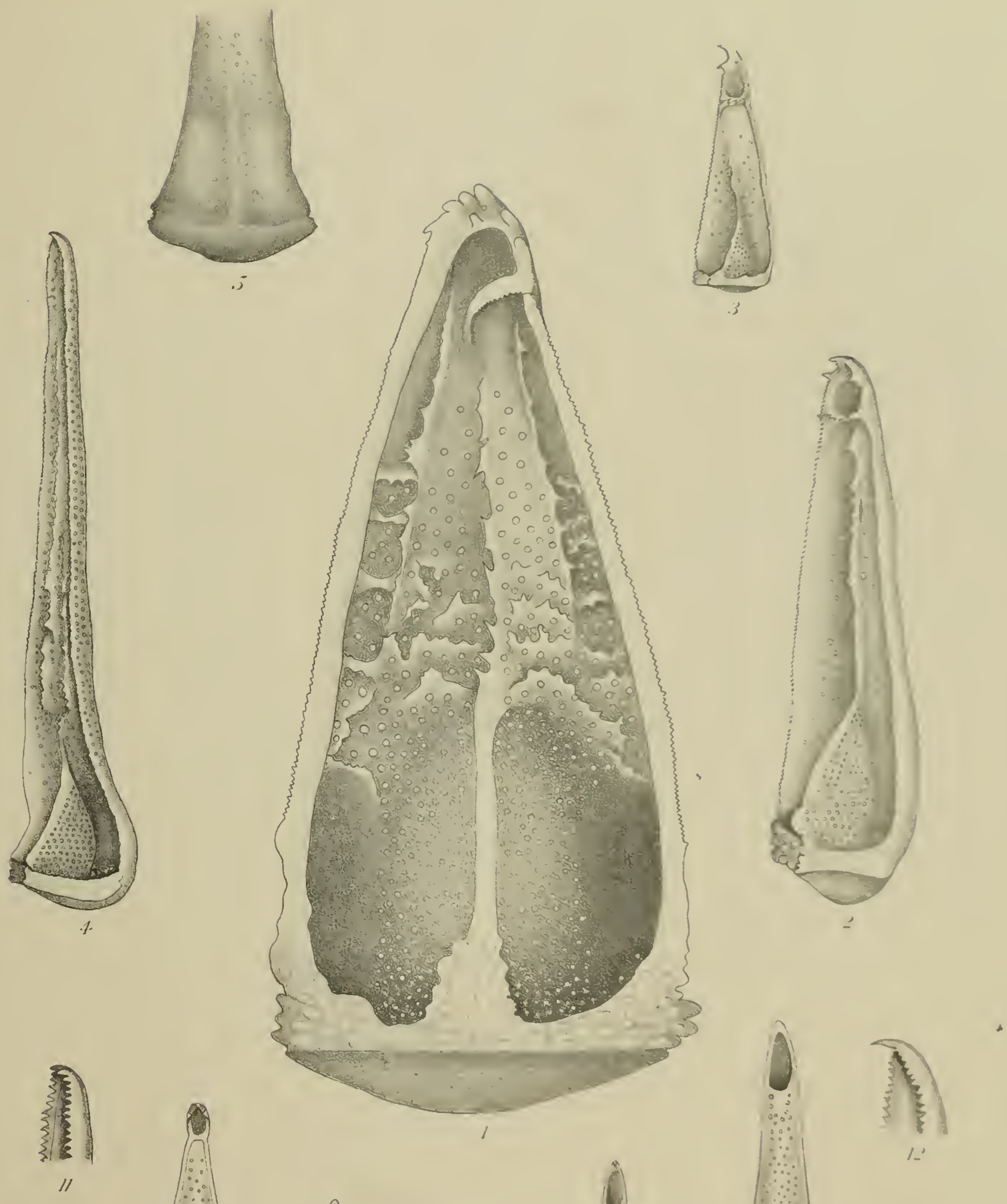

5
3
4
2
1
11
12
6
7
8
9
10

PLATE 12.

Plate 12.

1–17. **Acanthocidaris hastigera** A. Ag. and Clark.

1. Tip of stalk of globiferous pedicellaria, showing limb. × 156.
2. Most abactinal primary spine. Nat. size.
3. Abactinal primary spine. Nat. size.
4. Side view of ambital primary spine. Nat. size.
5. Ambital primary spine. Nat. size.
6. Subambital primary spine. Nat. size.
7. Actinal primary spine. Nat. size.
8. More actinal primary spine. Nat. size.
9. Still more actinal primary spine. Nat. size.
10. Most actinal primary spine. Nat. size.

11, 12. Interambulacral secondary spines. × 11.

13, 14. Ambulacral secondary spines. × 11.

15. Actinal view of actinal secondary spine. × 11.
16. Side view of same spine. × 11.
17. Miliary. × 11.

18–30. **Anomocidaris tenuispina** A. Ag. and Clark.

18. Valve of pedicellaria. × 156.
19. Ambital primary spine. × 3.
20. Actinal primary spine. × 3.
21. Most actinal primary spine. × 3.

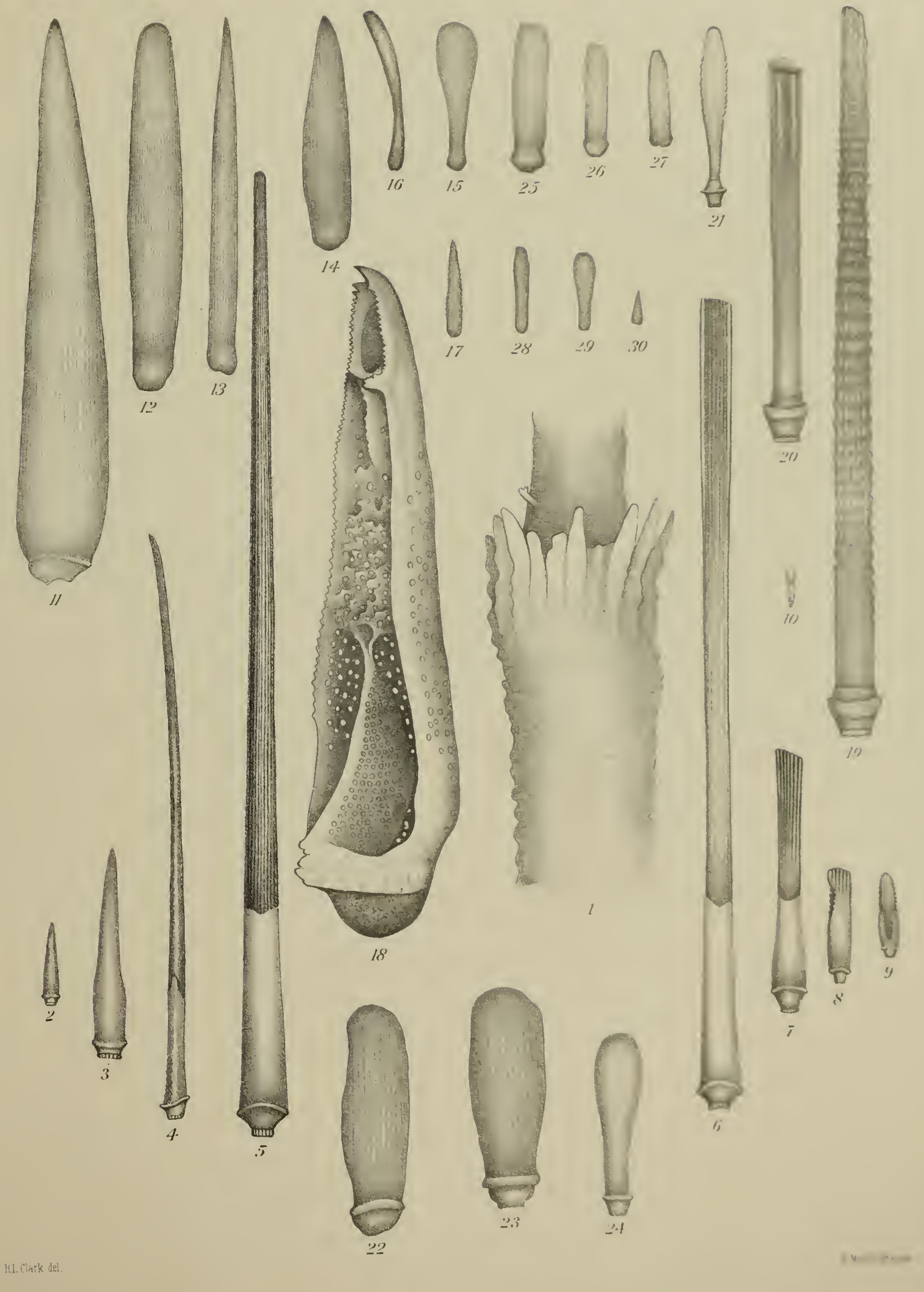
22, 23. Interambulacral secondary spine. × 11.

24. Actinal secondary spine. × 11.

25–27. Ambulacral secondary spines. × 11.

28, 29. Actinal ambulacral secondary spines. × 11.

30. Miliary. × 11.


11
12
13
14
16
15
25
26
27
21
20
19
17
28
29
30
18
1
10
2
3
4
5
6
7
8
9
22
23
24

H.L. Clark del.

PLATE 12[a].

Plate 12 a.

Parts of large globiferous pedicellariae of Dorocidaris; only the tips of the valves have been drawn, as the bases are more or less alike and no claim has been made that they afford generic characters. × 70.

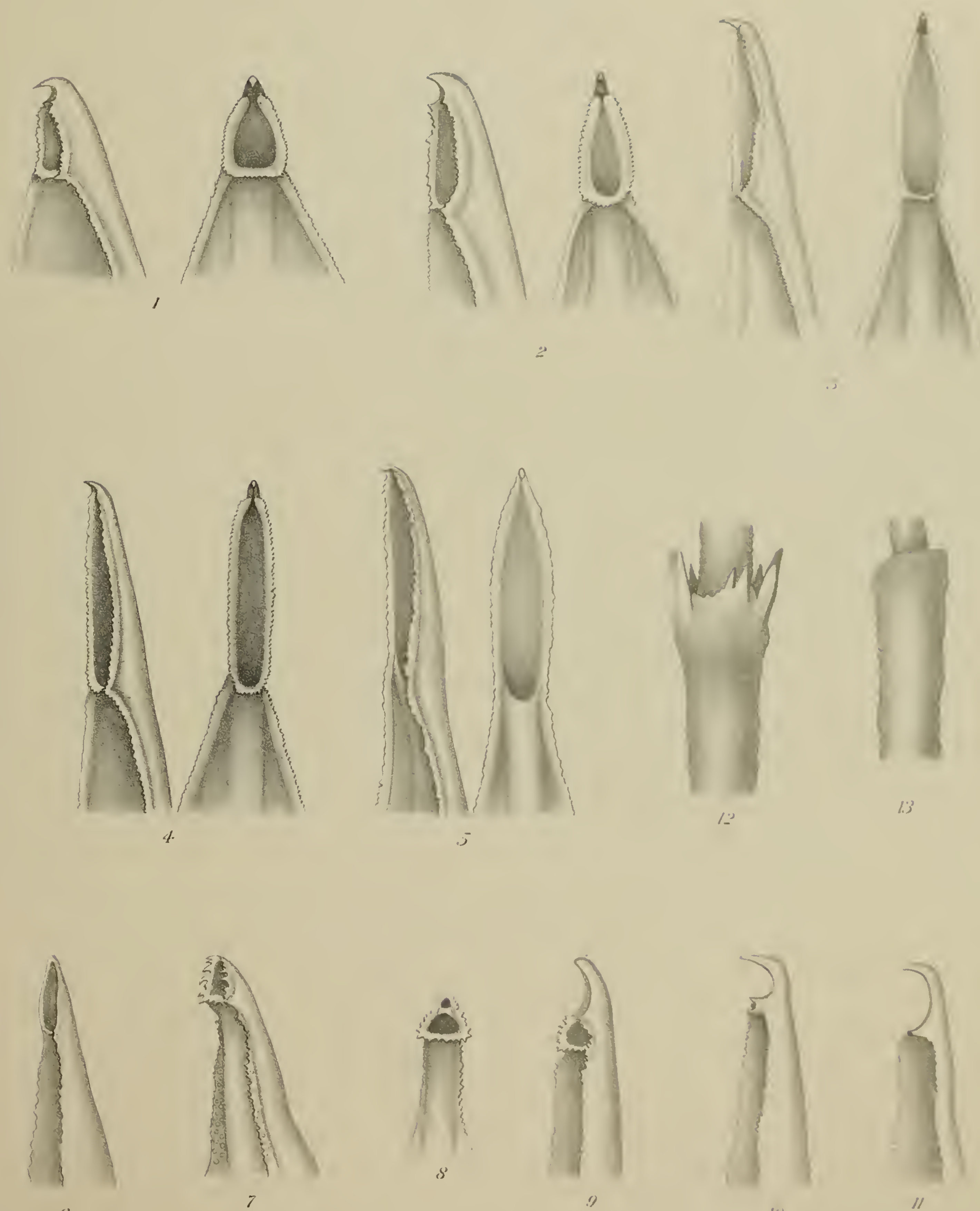
1–5. **Dorocidaris abyssicola** A. Ag.

All the figures are from a single individual, and show the great diversity in the large globiferous pedicellariæ.

6–13. **Dorocidaris Bartletti** A. Ag.

Figures 6–11 are from a single individual and show the extraordinary diversity which is exhibited by the large globiferous pedicellariæ of this species. The usual form is that shown in fig. 10 but the kind shown in fig. 7 is quite common.

Figures 12 and 13 are from a second individual and show that the "limb" on the stalk may be either present or wanting.



H.L. Clark del

PLATE 12 b.

PLATE 12 b.

1–3. **Dorocidaris affinis** A. Ag.

All the figures are from a single individual. × 70.

1. Tip of valve of a large pedicellaria of exactly the same appearance as the small pedicellaria of the same individual.
2. Tip of valve of an ordinary large globiferous pedicellaria, but the opening is not quite terminal.
3. Tip of valve of a somewhat larger pedicellaria with the opening distinctly terminal.

4–6. **Dorocidaris Blakei** A. Ag.

All the figures are from a single individual, to show the diversity in the form of the opening. × 70.

7–9. **Centrocidaris Doederleini** A. Ag.

7. Valve of an ordinary large globiferous pedicellaria; side view. × 70.
8. Valve of peculiar large globiferous pedicellaria; inner view. × 70.
9. Valve of tridentate pedicellaria; side view. × 70.

10–19. Actinal Primary Spines. × 5.

The even numbers show the abactinal side; the odd numbers, the actinal side.

10, 11. Stephanocidaris bispinosa A. Ag.

12, 13. Stephanocidaris hawaiiensis A. Ag. and Clark.

14, 15. Phyllacanthus annulifera A. Ag.

16, 17. Phyllacanthus baculosa A. Ag.

18, 19. Acanthocidaris hastigera A. Ag. and Clark.

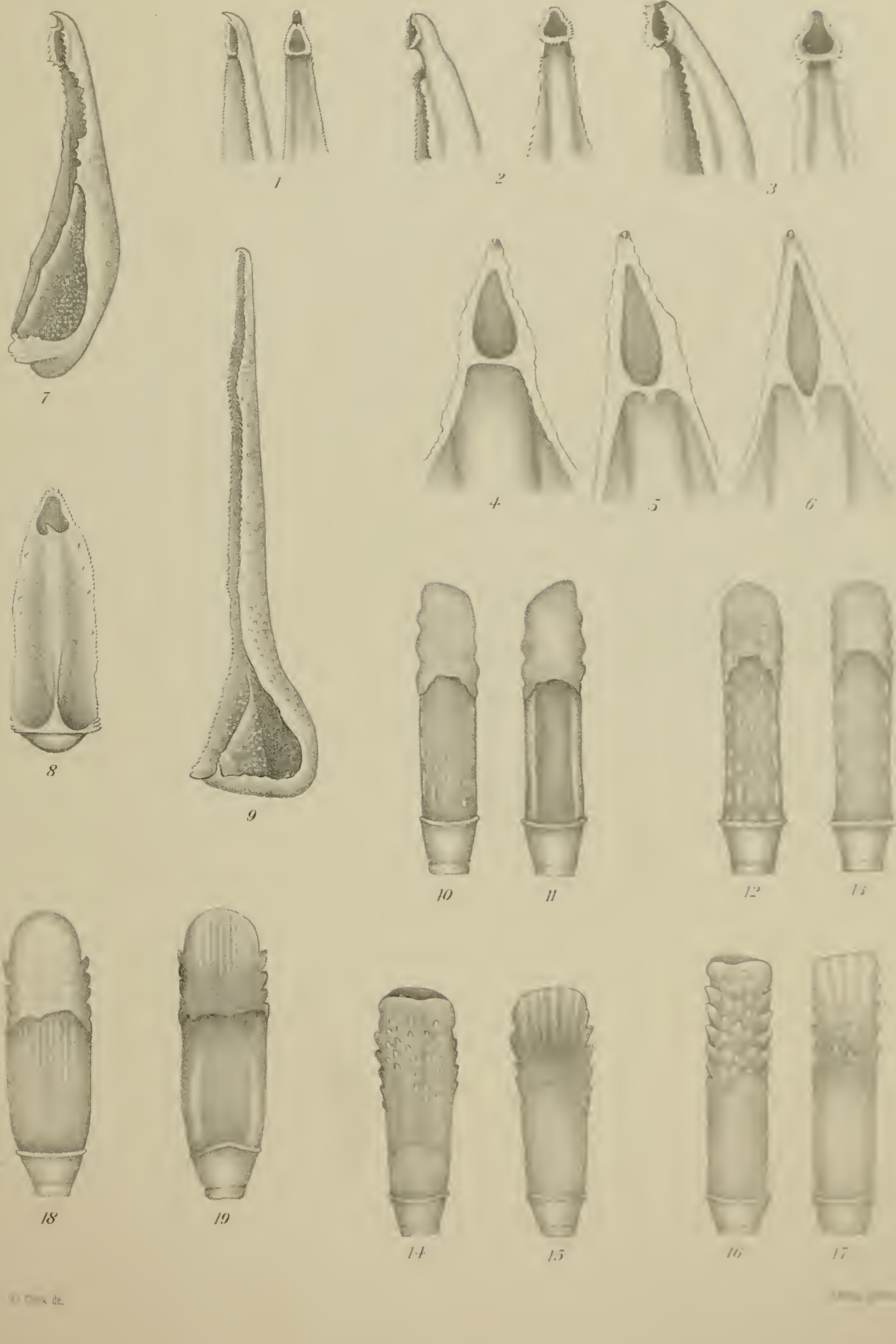

1
2
3
7
4
5
6
8
9
10
11
12
13
18
19
14
15
16
17

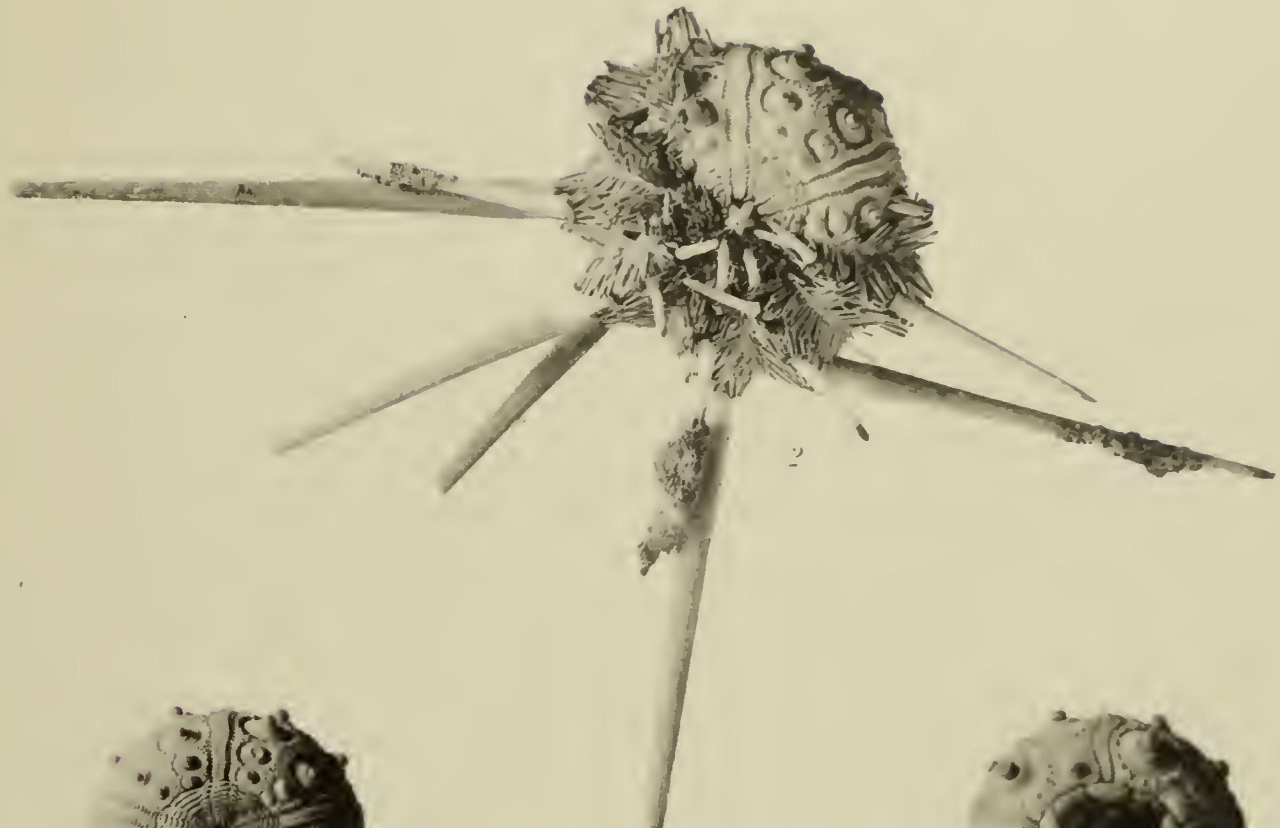
PLATE 13.

Plate 13.

Dorocidaris calacantha A. Ag. and Clark.

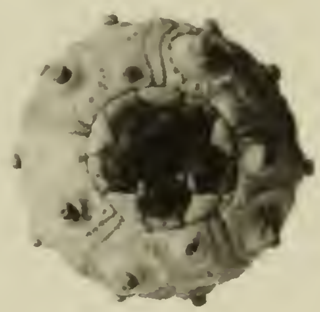
1. (7 on Plate.) Abactinal view of partly cleaned specimen.
2. Actinal view of same.
3. Abactinal view of cleaned test.
4. Actinal view of same.

All figures natural size.



2

4



6

1

HELIOTYPE CO. BOSTON

PLATE 14.

Plate 14.

Dorocidaris calacantha A. Ag. and Clark.

1. Ambulacral view of partly cleaned specimen.
2. Interambulacral view of same.
3. Interambulacral view of cleaned test.
4. Ambulacral view of same.
5. Abactinal view of partly cleaned young specimen.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

PLATE 15.

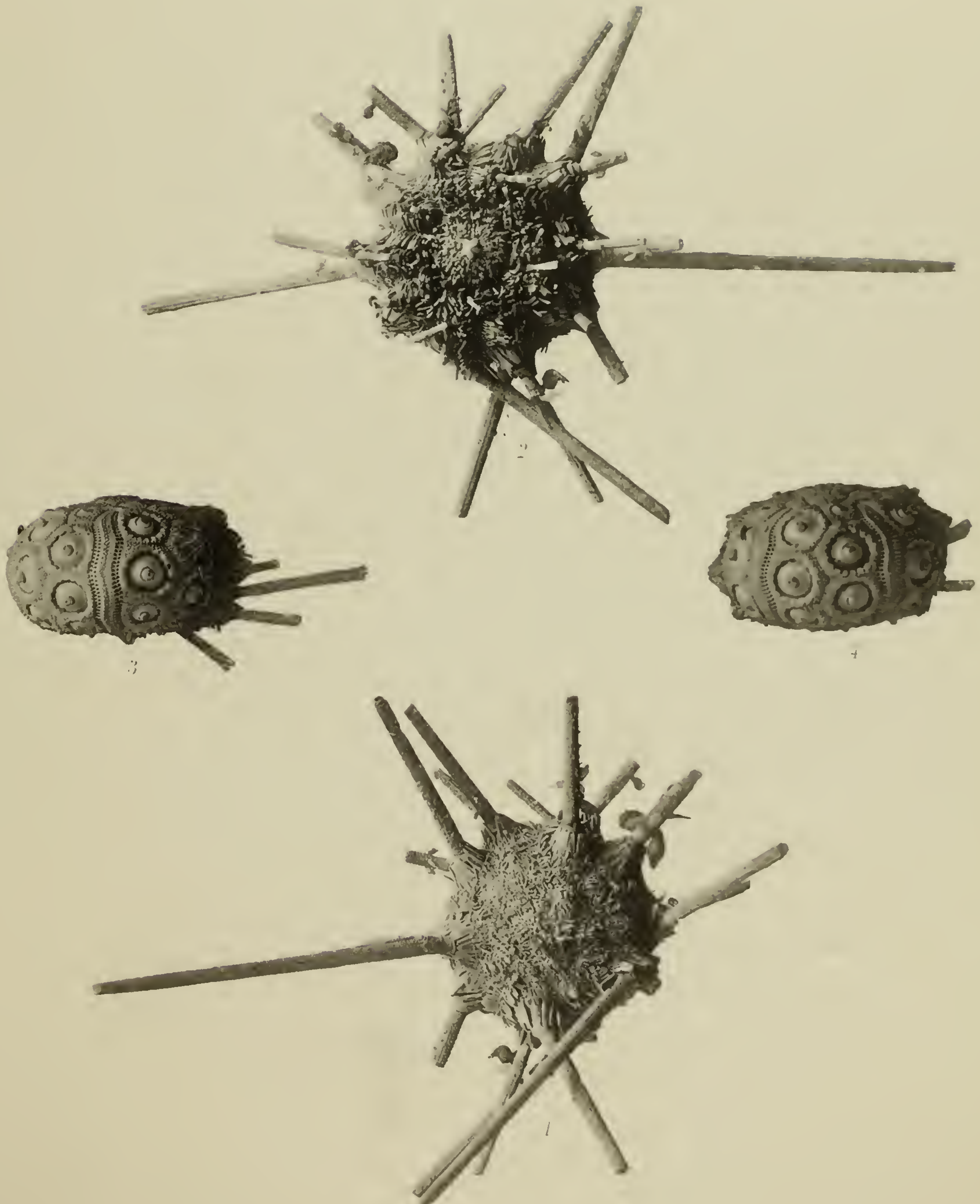
Plate 15.

Stereocidaris leucacantha A. Ag. and Clark.

1. Abactinal view of medium-sized specimen.
2. Actinal view of same.
3. Ambulacral view of partly cleaned specimen.
4. Interambulacral view of same.

Other views of specimen shown in figs. 3 and 4 will be found on Plate 32, figs. 5 and 6.

All figures natural size.



2
3
4
1

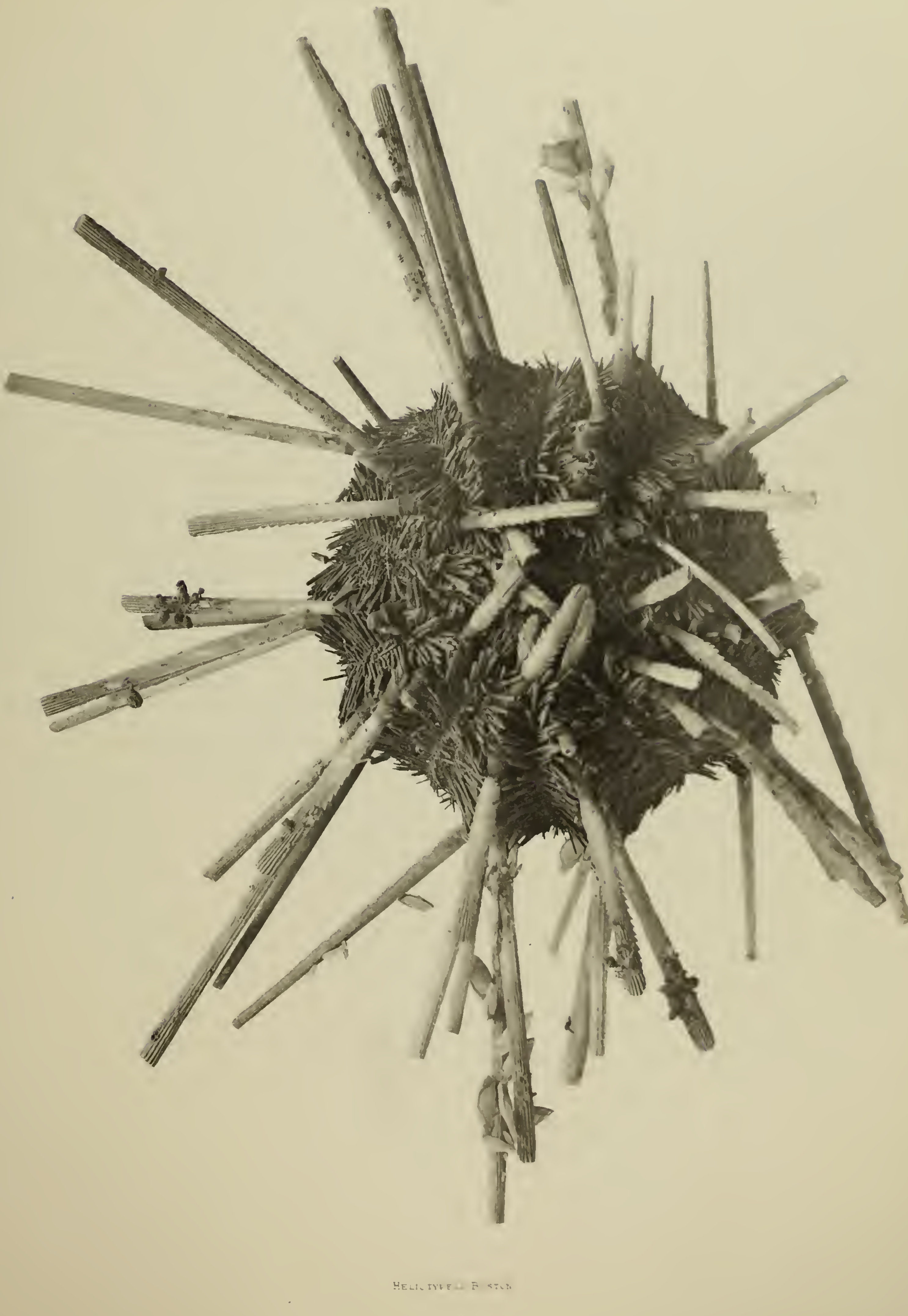
Plate 16.

Plate 16.

Porocidaris variabilis A. Ag. and Clark.

Actinal view. Natural size.

Another view of same specimen is shown in Plate 17.



Heliotype Co. Boston

Plate 17.

Plate **17**.

Porocidaris variabilis A. Ag. and Clark.

Abactinal view. Natural size.

Another view of same specimen is shown in Plate 16.

Heliotype Co. Boston

Plate 18.

Plate 18.

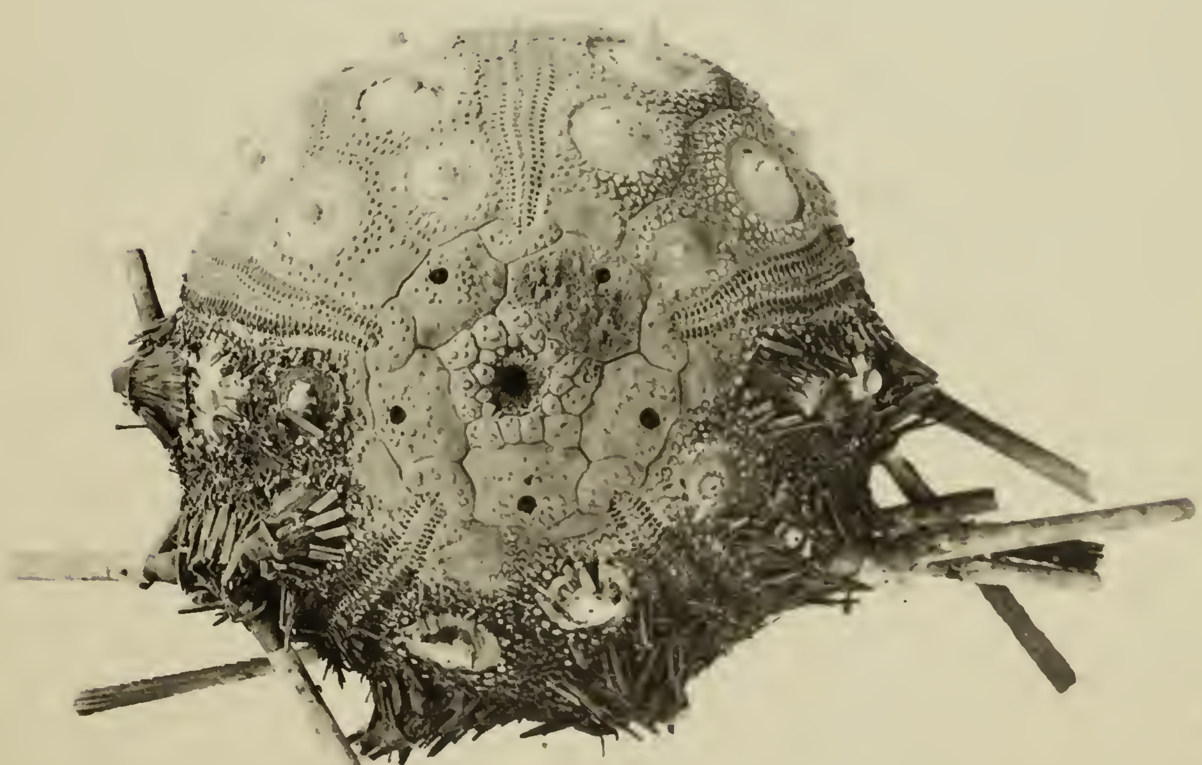
Porocidaris variabilis A. Ag. and Clark.

1. Abactinal view of partly cleaned specimen.
2. Actinal view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 19.

2



1

PLATE 19.

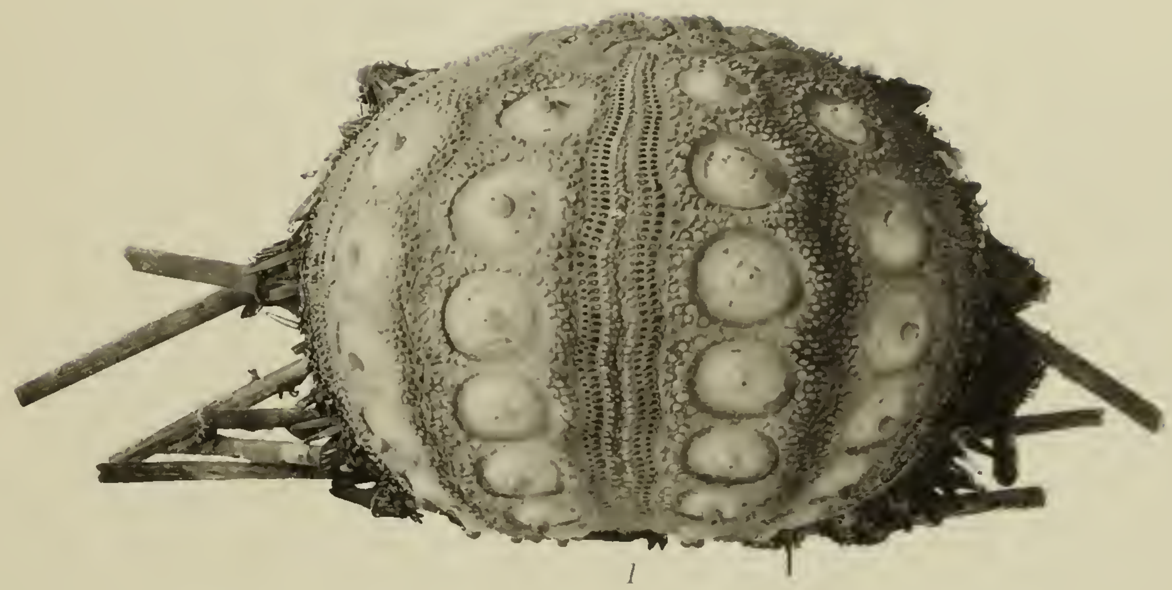
Plate 19.

Porocidaris variabilis A. Ag. and Clark.

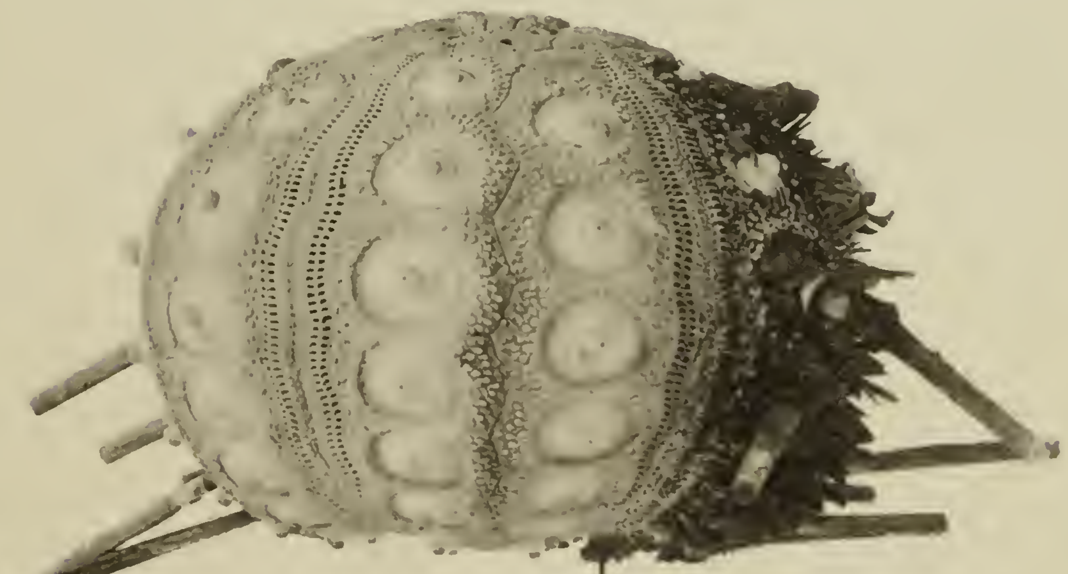
1. Ambulacral view of partly cleaned specimen.
2. Interambulacral view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 18.



1



2

HELIOTYPE CO. BOSTON

Plate 20.

Plate 20.

Porocidaris variabilis A. Ag. and Clark.

Actinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 21.

PLATE 21.

Plate 21.

Porocidaris variabilis A. Ag. and Clark.

Abactinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 20.

HELIOTYPE CO. BOSTON

PLATE 22.

Plate 22.

Porocidaris variabilis A. Ag. and Clark.

1. Actinal view of small specimen.
2. Abactinal view of same.

Both figures natural size.

HELIOTYPE Co. BOSTON

PLATE 23.

PLATE 23.

1–4. **Porocidaris variabilis** A. Ag. and Clark.

1. Abactinal view of partly cleaned, light-colored specimen.
2. Actinal view of same.
3. Ambulacral view of same.
4. Interambulacral view of same.

5–8. **Aporocidaris fragilis** A. Ag. and Clark.

5. Abactinal view of cleaned test.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

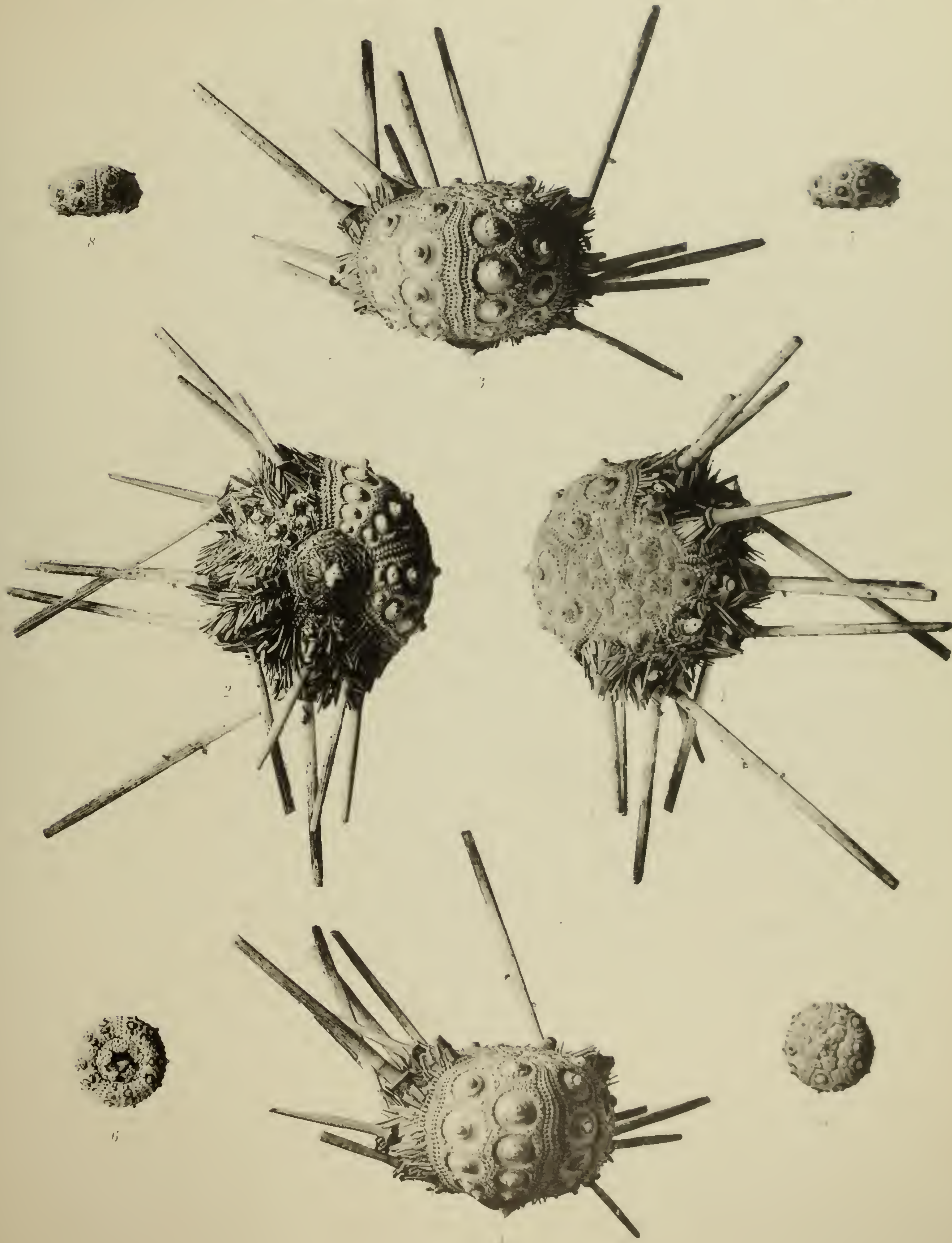


PLATE 24.

Plate **24**.

Stephanocidaris hawaiiensis A. Ag. and Clark.

Actinal view. Natural size.

Another view of same specimen is shown in Plate 25.

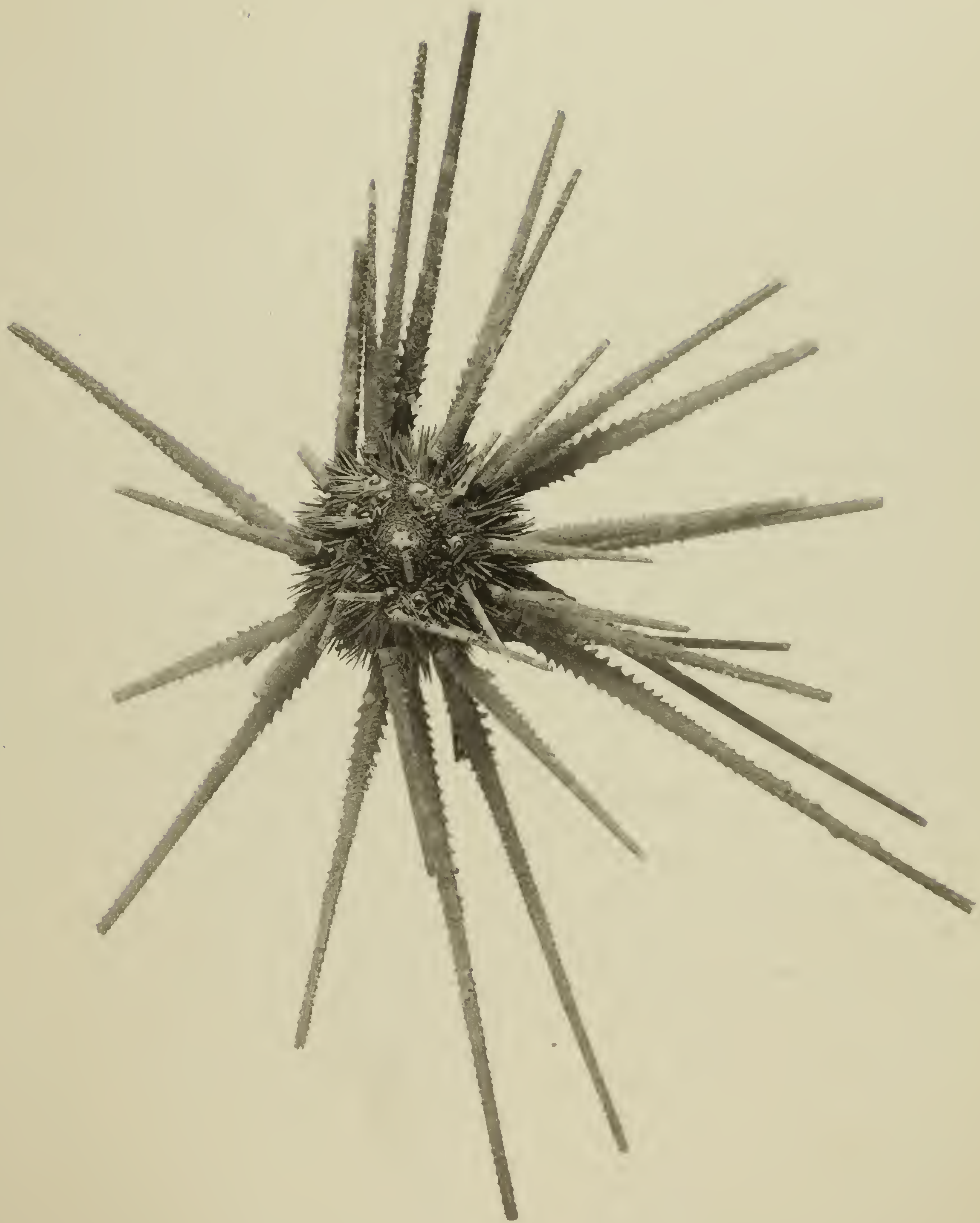


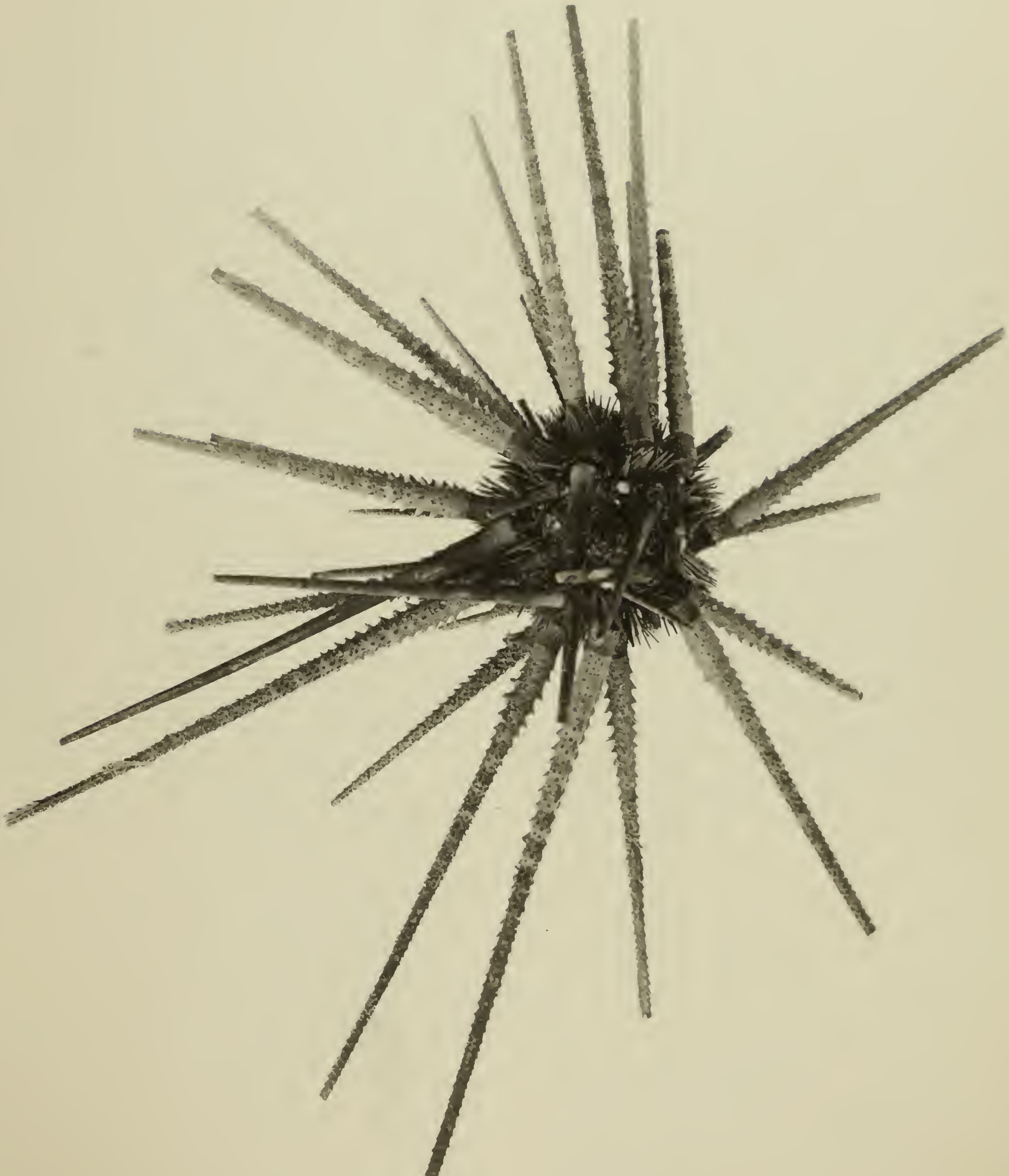
Plate 25.

PLATE 25.

Stephanocidaris hawaiiensis A. Ag. and Clark.

Abactinal view. Natural size.

Another view of same specimen is shown in Plate 24.



HELIOTYPE CO. BOSTON

Plate 26

Plate 26.

1–4. **Stephanocidaris hawaiiensis** A. Ag and Clark.

1. Abactinal view of cleaned test.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.

5–8. **Phyllacanthus Thomasii** A. Ag. and Clark.

5. Abactinal view of cleaned test of medium-sized specimen.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

2 1

4

6

8

PLATE 27.

PLATE 27.

Phyllacanthus Thomasii A. Ag. and Clark.

Actinal view of partly cleaned specimen. Natural size.

Other views of same specimen are shown in Plates 28 and 29.

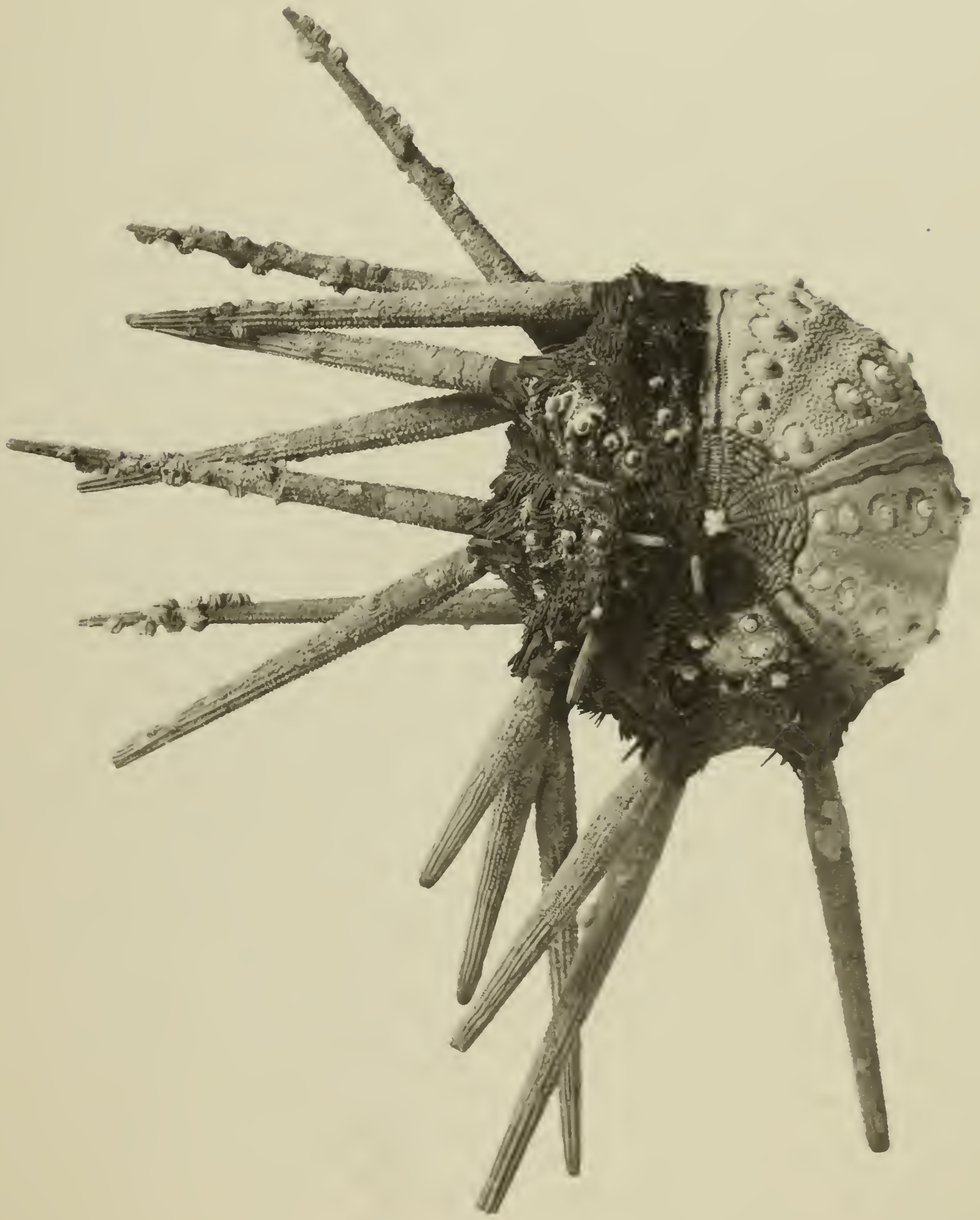


Plate 28.

Plate 28.

Phyllacanthus Thomasii A. Ag. and Clark.

Abactinal view of partly cleaned specimen. Natural size.

Other views of same specimen are shown in Plates 27 and 29.

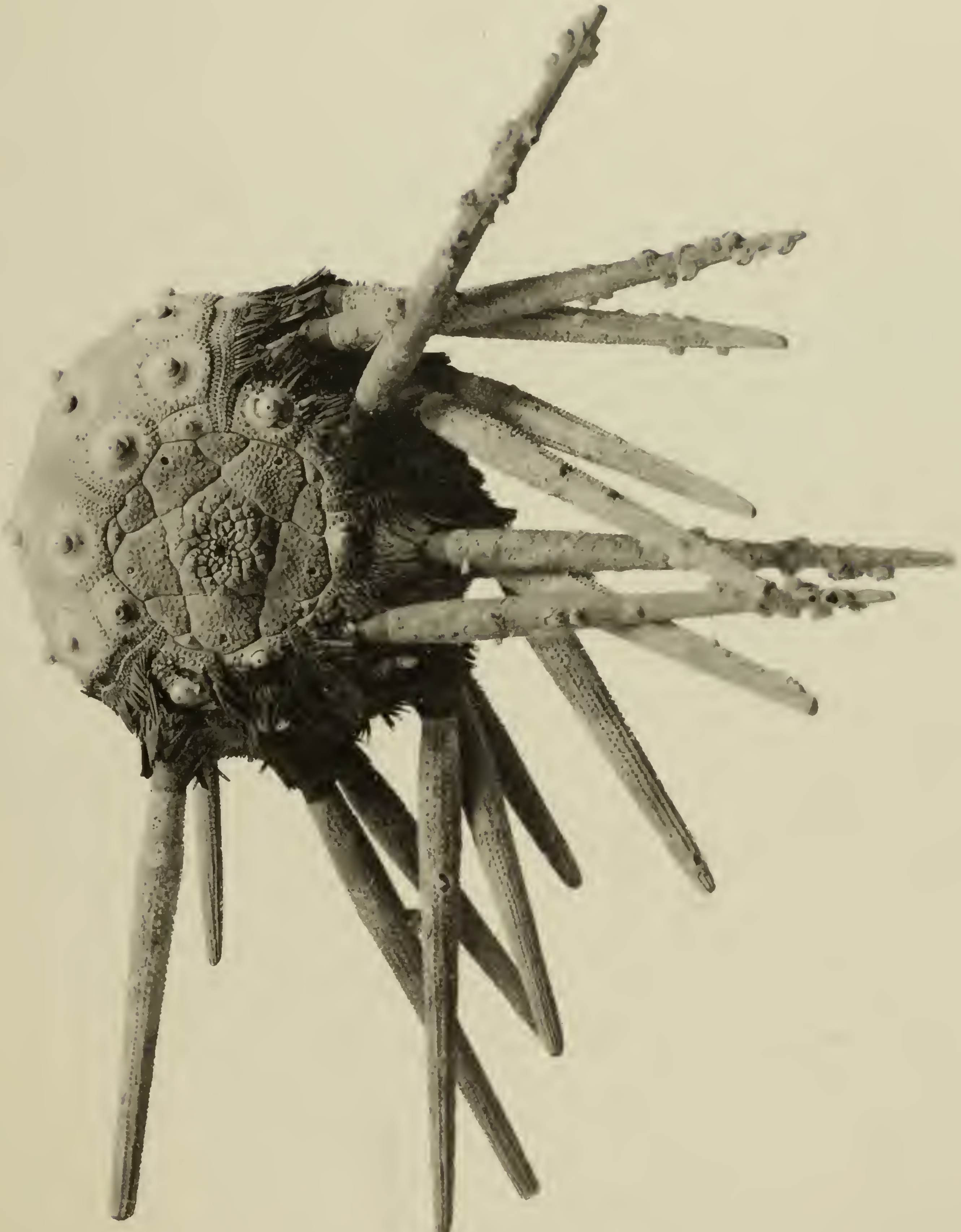


Plate 29.

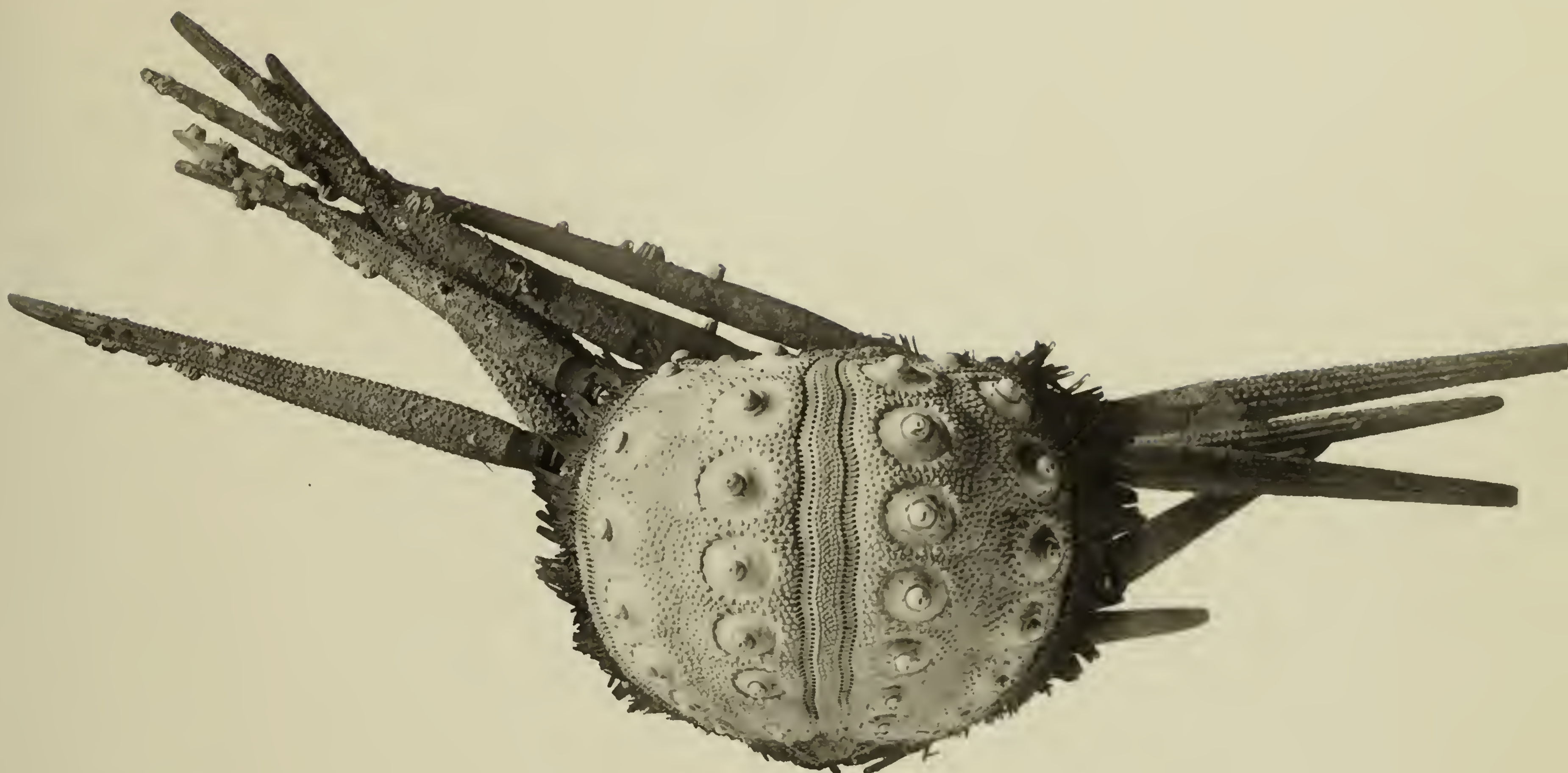
Plate 29.

Phyllacanthus Thomasii A. Ag. and Clark.

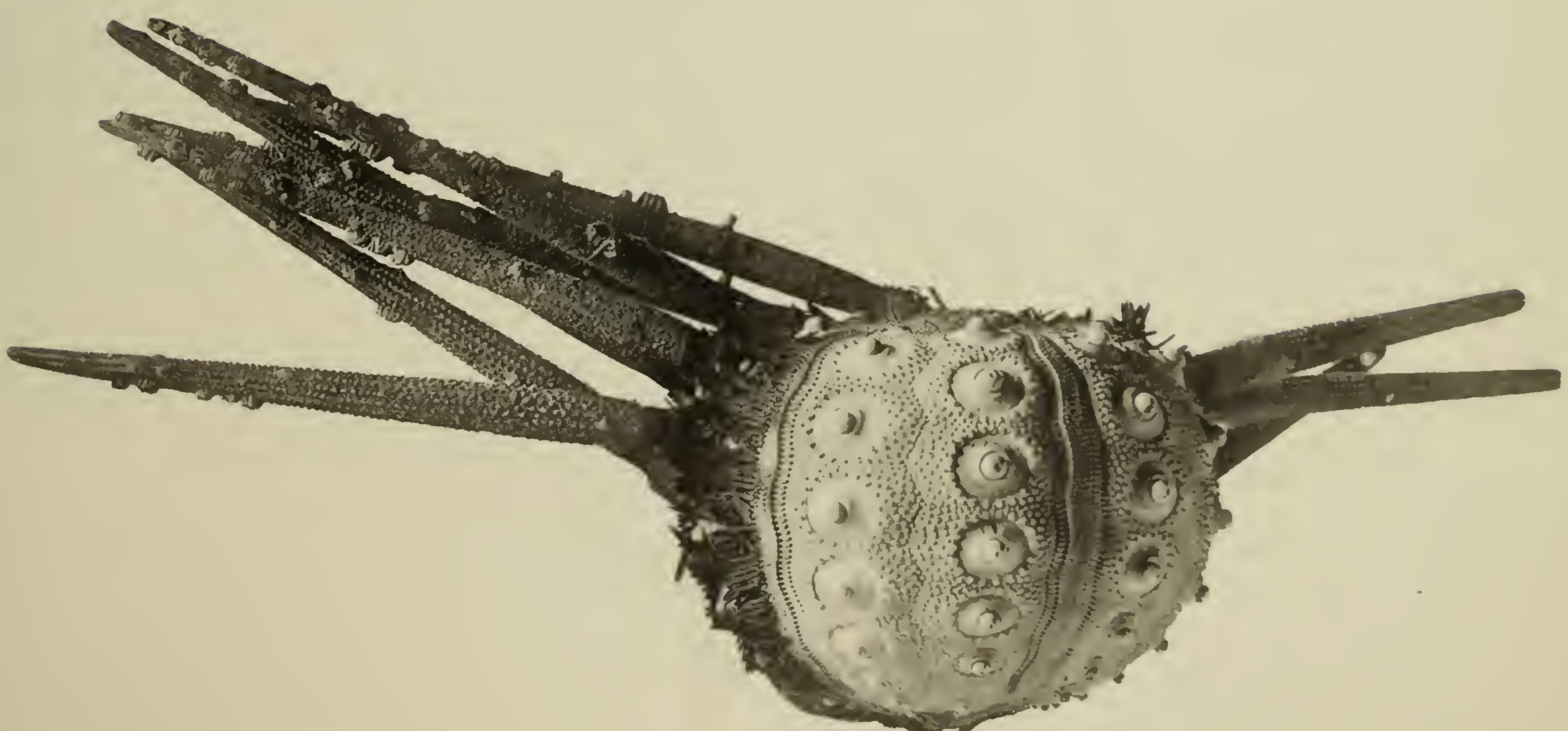
1. Ambulacral view of partly cleaned specimen.
2. Interambulacral view of same.

Both figures natural size.

Other views of same specimen are shown in Plates 27 and 28.



1



2

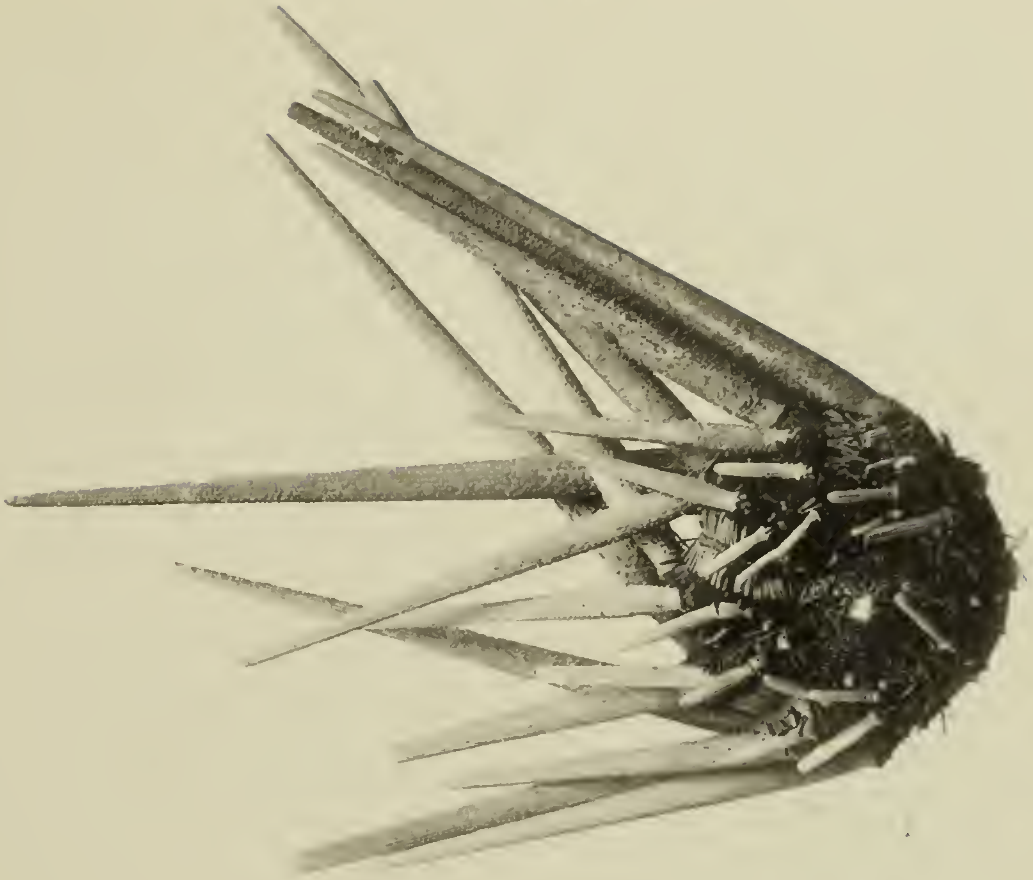
PLATE 30.

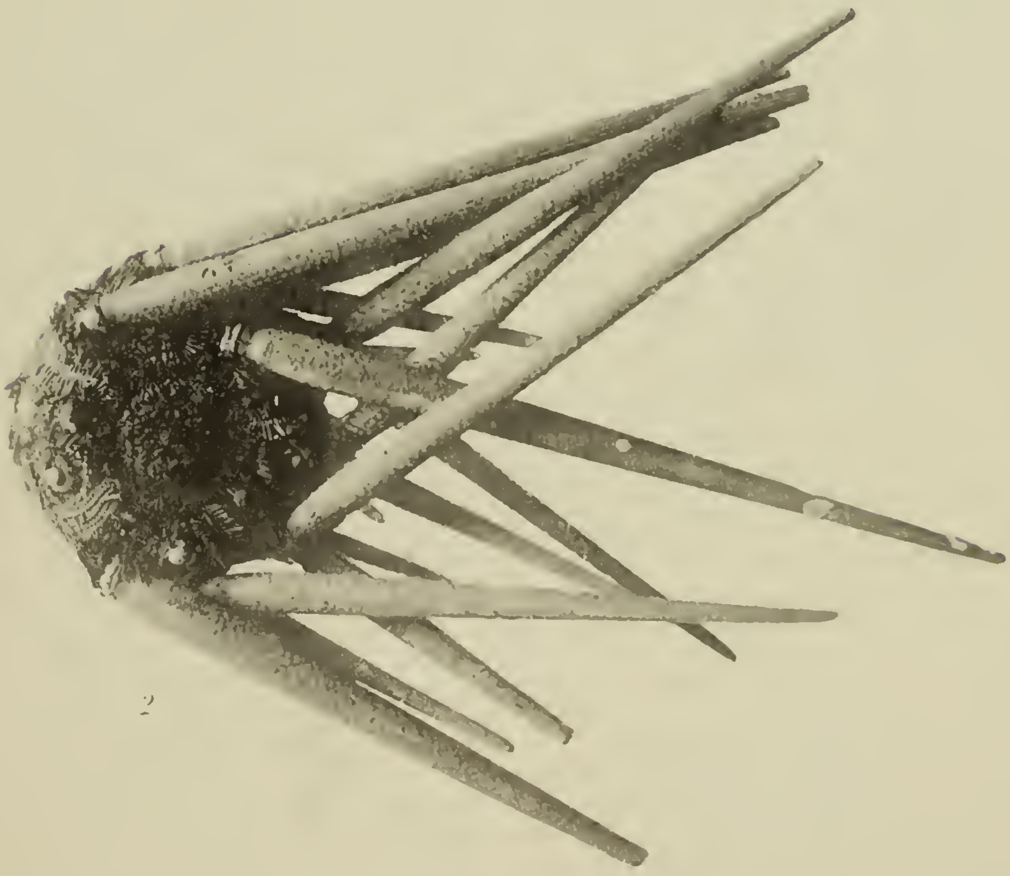
Plate 30.

Phyllacanthus Thomasii A. Ag. and Clark.

1. Actinal view of small specimen.
2. Abactinal view of same.

Both figures natural size.





2

PLATE 31.

Plate 31.

1-4. **Phyllacanthus Thomasii** A. Ag. and Clark.

1. Abactinal view of cleaned test of small specimen.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.

5-8. **Anomocidaris tenuispina** A. Ag. and Clark.

5. Abactinal view of partly cleaned specimen.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

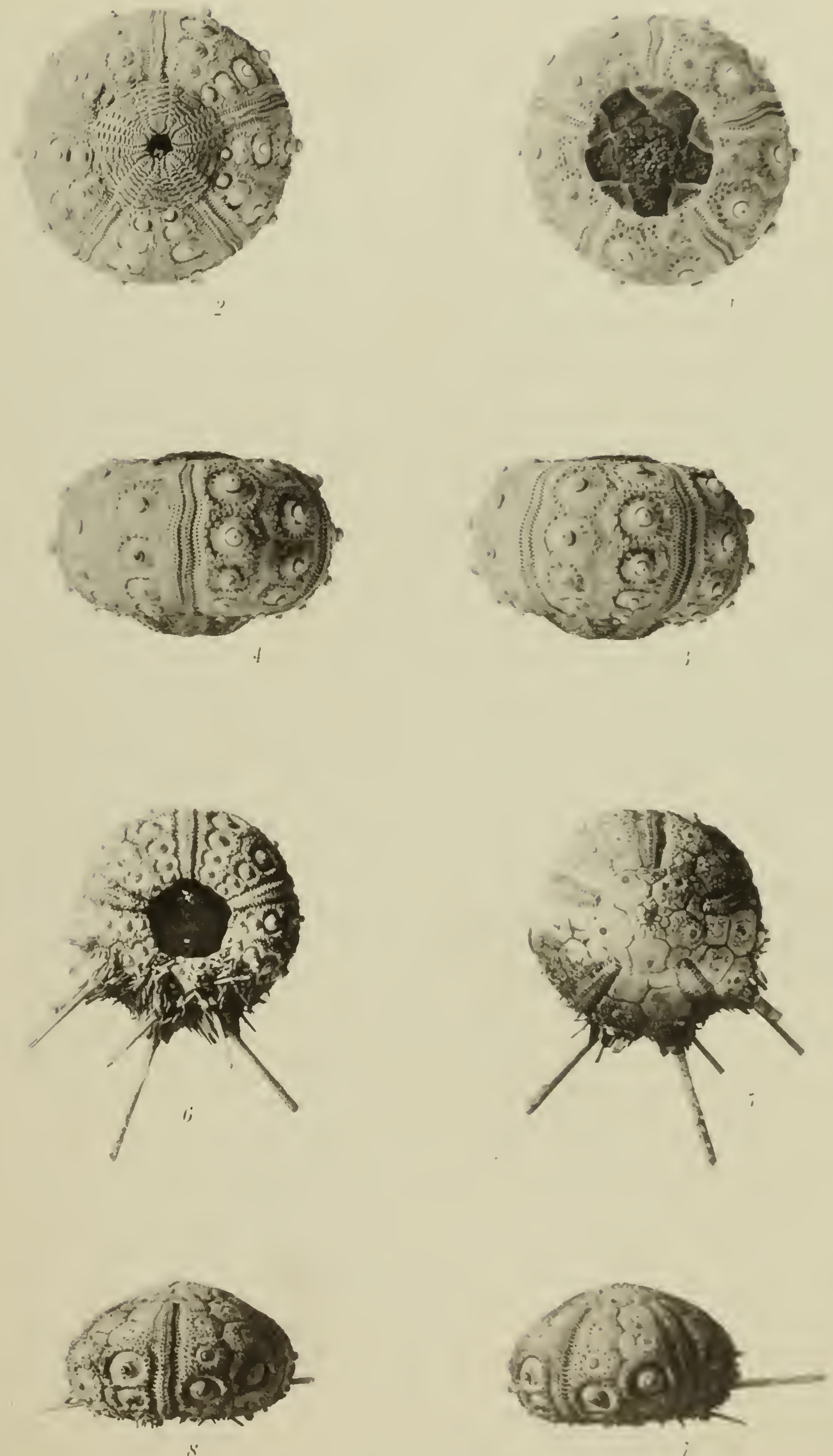

2
4
6
8

PLATE 32.

Plate 32.

Stereocidaris leucacantha A. Ag. and Clark.

1. Abactinal view of partly cleaned, large specimen; primaries all broken.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.
5. Abactinal view of partly cleaned, small specimen.
6. Actinal view of same.

All figures natural size.

Other views of specimen shown in figs. 5 and 6 will be found in Plate 15, figs. 3 and 4.

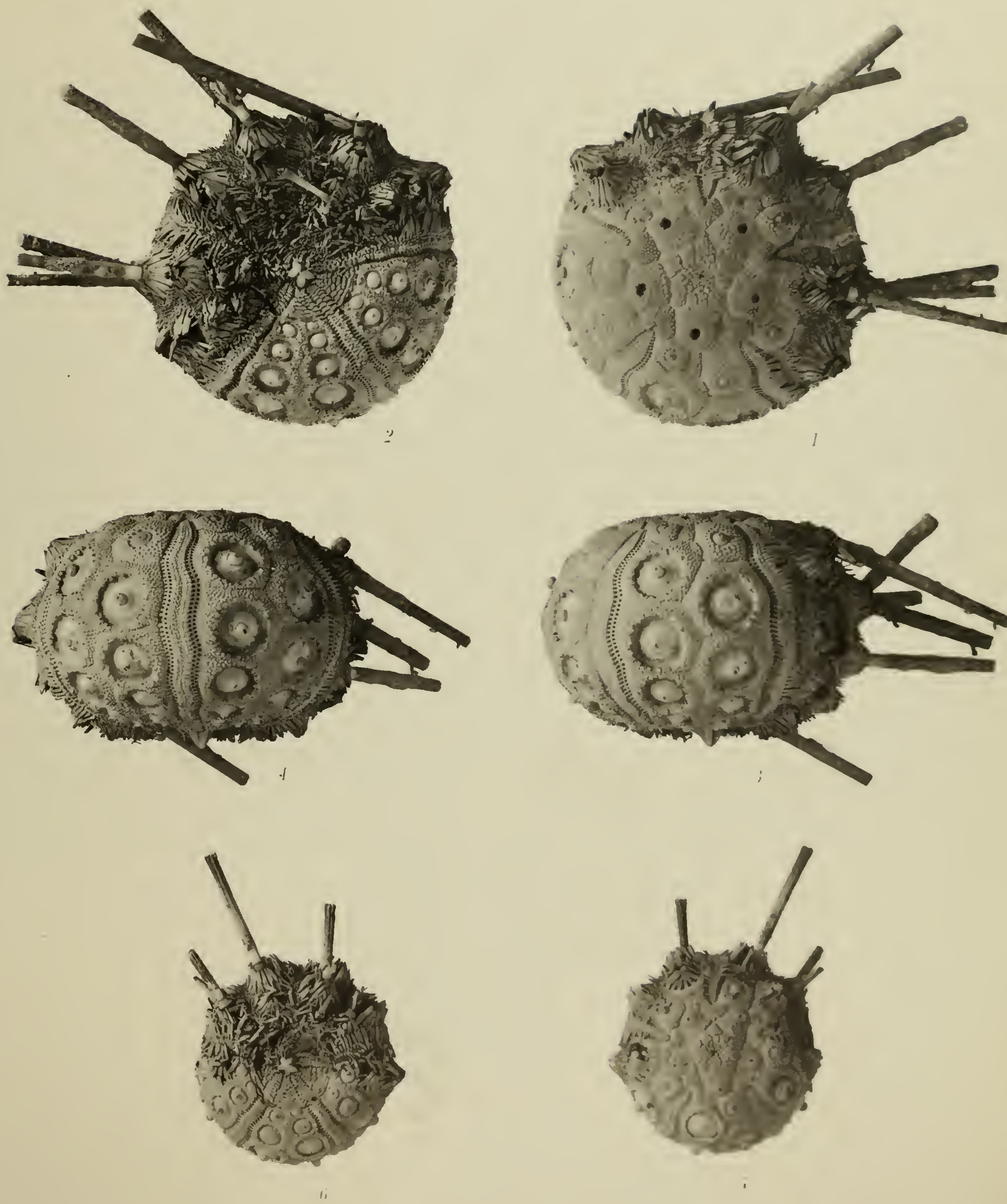

2
1
4
3
6

Plate 33.

Plate 33.

Stereocidaris grandis Döderlein.

1. Ambulacral view of partly cleaned specimen from Hawaii.
2. Abactinal view of same.
3. Actinal view of same.
4. Interambulacral view of same.

All figures natural size.

1

2

3

4

PLATE 34.

Plate 34.

Dorocidaris calacantha A. Ag. and Clark.

Actinal view. Natural size.

Another view of same specimen is shown in Plate 35.

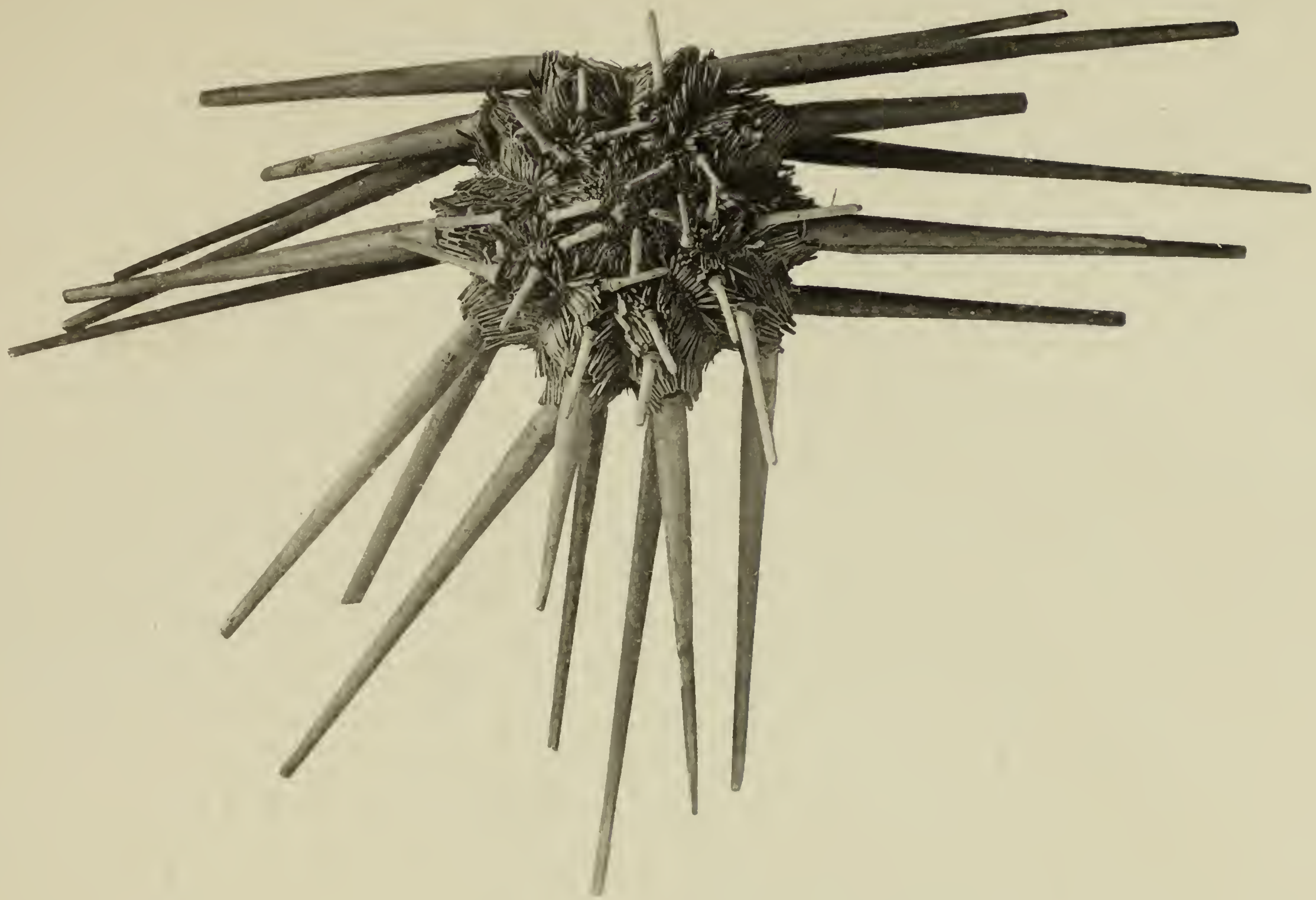


Plate 35.

PLATE 35.

Dorocidaris calacantha A. Ag. and Clark.

Abactinal view. Natural size.

Another view of same specimen is shown in Plate 34.

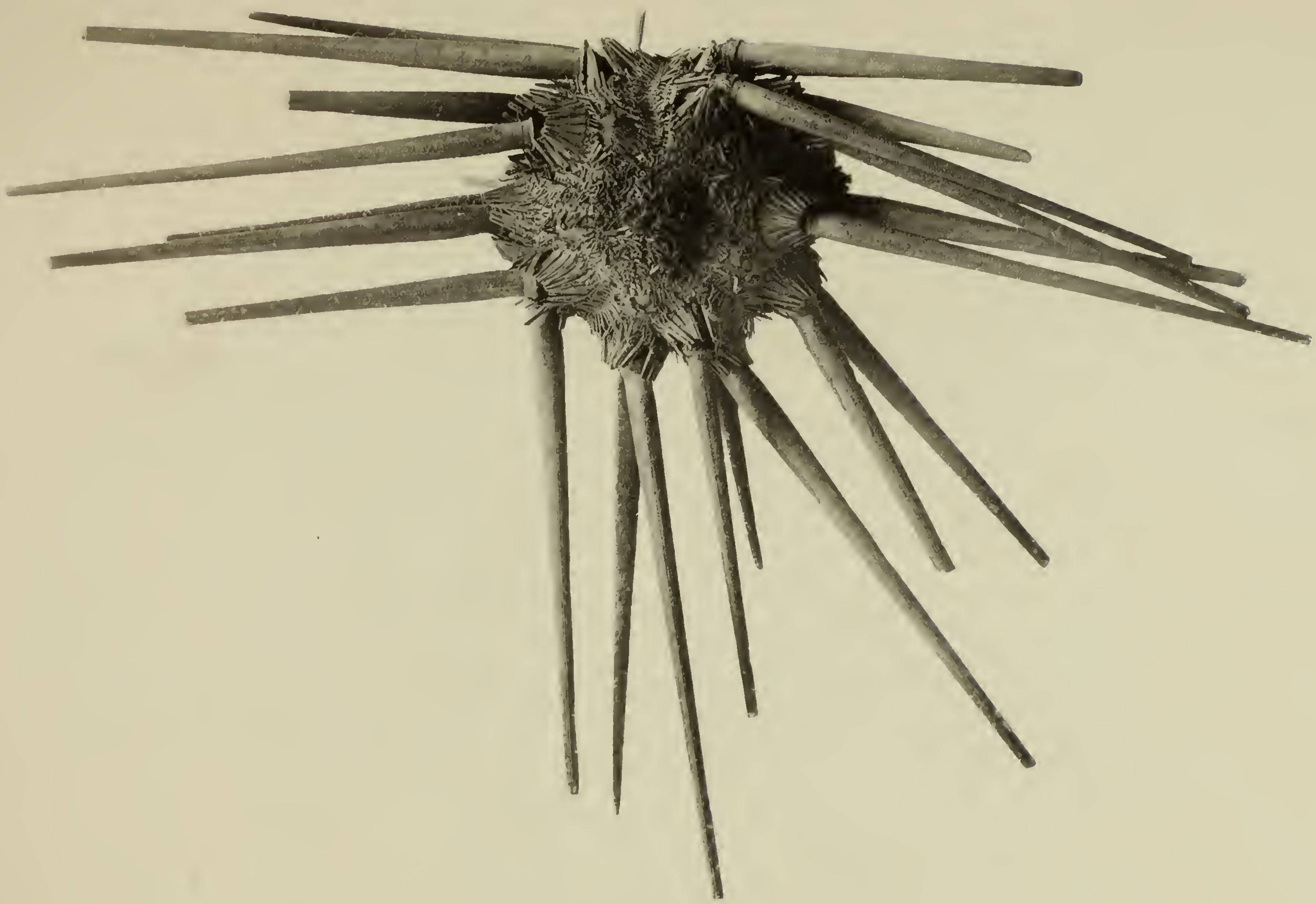


PLATE 36.

PLATE 36.

Stereocidaris grandis Döderlein.

1. Abactinal view of partly cleaned specimen from Japan.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.

All figures natural size.

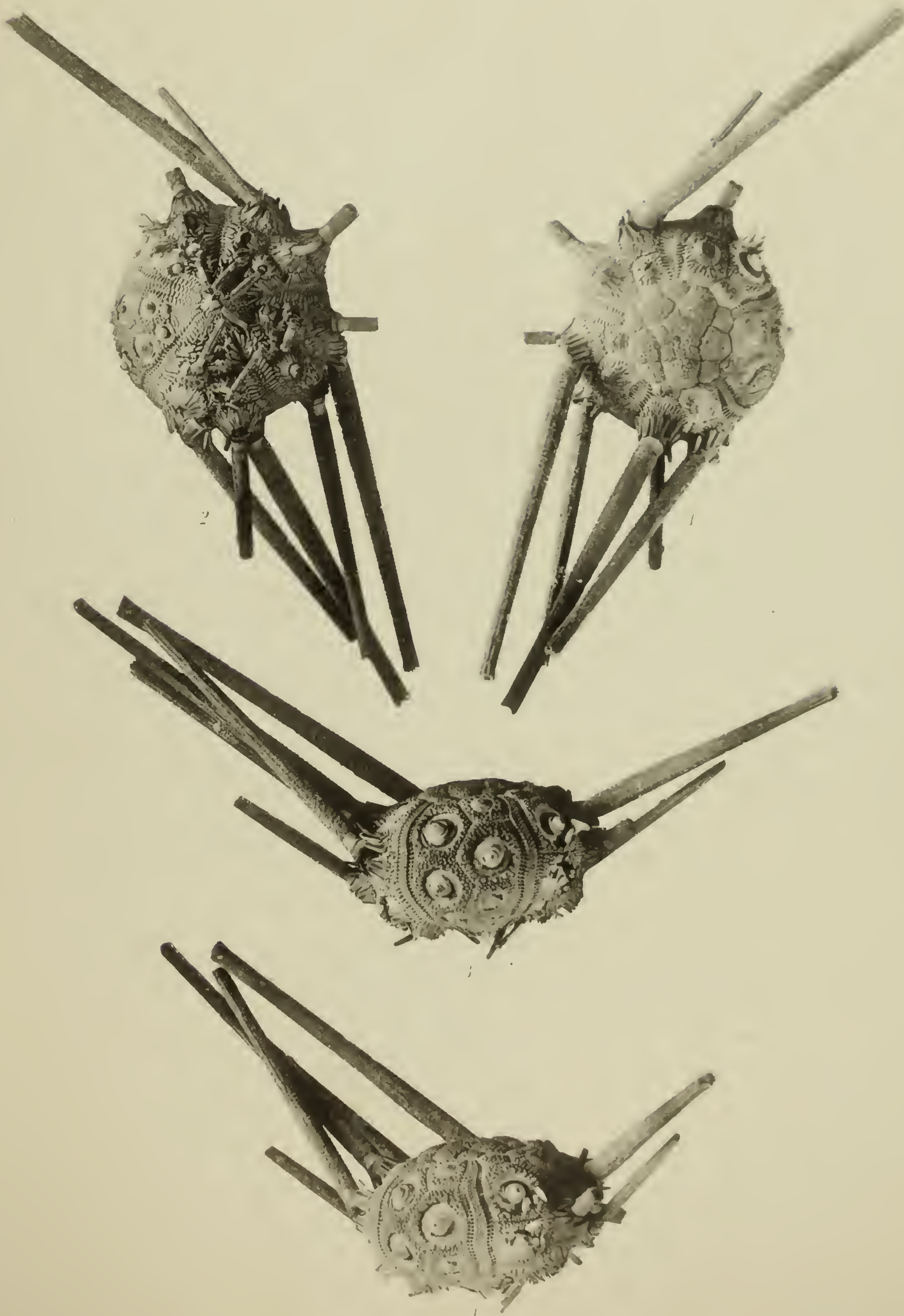

2
1
3
4

Plate 37.

Plate 37.

Acanthocidaris hastigera A. Ag and Clark.

Actinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 38.

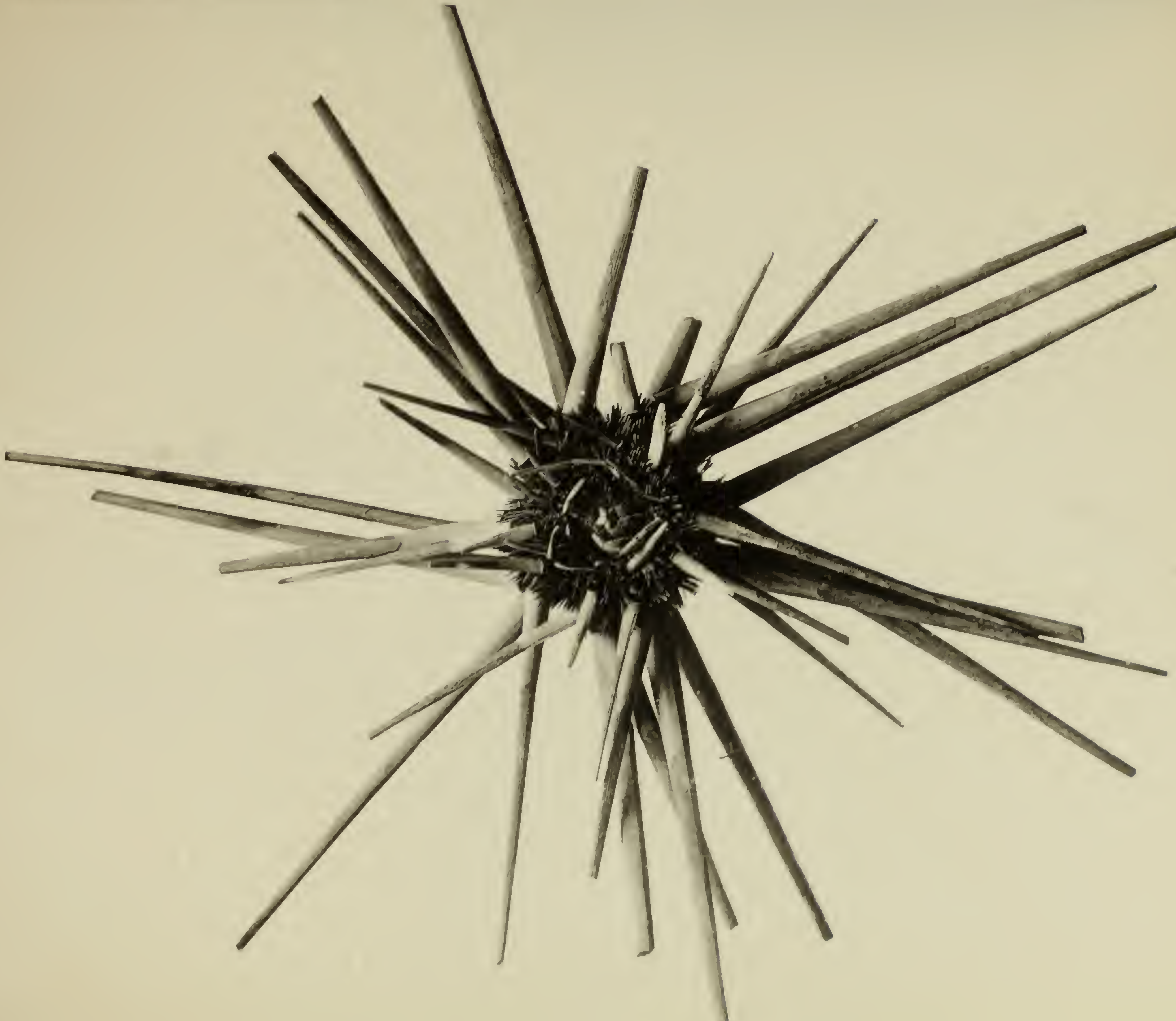


Plate 38.

Plate 38.

Acanthocidaris hastigera A. Ag and Clark.

Abactinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 37.

PLATE 39.

Plate 39.

Acanthocidaris hastigera A. Ag and Clark.

1. Actinal view of partly cleaned, large specimen.
2. Abactinal view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 40.

1

2

PLATE 40.

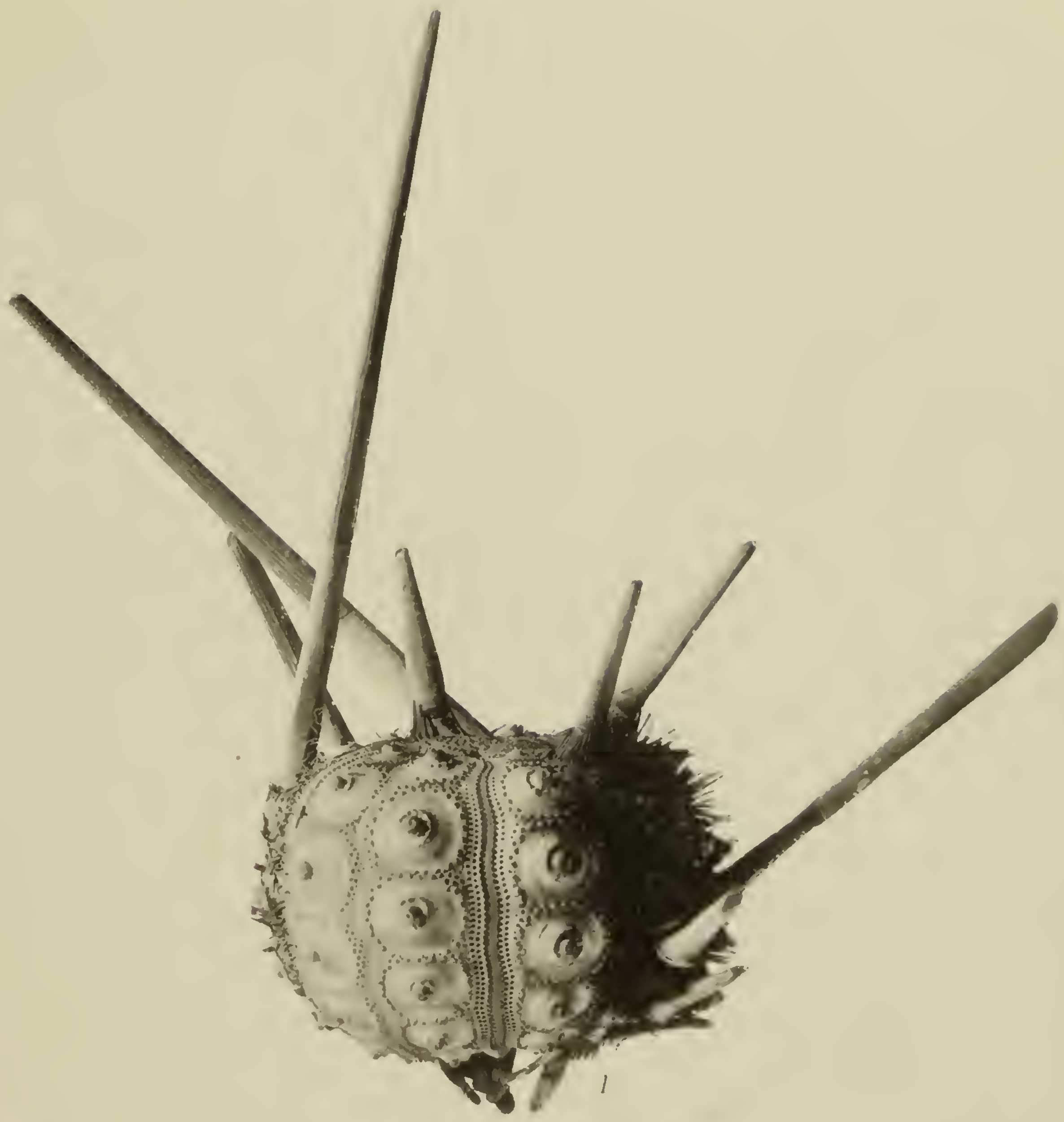
Plate 40.

Acanthocidaris hastigera A. Ag. and Clark.

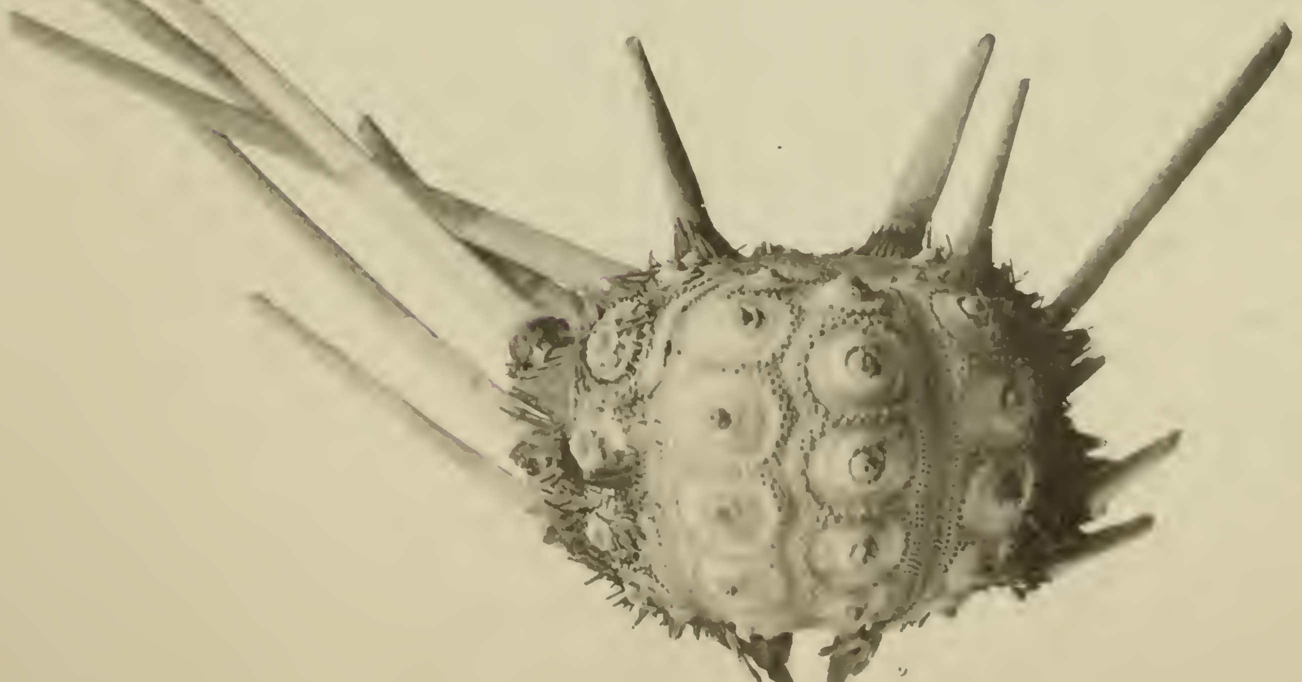
1. Ambulacral view of partly cleaned, large specimen.
2. Interambulacral view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 39.



1



2

HELIOTYPE CO. BOSTON

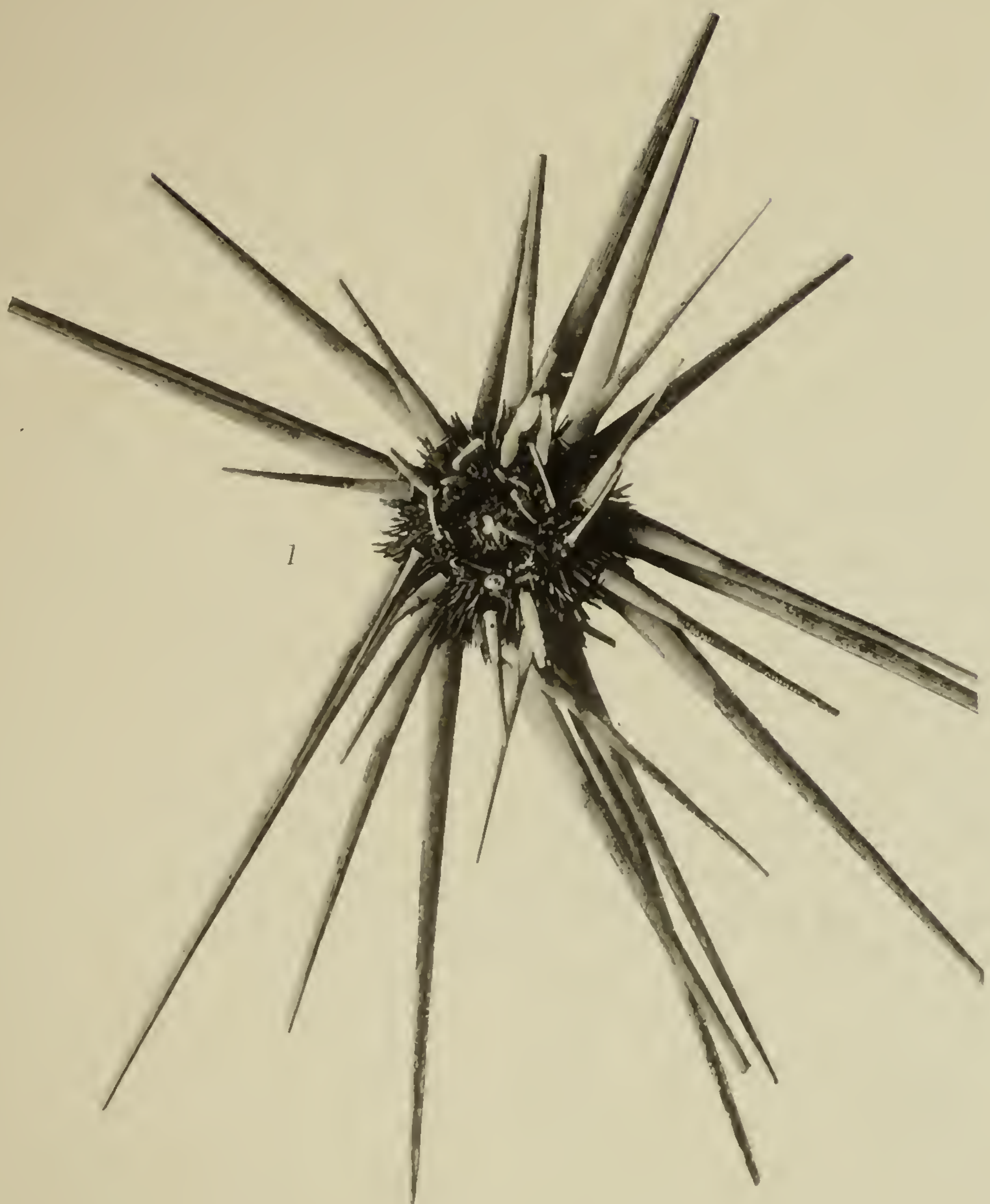
PLATE 41.

PLATE 41.

Acanthocidaris hastigera A. Ag. and Clark.

1. Actinal view of small specimen.
2. Abactinal view of same.

Both figures natural size.



1

2

Plate 42.

Plate 42.

Acanthocidaris hastigera A. Ag. and Clark.

1. Abactinal view of partly cleaned, small specimen.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.
5. Abactinal view of small specimen.
6. Actinal view of same.
7. Abactinal view of partly cleaned, very small specimen.
8. Actinal view of same.
9. Interambulacral view of same.
10. Ambulacral view of same.

All figures natural size.

Heliotype Co. Boston

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXXIV. No. 2.

HAWAIIAN AND OTHER PACIFIC ECHINI.

THE SALENIDÆ, ARBACIADÆ, ASPIDODIADEMATIDÆ, AND DIADEMATIDÆ.

BY

ALEXANDER AGASSIZ and HUBERT LYMAN CLARK.

WITH SEVENTEEN PLATES.

Plates 43–59.

[Published by Permission of George M. Bowers, U. S. Commissioner of Fish and Fisheries.]

CAMBRIDGE, U. S. A.:
Printed for the Museum.
September, 1908.

CONTENTS.

CONTENTS.

* Hawaiian species.

The *quadridentate* pedicellariæ (Pl. 45, fig. *1*) are much less common than the tridentate, and are only known to occur in three species. They are usually found on the actinal part of the interambulacra. The head is shorter than the stalk, sometimes very much so, and there is practically no neck. The valves (Pls. 45, fig. *2*; 46, figs. *1*, *2*) range from about three-fourths of a millimeter up to two millimeters in length and are straight and commonly more or less flat. They may afford useful specific characters. Döderlein found one of these pedicellariæ with *five* valves, but we have never seen more than four.

The *ovoid* pedicellariæ (Pl. 45, fig. *4*) are not very common, but are usually to be found on the interambulacra. The head (Pl. 45, fig. *18*) is about one-fourth of a millimeter long, and is attached to the stalk by a neck of about the same length. The stalk itself is three to six times as long as the head. The three valves (Pls. 45, figs. *5*, *12*, *23*; 46, figs. *5*, *6*) are all alike and are distinctly longer than broad. They commonly lack an "articular loop" on the base, but this is occasionally present. For this reason, they seem to us to be modified ophicephalous pedicellariæ, while Döderlein considers them to be small tridentate. They are undoubtedly comparable to the triphyllous pedicellariæ of other Echini, but are hardly sufficiently modified to be called by that name.

The *globose* pedicellariæ (Pl. 45, fig. *6*) are usually common and often abundant, and are to be found on all parts of the test, though they are most frequent on the ambulacra and about the abactinal system. There are often five groups of them present on the buccal plates in large specimens. The head is about one-fourth of a millimeter in length, and the stalk is usually about the same, though it may be twice as much; there is no neck. The valves (Pls. 45, figs. *7*, *13*, *19*, *22*; 46, fig. *4*) are provided with an "articular loop" on the base, but as this is never very large, those of the same head do not differ appreciably from each other. The valves are short and deep, rounded at the tip, and about as wide as long. While there are usually only three, pedicellariæ with four such valves are occasionally to be found. In spite of the small size of the articular loop, there is no reason to doubt that these globose pedicellariæ of the Salenidæ are ophicephalous.

The sphæridia of the Salenidæ (Pls. 45, figs. *8*, *14*, *15*, *25*; 46, fig. *8*; see also A. Agassiz's Panamic Deep Sea Echini, Pl. 19, fig. *2*) occur on each ambulacrum, at or near the peristome. There are usually two, sometimes three or even more, rather close together, at the middle of the ambulacrum, between the two columns of large tubercles. They are attached, in a more or less pendant condition, by very short stalks, to minute tubercles on the surface of the test. They are spheroidal in Salenia, but are usually ovoid or ellipsoidal in Salenocidaris. In all the recent species the sphæridia are attached flush with the test and not in any depression or concavity, but in the Upper Cretaceous Goniophorus, what are apparently deep pits for the sphæridia, like those of Cœlopleurus, are present in the actinal part of the ambulacra.

The calcareous particles or spicules of the Salenidæ (Pls. 45, figs. *9*, *20*; 46, fig. *7*) are curved rods and perforated plates with more or less numerous and conspicuous projections. They exhibit great diversity, both in abundance and in size and degree of development. In their simplest form the curved rods have projections only on the convex side, but later (or in more developed examples) the projections are found on both sides. As these projections increase in length and thickness, they anastomose more or less freely, and very irregular, perforated plates are thus built up. The simplest rods occur in the pedicels, especially near the tips of the abactinal ones, while the most fully formed plates are found in the buccal membrane. Apparently the abundance and complexity of the calcareous particles increase with age. The slight differences noted between the species do not seem to be sufficiently tangible or constant to warrant their use as a specific character.

The general arrangement of the internal organs of the Salenidæ is shown in figs. *3–6*, Pl. 43. The reproductive organs consist of short, dense tufts of tubules, apparently confined to the abactinal part of the test and body-cavity. The œsophagus is short and nearly straight. The stomach-intestine is only of moderate length, but shows the usual undulations. Its arrangement, however, is quite different in Salenocidaris from what it is in Salenia, as shown by the examination of a number of specimens of each genus. In Salenia (figs. *3*, *4*), the lower or actinal half of the stomach-intestine is distinctly undulated, raised in the ambulacra, lowered in the interambulacra, while the upper or abactinal half is much longer and narrower, and is nearly cylindrical; it is also greatly undulated, the interambulacral loops being particularly well marked. In Salenocidaris (figs. *5*, *6*), on the other hand, the undulations of the actinal half of the canal are scarcely visible, while the abactinal half is much shorter and stouter than in Salenia, with only the undulations of the posterior interambulacra marked, and at least two of these modified into small pouches.

The Genera and Species of Salenidæ.

This well-marked family contains ten apparently valid and clearly recognizable genera, of which, however, only two contain recent species. These genera are distinguished from each other by the position of the suranal plate, the condition of the tubercles (i. e. whether perforate or not), the presence or absence of compound ambulacral plates abactinally, the presence or absence of sphæridial pits, and the ornamentation of the abactinal system. A convenient grouping of the genera according to these characters may be made as follows:

- Suranal plate axial and anterior, in contact with only four genital plates.
  - Primary interambulacral tubercles perforate.
    - Ambulacra broad, straight, or little flexuous, with perforate primary tubercles.
      - Ambulacral plates above ambitus, compound.
        - Compound ambulacral plates made up of 3 plates . . . *Acrosalenia.*
        - Compound ambulacral plates made up of 2 plates . . . *Plesiosalenia.*
      - Ambulacral plates above ambitus simple primaries . . . . . *Perisalenia.*
    - Ambulacra narrow, flexuous, with only imperforate small tubercles or granules . . . . *Pseudosalenia.*
  - Primary interambulacral tubercles, imperforate.
    - Large pits (for sphæridia ?) present in actinal, ambulacral plates . *Goniophorus.*
    - No such pits present . . . . *Peltastes.*
- Suranal plate not axial, but in contact with all five genital plates.
  - Primary interambulacral tubercles perforate . . . . *Heterosalenia.*
  - Primary interambulacral tubercles imperforate.
    - Ambulacral plates compound, made up of 2 plates . . . . *Salenia.*
    - Ambulacral plates, except one or two at peristome, simple primaries only.
      - Ambulacral tubercles numerous (more than 20); abactinal system with plates distinctly separated by grooves or pits and not covered with tubercles . . . . *Salenidia.*
      - Ambulacral tubercles usually less than 15, rarely more than 20; abactinal system with plates not distinctly separated and covered with small, rough tubercles . . . . *Salenocidaris.*

The genera Hyposalenia Desor and Poropeltaris (or Poropeltis) Quenstedt (1875, Petr. Deutsch.: Ech. p. 242) are simply synonyms of Peltastes, while Trisalenia Lambert appears to have been based on a misconception, and Eosalenia Savin is not one of the Salenidæ. Pomel's genera Bathysalenia and Pleurosalenia are not distinguishable from Salenidia and Salenocidaris.

Acrosalenia.

Agassiz, 1840. Ech. foss. Suisses, Pt. 2, p. 38.
Type-species, *Acrosalenia spinosa* Agass., 1840. Ech. foss. Suisses, Pt. 2, p. 39.
Jurassic and Lower Cretaceous Salenidæ.

Plesiosalenia.

Valette, 1906. Bull. Soc. Sci. Hist. Nat. Yonne, LIX, p. 275.
Type-species, *Acrosalenia pentagona* Cott., 1879. Pal. Franç., Terr. Jur., p. 365.
Jurassic Salenidæ.

Perisalenia.

Valette, 1906. Bull. Soc. Sci. Hist. Nat. Yonne, LIX, p. 276.
Type-species, *Acrosalenia Gauthieri* Cott., 1879. Pal. Franç., Terr. Jur., p. 357.
Jurassic Salenidæ.

Pseudosalenia.

Cotteau, 1859. Rev. Mag. Zool., No. 4, p. 22.
Type-species, *Pseudosalenia flexuosa* Cott., 1859. Rev. Mag. Zool., No. 4, p. 24.
Jurassic Salenidæ.

Goniophorus.

Agassiz, 1838. Mon. d'Ech. Viv. et Foss., I, p. 30.
Type-species, *Goniophorus lunulatus* Agass., 1838. Mon. d'Ech. Viv. et Foss., I, p. 30.
Upper Cretaceous Salenidæ.

Peltastes.

Agassiz, 1838. Mon. d'Ech. Viv. et Foss., I, p. 27.
Type-species, *Peltastes pulchellus* Agass., 1838. Mon. d'Ech. Viv. et Foss., I, p. 27.
Upper Jurassic and Cretaceous Salenidæ.

Heterosalenia.

Cotteau, 1861. Pal. Franç., Terr. Crét., p. 96.
Type-species, *Heterosalenia Martini* Cott., 1861. Pal. Franç., Terr. Crét., p. 97.
Cretaceous Salenidæ.

Salenia.

Gray, 1835. Proc. Zool. Soc. London, p. 58.
Type-species, *Cidarites scutiger* Goldfuss, 1829. Petrefacta, Pt. 1, p. 121.
Cretaceous, Tertiary, and Recent Salenidæ.

Three recent species of this genus are now to be recognized: *S. Pattersoni* A. Ag., which occurs from Western Cuba and Yucatan to Barbados, in 50–315 fathoms; the form collected by the "Valdivia" on Agulhas Bank, off the Cape of Good Hope, in 56 fathoms, and identified by Döderlein as *Pattersoni*, but which is undoubtedly distinct from that species, and may be appropriately called *phoinissa* (= dark red); and *S. cincta* A. Ag. and Cl., collected by the "Albatross" in the northwestern Pacific, in 95–152 fathoms. (So far as can be judged from de Meijere's brief description, the small Salenia collected by the "Siboga" in the Sulu Archipelago, in 290 fathoms, and referred by him to *Pattersoni*, is probably *cincta*.) These three living species are all notable for their handsome coloration, the abactinal system being prettily ornamented, and the primary spines conspicuously banded or spotted with some shade of red. They may be distinguished from each other as follows:

Actinal system, .40–.55 h. d.[1]; primaries rather slender, thickness commonly much less than 5 per cent of length; no red-brown pigment on test or secondaries.
  Abactinal system, .60–.70 h. d., light colored with plates outlined in deep violet; primaries with 3–5 broad bands of bright red . . . . *Pattersoni.*
  Abactinal system, .55–.60 h. d., deep purplish; primaries with 12–16 narrow bands of dull red . . . . *cincta.*
Actinal system, .30–.35 h. d.; primaries rather stout, thickness often 4–5 per cent of length; test and secondaries with red-brown pigment; abactinal system about .55 h. d., very dark; primaries with 9 broad, brown-red spots on upper surface . . . . *phoinissa.*

In addition to these differences, it is interesting to note that *Pattersoni* has both tridentate and quadridentate pedicellariæ, the latter with valves up to 2 mm. long, while *phoinissa* apparently lacks quadridentate, and the valves of the tridentate are seldom half a millimeter in length. In *cincta* neither tridentate nor quadridentate pedicellariæ have been found, and it would seem that they are characteristically absent. In Döderlein's description of the "Valdivia" specimen, he says there are 3 rows of secondary tubercles in the ambulacra. It is impossible to tell from the illustrations given whether this is really the case, or whether the "3" is not a misprint for 2. If it is not a misprint, we have here another very important difference between *phoinissa* and *Pattersoni*, for even the largest specimens of the latter have only 2 series of ambulacral tubercles.

[1] There are two abbreviations used frequently in the following pages, h. d. and v. d.; the former refers to the horizontal, the latter to the vertical diameter of the test.

Salenia Pattersoni A. Ag.

Salenia Pattersoni A. Agassiz, 1878. Bull. M. C. Z., V, p. 187.

Plates 43, figs. *3, 4;* 46, figs. *1–8.*

This species was not taken by the "Albatross," but is included in order to describe its pedicellariæ.

The distribution of the pedicellariæ is not peculiar, except that the abactinal system is strikingly free from them, save around the ocular plates; a few are also scattered among the anal plates.

The quadridentate pedicellariæ are very large, the head alone measuring up to as much as 2 mm. in length; the valves (Pl. 46, figs. *1* and *2*) are straight, broad, and usually flat, but may be more or less compressed and hollowed out.

The tridentate are much smaller, the valves (Pl. 46, fig. *3*) only .50–.75 mm. in length.

The ovoid pedicellariæ show some diversity in size and form; the valves (Pl. 46, fig. *6*) are sometimes over .30 mm. long, and occasionally are distinctly pointed and provided with an "articular loop" (Pl. 46, fig. *5*).

The globose pedicellariæ have the valves (Pl. 46, fig. *4*) somewhat elongated, .16–.30 mm. in length.

Salenia cincta A. Ag. and Cl.

Salenia cincta A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 116.

Plates 45, figs. *22–25;* 52, figs. *8–13;* 57, figs. *1–3.*

This handsome species is closely related to *S. Pattersoni* A. Ag., but is easily distinguished by its coloration. The test, secondary spines, and especially the abactinal system are a deep purple, or greenish more or less tinged with purple (Pl. 57, figs. *1–3*). The primary interambulacral radioles are white, more or less tinged with green on the upper side, with 12 to 16 broad rings of dull brick-red. The longest radiole of the specimen figured (Pl. 57, fig. *1*) is 52 mm., with sixteen bands.

The ambulacral miliary spines are stout, flat, rectangular, with rounded outer angles about 1.75 mm. long, in marked contrast to the thin ones of *S. Pattersoni.* The test is much flatter than that of *Pattersoni;* a specimen (Pl. 52, figs. *8, 9*) 12 mm. in diameter is 7 mm. in height, while a specimen of *Pattersoni* 11.5 mm. in diameter is more globular, being 9 mm. in height. The proportions of the actinal and abactinal systems are nearly the same; in *S. cincta* the abactinal system is 7 mm. in greatest diameter, the actinal, 5.7 mm; in *S. Pattersoni* they are 7.5 mm. and 5.6 mm. The interambulacral system is composed of six or seven primary plates in each column. The primary tubercles are comparatively small, the median edge of the plates being occupied by rather large secondary tubercles (Pl. 52, fig. *11*) set closely together and forming two vertical lines, with a deeply sunken and narrow groove between them, giving the interambulacral face of the test much the appearance of having a sunken groove as in *Goniocidaris canaliculata*. This feature is scarcely shown in Pl. 52, figs. *8* and *11*, as the drawing is not shaded. On the edge of the plate adjoining the ambulacral system there are only two secondary tubercles, one in each angle of the coronal plate (Pl. 52, fig. *11*).

In the ambulacral system there are either 14 or 15 plates of nearly uniform size in each column. Each plate carries a primary tubercle and, except the uppermost and lowermost, one or two secondaries. These plates are made up of two components which are abactinally of nearly equal size but actinally appear more clearly as a primary plate and an accessory plate. The Hemicidaris character of the actinal ambulacral tubercles is but slightly developed (Pl. 52, figs. *8*, *10*).

The actinal system is covered by six more or less concentric series of irregularly pentagonal or hexagonal plates, the pairs of poriferous plates forming the most prominent series; these pairs are separated from each other by a set of narrow intercalated plates connecting the actinal with the outer rows.

The abactinal system is very striking from the prominent horseshoe-shaped ridge which borders the ocular plates (Pl. 52, fig. *9*) and the regular heptagonal outline of the lateral genital plates. The suranal plate, the odd genital, the right posterior ocular and the right posterior genital plates surround the anal system. This is covered with small irregularly arranged pentagonal or polygonal plates, the larger plates carrying a single minute miliary. The ocular plates are of uniform size, with the exception of the right posterior ocular, which is somewhat smaller. The genital ring and the suranal plate are covered with a fine granulation; a small heart-shaped shield covers the surface of the oculars, which appear like triangular plates with convex pointed sides cutting into the genital ring, but owing to their nearly straight outer sides they scarcely project beyond the general line of the genital ring.

The tridentate and quadridentate pedicellariæ are entirely wanting in all the specimens examined. The ovoid pedicellariæ are very small, the valves (Pl. 45, fig. *23*) less than .20 mm. long and the stalk little longer; they are very scarce, and appear to be confined to the vicinity of the actinostome. The globose pedicellariæ are also very small, the valves (Pl. 45, fig. *22*) measuring only .15–.25 mm., but the stalk is in proportion noticeably long, .25–.50 mm. They are rather infrequent, occurring only near the ocular plates, along the ambulacra and on the actinostomal plates.

This species was collected at the following stations:

Station 4893. Southwest of Goto Islands, Japan. Bott. temp. 55.9°. 95–106 fathoms. Gy. s. br. sh. p.

Station 4894. Southwest of Goto Islands, Japan. Bott. temp. 55.9°? 95 fathoms. Gy. s. br. sh. p.

Station 4895. Southwest of Goto Islands, Japan. Bott. temp. 55.9°? 95 fathoms. Gy. s. br. sh. p.

Station 4934. Off Kagoshima Gulf, Japan. Bott. temp. 56°? 103–152 fathoms. Rky.

Station 4936. Off Kagoshima Gulf, Japan. Bott. temp. 60.6°? 103 fathoms. St.

Bathymetrical range, 95–152 fathoms. Extremes of temperature, 60.6°?–55.9°. Twelve specimens.

Salenidia.

Pomel, 1883. Class. Meth., p. 94.

Type-species, *Salenia gibba* Agass. 1838. Mon. d'Ech. Viv. et Foss., I, p. 13.

Upper Cretaceous and Tertiary Salenidæ.

Salenocidaris.

A. Agassiz, 1869. Bull. M. C. Z., I, p. 254.

Type-species, *Salenocidaris varispina* A. Ag., 1869. Bull. M. C. Z., I, p. 254.

Recent Salenidæ.

Four valid species of this genus may now be recognized, although they are very closely related, and young specimens are very difficult to identify. In the order of their discovery these species are as follows: *S. varispina*

A. Ag., which occurs in the Western Atlantic Ocean and Caribbean Sea, at depths of 150–950 fathoms, though most commonly below 400; *S. profundi* Duncan (commonly known as *S. hastigera* A. Ag., but as the two names refer to the same species, the earlier must have precedence), which is apparently almost cosmopolitan, having been reported from the north and south Atlantic and from a number of stations in the East Indian region, at depths of 100–1850 fathoms, though most commonly below 1000; *S. miliaris* A. Ag., which is known from various stations in the north Pacific, between the Gulf of Panama and Japan, at depths of 670–1680 fathoms; *S. crassispina* A. Ag. and Cl., which is known only from a single Hawaiian specimen, taken in 147–198 fathoms. There can be no doubt that *goesiana* Lovén is based on a very young specimen of either *varispina* or *profundi*, one cannot say which. The species figured by Wyville Thomson in "The Voyage of the Challenger: The Atlantic" (Vol. I, figs. *31, 32*), as *varispina* is a young *profundi*. The specimens given by de Meijere (1904) and Döderlein (1906) as *hastigera* are probably *miliaris*, but as those writers neither describe nor figure the relation of the ocular plates to the anal system, the point cannot be positively determined; the large number of ambulacral plates and the great height of the test in Döderlein's specimen indicate *miliaris*. Döderlein now (1906) considers his Japanese species, *pacifica*, as identical with *hastigera*, but it seems more probable that it is *miliaris*; this is certainly indicated by the abactinal system (compare A. Agassiz, 1881, Challenger Echini, Pl. 4, fig. *10*; Döderlein, 1887, Jap. Seigel, Pl. 11, fig. *9*; and A. Agassiz, 1904, Panamic Deep Sea Echini, Pl. 16, fig. *4*). The species of this genus have pure white primary spines, while the test, secondaries, and abactinal system are more or less deeply colored with violet or purple pigment. They may be distinguished from each other, when adult, by the following characters, but it must be borne in mind that specimens under 9 mm. h. d. are young and cannot be distinguished in all cases with certainty.

Primary spines, long and slender, with numerous whorls of minute, delicate teeth; greatest thickness of shaft rarely equalling, and usually much less than, diameter of milled ring.

Coronal plates 8 or 9 (often 7 in specimens less than 9 mm. in diameter); each of the two series of ambulacral tubercles consists of 5 (3–6) larger tubercles actinally and 8 (7–10) smaller ones abactinally; size small, h. d. seldom exceeding 10 mm.; v. d., .40–.50 h. d., or, including the abactinal system, .50–.70 h. d., but usually less than .60; abactinal system usually less than .60 h. d.; actinal system usually less than .50 h. d. . . . . *varispina*.

Coronal plates 6 or 7 (rarely 8 in specimens over 15 mm. h. d.); each of the two series of ambulacral tubercles consists of 3 (2–4) larger tubercles actinally and 11 or more (8–19) abruptly smaller ones abactinally; size larger, h. d. sometimes exceeding 16 mm.

V. d., .50–.55 h. d., or, including the abactinal system, .60–.80 h. d., but usually about .70; abactinal system, .65–.75 h. d.; actinal system, .50–.60 h. d.; abactinal system, *even in mature specimens*, with right posterior ocular plate excluded from the periproct; ambulacral plates 10–15 in each column . . . . *profundi.*

V. d., .60–.70 h. d., or, including the abactinal system, .75–.90 h. d., but usually about .80; abactinal system, .60–.70 h. d.; actinal system about .50 h. d.; abactinal system with right posterior ocular plate usually in contact with the periproct; ambulacral plates 14–22 in each column . . . . *miliaris.*

Primary spines shorter and much stouter, verticillate but quite smooth; greatest thickness of shaft equalling or exceeding diameter of milled ring . . . . *crassispina.*

Salenocidaris varispina A. Ag.

Salenocidaris varispina A. Agassiz, 1869. Bull. M. C. Z., I, p. 254.

Plate 45, figs. *10–15.*

This species was not taken by the "Albatross," but is included so as to give an account of the pedicellariæ.

The distribution of the pedicellariæ is practically the same as in the other Salenidæ, but they seem to be less abundant. The abactinal system carries very few as compared with that of *miliaris.*

The quadridentate seem to be entirely wanting, but the tridentate are not rare and are very characteristic. The valves (figs. *10, 11*) are .50–.60 mm. in length, strongly curved and indented near the tip. The ovoid pedicellariæ are very scarce, and have valves (fig. *12*) only .15–.25 mm. long. The globose show little variety in appearance; the valves (fig. *13*) range from .12–.30 mm. in length and are decidedly longer than broad.

Salenocidaris profundi A. Ag. and Cl.

Salenia profundi Duncan, 1877. Ann. Mag. Nat. Hist. (4), XX, p. 70.
Salenia hastigera A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 198; 1881, Challenger Echini, p. 54, Pl. 4, figs. *3–17*.

Plate 45, figs. *16–21*.

This species was not taken by the "Albatross," but is included so as to give an account of the pedicellariæ.

The distribution of the pedicellariæ is much as in the other species of the genus, but the globose are very abundant, particularly on the abactinal system. The quadridentate and tridentate are infrequent or rare, and almost wholly on the actinal side. Their valves (figs. *16*, *17*) are long, narrow, and nearly straight, and thus quite different from those of *varispina*. The ovoid pedicellariæ (fig. *18*) are not peculiar, but the globose are commonly distinguishable from those of *varispina* by the valves (fig. *19*) being nearly as wide as they are long.

Salenocidaris miliaris A. Ag. and Cl.

Salenia miliaris A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 74.

Plates 43, figs. *5*, *6*; 45, figs. *1–8*.

The quadridentate pedicellariæ (Pl. 45, fig. *1*) are rather infrequent, and occur only actinally and usually on the interambulacra. The stalk is shorter than the valves (Pl. 45, fig *2*), which are from .75–.95 mm. long.

The tridentate pedicellariæ (Pl. 45, fig. *3*) occur also on the interambulacra, but only near the ambitus, and are not very common. The stalk is about equal to the valves, which are .60–.80 mm. in length.

The ovoid pedicellariæ (Pl. 45, fig. *4*) are quite infrequent, and are found chiefly on the interambulacra. The stalk nearly equals the head in thickness, and is five or six times as long; the valves (Pl. 45, fig. *5*) measure about .20–.25 mm. in length.

The globose pedicellariæ (Pl. 45, fig. *6*) are very abundant all over the abactinal system and on the ambulacra; they are less common on the interambulacra; on the actinostomal membrane there are five small, radial clusters of them. The valves (Pl. 45, fig. *7*) nearly equal the stalk in length, measuring .12–.30 mm.

This species was taken by the "Albatross" at the following stations:

Station 4060. Off Alia Point Light, N. E. coast of Hawaii, Hawaiian Islands. Bott. temp. 36.5°. 759–913 fathoms. Fne. gy. vol. s. for. r.

Station 4125. Off Kahuku Point, Oahu, H. I. Bott. temp. 36.4°. 963–1124 fathoms. Br. m. for. r.

Station 4181. Off Hanamaulu, Kauai, H. I. Bott. temp. 38.1°. 671–811 fathoms. Mang. s. glob.

Station 5084. Off Omai Saki Light, Hondo, Japan. Bott. temp. 36.8°. 918 fathoms. Gn. m. fine. s. glob.

Bathymetrical range, 671–1124 fathoms. Extremes of temperature, 38.1°–36.4°. Six specimens.

Salenocidaris crassispina A. Ag. and Cl.

Salenia crassispina A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 234.

Plates 45, fig. *9*; 52, figs. *1–7*.

A single small specimen of this species (Pl. 52, figs. *1–2*) was collected off the West coast of Hawaii in comparatively shallow water, 147–198 fathoms. It measures 4.8 mm. in diameter and 3 mm. in height, and the actinostome is 1.7 mm. in diameter. It is undoubtedly an immature specimen.

It has five-six or six-six interambulacral plates, with two large secondary tubercles at the median suture and one or two smaller tubercles at the line of junction (Pl. 52, fig. *4*) between the ambulacral and interambulacral systems. Three or four of the primary interambulacral tubercles, with huge mammary bosses, are much larger than the others and carry remarkably stout radioles (Pl. 52, figs. *5–7*), which, though distinctly distantly verticillate, yet are quite smooth (Pl. 52, fig. *6*) save for a little serration near the slightly curved tip of the spine (Pl. 52, fig. *7*).

The diameter of the radioles is frequently equal to, or even larger than, that of the milled ring, and the longest one is only 19 mm. There are nine-nine or nine-ten ambulacral plates, their tubercles occupying the whole median part of the plates. The ambulacral pores are on the lower angle of the plates, and on the upper plates can barely be distinguished (Pl. 52, fig. *3*), the tubercles occupying nearly the whole of these upper plates. The Hemicidaris-like development of the actinal tubercles is very marked (Pl. 52, figs. *1, 3*). The ambulacral miliaries are short. On the actinal side of the test there are a few short, pointed, flat serrated radioles.

The actinostome (Pl. 52, fig. *1*) is covered with a pavement of three rows of comparatively large pentagonal or hexagonal plates, the row of poriferous plates being the largest.

The second actinal ambulacral plate in each column and rarely the third, are compound plates (Pl. 52, fig. *1*).

The sculpture of the abactinal system consists of an irregular indefinite pattern (Pl. 52, fig. *2*) which is most prominent on the left lateral genitals and the left anterior ocular. The anal system is wholly included by the suranal plate, the odd and the right posterior genital plates, the right posterior ocular not being in contact with the anal system. The genital plates are irregularly longitudinally heptagonal and form a continuous ring. The oculars are pentagonal widest in the angle of contact with the genital plates. The anal system is covered by eight triangular plates, four of which are larger than the others and carry indistinct miliaries.

Although the primary spines appear to be so characteristic, it is quite possible that more extensive material will prove this species to be based on an aberrant, young individual of *miliaris*.

So far as can be determined from the single, small specimen, the pedicellariæ do not differ from those of *miliaris*, but no quadridentate or tridentate pedicellariæ were found.

This species was taken by the "Albatross" only at

Station 4045. Off Kawaihae Light, W. coast of Hawaii, H. I. Bott. temp. 49°. 147–198 fathoms. Co. s. for. One specimen.

ARBACIADÆ Gray.

The Pedicellariæ and Other Structural Characters.

Plates 44, figs. *1, 2*; 46, figs. *9–16*; 47; 48; 49.

The pedicellariæ of the Arbaciadæ are of two quite distinct types, the tridentate and ophicephalous. Whether true triphyllous pedicellariæ also occur is a debatable question, but we have found it convenient to differentiate under that name certain small pedicellariæ, occurring in a number of species, in which the valves are relatively wider and more leaf-like than in even the smallest tridentate pedicellariæ of the same species. It may be frankly stated, however, that as these small pedicellariæ intergrade completely, in most cases, with the tridentate and in some species are not distinguishable at all, it would be equally correct to consider them simply as a form of the tridentate, and this position would be strengthened by the fact that they are provided with a "neck" and the valves have an "articular loop," quite like those of the tridentate.

One of the most striking features of the family, so far as the pedicellariæ are concerned, is found in the structure of the stalk, which is always made up of a bundle of calcareous threads, parallel and unconnected, united only at the top and base, save for their organic covering. When treated with alkali, therefore, and this covering thereby removed, the threads easily separate from each other (Pls. 46, fig. *12*; 47, fig. *4*). The upper end of the stalk is always a dense mass of calcareous tissue of variable size and shape, and it is interesting to note that each species shows a fairly constant, characteristic form. The constancy is not so great, however, as to warrant the use of this feature for a specific character (compare Pls. 47, figs. *4*, *13*, and *18*; 48, fig. *18*).

The tridentate pedicellariæ (Pls. 46, fig. *9*; 47, fig. *1*) are seldom abundant, frequently common, often rare, and occasionally wholly wanting. If present, they occur at or below the ambitus, less commonly on the abactinal surface, and very rarely on genital or ocular plates. They show a very extraordinary range of size and form. They are always provided with three, and only three, valves, and these are attached to the stalk by a more or less elongated, muscular "neck." The upper end of the stalk is commonly enlarged and rounded (Pl. 49, fig. *25*). The valves may be very narrow, (Pl. 49, fig. *23*), and even compressed (Pl. 46, fig. *11*), the greatest width less than one-third the length, or they may be very broad and flat (Pls. 48, fig. *15*; 49, fig. *19*), the width two-thirds the length. They range in length from .20 to 2.65 mm., while the stalk is equally variable, sometimes barely equalling the head, often 3–5, rarely 10–15, times as long. The blade usually contains a more or less considerable meshwork of calcareous matter, and often the apophysis is continued as a noticeable ridge, well toward the tip of the valve. Sometimes, however, there is no calcareous meshwork, and often the apophysis simply forks at the base of the blade. In one particular the tridentate pedicellariæ of this family are remarkable, and resemble the ophicephalous pedicellariæ, and that is in the presence of a distinct "articular loop" on the base of each valve. Unlike the ophicephalous pedicellariæ, however, the three valves do not show any noticeable individual diversity in any one pedicellaria, the articular loop being of practically the same size on each valve. Individual diversity among the tridentate pedicellariæ is comparatively slight, except in the matter of size, and it seems possible to find good generic, and even specific, characters in the form of the valves. In view of the difficulty, if not impossibility, of doing this in the Cidaridæ, it may seem very improbable that it can be done in the Arbaciadæ; but a little consideration will make clear the difference between the two families. In the Cidaridæ, the spines, as well as all other outgrowths from the test, show a remarkable diversity of form even in a single species, and individual differences are very great; it is not strange, therefore, that little reliance can be placed on the pedicellariæ for purposes of classification. In the Arbaciadæ, on the other hand, the spines are remarkably constant in form in any given species, and it is not strange, therefore, that the pedicellariæ show a similar constancy. It is interesting to note further that the longest and slenderest tridentate pedicellariæ occur in that genus (Cœlopleurus) which has the longest and slenderest spines, while those genera (Habrocidaris, Podocidaris) which have short flattened spines have the valves of the tridentate pedicellariæ short and flat.

The ophicephalous pedicellariæ (Pl. 47, fig. *2*) are almost invariably abundant, especially on the actinal surface, but their abundance shows considerable variability in different individuals. They are always to be found, and usually in numbers, on the buccal plates and on the ambulacral plates of the peristome, and the whole ambulacrum, even up to the ocular plate, is sometimes thickly covered with them. The heads vary in length from .20 to .75 mm., but there is comparatively little diversity in any one individual. The stalks, on the other hand, are exceedingly variable in length, ranging from three to twenty times the length of the head. The valves rest almost directly on the head of the stalk, no "neck" being present, and the upper end of the stalk is accordingly flattened or even concave. The exact form of this upper end is very variable, though fairly constant within specific limits. The valves are always provided with a conspicuous articular loop, and as this varies greatly in size on the three valves, we can readily distinguish between valves *a*, *b*, and *c* (Pl. 47, figs. *7–9*). In *a* the loop is largest, in *c* it is smallest. In their natural position the loop of *b* overlies that of *c*, while that of *a* overlies both. The blade of the pedicellaria is not appreciably modified by this striking difference in the basal part. Although the apophysis always forks at the base of the blade, one branch merging into each margin, a portion of it often continues nearly to the tip as a more or less conspicuous ridge, which is usually accompanied by a group of coarse calcareous branches on each side. The shape of the blade differs greatly in the different genera, and even in different species.

The triphyllous pedicellariæ (Pl. 47, fig. *3*) are always uncommon, often rare, and frequently wanting. When present, they are usually to be found on the abactinal surface near the boundaries of the interambulacra, and rarely on the genital plates. They are always small, provided with a long neck, and intergrade almost completely with the tridentate. The head is only .18–.40 mm. in length, but the stalk is commonly eight to ten times as long. The valves (Pl. 46, fig. *16*) are provided with a small articular loop, but these do not overlap, and the three valves of a head are all alike. The apophysis does not continue into the blade, nor is any calcareous network developed there. No "cover plate," so evident in the triphyllous pedicellariæ of the Aspidodiadematidæ and Echinothuridæ, is ever present.

Sphæridia (Pls. 47, figs. *10, 15–17*; 48, fig. *19*; 49, figs. *1, 9, 15, 26*) are present in the ambulacra of all the Arbaciadæ, at least at the peristome. They show considerable diversity in size (.20–.50 mm. in diameter) and form, and apparently vary more or less with the age of the individual (compare figs. *15* and *16*, Pl. 47). No reliance can be placed on their form as a specific character. They may be nearly or quite globular, and occasionally they are longer than wide, but as a rule they are much wider than long. They are borne in an upright position on a very short stalk which is jointed to a small knob or projection of the test. They may be placed on the surface of the test with little or no concavity back of them (Podocidaris, Dialithocidaris, Habrocidaris), or they may be more or less deeply sunken in pits in the test (Arbacia, Cœlopleurus). In Cœlopleurus there are 6–12 sphæridia in each ambulacrum, arranged vertically, so that there is a pit at the inner angle of each of the lowermost ambulacral plates (Pl. 53, fig. *1*). In all the other genera a single sphæridium is present in each ambulacrum close to the peristomal margin.

The pedicels of the actinal surface are always provided with the usual calcareous terminal rosette and its accompanying supporting plates (Pl. 48, figs. *7, 8*), but on the abactinal surface of the test these are commonly wanting. In some species no other calcareous deposits appear to be present in the pedicels, but usually some sort of supporting rods are found (Pls. 48, figs. *9, 17, 21*; 49, figs. *3, 11, 20, 27*). These may be simple, rough, irregular, slightly curved, non-perforated rods (Cœlopleurus), or straight, smooth rods, expanded and perforated at the middle (Podocidaris, Habrocidaris, some Arbacias), or narrow, curved perforated plates (Dialithocidaris), or more irregular, wider, rough perforated plates (*Arbacia stellifera*). It is doubtful how much reliance can be placed on these calcareous particles for specific characters.

The gills of the Arbaciadæ contain more or less numerous perforated plates (Pls. 47, figs. *11*, *19*; 49, fig. *28*), which apparently increase in number and complexity with age. In their simplest condition they are smooth, flat plates with few, large perforations (Pl. 47, fig. *11*), but they often have numerous knobs or projections on the surface and are perforated with many small holes. Sometimes they become still more complex, and are irregular masses of calcareous tissues (Pl. 47, fig. *19*). When very large and well developed, they frequently carry pedicellariæ.

The general arrangement of the internal organs of the Arbaciadæ is shown in the figures given of Cœlopleurus (Pl. 44, figs. *1*, *2*). The reproductive organs form finely divided tufts in each interambulacrum, the size of which varies of course with the sexual condition of the specimen. The œsophagus is moderately long and connects abruptly with the remarkably large, flat, stomach-intestine, which is very slightly undulated. The upper intestine is more undulated and shows five distinct interradial "pockets." It ends in a short but wide rectum.

The Genera and Species of Arbaciadæ.

This easily recognized family contains seven apparently valid genera, all of which contain recent species. These genera are distinguished from each other by the primary spines, the thickness of the test, the number of anal plates, the structure of the ambulacral plates, the absence or presence and arrangement of non-articulated spines and of secondaries, and the pedicellariæ. A convenient grouping of the genera according to these characters may be made as follows:

- Primary spines short, never much longer than diameter of test; sphæridial pits wanting or one present at peristome in each ambulacrum.
  - Test thick and solid as in most regular Echini; primary spines cylindrical or flattened; valves of tridentate pedicellariæ not remarkably flattened; valves of ophicephalous pedicellariæ not extraordinarily constricted nor with unusually expanded apophysis.
    - Abactinal surface with numerous articulated primary spines, which are more or less cylindrical, though they may be flattened near tip.

Ambulacral plates at ambitus with 3 (exceptionally 4) pairs of pores; secondary spines and tubercles wholly wanting . . *Arbacia.*
Ambulacral plates at ambitus with 4 or 5 pairs of pores; secondaries present in interambulacra at and above ambitus . . *Tetrapygus.*
Abactinal surface with numerous short, non-articulated spines; primary spines flattened, with more or less serrate edges, confined to ambitus or actinal surface of test.
Abactinal system small or of moderate size, not .60 h. d.; anal plates, 4.
Abactinal system about .35 h. d.; non-articulated spines not arranged in horizontal series on each abactinal coronal plate; tridentate pedicellariæ small, with valves only about .30 mm. long . . . . *Podocidaris.*
Abactinal system about .50 h. d.; non-articulated spines arranged in horizontal series of 4–7 on each abactinal coronal plate; tridentate pedicellariæ very large, with compressed valves, 2–2.5 mm. long . . *Dialithocidaris.*
Abactinal system very large, about .66 h. d.; anal plates, 5 . *Pygmæocidaris.*
Test thin and delicate; anal plates, 5; primary spines decidedly triangular in cross-section; valves of tridentate pedicellariæ remarkably wide and flat; valves of ophicephalous pedicellariæ extraordinarily constricted, with notably expanded and hollowed apophysis . . . . *Habrocidaris.*
Primary spines very long and usually tapering, greatly exceeding twice diameter of test; sphæridial pits 6–12 in each ambulacrum actinally . *Cœlopleurus.*

Arbacia.

Gray, 1835. Proc. Zool. Soc. London, p. 58.

Type-species, *Cidaris pustulosa* Leske, 1778. Add. Klein, p. 85.

Tertiary (?) and Recent Arbaciadæ.

There seem to be only five valid species of this genus, although Lovén, in his revision of it in 1887, recognized double that number. Lovén, however, considered as a good subgeneric character, one which we find cannot be relied on even to distinguish a given species, namely, the extent to which the abactinal interradial areas are free from spines, and he recognized individual differences such as the form of the test as valid specific characters. We are entirely unable to find any character which will distinguish specimens from Brazil from those taken in the Mediterranean, while Lovén considered them as two quite distinct species. It is possible that further material from the west coast of Africa will make the recognition of the species *africana* Troschel desirable, and there is also a possibility that *alternans* Troschel may ultimately be separable from *Dufresnii* Bl., but in the light of such material as is now available either in the M. C. Z. or elsewhere, these three names seem to be synonyms. The species which we recognize are *lixula* Linn. (including *pustulosa* Leske, *æquituberculata* Bl. and *australis* Trosch.), from the tropical Atlantic, ranging from the Mediterranean and Gulf of Guinea to Brazil; *Dufresnii* Bl. (including *africana* and *alternans* of Troschel), from southern South America, Tristan d'Acunha, and West Africa; *punctulata* Lamk., from the east coast of the United States and Mexico; *spatuligera* Val. (including *grandinosa* Val.), from Peru and Chili; and *stellata* Bl., from the west coast of Mexico and Central America. All of these species are distinctly littoral, rarely occurring in depths exceeding 100 fathoms.

In distinguishing the species of this genus, we find that no reliance can be placed on the extent to which the interambulacra are covered by the primary spines. Nor is this even an age character, for specimens of the same size, of *punctulata* from Woods Hole and Newport, reveal the most striking differences in this particular. The relation of the oculars to the periproct, the number of primary tubercles on each coronal plate at the ambitus, the sculpturing of the epistroma, and even, to some extent, the color and size, appear to furnish the best characters by which the species are to be distinguished. The following table shows the characters revealed by the species we recognize.

Abactinal interradial areas, at least when cleaned, more or less distinctly green . . . . *Dufresnii.*

Abactinal interradial areas not at all green.

- Oculars large, usually 2, and often 3, in contact with periproct; rarely in small specimens there may be none fully insert; size large, h. d. usually 50–65 mm. and often up to 75 . . . . *spatuligera.*
- Oculars small, all distinctly exsert, or rarely one insert; size moderate, usually 30–45 mm., rarely up to 60.
  - Primary tubercles numerous, 4–7 well-developed ones on each coronal plate at ambitus in specimens over 30 mm. h. d.; bare abactinal interambulacral spaces usually indistinct or wanting . . . . . . *lixula.*
  - Primary tubercles fewer, seldom more than 3 well-developed ones on a coronal plate at ambitus even in large specimens; bare abactinal interambulacral spaces usually more or less distinct.
    - Plates of abactinal system and bare interambulacral areas so finely granular as to have an almost velvety appearance, and prettily marked with deep red in contrast to the gray or whitish ground color . . . . *stellata.*
    - Plates of abactinal system and upper interambulacral plates coarsely granular, not marked with deep red in contrast with the ground color . . . . *punctulata.*

None of the species of this genus were taken by the "Albatross," but they are included here in order that an account of their pedicellariæ may be given.

Arbacia Dufresnii Gray.

Echinus Dufresnii Blainville, 1825. Dict. Sci. Nat., XXXVII, p. 76.
Arbacia Dufresnii Gray, 1835. Proc. Zool. Soc. London, p. 38.

Plate 47, figs. *1–11*.

The tridentate pedicellariæ (fig. *1*) are rather infrequent and occur chiefly on the actinal surface, though some occur at the ambitus. They appear to be wanting in young individuals. The valves (fig. *5*) are broad, rather flat, and rounded at tip. They measure from .70 to 1 mm. in length, and are attached to the stalk by a "neck" of about half that length. The stalk itself is from 2.5 to 3.5 mm. long.

The ophicephalous pedicellariæ (fig. *2*) are very abundant on the ambulacra, among the spines on the interambulacra, and on the buccal plates. A few may occur on the ocular plates. The valves (figs. *7–9*) are short, broad, and rounded at the tip, and differ from each other in the size and form of the articular loop. They measure from .50 to .75 mm. in length, and are attached to stalks 4–6 times as long. There is no "neck," but the upper end of the stalk is slightly expanded.

The triphyllous pedicellariæ (fig. *3*) are rather scarce, but are to be found on the bare parts of the interambulacra, and rarely on the genital plates. The valves (fig. *6*) are broad and flat, rounded at the end, with no "cover-plate," but with a slight articular loop. They measure from .20 to .40 mm. in length, and are attached to the stalk by a neck nearly twice as long. The stalk is from 1 to 1.3 mm. in length.

Calcareous particles appear to be quite wanting in the walls of the pedicels, except for the terminal rosettes and their supporting rods in those of the actinal surface, but large, flat, perforated plates occur in the gills.

The sphæridia are large and nearly globular.

Arbacia spatuligera A. Ag.

Echinus (Agarites) spatuliger Valenciennes, 1846. Voy. Venus, Pl. 5, fig. *2*.
Arbacia spatuligera A. Agassiz, 1872. Rev. Ech., pt. 1, p. 93.

Plate 48, figs. *15–19*.

The tridentate pedicellariæ are abundant in some specimens but rare in others. They are very variable in form and size, but resemble those of *lixula*. The valves (fig. *15*) are broad, rounded at the tip, and often have a marked notch on each side just above the base; they range from .25 to 1 mm. in length.

The ophicephalous pedicellariæ resemble those of *punctulata*, and cannot be certainly distinguished from them. The heads of the stalks (fig. *18*) are, however, not constricted.

The triphyllous pedicellariæ are rare. They have very broad valves (fig. *16*), about .25 mm. long, and are difficult to distinguish from the smallest tridentate pedicellariæ.

The calcareous particles in the pedicels (fig. *17*) resemble those of *punctulata*, but are stouter and rougher. Those of the gills are also similar to those of *punctulata*, but are remarkable for the fact that they often carry pedicellariæ.

The sphæridia (fig. *19*) are like those of *punctulata*.

Arbacia lixula Lovén.

Echinus lixula Linnæus, 1758. Sys. Nat., p. 664.
Arbacia lixula Lovén, 1887. Ech. desc. by Linn., p. 112.

Plate 48, figs. *10–14*.

The tridentate pedicellariæ are very variable in size and number, but are generally small, and actinal in position. The valves are very wide in proportion to the length, which ranges from .25 to .95 mm.; they may be bluntly pointed (fig. *10*) or more or less rounded at the tip (figs. *11* and *12*).

The ophicephalous pedicellariæ are common, especially actinally. The valves (fig. *14*) are much narrower than in *punctulata* and less rounded at the tip. They measure about .50 mm. in length, while the stalks are 2 or 3 mm. long. The heads of the stalks are often somewhat constricted as in *punctulata*.

The triphyllous pedicellariæ are very scarce. The valves (fig. *13*) are considerably more constricted than in *punctulata*.

Calcareous particles in the pedicels are like those which occur in *punctulata*, but the perforated plates in the gills are more like those of *Dufresnii*.

The sphæridia are like those of *punctulata*.

Arbacia stellata Gray.

Echinus stellatus Blainville, 1825. Dict. Sci. Nat., XXXVII, p. 76.
Arbacia stellata Gray, 1835. Proc. Zool. Soc. London, p. 38.

Plate 48, figs. *20, 21.*

The tridentate pedicellariæ appear to be wanting, for none were found in the ten specimens examined.

The ophicephalous pedicellariæ, which resemble those of *lixula*, vary greatly in abundance in different specimens. They also vary considerably in size, the length of the head ranging from .35 to .65 mm. The heads of the stalks are often somewhat constricted as in *punctulata.*

The triphyllous pedicellariæ are scarce and small, the valves (fig. *20*) measuring only .25 mm. in length. The latter are remarkably narrow, more slender even than those of *punctulata.*

The calcareous particles in the pedicels seem to be very characteristic, for in all the specimens examined large, swollen, knobbed, and perforated plates (fig. *21*) were found. These are sometimes numerous and sometimes few, and it is possible that they are sometimes wanting. The plates in the gills are flat and smooth, as in *Dufresnii.*

The sphæridia are like those of *punctulata.*

Arbacia punctulata Gray.

Echinus punctulatus Lamarck, 1816. Anim. s. Vert., III, p. 47.
Arbacia punctulata Gray, 1835. Proc. Zool. Soc. London, p. 38.

Plates 47, figs. *17–19 ;* 48, figs. *1–9.*

The tridentate pedicellariæ are abundant in some southern specimens, but are usually infrequent, and in northern specimens are often entirely wanting. They are to be found, when present, chiefly on the actinal surface. They are very variable in size, the valves ranging from .20 to 1.30 mm., and also show considerable diversity of form. They intergrade with the triphyllous pedicellariæ very clearly. The valves are either broad and regularly tapering to a blunt point (Pl. 48, fig. *2*), or narrower and distinctly constricted near the middle (Pl. 48, fig. *1*).

The ophicephalous pedicellariæ are common, but chiefly actinally and particularly on the buccal plates; they are abundant abactinally only in occasional specimens. The valves show great diversity in form, but are convex or rounded at the tip; they may be greatly constricted near the middle (Pl. 48, fig. *6*) or not at all so (Pl. 48, fig. *5*). They are .40–.60 mm. in length, and the stalk is 3–6 times as long. The heads of the stalks (Pl. 47, fig. *18*) nearly always show a more or less evident constriction which is quite characteristic.

The triphyllous pedicellariæ are very scarce and small, the valves (Pl. 48, fig. *4*) measuring only .20–.30 mm. in length.

The pedicels, at least those of the actinal surface, in addition to the terminal rosettes and supporting rods (Pl. 48, figs. *7*, *8*) are provided with very characteristic straight rods (Pl. 48, fig. *9*), which are expanded and more or less perforated at the middle. The gills have large, more or less irregular, knobbed and perforated plates or spheroidal masses of lime (Pl. 47, fig. *19*), and similar but larger plates occur in the buccal membrane. These latter are so large that they sometimes carry pedicellariæ.

The sphæridia are somewhat ellipsoidal, usually distinctly wider than long.

TETRAPYGUS.

L. Agassiz and Desor, 1846. Cat. Rais., Ann. Sci. Nat. (3) VI, p. 354.
Type-species, *Echinus niger* Molina, 1782. Saggio St. Nat. Chili, p. 175.

The peculiar structure of the ambulacra in this genus has been well worked out and figured by Duncan and Sladen (1885), and appears to warrant its separation from Arbacia. Their attempt to attach Desmoulins' old name (Echinocidaris) to it is, however, perfectly futile, for Echinocidaris is as complete a synonym of Arbacia as could be found, and therefore, of course, cannot be used in any other sense. Desmoulins himself recognized this fact, but sought to maintain his name on the ground of priority. As a matter of fact, Gray's name was published in April, and not in October as Desmoulins asserts. Lovén (1887) attempts to maintain Echinocidaris on the ground that the first species mentioned by Desmoulins is *niger*, although he calls it *pustulosa*. This appears to be a pure assumption, however, and quite unwarranted, so that the name Echinocidaris must be abandoned, notwithstanding Duncan's (1891) redefinition of it. The name Tetrapygus is, however, available, for while the definition given by Agassiz and Desor is not based on the structure of the ambulacra, the first species mentioned is *niger*, and that may well be considered the type.

The only species of this genus known is the common littoral urchin of Chili and Peru, to which Molina gave the name *Echinus niger*. The peculiarities of the ambulacra are evident even in very small specimens.

Tetrapygus niger Agass.

Echinus niger Molina, 1782. Saggio St. Nat. Chili, p. 175.
Tetrapygus niger Agassiz, 1846. Ann. Sci. Nat., VI, p. 354.

Plate 47, figs. *12–16*.

The tridentate pedicellariæ are small and scarce, and are found only on the actinal surface. The valves (fig. *12*) are more slender than in *A. Dufresnii*, and are distinctly constricted near the middle. They measure from .25 to .85 mm. in length, while the stalks on which they are borne are 5–15 times as long.

The ophicephalous pedicellariæ are abundant everywhere, particularly on the buccal membrane. They are very characteristic, for the valves (fig. *14*) are usually flattened or even concave at the tip, and have a broad and deeply grooved apophysis, while the head of the stalk (fig. *13*) is swollen but contracted at the tip. The valves measure from .25 to .75 mm. in length, and the stalks are 3–20 times as long. Intermediate forms between the ophicephalous and tridentate pedicellariæ are not uncommon.

The triphyllous pedicellariæ are very scarce, and are not peculiar. The heads measure .35 mm. in length, and the stalks are about nine times as long. All the pedicellariæ are purple in color in adult specimens.

There seem to be no calcareous particles in the pedicels, except the usual terminal plates and their supporting rods in those of the actinal surface, but the plates in the gills are numerous and large, with from 10–60 perforations. Similar but larger plates occur in the buccal membrane.

The sphæridia (figs. *15, 16*) in young individuals are approximately globular, but in large specimens they are wider than long, and may even become somewhat angular.

Podocidaris.

A. Agassiz, 1869. Bull. M. C. Z., I, p. 258.

Type-species, *Podocidaris sculpta* A. Agassiz, 1869. Bull. M. Z. C., I, p. 258.

The establishment of Pygmæocidaris and Habrocidaris leaves this a monotypic genus, containing only the species which has been taken a number of times, but not commonly, off southern Florida and among the West Indies, at depths of 134–400 fathoms.[1]

Podocidaris sculpta A. Ag.

Podocidaris sculpta A. Agassiz, 1869. Bull. M. C. Z., I, p. 258.

Plate 49, figs. *1–8*.

This species was not taken by the "Albatross," but is included for its pedicellariæ.

The tridentate pedicellariæ are small and infrequent, occurring chiefly near or below the ambitus. The valves are broad and not much flattened, and are either somewhat pointed (fig. *6*) or almost square-cut (fig. *7*) at the tip. They are only about .30 mm. long.

The ophicephalous pedicellariæ are abundant, at least abactinally, and some of them at least are as large as the tridentate. The valves (figs. *4*, *5*), which are about .30 mm. in length, are strongly constricted above the middle and rounded at the tip, with a more or less sharp corner on each side. The apophysis is very broad, and although it forks where the valve is constricted and passes into the margin on each side, a certain portion of it continues to the tip of the valve. The upper end of the stalk is very markedly constricted (fig. *2*).

The triphyllous pedicellariæ are relatively very large, and are scarcely to be distinguished from the tridentate, though the valves (fig. *8*), which are about .18 mm. long, are proportionately wider and less constricted.

The calcareous deposits in the pedicels are quite common. They consist of small rods (fig. *3*), nearly straight, rounded at the ends, flattened and with a single perforation at the middle. They are about .15 mm. long, and probably lie at right angles to the axis of the foot, in life.

The sphæridia (fig. *1*), of which there is a single one at the actinal end of each ambulacrum, are wider than long, and are little or not at all sunken in any depression in the test.

[1] In Mem. M. C. Z., XXXI, "Panamic Deep Sea Echini," heading of Explanation of Plate IX, for "Podocidaris Cobosi" read "Porocidaris Cobosi."

Dialithocidaris.

A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 75.

Type-species, *Dialithocidaris gemmifera* A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 75.

This monotypic genus is still known only from the single specimen collected by the "Albatross" in 1891, off Mariato Point, Panama, in 1793 fathoms.

Dialithocidaris gemmifera A. Ag.

Dialithocidaris gemmifera A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 75. 1904, Mem. M. C. Z., XXXI, p. 56; Pls. XV, figs. *3–5*; XXIII.

Plate 46, figs. *9–16*.

Although not taken by the "Albatross" since 1891, we include this species in order to describe and figure the pedicellariæ.

The tridentate pedicellariæ (fig. *9*) are common, as many as 4–6 occurring on each of the coronal plates. They are very large in proportion to the diameter of the test. The valves (figs. *10* and *11*) are strongly compressed, especially just above the apophysis, and are coarsely serrate. They measure from 2 to 2.5 mm. in length, while the stalks are twice as long. The upper end of the stalk (fig. *12*) is flattened and expanded.

The ophicephalous pedicellariæ (fig. *13*) are abundant, particularly near and upon the abactinal system. The valves (figs. *14*, *15*) are stout, almost flattened at the tip and strongly constricted near the middle. They are only .30–.45 mm. long, while the stalks may be 6–8 times that length.

The triphyllous pedicellariæ are much less common than either of the other kinds. The valves (fig. *16*) are somewhat flattened and rounded at the end; they measure .35–.40 mm. in length, and the stalks are 6–8 times as long.

The calcareous deposits in the pedicels seem to be very scarce. They are simple, perforated plates, so narrow as to be hardly more than flat rods with irregular margins, and little or not at all curved.

The sphæridia are situated one in each ambulacrum, on the peristome, and are not in a marked depression, though the test behind each is slightly hollowed.

PYGMÆOCIDARIS.

Döderlein, 1905. Zool. Anz., XXVIII, p. 622.

Type-species, *Podocidaris prionigera* A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 199; 1881, "Challenger" Echini, p. 59; Pl. XXXIV, figs. 14, 15.

This is still another monotypic genus, the characters of which have been well discussed by Döderlein (1906), who points out some remarkable similarities between it and the notable genus Tiarechinus. It has so far been found only in the East Indian region, at depths of 372–1534 fathoms. It seems clear to us that the specimens collected by the "Siboga" and called by de Meijere "*Podocidaris* spec." are not only not *prionigera*, as Döderlein lists them, but are not even congeneric with it.

HABROCIDARIS.

A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 234.

Type-species, *Podocidaris scutata*, A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 72.

This genus, established for *Podocidaris scutata* A. Ag., from the West Indies, also includes the closely allied species, *H. argentea,* from the Hawaiian Islands. It is evident from the peculiar structure of the actinal interambulacral system of Podocidaris and its allies that we are justified in separating *P. scutata* A. Ag. from *Podocidaris sculpta* A. Ag., and that we must agree with Döderlein also in separating the remarkable *Podocidaris prionigera* A. Ag. as a distinct genus, allied to Tiarechinus, under the name of Pygmæocidaris.

Habrocidaris A. Ag. and Cl. is more closely allied to Pygmæocidaris Död. than to Podocidaris as now limited, which in the arrangement of its interambulacral tubercles retains more its Arbacia-like characters than do these other genera.

Characteristic of Habrocidaris is the very thin, delicate test, the slightly indented peristome, the close plating of the actinal system, and the distinctly triangular primary radioles.

While studying the permanence of the odd actinal interambulacral primordial plate among the regular Echini, one of us, as far back as 1883,[1] was struck with the possible affinity of the Arbaciadæ to Tiarechinus Neumayr,

[1] "Blake" Echini, Mem. M. C. Z., X, No. 1, p. 22.

and attempted further to trace out this affinity in old and young Arbaciadæ by showing the permanence of this plate in Dialithocidaris[1] and in *Arbacia stellata*.[2]

Our attention was again called to the subject by Döderlein's interesting discovery[3] of the existence of a well-developed primordial interambulacral plate in *Podocidaris prionigera* A. Ag., for which he established the genus Pygmæocidaris. He furthermore found that the interambulacral zones consist at the base of three plates much as in Tiarechinus. Pygmæocidaris seems to be slightly more developed than Tiarechinus, however, having beyond the row of three plates, interambulacral zones with two rows of plates. This led us to examine again *Podocidaris sculpta* and *Habrocidaris scutata*[4] in connection with the new *H. argentea* from the Hawaiian Islands, and to our gratification we found that in all the primordial plate is as fully developed as in *Pygmæocidaris prionigera.* The details of this primitive structure in *H. argentea* and *H. scutata* are fully shown on Pl. 54, figs. *1–4*, *6*, *7* of this Memoir. Neither of these species, however, has the third interambulacral plate with a large tubercle immediately above the primordial plate, as shown by Döderlein in figs. e, f, p. 184, of the "Valdivia" Echini. Yet we can agree fully with Döderlein's view of the affinity of these interesting species of Arbaciadæ, as well as of the family, to the Triassic Tiarechinus.

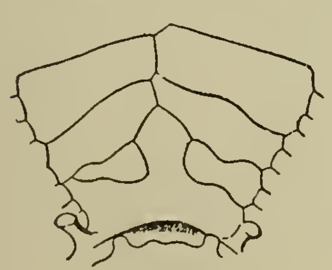


Fig. *a*.

On re-examination of a specimen of *Podocidaris sculpta* 7 mm. in diameter we find that the primordial plate (figs. *a*, *b*) extends abactinally so as to separate the first two pairs of interambulacral plates, slightly encroaching upon the third pair, while in Habrocidaris it separates only the first pair slightly encroaching upon the second pair. The primordial plate is not cut into two plates as it is figured for Pygmæocidaris by Döderlein, pp. 184, 185, "Valdivia" Echini. Seen from the interior of the test, fig. *a*, the primordial plate only separates the first pair of interambulacral plates and encroaches upon the second

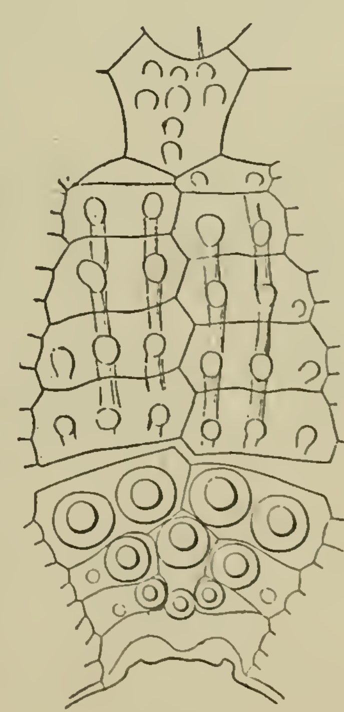


Fig. *b*.

[1] Panamic Deep Sea Echini, Mem. M. C. Z., XXXI, Pl. 23, figs. *1*, *4*, *6*.

[2] Mem. M. C. Z., XXXI, Pl. 54, figs. *5*, *6*.

[3] "Valdivia" Echini, p. 182 (figs. p. 183).

[4] Collected by the "Blake" off Santa Cruz, in 580 fathoms.

pair. This difference is due to the slanting of the sutures upon passing through the test. Dialithocidaris (Pl. 23, Panamic Ech.) is more closely allied to Podocidaris than to any other of the Arbaciadæ, while the crowding of the poriferous zones at the ambitus allies it more to Arbacia than to such genera as Habrocidaris, Pygmæocidaris and Podocidaris.

In *Podocidaris sculpta*, in a specimen measuring 11.75 mm. in diameter, there are, beginning at the actinal system, five and four primary ambulacral tubercules. In the interambulacral system the primary tubercules are arranged in transverse rows of three small ones, four somewhat larger, four still larger, five still larger at the ambitus, with a central odd primary in the median line, and the next and last row with only one large tubercule in the outer angle of each interambulacral plate, a much more Arbacian-like arrangement than that of the species once associated as Podocidaris.

The two species of this genus are distinguished from each other as follows:

Abactinal system, about .60 h. d.; actinostome distinctly pentagonal . . . . . . *argentea.*
Abactinal system, .50–.55 h. d.; actinostome circular . . . . *scutata.*

Habrocidaris argentea A. Ag. and Cl.

Habrocidaris argentea A. Agassiz and Clark, 1907.
Bull. M. C. Z., L, p. 234.

Plate 49, figs. *9–14*; 54, figs. *1–3*.

A single specimen of this species was collected by the "Albatross" near French Frigate Shoal. Its diameter is 11.5 mm., that of the actinal system 7 mm., of the anal 2 mm., and of the abactinal 4 mm. Unfortunately all the primary radioles are broken and only the basal portions of a few remain attached to the test. The radioles, like those of *H. scutata* (Pl. 54, figs. *8* and *9*), are triangular in cross section, and the three edges though rounded project conspicuously from the solid axis. The test is silvery, tinged with brown, and the primary radioles were evidently white. This species is closely allied to *H. scutata* (Pl. 54, figs. *4*, *5*) from which it differs in having a distinctly pentagonal, slightly indented actinal system and larger actinal plates (Pl. 54, fig. *1*) with comparatively large and prominent poriferous plates, while in *H. scutata* (Pl. 54, fig. *4*) the actinal poriferous pairs of plates are very small, scarcely distinguishable from the great number of small angular plates covering the actinal system. In both species the abactinal system is distinctly pentagonal, somewhat more markedly so in *H. argentea* (Pl. 54, fig. *2*). It is but sparsely covered with small, sessile granules which become somewhat club-shaped on the three upper abactinal plates of each interambulacrum. There are five anal plates. The genital plates are elongated, each with one small genital pore. The pore of the madreporic genital is somewhat larger and placed nearer the centre of the plate than in the other genitals where it is close to the anal system.

There are only five primary interambulacral plates (Pl. 54, fig. *3*) on each side of the median line above the large, odd, primary interambulacral plate. This is irregularly heptagonal, elongate with concave lateral sides and a broad actinal base slightly indented; it carries one small primary tubercle in the centre of the plate (Pl. 54, fig. *1*). This plate separates the next pair of ventral interambulacral plates, each of which has a single primary tubercle near the upper suture. The next pair of plates join along the median line, and each carries a large primary tubercle close to the ambulacral edge of the plates. Riding across the median suture is a large primary tubercle, above which the interambulacral plates bear only minute, scattered, somewhat club-shaped granulations (Pl. 54, figs. *2*, *3*).

In the ambulacral areas (Pl. 54, figs. *1*, *2*) the first four or five pairs of plates are narrow with a slight pit near the sutures, carrying the pores. A similar depression in the median line in the angles of the first two pairs of ambulacral plates contains the sphæridium. The next three plates each carry near the centre a primary tubercle, the largest of which is on the upper plate. The pores of these and the six or seven small primitive plates are not in pits, each pair of pores with one exception in the angle of each plate (Pl. 54, fig. *2*). On each of these upper plates there are but two or three minute granules.

The tridentate pedicellariæ are rare and occur only near the ambitus. The valves (Pl. 49, fig. *14*) are about .38 mm. long, narrower than in *scutata*, more rounded at the tip, and the branches of the apophysis nearly reach the margins of the valve.

The ophicephalous pedicellariæ are abundant abactinally and have very long stalks. The valves (Pl. 49, figs. *12* and *13*) are about .28 mm. long, much narrower and more slender than in *scutata*, but of the same general pattern. The upper end of the stalk (Pl. 49, fig. *10*) is slightly different.

The triphyllous pedicellariæ are apparently wanting.

The calcareous deposits in the pedicels (Pl. 49, fig. *11*) are similar to those in *scutata*, but are smaller and more slender.

The sphæridia (Pl. 49, fig. *9*) are a trifle longer than wide. Their position and arrangement are the same as in *scutata.*

This species was taken only at:

Station 3973. Near French Frigate Shoal; 23°47′10″ N., 166°24′55″ W. Bott. temp. 41°. 395–397 fathoms. Crs. co. s. sh. co. r.

Habrocidaris scutata A. Ag. and Cl.

Podocidaris scutata A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 72.
Habrocidaris scutata A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 234.

Plate 49, figs. *15–20;* 54, figs. *4–9.*

This species was not taken by the "Albatross," but is included for comparison with the preceding.

The test of the specimen figured in plate 54 is silvery with a brownish tinge. The diameter is 17.5 mm., height 9 mm. The striation of the plates, so marked in the abactinal system of Salenia, and on some of the abactinal coronal plates of Dialithocidaris and of youthful stages of Arbacia, is slightly seen in *H. argentea,* but is very marked in *H. scutata.* The short club-shaped granules of the abactinal parts of the test are irregularly scattered over the abactinal system (Pl. 54, fig. *5*). They are far more numerous than in *H. argentea,* and on the abactinal interambulacral plates they are arranged in irregular lines parallel to the sutures. These lines are most prominent at the equatorial belt (Pl. 54, fig. *5*), but have nothing of the prominence and regularity which distinguishes *Podocidaris.* The abactinal system is pentagonal, but less so than in *H. argentea,* the genital plates shorter and the ocular plates comparatively larger and higher (compare figs. *5* and *2*, Pl. 54). The madreporic genital is the largest and has its pore placed in a slightly raised protuberance much as in Tiarechinus.[1] There are five anal plates. The actinal ambulacral plates are chiefly compound plates only one or two of the four or five which carry no tubercles (Pl. 54, fig. *4*), being simple plates as in *P. argentea* (Pl. 54, fig. *1*). In two of the ambulacra one of the actinal plates carries a minute tubercle, while on each of the next five plates a large tubercle is found near the lower median angle of the plate (Pl. 54, figs. *4*, *6*). The plates are provided with three (or rarely four) pairs of pores.

[1] See p. 184, fig. *a*, Död. "Valdivia" Echini.

The remaining 6 or 7 abactinal ambulacral plates have one or two pairs of pores and each of the larger plates carries a diminutive granular tubercle.

The arrangement of the primary interambulacral tubercles is well shown in Pl. 54, figs. *4*, *5*, *7*. The single primordial interambulacral actinal plate carries from two to four minute granular tubercles, while that of *H. argentea* (Pl. 54, figs. *1*, *3*) carries a small primary tubercle.

The pairs of pores of the actinal ambulacral plates are sunken in small pits as in *H. argentea* and in the median line there is the larger sphæridial depression seen in that species.

The tridentate pedicellariæ are not uncommon, especially near the ambitus. The valves (Pl. 49, fig. *19*) are very broad and flat, with nearly parallel sides and almost truncate tip. The apophysis is narrow and forks widely at the end, but the two divisions do not reach the margins of the valve. The length of the valve is about .40 mm., while its width is nearly one-half as much.

The ophicephalous pedicellariæ are very characteristic and are remarkable for the very great constriction of the valves (Pl. 49, fig. *17*) just above the middle and the peculiar widening and hollowing of the apophysis. The articular loop (Pl. 49, fig. *18*) of the chief valve is relatively very large. The valves are about .30 mm. in length, while the stalks are 6–8 times as long. The upper end of the stalk (Pl. 49, fig. *16*) is very rough, obliquely truncate and slightly constricted.

The triphyllous pedicellariæ are apparently wanting.

The calcareous particles in the pedicels are straight rods (Pl. 49, fig. *20*) with blunt tips. They are expanded at the middle and perforated there with from one to four small holes. They are relatively very long (.40–.70 mm.) and presumably lie horizontally in life, though they are more or less oblique or even vertical in dried pedicels.

The sphæridia (Pl. 49, fig. *15*) are proportionately large and are nearly as long as wide. There is one in each ambulacrum, at the peristome, and it lies on the surface of the test, in only a very slight depression.

The type and only known specimen of this species was taken by the "Blake" off Santa Cruz, Danish West Indies, in 580 fms.

CŒLOPLEURUS.

Agassiz, 1840. Cat. Sys. Ectyp. Ech., p. 19.
Type-species, *Cidaris coronalis* Leske, 1778. Add. Klein, p. 72.
Tertiary and Recent Arbaciadæ.

The considerable amount of material which we have been able to examine, including specimens collected by the "Challenger," "Blake," "Albatross," and "Siboga," besides Michelin's type of *Maillardi*, has satisfied us that at least five recent species of this genus must be recognized. The specimens collected by the "Siboga" appear to be identical with Michelin's species, which accordingly ranges from Mauritius to the Kei Islands in 38–120 fms. The "Blake" specimens are all *floridanus* A. Ag., which is found throughout the West Indian region in depths of 56 – 1323 fms. Whether the specimen from Agulhas Bank, off the southeastern coast of South Africa, collected by the "Valdivia," and identified by Döderlein as *floridanus*, is really identical with the West Indian species seems to us open to doubt. The Saleniæ taken in the same locality and called *Pattersoni* by Döderlein is certainly not the West Indian species, and it seems highly improbable that the specimen of Cœlopleurus should belong to the Caribbean fauna. The "Albatross" specimens are all *maculatus* A. Ag. and Cl., while those taken by the "Challenger" appear to have been in part *maculatus*, and in part a hitherto undescribed species to which we have given the name *longicollis* on account of the extremely long collar on the fully developed primaries. The specimens of *longicollis* were taken in Basilan Straits, Philippine Islands, in 82–102 fms. while *maculatus* was taken at Amboina, by the "Challenger," in 100 fms. and off western and southern Japan, by the "Albatross," in 40–59 fms. There is also a specimen of *maculatus* from the Uraga Channel, Gulf of Tokyo (East Coast of Japan), 70 fms., in the M. C. Z. collection. The fifth species which we consider it necessary to recognize is the handsome form brought by Dr. Willey from New Britain, called by Bell (1899) "*Salmacis*? *elegans*," but which, as de Meijere (1904) has pointed out, is so obviously a Cœlopleurus, it seems odd that Bell failed to recognize the genus. Assuming that the colored drawings are accurate, this species is characterized by stout primaries with a very short collar, that taper very little and are apparently not curved, as well as by its unusual coloration.

The recent species of this genus are remarkable for their striking colors, as well as for their slender, curved primary spines. The slenderness and curvature of the primaries is not so marked in small specimens as in the large ones, and the peculiarity of *elegans* in these particulars may be due, in part at least, to the small size of the specimen, which is only about 10 mm. h. d. Aside from the obvious differences in color, the species are distinguished from each other by the characters of the collar on fully developed primaries and the form of the valves of the ophicephalous pedicellariæ. The following table will make these differences clear, it being understood that only unbroken, fully developed spines from the interambulacra, at or near the ambitus, of mature specimens, are meant, when "primaries" are referred to; when "length" of valve is mentioned in connection with pedicellariae, it is understood that the "articular loop" is *not* included in the measurement.

Primaries spotted or banded, at least on basal half; collar less than ten per cent of length of spine.
- Markings on primaries distinctly purple; ground color green; collar about eight per cent of spine-length, finely granular, without conspicuous longitudinal ridges but with distal margin oblique; valves of ophicephalous pedicellariæ decidedly constricted, the least width of blade not more than .40 of length of valve . . . . *Maillardi.*
- Markings on primaries bright red; collar about five per cent of spine-length.
  - Ground color of primaries bright green; collar rough with 12–15 conspicuous longitudinal ridges and with distal margin horizontal; valves of ophicephalous pedicellariæ not greatly constricted, the least width exceeding .60 of length . . . . *maculatus.*
  - Ground color of primaries bright yellow; character of collar and pedicellariæ unknown . . . . *elegans.*

Primaries not spotted or banded except occasionally on distal half; collar more than ten, often more than twenty per cent of spine-length, rough with finely serrate longitudinal ridges.
- Primaries more or less uniformly red, at least on abactinal surface; collar extends distinctly farther on abactinal ridge than on sides of spine; valves of ophicephalous pedicellariæ decidedly constricted, the least width not exceeding .50 of length . . . . *floridanus.*
- Primaries more or less uniformly whitish, sometimes with spots of red distally; collar does not extend distinctly farther on abactinal ridge than on sides of spine; valves of ophicephalous pedicellariæ not constricted, the least width exceeding .70 of length . . . . *longicollis.*

Cœlopleurus Maillardi A. Ag.

Keraïaphorus Maillardi Michelin, 1862. Maillard's Bourbon. Annéx. A, p. 2; Pl. XIV.
Cœlopleurus Maillardi A. Agassiz, 1871. Bull. M. C. Z., II, p. 456.

Plates 49, fig. *34;* 53, figs. *8, 9.*

Although small specimens (6–19 mm. in diameter) of what appears to be this species were taken in considerable numbers by the "Siboga" in the Dutch East Indies, de Meijere (1904) gives no figures or description of the pedicellariæ. Thanks to Dr. Weber of the Amsterdam Museum, the Museum of Comparative Zoölogy received in exchange one of these "Siboga" specimens, and there is little reason to doubt the correctness of de Meijere's identification. These young specimens, however, show only indistinctly the peculiar, nearly horizontal markings on the bare, abactinal, interambulacral spaces, so clearly shown in Michelin's figures. These bare areas are purplish-blue in the "Siboga" specimens, and there is far less of a reddish tinge on the abactinal parts of the test than is indicated by Michelin. These slight differences may well be due to the difference in size, as Michelin's specimen was 42 mm. in diameter.

The tridentate pedicellariæ show no peculiarities, resembling those of *floridanus,* but the ophicephalous are remarkable for their very slender, highly constricted valves, resembling far more closely those of *floridanus* than they do those of either *maculatus* or *longicollis.* The valves of the tridentate pedicellariæ are colorless, and measure .18–.90 mm. in length. The valves of the ophicephalous pedicellariæ are lightly colored with greenish and reddish as in *maculatus*, but much less markedly so ; they are .20–.45 mm. in length. The small size of the pedicellariæ is doubtless due, at least in part, to the small size of the specimen from which they were taken, the test of which was only about 10 mm. in diameter. The calcareous particles and sphæridia showed no peculiarities.

Cœlopleurus maculatus A. Ag. and Cl.

Cœlopleurus maculatus A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 116.
Cœlopleurus Maillardi A. Ag. "Challenger" Echini, p. 60 (*partim*). Pls. V, fig. 3; VI, figs. 8–14 (non Michelin).

Plates 49, figs. *21–28;* 53, figs. *1–7;* 57, figs. *4–6.*

In the "Challenger" Echini Report (pp. 60–64) a number of specimens of Cœlopleurus collected at Amboina and in the Philippines were referred to

Cœlopleurus Maillardi. This identification is not correct, the specimens alluded to belonging in part to a new species which we have called *Cœlopleurus longicollis* (q. v.) (described and figured under the name of *C. Maillardi* on Pl. VI of the "Challenger" Echini, and on Pl. V, figs. *1, 2*), and in part to the species we have called *Cœlopleurus maculatus* ("Challenger" Echini, Pl. V, fig. *3*). The latter may be at once recognized by the peculiar ornamentations of the median abactinal part of the interambulacral area which we figure on Pl. 53, figs. *2, 4*, of this memoir; this, with the red and green color of the primary spines, at once distinguishes it from all the other species of Cœlopleurus.

The specimen figured on Pl. 53, figs. *1, 2*, measures 24 mm. in diameter and 15 mm. in height; the actinal system is 10 mm. in diameter, the abactinal system 5 mm., and the anal system 4 mm. The greatest width of the interambulacral system is 8 mm., while the greatest width of the ambulacral system is 6 mm. There are ten and ten primary ambulacral tubercles occupying the whole median ambulacral space; the six at the ambitus are the largest, and they diminish in size towards both the actinal and abactinal systems.

The pores are arranged close to the edge of the scrobicular area in irregular arcs of three pairs to each plate. They are largest on both sides of the ambitus (Pl. 53, figs. *1–3*). The primary tubercle occupies nearly the whole of each plate with the exception of the small tubercles filling the median ambulacral space. The interambulacral primaries extend only to the seventh plate from the actinal system. Tubercles similar to those in the ambulacral median area occupy the median interambulacral space actinally, and extend in the outer angle of each plate between the primaries and the poriferous zone. Above the primary tubercles the interambulacral plates are covered on the outer sides with a coarse granulation, leaving a straight, narrow, smooth median area ornamented with a bare S-shaped marking. The bare space being whitish is very prominent, the granules which flank it being dark violet in striking contrast. The appearance of this bare interambulacral space (Pl. 53, fig. *2*; Pl. V, fig. *3*, "Challenger" Echini) is thus very different from what it is in other species of the genus (see the corresponding figures of *Cœlopleurus floridanus* A. Ag., "Blake" Echini, Pls. VII, figs. *1, 3*; VIII, figs. *1, 4, 7, 10, 11, 14, 15, 16*; of *Cœlopleurus Maillardi* A. Ag., Michelin, Maillard's Bourbon, Ann. A., Pl. XIV; and of *Cœlopleurus longicollis*, A. Ag. and Cl. "Challenger" Echini, Pls. V, fig. *1*; VI, figs. *1, 2, 6*).

The ambulacral pores near the actinal system are somewhat crowded together; the membrane of the slight actinal cuts extends well up in the angle between the ambulacral and interambulacral areas (Pl. 53, fig. *1*). There are from six to nine small but deep actinal sphæridial pits in the median ambulacral zone.

There are four anal plates, surrounded by a narrow raised ring formed by the genitals (Pl. 53, fig. *2*). The genital pores are distal, placed close to the outer angle of the genital plates; the madreporic body is clearly indicated by small pores. The genital plates, which are irregularly heptagonal, carry scattered tubercles of the size of those of the abactinal interambulacral plates (Pl. 53, fig. *2*). The ocular plates are pentagonal and are excluded from the anal system.

The actinal system is decagonal, slightly indented in the median ambulacral line, and is closely covered with minute longitudinal plates, among which are placed the five widely separated pairs of buccal plates with their minute pores (Pl. 53, fig. *1*).

Cœlopleurus maculatus is a strikingly handsome species (Pl. 57, figs. *4–6*) with its polished, bright pea-green primary spines conspicuously spotted on the upper side with scarlet red. The lower side is white, with somewhat indistinct red markings, as though the spots on the upper side showed through (Pl. 53, figs. *5*, *6*, *7*). Towards the tip of the spine, on the upper side, the red spots become confluent so that the distal part of the spine is red for a greater or less distance, though it may be tipped with green or white. The primary spines are sharply triangular, especially near the base, and are distinctly curved towards the tip. The collar is short, rarely over 5 mm. in length, dull and usually rough, with four or five longitudinal series of coarse granules, on each side. The small actinal primary spines are flat and smooth, pure white, with very conspicuous gray collars extending half their length. The secondary spines are stout and blunt. In the largest specimen of *C. maculatus*, measuring 37 mm. in diameter, the primary spines are from three to three and a half times the diameter of the test. With the additional material from Japan at our disposal we find that the different species of this genus can at once be readily distinguished by the marking of the abactinal interambulacral area, the coloration of the spines, and the length of the collar. In *C. Maillardi* the primaries are green, marked with deep purple spots. The collar is 8 mm. long and finely and uniformly granular (Pl. 53, figs. *8*, *9*). In *C. maculatus* the primaries are green, with the spots bright red. In *C. floridanus* the primaries are uniformly red. In *C. longicollis* the primaries are whitish, with a long collar marked with granular lines (Pl. 53, figs. *10, 11*). In *C. elegans,* the primaries are bright yellow, with the spots red.

Döderlein (1906) has given quite a full account of the pedicellariæ and calcareous particles of this species, with some figures ("Valdivia" Echini, Pl. 45, fig. *1*), under the name of *C. Maillardi.* Aside from his statement that the specimen was from Japan, his figure of an ophicephalous pedicellaria shows clearly that he had *maculatus* and not *Maillardi* in hand. It has seemed to us that additional figures were desirable for the sake of comparison with the other species of the genus.

The tridentate pedicellariæ are common, and show considerable diversity of form and size. The valves (Pl. 49, figs. *23, 24*) are slender and rounded at the end; their length ranges from .30 to 1.85 mm. They are sometimes tinged with green at the tip, while reddish at the base, but are often colorless. The stalks are 1.5–5 times as long as the valves, and their upper ends (Pl. 49, fig. *25*) are enlarged and rounded without any constriction.

The ophicephalous pedicellariæ are abundant, especially actinally. The valves (Pl. 49, fig. *21*) are much stouter than in *floridanus,* but are not quite so stout as those of *longicollis.* They are easily distinguished from the latter, moreover, by their evident constriction near the middle. They (i. e., the lime) are usually quite deeply colored, red near the base and green at the tip. The upper ends of the stalks are also colored red. The valves are .60–.70 mm. in length, while the stalks are 3–6 times as long.

The triphyllous pedicellariæ appear to be wanting, unless we call the smallest of the tridentate by that name.

The calcareous particles in the pedicels are irregular, rough, more or less curved rods (Pl. 49, fig. *27*), in addition to the usual terminal rosettes and supporting plates. The calcareous particles of the gills (Pl. 49, fig. *28*) are smooth perforated plates of small size and irregular form.

The sphæridia are numerous (6–12) in each ambulacrum on the actinal surface. They are decidedly wider than long, and are deeply sunken in pits in the test (Pl. 49, fig. *26*).

This species was taken by the "Albatross" at the following stations:

Station 4881. Eastern Channel, Korea Strait. Bott. temp. 64.9°; 40–59 fathoms. Fne. gy. s. br. sh.

Station 4937. In Kagoshima Gulf, Japan. Bott. temp. 64.8°. 58 fathoms. M. lav. p.

Bathymetrical range, 40–59 fathoms. Extremes of temperature, 64.8°–64.9°. Five specimens.

Cœlopleurus floridanus A. Ag.

Cœlopleurus floridanus A. Agassiz, 1872. Rev. Ech., Pt. I, p. 102.

Plates 44, figs. *1, 2;* 49, figs. *31–33;* 53, fig. *11.*

This species was not taken by the "Albatross," but is included for comparison with the other species of the genus.

Döderlein (1906, Pl. 45, fig. *2*) has given a series of figures illustrating the pedicellariæ and calcareous particles of *floridanus*, but as his specimen came from southeast of the Cape of Good Hope, and is quite possibly *not* this species, it seems desirable to give a few figures of pedicellariæ from a typical West Indian specimen.

The tridentate pedicellariæ are common, and show a remarkable diversity of size and form. The valves measure from .35 to 2.30 mm. in length, and are commonly rosy-red in color, at least along the mid-line. They may be very slender (Pl. 49, fig. *32*) or somewhat widened, with a constriction near the middle (Pl. 49, fig. *33*). The latter are small, and approach triphyllous pedicellariæ in their general appearance, but intergrade completely with the larger ones. The stalks of the tridentate pedicellariæ are commonly several times as long as the head, but in the large ones the heads may equal or even exceed the stalk. The upper end of the stalk is slightly enlarged and rounded, as in *maculatus*.

The ophicephalous pedicellariæ are very common, especially on the actinal surface. The heads and even the upper end of the stalks are strongly tinged (in the lime itself) with red, but the larger the pedicellaria the paler is the color. The valves (Pl. 49, fig. *31*) are somewhat elongate, and are markedly constricted at the middle. They measure about half a millimeter in length, while the stalk is four or five times as long. The upper end of the stalk is flat and expanded, as in *maculatus*.

Triphyllous pedicellariæ appear to be wanting.

The calcareous particles of the pedicels are rough, curved irregular rods like those of *maculatus*, and the perforated plates from the gills cannot be distinguished from those of that species.

The sphæridia, of which there are from 6 to 12 on each ambulacrum, are wider than long, and are deeply sunken in pits in the test, as in *maculatus*.

Cœlopleurus longicollis A. Ag. and Cl.

Cœleopleurus Maillardi A. Agassiz, 1881. "Challenger" Echini, p. 60 (*partim*). Pls. V, figs. 1, 2; VI, figs. 1–7, 15–22.

(Non **Keraïaphorus Maillardi** Michelin, 1862. Maillard's Bourbon. Ann. A, p. 2.)

Plates 49, figs. *29, 30*; 53, fig. *10*.

We need not describe this species here further than to refer to the description of specimens collected at Station 201, Straits of Basilan, P. I., in the "Challenger" Echini, p. 60, which applies to *C. longicollis*, with the exception of such part as applies to the description of the banded, colored spines, a feature of *C. maculatus* (Pl. V, fig. *3*).

The tridentate pedicellariæ are scarcely distinguishable from those of *maculatus*, except that the lime is colorless and the upper end of the stalk (Pl. 49, fig. *30*) has a marked constriction near the tip. The valves are .30–2.65 mm. in length.

The ophicephalous pedicellariæ are very characteristic, for not only are they colorless (i. e. the lime), but the valves (Pl. 49, fig. *29*) are very broad and not at all constricted, and have a narrow apophysis; they are about two-thirds of a millimeter long.

Triphyllous pedicellariæ are apparently wanting.

The calcareous particles in the pedicels and gills and the sphæridia are not distinguishable from those of *maculatus*.

ASPIDODIADEMATIDÆ Duncan.

The Pedicellariæ and Other Structural Characters.

Plates 44, figs. *3, 4*; 50, figs. *1–15*.

Thanks to the descriptions and figures of Mortensen (1904), de Meijere (1904), and Döderlein (1906) the pedicellariæ of this family are very completely known, the only species not examined by any of those writers being *Dermatodiadema horridum* and *globulosum*, which we describe and figure herewith. As we have also examined *D. antillarum* and all of the four species of Aspidodiadema, a brief account of the pedicellariæ of the family will not be out of place. There are no constant differences between the pedicellariæ of Dermatodiadema and those of Aspidodiadema, but there are such differences between the larger pedicellariæ of some of the species of Dermatodiadema which are useful in their identification.

The size and form of the pedicellariæ show an extraordinary diversity, as many as seven different kinds sometimes occurring on a single specimen, while most individuals have at least four. There can generally be found triphyllous, ophicephalous, and tridentate pedicellariæ; in some individuals, two forms of triphyllous occur, while there are very commonly two forms of tridentate present, and there may be three or four. The stalks of the pedicellariæ are calcareous rods, more or less enlarged, and fenestrated at the ends, the extent of the fenestration depending chiefly on the size of the pedicellaria.

The tridentate pedicellariæ in their most common form have the valves long and slender (Pl. 50, figs. 7, *12*), usually straight, but sometimes curved; these may be called the "*slender tridentate*." Other very large pedicellariæ are usually present of which the three valves are very broad and deep in proportion to their length and have the blade more or less filled by a calcareous network (Pl. 50, figs. *1*, *6*, *11*). These pedicellariæ are called "globifere" by Döderlein, which is convenient but inaccurate, as they are certainly not homologous with the globiferous pedicellariæ of the other Diadematoida. Mortensen calls them "large ophicephalous," and while in some cases their resemblance to ophicephalous pedicellariæ is apparent, the absence of an "articular loop" and their great size are objections to regarding them as such. As de Meijere calls them "grosse tridentate," and we incline to the view that that name best expresses their real character, we shall designate them as "*stout tridentate*." Although these stout tridentate pedicellariæ usually have the blade rather deep, with the sides converging to a blunt point, they sometimes occur with broad, rather flat blades and wide tips (Pl. 50, fig. *3*); such pedicellariæ may be designated as "form *b*." Another peculiar form is rarely found, which is quite intermediate between the tridentate and ophicephalous pedicellariæ, having the "articular loop" of the latter and the blade free from a calcareous network, but with the general appearance of the former (Pl. 50, fig. *4*); these may be called "form *c*."

The *slender tridentate* pedicellariæ are very common, and occur on all parts of the test, even on the abactinal system and the buccal membrane. The heads are attached to the stalks, which are rarely more than twice as long, by a relatively short "neck," and the upper end of the stalk is rounded. The valves (Pl. 50, figs. *7, 12*) range in length from .30 to 2.00 mm., and their greatest width does not exceed .40 of the length. They may be straight and meet for nearly their whole length, or else straight or curved and meet only at the tips. The blade is often compressed; it seldom contains much of a calcareous network, only a few transverse pieces. The *stout tridentate* are usually rare and often wanting. They occur chiefly on the abactinal surface, especially close to the genital and ocular plates. The heads are attached to the stalks, which seldom greatly exceed them in length, by a very short neck, and the upper end of the stalk (Pl. 50, fig. *15*) is much enlarged and slightly flattened. The valves (Pl. 50, figs. *1, 6, 11*) are roughly triangular with a blunt point and are always very deep at the base, but the blade is more shallow and is largely filled by a calcareous network. The valves are from .60 to 2.00 mm. in length, and the breadth at base is from a half to three-fourths of the length. Form *b* is rarely met with, but is sometimes found abactinally. The valves (Pl. 50, fig. *3*) are comparatively flat, more oblong than triangular, and the calcareous network is only in the lower part of the blade. The length of the valves is rather more than a millimeter, and the width is about half as much. Form *c* is quite as rare as *b*. The valves (Pl. 50, fig. *4*) are only about .50–.60 mm. in length and .20–.25 mm. wide at base, and are remarkable for the presence of an articular loop and the absence of the calcareous network in the blade.

The ophicephalous pedicellariæ are common on all parts of the test, but are chiefly found on the interambulacra. They are remarkable for the very small heads and the presence of three large glands on the stalk. The head rests directly on the enlarged, flattened, or concave end of the stalk, which is 6–10 times its length. The valves (Pl. 50, figs. *9, 14*) are only about .20 mm. in length, and their width is a little more than half as much. They may be rounded or pointed at the tip. An articular loop is present, but is small and the three valves do not differ essentially from each other. Döderlein and Mortensen both speak of these pedicellariæ as sometimes having four valves, but we have never seen any with more than three.[1]

[1] Dr. Mortensen's figures (1904, Pl. 4, figs. 10 and 12) represent the valves of ophicephalous pedicellariæ much flatter than they appear to be to us, and with a rudimentary articular loop or none, a condition we have not observed. We may also mention that his figure 35, pl. 4, cannot possibly be a triphyllous valve, as is stated in the explanation of the plates. This is doubtless a slip of the pen for "tridentate."

The triphyllous pedicellariæ are common everywhere on the coronal plates, and are easily recognized by the very slender stalk, several times as long as the head, and the very long neck, about twice the length of the valves. The latter are from .30 to .50 mm. in length and are greatly constricted just above the base. The blade expands at the tip, and is provided with a perforated "cover-plate" which conceals more or less of the basal part. Two quite distinct kinds of triphyllous pedicellariæ are found sometimes on the same individual. In the common kind the valve (Pl. 50, figs. *8*, *13*) is rounded at the tip, and the greatest width of the blade is 1.25 times the width of the base of the valve or less. In the other kind, which seems to be quite rare, the valve (Pl. 50, fig. *5*) is almost square cut at the tip, and its width there is twice that of the basal part. The larger triphyllous pedicellariæ of the common kind intergrade completely with the slender tridentate, the blade becoming elongate and the cover-plate reduced or even practically wanting. Neither tridentate (except form *c*) nor triphyllous pedicellariæ ever have an articular loop.

The sphæridia (Pl. 50, figs. *2*, *10*) in the Aspidodiadematidæ are either globular or ovoid and never wider than long. They are suspended by short stalks from minute tubercles on the ambulacral plates, and are entirely on the surface, never sunken in depressions or pits. They are remarkably numerous, for a number are always to be found on the actinal half of each ambulacrum, and not infrequently the abactinal half is also provided with them. In some individuals they extend all the way from peristome to ocular plate, as many as fifteen being found in each ambulacrum. They are rather small, however, seldom exceeding .35 mm. in length.

The calcareous particles of the pedicels and gills consist of smooth, perforated plates of comparatively small size and with few holes. In the gills they are quite irregular, but in the pedicels they tend to assume one of two forms: in one the ends are somewhat drawn out, and the perforations are minute and confined to the middle of the plate, while in the other the perforations are larger and occur in all parts of the usually elongated plates. We are unable to draw any sharp line between these two forms, nor can we find that any generic or specific characters are to be drawn from the calcareous particles of any sort.

The arrangement of the internal organs of Aspidodiadema are shown in figures *3* and *4*, Pl. 44. The reproductive organs are narrow, elongated tufts of rather thick, short tubules, which, when fully developed, occupy most of the interambulacrum from genital plate to peristome. The œsophagus is rather short, and the lower coil of the stomach-intestine is wide and little undulated, though with large radial pouches in all of the ambulacra except the anterior one. The upper coil of the intestine is somewhat narrower, and is scarcely undulated at all, so that the entire intestine is remarkably short. The rectum is held in position by numerous strands of connective tissue which are attached to the abactinal margin of the corona.

The Genera and Species of Aspidodiadematidæ.

The better acquainted we become with this characteristically deep-sea group of recent Echini the stronger becomes the conviction that Duncan was right when he separated them as a distinct family from the Diadematidæ. The group is a very homogeneous one, for while we find it desirable to recognize 10 species, there are only 2 genera, and these are distinguished solely by the not very important but very constant character of the size of the primary tubercles in the lower half of the ambulacra. It is an interesting fact that essentially the same difference distinguishes Diadema and Echinothrix. The two genera of Aspidodiadematidæ are as follows:

Large primary tubercles present in ambulacra actinally . . . . . *Aspidodiadema.*
No large primary tubercles present in ambulacra actinally . . . . *Dermatodiadema.*

Aspidodiadema.

A. Agassiz, 1879. Proc. Amer. Acad., XIV., p. 199.
Type-species, *Aspidodiadema tonsum* A. Agassiz, 1879. Proc. Am. Acad., XIV., p. 199.

The four species which we consider it desirable to recognize in this genus are very closely allied to each other, but appear to be constantly distinguishable by the characters given in the table below. One of them, *Jacobyi* A. Ag., occurs in the West Indian region, in 95–287 fms., but the others occur in the Indo-Pacific region, especially its eastern half, in depths of 100–1700 fms. The "Challenger" species, *tonsum* A. Ag., is known from the East Indies and Japan; the "Valdivia" species, *nicobaricum* Död., from the Nicobar and Hawaiian Islands; and the "Siboga" species, *meijerei* Död., from the Kei and the Hawaiian Islands. While *nicobaricum* commonly occurs at depths of over 400 fms., *meijerei* is usually found in water of less than 300 fms.

Ambulacra broad, about $\frac{3}{4}$ as wide as interambulacra, or even wider; miliary tubercles rather few actinally, 2–6 on a buccal plate, usually fewer than 10 on larger interambulacral plates, except in the largest specimens (25–30 mm. h. d.).
- Primary spines purple or purplish; test tending to become deep purple actinally . . . . *nicobaricum.*
- Primary spines green or greenish; test tending to become purple abactinally . . . . *meijerei.*

Ambulacra narrower, about $\frac{3}{5}$ as wide as interambulacra or less; miliary tubercles numerous actinally, 8–12 on a buccal plate, usually more than 10 on larger interambulacral plates.
- Primary spines purplish; anal plates densely covered with rather stout miliary spines . . . . *tonsum.*
- Primary spines greenish; anal plates each with 5–10 rather slender miliary spines . . . . *Jacobyi.*

Aspidodiadema nicobaricum Död.

Aspidodiadema nicobaricum Döderlein, 1901. Zool. Anz., XXIV., p. 21.

Plate 50, figs. *1, 2.*

One needs but to compare the descriptions and figures given by de Meijere (1904), Mortensen (1904), and Döderlein (1906), of the pedicellariæ of this species, to realize how elusive and unsatisfactory a classification based to any considerable extent on these minute structures is sure to be. While the "personal equation" will probably explain some of the differences shown by these writers, it seems to be true that this is a very variable species so far as the pedicellariæ are concerned. Our Hawaiian specimens exhibit certain peculiarities which would seem to distinguish them from East Indian specimens. Thus, we find the ophicephalous pedicellariæ have only 3 valves, while Mortensen and Döderlein say there are 4; however, de Meijere describes and figures them as though there were only 3 in his specimens. Again, none of the Hawaiian specimens have slender, tridentate pedicellariæ with curved valves, as figured by Döderlein; however, he says he missed them in most of the "Valdivia" specimens, so this is not an important difference. Again, some of the Hawaiian specimens have very large, *stout tridentate* pedicellariæ, with valves (Plate 50, fig. *1*) over a millimeter and a half in length; however, these are more frequently absent than not, so no great weight can be attached to them. If we sum up all the observations so far made on the pedicellariæ of this species, the result is as follows:

Slender tridentate pedicellariæ, abundant, of very variable size and form; usually the valves are straight and meet either for their full length or only at the tip, but in some Nicobarian specimens they are conspicuously curved. The length of the valves ranges from .60 to 1.65 mm., and the margin is either smooth or finely serrate, rarely coarsely dentate.

Stout tridentate pedicellariæ, rare and often wanting in Hawaiian specimens, wholly wanting in Nicobarian specimens, common or sometimes infrequent in specimens from the Kei Islands. The valves are either about a millimeter long and nearly as wide, with a tooth at the tip (specimens from Kei), or they are over a millimeter and a half long, only a little more than half as wide, and rounded at the tip (specimens from Hawaii).

Ophicephalous pedicellariæ are of the usual form and size, and exhibit little diversity. There are 3 glands on the stalk, and in specimens from Kei and Hawaii there are 3 valves in the head; specimens from Nicobar have 4 valves.

Triphyllous pedicellariæ are common, and exhibit no special peculiarities. The valves are relatively narrower at the tip, and the lower part of the blade is thicker in specimens from Kei than in those from either Nicobar or Hawaii.

Such diversity of pedicellariæ naturally suggests the possibility that we are dealing with three different species, but it appears to be impossible to point out any constant character of any kind by which specimens from the three widely separated localities where this species has been taken can be distinguished from each other. Possibly an actual comparison of specimens might reveal some tangible differences, but Döderlein's and de Meijere's descriptions are so detailed they seem to leave no reasonable ground for such an expectation.

This species was taken by the "Albatross" at the following stations:

Station 3892. Off Mokapu Islet, N. coast of Molokai, Hawaiian Islands. Bott. temp. 42.5°. 328–414 fathoms. Fne. gy. s.

Station 3981. Off Nawiliwili Light, Kauai, H. I. 414–636 fathoms. Glob. oz.

Station 3988. Off Hanamaulu, Kauai, H. I. Bott. temp. 40 . 165–469 fathoms. Gy. for. s. p.

Station 3989. Off Hanamaulu, Kauai, H. I. Bott. temp. 37.5°. 385–500 fathoms. Co. s. r.

Station 3994. Off Mokuaeae Islet, Kauai, Hawaiian Islands. Bott. temp. 42.9°. 330–382 fathoms. Fne. gy. s. for.

Station 4013. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 399–419 fathoms. Fne. gy. s. for.

Station 4014. Off Hanamaulu, Kauai, H. I. Bott. temp. 40.8°. 362–399 fathoms. S. for.

Station 4021. Off Hanamaulu, Kauai, H. I. Bott. temp. 44°. 286–399 fathoms. Co. s. for.

Station 4022. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 374–399 fathoms. Co. s. for. r.

Station 4025. Off Mokuaeae Point, Kauai, H. I. Bott. temp. 44.9°. 275–368 fathoms. Fne. gy. s. br. sh. for.

Station 4030. Off Ukula Point, Kauai, H. I. Bott. temp. 41°. 423–438 fathoms. Fne. co. s. for. r.

Station 4107. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 41.6°. 350–355 fathoms. Co. s. for.

Station 4110. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.3°. 449–460 fathoms. Gy. s.

Station 4112. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.5°. 433–447 fathoms. Fne. s.

Station 4131. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.7°. 257–309 fathoms. Fne. gy. s.

Station 4137. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 411–476 fathoms. Co. vol. s. for. r.

Station 4140. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.4°. 339–437 fathoms. Fne. gy. s.

Station 4141. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 437–632 fathoms. Vol. s. for.

Station 4166. Off Modu Manu, H. I. Bott. temp. 45.6°. 293–800 fathoms. Co. s. for. r.

Station 4177. Off Kawahioa Point, Niihau, H. I. Bott. temp. 41°. 319–451 fathoms. Gy. s. glob.

Station 4180. Off Kawahioa Point, Niihau, H. I. Bott. temp. 41°. 417–426 fathoms. P. glob. r.

Station 4187. Off Hanamaulu, Kauai, H. I. Bott. temp. 40°. 508–703 fathoms. Gy. s. for.

Bathymetrical range, 165–800 fathoms, but averaging considerably over 400 fathoms.

Extremes of temperature, 45.6°–37.5°; average temperature, 41.6°.

One hundred and sixty-four specimens.

Aspidodiadema meijerei A. Ag. and Cl.

Aspidodiadema nicobaricum var. *meijerei* Döderlein, 1906. Echin. Deutsch. Tiefsee-Exp., p. 165.

Aspidodiadema meijerei A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 235.

Plates 44, figs. *3* and *4*; 58, figs. *7* and *8*.

There is nothing of importance to add to the descriptions and figures of the pedicellariæ, etc., given by de Meijere (1904) and Döderlein (1906), as the Hawaiian specimens before us agree in all essentials with those collected by the "Siboga" and "Valdivia." The *stout tridentate* pedicellariæ, however, occur in only a very few individuals.

One of the specimens from Station 3839 was deformed by the presence of five parasitic gasteropods (Stylifer ?) on or near the abactinal system. The hypertrophy of some of the genital and ocular plates (Pl. 58, fig. *8*) is very marked, and with this is associated a notable increase in the number of slender spines upon those plates, which are further remarkable for their very light (nearly white) color (Pl. 58, fig. *7*).

This species was taken by the "Albatross" at the following stations:

Station 3817. Off Diamond Head, Oahu, Hawaiian Islands. Bott. temp. 73.5°. ? 320 fathoms. Crs. lav. co. s. sh.

Station 3818. Off Diamond Head, Oahu, H. I. Bott. temp. 44.3°. 293–295 fathoms. Fne. co. s. bk. sp.

Station 3836. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 48°. 238–255 fathoms. Br. gy. m. s.

Station 3839. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 46.3°. 259–266 fathoms. Lt. br. m. s.

Station 3865. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 44.8°.–45°. 256–283 fathoms. Fne. vol. s. r.

Station 3914. Off Diamond Head, Oahu, H. I. 289–292 fathoms. Gy. s. m.

Station 3918. Off Diamond Head, Oahu, H. I. Bott. temp. 44.5°. 257–294 fathoms. Wh. s. m.

Station 3920. Off Diamond Head, Oahu, Hawaiian Islands. Bott. temp. 44.6°. 265–280 fathoms. Gy. s. br. sh.

Station 4096. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4097. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 44.2°. 286 fathoms. Fne. gy. s.

Station 4105. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 43.8°. 314–335 fathoms. Fne. co. s. for.

Station 4107. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 41.6°. 350–355 fathoms. Co. s. for.

Station 4116. Off Kahuku Point, Oahu, H. I. Bott. temp. 48.8°. 241–282 fathoms. Co. s. for.

Station 4122. Off Barber's Point Light, Oahu, H. I. Bott. temp. 64.6°. 192–352 fathoms. Crs. co. s. sh.

Station 4178. (?) Off Kawahioa Point, Niihau, H. I. 319–378 fathoms. Co. s. r. p.

Bathymetrical range, 192–378 fathoms, but averaging under 300 fathoms. Extremes of temperature, 48.8°–41.6°; average temperature, 44.7°.[1] One hundred and forty-nine specimens.

Aspidodiadema tonsum A. Ag.

Aspidodiadema tonsum A. Agassiz, 1879. Proc. Amer. Acad., XIV, p. 199.

Plate 50, figs. *3–5*.

The pedicellariæ of this species show greater diversity of form than in any other Echinoid we have examined. In the specimens collected by the "Siboga," de Meijere found slender tridentate (of two kinds), ophicephalous and triphyllous pedicellariæ, while Mortensen found stout tridentate also in the specimens which he examined. The latter speaks of two kinds of ophicephalous pedicellariæ, one with, the other without, glands on the stalk; we are inclined to think that this difference is due to the condition of the glands, whether full or recently discharged, and not to their actual presence or absence. We have found all of the forms of pedicellariæ, described and

[1] The temperatures of Stations 3817 and 4122 are obviously wrong; they should probably read 43.8° and 42.3°, as shown by Stations 3815 and 4123, which are immediately adjoining and at essentially the same depth. By the same reasoning, the temperatures for Stations 3914 and 4178 may be stated as 46° and 42° respectively. In estimating the average temperature these corrected figures have been used.

figured by de Meijere and Mortensen, and in addition two other varieties. A very careful examination of a specimen from Station 5079 revealed no less than *seven* easily distinguishable kinds. The pedicellariæ of this species may therefore be grouped as follows:

The *slender tridentate* are fairly common all over the test. The valves are about one millimeter long, with straight margins and rounded tips. The length of the blade varies proportionally as well as actually, but these pedicellariæ are always easily recognized.

The *stout tridentate* are often common, sometimes rare, and occasionally wholly wanting. They occur mainly near the abactinal system. The valves are comparatively short, usually under a millimeter long, but very broad in proportion, the width about 80 per cent of the length. The margins are scarcely sinuate and the tip is blunt, sometimes truncate, sometimes bent inward as a broad, flat tooth. The blade is nearly filled with a calcareous network.

The *form b* is very different, and is very rare. The few specimens we found were near the abactinal system. The valves (Pl. 50, fig. *3*) are rather more than a millimeter long, about half as wide, rather flat, and broadly rounded at the tip. There is a well-developed network in the blade and no articular loop.

The *form c*, which is quite rare and frequently wanting, is closely allied, though we do not find intermediate stages. The valves (Pl. 50, fig. *4*) are about .50 mm. long, with the blade about equal to the basal part. The tip may be bluntly pointed (as in our figure) or more truncate (as shown by de Meijere), while a small articular loop is usually present at the base.

The *ophicephalous* pedicellariæ are not very common, and occur mainly on the interambulacra. They have three small valves, each with an articular loop, and are broadly rounded at the tip.

The *triphyllous* pedicellariæ are common everywhere. The valves are rather slender, with round tips, as figured by de Meijere.

The *broad triphyllous* are rare, and are at once distinguished by the flat, truncate, almost square-cut tips (Pl. 50, fig. *5*), which are twice as broad as the base. We found none intermediate between these and the common form.

The calcareous particles in the pedicels commonly have the ends drawn out and imperforate as figured by de Meijere, but narrow, irregular, perforated plates also occur. The sphæridia show no characteristic features. This species was taken by the "Albatross" at the following stations:

Station 4980. Between Kobe and Yokohama, Japan. Bott. temp. 39°. 507 fathoms. Br. m. fne. s. for.

Station 5078. Off Omai Saki Light, Japan. Bott. temp. 38.9°. 475–514 fathoms. Fne. gy. s. glob.

Station 5079. Off Omai Saki Light, Japan. Bott. temp. 39.1°. 475–505 fathoms. P.

Station 5080. Off Omai Saki Light, Japan. Bott. temp. 38.7°. 505 fathoms. Fne. gy. s. glob.

Bathymetrical range, 475–514 fathoms. Extremes of temperature, 39.1°–38.7°. Fifteen specimens.

Dermatodiadema.

A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 76.

Type-species, *Dermatodiadema globulosum* A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 76.

The attempt of Pomel (1883) to divide Aspidodiadema into two genera, without having any specimens before him, has led to a little confusion in regard to the generic name for this group, but there seems to be general agreement now that the name Plesiodiadema Pomel is quite unusable. This genus contains six species, which are distinguishable from each other with more or less difficulty. One of them, *antillarum* A. Ag., is characteristic of the West Indian region, where it occurs at depths of 157–1589 fathoms; it was also taken south of the Canary Islands, by the "Valdivia," in 1389 fathoms. Two species, *horridum* and *globulosum*, A. Ag., are known only from the Panamic region, at depths of 902–1772 fathoms. The "Valdivia" collected a species very near *globulosum* in the Indian Ocean at a depth of 1622 fathoms, which Döderlein (1901) has named *molle*, and a second very well characterized species, *indicum* Död., near Sumatra, in 261 fathoms. The latter was taken by the "Siboga" also, in the Java Sea at 289, and in the Banda Sea at 113 fathoms. The "Siboga" took a second species, south of Celebes in 643 fathoms, which de Meijere (1904) has called *amphigymnum*. The three specimens were obviously immature, and we fail to find any character by which they could be distinguished from *horridum* of the same size; the apparent difference in the anal system is neither sufficiently marked nor constant to warrant their separation. The sixth species, which seems to us valid, is *microtuberculatum* A. Ag., taken by the "Challenger" in the southern Atlantic and Pacific Oceans, at depths of from 2025 to 2225 fathoms. These six species are so nearly related that they can be distinguished only when all their characters are taken into account. We find that the number of coronal plates and of ambulacral plates are important features, while the relative size of the abactinal system, the number and arrangement of the anal plates, the distribution of miliary spines and tubercles, and even the pedicellariæ, variable as they are, afford characters which must not be overlooked. Not having had a specimen of *molle* for comparison, we find it difficult to make the distinction between it and *globulosum* tangible, for Döderlein's figures are too indistinct to enable us to determine whether apparent differences in the ambulacral tubercles and the actinostome are real or not. We have been obliged, therefore, to be content with the rather marked differences in the pedicellariæ of these two species.

Coronal plates numerous, 10–12; abactinal system small, about $\frac{1}{2}$ h. d.; size large, 23–34 mm. h. d. . . . . *indicum.*

Coronal plates fewer, 6–9; abactinal system larger, usually about $\frac{2}{3}$ h. d.

- Anal system with 5–8 large plates around anus; other anal plates small and few, or wanting; vertical diameter of test, .65–.85 h. d.; ambulacra broad, usually exceeding .15 h. d.
  - Pedicellariæ valves long and slender (stout tridentate valves about 1.5 mm. long, the width little more than half length; slender tridentate valves about 1.6 mm., perfectly straight and not widened at tip; triphyllous valves about .50 mm.) *globulosum.*
  - Pedicellariæ valves shorter and stouter (stout tridentate valves about 1 mm. long, the width $\frac{2}{3}$ of length; slender tridentate valves about 1.8 mm., expanded at tip and slightly curved; triphyllous valves about .33 mm.) . . . . *molle.*
- Anal system with more or less numerous plates, chiefly of small size, those around anus seldom conspicuously bigger; vertical diameter of test usually under .70 h. d., but may be .80; ambulacra not so broad, usually under .15 h. d.
  - Ambulacral plates numerous (5–6 to each of largest interambulacrals); buccal plates with spines; valves of slender tridentate pedicellariæ slightly curved, meeting only near tip *microtuberculatum.*
  - Ambulacral plates fewer (3–4 to each of largest interambulacrals); buccal plates commonly without spines, though rarely in large specimens one or two may be present on each plate; valves of slender tridentate pedicellariæ straight, meeting for most of their length.
    - Size large, up to 20 mm. h. d.; ambulacra with 2–4 tubercles on each plate, none conspicuously larger than the others . . . . *horridum.*
    - Size small, up to 13 mm. h. d., but rarely exceeding 10; ambulacra with 1–3 tubercles on each plate, 1 tubercle on every second or third plate noticeably larger than the others . . . . *antillarum.*

Dermatodiadema globulosum A. Ag.

Dermatodiadema globulosum A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 76.
1904, Panamic Deep Sea Echini, Pl. 24, figs. *1–3*.

Plate 50, figs. *6–10*.

This species has not yet been taken outside of the Panamic region, but we include it here in order to describe and figure the pedicellariæ.

The *slender tridentate* pedicellariæ are common. In the largest ones the valves (Pl. 50, fig. *7*) are remarkably long (about 1.65 mm.) and narrow, with nearly straight margins, and meet each other for nearly their entire length. Smaller ones have the valves from .50 to 1.50 mm. long and not essentially different in form.

The *stout tridentate* are unfortunately rare, for they are very characteristic. The valves (Pl. 50, fig. *6*) are about 1.5 mm. long, with the base about .90 mm. broad, and the tip rounded. The blade is filled with a coarse network and the margins are decidedly sinuate.

The *ophicephalous* are not very common. The valves (Pl. 50, fig. *9*) are very small, only .20 mm. in length, and are broadly rounded at the tip.

The *triphyllous* are common everywhere and appear to intergrade with the slender tridentate. The valves (Pl. 50, fig. *8*) are remarkably long (up to .50 mm.) and have the cover-plate deeply cleft.

The spicules in the pedicels have the ends usually drawn out and imperforate as in *tonsum*, but sometimes flat and perforated.

The sphæridia (Pl. 50, fig. *10*) are large, somewhat longer than thick.

Dermatodiadema horridum A. Ag.

Dermatodiadema horridum A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 76.
1904, Panamic Deep Sea Echini, Pl. 24, figs. *4–12*.

Plate 50, figs. *11–15*.

We include this species also for the sake of the pedicellariæ, which appear to be very easily distinguished from those of *globulosum*; so far as our limited material of the latter permits us to speak, we should say the differences are very constant.

The *slender tridentate* are fairly common. The valves (Pl. 50, fig. *12*) rarely exceed 1 mm. in length, and the blade is relatively broader and flatter than in *globulosum*.

The *stout tridentate* are small, infrequent, and very characteristic. The valves (Pl. 50, fig. *11*) are only about .60 mm. long, but they are over .40 mm. broad and are noticeably deep. The blade is full of a calcareous network and the tip is rounded or bluntly pointed. They are thus much more like the ordinary form in *A. tonsum* than they are like those of *D. globulosum.*

The *ophicephalous* pedicellariæ have the valves (Pl. 50, fig. *14*) a trifle larger and distinctly more pointed than in *globulosum.*

The *triphyllous* have the valves (Pl. 50, fig. *13*) relatively shorter and broader than those of *globulosum,* and the cover-plate is not so deeply cleft.

The spicules in the pedicels do not appear to have the ends drawn out and imperforate as in *globulosum,* but are narrow, irregular, perforated plates.

The sphæridia are not peculiar.

DIADEMATIDÆ Peters.

The Pedicellariæ and Other Structural Characters.

Plates 44, figs. *5, 6 ;* 50, figs. *16–21 ;* 51.

The Diadematidæ show great diversity in the form of the pedicellariæ and the structure of these organs afford useful characters for the distinctions to be made between genera and species; and yet no very great reliance can be placed on them, because of the frequent absence of a characteristic form and the intergradations shown by the same kind of pedicellariæ in closely related species. As nearly all of the known species have been carefully examined by Mortensen, who has described and figured the pedicellariæ and calcareous spicules in detail (1904), we have confined our figures to one or two species not accessible to him and to the new species we have been called on to describe. No less than *seven* different sorts of pedicellariæ occur in this family, two kinds of tridentate, three kinds of ophicephalous, one triphyllous, and one globiferous. These are never all found in a single specimen, and usually only three or four kinds occur. The globiferous pedicellariæ are found only in Centrostephanus, in which genus they are common and sometimes very abundant. In young individuals of the other genera only small tridentate pedicellariæ, usually with some triphyllous and ophicephalous, are commonly found, the large tridentate appearing only with maturity. In some specimens of Diadema and Chætodiadema pedicellariæ are infrequent and the tridentate are very rare or wholly wanting. In Leptodiadema we have failed to find any pedicellariæ whatever.

The *slender tridentate* pedicellariæ (Pl. 51, figs. *3, 12*) are commonly present on all parts of the test, but are often infrequent and may be wholly wanting, especially in young individuals. The heads are from .30 to 3 mm. long, and the neck and stalk show an equally great diversity. The head is usually shorter than the stalk, and the latter may be many times as long, but when the head is greatly elongated the stalk may be actually shorter. The neck is longest when the head is shortest, and is so short when the head is very long that it is virtually absent. The valves (Pls. 50, fig. *16* ; 51, fig. *1*) of which there are commonly three but sometimes four, are straight or very little curved, usually compressed, especially at the base of the blade, but often more or less flattened, and the margins are coarsely dentate, becoming more finely serrate near tip. The valves are 3–6 times as long as the width of the basal part, or 6–15 times as long as the width of the blade. There is usually, but not always, a calcareous network more or less developed in the basal half of the blade, and it sometimes extends nearly to the tip.

The *stout tridentate* pedicellariæ (Pl. 51, figs. *4, 13*) which are found scattered on the test in varying abundance and are often wholly wanting, when fully developed are strikingly different from the slender tridentate, but it is not possible to draw a sharp line between them, for they seem to intergrade, particularly in the genus Diadema, where one species has only slender tridentate and another has only stout tridentate, and others have forms which might be called by either name. The stout tridentate do not show as great a diversity of size as the slender ones, for the head is rarely less than .50 mm., and seldom exceeds 1.50 mm. There is little or no neck and the stalk is usually about as long as the head, though it may be shorter, or in other cases very much longer. The valves are usually decidedly curved and meet only at or near the tip. The margins are coarsely dentate or serrate for a part or all of their length. The length of the valve is only 2–4 times the width of the basal part, and only 3–4 times the width of the widest part of the plate, which is commonly near the tip. There is usually little or no calcareous network in the blade, but it may be very largely developed.

The *non-glandular ophicephalous* pedicellariæ (Pl. 51, figs. *5, 14*) are very variable in their occurrence, as they are frequently rare and often entirely wanting. When present, they are more likely to be found actinally than abactinally. The head is from .20 to .65 mm. long, while the stalk is 3–5 times that length ; there is no neck. The valves are usually provided with an articular loop, which differs greatly in size in the three, and may be wholly wanting in one. The blade may be sinuate, coarsely dentate, serrate, or nearly smooth on the margin.

The *glandular ophicephalous* pedicellariæ (Pl. 51, fig. *6*) do not differ in any essential particular from the non-glandular save in the presence of three conspicuous glands on the stalk. It is quite possible that this difference is due to the stage of development of the pedicellaria, or even that it is apparent rather than real, the difference in appearance being due to the condition of the glands.

The *claviform ophicephalous* pedicellariæ appear to be simply a degradational form of the glandular ophicephalous, in which the glands seem to be developed at the expense of the valves, the latter becoming very small or more often entirely wanting. Such pedicellariæ are very common in the Diadematidæ, especially on the actinal side of the test.

The *triphyllous* pedicellariæ (Pl. 51, figs. *7*, *15*) are generally common, scattered all over the test, but in some cases are rather rare. The heads are small, only .20–.40 mm. long, and are attached to the very slender stalk by a long neck. The valves (Pl. 50, fig. *18*) are flat and more or less leaf-shaped, sometimes narrowed and rounded at the tip, but more commonly truncate or square-cut, and in some cases widest there. No cover-plate is present; Mortensen (1904) describes and figures a cover-plate on the valve of the triphyllous pedicellariæ in Micropyga, but there is none in the specimens we have examined, and if it occurs, it must be quite unusual, and not the normal condition.

The *globiferous* pedicellariæ (Pl. 51, figs. *8*, *16*) are very different from any of the preceding, and are characteristic of the genus Centrostephanus. They are conspicuous because of the glands, which not only enclose and may even entirely conceal the valves, but which may also occur on the upper part of the stalk. There is no neck, but the stalk is 2–8 times as long as the head. The valves (Pl. 51, figs. *9*, *10*, *18*, *19*) are small, rarely exceeding .45 mm. in length. The basal part is wide, but the blade is abruptly narrowed and at the tip is provided with 4–6 very long and conspicuous teeth. The blade may be shorter than the basal part, and quite evidently hollowed or concave on the inner side, or it may exceed the basal part and be nearly cylindrical, hardly more than flattened on its inner face. The glands vary greatly in their development in different examples. They are sometimes scarcely evident on the stalk but very conspicuous on the valves (Pl. 51, fig. *16*), while at other times they are very large on the stalk but hardly noticeable on the valves. As a general rule one may say that if they are conspicuous on the valves, they will be small on the stalk, and vice versa. The stalk is greatly expanded and more or less concave at the top (Pl. 51, fig. *20*).

In all pedicellariæ in this family the stalk consists of a calcareous rod more or less pitted or fenestrated, at least at the enlarged ends. In its simplest and slenderest condition the rod is nearly smooth and cylindrical for the great part of its length, but is more or less abruptly and conspicuously enlarged both at the base and at the top; the enlarged portions are rough, rather distinctly ridged, with cross-bars and pits or openings between the ridges. In other cases the rod is rough with projections, and it may be somewhat flattened and regularly fenestrated in such a way as to appear ladder-like, as though it were made up of two rods united by cross-pieces. Where still more developed the rod is much thicker and is ridged for its whole length with cross-bars, perforations, or pits in between the ridges, and the enlargement of the base and top are relatively small. In its extreme development the stalk has eight or more ridges, and may appear as though made up of that number of rods, closely united by cross-bars, particularly at the two ends. In Micropyga the component parts of the stalk are very slender, and the connections between them few and widely separated; such a stalk is best described as made up of numerous calcareous threads, closely united at the ends but only loosely and irregularly connected with each other elsewhere. While at first sight such a stalk appears quite different from that found in other Diadematidæ, the difference is, after all, in degree rather than in kind.

The sphæridia (Pl. 50, fig. *20*) are more or less ellipsoidal, rarely globular bodies, attached to the surface of the test and seldom sunken in depressions or pits of any kind. They are very small (.15–.30 mm. long), and are provided with short stalks which connect them with minute tubercles on the plates. They are confined to the ambulacra and are generally rather numerous, from 3 to 12, or even more, occurring in each ambulacrum. They are most common on the actinal surface, especially near the peristome, but in some cases they occur only near the ambitus, and in others they are found all along the ambulacrum, from peristome to ocular plate. They most commonly occur near one of the large tubercles, and usually at its outer side, so that they frequently form a vertical series between the large tubercles and the poriferous zone. In life, they are probably more or less pendent; but in preserved, and especially dried specimens, they are often quite erect.

The calcareous particles of the Diadematidæ are quite characteristic in that they are fundamentally triradiate, and in their simplest condition they exhibit this form very prettily. Such spicules have three branches of equal length, equally distant from each other, perfectly straight, smooth, and pointed; they are to be found chiefly near the tips of the pedicels, and most commonly on the abactinal surface. Usually, however, the branches are not equal, nor are they straight, and they often have subordinate branches growing out from them (Pl. 50, fig. *21*). As these branches become more numerous (Pl. 51, fig. *11*), they tend to coalesce and make small, irregular plates with few perforations (Pl. 50, fig. *19*); these occur in the lower part of the pedicels, or in those of the actinal surface, or sometimes in the gills. These plates may continue their growth in either of two different ways: they may elongate, but remain narrow, increase in thickness, and decrease the diameter of the perforations, and thus become such supporting plates as occur in the pedicels, especially of the actinal surface, of many individuals; or they may increase in diameter irregularly in all directions, remaining thin and with large perforations, and thus become the fenestrated plates which occur commonly in the gills, and sometimes in the pedicels, of many species. These plates sometimes grow to a large size, in the basal part of the gills becoming large enough to be seen with the unaided eye. In Micropyga, one branch of the fundamental triradiate spicule becomes greatly elongated, and either forms the handle of the characteristic anchor-shaped particles found in the pedicels of that genus, or becomes a rod, expanded and fenestrated at each end and in the middle; these rods often show their triradiate origin plainly, and not infrequently develop into irregular perforated plates. As age and condition appear to affect profoundly the size and number of the calcareous particles, we fail to find in them any satisfactorily constant generic or specific characters, except, of course, in Micropyga.

The arrangement of the internal organs in Chætodiadema (Pl. 44, figs. *5*, *6*) is illustrative of the whole family; for a careful examination of specimens of Diadema, Echinothrix, Astropyga, and Micropyga reveals no important character in which these genera differ from each other. The reproductive organs are very dense masses of short tubules, which occupy a greater or less proportion of each interambulacrum according to their maturity. The alimentary canal is remarkable for its very great development, its total length exceeding $2\frac{1}{2}$ times the external circumference of the test. The œsophagus is remarkably long, first bending backwards above the lantern and then turning to the left and running forwards to the anterior ambulacrum, where it enlarges abruptly to form the stomach-intestine. The first or lower coil of the intestine, which runs from left to right (*i. e.*, contrary to the hands of a clock), is arranged in a double fold in each ambulacrum except in the anterior one, where only the right-hand fold occurs, the other being replaced by the abrupt, upward and backward turn of the canal. The second or upper coil, running back from right to left above the other, is not so extensively folded, but is yet greatly lengthened by a very deep loop in each interambulacrum. The loop in the left anterior interambulacrum is the smallest, and passes by gradual change into the rectum, which is straight and not noticeably enlarged. The two intestinal coils fit into each other in such a manner that the loops of the upper reach down into the actinal half of the test and lie snugly between the double folds of the lower. The two are united so extensively with each other and with the test by mesenteries and strands of connective tissue that they are held firmly in place, and can only be separated, without injury, by very careful dissection.

The Genera and Species of Recent Diadematidæ.

There is still much room for difference of opinion as to the limits of this family when the fossil forms are taken into account, but so far as recent species are concerned, the only point which causes discussion is whether Micropyga should be regarded as one of the family or not. Mortensen (1904) established a separate family for Micropyga, and Döderlein (1906) has followed him in this arrangement. We have given very careful attention to the matter, and have made extensive comparisons of the internal anatomy of Micropyga, as well as its external features, with other genera of Diadematidæ, and we find no sufficient reason for removing the genus from that family. The characters upon which the family Micropygidæ are based, are stated by Mortensen (1904, p. 45) as follows: "This family is characterized above all by its anchor-shaped spicules, further by wanting ophicephalous pedicellariæ, either in the form of true ophicephalous or of claviform ones; the triphyllous pedicellariæ are finely serrate in the outer edge, and the stalk of the pedicellariæ consists of several slender rods, almost not united, except at the ends. The tubercles are perforate, non-crenulated. The biserial arrangement of the pores and the deep actinal cuts may probably not be family characters; that the extraordinary development of the tube-feet in *M. tuberculata* is no character of high order is proved by the fact that in *M. violacea* these tube-feet are simple." If we examine these characters with a little care we find that only the first one is remarkable, for Döderlein (1906) has already noted the occasional presence of ophicephalous and claviform pedicellariæ, while the extremely minute serration of the end of the triphyllous valves is surely not of family importance. The structure of the stalk of the pedicellariæ, while very characteristic, differs only in degree and not in kind from what we find in the other Diadematidæ; even if essentially different, Dr. Mortensen could hardly consider it a family character, for a similar difference in the Echinothuridæ, he regards as a characteristic of his genus Kamptosoma. Non-crenulate tubercles are not unknown in the Diadematidæ; Dr. Mortensen gives them as one of the characters of his genus Lissodiadema. The anchor-shaped spicules are, then, the one characteristic feature of the Micropygidæ; we are inclined to add also the remarkable biserial arrangement of the pores, though Dr. Mortensen says that is "probably not" a family character. One feature of the internal anatomy is very striking and seems to us worthy to be mentioned with these two; namely, the ends of the compass-rods of the "lantern" are perfectly simple and similar, the outer end not being widened and more or less bifurcate as it is in other echini. Against these three notable peculiarities of Micropyga, we have to set the important resemblances to the Diadematidæ, which are present. The arrangement of the alimentary canal and the structure of the "lantern" and teeth are essentially as in Echinothrix and Astropyga. The form and structure of the test and the abactinal and anal systems are distinctly Diadematoid. The composition of the compound plates of the ambulacra is, in spite of the biserial arrangement of the pores, surprisingly like Diadema, more so indeed than we find to be the case in Astropyga.[1]

[1] Dr. Mortensen (1904, p. 42) makes a curious slip in regard to the value of the characters shown by the ambulacra, for he says: "I can only admit three different types, viz.: the Cidaroid type, with simple primaries which do not combine to form compound plates, the Diadematoid type in which the adoral primary plate is a small plate, the following one being the largest, and the Echinoid type in which the adoral component is the largest and never a demi-plate, the following being smaller. But these features do not present generic or family characters; they are of higher value. All the families of Ectobranchiata may be arranged in three groups, namely, with simple, or diadematoid or echinoid ambulacra; these are then characters of orders." If this be true we are wrong in placing Tetrapygus in the Arbaciadæ, for Duncan and Sladen (1885) long since showed that its ambulacra are "echinoid" and not "diadematoid" as are those of the Arbaciadæ. Are we to presume that Dr. Mortensen will establish a family "Tetrapygidæ" under his "Tribus 4. Echinina," for this aberrant genus?

Finally the hollow, verticillate spines and perforate tubercles show a close relationship to the Diadematidæ. In view of all these facts, we feel obliged to reject the family Micropygidæ, since its recognition seems to us to involve a most unnatural separation of Micropyga from its nearest allies.

In addition to Micropyga, we find it desirable to recognize eight genera of recent Diadematidæ, of which Diadema, Echinothrix, Centrostephanus, and Astropyga are old and well-established. There can be no question, either, as to the validity of Chætodiadema, but Lissodiadema and Leptodiadema are both based on very small specimens and their real status is not perfectly clear. As the eighth genus, we wish to establish Eremopyga, based on *Astropyga denudata* de Meijere, from the Dutch East Indies. This handsome "Siboga" echinoid has hollow spines, few primary tubercles in the interambulacra, a primary tubercle on each ambulacral plate (at least near the ambitus) and narrow poriferous zones with the arcs of pores in a nearly vertical series; while Astropyga has solid spines, many primary tubercles in the interambulacra, a primary tubercle only on every second or third ambulacral plate (even at the ambitus), and broad poriferous zones with the arcs of pores decidedly oblique. These differences appear to us to be too important to warrant placing *denudata* in Astropyga.

The genera we recognize are distinguished from each other largely by the structure of the primary spines and the distribution of the primary tubercles, but the form and structure of the test, the presence of spines on the buccal plates, the width of the poriferous zones, the crenulation of the tubercles, the size of the actinostome, the structure of the pedicellariæ and even the calcareous particles in the pedicels, furnish more or less important and usable characters. The following table will make the differences clear.

Primary spines of interambulacra rough with minute teeth, which are arranged either in whorls or in crowded longitudinal series.

- Normal primary spines hollow for the greater part of their length.
  - Test moderately thick, more or less flattened, with vertical diameter about half horizontal, always exceeding .40 h. d., sometimes over .60.
    - Buccal plates with few or no spines; no globiferous pedicellariæ.
      - Ambulacra with few or no secondary tubercles abactinally and narrower there than at ambitus; ambulacral primary spines not essentially different from those of interambulacra . . . . *Diadema.*

Ambulacra with numerous secondary tubercles abactinally and distinctly wider there than at ambitus; ambulacral spines filiform, smooth except near tip . . *Echinothrix.*
Buccal plates with numerous spines; globiferous pedicellariæ present . . . . *Centrostephanus.*
Test thin, much flattened, with vertical diameter about one-third horizontal and never exceeding .40 h. d.
Pores distinctly biserial; anchor-shaped spicules in pedicels . . . . *Micropyga.*
Pores uniserial or nearly so; no anchor-shaped spicules in pedicels . . . . *Eremopyga.*
Normal primary spines with central cavity so filled by a calcareous network that under low magnification they appear solid in cross-section.
Actinal surface with normal primary tubercles; poriferous zones becoming wider at peristome; primary tubercles in ambulacra, near ambitus, only on every second or third plate; actinostome, .25–.35 h. d. . . . . *Astropyga.*
Actinal surface with tubercles tending to become small and densely crowded near peristome; poriferous zones at peristome reduced to a single series of widely separated pairs of pores; primary tubercles on each ambulacral plate, at least near ambitus; actinostome very small, only .15–.25 h. d. . . . *Chætodiadema.*
Primary spines of interambulacra nearly or quite smooth, even under high magnification.
Primary tubercles non-crenulate; each coronal plate at ambitus with 3 primary and 8 or 9 secondary tubercles . . . . *Lissodiadema.*
Primary tubercles finely crenulate; each coronal plate at ambitus with not more than 2 primary and 4 or 5 secondary tubercles . . *Leptodiadema.*

Diadema.

Gray, 1825. Ann. Phil., p. 4.

Type-species, *Echinometra setosa,* Leske, 1778. Add. Klein, p. 36.

Few genera of Echini afford as much difficulty as does this one in the way of distinguishing its component species, for while typical examples from widely separated localities look quite different and seem to be readily distinguishable, as soon as one attempts to state the differences it is found that they are remarkably intangible. For example, the olive cast of color of typical Hawaiian specimens is very different from the reddish tinge of certain examples from Zanzibar, and neither is at all like the deep purplish-black of West Indian specimens. But when large series of specimens are examined these differences of color are found to be very unreliable, and it seems clear that no reliance can be placed on color for separating the species.

The same is true to a greater or less degree of all the other characters by which it is customary to distinguish species, and we are finally driven to lay weight on characters which seem trivial and of doubtful value. There seems to be no doubt that the type-species (*setosum*) can always be distinguished when mature ; it ranges from Zanzibar to Tahiti and perhaps even to Japan. But other Diademas, which are certainly not *setosum*, occur throughout the Indo-Pacific region, as well as in the West Indies, and on both coasts of tropical America. Do these all represent a single species, or are there characteristic forms in each of these widely separated areas? After careful study of large series of specimens, it has seemed better to us to try and distinguish five species than to mass all this material together under one name. Accordingly we distinguish *antillarum* Phil. from the tropical Atlantic, *mexicanum* A. Ag. from the West Coast of tropical America and the Galapagos Islands, *paucispinum* A. Ag. from the Hawaiian Islands, *globulosum* A. Ag. (including *nudum* A. Ag.) from the Gilbert and Society Islands and Hong Kong, and *Savignyi* Mich. from the whole Indo-Pacific region, Zanzibar to Easter Island. All of the species are littoral. The characters by which they are distinguished are the arrangement of the primary tubercles in the interambulacra abactinally, the character of the spines, the size of the abactinal system, the depth of the actinal cuts, and the form of the tridentate pedicellariæ. The following table will show how these features are combined in the six species which we recognize.

Second series of interambulacral primary tubercles begins abactinally on 7th or 8th coronal plate; spines slender, fragile, with 24–32 longitudinal series of teeth; tridentate pedicellariæ slender, with narrow, compressed valves *setosum*.

Second series of tubercles begins abactinally on 4th, 5th, or 6th (rarely 7th) coronal plate; spines stouter, with 20–28 longitudinal series of teeth; tridentate pedicellariæ stout, with wide valves which are little or not at all compressed.

- Abactinal system less than half diameter of actinostome.
  - Actinal cuts usually deep and narrow; secondary and miliary tubercles rather few actinally; valves of tridentate pedicellariæ rather flat, nearly straight, with apophysis ending in a T . . . *antillarum*.
  - Actinal cuts usually wide and shallow; secondary and miliary tubercles rather numerous actinally; valves of tridentate pedicellariæ slightly compressed at base of blade, wide near tip, curved, with apophysis ending in a Y . . . . *mexicanum*.
- Abactinal system more than half diameter of actinostome.
  - Abactinal system .50–.55 of diameter of actinostome; second series of tubercles begins on 4th or 5th coronal plate; ambulacra narrow, about $\frac{1}{4}$ of interambulacra; valves of tridentate pedicellariæ somewhat compressed though broad, not narrowed near tip . . *paucispinum*.

Abactinal system about .60 of diameter of actinostome; second series of tubercles begins on 6th (sometimes 5th or 7th) coronal plate; ambulacra wider, sometimes $\frac{1}{3}$ of interambulacra.

Valves of tridentate pedicellariæ widened near tip, distinctly curved, not very flat; color usually with more or less of a reddish cast . . . . *Savignyi.*

Valves of tridentate pedicellariæ distinctly narrowed near tip, nearly straight, flat; color usually with an olive cast or nearly uniform black . . . . *globulosum.*

Diadema setosum Gray.

Echinometra setosa Leske, 1778. Add. Klein, p. 36.
Diadema setosa Gray, 1825. Ann. Phil., X, p. 4.

We have nothing to add to Mortensen's account of this species under the name *saxatile* L. The slender tridentate pedicellariæ are certainly very characteristic when present, but are unfortunately often wanting, particularly in young specimens. Occasionally tridentate pedicellariæ of large size are met with in which the valves are much wider than usual and approach the form of those of *paucispinum*, but as a rule a single glance with a magnifying glass at one of the large tridentate pedicellariæ of a Diadema is sufficient to determine whether it is *setosum* or not.

This species was taken by the "Albatross" on the reef of Neiafu, Vavau, Tonga Islands. Dec. 5, 1899. One specimen.

Diadema mexicanum A. Ag.

Diadema mexicanum A. Agassiz, 1863. Bull. M. C. Z., I, p. 19.

We have but little to add to Mortensen's description of the pedicellariæ of this species, except as regards the large tridentate. The "inward fold" at the tip of the valve which he describes and figures we find to be rather rare in our specimens, but on the other hand there are some details of structure by which these pedicellariæ can be distinguished from those of *antillarum.* The valves are generally quite distinctly curved, wide near the tip and somewhat compressed above the basal part, so that the end of the apophysis is Y-shaped, while in *antillarum* the valves are straighter and flatter and the end of the apophysis is T-shaped. The differences are so slight that we are not inclined to lay much stress upon them, and yet we find they are fairly constant. The pedicels often contain larger and more numerous perforated plates than we have found in any other species, but this feature is not sufficiently constant to be relied upon for a specific character.

This species was taken by the "Albatross" at Acapulco, Mexico, 1905. Two specimens.

Diadema paucispinum A. Ag.

Diadema paucispinum A. Agassiz, 1863. Bull. M. C. Z., I, p. 19.

Plate 51, figs. *1, 2.*

As Mortensen was unable to examine the pedicellariæ of this species, we have given a figure of a valve of one of the large tridentate, which shows some characteristic features. It is an open question whether these pedicellariæ should be called "slender" or "stout" tridentate, but we have preferred to regard them as "slender," because the valves, though broad, are distinctly compressed and are very straight. Occasionally they approach in form the slender tridentate of *setosum*, but the valves are never sufficiently narrowed to make confusion with that species possible. The margin of the valves is strongly dentate, and the tip is broad and bluntly rounded. The calcareous network in the blade is well developed.

This species was taken by the "Albatross" at the following stations:

Puako Bay, Hawaii, Hawaiian Islands.

Honolulu, Oahu, H. I.

Station 3968. French Frigate Shoal, H. I. 14½–16½ fathoms. Crs. s. co.

Station 4169. Off Modu Manu, H. I. Bott. temp. 78.6°. 21–22 fathoms. Co.

Nine specimens.

Diadema Savignyi Mich.

Diadema Savignyi Michelin, 1845. Rev. Mag. Zool., p. 15.

It is an interesting fact that the Diadema found by the "Albatross" at Easter Island should prove to be of this species, thus extending its known range far to the southeastward. As there is only a single specimen, and that not in good condition, we have only found one or two examples of large tridentate pedicellariæ. These, however, agree sufficiently well with those of *Savignyi* to warrant our calling the specimen by that name, especially since the reddish color, the large abactinal system, and the beginning of the second series of interambulacral tubercles on the sixth coronal plate are features that it shares with *Savignyi* and combine to distinguish it from the other members of the genus.

This species was taken by the "Albatross" only at Easter Island. Dec. 21, 1904, littoral, one specimen.

Diadema globulosum A. Ag.

Diadema globulosum A. Agassiz, 1863. Bull. M. C. Z., I, p. 20.

As pointed out by Mortensen, this species is very near *Savignyi*, and yet the large tridentate pedicellariæ, when fully developed, are so readily distinguished from those of that species that we are inclined to keep them separate. The valves in *globulosum* are remarkably flat and very nearly straight, with the blade broad but becoming distinctly narrower near the tip. The example figured by Mortensen is not quite typical, as this narrowing is not clearly shown. In some cases it is very marked, one might almost call it abrupt; but, unfortunately, it is not always so. Examination of the type-specimen of *D. nudum* A. Ag. from Hong Kong shows that the pedicellariæ are like those of *globulosum*, and there seems to be no good reason why the two should not be united under the latter name, which has four months' priority.

This species was taken by the "Albatross" only on the reef of Papeete, Tahiti, Society Islands. "Albatross" collection. Sept. 29, 1899. One specimen.

Echinothrix.

Peters, 1853. Monatsb. Berlin Akad., p. 484.
Type-species, *Echinus calamaris* Pallas, 1774. Spic. Zool., I, fasc. 10, p. 31.

Typical examples of the two species belonging to this genus are so very different from each other that their confusion seems impossible, but when a large series of specimens of all ages and sizes is examined, the characters which are supposed to separate them prove very inconstant, with the single exception of the structure of the spines. Thus the color is ordinarily very different, *E. diadema* being often uniform black, or with only faint indications of banding with light and dark shades on the spines, while *E. calamaris* is often very light colored, with the interambulacral primaries beautifully annulated and the ambulacral primaries a uniform pale yellowish-green; but young specimens of *diadema* are much lighter and have the spines as distinctly annulated as *calamaris*, while large specimens of the latter are frequently so dark that their coloration is just like that of *diadema*. Döderlein (1902) has suggested that the two species may be distinguished by the coloration of the primary spines of the ambulacra, which he says are distinctly banded in *diadema* and unicolor in *calamaris*. While this seems to be true in most cases, we have found exceptions in both species, some specimens of *diadema* having the annulations wanting (and they are often very faint), while some specimens of *calamaris* have faint, but still distinct, indications of the bands. As regards the tuberculation of the test, *diadema* rarely has more than three primary tubercles on a coronal plate, while *calamaris* may have five or even six; but unfortunately most specimens of the latter have, like *diadema*, only three, and occasional specimens of *diadema* have four. The difference in the structure of the primary spines seems, however, to be remarkably constant at all ages, and we therefore distinguish the two species by that character. It seems to be true also that the tridentate pedicellariæ are constantly different and furnish an additional specific character.

There are apparently only two species which can be constantly recognized in the genus, both littoral and ranging throughout the Indo-Pacific region from Zanzibar to the Society and Hawaiian Islands. The species *Desorii* Agass. seems to be undoubtedly a form of *calamaris*, probably the fully matured adult; the essential structure of the spines and the pedicellariæ are like *calamaris*, and the differences in the test do not appear to be constant. We distinguish *calamaris* and *diadema* as follows:

Primary spines of interambulacra rather solid, diameter of central cavity much less than ½ diameter of spine; minute teeth covering spine, arranged in crowded longitudinal series and not in distinct whorls; blade of valves of tridentate pedicellariæ widest near middle . . . . *diadema*.

Primary spines of interambulacra fragile, diameter of central cavity more than ½ diameter of spine; minute teeth covering spine, arranged in distinctly separated whorls; blade of valves of tridentate pedicellariæ widest at or near tip . . . . *calamaris*.

Echinothrix diadema Lovén.

Echinus diadema Linnæus, 1758. Sys. Nat., p. 664.

Echinothrix diadema Lovén, 1887. Ech. desc. by Linn., p. 137.

This species was taken by the "Albatross" at the following stations:

Puako Bay, Hawaii, Hawaiian Islands.

Honolulu, Oahu, H. I.

Papeete, Tahiti, Society Islands. Sept. 29 and Nov. 14, 1899. Reef. Thirty-one specimens.

Echinothrix calamaris A. Ag.

Echinus calamaris Pallas, 1774. Spic. Zool., I, fasc. 10, p. 31.

Echinothrix calamaris A. Agassiz, 1872. Rev. Ech., Pt. I, p. 119.

This species was taken by the "Albatross" at the following stations:

Puako Bay, Hawaii, Hawaiian Islands.

Station 4033. Penguin Bank, S. coast of Oahu, H. I. 28–29 fathoms. Fne. co. s. for.

Two specimens.

Centrostephanus.

Peters, 1855. Denk. Akad. Berlin für 1854, p. 109.

Type-species, *Diadema longispina* Philippi, 1845. Arch. f. Naturg. XI (1), p. 354.

The species of this genus are remarkable not only for the fact that they are so easily recognized, — synonyms are almost unknown among them, — but also for the presence of peculiar glandular, globiferous pedicellariæ, and for their geographical distribution. Unlike all the other genera of Diadematidæ, Centrostephanus is unknown from the Indo-Pacific region, nor does it occur in the West Indies, and yet the four species are widely separated from each other. One species, *longispinus* Phil., occurs in the Mediterranean and eastern Atlantic, a second, *coronatus* Verr., is found on the west coast of Mexico, a third, *asteriscus* A. Ag. and Cl., is known only from the Hawaiian Islands, while the fourth, *Rodgersii A. Ag.*, inhabits the coasts of Australia, Lord Howe Island, and Tasmania. All are strictly littoral. These species are easily distinguished from each other by the coloration, which appears to be unusually constant. They may be recognized by the following characters:

Primary spines unicolor, deep reddish-purple (lighter in very small specimens, and with faint indications of bands); size large, up to 100 mm. h. d. or more . . . . *Rodgersii.*

Primary spines banded with two colors or shades; size small, rarely exceeding 40 mm. h. d.

- No whitish markings on abactinal part of test; spines banded with light and dark reddish or reddish-brown . . . . *coronatus.*
- Conspicuous whitish lines present on abactinal part of test; spines banded in two colors.
  - Whitish lines present in middle of each ambulacrum and interambulacrum, and along margin of each ambulacrum, abactinally; spines banded with light yellowish-green and purplish . . . . . *longispinus.*
  - Whitish lines run only from centre of anal system to upper end of each ambulacrum, thus forming an abactinal star; spines banded with deep red and white . . . . *asteriscus.*

Centrostephanus coronatus A. Ag.

Echinodiadema coronata Verrill, 1867. Trans. Conn. Acad., I, p. 295.
Centrostephanus coronatus A. Agassiz, 1872. Rev. Ech., Pt. I, p. 97.

Plate 51, figs. *12–20*.

As this is one of the very few species of Diadematidæ, whose pedicellariæ have not been examined by Mortensen, we have given figures of them, since they are very different from those of the other species in the genus.

The *globiferous* pedicellariæ (figs. *16, 17*) are very abundant and are strikingly characteristic, because of the conspicuous, nearly globular, deep purple glands on the valves. The latter (figs. *18, 19*) are remarkably small, only .12–.18 mm. in length, and decidedly curved. The blade is very short, concave on its inner face, and terminates in 4 very long, sharp teeth. The stalk (fig. *20*) is greatly expanded at the tip, which is distinctly concave. The organic covering of the stalk is prettily spotted with pigment cells (figs. *16, 17*). At the top of the stalk, glands are often but not always present.

The *slender tridentate* pedicellariæ (fig. *12*) are very rare and are found only on the abactinal surface. The valves are a trifle over a millimeter long and the stalk is little longer. The blades are narrow and compressed and are in contact for nearly one-half their length. The margins are irregularly serrate.

The *stout tridentate* pedicellariæ (fig. *13*) are common on all parts of the test and vary greatly in size. The valves range from .40 to 1.75 mm. in length. They are decidedly curved, with short wide blades, in contact only at the tip. The margins carry few or no teeth, but the tips are strongly serrate. The stalk scarcely equals the valves in large examples, but may be much longer in small ones.

The *ophicephalous* pedicellariæ (fig. *14*) seem to be all of the glandless type. They are abundant everywhere, but especially on the actinal surface. The valves are rather short and blunt, only .30–.40 mm. in length.

The *triphyllous* pedicellariæ (fig. *15*) are common, and are noticeable because of the scattered pigment cells which adorn the organic covering of the stalk and the neck. The latter is considerably thicker than the stalk, while the diameter of the head is only a little greater. The valves are only .20–.30 mm. long, and are wider in proportion to their length than in the other species of the genus.

The calcareous particles in the pedicels are distinctly triradiate, and show little or no tendency to become perforated plates.

The sphæridia are not peculiar.

This species was not collected by the "Albatross."

Centrostephanus asteriscus A. Ag. and Cl.

Centrostephanus asteriscus A. Agassiz and Clark. Bull. M. C. Z., L, p. 237.

Plates 51, figs. *3–11*; 55, figs. *1–6*; 58, figs. *1–6*.

This very pretty small species is easily distinguished from other members of the genus by the large number of coronal plates and the peculiar abactinal system. In a specimen of 3.5 mm. in diameter there are already eight interambulacral coronal plates and an individual 14 mm. in diameter has thirteen (Pls. 55, figs. *1–3*; 58, fig. *6*), with fifteen or sixteen ambulacral plates, while in a young specimen of *C. Rodgersii* A. Ag. of 14 mm. there are only nine interambulacral coronal plates, and the large primary tubercles are all placed on the abactinal surface above the ambitus. In *asteriscus* many are at the ambitus and below it. In a specimen of *C. coronatus* Verrill of 14 mm. there are only eight and nine interambulacral plates, and in the abactinal system the genitals are well separated by the oculars which reach the anal system. The latter is covered by fewer and larger plates, more like that of *Rodgersii*. In *Rodgersii* the oculars separate the genitals, but scarcely reach the anal system, which is covered by comparatively few large plates, in great contrast to the very numerous plates covering the anal system of *asteriscus* (Pls. 55, fig. *2*; 58, fig. *4*). In small specimens of *asteriscus* the small oculars appear to reach the anal system by the extension of a slightly raised white ridge (Pl. 58, fig. *2*) running from the median part of each ocular plate and extending to the centre of the anal system, thus forming a conspicuous star on the red abactinal surface. With increasing size the ocular plates are crowded further out by the genitals, which form an independent ring. The genital plates are very uniform in size and shape (heptagonal) and carry three to six distinct miliaries. The madreporic openings are small, forming a narrow band across the promixal part of the right anterior genital (Pl. 55, fig *2*). The genital openings are well marked and placed near the outer edge of the plates.

In all the Pacific species of Centrostephanus the radioles are banded with reddish brown upon a lighter shaft; the bands are fewest, darkest, and widest, and are least distinct in *Rodgersii*, in adult specimens of which they are wholly wanting, and are most numerous in the Californian *coronatus*, which at first glance most resembles *asteriscus*. The colors are much the brightest in *asteriscus*. The radioles of the largest specimen of *asteriscus* (14 mm.) are about one-half longer than the diameter of the test. This specimen is 6.25 mm. high, the abactinal system is 5.5 mm. in diameter, and the actinal, 6 mm. The radioles are marked by widely spaced whorls of very minute sharp spinelets (Pl. 55, figs. *5, 6*).

The primary interambulacral tubercles form two rows flanked by a row of indistinct secondaries adjoining the poriferous zone and an irregular double median row along the vertical suture. The secondaries are most prominent about the equatorial zone or ambitus (Pls. 55, figs. *1–3*; 58, figs. *4–6*).

The primary ambulacral tubercles are much smaller and form two single vertical rows separated on the median line by a few irregularly placed secondaries. At the actinal edge of the ambulacral zone the pairs of pores of the first three plates are more or less crowded together but have their regular arrangement somewhat higher up (Pl. 55, fig. *4*). The actinal membrane is covered with five or six rows of narrow elongate plates outside of the five pairs of buccal plates, which are large, forming a connected ring. Between the buccal plates and the teeth there are two or three irregular rows of small rounded plates. The color of the test is light reddish, becoming reddish-white actinally, and the primary radioles are banded with red and whitish; from the end of each ambulacrum a conspicuous white line runs straight to the centre of the anal system, the five lines forming a conspicuous star on the red abactinal surface. This star is well marked in alcoholic specimens, but becomes very faint when they are dried.

The pedicellariæ are abundant, diverse, and very characteristic. The *globiferous* (Pl. 51, fig. *8*) are the most striking because of the conspicuous, dark-colored glands which enclose or at least conceal the terminal half of the valves. These pedicellariæ are quite common and occur all over the test and on the actinostome. The heads are about .35–.45 in length and are borne on stalks two or three times as long. Glands are commonly present at the upper end of the stalk, but are never very conspicuous. The valves (Pl. 51, figs. *9, 10*) are .30–.40 mm. long and terminate in 5 or 6 long and conspicuous teeth. The blade is nearly cylindrical, except at the expanded tip, and is scarcely at all hollowed, though flattened on its inner surface. The basal part is not so long as the blade, but the apophysis is very high and conspicuous.

The *slender tridentate* pedicellariæ (Pl. 51, fig. *3*) are common all over the test. The valves range from .80–2.20 mm. in length and the stalk is usually longer, sometimes two or three times as long. The blade is very narrow, straight, and somewhat compressed, and the margin is coarsely dentate.

The *stout tridentate* pedicellariæ (Pl. 51, fig. *4*) are rare and occur on the abactinal half of the test only. The valves are only .60–.70 mm. in length, while the stalk may be two or three times as long. The blades are broad, rather flat, and considerably expanded at the tip, the only point where they are in contact. The margin is irregularly serrate. Although these pedicellariæ are so obviously different from the normal slender tridentate, intermediate forms with the valves only slightly curved are occasionally to be found.

The *glandless ophicephalous* pedicellariæ (Pl. 51, fig. *5*) are not uncommon, and are scattered all over the test. The valves are large, wide, and rounded at the tip and may be as much as .60 mm. long. The stalk is several times that length and appears to be entirely without glands.

The *glandular ophicephalous* pedicellariæ (Pl. 51, fig. *6*) are common all over the test and especially on the buccal plates. They do not differ essentially from the glandless ones, but the valves are usually smaller and narrower near the tip, and the stalk carries three large and conspicuous glands.

The *triphyllous* pedicellariæ (Pl. 51, fig. *7*) are rather rare, but occur scattered on the test. They are very small, the heads only about .20 mm. long, the neck a little longer, and the stalk five or six times as long. The valves are rather narrow, the blade little wider than the basal part, but widest above the middle.

The calcareous particles in the pedicels (Plate 51, fig. *11*) are rather common. They show their triradiate origin plainly, and rarely form perforated plates.

The sphæridia are minute, scarcely .25 mm. long, and are elongated ellipsoidal in form, the length nearly equalling twice the width. They are pendent at the outer, lower side of the large ambulacral tubercles and are not placed in depressions. Only a few (4–8) are present in each ambulacrum.

Station 4034. Penguin Bank, S. coast of Oahu, Hawaiian Islands. 14–28 fathoms. Fne. co. s. for.

Station 4066. Off Ka Lae-o Ka Ilio Point, Maui, H. I. Bott. temp. 52.5°. 49–176 fathoms. Rky.

Station 4128. Off Hanamaulu, Kauai, Hawaiian Islands. Bott. temp. 47.8°. 68–253 fathoms. Crs. br. co. s. for.

Station 4161. Off Modu Manu, H. I. Bott. temp. 77.9°. 39–183 fathoms. Co. corln.

Station 4163. Off Modu Manu, H. I. Bott. Temp. 78.1°. 24–40 fathoms. Co.

Bathymetrical range, 14–253 fathoms. Extremes of temperature, 78.1°–47.8°. Five specimens.

MICROPYGA.

A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 200.

Type-species, *Micropyga tuberculata* A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 200.

Having already discussed the peculiarities of this genus, we need only add here that there seem to be two well-marked species, the "Siboga" having collected a single specimen, which, while a Micropyga, is clearly not *tuberculata* A. Ag. To this form, which was taken off Ceram in 512 fms., de Meijere has given the name *violacea*. The "Challenger" species was taken by the "Siboga" at two stations and was also taken once by the "Valdivia," so that it is now known to range from Sumatra to the Fiji Islands in depths of 100 to 225 fms. (possibly 610 at Fiji). The two species are easily distinguished as follows:

Ambulacra with only 2 columns of primary tubercles; abactinal surface with comparatively few primary tubercles (about 600 in a specimen, 100 mm. h. d.); buccal membrane perfectly bare . . . . *tuberculata.*

Ambulacra with 4 columns of primary tubercles; abactinal surface with numerous primary tubercles (about 1100 in a specimen, 84 mm. h. d.); buccal membrane covered with pedicellariæ . . . . *violacea.*

EREMOPYGA.

Gen. nov.

Type-species, *Astropyga denudata* de Meijere, 1903. Tijdschr. Ned. Dierk. Vereen. (2) VIII, p. 4.

The specimens of this handsome Echinoid, on which de Meijere based his new species of Astropyga, were taken by the "Siboga" at three widely separated stations, near Celebes, Flores, and Sumbawa, at depths of 82–152 fms. As already stated, they seem to us to be quite distinct from Astropyga, and we have accordingly formed this new genus for them. Mortensen

(1904) suggests that they seem to be near Chætodiadema; while this is true in certain respects, the hollow spines show they are no nearer to that genus than to Astropyga.

Astropyga.

Gray, 1825. Ann. Phil. p. 4.
Type-species, *Cidaris radiata* Leske, 1778. Add. Klein, p. 116.

Since Agassiz in 1846 named *Astropyga pulvinata*, no valid species has been added to this genus, so that we find it necessary to recognize only two. Of these, *radiata* (Leske) occurs throughout the Indo-Pacific region from Zanzibar to Hawaii, while *pulvinata* Agass. is known only from the West Coast of Mexico and Central America. The tuberculation of the actinal side of the test will always distinguish specimens of these two species, but the color is also a useful character. Both are distinctly littoral.

Columns of primary tubercles on actinal surface parallel with ambulacra, so that outermost column (next to ambulacrum) at ambitus, extends to peristome, though the tubercles may become much smaller there; general coloration more or less red or reddish . . . . *radiata*.
Columns of primary tubercles on actinal surface parallel with midline of interambulacrum, so that outermost 2 columns on each side do not reach peristome; general coloration more or less greenish; no red . . . . *pulvinata*.

Astropyga radiata Gray.

Cidaris radiata Leske, 1778. Add. Klein, p. 116.
Astropyga radiata Gray, 1825. Ann. Phil., X, p. 4.

The "Albatross" took a single, young specimen (26 mm. in diameter) of this species at the following station:

Station 3875. Auau Channel, between Maui and Lanai. Bott. temp. 70.8°. 34–65 fathoms. Fne. gy. s. One specimen.

Chætodiadema.

Mortensen, 1903. Vid. Med. Nat. For. Kjöbenhavn, p. 1.
Type-species, *Chœtodiadema granulatum* Mortensen, 1903. Vid. Med. Nat. For. Kjöbenhavn, p. 1.

Although closely allied to Astropyga, this genus is easily distinguished by the much flatter test and smaller actinostome, as well as by the more important characters of the ambulacra and actinal surface, already mentioned.

There appear to be three quite distinct species in the group, of which *granulatum* Mortensen is from the East Indian region, ranging from the Maldives to New Guinea, in 10–120 fathoms; *japonicum* Mortensen is from Sagami Bay, Japan, 30 fathoms; and *pallidum* A. Agassiz and Clark is from the Hawaiian Islands, in 123–220 fathoms. These species may be distinguished as follows:

Color of test and spines brown; blue spots or a blue line along each side of bare, abactinal, interambulacral space.
- At ambitus, in each interambulacrum, 10–12 columns of primary tubercles; most of actinal surface densely covered with secondary and miliary tubercles, and without primaries; blue spots at sides of abactinal interambulacra . . . . *granulatum.*
- At ambitus, in each interambulacrum, 6–8 columns of primary tubercles; most of actinal surface with primary tubercles; a blue line at sides of abactinal interambulacra . . . . *japonicum.*

Color of test buff; spines whitish; primaries often more or less banded with purple; no blue anywhere . . . . *pallidum.*

Chætodiadema pallidum A. Ag. and Cl.

Chætodiadema pallidum A. Agassiz and Clark, 1907. Bull. M. C. Z., L., p. 237.

Plates 44, figs. *5, 6*; 50, figs. *16–19*; 56; 59.

Of the interesting genus Chætodiadema Mortensen a handsome new species proves to be common in certain localities among the Hawaiian Islands (Pls. 56, 59). As stated by Mortensen[1] of *Ch. granulatum*, the test, when seen from above, resembles closely that of Astropyga, but in our species the test has not the flexibility of that of the Echinothuridæ.

In the tuberculation of the actinal surface this species is more closely allied to *Ch. japonicum* Mortensen (l. c. Pl. 2, figs. *16, 19*) than to *granulatum* Mortensen (l. c. Pl. 1, figs. *1 3, 21, 22*), as the former species does not have the whole actinal side covered by such close and fine uniform granulation (see Pl. 59, fig. *3*, and Mortensen l. c. Pl. 2, fig. *19*). As Mortensen has given no detailed figures of either the actinal or abactinal systems, nor of the peculiar arrangement of the tuberculation on the actinal surface of the test, it is difficult to compare our species with the two he has described. It is apparent, however, by a comparison of the photographic figures of *Ch. pallidum* on Pl. 59 with his figures on Pl. 1, and on Pl. 2, that *pallidum*

[1] Danish Exp. to Siam: Echinoidea, p. 22, 1904.

is at once distinguished from *granulatum* by the comparatively large size of the abactinal system (Pl. 59, fig. *4*, compare with that of *Ch. granulatum*, Pl. 1, fig. *1*), which is much smaller in proportion to the size of the test. In the specimen of *pallidum*, figured in Pl. 59, figs. *3, 4*, the abactinal system measures 19.50 mm., the anal system 11 mm., and the actinal system only 10.25 mm. in diameter. In a larger specimen (Pl. 59, fig. *2*) the abactinal system measures 22 mm. There are no papillæ covering the genital openings, which are surrounded by a slightly raised ring (Pls. 56, figs. *2, 5*; 59, fig. *4*). The oculars and genitals are all in contact with the distal ring of large irregularly pentagonal anal plates, inside of which are two rings of irregularly polygonal smaller plates, and immediately at the base of the anal tube the anal membrane is covered with minute papillæ. The large anal plates carry small miliaries and an occasional secondary tubercle. The genitals as well as the oculars are sparsely covered with miliaries (Pl. 56, fig. *2*). The madreporite covers the greater part of the madreporic genital (Pl. 56, fig. *5*).

The actinal system is markedly pentagonal, with prominent actinal indentations. The five pairs of buccal plates form a closed ring round the mouth, and outside of them the actinal membrane is covered with a narrow belt of small more or less elliptical plates. At the actinal angle of the ambulacra a larger plate is found (Pl. 56, fig. *1*). The actinal system is deeply sunken (Pl. 59, fig. *1*) far more than is the case in *granulatum*, which, judging from the figure (Pl. 1, fig. *3*) given by Mortensen, is comparatively flat. The actinal part of the ambulacra is most indistinct in *granulatum* (Mortens. Pl. 1, fig. *3*), while in *Ch. pallidum* (Pl. 59, fig. *3*) the pores form well-marked zones. The close tuberculation of the actinal surface is well shown in Pl. 59, fig. *3*, and more in detail in Pl. 56, fig. *1*. It will be seen that the vertical rows of primary tubercles, diminishing in size, extend almost to the actinal system, and that the close granulation of the actinal surface mentioned by Mortensen in the interambulacral area is limited to the interambulacral space of that surface and does not cover the whole actinal surface nearly to the ambitus, as is the case in *granulatum*. It is true that the large tubercles of the actinal surface of *pallidum*, which form the continuation of the vertical columns of primary tubercles from above the ambitus, are different from those at the ambitus and above it. The latter are perforate and crenulate, while the former are not usually perforate and are not crenulate (Pl. 56, fig. *5*). It is quite possible in our species to distinguish from the exterior the sutures of the primary plates both of the ambulacral and interambulacral areas in spite of the maze of granules which cover the actinal surface (see Pl. 56, figs. *1, 5*). These sutures, Mortensen says, can be traced in *granulatum* only by examining the interior.

On the inner surface of the test the lapping of the interambulacral plates on the abactinal side is plainly seen; it is more marked along the sutures of the median line than along the horizontal sutures. The interambulacral plates carry minute spicular granules irregularly scattered along the median and lateral side of each plate. These granules become more numerous towards the ambitus. At the ambitus, where the rows of large tubercles begin, their presence is indicated by deep circular cavities which extend both in the interambulacral and ambulacral areas nearly to the actinostome.

FIG. *c*.

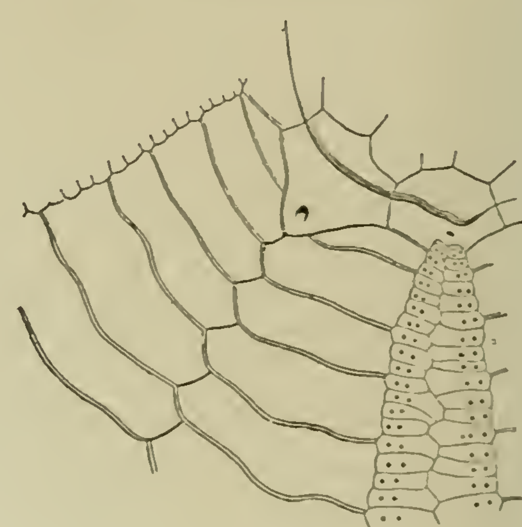


FIG. *d*.

The splitting of the interambulacral plates which was noticed in Astropyga (A. Agassiz, Challenger Echini Pl. 10[a], fig. *9*) is found mainly in the larger actinal plates near the ambitus; in Chætodiadema the splitting of the interambulacral plates takes place, according to Mortensen, at the median end. See figs. *c* and *d*.

Seen from the interior the ambulacral and interambulacral plates of the actinal side are covered with rows of deep pits corresponding to the rows of primary and secondary tubercles, and the surface of the plates is covered with irregularly arranged patches of minute granular spicules. The ambulacral plates on the actinal face show a splitting up into irregular plates like that of the interambulacra. The lapping of the plates on the actinal surface is not as clearly indicated as on the abactinal. The lapping of the interambulacral sutures on the actinal surface, when compared to that of the abactinal side, is most irregular, owing to the crowding of the tubercles.

The actinal plates of the ambulacral area each carry only a single pair of pores. At about the sixth (Pl. 56, fig. *4*) plate from the actinostome, small secondary plates are intercalated, forming compound plates with irregular arcs of three pairs of pores. On the abactinal part of the test, except near the abactinal system, and even below the ambitus, each such plate carries a primary tubercle, perforate and crenulate, which completely obliterates the sutures of the primitive plates. The arrangement of the pores on the actinal face is thus quite different from that described by Mortensen (l. c. p. 24).[1]

The whole abactinal part of the interambulacral area is nearly bare, the upper six or seven plates carrying only a few miliaries and small secondaries adjoining the poriferous zone. There are six vertical rows of perforate and crenulate primary tubercles, each row consisting of three, four or five tubercles; of the outer rows three primaries are above the ambitus and two below; of the inner row three (or two) below and two (or one) above; a fourth row, between the outer two, is indicated below the ambitus by the presence of one or two primaries.

This species is readily distinguished from the two species hitherto known by its color, which is pale buff when dry, more or less tinged with purple when wet, becoming a buff white beneath. The sides of the bare interambulacral areas on the abactinal surface are more or less distinctly yellow; in many specimens the ambulacral edge of this area is marked by a broad dull red line extending from the ambitus to the genital plates (Pl. 59, fig. *2*), but these lines may be interrupted, and in about half the specimens are entirely wanting. There is no blue either on the test or spines, as in the figure of *Ch. granulatum* given by de Meijere (Pl. XI, fig. *101*). A similar band is prominent in one of the figures of *Ch. japonicum* given by Mortensen (*l. c.* Pl. 2, fig. *16*). It is less distinct in *Ch. granulatum* (Mort., Pl. 1, fig. *22*). Some of the individuals have on the actinal side a deep brown line, forming a more

[1] I would not venture to doubt the existence of the splitting of the actinal interambulacral plates as observed by Dr. Mortensen or to intimate as he has done that the splitting of the actinal interambulacral plates which I observed in Astropyga was probably due to rough handling of the specimens; or as he says, "and it is rather probable that the splitting up of the plates in large specimens may be due simply to the breaking of the delicate plates by the handling of the specimens." This is but one of the many instances of acidulous criticism and endless fault finding indulged in by Dr. Mortensen. He is constantly objecting to this or that figure as being bad. I would call his attention to the very unsatisfactory figures he has given of *Chætodiadema granulatum* and *Ch. japonicum* on Plates I, figs. *1*, *3*, and II, figs. *16*, *19* of his Siam Ex. Echini, and to the confusion he creates, far more aggravating than anything he finds to correct, by his irregular numbering on the same Plate of figures belonging to the same species (Pl. I, *1*, *3*, *21*, *22*; Pl. II, figs. *16*, *19*); his standard of convenience and of excellence is a most variable quantity. —A. Agassiz.

or less perfect pentagon round the actinostome, about one third of the distance to the ambitus.

The primary radioles are slender (Pl. 56, figs. *6, 7*; 59, figs. *1, 2*), of moderate but variable length, the longest equalling the diameter of the test. They are decidedly flattened, nearly white, but many have a purplish longitudinal stripe on the abactinal side, and not infrequently they are handsomely banded with purple (Pl. 56, fig. *6*). The whole length of the shaft is finely serrated in close longitudinal lines. The verticillation is very delicate, caused by longitudinal furrows alternating with the irregular longitudinal rows of minute teeth (Pl. 56, figs. *6, 7*).

The aspect of this species as seen from the abactinal surface (Pl. 59, fig. *2*), with its primary spines limited to the ambitus and extending but a few plates towards the abactinal system, and its bare abactinal interambulacral areas with the few scattered, thin, sharp secondary spines, is in striking contrast to its appearance as seen from the actinal side (Pl. 59, fig. *1*); see also Mortensen, Siam. Echini, Pl. 1, fig. *21*. The primary spines are limited to the vicinity of the ambitus, and on the rest of the actinal surface the secondary and miliary spines are short, slightly curved or club-shaped, and flattened at the tip and striated; so that on a first examination it would seem as if the actinostome with its small spines extended far out towards the ambitus.

The specimens range in diameter from 42 to 70 mm. The test is very flat, the greatest height being only .25–.30 of the diameter (Pl. 59, fig. *5*), the abactinal system is .30–.42, and the actinal only .17–.24 of the diameter, while the anal system is .60–.65 of the abactinal. The test is relatively higher, and the abactinal and actinal systems larger, in small than in large individuals.

Dr. Mortensen, after laying great stress (by printing it in capitals) upon the uniform granulation of the actinal surface as typical of the genus Chætodiadema, modifies this in ordinary print a few pages further on, when describing *Ch. japonicum*.

One of the most striking characters of this interesting species is the extraordinary scarcity of pedicellariæ. Careful and long-continued examination of ten specimens brought to light only a single tridentate pedicellaria, and that had the tip broken off. It was of the *slender tridentate* form, with the valves meeting only near the tip. These valves (Pl. 50, figs. *16, 17*) when complete would have measured about a millimeter and a half in length, with the strongly compressed blade hardly a tenth as wide. The margin is coarsely dentate. The most characteristic feature is the very conspicuous apophysis, which is nearly twice as high as the depth of the basal part of the pedicellaria and is abruptly truncate at the end. Such an apophysis is quite unique and it is unfortunate that the slender tridendate pedicellariæ appear to be so exceedingly rare.

The *triphyllous* pedicellariæ are infrequent, but occur here and there, more particularly on the ambulacra. They are very small, and of simple structure. The valves (Pl. 50, fig. *18*) are .15–.20 mm. in length, while the stalks are five or six times as long. The blade is oval, rounded at the tip and without any trace of a cover-plate.

The calcareous particles in the pedicels are very infrequent, but are somewhat more plentiful in the gills (Pl. 50, fig. *19*). They are not peculiar, except for their small size, and usually show their triradiate origin very plainly, though some of the plates may have seven or eight perforations.

The sphæridia are much more common than in the other species of the genus, for there may be as many as sixteen in an ambulacrum. They do not occur near the peristome, but are first found about three-fifths of the distance from that point to the ambitus. In all cases they are found at or near the ambitus, and not infrequently they are placed on the abactinal surface. They are nearly globular and of moderate size, about .30 mm. in diameter. They are placed in very evident depressions or hollows in the test, and are distinctly pendent from the upper side of the hollow.

This species was taken by the "Albatross" at the following stations:

Station 3856. Pailolo Channel, between Maui and Molokai, Hawaiian Islands. Bott. temp. 66.5°. 127 fathoms. Fne. s. yl. m.

Station 3857. Pailolo Channel, between Maui and Molokai, H. I. Bott. temp. 62.5°. 127–128 fathoms. Fne. s. yl. m.

Station 3957. Vicinity of Laysan Island, H. I. Bott. temp. 53.5°. 173–220 fathoms. Fne. wh. s.

Station 4103. Pailolo Channel, between Maui and Molokai, H. I. Bott. temp. 61.7°. 132–141 fathoms. Fne. gy. s.

Station 4104. Pailolo Channel, between Maui and Molokai, H. I. Bott. temp. 60.8°. 123–141 fathoms. Fne. gy. s. for.

Bathymetrical range, 123–220 fathoms. Extremes of temperature, 66.5°–53.5°.

Eighty-two specimens.

Lissodiadema.

Mortensen, 1903. Rev. Suisse de Zool., XI, p. 393.

Type-species, *Lissodiadema Lorioli* Mortensen, 1903. Rev. Suisse de Zool., XI, p. 393.

The two specimens upon which this genus and species are based were taken at Amboina. They measure 10 and 22 mm. in diameter and were regarded by de Loriol, who first described them, as young individuals, possibly of Asthenosoma. Mortensen has shown that they can hardly be young Echinothurids, and are almost certainly Diadematids, though they are unlike any known young of the latter family. The genital pores are undeveloped, and they appear in other ways to be immature, yet it seems to be necessary to give them a genus of their own, at least for the present.

Leptodiadema.

A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 238.

Type-species, *Leptodiadema purpureum* A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 239.

This genus is established for a very small Diadematoid apparently quite different from any known genus. The size, form, and spines remind one of Lissodiadema, and the abactinal system is not altogether unlike that genus, but the tuberculation is entirely different. The test is flattened both actinally and abactinally; the ambulacra narrow, with pores in a single straight series not becoming crowded at the actinostome. Each ambulacrum carries a double series of primary tubercles extending from the abactinal system to the actinostome. The coronal plates are numerous, each with a large primary tubercle at the outer end. Below the ambitus these tubercles are increasingly nearer the center of the plate, so that the two series converge and meet at the actinostome. Beginning at the fifth from the abactinal system, each coronal plate carries a second somewhat smaller tubercle at the inner end, and these two series terminate at about the fourth plate from the actinostome. Secondary spines few, miliaries almost wanting. The primary tubercles are low, indistinctly perforate and apparently finely crenulate. From the ambitus to the abactinal system the ambulacral tubercles are small. On the actinal side the tubercles of both systems are nearly uniform in size.

Abactinal system moderate, the oculars on each side of the madreporic plate and the left anterior one are excluded from, while the other oculars extend to, the large anal system, which is covered with two rows of plates, an outer row of larger plates and an inner row of small plates surrounding the anal opening.

The two anterior genitals are roughly heptagonal, the right and left posterior genitals are hexagonal, and the odd posterior genital is pentagonal. In all five the genital openings are well developed and surrounded by a raised ring.

The actinostome is somewhat larger than the abactinal system; actinal cuts slight; buccal membrane closely covered with narrow elongate plates, as in young Diadema, arranged in five wedge-shaped, ambulacral divisions; buccal plates large, in five approximated pairs. Primary radioles about half the diameter of the test, those of the ambulacra scarcely shorter or more slender than the others; all are delicate, glassy, slightly curved, and blunt, with five to seven prominent ridges, two of which (on opposite sides of the spine) may bear, at least near the base, a few widely separated, very slender teeth.

Leptodiadema purpureum A. Ag. and Cl.

Leptodiadema purpureum A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 239.

Plates 50, figs. *20, 21*; 55, figs. *7–10*.

The single specimen obtained is 9 mm. in diameter with 13–14 coronal, interambulacral plates. The color is dull purplish, becoming bright purple on the buccal membrane. The spines are nearly colorless. The two anterior genital plates are larger than the posterior ones. The genital openings are nearly in the centre of the irregularly pentagonal plates, and are surrounded by a small protuberance. The madreporic body is well marked (Pl. 55, fig. *8*). The oculars are pentagonal or hexagonal, and the three anterior are excluded from the anal system. The distal part of the actinal system beyond the five pairs of large buccal plates is covered with long narrow plates arranged in five separate wedge-shaped groups, one in each ambulacrum. On the actinal side of the test the primary tubercles of both the ambulacral and interambulacral areas are nearly of the same size (Pl. 55, fig. *7*); but above the ambitus the tubercles of the ambulacral system are quite small (Pl. 55, fig. *8*). The median abactinal part of the interambulacral area is nearly bare, only a very few miliaries and secondaries being carried by the four uppermost abactinal plates.

No pedicellariæ of any kind were present in the single specimen of this species, possibly further evidence of its immaturity.

The calcareous particles in the pedicels (Pl. 50, fig. *21*) were numerous and characteristic. They are distinctly triradiate, but the branches are more or less curved and often give off secondary branches. They do not, however, become perforated plates.

The sphæridia (Pl. 50, fig. *20*), of which several are pendent in each ambulacrum, are variable in shape, some being nearly globular, while others are much longer than thick.

The single specimen of this species was taken by the "Albatross" at

Station 3847. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. 23–24 fathoms. S. st.

EXPLANATION OF THE PLATES.

The abbreviations used on Plates 43 and 44 are as follows:

as = abactinal system of plates, seen from within.
cts = connective tissue strands.
go = reproductive organs.
l = lantern, seen from above.
lc = lower, or actinal, half of stomach-intestine.
m = mesentery.
oe = œsophagus.
pg = perignathic girdle.
r = rectum.
sc = stone-canal.
uc = upper, or abactinal, half of stomach-intestine.

In all abactinal and actinal views of the entire animal and of the denuded test, and in Pls. 43, 44, and 56, figs. *1*, *2*, the anterior ambulacrum is uppermost.

Plate 43.

Plate 43.

Showing the Arrangement of the Digestive and Reproductive Organs.

1, 2. **Porocidaris variabilis** A. Ag. and Cl.

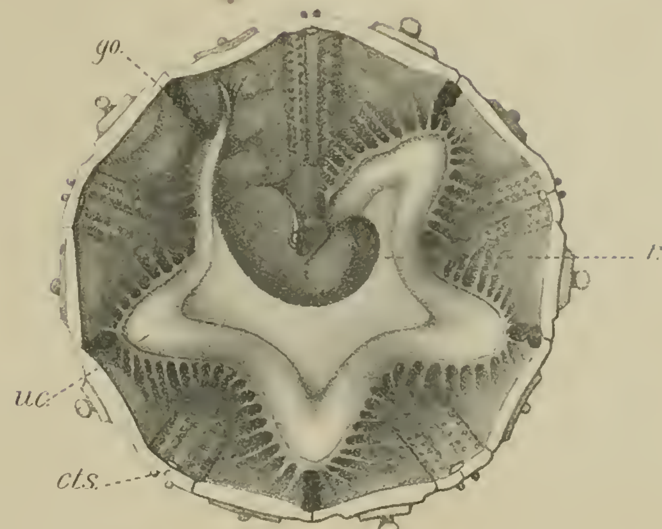
1. Interior view of abactinal half of test, with organs in place. Nat. size.
2. Interior view of actinal half. Nat. size.

3, 4. **Salenia Pattersoni** A. Ag.

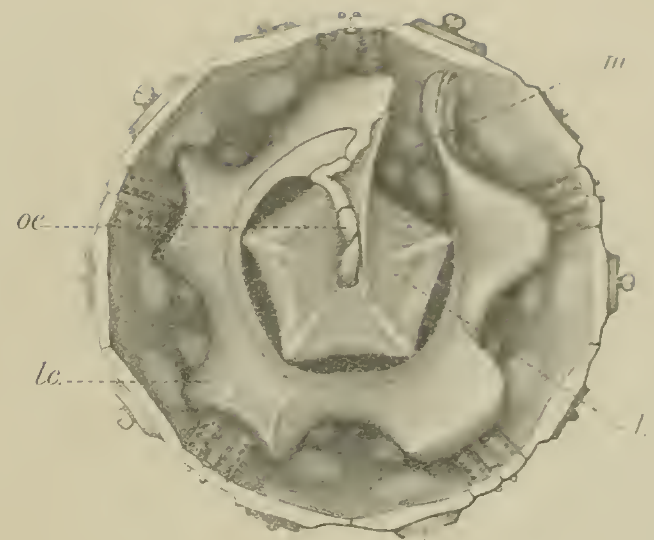
3. Interior view of abactinal half of test, with organs in place. $\times$ 3.
4. Interior view of actinal half. $\times$ 3.

5, 6. **Salenocidaris miliaris** A. Ag. and Cl.

5. Interior view of abactinal half of test, with organs in place. $\times$ 3.
6. Interior view of actinal half. $\times$ 3.

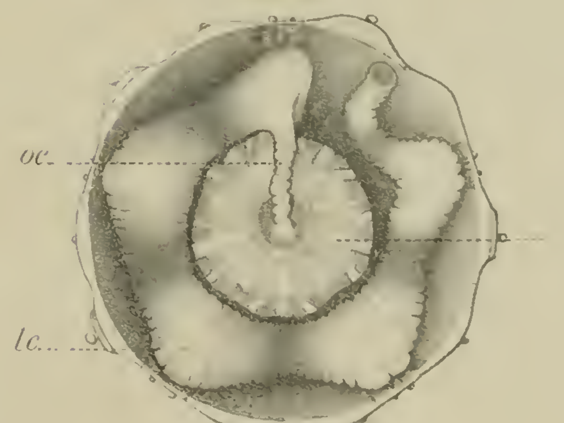


1



2

3



4

5

6

H.L. Clark del.

PLATE 44.

Plate 44.

Showing the Arrangement of the Digestive and Reproductive Organs.

1, 2. **Cœlopleurus floridanus** A. Ag.

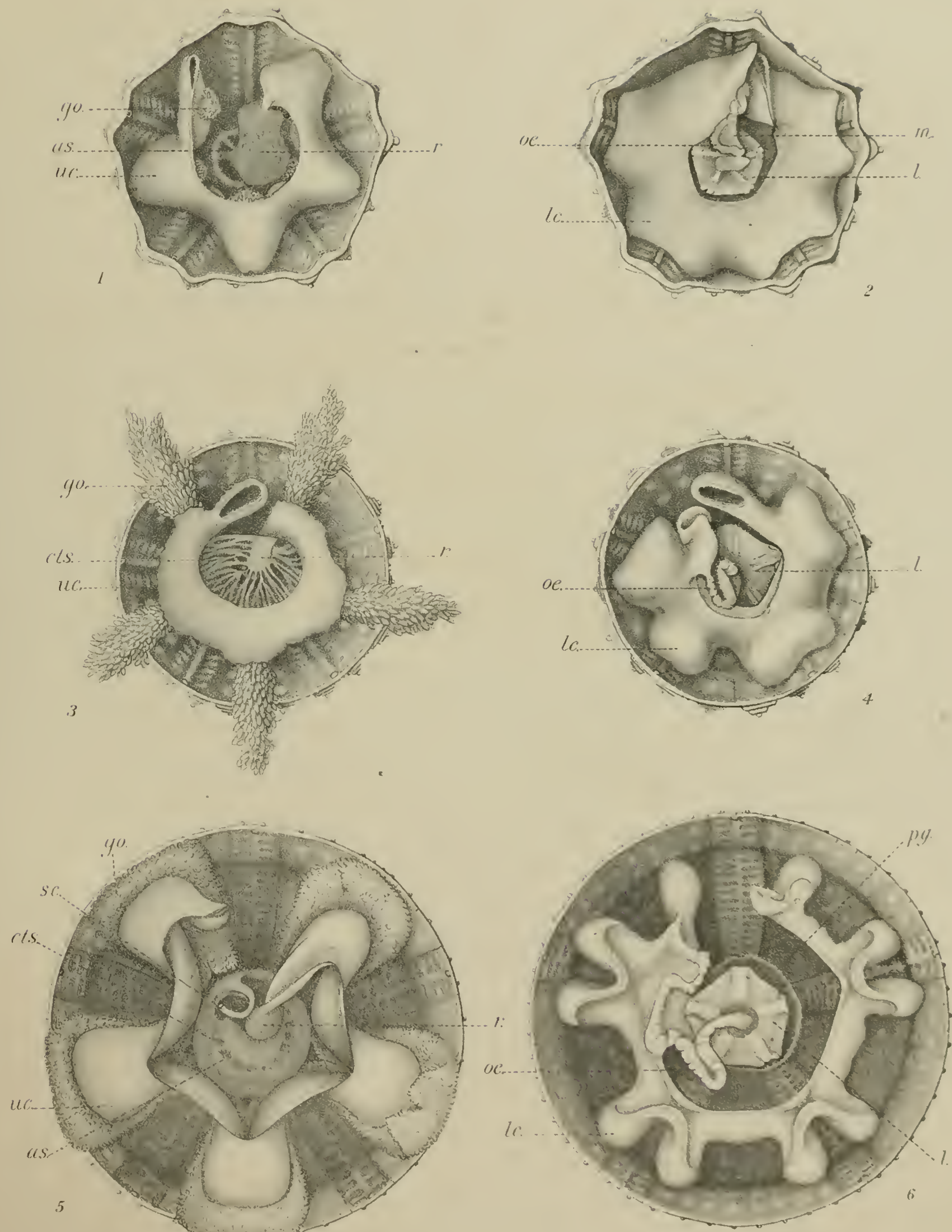
1. Interior view of abactinal half of test, with organs in place. × 2.
2. Interior view of actinal half. × 2.

3, 4. **Aspidodiadema meijerei** A. Ag. and Cl.

3. Interior view of abactinal half of test, with organs in place. × 2.
4. Interior view of actinal half. × 2.

5, 6. **Chætodiadema pallidum** A. Ag. and Cl.

5. Interior view of abactinal half of test, with organs in place. Nat. size.
6. Interior view of actinal half. Nat. size.



H.L. Clark del. B.Meisel

Plate 45.

Plate 45.

1–8. **Salenocidaris miliaris** A. Ag. and Cl.

1. Quadridentate pedicellaria. × 55.
2. Valve of quadridentate pedicellaria. × 55.
3. Tridentate pedicellaria. × 55.
4. Ovoid pedicellaria. × 55.
5. Valve of ovoid pedicellaria. × 156.
6. Globose pedicellaria. × 55.
7. Valve of globose pedicellaria. × 156.
8. Sphæridium. × 70.

9. **Salenocidaris crassispina** A. Ag. and Cl.

9. Spicules from pedicels. × 215.

10–15. **Salenocidaris varispina** A. Ag.

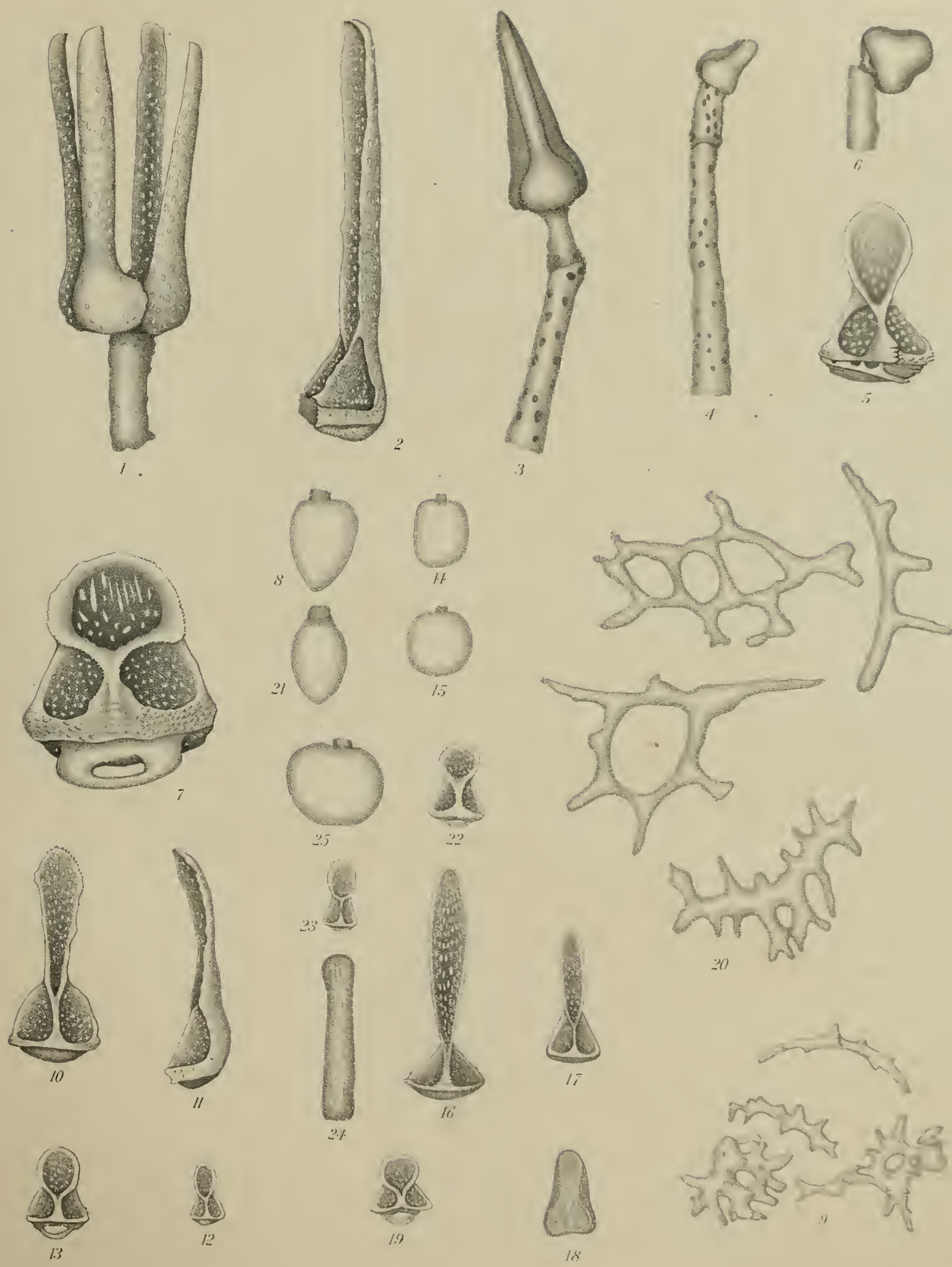
10. Valve of tridentate pedicellaria. × 70.
11. Side view of similar valve. × 70.
12. Valve of ovoid pedicellaria. × 70.
13. Valve of globose pedicellaria. × 70.
14, 15. Sphæridia. × 70.

16–21. **Salenocidaris profundi** A. Ag. and Cl.

16. Valve of tridentate pedicellaria. × 70.
17. Valve of a smaller tridentate pedicellaria. × 70.
18. Ovoid pedicellaria. × 70.
19. Valve of globose pedicellaria. × 70.
20. Spicules from pedicels. × 215.
21. Sphæridium. × 70.

22–25. **Salenia cincta** A. Ag. and Cl.

22. Valve of globose pedicellaria. × 70.
23. Valve of ovoid pedicellaria. × 70.
24. Stalk of globose pedicellaria. × 70.
25. Sphæridium. × 70.



H.L.Clark del

Plate 46.

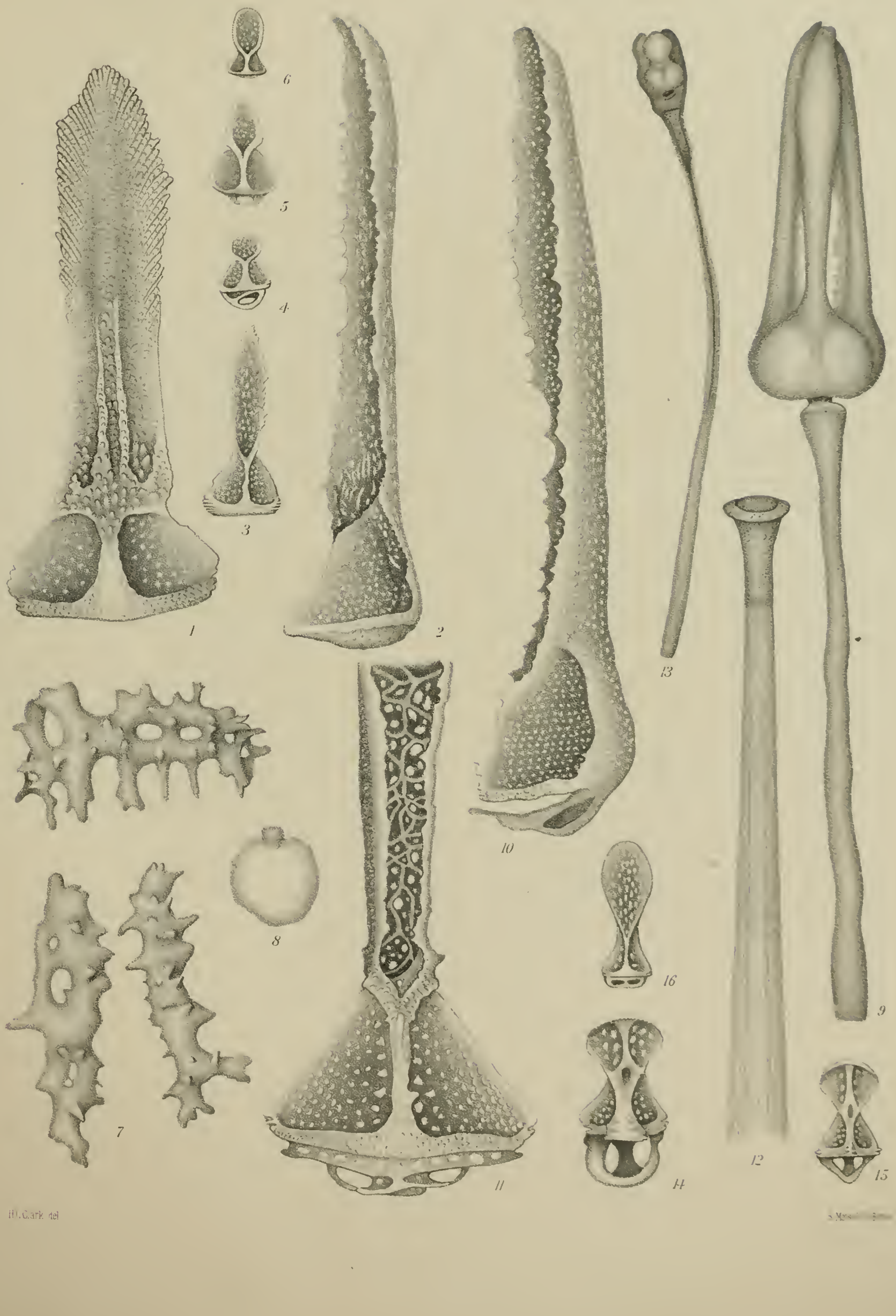
Plate 46.

1–8. Salenia Pattersoni A. Ag.

1. Valve of quadridentate pedicellaria. × 70.
2. Side view of valve of another quadridentate pedicellaria. × 70.
3. Valve of tridentate pedicellaria. × 70.
4. Valve of globose pedicellaria. × 70.
5. Valve of ovoid pedicellaria. × 70.
6. Valve of another ovoid pedicellaria. × 70.
7. Spicules from pedicels. × 215.
8. Sphæridium. × 70.

9–16. Dialithocidaris gemmifera A. Ag.

9. Tridentate pedicellaria. × 30.
10. Valve of tridentate pedicellaria, from side. × 70.
11. Valve of tridentate pedicellaria; interior view of base. × 70.
12. Stalk of tridentate pedicellaria, after treatment with alkali. × 70.
13. Ophicephalous pedicellaria. × 30.
14. Large valve of ophicephalous pedicellaria. × 70.
15. Small valve of ophicephalous pedicellaria. × 70.
16. Valve of triphyllous pedicellaria. × 70.



H.L.Clark del.

PLATE 47.

Plate 47.

1–11. **Arbacia Dufresnii** Gray.

1. Tridentate pedicellaria. × 30.
2. Ophicephalous pedicellaria. × 30.
3. Triphyllous pedicellaria. × 30.
4. Upper end of stalk of ophicephalous pedicellaria. × 70.
5. Valve of tridentate pedicellaria. × 70.
6. Valve of triphyllous pedicellaria. × 70.
7. Valve (*b*) of ophicephalous pedicellaria. × 70.
8. Basal part of second valve (*a*) of same ophicephalous pedicellaria. × 70.
9. Basal part of third valve (*c*) of same ophicephalous pedicellaria. × 70.
10. Sphæridium. × 70.
11. Calcareous plates from gills. × 70.

12–16. **Tetrapygus niger** Agass.

12. Valve of tridentate pedicellaria. × 70.
13. Upper end of stalk of ophicephalous pedicellaria. × 70.
14. Valve of ophicephalous pedicellaria. × 70.
15. Sphæridium from a small individual. × 70.
16. Sphæridium from a large individual. × 70.

17–19. **Arbacia punctulata** Gray.

17. Sphæridium. × 70.
18. Upper ends of stalks of ophicephalous pedicellariæ. × 70.
19. Calcareous plates from gills. × 70.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 48.

PLATE 48.

Plate 48.

1–9. **Arbacia punctulata** Gray.

1. Valve of tridentate pedicellaria. × 70.
2. Valve of large tridentate pedicellaria. × 70.
3. Valve of small tridentate pedicellaria. × 70.
4. Valve of triphyllous pedicellaria. × 70.
5. Valve of ophicephalous pedicellaria. × 70.
6. Another valve of another ophicephalous pedicellaria. × 70.
7. Disk-plate of pedicel. × 70.
8. Supporting-plate of disk of pedicel. × 70.
9. Calcareous rods from pedicels. × 70.

10–14. **Arbacia lixula** Lovén.

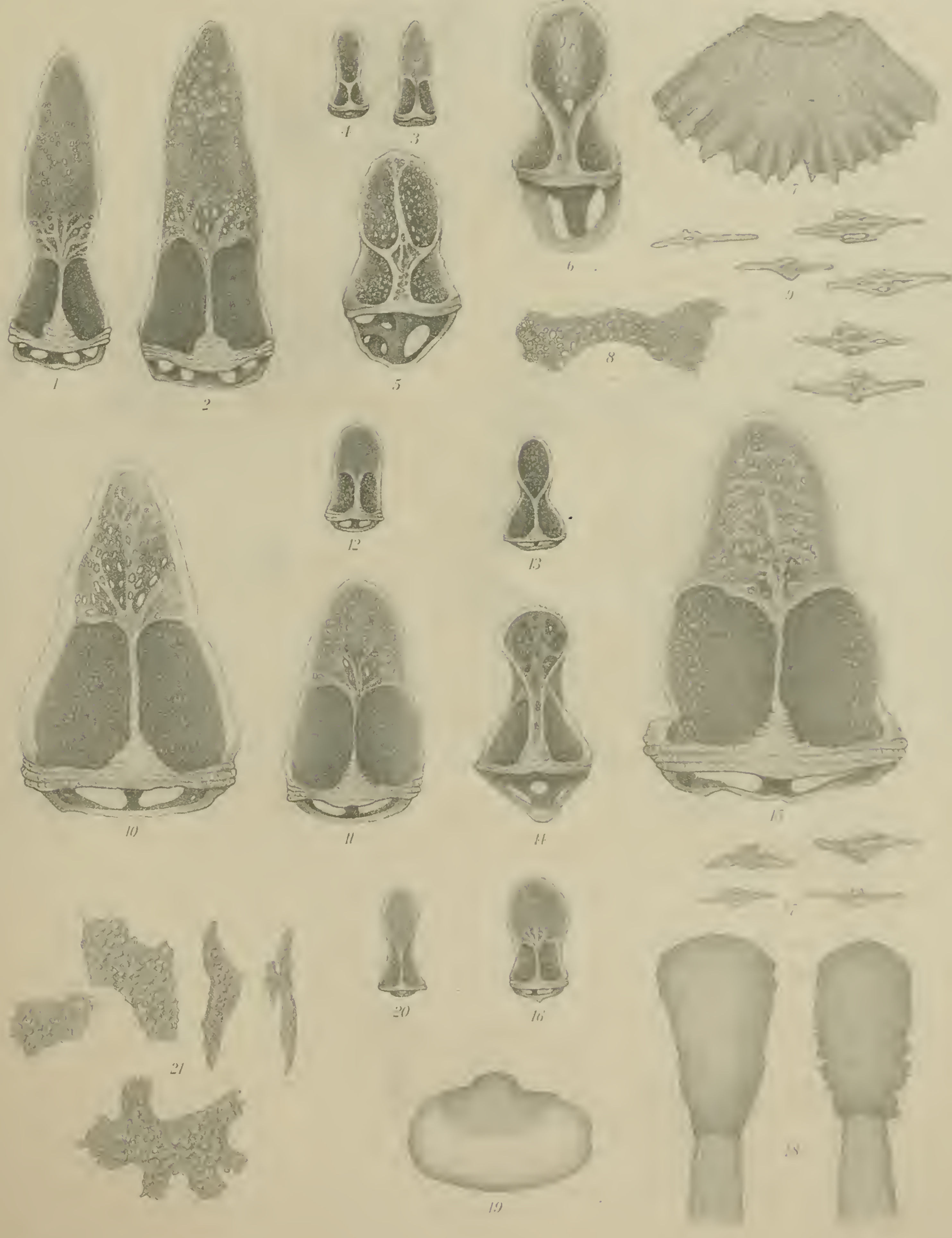
10. Valve of tridentate pedicellaria. × 70.
11. Valve of smaller tridentate pedicellaria. × 70.
12. Valve of very small tridentate pedicellaria. × 70.
13. Valve of triphyllous pedicellaria. × 70.
14. Valve of ophicephalous pedicellaria. × 70.

15–19. **Arbacia spatuligera** A. Ag.

15. Valve of tridentate pedicellaria. × 70.
16. Valve of triphyllous pedicellaria. × 70.
17. Calcareous rods from pedicels. × 70.
18. Upper end of stalks of pedicellariæ. × 70.
19. Sphæridium. × 70.

20, 21. **Arbacia stellata** Gray.

20. Valve of triphyllous pedicellaria. × 70.
21. Calcareous plates from pedicels. × 70.



H. L. Clark del.

Plate 49.

Plate 49.

1-8. **Podocidaris sculpta** A. Ag.

1. Sphæridium in position on test. × 70.
2. Upper end of stalk of ophicephalous pedicellaria. × 70.
3. Calcareous rods from pedicels. × 70.
4. Valve of ophicephalous pedicellaria. × 70.
5. Terminal part of another valve of similar pedicellaria. × 70.
6. Valve of tridentate pedicellaria. × 70.
7. Terminal part of another valve of similar pedicellaria. × 70.
8. Valve of triphyllous (small tridentate?) pedicellaria. × 70.

9-14. **Habrocidaris argentea** A. Ag. and Cl.

9. Sphæridium. × 70.
10. Upper end of stalk of ophicephalous pedicellaria. × 70.
11. Calcareous rods from pedicels. × 70.
12. Valve of ophicephalous pedicellaria. × 70.
13. Basal part of largest valve of similar pedicellaria. × 70.
14. Valve of tridentate pedicellaria. × 70.

15-20. **Habrocidaris scutata** A. Ag. and Cl.

15. Sphæridium. × 70.
16. Upper end of stalk of ophicephalous pedicellaria. × 70.
17. Valve of ophicephalous pedicellaria. × 70.
18. Basal part of largest valve of similar pedicellaria. × 70.
19. Valve of tridentate pedicellaria. × 70.
20. Calcareous rods from pedicels. × 70.

21-28. **Cœlopleurus maculatus** A. Ag. and Cl.

21. Valve of ophicephalous pedicellaria. × 70.
22. Upper end of stalk of ophicephalous pedicellaria. × 70.
23. Valve of large tridentate pedicellaria. × 70.
24. Valve of very small tridentate (triphyllous ?) pedicellaria. × 70.
25. Upper end of stalk of tridentate pedicellaria. × 70.
26. Sphæridial cavity with sphæridium in place. × 70.
27. Calcareous particles from pedicels. × 70.
28. Calcareous particles from gills. × 70.

29, 30. **Cœlopleurus longicollis** A. Ag. and Cl.

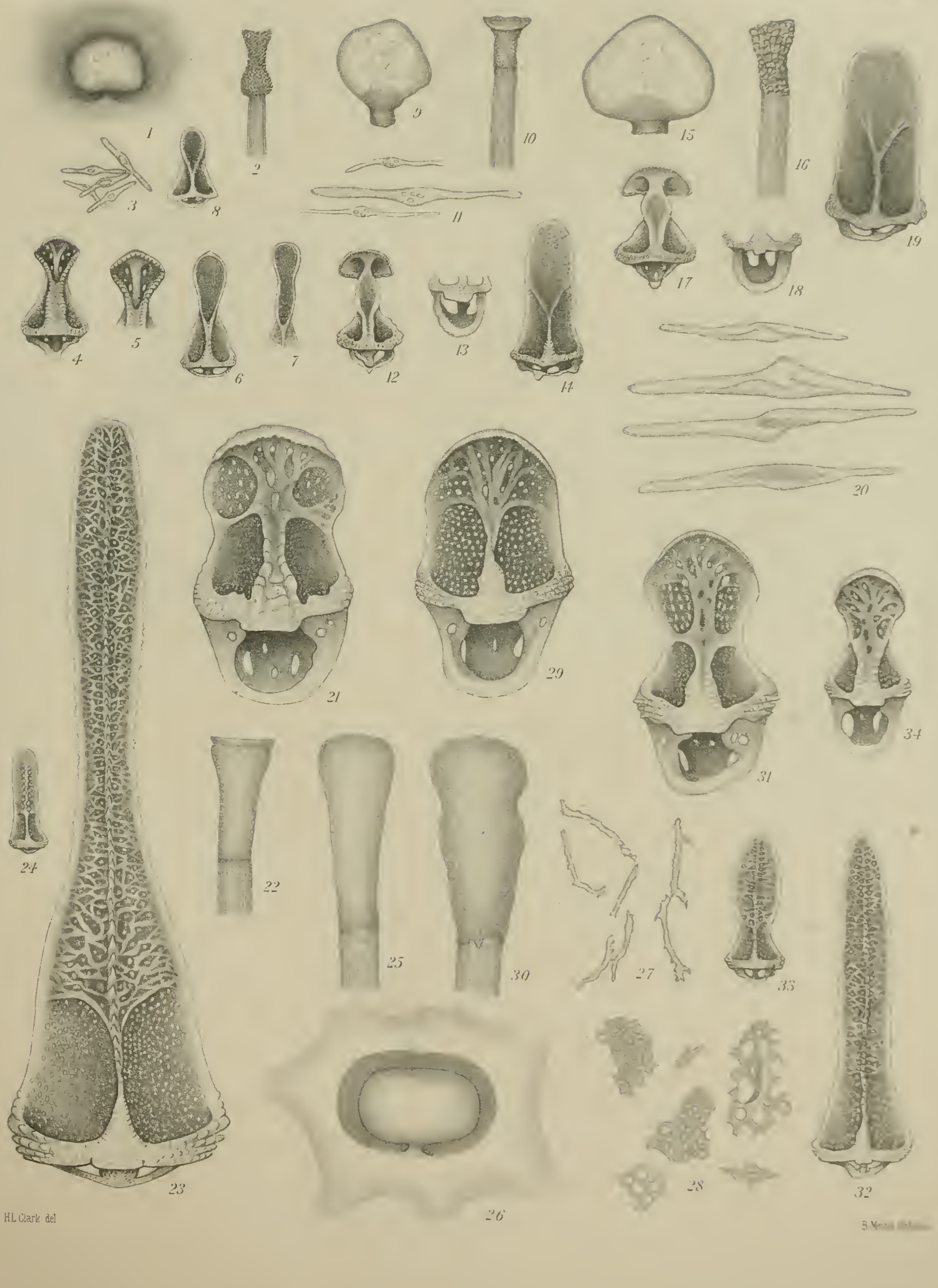
29. Valve of ophicephalous pedicellaria. × 70.
30. End of stalk of tridentate pedicellaria. × 70.

31-33. **Cœlopleurus floridanus** A. Ag.

31. Valve of ophicephalous pedicellaria. × 70.
32. Valve of tridentate pedicellaria. × 70.
33. Valve of small tridentate (triphyllous ?) pedicellaria. × 70.

34. **Cœlopleurus Maillardi** A. Ag.

34. Valve of ophicephalous pedicellaria. × 70.



H L Clark del

B. Meisel lith.

PLATE 50.

1, 2. Aspidodiadema nicobaricum Död.

1. Valve of stout tridentate pedicellaria. × 70.
2. Sphaeridium. × 70.

3–5. Aspidodiadema tonsum A. Ag.

3. Valve of stout tridentate pedicellaria. "form b." × 70.
4. Valve of pedicellaria midway between tridentate and ophicephalous. "form c." × 70.
5. Valve of broad triphyllous pedicellaria. × 70.

6–10. Dermatodiadema globulosum A. Ag.

6. Valve of stout tridentate pedicellaria. × 70.
7. Valve of slender tridentate pedicellaria. × 70.
8. Valve of triphyllous pedicellaria. × 70.
9. Valve of ophicephalous pedicellaria. × 70.
10. Sphaeridium. × 70.

11–15. Dermatodiadema horridum A. Ag.

11. Valve of stout tridentate pedicellaria. × 70.
12. Valve of slender tridentate pedicellaria. × 70.
13. Valve of triphyllous pedicellaria. × 70.
14. Valve of ophicephalous pedicellaria. × 70.
15. Upper end of stalk of pedicellaria. × 70.

16–19. Chaetodiadema pallidum A. Ag. and Cl.

16. Valve of tridentate pedicellaria (broken at tip). × 70.
17. Side view of base of same. × 70.
18. Valve of triphyllous pedicellaria. × 70.
19. Calcareous particles from gills. × 70.

20, 21. Leptodiadema purpureum A. Ag. and Cl.

20. Sphaeridia. × 70.
21. Calcareous particles from pedicels. × 70.

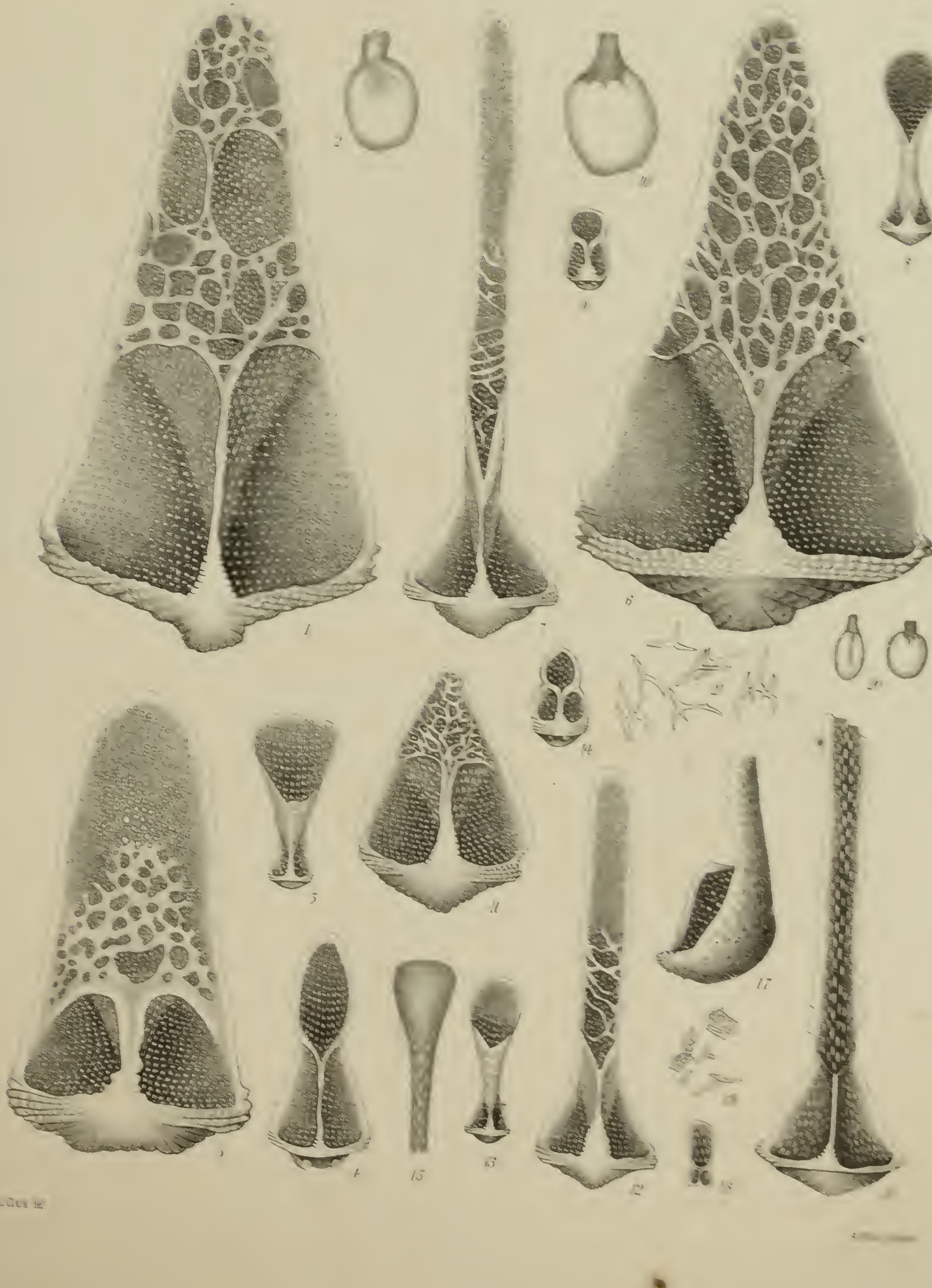


PLATE 51.

Plate 51.

1, 2. **Diadema paucispinum** A. Ag.

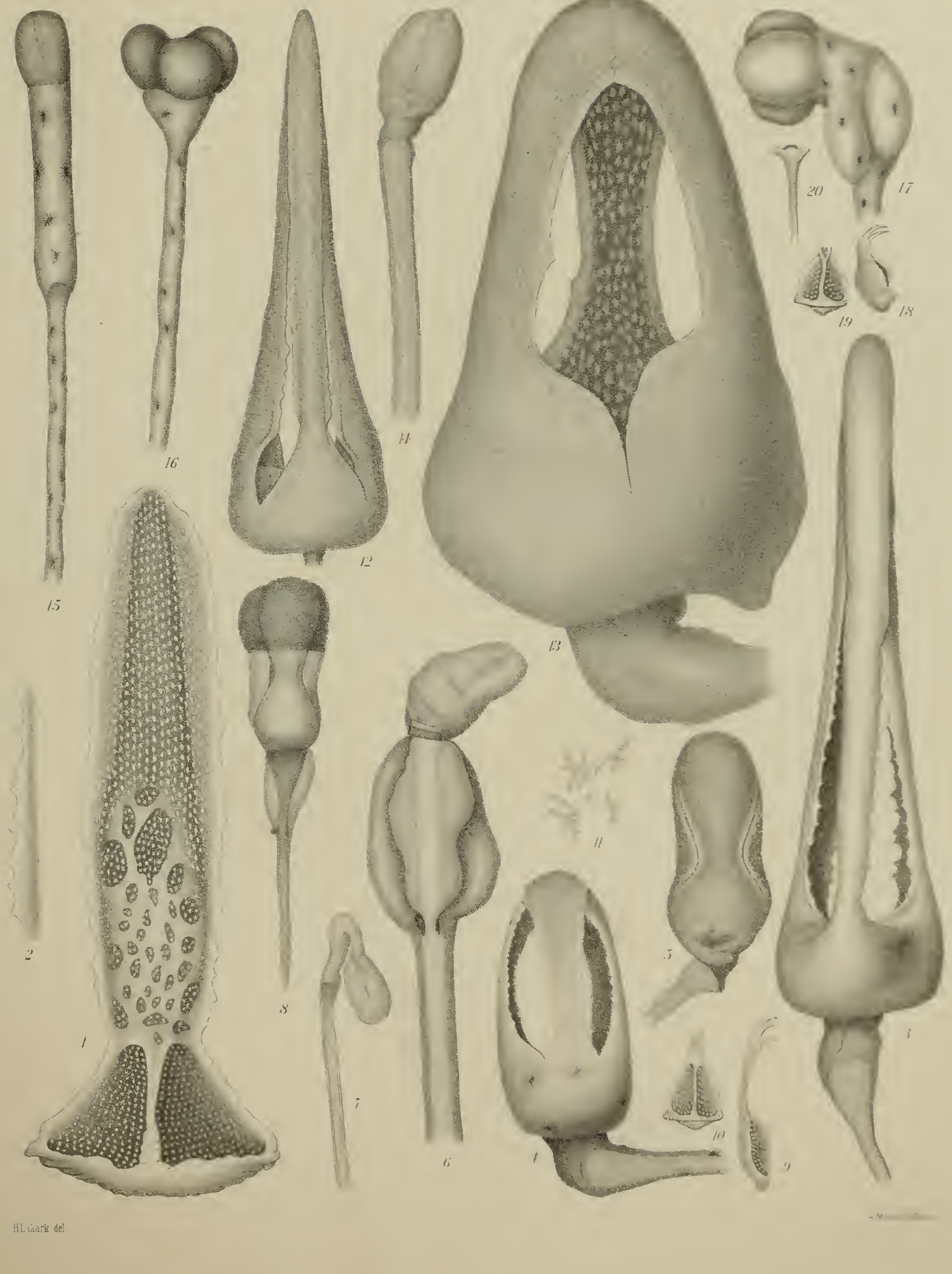
1. Valve of large tridentate pedicellaria. × 70.
2. Part of margin of same, seen from side. × 70.

3–11. **Centrostephanus asteriscus** A. Ag. and Cl.

3. Slender tridentate pedicellaria. × 70.
4. Stout tridentate pedicellaria. × 70.
5. Large ophicephalous pedicellaria without glands. × 70.
6. Ophicephalous pedicellaria with glands. × 70.
7. Triphyllous pedicellaria. × 70.
8. Globiferous pedicellaria. × 70.
9. Side view of valve of globiferous pedicellaria. × 70.
10. Interior view of base of same. × 70.
11. Calcareous particles from pedicels. × 70.

12–20. **Centrostephanus coronatus** A. Ag.

12. Slender tridentate pedicellaria. × 70.
13. Stout tridentate pedicellaria. × 70
14. Ophicephalous pedicellaria. × 70.
15. Triphyllous pedicellaria. × 70.
16. Globiferous pedicellaria. × 70.
17. Globiferous pedicellaria with glands on stalk. × 70.
18. Side view of valve of globiferous pedicellaria. × 70.
19. Interior view of base of same. × 70.
20. Upper end of stalk of globiferous pedicellaria. × 70.



H.L. Clark del

PLATE 52.

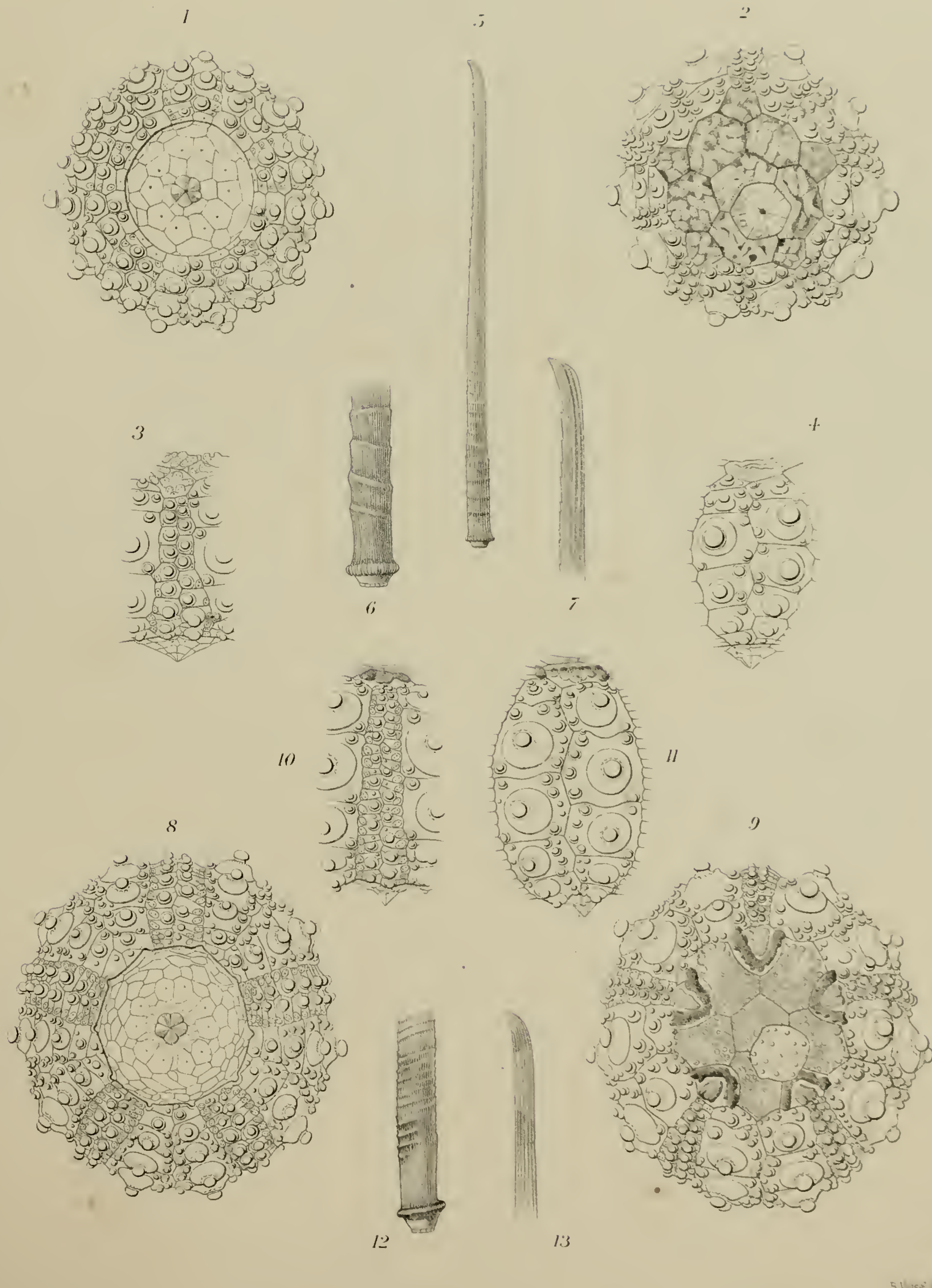
Plate 52.

1–7. **Salenocidaris crassispina** A. Ag. and Cl.

1. Actinal view of denuded test. × 10.
2. Abactinal view of same. × 10.
3. Left anterior ambulacrum. × 10.
4. Right posterior interambulacrum. × 10.
5. Primary spine. × 4.
6. Base of primary spine. × 8.
7. Tip of primary spine. × 8.

8–13. **Salenia cincta** A. Ag. and Cl.

8. Actinal view of denuded test. × 4.
9. Abactinal view of same. × 4.
10. Odd anterior ambulacrum. × 4.
11. Left posterior interambulacrum. × 4.
12. Base of primary spine. × 4.
13. Tip of primary spine. × 4.



A. M Westergren del

B. Meisel lith.

Plate 53.

Plate 53.

1–7. **Cœlopleurus maculatus** A. Ag. and Cl.

1. Actinal view of denuded test. × 2.
2. Abactinal view of same. × 2.
3. Odd anterior ambulacrum. × 2.
4. Left posterior interambulacrum. × 2.
5. Primary spine, seen from side. × 1.5.
6. Base of primary spine, seen from above. × 4.
7. Tip of primary spine, seen from above. × 4.

8, 9. **Cœlopleurus Maillardi** A. Ag.

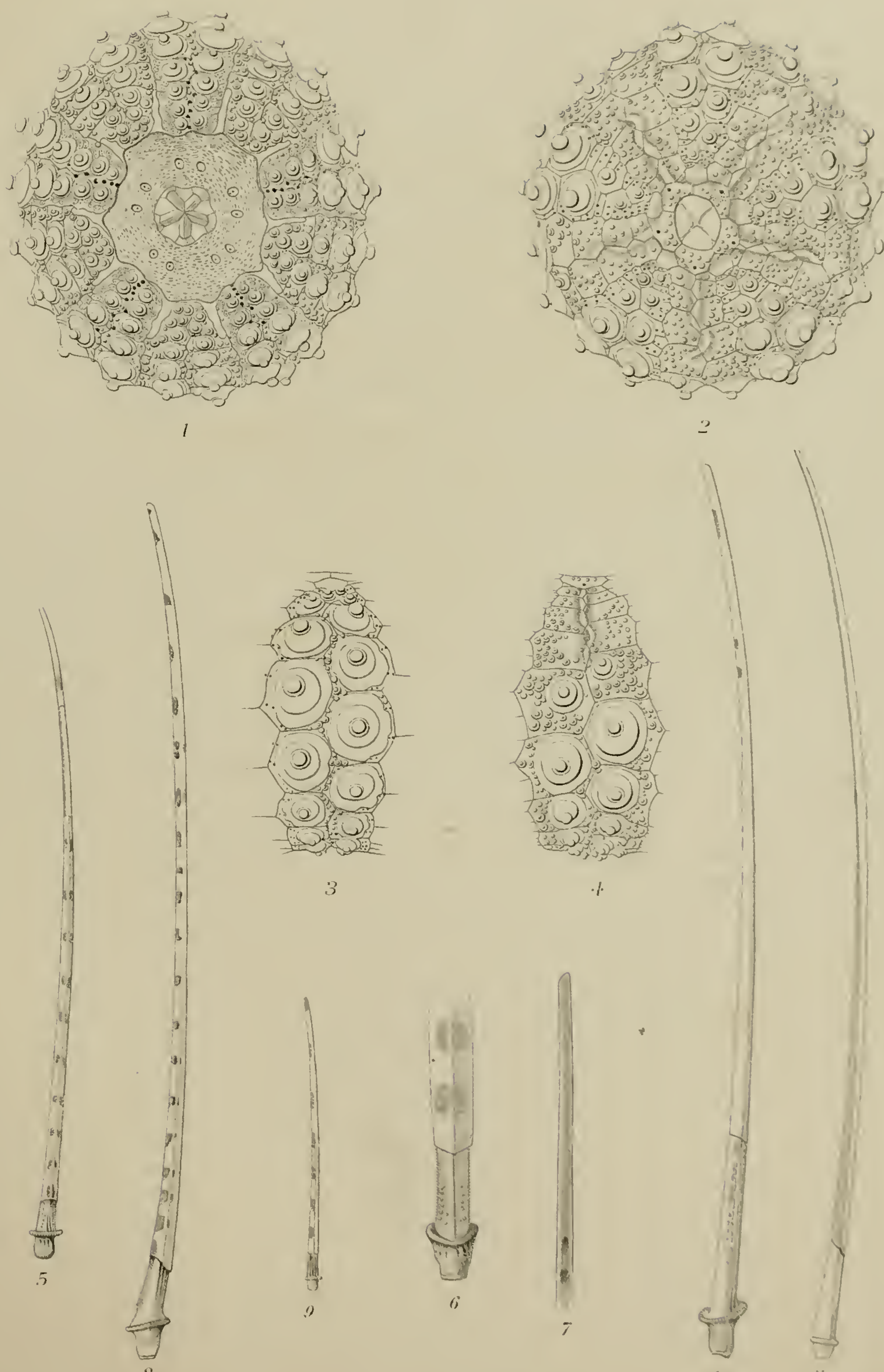
8. Primary spine of type specimen from Bourbon. × 1.5.
9. Primary spine of young specimen from Kei Islands. × 1.5.

10. **Cœlopleurus longicollis** A. Ag. and Cl.

10. Primary spine of type specimen. × 1.5.

11. **Cœlopleurus floridanus** A. Ag.

11. Primary spine. × 1.5.



A. M. Westergren del.

PLATE 54.

Plate 54.

1–3. **Habrocidaris argentea** A. Ag. and Cl.

1. Actinal view of denuded test. × 4.
2. Abactinal view of same. × 4.
3. Right anterior interambulacrum. × 4.

4–9. **Habrocidaris scutata** A. Ag. and Cl.

4. Actinal view of denuded test. × 3.
5. Abactinal view of same. × 3.
6. Side view of same, showing left anterior ambulacrum. × 3.
7. Left anterior interambulacrum. × 3.
8. Part of primary spine. × 6.
9. Cross-section of spine. × 8.

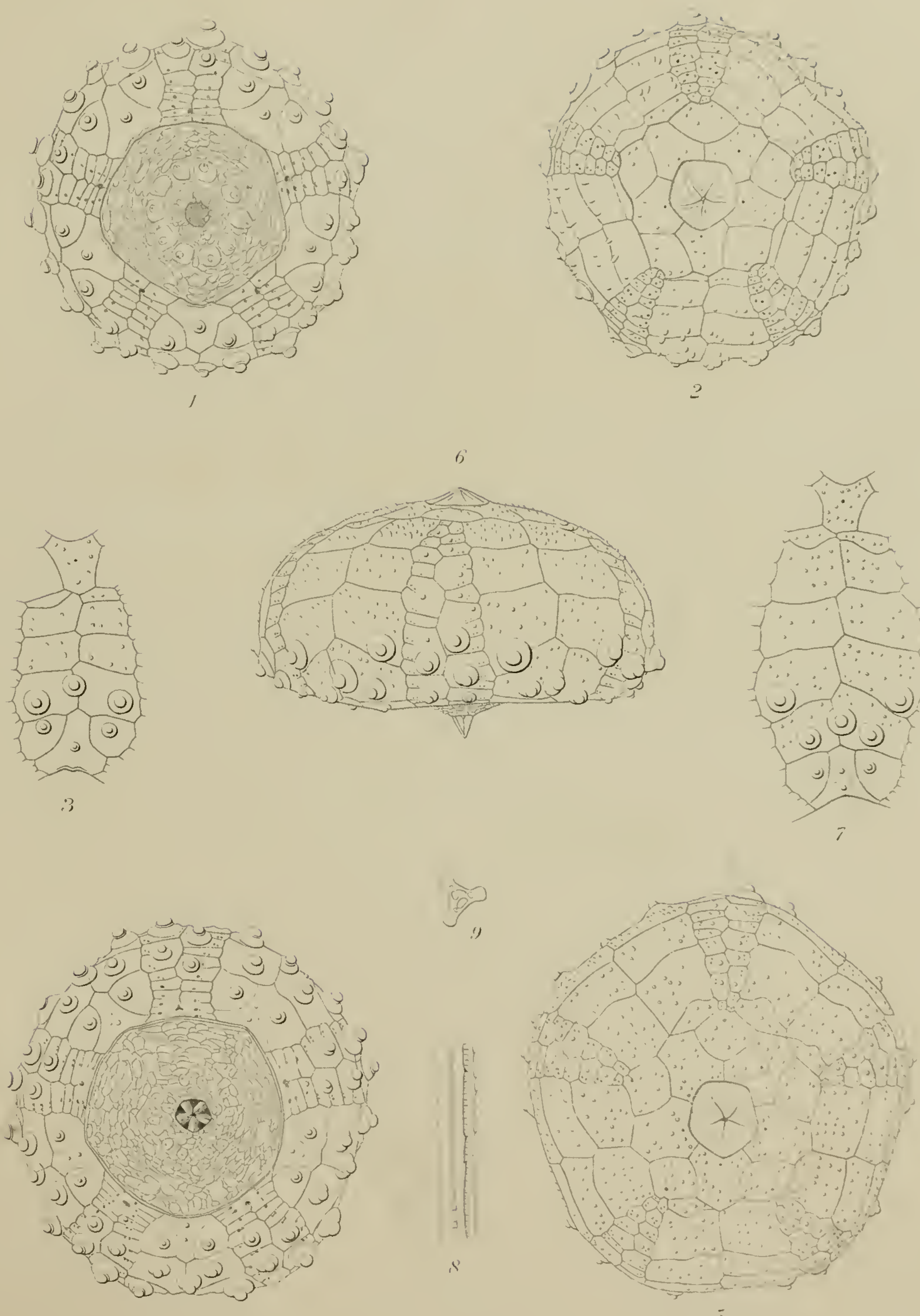

1
2
6
3
7
9
8
4
5

Plate 55.

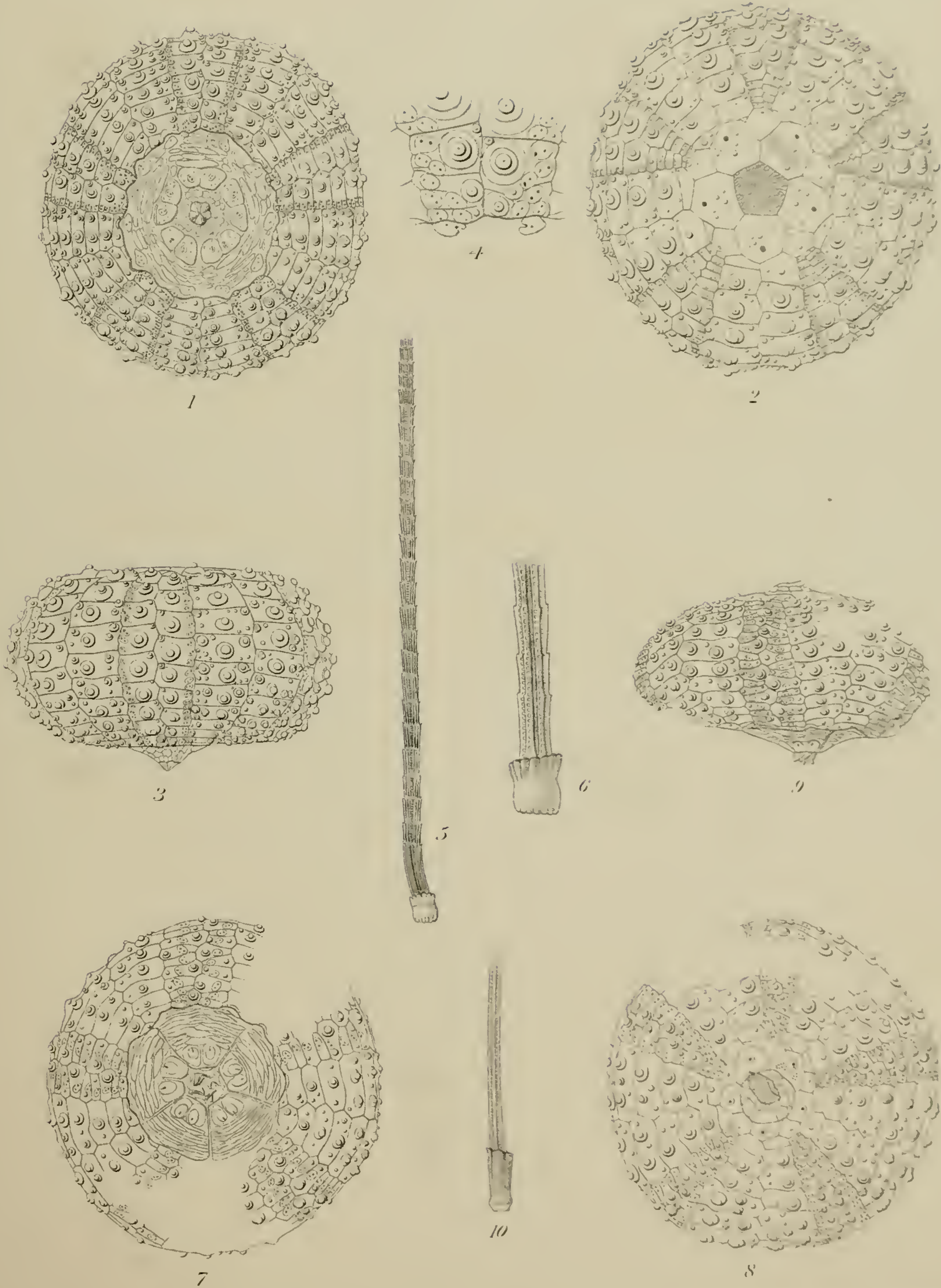
Plate 55.

1–6. **Centrostephanus asteriscus** A. Ag. and Cl.

1. Actinal view of denuded test. × 4.
2. Abactinal view of same. × 4.
3. Side view of same, showing left anterior ambulacrum. × 4.
4. Actinal portion of odd anterior ambulacrum. × 10.
5. Basal half of primary spine. × 5.
6. Base of same. × 10.

7–10. **Leptodiadema purpureum** A. Ag. and Cl.

7. Actinal view of denuded test. × 5.
8. Abactinal view of same. × 5.
9. Side view of same, showing right anterior ambulacrum. × 5.
10. Basal part of primary spine. × 5.



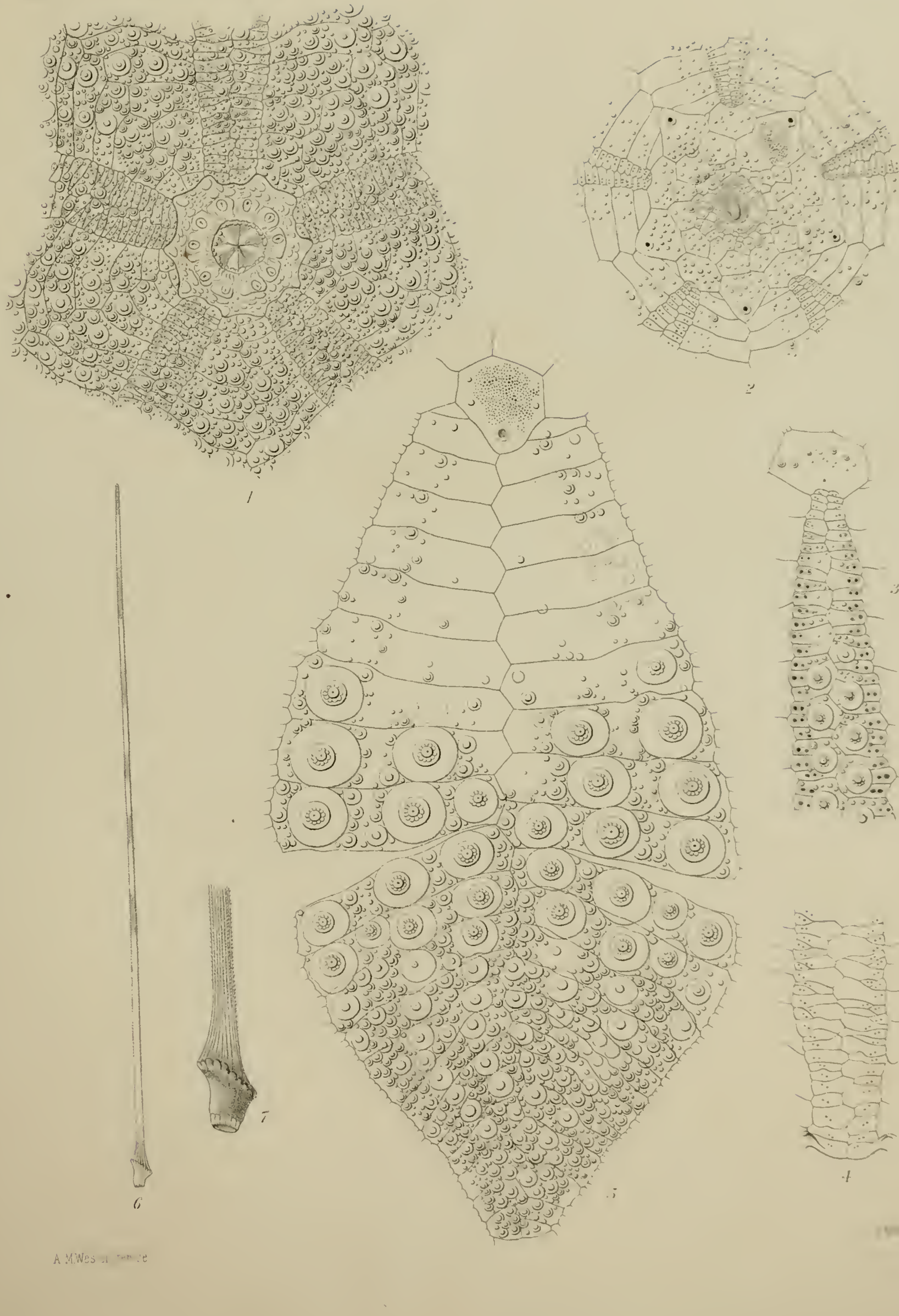
A. H. Westergren del.

PLATE 56.

Plate 56.

Chætodiadema pallidum A. Ag. and Cl.

1. Actinostome and adjoining part of denuded test. × 2.
2. Abactinal system of same. × 2.
3. Abactinal part of odd anterior ambulacrum seen from without. × 3.
4. Actinal part of same ambulacrum seen from within. × 3.
5. Right anterior interambulacrum, laid out flat. × 3.
6. Primary spine. × 2.
7. Base of same. × 4.



A. M. Wes[illegible]

PLATE 57.

Plate **57**.

1–3. **Salenia cincta** A. Ag. and Cl.

1. Ambulacral view of a specimen somewhat inclined.
2. Actinal view of partly denuded specimen.
3. Abactinal view of same.

4–6. **Cœlopleurus maculatus** A. Ag. and Cl.

4. Actinal view of medium-sized specimen.
5. Abactinal view of same.
6. Side view of same.

All figures natural size.

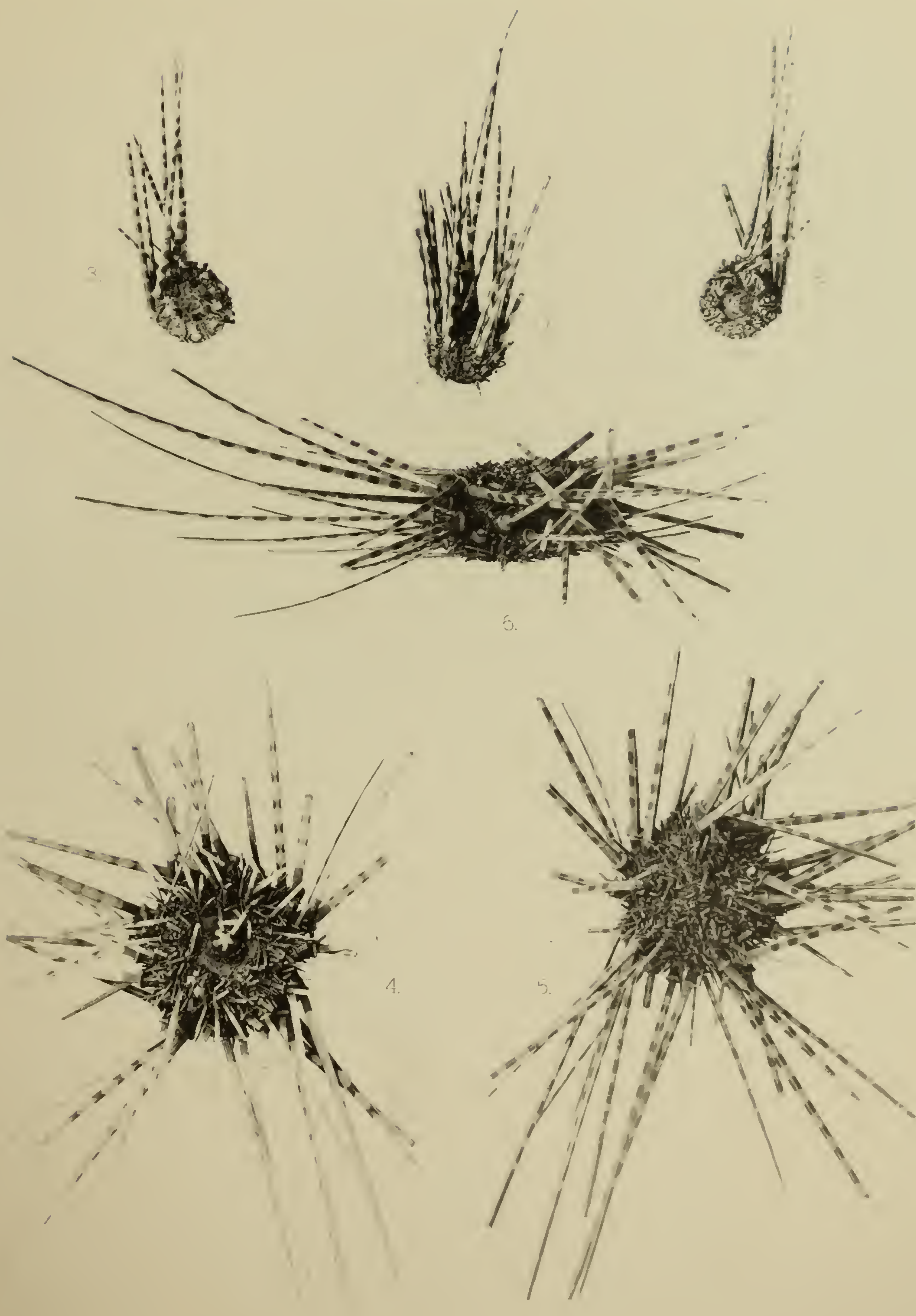

3.
6.
4.
5.

PLATE 58.

Plate 58.

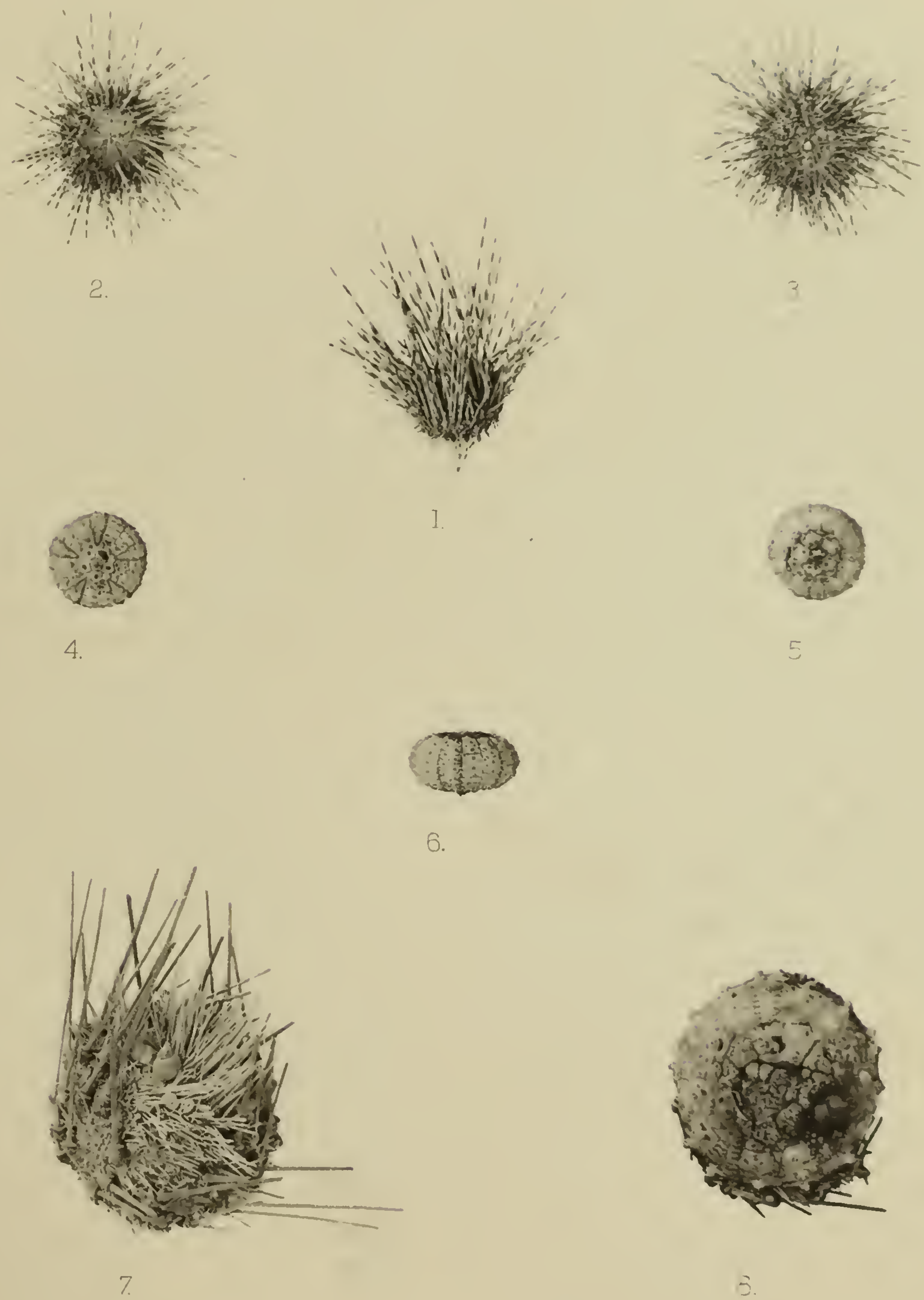
1–6. **Centrostephanus asteriscus** A. Ag. and Cl.

1. Side view.
2. Abactinal view, showing the white star.
3. Actinal view.
4. Abactinal view of denuded test.
5. Actinal view of same.
6. Ambulacral view of same.

7–8. **Aspidodiadema meijerei** A. Ag. and Cl.

7. Abactinal view of a specimen from Station 3839, in which the abactinal system is hypertrophied by several parasitic gasteropods (Stylifer ?).
8. Abactinal view of the same specimen, with abactinal system denuded to show the modification of the genital and ocular plates.

All figures natural size.



2.
3.
1.
4.
5.
6.
7.
8.

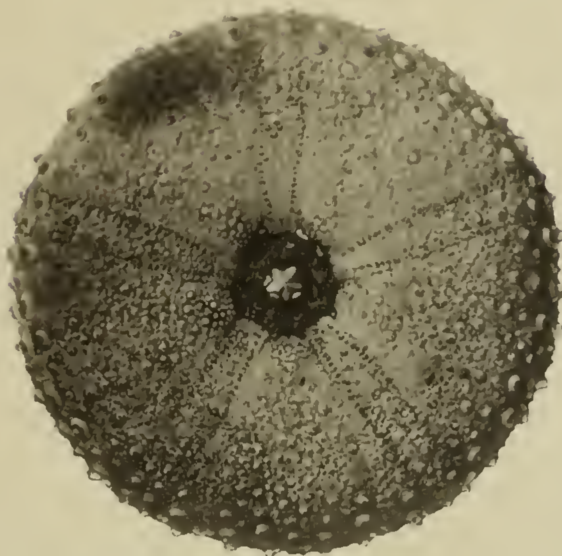
Plate 59.

Plate 59.

Chætodiadema pallidum A. Ag. and Cl.

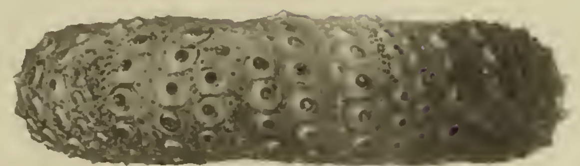
1. Actinal view.
2. Abactinal view.
3. Actinal view of denuded specimen.
4. Abactinal view of same.
5. Side view of same.

All figures natural size.



3.

4.



5

1.

2.

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
VOL. XXXIV. NO. 3.

HAWAIIAN AND OTHER PACIFIC ECHINI.

THE ECHINOTHURIDÆ.

BY

ALEXANDER AGASSIZ AND HUBERT LYMAN CLARK.

WITH THIRTY PLATES.

PLATES 60–89.

[Published by Permission of GEORGE M. BOWERS, U. S. Commissioner of Fish and Fisheries.]

CAMBRIDGE, U. S. A.:
Printed for the Museum.
NOVEMBER, 1909.

CONTENTS.

CONTENTS.

* Hawaiian species.

* Hawaiian species.

HAWAIIAN AND OTHER PACIFIC ECHINI.

Collected by the U. S. Fish Commission Steamer "Albatross," Commander Chauncey Thomas, U. S. N., Commanding in 1902, and Lieut. Commander L. M. Garrett, U. S. N., Commanding in 1906.

ECHINOTHURIDÆ Wyv. Thom.

Some Anatomical Features.

Plates 60–63.

Although various writers[1] have discussed the anatomy of the Echinothuridæ in more or less detail, and some have published figures to illustrate certain anatomical peculiarities, it has seemed to be desirable to give a few figures showing the general arrangement of the alimentary canal and the lantern in some of the species, whose anatomy has not hitherto been figured. As our investigations have led us to believe that the Echinothuridæ and Diadematidæ are nearly related families, we have also added a few figures showing the anatomy of several species of Diadematidæ.

A comparison of the figures given on Plates 62 and 63 shows that the genera of Echinothuridæ differ not a little among themselves in the details of their structure. It is, nevertheless, instructive to compare these figures with those of the genera of Diadematidæ given on Plates 60 and 61. The œsophagus, for example, is shortest in Echinothrix (Pl. 60, fig. *3*), somewhat longer in Micropyga (Pl. 61, fig. *1*) and Phormosoma (Pl. 62, fig. *2*), much longer in Echinosoma and Sperosoma (Pl. 62, figs. *3*, *4*), and longest in Asthenosoma (Pl. 62, fig. *1*) and Astropyga (Pl. 61, fig. *3*).

The alimentary canal of Phormosoma is remarkably different from that of Asthenosoma (compare figs. *1* and *2*, Pl. 62), but it is interesting to note that that of Echinosoma (Pl. 62, fig. *3*) is quite intermediate.

[1] Wyville Thomson, 1874: "Porcupine" Echinoidea, Trans. Roy. Soc. London, 164, pt. 2, Pls. LXIII–LXVII. A. Agassiz, 1881: "Challenger" Echinoidea, Pls. XII, XIV, XVIII[b]. Paul and Fritz Sarasin, 1888: Ergeb. Nat. Forsch. Ceylon, I, Pls. XII–XVII. Kœhler, 1898: "Hirondelle" Echinides, Pls. IV and IX. Schurig, 1906: Wiss. Ergeb. d. Deutsch. Tiefsee-Exp. 5, lfg. 3, Pls. LI–LIV.

That of Sperosoma (Pl. 62, fig. *4*) shows some noticeable resemblances to the arrangement in Echinothrix (Pl. 60, fig. *3*), though it has certain peculiarities of its own, in addition to the long, slender œsophagus. There can be no question that the general arrangement of the canal in Asthenosoma (Pl. 62, fig. *1*) is quite as near what we find in Astropyga (Pl. 61, fig. *3*) as it is to that of any genus of Echinothurids.

A comparison of the lanterns and perignathic girdles figured on Plate 63 with those of the three genera of Diadematidæ (Pl. 60, fig. *4*; Pl. 61, figs. *2*, *4*) reveals two very important differences. In the Echinothurids, the apophyses, whether conspicuous as in Phormosoma (Pl. 63, fig. *3*), or relatively inconspicuous as in Asthenosoma (Pl. 63, fig. *2*), are single, in keeping with the presence of the single primordial interambulacral plate, while in the Diadematids they are paired. In the Echinothurids (Pl. 63), the Stewart's organs, though very different in appearance from those of the Cidaridæ, are well developed,[1] while in the Diadematids they are either wholly wanting or are reduced to mere rudiments as shown in Echinothrix (Pl. 60, fig. *4*). Aside from these two points, the differences between the girdle and lantern of Phormosoma and those of Asthenosoma are as great as those which distinguish Phormosoma from Astropyga, or Echinothrix from Micropyga. We find there is noticeable individual diversity in certain points, such as the bulk of the auricles and the amount of forking at the end of the compasses, so that these features are of little value in determining generic limits.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plates 64–67.

The spines of the Echinothuridæ show so much diversity of form, aside from the differences between primary, secondary, and miliary spines, that they deserve a special paragraph. They may be conveniently classified under four heads, — naked spines, sheathed spines, glandular spines, and hoofed spines. The *naked spines* are the ordinary spines, more or less abundant on all parts of the test; they may be slender or stout, primaries, secondaries, or miliaries; they may be either sharp or blunt, or rarely, widened and flattened at tip, long or short, smooth or rough; they

[1] Those writers who have said that Stewart's organs are rudimentary or wanting in certain Echinothurids have either had poor material or have overlooked these long, slender outgrowths. Or else there is more individual diversity than would naturally be expected.

are rarely verticillate as in Diadema. They are commonly hollow, though some of the very slender ones and those on the buccal membrane are often solid, at least in their distal half. The *sheathed spines* are commonly primary spines, but may be secondaries or even miliaries; when the sheath of skin is thick and loose they are conspicuous and unmistakable, but when the sheath is thin and close-fitting they can scarcely be distinguished from ordinary "naked" spines, which are, of course, really covered by the skin. Sheathed spines may be either actinal or abactinal in position, and the sheath may be either cylindrical or distally swollen; when cylindrical, it may have one or more circular constrictions. The *glandular spines* are secondaries or miliaries, exceedingly sharp, and provided with a poison-gland at the tip. They are commonly abactinal in position, and may be arranged in regular series on the interambulacra. The *hoofed spines* are always actinal primaries, and are the most conspicuous spines on the test when present. They are usually hollow, even the shining white hoof-shaped swelling in which they terminate being only loosely filled with calcareous strands; but in some species the hoof and the distal half of the spine are perfectly solid; there is more or less diversity however in different spines, even of a single individual. Unfortunately the hoofs are very easily broken off, and otherwise good specimens may show few or none. All four of these different kinds of spines may occur on a single individual, but as Mortensen has pointed out, species which have sheathed spines actinally do not have hoofed spines.

The pedicellariæ of the Echinothuridæ have been so fully discussed and satisfactorily figured by Mortensen and Döderlein, it is hardly necessary to devote much space to their description. There are four different sorts, two or more of which may be found in any individual. The *triphyllous* pedicellariæ (Pl. 64, fig. *3*) are always present, and always have three valves, which are broadest at or near the tip and are well separated from each other just below the middle when the pedicellaria is closed; the valves (Pl. 64, figs. *8*, *12*) are provided with a "cover-plate" which is usually more or less perforated. These pedicellariæ are abundant on almost all parts of the test, and are borne on long slender stalks, which are several times as long as the head. The *tridentate* pedicellariæ (Pls. 64, fig. *9*; 66, figs. *1*, *2*, *15*, *17*; 67, figs. *2*, *3*, *4*, *6*, *8*, *9*, *12*, *17*) are nearly or quite as common as the triphyllous, but are very much more diverse in size and form. They occur on all parts of the test, but their abundance varies greatly in different individuals. The length of stalk is also very variable, though it commonly exceeds that of the head. The structure of the stalk is of the usual type in the Diadematidæ, a cylinder of irregularly but closely united coarse rods. It is very interesting to note that in Kamptosoma the stalk is made up of "long threads, almost only united at the ends" (Mortensen); the stalk in this genus, therefore, bears the same relation to the stalk in other Echinothurids that the stalk of the pedicellariæ in Micropyga does to that of the other Diadematids, — a very notable case of "parallelism." The valves of the tridentate pedicellariæ vary so much in size and form that a general description of them is impracticable, but certain kinds are very constant and easily recognizable, and these deserve a few words. First of all are *involute* valves, which are more or less curved and meet only at tip (Pl. 66, fig. *1*); in these the margins of the blade are rolled in, forming a nearly cylindrical middle part of greater or less length between the base of the blade and the somewhat expanded tip; secondly, there are *contiguous* valves, which are straight and in contact for nearly their entire length, — these may be very broad (Pl. 65, fig. *18*), or rather narrow (Pl. 64, fig. *5*); a third sort may be referred to as *convergent* valves, which are straight or little curved, little or not at all involute, meeting only at tip or for their distal half; such valves are shown on Pl. 65, fig. *5*; see also Pl. 67, figs. *4*, *12*. Although these three sorts of valves are usually recognizable with ease, they do intergrade more or less (Pl. 65, fig. *4*; 66, fig. *2*). The *ophicephalous* pedicellariæ (Pl. 65, figs. *1*, *2*) are much less common, as a rule, than the tridentate, and have been found as yet in only a comparatively few species; they are strongly constricted at the middle, and the articular loops on the valves (Pl. 65, fig. *3*; 67, fig. *21*) are well developed; these pedicellariæ show no tendency to intergrade with the other forms. The fourth form of pedicellaria was first described by Wyville Thomson as a "tetradactyle" pedicellaria, and Mortensen has retained the name. Unfortunately, however, the number of valves is often three or five, so that the "tetra" — is very inappropriate; we would suggest that this form be called simply the *dactylous* pedicellariæ. They are known only from certain species of Aræosoma, and show considerable diversity in the form of the valves; these may be long and slender, united only near the base and quite free distally (Pl. 66, fig. *20*), or they may be much shorter and well surrounded by tissue as de Meijere figures them, or the valves may be wholly imbedded in tissue (Pl. 64, fig. *1*). The valves differ notably in shape (compare Pl. 64, fig. *4*, and

66, fig. *20*) and may even be greatly reduced, with the expanded tip entirely lacking; this form, which occurs in *A. pellucidum*, was at first regarded by Mortensen as a "globiferous" pedicellaria; but he was subsequently satisfied by de Meijere's evidence, that it is simply a degradational form of dactylous pedicellaria. There are no globiferous pedicellariæ known in the Echinothuridæ.

As Döderlein has well pointed out, the three families Aspidodiadematidæ, Diadematidæ, and Echinothuridæ show such agreement in the essential features of their pedicellariæ that they form a group apart from the other regular Echini, and arouse the suspicion that they are mutually interrelated. In the absence of globiferous pedicellariæ (present only in Centrostephanus) they agree with the Salenidæ and Arbaciadæ, and differ markedly from the Cidaridæ, Echinometridæ, and Echinidæ. Their mutual agreement in tridentate pedicellariæ is obvious, but in view of the great diversity of form which these pedicellariæ show in the three families, and of the fact that very similar pedicellariæ occur in other families, no great weight can be laid on this point. The ophicephalous pedicellariæ of the Echinothuridæ are peculiar but are as much like those of the Diadematidæ as of any other echini, excepting only some of the spatangoids. The triphyllous are similar to those of the Aspidodiadematidæ; they are less like those of Astropyga and Micropyga, but still the resemblance even here is not to be ignored.

The *sphæridia* of the Echinothuridæ (Pls. 66, figs. *4*, *5*, *18*; 67, fig. *11*), as in the Aspidodiadematidæ and many Diadematidæ, are more or less numerous in each ambulacrum and occur at the inner lower side of the tube-feet in the innermost series. In Phormosoma they are also present next to the feet of the middle series. They may be confined to the actinal surface of the test, but commonly they extend above the ambitus. They sometimes accompany the tube-feet nearly or quite to the ocular plate, and occasionally they may be found on the buccal plates. In Phormosoma they are nearly spherical, but in the other genera they are more or less elongated; sometimes the length and appearance (Pl. 66, fig. *18*) indicate clearly their origin as modified spines.

The *calcareous spicules* of the tube-feet are commonly in the form of perforated plates (Pl. 65, figs. *14*, *20*), which show great diversity in form and size. In some species, however, the spicules, either in the basal part of the foot or throughout its length, are simply more or less irregular triradiate rods (Pl. 66, fig. *13*), similar to those found in the Diadematidæ. There seems no reason to question the fundamental triradiate origin of even the larger perforated plates, so that we have here again a suggestion of Diadematid relationship.

The Systematic Position of the Echinothuridæ.

In all discussion as to the proper position of the Echinothuridæ in our classification of the Echini, the crucial point is as to the stress that shall be laid on the occurrence of regular series of ambulacral plates on the actinostome. If this character is regarded as of fundamental importance, then of course the Echinothurids stand quite apart from all the other regular Echini, excepting only the Cidaridæ; but if the possibility be admitted that this character has appeared independently in the Echinothurids, or has been retained by them, while lost by the other families, then we may well examine with care the other characters of the family to see if we cannot ascertain its relationships.

Mortensen is one of those who hold to the fundamental importance of the Echinothurid actinostome, and has expressed himself (1904) as favoring their union with the Lepidocentridæ in a suborder (Streptosomata) apart from the other Ectobranchiate Regulares. Döderlein, on the other hand, has expressed himself (1906) as believing in the close relationship of the Echinothurids and Diadematids, and he recognizes a suborder (Diadematida) which includes the Streptosomata as a special "tribe" containing the Echinothurids only and the Stereosomata, a tribe made up of the Diadematidæ and its closest allies. In attempting to reach a correct conclusion on the question, it has seemed to us that it would be helpful to tabulate in parallel columns all the morphological characters of the Echinothuridæ and Diadematidæ. By so doing the similarities and differences will be made to stand out more vividly, and we may perhaps be able to decide whether the resemblances indicate relationship or not. The characters are arranged in what seems to us to be the order of importance.

The careful comparison of the ambulacra in Echinothrix, Astropyga, Micropyga, Phormosoma, Asthenosoma, and Sperosoma demonstrates that the differences are superficial, and that in all these genera each ambulacral plate consists of three elements, of which the middle one (primary) is largest, while the adoral and aboral (secondary) elements show great diversity in size and position. In Echinothrix the secondary elements are rather large and lie next to the interambulacrum; the pore-pair of the

TABLE OF THE MORPHOLOGICAL CHARACTERS OF THE ECHINOTHURIDÆ AND DIADEMATIDÆ.

	DIADEMATIDÆ.	ECHINOTHURIDÆ.
STRUCTURE OF AMBULACRA.	Diadematoid; each compound plate consists of a middle primary, and abactinal and actinal secondary elements. Adoral imbrication usually slight or wanting.	Essentially diadematoid; some diversity shown in relative size and position of plate-elements. Adoral imbrication usually well-marked.
INTERAMBULACRAL AREAS.	Interambulacral plates bevelled on edge.	Interambulacral plates imbricating.
	Primordial interambulacral plate resorbed. Aboral imbrication not usually noticeable. Without evident membranous interspaces.	Primordial interambulacral plate retained. Aboral imbrication more or less marked. Membranous interspaces often very marked.
PRIMARY TUBERCLES.	Perforated; usually crenulated.	Perforated; non-crenulated.
ABACTINAL SYSTEM.	Large; anal system covered by numerous small plates; anal tube often present; commonly 2–5 oculars in contact with anal system; genito-ocular ring continuous, with rare exceptions; genital plates seldom split.	Large; anal system covered by numerous small plates; anal tube wanting; all oculars in contact with anal system; genito-ocular ring often discontinuous; genital plates often split.
ACTINOSTOME.	With five pairs of buccal plates and more or less numerous small scattered plates, either confined to, or much more conspicuous in the ambulacral areas.	Covered by five double columns of perforated ambulacral plates.
TEETH.	Grooved.	Grooved.
JAWS.	More or less erect, with open foramen magnum.	More or less inclined, with open foramen magnum.
PERIGNATHIC GIRDLE.	Continuous; auricles and apophyses more or less extensively developed.	Continuous; auricles and apophyses more or less extensively developed.
ARRANGEMENT OF TUBE-FEET.	In three longitudinal series, commonly; sometimes in two; rarely in one actinally.	In one, two, or three longitudinal series.
SPINES.	Hollow; long, usually verticillate, sometimes smooth; hoofs and conspicuous skin-sheaths wanting.	Hollow; short, usually smooth and very rarely verticillate, hoofs or conspicuous skin-sheaths often present, at least on actinal primaries.
STEWART'S ORGANS.	Rudimentary or usually wanting.	Well-developed; rarely rudimentary, and possibly wanting in some individuals.
GILLS.	Well-developed.	Commonly well-developed.
ALIMENTARY CANAL.	Long and large; œsophagus long and more or less coiled.	Long and large; œsophagus long and more or less coiled.
PEDICELLARIÆ.		
Globiferous.	Wanting (except Centrostephanus).	Wanting.
Ophicephalous.	Valves constricted at middle; blade deeply hollowed, with little calcareous material within.	Valves very wide near tip and deeply constricted, essentially as in Diadematidæ.
Triphyllous	Flat and leaf-shaped, commonly without cover-plate.	Flattened and widened at tip, with cover-plate.
Tridentate.	Very diverse, both large and small.	Very diverse, both large and small.
TUBE-FEET.	With sucking disc actinally, but usually not abactinally.	No sucking disc abactinally, and often not actinally.
SPHÆRIDIA.	Usually numerous, not sunken in pits, arranged in a vertical series, at inner side of inner series of tube-feet, in each half ambulacrum.	As in Diadematidæ.
CALCAREOUS SPICULES.	Essentially triradiate, often forming perforated plates.	Usually perforated plates, often showing triradiate origin; sometimes triradiate spicules.
COLOR.	Usually very dark, black, olive, purple, or red; sometimes light; spines often banded.	Deep purple, red, dull yellowish, gray, or greenish; spines often banded.
SIZE.	Usually large, up to 150 mm. h. d.	Large, 70–320 mm. h. d.

primary element is the outermost of the three, that of the adoral secondary is innermost, while that of the aboral secondary is intermediate; we thus get the characteristic arrangement of the pore-pairs in arcs of three. In Astropyga, only the alternate primary elements are like each other in form, one series being broadest at the inner end, and those alternating with them broadest at the middle; the secondary elements accompanying the latter occupy the same position they do in Echinothrix, while those which accompany the plates with a wide inner end lie close to that end; the pore-pairs of the primary elements are here median in position, while the pore-pairs of the secondary elements alternate, two pairs being inner, then two outer, then two inner, etc. The characteristic arcs of three are thus maintained. In Micropyga the elements are arranged essentially as in Echinothrix, but the pore-pairs of the primaries alternate in position, as well as those of the secondaries (as in Astropyga); thus, if the pore-pair of a given primary element lies at the outer end of the plate, the pore-pairs of the secondary elements of the same plate occupy a median position, while in the adjoining plates the pore-pairs of the primary elements will be median in position and those of the secondary elements take an outside position; we thus get the double column of pore-pairs characteristic of Micropyga. In most of the Echinothuridæ the condition is essentially as in Echinothrix, but the secondary plate elements remain so small and are so generally pushed out of position, the appearance of an ambulacrum is quite different from that of any Diadematid; the abactinal arrangement of the pore-pairs is commonly as in Echinothrix. In Sperosoma, the secondary plate elements become so large actinally, they separate the inner half of the primary element from the outer, and there thus appear to be *four* columns of plates in each half-ambulacrum. Mortensen says, in his diagnosis of Sperosoma, "The secondary ambulacral plates on the actinal side of the same size as the primary ones." We do not find this to be the case in the type-species, *Grimaldii*, nor in any other of the species we have examined; it seems to us that the halves of the primary element are, with rare exceptions, noticeably larger than the secondary elements.

The difference between the Echinothuridæ and Diadematidæ in the imbrication of the coronal plates is one of degree and not of kind, and the same is true of the presence of membranous interspaces between the plates. The difference between the test of an Echinothrix or Centrostephanus and that of an Astropyga or Micropyga is fully as great in these particulars as that between Astropyga and such Echinothurids as *Araeosoma Owstoni* or *A. thetidis*. In fact the resemblances between the two families in the general character of the test are far more weighty than are the differences. The crenulation of the primary tubercles is generally marked in the Diadematidæ, but it is quite wanting in Micropyga and Lissodiadema, in which genera the tubercles are like those of the Echinothurids.

The abactinal system of the Echinothurids represents merely an extreme condition of the Diadematid form. There is really no difference of importance between the arrangement of the plates in some species of Aræosoma and that which we find in Astropyga and Chætodiadema. When the abactinal system of Leptodiadema is compared with that of some species of Echinosoma the differences are most striking, but when we examine other genera we can trace every step of the transition from one into the other.

As regards the actinostome, it must be admitted that the fully plated buccal membrane of the Echinothurids is quite unlike anything to be found in the Diadematidæ. As Döderlein has well pointed out, we may regard the plating as a character developed in the Echinothuridæ independently, an interesting parallelism with what is found in the Cidaridæ and some Palæozoic Echini, or we may look on it as a heritage, from some ancestral form, which the Diadematidæ have lost. The actinostomal plates of the Diadematidæ, aside from the customary buccal ten, are usually numerous and often abundant. And it is interesting, if not important, to note that in nearly all Diadematids these plates are confined to, or at least are much more abundant in, the ambulacra, and sometimes form a double column in each ambulacrum. In Astropyga it is these ambulacral plates which carry the pedicellariæ, and in young specimens what appear to be rudimentary tube-feet are sometimes present; we have never found any visible perforation of the plates, however. We incline to the view, nevertheless, that the condition of the actinostome in the Diadematids indicates the gradual loss of ambulacral plates similar to those of the Echinothurids.

The teeth, jaws, and perignathic girdle in the two families are so similar, we have not found any important constant difference. The jaws are decidedly more inclined in the Echinothurids than in Diadema, but Astropyga and Micropyga are intermediate in this respect. The lantern of Astropyga is surprisingly like that of *Asthenosoma Ijimai.* There is great individual diversity in both families in the amount of calcification in the perignathic girdle. In some specimens the auricles are very moderate and the apophyses almost wanting, while in others the auricles are enormous and the apophyses stout.

In the internal anatomy the two families are much alike, except that the Echinothuridæ have well-developed Stewart's organs and longitudinal body-wall muscles, both of which are rudimentary or wanting in the Diadematidæ. The Stewart's organs are undoubtedly a heritage, and their form would seem to indicate that they now have little functional importance. The body-wall muscles have doubtless been developed in connection with the increasing mobility of the test. The gills of the two families and the sphæridia show the greatest similarity.

The spines are fundamentally alike in their structure, commonly hollow, though not infrequently more or less solid, at least near tip. They are much longer in many Diadematidæ than in the Echinothuridæ, but Astropyga and Micropyga are more like the latter family. The presence of poison-tipped spines is a character found in both families, but hoofs and skin-bags seem to belong to the Echinothuridæ exclusively. It should be noted, however, that Döderlein has figured spines in Dermatodiadema, which are so formed as to almost warrant their being called "hoofed," and somewhat similar spines occur in Micropyga. Some of the spines of Echinothrix, moreover, might almost be called "sheathed." Such special modifications of the spines cannot be regarded as of great weight in estimating relationships.

The similarities between the two families in their pedicellariæ have been referred to above; they have also been discussed quite fully by Döderlein. The fundamental resemblance of the spicules in the tube-feet is noteworthy, though they are much more fully developed in most Echinothuridæ than in the Diadematids. In color and size the similarity between the two families is more noticeable than the difference. The banding of the primaries, so marked in young Diademas, is noticeable in some Asthenosomas. The Diadematidæ and the shallow-water Echinothurids are tropical and particularly East Indian forms. The deep-water Echinothurids have spread both north and south of the tropics.

In view of all these facts, we find ourselves driven to the opinion that the relationship between the Echinothuridæ and Diadematidæ is very close. We cannot believe that the many points of resemblance are either coincidences or examples of parallelism. On the other hand, it seems clear that many of the differences, such as those in the abactinal system and test, are due to the increased size of the Echinothurids accompanied by decrease in calcification. The relationship between Astropyga and Micropyga on the one hand and Aræosoma on the other is very close; were it not for the difference in the actinostome they would certainly be regarded as belonging in a single family. The recognition of a separate suborder (Streptosomata) for the Echinothuridæ, based on the flexibility of the test, seems to us quite unnecessary. The test of several Echinothurids is little or no more flexible than that of Astropyga and Micropyga, and it is certainly an exaggeration of the differences between these genera and the Echinothuridæ to place them in different suborders. The Aspidodiadematidæ, Diadematidæ, and Echinothuridæ form a natural group with some interesting primitive characters, and if suborders of the Diadematoida are to be recognized they should certainly form one together.

The Genera and Species of Echinothuridæ.

The Echinothuridæ are a fairly homogeneous and well-defined group, the limits of which are so clear that there has never been any question raised as to whether a given recent species were an Echinothurid or not. For many years, only two genera (Phormosoma, Asthenosoma) were recognized, but in 1897 Kœhler described a new form (Sperosoma), the actinal ambulacra of which are quite unique. In 1903 Mortensen split the family into ten genera, and suggested the possibility of two more; while he gave attention to the structure of the test, his classification was based chiefly on the characters furnished by the spines and pedicellariæ, especial emphasis being placed on the latter. Three of his genera (Calveria, Hapalosoma, Tromikosoma) are based almost exclusively on the pedicellariæ, and he has suggested in later writings that they might not be maintained, a suggestion in which we fully concur. Mortensen says "it is the spines, the pedicellariae, the tube-feet, and the spicules which bear the principal part in the new classification of the Echinothurids." "Of course also the structure of the test is always of importance, but the all predominant importance that has hitherto been attached to the form and mutual relation of the plates will have to be very much reduced." — "The arrangement of the plates is generally only to be seen in dried specimens. But the Echinothurids are only very little adapted for preservation in dried state, and if the material in hand be slight, one does not like to destroy it for the sake of determination." — "The sphæridiæ . . . show no differences so great that they can be of any systematic importance. The pedicellariæ, on the other hand, are of the greatest importance with regard to the classification." It is because we do not think that the "spines, the pedicellariæ, the tube-feet, and the spicules" should "bear the principal part" in a satisfactory classification of the Echinothurids, and because we consider "the structure of the test," using that phrase in the widest sense, to be of "all predominant importance" that we are obliged to dissent from Mortensen's classification. Moreover, we find the Echinothurids admirably adapted "for preservation in dried state"; all of the photographic plates given herewith and those in the report on the Panamic deep-sea Echini (Mem. M. C. Z., XXXI) are from dried specimens; so far from drying, destroying the specimens, it prepares them very satisfactorily for systematic study. As will be noted in our discussion of the genus Phormosoma, we find the sphæridia afford an interesting character of real "systematic importance."

Our studies of the Echinothuridæ have led us to the conclusion that there are six natural genera in the family. We believe Mortensen is right in limiting Phormosoma to the group of species allied to *placenta*, but we fail to find any character of importance by which his genera Hygrosoma and Tromikosoma are to be distinguished from Echinosoma Pomel. Of course, if one considers the possession of certain peculiar pedicellariæ, in small numbers, by some individuals, as a valid generic character, then one must accept Mortensen's groups, but, as we have often stated, we cannot believe such a criterion is right. The peculiar ambulacra of Kamptosoma and Sperosoma warrant the recognition of those genera, while the numerous, small, uniform primary tubercles, bearing sheathed spines, which cover the abactinal surface of Asthenosoma, make that genus, as limited by Mortensen, an easily recognized group. We have not been able to find any satisfactory characters by which Mortensen's genera Hapalosoma and "Calveria" are to be distinguished from Aræosoma, and we have therefore united the three groups under the last name.

The six genera which are thus accepted by us may be distinguished from each other as follows:

Actinal tube-feet in a single (or rarely two) more or less irregular series.
  Primary ambulacral plates throughout most of ambulacra accompanied, each by two secondary poriferous elements.
    Many actinal primary spines enclosed in skin-bags, none with hoofs; abactinal and actinal surfaces strikingly and abruptly unlike . . . . *Phormosoma.*
    Actinal primary spines not enclosed in skin-bags, some at least ending in hoofs; abactinal and actinal surfaces not strikingly and abruptly unlike . . . . *Echinosoma.*
  Primary ambulacral plates, each accompanied by a single secondary element or none . . . . *Kamptosoma.*
Actinal tube-feet in three more or less distinct series.
  Each half of an ambulacrum, actinally, consists of a column of wide low primary plates, each accompanied by two small secondaries.
    Abactinal surface covered by numerous small primary tubercles none of which are conspicuously larger than the others; abactinal primary spines encased in loose skin-sheaths . . . . . . *Asthenosoma.*
    Abactinal surface with at least 30 conspicuous primary tubercles; abactinal primary spines not encased in loose skin-sheaths . . . *Aræosoma.*
  Each half of an ambulacrum, actinally, consists of four columns of plates, the two median columns made up of the secondary plate-elements, the inner column made up of the inner halves of the primary plates, the outer column, of the outer halves . . . . *Sperosoma.*

PHORMOSOMA.

Wyville Thomson, 1872. Proc. Roy. Soc. Edinburgh, VII, 84, p. 617.
Type-species, *Phormosoma placenta* Wyville Thomson, l. c.

It seems to us desirable to accept Mortensen's limitation of this genus, as the group is well defined and easily recognized. The test is rather rigid, with actinal side markedly different from abactinal. The actinal primary tubercles and areolæ are large, while the loose skin-sheaths of the spines are very characteristic. We beg to call attention to the arrangement of the nearly spherical sphæridia, an interesting generic character overlooked by Mortensen but which seems to be very constant. They are present actinally on both secondary elements of each primary plate. Of course one occasionally finds a secondary plate-element actinally which has no sphæridium, but it is usually clear that the absence is accidental. In all other Echinothurids, only the inner (lower) secondary element carries a sphæridium. This genus, as now limited, contains eight recognizable species, but they are closely related to each other and the lines of separation are not distinct. Both Mortensen (1903) and Döderlein (1906) are inclined to regard *rigidum* A. Ag. as a synonym of *placenta*, in spite of its great geographical separation from that species. The size and arrangement of the abactinal pores are so different from what is found in specimens of *placenta* of the same size as the type of *rigidum*, that we think it better to keep the latter separate, at least until more material is available. Döderlein considers a form of *placenta* which he calls *Sigsbei* recognizably distinct from *placenta* proper, because of fewer and higher abactinal coronal plates. Mortensen (1907) finds that this difference is not constant, but believing the tridentate pedicellariæ of true *placenta* to differ from those of "*Sigsbei*," he thinks the latter may be a recognizable variety. Examination of a considerable series of specimens of both *P. placenta* and *P. bursarium* has satisfied us that in those two species, the height, and consequently the number, of coronal plates is subject to considerable individual diversity not associated with definite localities, and that the tridentate pedicellariæ are also very variable. Specimens from the same or adjoining stations have very different pedicellariæ; the best illustration of this is found in two specimens of *bursarium* from Stations 5082 and 5084; the specimen from 5082 has only short and thick tridentate pedicellariæ, while in the one from 5084 these pedicellariæ are longer and more slender than in any Phormosoma we have seen. It may be well to add that other specimens are intermediate between these two extremes. In view of these facts, we do not think that the form to which Döderlein and Mortensen refer can well be distinguished, but we are now satisfied that *P. Sigsbei* is really as valid a species as most of those in the genus, if we recognize others than *placenta*. The name was originally applied to the Phormosoma collected by the "Blake" west of the Lesser Antilles. Subsequently this form was considered identical with the Phormosoma collected off the eastern coast of the United States, and all were determined as *P. placenta*. Recent examination of the Caribbean specimens, and comparison with large numbers of Phormosoma from both the Atlantic and Pacific Oceans, have led us to believe that they are distinct from *placenta* and somewhat nearer *bursarium*. We have decided therefore to revive the name *Sigsbei* for them; if the American form of *placenta*, usually having short, thick pedicellariæ and relatively few coronal plates is to be distinguished from the European form, a new name must be given to it. In this connection it may be well to state that a renewed examination of the specimens of young Phormosomas, the figures of which ("Blake" Echini, Pl. XV) are criticised by Mortensen ("Ingolf" Ech., Pt. I, p. 69), has satisfied us that those figures are essentially correct.

Mortensen dismisses the possibility of the differences between his specimens and these figures being specific, by saying he has had specimens from the Gulf of Mexico which are exactly like those from Davis Strait, where his young specimens were taken. This is interesting as confirming our opinion that the Lesser Antillean species is distinct, and also as showing that *placenta* extends its range as far southwestward as the Gulf of Mexico.

The eight species of Phormosoma which we here recognize may be distinguished from each other as follows:

Primary tubercles of ambulacra, abactinally, very much smaller than those of interambulacra and arranged in four vertical series . . . . *alternans.*
Primary tubercles of ambulacra, abactinally, not conspicuously smaller than those of interambulacra.
  Abactinal primary spines rough with minute teeth which are in whorls on distal part of spine . . . . *verticillatum.*
  Abactinal primary spines smooth, or at least never verticillate.
    Abactinal primary tubercles small and rather numerous (300–500), occurring on all or nearly all the coronal plates.
      Ambulacral pores large, in a nearly vertical series at extreme outer end of ambulacral plates, abactinally . . *rigidum.*
      Ambulacral pores smaller, in more oblique arcs of three abactinally, and not at extreme outer end of plates.
        Actinostome small (less than .30 h. d.), little larger than abactinal system . . . . *adenicum.*
        Actinostome more than .30 h. d., distinctly larger than abactinal system . . . . *placenta.*
    Abactinal primary tubercles larger and less numerous (70–300), wanting on many of the upper coronal plates.
      Abactinal arcs of pores few and nearly vertical, rarely exceeding ten even when there are nine interambulacral plates . . . . *Sigsbei.*
      Abactinal arcs of pores 12–25, quite oblique.
        Abactinal primary tubercles few (70–150), large, confined to peripheral half of test . . . . *indicum.*
        Abactinal primary tubercles more numerous (150–300), smaller, not confined to peripheral half of test . . . . *bursarium.*

Phormosoma alternans de Meij.

Phormosoma alternans de Meijere, 1903. Tijdschr. Ned. Dierk. Ver., (2) VIII, p. 2. 1904. Ech. "Siboga" Exp., Pls. III, figs. *21, 22;* XII, figs. *143–148.*

Dutch East Indies; 386 fathoms.

Although this species is known from only a single specimen (very dark brown, 52 mm. in diameter), it seems to be better characterized than any of the other species recognized as distinct from *placenta.* Its general facies, both with and without the spines, would seem to be quite different from that of any other species, but further material is necessary to determine how constant these characters are and what are the limits of their variation.

Phormosoma verticillatum Mortens.

Phormosoma verticillatum Mortensen, 1904. Ann. Mag. Nat. Hist. (7) XIV, p. 90; Pls. IV, figs. *1, 2;* V, figs. *15–17.*

Bay of Bengal; 678 fathoms.

In addition to the characteristic verticillated abactinal spines, Mortensen points out the small actinal and abactinal systems as features in which this species differs from *placenta;* thus the abactinal system of a *placenta,* 66 mm. h. d., is about 30 % h. d., while in *verticillatum,* 63 mm. h. d., it is only about 20. The color of *verticillatum* may prove to be a good character, for although the specimens are bleached, there is some indication of violet actinally, not a common color in the genus.

Phormosoma rigidum A. Ag.

Phormosoma rigidum A. Agassiz, 1881. "Challenger" Ech., p. 104; Pl. XIIa, figs. *1–4.*

Off New Zealand; 700 fathoms.

Although the specimens on which this species is based are small, the largest only 40 mm. h. d., the abactinal ambulacral pores are quite characteristic, and we do not think they can wisely be referred to either *placenta* or *bursarium*

Phormosoma adenicum Död.

Phormosoma adenicum Döderlein, 1905. Zool. Anz. XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XV, figs. *3, 3a;* XXXVIII, figs. *4a–h.*

Gulf of Aden; 816 fathoms.

In addition to the characters given above, this species has an unusual number of abactinal ambulacral plates, in comparison with the number of abactinal interambulacral plates. Thus, in Döderlein's larger specimen (55 mm. h. d.) there are 17 ambulacral and 10 interambulacral plates abactinally, while in *placenta* of the same size there are 10–15 and 7–11 respectively; in *adenicum,* the abactinal interambulacral plates are less than .60 of the ambulacral, while in *placenta* they are .70–.75. Possibly the color may be a good specific character, for Döderlein says his specimens appear to have been dark red.

Phormosoma placenta Wyv. Thom.

Phormosoma placenta Wyville Thomson, 1872. Proc. Roy. Soc. Edinburgh, VII, 84, p. 617. 1874. "Porcupine" Ech., Trans. Roy. Soc. London, 168, pt. 2, Pls. LXII and LXIII, figs. *1–8*.

North Atlantic, from Davis Strait to Gulf of Mexico on the west and from Iceland to 3° N. on the east; 235–1389 fathoms.

This species is so well known, we need add nothing here to the descriptions and figures which have already been published.

Phormosoma Sigsbei A. Ag.

Phormosoma Sigsbei A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 75. 1883. "Blake" Ech., Mem. M. C. Z., X, Pls. XII; XV, figs. *3–19*.

Eastern Caribbean Sea; 120–573 fathoms.

This species is in life reddish-orange, pinkish abactinally; preserved specimens are decidedly pinkish-purple when not bleached. Wyville Thomson says *placenta* is gray flecked with purple; preserved specimens are yellowish-brown, sometimes very dark, often more or less bleached. There is no doubt that this species lives in shallower water, ordinarily, than does *placenta;* the latter is most common at depths ranging from 400 to 1000 fathoms, while *Sigsbei* is found chiefly between 150 and 400 fathoms. The difference in temperature range is even more noticeable, for, while *placenta* is found only in cold water, 37°–41°, *Sigsbei* occurs in water ranging from 40° to 63°, but averaging about 50°.

Phormosoma indicum Död.

Phormosoma indicum Döderlein, 1905. Zool. Anz., XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XV, figs. *1, 2;* XXXVIII, figs. *2–2c, 3–3c*.

Indian Ocean, coasts of Africa and Sumatra; 257–543 fathoms.

The large size of the abactinal primary tubercles and areolæ is very notable, as they are nearly or quite twice the diameter of those in *placenta* and *bursarium*. The color of this species is rather variable, ranging from yellow to dark brown, commonly lighter above than below, and often with a reddish tinge.

Phormosoma bursarium A. Ag.

Phormosoma bursarium A. Agassiz, 1881. "Challenger" Ech., p. 99; Pl. Xb.
East Indies; off Japan; Hawaiian Islands; 165–1050 fathoms.

Plates 62, fig. *2;* 63, fig. *3.*

This is the Pacific representative of *placenta*, and very near it in all essential characters. The difference in tuberculation of the test abactinally seems to be fairly constant, but certain specimens of the two forms approach each other very nearly. The color of *bursarium* appears to be quite uniformly yellow-brown, though the shade varies a great deal; some specimens are very dark, while others are bleached almost white; one of the latter is very decidedly pink on the actinal surface. This species was taken by the "Albatross" at the following stations, the specimens ranging from 20 to 110 mm. in diameter:

Station 3884. Between Maui and Molokai, Hawaiian Islands. Bott. temp. 44°. 284–290 fathoms. Glob. m.

Station 3892. Off north coast of Molokai, H. I. Bott. temp. 42.5°. 328–414 fathoms. Fne. gy. s.

Station 3904. Off north coast of Molokai, H. I. Bott. temp. 43.9°. 295 fathoms. Br. m., s., r.

Station 3957. Vicinity of Laysan Island, H. I. Bott. temp. 53.5°. 173–220 fathoms. Fne. wh. s.

Station 3988. Off Hanamaulu, Kauai, H. I. Bott. temp. 40°. 165–469 fathoms. Gy. for. s., p.

Station 3994. Off Mokuaeae Islet, Kauai, H. I. Bott. temp. 42.9°. 330–382 fathoms. Fne. gy. s., for.

Station 3997. Off Ukula Point, Kauai, H. I. Bott. temp. 41°. 418–429 fathoms. Fne. gy. s., br. m.

Station 4019. Off Hanamaulu, Kauai, H. I. Bott. temp. 37.8°. 409–550 fathoms. Gy. s., for., r.

Station 4022. Off Hanamaulu, Kauai, H. I. Bott. temp. 41.° 374–399 fathoms. Co., s., for., r.

Station 4025. Off Mokuaeae Point, Kauai, H. I. Bott. temp. 44.9°. 275–368 fathoms. Fne. gy. s., brk. sh., for.

Station 4087. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.6°. 306–308 fathoms. Fne. gy. s.

Station 4089. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 297–304 fathoms. Fne. gy. s.

Station 4091. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 306–308 fathoms. Fne. gy. s.

Station 4110. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.3°. 449–460 fathoms. Gy. s.

Station 4111. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40°. 460–470 fathoms. Fne. s., r.

Station 4112. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.5°. 433–447 fathoms. Fne. s.

Station 4113. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.6°. 395–433 fathoms. Co., for., s.

Station 4141. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 437–632 fathoms. Vol. s., for.

Station 4906. Southwest of Koshika Islands, Japan; 31° 39′ N., 129° 20′ 30″ E. Bott. temp. — 369–406 fathoms.

Station 4907. Southwest of Koshika Island; 31° 39′ 30″ N., 129° 24′ E. Bott. temp. 42.6°. 406 fathoms. Gy. glob. oz.

Station 4911. Southwest of Koshika Islands; 31° 38′ 30″ N., 129°. 19′ E. Bott. temp. 41.9°. 391 fathoms. Gy. glob. oz.

Station 4912. Southwest of Koshika Islands; 31° 39′ 40″ N., 129° 20′ E. Bott. temp. 41.9°. 391 fathoms. Gy. glob. oz.

Station 4913. Southwest of Koshika Islands; 31° 39′ 10″ N., 129° 22′ 30″ E. Bott. temp. 41.9°. 391 fathoms. Gy. glob. oz.

Station 4914. Southwest of Koshika Islands; 31° 33′ N., 129° 26′ 30″ E. Bott. temp. 41.9°. 427 fathoms. Gy. glob. oz., brk. sh.

Station 4915. Southwest of Koshika Islands; 31° 31′ N., 129° 25′ 30″ E. Bott. temp. 41.9°. 427 fathoms. Gy. glob. oz., brk. sh.

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 25′E. Bott. temp. 39.8°. 437 fathoms. Gn-br. m., fne. gy. s., for.

Station 4968. Between Kobe and Yokohama; 33° 24′ 50″ N., 135° 38′ 40″ E. Bott. temp. 45.7°. 253 fathoms. Dk. gy. s., br. m., brk. sh.

Station 4969. Between Kobe and Yokohama; 33° 23′ 40″ N., 135° 33′ E. Bott. temp. 38.9° 587 fathoms. Br. m., s., st.

Station 5078. Off Omai Saki Light, Japan; 34° 12′ 20″ N., 138° 2′ 30″ E. Bott. temp. 38.9°. 475–514 fathoms. Fne. gy. s., glob.

Station 5082. Off Omai Saki Light; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Station 5084. Off Omai Saki Light; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8°. 918 fathoms. Gn. m., fne. s., glob.

Station 5086. Sagami Bay, Hondo Island, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7. 292 fathoms. Gn. m., crs. bk. s.

Station 5088. Sagami Bay; 35° 11′ 25″ N., 139° 28′ 20″ E. Bott. temp. 41.8°. 369–405 fathoms. Gn. m.

Bathymetrical range, 165–918 fathoms. Extremes of temperature, 53.5°–36.8°.

One hundred and eighty-four specimens.

Echinosoma.

Pomel, 1883. Class. Méth. Ech., p. 108.

Type-species, *Phormosoma tenue* A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 202.
(Including Hygrosoma and Tromikosoma Mortensen.)

In this genus, the thin and flexible test has the larger spines and areolæ on the actinal side, but the contrast with the abactinal is not marked. The hoofs of the actinal primaries are usually large and shining white. The sphæridia are more or less elongated and are present only on the inner (lower) secondary plate-element. Although it is not difficult to distinguish the genus from the preceding, the species of which it is composed are exceedingly hard to diagnose in such a way as to make them generally recognizable. No less than 11 different forms have been described and named which certainly belong in Echinosoma, but some of these are of doubtful standing. We are unable to distinguish *mordens* de Meij. from *tenue* A. Ag., or *æthiopicum* Död. from *luculentum* A. Ag. Döderlein himself says that the latter is "sehr nahe" *æthiopicum*, but he distinguishes them by means of the stout, broad-valved, tridentate pedicellariæ which are present in *luculentum* and wanting in *æthiopicum*. In view of the fact that the presence or absence of a given form of pedicellariæ has been shown, in numerous cases, to be a matter of individual diversity only, we cannot consider *æthiopicum* a valid species. Moreover, *hispidum* and *zealandiæ* are very near *tenue*, and *panamense* and *Petersii* are very near *uranus*. Finally, the line between *hoplacantha* and *luculentum* is not as sharp as could be wished. There seems little reason to doubt that *hoplacantha*, *tenue*, and *uranus* are good species, but the others herein recognized are of less certain validity. The nine accepted species are to be distinguished from each other as follows:

Tube-feet abactinally in three series; valves of large tridentate pedicellariæ strongly involute at middle.
  Abactinal ambulacral plates only two or three times as numerous as actinal; abactinal spines small and numerous . . . . . . *hoplacantha.*
  Abactinal ambulacral plates four-seven times as numerous as actinal; abactinal primaries long and conspicuous, secondaries and miliaries few . . . . *luculentum.*
Tube-feet abactinally in one or two series.
  Abactinal surface sparsely covered with spines, rarely more than two primary or large secondary tubercles on a plate; secondaries and miliaries not abundant.
    Abactinal coronal plates rather high, 11–14 in a specimen 125 mm. h. d.; tridentate pedicellariæ with slightly involuted valves *hispidum.*
    Abactinal coronal plates lower and more curved, 14–16 in specimens 100–125 mm. h. d.; valves of tridentate pedicellariæ not involute at all . . . . *tenue.*
  Abactinal surface more or less thickly covered with spines, often three or more large tubercles on a plate; secondaries and miliaries often abundant.
    Ambulacra distinctly broader than interambulacra. . . . *Kœhleri.*
    Ambulacra not broader than interambulacra.
      Actinostome very large, exceeding .35 h. d., with deep buccal slits . . . . *zealandiæ.*
      Actinostome not so large, buccal slits slight.
        Whole test thickly tuberculated; actinal primary tubercles rather small, in vertical series of 6–8 extending nearly to actinostome . . . . *panamense.*
        Test not so thickly tuberculated; actinal primary tubercles in vertical series of 3–6, confined to peripheral half of actinal surface.
          Valves of tridentate pedicellariæ rather flat, not involute near middle . . . . *uranus.*
          Valves of tridentate pedicellariæ strongly involute at middle, and more or less curved . . . . . *Petersii.*

Echinosoma hoplacantha A. Ag. and Cl.

Phormosoma hoplacantha Wyville Thomson, 1877. Voy. "Challenger," Atlantic, I, p. 148.

Phormosoma hoplacantha A. Agassiz, 1881. "Challenger" Ech., Pls. XI; XII; XIIa, figs. *10–13.*

Hygrosoma hoplacantha Mortensen, 1903. "Ingolf" Ech., I, p. 59.

Pacific and Indian Oceans; 402–1375 fathoms.

This is not only one of the largest (312 mm. h. d.) of the Echinothuridæ, but it is one of the most easily recognized for the numerous, slender spines of the abactinal surface, with primary spines in the ambulacra nearly or quite to the ocular plates, combined with the three distinct rows of abactinal tube-feet, give it a characteristic appearance. The color of the test is dark violet, sometimes with a reddish cast, the spines are dark, often almost black, but the hoofs are pure white. The specimen collected by the "Valdivia" and described by Döderlein differs so much in color from the usual condition that one cannot avoid the suspicion that it may not be this species, and a careful comparison of the photographs given with Japanese specimens of *hoplacantha* strengthens this feeling. Döderlein is doubtful whether de Meijere's *hoplacantha* is not rather *œthiopicum,* as he thinks the pedicellariæ figured are nearer the latter species. After examination of Döderlein's photographs, de Meijere's drawings, and numerous pedicellariæ, we find ourselves driven to this conclusion, — many specimens have some very large pedicellariæ (A. Agassiz, 1881, "Challenger" Ech., Pl. XLIII, fig. *1;* Döderlein, 1906, "Valdivia" Ech., Pl. XXXIX, fig. *3d*), and these specimens all writers call *hoplacantha;* other specimens, equally well preserved, do not have such large pedicellariæ, but do have very short, stout ones, with widely expanded valves (A. Agassiz, l. c., Pl. XLIV, figs. *25, 26;* Döderlein, l. c., Pl. XXXIX, fig. *1a*), and these specimens are called *luculentum.* Other equally good specimens have neither of these characteristic forms, and these specimens de Meijere calls *hoplacantha,* and Döderlein, *œthiopicum.* For our part, we consider the absence of either of these characteristic pedicellariæ as a matter of individual diversity and not a specific character, and we therefore believe de Meijere's identification is correct. Döderlein considers de Meijere's figure *159* ("Siboga" Ech., Pl. XIII) more like the valve of a large tridentate pedicellaria of *œthiopicum,* than it is like one of *hoplacantha,* but it seems to us that de Meijere's outline sketch is quite as near Döderlein's figure *3a* (l. c., Pl. XXXIX) as it is to his figure *2c.*

This species was taken by the "Albatross" at the following stations, the specimens ranging from 20 to 170 mm. in diameter:

Station 4928. In Colnett Strait, Japan; 29° 51′ N., 131° 2′ 30″ E. Bott. temp. 36.8°. 1008 fathoms. Gy. s. glob.

Station 4956. Between Kagoshima and Kobe, Japan; 32° 32′ N., 132° 25′ E. Bott. temp. 37.5°. 720 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 23′ E. Bott. temp. 39.8°. 437 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 4958. Between Kagoshima and Kobe, Japan; 32° 26′ 20″ N., 132° 24′ 30″ E. Bott. temp. 40.1°. 405 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 4973. Between Kobe and Yokohama, Japan; 33° 24′ 15″ N., 135° 30′ 30″ E. Bott. temp. 38.2°. 600 fathoms. Bn. m., st.

Station 4980. Between Kobe and Yokohama, Japan; 34° 9′ N., 137° 55′ E. Bott. temp. 39°. 507 fathoms. Bn. m., fne. s., for.

Station 5078. Off Omai Saki Light, Japan; 34° 12′ 20″ N., 138° 2′ 30″ E. Bott. temp. 38.9°. 475–514 fathoms. Fne. gy. s., glob.

Station 5080. Off Omai Saki Light, Japan; 34° 10′ 30″ N., 138° 40′ E. Bott. temp. 38.7°. 505 fathoms. Fne. gy. s., glob.

Station 5082. Off Omai Saki Light, Japan; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Station 5084. Off Omai Saki Light, Japan; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8°. 918 fathoms. Gn. m., fne. s., glob.

Station 5086. Sagami Bay, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7°. 292 fathoms. Gn. m., crs. bk. s.

Bathymetrical range, 292–1008 fathoms. Extremes of temperature, 43.7°–36.8°.

Thirteen specimens.

Echinosoma luculentum A. Ag. and Cl.

Phormosoma luculenta A. Agassiz, 1879. Proc. Am. Acad., XIV., p. 201.

Phormosoma luculentum A. Agassiz, 1881. "Challenger" Ech., p. 97; Pls. IX; X; Xa, figs. *3–7*.

Hygrosoma luculentum Mortensen, 1903. "Ingolf" Ech., I, p. 59.

Hygrosoma æthiopicum Döderlein, 1905. Zool. Anz. XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp. Pls. XVI; XVII, fig. *2*; XXXIX, figs. *1–2f*.

We are so fortunate as to have before us a small specimen of *æthiopicum* from "Valdivia" Station 246. A careful examination of this specimen, in connection with Döderlein's description and figures, leads us to believe that the form cannot properly be distinguished from *luculentum*, for as already stated we do not consider the absence of the short, thick pedicellariæ a valid specific character. We are even suspicious of the validity of *luculentum* itself, for we shall not be surprised if this species proves to be simply a form of *hoplacantha*. The differences that have been pointed out in either the test or the pedicellariæ do not seem to us very weighty, and their constancy has yet to be proven.

Echinosoma hispidum Mortens.

Phormosoma hispidum A. Agassiz, 1898. Bull. M. C. Z. XXXII, p. 77. 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, Pls. XXX–XLIX.

Echinosoma hispidum Mortensen, 1907. "Ingolf" Ech., Pt. II, p. 24.

Gulf of Panama, west to the Galapagos Islands and north to the Gulf of California; 995–1421 fathoms.

Plates 62, fig. *3*; 63, fig. *4*; 67, figs. *4–11*.

The pedicellariæ of this species are numerous and variable, but we have found only tridentate and triphyllous ones, no ophicephalous. Mortensen ("Ingolf" Ech., II, p. 25) says he has found "a kind of ophicephalous pedicellariæ." Examination of several good specimens, with hundreds of pedicellariæ, has not enabled us to find this form, so we conclude it must be quite exceptional. The triphyllous pedicellariæ are abundant and not peculiar, though the neck may be twice or three times as long as the head (Pl. 67, fig. *10*), and the stalk three or four times as long as the neck; the valves are .40–.50 mm. long and the width at the tip is rather more than half the length.

The *tridentate* pedicellariæ appear in at least four different forms, but they integrade with each other to such an extent it is not easy to draw lines between them. The largest ones (Pl. 67, fig. *4*) are tolerably common; the valves (fig. *5*) are 3–4.75 mm. long, slightly curved, widened at tip, and meet only for the terminal quarter; the edges of the blade are slightly involute, while the centre is occupied by more or less of a calcareous mesh-work. The stalk of these pedicellariæ is scarcely as long as the head, and there is almost no neck. A more abundant form of tridentate pedicellaria is decidedly smaller (Pl. 67, fig. *6*), has the stalk two or three times as long as the head and there is a short neck; the valves (fig. *7*) are straight, 1–1.75 mm. long, not widened at tip or involute at sides, and meet for their whole length. In another form (Pl. 67, fig. *8*), which seems to be very rare, the valves are narrow, nearly straight, a trifle widened at tip, and meet for about three-fourths of their length. They are 1–1.25 mm. long. A fourth form (Pl. 67, fig. *9*), which is also rare, is the smallest of all, but has a long, thick neck and a stalk three to five times as long as the head; the valves are only .35–.75 mm. long, straight, somewhat expanded at tip, and meet for nearly their entire length.

The *sphæridia* (Pl. 67, fig. *11*) are slightly elongated and seem to be most abundant near the ambitus, though they may occur far up on the abactinal surface. The *calcareous particles* in the tube-feet are small and not very abundant, irregular, perforated plates.

Echinosoma tenue Pomel.

Phormosoma tenuis A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 202.
Phormosoma tenue A. Agassiz, 1881. "Challenger" Ech., p. 91; Pls. XIII, XIV, et al.
Echinosoma tenue Pomel, 1883. Class. Méth. Ech., p. 108.

Pacific Ocean; 1875–2750 fathoms.

Plate 67, figs. *12–21.*

The specimens before us, collected by the "Albatross," show that unless there is some mistake in the labels, this species has an astonishing bathymetrical range. We have compared most carefully the specimens from Stations 3784, 4928 and 5084 with one of the co-types of *tenue* from "Challenger" Station 237, and we find they agree so perfectly in all details that it is impossible to doubt their identity. The specimen from 3707, on the other hand, is small (about 30 mm. h. d.) and more or less damaged, and the original label has the station number so faint that it has been repeated in lead pencil, and in this repetition there is chance for error; Stations 3710, 3711, 3712, and 3736 were the only Japanese stations occupied by the "Albatross" in 1900 where this species would be expected to occur. This small specimen has the tube-feet arranged as in *tenue,* so far as they can be made out, and the pedicellariæ, so far as may be judged from a very few examples, are like those of *tenue.* We therefore believe that the identification of the specimen is correct, but we do not believe it was taken at Station 3707. The color of the specimens before us is varied; the "Challenger" specimen is yellowish, with strong indications of violet actinally, and has light-colored tube-feet; one of the specimens from 3784 is also somewhat yellowish, especially abactinally, but the tube-feet are dark violet in striking contrast; the other specimens range from light to dark violet without a trace of yellow on the test, but in some cases the tube-feet are brownish-yellow. The color of both test and feet seems to depend on the extent to which the bright violet pigment is developed.

The arrangement of the tube-feet, abactinally, in *tenue,* is characteristic when well marked, but there is some individual diversity. In the "Challenger" specimen there are two series closely approximated to each other, on each side of the ambulacrum; in the outer series there are practically twice as many feet as in the inner, each foot in the latter series being opposite alternate feet in the former; in the inner series, small primary or large secondary tubercles alternate with the feet, so that, while the outer series consists of feet only, the inner consists of alternating tubercles (spines) and feet. In the specimens from 3784 this arrangement is very evident, but it is not quite so clear as in the "Challenger" specimen, because the feet are larger and nearer together vertically. In the specimens from 4928 and 5084, it is not at all noticeable, because the tube-feet are small, light colored, and rather far apart vertically.

The pedicellariæ of *tenue* are not very characteristic, for while they show no little diversity, no one form is really distinctive. Ophicephalous pedicellariæ are numerous on the abactinal surface just above the ambitus in one of the specimens from 4928 and in one of those from 5084; a few were also found in the second specimen from 4928 and one in the second (smaller) specimen from 5084; in the "Challenger" specimen and in the two fine individuals from 3784 there are none. The occurrence of ophicephalous pedicellariæ seems to be, therefore, an individual and not a specific character. Tridentate and triphyllous pedicellariæ are abundant and more or less variable.

The *triphyllous* pedicellariæ (Pl. 67, fig. *19*) have very slender stalks, with the neck of variable length, usually several times as long as the head. The valves (Pl. 67, figs. *15*, *20*) are rather broad, about half as wide at the tip as they are long, or a little wider; they are usually somewhat truncate at the tip, but those on the specimens from 3784 are often more rounded (fig. *15*); they are about half a millimeter long.

The *tridentate* pedicellariæ (Pl. 67, figs. *12*, *17*) vary greatly in size and more or less in form. In the larger ones the neck is short and the stalk is only a little longer than the head, while in the smaller ones the neck may equal the head and the stalk be several times as long. In the largest the valves (Pl. 67, figs *13*, *16*) may be 2.5 mm. long; they are straight, usually meet for their full length, and the sides of the blade are more or less nearly parallel and not at all involute; the blade is more or less filled with a calcareous mesh-work, and the apophysis usually extends into the blade as a serrate median ridge. In the specimens from 3784 the large pedicellariæ are quite variable, and in many of them the valves are separate at the base (see Pl. 67, fig. *12*) for a greater or less distance; the valves are also more or less constricted at the base of the blade and the apophysis fails to extend into it (fig. *13*). The smaller tridentate pedicellariæ are not peculiar; the valves (Pl. 67, figs. *14*, *18*) are about .40 mm. long and closely in contact throughout, usually they are more or less pointed (fig. *18*), but many of those on the specimens from 3784 are rounded (fig. *14*). Perhaps it ought to be emphasized that the tridentate pedicellariæ integrade with each other in form as well as in size, and the specimens from 3784 have the ordinary forms as well as the more unusual forms figured.

The *ophicephalous* pedicellariæ resemble those of Sperosoma. The stalks are very long, five or six times as long as the head, straight and relatively stout. There is almost no neck. The valves (Pl. 67, fig. *21*) are about .70 mm. long, strongly constricted near the middle and have large articulating loops.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 30 to 135 mm. in diameter.

Station 3707 (?). Off Ose Zaki, Honshu Island, Japan. 63–75 fathoms. Vol. s., a., g.

Station 3784. North of Aleutian Islands; 54° 32′ N., 178° 31′ E. 850 fathoms.[1] Gn. m., fne. gy. s.

Station 4928. In Colnett Strait, Japan; 29° 51′ N., 131° 2′ 30″ E. Bott. temp. 36.8°. 1008 fathoms. Gy. s., glob.

Station 5084. Off Omai Saki Light, Japan; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8. 918 fathoms. Gn. m., fne. s., glob.

Bathymetrical range, 63–1008 fathoms; probably 850–1008 fathoms is correct.

Eight specimens.

Echinosoma Kœhleri A. Ag. and Cl.

Tromikosoma Kœhleri Mortensen, 1903. "Ingolf" Ech., I, p. 78; figs. *5*, *6*. Davis Strait, 1435 fathoms.

In addition to the extraordinary width of the ambulacra, the abactinal arrangement of the tube-feet is an interesting character of this species; for the inner series contains twice as many feet as the outer, just the reverse of the condition found in *tenue*.

[1] The depth as published in the "Albatross" Records is 85 fathoms. But on the label with these specimens, it is distinctly "850 fms." The "85" is doubtless a misprint.

Echinosoma zealandiae A. Ag. and Cl.

Phormosoma zealandiae A. Agassiz, 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, p. 105; Pl. LI, figs. *1–4*.

Off New Zealand; 700 fathoms.

As the specimen on which this species is based is extremely young (24 mm. h. d.), it is difficult to differentiate it clearly from the other members of the genus. Like *Phormosoma rigidum*, from the same station, it must await further material before having its true status determined beyond doubt.

Echinosoma panamense Mortens.

Phormosoma panamense A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 77. 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, p. 101; figs. *145–148*.

Echinosoma panamense Mortensen, 1907. "Ingolf" Ech., II, p. 24.

Off Gulf of Panama; 1823 fathoms.

Plate 67, figs. *1–3*.

The pedicellariæ of this species are remarkably short and stout and show little diversity of form.

The *tridentate* pedicellariæ (Pl. 67, figs. *2*, *3*) are all of essentially the same structure, but differ considerably in size. Mortensen ("Ingolf" Ech. II, p. 24) says he has not found the large form of tridentate pedicellaria in *panamense;* as we have also failed to find this form, it probably does not occur in this species. The form which is common, has very wide valves, rounded or bluntly pointed at the tip, in contact for their whole length; the necks are longest in the small ones and may be very short in large ones; the stalk only equals the head in large ones, but is four or five times as long as the head in small ones. The valves range from .35 to 1 mm. in length, and the width is two-thirds of the length or even more. In form the valves are almost exactly like those of the Echinothurid which we have called *Sperosoma biseriatum* (see Pl. 65, fig. *18*), but the blade is often wider at the tip, the sides being nearly parallel.

The *triphyllous* pedicellariæ (Pl. 67, fig. *1*) are common and show little diversity. The stalk is about four times as long as the neck and the latter is equal to, or usually exceeds, the head. The valves are like that shown on Plate 65, fig. *19*.

The *calcareous particles* in the tube-feet are perforated plates of varying size and form, but in general like those shown on Plate 65, fig. *20*. They are commonly larger and more abundant than in *hispidum*.

Echinosoma uranus Pomel.

Phormosoma uranus Wyville Thomson, 1877. Voy. "Challenger," Atlantic, p. 146; figs. *33*, *34*.

Echinosoma uranus Pomel, 1883. Class. Méth. Ech., p. 108.

North Atlantic, 1000–1525 fathoms.

The difference between the tridentate pedicellariæ of this species and the next is marked and can be easily detected with a hand lens, but whether it constitutes a specific difference seems to us open to question. Aside from the characteristic pedicellariæ, this species is very near the following and we shall not be surprised if further material proves that the two are identical.

Echinosoma Petersii A. Ag. and Cl.

Phormosoma Petersii A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 76. 1883. "Blake" Ech., Mem. M. C. Z., X, Pls. X, XI.

Hygrosoma Petersii Mortensen, 1903. "Ingolf" Ech., I, p. 59.

North Atlantic, particularly Caribbean region; 647–1224 fathoms.

As stated above, we are not wholly satisfied as to the validity of this species, but are inclined to let it stand for the present. Mortensen (op. cit., p. 59) says that the tube-feet abactinally are in "three series very close together." Plate X and Plate XI, fig. *1*, of the "Blake" Echini seem to confirm the statement. The true condition is shown in Plate XI, fig. *5*, of the "Blake" report, where it will be seen that the arrangement really is in two series. When a specimen is compared with *hoplacantha* and *tenue*, it is obviously nearer *tenue*, but in large specimens, the feet may become so crowded that the tendency towards three series is evident.

Kamptosoma.

Mortensen, 1903. "Ingolf" Ech., I, p. 60.

Type-species, *Phormosoma asterias* A. Agassiz, 1881. "Challenger" Ech., p. 104.

The rather thin and delicate test has the actinal side quite different from the abactinal in the form of the plates but not in the size of spines or tubercles. Few of the primary ambulacral plates are accompanied by secondary plate elements and never by more than a single one. The sphæridia are carried on the primary plates actinally but may be on secondary plates abactinally. The stalk of the pedicellariæ is made up of loosely connected calcareous threads. This remarkable genus appears to be confined to the deep parts of the southern Pacific Ocean, having been met with hitherto only by the "Challenger." Its relationship to the other Echinothuridæ is still unsettled and more material is greatly to be desired. There is an interesting parallelism between this genus and Micropyga in the structure of the stalks of the pedicellariæ; each is the only genus in its family with these stalks noticeably different in structure from those found in the allied genera.

There appear to be two quite distinct species of Kamptosoma which may be separated from each other as follows:

Abactinal ambulacral areas not noticeably expanded just above ambitus, composed of high plates not wider than those of the actinal side, their width not exceeding twice their height and sometimes not equalling it . . . . *asterias.*
Abactinal ambulacral areas markedly expanded just above ambitus, composed of low plates, much wider than those of the actinal side, their width often four times the height . . . . *indistinctum.*

Kamptosoma asterias Mortens.

Phormosoma asterias A. Agassiz, 1881. "Challenger" Ech., p. 104; Pl. XII^{a}, figs. *7–9*.
Kamptosoma asterias Mortensen, 1903. "Ingolf" Ech., p. 60.

Off the coast of Chili; 2160 fathoms; "Challenger" Station 299.

The type-specimen of this interesting species, 30 mm. in diameter and doubtless young, is still unique.

Kamptosoma indistinctum A. Ag.

Kamptosoma indistinctum A. Agassiz, 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, p. 110; Pl. *50*. North of the Society Islands, East of Malden Island, 2600 fathoms; "Challenger" Station 272.

In spite of Mortensen's decision to the contrary, we think this species must be maintained, unless the differences of ambulacral structure referred to above, which distinguish this species from the preceding, can be shown to be unreliable. We beg to call attention to two facts which bear on this point. First: it was only in this species that Mortensen found the large, characteristic tridentate pedicellariæ; they were not found in the type of *asterias*. Second: Mortensen says that secondary ambulacral plate elements are wanting, except "nearest to the peristome a single one may be found." Unfortunately he does not say whether this was observed in the type of *asterias* or in a specimen from "Challenger" Station 272. If in the former, it gives us an additional specific character; if in the latter, we are at a loss to reconcile his statement with the real condition in *indistinctum* (see Panam. Deep-Sea Ech., p. 111, fig. *151* and Plate 50, fig. *3*).

ASTHENOSOMA.

Grube, 1868. 45er Jahres-Bericht d. Schles. Gesell, p. 42.

Type-species, *Asthenosoma varium* Grube, l. c.

After careful consideration it has seemed desirable to limit Asthenosoma, as Mortensen proposed, to the species on which Grube based the genus and its nearest allies. They are characterized by a rather firm test having the actinal side markedly different from the abactinal. The coronal plates of the upper side are very low and wide, each with a horizontal series of 5–20 small primary tubercles, none of which are noticeably larger than the others. The abactinal primary spines are small and numerous, and are encased in loose skin-sheaths. The actinal tube-feet have well-developed sucking-discs. The sphæridia are more or less elongated and occur only on the inner (lower) secondary plate-element. In this limited sense Asthenosoma includes at most only four species, and probably only two. The evidence accumulated by de Loriol, Döderlein, and de Meijere seems to prove that *A. Grubei* A. Ag. is really a synonym of *varium* Grube, as Agassiz himself suggested in 1881 ("Challenger" Echini, p. 84). From the descriptions and figures which have been published we are strongly inclined to consider *A. urens* Sarasins and *A. heteractis* Bedford as also synonyms of *varium*, but as we have no material at hand for comparison, we let them stand for the present as distinct. The following table shows how closely related the four accepted species are:

Actinal primaries more or less distinctly banded (usually greenish banded with purple).
- Ambulacral primary spines, abactinally, much longer than those of interambulacra but not markedly unlike them in color.
  - Naked radial areas of abactinal surface, relatively narrow, or wanting; that of median interambulacral field not exceeding .10 of interambulacrum . . . . *varium.*
  - Naked radial areas of abactinal surface, conspicuous; that of median interambulacral field exceeding .20 of interambulacrum . . . . *urens.*
- Ambulacral primary spines, abactinally, about equal to those of interambulacra, markedly different from them in appearance, the sheaths being very distinctly and regularly banded with purple . . . . *heteractis.*

Actinal primaries white and unbanded . . . . *Ijimai.*

Asthenosoma varium Grube.

Asthenosoma varium Grube, 1868. 45[er] Jahres-Bericht d. Schles. Gesell., p. 42.

Asthenosoma Grubei A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 200. 1881. "Challenger" Ech., Pls. XV–XVII.

East Indies. Littoral.

There seems to be no sufficient ground, in the present state of our knowledge, for regarding *varium* and *Grubei* as distinct. It is certainly to be doubted whether either of the two succeeding forms is really different from *varium*.

Asthenosoma urens Saras.

Cyanosoma urens Paul and Fritz Sarasin, 1886. Zool. Anz., IX, p. 80.

Asthenosoma urens Paul and Fritz Sarasin, 1888. Ergeb. Nat. Forsch. Ceylon, I, p. 86; Pls. X–XVII.

Ceylon. Littoral.

It seems very doubtful whether this species is distinguishable from *varium*, but further study of fresh material in the East Indies will be necessary before the point can be settled. Attention ought to be called to the astonishing discrepancy between the Sarasins' colored figure (Pl. X) and the photograph given by Döderlein (Semon's Zool. Forsch. Aust., Pl. LX, fig. *3*) of what he tells us is an "Originalexemplar" of *urens* from the Sarasins' collection. It is incredible that this photograph can represent an animal which had ever had the coloration shown in the Sarasins' figure, yet strangely enough Döderlein makes no reference to the color. If *urens* has the coloration shown by the Sarasins it must be very different from *varium* ; while, on the other hand, if Döderlein's figure represents the normal appearance of *urens* it must be very near, if not identical with, Grube's species. The differences described by Döderlein between *varium* and *urens* do not seem to us to be very weighty, and his suggestion that the two forms are varieties of one species seems quite probable, if they are distinguishable at all.

Asthenosoma heteractis Bedford.

Asthenosoma heteractis Bedford, 1900. Proc. Zool. Soc. London, p. 278 ; Pl. XXI, fig. 2.

Singapore; 5 fathoms.

We do not consider the characters assigned to this species as of very great importance, and we are strongly inclined to think that the original specimens are young examples of *varium*.

Asthenosoma Ijimai Yosh.

Asthenosoma Ijimai Yoshiwara, 1897. Ann. Zool. Japon., I, p. 8; Pl. II, figs. *8–12*.
Asthenosoma Ijimai Mortensen, 1904. Ann. Mag. Nat. Hist. (7) XIV, p. 87; Pls. III; V, figs. *1–3, 10, 12–14*.

Sagami Bay, Japan; 50–55 fathoms.

The arrangement of the tubercles in the interambulacral plates of the abactinal side of the test in this species resembles closely that of *A. varium*. The columns of primary tubercles of the actinal side do not reach beyond the ambitus, and there is nothing of the characteristic arrangement of the extension of the primaries toward the abactinal system so striking in many species of Aræosoma.

Mortensen criticises Yoshiwara's description of the madreporic plate, as he does not consider the madreporic plate divided, but rather that the madreporic pores have spread into adjoining plates. In the specimens before us there seems to be no room to doubt that the madreporic plate is divided, exactly as Yoshiwara described it, "into four separate pieces of unequal size, the largest occupying the normal position." In addition there are a dozen or more very small fragments of the plate, around the genital opening, distal to the main plate. The madreporic pores spread into the ocular plates on each side, but chiefly into the one in the right anterior ambulacrum. The splitting up of the genital plates is now so well known in the Echinothuridæ that the condition of the madreporic plate in this species, while interesting, is far from exceptional. On the other hand, the extension of madreporic pores into anal plates is a very rare phenomenon, never occurring normally so far as we know, so that we cannot assent to Mortensen's interpretation of the condition in *Ijimai*. When he says that the spread of madreporic pores "over the neighboring plates" is a feature "upon the whole not very seldom occurring among Echinids," it must be assumed that he means by "neighboring" plates only genitals and oculars, for the presence of madreporic pores in plates either inside or outside of the genito-ocular ring is most unusual. In *Ijimai*, the plates in question must be either anal plates or parts of the genital, and we feel no doubt that they are the latter.

Aræosoma.

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 53.

Type-species, *Calveria fenestrata* Wyville Thomson, 1872. Proc. Roy. Soc. London, XX, p. 494.

(Including Calveria and Hapalosoma of Mortensen.)

Actinally this genus is not essentially different from Asthenosoma, but seen from above the difference is quite marked. In Aræosoma none of the abactinal primary spines are encased in loose skin-sheaths. There are at least 25–30, and sometimes several hundred, primary tubercles which are much more conspicuous than the rest and their areolæ are correspondingly large. The coronal plates are also much higher than in Asthenosoma, but the texture of the test varies much in the different species. This is the largest genus of the family, but although the species show some tendency to an arrangement in three or four groups, we have failed to find any satisfactory characters by which such groups may be constantly distinguished. We can hardly believe that the texture of the test, the relative width of ambulacra and interambulacra, or the relative number of ambulacral and interambulacral plates, are any better generic characters, taken by themselves, than the color or the pedicellariæ. And while by using any one of these characters we might arbitrarily establish several "genera," they would intergrade so completely in their other characters, we do not think such subdivisions would be either natural or desirable. Accepting Mortensen's view that *A. Reynoldsii* A. Ag. is a synonym of *fenestratum* Wyv. Thom., and *A. longispinum* Yosh. is identical with *A. gracile* A. Ag., we still recognize 14 species of Aræosoma. They show great diversity in color, texture of the test, distribution of primary spines, relative number of ambulacral and interambulacral plates, relative width of ambulacra and interambulacra, length of spines, and form of pedicellariæ; and it is surprisingly hard to distinguish them from each other, for not only do their characters reveal more or less individual diversity, but they intermingle most perplexingly in the different forms. We have reached the conclusion that color is often a good character in this genus, and it proves to be of considerable service in distinguishing certain species. The form of the valves of the large tridentate pedicellariæ, which can be easily seen with an ordinary lens, is also a useful character, even if we cannot follow Mortensen in making it generic. The width of the ambulacra and the number of ambulacral plates are valuable, within certain limits, but age differences need to be guarded against, and the same is true of the spines and primary tubercles. Only rarely is the relative size of the actinostome or abactinal system of any importance, but the relative amount of calcification of the coronal plates and the degree to which they are bent adorally are often very useful characters. The species which seem to us probably valid may be distinguished as follows:

Actinal primary tubercles not forming an uninterrupted marginal series at ambulacral edge of each half-interambulacrum, since some interambulacral plates (usually every other one, at least near ambitus) do not have a primary tubercle at extreme outer end.

- Abactinal primary tubercles fewer than 100, nearly or quite as large as those of actinal surface . . . . *thetidis.*
- Abactinal primary tubercles more than 200, much smaller than those of actinal side . . . . *bicolor.*

Actinal primary tubercles forming an uninterrupted marginal series at ambulacral edge of each half-interambulacrum, since each interambulacral plate has a primary tubercle at its extreme outer end.

- Ambulacra very narrow, about .40 of interambulacra; primary spines near ambitus banded with red or reddish-purple . . . . *pellucidum.*
- Ambulacra more than half as wide as interambulacra; primary spines not banded.
  - Ambulacra very broad, more than .75 of interambulacra.
    - Ambulacra .90 of interambulacra; interambulacral plates much more numerous abactinally than actinally, strongly inclined (near ambitus, curved) towards mouth, those at ambitus with inner end so much more adoral than outer, that the plate is 30 per cent longer than one-half the width of interambulacrum . . . . *eurypatum.*
    - Ambulacra .80 of interambulacra; interambulacral plates nearly as numerous actinally as abactinally, more or less oblique, but even at ambitus their length is only about 10 per cent longer than one-half the width of interambulacrum . . . . *leptaleum.*
  - Ambulacra moderately broad, .50–.75 of interambulacra.
    - Entire test bright red, the color more or less well-preserved in alcoholic and dry specimens; large tridentate pedicellariæ with curved valves having the blade strongly involute except at tip.
      - Test bright rose-red; actinostome about .25 h. d.; few actinal interambulacral plates with two or more primaries *hystrix.*
      - Test bright vermilion; actinostome less than .20 h. d.; most actinal interambulacral plates with two or more primaries . . . . *pyrochloa.*
    - Test never bright red; colors variable, the actinal and abactinal surfaces often different; colors usually more or less bleached or altered in preserved specimens.
      - Ambulacral plates rather high and few, interambulacral about four-fifths as many; test reddish-purple above, lighter, often yellowish, beneath . . . . *Belli.*

Ambulacral plates low and numerous, interambulacral only three-fifths — three-fourths as many.
Color uniform dark violet; actinal primary spines (except hoofs) equally dark . . . . *violaceum.*
Color never uniformly dark violet; actinal primary spines usually lighter than test.
Coronal plates, especially abactinally, with wide interspaces of leathery skin.
Abactinal interambulacral plates strongly curved or bent adorally so that their expanded inner ends are much nearer mouth than the outer ends, in large specimens as much as 15 mm. nearer . . . . *coriaceum.*
Abactinal interambulacral plates nearly or quite straight, though they are not necessarily horizontal . . . . *tessellatum.*
Coronal plates with small interspaces or none.
Number of ambulacral plates abactinally little or not at all exceeding actinal number *fenestratum.*
Ambulacral plates abactinally 50–60 per cent more numerous than actinally.
Test thin; valves of large tridentate pedicellariæ curved, with blades strongly involute except where they meet at tip *gracile.*
Test rather stout; valves of large tridentate pedicellariæ straight or nearly so, the blades not involute but in contact for most of their length . . . *Owstoni.*

Aræosoma thetidis A. Ag. and Cl.

Asthenosoma thetidis H. L. Clark, 1909. Bull. M. C. Z., LII, p. 134.

Off Botany Bay, New South Wales; 80 fathoms.

Plates 66, figs. *6–17;* 68–70.

Although at first sight this species appears to be closely related to *A. Owstoni* Mort., careful examination reveals some very decided differences, particularly on the actinal surface. The largest specimen before us measures 180 mm. in diameter; the interambulacra are 63 mm. broad at the ambitus, while the ambulacra are 46 mm. across in the same region. The abactinal system is 32 mm. in diameter, while the actinostome is 41 mm. across. There are 45 coronal plates in each half of an interambulacrum, of which 18 are below the ambitus. The ambulacral plates number 70 from the peristome to the ocular plate; of these 28 are on the actinal side; there are 12–14 additional pairs of poriferous plates in each radius of the actinostome. The primordial interambulacral plate at the peristome is very evident (Pls. 69; 70, fig. *2*) and bears several small primary tubercles.

The other actinal coronal plates each carry one or two primary tubercles; these vary greatly in their position on the plate, but as a rule every other plate has one such tubercle near its outer end and a second near the inner end; the alternating plates usually have a single large tubercle at the middle, but occasionally there are two tubercles present. Sometimes a plate occurs with no primary tubercles. It will be seen, therefore (Pl. 69), that there is a tendency to form three well-spaced longitudinal series in each half of the interambulacrum. On the abactinal surface most of the coronal plates carry no primary tubercles, but six or eight plates in each column are made conspicuous (Pl. 68) by the single large tubercle which each bears. The inner, imbricating ends of the coronal plates are abactinally quite bare and perfectly smooth (Pl. 68), but there is no uncalcified membrane between the plates, except for a very small area at the lower margin of about a dozen plates, beginning with the fifth or sixth from the genital plate. Actinally the coronal plates are well covered, clear to the median line, with secondaries and miliaries, but abactinally the margins of each plate are, on all sides, more or less bare.

Each half-column of an ambulacrum actinally (Pl. 69) is made up of very wide, rather large primary plates, each accompanied by two small secondary plate-elements. The latter are very little larger than the peripodium which each bears. Although the tubercles are arranged in two series, on each side, their distribution is quite irregular. It is rather more common to find two tubercles on a single plate, one at each end, with the adjoining plates above and below without tubercles, than to find them alternating, as might be expected, plates with a tubercle at the inner end succeeding and being followed by plates with an outer tubercle. Abactinally (Pl. 68) only five or six plates in each column bear large tubercles, and these are irregularly scattered. The remaining surface of the ambulacral plates is fully covered actinally with secondaries and miliaries, but abactinally the margins of each plate, especially the outer ends, are quite smooth and bare. The three series of pore-pairs run rather close together the full length of the ambulacrum; even just above the ambitus (Pl. 70, fig. *4*) the outer series (in the primary plates) is not very widely separated from those in the secondary plates.

The abactinal system (Pl. 70, fig. *1*) is small and well defined. The genital and ocular plates are not in contact with one another. The genitals are long, triangular, separating the two upper pairs of plates of each interambulacrum; the pores are large, occupying the greater part of the distal half of the plate. The ocular plates are somewhat pentagonal, with very small pores. The anal system is large, 18 mm. across, and is covered by several concentric circles of small plates, the inner ones the smallest; many of the outer ones carry one or more secondary spines.

The smallest specimen of *thetidis* which we have is 72 mm. across, with the actinal system 18 mm., the abactinal system 11 mm., and the anal system 8 mm. in diameter. The interambulacra are 26 mm. wide at the ambitus and have 32 plates in each half-column, while the ambulacra are 20 mm. wide and are made up of 43 pairs of plates. The primary tubercles of the abactinal side are about as numerous as in large specimens and therefore appear much more numerous relatively. Actinally they are fewer and tend to form a regular marginal row along the outer border of each interambulacrum, a much less regular series at the inner ends of the same plates, and two very irregular series in the middle of each ambulacrum.

The spines of this species offer no peculiarities and the pedicellariæ are very much like those of *Owstoni* and *bicolor*. We have not found any "dactylous" ones, however, although careful examination has been made of several specimens. The tridentate pedicellariæ are exceedingly abundant, particularly just below the ambitus, while the triphyllous are less common.

The *tridentate* pedicellariæ (Pl. 66, figs. *15, 17*) are extraordinarily diversified in size and form, though on the same general plan. The heads are thick and blunt, and the stalks are about twice as long as the head or longer. The valves (Pl. 66, figs. *6–12*) range in length from one-fifth of a millimeter to over two millimeters; they are in contact for nearly their entire length, except in rare cases, where only the terminal halves touch. In small pedicellariæ, the valves have a nearly straight or somewhat convex, smooth margin, but in the larger ones it is more and more sinuate, until in the largest it is very coarsely toothed. In all large pedicellariæ the blade is filled with a coarse mesh-work which may rise up into irregular serrate ridges (Pl. 66, figs. *11* and *12*); in large valves the tip may be very strongly hooked.

The *triphyllous* pedicellariæ (Pl. 66, fig. *16*) are not very numerous and have rather elongated heads on slender stalks; the valves (fig. *17*) are narrow, with a very long, perforated cover-plate, and rounded at the tip. The *calcareous spicules* (Pl. 66, fig. *13*) in the tube-feet are small, irregular, but essentially triradiate, bodies, sometimes appearing as small perforated plates.

Aræosoma bicolor A. Ag. and Cl.

Asthenosoma bicolor A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 118.

Plates 64, figs. *1–8*; 71; 72.

This species, of which only a single specimen was collected, is nearly related to *Owstoni*, but differs in color and in certain features of the test. The coronal plates are low and very numerous, 44 in the interambulacra and 75 in the ambulacra (Pls. 71, 72, figs. *3*, *4*); in *Owstoni* of the same size (125 mm.) the numbers are 38 and 60 respectively. The test is more flexible abactinally than in *Owstoni*, and the bare median ambulacral and interambulacral areas are more marked (Pl. 71, figs. *1*, *2*). The test and spines are dull yellowish actinally, while on the abactinal surface the interambulacra are chiefly yellow and the ambulacra are dull violet. These colors are not sharply defined, but contrast with each other nevertheless. On the actinal side the primary ambulacral tubercles form two median longitudinal series (Pl. 71, fig. *2*). At the ambitus there are two additional series of primaries somewhat smaller which extend irregularly along the ambulacrum for about two-thirds the distance from the ambitus to the apex (Pl. 71, fig. *1*). The actinal primary interambulacral tubercles are arranged in six very irregular rows; in the outer rows, adjoining the ambulacral area, they are closely packed (Pl. 71, fig. *2*) two-thirds of the distance from peristome to ambitus. On the abactinal surface the primary interambulacral tubercles extend in irregular open rows almost to the apical system (Pl. 71, fig. *1*). The rest of the plate is closely covered with miliaries (Pl. 72, fig. *4*). The primordial actinal interambulacral plate is large and prominent (Pl. 72, fig. *1*). The imbricating actinal plates, in prolongation of the ambulacral series, cover the whole buccal membrane except at the actinal margin of the interambulacra, where there are a few minute plates (Pl. 72, fig. *1*). The actinal plates are covered with minute secondaries and miliaries arranged in horizontal rows.

The genital plates in *bicolor* are not so elongated as in *Owstoni*, for they separate only the first pair of interambulacral plates and touch the second (Pl. 72, fig. *2*), while in *Owstoni* they separate the first two pairs and touch, sometimes nearly separating, the third. In *bicolor* four of the genital plates are remarkable in that the outer part of the plate (i. e. the part distal to the pore) is separated by a regular suture from the remainder of the genital and thus is a perfectly distinct plate (Pl. 72, fig. *2*). The madreporic genital is divided into three parts. The anal system is covered with two outer rows of small irregularly shaped polygonal plates, each carrying a small miliary or secondary; close to the anus the membrane is covered by minute elliptical plates.

The pedicellariæ of this species resemble closely those of *Owstoni*, but show some interesting differences.

The *dactylous* pedicellariæ (Pl. 64, fig. *1*) are very scarce and seem to be confined to the actinal side near the ambitus. The stalk is much longer than the head. The three valves are about 1.4 mm. long and completely concealed in the glandular tissue which surrounds them; when cleaned from this organic matter they are found to be very asymmetrical (Pl. 64, fig. *4*); the blade is greatly compressed for most of its length, but is expanded, with infolded margins, at the tip, and is more or less abruptly bent below this expanded tip.

The *tridentate* pedicellariæ (Pl. 64, fig. *2*) are very abundant and vary greatly in size and somewhat in form, though the connecting links are plentiful. The smallest have the valves (Pl. 64, fig. *7*) about .45 mm. long, very blunt, with nearly parallel, straight sides; the apophysis continues to some extent into the blade. In the largest, the valves (Pl. 64, figs. *5*, *6*) are two and a half millimeters long, narrow, and more or less closely in contact throughout; the blade has a very sinuate margin, and on the convex curves the margin is somewhat infolded and rough, with minute teeth (see fig. *6*); the blade is filled with a calcareous mesh-work and the apophysis is prolonged as a prominent, serrate ridge. Between these two extremes all sorts and sizes of tridentate pedicellariæ may be found.

The *triphyllous* pedicellariæ (Pl. 64, fig. *3*) have very long and slender stalks and rather long necks; the valves (fig. *8*) are about half a millimeter long, and like those of *thetidis* and *Owstoni* have a very extensive, more or less perforated, cover-plate. The sphæridia and calcareous spicules are not noteworthy.

This species is based on a single specimen, 125 mm. in diameter, taken by the "Albatross" at the following station:

Station 4939. Kagoshima Gulf, Japan; 31° 18′ 30″ N., 130° 42′ E. 85 fathoms. Character and temperature of bottom not recorded.

Aræosoma pellucidum A. Ag. and Cl.

Asthenosoma pellucidum A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 200. 1881. "Challenger" Ech., Pls. XVIII, figs. *1–6;* XIX, figs. *1–6;* etc.
Hapalosoma pellucidum Mortensen, 1903. "Ingolf" Ech., pt. I, p. 56.
East Indies; 100–129 fathoms.

The small size, pretty colors, and very narrow ambulacra combine to make this a very easily recognized species. The "Albatross" specimens which are less than 50 mm. in diameter, and intermediate in size between those figured on the "Challenger" Ech. Pl. XIX, figs. *1–6,* were taken at the following station:

Station 4934. Off Kagoshima Gulf; 30° 58′ 30″ N., 130° 32′ E. 103–152 fathoms. Rocky.

Three specimens.

Aræosoma eurypatum A. Ag. and Cl.

Plates 66, figs. *18–19;* 73–75.

As far as can be judged from the single specimen of this species, the test must have been very flexible, the outline was lobed, the median ambulacral and interambulacral lines bulging out beyond the vertical furrow formed at the junction of the ambulacral and interambulacral zones (Pl. 73). The curve of the test at the ambitus is high, projecting well beyond the concave abactinal surface of the test at the centre of which rises the abactinal system (Pl. 73, fig. *1*). This is well seen in the profile view of the test (Pl. 73, fig. *2*) as well as in the figure taken from the actinal side (Pl. 74), which also shows the ambitus swelling well above the concave actinal surface in the centre of which rises the highly arched, slightly conical actinal system. The test of the specimen figured is, as far as it can be measured in its dry and somewhat folded state, 140 mm. in diameter; the actinal system is 35 mm. across, while the abactinal measures 20–25 mm. from the distal tip of a genital plate to the distal edge of the opposite ocular plate (Pl. 75, fig. *2*). From the ambitus to the abactinal system in the ambulacral zone there are 42 plates and in the interambulacral zone 32. On the actinal side in the interambulacral column there are 19 plates and in the ambulacral 31. The test of this species is remarkable for the great uniformity in the size of the coronal plates. Those of the actinal side are but little larger than those of the abactinal side (compare Pls. 73 and 74). The interambulacral plates of the abactinal side are curved downward toward the ambitus from the outer edge of the interambulacral zone to the median line (Pl. 73, fig. *1*) all the way from the abactinal system to the ambitus (Pl. 75, fig. *2*). The same is the case with the ambulacral plates to a limited extent, only the plates about one-third of the way from the ambitus towards the abactinal system being curved towards the median ambulacral line (Pl. 73, fig. *1*), those nearer the abactinal system being only slightly curved or horizontal (Pl. 75, fig. *2*).

At the ambitus the ambulacral and interambulacral areas are of nearly the same width (Pls. 73, 74). On the abactinal side the interambulacral areas are bordered along the ambulacra by a more or less regular vertical series of small primary tubercles flanked near the ambitus by a shorter row of similar tubercles extending on five or six interambulacral plates. The rest of the interambulacral plates are for the most part covered with distinct small secondaries and miliaries, but along the median interambulacral line are found two rows of small primaries extending from the actinal side to the abactinal side of the ambitus. These rows are well seen in the profile view of the test (Pl. 73, fig. *2*). On the abactinal surface, in the median ambulacral area, occur two or three irregular vertical series of small distant primaries and secondaries extending from the ambitus to the abactinal system. The poriferous zones on the abactinal surface occupy two-thirds of the ambulacral area; the two vertical inner rows of pairs of pores are well separated from the single outer line (Pl. 75, fig. *4*).

On the actinal side the poriferous zones approach the outer edge of the ambulacra and at the actinostome are closely packed (Pl. 75, figs. *1, 3*). On the actinal side of the test (Pl. 74) the interambulacral plates are of uniform height, sharply inclined towards the median line; only the nine or ten plates nearest the actinostome are separated by uncalcified membrane. The vertical series of interambulacral primaries next the ambulacra are regular and prominent (Pl. 74), while the less marked rows of similar tubercles on each side of the median interambulacral line are not very noticeable. The actinal system is about 35 mm. in diameter and has prominent gill cuts. There are twelve to fourteen rows of narrow imbricating plates between the teeth and the ambulacral coronal plates (Pl. 75, fig. *1*), which carry secondaries arranged in horizontal rows.

The abactinal system (Pl. 75, fig. *2*) is from 20 to 25 mm. in diameter. The genital plates are pointed and much elongated with the genital openings placed in the proximal part of the genital membrane, which carries along its edges small irregularly shaped polygonal plates. The proximal part of the genital plate is divided into two large plates each of which carries a small secondary. The ocular plates are polygonal, separating the genitals, and each carries one or two secondaries.

The anal system is covered with irregular polygonal plates varying greatly in size (Pl. 75, fig. *2*), with a few small elliptical plates round the anal opening, arranged in two irregular rows.

As this species is allied to *A. coriaceum,* it is interesting to compare the details of the abactinal system given on Plate 52 of the Panamic Deep Sea Echini (Mem. M. C. Z., XXXI) with those of *A. eurypatum* on Plate 75 of this Memoir.

The test is scraped so nearly bare, only a very few broken, secondary spines, a few triphyllous pedicellariæ and some scattered sphæridia are left in a couple of abactinal folds of the test. The sphæridia (Pl. 66, fig. *18*) are remarkable for their greatly elongated form; they are more spine-like than in any other known Echinothurid. The triphyllous pedicellariæ are, as usual, on long, slender stalks; the valves (Pl. 66, fig. *19*) are noticeably slender but expand rather abruptly at the tip, where they are very flat; they are about half a millimeter long and have a well-developed cover-plate with an irregular margin.

This remarkable specimen was taken in 1888 by the "Albatross" on her way from New York to San Francisco, at the following station:

Station 2819. Near Galapagos Islands; 6′ S., 90° 6′ W. Bott. temp. 39.9°. 671 fathoms. Wh. s.

Aræosoma leptaleum A. Ag. and Cl.

Plates 76 and 77.

This species belongs to the *fenestratum* group of Aræosoma, and may be considered the Pacific representative of that Atlantic species. A single specimen was collected by the "Albatross" in 1904 off Mariato Point, while looking up for further investigation the green-sand patch discovered by her in the Panamic region during the cruise of 1891.

The diameter of this specimen is 125 mm.; the greatest diameter of the abactinal system 21 mm.; of the actinal system, 30 mm. There are 19 plates in each half of an interambulacrum from the actinal system to the ambitus and 27 in the ambulacral column. Between the abactinal system and the ambitus there are 24 plates in each half of an interambulacrum and 38 in an ambulacrum. At the ambitus the interambulacral area has a width of 42 mm., the ambulacral, 32. The greatest diameter of the abactinal system is 21 mm., that of the actinal system 30 mm. The primary spines both on the actinal and abactinal surfaces are sharp and slender, from 12 to 22 mm. in length (Pl. 76). The longer spines of the actinal side are slightly expanded at the tip (Pl. 76; fig. *2*), and terminate in a small white "hoof" which is remarkable for being thickest at base and nearly pointed at tip. Between the actinal interambulacral plates there is even more uncalcified membrane than in *A. fenestratum*. On the abactinal side the calcification of the plates increases gradually from below the ambitus to the abactinal system (Pl. 76, fig. *1*). Both the ambulacral and interambulacral plates are higher in *fenestratum* than in *leptaleum*.

On the actinal side the vertical row of interambulacral primaries bordering the ambulacrum is very marked, and extends just over the ambitus to the abactinal surface, close to the ambulacral plates. On the abactinal surface two irregular series of smaller primaries extend on each half of the interambulacrum, two-thirds of the way to the abactinal system (Pl. 76, fig. *1*). The two median rows of ambulacral primary tubercles are distant and irregular (Pl. 77, fig. *3*), but extend from the actinostome (Pl. 77, fig. *1*) over the ambitus (Pl. 77, fig. *4*) nearly to the abactinal system (Pl. 76, fig. *1*). The two inner series of pairs of pores are well separated from the outer row for nearly the whole length of the ambulacrum (Pl. 77, fig. *4*), approaching closely only near the actinostome (Pl. 77, fig. *3*).

There are from ten to twelve rows of rather high imbricating poriferous plates extending from the teeth to the coronal, ambulacral plates (Pl. 77, fig. *1*). They each carry a horizontal row of small secondaries and miliaries. The small area between the ambulacral plates at the proximal margin of the primary interambulacral plate is covered with a few minute elliptical plates. The actinal plates near the teeth all abut on each other as regularly as the coronal plates of the typical echinoid test; it is only the plates near the coronal plates which are imbricating. The median suture of the interambulacral area extends almost unbroken from the actinal edge of the test to the teeth, and the adjoining ambulacral areas are separated only near the corona by the small irregular wedge-shaped interambulacral plates. Such an arrangement is suggestive of Bothriocidaris, where the interambulacral area is reduced to a minimum.

The abactinal system is comparatively small (Pl. 77, fig. *2*). The genital plates are pointed triangular with rounded angles, while the genital membranes are elongated and more or less rectangular. The genital plate is made up of two parts, a small outer piece distal to the membrane and a broadly horse-shoe-shaped plate proximally, which carries from one to three small secondaries or miliaries. The madreporic body is transverse elongate with slightly concave sides. The anal system is covered with two outer rows of larger polygonal plates, each carrying one or two secondaries or miliaries and two or three interior series of small elliptical and polygonal plates adjacent to the anus.

The pedicellariæ of this species are remarkably indistinctive, and it has not seemed necessary to figure them. No dactylous pedicellariæ were found. The *tridentate* pedicellariæ are not very abundant and show comparatively little diversity of size. Most of them have the heads about a millimeter long and the stalk three or four times that length. The shape of the head and valves is much like what we find in *thetidis* (see Pl. 66, fig. *17*), but some pedicellariæ are much more like those of Sperosoma (see Pl. 64, fig. *9*). Occasionally one is met with which approaches fig. *12*, Pl. 67, and the valves are often broadened distally and narrowed near the base, like fig. *13*, Pl. 67.

The *triphyllous* pedicellariæ are more common, though hardly abundant. The necks and stalks are very long and slender; the valves are very much like that shown in fig. *19*, Pl. 66, but are not quite so flattened or abruptly widened at the tip.

The *sphæridia* are very long and club-shaped, reminding one very much of those of the previous species (*eurypatum*).

The single specimen of this interesting species was taken by the "Albatross" at the following station:

Station 4621. Off Mariato Point, Panama; 6° 36′ N., 81° 44′ W. 581 fathoms; modern green-sand; temperature of bottom not recorded, but adjoining this station, 40.2° was recorded in 555 fathoms, in 1891.

Aræosoma hystrix A. Ag. and Cl.

Calveria hystrix Carpenter and Jeffreys, 1871. Proc. Roy. Soc. London, XIX, p. 154.
Calveria hystrix Wyv. Thomson, 1872. Proc. Roy. Soc. London, XX, p. 494.
(Not *Calveria hystrix* Carpenter, Jeffreys and Thomson, 1870, Proc. Roy. Soc. London, XVIII, p. 445.)
Asthenosoma hystrix A. Agassiz, 1872. Rev. Ech. Pt. I, p. 93.
North Atlantic; 100–1000 fathoms.

In confirming Agassiz's rejection of Calveria (Pan. Deep-Sea Ech., p. 84), Bather has pointed out (Ann. Mag. Nat. Hist. (7) XVII, p. 249) that the specific name (*hystrix*) having been rejected as a homonym, it should not be used for this species. This may be correct nomenclature, but we cannot see what is gained by any change from the universally used specific name.

Aræosoma pyrochloa A. Ag. and Cl.

Asthenosoma pyrochloa A. Agassiz and Clark, 1907. Bull. M. C. Z., LI. p. 118.

Plates 66, figs. *1–4;* 78–80.

Although this species bears a close resemblance to the preceding, the differences pointed out on p. 175 seem to be constant, and warrant the recognition of this form as the North Pacific representative of *A. hystrix.* The small size of the actinostome is particularly worthy of note. The diameter of the specimen figured on Plates 78 and 79 is 196 mm. From the ambitus to the abactinal system there are in each column 35 interambulacral plates, each carrying from one to four primary tubercles arranged in four or five irregular vertical rows. On the actinal side of the test there are 25 plates in each half-interambulacrum, and each plate carries two to four primary tubercles, one of which is always at the extreme ambulacral end of the plate. A very complete marginal series is thus formed, but the series near the median line is much less regular. The rest of the interambulacral plates are covered with numerous secondaries and miliaries. The plates increase in height somewhat as they pass from the ambitus towards the abactinal system and actinostome. On the abactinal side of the test (Pl. 78) there are in each column 48 ambulacral plates, increasing very gradually in height from the ambitus to the abactinal system. Each plate carries one or two primary tubercles, which form two very irregular vertical rows on each half-ambulacrum. Excepting the extreme outer end, the ambulacral plates are covered with a series of large miliaries. Towards the ambitus, on the abactinal side of the test, the poriferous zone is equal in width to half that of the ambulacral plates. At the ambitus the width of the ambulacral area is 50 mm., and that of the interambulacral 73 mm. There is a narrow bare space running between the ambulacral and the interambulacral areas, and a somewhat wider bare space on the median interambulacral line. On the actinal side there are 34 plates in each half-ambulacrum. These plates carry two principal vertical rows of primary tubercles (Pl. 79); one row of small tubercles extends from the actinostome above the ambitus in the space separating the single series of pores from the double column, and one row of large tubercles runs along the median ambulacral line. The latter is flanked with an irregular row of smaller primaries extending about half way from the ambitus to the actinal system. The rest of the ambulacral plates carry small secondaries and miliaries irregularly arranged, as on the interambulacral plates.

The uncalcified membrane between the interambulacral plates has its greatest width about half way between the ambitus and the actinal system. On the abactinal side of the test (Pl. 79) the bare space separating the coronal plates is reduced to a narrow line (Pl. 80, fig. *4*).

On the actinal side of the test many of the larger primary spines are somewhat flaring at the extremity; the others are straight and sharp, as are the miliary and secondary spines. On the abactinal side of the test the primary spines are sharp, slender, and straight, very slightly tapering. The miliary and secondary spines are slender and fine; those of the abactinal part of the test are longer than the others, especially in the interambulacral area.

The greatest diameter of the abactinal system is 26 mm. (Pl. 80, fig. *2*). The genital plates are comparatively small, very pointed, with a broad plate adjoining the anal system and smaller plates adjoining the genital membranes. The larger plates carry from five to seven secondaries, with a few miliaries irregularly arranged; the other plates carry large or small miliaries according to their size.

The oculars are large, irregularly heptagonal (Pl. 80, fig. *2*), carrying, next to the anal system, from seven to ten medium-sized secondaries with a few miliaries. The ocular pore is very small. The anal system is covered by three or four unevenly concentric rows of irregularly shaped polygonal plates, carrying small secondaries like those of the genital and ocular plates, and occasionally a few small miliaries, with an inner belt of very small elliptical plates round the anal opening.

The madreporic body is divided into two plates, the larger being rectangularly elongated transversely, forming the proximal base of the genital plate; the smaller is pentagonal and adjoins the odd anterior ocular plate.

The actinal system measures 32 mm. in greatest diameter. It is covered with twelve or thirteen rows of imbricating concentric ambulacral plates, each carrying a horizontal row of small secondaries (Pl. 80, fig. *1*). The plates do not extend quite to the teeth, and diminish rapidly in size from the base of the corona where they overlap sideways and vertically. A wide, bare, triangular space is thus left between each set of ambulacral plates (Pl. 80, fig. *1*) next the teeth, much as in *A. thetidis*, but not quite as marked as in that species (Pl. 70, fig. *2*).

The pedicellariæ of *pyrochloa* are so nearly like those of *hystrix* that no extended description is necessary. The *large tridentate* (Pl. 66, fig. *1*) have the valves .80–1.75 mm. long, while in the *small tridentate* (fig. *2*) they are only .70–.85 mm. in length. The *triphyllous* pedicellariæ (Pl. 66, fig. *3*) are very small, on very slender stalks; the valves measure only .30–.40 mm. in length. The *sphæridia* are somewhat club-shaped, .50–.60 mm. long. The *calcareous spicules* in the tube-feet are very numerous perforated plates of irregular form and size; some are nearly half a millimeter in diameter, and have about a hundred perforations.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 100 to 195 mm. in diameter:

Station 4919. Off Kagoshima Gulf, Japan; 30° 34′ N., 129° 19′ 30″ E. Bott. temp. 41.8°. 440 fathoms. Glob. oz.

Station 5086. Off Joka Sima Light, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7°. 292 fathoms. Gn. m., crs. bk. s.

Three specimens.

Aræosoma Belli Mortens.

Asthenosoma hystrix A. Agassiz, 1874. "Hassler" Ech., Mem. M. C. Z., IV, p. 3; Pl. II, figs. *1*, *2*. 1880. Bull. M. C. Z., VIII, p. 74.
Aræosoma Belli Mortensen, 1903. "Ingolf" Ech., I, p. 55.
Caribbean Sea; 103–140 fathoms.

Plate 66, fig. *5*.

Although Mortensen's species is based on the characters shown by the pedicellariæ, we find that the peculiarities of the test, pointed out in 1874, justify the recognition of this small West Indian species. The largest specimen before us is only 105 mm. in diameter.

This species is readily distinguished from *A. hystrix* by the greater height of both the ambulacral and interambulacral plates. In a specimen of *A. Belli* 72 mm. in diameter there are 22 interambulacral and 27 ambulacral plates in each column, from the ambitus to the abactinal system. On the actinal side, 16 interambulacral and 17 ambulacral plates in a column lie between the ambitus and the actinal system.

In a specimen of the same species 105 mm. in diameter there are 27 interambulacral and 40 ambulacral plates between the ambitus to the abactinal system. On this actinal side there are, from the ambitus to the actinal system, 18 interambulacral and 18 ambulacral plates.

In a specimen of *A. hystrix* 130 mm. in diameter we find on the abactinal side 27 interambulacral and 38 ambulacral plates between the abactinal system and the ambitus, and on the actinal side between the actinal system and the ambitus there are 22 interambulacral and 33 ambulacral plates.

In *A. Belli* there are two principal columns of interambulacral primaries on the actinal side, one of which includes a primary on each plate adjoining the ambulacral system; the other is nearer the median line, and includes only one on every other plate. These columns extend but little beyond the ambitus ("Hassler" Ech., Pl. II, figs. *1*, *2*); a secondary column of distant and irregularly placed primaries extends from the ambitus to the abactinal system. The ambulacral and interambulacral plates each carry one irregular row of small secondaries and miliaries at the centre of the plate.

In *A. hystrix* there are on the interambulacral plates six or seven vertical rows of primaries and secondaries, four of which are more prominent and regular than the others. In the median ambulacral area there are two series of primary tubercles. The rest of the plates, in both areas, are thickly covered with miliaries and a few very small secondaries.

The arrangement of the primaries and secondaries is much the same on the abactinal side, with the exception that the primary tubercles are smaller.

There are, both in *A. Belli* and *A. hystrix*, on the actinal side, spines with hoofs and many with a flaring extremity.

Aræosoma violaceum Mortens.

Aræosoma violaceum Mortensen, 1903. "Ingolf" Ech., I, p. 176.
West of Ireland; 199 fathoms.

We know nothing further of this species than what is given in the original brief description.

Aræosoma coriaceum Mortens.

Asthenosoma coriaceum A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 201. 1881. "Challenger" Ech., Pl. XVIIa, figs. *5–7*. 1904. Pan. Deep Sea Ech., p. 115, Pl. 52.
Aræosoma coriaceum Mortensen, 1903. "Ingolf" Ech., I, p. 53.
Vicinity of Tonga and Fiji Islands; 240–310 fathoms.

The large size, dark brown color, and very leathery test are noticeable features of this species.

Aræosoma tessellatum Mortens.

Asthenosoma tessellatum A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 201. 1881. "Challenger" Ech., Pls. XIXa, fig. *1;* XIXb. (Not *A. tessellatum* A. Ag. and Cl., 1907. Bull. M. C. Z., LI, p. 117.)
Aræosoma tessellatum Mortensen, 1903. "Ingolf" Ech., I, p. 54.
Philippine Islands; 100–115 fathoms. Kei Islands; 168 fathoms.

We are unable to add anything further to the facts known about this species.

Aræosoma fenestratum Mortens.

Calveria fenestrata Wyville Thomson, 1872. Proc. Roy. Soc. London, XX, p. 494. 1874. Phil. Trans. Roy. Soc. London, 164, pt. 2, Pls. LXIII, figs. *9, 10;* LXVI, LXVII.
Asthenosoma fenestratum A. Agassiz, 1881. "Challenger" Ech., p. 210.
Aræosoma fenestratum Mortensen, 1903. "Ingolf" Ech., I, p. 52.
Asthenosoma Reynoldsii A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 75.
Asthenosoma hystrix A. Agassiz, 1883. "Blake" Ech., Pls. XIII, XIV.
North Atlantic Ocean; 81–373 fathoms.

Pl. 66, fig. *20*.

While we do not feel sure that the Caribbean species (*Reynoldsii*) is identical with Wyville Thomson's *fenestratum*, as we have had no European specimens for comparison, it seems to be true, as Mortensen has pointed out, that both are distinct from *hystrix*. It is worthy of note that in the Caribbean specimens the dactylous pedicellariæ, which may be entirely wanting in otherwise normal specimens, not rarely have five valves (Pl. 66, fig. *20*). The very large tridentate pedicellariæ are sometimes wanting.

Aræosoma gracile A. Ag. and Cl.

Asthenosoma gracile A. Agassiz, 1881. "Challenger" Ech., p. 89; Pl. XVIIa, figs. *1–4*.
Asthenosoma longispinum Yoshiwara, 1897. Ann. Zool. Japon., I, p. 5.
Calveria gracilis Mortensen, 1903. "Ingolf" Ech., I, p. 51.
Asthenosoma tessellatum A. Ag. and Cl., 1907. Bull. M. C. Z., LI, p. 117. (Not *A. tessellatum* A. Ag. "Challenger" Ech., p. 88.)

Off Japan and the Philippines; 50–255 fathoms.

Plates 81, figs. *3, 4;* 82, figs. *5–8*.

On drying the specimen and making a more careful examination of it, we find that we were mistaken in referring to *A. tessellatum* an Echinothurid taken by the "Albatross" in 1906. The specimen is badly damaged, and the uniform dark brown color like that of *tessellatum* misled us. In spite of the peculiar color, it seems best to us now to refer the specimen to *A. gracile*, the structure of the test and the pedicellariæ agreeing well with that species. But there can be little doubt that *gracile* and *pyrochloa* are very near each other and both are very near *hystrix*, and the differences of color are as important as any that have been pointed out. But if we make color the criterion, the specimen before us cannot belong to any of the three species mentioned.

We refer to *gracile* with some hesitation, the small specimen from Station 3750, shown on Plate 81 (figs. *3–4*). The arrangement of the actinal tube-feet shows clearly that it is an Aræosoma, while comparison with young specimens of *Owstoni*, the commonest Japanese form of that genus, shows it cannot belong to that species. The coronal plates are much more numerous than in *Owstoni* at the same age, and the tuberculation of the test is different, the abactinal interambulacral plates being quite bare (Pl. 81, fig. *4*). As the large pedicellariæ are like those of *gracile* and *pyrochloa*, we believe it belongs to one of those species (though the color is quite bleached), and the depth at which it was taken certainly indicates *gracile*.

The specimens, which are 30 and 140 mm. in diameter respectively, were taken by the "Albatross" at the following stations:

Station 3750. Off Suno Saki, Honshu Island, Japan. 83–140 fathoms.[1] Gy. s., brk., sh.. p.

Station 4943. Kagoshima Gulf, Japan; 31° 24′ 35″ N., 130° 38′ 40″ E. 119 fathoms. Character and temperature of bottom not recorded.

[1] The label with the specimen gives the depth as 83–89 fathoms.

Aræosoma Owstoni Mortens.

Aræosoma Owstoni Mortensen, 1904. Ann. Mag. Nat. Hist. (7) XIV, p. 82; Pls. II and V, figs. *4–9, 11, 18–20.*
Asthenosoma Owstoni A. Agassiz and Clark, 1907. Bull. M. C. Z. LI, p. 117.
Sagami Bay, Japan; 50 fathoms.

Plates 81, figs. *1, 2, 5, 6;* 82, figs. *1–4.*

The specimens before us show considerable diversity of color, but it is difficult to say how much of this is due to preservation. The small individuals are very pale, almost white. Some medium-sized specimens are decidedly reddish; one is nearly brick red. The larger specimens are dull pale purplish. In most of the specimens the actinal spines are decidedly pinkish, while those of the abactinal side are greenish or not colored. The pedicellariæ agree with Mortensen's description and figures. Young specimens of *A. Owstoni* measuring 53 mm. and 21 mm. in diameter (Pls. 81, figs. *1, 2, 5, 6;* 82, figs. *1–4*) are characterized by the proportionally wider ambulacral area as compared to the interambulacral one. In the specimen measuring 53 mm. in diameter (Pl. 81, fig. *2*) the actinal primary interambulacral spines already carry a hoof. In the smaller specimen all the actinal primary spines are broken or missing. The hoofs are very numerous and very large on the primary actinal interambulacral spines of large specimens (150 mm. in diameter).

In the younger specimen (21 mm.) the two principal vertical rows of interambulacral primaries are largest near the apical system (Pl. 81, fig. *5*), but in the older one (Pl. 81, fig. *1*) they already have all the characters of the larger and full-grown specimens, both on the actinal and abactinal side of the test. In the specimen of 52 mm. the primary abactinal interambulacral spines are proportionally more slender and longer than in larger specimens (150 mm. in diameter) in which they are relatively stout.

The actinal system of the 52 mm. specimen (Pl. 82, fig. *1*) is covered with four and five horizontal rows of ambulacral plates, and close to the interambulacra there are a few minute elliptical plates. The ambulacral plates carry a small secondary at the extremity of each plate and occasionally a small miliary. At this stage (Pl. 81, fig. *1*) the genitals and oculars are of nearly the same size, the genitals separating the oculars (Pl. 82, fig. *2*). The oculars, as in the young of many other species of Aræosoma, extend outward between the two upper plates of the adjoining interambulacral areas. The genitals and oculars each carry a small secondary, with one or two miliaries in the central part of the proximal margin of the plate. The anal system is covered with three or four irregular concentric rows of polygonal plates, a few of the larger of which each carry a small secondary.

In the small specimen, measuring 21 mm. in diameter (Pl. 81, figs. *4, 5*), there are from the ambitus to the abactinal system 9 interambulacral and 15 ambulacral plates, in each column, while between the ambitus and the actinal system there are 7 interambulacral and 12 ambulacral plates. In the specimen measuring 52 mm. in diameter (Pl. 81, figs. *1, 2*) there are 14 interambulacral and 23 ambulacral plates, from the ambitus to the abactinal system. On the actinal side there are 11 interambulacral and 14 ambulacral plates from the ambitus to the actinal system. In a large specimen measuring 150 mm. in diameter, from the ambitus to the actinal system there are 17 interambulacral and 27 ambulacral plates, and between the ambitus and the abactinal system, 25 interambulacral and 47 ambulacral plates. The plates of the ambulacral areas are thus seen to increase in number much more rapidly than the interambulacral plates.

The specimens, which range from 20 to 150 mm. in diameter, were taken by the "Albatross" at the following stations:

Station 4875. Eastern channel, Korea Strait; 34° 19′ N., 130° 9′ E. 59 fathoms. Fne. gy. s., brk. sh.

Station 4876. Eastern channel, Korea Strait; 34° 20′ N., 130° 10′ E. Bott. temp. 62.1°. 59 fathoms. Fne. gy. s., brk. sh.

Station 4877. Eastern channel, Korea Strait; 34° 20′ 30″ N., 130° 11′ E. 59 fathoms. Fne. gy. s., brk. sh.

Station 4880. Eastern channel, Korea Strait; 34° 16′ N., 130° 16′ E. 59 fathoms. Fne. gy. s., brk. sh.

Station 4946. Between Kagoshima and Kobe, Japan; 31° 29′ 10″ N., 130° 34′ 30″ E. Bott. temp. 68.7°. 39 fathoms. Br. s., brk. sh., p.

Station 5095. In Uraga Strait, Gulf of Tokyo, Japan; 35° 5′ 34″ N., 139° 38′ 36″ E. Bott. temp. 57.8°. 58 fathoms. Fne. bl. s., brk. sh.

Bathymetrical range, 39–59 fathoms. Extremes of temperature, 68.7°–57.8°.

Eleven specimens.

Sperosoma.

Kœhler, 1897. Zool. Anz. XX, p. 302.
Type-species, *Sperosoma Grimaldii* Kœhler, l. c.

The general appearance of Sperosoma is much like that of Echinosoma, the test being, as in that genus, thin and flexible with little difference between the upper and lower sides. The spines and tubercles of the actinal side are larger than those above and the primaries have well-developed hoofs. The actinal tube-feet are in three distinct series and have small sucking-discs or none. The sphæridia are as in Echinosoma. Although the characteristic actinal ambulacra are very remarkable and serve well to distinguish the genus, it must not be supposed that the separation of the primary ambulacral plate into an outer poriferous and an inner non-poriferous part is a feature confined to Sperosoma. Many specimens of *Echinosoma tenue* (and doubtless other members of that genus) show the same phenomenon to a greater or less degree. It is quite common in *tenue* to find the inner and outer halves of the primary plate separated by a suture, even though narrowly in contact, and occasionally the two secondary elements nearly, if not quite, meet between them. This formation of plates by resorption is one of the characters in which the Echinothuridæ are most unique. The essential difference between Sperosoma and Echinosoma in the structure of the ambulacrum is in the *position* of its component parts; thus although the primary plate of Echinosoma may be divided into two parts, there are not four columns of plates in each half-ambulacrum, for the upper (outer) secondary element lies above the outer half of the primary plate and is more or less extensively a part of the interambulacral margin of the ambulacrum. In Sperosoma, the outer halves of the primary plates lie one above the other, broadly in contact, and forming the outer of the four half-ambulacral columns. In Echinosoma this is not the case, the outer column consisting of outer halves of primaries alternating with the upper secondary plate elements, more or less irregularly. The existence of a pair of median columns of imperforate ambulacral plates is a feature in which Sperosoma is absolutely unique among all recent regular Echini, but when we recognize the origin of the plates which compose them, we see that it is not so much their presence, as the way in which they are formed, that is really remarkable. In well-preserved specimens one can trace (as Mortensen ("Ingolf" Ech. II, p. 171, fig. *27*) has done in a very young specimen) the development of the ambulacral plates from their origin next the ocular plate, where we find a primary with a secondary element above and another below it, the three of nearly equal size; through the stage where the primary is much the largest and much wider than high, while the upper secondary has taken an outer, the lower an inner position; through another stage where the secondary elements have so encroached on the primary that the outer and inner halves are only narrowly connected, the pore-pair being in the outer half; to the full four-column arrangement of the actinal side, where the plates are more or less nearly of a size and the distinction between primary and secondary elements is almost obliterated.

Mortensen (1903, "Ingolf" Ech., I, p. 63) says of Sperosoma that sucking-discs are well developed on the feet. We judge this is a slip of the pen, for observation on many specimens indicates that they are wanting, or rudimentary, as shown in his Pl. XIV, fig. *4*.

There seem to be six recognizable species in this genus, which may be distinguished as follows:

Abactinal ambulacral plates not twice as numerous as actinal.
- Primary spines of abactinal surface numerous, 150–500 or more in specimens over 100 mm. h. d.
  - Abactinal tube-feet few in an imperfect double series; poriferous zone very narrow; actinal primary spines rather less than 150 . . . . *Grimaldii.*
  - Abactinal tube-feet more numerous in three unequal series, a more or less distinct quincunx arrangement being evident; poriferous zones often quite broad; actinal primary spines rather more than 150 . . . . *quincunciale.*
- Primary spines of abactinal surface few, never exceeding 125 and usually fewer than 75, sometimes nearly or quite wanting.
  - Abactinal primary tubercles very small or wanting; ambulacra much wider than interambulacra . . . . *giganteum.*
  - Abactinal primary tubercles large, with areolæ often occupying whole height of plate; ambulacra about as wide as interambulacra . . . . *obscurum.*

Abactinal ambulacral plates more than twice as numerous as actinal.
  - Abactinal tube-feet in two distinct series; no ambulacral plates extending across an entire half-ambulacrum . . . . *biseriatum.*
  - Abactinal tube-feet in a single crowded series; some ambulacral plates extend across the entire half-ambulacrum . . . . . . *durum.*

Sperosoma Grimaldii Kœhler.

Sperosoma Grimaldii Kœhler, 1897. Zool. Anz., XX, p. 302. 1898, "Hirondelle" Ech., Pls. II, III, etc.
North Atlantic; 165–930 fathoms.

In addition to one of the "Thor" specimens, received in exchange from the Copenhagen Museum, there lies before us a specimen of Sperosoma taken by the "Blake" off Barbados in 399 fathoms. This specimen is only 110 mm. in diameter, but the structure of the actinal ambulacra is the same as in large specimens. The color is reddish purple. This specimen had been identified as "*Phormosoma Petersii*," no part of an actinal ambulacrum having been cleaned for examination of the plates, and the general facies being very much like *Petersii.* Its pedicellariæ are all rather small and agree well with Mortensen's figures of those of *Grimaldii.* The "Thor" specimen has some very large pedicellariæ, but they are widely scattered; the smaller ones are rather different in form from the published figures, the base of the valves being somewhat swollen.

Sperosoma quincunciale de Meij.

Sperosoma quincunciale de Meijere, 1904. "Siboga" Ech., p. 40; Pl, XIII. figs. *166–176.*
South of Timor; 490 fathoms.

The specimens before us, except for some diversity in color and in the arrangement of the feet abactinally, agree well with de Meijere's description. While the general coloration is distinctly violet of some shade, two or three of the specimens have the abactinal surface and the actinal spines quite yellow. None of the specimens are as large as de Meijere's type. They range from 140 to 170 mm. in diameter. In most of the specimens the tube-feet show the quincunx arrangement abactinally quite plainly, but in one or two specimens the foot on the upper secondary plate-element, instead of being on the same level as that of the lower secondary element of the plate above, is decidedly below it, and the quincunx arrangement, is thereby obscured, the first impression being that of a zigzag line of feet. In other respects these specimens are normal, and we see no reason to consider this peculiarity other than individual variation. The actinal primary spines are provided with large and conspicuous white "hoofs."

Many of the actinal primary spines of these Japanese specimens are infested with a parasitic copepod, apparently identical with *Echinocheres globosus*

Hansen, which Mortensen found in the spines of *Aræosoma gracile.* They produce a swelling in the shaft of the spine, with a small opening at the distal end, giving water access to the cavity in which the animal lives. Not rarely there are two of these parasites in the shaft of a single spine.

The "Albatross" took the species at the following stations:

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 23′ E. Bott. temp. 39.8°. 437 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 5079. Off Omai Saki, Japan; 34° 15′ N., 138° E. Bott. temp. 39.1°. 475–505 fathoms. P.

Station 5080. Off Omai Saki, Japan; 34° 10′ 30″ N., 138° 40′ E. Bott. temp. 38.7°. 505 fathoms. Fne. gy. s., glob.

Bathymetrical range, 437–505 fathoms. Extremes of temperature, 39.8°–38.7°.

Seven specimens.

Sperosoma giganteum. A. Ag. and Cl.

Sperosoma giganteum. A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 120.

Pl. 64, figs. *9–12*; 65, figs. *1–3*; 83–86.

This remarkable sea urchin measures nearly 320 mm. in its greatest diameter. The color is deep purple, almost black. The ambulacral area is extraordinarily wide, for on the abactinal surface just above the ambitus it measures over 110 mm., while the interambulacrum is a little over 80 mm. (Pl. 83). The outer and inner columns in each half of each ambulacrum are made up of remarkably long low plates, which just above the ambitus are 25 mm. long and only 5 mm. high (Pls. 83, 86, fig. *2*). There are no primary tubercles above the ambitus, but the whole abactinal surface is rather closely covered with slender secondaries and miliaries (Pl. 83). On the actinal surface (Pls. 84, 86, fig. *1*) primary spines are fairly numerous but irregularly placed, showing no regular arrangement. Many ambulacral plates have two, and many interambulacral plates four, spines. The areolæ are small (Pl. 86, fig. *1*), the diameter usually less than half the height of the plate. The primary spines of the actinal surface are nearly all broken off; the remaining ones are seldom 25 mm. long, and terminate in a conspicuous white hoof (Pl. 84).

Both the actinal and abactinal systems of this species (Pl. 85, figs. *2*, *1*) differ greatly from the figures given by Kœhler of *S. Grimaldii,* as well as those by Döderlein of *S. biseriatum* and those here given of *S. obscurum* (Pl. 89).

The actinal system of *S. Grimaldii* as figured by Kœhler shows its plates to be closely packed with small secondaries arranged horizontally completely connecting the sutures; nor does Kœhler figure any actinostomal ambulacral pores. The actinostomal ambulacral plates of *S. giganteum* (Pl. 85, fig. *2*) are, on the contrary, well separated, arranged in ten vertical series.

In all the other species of Sperosoma, of which the abactinal system has been figured, the genital and ocular plates are most distinct, and while each genital is made up of many plates, it is a simple matter to distinguish them from the anal plates. However, such is not the case in *S. giganteum*, for it seems impossible in the maze of polygonal anal plates, with their close granulation (Pl. 85, fig. *1*) encroaching upon the broken genital and ocular plates, to distinguish the limits of the latter. It is of course possible that this great breaking up of the plates of the abactinal system may be due to age. The madreporic plate is irregularly circular, surrounded with small plates and edged with miliaries. It is the only genital one can trace with any certainty (Pl. 85, fig. *1*), and of the oculars, the left posterior is the only one at all distinct.

The pedicellariæ are interesting, for in addition to tridentate pedicellariæ similar to those of *S. biseriatum* Död. (but seldom with valves as much as two millimeters long) we find ophicephalous and triphyllous pedicellariæ abundant. The latter are not peculiar, but the former are almost exactly like those figured by Mortensen (1903, Pl. 14, fig. *23*) as characteristic of his proposed new genus "Tromikosoma"! In no other respect, however, does this species resemble that group. All the pedicellariæ are numerous but small. The tridentate and triphyllous occur practically everywhere, but the ophicephalous seem to be confined to the ambital region.

The *tridentate* (Pl. 64, fig. *9*) are provided with comparatively short stalks and have a very short neck; the stalks slightly exceed the head in large examples, but are three or four times the head in small ones. The valves (Pl. 64, figs. *10–11*) range from .40 to 1.20 mm., but are most commonly less than a millimeter. They are blunt, often decidedly rounded at tip, and the margins are very slightly sinuate, or a little concave at the base of the blade. In large examples there is more or less of a calcareous mesh-work in the blade.

The *triphyllous* pedicellariæ are not peculiar, save that the valves (Pl. 64, fig. *12*) are rather wide, with a fairly well developed and apparently imperforate cover-plate; they measure about half a millimeter in length and more than half that in width at the tip.

The *ophicephalous* pedicellariæ (Pl. 65, figs. *1*, *2*) are very common on the abactinal surface, just above the ambitus, but become less common as we pass toward either pole, and are practically wanting at a distance of 75 mm. from the ambitus. The stalks are three or four times as long as the heads. The valves (Pl. 65, fig. *3*) are .60–.70 mm. in length and have the form usual in the Echinothuridæ.

The sphæridia and calcareous spicules (perforated plates) in the tube-feet show no noteworthy features.

The single specimen of this species was taken by the "Albatross" at the following station:

Station 5082. Off Omai Saki Light, Honshu Island, Japan; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Sperosoma obscurum A. Ag. and Cl.

Sperosoma obscurum A. Agassiz and Clark, 1907. Bull. M. C. Z., L., p. 239.

Plates 62, fig. *4*; 63, fig. *1*; 65, figs. *4–14*; 87–89.

A large number of specimens of Sperosoma were collected among the Hawaiian Islands, which could not be referred to any previously known species of the genus. In a specimen measuring 169 mm. in diameter there are 19 interambulacral plates (Pl. 87) between the ambitus and the abactinal system in each column, and 25 ambulacral plates. At the ambitus the interambulacral area measures 55 mm. across and the ambulacral 50. On the abactinal surface there are comparatively few primary tubercles, forming irregular vertical rows on each side of the interambulacral area. They have large scrobicular circles (Pl. 87), and carry comparatively stout spines. The rest of the abactinal surface of the test is covered with distant small, sharp, and slender secondary and miliary spines (Pl. 89, fig. *4*).

On the actinal side there are 18 ambulacral and 13 interambulacral plates between the actinal system and the ambitus. Each of the central ambulacral plates near the ambitus carries one large primary tubercle (Pls. 88, 89, fig. *3*), and in the interambulacral area (Pls. 88, 89, fig. *4*) there is one at each extremity of the plate.

The pores on the abactinal surface are arranged in a double series on each side of the ambulacrum, but the outer series contains fifty per cent more pores than the inner, and a quincunx arrangement is seldom visible (Pl. 89, fig. *4*). The greater part of the actinal surface, especially about the actinostome, is closely covered with small tubercles of more or less uniform size (Pls. 88, 89, fig. *1*), giving an appearance not wholly unlike *Chætodiadema;* this is most marked in large individuals.

The actinal system (Pl. 89, fig. *1*) is well covered by about eight concentric series of narrow plates, each carrying one row of small secondaries; the plates decrease rapidly in size adorally and leave small bare areas between the adjoining ambulacra close to the mouth.

In the abactinal system (Pl. 89, fig. *2*) the ocular plates are comparatively small, with distinct pores, and each carries two or three miliaries or secondaries. In the specimen figured three of the genital plates are well limited, and each carries from two to six small secondaries and miliaries. With the other genitals, one cannot separate the plates of the anal system from those which may be small proximal parts of the genital plates. The genital pore is about in the centre of an elongate rectangular membrane extending well down between the columns of abactinal interambulacral plates. There are three to five rows of irregularly shaped small anal plates, each carrying one or two small secondaries or miliaries.

The coloration of this species is rather variable, for while most of the specimens are more or less decidedly violet or purple, some large ones are distinctly gray or yellowish-brown; the plates, at least abactinally, are frequently quite plainly outlined in a shade darker than the rest of the test.

The pedicellariæ are abundant and rather characteristic. No ophicephalous pedicellariæ were found. The *tridentate* pedicellariæ (Pl. 65, figs. *4*, *5*) occur everywhere and in very diverse sizes. The stalks (Pl. 65, fig. *7*) are usually twice the length of the head, and may be three or four times as long. The valves (Pl. 65, figs. *6*, *9*, *10*) are slender, often very slender, compressed, in contact distally, and usually well separated at the base; the lateral margin is broadly curved where the blade joins the base (fig. *10*); much more rarely the blades are in contact for most of their length, and the lateral margins are abruptly curved in (fig. *9*) where the blade joins the base. The valves range in length from half a millimeter to nearly three millimeters.

The *triphyllous* pedicellariæ are abundant everywhere. The necks are long and slender, often three times as long as the head, and the stalks (Pl. 65, fig. *8*) may be twice as long as the neck or even longer. The valves (Pl. 65, figs. *11, 12*) are somewhat variable in form and proportions; they are one-third to one-half a millimeter in length, and the tip may be rather abruptly truncate, and in width considerably more than half the length, or it may be more rounded and in width less than half the length. The cover-plate is perforated but is only slightly developed.

The *sphæridia* (Pl. 65, fig. *13*) are rather large and occur well up on to the abactinal side. The *calcareous plates* (Pl. 65, fig. *14*) in the tube-feet are rather small but fairly abundant.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 20 to 220 mm. in diameter:

Station 3824. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 49.5°. 222–498 fathoms. Co., r., brk. sh.

Station 3865. Between Maui and Molokai, H. I. Bott. temp. 44.8°–45°. 256–283 fathoms. Fne. vol. s., r.

Station 3979. Off Modu Manu, H. I. Bott. temp. 54°. 222–387 fathoms. Fne. wh. s., for., r.

Station 3988. Off Hanamaulu, Kauai, H. I. Bott. temp. 40°. 165–469 fathoms. Gy. for., s., p.

Station 4015. Off Hanamaulu, Kauai, H. I. Bott. temp. 41.2°. 318–362 fathoms. Gy. s., r.

Station 4021. Off Hanamaulu, Kauai, H. I. Bott. temp. 44°. 286–399 fathoms. Co. s., for.

Station 4025. Off Mokuaeae Point, Kauai, H. I. Bott. temp. 44.9°. 275–368 fathoms. Fne. gy. s., brk. sh., for.

Station 4036. Off Kawaihae Light, Hawaii, H. I. Bott. temp. 38.2°. 687–692 fathoms. Fne. dk. gy. s., for.

Station 4089. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 297–304 fathoms. Fne. gy. s.

Station 4096. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4112. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.5°. 433–447 fathoms. Fne. s.

Station 4117. Off Kahuku Point, Oahu, H. I. Bott. temp. 45.6°. 253–282 fathoms. Co. s., for.

Station 4130. Off Hanamaulu, Kauai, H. I. Bott. temp. 46.1°. 283–309 fathoms. Fne. gy. s.

Station 4131. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.7°. 257–309 fathoms. Fne. gy. s.

Station 4134. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.3°. 225–324 fathoms. Fne. co. vol. s.

Station 4136. Off Hanamaulu, Kauai, H. I. Bott. temp. 44.2°. 294–352 fathoms. Fne. co. s.

Station 4137. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 411–476 fathoms. Co., vol. s., for., r.

Bathymetrical range, 165–692 fathoms. Extremes of temperature, 54°–38.2°.

Thirty-nine specimens.

Sperosoma biseriatum Död.

Sperosoma biseriatum Döderlein, 1901. Zool. Anz., XXIII, p. 20. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XIX; XL, figs. *1–1h*.

Sperosoma biseriatum Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 120.

Western Indian Ocean; 563 fathoms.

Plate 65, figs. *15–20*.

The specimen which we have referred to this species differs very markedly from Döderlein's type, and, taking these differences in connection with the very great geographical and bathymetrical distances between the two specimens, we have little doubt that they are not identical. But in view of the poor condition of our specimen and the fact that in certain important particulars it agrees well with *biseriatum*, it has seemed to us better to let it remain under this name, than to attempt the diagnosis of a new species based upon it.

The test is thicker and tougher than in Döderlein's specimen, and the color, which is a deep violet where the epidermis is not rubbed off, is very different. The pedicellariæ also show some slight differences which we have thought worth figuring. They are very abundant all over the test, but only tridentate and triphyllous were found; there seem to be no ophicephalous ones. The *tridentate* pedicellariæ (Pl. 65, figs. *15*, *16*) have the necks very short and the stalks 2–5 times as long as the head; the valves (fig. *18*) are short and wide, closely in contact for practically their whole length, and with nearly even, scarcely at all sinuate, margins; the middle of the blade is filled by an extensive calcareous mesh-work; the valves measure from .30–1.40 mm. in length, and the width at base is about two-thirds as much.

The *triphyllous* pedicellariæ (Pl. 65, fig. *17*) are not peculiar, though neck and stalk are both very slender; the valves (fig. *19*) are very much like those of *S. obscurum*, and are about .50 mm. in length.

The *calcareous particles* in the tube-feet (Pl. 65, fig. *20*) are large, perforated plates, half a millimeter more or less in diameter; the largest have rough ridges and projections near the middle. No sphæridia were found.

The single specimen, about 175 mm. in diameter, was taken by the "Albatross" at the following station:

Station 4766. Between Atka Island and Bowers Bank, Bering Sea; 52° 38′ N., 174° 49′ W. 1766 fathoms. Character and temperature of bottom not recorded.

Sperosoma durum Död.

Sperosoma durum Döderlein, 1905. Zool. Anz., XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XVIII, figs. *2, 2a;* XL, figs. *4–4n.*

Western Indian Ocean; 913 fathoms.

In addition to the characters given on p. 195, the deep purple-red color and the presence of ophicephalous pedicellariæ are interesting features of this species, of which only a single specimen, 112 mm. in diameter, is known. The name refers to the character of the test, which is firmer and stouter than in *biseriatum*, particularly abactinally.

EXPLANATION OF THE PLATES.

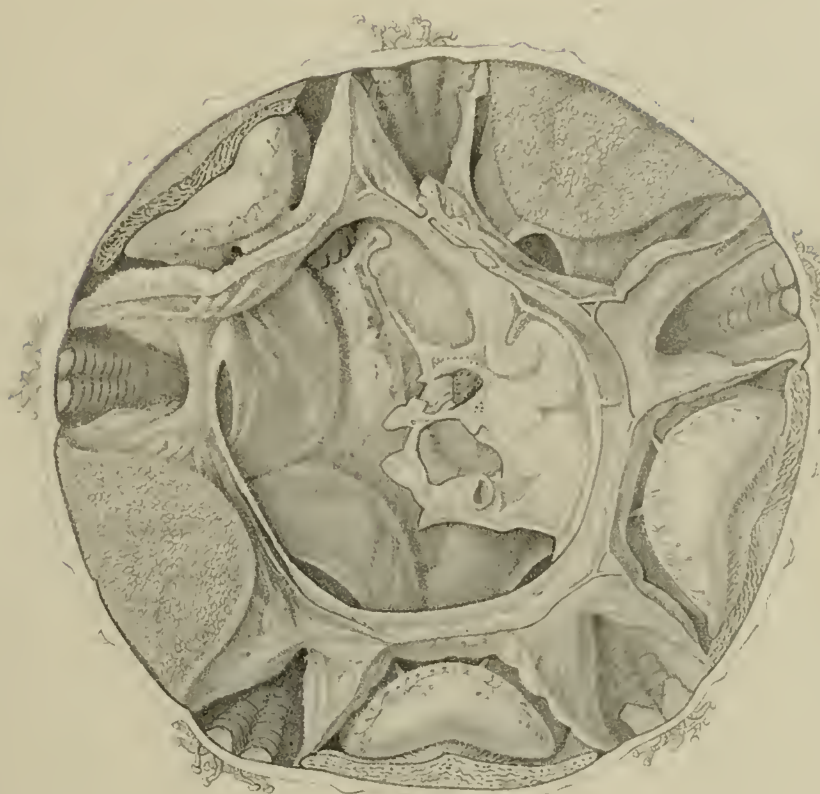
Plate 60.

Plate 60.

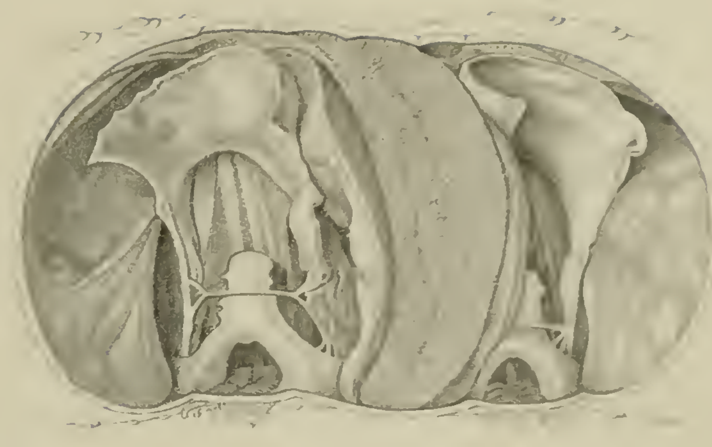
Showing some Features of the Internal Anatomy of
Echinothrix diadema Lovén.

1. Interior view, showing arrangement of alimentary canal; actinal half of test and lantern removed.
2. Interior view, showing part of reproductive organs, alimentary canal and perignathic girdle; one side of test removed.
3. Alimentary canal, removed from test; natural position, seen from below.
4. Lantern and perignathic girdle in position, seen from the side, showing the rudimentary Stewart's organ just below the forked end of the compass.

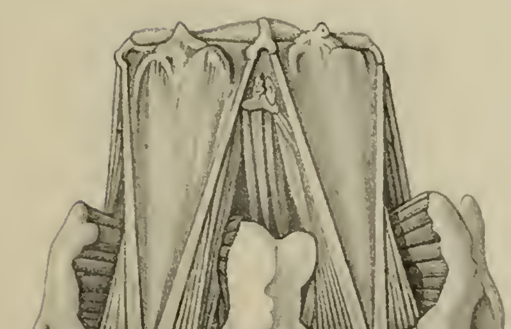
All figures natural size.



1



2



4

3

H.L. Clark del.

Plate 61.

Plate 61.

Showing some Features of the Internal Anatomy of
Astropyga and Micropyga.

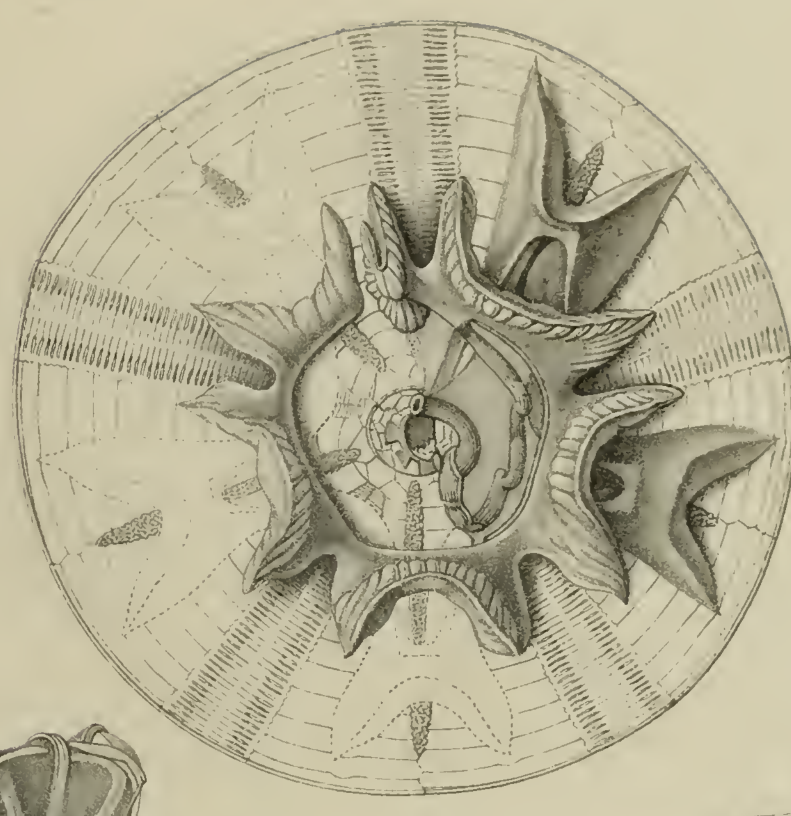
1, 2. **Micropyga tuberculata** A. Ag.

1. Interior view, showing arrangement of alimentary canal; actinal half of test and lantern removed. The dotted lines surrounding unshaded parts are hypothetical, the specimen being somewhat damaged.
2. Lantern and perignathic girdle in position, seen from the side.

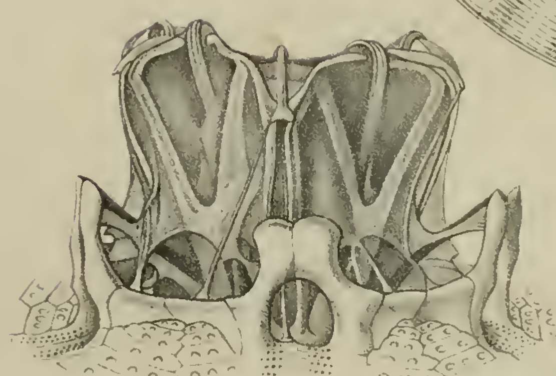
3, 4. **Astropyga radiata** Gray.

3. Interior view, showing arrangement of alimentary canal; actinal half of test and lantern removed.
4. Lantern and perignathic girdle in position, seen from the side.

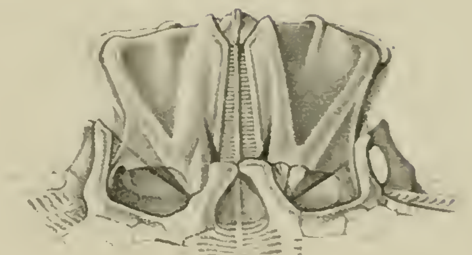
All figures natural size.



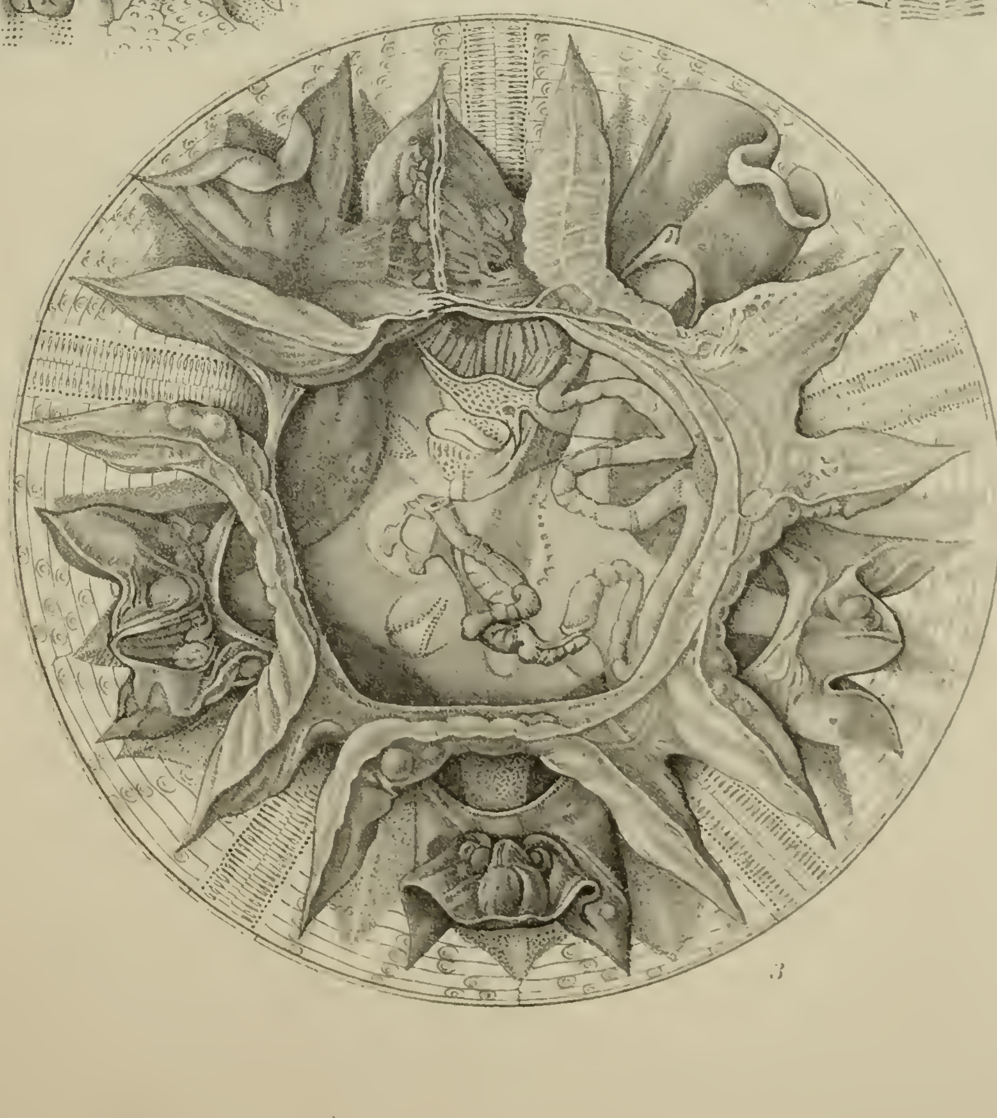
1



4



2



3

PLATE 62.

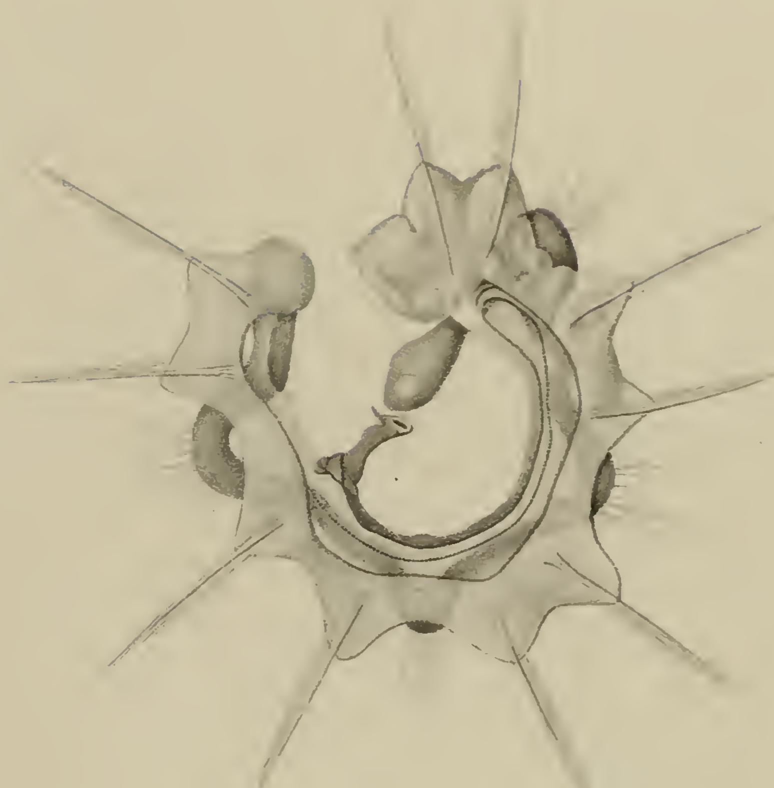
Plate 62.

Alimentary canals of Echinothurids, removed from the tests, natural position, seen from below.

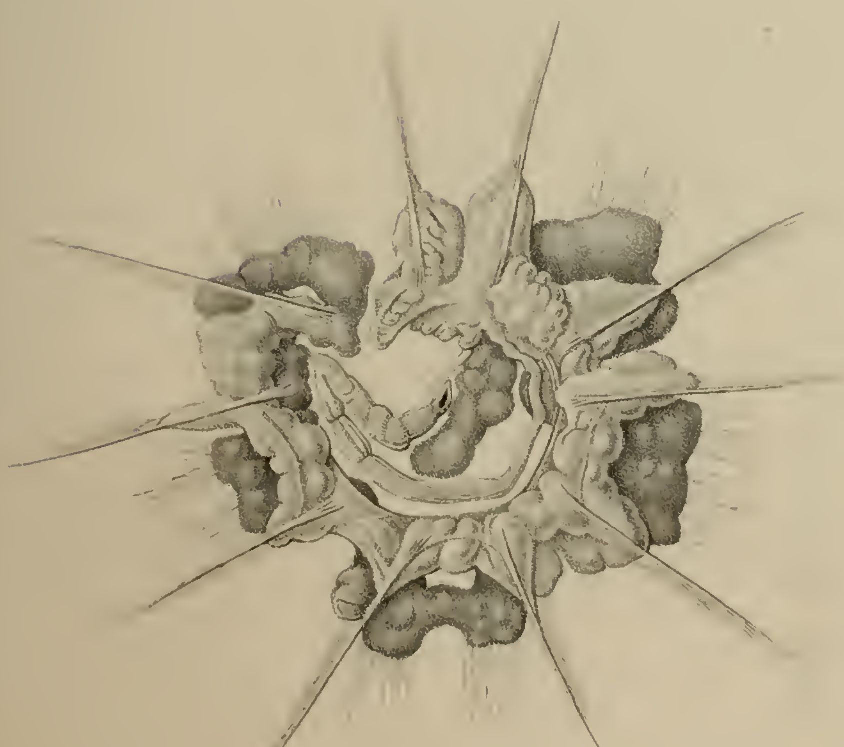
1. Asthenosoma Ijimai Yosh.
2. Phormosoma bursarium A. Ag.
3. Echinosoma hispidum Mortens.
4. Sperosoma obscurum A. Ag. and Cl.

All figures natural size.

1



2



3

4

A.M.Westergren, del.

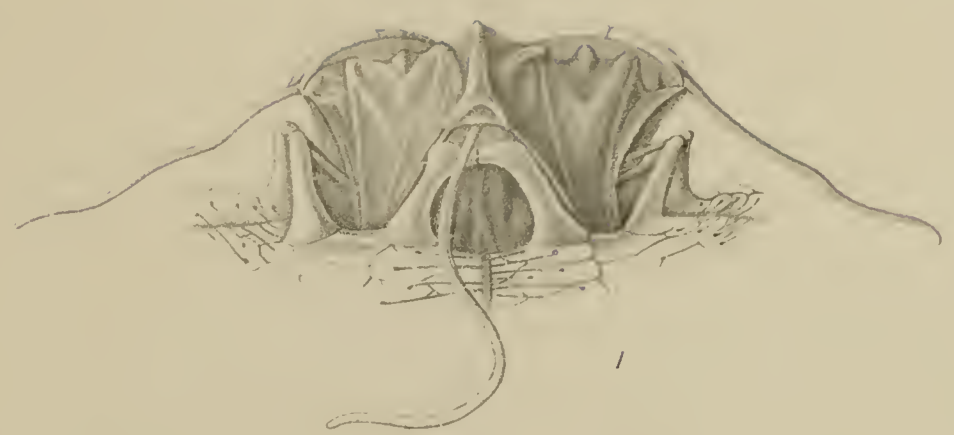
Plate 63.

Plate 63.

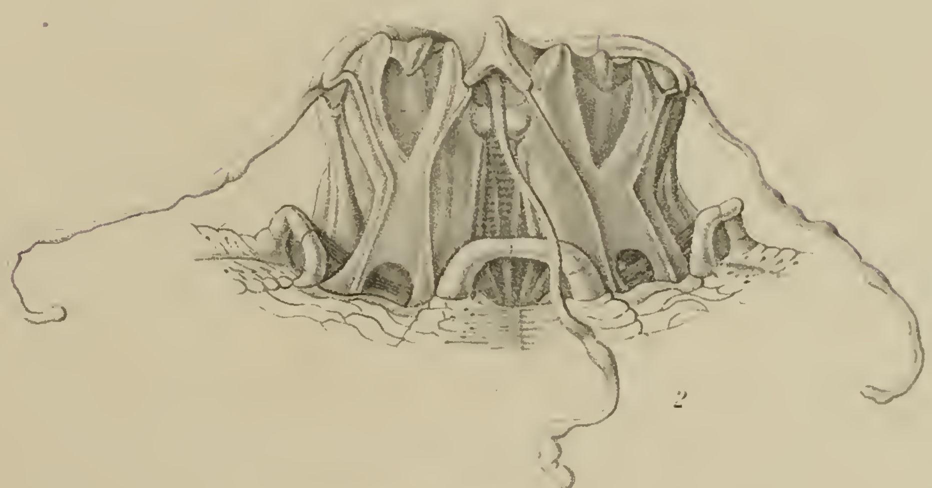
Perignathic Girdles, Lanterns, and Stewart's Organs of Echinothurids, in natural position, seen from the side.

1. **Sperosoma obscurum** A. Ag. and Cl.
2. **Asthenosoma Ijimai** Yosh.
3. **Phormosoma bursarium** A. Ag.
4. **Echinosoma hispidum** Mortens.

All figures considerably enlarged.

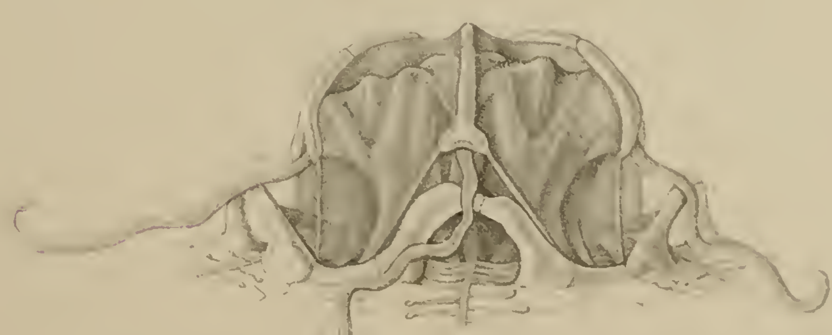


1



2

3



4

A. M. Westergren del.

PLATE 64.

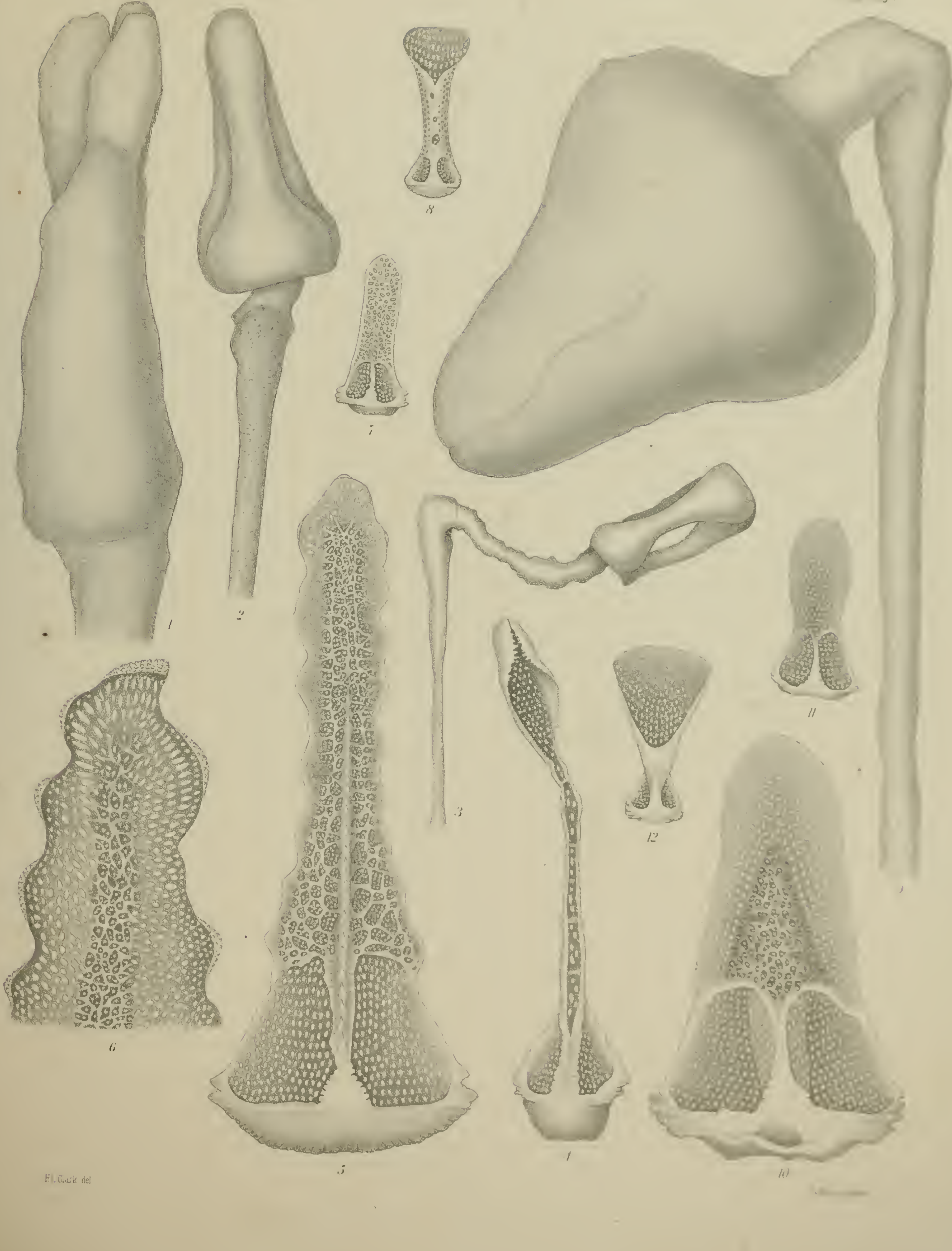
Plate 64.

1–8. **Aræosoma bicolor** A. Ag. and Cl.

1. Dactylous pedicellaria. × 70.
2. Large tridentate pedicellaria. × 30.
3. Triphyllous pedicellaria. × 70.
4. Valve of dactylous pedicellaria. × 70.
5. Valve of large tridentate pedicellaria. × 70.
6. Tip of valve of large tridentate pedicellaria. × 150.
7. Valve of small tridentate pedicellaria. × 70.
8. Valve of triphyllous pedicellaria. × 70.

9–12. **Sperosoma giganteum** A. Ag. and Cl.

9. Large tridentate pedicellaria. × 70.
10. Valve of large tridentate pedicellaria. × 70.
11. Valve of small tridentate pedicellaria. × 70.
12. Valve of triphyllous pedicellaria. × 70.



H. Clark del.

PLATE 65.

Plate 65.

1–3. Sperosoma giganteum A. Ag. and Cl.

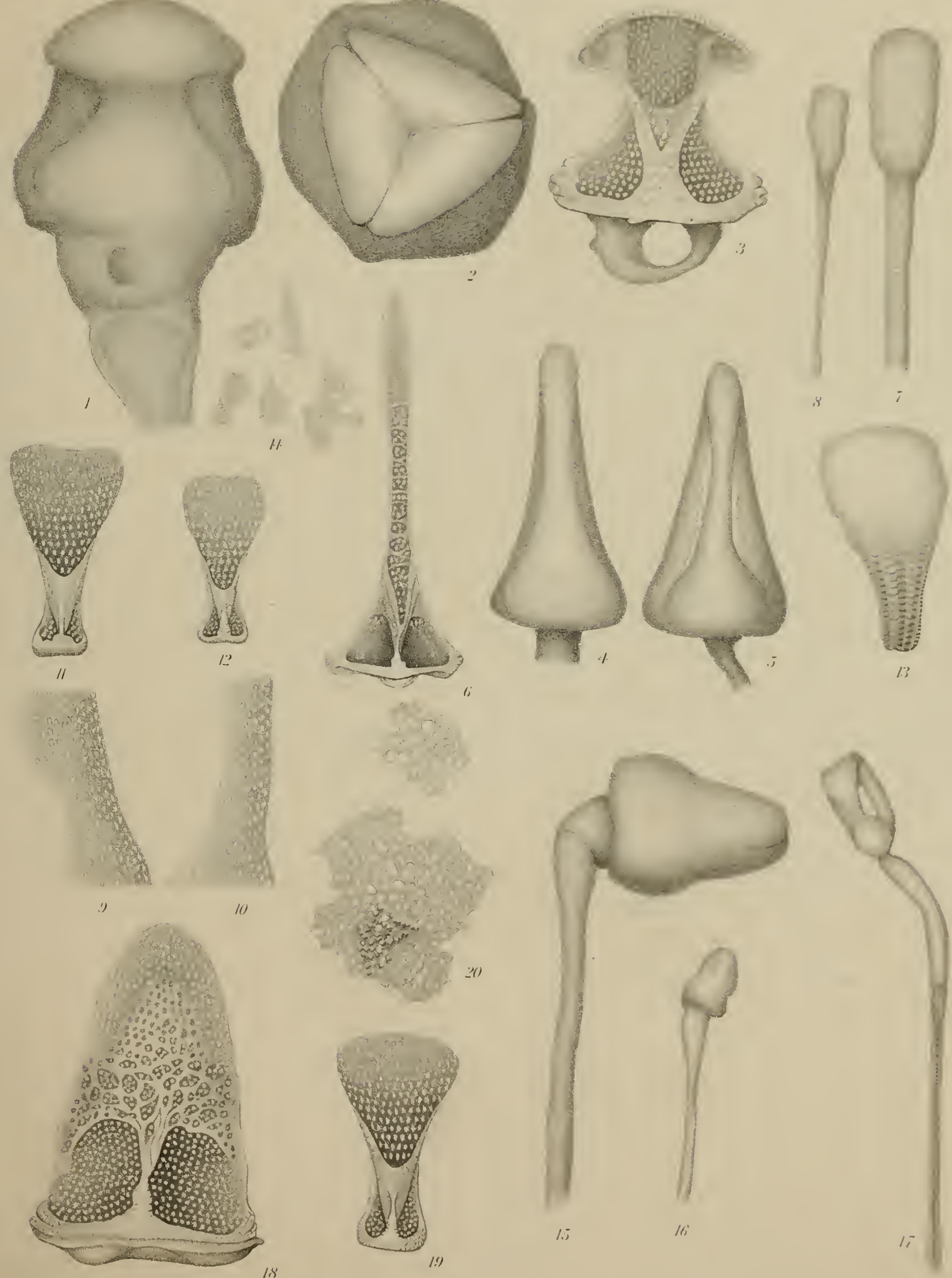
1. Ophicephalous pedicellaria, seen from the side. × 70.
2. The same, seen from distal end. × 70.
3. Valve of same, seen from within. × 70.

4–14. Sperosoma obscurum A. Ag. and Cl.

4. Tridentate pedicellaria, with valves in contact throughout. × 30.
5. Tridentate pedicellaria, with valves in contact only at tip. × 30.
6. Valve of a tridentate pedicellaria like fig. 5. × 70.
7. Stalk of tridentate pedicellaria. × 70.
8. Stalk of triphyllous pedicellaria. × 70.
9. Base of blade of valve of tridentate pedicellaria like fig. 4, side view. × 70.
10. Base of blade of valve of tridentate pedicellaria like fig. 5, side view. × 70.
11. Valve of a triphyllous pedicellaria. × 70.
12. Valve of another triphyllous pedicellaria. × 70.
13. Sphæridium. × 70.
14. Calcareous particles from pedicels. × 70.

15–20. Sperosoma biseriatum Död. (?). From Station 4766.

15. Large tridentate pedicellaria. × 30.
16. Small tridentate pedicellaria. × 30.
17. Triphyllous pedicellaria. × 30.
18. Valve of tridentate pedicellaria. × 70.
19. Valve of triphyllous pedicellaria. × 70.
20. Calcareous particles from pedicels. × 70.



H. L. Clark del.

Plate 66.

Plate 66.

1–4. **Aræosoma pyrochloa** A. Ag. and Cl.

1. Large tridentate pedicellaria. × 30.
2. Small tridentate pedicellaria. × 30.
3. Triphyllous pedicellaria, with partly open valves. × 30.
4. Sphæridium. × 30.

5. **Aræosoma Belli** Mortens.

5. Sphæridium. × 70.

6–17. **Aræosoma thetidis** A. Ag. and Cl.

6. Valve of very small tridentate pedicellaria. × 70.

7–10. Margins of valves of tridentate pedicellariæ. × 70.

11. Blade of valve of large tridentate pedicellaria, from within. × 70.
12. Tip of blade of large tridentate pedicellaria, side view. × 70.
13. Calcareous particles from pedicels. × 70.
14. Valve of triphyllous pedicellaria. × 70.
15. Large tridentate pedicellaria. × 30.
16. Triphyllous pedicellaria. × 30.
17. Tridentate pedicellaria. × 30.

18, 19. **Aræosoma eurypatum** A. Ag. and Cl.

18. Sphæridia. × 70.
19. Valve of triphyllous pedicellaria. × 70.

20. **Aræosoma fenestratum** Mortens.

20. Dactylous pedicellaria with *five* valves. × 30.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Plate 67.

Plate 67.

1–3. **Echinosoma panamense** Mortens.

1. Triphyllous pedicellaria. × 70.
2, 3. Tridentate pedicellariæ. × 70.

4–11. **Echinosoma hispidum** Mortens.

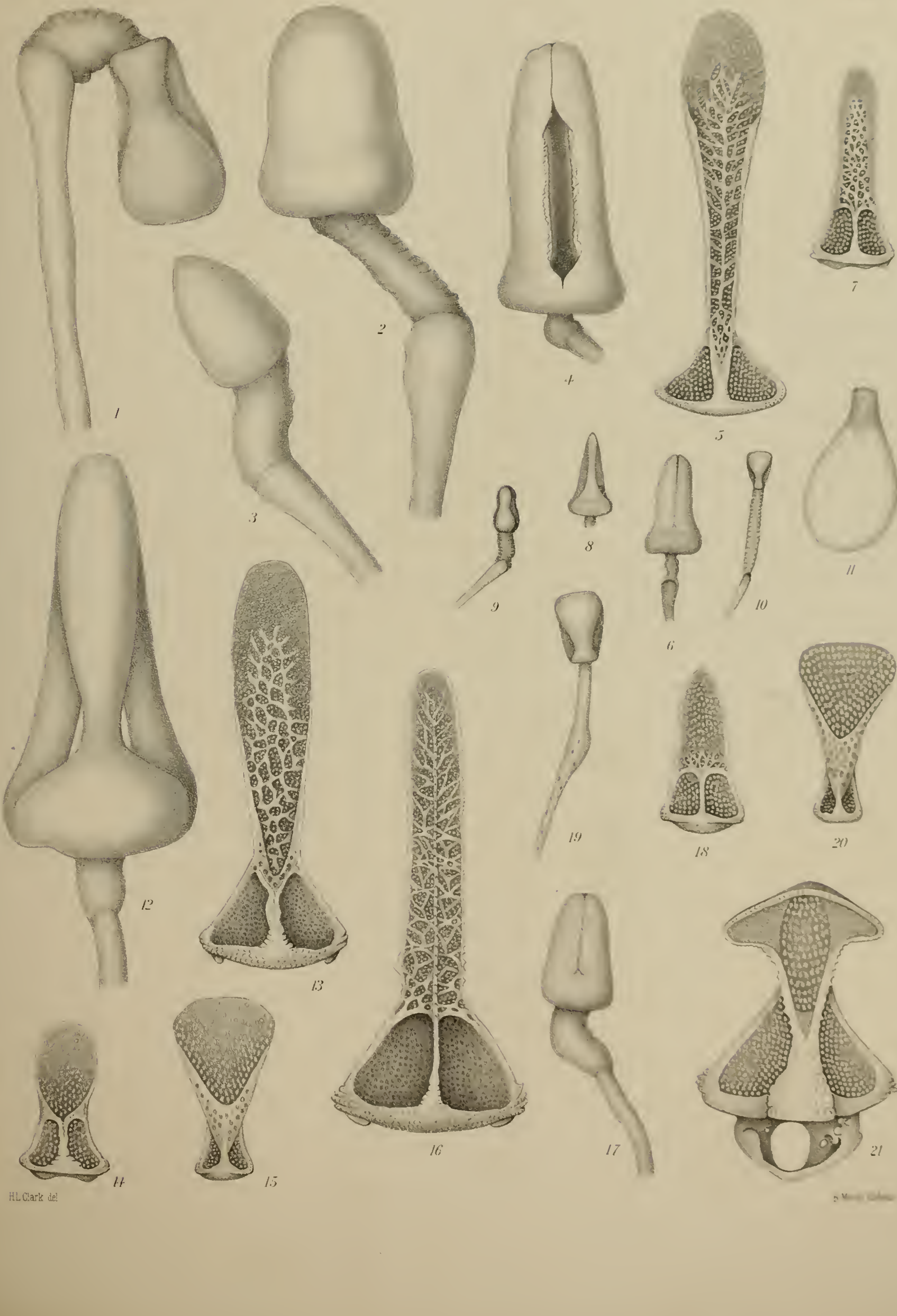
4. Large tridentate pedicellaria. × 10.
5. Valve of large tridentate pedicellaria. × 15.
6. Ordinary small tridentate pedicellaria. × 10.
7. Valve of ordinary small tridentate pedicellaria. × 30.
8, 9. Rare forms of small tridentate pedicellariæ. × 10.
10. Triphyllous pedicellaria. × 10.
11. Sphæridium. × 70.

12–15. **Echinosoma tenue** Pomel. From Station 3784.

12. Large tridentate pedicellaria. × 30.
13. Valve of large tridentate pedicellaria. × 30.
14. Valve of small tridentate pedicellaria. × 70.
15. Valve of triphyllous pedicellaria. × 70.

16–21. **Echinosoma tenue** Pomel. From Station 5084.

16. Valve of large tridentate pedicellaria. × 30.
17. Small tridentate pedicellaria. × 30.
18. Valve of small tridentate pedicellaria. × 70.
19. Triphyllous pedicellaria. × 30.
20. Valve of triphyllous pedicellaria. × 70.
21. Valve of ophicephalous pedicellaria. × 70.



H.L.Clark del

Plate 68.

PLATE 68.

Aræosoma thetidis A. Ag. and Cl.

Abactinal view of partly denuded specimen.
Natural size.

Heliotype Co. Boston.

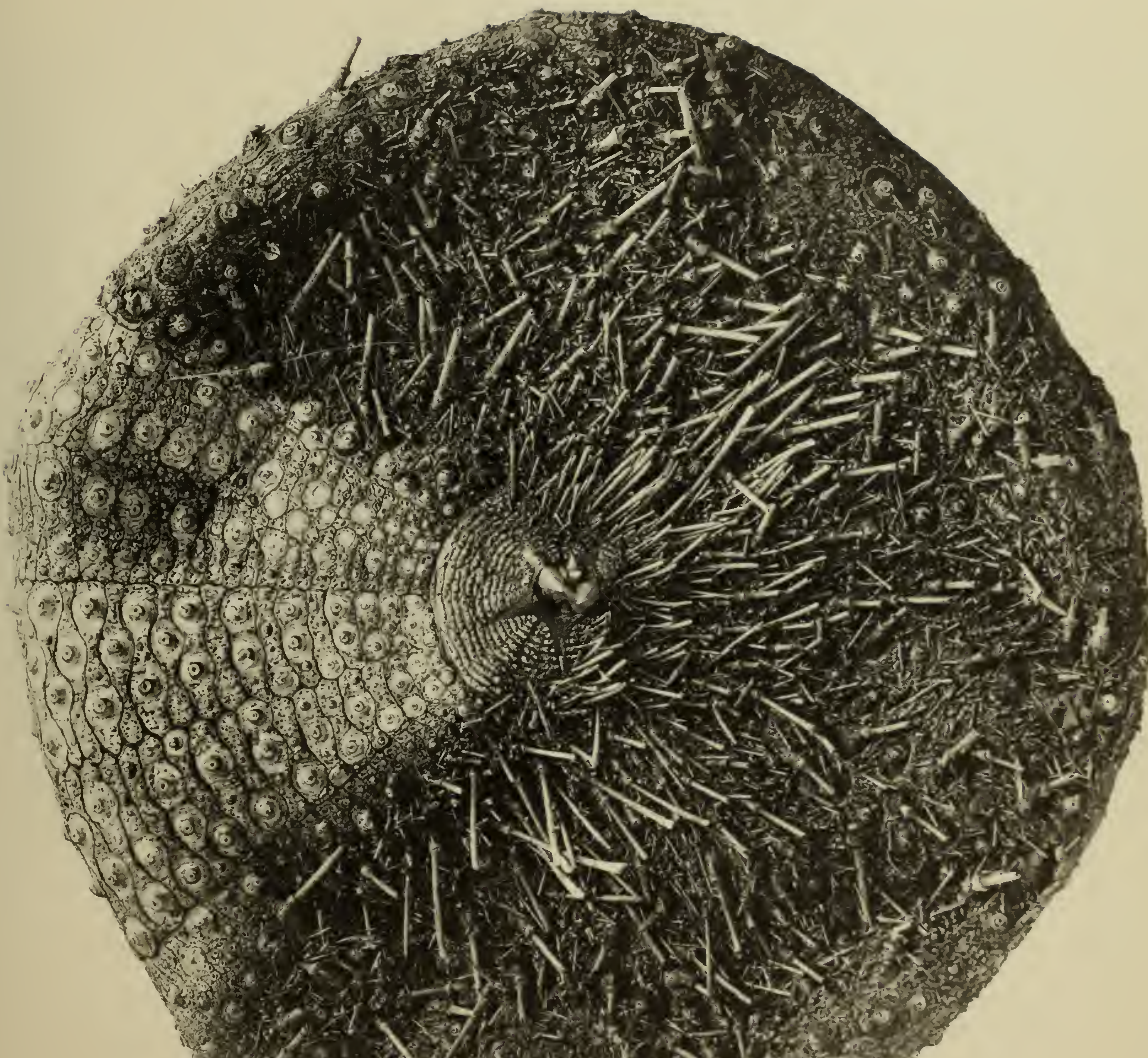
PLATE 69.

Plate 69.

Aræosoma thetidis A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 68.

Natural size.



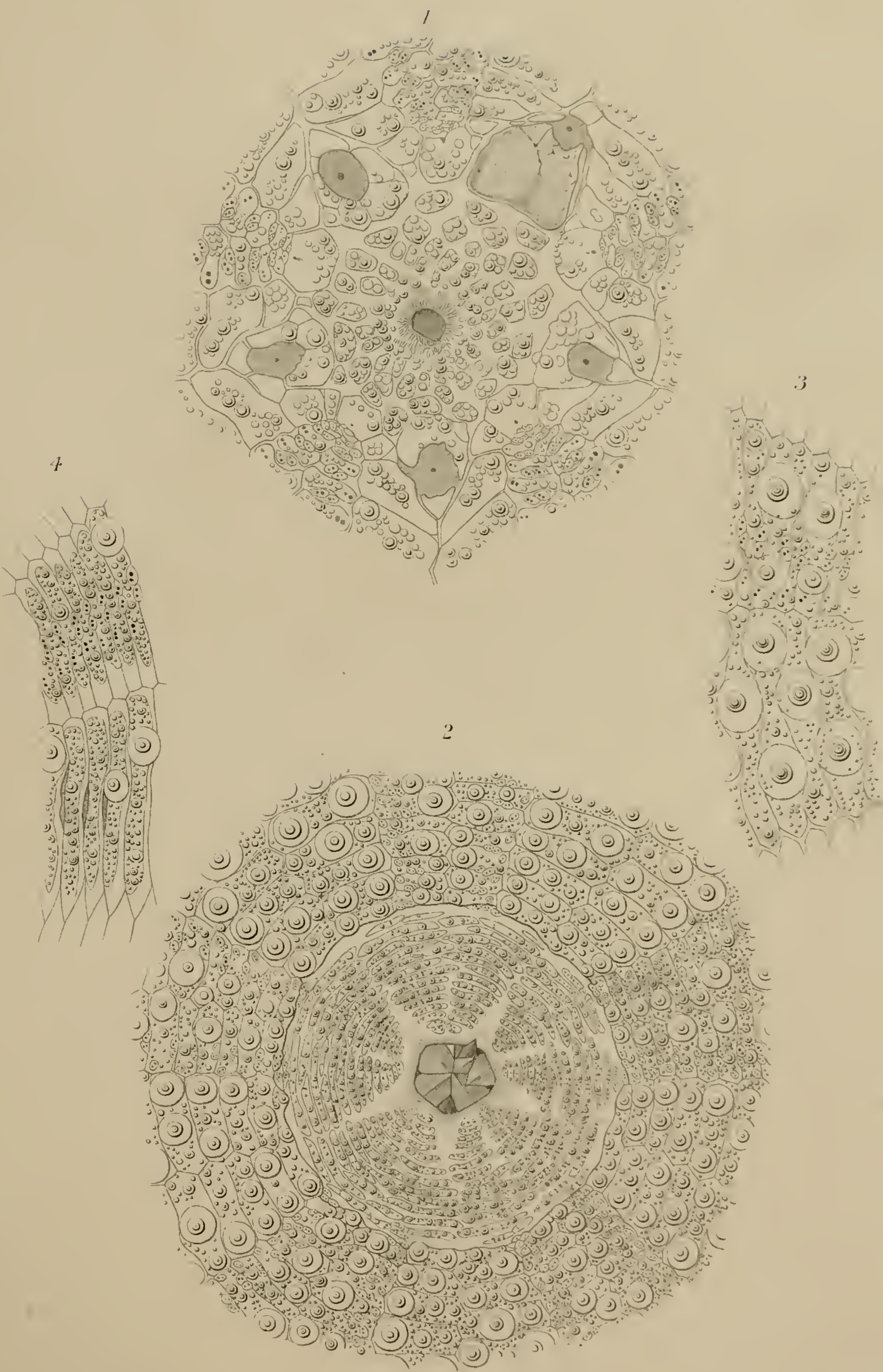
Heliotype Co. Boston.

PLATE 70.

Plate 70.

Aræosoma thetidis A. Ag. and Cl.

1. Abactinal system. × 1.7.
2. Actinostome and base of corona. × 1.1.
3. Actinal ambulacral and interambulacral plates, ten millimeters from ambitus. × 1.3.
4. Abactinal ambulacral and interambulacral plates, ten millimeters from ambitus. × 1.1.



A. M. Westergren del.

B. Meisel lith.

Plate 71.

Plate 71.

Aræosoma bicolor A. Ag. and Cl.

1. Actinal view of partly denuded specimen.
2. Abactinal view of same.

Natural size.

Owing to an oversight of the printer the position of the figures of this plate has accidentally been reversed. In all the other plates the right anterior interambulacrum is on the right of the anterior or median ambulacrum.

2

1

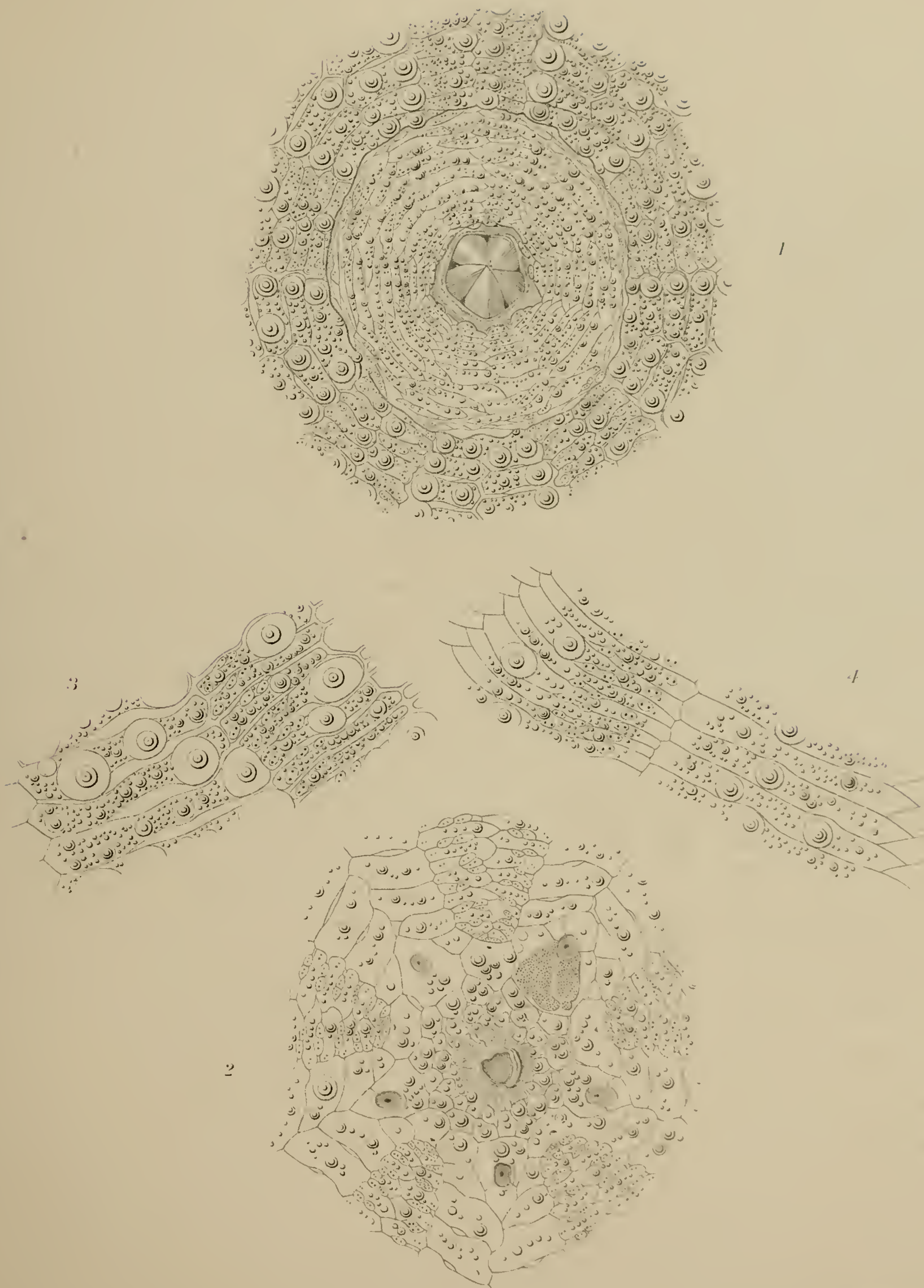
Heliotype Co. Boston.

Plate 72.

Plate 72.

Aræosoma bicolor A. Ag. and Cl.

1. Actinostome and base of corona. × 1.7.
2. Abactinal system. × 2.3.
3. Actinal ambulacral and interambulacral plates, seven millimeters from ambitus. × 1.8.
4. Abactinal ambulacral and interambulacral plates, eight millimeters from ambitus. × 2.



A M W[illegible] del

PLATE 73.

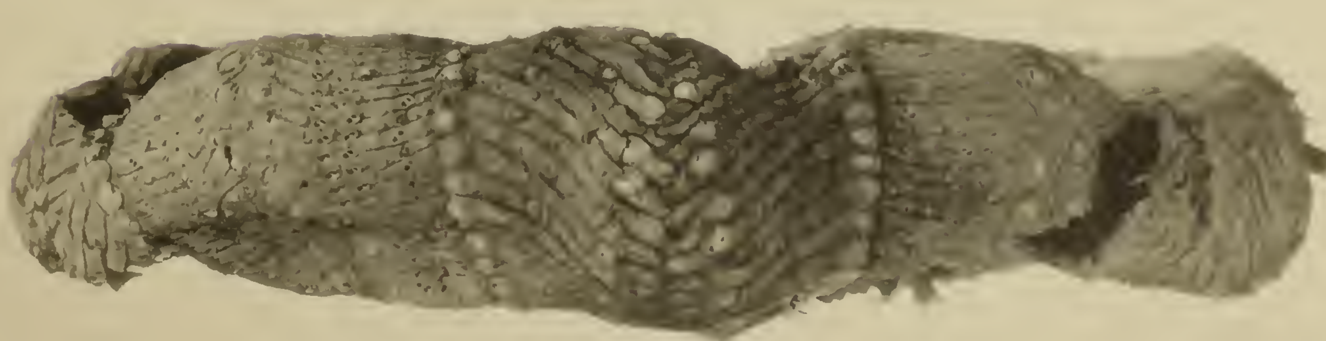
Plate 73.

Aræosoma eurypatum A. Ag. and Cl.

1. Abactinal view of nearly denuded specimen.
2. Side view of same, looking towards an interambulacrum.

Natural size.

1



2

Heliotype Co. Boston.

PLATE 74.

PLATE **74**.

Aræosoma eurypatum A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 73.
Natural size.

Heliotype Co. Boston.

PLATE 75.

Plate 75.

Aræosoma eurypatum A. Ag. and Cl.

1. Actinostome and base of corona, somewhat damaged. × 1.3.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates, five millimeters from ambitus. × 1.5.
4. Abactinal ambulacral and interambulacral plates, just above ambitus. × 1.3.


2
3
4
1

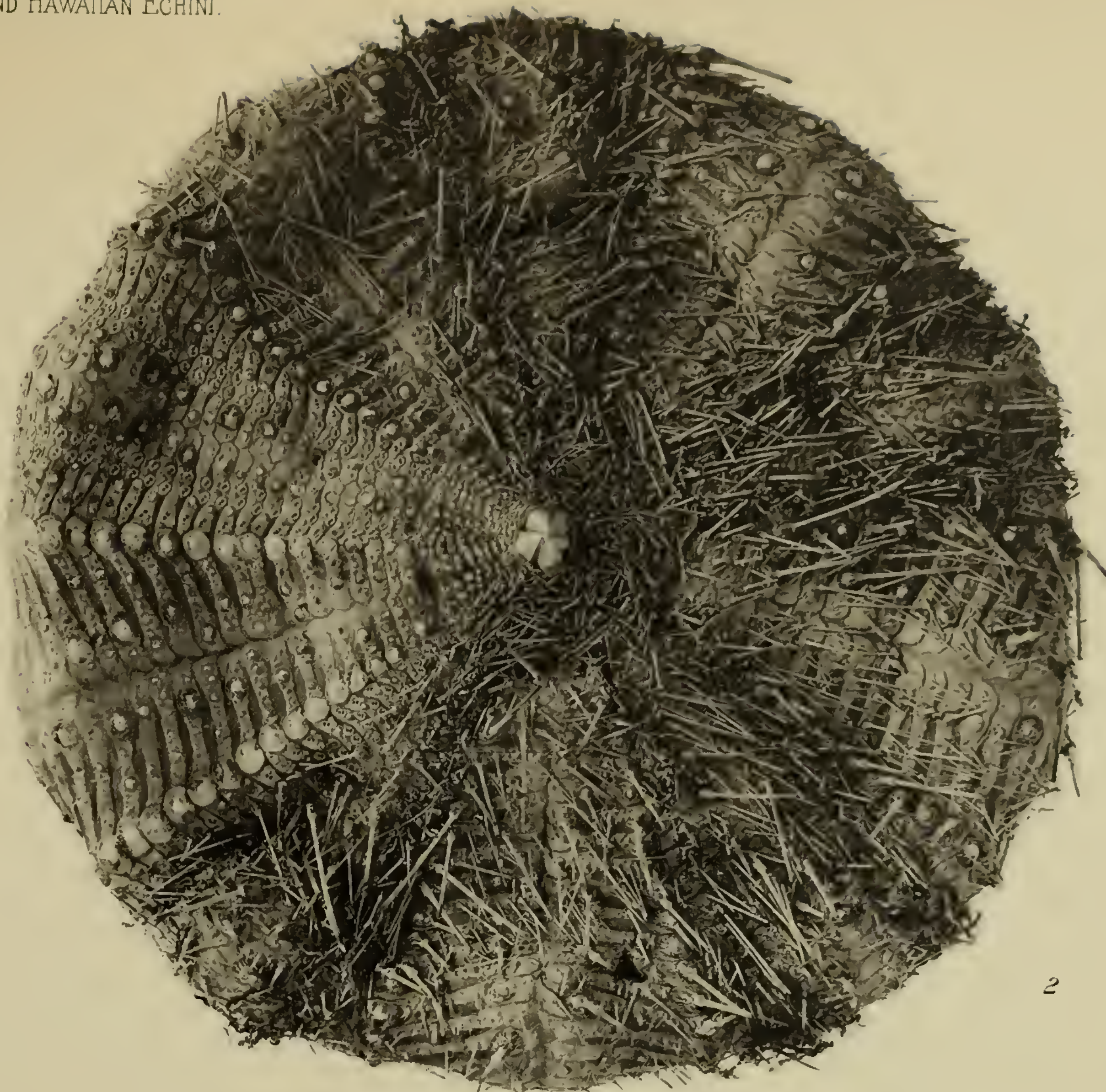
PLATE 76.

Plate 76.

Aræosoma leptaleum A. Ag. and Cl.

1. Abactinal view of partly denuded specimen.
2. Actinal view of same.

Natural size.



2

1

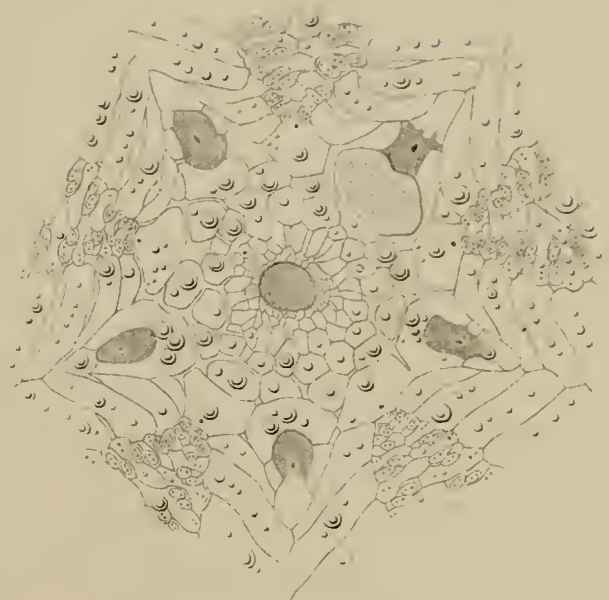
Heliotype Co. Boston.

Plate 77.

PLATE 77.

Aræosoma leptaleum A. Ag. and Cl.

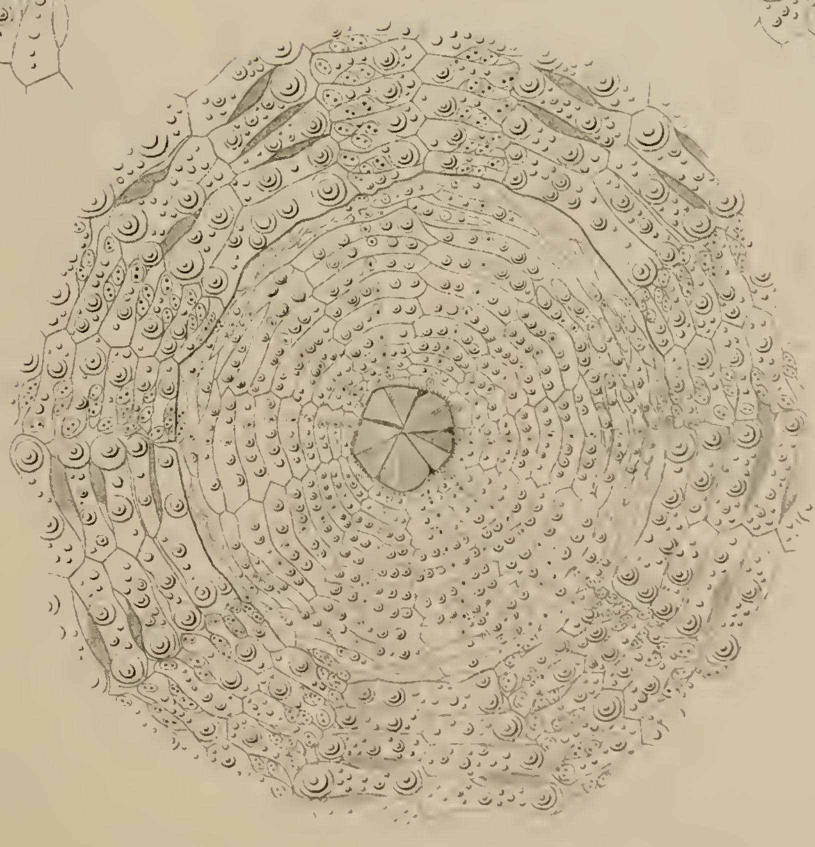
1. Actinostome and base of corona. × 1.8.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates twelve millimeters from ambitus. × 1.6.
4. Abactinal ambulacral and interambulacral plates eight millimeters from ambitus. × 2.



2

4

3



1

A M Westergren del

Plate 78.

PLATE 78.

Aræosoma pyrochloa A. Ag. and Cl.

Abactinal view of partly denuded specimen.
Natural size.

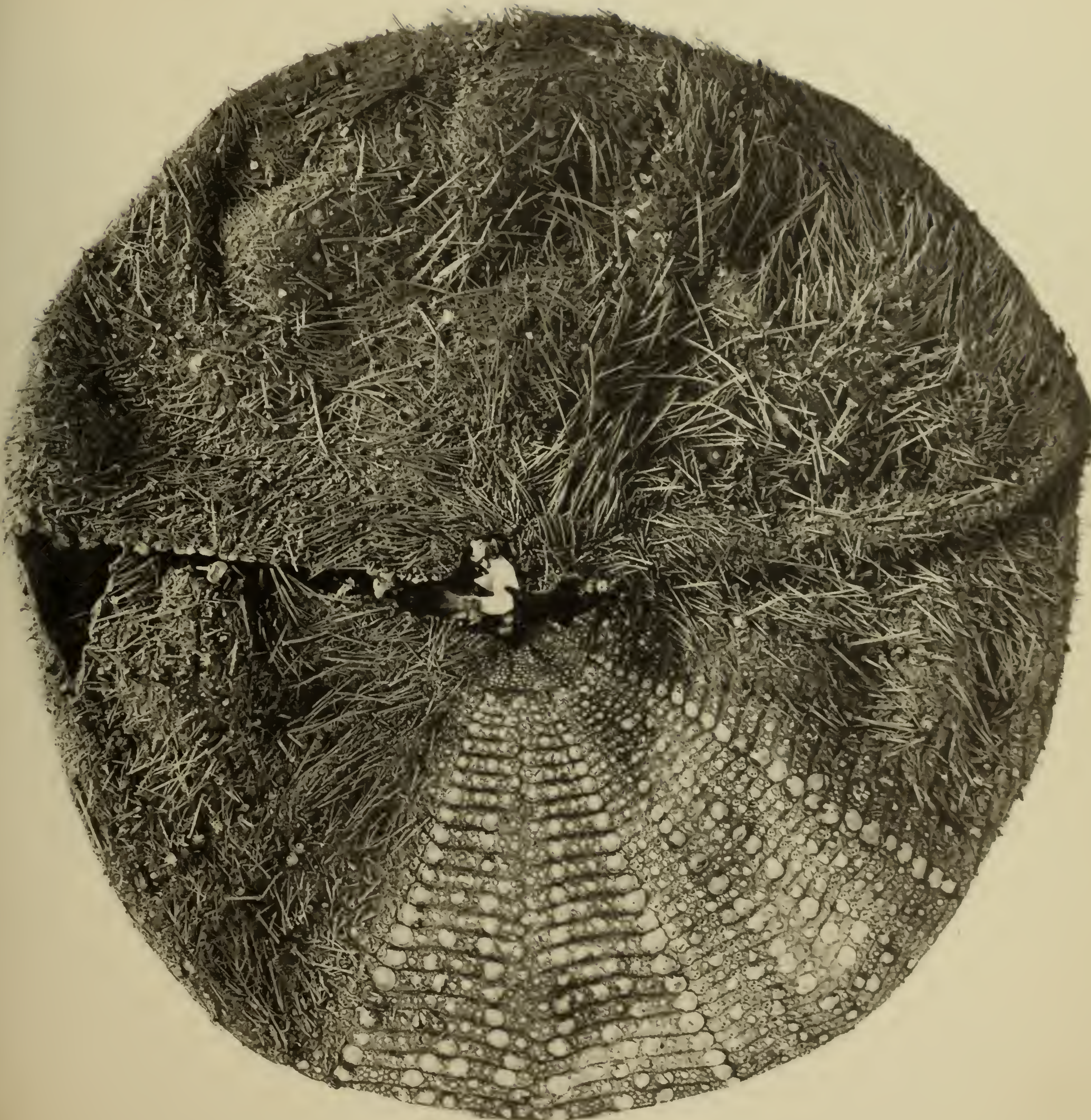
Heliotype Co. Boston.

PLATE 79.

Plate **79**.

Aræosoma pyrochloa A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 78.
Natural size.



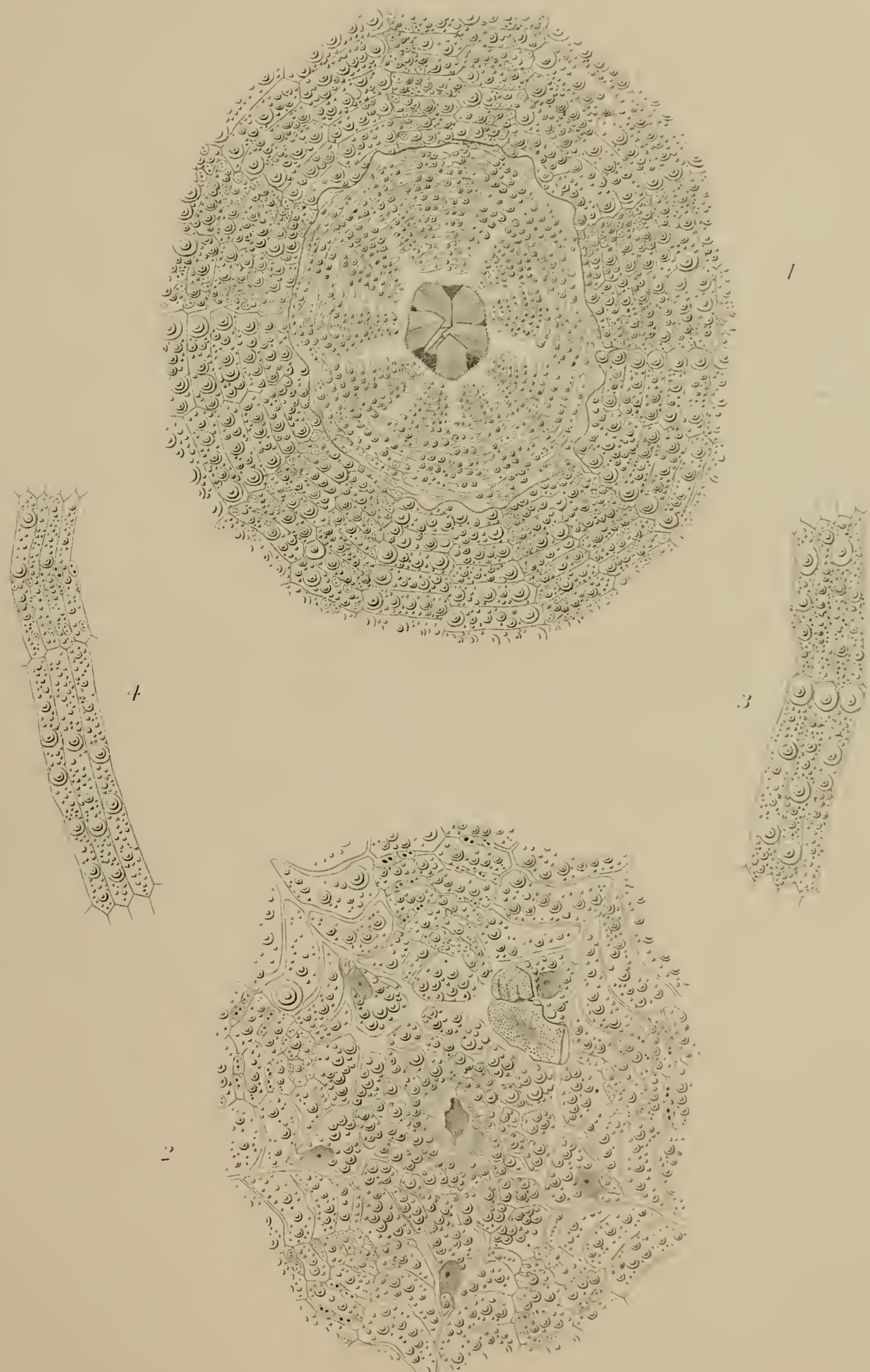
Heliotype Co. Boston.

PLATE 80.

Plate 80.

Aræosoma pyrochloa A. Ag. and Cl.

1. Actinostome and base of corona. × 1.3.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates, nine millimeters from ambitus. Slightly reduced.
4. Abactinal ambulacral and interambulacral plates, nine millimeters from ambitus. Natural size.



A M Westergren del.

PLATE 81.

PLATE 81.

1, 2, 5, 6. **Aræosoma Owstoni** Mortens., juv.

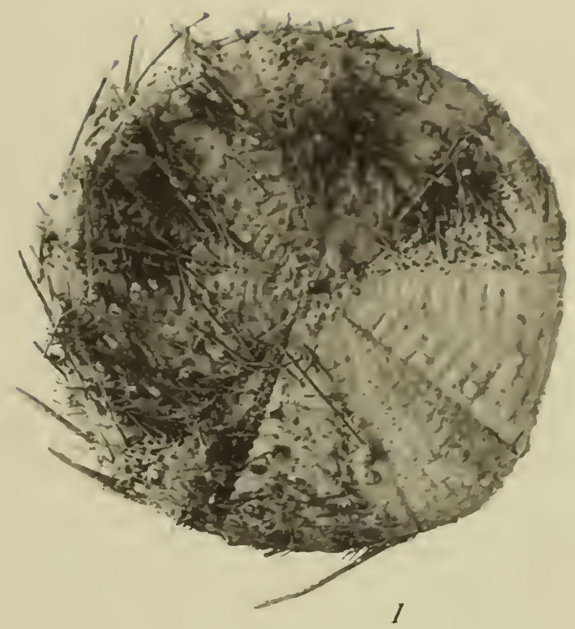
1. Abactinal view of partly denuded specimen.
2. Actinal view of same.
5. Abactinal view of partly denuded very young individual.
6. Actinal view of same.

3, 4. **Aræosoma gracile** A. Ag. and Cl., ? juv.

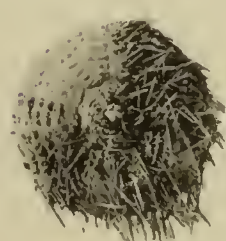
3. Abactinal view of partly denuded specimen.
4. Actinal view of same.

All figures natural size.

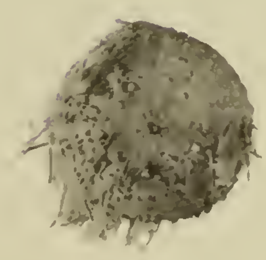
2



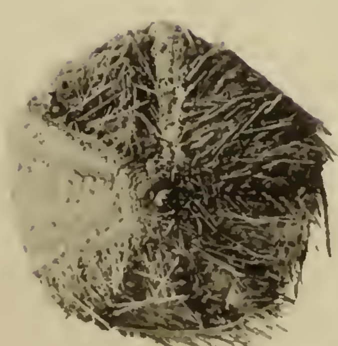
1



6



5



4

3

Heliotype Co. Boston.

PLATE 82.

Plate 82.

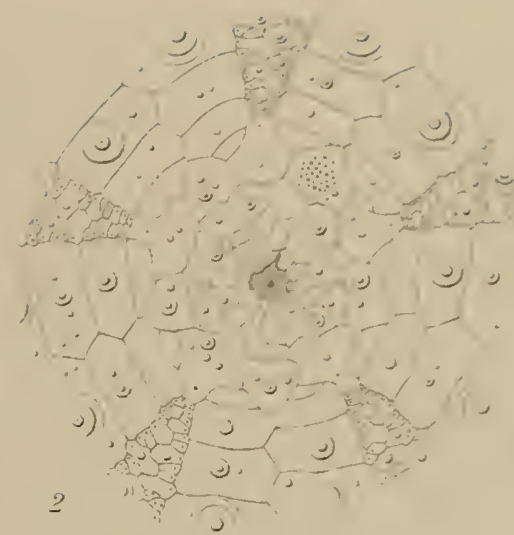
1–4. **Aræosoma Owstoni** Mortens., juv.

1. Actinostome and base of corona of young individual shown in figures 5 and 6, Plate 81. × 5.
2. Abactinal system of same. × 5.
3. Actinal ambulacral and interambulacral plates, just below ambitus. × 5.
4. Abactinal ambulacral and interambulacral plates, just above ambitus. × 5.

5–8. **Aræosoma gracile** A. Ag. and Cl., ? juv.

5. Actinostome and base of corona of individual shown in figures 3 and 4, Plate 81. × 4.
6. Abactinal system of same. × 5.
7. Actinal ambulacral and interambulacral plates, just below ambitus. × 4.
8. Abactinal ambulacral and interambulacral plates, just above ambitus. × 5.

1

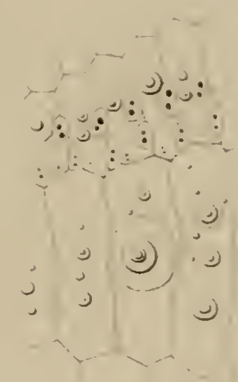


2

3

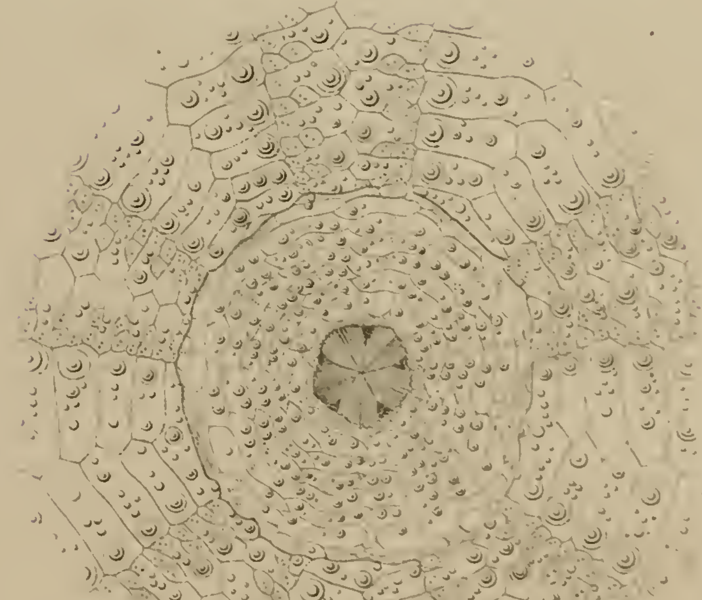
4

7



8

6



5

A M Westergren del.

Plate 83.

Plate 83.

Sperosoma giganteum A. Ag. and Cl.

Abactinal view of partly denuded specimen.
About two-thirds natural size.

· Heliotype Co. Boston.

Plate 84.

Sperosoma giganteum A. Ag. and Cl.

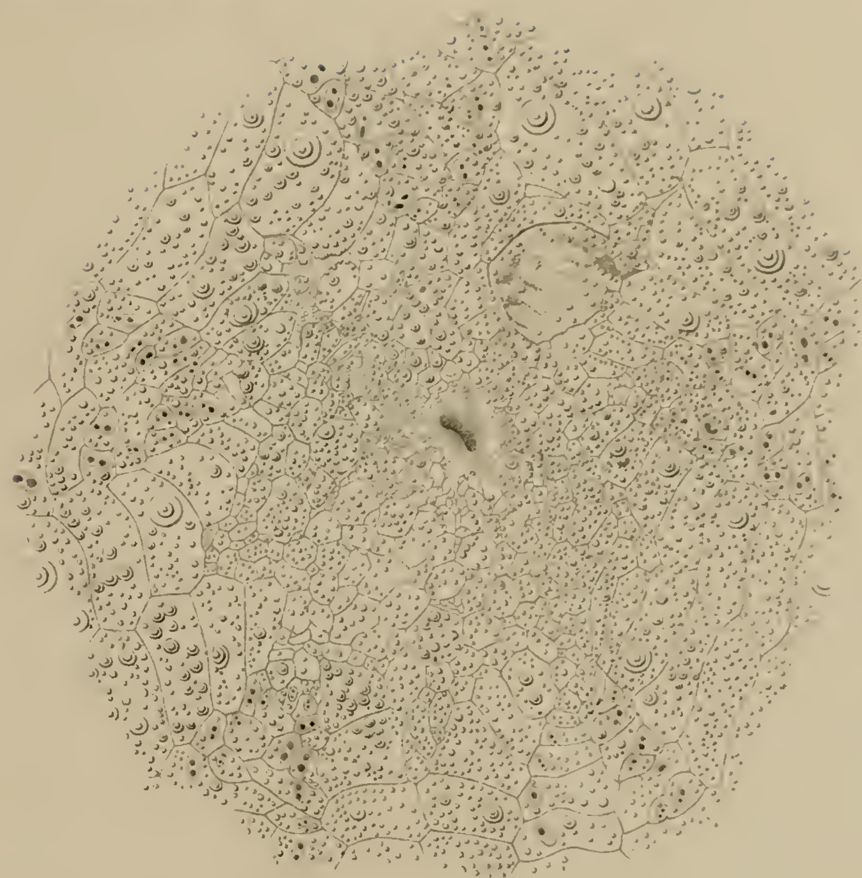
Actinal view of same specimen as that shown on Plate 83.
About two-thirds natural size.

Heliotype Co. Boston.

Plate 85.

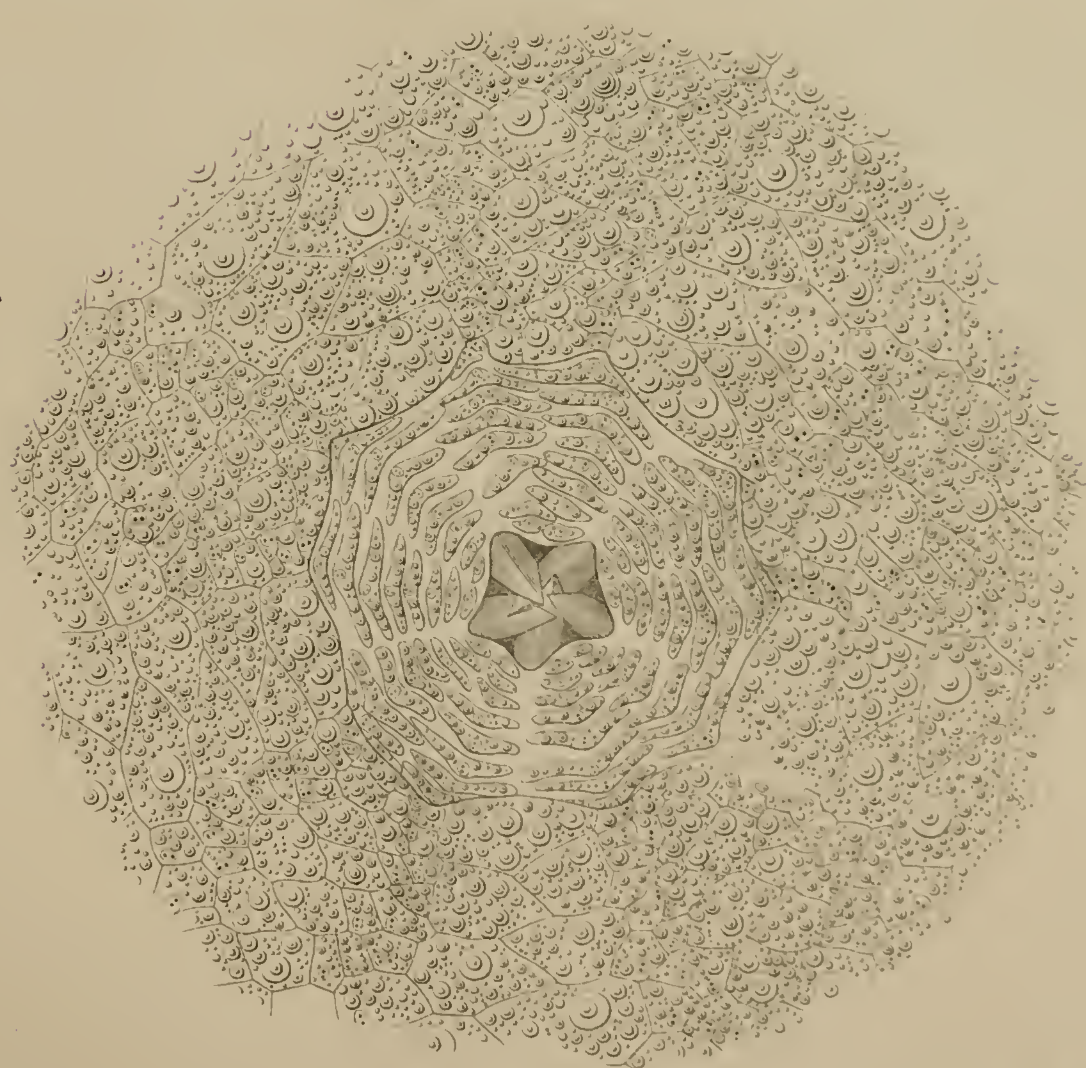
Sperosoma giganteum A. Ag. and Cl.

1. Abactinal system. $\times$ 1.5.
2. Actinostome and base of corona. Natural size.



1

2



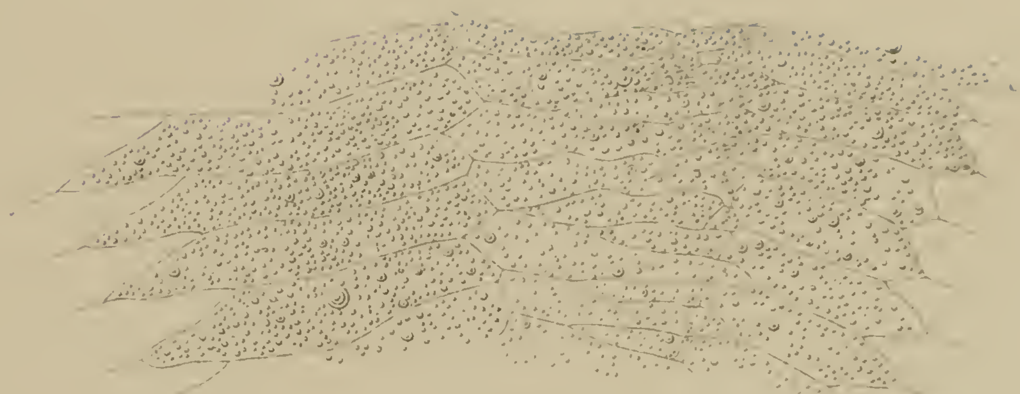
A.M. Westergren del.

Plate 86.

PLATE 86.

Sperosoma giganteum A. Ag. and Cl.

1. Actinal ambulacral and interambulacral plates, three millimeters below ambitus. Natural size.
2. Abactinal ambulacral and interambulacral plates, ten millimeters above ambitus. Natural size.



2

1

PLATE 87.

PLATE 87.

Sperosoma obscurum A. Ag. and Cl.

Abactinal view of partly denuded specimen.
Natural size.

Heliotype Co. Boston.

Plate 88.

PLATE 88.

Sperosoma obscurum A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 87.
Natural size.

Heliotype Co Boston

Plate 89.

Plate 89.

Sperosoma obscurum A. Ag. and Cl.

1. Actinostome and base of corona. × 2.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates, just below ambitus. × 1.3.
4. Abactinal ambulacral and interambulacral plates, just above ambitus. × 1.2.

2

3

4

1

A M Westergren del.

[illegible]

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXXIV. No. 4.

HAWAIIAN AND OTHER PACIFIC ECHINI.

THE PEDINIDÆ, PHYMOSOMATIDÆ, STOMOPNEUSTIDÆ, ECHINIDÆ, TEMNOPLEURIDÆ, STRONGYLOCENTROTIDÆ, AND ECHINOMETRIDÆ.

BY

HUBERT LYMAN CLARK.

WITH THIRTY-TWO PLATES.

Plates 90–121.

[Published by Permission of George M. Bowers, U. S. Commissioner of Fish and Fisheries.]

CAMBRIDGE, U. S. A.:
Printed for the Museum.
June, 1912.

CONTENTS.

* Hawaiian species.

* Hawaiian species.

HAWAIIAN AND OTHER PACIFIC ECHINI.

Collected by the U. S. Fish Commission Steamer "Albatross," Commander Chauncey Thomas, U. S. N., Commanding in 1902, and Lieut. Commander L. M. Garrett, U. S. N., Commanding in 1906.

PEDINIDÆ Gregory.

General Characteristics.

It is quite remarkable that the recent species of this family represent but a single genus and, with one exception, are very much alike in all essentials. The solid spines, the firm test, and the bright colors make their resemblance to the Echinidæ rather striking but the grooved teeth and the perforated tubercles indicate a nearer relationship to the Centrechinidæ.[1] On the other hand we find such peculiarities in the alimentary canal and abactinal system that it is an open question whether the relationship to the Centrechinidæ is really as close as it seems. Yet it must be admitted that the resemblance of the recent species of Cænopedina to Centrostephanus, particularly to *C. longispinus,* is very close and it is extremely difficult to draw the line so sharply as to warrant their being placed in separate families. The structure of the ambulacrum, the perforation of the primary tubercles, the plating of the buccal membrane and the appearance of the lantern are identical in the two genera, while the abactinal system and the pedicellariæ of Cænopedina are so similar to those of *Centrostephanus asteriscus* that no possible generic difference can be found in those characters. Indeed the only distinct and constant differences are found in the primary spines (which are ordinarily smooth and solid in Cænopedina, rough and hollow in Centrostephanus) and in the primary tubercles (which are distinctly crenulated in Centrostephanus but perfectly smooth in Cænopedina). The smaller spines of Cænopedina are sometimes hollow however, and the larger primaries are, in *C. hawaiiensis* at least, decidedly rough. Were it not for the large number of fossil forms known, which seem to represent a different group from our modern Centrechinidæ, the family Pedinidæ would not be either necessary or desirable, for Cænopedina could well be referred to the Centrechinidæ. But until a more complete revision

[1] For the use of this name, see Jackson, 1912, Phylogeny of the Echini. Mem. Boston Soc. Nat. Hist., VII, p. 27–28. The conclusion that Diadema cannot be used for Echini seems to be unavoidable.

of the extinct species reveals the needlessness of the Pedinidæ, it may be better to leave the genus Cænopedina in that family. In any case, it certainly belongs in the suborder Aulodonta Jackson.

The species of Cænopedina agree in having a large abactinal system, nearly or quite equal to half the diameter of the test; the ambulacral primary tubercles are continued well above the ambitus; and secondary tubercles are more or less numerous. In other particulars they are much like Pseudopedina Cotteau, to which genus they are perhaps more nearly allied than to the true Hemipedinas. They cannot properly be referred to Pseudopedina however and therefore Mortensen's revival of the name Cænopedina, under which the type-species (*cubensis*) was originally described, may be accepted, without however agreeing with him that recent species cannot well be referred to genera known originally only as fossils.

Having already showed the close resemblance of Cænopedina to Centrostephanus, it will be unnecessary to repeat the various structural features of the genus, but some of the details regarding which little has been published, may be briefly referred to here.

The most striking feature of the internal anatomy is seen in the brevity of the upper coil of the intestine, which, unlike that of Echinothrix and the other Diadematidæ, almost wholly lacks the interradial loops and follows a very short course near the abactinal surface of the test (Pl. 90, fig. *2*). The lantern and teeth (Pl. 90, figs. *3*, *4*) are like those of the Centrechinidæ in every detail, but the perignathic girdle is less developed than is the rule in that family; the auricles are slender and do not quite meet over the ambulacra. Rudimentary Stewart's organs can be easily distinguished. The characters of the test, and other external features, are so well known we need only mention them here. The ambulacra are typically centrechinoid, while the primary tubercles of both areas are equally so. The tubercles are high and without a trace of crenulation and the areolæ are very little or not at all sunken. The abactinal system is very large, with a big periproct and small ocular plates. There is no trace of an anal tube. The actinostome is well plated, especially in the ambulacra, as in the Centrechinidæ, and the buccal plates carry spines as in Centrostephanus.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plate 91.

The spines of the Pedinidæ are typically smooth and solid. In the recent species, they form the most obvious distinguishing mark to separate them from the Centrechinidæ. The larger primaries are ordinarily very solid, though they may be slender; their length usually exceeds the diameter of the test. They are finely striated, and when pointed (as in *C. pulchella*), they strongly resemble those of Echinometra. As a rule however, they are not pointed but very blunt and they even may be flaring at the tip. Under the magnifying glass, they reveal the same longitudinal series of minute serrations which is found in many Centrechinidæ, but ordinarily much smaller than in that family. The smaller primaries and larger secondaries are often quite hollow, suggesting how little weight ought to be placed on the characters afforded by the spines.

The pedicellariæ, so far as they are known, show a marked resemblance to those of Centrostephanus. While at least four different kinds occur on most individuals, either globiferous or tridentate may be quite wanting. It seems to be true, as in the case of many other Echini, that if globiferous pedicellariæ are abundant, the tridentate are wanting or very rare, while if the latter are abundant, the former seem to be missing or infrequent. The stalks of the pedicellariæ are much as in the Centrechinidæ, those of the tridentate and ophicephalous rather stout and a little enlarged at the upper end, while those of the globiferous are very slender, scarcely more than a single rod at the middle, and are abruptly enlarged where they join the head. The valves of the *globiferous* pedicellariæ are more or less concealed by the glands, which are often heavily pigmented. They are quite small and terminate in 2–4 teeth. These teeth may be very long (Pl. 91, fig. *18*) or quite short (fig. *17*). The *tridentate* pedicellariæ vary greatly in size and form (Pl. 91, figs. *1, 4, 5, 6*) but the valves are nearly always narrow and compressed. The heads range from .20 to 4 mm. in length, while the stalks may hardly equal them or may be several times as long. The valves are either straight or curved and may be in contact for most of their length or only just meet at the tip. The *ophicephalous* pedicellariæ are more or less common and occur with valves of two quite distinct forms. That one which is really characteristic (Pl. 91, figs. *14, 20*) is very greatly constricted at the base of the blade, while the other is broader (fig. *15*) or longer (fig. *7*) and much less constricted. The latter form intergrades with the tridentate pedicellariæ and have been called tridentate by Döderlein, but as they usually have a well-marked articular loop, it seems better to call them ophicephalous. The *triphyllous* pedicellariæ are small and hard to detect but are usually common. The valves are .10–.20 mm. in length and quite variable in form, though generally rather wide and truncate at tip (Pl. 91, fig. *8*). The stalks are, as usual in triphyllous pedicellariæ, much longer than the neck, which is several times as long as the head.

The *sphæridia* (Pl. 1, figs. *13, 22*) as in the Centrechinidæ, are present on the lower secondary element of the ambulacral plates, at the inner side of the foot, from the peristome nearly to the ocular plate. They do not exhibit great variety of form or possess any distinctive characters.

The *calcareous spicules* (Pl. 91, fig. *21*) are large, fenestrated plates, of very diverse forms and sizes. The surface may be smooth or provided with a few, or with numerous spinelets. Such deposits are obviously very different from the normally triradiate spicules of the Centrechinidæ.

Cænopedina.

A. Agassiz, 1869. Bull. M. C. Z., I, p. 256.
Type-species, *Cænopedina cubensis* A. Agassiz, l. c.

Careful comparative study of the material available, and of the descriptions and figures of de Meijere, Döderlein, and Mortensen shows that there are now known five species of this genus. They are distinguished from each other most satisfactorily, by the characters found in the abactinal system, the primary spines, and the coloration. The species of the West Indian region (*cubensis* A. Ag.) has been longest known and is the type of the genus; the specimens before us are all small, but Koehler has been so fortunate as to have some very fine material from depths of 605–660 fathoms in the eastern North Atlantic and his beautiful colored figure (1909, Ech. "Princesse Alice," Pl. 1, fig. *1*) well shows the appearance of this interesting species. The Japanese form (*mirabilis* Död.) was the next to be discovered and the "Albatross" collection fortunately supplies sufficient material for a satisfactory understanding of that species. The "Siboga" collected specimens of a Cænopedina near the Kei Islands, which was regarded by de Meijere as undescribed and to which he gave the name *indica*. Döderlein (1906, "Valdivia" Ech., p. 176) has expressed the opinion that this is only a variety of *mirabilis* but I am not able to agree with him. The two forms seem to be quite distinct. In 1907 (Bull. M. C. Z., L, p. 245) de Meijere's species was recorded from the Hawaiian Islands but a more careful comparison of these specimens with de Meijere's description and figures shows that they are really quite a distinct species, which may be called *hawaiiensis*. It is interesting and important to note in this connection that, so far as can be judged from de Meijere's description and figures, *indica* appears nearer *cubensis*, than to any other species. Indeed the differences between the two, which de Meijere mentions are for the most part trivial, but it is possible that a direct comparison of specimens would show more important distinctions than those given below. The fifth species of the genus, from the Hawaiian Islands, is strikingly different from any of the others and because of its fine coloring well deserves its name, *pulchella*.

The following table shows the characters by which the five species may be distinguished.

- Anal system covered by numerous minute plates; primary spines long and slender, more or less cylindrical, thickness less than .05 of length.
  - Primary spines not banded; genital plates with very few spines or at least, bare at the centre.
    - Abactinal region not at all violet; genital plates, each with several secondary and rather numerous miliary tubercles.
      - Actinostome distinctly smaller than periproct; few, scattered secondary tubercles in ambulacra; tridentate pedicellariæ common; usually more or less greenish abactinally . . . . *cubensis.*
      - Actinostome equals periproct; a double row of secondary tubercles in each ambulacrum; tridentate pedicellariæ seem to be wanting; no green in coloration . . . . *indica.*
    - Abactinal region distinctly violet; genital plates quite bare, each with about 8 tubercles chiefly on proximal margin; tridentate pedicellariæ abundant and varied; ophicephalous pedicellariæ with markedly constricted valves, wanting *hawaiiensis.*
  - Primary spines greenish or very light brown with several broad ill-defined bands of red or reddish brown; genital plates with more or less numerous secondaries . . . *mirabilis.*
- Anal system covered by few (15–30) plates; primary spines short and stout, tapering to a blunt point, thickness nearly .10 of length . . . . *pulchella.*

Cænopedina hawaiiensis, nom. nov.

Hemipedina indica A. Agassiz and Clark, 1907, Bull. M. C. Z., L, p. 245. NON *Hemipedina indica* de Meijere 1903, Tijds. Ned. Dierk. Vereen., (2), VIII, p. 3.

Plates 90, figs. *1–4;* 91, figs. *1–13;* 105, figs. *1–5.*

The largest of the specimens measures 37 mm. in diameter and the height of the test is 17 mm. There are 10 interambulacral plates in each column and 15 ambulacral plates in each half-area. The longest primary is 41 mm. in length. In another specimen, 32 mm. in diameter the longest primary is 50 mm. long and only 1.8 mm. in thickness. In a specimen 30 mm. in diameter, there are 10 interambulacral and 15 ambulacral plates to a column. The abactinal system is 15 mm. in diameter and the actinostome 11.5 mm. In the smallest specimen the test is 15 mm. in diameter and nearly 8 high; the abactinal system measures almost 8 mm. across and the actinostome 6 mm.; there are 8 interambulacral and 10 or 11 ambulacral plates to a column.

The periproct is large, its diameter about half that of the abactinal system; it is covered by upwards of five hundred small, rounded plates of which ten or a dozen near the approximately central anus, are noticeably larger than the others and carry a few miliary spines and pedicellariæ; there is no indication whatever of an anal tube. The genital plates are large, broadly in contact with each other and completely exclude all the oculars from the periproct. The genital pores show such diversity as to indicate a sexual difference; in some specimens they are moderately large, circular and near the centre of the plate while in the others they are very small and occupy a notch in the distal angle of the plate, from which a narrow, shallow but quite distinct groove runs down nearly or quite to the ambitus. The madreporic genital is no larger than the others and the pores occupy only a small area at the centre of the plate. Each plate carries 4 or 5 small spine-bearing tubercles near the periproct and 2 or 3 others may be scattered on the plate; there are also a number of minute pedicellaria-bearing granules which are hardly visible to the unaided eye. The ocular plates are about one third as large as the genitals; the pore is near the distal margin and proximal to it are 2 or 3 small tubercles.

The interambulacral plates are high but the surface of each is largely covered by the primary tubercle; at both the outer and inner ends however, there are secondary and miliary tubercles, which are largest and most numerous on the actinal plates. The ambulacral plates are nearly as high as they are wide, with the rather large pore-pairs occupying most of the outer end, while the inner half is covered by the primary tubercle; there are, however, some small secondaries beside the median suture especially actinally, and miliaries occur wherever there is room especially abactinally. The pore-pairs form a nearly vertical series, though below the ambitus the "arcs of three" are evident. The ambulacra are half as wide as the interambulacra at the ambitus.

The buccal membrane carries a considerable number of small plates, but these are chiefly in the ambulacra distal to the primordial ambulacrals. The latter carry small spines as well as pedicellariæ while the little plates carry pedicellariæ alone. The gills are relatively small and the cuts are broad and shallow.

The primary tubercles are very large, especially at the ambitus. In the interambulacra, their areolæ coalesce vertically for nearly their full width, but the uppermost and lowest are naturally not so extensively developed. In the ambulacra, the areolæ do not coalesce even at the ambitus but are separated by a few minute miliaries. In both areas, the boss is moderately high without a trace of crenulation, while the mamelon is very well formed and conspicuously perforated. The larger secondary tubercles are also perforated and are otherwise similar. The primary spines at and above the ambitus are long and slender, those of the interambulacra greatly exceeding those of the ambulacra. They are very finely striated longitudinally and very minutely rough. They are solid but the central core is obviously less solid than the surrounding wall and towards the tip of the spine becomes very poorly developed. Some of the smallest primaries are perfectly hollow and the larger secondaries resemble them in that respect as well as in general appearance.

The pedicellariæ are abundant but are mostly tridentate. The *globiferous* pedicellariæ (Pl. 91, fig. *10*) are nearly or quite confined to the abactinal system and may be wanting even there. They are quite small but are easily detected because of the brown or purple glands which enclose the valves. The latter are about half a millimeter long and terminate in two very short, sharp, diverging teeth (Pl. 91, figs. *11*, *12*). The *tridentate* pedicellariæ occur in a great variety of sizes and forms and are found on all parts of the corona, as well as on the abactinal system and occasionally even on the actinostome. They may have a short neck or none and the stalk may equal, or exceed more or less markedly, the head. The valves may be straight and in contact for nearly their entire length (Pl. 91, fig. *4*) or in contact only, to a varying amount, near the tip (Pl. 91, figs. *5*, *6*), or they may be strongly curved and in contact only at tip (Pl. 91, figs. *1*, *2*). The length of the valves ranges from .35 to nearly 4 mm. The thickness of the head at the base varies from one quarter to one half the length (compare Pl. 91, figs. *1* and *4* or *5* and *6*). The *ophicephalous* pedicellariæ are common but resemble some forms of the tridentate and are chiefly distinguished by the loop on the valves. The latter (Pl. 91, fig. *7*) are somewhat elongated with rather flattened blades and measure about .40–.50 mm. No pedicellariæ of the form characteristic of the genus (Pl. 91, figs. *14*, *20*) were found. The *triphyllous* pedicellariæ are not uncommon but are so small as to be easily overlooked. The valves, which are about .20 mm. in length, show considerable diversity in form, as the blade may be nearly circular, or narrow and truncate or, as is usually the case, broad and truncate; the one figured (Pl. 91, fig. *8*) is intermediate between the two latter. The *sphæridia* (Pl. 91, fig. *13*) are somewhat elongated and a trifle angular; they occur on the lower secondary element of most of the ambulacral plates. The *calcareous spicules* of the tube-feet are large, irregular, fenestrated plates with an essentially smooth surface; they occur in considerable numbers.

The coloration of this species shows almost no variation and is very characteristic. The test is violet, at least abactinally, deepest and most marked on the genital plates which are, at least proximally, very close to violet no. 507 of Klincksieck and Valette's Code; actinally the violet fades into a dingy white. The primary spines are dull reddish (about no. 87 K. & V.) at base, but fade into a clear greenish yellow (about no. 266 K. & V.) at tip. The small spines are very light and the buccal membrane and periproct are pale bluish. These colors are taken from an alcoholic specimen, but they are not essentially modified by drying.

On first examination of the Hawaiian specimens, Mr. Agassiz and I were led by the unbanded spines and the general features of the test to consider them identical with the "Siboga" species, described by de Meijere as *indica*. A more careful comparison of this material with the specimens of *mirabilis*, subsequently received, together with a more critical examination of de Meijere's description and figures showed that *indica* is quite distinct from any of the other species. The characteristic differences have been set forth in the table above and do not need to be repeated here, save to emphasize the fact that in *indica* the test and spines are reddish flesh-color, the spines becoming whitish at the tip. The test of de Meijere's specimen is recorded as 19 mm. in diameter and 12 mm. high, which would indicate a much higher test than in *hawaiiensis* but as the photograph is about 22 mm. by 11, the apparent difference is unimportant. According to de Meijere the actinostome in *indica* is as large as the abactinal system and this may be a good specific character for in our specimens of *hawaiiensis,* small and large alike, the actinostome is only three quarters as large as the abactinal system.

The "Albatross" took this species at the following stations:—

Station 3865. Off Mokuhooniki Islet, Pailolo Channel, Hawaiian Islands. Bott. temp. 44.8°–45°. 256–283 fathoms. Fne. vol. s., r.

Station 3879. Off Molokini Islet, south of Lanai, H. I. Bott. temp. 37.1°. 923–1081 fathoms. Glob. oz., r.

Station 3914. Off Diamond Head, Oahu, H. I. Bott. temp. 46°? 289–292 fathoms. Gy. s., m.

Station 4178. Off Kawahioa Point, Niihau, H. I. Bott. temp. 43°? 319–378 fathoms. Co. s., r., p.

Station 4179. Off Kawahioa Point, Niihau, H. I. Bott. temp. 42°. 378–426 fathoms. Co. s., r., p.

Bathymetrical range, 256–1081 fathoms. Extremes of temperature, 46°(?)–37.1°.

Eleven specimens.

Cænopedina mirabilis Mrtsn.

Hemipedina mirabilis Döderlein, 1885. Arch. f. Naturg., Jahrg. LI, 1, p. 24.
Caenopedina mirabilis Mortensen, 1904. Dan. Exp. Siam: Ech., p. 34.

Plates 91, figs. *14–17;* 105, fig. *8*.

This species has been very fully described by Döderlein (1906, "Valdivia" Ech., p. 174) and the pedicellariæ have been discussed and figured by Mortensen (l. c.), so that there is little to add, but as many of the "Albatross" specimens are considerably larger than Döderlein's, there are a few points worth mentioning. The largest specimen is 22 mm. in diameter, and 11 mm. high; the abactinal system is 11 mm. across and the actinostome 10 mm. There are 9 interambulacral plates and 14 ambulacral, in each column. The longest primaries measure 27 mm. It will be noticed that the test is a little higher, the abactinal system a little smaller, the number of coronal plates, especially ambulacrals, somewhat larger and the primary spines a little shorter than in the type but the differences are too trivial to be of importance.

True tridentate pedicellariæ seem to be very rare as only one was found, in the examination of five specimens, but the globiferous ones are abundant, and conspicuous because of the very dark-colored glands on their valves. The latter are about .30 mm. in length and have, as figured by Mortensen, a truncate or rounded tip with a prominent tooth on each side. But they are quite variable, for between the two conspicuous teeth there are several others, which are typically very minute, but one or more of them may be nearly or quite as large as the lateral teeth; there are thus often three, four (Pl. 91, figs. *16, 17*), or even five large terminal teeth. The length of these teeth is variable but I have not happened to see any as long, relatively, as in Mortensen's figure. The ophicephalous pedicellariæ occur in two forms, that characteristic of the genus (Pl. 91, fig. *14*) and one which intergrades with the tridentate (Pl. 91, fig. *15*).

The latter are called tridentate by Döderlein, but ophicephalous is preferable because of the articular loops.

The specimens studied show greater diversity of color than would be expected from Döderlein's description, to which none of them answer exactly. The test, although very light actinally, is light brown, dull violet or reddish brown above; the color is deepest on the genital plates, while the periproct is often much lighter, in decided contrast. The small spines are all light-colored and those of the actinal side are nearly or quite white, but abactinally they are more or less deeply tinged with yellowish green. The primaries are very pale brown or yellowish green, with 3–6 narrow and indistinct bands of brownish red; as a rule the bands are narrower than the light spaces which separate them, but near the tip of the spine they may be as wide. The primaries are very slender and the general appearance of this species is so different from *hawaiiensis*, as to leave no doubt of its distinctness from that form. As *hawaiiensis* and *indica* are obviously very nearly allied, I cannot follow Döderlein in considering *indica* merely a variety or form of *mirabilis*.

The latter was taken by the "Albatross" at the following stations, the specimens ranging from 7 to 22 mm. in diameter.

Station 3708. Off Ose Zaki, Honshu Island, Japan. 60–70 fathoms. Gr. m., vol. s., a.

Station 4807. Off Cape Tsiuka, Japan, 41°36′ 12″ N., 140° 36′ E. 44–47 fathoms. Sh., crs. g.

Station 4808. Off Cape Tsiuka, Japan, 41° 35′ 50″ N., 140° 36′ 45″ E. 47 fathoms. S., sh., crs. g.

Station 4900. Off Ose Saki Light, Eastern Sea, 32° 28′ 50″ N., 128° 34′ 40″ E. Bott. temp. 52.9°. 139 fathoms. Gy. s., brk. sh.

Station 4933. Off Kagoshima Gulf, Japan, 30° 59′ N., 130° 29′ 50″ E. Bott. temp. 56°. 152 fathoms. Rky.

Station 4934. Off Kagoshima Gulf, Japan, 30° 58′ 30″ N., 130° 32′ E. Bott. temp. 60.6°–56°. 103–152 fathoms. Rky.

Station 4965. Off Hiro Misaki Light, Japan, 33° 35′ 20″ N., 135° 10′ 50″ E. Bott. temp. 49.4°. 191 fathoms. Dk. gn.-gy. s., sh.

Station 5047. Off Kinka San Light, Japan, 38° 12′ 50″ N., 141° 49′ 15″ E. Bott. temp. 49.6°. 107 fathoms. Dk. gy. s., brk. sh., p.

Bathymetrical range, 44–191 fathoms. Extremes of temperature, 60.6°–49.4°.

Forty specimens.

Cænopedina pulchella, comb. nov.

Hemipedina pulchella A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 245.

Plates 91, figs. *18–22;* 103, figs. *1–3;* 105, figs. *6, 7.*

In superficial appearance this species is so unlike any other member of the genus that its real relationship was not suspected until the abactinal system was examined, and it was only by the inspection of the tubercles that its generic position was determined. The larger specimen is 14 mm. in diameter, while the height of the test, the diameter of the abactinal system and that of the actinostome, are each about half as much. In the smaller specimen, which is only about half as large the proportions do not seem to be essentially different, though, as might be expected, the abactinal system and actinostome are perhaps a little larger relatively. But while the smaller specimen has 6 interambulacral and 7 ambulacral plates in each column, the larger has 8 and 11 respectively. The genital plates (Pl. 103, fig. *1*) are large, heptagonal and broadly in contact with each other. The central part of each plate is rough, one might almost say sculptured, and on the proximal portion are two or three secondary tubercles. The pore is near the centre. The ocular plates are small, scarcely one fifth as large as the genitals; like the latter, their surface is rough but they carry no tubercles. The periproct is small, not so large as a genital, and is covered by about 20 rather large plates, none of which however carry tubercles.

The interambulacral plates are high, but those above the ambitus are each almost completely covered by the primary tubercle; there is just room at the corner of each plate for a small secondary tubercle. Actinally the primary tubercles are much smaller and there is room, on both the outer and inner sides, for some small secondary tubercles; miliary tubercles seem to be wanting. Excepting one or two of the uppermost in each column, the ambulacral plates each carry a primary tubercle; those at the ambitus are largest but even they are little larger than the actinal interambulacral tubercles. Aside from the primaries only a very few tubercles and those, small actinal secondaries, are found in the ambulacra. The pore-pairs are small, forming a narrow almost vertical area. The ambulacra are about three fourths as wide as the interambulacra at the ambitus.

Aside from the primordial ambulacral plates, the buccal membrane (Pl. 103, fig. *2*) is almost naked, only a very few, small, rounded, non-ambulacral plates being scattered here and there. There are pedicellariæ and a few small spines on the primordial plates. The gills are small and their slits insignificant. The auricles are moderately high but widely separated, showing no tendency to meet.

The primary tubercles, especially those above the ambitus, in the interambulacra, are very large, with disproportionately large, perforated mamelons. Of the secondary tubercles, only one or two are perforated. There is not the least trace of crenulation on any of the tubercles. The primary spines are very conspicuous, at least those on the uppermost three or four interambulacral plates in each column. These measure from 12 to 22 mm. in length and from 1 to 2 mm. in thickness; the thickness is from .06 to .15 of the length but is usually less than .10. All the spines taper to a blunt point, the large ones rather abruptly, the small ones gradually. They are very finely and uniformly striated longitudinally but are quite smooth. All are perfectly solid throughout.

Pedicellariæ of all kinds are fairly common. The *globiferous* are not conspicuous, for the glands are light brown, not dark brown or purple as in the other species. Their valves (Pl. 91, fig. *18*) terminate in two slender teeth, remarkable for their length. The *tridentate* pedicellariæ are very variable, the valves ranging from .20 to 2 mm. in length; they are sometimes broad and flat (Pl. 91, fig. *19*) but are usually narrow and compressed, and may be either straight and in contact for some distance or curved and meeting only at tip. The *ophicephalous* pedicellariæ occur in the same two forms which were referred to under *mirabilis;* the characteristic forms are remarkable for their very narrow valves (Pl. 91, fig. *20*), which are about .30 mm. long, including the loop; the other form intergrades completely with the tridentates. The *triphyllous* show no peculiarities; the valves are .10 –.13 mm. long.— The *sphæridia* (Pl. 91, fig. *22*) are somewhat elongated but show no characteristic features. The *calcareous spicules* of the tube-feet (Pl. 91, fig. *21*) are remarkable only for being finely spiny on their convex surface.

The coloration of this species, as shown in the alcoholic specimens, is unusually handsome. The test is white actinally, becoming rosy above; the genital and ocular plates are deep brownish rose. The periproct is white. The large primaries are light green (near no. 286 K. & V.) at base, dull rose-red (near no. 17 K. & V.) on the distal half and light, almost or quite white, at tip. The ambulacral primaries and all the secondaries are white. The actinal interambulacral primaries are nearly or quite white with one or two bands of reddish.

Were it not for the fact that the outline of the test is circular, this beautiful sea-urchin would be easily mistaken for an Echinometra, the short stout primaries are so suggestive of that genus. It is obvious however that it has no near relationship with the Echinometridae but is undoubtedly a Cænopedina, though it is so strikingly different from the other members of that group.

The "Albatross" took this species only at the following place:—

Station 3991. Off Mokuaeae Islet, Kauai, Hawaiian Islands. Bott. temp. 43.7°. 272–296 fathoms. Fne. s., r.

Two specimens.

PHYMOSOMATIDÆ[1] Meissner.

General Characteristics.

Although the superficial appearance of the single living representative of this family, *Glyptocidaris crenularis*, is quite like that of an Echinus, the structure of the "lantern" shows that it belongs in the suborder Stirodonta Jackson and the ambulacra are also very different from those of the Echinidæ. The ambulacra are very similar to what is found in a number of fossil Phymosomatidæ, but as Duncan (1885, Quart. Journ. Geol. Soc., XLI, p. 449) pointed out, the fact that the pores are not "diplopodous" abactinally prevents our placing the recent species in Phymosoma and necessitates retaining the name Glyptocidaris, under which it was originally described. The structure of the ambulacral plates is very characteristic and is well shown in the Revision of the Echini (Pl. VI, fig. *2*) where it may be seen that the pores are in arcs of five and not in alternate arcs of two and three as one would naturally suppose from the photograph (Rev. Ech., Pl. VII[a], fig. *6*). Each ambulacral plate is made up of three primary and two secondary elements. The demi-plates lie between the primaries so that the adoral primary element is followed by a demi-plate, then by the middle primary element, then by the second demi-plate and lastly by the aboral primary element. It is easy to see in such a plate a modification of the more simple centrechinid tripartite plate by the introduction of secondary elements in a very different order of succession from what is found in the Echinidæ and Echinometridæ. In those families only two primary elements are normally retained in each ambulacral plate, the elements between them being, in most cases, demi-plates. When three primary elements are present, one is adoral and two lie together aborally, while one or more demi-plates follow the adoral element.

[1] In reviving the name Cyphosoma and establishing a family Cyphosomatidæ, for this group, Duncan (1885 and 1889) appears to have overlooked the fact, although the necessary data are given in the Revision of the Echini, pt. 1, p. 151, that Cyphosoma, as a genus of Coleoptera antedates Cyphosoma, a genus of Echini, by three years.

The "lantern" of Glyptocidaris (Pl. 90, figs. *7–9*) is remarkably like that of Arbacia. The teeth are strongly keeled, the jaws are very erect, the foramen magnum is deep and the epiphyses do not meet above it. Unlike Arbacia, but like Stomopneustes, the top of each half-pyramid gives rise to a process extending down on each side of the tooth giving support to the latter. These processes are not from the epiphyses. One is well shown in fig. *7*, Pl. 90, but in figures *8* and *9* this important character is not clearly indicated. The pits beneath the epiphyses, characteristic of the Centrechinoida, as recently shown by Jackson (1912, Mem. Boston Soc. Nat. Hist., VII, p. 178, 183) are remarkably large and deep. The perignathic girdle is similar to that of Arbacia, the auricles being more or less in contact but the apophyses between them being inconspicuous. Unlike Arbacia the primordial interambulacral plate is resorbed.

The alimentary canal (Pl. 90, figs. *5, 6*) is surprisingly like that of Centrechinus. There is a very long œsophagus followed by a capacious and much folded intestine, the loops of the upper coil alternating with those of the lower. The anus lies to the right and a little behind the centre of the periproct, and a small but distinct suranal plate is evident on the opposite side. The right posterior ocular plate is in contact with the periproct but all of the others are excluded, in all of the five specimens examined.

The buccal membrane carries, in addition to the five pairs of buccal plates, numerous smaller plates, many of which carry spines as well as pedicellariæ. The gill-slits are neither deep nor conspicuous, though the gills are well developed. Rudiments of Stewart's organs are obvious on the sides of the lantern-membrane, below the ends of the compasses.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plate 92, figs. *1–11*.

The spines are long, slender, and pointed, and the primaries are especially conspicuous. The surface of the spines is very smooth, while the inner structure is very compact and, to a certain extent, resembles that of some Arbacia spines. (See McIntosh, 1883, Trans. Roy. Irish Acad., XXVIII, p. 255, Pl. 8, fig. *32*.) The tubercles are all imperforate and the larger secondaries as well as all the primaries are very markedly crenulated. The boss is very high and the scrobicule is nearly or quite flush with the surface of the test.

The pedicellariæ of Glyptocidaris are very characteristic. They have been briefly described by Döderlein (1906, Zool. Anz., XXX, p. 520), who proposes to place the genus in Mortensen's family Toxopneustidæ, because the valves of the globiferous pedicellariæ terminate in a single prominent tooth. It is interesting to note that the first protest against this classification is made by Mortensen himself (1910, Vid. Med., p. 31), who considers the pedicellariæ an unsafe guide in this case.

The *globiferous* pedicellariæ (Pl. 92, fig. *1*) are remarkable for their stalks, which have 3–5 branches on each side. These pedicellariæ are well distributed and fairly common. The valves (figs. *6*, *7*) are of very variable size, ranging from .25 to .75 mm. in length, while the single terminal tooth is from one fourth to one third as long. These pedicellariæ are quite unlike anything found in the Arbaciadæ and resemble only in a general way certain forms occurring in the Echinidæ.

The *tridentate* pedicellariæ (Pl. 92, fig. *2*) are rather uncommon and in one of the two specimens examined appear to be wanting. They usually have a neck, which may be quite long, but in some cases appears to be wanting. The valves (Pl. 92, fig. *5*) are broad and in contact only along the distal half. They are 1–1.60 mm. in length and the margin is either entire or finely sinuate.

The *ophicephalous* pedicellariæ (Pl. 92, fig. *3*) are very common, particularly actinally. The valves (Pl. 92, fig. *9*) are short and wide, somewhat rounded triangular in outline, with a low wide "loop" which is essentially the same on each valve. The apophysis is prominent and continuous with the coarse meshwork which occupies the centre of the blade. The margin is slightly sinuous at least near the tip. The valves measure about .75 mm. in length and are nearly two thirds as wide.

The *triphyllous* pedicellariæ (Pl. 92, fig. *4*) are small and not very abundant. The valves (Pl. 92, fig. *8*) are rather elongated and rounded at the end. They measure about .25 mm. in length and are a little more than half as broad.

The *sphæridia* (Pl. 92, fig. *10*) of Glyptocidaris are numerous, as many as 15–20 occurring on each side of each ambulacrum. They are not sunken in pits but are borne on the surface of the upper demi-plate, of each ambulacral plate, from the actinostome to some distance above the ambitus. They are nearly spherical and are situated at the inner end of the demi-plate, beside the tube-foot.

The *spicules* (Pl. 92, fig. *11*) in the tube-feet are in the form of rods, expanded and perforated at the middle but more or less drawn out at each end.

Glyptocidaris.

A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 356.
Type-species, *Glyptocidaris crenularis* A. Agassiz, l. c.

This, the only living genus of the family, is distinguished from all of its extinct allies, by the structure of the ambulacra. Each plate is made up of five elements, an adoral primary being followed by a demi-plate, a middle primary, an upper demi-plate, and an aboral primary. Near the ambitus the pore-pairs of the aboral primary, the upper demi-plate and the middle primary form an oblique arc of three, which is followed by an arc of two made up of the pore-pairs of the lower demi-plate and the adoral primary; this alternation is marked by the fact that the outermost pore-pair of each plate is that of the middle element while the pore-pair of the aboral primary is further in than that of the upper demi-plate; that of the lower demi-plate is directly below that of the aboral primary, while that of the adoral primary is further out. As we follow the ambulacrum dorsally, we find the pore-pairs come to lie more and more in a single vertical series and are never diplopodous as in Phymosoma and allied genera.

Glyptocidaris crenularis A. Ag.

Glyptocidaris crenularis A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 356.

Plates 90, figs. *5–10;* 92, figs. *1–11;* 106, figs. *1*, *2*.

This species appears to be confined to the coasts of northern Japan. It was first discovered near Hakodate by Stimpson and has been recorded from the same region by Döderlein (1906, Zool. Anz., XXX, p. 520). It appears to be not only local but rare, for the "Albatross" took but few specimens. The largest (Pl. 106) measures 75 mm. in diameter and the primary spines are about 50 mm. long.

These specimens were taken at the following stations: —

Station 4807. Off Cape Tsiuka, Japan; 41° 36′ 12″ N., 140° 36′ E. 44–47 fathoms. Sh., crs. g.

Station 5046. Off Kinka San Light, Japan; 38° 15′ 7″ N., 141° 44′ 20″ E. Bott. temp. 50.8°. 82 fathoms. Dk. gy. s., p.

Four specimens.

STOMOPNEUSTIDÆ Mortensen.

Plate 90, figs. *11, 12*.

To Mortensen (1903, "Ingolf" Ech., pt. 1, p. 133) belongs the credit of separating Stomopneustes from the other regular Echini and placing it in a family by itself. While his reasons for so doing seem quite trivial, the examination of the internal anatomy reveals the soundness of his conclusion and strongly suggests that where the pedicellariæ and spicules of a sea-urchin show really important characters, there will be found morphological characters of real significance. And the corollary would naturally follow that if the careful study of an echinoid fails to reveal characters in the test or the internal anatomy, of real morphological value, whatever differences the spines, pedicellariæ, and spicules may show, however interesting they may be, are not significant and have little bearing on a natural classification.

The alimentary canal of Stomopneustes is very long and much looped, as in the Centrechinidæ. Its most noticeable peculiarities are the short œsophagus, and the very large intestinal appendage. The lantern shows at once how distinct from either the Echinidæ or Echinometridæ, Stomopneustes is, for the epiphyses are relatively small and do not arch over the foramen, as they do in those families. The teeth are however strongly keeled. The general appearance of the lantern and teeth is very similar to that of *Glyptocidaris crenularis* (Pl. 90, figs. *3, 4*) and shows that the family undoubtedly belongs in the suborder Stirodonta Jackson. The auricles in Stomopneustes are only moderately developed, meeting but hardly fusing, in an arch.

The test is essentially similar to what is found in the Echinidæ. The outline of the ambitus is typically circular, but there seems to be a slight tendency to elongation of one axis. The M. C. Z. collection contains a specimen 69 mm. measured through interradius 2 and ambulacrum V, but only 67 mm. at right angles to that line. Another specimen is 59 mm. through ambulacrum III and interambulacrum 5, but only 57 mm. at right angles to that line. In both of these specimens, the test is somewhat asymmetrical and the elongation may be pathological and not normal. The primary interambulacral plates are resorbed. The primary ambulacral (buccal) plates carry numerous pedicellariæ and some small spines. Scattered in the buccal membrane are a number of small plates, some of which, at least, carry pedicellariæ. The ambulacra are remarkable for the excessive development of certain primary tubercles. Seen from the inside, the ambulacral plates, are obviously made up of three elements, as in the Echinidæ, an adoral primary element and two secondary elements above it. But every fourth plate is typically greatly enlarged at its inner end and shuts out the three succeeding plates from the median line. Examination of the exterior shows that it is the primary tubercle of this enlarged plate which has grown over the four plates concealing their sutures, and giving the impression of high ambulacral plates with a dozen pairs of pores. So far as known this type of ambulacral plate does not occur elsewhere among Echini. The abactinal system of Stomopneustes is much like that of the Strongylocentrotidæ; that is, oculars I and V are typically in contact with the periproct, while ocular IV, or less commonly ocular II, may also reach it. The periproct is covered by numerous small plates, many of which carry spinelets. No suranal plate is distinguishable in mature specimens.

The spines of Stomopneustes are very stout and moderately long. In cross-section they are obviously polycyclic. There are several (4–8) sphæridia on the actinal part of each ambulacrum; each is attached to a miliary tubercle, but is not associated with any depression or other shelter. The pedicellariæ and remarkable spicules have been fully described by other writers (see Mortensen, 1903, "Ingolf," Ech., pt. 1, p. 126). In a careful examination of four specimens from the Persian Gulf, Mozambique, and New Guinea, only one kind of globiferous pedicellariæ was found, the characteristic form, and I can therefore fully confirm Mortensen's statement as to the scarcity of this to him very important organ; for on the two largest and best preserved specimens, there appear to be none, and on each of the small specimens but a single example. As Mortensen gives no measurements it may be well to add some based on my observations. The valves of the globiferous pedicellariæ are about .80 mm. long, while the base of each is about .35, and the tip of the blade .07 mm., in width. The tridentate valves range from .30 to 1.10 mm. in length, the ophicephalous from .35 to .80, besides the loop, and the triphyllous, which are the only really common pedicellariæ, from .15 to .20 mm. The extraordinary spicules of the tube-feet are about three quarters of a millimeter in length and about one tenth as much in diameter.

Lack of material makes it impossible to decide positively whether there is more than a single species in this genus. Specimens from New Guinea do not seem to be distinguishable from those from Mauritius, but they are not "almost black" and so may not be identical with the supposed form "*atropurpureus*" from Queensland. The examination of numerous specimens from a considerable number of localities makes it very doubtful whether the characters which were supposed to distinguish *atropurpureus* have any real systematic significance.

Stomopneustes has not been recorded from the northern Pacific Ocean, nor did the "Albatross" find it in either Hawaiian or Japanese waters.

ECHINIDÆ Agassiz.

General Considerations.

There can be little reason to doubt that the Echinidæ are the present-day representatives of the stock from which in the past the Temnopleuridæ, Strongylocentrotidæ, and Echinometridæ have been derived. Indeed the relationship with each family is so close that it is impossible to fix a natural boundary, passing which no exceptions will be found. It is necessary therefore to choose between fixing arbitrary lines and the alternative proposition of uniting all four groups in a single family. The real interrelationships of the regular Echini are much better shown by following the former course. The question then arises as to the characters for distinguishing the groups. As in the case of the families hitherto treated, the test furnishes the characters of morphological significance.[1] Mortensen (1903, "Ingolf" Ech., pt. 1 and 1904, Dan. Exp. Siam: Ech.) has chosen the pedicellariæ as the chief source for light on the relationships of these Echini, and his lead has been followed by some other students of the group. It is not altogether strange that my results differ greatly from his, and it is to be regretted that they cannot be brought into something more nearly like harmony. But in addition to the objections previously urged against the use of the pedicellariæ as a factor of primary importance in classification, study of the Echinidæ and their allies has suggested two others which are of special weight in connection with these forms.

The first important objection to Mortensen's system is the separation which results, of species obviously and by all the characters of the test very closely allied, and the union of species, which it seems impossible to associate together. To illustrate this objection the placing of *Echinus magellanicus* Phil. and *E. albocinctus* Hutton in separate families, may be mentioned, although the two are so

[1] This was written before the publication of Jackson's magnificent monograph on the Phylogeny of the Echini (Mem. Boston Soc. Nat. Hist., VII, 1912) in which the same course is followed. The classification used herein is essentially identical with that to which he has been led by his prolonged morphological studies.

much alike that they can be separated only with the greatest difficulty and I am unable to regard them as really distinct species. Mortensen himself ("Ingolf" Ech., pt. 1, p. 140) recognizes the close relationship of these two forms but considers it desirable to separate them in order to make the family definitions more precise. The difference in their globiferous pedicellariæ, upon which their position in different families is based, is so slight, that the comparison of Mortensen's figures ("Ingolf" Exp., pt. 1, Pl. 19, figs. *19* and *23*) and the perusal of Döderlein's paragraphs ("Valdivia" Ech., p. 232) in which Mortensen's course is defended, is suggested to any one interested in the matter. It is unfortunately necessary in systematic work to use lines of division which do not exist in nature, and it must be frankly admitted that some of those employed here are open to serious criticism, but it is hoped that the separation of any two closely allied forms upon such an utterly trivial basis as this which is supposed to separate *magellanicus* and *albocinctus* has been avoided. Similar cases of wide separation of forms which seem very closely allied are the cases of *Strongylocentrotus lividus* and *dröbachiensis*, *S. tuberculatus* and *franciscanus*, and *S. albus* and *S. gibbosus*. On the other hand, we find more or less close relationship proposed between *S. albus* and *Echinus microtuberculatus*, between *S. lividus* and the species of Echinus, between *Sphærechinus granularis* and Tripneustes and between Heliocidaris and the Echinometridæ. All of these seem most improbable if not impossible associations. In view of these striking cases it is not easy to understand how Mortensen can express himself as he does (l. c., p. 140) concerning the "natural relation" of his proposed groups.

The second objection to Dr. Mortensen's system as applied to the Echinidæ is the inconsistency of relying on it for the greater part of the regular Echini but failing to use it for the Temnopleuridæ. I can hardly do better than quote Mortensen's own words on this point (Dan. Exp. Siam: Ech., p. 56): "It is a very surprising fact that the pedicellariæ of the Temnopleurids prove to be only of subordinate value for classification. * * * they mostly give only specific characters. In the larger genera * * * the globiferous pedicellariæ assume the forms occurring both in the Echinidæ, Toxopneustidæ and Echinometridæ; in some species * * * they even occur in the same specimen in both the two forms which distinguish the families Toxopneustidæ and Echinometridæ. This very curious fact, of course, does not alter the classificatory value of the pedicellariæ in the other regular echinids; but we are forced to seek the generic characters of the Temnopleurids in the structure of the test." The conclusion which Dr. Mortensen reached for the Temnopleurids, from his study of the pedicellariæ of that family coincides with that which I have reached from the study of all the regular Echini: *i. e.* that while the pedicellariæ often afford good specific characters (doubtless in correlation with other features) they are not, taken by themselves, reliable as a guide in seeking for the true interrelationships of the species. It does not seem that a character of such uncertain value in the Temnopleuridæ can possibly become of *prime* importance in the closely related Echinidæ. Taken in connection with the other characters however, the globiferous pedicellariæ undoubtedly assist in tracing the differentiation of the species, and in grouping them in genera, and in a few cases they are the most obvious, if not the most important, generic character.

On turning to the test for the characters upon which to base a natural classification, it is apparent at once that in all the less specialized Echinidæ as well as in the Temnopleuridæ the outline of the test is circular [1] and the ambulacral plates are made up of an adoral primary element and two secondary elements, the pairs of pores being placed in nearly vertical arcs of three. From this simple ancestral form, development has proceeded along at least four different lines.

(1) The Temnopleurids have developed more or less sculptured tests, with the coronal plates often united by dowelling, while undergoing little if any modification of the ambulacral structure; until we reach the highly specialized condition of Holopneustes where the lateral spreading of the poriferous areas, associated probably with some sort of vertical pressure, has greatly increased the number of ambulacral plates, with accompanying displacement, but without increasing the number of their elements.

(2) A similar development of the ambulacra, by great increase in the number of ambulacral plates, without altering their tripartite structure has occurred in Tripneustes and its allies in the Echinidæ proper. In the Strongylocentrotidæ and Echinometridæ, development of the ambulacra has been along a different line, for there is rarely any great crowding of the ambulacral plates or displacement of their elements but instead there has been a more or less marked increase in the number of component elements in each plate. The connection between these families and the Echinidæ is obvious and it is very interesting to note that in the case of each one, there is a genus which might properly be assigned either to the parent or the derived family.

(3) The Echinometridæ differ from the Echinidæ, besides the difference in the ambulacral plates, in the elongated form of the test. Yet in Parasalenia

[1] The case of *Microcyphus annulatus* Mortensen appears to be no exception, as a series of eight specimens shows that the outline of the ambitus is circular or slightly pentagonal.

an elongated test is associated with only three pairs of pores in each ambulacral plate. As a further indication of the intermediate position of Parasalenia, attention may be called to the fact that the elongation of the test in that genus is through IIIb–5b, while in Echinometra it is ordinarily through 3–I and in Heterocentrotus, the most extreme of the family, it is through IVb–1b or 4a–IIa. There is thus a progressive movement of the axis to the animal's left, which is least marked in Parasalenia. It seems that it would be perfectly proper to class that genus with the Echinidæ if one preferred, although for convenience it is here placed in the Echinometridæ.

(4) The genus Echinostrephus, in a somewhat similar manner, serves to connect the Echinidæ, characterized by only three pairs of pores in each ambulacral plate, with the Strongylocentrotidæ, characterized by more than three pairs. For in one species of Echinostrephus there are three pairs of pores and in the other there are four. The line of division between the two families thus cuts the genus Echinostrephus exactly in two and it might therefore be properly placed in either family. On account of the specialized form of the test however, I place it in the Strongylocentrotidæ, and consider this view strengthened by the fact that specimens of Strongylocentrotus, of two different species, occur in which the ambitus is above the mid-zone, as is so characteristic of Echinostrephus. This peculiarity has not been noted in any species of the Echinidæ.

Since so much stress is laid on the importance of the number of pore-pairs in an arc, or rather on the number of elements in each ambulacral plate, it is proper to utter a word of caution in regard to the use of this character. It must continually be borne in mind that the oldest plates in each ambulacrum are those at the peristome, while the youngest are next to the ocular plate. The former often show therefore features characteristic of recent ancestors, while the latter show youthful characters, *i. e.*, are not fully developed. Consequently it is in the area between these two regions, aptly termed by Jackson the "mid-zone," that the specific characters must be sought. For practical purposes, the region just above the ambitus (in Echinostrephus, just below the ambitus) will show the species character in adult specimens. In young specimens, obviously the species character will be further above the ambitus and in very young specimens it will be found, if at all, near to the ocular plate. On the other hand in very old specimens, old age characters will begin to appear near the ocular, senescence having set in. In an old specimen therefore of a Strongylocentrotus with six elements in the ambulacral plates, as its specific character, there will be found near the peristome five (sometimes four or even three) pore-pairs in each arc; at the ambitus and above there will be six and near the ocular plate, there will often be five or only four. In a really young specimen of the same species there will be four (or only three) pairs near the peristome, five at and above the ambitus and six near and adjoining the ocular plate. In the Echinidæ and Temnopleuridæ, there is no change in the number of elements in each plate as one passes from the peristome upward but the relation between them becomes more and more simple and obvious as one passes from the mid-zone to the ocular. This increasing simplicity is most marked in forms like Holopneustes and Tripneustes. Finally, it should be remembered, that any individual plate is liable to malformation and to variation from the typical condition, so that plates with only four or five elements are occasionally found intercalated between those having six or even more.

Immature specimens are often a source of difficulty and error. The absence of genital pores is one of the most obvious evidences of immaturity but unfortunately these pores appear long before maturity so that their presence is no criterion of age. Disproportionately large abactinal and actinal systems are youthful characters, while the appearance of the periproct, the pore-pairs, and the spines often show whether a specimen is mature or not. The identification of young Echini is often very difficult and it is frequently impossible to distinguish the young of allied species or even of allied genera, unless a series of specimens showing growth changes is available for comparison.

No reliable system of classification permits the certain identification of isolated, immature specimens. One of the very few conveniences of using the pedicellariæ as the basis of classification in Echini, is that they are essentially the same in the youngest specimens in which they are found, as in the adult. In reality however this is an important argument against their validity for systematic purposes, for it can hardly be questioned that a character which appears full-fledged in early youth and undergoes no change in ontogeny, has no phylogenetic significance. The occasional convenience therefore of using the pedicellariæ in identifying young Echini should not be construed as evidence of their systematic value.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plate 93, figs. *1–15*, *22*, *23*, *32*.

The spines of the Echinidæ are smooth and solid and afford few characters of value for systematic purposes. Generally there is no very marked difference between the primaries, secondaries, and miliaries, but in a few cases the primaries are conspicuously longer. As a rule the primaries are relatively short and stout but in a few cases they are long, slender, and pointed. The secondaries also are usually rather short and stout, but are occasionally very slender and sometimes are noticeably rough.

The pedicellariæ of the Echinidæ show considerable diversity, all of the four kinds being more or less common. The following summary of their characters is necessarily largely a repetition of the very complete publications of Mortensen. The *globiferous* pedicellariæ are remarkable for the very great development of poison-glands in connection with the valves. These glands may be on the stalk or on the valves of the pedicellariæ, but in either case are commonly quite conspicuous. They may be present in both positions. The stalks themselves are made up of slender calcareous threads, which are only very slightly connected with each other; or the threads may be stouter and very fully united together making either a somewhat tubular or a solid stalk. In some cases the head is connected with the stalk by a neck of greater or less length but often the neck is wanting. The valves show a greater or less specialization in the different species, the most specialized valves being found in those species which have some specialized condition in the test. In their simplest condition, the valves have the blade open, but more or less deeply concave and in addition to the terminal tooth which is of moderate size there are additional teeth on each lateral margin. In a slightly advanced condition the terminal tooth is larger, there are only one or two teeth on each side and there are cross-bars of lime connecting the margins of the somewhat compressed blade. Further specialization occurs by the closer and more complete union of the margins and the development of the terminal tooth with the accompanying reduction or loss of the lateral teeth. In the most specialized condition the blade is cylindrical and terminates in a single very prominent tooth, but in other cases, there is a very large lateral tooth on the left side, slightly below the tip. Sometimes, in species which typically have this unpaired tooth, valves with a similar but somewhat smaller tooth on the right (Pl. 95, fig. *24*) are found. The steps by which the transformation from the simple to the most specialized form takes place are easily followed, although as a rule the form found in any one species is very constant. In some species however, like *P. magellanicus*, considerable diversity is found even in one specimen. Aside from the great differences shown in the actual size of the valves, there is much variation in the relative length and breadth of the blade, the base and the terminal tooth. In many species the tissue surrounding the valves is more or less filled with calcareous spicules, which may be either dumb-bell shaped, or bluntly, or sharply bihamate.

The *tridentate* pedicellariæ reveal as great a diversity of structure as that shown by the globiferous, but the diversity is much less correlated with specific limits and it is difficult to detect anything like progressive specialization. The simplest condition of the valves is probably that shown by many of the small ones, where the blade is about twice as long as the base, perhaps a little more than twice its own width, only slightly curved and roundly pointed at the tips. From this simple condition, specialization has diverged, on the one hand towards excessively elongated, compressed valves, and on the other towards broad, stout valves little compressed. Several forms are often found on one specimen, but the two extremes do not occur togethrer. The amount of calcareous meshwork in the cavity of the blade is variable; sometimes it is almost wholly wanting while in other cases it occupies nearly the entire inner surface of the blade. These pedicellariæ have a slender stalk, and usually more or less of a neck. The valves themselves may be more than three millimeters in length but are usually about a millimeter, though they are often much less. It is an interesting fact that the globiferous and tridentate pedicellariæ seem to be more or less supplementary to each other, for when one kind is unusually abundant, the other is often quite wanting. Thus in some specimens, even to some extent in certain species, tridentate pedicellariæ are common enough, but we search in vain for the globiferous, while in others tridentates are not found but the globiferous occur in sufficient quantity.

The *ophicephalous* pedicellariæ are always present in greater or less numbers and although ordinarily easily recognized, they may intergrade more or less with the tridentate. They have no neck but the valves have well-developed "articular loops," which differ strikingly in size on the three valves. The stalk is thick and solid. In the form of the valves two quite distinct types occur, the unconstricted and the constricted. In the former there is no sharp distinction between base and blade, and the valves are more or less triangular; they are sometimes narrow and elongated and then intergrade very naturally with the tridentate through the suppression of the loop, which is in any case rather small. In the constricted pedicellariæ, the loop is usually very well developed, and a marked constriction separates the blade from the base of the valve; the blade itself may be nearly circular or more or less elongated, but it usually contains a very considerable calcareous mesh-work.

The *triphyllous* pedicellariæ seem to be constantly present, though on account of their very small size, they are often difficult to find, especially when the other sorts of pedicellariæ are very abundant. Their heads are usually from .10 to .20 mm. long and are borne on stalks four or five times as long, with which they are connected by a very extensile neck. The valves themselves show little diversity in form and scarcely any structural peculiarities. The distal half is commonly wider than the base and is distinctly truncate, though in a few species it is rounded. The breadth of the valve is usually about equal to the length and may exceed it. In most cases the ending of the apophysis in the blade is quite indistinct, but it may appear as a well-marked fork and rarely it gives rise to ridges which run out onto the blade.

The *sphæridia* show very little indication of specialization. They are present in some numbers on the actinal part of each ambulacrum, but are not sunken in any depressions, nor have they any unusual relation to the plates. They occasionally occur on the buccal plates, and as Mortensen has shown, their intergradation with miliary spines is sometimes quite evident. They are more or less elongated and are usually smooth but may be quite rough, at least at the tip.

The *calcareous spicules* of the tube-feet, when fully developed, are of the typical bihamate form, but they are often found with the ends blunt instead of sharp. Mortensen ("Ingolf" Ech., pt. 1, Pl. 21, fig. *31*) has given a good series of figures showing the transition from simple granules to dumb-bell shaped spicules and from the latter to complete bihamate rods. Sometimes the bihamate spicules are more or less branched or provided with teeth at and near the tip. Spicules are sometimes abundant but are often uncommon and very hard to find, and are not of the least value for systematic purposes in this family.

The Genera and Species of Recent Echinidæ.

There are rather more than fifty recent species, belonging in this family as here limited; the fossil forms unfortunately must be left out of account. The recent species form a homogeneous group and it is difficult to arrange them in genera, which shall be at the same time, natural and sharply defined. For few groups show more clearly than do the Echinidæ, the progressive differentiation of species and while it is possible to trace out the probable lines of development, it is exceedingly hard to arrange the species in genera in such a way as to indicate those lines. Taking any single character as a standard we can indeed make lines of division sufficiently sharp to be easily seen, but such a course works havoc with the natural relationships. Moreover some of the most important characters show such a perfect series of steps from the simple to the specialized condition, even within the limits of a single species, that they are of little value in defining genera, or at least, must be used with great caution. As an illustration of this point reference may be made to the tuberculation of the ambulacra. Mortensen ("Ingolf" Ech., pt. 1, p. 93) first called attention to the marked difference between having a primary tubercle on each ambulacral plate, and having one, only on each second, third, or fourth plate. Associated as this is with a change in the form of the plates and the arrangement of the pores, it is indeed a most important character. The use of it however as a factor of primary importance in the classification of the family is nullified by the fact that in *Echinus acutus*, specimens may be found in which every ambulacral plate has a normal primary tubercle, while in others not only are many ambulacral plates smaller than their fellows and lacking a primary tubercle, but some of the abactinal ones are actually made up of only *two* elements, a most unusual condition in this family. Between these two extremes, all possible intermediate stages are found. An attempt therefore to define genera with reference to the tuberculation of the ambulacra, necessitates putting some specimens of *acutus* in one genus and some in another, while some would be exceedingly hard to place. A similar difficulty arises when stress is laid on the condition of the gill-cuts. Thus in *Lytechinus* [1] *variegatus*, the adults have deep and well-marked gill-cuts while in *L. semituberculatus* they are smaller and less distinct and in *L. verruculatus* they are scarcely specialized at all. Moreover as Mortensen has pointed out ("Ingolf" Ech., pt. 1, p. 115) in small specimens of *variegatus*, the gill-cuts are no more noticeable than in many other species. There can be no question however, that the absence of primary tubercles on many ambulacral plates and the presence of sharply defined gill-cuts are evidences of specialization and while their occurrence in Echinus and Lytechinus respectively is not of any value for the definition of those genera, in Toxopneustes and Tripneustes, where they have become fully differentiated and fixed, they are important generic characters.

[1] For the use of this and other generic names, see below under the respective genera.

The arrangement of the ocular plates with reference to the periproct, a morphological character so beautifully worked out in Jackson's recent monograph (1912, Mem. Boston Soc. Nat. Hist., VII., p. 86–164) is of great importance in tracing the lines of development in the Echinidæ, but it is impossible to rely on it alone. The same is true of the amount of calcification in the buccal membrane, the relative sizes of the spines and tubercles and the characters of the globiferous pedicellariæ, though all of these are of the greatest help. Finally it may be emphasized that, as Mortensen has pointed out, color is often a suggestive character, and although in certain species (as *Echinus acutus* and *Lytechinus variegatus*) it is very variable, in most cases it affords a good deal of assistance in determining specific limits.

Having thus indicated the characters in which the specific differentiation of the Echinidæ is best shown, it is desirable to point out what seem to have been the lines of development and the resultant, most highly specialized genera. There can be little question that the two species of Psammechinus (*Echinus miliaris* Gmel. and *E. microtuberculatus* Bl.) are the least specialized members of the family, at present known. This is shown by the uniform series of ambulacral plates, the small exsert oculars, the absence of distinct gill-cuts, the heavily plated buccal membrane, the slight differentiation of primary spines and tubercles, and the character of the globiferous pedicellariæ. From some such stock, the species of Echinus have undoubtedly come and it is not difficult to trace possible lines of differentiation. It seems probable that *Alexandri* is not far from the ancestral stock, as shown by the ambulacra and abactinal system, though the buccal membrane, the primary spines, and the globiferous pedicellariæ, all show considerable specialization. Although *Wallisii*, *atlanticus*, and *gracilis* all show a very high degree of specific differentiation, it seems likely they originated from the Echinus-stock near *Alexandri*. *Echinus acutus* is the most highly variable species of the family, and while some of its forms are very near *Alexandri*, it shows tendencies towards specialization in several different directions. The resulting extremes are so utterly unlike, one would never consider them conspecific were it not for the completeness of the intermediate series. From *acutus* as a centre, such species as *esculentus* and *tenuispinus* have arisen on the one hand by marked changes in the ambulacra without accompanying changes in the abactinal system, while on the other hand *margaritaceus* has developed with less specialization of the ambulacra but with greater changes in the abactinal system. From similar stock the development, through *E. armatus*, of Evechinus, the most specialized genus of this branch of the family, well characterized by its remarkable ambulacra, abactinal system, and pedicellariæ, can be traced. From Psammechinus, another line of development runs out through Lytechinus to Toxopneustes and Tripneustes, characterized by increasing specialization of the ambulacra, abactinal system, gill-cuts, and pedicellariæ. It is not easy to draw a line between Psammechinus and Lytechinus, as the less specialized members of the latter genus have no noticeable gill-cuts and only one ocular, or none, insert. For convenience, we have drawn an arbitrary line based chiefly on the specialized globiferous pedicellariæ of Lytechinus. It is probable that Gymnechinus, with its remarkable abactinal system and globiferous pedicellariæ, has been differentiated from Lytechinus through such a group as Nudechinus, which is sharply distinguished from Lytechinus by the thin, naked buccal membrane. From Psammechinus again, still a third group of species has developed in the far south, for which Mortensen's name Parechinus is employed. Of this group, *angulosus* is nearest the original stock in its ambulacra, spines, and pedicellariæ, but shows decided specialization in the abactinal system and buccal membrane; *annulatus* is a very close ally. In *magellanicus*, the buccal membrane shows further loss of calcareous matter and the globiferous pedicellariæ, though variable, are more specialized than in *angulosus*. The most extreme member of this group is *huttoni*, as shown by the globiferous pedicellariæ and the tuberculation of the test.

While it is impossible to show in a linear arrangement, the relationships of the genera as here pointed out, the following table will indicate the limits which are assigned to each one. It will be observed that it is not possible to use the generic names Sterechinus Koehler, Pseudechinus Mortensen, Protocentrotus Döderlein, Notechinus Döderlein, or Selenechinus de Meijere. It is to be regretted that no one of them is available for the little group of species for which the name Nudechinus is herein proposed.

Periproct approximately central; if two oculars reach it, they are typically I and V.
  Buccal membrane more or less heavily plated (except *L. rufus*); a primary tubercle on every ambulacral plate.
    Oculars plates all exsert; abactinal system well covered with tubercles; gill-cuts insignificant; valves of globiferous pedicellariæ with lateral teeth . . *Psammechinus.*
    Ocular I often, and in some species ocular V also, insert or nearly so; abactinal system usually with few tubercles; gill-cuts, in specimens over 30 mm. h. d., usually deep and sharply defined; valves of globiferous pedicellariæ without lateral teeth . . . . *Lytechinus.*
  Buccal membrane not plated but with more or less numerous, small, scattered plates or none in addition to primordial ambulacrals.
    Gill-cuts shallow and not sharply defined.
      Poriferous areas not very broad; pore-pairs in arcs of three.

Ocular plates small, completely excluded from periproct (except in *margaritaceus*); primary spines much longer, and primary tubercles much larger, than secondaries; buccal membrane with more or less numerous plates; valves of globiferous pedicellariæ with small lateral teeth on each side near tip (except in *armatus*); spines unicolor or becoming lighter at tip; size usually large, often exceeding 75 mm. h. d. . . . . *Echinus.*

Ocular I usually, ocular V not rarely, nearly or quite insert; a primary tubercle on each ambulacral plate; primary spines and tubercles not especially conspicuous; buccal membrane thin and usually bare (except in *angulosus* and *annulatus*); size small rarely exceeding 40 mm. h. d. and usually under 30.

Valves of globiferous pedicellariæ with one or more lateral teeth *Parechinus.*

Valves of globiferous pedicellariæ with no lateral teeth . . . *Nudechinus.*

Poriferous areas very broad; pore-pairs at ambitus in three distinct vertical series; a primary tubercle only on every second, third, or fourth ambulacral plate . . . . *Evechinus.*

Gill-cuts deep and sharply defined; a primary tubercle usually only on every second, third, or fourth ambulacral plate; valves of globiferous pedicellariæ with no lateral teeth.

Poriferous area not one half as broad as interporiferous; pairs of pores in arcs of three . . . . *Toxopneustes.*

Poriferous area more than half as broad as interporiferous; pairs of pores in three, more or less well separated vertical series . . . . *Tripneustes.*

Periproct excentric at right, with oculars I and II insert . . . . *Gymnechinus.*

Psammechinus.

Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI., p. 368.

Type-species, *Echinus miliaris* Gmelin, 1788. Linné Syst. Nat., ed. 13, p. 3169.

Mortensen's extraordinary course in selecting "*Echinus variegatus* Lam'k." [1] as the type of this genus and proposing a new generic name for *miliaris* and its allies ("Ingolf" Ech., pt. 1, p. 108, 114) is so contrary to all the accepted rules of nomenclature, that it is necessary to discuss the matter fully here. The name Psammechinus was proposed by Agassiz and Desor in 1846 for a subgenus of

[1] The argument of Lambert (1906, Mem. Geol. Soc. France, XIV, p. 66, footnote 3) that the use of the name *variegatus* for this common and well-known species is not justifiable, would be unassailable were it not for an error in the first premise, that "*Cidaris variegata* Leske est un réalité un Tripneustes." There can be little question that Klein's figure, to which Leske refers, is a Tripneustes, but it is equally certain that the figures of Seba and Gualtieri to which Leske also refers are the West Indian species, long known as *Toxopneustes variegatus*, and a careful reading of Leske's description shows that it is the latter he is describing and not a Tripneustes; his description of the ambulacra clearly proves this. Moreover Leske and all the earlier writers (except Klein) refer to the *green* and white coloration, and so far as known, no one has ever found a *green* and white Tripneustes. It seems clear therefore that *variegatus* must be retained as a specific name but should be credited to Leske 1778, instead of to Lamarck, 1816. The nomenclature of the genus Tripneustes will not suffer, for the species to which Leske's name *variegata* was long applied, was described by Linné, and thanks to Lovén's work, has now for more than twenty years borne its Linnæan name, *gratilla*.

Echinus, into which they put a rather heterogeneous group of species. In 1855, Desor raised the group to generic rank and in 1862, Dujardin and Hupé rearranged the species, but in neither instance was there any revision of the group attempted. In 1863 however both A. Agassiz and Lütken, quite independently recognized the unnatural association of species in the group, and removed from it the species with deep gill-slits. Agassiz, whose paper has a few months priority, is clearly the "first reviser" and he definitely restricts Psammechinus to the forms with shallow gill-slits (though he gives no diagnosis) and names *miliaris* as the first species. To the species with deep gill-slits he gives the name Lytechinus, and under it names three species, all of which Mortensen, and all other recent writers, regard as synonyms of *variegatus*. While the action of Agassiz does not settle the type of Psammechinus, it does forever preclude the use of *variegatus* as the type of that genus; unless indeed the name is used in the same sense and with the same contents as when originally proposed! Lütken's paper, while entirely in agreement with Agassiz's, very naturally gives a different name (Psilechinus) to the *variegatus* group, which of course is a synonym of Lytechinus, but he also fails to designate a type for the restricted Psammechinus. He suggests *verruculatus* as a typical example of the genus and it might have been accepted as the type, were that not impossible since *verruculatus* is not among the species known to Agassiz and Desor, and therefore is not in their genus. In 1867, Verrill (Trans. Conn. Acad., I, p. 302) definitely designates "*Echinus variegatus*" as the type of Lytechinus. In 1869, Pomel (Rev. des Ech., p. 42) says that Psammechinus Agassiz and Desor is not a homogeneous group and ought to be restricted to the type of *miliaris* and *microtuberculatus*. Schizechinus is very unnecessarily proposed for *variegatus* and its allies. It seems impossible to doubt that at the time of the publication of the "Revision of the Echini" (1872) all students of the Echini were agreed that the name Psammechinus belonged to *miliaris* and its allies, while *variegatus* typified a very different group, for which three different names had been suggested, the earliest being Lytechinus A. Ag. In the "Revision of the Echini" Mr. Agassiz thought best to unite Psammechinus with Echinus, and Lytechinus with Toxopneustes and these unions have been almost universally accepted. Mortensen (1903, "Ingolf" Ech., pt. 1, p. 106, 114) has however shown excellent reasons, in the structure of the ambulacra and in other characters for separating the groups thus united, but it is clearly impossible to follow his nomenclature. While it seems possible to argue as to whether any type has ever hitherto been definitely and correctly assigned to Psammechinus, the type of Lytechinus is beyond doubt. Lambert's

(1906, Mem. Geol. Soc. France, XIV., p. 67) and Mortensen's (1907, "Ingolf" Ech., pt. 2, p. 174) statements that Anapesus Holmes must take precedence over Lytechinus for *variegatus* and its allies, shows that neither of them has consulted Holmes's paper (1860, Post-Pliocene Fossils S. Carolina, p. 5, Pl. II, fig. 2) but each has been misled by Pomel. The mistake of the latter was doubtless due to the unfortunate error in the "Revision" (p. 167, 168, and 172) by which Anapesus Holmes is made a synonym of Toxopneustes instead of being assigned to Arbacia, to which it is correctly referred on p. 72 of the "Revision." Holmes's excellent figure permits no doubt on this point. It is most fortunate that *miliaris* may be accepted as the type of Psammechinus for of all the species included by Agassiz and Desor in their subgenus, it is the only one to which the diagnosis given, accurately applies. Mortensen's attempt to fit that diagnosis to *variegatus* is scarcely convincing.

As herein limited, Psammechinus includes only the two well-known European species, which may be distinguished from each other as follows: —

Buccal membrane well covered with whitish plates; tuberculation of test, coarse; secondary tubercles very large . . . . *miliaris*.
Buccal membrane completely covered by green or greenish plates; tuberculation of test, fine; primary tubercles much larger than secondaries . . . . *microtuberculatus*.

Lytechinus.

A. Agassiz, 1863. Bull. M. C. Z., I, p. 24.
Type-species *Cidaris variegata* Leske, 1778. Add. ad Klein, p. 85.

It is not necessary to repeat here what has just been said under Psammechinus, regarding the type of this genus. Careful study of large series of specimens from Bermuda, South Carolina, Florida, Yucatan, various West Indian islands, and Brazil shows that the Bermudian form, originally described under the name of *atlanticus*, which has recently been reinstated by Jackson (1912, Mem. Boston Soc. Nat. Hist., VII, p. 121), can hardly be maintained as a valid species. Typical specimens from Bermuda are strikingly different from Floridian and Carolinian specimens, while in both regions, the characteristic green and white West Indian form seems to be unknown. We have specimens from Brazil however, which are much like the Bermudian form, while many Bermudian specimens are distinctly green. It seems clear that *variegatus* is a highly variable species, which in Bermuda is developing into a very slender spined, deep purple form, while along the continental coast it is becoming stout spined and deep pink. In the Brazilian region, variation does not seem to have become fixed in any special line.

To indicate these facts it seems desirable to use subspecific names, and the characteristic Bermudian Lytechinus is accordingly designated as *L. variegatus atlanticus* A. Ag., while that from the continental coast is called *L. variegatus carolinus* A. Ag.

In attempting to draw lines of division between this genus and Psammechinus on the one hand and Toxopneustes on the other, there is very great difficulty as the species of these genera appear to form an almost unbroken intergrading series. The only sharp line appears to be in the globiferous pedicellariæ, which in *miliaris* and *microtuberculatus* are quite simple with lateral teeth, while in all the other species, the lateral teeth are wanting and the blade is tubular with a long terminal tooth which reaches its most extreme development in Toxopneustes. By this character, a number of small tropical species are separated from Psammechinus, with which genus they are otherwise quite closely allied. As however they all show a more or less decided tendency to have one or two oculars insert and the gill-cuts more sharply defined, it has seemed justifiable to associate them with Lytechinus. The line of division between this genus and Toxopneustes is not suggested by the pedicellariæ but is based on the reduction of calcareous matter in the buccal membrane and the increased specialization of the ambulacra in Toxopneustes. In the latter character however, the Japanese species, *T. elegans* Död., is very little advanced over Lytechinus, while the calcification of the buccal membrane is more or less variable in both genera.

As used here, Lytechinus is a somewhat heterogeneous group of nine species, of which four are here described for the first time. Of the other five, two (*variegatus* Leske from the West Indian region and *semituberculatus* Agas. and Des. from the Panamic region) have long been known as congeneric species, while the relationships of the third and fourth (*verruculatus* Ltk. and *rufus* Bell from the Indo-Pacific region) and the fifth (*pictus* Verr. from Lower California) have only recently been made clear. Mortensen (1903) first pointed out the relationship of *verruculatus* to Lytechinus and (in 1904) of *rufus* to *verruculatus*, while *pictus* has up to the present time been confused with other species. It is therefore a pleasure to now give it its rightful position as a valid species of this genus. The nine species are easily distinguished from each other when adult, but young specimens of the larger species are not always easily recognized, and since the specific characters shown by the abactinal system and the gill-cuts are not assumed fully until the individuals are 8–10 mm. in diameter or even larger, it has been found necessary to base the distinctions of the following table largely on color. Not having seen specimens of Bell's "*Salmacis rufa*" follow

Mortensen who has examined the type and other specimens, in regarding it as nearly related to *verruculatus*. Bell says nothing about the buccal membrane; de Meijere says it is "sehr nacht"; Mortensen that it contains a "great number of small irregular plates." It seems probable that, as Mortensen suggests, this species serves as the connecting link between Lytechinus and the group here called Nudechinus. It is not possible to determine whether the species *dyscritus* and *callipeplus* are based on full grown specimens or not but it does not seem probable that they are.

Test white or whitish more or less shaded with yellowish green abactinally; spines white or whitish, often yellowish or yellow-green at base; oculars small, all exsert or rarely I insert.
- Test high; primary tubercles small, little larger than secondaries; primary spines short, rather stout; size moderate, up to 30 mm. h. d. . . . . *euerces.*
- Test much flattened; primary tubercles very conspicuous; primary spines long; size small, less than 10 mm. h. d. . . . . *dyscritus.*

Test and spines not as above.
- Oculars all exsert or sometimes I insert; test variegated with reddish or red; primary tubercles, at least abactinally often reddish; primary spines more or less red or with red bands.
  - Spines pale red, not banded . . . . *callipeplus.*
  - Many primary spines with 2 or 3 red rings . . . . *rufus.*
- Oculars relatively large, not usually all exsert; test and spines not as above.
  - Spines light with 1–4 faint, narrow rings of brown, dull green or pinkish; oculars I and V usually insert; size moderate, rarely exceeding 30 mm. h. d. . . . . *verruculatus.*
  - Spines not as above.
    - Oculars variable, often exsert but often I, or I and V insert; test depressed, low; primary tubercles, at least abactinally, often very dark; spines dull greenish or light; size moderate, seldom exceeding 25 mm. h. d. . . . . *anamesus.*
    - Oculars I and V usually insert, and sometimes IV also; test and spines not as above; gill-cuts in adults usually deep and sharply defined.
      - Spines bright yellow-green (K. & V. 282); in very young individuals they are darker and are tipped (sometimes banded also) with white; abactinal interambulacral areas very bare, most of the plates above ambitus carrying no tubercles between the two rows of primaries; size moderate, up to 45 mm. h. d. . . . . *semituberculatus.*
      - Spines not bright yellow-green; abactinal interambulacral areas with secondary tubercles.
        - Abactinal interambulacral plates with many secondary and miliary tubercles, only the extreme inner end of each plate, bare; coloration prevailingly rose-purple when young, becoming paler and duller with age, with no indications of either green or deep violet; primary

spines stout and blunt; size moderate, up to 40 mm. h. d. *pictus.*

Abactinal interambulacral plates largely bare, usually with only 3 or 4 small tubercles; primary spines slender and pointed; size large, up to 80 mm. h. d.

Color variable, but rarely deep violet; primaries moderately slender; ocular IV seldom insert (in only 8 per cent of the specimens).

Colors prevailingly green and white; primary spines rather slender . . . . *variegatus typicus*

Color prevailingly dull pink; primary spines stouter . . . . *variegatus carolinus*

Color deep, rich violet; primary spines very slender; ocular IV often insert (28 per cent of the specimens) . . . . *variegatus atlanticus.*

Lytechinus euerces,[1] sp. nov.

Plates 93, figs. *4, 5;* 98, figs. *3, 4;* 107, figs. *4–6.*

The largest of the specimens (Pl. 107, figs. *4–6*) measures 32 mm. in diameter while the height of the test is 22.5 mm. There are 18 interambulacral plates in each column and 23 ambulacral plates in each half-area. The longest primary from just below the ambitus, is only about 6 mm. in length. The abactinal system is 8 mm. in diameter and the actinostome 12 mm. A smaller specimen, 18 mm. in diameter, has the test 12 mm. high, the abactinal system less than 5 mm. across and the actinostome 8 mm. There are 14 interambulacral and 16 ambulacral plates in each column. In a still smaller specimen, 10 mm. in diameter and 6 mm. high, the abactinal system is 4 mm. across, the actinostome 6 mm., and there are 8 interambulacral and 10 ambulacral plates in each column.

The periproct (Pl. 98, fig. *4*) is moderately large, decidedly exceeding a genital plate in area. It is covered by a dozen or more plates, of which those adjoining the anus are quite small; the outer series are much bigger and the one adjoining the left anterior genital plate is so much the largest it may properly be called a suranal; in the largest specimen, it carries a well-developed secondary tubercle and spine. The genital plates are of approximately equal size, though the madreporic plate may be a trifle the largest. They usually form a closed ring, but 1 and 5 may be separated. They are noticeably bare, carrying only 1–3 secondary tubercles, situated near the proximal margin. The pores are circular and quite large, in the distal part of the plate. The oculars are small

[1] ἐνερκής = well protected.

and bare, carrying only 1–3 very small tubercles. They are usually all exsert but in one specimen I is distinctly insert and in another it is nearly so.

The interambulacral plates at the ambitus are rather more than twice as wide as high. Each plate carries a small imperforate, non-crenulate, primary tubercle and 6–8 well-spaced secondaries, some of which are nearly as large as the primary. Miliary tubercles are small and abactinally they are few and very indistinct; actinally they become more numerous and better defined. The ambulacral plates are high, those at the ambitus half as high as wide and those near the ocular plate as high as wide. Each plate carries a small primary tubercle and 2–4 secondaries one of which is often nearly equal to the primary. The pore-pairs are small, well spaced and form a nearly vertical series, especially abactinally. The poriferous area is thus very narrow, occupying only the outer third of each plate, though near the actinostome it becomes a little wider. At the ambitus, the interambulacra are not quite twice as wide as the ambulacra.

The buccal membrane (Pl. 98, fig. *3*) is heavily plated. The primordial ambulacrals are approximated in pairs and are distinctly larger than the other plates. All the plates are thick, white, and polygonal and carry more or less numerous pedicellariæ. In the small specimens, there are practically no gill-cuts but in the large ones, the cuts are well defined though not very deep.

The primary spines are remarkably short, slender, and pointed. They show under the lens about a dozen longitudinal striations. The milled ring is only imperfectly developed. The secondary spines are similar but much more blunt. Miliaries are few and scattered, and are remarkably long and slender.

Pedicellariæ are abundant, the tridentate being the most common. The *globiferous* pedicellariæ are fairly common. The valves (Pl. 93, fig. *4*) are slender, about .65 mm. long, with the base not quite half so wide. The stalks are very slender, two or three times as long as the head, and there is no neck. The heads contain numerous spicules which are distinctly bihamate and not dumb-bell shaped; at least none of the latter were seen. The *tridentate* pedicellariæ show great diversity in size, the valves (Pl. 93, fig. *5*) ranging in length from .35 to 1.25 mm. The blade is moderately broad, rounded at the tip and contains a small amount of calcareous mesh-work. In the small tridentates, the valves are more compressed, there is no mesh-work, the margins are somewhat more dentate and the tip is bent in more. The *ophicephalous* are not rare and are rather conspicuous as the head is quite heavy and the stalks are long and stout. The valves are somewhat constricted but not markedly so. They measure about .40 mm. besides the loop which may be half as much again. The *triphyllous* are very small and are common. The valves measure about .15 mm. in length and are two thirds as broad. The *sphæridia* are sphæroidal or less commonly ellipsoidal; they occur only on the actinal part of the ambulacra and five or six may be grouped at the peristome. They seem to be perfectly smooth.

The coloration of this species is variable only in the amount of green. The general appearance of both test and spines is creamy white, while the plated buccal membrane is clear white. Abactinally, particularly along the sides of the interambulacra, there is a more or less marked shading of light green; in some specimens this is very marked, while in others it is almost wanting. Above the ambitus, the primary spines are as a rule, light green at base fading out into white at the tip. In some specimens, the spines are mostly green, but usually the white greatly predominates.

This interesting species was collected by the "Blake" in the West Indian region, but the specimens were identified either as *Trigonocidaris albida* or as *Toxopneustes variegatus,* although in most cases the doubtfulness of the identification was indicated on the label by one or more question marks. The resemblance of small specimens to *Trigonocidaris albida* is very marked, the absence of the sculpturing of the test being the only important difference, although the difference in color is more or less evident. From *Lytechinus variegatus,* this species is easily distinguished by the exsert oculars and the very short primary spines, as well as by the coloration. The geographical range of *euerces* as indicated by the "Blake" collection is from the Gulf of Mexico, northwest of the Tortugas, to Barbados, but three fourths of the thirty-nine specimens are from the vicinity of St. Lucia and Barbados. The bathymetrical range is from 84 to 300 fathoms.

Lytechinus dyscritus,[1] sp. nov.

Plates 93, fig. *10;* 96, figs. *1–3.*

The larger of the two available specimens, which are nearly of a size, is 7 mm. in diameter and only 3 mm. high. There are 8 interambulacral plates in each column and 9 ambulacral. The longest primary, from the ambitus, is about 5 mm. long. The abactinal system is 3 mm. in diameter and the actinostome is 3.5 mm. across.

The periproct (Pl. 96, fig. *3*) is rather large, distinctly bigger than a genital plate and is covered by 4 or 5 large plates, of which the one adjoining genital 3

[1] δύσκριτος = hard to determine.

is largest, covering half of the area or more. The genital plates are approximately equal and broadly in contact with each other. Each carries one secondary tubercle on the proximal margin, and occasionally there is a miliary tubercle beside it. The madreporic genital is perforated by only a few pores and these are situated in an elevation near the centre of the plate. The oculars are very small, all broadly exsert; each one carries a small secondary tubercle or two. There are no genital pores visible but with a lens, the ocular pores can be seen close to the distal margin of the plates.

The interambulacral plates at the ambitus are rather high, but the greater part of the surface is covered by the big primary tubercle, around which a few minute secondary tubercles are scattered. The ambulacral plates are high but their primary tubercles are very unequally developed. On some plates they are very large occupying most of the surface, while on others they are so small as to be more naturally called secondaries. There are usually more primaries developed on one side of the area, than on the other, giving the ambulacra a one-sided appearance. The pore-pairs are very small, three for each plate, and the poriferous area is a narrow, nearly straight, vertical line. At the ambitus, the ambulacra are about three fourths as wide as the interambulacra.

The buccal membrane (Pl. 96, fig. *2*) is thin and although well covered with plates, it is not heavily plated as in *euerces*. The primordial ambulacral plates are much larger than the others and form a nearly closed ring. There seem to be no spines or pedicellariæ borne by any of the actinostomal plates. Gill-cuts are scarcely to be detected at all.

The primary spines are noticeably long and correspondingly conspicuous, but are rather slender and taper to a point. Those at the ambitus are the longest and those of the ambulacra are smaller than the interambulacral. The secondary spines are very few; they are long and slender.

Pedicellariæ appear to be very scarce. The *globiferous* valves (Plate 93, fig. *10*) have the blade tubular and terminating in a single tooth, without lateral teeth. They are relatively large, measuring about .45 mm. in length. The *ophicephalous* do not show any special peculiarities but the valves are constricted above the base. No tridentate or triphyllous pedicellariæ were found, neither were there any sphæridia, or spicules in the tube-feet. No doubt the poverty of the available material accounts in large part for this lack.

The ground color of this species is white but abactinally there is, under a lens, a more or less evident yellow-green shade. This color is most marked on the outer ends of the genital plates, on the periproctal plates, along the sides of the interambulacra, especially around the tubercles or in the tubercles themselves, and at the bases of the abactinal spines.

The two specimens upon which this species is based are labelled "*Echinometra lucunter*, Florida. L. Agassiz," but in the catalogue both name and locality are followed by a question mark. The specimens are obviously immature, but the description and figures here given show clearly they do not belong in Echinometra. The buccal membrane is not plated nearly so heavily as in other species of Lytechinus, but the globiferous pedicellariæ indicate a probable relationship with that group. When compared with specimens of *L. variegatus* of the same size, the shape of the test, the characters of both abactinal system and buccal membrane, the long primary spines, and the coloration all serve to show that these little Echini cannot be the young of that species. And I have failed to find any other known species to which they show any closer relationship. They may prove to be the young of *euerces*, but the long primary spines, the conspicuous primary tubercles and the low, flat test separate them rather sharply from that species, as at present known.

Lytechinus callipeplus,[1] sp. nov.

Plate 96, figs. *4–6*.

The largest specimen is a bare test, 11.5 mm. in diameter and 6 mm. high. The abactinal system is 4 mm. in diameter and the actinostome is 6 mm. across. The type is 8.5 mm. in diameter and 5 high, with the abactinal system not quite 3 mm. across and the actinostome, 4.5; the longest spine is 2.5 mm. long. In a smaller specimen, 6.5 mm. in diameter, the longest spines are 3 mm. long. In the largest specimen, there are 11 or 12 interambulacral, and 12 ambulacral plates in each column, while in the type, there are 10 or 11 and 10 respectively. In a specimen, 7 mm. in diameter, the numbers are 9 and 9.

The periproct (Pl. 96, fig. *6*) is moderately large, decidedly larger than a genital plate. It is covered by about four plates of which the one adjoining genital 3 is largest. The genital plates are about equal and are about as high as broad. Each one carries a small tubercle near the proximal margin and there may also be one or two miliary tubercles on the plate. The genital pore is large and distinct at the distal end of the plate. The madreporic genital is fairly well covered with the minute pores of the water system. The oculars are

[1] καλλίπεπλος = beautifully robed.

large, and broadly exsert, except I, which is insert or nearly so in specimens more than 7 mm. h. d. Each ocular carries 1–3 small tubercles. The ocular pore is well developed near the distal margin of the plate.

The interambulacral plates are high, only those at the ambitus being nearly twice as wide as high. Each plate carries a small, but well-developed primary tubercle and 4–9 secondary tubercles, one or two of which approach the primary in size. The ambulacral plates are remarkably high, as high as wide or higher. Each plate carries a primary tubercle and 2–4 small secondaries of variable size. The pores are relatively large, three pairs in each plate, and are placed close to the interradial margin. The poriferous area is narrow and nearly straight. The ambulacra are about three fourths as wide as the interambulacra at the ambitus.

The buccal membrane (Pl. 96, fig. *5*) is very fully covered with thick white plates, among which the primordial ambulacrals, although distinctly the largest, are not conspicuous. The larger plates all carry pedicellariæ in small numbers, often only one to a plate. The gill-cuts are sharply defined but are not very deep.

The primary spines are rather short, and though relatively thick at the base, taper rapidly to a blunt point. They are finely, longitudinally striated. The scattered secondaries are short, thick, and pointed.

Pedicellariæ are not at all common, though the ophicephalous, because of their white color and long white stalks may be rather conspicuous. The *globiferous* pedicellariæ are small and show no special peculiarities. The valves have the usual tubular blade without lateral teeth and measure .25–.30 mm. in length. The *ophicephalous* show considerable variation in size; the valves, which are somewhat constricted above the base, range from .14 to .25 mm. in length, while the articular loop adds .03–.07 more. The stalks are stout and long, exceeding many of the secondary spines. No tridentate or triphyllous pedicellariæ and no sphæridia were observed. The *calcareous spicules* are distinctly bihamate.

The color of the test is quite variable; actinally it is white like the plated buccal membrane but abactinally it becomes pale brownish. The median ambulacral and interambulacral areas abactinally are more or less brick-red or less commonly reddish brown. There are traces of red also on the abactinal system. In some specimens, there are patches of light green at the ambitus and a similar color may sometimes be noted on the genital plates. The primary tubercles, abactinally at least, are more or less reddish. The plates of the periproct are white. The primary spines are pale red, lightest at the tip; those on the actinal side, especially in young specimens, show faint bands of red.

This pretty little species was collected by the "Blake" in the West Indian region, but many of the specimens were not distinguished from *Genocidaris maculata*, a species with which they were often taken and from which they are not easily distinguished, unless the specimens are dry. The coloration is very distinctive even though variable, while the small number of ambulacral plates as compared with the interambulacral is quite remarkable. The relationship of this species to both *euerces* and *variegatus* is obvious, but it cannot be confused with either. It was taken by the "Blake" only in the vicinity of Dominica, Grenada, and Barbados, in 69 to 170 fathoms of water. Of the seventeen specimens at hand twelve are from Barbados.

Lytechinus verruculatus, comb. nov.

Psammechinus verruculatus Lütken, 1864. Vid. Med., p. 166.

It seems probable that Mortensen is right in associating this species with *variegatus*. Although none of the specimens before me are nearly so large as those which de Loriol had from Mauritius, there seems to be no doubt of their identity. The "Albatross" specimens reveal the same peculiarities of coloration described by Mortensen (1904, Siam Ech., p. 123). In the smallest specimen the rings on the spines are red and the same color appears on small spines of larger specimens. Many primaries are red at base while in a few specimens, the base of the primaries is violet. There is great diversity in the depth of the colors marking the test. Although all the "Albatross" specimens are immature ranging only from 5 to 12 mm. in diameter, the seven examined in regard to the ocular plates showed the adult character nearly acquired. For five have ocular I broadly insert, and in three specimens, V also is almost in. Of the other two specimens one is a very rare variant, with only ocular IV insert and the other is a much more interesting variant with I and II insert as in Gymnechinus; the periproct is not however excentric.

Station 3847. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp.? 23–24 fathoms. S., st.

Station 3871. Off Mokuhooniki Islet, Molokai, H. I. Bott. temp.? 13–43 fathoms. Fne. wh. s.

Station 3872. Off Mokuhooniki Islet, Molokai, H. I. Bott. temp. 74.6°. 32–43 fathoms. Yl. s., p., co.

Station 3955. Off Laysan Island, H. I. Bott. temp. 74°. 20–30 fathoms. Co., r., alg.

Station 3970. Off French Frigate Shoal, H. I. Bott. temp.? 17–17½ fathoms. Crs. s., sh., co.

Station 4031. Off Diamond Head, Oahu, H. I. Bott. temp.? 27–28 fathoms. Fne. co. s., for., co.

Station 4032. Off Diamond Head, Oahu, H. I. Bott. temp.? 27–29 fathoms. Fne. co. s., for., co.

Station 4149. Off Modu Manu, H. I. Bott. temp. 77.7°. 33–71 fathoms. Co., corln.

Station 4162. Off Modu Manu, H. I. Bott. temp.? 21–24 fathoms. Co.

Station 4168. Off Modu Manu, H. I. Bott. temp. 78.3°. 20–21 fathoms. Co. s., for.

Bathymetrical range, 13–71 fathoms. Extremes of temperature, 74°–78.3°.

Sixteen specimens.

Lytechinus anamesus,[1] sp. nov.

Plates 99, figs. *4, 5;* 107, figs. *7–11.*

The largest specimen measures 25 mm. in diameter and 13 mm. high. It has 15 interambulacral and 19 ambulacral plates in each column. The abactinal system is 8 mm. in diameter and the actinostome is 9 mm. across. The longest primary is 15 mm. long. In a specimen 11 mm. in diameter and 5 mm. high, the abactinal system is 4 mm. and the actinostome 5 mm. in diameter. There are 10 interambulacral and 12 ambulacral plates in each half-area. A specimen 17 mm. in diameter is 9 mm. high, while another, 18 mm. horizontally is only 8 mm. vertically. A specimen 18 mm. in diameter has the primary spines about 16 mm. long, while in another, 17 mm. in diameter they only measure 9 mm. The smallest specimen in the series is 7 mm. in diameter and 3.5 mm. high. The abactinal system measures 2.5 mm. across and the actinostome 4 mm. There are in each column, 10 interambulacral and 12 ambulacral plates and the primary spines are about 2 mm. long.

The periproct (Pl. 99, fig. *5*) is large, much larger, as a rule, than a genital plate. It is covered by a number of plates (4–10 in the young, 12–20 in adults) of which one, adjoining genital 3, is usually much the largest. In adults, many of the plates carry small tubercles. The genitals are of approximately equal, moderate size, about as high as wide, and often form a closed ring, but often 1 and 5 are separated and often 5 and 4 also. Each plate has a large genital

[1] ἀνάμεσος = intermediate.

pore near the distal tip, while on the proximal margin it carries a secondary tubercle. There may be one or rarely two other tubercles on the plate but otherwise its surface is quite smooth. The madreporic genital is conspicuous, with a large group of pores. The ocular plates are large and each carries at least one secondary and a number of miliary tubercles. The pore is evident near the distal margin. Of fifty specimens examined, all exceeding 15 mm. h. d., 19 (38%) have no oculars insert, 17 (34%) have ocular I insert, 11 (22%) have oculars I and V, while 3 (6%) have ocular V only. Of the ten largest specimens, three have no oculars insert, three have I, three have I and V, and one has V alone. Where such diversity is shown, it is clear that the oculars do not furnish a very helpful specific character.

The interambulacral plates at the ambitus are low, the width exceeding twice the height. Each plate carries a conspicuous primary tubercle, which, at and below the ambitus, is accompanied by two or three secondaries and several miliaries; one of the secondaries is sometimes almost as large as the primary. Above the ambitus, there are few secondaries and only scattered miliaries, and the uppermost half dozen plates have their inner ends noticeably smooth and bare. The ambulacral plates are relatively higher at the ambitus than the interambulacral. The arrangement of their tubercles is essentially the same, so that, while the test is well covered with tubercles actinally, there are ten distinct, bare, areas abactinally, radiating out from the periproct. The ambulacra are relatively wide, about four fifths as wide as the interambulacra, at the ambitus. The pore-pairs are in distinct arcs of three and as the pores are large, the poriferous areas are relatively broad.

The buccal membrane (Pl. 99, fig. 4) is heavily plated, especially in the young; in some adults, the distal plates show indications of resorption and the membrane is occasionally visible between them. The primordial ambulacral plates are much larger than any of the others and form a well-spaced ring. They carry pedicellariæ, as do some of the larger plates distal to them. The gill-cuts are fairly well defined but are not deep.

The primary spines are of variable length but are quite conspicuous. They are longest at the ambitus, where their length may nearly equal the diameter of the test. They are slender and taper very gradually from the low, inconspicuous milled-ring to the rather blunt point. Secondaries and miliaries are similar, save for their much smaller size, but they are not abundant anywhere.

Pedicellariæ of all kinds are abundant but are not especially distinctive. The *globiferous* have valves about .60 mm. long, of which the base is about one half; the width of the base is .30 mm. The blade is tubular, ending in the usual sharp tooth, which may be as much as .20 mm. long. The *ophicephalous* are conspicuous because of their long, stout stalks and heavy heads; the valves are .30–.40 mm. long, besides the loop, which adds .03–.10 mm. more, and are not constricted above the base; their general form is similar to those of *Echinus tylodes* (Pl. 93, fig. *12*). The *tridentate* pedicellariæ vary greatly in size but are otherwise all alike; the valves, which range from .40 to 1.00 mm. in length, are rather narrow and are strongly compressed at the base of the blade. The *triphyllous* are not peculiar; the valves measure about .20 mm. in length by .15 in breadth of blade. The *sphæridia* are not peculiar. The *calcareous spicules* of the tube-feet although arcuate, are scarcely bihamate.

The ground color of the test is dull white, at least actinally, becoming grayish or greenish abactinally, where it is blotched or marbled with dull olive-green or purplish brown. The spines are dull greenish, or yellowish becoming lighter at the tip; they are often dirty cream-color. Although very variable in detail, the general impression of this sea-urchin as seen from above is dull olive-green, mottled with cream-color, or cream-color mottled with dull shades.

This interesting species seems to be abundant off southern and Lower California in water of moderate depth. Apparently it is not littoral for none of the collectors who have gathered the shore forms there seems to have found a specimen. It cannot be confused with any other echinoid of that region, nor does it approach very closely to any known member of the Echinidæ. But the variable character of the abactinal system, the tendency of the buccal membrane to become less heavily plated in adults, and the appearance of the pedicellariæ all point to the "intermediate" position it occupies between *euerces* and *semituberculatus*.

It was taken by the "Albatross" at the following places:—

Station 2838. Off Cedros Island, Lower California; 28° 12′ N., 115° 9′ W. Bott. temp.? 44 fathoms. Gn. m.

Station 2899. Off Santa Barbara, California; 34° N., 120° 23′ W. Bott. temp.? 44 fathoms. Gy. s., brk. sh.

Station 2906. Off Santa Barbara, California; 34° 23′ 30″ N., 120° 19′ 30″ W. Bott. temp. 55.5°. 96 fathoms. S., m.

Station 2907. Off Santa Barbara, California; 34° 24′ 30″ N., 120° 20′ W. Bott. temp.? 44 fathoms. Fne. gy. s.

Station 2913. Off San Diego, California; 32° 25′ 30″ N., 119° 3′ 30″ W. Bott. temp. 59°. 26 fathoms. Brk. sh.

Station 2922. Off San Diego, California; 32° 27′ 15″ N., 119° 5′ 15″ W. Bott. temp. 57.1°. 47 fathoms. Fne. gy. s.

Station 2930. Off San Diego, California; 32° 25′ N., 117° 18′ 45″ W. Bott. temp. 52.9°. 60 fathoms. M.

Station 2931. Off San Diego, California; 32° 25′ 30″ N., 117° 16′ 45″ W. Bott. temp. 55.9°. 34 fathoms. Gy. s., sh.

Station 2932. Off San Diego, California; 32° 26′ 15″ N., 117° 16′ 15″ W. Bott. temp. 58°. 20 fathoms. Gy. s., brk. sh.

Station 2934. Off San Diego, California; 32° 33′ 30″ N., 117° 16′ W. Bott. temp. 58.2°. 36 fathoms. Gy. s.

Station 2938. Off San Pedro, California; 33° 35′ 15″ N., 118° 8′ 30″ W. Bott. temp. 58°. 47 fathoms. Fne. gy. s., st.

Station 2939. Off San Pedro, California; 33° 36′ N., 118° 9′ 30″ W. Bott. temp.? 27 fathoms. Fne. gy. s., st.

Station 2942. Off San Pedro, California; 33° 38′ 45″ N., 118° 13′ 45″ W. Bott. temp.? 20 fathoms. Gy. s., brk. sh.

Station 2943. Off Santa Barbara, California; 34° 0′ 30″ N., 119° 28′ 30″ W. Bott. temp. 56°. 31 fathoms. Rky.

Station 2944. Off Santa Barbara, California; 34° N., 119° 28′ 30″ W. Bott. temp.? 30 fathoms. Rky.

Station 2945. Off Santa Barbara, California; 34° N., 119° 29′ 30″ W. Bott. temp.? 30 fathoms. P.

Station 2951. Off Santa Barbara, California; 33° 55′ 30″ N., 119° 55′ W. Bott. temp.? 48 fathoms. Fne. gy. s.

Station 2965. Off Santa Barbara, California; 34° 21′ 20″ N., 119° 38′ 30″ W. Bott. temp. 58°. 27 fathoms. Fne. gy. s., r.

Station 2966. Off Santa Barbara, California; 34° 20′ 40″ N., 119° 38′ 50″ W. Bott. temp. 58.5°. 30 fathoms. Crs. m.

Station 2967. Off Santa Barbara, California; 34° 21′ 15″ N., 119° 39′ 10″ W. Bott. temp. 58°. 30 fathoms. Crs. m.

Station 2969. Off Santa Barbara, California; 34° 20′ 40″ N., 119° 37′ 45″ W. Bott. temp. 58°. 26 fathoms. Gy. s., p., st.

Station 2975. Off Santa Barbara, California; 34° 1′ 30″ N., 119° 29′ W. Bott. temp. 57°. 36 fathoms. G., brk. sh.

Station 2978. Off Santa Barbara, California; 33° 59′ 45″ N., 119° 22′ 15″ W. Bott. temp. 56.5°. 46 fathoms. Gy. s.

Station 2983. Off Guadeloupe Island, Mexico; 28° 58′ 30″ N., 118° 15′ 45″ W. Bott. temp. 55.8°. 58 fathoms. Gy. s., brk. sh.

Station 2984. Off Guadeloupe Island, Mexico; 28° 57′ 15″ N., 118° 15′ 45″ W. Bott. temp. 49.8°. 113 fathoms. Gy. s., brk. sh.

Bathymetrical range, 20–113 fathoms. Extremes of temperature, 59°–49.8 °.

Four hundred and fourteen specimens.

Lytechinus semituberculatus Verr.

Echinus (Psammechinus) semituberculatus Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 368.
Lytechinus semituberculatus Verrill, 1867. Trans. Conn. Acad., I, p. 301.

Now that it has become clear that *Psammechinus pictus* Verr. is quite distinct from this species, it would seem that *semituberculatus* is not found on the continental coast, but is confined to the Galapagos Islands. All of the specimens taken by the "Hassler" and "Albatross" are from the Galapagos, nor did the collectors on those vessels meet with it elsewhere. The extensive collections of Echini from Lower California and Mexico, studied by Verrill and Lütken contained no specimens, and there are none in the M. C. Z. collections from the mainland coast. The bright coloration is very distinctive and seems to be quite constant. It is much nearer that of some West Indian specimens of *variegatus* than it is to the dull shades of *pictus*.

The "Albatross" took this species at the following places: —

Hood Island, Galapagos.

Indefatigable Island, Galapagos.

Station 2810. Off Hood Island, Galapagos; 1° 22′ S., 89° 39′ 30″ W. 6.5 fathoms. Co. s.

Fourteen specimens.

Lytechinus pictus, comb. nov.

Psammechinus pictus Verrill, 1867. Trans. Conn. Acad., I, p. 301.

Plates 99, figs. *6, 7;* 107, figs. *12–14.*

The series of specimens collected by the "Albatross," taken in connection with those which have gradually accumulated in the M. C. Z. collection, enables us to give this species its rightful place. Verrill's original description is sufficiently complete so that it is unnecessary to repeat its details, but since its main points have been obscured by his considering a large specimen of *Toxopneustes roseus* as an adult *pictus* (*l. c.*, p. 581), it seems desirable to give figures of this interesting species and to discuss some of its characteristic features.

The series at hand ranges from 5 to 40 mm. in diameter. In the full-grown specimens, the height is clearly more than half the diameter. The abactinal system (Pl. 99, fig. 7) is rather small, only about .25 h. d. The actinostome is also small, about .35 h. d. Oculars I and V are well insert, but in most of the small specimens, ocular V is more or less fully excluded. The adult character in this respect seems to be acquired when the individuals are between 15 and 20 mm. in diameter. The buccal membrane (Pl. 99, fig. 6) is heavily plated in all the specimens, except the largest, where more or less resorption has occurred and the membrane is visible between the plates. Coronal plates are numerous; in a specimen 20 mm. h. d., there are 14 interambulacral and 17 ambulacral plates in each column, and in the specimen, 40 mm. h. d., there are 21 and 30 respectively. The gill-cuts, though well defined are not deep, even in the largest specimens. The primary spines are short, the longest ones only about one fifth the diameter of the test. Pedicellariæ are only fairly common. The *globiferous* were found in both young and old; the valves range from .50 to .60 mm. in length and have the usual tubular blade and long end tooth; the blade may be constricted, just above the broadly expanded base. The *ophicephalous* are fairly common; the valves of those found in the large specimens, are about .60 mm. long, nearly triangular, and not at all constricted, while in the young specimens, the valves are only about .35 long, they are distinctly constricted and the lime of which they are composed is strongly tinged with brown. The *tridentate* were found only in the large specimens. They closely resemble those of Toxopneustes (Plate 93, fig. 7); the valves measure .30–1.00 mm. in length. The *triphyllous* are fairly common, but very small; the valves measure about .15 mm. in length by .13 mm. across the blade. The *sphæridia* are very numerous, for although they do not extend far up the ambulacra from the peristome, as many as twenty may be found at the base of a single ambulacrum; of course, in the young they are far less abundant. They are not peculiar in either size or shape. The *spicules* in the tube-feet are arcuate but not bihamate, the ends being blunt or almost knobbed.

This species has hitherto been regarded as the young of some larger species. The specimens received at the Museum of Comparative Zoölogy have usually been labelled *Toxopneustes pileolus* or *Tripneustes depressa*. The structure of the ambulacra shows conclusively that these identifications are wrong. Although nearly related to *L. semituberculatus*, there is not the least superficial resemblance to that species. On the other hand, except for differences in color, the resemblance to *L. verruculatus* is noteworthy.

The M. C. Z. collection contains specimens of *pictus* from San Diego, Cala., and La Paz, and Cape St. Lucas, Lower California.

The "Albatross" collected it at the following stations:—

Station 2824. Off Espiritu Santo Island, Lower California; 24° 22′ 30″ N., 110° 19′ 30″ W. Bott. temp.? 8 fathoms. Brk. sh.

Station 2825. Off Espiritu Santo Island, Lower California; 24° 22′ 15″ N., 110° 19′ 15″ W. Bott. temp.? 7 fathoms. Brk. co.

Station 2827. Off Espiritu Santo Island, Lower California; 24° 11′ 45″ N., 109° 55′ W. Bott. temp.? 10 fathoms. Sh.

Station 2828. Off Espiritu Santo Island, Lower California; 24° 11′ 30″ N., 109° 55′ W. Bott. temp.? 10 fathoms. Sh.

Station 2829. Off Cape St. Lucas, Lower California; 22° 52′ N., 109° 55′ W. Bott. temp. 74.1°. 31 fathoms. Rky.

Station 3002. Off San José Island, Lower California; 25° 2′ 15″ N., 110° 43′ 30″ W. Bott. temp.? 17 fathoms. S., sh.

Station 3005. Off San José Island, Lower California; 25° 2′ 45″ N., 110° 43′ 30″ W. Bott. temp.? 21 fathoms. S., sh., corln.

Station 3006. Off San José Island, Lower California; 25° 2′ 30″ N., 110° 43′ 30″ W. Bott. temp.? 8 fathoms. Sh., s.

Bathymetrical range, 7–31 fathoms.

Thirty-one specimens.

Echinus.

Linné, 1758. Syst. Nat., ed. 10, p. 663.
Type-species, *Echinus esculentus* Linné, l. c.

This genus as here limited contains seventeen species of which three are now described for the first time. Having already (p. 240) discussed the general inter-relationships of this group, it is not necessary to repeat here the arrangement there outlined. Whether *Alexandri* is nearest the original stock or not, there can be little doubt that the North Atlantic is the geographical centre of the genus. We find in European waters, besides *Alexandri*, no less than five species (*acutus*, *elegans*, *esculentus*, *melo*, *tenuispinus*), while in the tropical Atlantic we find four more (*atlanticus*, *gracilis*, *tylodes*, *Wallisii*). If it is correct to consider *affinis* as only an extreme and as yet incompletely differentiated form of *acutus* var. *norvegicus*, that species extends in deep water along the eastern coast of the American continent at least as far as New Jersey. Of the other species, one (*lucidus*) is from the coast of Japan, and is nearly related to *Alexandri* and *elegans,* while another (*armatus*), the relationships of which are doubtful, was taken by the "Siboga" in the East Indies. The remaining species are all from the southern hemisphere. Two (*Gilchristi* from South Africa and *anchistus,* from deep water off the coast of Chile) are very near to some forms of *acutus,* though now so widely separated geographically. Other southern species are *horridus* and *euryporus* from "Challenger" Station 308, off the coast of Chile, in 175 fathoms. Döderlein has recorded *horridus* from off South Africa also, and a young specimen from off St. Paul Island still further to the east: the latter individual is so small that its identification seems very doubtful. The most characteristic of the southern species is *margaritaceus,* which appears to have a wide distribution in the Antarctic Ocean.

The status of many of these species is open to question, due no doubt, in part at least, to the lack of material. It is probable that knowledge of the color in life would help in determining the true position of some forms. There seems to be a general and justified feeling of doubt as to whether *melo* is specifically different from *acutus.* It has seemed best however, to retain *melo* for the present as few specimens are available and those are quite easily recognizable. The similarities between *Alexandri* and *elegans* are striking and *lucidus* is very near indeed to the latter. One has to search very carefully for any differences whatever between these three species and all found seem exceedingly trivial. Moreover the three are very near some forms of *acutus* var. *norvegicus.* Typical *acutus,* when full grown, is so very different from *norvegicus* that it was hard to accept Mortensen's claim that they are identical, but examination of a large series of specimens shows that it is not practicable to draw the line between the two forms. It is necessary however to go still further for *affinis* is not distinguished from *norvegicus* by any constant characters; the one is simply the most highly specialized form of the other. This form (*affinis*) is remarkable for the frequency with which the uppermost ambulacral plates have only *two* elements, as noted and figured by Jackson (1912, Mem. Boston Soc. Nat. Hist., VII, p. 118, text-fig. 115).

There is no question about the validity of *esculentus* and Mortensen's description of *tenuispinus* would indicate the desirability of accepting that species. There is no doubt about the standing of *gracilis* and *atlanticus,* which are very distinct and easily recognized species, and the same is true of *tylodes.* I consider *Wallisii* as somewhat doubtful as it may be simply the full-grown adult of *Alexandri*; the smallest *Wallisii* is 60 mm. h. d. while the largest *Alexandri* is only 50 mm. The test in *Wallisii* is so thick and rough, that it is hard to believe that *Alexandri* would reach such a condition, even with a great increase in size. As de Meijere's description of *armatus* fails to make clear the character of either the buccal membrane or the abactinal system, its true position is doubtful. It appears to be a connecting link between Echinus and Heliocidaris, having the ambulacra of the former, with the globiferous pedicellariæ of the latter. Although, as already stated, *Gilchristi* and *anchistus* are near some forms of *acutus* (notably *affinis*), they seem to be valid species and the same may be true of *euryporus*, but it is very difficult to separate the last from *elegans* in any satisfactory way. More material is greatly needed for the elucidation of *horridus*; the specimen from South Africa figured by Döderlein seems to be identical with the "Challenger" specimens. One of the latter, the only specimen accessible, is very remarkable for the form of the test; although when collected it was broken into a number of pieces, some of which are missing, there is no question that in life the vertical diameter greatly exceeded the horizontal, and so far as it can be estimated, must have been nearly twice as much. Such a high test has not hitherto been recorded among Echini either living or fossil.

As regards *margaritaceus*, I disagree with the eminent Continental zoölogists who make it the type of a genus Sterechinus, in which they recognize four species (*margaritaceus, Neumayeri, antarcticus, diadema*). Although the material studied is not extensive, it is very representative, consisting of specimens from Patagonia, Kerguelen, Heard Island, Coulman Island, "Gauss" winter station, and Antarctica (Mission Charcot), and including specimens identified by Kœhler as *Neumayeri* and by Mortensen as *diadema, antarcticus,* and *Neumayeri*. Although these specimens reveal a certain amount of diversity, it is not nearly so great as that shown by *acutus* or by our common northern sea-urchin, *Strongylocentrotus dröbachiensis*. Moreover the differences are not only slight but are very inconstant and it seems unwise to distinguish more than a single species. Owing to the characteristic form and appearance, and particularly the specialized abactinal system, it would have been advantageous to recognize the genus Sterechinus (see below under Evechinus) but *horridus* is such an obvious connecting link in certain particulars, though so different in others, and the resemblance to *esculentus* in ambulacra and buccal plates is so noteworthy that *margaritaceus* cannot be removed from Echinus.

The species of Echinus which seem valid may be distinguished as follows, although in some cases the general appearance is of more value than the trivial characters here used. Attention should be called to the fact that *acutus* occurs in two places in the table owing to its variable ambulacra. Not having seen *armatus*, the globiferous pedicellariæ are used as the distinguishing mark of that species.

Ambulacral plates, at least at and below the ambitus, each with a primary tubercle.
- Test rather low, often depressed, vertical diameter rarely exceeding .55 horizontal.
  - Ambulacral plates few (18–20 in specimens 45–50 mm. h. d., 24–28 in specimens 65–100 mm.); valves of large tridentate pedicellariæ, broad and flattened.
    - Test not specially thick or rough; v. d. about equal to half h. d.; abactinal system much smaller than actinostome . . . . . *Alexandri.*
    - Test very stout and rough; v. d. .55–.65 h. d.; abactinal system nearly equal or even exceeds actinostome . . . . *Wallisii.*
  - Ambulacral plates more numerous (25 or more in specimens over 40 mm. h. d.); valves of large tridentate pedicellariæ, slender and compressed.
    - Pore-pairs small; poriferous areas narrow (each about one sixth of ambulacrum at ambitus) with no noticeable tendency to widen at peristome; arcs of pores at ambitus especially two outer pairs nearly vertical; ambulacral tubercles usually diminishing unequally towards abactinal system, or else unequal in two halves of same ambulacrum; abactinal system usually large (.30 h. d. or more) with periproct about half as large . *acutus* var. *norvegicus.*
    - Pore-pairs large; poriferous areas moderate (each about one fifth or more of ambulacrum at ambitus), tending to become somewhat expanded at peristome; arcs of pores at ambitus, distinctly oblique, becoming more or less nearly horizontal; abactinal system usually about .25 h. d. with periproct not usually half as large.
      - Actinal membrane with scattered plates distal to the buccal circle, of which some (one at least) are rounded and thickened, and carry pedicellariæ; valves of globiferous pedicellariæ with 2–3 lateral teeth on each side.
        - Primary tubercles of ambulacra, of irregular size, not diminishing equally from ambitus upward and downward; color of test dull purplish brown . . . *euryporus.*
        - Primary tubercles of ambulacra, regular, diminishing equally from ambitus; color variable but usually with some red . . . . *elegans.*
      - Actinal membrane with numerous small thin plates, none of which carry pedicellariæ; valves of globiferous pedicellariæ with only one lateral tooth on each side . . . . *lucidus.*
- Test high, v. d. two thirds h. d. or more.
  - Test remarkably bare above ambitus, there being but few spines, besides the long widely spaced primaries . . . . *atlanticus.*
  - Test well covered with spines above ambitus.
    - Test beautifully marked with deep green and white (or yellowish); primary spines very short, white (or yellowish) . . . . . *gracilis.*

Test not marked with green and white; primary spines moderately or quite long, red or reddish.

Test stout, rough, and almost sculptured, with tubercles elevated and sutures and peripodia depressed . . . . . *tylodes.*

Test not very stout nor rough, very closely covered with secondary and miliary tubercles . . . . *horridus.*

Ambulacral plates at and below ambitus often lack primary tubercles; usually plates lacking tubercles alternate with those which have them.

Valves of globiferous pedicellariæ with lateral teeth, at least one on each side.

Buccal plates do not carry spines; ambulacral plates not twice as many as interambulacrals.

Primary tubercles very small, wanting from many abactinal interambulacral plates; diameter of areolæ at ambitus less than half the height of interambulacral plates; pore-pairs close to central primary tubercle of ambulacral plate, more or less removed from interambulacrum and usually with tubercles between them and marginal suture; primary spines, slender, green . . . . *melo.*

Primary tubercles large, present on abactinal interambulacral plates; areolæ at ambitus more than half the height of interambulacral plate; pore-pairs close to or near interambulacrum, with no tubercles between them and marginal suture; primary spines more or less stout, not uniformly green.

Abactinal coronal plates with few secondary tubercles; median abactinal interambulacral areas more or less bare.

Test not exceedingly flattened, often high, v. d. = .45 h. d. or more, usually over .50; one or more periproctal plates with at least one spine; test and primary spines usually with more or less red . . . . *acutus.*

Test very flat, v. d. = .40 h. d. or less; suranal plate more or less circular and very conspicuous but neither it nor any other periproctal plate carries a spine; no red (in preserved specimens) . . . . *anchistus.*

Abactinal coronal plates with numerous secondary tubercles; no bare spaces, in the abactinal interambulacra . . . . *Gilchristi.*

Buccal plates with at least a few spines among the numerous pedicellariæ; secondary spines and tubercles numerous; ambulacral plates nearly or quite twice as many as interambulacrals.

Test rather stout, high, v. d. usually more than .60 h. d.; primary spines short, with secondaries nearly as large; all oculars broadly exsert.

Color orange reddish or purplish; abactinal spines more or less numerous; coronal plates numerous (in specimens 50-60 mm. h. d., 22 or more interambulacral and 50 or more ambulacral in each column) . . . . *esculentus.*

Color white or whitish; abactinal spines few and scattered;

coronal plates less numerous (in specimens 50–60 mm. h. d., about 18 interambulacral and 38–40 ambulacral in each column) . . . . *tenuispinus.*

Test thin, rather fragile, low, v. d. less than .55 h. d.; primary spines much longer than the slender secondaries; usually two or more oculars reach the periproct; if all are excluded, one is very slightly so . . . . *margaritaceus.*

Valves of globiferous pedicellariæ have a lateral tooth on only one side but that one is conspicuous . . . . *armatus.*

Echinus Wallisii A. Ag.

Echinus Wallisii A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 77.

Plates 93, fig. *32;* 108, figs. *1, 2.*

The type of this species (Pl. 108, figs. *1–2*) has never before been figured. The statement in the original description that the pairs of pores are in sets of two was based on the examination of the abactinal part of a single ambulacrum, which possesses this peculiarity. Examination of other ambulacra and of another specimen shows that this is not a characteristic feature at all, but is only seen clearly in one ambulacrum. It is interesting to note (as stated above, p. 261) that in the *affinis* form of *Echinus acutus* the abactinal ambulacral plates very commonly consist of only two elements. As already indicated it is by no means clear that *Wallisii* is not the adult form of *Alexandri* or possibly a local variety. As bearing on the point, it may be noted that: — the two specimens at hand are respectively 60 and 100 mm. in diameter, 35 and 55 mm. high. The abactinal systems are 15 and 29 mm. across, while the actinostomes are only 15.5 mm. and 26 mm. Although the primary spines are all more or less broken, it is evident that in the type they measured between forty and fifty millimeters. They are slender and smooth and have about 24 longitudinal striations. The secondaries are short, rarely exceeding 12 mm. and are very slender. They are not abundant, but are scattered over the test, with a fair degree of uniformity. The test itself is very stout and rough, especially in the smaller specimen. The roughness is due to the elevation of the tubercles and the depression of the sutures. At and below the ambitus, each ambulacral plate carries a normal primary tubercle, but above the ambitus, the tubercles are of irregular size and occurrence. They are not so large as those of the interambulacra but they cover a large part of the plate. The pores are large and the poriferous areas quite broad. In the smaller specimen there are 26 ambulacral, and 16 interambulacral plates while in the larger specimen the figures are 28 and 20 respectively. The ocular plates are all broadly exsert in both specimens and they, as well as the genitals, are somewhat swollen. The periproct is large, covered by numerous small plates, among which a suranal can easily be distinguished. The actinostomal membrane is thick, and carries few plates outside the buccal circle. The buccal plates are thickly covered with pedicellariæ but carry no spines. The gill-cuts are shallow and poorly defined. The pedicellariæ, sphæridia, and spicules are essentially the same as in *Alexandri*. The globiferous pedicellariæ (Pl. 93, fig. *32*) have heads about .70 mm. long and are borne on long, flexible stalks, 10–12 times as long as the head. The valves of the large tridentate pedicellariæ measure up to 1.75 mm. in length, and the blade contains more mesh-work than in *Alexandri*. The spicules are bihamate.

Echinus euryporus,[1] sp. nov.

Plates 93, figs. *2, 3;* 109, figs. *4–6*.

The single specimen upon which this species is based is 46 mm. in diameter and 26 mm. high. The test is well arched and the actinostome is not sunken. There are 15 interambulacral plates in each column, and 26 ambulacrals. The abactinal system is 12 mm. across, and the periproct is 15 mm. The ocular plates are all broadly exsert. The periproct is covered by small but somewhat swollen plates, among which the suranal can be easily distinguished. Each interambulacral plate at ambitus carries, besides its primary tubercle, 8–12 secondaries and 50–60 miliaries. All the tubercles, even the miliaries, are sufficiently elevated to be quite distinct and the test therefore appears rather rough. In the ambulacra, the primary tubercles do not diminish uniformly from the ambitus to the actinostome and abactinal system, but are of rather unequal and irregular sizes. The poriferous area is moderately broad at the ambitus, with the pores large and the arcs quite oblique. At the peristome, the poriferous areas become decidedly widened, so that each one is wider than the interporiferous area, and the arcs approach the horizontal. This feature, upon which the proposed name is based, serves to distinguish *euryporus* from any forms of *acutus* with which it might otherwise be confused, but it does not assist much in separating it from *elegans* which resembles it in this particular. The genital and ocular plates, except the distal tips of the genitals, are well covered with small tubercles. The buccal membrane carries besides the small

[1] εὐρύς = broad + πόρος = a way.

primordial ambulacral plates, a few rounded scattered plates, distal to them. All the plates carry more or less numerous pedicellariæ, but no spines. The primary spines are 20–25 mm. in length, rather slender and tapering. The secondaries are much shorter and even more slender relatively. The pedicellariæ are abundant, but not peculiar. The valves of the *globiferous* (Pl. 93, figs. *2, 3*) measure about .80 mm. long; the base is about .30 mm. long by .23 wide. There are two or three teeth on each side of the blade near the tip. The small *tridentate* pedicellariæ have broad, curved, truncate valves, but the large ones have narrow straight, pointed valves, which may be over a millimeter long. The valves of the *ophicephalous* pedicellariæ are very broad and are not constricted; they are .35–.45 mm. long besides the loop. The *triphyllous* valves are about .16 by .14 mm. The spicules are bihamate and the sphæridia are not peculiar.

The color of the test is light purplish brown, lightest on the poriferous areas and along the median interambulacral suture. The spines are light reddish brown. Actinally both test and spines are much lighter, practically white.

The specimen upon which this species is based was taken by the "Challenger" (St. 308) off the coast of southern Chile, in 175 fms. It is listed, without comment, in the Report on the "Challenger" Echini, as *Echinus norvegicus*. Although very close to that species, it is even nearer to *elegans*, so that its rightful position is doubtful. The color is so unlike any *elegans*, that it looks very different, and this fact, in connection with the geographical isolation of the specimen favors its specific separation.

Echinus lucidus Död.

Echinus lucidus Döderlein, 1885. Arch. f. Naturg., Jahrg. LI, 1, p. 97.

Plate 107, figs. *1–3*.

The series of specimens, ranging in diameter from 12 to 40 mm., has made very clear the close relationship which this species bears to *elegans* and it is doubtful if the two characters by which they are separated in the table above (p. 263) are likely to prove either important or constant. I am not ready however to affirm the identity of the two and expect that in life there may be important color differences. Among the preserved specimens however, there are dingy yellowish and whitish individuals of both species. The specimens of *lucidus* show great diversity in the length and stoutness of the primary spines, and in the elevation of the test. Thus the largest specimen (40 mm. h. d.) (Pl. 107, fig. *3*) has primary spines less than 7 mm. long, and the vertical diameter of the test is only 17 mm., while another specimen from the same station, 30 mm. h. d., is 15.5 mm. high and has primary spines 17 mm. long. A specimen (Pl. 107, fig. 1) from an adjoining station is 37 mm. in diameter and almost 21 mm. high.

The "Albatross" took *lucidus* at the following stations: —

Station 4917. Off Kagoshima Gulf, Japan; 30° 24′ N., 129° 6′ E. Bott. temp. 42.7°? 361 fathoms? Gy. s., glob., brk. sh.?

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 23′ E. Bott. temp. 39.8°. 437 fathoms. Gn.-br. m., fne. gy. s., for.

Station 4958. Between Kagoshima and Kobe, Japan; 32° 36′ 20″ N., 132° 24′ 30″ E. Bott. temp. 40.1°. 405 fathoms. Gn.-br. m., fne. gy. s., for.

Station 4959. Between Kagoshima and Kobe, Japan; 32° 36′ 30″ N., 132° 23′ 20″ E. Bott. temp.? 405–578 fathoms. Gn.-br. m., fne. gy. s., for.

Station 4965. Between Kobe and Yokohama, Japan; 33° 35′ 20″ N., 135° 10′ 50″ E. Bott. temp. 49.4°. 191 fathoms. Dk. gn.-gy. s., sh.

Station 4980. Between Kobe and Yokohama, Japan; 34° 9′ N., 137° 55′ E. Bott. temp. 39°. 507 fathoms. Br. m., fne. s., for.

Station 5048. Between Hakodate and Yokohama, Japan; 38° 9′ 24″ N., 141° 52′ 30″ E. Bott. temp. 40.7°. 129 fathoms. Dk. gy. s., brk. sh.

Station 5049. Between Hakodate and Yokohama, Japan; 38° 12′ N., 142° 2′ E. Bott. temp. 37.8°. 182 fathoms. Dk. gy. s., brk. sh., for.

Station 5051. Between Hakodate and Yokohama, Japan; 38° 11′ N., 142° 12′ E. Bott. temp. 38.1°. 399 fathoms. Dk. gy. s., brk. sh., for.

Station 5078. Off Omai Saki Light, Japan; 34° 12′ 20″ N., 138° 2′ 30″ E. Bott. temp. 38.9° 475–514 fathoms. Fne. gy. s., glob.

Station 5079. Off Omai Saki Light, Japan; 34° 15′ N., 138° E. Bott. temp. 39.1°. 475–505 fathoms. P.

Station 5082. Off Omai Saki Light, Japan; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Station 5083. Off Omai Saki Light, Japan; 34° 4′ 20″ N., 137° 57′ 30″ E. Bott. temp. 38.1°. 624 fathoms. Fne. gy. s., glob.

Station 5084. Off Omai Saki Light, Japan; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8°. 918 fathoms. Gn. m., fne. s., glob.

Station 5088. In Sagami Bay, Japan; 35° 11′ 25″ N., 139° 28′ 20″ E. Bott. temp. 41.8°. 369–405 fathoms. Gn. m.

Bathymetrical range, 129–918 fathoms. Extremes of temperature, 49.4°–36.8°.

Fifty-six specimens.

Echinus atlanticus Mrtsn.

Echinus atlanticus Mortensen, 1903 "Ingolf" Ech., pt. 1, p. 101.

Plate 110, figs. *1–3*.

As no figures of this fine species have ever been published, it seems worth while to give illustrations showing the general appearance. The specimen figured is from the type locality, "Challenger" St. 343, off Ascension Island, Atlantic Ocean, 425 fathoms.

Echinus tylodes,[1] sp. nov.

Plates 93, figs. *11–15;* 109, figs. *1–3*.

Although there are but two specimens, and one of those quite young, I feel little hesitation in naming this new species. The type (Pl. 109, figs. *1–3*) is 57 mm. in diameter and 39 mm. high, with an abactinal system 13 mm. across and an actinostome 19 mm. in diameter. There are 17 interambulacral, and 23 ambulacral plates in each column. The longest primary spines are only 18 mm. long. The test is well arched, thick, and rough. The roughness is due to all the tubercles being more or less elevated, without sunken areolæ, while the sutures and peripodia are more or less depressed. Each coronal plate bears a well-developed primary tubercle, and these diminish regularly from the ambitus upward and downward. There is a faint indication of a vertical ridge connecting these tubercles; this is much more evident in the ambulacra than in the interambulacra and is most noticeable abactinally. The secondary spines and tubercles are not very numerous, but on cleaned plates the tubercles are very conspicuous. The plates of the abactinal system are distinctly swollen but carry very few tubercles. The oculars are all broadly exsert. The periproct is nearly 6 mm. across and is covered by numerous small rounded plates, among which the suranal can scarcely be distinguished. The ambulacra are 13 mm. wide at the ambitus and the interambulacra, 22 mm. The pore-pairs are large, and the poriferous areas rather wide, becoming somewhat expanded at the peristome. The arcs of pores are quite oblique, and approach the horizontal at the peristome. The gill-cuts are broad and shallow, almost wanting. The buccal membrane is thick and carries only a few scattered plates distally.

The smaller specimen is only 19 mm. in diameter and 10 mm. high, and is

[1] τύλος = a swelling or lump + εἶδος = form.

thus relatively more flattened than the adult. The abactinal system and actinostome are 6 and 9 mm. in diameter respectively and are thus relatively much larger than in the adult. The primary spines are also longer than in the adult, equalling about one half the diameter of the test. The latter is stout and rough as in the large specimen, and the abactinal system is essentially the same, though, as might be expected, the suranal plate is more obvious. The buccal membrane is thinner and contains numerous, minute plates.

Pedicellariæ are abundant. The *globiferous* are found mostly on the abactinal surface. The valves (Plate 93, fig. *13*) are .55–.70 mm. in length; the blade and base are about equally long, and the latter is .20–.30 mm. wide. Besides the conspicuous terminal tooth (Pl. 93, fig. *14*) there are two or three lateral teeth on each side near the tip. The *ophicephalous* pedicellariæ occur everywhere. The valves (Pl. 93, fig. *12*) are short, wide, and stout, not at all constricted; they measure .20–.32 mm. long besides the loop, which adds about a quarter more; the width is .75–.85 of the length. The *tridentate* are less common and are chiefly actinal in position; the valves (Plate 93, fig. *15*) are short, only .30–.50 mm. long, and are .10–.13 mm. wide near the tip of the blade. The *triphyllous* are very abundant everywhere, and the valves (Pl. 93, fig. *11*) are as wide as long .10–.12 mm. The sphæridia show no particular features and the spicules, though excessively scarce in these specimens, appear to be normally bihamate.

The two specimens agree fairly well in color. The test is light reddish buff, so light in the small individual as to be almost white. The spines are pale red, brighter in the young one, where the shade is quite orange; they are lighter, almost whitish, distally but in the adult each one has a dusky brownish tip; this however is not conspicuous and may be artificial.

The larger of these two specimens was taken by the "Blake" (Station 319) in 262 fathoms, off South Carolina, was labelled and catalogued, without careful examination, "*Toxopneustes variegatus*," and is listed thus in the final report on the "Blake" Echini. The smaller specimen was taken by Count Pourtalès in 1868, off Sombrero Key, Florida, in 195 fathoms and is labelled "*Echinus Flemingii. Echinus norvegicus*?" There appears to be no reason to doubt the specific identity of the two specimens, or the distinctness of the species. Small specimens might be mistaken for *Wallisii*, save for the bright coloration, but in the adult, the height of the test is very characteristic.

Echinus anchistus,[1] sp. nov.

Plates 93, figs. *8, 9;* 103, figs. *4, 5;* 111, figs. *1–3.*

The greatly flattened test is the most striking feature of this southern species and serves to distinguish it at a glance from its neighbor, *euryporus.* The largest specimen at hand (Pl. 111, figs. *1–3*) is 23 mm. in diameter but only 9.5 mm. high; the height is thus .41 v. d. In smaller specimens the height is relatively greater and in the smallest specimen (7 mm. in diameter) it is a trifle over .50 h. d. The abactinal system is about .30 h. d. and the periproct is more than half of that. The actinostome is about equal to the abactinal system. In the largest specimen there are 12 interambulacral and 18 ambulacral plates in each column, while in the smallest the numbers are 8 and 10 respectively. Although the type has 18 ambulacral plates, there are only 9–11 primary tubercles n each half-area, and in the little specimen only 6 or 7 can be counted. The pore-pairs are small, the arcs nearly vertical and the poriferous areas very narrow, particularly at the peristome, in striking contrast to the condition in *euryporus.* The coronal plates at ambitus are fairly well covered with secondary and miliary tubercles but abactinally they become barer. They are not at all rough and the areolæ are not depressed nor are the bases of the tubercles noticeably elevated. The ocular plates (Pl. 103, fig. *4*) are all excluded from the periproct by the wide genitals, and both sets of plates carry many small tubercles. The periproct is covered by relatively few, rounded, flat plates, among which the suranal is very prominent. None of these plates carry tubercles. In the type the plates are so few and scattered that the periproctal membrane is plainly visible among them, but this is not usually the case. The actinostomal membrane (Pl. 103, fig. *5*) contains numerous small and thin plates distal to the buccal circle, but none of them bear any pedicellariæ. The gills are very small and the gill-cuts are almost wanting.

The primary spines are slender and fragile, when unbroken about half as long as the test diameter, smooth and even polished, but showing clearly numerous longitudinal striations. The smallest primaries are not so smooth and the very slender secondaries, which are not numerous, are distinctly rough (under a lens) particularly at the tip.

Pedicellariæ are common but not abundant. The *globiferous* are found chiefly on the ambulacra. The valves (Pl. 93, figs. *8, 9*) are very similar to

[1] ἄγχιστος = nearest of kin.

those of *horridus*, having a very square-cut base and 2 or 3 lateral teeth on each side of the tip of the blade. They measure about .60 mm. long, with the end-tooth some .10 mm., and the base .15 mm. wide. The *ophicephalous* have the valves about .35 mm. long, besides the loop which may be .08–.10 more; they are distinctly constricted near the middle. The *tridentate* are found chiefly on the actinal surface. The valves are .80–1.40 mm. in length, narrow, compressed and in contact only at the slightly expanded tip. The valves of the *triphyllous* pedicellariæ are more elongated than usual, measuring .13 by .095 mm. Nothing peculiar was noted in regard to the sphæridia and no spicules were found.

The color is dirty yellowish or pale buff, with the primary spines more or less nearly pure white, and the periproctal plates and secondary spines whitish.

Although this species is very near some forms of *acutus* var. *norvegicus*, the test is much flatter than in any specimens of that variety and the periproct and globiferous pedicellariæ are different.

It was collected by the "Albatross" in February, 1888, at the two following stations: —

Station 2788. Off Chile; 45° 35′ S., 75° 55′ W. Bott. temp. 36.9°. 1050 fathoms. Gn. m.

Station 2789. Off Chile; 42° 36′ S., 75° 28′ W. Bott. temp. 35.9°. 1342 fathoms. Bu. m.

Eighteen specimens.

Parechinus.

Mortensen, 1903. "Ingolf" Ech., pt. I, p. 108; 134.
Type-species, *Cidaris angulosa* Leske, 1778. Add. ad Klein, p. XVII; 28.

It is fortunate that Mortensen designated no type for his genus Parechinus for had he selected either *miliaris* or *microtuberculatus*, the name would be simply a synonym of Psammechinus. As it is those two species must be left in the latter genus (see p. 242) and thus *angulosus* becomes *ipso facto* type of Parechinus. Döderlein's name Protocentrotus thus becomes a synonym of Parechinus, having the same type.

I have placed in this genus with *angulosus*, the closely related *annulatus* and the more distantly connected *magellanicus* and *Huttoni*. While these four species show a similar tendency towards a specialized abactinal system, it is interesting to note that whereas in *angulosus*, the buccal membrane of which is more or less fully provided with plates, 54 per cent of the specimens have all the oculars exsert (as in Psammechinus) and 30 per cent have ocular I insert, in *magellanicus,* the buccal membrane of which is thin and naked, only 3 per cent have all the oculars exsert and 88 have I insert. Few specimens of *annulatus* have been examined and they resemble young *angulosus* in having the oculars all exsert as a rule, with ocular I not rarely insert. Of *Huttoni* too few specimens are known to make deductions of any value. Benham, in his description of the species, says that the oculars are all exsert but in the specimen, which he kindly sent the Museum, ocular I is broadly insert. Unfortunately he says nothing as to the character of the buccal membrane, but as he first placed the species in Mortensen's genus Pseudechinus, it is fair to infer that *Huttoni* agrees with *magellanicus* in that particular; in the M. C. Z. specimen the buccal membrane is wanting.

Although the species of Parechinus are all southern, their geographical distribution is unknown. New Zealand and Australian material is infrequent in most museums, and such specimens as have been accessible are lacking in some important particulars; either the locality labels are open to suspicion, or the tests are bare and usually lack the buccal membrane as well as all spines and pedicellariæ; they often lack the abactinal system also. With the exception of bare tests not a single specimen of this *family* has been seen (save Evechinus and Tripneustes) from any definite locality in either Australia or New Zealand, and in every case of a bare test where the label reads "Australia" there is reason for suspecting its correctness. I agree with Mortensen that *angulosus* is not certainly known from any place except South Africa, but we have unquestionable specimens labelled "Red Sea," "Australia," "Hakodate, Japan," and "Nicobar Islands." The last is of the same lot apparently as the one in the Copenhagen Museum, as it was received by the M. C. Z. from the Vienna Museum. The specimens recorded by Benham (1909, Rec. Canterbury Mus., I, no. 2, p. 25) from New Zealand as *angulosus* seem to be *magellanicus.* This opinion, which was originally based on the published description, has since been confirmed by Dr. Benham's kind sending of one of the Stewart Island specimens. There is little reason to doubt that Filhol's *margaritaceus* (*auct.* Perrier), said to be common on Stewart Island and in Cook Strait is *magellanicus.* This species is quite variable and Döderlein (1906) has suggested names for two varieties, *Hassleri* from Eastern Patagonia and *novæ-amsterdamiæ* from New Amsterdam Island. The latter is a well-marked variety, characterized by the very small abactinal system and the stout greenish spines. Having received a specimen from Dr. Döderlein, and compared it with a large series of specimens from southern

South America, Falkland Islands, and Marion Islands, its specific rank seems probable. On the other hand, the variety *Hassleri* is not at all constant, and as specimens from Marion Island resemble it very closely, it is clear it has no fixed geographical limits. There are more than a dozen bare tests of what seem to be *magellanicus* from Australia and New Zealand in the M. C. Z. Four of these are labelled *albocinctus* and were received from Captain Hutton himself. After a careful study of these tests and Benham's description (1908, Ann. Mag. Nat. Hist., (8), I, p. 107), we have failed to find any character by which *albocinctus* can be distinguished from *magellanicus*, for even the globiferous pedicellariæ, upon which Mortensen bases his placing of the two species in separate families, are quite unreliable. It may well be granted that most New Zealand specimens have the valves of the globiferous pedicellariæ with a lateral tooth only on one side, although no personal observations support such a view; that such is the case uniformly seems very doubtful. In the light of all the evidence available, it is probable that *magellanicus* is a circumpolar, subantarctic sea-urchin, wanting on the South African coast, but without doubt occurring on most of the other continental coasts, and on the islands, between 30° and 60° S. lat. On the isolated island of New Amsterdam, it has become differentiated into a well-marked variety, and possibly a New Zealand variety (*albocinctus*) may be entitled to recognition. In New Zealand, moreover, a species has arisen, *Huttoni*, which though nearly allied to *magellanicus*, seems to be well distinguished by the much finer tuberculation of the test and some associated characters. It is to be hoped that some New Zealand zoölogist will soon determine, from the study of good series of fresh material, the true relationships of *albocinctus*, *Huttoni*, and *magellanicus*.

The four valid species of Parechinus may be distinguished as follows:—

Buccal membrane with more or less numerous plates (besides the primordial ambulacrals) some of which are often thickened and bear pedicellariæ.
- Primary spines not banded . . . . *angulosus*.
- Primary spines with 2–3 brown rings . . . . *annulatus*.

Buccal membrane thin and except for primordial ambulacrals, perfectly bare, or rarely with a few minute plates.
- Primary tubercles large and distinct, easily distinguished from secondaries, not pink or pinkish orange; coloration variable . . . . *magellanicus*.
- Primary tubercles very small, not occupying half the height of interambulacral plates at ambitus, forming with the similar secondaries a horizontal row of 8–10 tubercles on each interambulacral plate at ambitus; outer half of this row often double; test white or light yellowish brown; tubercles pink or pinkish orange; primary spines pink or red at base, distally white . . . . *Huttoni*.

Parechinus magellanicus, comb. nov.

Echinus magellanicus Philippi, 1857. Arch. f. Naturg., Jahrg. XXIII, 1, p. 130.

In addition to the more than two hundred and forty specimens in the M. C. Z. collection, the large series taken by the "Albatross" when on her voyage from New York to San Francisco, in the Straits of Magellan in the winter of 1887–88 has been available. There is a range in size from 2 to upwards of 40 mm. h. d., the largest specimens being from the Falkland Islands. There is great diversity in the length of the primary spines and in color. It is rather striking that although the "Albatross" covered essentially the same ground as the "Hassler," no specimens of *magellanicus* were taken having the short, blunt reddish spines so characteristic of a large proportion of the "Hassler" collection. All of the "Albatross" specimens have whitish or light colored primary spines. The color of the test on the other hand is very variable. As a rule the median ambulacral and interambulacral areas are grayish or dull violet but they may be bright violet or reddish, and in one specimen they are bright red. The poriferous areas are usually rather light and often have a greenish tinge and in some specimens they are, abactinally at least, distinctly yellow-green.

The "Albatross" specimens were taken at the following places:—

Mayne Harbor, Patagonia, Chile.

Port Otway, Patagonia, Chile.

Station 2768. Off San José Peninsula Patagonia, Argentina; 42° 24′ S., 61° 38′ 30″ W. Bott. temp.? 43 fathoms. Dk. s., bk. sp.

Station 2769. Off Cape Two Bays, Patagonia, Argentina; 45° 22′ S., 64° 20′ W. Bott. temp.? 51.5 fathoms. Gn. m., fne. s.

Station 2776. Straits of Magellan; 52° 41′ S., 69° 55′ 30″ W. Bott. temp.? 21 fathoms. S., g.

Station 2777. Straits of Magellan; 52° 38′ S., 70° 10′ 30″ W. Bott. temp.? 19.75 fathoms. G.

Station 2778. Straits of Magellan; 53° 1′ S., 70° 42′ 15″ W. Bott. temp. 47.9°. 61 fathoms. Gy. s., bk. sp.

Station 2779. Straits of Magellan; 53° 6′ S., 70° 40′ 30″ W. Bott. temp. 46.9°. 77.5 fathoms. Gn. oz.

Station 2780. Near Port Otway, Patagonia, Chile; 53° 1′ S., 73° 42′ 30″ W. Bott. temp. 46.9°. 369 fathoms. Gn. m.

Station 2785. Gulf of Peñas, Chile; 48° 9′ S., 74° 36′ W. Bott. temp. 46.9°. 449 fathoms. Bu. m.

Station 2787. Off Taytao Peninsula, Chile; 46° 47′ 30″ S., 75° 15′ W. Bott. temp. 53.9°. 61 fathoms. Gn. m.

Bathymetrical range, 19.75–449 fathoms. Extremes of temperature, 53.9°–46.9°.

One hundred and thirty-one specimens.

Nudechinus, gen. nov.

Type-species, *Nudechinus scotiopremnus*, sp. nov.

The group of species to which the name of Nudechinus is given is probably the least known of any similar group of Echinidæ. They are small species having in common the two characters of a thin, bare buccal membrane and Lytechinus-like globiferous pedicellariæ. That they form the connecting link between Lytechinus and Gymnechinus seems unquestionable, but I cannot follow Mortensen in putting them in the latter genus. The highly specialized abactinal system of Gymnechinus is of far greater value for limiting a natural genus than any character shown by buccal membrane or pedicellariæ. Not having seen specimens of *darnleyensis* Woods, *inconspicuous* Mortensen, or *Gravieri* Kœhler, I have selected for the type of the genus the larger of the two new species herein described, though its status is not any more satisfactorily settled than that of the other species. We have placed *multicolor* Yoshiwara in this genus after examining the type-specimen, which was most courteously loaned by Professor Goto of the Imperial University, Tokyo. The specimen (Pl. 111, figs. *7–8*) is 14 mm. in diameter and 8 mm. high. The actinostome is large, 7 mm. across, while the abactinal system is very small, 3 mm. in diameter. There are 14 or 15 interambulacral and 17 or 18 ambulacral plates in each column. The buccal membrane is thin and except for the ten small, well-separated buccal plates, is perfectly bare. Oculars I and V reach the periproct. The globiferous pedicellariæ have valves about .35 mm. long, with a very conspicuous, straight terminal tooth, .15 or .16 mm. in length. The ophicephalous pedicellariæ are abundant and not peculiar. No tridentate could be found, though prolonged search was made. The coloration is slightly different from Yoshiwara's description, for we find no brown markings on the test; all such markings seem to be deep green. The spines are essentially as described by Yoshiwara, the violet bands being very distinct though not sharply defined. Kœhler's species *Gravieri* is very near *multicolor* but if the color of the spine-bands in the former is really "clear rose," the general appearance must be very different from *multicolor*. It seems that *Gravieri* may also be very near *Lytechinus verruculatus* and *rufus*, but if the buccal membrane is really free from calcareous matter, the resemblance is not significant. Unfortunately Kœhler does not state what the condition of the buccal membrane in *Gravieri* is, as regards plates, and it is only because he places the species in Gymnechinus that it is inferred the buccal membrane is thin and naked. None of the species are known from more than one or two localities, but all are from the Indo-Pacific region.

So far as our present knowledge goes, the six species of Nudechinus may be distinguished from each other as follows:—

Primary spines not distinctly banded with violet or rose.
- Test green or yellowish green or light with green blotches; spines white or whitish, green or brown at the very base . . . . *scotiopremnus.*
- Test and spines not as above.
  - Secondary spines not swollen at tip; valves of tridentate pedicellariæ wide, not compressed at base of blade . . . . *darnleyensis.*
  - Secondary spines somewhat swollen at tip; valves of tridentate pedicellariæ strongly compressed in basal part of blade . . . . *inconspicuus.*

Primary spines distinctly banded with violet or rose.
- Test whitish blotched with deep violet; primary spines white, each with a broad band of rose-violet (K. & V. 597) . . . . *stictus.*
- Test and spines not as above.
  - Test gray greenish with some deep green spots; primaries grayish white with 2 or 3 bands of clear rose . . . . *Gravieri.*
  - Test variegated with white and light and dark green; primaries with 2 or 3 violet bands near tip . . . . *multicolor.*

Nudechinus scotiopremnus,[1] sp. nov.

Plate 97, figs. *4–6*.

The type-specimen (Pl. 97, fig. *4*) is 17 mm. in diameter and 10 mm. high; the actinostome is 7 mm. in diameter while the abactinal system is only 3.5 mm. and the periproct 1.5 mm. There are 18 interambulacral plates in each column and 22 ambulacrals. The primary spines are about 3.5 mm. long at the ambitus. In the largest specimen, the diameter is 21 mm., the height 13 mm., the actinostome 10 mm., the abactinal system 4.5 mm., the periproct, 2 mm., and the primary spines about 4 mm.; there are 18 interambulacral, and 23 ambulacral plates in each column. In the smallest specimen, the figures are, 13 mm. h. d. 9 mm. v. d.; 6 mm. actinostome, 3 mm. abactinal system; 1.33 mm. periproct; 2.5 mm., primary spines; 14 interambulacrals; 17 ambulacrals.

[1] σκότιος = dark + πρέμνον = the lowest part of the trunk of a tree, the base.

The test is well arched with a circular, or in the largest specimen somewhat pentagonal ambitus. It is very completely covered with tubercles, but in the type and in the large specimen, a sunken zigzag line is more or less marked in the abactinal part of both the ambulacral and interambulacral areas. Seen from above, the small specimen and the type show distinctly, twenty radiating series of primary tubercles, two series in each area; these are of approximately equal size and are decidedly larger than the numerous accompanying secondaries. In the large specimen these twenty series are much less conspicuous as some of the secondaries particularly at and near the ambitus are almost as large as the primaries. Each ambulacral plate at the ambitus carries a primary tubercle, a large secondary near the inner end of the plate and three to five small secondaries. Each interambulacral plate has a large secondary tubercle on each side of the median primary and there are four to six small secondaries also. Scattered miliary tubercles occur in both areas. The abactinal system (Pl. 97, fig. *6*) is noticeably small and the periproct is covered by few plates. The madreporic genital is decidedly swollen and larger than the others; in the largest specimen it has a single tubercle on the proximal margin but in the other specimens it has none. Each of the other genitals carries two to four large tubercles. The oculars are rather small, each with a large tubercle. In the type they are all exsert, though I is only slightly so, and V is more nearly insert than any of the other three. The same condition is found in the small specimen, but in the large one, I is broadly insert and V is only barely excluded. The poriferous areas are broad, the rather large pores being arranged in quite oblique arcs of three pairs; at the peristome the areas are narrower and the arcs are more nearly vertical. The actinostome (Pl. 97, fig. *5*) is large, twice the diameter of the abactinal system. The buccal membrane is thin and perfectly bare, except for the small primordial ambulacrals. The gill-cuts are very well marked and are moderately deep and wide. The primary spines are short, rather stout, blunt, and not very conspicuous.

The pedicellariæ are fairly common but are not peculiar. The *globiferous* have valves about .25 mm. long, the narrow tubular blade about as long as the rather wide base, and terminating in a single long tooth. The *ophicephalous* have valves of nearly the same length, with the loop adding about a third as much more. The *tridentate* are chiefly actinal in position and have valves, half a millimeter long, more or less; these valves are somewhat curved, compressed at the base of the blade and somewhat expanded distally, where they are in contact with each other. The *triphyllous* are very small, the valves measuring only .10 mm. in length, the width of the blade being a trifle less. No calcareous spicules were found.

The color of the three specimens displays some diversity. The smallest has a light gray test, with a few scattered greenish blotches abactinally; the spines are white, dark brown at the very base. The type is greenish yellow with the primary spines whitish, dull green at the very base. The large specimen is yellowish green with the primaries whitish, deep green at the very base.

The type and the small specimen are labelled "de Suez, Vaillant. Psammechinus de Lütken." They were obtained in Paris in 1869 by Mr. Agassiz, but were never identified by him. The large specimen was purchased in Hamburg in 1870 by Mr. Agassiz and bears the label "New Zealand." It is probable that one, if not both, of these locality labels is erroneous and as the latter appears to be the less reliable of the two, the Indian and East African coasts will possibly prove to be the home of this species. It seems to be nearly related to *inconspicuus* Mortensen but is easily distinguished by the genital plates, the tuberculation and the coloration. The pedicellariæ are remarkably similar to those of *inconspicuus*.

Nudechinus stictus,[1] sp. nov.

Plates 93, fig. *1*; 97, figs. *1–3*.

The type and only available specimen (Pl. 97, fig. *1*) of this new form is undoubtedly very young, although the pores in the genital plates are perfectly distinct. It measures 6 mm. in diameter and rather more than 3 mm. in height; the actinostome is more than 3 mm. across and the abactinal system, more than 1 mm. The primary spines are about 1.3 mm. long. There are 9 or 10 interambulacral, and 10 or 11 ambulacral plates in each column. Aside from the primary tubercles, only a few small scattered secondaries or miliaries have been observed; on the interambulacral plates at the ambitus an imperfect circle around the primary tubercle is formed by these secondaries. The genital plates (Pl. 97, fig. *3*) are nearly of a size and each carries a single tubercle or none; the pore is in the distal angle. The oculars are relatively large, all exsert, though I is nearly insert; each with a single tubercle but apparently with no pore. The periproct is rather larger than a genital plate and is covered by four plates of which the suranal is largest. The poriferous areas are narrow, with the pores

[1] στικτός = spotted, dappled.

small, in nearly vertical arcs of three pairs. The ambulacra are nearly as wide as the interambulacra. The actinostome (Pl. 97, fig. *2*) is relatively large but the gill-cuts are very shallow and inconspicuous. The buccal membrane is thin and perfectly naked save for the small primordial ambulacral plates. The primary spines are short, rather stout, and not very acute.

The pedicellariæ are common but very small. The *globiferous* are remarkable for the very short, hook-like blade of the valves (Plate 93, fig. *1*) which are only about .15 mm. long, with the base about .10 mm. wide. The *ophicephalous* have somewhat larger valves, about .20 mm. in length, with an additional .03 to .05 for the loop; they are slightly constricted at the base of the blade. No *tridentate* nor *triphyllous* pedicellariæ were found, nor were sphæridia or calcareous spicules seen.

The test is almost white with about a dozen irregularly scattered blotches of dull purple at and above the ambitus. The spines are white but the primaries are encircled at the middle by a broad, poorly defined band of rose-violet (K. & V. 597).

The specimen upon which this new species is based was taken by the "Siboga" in the Sulu Archipelago in 7–8 fathoms. (Station 109.) It was received by the Museum of Comparative Zoölogy from the Amsterdam Museum, through the kindness of Dr. Weber in 1907, bearing the label "*Psammechinus verruculatus* L. Agass." In the report on the "Siboga" Echini, (p. 89), de Meijere records nine specimens of "*Psammechinus verruculatus* Lütken" from Station 109 and doubtless this specimen is one of them. But it does not seem possible to regard it as *verruculatus* for in specimens of that species which are as small as, or smaller than, *stictus*, the buccal membrane is fully plated. Moreover the coloration is very different from any specimens of *verruculatus*, which I have seen, and the globiferous pedicellariæ are different, resembling those of "*Echinus darnleyensis*" as figured by Mortensen ("Ingolf" Ech., pt. 1, Pl. 21, fig. *36*) very closely. Indeed there can be little doubt that *darnleyensis* is the nearest ally of *stictus*, the difference in coloration being the most obvious distinction. Larger series of the two species may show that they are identical.

Evechinus.

Verrill, 1871. Trans. Conn. Acad., I, p. 583.
Type-species, *Echinuschloroticus* Valenciennes, 1846. Voyage "Vénus," Zoophytes, Pl. VII, fig. 2.

The revival of the name Heliocidaris by Mortensen (1903, "Ingolf" Ech., pt. 1, p. 116) leads to some rather interesting results as to the proper use of that name. Mortensen's remarks on the subject are as follows: —

"In 'Cat. rais.' the species *variolaris* Lamk., *paucituberculatus* Blainv., and *chloroticus* Val. are enumerated under the genus *Heliocidaris.*— For the first of these species the older name of *Stomopneustes* must be used; according to Agassiz (Rev. of Ech.) *paucituberculatus* is synonymous with this. As far as I can see, *chloroticus* must then be the type of the genus *Heliocidaris*; the name *Evecninus* Verr. (1871) must then be dropped as being a much younger one, and I cannot but wonder, why Agassiz, who otherwise takes great care to reestablish the oldest names, has here preferred the name of *Evechinus.*" So far as the data given in this paragraph go there is no escape from Mortensen's conclusion but why has he omitted to mention the *five* other species included in Heliocidaris by Agassiz and Desor? Presumably it is because he considers the first named valid species the type of the genus and hence does not consider it necessary to even mention those which follow *chloroticus*. It is hardly necessary to say that the selection of the type of a genus is not so simple a matter and in this case is by no means easy. Agassiz and Desor included in their genus, besides the three species mentioned by Mortensen, the following five: — *Echinus margaritaceus* Val., *E. erythrogrammus* Val., *E. omalostoma* Val., *Heliocidaris mexicana* Agass., and *Echinus mirabilis* Agass. The last named species was subsequently made the type of Phymechinus by Desor, while *Heliocidaris mexicana* is now known to be based on a specimen of *Echinometra lucunter* L. In 1863, A. Agassiz established the genus Toxocidaris, naming as the first species *Echinus Delalandi* Val., which was subsequently shown to be identical with *E. erythrogrammus* Val. In 1871, therefore, when Verrill proposed Evechinus, Heliocidaris contained *chloroticus, margaritaceus*, and *omalostoma*, and Verrill acted quite within his right in making the first of these the type of a new genus, if he chose. The type of Heliocidaris therefore must be either *margaritaceus* or *omalostoma* and fortunately, whether one accepts for the former, Kœhler's genus Sterechinus or rejects it, as I do, as not distinguishable from Echinus, *margaritaceus* is eliminated, and *omalostoma* is therefore the type of Heliocidaris. There is no question that *omalostoma* of Valenciennes is identical with *tuberculatus* Lamarck and thus *tuberculatus* becomes the type-species of Heliocidaris. This leads to some interesting but not very important nomenclatural changes which will be found fully discussed under Heliocidaris (p. 350).

The genus Evechinus is characteristic of the New Zealand region and so far as known there are no authentic records from elsewhere. There are specimens in the M. C. Z. collection labelled "Fiji," but they are old and bare. They were the gift of a sea-captain, and if obtained in Fiji, they were probably taken there from New Zealand. The genus is as isolated structurally as it is geographically but, as already suggested, it is probably a highly specialized Echinus and may find its nearest living relative in *E. armatus* (de Meij.). The genus appears to be monotypic. In spite of Farquhar's very strong evidence to the contrary, Mortensen thinks Bell's species *rarituberculatus* may be valid, because the tridentate pedicellariæ are slightly different from those of *chloroticus*. As I have found the form figured by Mortensen for *rarituberculatus*, mingled with the ordinary form of *chloroticus* on the same specimen, there is no doubt that Farquhar's view is correct; *i. e.* that *rarituberculatus* is the young of *chloroticus*. As for Wood's *Evechinus australiæ*, a careful reading of his description, with specimens of Tripneustes in hand, shows that the bare tests upon which his species is based, are simply young Tripneustes. The arrangement of the pores, the shape of the auricles, and especially the fact that the ambulacra are broader than the interambulacra constitute evidence scarcely to be doubted.

Toxopneustes.

L. Agassiz, 1841. Int. Mon. Scut., p. 7.
Type-species, *Echinus pileolus* Lamarck, 1816. Anim. s. Vert., III, p. 45.

In spite of the fact, referred to on p. 245, that *Toxopneustes elegans* Död. forms a connecting link with Lytechinus, this is a very natural and easily recognized group. The broad poriferous areas, the short primaries, the abundant tubercles, and the deep gill-slits combined with the absence, on many ambulacral plates, of primary tubercles adjoining the poriferous area, give the members of the genus an easily recognized appearance. Indeed the characters of the test are so uniform, that the most obvious and perhaps the best specific characters are found in the coloration. The difference in tuberculation between *roseus* and *pileolus*, to which Mortensen refers ("Ingolf" Ech., pt. 1, p. 112) is not constant, and some specimens of *pileolus* from Japan cannot be distinguished in this respect from *roseus*. Since color seems to be the best criterion in this genus for determining specific limits, Mortensen's restoration of *roseus* A. Ag. as a valid species may be accepted and a form (*chloracanthus*), of which several specimens of very distinctive coloration from Samoa are in the M. C. Z. collection, is here described as new. The most wide-ranging species is *pileolus*, which extends from Mauritius to New Caledonia and Japan, and perhaps even to the Hawaiian Islands. The little known and apparently rare species *maculatus* Lam'k. is from Bourbon and Christmas Island, Pacific Ocean, which indicates as wide a range practically, as that of *pileolus*. The American species *roseus* seems to be isolated on the west coast of Mexico and Central America, while *elegans* is known only from Japan.

The characters distinguishing these species are as follows: —

Test not conspicuously marked with a large abactinal blotch and an ambital band of bright violet.
- Primary spines varied but without any subterminal blackish ring.
  - Tubercles more or less pink; spines red at base and for more or less of their length . . . . *pileolus.*
  - Tubercles green or white; primary spines green at base, white at tip, usually indistinctly banded with green and white; small spines white; no red *chloracanthus.*
  - Test, tubercles and spines more or less unicolor, rosy, purplish, or some shade of brown . . . . *roseus.*
- Primary spines with a conspicuous subterminal blackish band . . . . *elegans.*

Test with a conspicuous abactinal blotch and an ambital band of bright violet (K. & V. 506) . . . . *maculatus.*

Toxopneustes chloracanthus,[1] sp. nov.

Plate 93, figs. *6*, *7*.

In size, proportions, and tuberculation this species is so much like *pileolus* that it would be superfluous to give a detailed account of these features. There are some slight differences in the pedicellariæ which may be mentioned though their constancy is doubtful. The *globiferous* are very abundant and have extraordinarily long valves, 1.20–1.60 mm. (Pl. 93, fig. *6*) of which the blade is about two thirds. They are mostly colorless, so far as the cleaned calcareous substance is concerned, but many are more or less tinged with yellow-green, while others have the base of the valve bright purple. The *ophicephalous* pedicellariæ are also abundant but vary greatly in size. The valves measure from .20 to 1 mm. in length; they are more or less triangular with the tip rounded or truncate and the blade very much filled with calcareous matter. The *tridentate* appear to be quite rare. They were found only on the actinal side of

[1] χλωρός = green + ἄκανθα = spine.

the largest specimen. The valves (Pl. 93, fig. 7) are only about a millimeter long and are strongly compressed. The *triphyllous* are rare and hard to find; the valves are about .30 mm. long and .25 wide. The dumb-bell shaped spicules in the globiferous pedicellariæ are not peculiar.

The ground color of the test is light drab, approaching white. In the smaller specimens this is very distinctly marked with broad, horizontal bands of green. There is such a band at or near the ambitus and one or two above it; there may be one on the actinal surface. These bands may be either continuous or broken at the poriferous areas. The abactinal system, excepting the periproct, is also more or less green. In the largest specimen all these green markings are either wanting or only faintly indicated. All of the smaller spines are white but the primaries are more or less green. At the ambitus, each primary has a single, broad, poorly defined band of green, leaving both base and tip white. Actinally this band becomes broader and more or less clearly divided into two or three narrower bands, the base and tip of the spine remaining white. Abactinally the green coloration becomes more or less completely diffused throughout the whole spine, though it is often most marked at the base. There is no hint of red anywhere.

The four specimens on which this species is based were received by the Museum of Comparative Zoölogy from the Godeffroy Museum in 1870, and are labelled "Samoa." The largest is 106 mm. in diameter and 56 mm. high while the smallest is only 40 mm. h. d. The latter and the next to the largest have the green markings very deep and well defined. It is quite possible that this species will prove to have the same relation to typical *pileolus* that the Florida form of *Lytechinus variegatus* has to the typical form of that species, and if such proves to be the case, then *chloracanthus* should rank only as a subspecies. In the absence of connecting forms however it is preferable to give it full specific rank. The occurrence of this green form of Toxopneustes at Samoa is interesting in connection with the existence of a well-marked green variety of Mespilia among the same islands (see p. 322). The latter however seems to occur with the usual form, while so far as known typical *pileolus* does not occur at Samoa.

Tripneustes.

L. Agassiz, 1841. Int. Mon. Scut., p. 7.
Type-species, *Echinus ventricosus* Lamarck, 1816. Anim. s. Vert., III, p. 44, = *Cidaris esculenta* Leske, 1778. Add. ad Klein, p. XVII.

As there seems to be practical unanimity in accepting Tripneustes, and as there is little room for doubt that Hipponoë of Gray is technically a *nomen nudum*, while it is also preoccupied, Agassiz's name for this genus should be accepted. There can be little doubt that it represents the extreme development of the Echinidæ, the specialized abactinal system, deep gill-slits, wide ambulacra, and great reduction of ambulacral primary tubercles all pointing to the same conclusion. There are nominally three species in the genus — *gratilla* L. (long known as *variegatus*) from the Indo-Pacific region, *esculentus* Leske from the West Indies, and *depressus* A. Agassiz from the Western coast of Mexico. Recent comparison of considerable numbers of specimens from various parts of the world shows that the characters by which the species are supposed to be distinguished are of slight importance and there is probably but a single species, which is very variable in form, proportions, tuberculation, character of spines, and color. It is true that all of the specimens with dark, slender spines are from the Indo-Pacific region, but unfortunately the converse is not true for many specimens from that region are as white and the spines are as coarse as in typical *esculentus*. Owing to lack of sufficient material from the west coast of Mexico the real status of *depressus* cannot be determined but it is doubtful whether it is properly distinguishable from the West Indian species. The only character, which has proved constant in the study of the material at hand, is the amount of plating on the buccal membrane. With the aid of that feature, and the comparison of tubercles and color, the three nominal species may be distinguished as follows: —

Buccal membrane with few, small scattered plates; tubercles rather large and numerous, covering well the whole abactinal surface; spines white or yellowish . . . . . *esculentus*.
Buccal membrane with numerous thick, moderately large plates; tubercles smaller and more irregularly scattered.
  Median interambulacral areas abactinally usually quite bare and dark colored; tubercles usually very small; primary spines slender often very dark, but in some specimens, white . . . . *gratilla*.
  Median interambulacral areas abactinally not bare nor conspicuous; tubercles moderate; spines fairly stout, white . . . . *depressus*.

Tripneustes gratilla Lovén.

Echinus gratilla Linné, 1758. Syst. Nat., ed. 10, p. 664.
Tripneustes gratilla Lovén, 1887. Bih. K. Sv. Vet.-Akad. Handl., XIII, afd, 4, no. 5, p. 77.

This well-known species was taken by the "Albatross" at the following places, but none of the specimens call for any special comment, save the largest, which is 145 mm. in diameter and pure white like *esculentus*.

Fakarava, Paumotu Islands.

Puako Bay, Hawaii, H. I.

Honolulu Reef, Oahu, H. I.

Honolulu Market, Oahu, H. I.

Clarion Island, Eastern Pacific Ocean.

Station 3876. Off Lahaina Light, Maui. Bott. temp. 74°. 28–43 fathoms. S., g.

Twenty-seven specimens.

Gymnechinus.

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 115.
Type-species, *Echinus Robillardi* de Loriol, 1883. Mem. Soc. Phys. et Hist. Nat. Genéve, XXVIII, no. 8, p. 23.

The remarkable abactinal system of *Echinus Robillardi* is easily sufficient ground for establishing a new genus. Mortensen considers this feature overshadowed by certain peculiarities of the pedicellariæ and the bare buccal membrane, and consequently includes in his genus two species (*darnleyensis* and *inconspicuus*) which I have placed in Nudechinus. He has however described two species (*pulchellus* and *versicolor*) which agree with *Robillardi* in the extraordinary abactinal system (see Dan. Exp. Siam: Ech., p. 113 et seq.) and there are two others in the M. C. Z. collections. There are thus five species which belong in Gymnechinus, all characterized by the fact that unlike any other known Echini, oculars I and II are in contact with the periproct. As correlated characters, it may be mentioned that the buccal membrane is thin and bare (save for the primordial ambulacrals), the globiferous pedicellariæ have a tubular blade ending in a single prominent tooth and the test is distinctly flattened. In connection with the excentric position of the periproct, which lies almost wholly on the right hand side of the antero-posterior axis, it is not uncommon to find either genital 3 or genital 4 excluded from the periproct by the two adjoining genitals.

The five species of this genus occur in the Indian region ranging from Mauritius and the Persian Gulf to Australia, Siam, and Macclesfield Bank. They are all of small size, rarely exceeding 25 mm. in diameter. They may be distinguished from each other as follows: —

Spines white; auricles meet and form an arch.
  Suranal small, without a tubercle, in contact with only two genitals; gill-slits shallow . . . . *Robillardi.*
  Suranal large (much larger than any one of the oculars) in broad contact with four genitals and, like each of them, carrying a tubercle; gill-slits deep . . . . . *megaloplax.*
Spines more or less colored; auricles not united.
  Interambulacral plates at ambitus with the tubercles arranged around the primary or scattered, not arranged in definite horizontal series.
    Primary spines rose-purple or reddish, with light tips, not banded . . . . *pulchellus.*
    Primary spines with 1–3 bands of red . . . . *versicolor.*
  Interambulacral plates at ambitus, each with at least four large secondaries which form a horizontal series with the primary tubercle; sutures between interambulacral plates, especially the horizontal ones, well marked; primary spines violet or pale reddish with a broad indistinct violet band, light tipped *epistichus.*

Gymnechinus megaloplax,[1] sp. nov.

Plate 102, figs. *2*, *3*.

The single specimen at hand is 17 mm. in diameter and 8 mm. high. The test is thus somewhat flattened and the actinostome is slightly sunken. The abactinal system measures 6 mm. in diameter along the axis IV–1 but only a trifle over 5 mm. along the axis V–2. The actinostome is symmetrical and is about 7 mm. across. The longest primaries are 4 or 5 mm. in length and occur at and below the ambitus. There are 15 interambulacral and 19 ambulacral plates in each column. The ambulacra are very wide, only a little narrower at the ambitus than the interambulacra. There is a well-developed primary tubercle on every coronal plate, those of the ambulacra being slightly smaller than those of the interambulacra. The secondary tubercles are small and scattered; only at the ambitus, in the interambulacra, do they become noticeable; there, there is one on each end of the plate, which is much larger than the others, but not nearly as large as the primary. The genital plates (Pl. 102, fig. *3*) vary much in size, 3 is the largest, 2 and 4 are a little smaller and of about equal size, 5 is distinctly smaller, while 1 is much the smallest, being no larger than ocular I. Each of the genitals, except 1, carries a single conspicuous tubercle. The oculars are of about equal size and each of them carries a small secondary

[1] μέγας (μεγάλ) = big + πλάξ = a plate.

and several miliary tubercles. Oculars I and II are broadly in contact with the periproct but the other three are completely excluded. The periproct is very large and of peculiar shape. The end opposite the anal opening is covered by a suranal plate which is larger than an ocular, and resembles that of many Salenidæ in being in contact with four genitals; but the arrangement is unlike any known in that family in that it is genital 1 which does not touch the suranal. The suranal bears a tubercle similar to those on the genitals. The remainder of the periproct is covered by ten or a dozen plates of which the largest adjoin the suranal. The poriferous areas are broad (each about equals half the interporiferous area) for the pores are rather large and the arcs are quite oblique. Near the peristome the areas become narrower as the arcs become more vertical. The actinostomal membrane (Pl. 102, fig. *2*) is thin and perfectly naked, save for the very small buccal plates. The gill-cuts are deep and sharply defined. The auricles meet across the ambulacra forming a closed arch. The spines are fairly long, moderately stout, and rather blunt, the primaries extending far beyond the secondaries.

The pedicellariæ resemble those of *G. Robillardi*. The *globiferous* are common and variable in size and proportions. The valves range from .35–.50 mm. in length, of which from one third to one half is the tubular blade. The *ophicephalous* are very common and show little diversity, except in the amount of constriction at the base of the blade. This may be distinct or scarcely noticeable. The valves are about .25 mm. in length, besides the loop which adds .05–.08 more. No *tridentate* pedicellariæ were found. The *triphyllous* are not very common nor variable; the valves are about .10 mm. long. No spicules or sphæridia were noted.

The specimen is perfectly white save for the tube-feet and buccal membrane which are light brown; on neither test nor spines is there a trace of color.

This specimen was dredged in the Persian Gulf in 1894 or 1895 by Capt. F. W. Townsend, but there are no data to show either the exact locality or the depth. If the remarkable suranal plate proves to be a constant character, it will serve to distinguish this species at once from all other known Echini. If however it is a variable feature, carried to an extreme in this particular individual, then the coloration and the deep gill-cuts become more important specific characters. Should the gill-cuts also prove to be a variable feature, *megaloplax* might be regarded as a synonym of *Robillardi* as it would be impracticable to distinguish between them.

Gymnechinus epistichus,[1] sp. nov.

Plates 93, figs. *22, 23;* 102, figs. *4, 5.*

The specimens are so nearly of a size that the measurements of the type will answer for all. It is 26 mm. in diameter and only 12 mm. high, showing clearly the flattened form of the test characteristic of the genus. The abactinal system is 7 mm. in diameter along the axis IV–1 and nearly as much along the axis V–2. The actinostome is a little larger, measuring 9 mm. across. There are 18 interambulacral plates in each column and 24 ambulacrals. The primary spines are about 5 mm. long at the ambitus. The tuberculation of the test is a characteristic feature for while there is, as usual, a primary tubercle on every coronal plate, the secondaries are also prominent and form with the primaries, at least on the mid-zone, nearly horizontal series. Thus on each interambulacral plate at or just above the ambitus we have a series, consisting of a primary tubercle in the middle and a pair of secondary tubercles on each side; at the outer (radial) end of the plate, there are often two pairs of secondaries. In the ambulacra, which are not nearly as wide at the ambitus as the interambulacra, the secondary tubercles are few and irregularly scattered. The poriferous area is moderately wide in the mid-zone, where the pores are fairly large, and the arcs quite oblique, but actinally they become very narrow, the pores being small and the arcs more nearly vertical. The genital plates (Pl. 102, fig. *5*) except 1 are nearly of a size, decidedly higher than wide, and each carries two or three small tubercles. Genital 1 is very small and carries no tubercle. The oculars are about equal to each other and carry one to three tubercles apiece. Oculars I and II are fully in contact with the periproct but the others are broadly exsert. The periproct is not specially peculiar, but is covered by a dozen or more plates of which the largest adjoin genital 3. The actinostomal membrane (Pl. 102, fig. *4*) is thin and perfectly bare, save for the buccal plates which are so small, they scarcely exceed in diameter the tube-feet which they bear. The gill-cuts are deep but are rather broad and not very sharply defined. The auricles are low and do not meet across the ambulacra. The primary spines are moderately stout, while the secondaries, though not much shorter, are very much more slender.

The pedicellariæ are very similar to those of the other members of the genus. The *globiferous* are rather rare and have valves (Pl. 93, fig. *22*) which measure

[1] ἐπί = in + στίχος = a row, rank.

about .40 mm. in length. The *ophicephalous* are common but small; the valves are only .20–.25 mm. besides the loop, and are very slightly constricted at the base of the blade. The *tridentate* seem to be rare and the only ones found were on the abactinal surface. The valves (Pl. 93, fig. *23*) measure about .55 mm. in length and resemble those of *Nudechinus darnleyensis* as figured by Mortensen but are somewhat flatter and more compressed at base of blade.

The test is dull gray with a purplish cast which becomes deeper on the abactinal median areas of both ambulacra and interambulacra, which thus stand out more or less clearly as darker regions; actinally the whole test is nearly white. The spines are light, particularly the secondaries. The primaries are violet or pale reddish with a broad indistinct violet band, and with the tip light. The general appearance of the preserved specimens is very dull.

The specimen selected as the type of this species was collected by Semper at Bohol, Philippine Islands, in 6–10 fathoms of water. It came into the M. C. Z. collection in 1873 but was never identified. There are also two other specimens, which bear the label "*Echinus darnleyanus* Wood. Australia," but there is no clue as to when they were received or whence they came. The label would seem to confirm Mortensen's view that Wood confused more than one species under his *Echinus darnleyensis*, for these specimens are certainly very different from those in the British Museum which bear that name.

TEMNOPLEURIDÆ Desor.

General Considerations.

The description of the Temnopleuridæ as Echinidæ with sculptured or pitted tests expresses briefly the only difference between the two families. It is difficult to determine just what the real importance of this character is, and the recognition of the Temnopleuridæ as a separate family is merely a matter of convenience. Where the sculpturing of the test is conspicuous or the pits are deep and large, the general appearance of the animal seems to warrant the separation from the Echinidæ, but where the sculpturing is very faint as in many specimens of Prionechinus, or the pits and grooves are so small or shallow as to be seen only with difficulty as in some specimens of Salmacis (and other genera), the line between the families is virtually blotted out and one can but wonder whether it really exists. It is not strange therefore that specimens of Echinidæ have often been identified as Salmacis, and specimens of Genocidaris and related genera as young Echinidæ. However such identifications have usually resulted from superficial or careless examination of the specimens and it is doubtless true that a careful study of any specimen will enable one to determine to which family it properly belongs.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plate 93, figs. *16–21*, *24–31*, *33–36*.

The resemblance of the Temnopleuridæ to the Echinidæ in all these characters is very marked and characteristic features are not found in any of them. Our researches add little of importance to the detailed accounts already published by Mortensen. The spines sometimes furnish helpful characters for distinguishing species though little reliance can be placed on them. In Amblypneustes, for example, Mortensen makes the form of the tip of the spine, whether club-shaped or not, an important specific character. This is not very satisfactory, as it is difficult to decide in the case of some spines whether the tip is club-shaped or not and in some specimens both club-shaped and simply blunt spines occur. In Temnotrema, the smoothness or roughness, and the form of the tip, of the spines is often a useful means of separating species, but even in this genus the lines between the different kinds of spines are sometimes difficult to observe.

The pedicellariæ are so similar to those of the Echinidæ, that a description of their characteristic features would be but a repetition of what has already been stated (p. 236–238). The spicules are uncommon and hard to find; they are triradiate in Hypsiechinus, according to Mortensen, but elsewhere are bihamate or simply bow-shaped. The sphæridia show no peculiarities.

The Genera and Species of Recent Temnopleuridæ.

As first pointed out by Duncan, the Temnopleuridæ fall into two groups which may well be ranked as subfamilies. One of these has been designated as Temnopleurinæ and this name has been generally agreed to, but for the other group several names have been suggested. Of these the one proposed by Mortensen but later rejected by him, Trigonocidarinæ is preferable. Our choice is due to the fact that it is based on a recent genus and for obvious reasons, it is desirable that whenever possible names should be based on recent types. No doubt fossil species are of equal importance with the recent in determining the history and natural relationships of Echini; indeed they have often proved of far greater importance, but since it is only the recent species of which the entire structure and the complete life-history can be discovered they should, when possible, furnish the types upon which names are based. It is to be regretted that the number of fossil Temnopleuridæ, which have been named, is so large as to make it impossible to take them into account in the present work, and the following review of the recent species of the family is given with the full understanding that a similar review of the fossil forms may make it necessary to modify some of the statements and to alter the generic limits herein laid down.

In no other family of Echini is there more general agreement as to the classification of the recent species than is found here, no doubt owing to the fact that all students of the group have sought for generic characters in the test and have made use of the spines and pedicellariæ only in a very subordinate way. The family contains at least fifty living species and probably many more, for specific limits in some genera are as yet unsatisfactorily known, and moreover the smallest species of regular Echini belong here and these are often overlooked by collectors. Even if collected, their identification being difficult, they are often erroneously labelled, frequently being considered the young of large species to which they have no close relationship. It is therefore to be expected that more species will be added hereafter to the Temnopleuridæ than to any other family.

As stated above the family falls into two sections according to the structure of the test. In one group (Trigonocidarinæ) the coronal plates, especially in the interambulacra and abactinally, are more or less sculptured, *i. e.* the surface of the plate is furrowed or is ornamented with elevated ridges or knobs or both. The amount of this sculpturing is very variable even within a given species, some specimens showing it plainly while in others it is very faint. Thus we have specimens from the West Indies, which connect *Trigonocidaris albida* with *Lytechinus euerces* so closely that it is to be feared the line drawn in this Memoir is quite arbitrary. Specimens showing any "sculpturing," have been assigned to Trigonocidaris and those where it was lacking to Lytechinus, but many of the latter have a most close resemblance to the former. It may be added that most of these doubtful cases are immature, though occasionally a full grown Trigonocidaris has the "sculpturing" very faint. In Prionechinus again, the amount of sculpturing is oftentimes very slight, no more than is found in young Echinidæ of the same age, and the placing of such specimens in the Temnopleuridæ is on the strength of their general appearance rather than on anything tangible. Sometimes the abactinal system is sculptured even when the test is not but this is not usually the case. In the other group (Temnopleurinæ) the test is not sculptured (with rare exceptions) but along the horizontal sutures or at the angles of the plates in the median line of each area are found deep pits, the form and size of which are very variable. They may be so large as to furnish the most conspicuous character of the test or they may be so small as to be easily overlooked, and they may be practically wanting in old specimens. In addition to these pits, the Temnopleurinæ have another characteristic feature in the union of the coronal plates by dowelling. No very extensive study of this feature has been made to determine its significance or its relation to youth and maturity. While it may be of more morphological importance than seems likely, it is so difficult a feature to detect that it is of little practical importance in distinguishing species and genera.

Aside from the structure of the corona, the character of the abactinal system, the condition of the buccal membrane, and the arrangement of the buccal plates all furnish characters of importance in classification. It is rather remarkable that while the abactinal system of the Temnopleuridæ retains, with few exceptions, the primitive character of having all the ocular plates small and broadly exsert, the actinostomal membrane is with few exceptions thin and bare and even the buccal plates may show indications of resorption or the buccal tube-feet be reduced to five. The crenulation of the primary tubercles is a matter of some importance in this family as it furnishes the most obvious character for distinguishing certain genera. The arrangement of the pore-pairs is of no little importance in distinguishing some species of the more highly specialized genera, and the number of coronal plates is frequently of value as a character. Size and color are often of very great significance and certain species are only to be distinguished by some characteristic feature of their coloration. As a rule the genera are not difficult to distinguish, if reasonable care is used, but in certain genera, notably Prionechinus and Amblypneustes, the separation of the species is very difficult and the results are not always satisfactory. The following table shows those characters which have proved of most use and reliability in arranging the forty-five species, which have been personally examined, all of the sixteen genera except Lamprechinus being represented.

Test without pits on sutures or at angles of coronal plates, but more or less extensively ornamented with grooves, depressions, ridges or knobs; coronal plates not united by dowelling . . . . TRIGONOCIDARINÆ.

Sculpturing of test, when well marked, consists of vertical or diagonal ridges, usually connecting tubercles, but it may be so faint as to show little character; it is sometimes best marked on abactinal system.

Actinostomal membrane fully plated; buccal plates not conspicuous among the others.

Sculpturing of test more or less well marked; madreporic genital with 10–15 pores or more; no sexual dimorphism . . . . . . *Trigonocidaris.*

Sculpturing of test slight or wanting; madreporic genital with only 2 or 3 large pores; marked sexual dimorphism; abactinal system of female greatly elevated and modified . . . . *Hypsiechinus.*

Actinostomal membrane naked, at least outside the ring of buccal plates which are usually conspicuous.

Periproct more than half covered by a single plate; actinostomal membrane with only the buccal plates . . . . *Genocidaris.*

Periproct not half covered by any one plate; peristomal membrane with at least a few plates proximal to the buccal circle.

Periproctal plates few, large, and more or less glassy.

Actinostomal membrane with few plates proximal to the buccal circle; coronal plates usually with distinct sculpturing; ocular plates more or less swollen and genitals usually more or less sculptured . . . . *Orechinus.*

Actinostomal membrane well plated within circle of buccal plates; coronal plates only faintly sculptured; ocular and genital plates flat, smooth, and not sculptured . . *Lamprechinus.*

Periproctal plates numerous and not glassy . . . . *Prionechinus.*

Sculpturing of test consists of a series of depressions along horizontal interambulacral sutures; there are 4–6 of these on each suture at ambitus . . *Opechinus.*

Test not sculptured (or rarely so) but with pits on horizontal sutures or at angles of coronal plates; latter united by dowelling . . . . TEMNOPLEURINÆ.

Primary tubercles distinctly crenulated.

Coronal plates, at least abactinally, with deep and more or less conspicuous pits at their sutural angles; these pits are usually extended more or less distinctly along the horizontal sutures; each interambulacral plate at ambitus with 1 or 3 (very rarely 4) primary tubercles . . . *Temnopleurus.*

Coronal plates usually with small sutural pits or none; if the pits are large enough to form a furrow along the horizontal suture, the interambulacral plates at ambitus each carry 4–9 subequal primary tubercles in a horizontal series . . . . *Salmacis.*

Primary tubercles small, not crenulated (faintly so in some large specimens).

Every ambulacral plate with a primary tubercle close beside the poriferous area.

Coronal plates with deep, conspicuous, usually oblong pits at the sutural angles and on their horizontal sutures; poriferous areas narrow, the pore-pairs in an approximately vertical series . . . *Temnotrema.*

Coronal plates with small sutural pits or none.

Median abactinal interambulacral areas (and usually ambulacral also) more or less extensively bare and free from spines and tubercles.

Interambulacral plates low and numerous (21 or 22 in each column in specimens 20 mm. h. d.); pore-pairs distinctly biserial . . . . *Mespilia.*

Interambulacral plates high and few, not more than 18, even in largest specimens (25 mm. h. d.); pore-pairs usually monoserial.

Actinal interambulacral plates not lower than abactinal nor noticeably different in shape; their primary tubercles not arranged in horizontal series of 3 or 4; bare interambulacral space extended more or less conspicuously along the horizontal sutures; oculo-genital ring not conspicuously dark . . . . *Microcyphus.*

Actinal interambulacral plates distinctly lower and more oblong than abactinal; primary tubercles on each one in a horizontal series of 3 or 4; bare interambulacral spaces not extended noticeably along horizontal sutures; oculo-genital ring more or less black or blackish . . . . *Salmacopsis.*

Median abactinal interambulacral areas not bare but more or less covered by secondary or miliary spines . . . . . . *Amblypneustes.*

Only every second or third ambulacral plate at and above ambitus with a primary tubercle close beside the poriferous area.

Ocular plates typically all exsert; interambulacral plates low and numerous (27–30 in specimens 23 mm. h. d.), each with several primary and some secondary tubercles; actinostomal membrane naked save for buccal plates . . . . *Holopneustes.*

Oculars I and V insert; interambulacral plates high and few (18 in specimen 23 mm. h. d.) each with 1 small primary, and 2–5 well scattered, small secondary tubercles; actinostomal membrane with numerous small plates, especially inside the buccal circle . *Goniopneustes.*

Trigonocidaris.

A. Agassiz, 1869. Bull. M. C. Z., I, p. 263.
Type-species, *Trigonocidaris albida* A. Agassiz, 1869, l. c.

Although a second species of this genus, from the Hawaiian Islands, was described in 1907 (A. Agassiz and Clark, Bull. M. C. Z., L, p. 242), comparison of those specimens with a large series from the West Indies shows that the peculiarities supposed to distinguish the Hawaiian form are not reliable but are quite inconstant and the genus is thus monotypic.

Trigonocidaris albida A. Ag.

Trigonocidaris albida A. Agassiz, 1869. Bull. M. C. Z., I, p. 263.
Trigonocidaris albidoides A. Ag. and Cl., 1907. Bull. M. C. Z., L, p. 242.

Examination of a large series of specimens from the West Indies shows so great diversity in the sculpturing of the test, in the number of spines on the abactinal system and in the amount and distribution of the red coloring, that it is impossible to satisfactorily distinguish the specimens collected by the "Albatross" in the Hawaiian Islands. This would seem to indicate that de Meijere was quite correct in identifying as *albida*, the Trigonocidaris collected by the "Siboga" in the Sulu Archipelago in 153 fms. Very likely this species will prove to be intertropical in its distribution in water 100–500 fathoms deep.

The specimens collected by the "Albatross" were taken at the following places: —

Station 3859. Off Mokuhooniki Islet, Pailolo Channel, Hawaiian Islands. Bott. temp. 60.5°–60.2°. 138–140 fathoms. Fne. s., m.

Station 3863. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 61°–60°. 127–154 fathoms. Brk. co., crs. g., r.

Station 3892. Off Mokapu Islet, north coast of Molokai, H. I. Bott. temp. 42.5°. 328–414 fathoms. Fne. g. s.

Station 4045. Off Kawaihae Light, west coast of Hawaii, H. I. Bott. temp. 49°. 147–198 fathoms. Co. s., for.

Bathymetrical range, 127–414 fathoms. Extremes of temperature. 61°–42.5°.

Five specimens.

Hypsiechinus.

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 81.
Type-species, *Hypsiechinus coronatus* Mortensen, 1903, l. c.

Mortensen (1904, Siam Ech., p. 57) holds that this genus is "the most primitive of all the Temnopleuridæ" and refers to the globiferous pedicellariæ and calcareous spicules as evidence of the fact. There may be suggested as confirmative facts, the structure of the abactinal system of the male, the plating of the buccal membrane, the rudimentary condition of the auricles and the paucity of spines. It is interesting to note that Trigonocidaris is only a little more specialized, the auricles being a little higher, the valves of the globiferous pedicellariæ having only a single lateral tooth on the left side and the spicules being bihamate.

Hypsiechinus is monotypic and is known only from deep water (450–799 fathoms) southwest and west of Iceland.

Genocidaris.

A. Agassiz, 1869. Bull. M. C. Z., I, p. 262.
Type-species, *Genocidaris maculata* A. Agassiz, 1869, l. c.

The discovery of additional species of this genus, agreeing in certain interesting details with the type species, seems to confirm the view of Pomel and Mortensen that the generic name originally bestowed on the West Indian specimens had better be retained. The exceptionally large suranal plate, which is no doubt a primitive character, is combined with a perfectly naked buccal membrane, a specialized feature, and quite specialized globiferous pedicellariæ; an unusual combination which makes the genus easy to recognize. The species originally described from the West Indies (*maculata*) is now known from the eastern Atlantic and from the Mediterranean, according to Mortensen and Kœhler. A second species (*decipiens*) was collected by the "Siboga" at Saleyer, Flores and Sumbawa, D. E. I., in shallow water. De Meijere's description of the abactinal system of this species would lead one to suppose that the arrangement of the plates is very similar to that which is characteristic of Gymnechinus. Examination of two specimens, received from the Amsterdam Museum, shows that the periproct is not noticeably excentric, but that the anus is crowded far to the right by the huge suranal plate. Genital 1 is rather low and genital 3 rather high but there is nothing like the disproportion shown in Gymnechinus. None of the ocular plates reach the periproct but I and II are appreciably nearer than the others, which suggests the condition of Gymnechinus. Owing to the deep sculpturing of the plates, it is not easy to make out the sutures and de Meijere was probably either misled in supposing two oculars to be insert or else the specimen on which his statement is based, was exceptional. That it is not a question of size is evident from the fact that his largest specimen was only seven millimeters h. d. while our larger one is over six. Comparison with the other species of the genus shows that the excentricity of the periproct and of the anus are little if at all greater in *decipiens* than in the others. The third species (*apoda*) was taken by the "Albatross" off southern Japan in rather deeper water than that in which its East Indian neighbor was found. The three species may be distinguished from each other as follows: —

Buccal tube-feet 10, one for each buccal plate.
- Buccal plates large forming a nearly closed ring around mouth . . . . *maculata*.
- Buccal plates small, not forming a ring around mouth, as one plate in each pair is decidedly more distal than its fellow . . . . *decipiens*.

Buccal tube-feet 5, wanting on one buccal plate of each pair . . . . *apoda*.

Genocidaris apoda A. Ag. and Cl.

Genocidaris apoda A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 126.

Plates 93, figs. *16*, *17;* 100, figs. *1–3*.

The largest specimen is 7 mm. in diameter and rather more than 3 mm. high. The abactinal system is well over 4 mm. across while the actinostome is not over

3.5. There are about eight coronal plates in each column in both ambulacral and interambulacral areas. The primary spines are all broken but in a smaller specimen, 5 mm. in diameter, they are 4–5 mm. long, and thus equal to h. d. The sculpturing of the test is well marked in the mid-zone and actinally but abactinally the plates become quite smooth, particularly the plates of the abactinal system itself. The latter are also remarkable for their relatively large size and freedom from tubercles. The genital plates (Pl. 100, fig. *3*) are nearly of a size, though 1 is somewhat smaller than the others. Each plate carries a minute tubercle on the distal margin, and the madreporic genital may have one or two smaller ones in addition. The genital pore is conspicuous and is surrounded by a raised ring. The madreporic pores are very few, only 6–10 in number; they are situated in an elevation of the plate surface. The ocular plates are nearly triangular and carry several minute tubercles, one of which may be distinctly larger than the others. In the largest specimen, the oculars are all excluded from the periproct, but in the others ocular I is more or less broadly insert. The periproct is very large and is covered by a huge suranal, nearly as big as a genital, and a number of very small plates near the anus, which lies very close to genital 1. None of the periproctal plates carry tubercles of any kind. The ambulacra are decidedly narrower than the interambulacra at the ambitus. The poriferous areas are very narrow and the arcs of pores are vertical or nearly so. The primary tubercles are of quite unequal sizes, particularly in the ambulacra.

The actinostome (Pl. 100, fig. *2*) is decidedly smaller than the abactinal system. The membrane is thin and perfectly naked save for the minute buccal plates. The latter are very remarkable for their relative size and arrangement. At first sight there seem to be but five, as shown in fig. *2*, Pl. 100, but more careful examination shows that instead of a single plate in each ambulacrum there are really two lying closely side by side, one of normal size with a well-developed tube-foot and the other very small and with no trace of a tube-foot. Placing the specimen with the mouth up and ambulacrum III anterior, it is seen that, beginning in ambulacrum I, the small and large plates are arranged in the following sequence — small, large; small, large, large, small; small, large; large, small; that is the large plates are I*b*, II*b*, III*a*, IV*b*, V*a*. It will be noted that while this is the reverse of Lovén's formula, it accords exactly with what Lovén shows to be the condition in a very young Strongylocentrotus ("Echinologica," Pl. IV, fig. 25) and what Jackson found in young Echinus (Mem. Boston Soc. Nat. Hist., VII, p. 119), for in these cases only one plate of each pair of primordial ambulacrals has a tube-foot and that is the one which according to Lovén's formula should be the smaller. In *Temnotrema Döderleini* .(Mortensen) there are but five primordial ambulacral plates, as the original description states. Examination of a specimen shows that, judged by their position with reference to the poriferous areas, these plates are likewise I*b*, II*b*, III*a*, IV*b*, V*a*. It seems probable therefore that when a tube-foot fails to become associated with one of the primordial ambulacral plates, that plate fails to develop and remains rudimentary as I*a*, II*a*, III*b*, IV*a*, and V*b* are in *Genocidaris apoda* or even becomes quite resorbed as the same series does in *Temnotrema Döderleini*. But why tube-feet fail to become associated with these particular plates still remains to be explained. It may be noted here that in *Genocidaris decipiens* de Meij. the arrangement of the primordial ambulacral plates accords with Lovén's law, for while each plate bears a tube-foot, the two plates of each pair are unequally distant from the mouth, and the distal plate is the larger; the sequence of these distal plates is I*a*, II*a*, III*b*, IV*a*, V*b* as would naturally be expected.

The primary spines of *apoda* are remarkably long and slender and so easily broken, that whole ones have been observed only in the smallest specimen. Pedicellariæ are not common. Only one *globiferous* was found; the valves (Plate 93, fig. *16*) are about .15 mm. long, the blade is not as tubular as in *maculatus* and the end tooth is not particularly long. The *ophicephalous* pedicellariæ have the valves (Pl. 93, fig. *17*) about .20 mm. in length and distinctly constricted at base of blade. No *tridentate* or *triphyllous* were found, nor were either sphæridia or calcareous spicules noted.

The test and spines are white with a grayish tinge and in the small specimen the terminal half of the longer primaries is red.

This little sea-urchin differs so decidedly from the other species of Genocidaris that it cannot fail to be recognized. The plates of the abactinal system are so much larger, thinner, and smoother than in *decipiens* or *maculata* that even aside from the peculiarly characteristic buccal plates, it would be easily distinguished.

It was taken by the "Albatross" at only two stations: —

Station 4891. Southwest of Goto Islands, Japan; 32° 27′ N., 128° 34′ E. Bott. temp. 50.2°. 181 fathoms. Gy. s., brk. sh., r.

Station 4904. Southwest of Goto Islands, Japan; 32° 31′ 20″ N., 128° 32′ 40″ E. Bott. temp.? 107 fathoms. Fne. gy. s., brk. sh.

Three specimens.

Orechinus.

Döderlein, 1905. Zool. Anz., XXVIII, p. 622.
Type-species, *Trigonocidaris monolini* A. Agassiz, 1879. Proc. Amer. Acad., XIV, p. 203.

In his report on the "Siboga" Echini, de Meijere removed *T. monolini* from Trigonocidaris and placed it in Genocidaris but it is not clear on just what grounds he made the change. Döderlein has showed however that the characters of both the abactinal system and buccal membrane prevent its association with Genocidaris and so he established the genus Orechinus for its reception. This genus is so near Trigonocidaris that it might be regarded as superfluous, but the lines of development are probably a little easier to follow if the two genera are retained. So far as known Orechinus is a monotypic genus confined to the deep waters of the Indo-Pacific region.

Orechinus monolini Död.

Trigonocidaris monolini A. Agassiz, 1879. Proc. Amer. Acad., XIV, p. 203.
Orechinus monolini Döderlein, 1905. Zool. Anz., XXVIII, p. 622.

Plate 93, figs. *27–31*.

The "Challenger" took a single specimen, 8 mm. in diameter, in 520 fathoms near the Kermadec Islands and the "Valdivia" also took a single, somewhat larger specimen in 278 fathoms off South Africa. The "Siboga" found the species fairly common, in the Dutch East Indies, taking it at ten widely scattered stations in from 262 to 1156 fathoms. These specimens ranged from 4 to 14 mm. in diameter. Finally the "Albatross" found *monolini* not uncommon among the Hawaiian Islands, and brought home a series of specimens ranging from 6 to 22 mm. in diameter. In spite of the larger size of some of these specimens, there is little to add to the details that have been published by de Meijere and Döderlein. Globiferous pedicellariæ are rare in some specimens but fairly common in others; the valves (Pl. 93, figs. *27, 28*) are about .60 mm. long, with the base .30 mm. wide and the terminal tooth about .15 mm. long. The ophicephalous are common; the valves (which have been figured by Döderlein) are .20–.25 mm. long, besides the loop which adds .05–.10 more. The tridentate are always rare and often wholly wanting, which is unfortunate as they are rather characteristic; the valves (Pl. 93, figs. *29, 30*) are .40–.70 mm. long, with the blade .12–.18 mm. wide; they are strongly curved and meet only at the tip. The triphyllous are rare or at least hard to find; the valves (figured by Döderlein) are about .13 mm.

long. The primary spines at the ambitus, if unbroken, often exceed the diameter of the test. The form of the test is very variable, the vertical diameter ranging from .45 to over .60 h. d. The distinctness of the sculpturing on both the coronal plates and the abactinal system, is also very variable and in some specimens is quite faint. The ocular plates are, without exception in these specimens, excluded from the periproct, which is covered by a variable number of plates. The buccal membrane is thin and very bare, for although the buccal plates are large, the small plates proximal to them are few and scattered. The auricles touch over the ambulacra, or nearly so, but they are not united to form an arch. The color of test and spines is more or less white, very uniform, but sometimes strongly tinged with brown.

The "Albatross" took this species at the following stations:—

Station 3839. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 46.3°. 259–266 fathoms. Lt. br. m., s.

Station 3865. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 44.8°–45°. 256–283 fathoms. Fne. vol. s., r.

Station 3914. Off Diamond Head, Oahu, H. I. Bott. temp. ? 289–292 fathoms. Gy. s., m.

Station 3918. Off Diamond Head, Oahu, H. I. Bott. temp. 44.5°. 257–294 fathoms. Wh. s., m.

Station 4085. Off Puniawa Point, Maui, H. I. Bott. temp. ? 267–283 fathoms. S., sh.

Station 4117. Off Kahuku Point, Oahu, H. I. Bott. temp. 45.6°. 253–282 fathoms. Co. s., for.

Station 4125. Off Kahuku Point, Oahu, H. I. Bott. temp. 36.4°. 963–1124 fathoms. Br. m., for., r.

Station 4126. Off Kahuku Point, Oahu, H. I. Bott. temp. 35.5°. 743–1278 fathoms. Gy. s., for.

Station 4131. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.7°. 257–309 fathoms. Fne. gy. s.

Bathymetrical range, 253–1278 fathoms. Extremes of temperature, 46.3°–35.5°.

Twenty-nine specimens.

Lamprechinus.

Döderlein, 1905. Zool. Anz., XXVIII, p. 622.
Type-species, *Lamprechinus nitidus* Döderlein, 1905, l. c.

Not having seen a specimen of this genus, I am in doubt as to its validity. Judging from Döderlein's description and figures it must be very near Orechinus, and so far as can be determined the points which separate it from that genus are quite trivial. The genus is monotypic and since the only specimens were taken off South Africa in 276 fathoms, at the same place where *Orechinus monolini* was taken, its supposed characters may represent only individual diversity of Orechinus.

Prionechinus.

A. Agassiz, 1879. Proc. Amer. Acad., XIV, p. 202.
Type-species, *Prionechinus sagittiger* A. Agassiz, 1879, l. c.

Of all the genera of Temnopleuridæ this is not only the least well defined, but it is also the one within which specific limits are hardest to draw. There are several reasons for this, particularly the small size, the occurrence only in deep water and the lack of sufficient material for careful comparative study. Test-sculpturing reaches its lowest limit in this genus; in some of the species, it is quite wanting and in others it is chiefly on the abactinal system. What characters are really of specific importance, it is hard to determine for so little of their significance is known. The position of the genital pore on the plate is used as a specific character but it may be only sexual, and the presence or absence of tube-feet on the buccal plates may be a matter of age. And the question whether color has any significance is also of importance. The result of my efforts to distinguish the described species follows but it is doubtful if all these species are valid, or if valid whether they are best distinguished by the characters used. It is probable that de Meijere is correct in assigning *Cottaldia Forbesiana* A. Ag. to this genus, although lack of material makes it very uncertain what its true relationships are. It seems quite probable, as Dr. Mortensen has pointed out with rather undue emphasis ("Ingolf" Ech., pt. 1, p. 82), that more than one species was included under the name *Prionechinus sagittiger* in the report on the "Challenger" Echini and that unfortunately the drawings on Plate VI[a] were not all taken from the same specimen. It seems best to follow Mortensen and de Meijere in taking the specimen from "Challenger" Station 218 (shown in "Challenger" Rept., Pl. VI[a], fig. 11) as the type of the species, as any other course would result in great confusion; and this decision is strengthened by the fact that the specimens collected by the "Siboga" and determined by de Meijere as *sagittiger* seem to be identical with it. This statement is made from the study of a specimen from the "Siboga" material now in the M. C. Z. collection. Mortensen states that the specimen from "Challenger" Station 207 is not a Prionechinus, "it is, no doubt, a quite different genus." As he gives no facts in support of this blunt assertion, except that "the pores are really very large and form a straight line," the matter cannot be regarded as settled. A reëxamination of a specimen from "Challenger" Station 164 shows that it has ten buccal tube-feet and several large plates covering the periproct, in both these respects differing from *sagittiger*. Apparently it was from such a specimen that fig. 13, Pl. VI[a] of the "Challenger" Report was drawn and so far as can be seen such specimens belong to the species *Agassizii*. But it is certainly very doubtful how important as a specific character the absence of a tube-foot from one or more of the buccal plates, really is, and the same is true of the presence or absence of several large plates in the covering of the periproct. In view of the fact that when *Prionechinus sagittiger* was described, very little indeed was known of the living members of the group now called Trigonocidarinæ, and that little was based on West Indian material, it seems quite natural that the "Challenger" specimens from Stations 164, 207, and 218 were all referred to one species, especially since in the character of the spines and in their superficial appearance they are very similar. And it should be borne in mind that it is not yet demonstrated that they do *not* belong to a single species, for should *Agassizii* prove to be identical with *sagittiger* as is by no means impossible, it will be difficult to determine how the specimens from the three stations are to be separated. The specimens collected by the "Siboga" and identified as *Forbesiana* by de Meijere, do not seem to belong to that species, so far as can be judged from the small specimen at hand. But the agreement in coloration is rather striking and the differences in tuberculation which we note may be largely a question of age. Döderlein's species, *Chuni*, appears to be very well characterized and this seems equally true of the Hawaiian species *sculptus*. The species *depressus* from the Hawaiian Islands and *ruber* from Japan are much more dubious.

The following table will show the characters that seem to separate these seven species from each other: —

Test high, vertical diameter distinctly more than one half horizontal; buccal plates 10, subequal, each with a tube-foot, the 5 pairs well separated from each other; periproct covered by numerous, nearly equal graniform plates . . . . *Chuni*.

Test more or less depressed; anal plates of variable number and size, one or more distinctly larger than the others.
- Some of the buccal plates, usually 5, lack a tube-foot . . . . *sagittiger.*
- All of the buccal plates carry tube-feet.
  - Genital pores near centre of genital plates.
    - Buccal plates large, all 10 usually more or less in contact with each other, though in some cases adjoining pairs may be well separated; area within the buccal circle more or less plated.
      - Color yellow-orange or whitish; spines white, yellow-orange at base *Forbesianus.*
      - Color red or reddish, the primaries lighter at tip . . . . *ruber.*
    - Buccal plates small, more or less widely separated from each other; area within their circle not well plated; color dull purplish red, often light . . . . *sculptus.*
  - Genital pores at distal tips of genital plates.
    - Buccal plates large, the two of each pair more or less in contact; area within their circle more or less fully plated; genital plates little sculptured, if at all . . . . *Agassizii.*
    - Buccal plates small, well separated; area within their circle with only a few scattered plates; genital plates prettily sculptured . . . . . . *depressus.*

Prionechinus Chuni Död.

Prionechinus Chuni Döderlein, 1906. Ech. Deuts. Tiefsee Exp. ("Valdivia" Ech.), p. 192.

This seems to be the most sharply defined and easily recognized species in the genus. There is nothing to add to Döderlein's very complete and satisfactory discussion of the "Valdivia" material.

The "Albatross" specimens, ranging from 2.5 to 11 mm. in diameter, were taken at only a single place.

Station 4126. Off Kahuku Point, Oahu, Hawaiian Islands. Bott. temp. 35.5°. 743–1278 fathoms. Gy. s., for.

Seven specimens.

Prionechinus ruber A. Ag. and Cl.

Prionechinus ruber A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 126.

Plate 100, figs. *4–6.*

The larger of our specimens is 11 mm. in diameter while the smaller is only 7 mm. The former is 5.5 mm. high and has the abactinal system and actinostome, each 5 mm. across, while the smaller specimen is 3.5 mm. high and its abactinal system and actinostome are each a trifle more than 3 mm. in diameter. In the larger specimen, the primary spines are 5 mm. long, and there are 11 interambulacral and 12 ambulacral plates in each column; in the smaller specimen also, the spines are 5 mm. long, but the number of interambulacral and ambulacral plates in each column is 9. The sculpturing of the test is almost wholly wanting; it is simply indicated by slight depressions on the sutures and granular swellings among the tubercles. The genital plates (Pl. 100, fig. *6*) are large, subequal, and rather closely covered with small tubercles; the pores are quite distinct near the centre of each plate. The madreporic pores are remarkably few (10 –12) and consequently the madreporite is not easily detected. The oculars are of moderate size, well covered with small tubercles and are all fully excluded from the periproct. The latter is larger than a genital plate and is covered by about a dozen plates (or more) among which the suranal can be distinguished by its size, though several other plates are nearly as large. The ambulacra are very broad but do not equal the interambulacra at ambitus. The poriferous areas are very narrow, the small pore-pairs being arranged in nearly vertical arcs of three. The primary tubercles, of which there is one on each coronal plate, form conspicuous vertical series on each column of plates, those of the ambulacra about as large as the others. Secondary tubercles are not numerous, usually two or three on each ambulacral plate and four to seven on the interambulacral. There are also rather numerous granular elevations which may be miliary tubercles, but their outlines are so indistinct that they may not be tubercles at all. The actinostomal membrane (Pl. 100, fig. *5*) is thin and outside the circle of buccal plates is almost bare. The buccal plates are large, each carries a tube-foot and they are nearly or quite in contact with each other, thus forming a more or less complete closed ring, within which the membrane is completely covered with small plates. The primary spines at ambitus are about half as long as the test-diameter, while the abactinal ones are very much smaller. The secondaries are short, stout, and somewhat club-shaped.

The pedicellariæ are not remarkable but resemble those of the other members of the genus, particularly those of *sagittiger* and *Chuni* as photographed by Döderlein. The *globiferous* are common and have the valves .30 –.35 mm. long; it is not uncommon to find a lateral tooth on each side, instead of on only the left side as is usually the case. In the *ophicephalous*, the valves are about .30 –.35 mm. long. The *tridentate* are fairly common, but of very variable size, the valves ranging from .35 to .80 mm. In the small ones the valves are relatively much wider than in the large ones, but even in the latter the valves are a little wider than in *sculptus*. No *triphyllous* were found, nor were spicules or sphæridia observed.

In the smaller specimen the colors, are quite bright; the test is orange-red, brightest on the abactinal system, with the poriferous areas and the median interambulacral areas, almost white. The spines are orange-red becoming lighter at the tip. In the larger specimen, the colors are much less bright; the test is paler and the whitish areas stand out in much less contrast. The spines are darker at base, with more of a brown or purple shade in the red and the whitish tips are more abrupt.

There is little reason to doubt that this species stands very near *Forbesianus,* but it seems to differ not only in the color, but in the tuberculation and in the plating of the buccal membrane. Unfortunately no reliable specimens of *Forbesianus* are available for comparison, so that there is much doubt as to the true relation of the two species. The specimens collected by the "Siboga" and identified by de Meijere as *Forbesianus* seem, so far as can be judged from a single specimen from Station 173, to be nearer to *Agassizii.* Were this specimen a little larger and more deeply colored it would be very difficult to distinguish it from the smaller specimen of *ruber.* On comparing the larger specimen of *ruber* with the figures given in the "Challenger" Report of *Forbesianus,* it may be noted that the tuberculation of both the abactinal system and the coronal plates is much less crowded in *ruber,* and in view of this fact and the striking difference in color, it seems better to await further material before finally deciding whether the two species are identical.

The "Albatross" took *ruber* at the following stations: —

Station 4933. Off Kagoshima Gulf, Japan; 30° 59′ N., 130° 29′ 50″ E. Bott. temp. 56°. 152 fathoms. Rky.

Station 4967. Between Kobe and Yokohama, Japan; 33° 25′ 10″ N., 135° 37′ 20″ E. Bott. temp. 45.9°. 244–253 fathoms. Br. m., s., for.

Two specimens.

Prionechinus sculptus A. Ag. and Cl.

Prionechinus sculptus A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 243.

Plates 93, figs. *24–26;* 101, figs. *4–6.*

The large series of specimens shows so little diversity in form that the measurements of the type-specimen will be sufficient to show the proportions of the species. The test is 10 mm. in diameter and 5 mm. high, while the actinostome is about 4.5 and the abactinal system a trifle over 4 mm. The primary spines are 3–5 mm. long at the ambitus but are decidedly shorter abactinally. There are 11 interambulacral and 12 ambulacral plates in each column. The test is well arched and only slightly flattened abactinally. The sculpturing is confined to the oculo-genital ring and there is great diversity in the degree to which it is developed there. The whole test is well covered with granules and tubercles and the median interambulacral suture is sufficiently depressed to be rather conspicuous. On the ocular and genital plates there are not only numerous small tubercles but irregular or radiating furrows and low ridges. In some specimens these are almost wholly wanting while in others, they are so conspicuous (under a lens) as to give the whole abactinal system a highly ornamented appearance. The genital plates (Pl. 101, fig. *6*) are moderate and subequal, the madreporite, with its minute group of a very few water-pores, being distinguishable only with difficulty. The genital pore is near the centre of each plate. The ocular plates are rather large, but are all broadly exsert. The periproct is covered by a considerable number of small, rounded plates but among them the suranal is easily distinguishable. The ambulacra are rather narrow, little more than half as wide at ambitus as the interambulacra. The poriferous areas are narrow but rather conspicuous, as the pores are large; the pore-pairs are arranged in nearly vertical arcs of three. The actinostomal membrane (Pl. 101, fig. *5*) is very thin and distal to the buccal plates is perfectly naked. Within their circle, there are small plates, sometimes abundant enough to cover that part of the membrane very fully but in other cases imperfect and scattered. The buccal plates themselves are of moderate size and all carry normal tube-feet; the two plates of each pair are very close together, but the pairs are well separated from each other. The gill-cuts are insignificant. The spines are rather thick and blunt or bluntly pointed. The primaries have about 10 longitudinal striations.

The pedicellariæ are abundant and not specially characteristic, as they are very similar to those of *Chuni*. While the globiferous (Pl. 93, fig. *24*) and ophicephalous are common enough, only two tridentates and no triphyllous were found. The tridentate have very narrow, compressed valves (Pl. 93, fig. *25*) about .60 mm. long, meeting only at the tip where they are somewhat expanded and have minutely serrate margins.

The color of the test and smaller spines is dull purplish red, often very light and becoming nearly white in some specimens. The primaries are white, but the longitudinal striations are purplish. As a result of this coloration, the general aspect of the specimens is rather diverse, the exact shade ranging from distinct, though dull, purplish red to almost white.

This is a well-marked species and it is not likely to be confused with any except *depressus*; the position of the genital pores distinguishes it at once from that species. It appears to be quite common among the Hawaiian Islands on sandy bottoms, in moderately deep water. It apparently does not reach a large size as our specimens range only from 2 to 10 mm. in diameter.

The "Albatross" collected *sculptus* at the following stations:—

Station 3818. Off Diamond Head, Oahu, Hawaiian Islands. Bott. temp. 44.3°. 293–295 fathoms. Fne. co. s., bl. sp.

Station 4028. Off Ukula Point, Kauai, H. I. Bott. temp. 40°. 444–478 fathoms. Gy. s., glob.

Station 4039. Off Kawaihae Light, Hawaii, H. I. Bott. temp. 38.7°. 670–697 fathoms. Gy. m., for.

Station 4083. Off Puniawa Point, Maui, H. I. Bott. temp. ? 238–253 fathoms. Gy. s.

Station 4086. Off Puniawa Point, Maui, H. I. Bott. temp. 44.6°. 283–308 fathoms. S., sh.

Station 4087. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.6°. 306–308 fathoms. Fne. gy. s.

Station 4088. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 297–306 fathoms. Fne. gy. s.

Station 4115. Off Kahuku Point, Oahu, H. I. Bott. temp. 55.1°. 195–241 fathoms. Co. s., for.

Bathymetrical range, 195–697 fathoms. Extremes of temperature, 55.1°–38.7°.

Sixty-seven specimens.

Prionechinus Agassizii Wood-Mas. and Alc.

Prionechinus Agassizii Wood-Mason and Alcock, 1891. Ann. Mag. Nat. Hist., (6), VIII, p. 441.

The status of this species is uncertain. The original specimens were unusually large (13.8 mm. h. d.) for representatives of this genus and the characters on which special stress was laid in the original description are probably due to age; in all our largest specimens of Prionechinus the median interambulacral suture tends to be sunken and the poriferous area tends to assume a zigzag appearance near the actinostome. The specimens referred to this species, from the "Albatross" collection are all small, 5–7 mm. in diameter, and though they show much diversity in color, they agree in the position of the genital pores and in the characters of the actinostome. One is pure white, another has the test pale brown and the base of the spines tinged with olive, while the third has the tubercles and the basal half of all the larger spines pale red.

These specimens were taken at the following stations: —

Station 4965. Between Kobe and Yokohama, Japan; 33° 35′ 20″ N., 135° 10′ 50″ E. Bott. temp. 49.4°. 191 fathoms. Dk. gn.-gy. s., sh.

Station 4967. Between Kobe and Yokohama, Japan; 33° 25′ 10″ N., 135° 37′ 20″ E. Bott. temp. 45.9°. 244–253 fathoms. Br. m., s., for.

Station 5086. Sagami Bay, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7°. 292 fathoms. Gn. m., crs. bk. s.

Bathymetrical range, 191–292 fathoms. Extremes of temperature, 49.4°–43.7°.

Three specimens.

Prionechinus depressus A. Ag. and Cl.

Prionechinus depressus A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 244.

Plate 101, figs. *1–3*.

The largest specimen of this species is 10 mm. in diameter but the height of the test is hardly 4 mm. The abactinal system and actinostome are about equal to each other, measuring 5 mm. across, which is practically the length of the primary spines at the ambitus. There are 11 coronal plates in the interambulacral as well as in the ambulacral columns. In another specimen, 7.5 mm. in diameter, the test is 3.5 mm. high, while in a still smaller one, 6.5 mm. h. d. the vertical diameter is fully half the horizontal. The depressed test therefore seems to be acquired with age. There is practically no sculpturing on the test and very little, if any, on the genital plates (Pl. 101, fig. *3*). The genital pores are at the extreme distal tips of the genital plates. The pore is placed in a notch which is continuous with the sunken, median interambulacral suture, which in this species is very marked clear to the ambitus, at least in specimens over 7 mm. h. d. The ambulacra are rather wide, decidedly more than half as wide as the interambulacrum at the ambitus. The pores are larger and the poriferous areas wider than in specimens of *sculptus* of the same size.

In all other particulars (tuberculation, character of actinostome (Pl. 101, fig. *2*), spines, pedicellariæ, and color) this species is so similar to *sculptus* as to be practically indistinguishable. The difference in the genital pores is very noticeable and in large specimens the shape of the test affords an obvious means of distinction. An examination of the reproductive organs fails to show that the difference in the genital pores is a sexual one. So far as could be determined from alcoholic material, which is not very well adapted to such an examination, there is no difference between the reproductive organs of the two species.

The "Albatross" took *depressus* at the following five stations, at all of which *sculptus* also occurred; a fact which certainly adds weight to the view that the two forms are simply sexes of the same species. If the two species really are distinct, their occurrence at the same stations is very interesting as tending to show that Echini, like ophiurans,[1] do not follow "Jordan's law."

Station 3818. Off Diamond Head, Oahu, Hawaiian Islands, Bott. temp. 44.3°. 293–295 fathoms. Fne. co. s., bl. sp.

Station 4028. Off Ukula Point, Kauai, H. I. Bott. temp. 40°. 444–478 fathoms. Gy. s., glob.

Station 4083. Off Kawaihae Light, Hawaii, H. I. Bott. temp. 38.7°. 670–697 fathoms. Gy. m., for.

Station 4086. Off Puniawa Point, Maui, H. I. Bott. temp. 44.6°. 283–308 fathoms. S., sh.

Station 4088. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 297–306 fathoms. Fne. gy. s.

Bathymetrical range, 283–697 fathoms. Extremes of temperature, 44.6°–38.7°.

Forty-five specimens.

Opechinus.

Desor, 1855. Syn. Éch. Foss., p. 107.

Type-species, *Temnopleurus costatus* d'Archiac et Haime, 1853. Anim. Foss. de l'Inde, p. 204.

There seems to be no escape from the fact, unfortunate as it may be, that the type of this genus was fixed by Pomel. Since he removed all of Desor's six species except *costatus* from Opechinus, and since he was clearly acting within his rights as first reviser, it is hard to see how any species except *costatus* can be the genotype. It is by no means certain that the two recent species from the East Indian region, referred to Opechinus by Mortensen, are really congeneric with *costatus*, but in order that the difficulties of the problem be not increased it is proposed to let the genus stand as Mortensen left it, so far as the recent species are concerned. The two species may be distinguished as follows:—

Each horizontal interambulacral suture in mid-zone, with 4 large shallow depressions; a distinct suranal plate distinguishable on periproct . . . . *variabilis*.
Each horizontal interambulacral suture in mid-zone, with 6 large, shallow depressions; no distinct suranal plate . . . . *spectabilis*.

[1] See Clark, H. L., 1911, Bull. 75, U. S. N. M., p. 22–23.

Opechinus variabilis Mrtsn.

Pleurechinus variabilis Döderlein, 1885. Arch. f. Naturg., Jahrg. LI, 1, p. 93.
Opechinus variabilis Mortensen, 1904. Dan. Exp. Siam: Ech., p. 92, 94.

Examination of the test of this species seems to confirm Mortensen's view that its relationship is with Temnechinus rather than with Temnopleurus, for there is no evidence of dowelling between the plates and they are rather thinner than would be expected from the outer surface. Our specimens are small (8–11 mm. in diameter) and the pits at the angles of the plates are often very small or wanting while the large depressions on the sutures are very conspicuous.

The "Albatross" took this species at the following stations:—

Station 4893. Southwest of Goto Islands, Japan; 32° 32′ N., 128° 32′ 50″ E. Bott. temp. 55.9°. 95–106 fathoms. Gy. s., brk. sh., p.

Station 4894. Southwest of Goto Islands, Japan; 32° 33′ N., 128° 32′ 10″ E. Bott. temp. ? 95 fathoms. Gy. s., brk. sh., p.

Station 5068. Suruga Gulf, Japan; 35° 2′ 25″ N., 138° 46′ 55″ E. Bott. temp. 63°. 77–131 fathoms. Bk. s., brk. sh.

Bathymetrical range, 77–131 fathoms. Extremes of temperature, 63°–55.9°.

Three specimens.

Temnopleurus.

L. Agassiz, 1841. Int. Mon. Scut., p. 7.
Type-species, *Cidaris toreumatica* Leske, 1778. Add. ad Klein, p. 155.

This genus has been so recently and so fully revised by Mortensen that only agreement with his general conclusions need be expressed. There seems to be no reason to doubt that *T. Reynaudi* is really synonymous with *toreumaticus* and therefore the species long known as *Reynaudi* must take Gray's name *Reevesii*. The other species, *Hardwickii*, is near *toreumaticus* but with the spines on, the two are very easily distinguished. All three species occur in Japanese waters, but *toreumaticus* extends westward to Arabia and southward probably to Queensland, while *Reevesii* ranges westward to Ceylon, and *Hardwickii* so far as known, is peculiar to Japan, the record from Unalaska being exceedingly dubious.

The three species[1] may be distinguished from each other regardless of the differences in the sculpturing of the test, which shows great individual diversity, as follows:—

[1] For *Perezi*, see below under *toreumaticus*.

Primary spines very dark (almost black) at base, not banded; poriferous area narrow, pore-pairs small in a vertical series close to margin of ambulacrum . . . . *Hardwickii.*

Primary spines not very dark at base; poriferous area not very narrow; pore-pairs medium or large, in an interrupted vertical series, not close to margin of ambulacrum, one or more miliary tubercles being present between some pore-pairs and the margin.

Primary spines, at least actinally, banded; all ocular plates excluded from periproct *toreumaticus.*

Primary spines light colored, not banded; in adults (over 20 mm. h. d.) ocular I is usually insert . . . . *Reevesii.*

Temnopleurus Hardwickii A. Ag.

Toreumatica Hardwickii Gray, 1855. Proc. Zool. Soc. London, p. 39.
Temnopleurus Hardwickii A. Agassiz, 1872. Rev. Ech., pt. 1, p. 166.

The specimens taken by the "Albatross" range in diameter from 13 to 31 mm., but show very little diversity in coloration. There are some differences in the size, depth, and form of the pits but they do not seem to be very remarkable. It is a little odd that the "Albatross" did not meet with this species during her extended third visit to Japan, but only on her second voyage and then only at the following adjoining stations:—

Station 3723. Off Yokkaichi Light, Honshu Island, Japan. 13–16 fathoms. M., s., p., sh.

Station 3725. Off Noma Saki, Honshu Island, Japan. 13 fathoms. S., sh., g.

Nine specimens.

Temnopleurus toreumaticus Agassiz.

Cidaris toreumatica Leske, 1778. Add. ad Klein, p. 155.
Temnopleurus toreumaticus L. Agassiz, 1841. Int. Mon. Scut., p. 7.

A single specimen, 42 mm. in diameter, is the only representative of this well-known species in the "Albatross" collections. It is dark colored and the banding of the primaries is only noticeable actinally. This is in striking contrast to the color of a fine series of specimens from the Persian Gulf, which the M. C. Z. received from Capt. F. W. Townsend in 1895. In these the ground color is very light, usually a pale cream-color, in some specimens with a more or less marked olive-green cast, and the primary spines are very conspicuously banded with brownish or purplish red. These specimens appear to be identical with those from the Red Sea (Arabian coast) described by Kœhler (1906, Bull. Paris Mus., XI, p. 460) as a new species, *T. Perezi.* Kœhler fails to mention a single character by which *Perezi* is to be distinguished from *toreumaticus*, except perhaps the height of the test. This is of little importance however as *toreumaticus* is very variable in that particular. The coloration seems of more importance, but the material at hand shows that the light and dark extremes intergrade. Perhaps the very light western specimens may be recognized as a subspecies or variety, *Perezi.* Aside from the remarkable difference in color, the Persian and Arabian specimens do not differ constantly in any particular from specimens from the East Indies, China, and Japan.

The specimen in the "Albatross" collection was taken at Nanao Beach, Japan.

Temnopleurus Reevesii Mrtsn.

Toreumatica Reevesii Gray, 1855. Proc. Zool. Soc. London, p. 39.
Temnopleurus Reynaudi A. Agassiz, 1872. Rev. Ech., pt. 1, p. 166.
Temnopleurus Reevesii Mortensen, 1904. Dan. Exp. Siam: Ech., p. 62.

Although a large series of this species is at hand, they show so little diversity, that little need be said about them. Since this species is one of the very few Temnopleuridæ in which an ocular is insert, it will be of interest to record the conditions of the oculo-genital ring as shown by the fifty specimens, ranging from 7 to 43 mm. h. d., which have been examined. Of the fifty, eleven have ocular I insert, and eight others have it almost in. This would seem like a small percentage on which to base the statement that it is a species character to have ocular I insert, but when the specimens are grouped according to size, interesting information in regard to this character is obtained. There are eighteen specimens less than 14 mm. in diameter; *i. e.*, since our largest specimen is 43 mm. h. d., less than one third grown. Of these eighteen, only three have ocular I insert, or say 17%; one other has it almost in, so it may be noted that 78% show no indication of the character. There are twenty-seven specimens from a third to a half grown (14–21 mm. inclusive) and of these, five have ocular I insert, or say 18½%; but six others have it almost in, so that less than 60% show no indication of the character. There are only five specimens more than half grown; of these three (60%) have ocular I insert and one other has it almost in, and thus only 20% show no indication of the character. The largest specimen (43 mm. h. d.) has ocular I very broadly insert. Is it not fair from these data to assume that having ocular I insert is a species character, assumed late in development and not usually acquired until the individual is more than half grown?

This species was taken by the "Albatross" at the following stations: —

Station 3717. Off Ose Zaki, Honshu Island, Japan. 63–100 fathoms. Vol. s., sh., r.

Station 4815. Between Hakodate and Sado Island, Japan; 38° 16′ N., 138° 52′ E. Bott. temp. 51°. 70 fathoms. Dk. gn. s.

Station 4832. Between Nanao and Tsuruga, Hondo, Japan; 36° 14′ 30″ N., 135° 56′ 30″ E. Bott. temp. 53.2°. 76–79 fathoms. Dk. gy. s.

Station 4893. Southwest of Goto Islands, Japan; 32° 32′ N., 128° 32′ 50″ E. Bott. temp. 55.9°. 95–106 fathoms. Gy. s., brk. sh., p.

Station 4894. Southwest of Goto Islands, Japan; 32° 33′ N., 128° 32′ 10″ E. Bott. temp. ? 95 fathoms. Gn. s., brk. sh., p.

Station 4895. Southwest of Goto Islands, Japan; 32° 33′ 10″ N., 128° 32′ 10″ E. Bott. temp. ? 95 fathoms. Gn. s., brk. sh., p.

Station 4902. Southwest of Goto Islands, Japan; 32° 30′ 50″ N., 128° 34′ 40″ E. Bott. temp. 52.9°. 139 fathoms. Gy. s., brk. sh.

Station 4904. Southwest of Goto Islands, Japan; 32° 31′ 20″ N., 128° 32′ 40″ E. Bott. temp. ? 107 fathoms. Fne. gy. s., brk. sh.

Station 4931. In Colnett Strait, Japan; 30° 12′ N., 130° 43′ 40″ E. Bott. temp. 75.4°. 83 fathoms. Brk. sh., p., co.

Station 4933. Off Kagoshima Gulf, Japan; 30° 59′ N., 130° 29′ 50″ E. Bott. temp. 56°. 152 fathoms. Rky.

Station 5074. In Suruga Gulf, Japan; 34° 40′ 45″ N., 138° 18′ 30″ E. Bott. temp. 74.9°. 47 fathoms. Gy. m.

Station 5095. Off Gulf of Tokyo, Japan; 35° 5′ 34″ N., 139° 38′ 36″ E. Bott. temp. 57.8°. 58 fathoms.

Bathymetrical range, 47–152 fathoms. Extremes of temperature, 75.4°–51°.

Thirty-two specimens.

Salmacis.

L. Agassiz, 1841. Preface to Valentin's Anat. Genre Echinus, p. VIII.
Type-species, *Salmacis bicolor* L. Agassiz, 1841, l. c.

The specific limits within this genus are at present imperfectly drawn, although the work of Döderlein and Mortensen has greatly increased our knowledge. The great variability of some species, in test sculpture and form, and also in color, coupled with the lack of large series of specimens, has made it very difficult to decide just what species really are valid. Fortunately the color of the type-species, *bicolor*, appears to be both constant and distinctive, and as it is particularly mentioned by Agassiz, it makes his diagnosis of both species and genus recognizable and valid. A closely related form has long been distinguished as *rarispina*, but the examination of our M. C. Z. material confirms Mortensen's statement that there is no constant difference between the two forms. Indeed the difference which his specimens showed in the number of ambulacral and interambulacral plates and which led him to retain *rarispina* as a variety of *bicolor* is not shown by our specimens, and it is not practicable to distinguish the variety. So far as can be determined from the available material, and the published notes on the different species, the form of the test is strikingly variable in *bicolor*, *virgulata*, *Alexandri*, and perhaps also in *sphæroides*, the vertical diameter ranging from little more than one half to nearly three fourths of the horizontal. We note also that most specimens fall into one of two groups, the one with the vertical diameter from .55 to .60 h. d. and the other with it about .70 h. d. Ramsay, who appears to be the only writer to have examined large series of living Salmacis, speaks emphatically of the diversity shown by *S. Alexandri* in the form of the test (1885, Cat. Ech. Australian Mus., p. 48). The question of the relation of *Alexandri* to *virgulata* appears to be a debatable one; the former is at least a subspecies characteristic of the Australian region, and as a connecting series of specimens is lacking, those at hand being easily recognized, it has seemed well to let *Alexandri* stand as a valid species. These two species (*virgulata* and *Alexandri*) are distinguished from the other members of the genus by the absence of bands on the primary spines, but this is of course, not so important a character as those which distinguish *Dussumieri*. In this species, the test appears to be always flattened, so much so that the vertical diameter is less than one half the horizontal, and ocular I is insert or very nearly so. Moreover the ambulacra are highly modified, so that there is a primary tubercle close to the poriferous zone, only on every other ambulacral plate, excepting only the oldest (near actinostome) and youngest (near ocular plate). Mortensen (1904, Dan. Exp. Siam: Ech., p. 73) refers to "a very dark colored form" of *Dussumieri* in the collection of the British Museum from Tuticorin (southern India) and he adds that Bell's *S. sulcata* from Zanzibar is similar. He says further that "it can only be regarded as a color variety." A fine specimen of this form from Zanzibar (Pl. 111, figs. *4–6*) is in the collection of the M. C. Z. and its color characters are so strikingly different from *Dussumieri* that it must rank as a new species, for which we suggest the name *erythracis* (ἐρυθρός, *red* + ἀκίς, *a pointed instrument*) in reference to the more or less conspicuously vermilion-red bases of the secondary and miliary spines. There is little question about the status of the form, which Lovén has showed Linné designated as *sphæroides*, but there is some doubt regarding *Belli* Döderlein. We have a beautiful specimen of the latter, or one at least from "Challenger" Station 188, and Mortensen (1904, Dan. Exp. Siam: Ech., p. 68) asserts that the Salmacis from that station is *Belli*. Moreover it answers well to the published descriptions, save for the following details: — the globiferous pedicellariæ do not "agree exactly with" those of *bicolor* as Mortensen says but, are easily distinguishable (Pl. 93, figs. *33–36*); the coronal (interambulacral) plates are not essentially different in proportions from those of *sphæroides*, for they are scarcely five times as wide as high, while in one of our *sphæroides* they are more than five times as wide as high, instead of less, as usual. Whether the differences in color, tridentate pedicellariæ, actinal primaries, and gill-cuts really have any significance remains to be determined. So far as can be determined, the following species may be accepted and distinguished from each other thus: —

Vertical diameter of test exceeds one half horizontal; all oculars exsert; each ambulacral plate with a primary tubercle close to the poriferous area.
- Primary spines not banded, greenish or light colored at base, becoming reddish or purple distally (or for most of their length) but sometimes with light tips.
  - Coronal plates separated from each other by distinct sutures, the edges of which may be slightly bevelled . . . . *virgulata.*
  - Coronal plates separated from each other by deep horizontal furrows, the sides of which are more or less vertical . . . . *Alexandri.*
- Primary spines banded, usually conspicuously so.
  - Primary spines more or less bright red, especially abactinally, at least at base; small spines red . . . . *bicolor.*
  - Primary spines green at base, at least abactinally.
    - Primaries, distal to green base, not rose-red; valves of tridentate pedicellariæ very narrow; actinal primaries not specially widened at tip; gill-cuts deep . . . . *sphæroides.*
    - Primaries, distal to green base, rose-red; valves of tridentate pedicellariæ, broad; actinal primaries noticeably widened at tip; gill-cuts insignificant . . . . *Belli.*

Vertical diameter of test less than one half horizontal; ocular I insert or nearly so; only every other ambulacral plate (at least in mid-zone) with a primary tubercle close to the poriferous area.
- Primary spines white or greenish with 2 or 3 broad bands of purple or purplish red, or the dark color may predominate, the white disappearing and the bands becoming indistinct; secondary and miliary spines not at all vermilion-red . . *Dussumieri.*
- Primary spines green or greenish; actinal ones with 2 or 3 indefinite broad bands of purplish brown; secondaries and miliaries vermilion-red at base . . . . . . *erythracis.*

Temnotrema.

A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 358.
Type-species, *Temnotrema sculpta* A. Agassiz, 1863, l. c.
(= *Pleurechinus* A. Agassiz, 1872, and later writers; non *Pleurechinus* L. Agassiz, 1841, Int. Mon. Scut., p. 7.)

The genus Pleurechinus was established by L. Agassiz in 1841 (l. c.) and he definitely selected *Cidaris bothryoides* Leske as the type-species (1841, Int. Valentin's Anat. Genre Echinus, p. viii). In 1846 however he abandoned the generic name and placed *bothryoides* in Temnopleurus. Although he says his *Temnopleurus bothryoides* is equivalent to Leske's *Cidaris bothryoides*, it is clear that such is not the case for his diagnosis does not apply at all to the species figured by Klein and described by Leske. Fortunately Agassiz labelled as *bothryoides* a fine bare test in the Michelin collection in Paris, to which his diagnosis of *Temnopleurus bothryoides* does apply, and this was taken by A. Agassiz in the "Revision" and by later writers as the type-specimen of *Pleurechinus bothryoides*. In the "Revision" however, it is distinctly stated that this specimen is entirely different from *Cidaris bothryoides* Leske, which is perhaps a Microcyphus. Clearly then the Paris specimen cannot be the type of *Pleurechinus bothryoides*, which according to Agassiz in 1841, was nothing more nor less than Leske's species. What names then should be applied to the Paris specimen and to the genus to which it belongs? Since it is not labelled "*Cidaris bothryoides* Leske," there seems to be no reason why its name may not stand as *Temnopleurus bothryoides* Agassiz, but of course, it cannot be the type of Pleurechinus which is the entirely different *Cidaris bothryoides* Leske. Since this latter is with little doubt, quite unrecognizable (for even if it is a Microcyphus the species is not determinable with certainty), the name Pleurechinus must be abandoned, and the group which has borne it for so many years must take another. Fortunately such a name already exists, having been proposed in 1863 by A. Agassiz, for a small sea-urchin from Japan, *Temnotrema sculpta*. Later the specimen was believed to be a young *Temnopleurus Hardwickii* and in the "Revision" *Temnotrema sculpta* is placed in the synonymy of the Temnopleurus. The type-specimen of *Temnotrema sculpta* (Pl. 112, figs. *1*, *2*) is in the M. C. Z. collection and comparison with other Japanese material shows that it is identical with the species described by Mortensen (1904, Dan. Exp. Siam: Ech., p. 84) as *Pleurechinus variegatus*. As a specimen of *variegatus* was received from Dr. Mortensen himself, there can be no doubt of the identification.

The difference in the descriptions of the color of the spines, is probably of degree rather than of kind, but in the type of Temnotrema the spines are now missing or broken, so that it is impossible to speak positively on this point. Since *sculpta* (= Mortensen's *variegatus*) seems to be undoubtedly congeneric with Agassiz's *bothryoides,* it is clear that the generic name Temnotrema must replace Pleurechinus for this group of Temnopleuridæ, and *sculpta* becomes the type in place of *bothryoides.*

As the genus has been so recently (1904) and so fully revised by Mortensen, there is no need for a discussion of the species. Only four of the seven species he tabulates are at hand, but there appears to be no reason for questioning any of the others and his list with the addition of the new species found by the "Albatross" among the Hawaiian Islands, may be accepted. All of the species are found in the Indo-Pacific region, especially among the East Indian Islands; perhaps *sculpta* is confined to Japanese and Formosan waters, as *hawaiiensis* appears to be to the Hawaiian region. A specimen of *Döderleini* in the M. C. Z. collection from Fiji may be recorded here; this however is not surprising as it was already known from Samoa.

As Mortensen has made considerable use of the pedicellariæ in his table, and as their characters seem of very little importance and not altogether reliable, the following table, showing additional characters by which the eight species may be distinguished, is offered.

Buccal plates 10; anal plates not very numerous, a suranal usually evident.
- Pits large, the distance between the two of same horizontal interambulacral suture less than the length of one.
  - Anus central or nearly so; periproct without a conspicuous suranal; test high (v. d. may equal .75 h. d.) uniformly dark; primary spines light with 2–4 red bands; valves of globiferous pedicellariæ with a lateral tooth on each side near tip . . . . *bothryoides.*
  - Anus more or less excentric; suranal distinct; test not uniformly dark; valves of globiferous pedicellariæ without lateral teeth.
    - Test not very high, v. d. = .50–.60 h. d.; suranal plate very large, covering half or more of periproct.
      - Spines, at least secondaries, thorny, not swollen at tip; poriferous area ⅓ to ½ as wide as interporiferous; coronal plates conspicuously sculptured around primary tubercles . . . . *scillæ.*
      - Spines smooth; primaries often swollen at tip; poriferous area ¼ to ⅓ as wide as interporiferous; coronal plates little sculptured around primary tubercles . . . . *siamensis*
    - Test rather high, v. d. = 60–.70 h. d.; suranal plate moderate not covering half the periproct.
      - Genital plates marked by a transverse line which appears to divide the distal from the proximal part; tubercles on coronal plates in horizontal rows; no green in coloration . . . . *maculata.*

Genital plates not marked by a transverse line: tubercles on coronal plates not in horizontal rows; more or less green on test, or if green is lacking, test is bright red . . . . *hawaiiensis.*
Pits small, the distance between the two of same horizontal interambulacral suture greater (often much greater) than the length of one.
Ambulacral plates equal interambulacral in height and number; test variegated gray and whitish; spines reddish at base, often with a small dark band distally; genital plates marked with a transverse line . . . . *sculpta.*
Ambulacral plates lower and somewhat more numerous than interambulacral; test red; spines red with white bands; no transverse line on genital plates . . *ruber.*
Buccal plates only 5; anal plates very numerous, subequal, with no distinct suranal . . *Döderleini.*

Temnotrema hawaiiensis, comb. nov.

Pleurechinus hawaiiensis A. Agassiz and Clark, 1907. Bull M. C. Z., L, p. 244.

Plate 99, figs. *1–3.*

The specimens at hand of this pretty species range in horizontal diameter from 5 to 9 mm. The vertical diameter ranges from about two thirds to three fourths of the horizontal. The test is therefore quite high and it is well arched. The actinostome of the largest specimen is 4 mm. across, while the abactinal system is only 3 mm. The longest primary spines are only a little over 3 mm. long. There are 12 interambulacral plates in each column and the number of ambulacrals appears to be the same. In the mid-zone, the interambulacral plates carry at the centre a small primary tubercle, on each side of which is a distinct secondary, and on the upper half of the plate, in an irregular, curved series are 4–6 smaller secondaries. The pits are very large and occupy most of the lower half of each plate. Of course, the tubercles are fewer and the pits smaller as the ocular plate or the peristome is approached. In the ambulacra the number of tubercles on each plate is less and the pits are smaller. The pit at the outer corner of each plate is insignificant or wanting. The genital plates (Pl. 99, fig. *3*) are of moderate size, pentagonal, and a little elevated; there is a tubercle (rarely two) on the proximal margin, and the rather large genital pore is just distal to the centre of the plate. The madreporite is very inconspicuous as the pores are comparatively few. The oculars are small and completely exsert; each one carries a couple of very small tubercles. At the proximal end of each ocular is a more or less conspicuous pit. The periproct is covered by a small number of plates (4–10) among which the suranal is usually easily distinguishable. The anus is approximately central. The actinostomal membrane (Pl. 99, fig. *2*) is very thin and bare. The buccal plates are very small, and although the two of a pair are placed side by side, the pairs themselves are well separated from each other. Each plate carries a tube-foot. The spines are slender, rather blunt, and perfectly smooth. The small ones may end with a distinct central point, and some at least are slightly swollen at the tip.

The pedicellariæ are very much like those of *siamensis*. The *globiferous* are fairly common; the valves measure about .16 mm. in length. The *ophicephalous* are abundant and quite variable in size, the valves ranging from .13 to .19 mm. besides the loop. In the larger ones, the valves are relatively longer and have a more sinuate margin than Mortensen figures for *siamensis*. No tridentate pedicellariæ were found. The *triphyllous* seem to be rare and the valves are only .10 mm. in length. Neither spicules nor sphæridia were noted.

The color of the test is prevailingly green, with the abactinal interambulacra lighter and often pure white in striking contrast. The primary spines are whitish with more or less red. The tendency towards a bright red coloration is noticeable and two specimens are almost uniformly bright red, test as well as spines. Around the actinostome the test often becomes whitish, while abactinally it is frequently marked with purplish brown. While the color is thus very variable, there is no tendency to approach that of *siamensis*, except that each species has a bright red variety.

Although this species appears to be very near *siamensis*, comparison of specimens of the same size reveals some important differences. The primary spines are noticeably longer and more slender and are not banded, in *hawaiiensis*, while the test is relatively higher and the suranal is smaller. We do not find any trace of a membrane surrounding the pits, as Mortensen figures for *siamensis*. The characters by which *hawaiiensis* is distinguished from *maculata* are given in the table above. It seems probable that with a specimen of *maculata* at hand for comparison, other and weightier differences might be found, for with only the published description and figures of *maculata*, some important points may have been overlooked.

The "Albatross" took *hawaiiensis* at the following stations:—

Station 3823. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 69°. 78–222 fathoms. Fne. s., p.

Station 3847. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. ? 23–24 fathoms. S., st.

Station 3871. Off Mokuhooniki Islet, Auau Channel, H. I. Bott. temp. 74.6°? 13–43 fathoms. Fne. wh. s.

Station 3872. Off Mokuhooniki Islet, Auau Channel, H. I. Bott. temp. 74.6°. 32–43 fathoms. Yl. s., p., co.

Station 3876. Off Lahaina Light, Maui, H. I. Bott. temp. 74°. 28–43 fathoms. S., g.

Station 3962. Off Laysan Island, H. I. Bott. temp. ? 16 fathoms. Wh. s., co.

Station 3978. Off Modu Manu (Bird Island), H. I. Bott. temp. ? 32–46 fathoms. Co. s., for., r.

Station 4148. Off Modu Manu (Bird Island), H. I. Bott. temp. 77.9°. 26–33 fathoms. Co. s., for.

Station 4150. Off Modu Manu (Bird Island), H. I. Bott. temp. 74°. 71–160 fathoms. Co.

Bathymetrical range, 13–222 fathoms. Extremes of temperature, 77.9°–69°.

Sixteen specimens.

Temnotrema sculpta A. Ag.

Temnotrema sculpta A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 358.
Pleurechinus variegatus Mortensen, 1904. Dan. Exp. Siam: Ech., p. 84; Pl. 1, figs. *5*, *6*, *8*, *19*; Pl. 2, fig. *6*.

Plate 112, figs. *1*, *2*.

The "Albatross" specimens range from 6 to 10 mm. in diameter, and are thus smaller than the type of *sculpta* which is 11 mm., but the latter is smaller than Mortensen's specimens which ranged from 11.5 to 17 mm. The "Albatross" specimens have scarcely a trace of red on the primaries but are not otherwise peculiar. Examination of the periproct in the specimens examined shows that the description in the original diagnosis of Temnotrema is misleading. The suranal plate is prominent and there may be two, or even three, other large plates, but there is no close resemblance to the quartet of equal plates seen in Arbacia.

This species was taken by the "Albatross" at the following stations:—

Station 4893. Southwest of Goto Islands, Japan; 32° 32′ N., 128° 32′ 50″ E. Bott. temp. 55.9°. 95–106 fathoms. Gy. s., brk. sh., p.

Station 4895. Southwest of Goto Islands, Japan; 32° 33′ 10″ N., 128° 32′ 10″ E. Bott. temp. ? 95 fathoms. Gn. s., brk. sh., p.

Station 5095. Off Gulf of Tokyo, Japan; 35° 5′ 34″ N., 139° 38′ 36″ E. Bott. temp. 57.8°. 58 fathoms. Fne. bk. s., brk. sh.

Bathymetrical range, 58–106 fathoms. Extremes of temperature, 57.8°–55.9°.

Three specimens.

Mespilia.

Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 357.
Type-species *Echinus globulus* Linné, 1758. Syst. Nat., ed. 10, p. 664.

Little need be said of this well-known genus, which still contains only the species on which it was based. It is true Yoshiwara (1897, Ann. Zoöl. Jap., I, p. 58) has described a second species but his description applies perfectly well to *globulus* except that he says the spines are "longitudinally striated with orange stripes and tipped with white." As he doubtless means transversely banded with orange, his name becomes a simple synonym of *globulus*.[1] Some Samoan specimens have the bare spaces on the test densely covered with globiferous pedicellariæ but this condition seems to be unusual. In the M. C. Z. collection are a number of specimens from Samoa, Fiji, the Caroline Islands, and the Philippines, which differ strikingly from the ordinary *globulus* in the complete absence of red from both test and spines. The primary spines are green banded with blackish or with blackish and whitish. The largest specimen is 47 mm. h. d. Though this form is not entitled to specific rank it is suggested that it be known as *Mespilia globulus* variety *pellocrica* (πελλός = *dark-colored* + κρίκος = *a circle*). It is certainly not a geographical form, for typical *globulus* occur in the same localities, with specimens of var. *pellocrica*.

Microcyphus.

Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 358.
Type-species, *Microcyphus maculatus* Agassiz and Desor, 1846, l. c.

Since Agassiz's references to this genus in 1841 are absolute *nomina nuda* for both genus and species, the names cannot date back earlier than 1846. No type has been definitely given the genus since it was first published, but there appears to be no objection to adopting *maculatus*, the first species mentioned by Agassiz. Mortensen (1904, Dan. Exp. Siam: Ech.) has added two species to the genus as known to Agassiz, but no other additions have been made.[2]

[1] Examination of Yoshiwara's type-specimen shows this conclusion to be correct.

[2] Unfortunately Mortensen selected *elegans* as the name of one of his species, overlooking the fact that a *Microcyphus elegans* (= *Temnopleurus hardwickii* juv.) was described by A. Agassiz in 1863. In place of *elegans*, I would propose for Dr. Mortensen's species, the Greek equivalent (κομψός), *compsus*.

These two species are from southeastern Australia, the home of *M. zigzag*, while *maculatus* ranges from Mauritius, where it appears to be common, to Japan and Samoa. It is a curious fact that adults of *maculatus* seem to be rare. Of three hundred and forty-three specimens in the M. C. Z. collection, three hundred and forty are less than 16 mm. h. d., one is 16 mm., one is 26.5 mm. and one is 30 mm. The two last are simply bare tests; the larger is the one figured in the "Revision." So far as can be judged these large ones are not different from the small ones except in such points as would be involved in their larger size. In coloring, tuberculation, and pitting of the test, *maculatus* appears to be very variable, but the coloring of the spines is fairly constant. For this reason, it cannot be doubted that the species mentioned by Mortensen, from Tor, on the Red Sea, is perfectly distinct, and may be called *cricacanthus* (*κρίκος = a circle + ἄκανθα = a thorn, spine*). It is unlikely it will prove to be *Rousseaui*, as the latter is most probably the adult of *maculatus*. As for *Anthechinus roseus* A. Ag., a reëxamination of the type-specimen, now in the M. C. Z. collection, leaves no room for question that it is *maculatus*. The test of young *maculatus* is usually somewhat greenish or yellowish, with the bare abactinal spaces, ranging from almost white to pure deep rose-color. Of the large specimens, one has the bare spaces dull rose and the other very dark gray. Among our three hundred and forty small specimens, no less than four are more or less perfectly tetramerous.

The five species of Microcyphus may be distinguished as follows: —

Test low, vertical diameter .50–.70 h. d.; interambulacral plates few, 6–10 in each column; ambulacral plates nearly or quite twice as numerous; poriferous areas broad; pore-pairs distinctly biserial actinally in large specimens, the inner series, of pore-pairs only, the outer, of pore-pairs alternating with small tubercles.

- Spines green, sometimes with light tips, and rarely with one or two distal bands . *maculatus.*
- Spines red-brown, banded with 2–4 lighter rings . . . . *cricacanthus.*

Test high, vertical diameter .75–.90 h. d.; interambulacral plates 10–18 in each column; ambulacrals only a little more numerous; poriferous areas narrow, without tubercles and not biserial actinally.

- Spines light, greenish at base, white at tip, broadly encircled by a band of red; bare interambulacral spaces broad and very light colored . . . . *annulatus.*
- Spines not banded.
  - Bare interambulacral spaces narrow and dark colored (yellowish brown in young, almost black in adults); spines deep red . . . . *zigzag.*
  - Bare interambulacral spaces narrow, rose-red; spines pale reddish . . . . *compsus*

Salmacopsis.

Döderlein, 1885. Arch. f. Naturg., Jahrg. LI, 1, p. 93.
Type-species, *Salmacopsis olivacea* Döderlein, 1885, l. c.

Little need be said regarding this genus, which appears to be well marked and characteristic of the Japanese fauna. Examination of the type-specimens of Yoshiwara's species "*pulchellimus*" shows that that species is based wholly upon specimens of *Mespilia globulus*. One of the specimens is peculiar in that the spines are almost uniformly green and the outer series of pore-pairs, usually conspicuous in Mespilia and in this specimen present at the ambitus, disappears entirely abactinally so that most of the younger ambulacral plates are made up of only two elements. Since Yoshiwara's species has no standing the genus remains as it was when established, monotypic.

Salmacopsis olivacea Död.

Salmacopsis olivacea Döderlein, 1885. Arch. f. Naturg., Jahrg. LI, 1, p. 93.

Plates 103, figs. *6*, *7*; 112, figs. *3*, *4*.

The specimens at hand range from 19 to 26.5 mm. in diameter and are thus somewhat larger than Döderlein's. They are also somewhat greener in color, though none of them is conspicuously green, even on the bare interambulacral areas. As the species has never been figured, photographs, as well as drawings of the abactinal and actinal (in part) systems are given.

The "Albatross" took this handsome species at the following stations: —

Station 3708. Off Ose Zaki, Honshu Island, Japan. Bott. temp.? 60–70 fathoms. Gn. m., vol. s., a.

Station 4894. Southwest of Goto Islands, Japan; 32° 33′ N., 128° 32′ 10″ E. Bott. temp.? 95 fathoms. Gn. s., brk. sh., p.

Station 4937. In Kagoshima Gulf, Japan; 31° 13′ N., 130° 43′ 10″ E. Bott. temp. 64.8°. 58 fathoms. M., lav., p.

Bathymetrical range, 58–95 fathoms.

Seven specimens.

Amblypneustes.

L. Agassiz, 1841. Int. Mon. Scut., p. 7.
Type-species, *Echinus griseus* Blainville, 1825. Dict. Sci. Nat., XXXVII, p. 81.

In the present state of our knowledge, this is one of the most perplexing genera of recent Echini. The species have always been in confusion, and in spite of Mortensen's excellent work (1904, Dan. Exp. Siam: Ech.), there is still great difficulty in identifying specimens and in determining specific limits. The difficulty has arisen largely from the facts that no trained echinologist has been able to examine these Echini in life, and practically all Museum material has consisted of bare tests, which show great individual diversity in color and proportions. It is only within recent years that our Museums have obtained material with the spines on and even now such material is not common. Mortensen's view that no reliance can be placed on the identifications of Amblypneustes hitherto is wholly justified and while his work, combined with the results here published, will not make identifications perfectly reliable, they will, it is hoped, increase the possibility of distinguishing the various species. It seems certain however that the truth in regard to the species of Amblypneustes can only be known, when some zoölogist in Australia carefully determines the valid species and the limits of individual diversity. This work must be done in southeastern Australia and Tasmania, which is the principal, if not the exclusive home of the genus. I have seen no authenticated specimens from elsewhere and although Amblypneustes has been recorded from the Cape of Good Hope, from the Fiji, and Santa Cruz Islands, from New Caledonia and New Zealand, and from western Australia, all these records need confirmation. There is no doubt that the Cape of Good Hope record is wrong, and that the western Australian record is correct, but there is great doubt as to the others. It is a curious fact that although two species (not to mention Studer's *grossularia*) have long been listed from New Zealand, the zoölogists of the present day there, apparently do not know the genus at first hand. In none of the valuable papers on New Zealand echinoderms by Farquhar or Benham, is there any new information regarding the occurrence of Amblypneustes in New Zealand.

So far as can be judged from Mortensen's key and from the material in the M. C. Z. collection there are probably half a dozen valid species of Amblypneustes; of the eight recognized in the table below, at least two seem very dubious. It is more than possible that *ovum* and *griseus* are identical, for although typical examples of each are obviously different, specimens that might with almost equal propriety, go in either one species or the other, are in the series studied. As Mortensen has pointed out, the name "*Amblypneustes ovum*" has been used very carelessly. It is borne on the original labels of more than two thirds of our specimens of Holopneustes! But typical examples of the true *ovum* are easily determined. The status of *grossularia* is troublesome but it is included in our table in accordance with the information given by Studer and Mortensen. The latter seems to think it may not be an Amblypneustes at all and this seems quite probable, but facts in support of the belief are wanting. It is very difficult to find tangible characters to distinguish it even as a species and we are obliged to rely upon the peculiarities of the pedicellariæ, as given by Mortensen, though unable to find in them constant characters. It is unfortunate that Mortensen does not include *grossularia* in his key to the species of Amblypneustes, so that its really diagnostic features might be made clear. The M. C. Z. specimens of *formosus* and *pallidus* appear to agree with those in the Copenhagen Museum.

In addition to the species already known, there are three others in the M. C. Z. collection which appear to be undescribed, so that eight species are distinguished in the following manner: —

Ambulacra narrower than interambulacra; pore-pairs in distinct arcs of three.
- Spines red; coronal plates handsomely marked in median interambulacral area with a broad zigzag, furrowed band, lighter colored than the lozenge-shaped areas which separate its outer angles; poriferous areas usually light-colored . . . . *formosus.*
- Spines not red; coronal plates not marked as above.
  - Interambulacral plates high and few (18 in a specimen 20 mm. h. d.); secondary and miliary spines and tubercles very few; valves of ophicephalus pedicellariæ constricted near middle; those of triphyllous expanded at tip . . *grossularia.*
  - Interambulacral plates numerous (more than 20 in specimens 20 mm. h. d.); secondary and miliary spines and tubercles more or less abundant; valves of ophicephalous pedicellariæ not specially constricted nor those of triphyllous expanded at tip.
    - Vertical diameter more than .90 of horizontal; test usually ovoid and little flattened actinally.
      - No secondary tubercles on interambulacral area between the two vertical series of primaries but the area is crossed by a zigzag line of miliary tubercles which connect the primary tubercles of opposite sides; primary spines green, secondaries pale purple . . . *pallidus.*
      - Secondary tubercles common on interambulacra; no zigzag line of miliaries at all obvious . . . . *ovum.*
    - Vertical diameter less than .90 of horizontal; test sphæroidal or depressed, more or less flattened actinally.
      - Poriferous areas rather wide, the two together forming nearly or quite half the ambulacrum.

Ambulacral plates not very numerous (31 or 32 in specimens 34 mm. in diameter) about 30–50 % more numerous than interambulacral; primary tubercles very small, those of ambulacra near ambitus occupying about one half the height of plate and those of interambulacra occupying about one third the height of plate . . . . *griseus.*

Ambulacral plates numerous (40–43 in specimens 34 mm. h. d.) about 50–70% more numerous than interambulacral; primary tubercles large, those of ambulacra occupying almost the entire height of plate, especially actinally, where they form a rather crowded vertical series; those of interambulacra occupy about one half the height of plate . . . . *pachistus.*

Poriferous areas narrow, the two together forming only one third of ambulacrum; vertical diameter .65–.75 of horizontal; tuberculation relatively coarse; test and primaries pale brown . . *grandis.*

Ambulacra broader than interambulacra; pore-pairs in three very distinct vertical series . . . . *triseriatus.*

Amblypneustes pachistus,[1] sp. nov.

Plates 104, fig. *6;* 112, figs. *10–11;* 121, figs. *1–3.*

There are in the M. C. Z. collection eleven specimens of Amblypneustes which are easily distinguished from *griseus* and *ovum* by their much stouter tests and coarser tuberculation. While it is possible that they are only a form of *griseus*, they are so easily distinguishable, it seems better to give them a name, and describe and figure them. The largest (Pl. 112, figs. *10, 11*) is 48 mm. in diameter and 34 mm. high. The actinostome is 15 mm. across, while the abactinal system is only two thirds as much. There are about 34 interambulacral and 54 ambulacral plates in each column. The spines are practically wanting. A somewhat smaller specimen is 30 mm. in diameter and 25 mm. high, and has the actinostome 11 mm. across. There are 25 interambulacral plates in each column and no less that 39 ambulacrals. The spines are present, in some numbers, and the largest primaries, just below the ambitus, are 4 mm. long. In a specimen 21 mm. h. d., there are 22 interambulacral plates, and more than 40 ambulacrals, in each column.

The test is well arched and rather high, the vertical diameter ranging from .70 to .80 of the horizontal. The coronal plates are all low and wide. At the ambitus, each interambulacral plate carries a primary tubercle, somewhat nearer the ambulacral than the median suture. On the inner side of this tubercle

[1] πάχιστος = very coarse or stout.

and on the same horizontal line are three or four secondaries, while on the ambulacral side are a pair or two pairs of similar tubercles. One or more of these secondaries are nearly or quite as large as the primary and none are very small, but each plate also carries about twenty miliaries. The areola of the primary tubercle occupies one half or more of the height of the plate. In the ambulacra, each plate has a primary tubercle close to the poriferous area, two secondaries little smaller on the inner half, and six to eight miliaries, of which two are in the poriferous area. The areola of the primary occupies nearly or quite the full height of the plate, particularly below the ambitus, but in large specimens even far above it. The ambulacra are .80–.90 of the interambulacra, in width at the ambitus, while each poriferous area is about .45 of the interporiferous. The genital plates are of moderate size, approximately equal, with the pores in the distal ends; the pores are often so large as to encroach on the coronal plates, cutting clear through the margin of the genital. The oculars are small and all are broadly exsert. The periproct is relatively rather large and is covered with numerous small plates. The entire abactinal system is completely covered with small tubercles. The actinostomal membrane is thin and bare, as usual in the family. The buccal plates are small, and though the two of a pair are near together, the pairs are widely separated. The spines are as usual short and rather stout. The primaries taper slightly or not at all and are truncate at the tip; many of the secondaries are distinctly swollen distally. The pedicellariæ and spicules show nothing of interest.

Although this species is similar to *griseus* in the form of the test, the much stouter and coarser appearance distinguish it easily. The coloration appears to be different also. The bare tests of the largest specimens are yellowish, the poriferous areas lighter than elsewhere. The three smallest specimens are dull gray rather than yellow and in one specimen a very evident greenish tinge is present actinally. The finest specimens, about 35 mm. in diameter (Pl. 121, figs. *1–3* is the type) collected at Westernport, Victoria, March, 1911, have the test very light, almost cream-color; the tube-feet and all the small spines are of about the same shade, but the primaries are deep greenish brown in striking contrast. There are two other specimens with some spines; in one, these are dull purple becoming light at the tip especially around the mouth where the distal half is almost white; in the other, the spines are very pale, almost white, but with a more or less evident purple tinge, especially near base. It is hard to decide whether this diversity in color is characteristic of the species or whether we have several different species included under the name *pachistus*.

So far as can be determined this is the species figured by Valenciennes on Plate 2 of the Zoophytes of the "Voyage of the Venus," as *Echinus* (*Amblypneustes*) *pallidus*. As Mortensen has pointed out that figure is certainly not *pallidus*, as that species is now understood.

Excepting those recently collected at Westernport, Victoria, not one of our specimens has a reliable locality label. These were purchased in Europe in 1870; five are labelled "New Zealand," two are labelled "Australia" and one has no label. It is rather remarkable that other specimens of this species have not been included among the many specimens of Amblypneustes and "Holopneustes" received during the past few years at the M. C. Z. from New South Wales and Victoria. It is apparently much less common at Westernport than *griseus*, of which we received a good series, showing practically no diversity in form or color.

Amblypneustes grandis,[1] sp. nov.

Plate 121, figs. *4–6*.

This is the largest species yet known, the type specimen having a horizontal diameter of 70 mm. It is 49 mm. high, with the actinostome 18 mm. in diameter and the abactinal system 13 mm. across. There are 33 interambulacral and 50 ambulacral plates in each column. The interambulacra are 26 mm. wide at the ambitus. The ambulacra are 17 mm. wide but of this the two poriferous zones together only occupy 6 mm. The pores are rather large and the arcs of pores are quite oblique especially abactinally. The tuberculation of the test is rather coarse for an Amblypneustes and it is virtually impossible to distinguish between the primary and secondary tubercles. Each interambulacral plate carries a horizontal series of these larger tubercles; on most of the plates, the series bifurcates so that on the outer (adradial) half of the plate there are two series, the whole group forming a narrow, elongated Y lying horizontally on the plate; the stem of the Y contains 6 or 7 tubercles while each of the branches consists of about 4. Besides these larger tubercles, there are some forty miliaries scattered about all over the plate. Each ambulacral plate has a horizontal series of four or five large tubercles, of which the innermost is smallest while the one adjoining the poriferous zone is largest, its areola occupying about one half the height of the plate; there are also a dozen or more miliaries on each plate; of these two are placed side by side just above the largest tubercle, but their

[1] *grandis* = large and fine.

distance from each other is variable. The whole abactinal system is covered by numerous tubercles of which four or five on the proximal margin of each genital are large secondaries. The genital pores are large and occupy the distal tips of the genital plates; the oculars are small and are all broadly exsert. The buccal membrane is of course thin and perfectly bare; the buccal plates are very small and not only are the pairs well separated from each other but the two plates of a pair are some distance apart. The primary spines are 7 or 8 mm. long; they taper little to the truncate tip, which usually has a conspicuous (under the lens) central thorn. Though some of the small secondaries are a little thickened at the tip, none of the spines are noticeably club-shaped. Pedicellariæ are exceedingly abundant all over the test.

The general color of the test is brown, darkest on the interambulacra where there is a distinct purple shade; the ambulacra are more greenish. In both areas there is a distinct band of a light color, 2 or 3 mm. wide, along the median vertical suture line, but these bands disappear actinally. The poriferous areas, with the adjoining margins of the interambulacral plates, are somewhat lighter than the remainder of the test. The small spines are almost white but the larger spines are pale brown, though actinally they are tipped with lighter, and around the mouth they are nearly white for their distal half. There is little indication of either green or violet in the coloration but along the abactinal portions of the poriferous areas, there are traces of dull rose-red.

A second specimen measures 43 mm. in horizontal diameter and is 31 mm. high. There are 30 interambulacral and 45 ambulacral plates in each column. The interambulacra are 16 mm. wide and the ambulacra, 11; the poriferous areas are each scarcely 2 mm. wide. The tuberculation of the test differs from that of the type only as might be expected from the difference in size; there are not so many large tubercles and the horizontal Ys on the interambulacral plates are much less regular and noticeable; the pair of miliary tubercles above the largest ambulacral primary (the one next the poriferous area) are very regular in position and form a noticeable feature of the ambulacra. The coloration is similar to that of the type but the median light colored bands in each area are less distinct, and the dull rose shade on the poriferous areas is more marked and is evident on all the abactinal coronal plates; it tends to form a more or less distinct pattern on the interambulacra. The large spines are all much lighter than in the type, but they are a little more brownish than the miliaries.

These two specimens were collected by Mr. J. Gabriel, in March, 1911, at Westernport, Victoria, in 2–5 fathoms. The coloration and form of the test distinguish them at a glance from *griseus*, while they are equally different from the specimens of *pachistus* which came with them. The very narrow poriferous areas, the peculiarities of the tuberculation and the color combine to make them representatives of an undescribed species. Among the specimens in the M. C. Z. collection, received from the "Challenger" material as *A. formosus* and taken in Bass Strait, 38–40 fms., are two which seem to be the young of *grandis*. One is 22 mm. in diameter and except for the fact that it is much lighter colored and has the dull rose markings more distinctly indicated, it resembles the larger specimens quite closely; the pair of miliaries above each of the outer ambulacral primaries is noticeable; the primary spines are white, but of course they may have become bleached with the passing of forty years. The other specimen is only 16 mm. in diameter and is quite possibly not *grandis*; the narrow poriferous areas and the tuberculation of the ambulacra are characteristic but the coloration is peculiar, for the test has a dull greenish cast and the large spines are bright green with white tips.

Amblypneustes triseriatus,[1] sp. nov.

Plates 104, fig. *5;* 112, fig. *5*.

The specimen upon which this new species is based is a bare test without actinostomal membrane or abactinal system, but so unique in the characters it shows that it is without doubt specifically distinct from any described Amblypneustes. This test is 30 mm. in diameter and 26 mm. high, with the actinostome 11 mm. in diameter and the abactinal system (wanting) 6.5 mm. across. There are 28 interambulacral, and 43 ambulacral plates in each column. The ambulacra (Pl. 104, fig. *5*) are 9.5 mm. wide at the ambitus, while the interambulacra are scarcely 9, so that the former are obviously the wider. The two poriferous areas together are about equal in width to the interporiferous space. The pores are small and the pore-pairs are so uniformly arranged and the arcs are so nearly horizontal that each poriferous area shows three distinct vertical series of pore-pairs. Corresponding to these but much more irregular and imperfect are three vertical series of miliary tubercles. Of these tubercles those just within and below the middle pair of pores are the largest. Each interambulacral plate at the ambitus bears a primary tubercle, a little outside of the centre, the areola of which occupies scarcely one half the height of the plate. On the outer end of the plate is a secondary tubercle (or often there are two) and on the inner half,

[1] *triseriatus* = in three series.

there are two (or often only one), and one (or more) of these secondaries is almost, if not quite, as large as the primary. On each of these plates there are also 15–20 miliaries, of diverse sizes but all small. On each ambulacral plate, there is a primary tubercle close to the poriferous area and on the inner half of the plate, there may be a second tubercle nearly as large. These inner tubercles are of somewhat variable size and are altogether wanting on many plates. Besides the miliaries in the poriferous area, already described, each plate carries five or six more on its inner half, irregularly scattered but chiefly near the margins. The areola of the primary tubercle occupies practically the whole height of the plate, so that this series of tubercles bordering the poriferous area is very similar to that of *pachistus*.

The color of the test is grayish olive, becoming lighter actinally so that around the actinostome it is nearly cream color. The poriferous areas are distinctly lighter than the spaces between them. The larger tubercles are all white. Under a lens, the coronal plates at least on the inner half are seen to be variegated with a lighter shade, and in the median interambulacral areas these lighter lines tend to form figures similar to those seen in *formosus*. The medial vertical suture in both areas is indicated by a lighter line and the pits at the angles of the plates, along this line, though very small, are still visible.

This specimen was received into the M. C. Z. collection from Louis Agassiz, in 1859. It bore no other label than "Australia," but was marked by A. Agassiz "Nov. gen." No description of it has ever been published, as it has been hoped that additional specimens might come into the collection. The hope has been in vain however and attention is now called to this noteworthy species. While it appears to be allied to *formosus*, as nearly as to any species of the genus, the appearance of the ambulacra, when the specimens are placed side by side, is strikingly different in the two.

Holopneustes.

Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 364.
Type-species, *Holopneustes porosissimus* Agassiz and Desor, 1846, l. c.

There can be no question that if the law of priority is to be rigidly enforced, this genus is without a name while the equally well-known Mespilia becomes Holopneustes. To prevent such a disaster it is preferable to ignore the first suggestion of Holopneustes by Agassiz in 1841, when he mistook one of Leske's species and selected it as the type, and date the genus from the time of its first real description. This is justified because it is clear that Agassiz intended, when he suggested the name in 1841, that Holopneustes should be the name of these Echini with highly specialized ambulacra; this is unmistakable from his accompanying remarks. It is not reasonable that his intent should be nullified by a mistake in identifying one of Leske's inadequately described, and poorly figured species, especially when that mistake was rectified at the first opportunity.

The simple method suggested by Mortensen (1904, Dan. Exp. Siam: Ech., p. 102) for distinguishing Holopneustes from Amblypneustes by means of the arrangement of the ambulacral tubercles, works very well and is a great convenience in distinguishing specimens of the two genera, when confused in the same lot, as they commonly are!

Three species of Holopneustes have usually been recognized but Mortensen has suggested that *inflatus* and *purpurascens* may be identical, and this is the case, as the material now at hand shows that the characters, supposed to be specific, are not constant. Mortensen (1904, Dan. Exp. Siam: Ech.) writes both *inflatus* and *purpurascens* with Lütken as the authority, and states that the types are in Copenhagen. While it is true that the names were *suggested* by Lütken, they were *published* by A. Agassiz and so far as we know were not even used by Lütken in print. It is hard to see therefore why they should be credited to Lütken. Dr. Mortensen is however consistent in this, for he quotes several of Agassiz and Desor's species, as from Valenciennes, although they were simply manuscript names of the latter, on museum labels. As for the location of the types, it is a question which cannot be settled, for Mr. Agassiz never definitely designated type-specimens. But there are specimens in the M. C. Z. collection, on which the descriptions and figures published were based, and these, by some at least, would be considered the type-specimens. In uniting the two species, the name *inflatus* is retained because it has "page-precedence" in publication, because it is shorter, and because *purpurascens* is often inappropriate.

More than half the specimens of Holopneustes at hand seem to be neither *porosissimus* nor *inflatus*, and a third species, *pycnotylus* is therefore described. The three species are all from southeastern Australia and Tasmania and are not even reported from elsewhere.

They may be distinguished as follows: —

Interambulacral plates fairly numerous (22–25 in specimens 22 mm. h. d., about 46 in specimens, 48 mm. h. d.), their tubercles small; areolæ of primaries only occupying about half height of plate, and forming a well-spaced vertical series on each side of interambulacrum.

Ambulacra decidedly wider than interambulacra; primary spines greenish, more or less extensively tipped with red . . . . *porosissimus.*
Ambulacra not appreciably wider than interambulacra and usually distinctly narrower; primary spines vary from very pale brown to reddish purple . . . *inflatus.*
Interambulacral plates very numerous (30 in specimens 22 mm. h. d., 40–50 in specimens over 36 mm. h. d.), their tubercles large, areolæ of primaries occupying nearly whole height of plate and hence forming more or less crowded vertical series on each side of interambulacrum; primary spines whitish or cream color, or pale purplish or greenish, often tipped with lighter or darker; ambulacra in adults usually distinctly wider than interambulacra . . . . *pycnotylus.*

Holopneustes pycnotylus,[1] sp. nov.

Plates 104, fig. *4;* 112, figs. *6–9.*

The form of the test in this species shows great individual diversity, apparently not associated with age. The type (Pl. 112, fig. *6*) is not quite 36 mm. in diameter, and is 32 mm. high, the height thus equalling .90 h. d.; the ambitus is circular. Another specimen (Pl. 112, figs. *8*, *9*) also with a circular ambitus, is 33 mm. in diameter and only 25 mm. high; the height is thus only about .75 h. d. A specimen 23 mm. in diameter is 19 mm. high (v. d. = .83 h. d.) while another almost as large is only 16 mm. high (v. d. = .71 h. d.). A specimen (Pl. 112, fig. *7*) 34 mm. in diameter and 30 mm. high has the ambitus very distinctly pentagonal. In a specimen 19 mm. h. d., there are 26 interambulacral and 49 ambulacral plates in each column; in another, 23 mm. h. d., the numbers are 30 and 55 respectively; in another, 33 mm. h. d., 45 and 88; in another, 34 mm. h. d. (pentagonal) 37 and 76; in the type, 36 mm. h. d., 38 and 90; and in another, 37 mm. h. d., 52 and 113. The relative width of ambulacra and interambulacra shows some diversity also. Thus the same six specimens give the following measurements, the ambulacral width being given first:— 6 and 6, 7 and 6.5; 11 and 8; 10 and 10; 11.5 and 10; 12 and 10. The ambulacra are thus on the average about 15% wider than the interambulacra. The abactinal system and actinostome are small, the latter averaging about .30 h. d., while the abactinal system is only half as large. The poriferous areas (Pl. 104, fig. *4*) are wide, each one at least half as wide as the interporiferous area, and in adults the proportion rises to three fourths or even four fifths. The arrangement of the pores and tubercles is as usual in the genus; there is a more or less perfect vertical series of pore-pairs on each margin of the poriferous area and between these are numer-

[1] πυκνός = crowded + τύλος = a tubercle.

ous scattered pore-pairs. Most of the ambulacral plates carry primary tubercles, but in scarcely a third of them is this tubercle adjoining the poriferous area. The plates are very unequally developed and some are much higher than others. The areolæ of the primary tubercles nearly or quite equal the height of the plates. Each plate has about four secondary tubercles, at least one of which is nearly or quite as large as the primary, and two are usually very small and are located in the poriferous area. In the type, miliary tubercles appear to be wanting but in other specimens, they are fairly numerous. Each interambulacral plate at the ambitus carries a primary and 5–8 secondaries. The primaries are a little nearer the outer than the inner end of the plates and form a regular vertical series. In typical cases, with low plates, this series is crowded, the areolæ occupying the full height of the plates, but in the type and some other specimens the plates are higher and the tubercles more separated. One or more of the secondaries is nearly or quite as large as the primary and sometimes the row of primaries is thus made to appear double for part of its length. The madreporic genital is conspicuously larger than the others. The oculars are small and fully exsert. Both genitals and oculars are well covered with tubercles, but the numerous periproctal plates carry none. The actinostomal membrane is very thin and perfectly naked. The buccal plates are very small and placed quite near the mouth.

The primary spines of the type are about 4 mm. long, rather stout and bluntly pointed. Most of them taper slightly to the tip, but many are distinctly swollen there. The secondaries are much more slender than the primaries but some are about as long. Many of them are swollen at the tip. Pedicellariæ are very numerous but excepting some of the ophicephalous, which have valves over half a millimeter long, they are all very small. Otherwise neither they nor the spicules afford any characters of interest.

The type is uniformly dirty cream color, spines and all, but most of the other specimens are gray with more or less of a purple, or a red, or a yellow tinge, and their spines show the same shades to a greater or less degree.

Most of the specimens of *pycnotylus* have been received from Port Jackson, New South Wales, labelled "*Amblypneustes ovum.*" One label further says: "Coastal beaches outside; after gales only," but other specimens do not have this limiting phrase on the label.

Goniopneustes.

Duncan, 1889. Journ. Linn. Soc. London. Zool., XXIII, p. 113.
Type-species, *Amblypneustes pentagonus* A. Agassiz, 1872. Bull. M. C. Z., III, p. 56.

There can be no doubt that Duncan was quite right in instituting a new genus for the remarkable and apparently very rare sea-urchin, which A. Agassiz described in 1872 as an Amblypneustes from Mauritius. The abactinal system with oculars I and V fully insert, the high coronal plates, the presence of scattered plates on the buccal membrane, the scarcity of spines and the large size of the primaries combine to make the genus unusually well characterized. The type and only known species was based on a single specimen, in the M. C. Z. collection, and figured in the Revision. (Since the text states correctly the measurements of the specimen as 22 × 21.5 mm. while the figures on Pl. VIII^{c} measure 32 × 30 mm., it is evident that the "explanation of the plate" is erroneous in saying the figures are natural size.) The locality, whence this specimen came, is very doubtful. It was purchased in Hamburg in 1870 and bears the label "Brandt. Hamburg." It is entered in the M. C. Z. catalogue as from "Ile de France?" So far as known, no other specimens are to be found in museums, and neither Pike nor Möbius, nor Robillard in their extensive collecting at Mauritius ever met with this remarkable echinoid. It is most probable that the specimen came from Australia.

Goniopneustes pentagonus Duncan.

Amblypneustes pentagonus A. Agassiz, 1872. Bull. M. C. Z., III, p. 56.
Goniopneustes pentagonus Duncan, 1889. Journ. Linn. Soc. London. Zool., XXIII, p. 113.

Plate 93, figs. *18–21*.

In addition to the characters given in the "Revision," the following points may be mentioned. There are 18 interambulacral plates in each column and each one bears a single, conspicuous, imperforate, non-crenulated tubercle. There are also on each plate a few (6 in the mid-zone) well-spaced secondaries, and some very minute and widely scattered miliaries; the latter bear pedicellariæ but not spines. There are 43 ambulacral plates in each column but not more than 12–15 carry primary tubercles; at the ambitus and below, every other plate has a primary but above the ambitus, there are very few indeed. There are rarely more than two well-developed secondary tubercles on each ambulacral plate, but there are quite a number of very small ones, in addition, in the poriferous area. The arcs of pores are very oblique and are not at all crowded. The pits at the angles of the plates are fairly distinct but are exceedingly small in both ambulacral and interambulacral areas.

The periproct is covered by about 30 small plates, no one of which is noticeably larger than the others. Oculars I and V are broadly insert but the others are completely shut out. The ocular pores are large and placed near the centre of the plate, but curiously enough no genital pores are to be seen, even with a lens. Each genital plate carries a single secondary tubercle and smaller ones are to be found on oculars I, III and IV. There are also rather numerous miliary tubercles on oculars, genitals, and periproctal plates. The buccal membrane is rather thick, thicker at least than in Amblypneustes, and, surprising to find, carries numerous small, scattered plates which are rather crowded around the mouth. The buccal plates themselves are rather large and carry large tube-feet; the two of each pair are near together but the pairs are well separated from each other. The buccal plates and the scattered plates distal to them carry pedicellariæ. The gill-cuts are deeper and more conspicuous than in Amblypneustes.

The primary spines are about 6 mm. long, in the mid-zone; they are very finely striated and taper to a blunt point. The secondaries are shorter and more slender and many appear to be pointed, though some are slightly swollen near the tip. Pedicellariæ are very common, but no *tridentate* could be found. The others remind one at once of Gymnechinus. The *globiferous* have valves (Pl. 93, fig. *19*) about .30 mm. in length, with a long end tooth (Pl. 93, fig. *20*) but no lateral teeth. The *ophicephalous* are larger, having valves (Pl. 93, fig. *18*) about .40 mm. long, but they show no distinctive characteristics. The *triphyllous* are very small, having valves (Pl. 93, fig. *21*) only .12 mm. long. The calcareous spicules in the tube-feet are C-shaped. Sphæridia are few and very small.

The test is almost fawn-color but has a distinct purplish cast, except in the bare median areas of both ambulacra and interambulacra. The primary spines are pure white but the secondaries are gray, tinged with purple. The buccal membrane is dark, but the plates it bears are light.

STRONGYLOCENTROTIDÆ Gregory.

General Considerations.

The real relationship of the polyporus Echini with the Echinidæ can probably be made more evident, if the forms with a circular ambitus are separated from those in which one axis is elongated. I therefore agree with Jackson (1912, Mem. Boston Soc. Nat. Hist., VII) when he follows Gregory in separating Strongylocentrotus and its nearest allies from the Echinometridæ and giving them family rank. The group contains some thirty or more species which form so complete a series from those nearest the Echinidæ to those most highly specialized that it is exceedingly hard to arrange them in genera. Of course taking some one character as the standard, artificial sections, called genera, can be recognized but the associations thus formed are often valueless. The connection of the family with the Echinidæ through its lowest genus Paracentrotus is so plain it will hardly be questioned, the resemblance of *Paracentrotus agulhensis* to certain species of Echinus is so great that the M. C. Z. has received specimens, labelled "*Echinus gilchristi*" from the describer of the latter species, himself! The Strongylocentrotidæ are widely distributed but it is a remarkable fact that not a single species is known from the Caribbean region. Nearly one third of the species are found in the northwestern Pacific, mostly in Japanese waters. All of the species are littoral and only a few extend into water exceeding one hundred fathoms.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plates 94, figs. *1–33;* 95, figs. *16–24.*

In the character of the *spines,* the Strongylocentrotidæ show little indications of advance over conditions found in the Echinidæ. In most of the species the spines are relatively short and there is no marked contrast between the primaries and the other spines. In Echinostrephus however the abactinal primaries are conspicuous; they are long, slender, very smooth, and rather sharp. In Heliocidaris and in some of the most specialized species of Strongylocentrotus, the primary spines are long and stout, usually quite smooth, and more or less pointed; in one species of Heliocidaris they are remarkably short and thick. The character of the primary spines may thus be of considerable use for specific distinctions.

In the *pedicellariæ*, the differentiation of special forms undergoes a series of changes identical with that which exists in the Echinidæ. Thus in the simplest forms, those with only four pairs of pores and all oculars exsert, the globiferous pedicellariæ, like those found in the most primitive species of Psammechinus and Echinus, have valves with lateral teeth on both sides. In forms somewhat more specialized, a lateral tooth on only one side is found and in many species that has disappeared and there is only the conspicuous terminal tooth, so characteristic of the most specialized Echinidæ. It is interesting to find that many of the more specialized species of Strongylocentrotidæ have retained the less specialized form of pedicellariæ; thus *Loxechinus albus*, a highly modified species, has the simple form of globiferous pedicellariæ. On the other hand, *Strongylocentrotus granularis*, which is very variable but without highly specialized ambulacra, has the most extreme form of pedicellariæ. There do not seem to be any characters in which the pedicellariæ of the Strongylocentrotidæ differ regularly from those of the Echinidæ. It is neither necessary nor desirable therefore to repeat here their characteristic features. Usually all four kinds are present on any given specimen; not infrequently the tridentate occur in two forms and in a few species, there are two forms of globiferous. In some species the globiferous pedicellariæ are quite wanting, at least in adult specimens, but they are usually common enough.

In their *sphæridia*, this family shows no special advance over what is found in the Echinidæ. There are several to many sphæridia on the actinal portion of each ambulacrum, attached to minute tubercles, not at all sunken in depressions in the test. They vary in shape from almost globular to oval or ellipsoidal. They are usually smooth but may be quite rough at the tip.

The *spicules* in the tube-feet and in the glands of the globiferous pedicellariæ are usually bihamate, with the ends simple or more or less branched; often the spicules are not developed completely but are short, slightly curved with rounded ends. What Mortensen calls "biacerate" spicules also occur. As any two or three of these forms may occur in a single specimen, they are without any real systematic importance.

The Genera and Species of Strongylocentrotidæ.

In attempting to arrange the species of this family in anything like a natural sequence, the genera, with the exception of Echinostrephus and Pseudoboletia, which are really a little off the main line of development, are exceedingly hard to define. Mortensen (1903, "Ingolf" Ech., pt. 1) has made clear the interesting characters shown by the pedicellariæ, and although he greatly exaggerates their importance, it is beyond question that they are suggestive and oftentimes useful for systematic purposes. By using them in connection with the structure of the ambulacra, the arrangement of the oculars, the buccal membrane, the thickness or thinness of the test, and the primary spines, it is possible to break up the large and heterogeneous genus Strongylocentrotus into smaller and more homogeneous genera. Mortensen made seven such groups, basing his divisions chiefly on the pedicellariæ and spicules, and placing the resulting genera in three different families. His genera are Strongylocentrotus, Paracentrotus, Loxechinus, Sphærechinus, Pseudocentrotus, Anthocidaris, and Toxocidaris. Of these the first three seem natural groups, and the same is true of the last, though it is necessary to recognize it under another name. As already shown (p. 281), the type of Toxocidaris is *Echinus erythrogrammus* Val. and the type of Heliocidaris is *Echinus tuberculatus* Lamk. As these two species are indubitably congeneric, the later name (Toxocidaris) becomes a synonym of the earlier (Heliocidaris), and the genus, which Mortensen calls Toxocidaris, and for which he definitely designates *erythrogrammus* as the type, must be called Heliocidaris. As regards Sphærechinus, it is impracticable to retain the genus, in spite of Mortensen's statement that it is "very well characterized." His definition of the genus as "large, short-spined forms, almost globular," and other references to the "high form" of the test, show that he has not examined large series of specimens. Many of our specimens of *Sph. granularis* from the Azores are greatly flattened, the vertical diameter scarcely exceeding one half the horizontal, and one specimen, 76 mm. in diameter is less than 37 mm. high. Many of these specimens also have somewhat longer spines than usual, and except for the deep gill-cuts and the insert oculars, would be easily mistaken for *Paracentrotus lividus* from the same islands. In the number of pore-pairs in an arc these specimens of *granularis* from the Azores, show great diversity, many arcs having as many as *seven* pairs, and *six* seems to be the typical number for adults. The deep narrow gill-cuts furnish a good specific character and one that is remarkably constant, but unfortunately it does not make a useful *generic* character, for it occurs nearly or quite as well developed in many specimens of *S. depressus* and *S. pulcherrimus*, but in these species, is very variable and of little significance. The species hitherto known as "*Sphærechinus*" *australiæ* proves to have little in common with *granularis*, except well-defined gill-cuts, and it may best be placed in a genus by itself. It cannot retain the name Sphærechinus since it was not included in the genus by the original describer of that group. It is possible that Sphærechinus may still be used for some fossil forms but considering *S. roseus* Russo a synonym of *granularis* and placing the latter in Strongylocentrotus, Sphærechinus is not available for recent Echini. The differences between the pedicellariæ of *granularis* and those of its allies in Strongylocentrotus, upon which Mortensen lays much weight, seem too trivial to be of any real value. So too with regard to the characters by which Pseudocentrotus and Anthocidaris are supposed to be distinguished. Had Dr. Mortensen examined larger series of specimens, it is improbable that he would have attempted to isolate those two genera.

There are two species, regarding whose status Mortensen expresses his doubt owing to his inability to examine sufficient material, and of which good series are at hand. One of these, *Sphærechinus australiæ* A. Ag., becomes, as suggested above, the type of the new genus Pachycentrotus. The other, *Toxopneustes gibbosus* Agas. and Des., while related to Paracentrotus in many ways has such a modified abactinal system and such specialized globiferous pedicellariæ, that it is better to make it the type of a new genus, Cænocentrotus. While therefore rejecting three of Mortensen's genera, two new ones are here proposed and thus the family contains only one less genus than he suggested.

The eight genera of Strongylocentrotidæ adopted, are distinguished from each other as follows; but the arrangement is very artificial and the various characters are used arbitrarily regardless of their real importance, the only object being to make the accepted genera tangible and easily recognized.

Test with ambitus above equator; not more than 4 pore-pairs in each arc; ocular plates all fully exsert; primary spines longest on flat abactinal surface . . *Echinostrephus.*

Test with ambitus at or below equator (if above, there are more than 4 pore-pairs in an arc, and one, at least, of the oculars is insert).

  Test thin with deep gill-cuts, having a very prominent flange ("lip" or "tag") on interradial side; plates of buccal membrane carry both spines and pedicellariæ . . . . *Pseudoboletia.*

  Test seldom thin; gill-cuts without a prominent flange, and usually shallow; plates of buccal membrane do not carry spines.

    Pore-pairs in arcs of 4–10; if more than 5, valves of globiferous pedicellariæ with one or more lateral teeth.

      Usually all oculars exsert but sometimes one and rarely more, are insert; buccal membrane with scattered plates; valves of globiferous pedicellariæ with one or more lateral teeth on each side.

        Test not very stout; primary spines usually rather long, at least .25 h. d.; valves of tridentate pedicellariæ not peculiar; pore-pairs 4 or 5 . . . . *Paracentrotus.*

        Test very stout; primary spines rather short; valves of tridentate pedicellariæ short, abruptly rounded at tip and with 6–8 conspicuous teeth there; pore-pairs 7–10 . . . . *Loxechinus.*

Usually two, not rarely three or more oculars insert; valves of globiferous pedicellariæ with a lateral tooth only on left side.

Oculars V and IV insert, often III also, sometimes II and not rarely all; test not very stout; buccal membrane with scattered plates *Cænocentrotus.*

Oculars I and V insert, rarely IV or II also; test very stout, thickly covered with tubercles; buccal membrane more or less heavily plated . . . . *Pachycentrotus.*

Pore-pairs in arcs of 4–10; if fewer than 6, valves of globiferous pedicellariæ with tubular blade, prominent end tooth and no lateral teeth.

Pore-pairs 7–10; test stout; valves of globiferous pedicellariæ with a lateral tooth on left side near tip . . . . *Heliocidaris*

Pore-pairs usually 4–7, rarely 8–10; test thin or moderate; valves of globiferous pedicellariæ with no lateral teeth . . . . *Strongylocentrotus.*

ECHINOSTREPHUS.

A. Agassiz, 1863. Bull. M. C. Z., I, p. 20.
Type-species, *Echinostrephus aciculatus* A. Agassiz, l. c.

A careful comparison of the "Albatross" material from the Hawaiian Islands with that in the M. C. Z. collections from Mauritius, and from the Pacific Ocean, shows that this interesting genus contains two species, *aciculatus* A. Ag. not being identical with *Echinus molaris* Bl. Owing to the fact that in the "Revision" they are regarded as identical, and the figures given are those of *aciculatus*, the description also being based on that species, Yoshiwara (1898, Ann. Zool. Jap., II, p. 59) on finding specimens of the true *molaris* (Pl. 105, figs. *10, 11*) in Japanese waters (Bonin Islands) was misled into describing it as a new species to which he gave the name *pentagonus*.[1] The two species seem to be quite distinct and are to be separated by the following characters: —

Pore-pairs 3; ambitus more or less evidently pentagonal; genital and ocular plates with no tubercles except on outer margin; test usually more or less bright green . . *molaris.*

Pore-pairs 4; ambitus circular; genital and ocular plates with more or less numerous tubercles; test dull purplish or greenish . . . . *aciculatus.*

Echinostrephus aciculatus A. Ag.

Echinostrephus aciculatus A. Agassiz, 1863. Bull. M. C. Z., I, p. 20.
Echinostrephus molare A. Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 242. Non Blainville, 1825.

Plates 95, figs. *23, 24;* 105, fig. *9.*

The discovery that *aciculatus* is not identical with *molaris* gives added interest to this unique genus and the specific characters have been studied in great detail.

[1] This conclusion is confirmed by examination of Yoshiwara's specimens.

Neither the pedicellariæ, sphæridia, or spicules show any constant differences between the two species but there is more or less individual diversity. The globiferous pedicellariæ are large and conspicuous (Pl. 95, fig. *23*) and it is interesting to find that while the valves usually have a lateral tooth on only one side, occasionally they occur with such a tooth on each side (Pl. 95, fig. *24*). This emphasizes the intermediate position occupied by the genus. The tridentate pedicellariæ are not usually common and they show the greatest diversity in size, and nearly as much in form; the valves measure from .20 mm. to over a millimeter in length. Most of our Hawaiian specimens lack tridentate pedicellariæ, although globiferous and ophicephalous are common. When tridentate are common, they are chiefly actinal in position, and ophicephalous are rare. The ophicephalous on the buccal plates are much smaller than those on the test. The latter have the valves about half a millimeter long, including the loop; they are provided with long muscular necks; the valves are constricted near the base of the very coarsely serrate or sinuate blade. The triphyllous pedicellariæ have valves .15–.20 mm. long and .10–.15 mm. across the blade. Sphæridia are numerous, 15–20 on the actinal part of each ambulacrum, but not extending to the ambitus.

The "Albatross" specimens show great diversity in size and color. The largest (Pl. 105, fig. *9*) is 37 mm. in diameter and nearly 25 mm. high; the ambitus is about 6 mm. above the equator. The longest primaries, which are very near the abactinal system, are 30 mm. in length. The test is dull grayish or purplish with a slight greenish tinge on the primary tubercles. The primary spines are very dark, almost bronze color and those below the ambitus are abruptly tipped with deep pink. This specimen is from Laysan Island. Another from the same vicinity differs strikingly in color, but is not otherwise peculiar. The test is dull lavender with no trace of green; the secondaries, and the basal half of the primaries below the ambitus, are bronze-brown; the abactinal primaries and the terminal half of the actinal, are very pale lavender, almost white, with more or less of a pink shade, especially at the very tip. The smallest of the Hawaiian specimens is 12 mm. in diameter. It is of interest because, as might be expected, there are only three pore-pairs in an arc actinally, but from the ambitus, which nearly coincides with the equator, upward, each arc has four.

It is a noteworthy fact, that all of the "Albatross" specimens are from the extreme northwestern part of the Hawaiian group, as will be seen from the following list of the stations where Echinostrephus was taken.

Station 3959. Off Laysan Island, Hawaiian Islands. Bott. temp. 75° ? 10 fathoms. Wh. s., co.

Station 3960. Off Laysan Island, H. I. Bott. temp. 74° ? 10–19 fathoms. S., sh., co.

Station 3968. French Frigate Shoal, H. I. Bott. temp. ? 14½–16½ fathoms. Crs. s., co.

Station 3969. French Frigate Shoal, H. I. Bott. temp. ? 15–16 fathoms. Crs. s., sh., co.

Station 3970. French Frigate Shoal, H. I. Bott. temp. ? 17–17½ fathoms. Crs. s., sh., co.

Station 3975. Off Necker Island Shoal, H. I. Bott. temp. ? 16–171 fathoms. Crs. s., co., sh.

Station 4147. Off Modu Manu, H. I. Bott. temp. 77.9°. 26 fathoms. Co., corln.

Bathymetrical range, 10–26 (171 ?) fathoms. Extremes of temperature, 77.9°–74° ? Twenty specimens.

Pseudoboletia.

Troschel, 1869. Sitzungsb. Niederrh. Gesel. Bonn, p. 96.

Type-species, *Pseudoboletia stenostoma* Troschel, l. c. = *Toxopneustes indianus* Michelin, 1862. Ech. et Stel.: Annéxe A, in Maillard's Notes sur Bourbon, p. 5.

The question as to the number of valid species in this interesting genus is still open in spite of the writings of de Loriol, Bell, Mortensen, de Meijere, and Kœhler. It cannot be doubted that Kœhler's species from the Atlantic Ocean, and which he called *maculata*, is really quite a new species and the name *atlantica* is suggested for it. Neither is there any good reason to question that the species so well described by de Loriol as *indiana* is really that species, and the type of *granulata* A. Ag. seems to be only a very large specimen (93 mm. h. d.) of the same. But whether the species called by Troschel, *maculata*, is really entitled to recognition seems doubtful. There are in the M. C. Z. collection, besides the type of *granulata*, three specimens of *indiana* from Mauritius, three specimens of the "Challenger" species from Zamboanga, which Bell and Mortensen call *maculata*, and a small bare test from an unknown locality. These specimens seem to prove that the size of the peristome and the depth of the gill-cuts do not furnish reliable specific characters and throw doubt on the value of the coloration as a means of separating the two species. In the type-specimen of *granulata*, the test is 3.2 times the diameter of the peristome, while in the other specimens it ranges from 2.2 in the smallest, to 2.5 in the next to the largest. As in all regular Echini, the peristome is relatively larger in young specimens, and is relatively smallest in the largest. In all the specimens, the depth of the gill-cuts is one fifth to one sixth the diameter of the peristome. In coloration none of the specimens from Mauritius show any blotches of dark color; the spines are greenish at base and more or less pinkish or light rose-purple distally. The specimens from Zamboanga have the brown blotches very distinct while the spines show considerable diversity in color; in one specimen they are green with very decidedly rose-purple tips. In *granulata*, there are rather indistinct, large dark blotches, the color including the base of the spines. Obviously this material is not sufficient to demonstrate whether the coloration furnishes a specific character in this genus or not. On the other hand, the size and arrangement of the buccal plates, are constant so far as our material goes, and Bell's division of *maculata* from *indiana* may be accepted at least until more abundant material shows the separation to be unnatural. While *indiana* ranges from Mauritius to the Hawaiian Islands, *maculata* has as yet been found only in the East Indian region. Kœhler's (1908, Trans. Roy. Soc. Edinburgh, XLVI, p. 641) statement that the example of *maculata* in the British Museum has no indication of locality is unaccountable; Bell (1884, Ann. Mag. Nat. Hist., (5), XIII, p. 108–111) refers to several specimens and gives the localities from whence they came.

The three nominal species are distinguished from each other as follows: —

Pore-pairs in arcs of four; actinal spines not banded.
- Buccal plates large, nearly or quite in contact; buccal membrane with many other rather large plates; test without dark blotches . . . . *indiana*.
- Buccal plates rather small, widely separated; some parts of test with bases of accompanying spines, dark colored, forming more or less distinct but indefinite blotches . . . . *maculata*.

Pore-pairs in arcs of five; actinal spines banded with green and white . . . . . . *atlantica*.

Pseudoboletia indiana A. Ag.

Toxopneustes indianus Michelin, 1862. Ech. et Stel.: Annéxe A, in Maillard's Notes sur Bourbon, p. 5.
Pseudoboletia indiana A. Agassiz, 1872. Rev. Ech., pt. 1, p. 153.
Psammechinus paucispinus A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 246.

Plate 92, figs. *12–18*.

It has become evident on further examination of the Hawaiian material that *Psammechinus paucispinus* is simply the youthful form of Pseudoboletia. The specimens range from 12.5–19 mm. in diameter and all of them have the actinal membrane fully plated. The latter character, taken with the small size, was misleading and the possibility of their being young Pseudoboletias did not suggest itself. But the presence of deep actinal cuts for the gills, spines on the buccal plates, and *four* pairs of pores in each arc, show their true position beyond doubt. The buccal plates are large and near together but are not as nearly in contact as in large specimens. One of the specimens is badly distorted, ambulacrum II being malformed, sunken, and without pores above the ambitus. The arrangement of the ocular plates in the other specimens is interesting as showing that the adult character is not acquired very early in all cases. In the two largest specimens, ocular I is broadly insert while ocular V is still exsert, although very nearly in. In the two smallest specimens ocular I is broadly insert while V is narrowly so. It seems fair to assume that in this species ocular I becomes insert before the individual is 10 mm. h. d. while ocular V comes in during the growth in diameter from 10 to 20 or perhaps 25 mm.

The coloration of these specimens is very plain. The test is whitish with a more or less pronounced green tinge when cleaned. The plated actinostome is almost pure white. The spines vary from white to deep pink, in four of the specimens being distinctly pink.

The pedicellariæ are remarkably numerous and varied, no less than *six* different forms being found on a single specimen. The *globiferous* occur in two different forms, a larger (Pl. 92, fig. *12*) without glands on the stalk and with valves (Pl. 92, fig. *15*) .65–.85 mm. long, and a smaller, with glands on the stalks (Pl. 92, *13*) and valves only about .20 mm. in length. The *ophicephalous* pedicellariæ are common everywhere but are not peculiar; the valves measure .20–.40 mm. in length besides the "loop" which may be half as much again. The *tridentate* occur in two very different forms, one (Pl. 92, fig. *14*) with very slender valves, about .70 mm. long; the other, with broad valves (Pl. 92, fig. *17*) .50–.90 mm. long. The latter are common everywhere but the former are rare and seem to occur only abactinally. The *triphyllous* are very small, with valves only .12–.14 mm. in length. There are 4 or 5 sphæridia (Pl. 92, fig. *18*) on the lower part of each ambulacrum. Calcareous spicules occur in both the pedicels and the heads of the globiferous pedicellariæ. The latter are smaller but are not otherwise different. The spicules are usually C- or (-shaped but they may have an irregular branch or two; they are sometimes perfectly bihamate. As Mortensen makes the form of these spicules one of the chief *subfamily* characters in his classification, it seems desirable to call attention to their variability.

The "Albatross" took no adult specimens of Pseudoboletia but the young ones were taken at the following stations:—

Station 3872. Off Mokuhooniki Islet, Auau Channel, Hawaiian Islands. Bott. temp. 74.6°. 32–43 fathoms. Yl. s., p., co.

Station 3876. Off Lahaina Light, Maui, H. I. Bott. temp. 74°. 28–43 fathoms. S., g.

Station 4033. Off Diamond Head, Oahu, H. I. Bott. temp. ? 28–29 fathoms. Fne. co. s., for.

Station 4164. Off Modu Manu, H. I. Bott. temp. 78.1°. 40–56 fathoms. Co. s., p., sh.

Bathymetrical range, 28–56 fathoms. Extremes of temperature, 78.1°–74°.

Five specimens.

Paracentrotus.

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 124, 135.
Type-species, *Echinus lividus* Lamarck, 1816. Anim. s. Vert., III, p. 50.

Although Mortensen does not designate *lividus* as the type of his genus, it is without doubt the species he intended as the type, and therefore it is here accepted as such. The similarity of this genus to Echinus is striking and Mortensen is undoubtedly right in describing it as a polyporous Echinus. It appears to be very near the parent stock from which the Strongylocentrotidæ have sprung. There are only three species known, *lividus*, which is found in the Mediterranean and in the eastern North Atlantic from the English Channel to the Azores and Canaries[1]; *Gaimardi* (Bl.), which appears to be confined to the Brazilian coast; and *agulhensis* Död., which occurs off South Africa, and in much deeper water than the others, having been taken by the "Valdivia" in 278 fathoms. The three species may be distinguished from each other by the following characters: —

Pores-pairs 4 in each arc.
  Unicolor; preserved material whitish or light yellowish . . . . *agulhensis.*
  Variegated; preserved material green and brown . . . . *Gaimardi.*
Pore-pairs generally 5; color variable, but dark . . . . *lividus.*

Loxechinus.

Desor, 1856. Syn. Ech. Foss., p. 136.
Type-species, *Echinus albus* Molina, 1782. Saggio St. Nat. Chili, p. 175.

Whether this genus contains more than a single species seems open to grave doubt, for it is not easy to believe that *bullatus* is distinct from *albus*. A series of

[1] Bell (1892, Cat. Brit. Ech., p. 158) records this species from Brazil. This is probably due to confusing *lividus* with *Gaimardi*, from which it is quite distinct.

specimens of *albus*, collected at various points on the Chilean coast, from Shoal Bay, Patagonia, northward, chiefly by the "Hassler", shows that that species is very variable in all those characters by which *bullatus* is supposed to differ. But with only a single authenticated specimen of *bullatus* at hand, its title to recognition is not clear. It is supposed to be characterized by having all the oculars exsert but this is true of more than half the specimens of *albus*, and by having only 7 or 8 pairs of pores in an arc instead of 9 or 10, but specimens of *albus* occur which have only 8. The color of *bullatus* is also supposed to be less green and more brown than *albus* but specimens of the latter are sometimes more brown than green. In the face of these facts the status of *bullatus* cannot be decided. Loxechinus is an interesting genus for several reasons. Its geographical isolation on the western coast of southern South America is noticeable. It combines remarkably unspecialized globiferous pedicellariæ with a very high specialization of the ambulacra, while the character of the abactinal system is apparently not at all firmly fixed as yet. It reaches an unusually large size and develops an exceedingly thick test, and finally it is one of the very few genera of echinoderms which are of use to man, its type species being the edible "erizo" of Peru and Chile.

CÆNOCENTROTUS,[1] gen. nov.

Type-species, *Echinus* (*Toxopneustes*) *gibbosus* L. Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 367.

Plate 95, figs. *16, 17.*

It is a remarkable fact that although this genus is nearer to Loxechinus geographically than to any other genus of the family, it does not seem to be very near it structurally but differs from it very strikingly. The only known species is common on the coast of Peru, especially at Payta and it is also known from the Galapagos Islands. In the very great majority of adult specimens, a parasitic crab lives in the periproct, which is thereby more or less distorted. Whether this is the cause of the unusual arrangement of the ocular plates by which ocular I is never insert unless all the others are also, is not yet definitely determined. It is unknown how large a proportion of the individuals of a given season reach adult size without being parasitized and also what the typical arrangement of the oculars is for such adults.

[1] καινός = new, strange + κέντρον = prickle.

The arrangement of the pore-pairs in arcs of four is a very obvious difference between this genus and Loxechinus and shows its relationship to Paracentrotus. The globiferous pedicellariæ are unlike either of those genera but are like those of Heliocidaris, the valves (Pl. 95, fig. *16*) having a prominent lateral tooth on the left side (Pl. 95, fig. *17*).

So far as known this genus is monotypic but attention may be called to the fact that specimens from Albemarle Island, Galapagos, are very different in color from those collected at James Island or on the mainland coast. They seem to be dull red-brown, with no trace of green, so that their general appearance is quite different from typical *gibbosus*.

PACHYCENTROTUS,[1] gen. nov.

Type-species, *Sphærechinus australiæ* A. Agassiz, 1872. Bull. M. C. Z., III, p. 55.

Plates 94, figs. *1–6;* 98, figs. *5–8.*

Although Mortensen had the opportunity to examine a specimen of this species in the British Museum, taken by the "Challenger" in Bass Strait, he does not attempt to "decide to which genus and species" it belongs, but simply points out the most striking feature of its pedicellariæ. It appears from other remarks which he makes that he has seen specimens of *S. granularis* labelled *australiæ* and it is not strange that this has led him to doubt whether he has ever seen the true *australiæ.* There is however little doubt that the "Challenger" specimen he saw in London is *australiæ* for a similar small specimen from the same station in the collection of the M. C. Z. is undoubtedly that species. The globiferous pedicellariæ are, as Mortensen says, like those of Heliocidaris in having a large lateral tooth near the tip only on the left side but they are quite characteristic nevertheless in certain details (Pl. 94, figs. *1, 2*); the stalk about equals the head (.90–1 mm.) and there is no neck. The tridentate vary greatly in size, the valves (Pl. 94, figs. *3, 4*) ranging from .15 to .80 mm. In the ophicephalous, the valves (Pl. 94, fig. *5*) are about .50 mm. long and in the triphyllous, they (Pl. 94, fig. *6*) measure .12 mm. The spicules in the pedicels are bihamate.

This genus is well characterized by its thick, heavily tuberculated test, with ambulacra having only 4 pore-pairs (rarely 5, Pl. 98, figs. *7, 8*) in each arc, and with oculars I and V (rarely IV or II, Plate 98, fig. *6*) insert. The sharp, distinct

[1] παχύς = thick, stout + κέντρον = prickle.

gill-cuts and more or less heavily plated buccal membrane (Pl. 98, fig. 5) are equally important and diagnostic. The short, small spines and the characteristic globiferous pedicellariæ are notable additional features. The genus appears to be monotypic and is probably confined to the Australian region. The records from Mauritius and New Zealand are open to very grave doubt.

Heliocidaris.

Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 371.
Type-species, *Echinus omalostoma* Valenciennes, 1846, Voy. "Vénus." Zoophytes, Pl. 6, fig. 2.
= *Echinus tuberculatus* Lamarck, 1816, Anim. s. Vert., III, p. 50.

The reasons for considering *tuberculatus* the type of this genus have already been given fully (p. 281) and need not be repeated here. As thus understood Heliocidaris is a fairly homogeneous group of five species confined to the Pacific Ocean, three of the species being characteristic of the Australian region. A fourth species, *stenopora* (new name for *mexicana* A. Ag.) is very little known; the specimens upon which it is based are supposed to have come from Lower California; the species itself is well characterized but that its home is really in the eastern Pacific needs verification. It cannot continue to bear its original name, *mexicana*, for it is entirely distinct from the *Heliocidaris mexicana* of Louis Agassiz and Desor described many years earlier. It may be called *stenopora*, because of the narrow abactinal poriferous areas. The fifth species, *crassispina* (A. Ag.) is Japanese and resembles *Strongylocentrotus nudus* (A. Ag.) quite closely, but can always be distinguished by the number of pore-pairs in an arc. It appears that *crassispina* is quite distinct from *E. tuberculatus* Lamk., and that *Anthocidaris homalostoma* Lütken, and *Toxocidaris purpurea* von Mart. are synonyms of *crassispina*. It also includes *Toxocidaris globulosa* A. Ag., as determined from examination of one of the type-specimens in the U. S. National Museum, kindly loaned through Mr. Austin H. Clark. Of the three Australian species of *Heliocidaris*, *erythrogramma* (Val.) and *tuberculata* (Lamk.) are quite distinct but it would not be surprising to have it demonstrated that *armigera* (A. Ag.) is simply a form of *erythrogramma*. Without intermediate specimens, the two are retained for the present. The five species of Heliocidaris may be distinguished as follows:—

Pore-pairs 7 or 8 in each arc, rarely 9.
  Primary spines short (20 mm. ±) and very stout (2 or 3 mm. in diameter) . . . *armigera*
  Primary spines longer and much more slender.

Actinostome .30–.35 h. d.; pore-pairs mostly in arcs of 7, of which only the outer 3 or 4 form more or less vertical series above the ambitus.
Primary spines very dark (blackish, purplish, or brownish); test very flat actinally with poriferous areas more or less petaloid . . . . *crassispina.*
Primary spines dull reddish or greenish, often with more or less of distal half, violet; test not flattened actinally and poriferous areas not petaloid . . . . *erythrogramma.*
Actinostome .35–.40 h. d.; pore-pairs mostly in arcs of 8 (occasionally 9), of which the outer 4–6 are in more or less vertical series above the ambitus, so that the poriferous areas are very narrow . . . . *stenopora.*
Pore-pairs 9 or often 10 in each arc . . . . *tuberculata.*

Heliocidaris stenopora,[1] nom. nov.

Toxocidaris mexicana A. Agassiz, 1863. Bull. M. C. Z., I, p. 22. Non *Heliocidaris mexicana* L. Agassiz and Desor, 1846, Ann. Sci. Nat., (3), VI, p. 372.

Plates 95, figs. *18–22;* 104, figs. *1–3;* 110, figs. *4, 5.*

As this species appears to be rather rare, few specimens having found their way into museums, it seems desirable to give figures of the specimen in the M. C. Z. collection, which is almost certainly the type. Its measurements correspond with those in the "Revision." All four kinds of the pedicellariæ figured were found on this specimen. The *globiferous* have valves about .45 mm. long (Pl. 95, fig. *18*) with a prominent lateral tooth on the left side of the blade near the tip (Pl. 95, fig. *19*). The *ophicephalous* have valves (Pl. 95, fig. *20*) of about the same length, counting the "loop"; they are not constricted at the base of the blade. The *tridentate* are also of about the same size, with rather wide, somewhat curved blades (Pl. 95, fig. *21*). These three kinds of pedicellariæ are covered with a dark tissue, which makes them all look much alike, but the ophicephalous and tridentate have long necks, which seem to be wanting in the globiferous. The *triphyllous* also have long necks, and valves (Pl. 95, fig. *22*) about .15 mm. long; the blade is the same width as the base, little constricted and very square cut at the tip.

This species appears to be very well characterized for when compared with *tuberculata* or *crassispina*, or with the west coast species of Strongylocentrotus (*franciscanus* and *purpuratus*), the differences are so obvious, there can be no question of assigning it to any of those species. The spines of the specimen at hand are all broken, but the primaries were evidently very stout; the remaining pieces are bright violet of a light shade. This specimen is supposed to have

[1] στενόπορος = with a narrow way.

been taken at Cape St. Lucas, Lower California, by John Xantus, about 1860, but if the locality is correct, it is remarkable that the explorations of the "Albatross" in the same region have failed to bring other specimens to light.

Strongylocentrotus.

Brandt, 1835. Prodrom. desc. Anim., p. 263 (or 63).

Type-species, *Strongylocentrotus chlorocentrotus* Brandt, l. c., p. 264 (or 64) = *Echinus dröbachiensis* O. F. Müller, 1776. Prodrom. Zool. Dan., p. 235.

So homogeneous is this genus and so completely do the forms intergrade that it is almost wholly a matter of opinion as to what species are to be considered valid. It seems nearly certain that the widely distributed *dröbachiensis* is the parent stock from which the others have sprung, but how many species are at the present time fully differentiated from this stock is very hard to decide. Of course a typical *franciscanus* is very easily distinguished and that is certainly a distinct species, yet it appears to intergrade with *purpuratus* which in turn connects very clearly with *dröbachiensis*. In the European seas, *granularis* (Lamk.) has become quite an easily recognized species particularly when its characteristic features are fully developed. The Japanese and Aleutian forms are not so well defined and although the attempt to distinguish, from those seas, *pulcherrimus* A. Ag., *depressus* A. Ag., *intermedius* A. Ag., *pulchellus* A. Ag. and Cl., *echinoides* A. Ag. and Cl., *polyacanthus* A. Ag. and Cl., and *nudus* A. Ag., typical examples of which are easily recognizable, is here made, it is probable that at least two or three of them are not really specifically distinct from *dröbachiensis*, and ought not to be honored with names. There is not the slightest ground for doubting that *chlorocentrotus* Brandt is a synonym of *dröbachiensis*. Alaskan specimens show very great diversity in the length of the spines as well as in coloration. The name *carnosus* A. Ag. might well be revived for the very handsome form from northeastern Asia, but as the coloration is not always striking and seems to intergrade with that of *dröbachiensis*, and as any other distinctive character is not apparent it is better to let the case stand as it is, until some zoölogist can make a special study, in the field, of the North Pacific forms of Strongylocentrotus. The form which Döderlein (1906, Zool. Anz., XXX, p. 517) described from Sakhalin as a variety of *dröbachiensis* under the name *sachalinica*, seems to be very well characterized by the remarkably small number of coronal plates and although specimens have not been seen, it is here raised to specific rank. His proposed species *hokkaidensis* is however nothing more or less than *nudus*. The recently described *fragilis* Jackson from off the coast of California, although obviously related to *dröbachiensis*, seems to be fully entitled to recognition.

The following table will show the most important characters for distinguishing the species herein recognized: —

Pore-pairs 4–7 in each arc, only very exceptionally 8.
- Poriferous areas very broad, with pore-pairs in arcs of 4 which are nearly horizontal at ambitus, with pore-pairs well separated so that they form 4 vertical series, the two outer sometimes crowded together . . . . *pulcherrimus.*
- Poriferous areas not as above.
  - Gill-cuts deep and sharply defined.
    - Test not depressed, v. d. rarely less than .50 h. d. and usually more than .66 h. d.; actinal surface not flat . . . . *granularis.*
    - Test depressed, v. d. usually less than .45 h. d.; actinal surface very flat *depressus.*
  - Gill-cuts neither deep nor sharply defined.
    - Pore-pairs 4–6, sometimes 7; abactinal primary tubercles small; primary spines short or moderately long; color rarely very dark.
      - Test very thin and fragile, depressed, v. d. less than .50, sometimes only .33 h. d.; auricles high, slender, racquet-shaped; spines exceedingly slender and fragile, bright reddish orange at base, with more or less of tip whitish . . . . *fragilis.*
      - Test and spines not as above.
        - Coronal plates very few; 11 interambulacral plates in each column in a specimen 30 mm. h. d., 15 in 60 mm. specimen . . *sachalinicus.*
        - Coronal plates much more numerous; 14 interambulacral plates in a column in 17 mm. specimen, 28 in a 56 mm. specimen.
          - Pore-pairs typically 5, sometimes 4, rarely 6.
            - Poriferous area much wider than half interporiferous, the arcs nearly horizontal at ambitus, with pore-pairs tending to form three vertical series, inner with two, median with one and outer with two (rarely 3) pore-pairs; primary spines greenish or reddish or both; valves of globiferous pedicellariæ with terminal tooth not half as long as blade . . . . *intermedius.*
            - Poriferous area about equal to half of interporiferous, the arcs very oblique at ambitus, the pore-pairs, forming only an inner series of two and an outer series of three; primary spines light violet tipped with white, the actinal ones often faintly banded; valves of globiferous pedicellariæ with a short blade and terminal tooth nearly as long . . . . *pulchellus.*
          - Pore-pairs typically 6, often 7, very rarely 8.
            - Primaries moderate, 10–15 mm. long or more; interambulacral plates 18–23 in each column; color not uniform dull rose-purple.
              - Pore-pairs 6 in an arc, in the mid-zone, occasionally 7; arcs horizontally oblique; abactinal

interambulacral areas well covered by secondary tubercles with relatively few miliaries; color more or less greenish with or without a violet tinge, passing on the one hand into a violet test with deep green spines, and on the other into dull yellowish or light brown, with little trace of either green or violet . . . . *dröbachiensis.*

Pore-pairs 7 in an arc, in the mid-zone, occasionally 6; arcs vertically oblique; abactinal interambulacral areas with few secondaries but closely covered with miliary tubercles, except along the bare median line; color more or less reddish white, darkest on abactinal interambulacral areas, which may be deep reddish purple; primaries light red or light green or both *echinoides.*

Primaries numerous, very short, 6–8 mm. long, scarcely distinguishable from secondaries; interambulacral plates 25 in each column; color uniform dull rose-purple . . . . *polyacanthus.*

Pore-pairs 6 or commonly 7; abactinal primary tubercles large and conspicuous; primary spines long; color usually dark brown or purplish . . . . *nudus.*

Pore-pairs 8–10 in each arc.

Pore-pairs 8; primary spines short; primary tubercles not conspicuous; globiferous pedicellariæ common; color, when adult, purple . . . . *purpuratus.*

Pore-pairs 9–10; primary spines long; primary tubercles large, in 6 conspicuous series in each interambulacrum; globiferous pedicellariæ usually very few; color commonly red-brown, rarely purple . . . . *franciscanus.*

Strongylocentrotus fragilis Jackson.

Strongylocentrotus fragilis Jackson, 1912. Mem. Boston Soc. Nat. Hist., VII, p. 128.

Plates 94, figs. *28, 29;* 113, figs. *3–6.*

As Jackson gives only a brief description of this fine species and leaves me the privilege of figuring it, photographs of the type and of a smaller specimen with spines are given, together with some notes on the structural characters. A large series of specimens at hand ranges from 9 to 90 mm. in diameter; the largest is 40 mm. high. A specimen 55 mm. h. d. is 26.5 mm. high, while another 38 mm. h. d. is only 12 mm. high. But these represent the two extremes and the great majority of specimens are about two fifths as high as they are across. The test is very thin and fragile, and the auricles are so high and slender, and expand at the tip so much like a racquet, that they make a good specific character. There are 5 (rarely 6) pairs of very large pores in each arc, and the arcs themselves approach the horizontal at ambitus, yet the poriferous areas and the ambulacra are rather narrow. The actinostome is more or less deeply sunken and measures about .30 h. d. in diameter. The actinostomal membrane is almost wholly free from calcareous plates, excepting the ten that make up the buccal ring. The abactinal system is about .20 h. d. across. Oculars I and V are broadly insert in 55–60% of the specimens, but in a number, V is exsert and in several none of the oculars reach the periproct. The primary spines are 15–20 mm. long and are exceedingly slender and brittle, as are the secondaries and miliaries. The color of the test ranges from orange-red to deep purple, but the spines are less varied, orange-red at base becoming yellowish or whitish at tip. The pedicellariæ (Pl. 94, fig. *28*, *29*), sphæridia, and spicules do not appear to be in any way different from those of *dröbachiensis*.

The "Albatross" took this species at the following stations off the west coast of the United States and Canada:—

Station 2839. Off Santa Barbara Islands, California, 33° 8′ N., 118° 40′ W. Bott. temp. 41.4°. 414 fathoms. Gy. s.

Station 2861. North of Vancouver Island, 51° 14′ N., 129° 50′ W. Bott. temp. 42.6°. 204 fathoms. There is some doubt as to whether the specimens really came from this station.

Station 2886. Off Oregon, 43° 59′ N., 124° 56′ 30″ W. Bott. temp. 48.1°. 50 fathoms. Rky.

Station 2890. Off Oregon, 43° 46′ N., 124° 57′ W. Bott. temp. 42.2°. 277 fathoms. Gy. s.

Station 2896. Off southern California, 33° 55′ 30″ N., 120° 28′ W. Bott. temp. 42.8°. 376 fathoms. Yl. m.

Station 2925. Off southern California, 32° 32′ 30″ N., 117° 24′ W. Bott. temp. 42.9°. 339 fathoms. M.

Station 2927. Off southern California, 32° 43′ N., 117° 51′ W. Bott. temp. 43.3°. 313 fathoms. Gn. m.

Station 2928. Off southern California, 32° 47′ 30″ N., 118° 10′ W. Bott. temp. 41°. 417 fathoms. Bk. s., g.

Station 2935. Off southern California, 32° 44′ 30″ N., 117° 23′ W. Bott. temp. 49.2°. 124 fathoms. Fne. gy. s.

Station 2936. Off southern California, 32° 49′ N., 117° 27′ 30″ W. Bott. temp. 49°. 359 fathoms. M.

Station 2946. Off southern California, 33° 58′ N., 119° 30′ 45″ W. Bott. temp. 56.5°. 150 fathoms. Crs. gy. s.

Station 2948. Off southern California, 33° 55′ 30″ N., 119° 41′ 30″ W. Bott. temp. ? 266 fathoms. Gy. s., g., brk. sh.

Station 2951. Off southern California, 33° 55′ 30″ N., 119° 55′ W. Bott. temp. ? 48 fathoms. Fne. gy. s.

Station 3051. Off Oregon, 43° 59′ 15″ N., 124° 58′ 30″ W. Bott. temp. ? 59 fathoms. Co., brk. sh., rky.

Station 3053. Off Oregon, 44° 4′ 30″ N., 124° 50′ W. Bott. temp. 47.3°. 64 fathoms. Co., brk. sh., rky.

Station 3076. Off Washington, 47° 46′ N., 125° 10′ W. Bott. temp. 43.4°. 178 fathoms. Gn. m.

Bathymetrical range, 48–417 fathoms. Extremes of temperature, 56.5°–41°.

One hundred and twenty-one specimens.

Strongylocentrotus pulchellus A. Ag. and Cl.

Strongylocentrotus pulchellus A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 121.

Plates 94, figs. *24–27;* 98, figs. *1, 2;* 111, figs. *9, 10.*

There are only two specimens of this species at hand and one of those is so small, only 8 mm. h. d., and so obviously immature, that it hardly reveals any distinctive characters. The other (from St. 5003) which may be considered the type (Pl. 111, figs. *9, 10*) is 17 mm. in diameter, and about 8 mm. high. The actinostome is about 8 mm. in diameter and the abactinal system half as much. There are 13 or 14 interambulacral plates in each column and 16 or 17 ambulacral. The ambulacra are only a little narrower than the interambulacra but the poriferous zones are rather narrow. There are five pairs of pores in each arc from below the ambitus to the ocular plate. The pairs, in the mid-zone, are in oblique, somewhat curved arcs, divided by a secondary tubercle into an inner group of two and an outer, lower group of three pairs. The vertical series of secondary tubercles thus divides the poriferous area into an inner and an outer band. Each ambulacral plate carries one primary tubercle, which is relatively rather large, and in the mid-zone a secondary tubercle at the inner end, in addition to the secondary tubercle in the poriferous zone. There are also smaller secondaries and miliaries. The tuberculation of the interambulacral plates is not essentially different but the secondaries are a trifle larger and those on the outer ends of the plates are as close as possible to the poriferous area. Oculars

I and V are broadly insert (Pl. 98, fig. *2*) and the large suranal carries a well-developed tubercle. The anus is decidedly excentric near ocular I. The madreporic genital is somewhat swollen and is much larger than any of the others. All five carry tubercles, 2 or 3 on the proximal margin of each plate.— The buccal plates (Pl. 98, fig. *1*) are of moderate size and are well spaced. Proximal to them the membrane is thickly covered with small plates but distally these become more and more scattered and a considerable part of the membrane is perfectly bare. The gill-cuts are well defined but are neither narrow nor deep. The primary spines are about 3 mm. long, stouter, and distinctly longer than the secondaries. The test is very light purplish, noticeably darker abactinally, particularly on the median interambulacral areas; on and around the abactinal system there is a very evident greenish tinge. The primary spines are light purple rather abruptly tipped with whitish. The smaller spines are much lighter.

In the smaller specimen, there are only 9 interambulacral and 10 ambulacral plates in each column. The arcs of pores contain only 4 pairs from the ambitus adorally but 5 aborally. The arcs are not so clearly divided into an inner pair and an outer trio by a small tubercle as in the larger specimen. Ocular V is wholly exsert and a genital pore is visible only in genital 1. The primary spines are purplish only at base and the terminal part is light greenish.

The pedicellariæ of *pulchellus* are quite characteristic, particularly the *globiferous*, the valves of which (Pl. 94, figs. *24*, *25*) are only about .50 mm. long; the base of the valves is .27 or .28 mm. wide and the terminal tooth is about .20 mm. long. These pedicellariæ are common and the stalks are about twice as long as the head. The *ophicephalous* pedicellariæ have valves about .20–.35 mm. in length, besides the loop which is .03–.12 mm. more; the valves are somewhat constricted at base of blade, but not greatly so. The *tridentate* seem to be quite rare; they have straight, narrow valves (Pl. 94, fig. *26*) only about half a millimeter long, and more or less in contact throughout. The *triphyllous* have the valves about .12 mm. long and the truncate tip of the blade is about .09 or .10 mm. wide. The sphæridia (Pl. 94, fig. *27*) are fairly numerous and seem to be rather elongated; they measure about .20 mm. in length but the width is scarcely half as much. Spicules are scarce in the pedicels; they are C-shaped with the ends branched.

While this species is certainly nearly related to *intermedius* and *dröbachiensis*, the globiferous pedicellariæ are sufficient to distinguish it from those or any other species.

It was taken by the "Albatross" only at the two following stations: —

Station 4794. Off east coast of Kamchatka, 52° 47′ 20″ N., 158° 44′ 30″ E. Bott. temp. ? 58–69 fathoms. S., p.

Station 5003. Off southwestern coast of Saghalin Island, 47° 32′ 30″ N., 141° 45′ E. Bott. temp. 42.4°. 35–38 fathoms. Fne. gy. s., gn. m.

Two specimens.

Strongylocentrotus dröbachiensis A. Ag.

Echinus dröbachiensis O. F. Müller, 1776. Prodrom. Zool. Dan., p. 235.
Strongylocentrotus dröbachiensis A. Agassiz, 1872. Rev. Ech., pt. 1, p. 162.

The large series of specimens brought in by the "Albatross" taken in connection with the hundreds of specimens in the M. C. Z. collection make the true limits of this widespread and variable species more uncertain than ever. Although recognizing the apparent inconsistency of considering *chlorocentrotus* and *carnosus* synonyms of *dröbachiensis*, while retaining *intermedius, sachalinicus, polyacanthus,* and *echinoides* as valid species, it is not easy to see any better solution of the difficulty. In length of primary spines, in abundance of tubercles, and in color, *dröbachiensis* is exceedingly variable. In some places, Puget Sound for example, the deeper-water specimens have long primaries and are light colored, while those from shallow water have short thick spines and a much darker coloration. The largest and finest specimen seen, is from "Albatross" Station 4302; it is 90 mm. in diameter and is very light colored. In its coloration indeed it approaches *echinoides*, but it is distinctly greener. The test is very pale brown or dirty cream-color and the spines are light green abactinally but become cream-color below. The longest primaries are nearly 22 mm. long. The arcs of pores above the ambitus contain 6 pairs, very rarely 7. (I have never seen 8 in *dröbachiensis* although that number is recorded and there is no good reason why it may not occur occasionally as an extremely progressive variation). Oculars I and V are broadly insert but the other three are quite as fully exsert. The suranal plate is large and hence easily distinguished. Pedicellariæ are exceedingly abundant.

The "Albatross" specimens were taken at the following places: —

Station 2878. Off Washington, 48° 37′ N., 125° 32′ W. Bott. temp. 45.5°. 66 fathoms. P.

Station 4200. Off Fort Rupert, Vancouver Island, British Columbia. Bott. temp. 46.8°. 68 fathoms. Gn. m., s., sponge.

Station 4205. Admiralty Inlet, near Port Townsend, Washington. Bott. temp. 50.8°. 15–26 fathoms. R., sh.

Station 4208. Admiralty Inlet, near Port Townsend, Washington. Bott. temp. 50.5°. 83–99 fathoms. Rky.

Station 4223. Boca de Quadra, southeastern Alaska. Bott. temp. 44.6°. 48–57 fathoms. Sft. gn. m.

Station 4245. Kasaan Bay, Prince of Wales Island, southeastern Alaska. Bott. temp. 48.9°. 95–98 fathoms. Dk. gn. m., s., sh., r.

Station 4262. Off Point Wimbleton, Dundas Bay, Icy Strait, Alaska. Bott. temp. ? 9 fathoms. Crs. s., rky.

Station 4270. Afognak Bay, Afognak Island, Alaska. Bott. temp. ? 14–19 fathoms. Hrd. gy. s., r.

Station 4278. Alitak Bay, Kadiak Island, Alaska. Bott. temp. ? 27–29 fathoms. Dk. gn. m.

Station 4280. Chignik Bay, Alaska. Bott. temp. ? 43 fathoms. Gn. m., fne. s.

Station 4285. Chignik Bay, Alaska. Bott. temp. ? 31–59 fathoms. Gy. s., brk. sh.

Station 4287. Uyak Bay, Kadiak Island, Alaska. Bott. temp. 43 ? 66–67 fathoms. Gy. m.

Station 4289. Uyak Bay, Kadiak Island, Alaska. Bott. temp. 42.2. 74–80 fathoms. Gy. m.

Station 4302. Off Shakan, Sumner Strait, southeastern Alaska. Bott. temp. 44.2°. 169–212 fathoms. Bu. m.

Port Townsend, Washington.

Union Bay, British Columbia.

Dutch Harbor, Unalaska.

Attu, Aleutian Islands.

Agattu, Aleutian Islands.

Medni, Komandorski Islands.

Bering, Komandorski Islands.

Petropavlovsk, Siberia.

Bathymetrical range, shore — 212 fathoms. Extremes of temperature, 50.8°–42.2°.

One hundred and thirteen specimens.

Strongylocentrotus echinoides A. Ag. and Cl.

Strongylocentrotus echinoides A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 122.

Plates 94, figs. *13–16;* 113, fig. *1*.

This species is so near to *dröbachiensis* that its separation as a distinct species is open to grave doubt, yet when specimens of the same size are compared *echinoides* shows certain features that lead one to consider it such. The light color of the test is very noticeable, being more or less reddish white, but specimens of *dröbachiensis* of essentially the same color have been seen. The light green and reddish shades of the spines are quite different from most specimens of *dröbachiensis,* but this difference is by no means constant. The difference in the granulation of the plates is noticeable, for while in *dröbachiensis,* an abactinal interambulacral plate may have 50–75 small secondary and miliary tubercles, in *echinoides* there are twice as many. In the ambulacra, there is an important difference, in that the arcs of pores are less horizontal, the ambulacral plates being correspondingly higher and therefore fewer. Thus, in a *dröbachiensis,* with about 20 interambulacral plates in each column, there are 35 ambulacral plates, but in an *echinoides* with 20 interambulacrals, there are only 27 or 28 ambulacrals. The arcs of pores in *dröbachiensis,* in the mid-zone, have 6 pairs, occasionally 7, while in *echinoides* they have 7, occasionally 6. The poriferous areas are distinctly narrower in *echinoides.* The primary spines of *echinoides* are longer and more slender than in most specimens of *dröbachiensis,* but specimens of the latter from Puget Sound cannot be distinguished from *echinoides* in this respect.

The pedicellariæ of the two species are indistinguishable so far as any characters of importance are concerned. In *echinoides,* the *globiferous* pedicellariæ have valves .40–1.00 mm. in length (Pl. 94, figs. *15, 16*); the length of the blade is about equal to the width of the base while the length of the terminal tooth is about one half as much. In the *tridentate* (Pl. 94, fig. *13*) which vary enormously in size, the valves are .20–2.00 mm. long; in the small ones the valves are narrow and meet for most of their length but in the large ones, the blades are somewhat expanded at the tip and meet only there. In the *ophicephalous,* the valves (Pl. 94, fig. *14*) are about half a millimeter long, besides the loop, and are distinctly constricted at base of blade. In the *triphyllous,* the valves are about .15 mm. long. All these different kinds of pedicellariæ are abundant, but the more globiferous there are, the fewer the tridentate and *vice-versa.* All forms have a neck but on the globiferous it is very short. The spicules show great diversity; they may be simply bihamate, or rods, more or less curved, more or less flattened and more or less branched at the tips.

The geographical distribution of *echinoides* apparently coincides with that of *dröbachiensis,* in the North Pacific, as will be seen from the table of stations given below. When described it was supposed to be confined to the western side of the ocean but a specimen from Alaska and another from off Oregon is at hand. The former is quite young but the latter is an adult in fine condition and very typical of the species, and there seems to be no reason for doubting the correctness of the label. The following list shows the conditions under which *echinoides* lives: —

Station 3053. Off Oregon, 44° 4′ 30″ N., 124° 50′ W. Bott. temp. 47.3°. 64 fathoms. Co., brk. sh., rky.

Station 4253. Off Thistle Ledge, Stephens Passage, Alaska. Bott. temp. 40.9°. 131–188 fathoms. R., brk. sh.

Station 4777. Petrel Bank, Bering Sea, 52° 11′ N., 179° 49′ E. Bott. temp.? 43–52 fathoms. Fne. g.

Station 4778. Petrel Bank, Bering Sea, 52° 12′ N., 179° 52′ E. Bott. temp.? 33–43 fathoms. Fne. blk. g.

Station 4779. Petrel Bank, Bering Sea, 52° 11′ N., 179° 57′ W. Bott. temp.? 54–56 fathoms. Brk. sh., p., s.

Station 4782. Off East Cape, Attu Island, Aleutians, 52° 55′ N., 173° 27′ E. Bott. temp.? 57–59 fathoms. R., g.

Station 4784. Off East Cape, Attu Island, Aleutians, 52° 55′ 40″ N., 173° 26′ E. Bott. temp.? 135 fathoms. Crs. p.

Station 4786. Between Medni and Bering Islands, Komandorskis, 54° 51′ 30″ N., 167° 14′ E. Bott. temp.? 54 fathoms. Gn. s.

Station 4787. Between Medni and Bering Islands, Komandorskis, 54° 50′ 50″ N., 167° 13′ 30″ E. Bott. temp.? 54–57 fathoms. Gn. s.

Station 4788. Between Medni and Bering Islands, Komandorskis, 54° 50′ 24″ N., 167° 13′ E. Bott. temp.? 56–57 fathoms. Gn. s.

Station 4789. Between Medni and Bering Islands, Komandorskis, 54° 49′ 45″ N., 167° 12′ 30″ E. Bott. temp.? 56 fathoms. Gn. s.

Station 4790. Between Medni and Bering Islands, Komandorskis, 54° 38′ 45″ N., 167° 11′ 45″ E. Bott. temp.? 64 fathoms. P.

Station 4791. Between Medni and Bering Islands, Komandorskis, 54° 36′ 15″ N., 166° 58′ 15″ E. Bott. temp.? 72–76 fathoms. Rky.

Station 4792. Between Medni and Bering Islands, Komandorskis, 54° 36′ 15″ N., 166° 57′ 15″ E. Bott. temp.? 72 fathoms. P.

Station 4794. Off eastern coast of Kamchatka, 52° 47′ 20″ N., 158° 44′ 30″ E. Bott. temp.? 58–69 fathoms. S., p.

Station 4795. Off eastern coast of Kamchatka, 52° 46′ 50″ N., 158° 44′ 30″ E. Bott. temp.? 48–69 fathoms. Gn. s., p.

Station 4796. Off eastern coast of Kamchatka, 52° 47′ N., 158° 43′ E. Bott. temp.? 48 fathoms. S., p., sh.

Station 4804. Off Simushir Island, 46° 42′ N., 151° 47′ E. Bott. temp. 35.9°? 229 fathoms. Crs. p., bk. s.

Station 4810. Between Hakodate and Sado Island, Japan, 41° 17′ 20″ N., 140° 7′ E. Bott. temp. 44.7°. 90–195 fathoms. Fne. gy. s.

Station 4822. Between Nanao and Tsuruga, Hondo, Japan, 37° 8′ 10″ N., 137° 8′ E. Bott. temp. 39.4°. 130 fathoms. Gn. m.

Station 4982. Between Hakodate and Otaru, Hokkaido, Japan, 43° N., 140° 10′ 30″ E. Bott. temp. 32.7°. 390–428 fathoms. Gn. m.

Station 4987. Between Hakodate and Otaru, Hokkaido, Japan, 43° 19′ 20″ N., 140° 17′ E. Bott. temp. 44.8°. 59 fathoms. Rky.

Station 4993. Between Otaru, Hokkaido, and Korsakov, Saghalin, 45° 25′ 30″ N., 140° 53′ E. Bott. temp. 35.1°. 142 fathoms. Gy. m., s., g.

Station 4996. Between Otaru, Hokkaido, and Korsakov, Saghalin, 45° 35′ N., 140° 55′ E. Bott. temp. 43.4°. 86 fathoms. Bk. s., p.

Station 5016. Off eastern coast, southern end of Saghalin, 46° 44′ 30″ N., 143° 45′ E. Bott. temp. 29.8°. 64 fathoms. Br. m., fne. bk. s., r., co.

Station 5041. Off southern coast of Hokkaido, Japan. 42° 16′ 30″ N., 142° 4′ E. Bott. temp. 49.8°–41.1°. 61–140 fathoms. Br. m., fne. bk. s., co., s.

Station 5048. Between Hakodate and Yokohama, Japan, 38° 9′ 24″ N., 141° 52′ 30″ E. Bott. temp. 40.7°. 129 fathoms. Dk. gy. s., brk. sh.

Station 5049. Between Hakodate and Yokohama, Japan, 38° 12′ N., 142° 2′ E. Bott. temp. 37.8°. 182 fathoms. Dk. gy. s., brk. sh.

Bathymetrical range, 33–428 fathoms. Extremes of temperature, 49.8°–29.8°.

One hundred and sixty-four specimens.

Strongylocentrotus polyacanthus A. Ag. and Cl.

Strongylocentrotus polyacanthus A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 123.

Plates 94, figs. *30–33;* 113, fig. *2.*

This species is so near to *dröbachiensis*, that it would be quite superfluous to give a detailed description of the single specimen upon which it is based.

The test is 73 mm. in diameter and 40 mm. high. When compared with a specimen of *dröbachiensis* of the same size, the only noticeable difference, aside from the characteristic coloration, is the smaller size and larger number of the primary tubercles, and spines. There are 25 or 26 interambulacral plates, and 39 or 40 ambulacral, in each column, while in a *dröbachiensis*, 75 mm. h. d. and 42 mm. high, the numbers are 22 and 38 respectively. The primary spines of the latter specimen are 11 or 12 mm. long, while those of *polyacanthus* are only 6–8 mm. The arc of pore-pairs are essentially as in *dröbachiensis*, oblique approaching the horizontal, and with only *six* pairs in each arc. The test and spines are uniformly dull rose-purple, without a trace of green.

The pedicellariæ show some characters which may prove to be of importance. The *globiferous* are all small and the valves (Pl. 94, figs. *31, 32*) have a short terminal tooth; they are about .50 mm. long with the terminal tooth scarcely one fourth as much. The *ophicephalous* are peculiar in that the valves (Pl. 94, fig. *33*) which measure .40–.60 mm. in length, are not at all constricted but are bluntly triangular in form; the articular loops are also noticeably low and flattened. The *tridentate* pedicellariæ (Pl. 94, fig. *30*) are all rather long and narrow; none of those, so common in *dröbachiensis*, with broad curved blades, were found; the valves are .40–1.60 mm. in length and are more or less fully in contact throughout. The *triphyllous* are very common and show some diversity in the relative width of the blade; the valves are about .15 mm. long. The calcareous spicules are either bihamate or curved rods with branched ends.

The single specimen of this species was taken by the collectors of the "Albatross" on the shores of Milne Bay, Simushir Island, Kuril Group, Northern Japan, June 23, 1906.

Strongylocentrotus nudus A. Ag.

Toxocidaris nuda A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 356.
Strongylocentrotus nudus A. Agassiz, 1872. Rev. Ech., pt. 1, p. 165.
Strongylocentrotus hokkaidensis Döderlein, 1906. Zool. Anz., XXX, p. 518.
Strongylocentrotus tuberculatus A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 122. Non *Echinus tuberculatus* Lam'k.

Plate 94, figs. *17–23.*

In view of the fact that this species is now known to be one of the common sea-urchins of northern Japan but does not appear to occur in the warmer southern seas of that country, it seems very probable that the original specimens, brought home by the United States Exploring Expedition and described in 1863, were all from Hakodate and not in part from Hilo, Hawaii, as they were labelled. Original specimens in the M. C. Z. collection from "Hilo. W. Stimpson" and "N. E. end of Niphon. W. Stimpson" are indistinguishable. This view is confirmed by the fact that the "Albatross" failed to collect any Strongylocentrotus in the Hawaiian Islands.

The pedicellariæ of this species show some interesting features. The *globiferous* are not rare in very young specimens but are less common in those half grown and are almost entirely wanting in adults. The reverse of this is true of the tridentates, which are very common in adults and occur in two or three different forms, but are less common in half grown specimens, and are rare in very young individuals. The globiferous appear to be of two different sizes, one with valves .30 mm. long and the other with valves about .80 mm. (Pl. 94, figs. *18, 19*). It is possible these forms intergrade but intermediate sizes do not occur in the M. C. Z. material. The *tridentate* occur in such a variety of forms that it is not easy to group them exactly, but three rather distinct kinds may be recognized. In one of these the valves (Pl. 94, fig. *21*) are from .20 to .50 mm. in length, rather wide and flat, bluntly rounded and in contact for most of their length; in a second, the valves (Pl. 94, figs. *22, 23*) are very long (1.5–2 mm.) and narrow and in contact only for more or less of their distal half; in the third, the valves are about 1.5 mm. long, with broad, curved blades in contact at their tips. The *ophicephalous* occur in two forms, one with valves .20 mm. besides the loop and the other about .50 mm. also besides the loop; the valves are noticeably constricted. The *triphyllous* (Pl. 94, fig. *20*) are neither rare nor peculiar. The spicules are not common; they are curved rods, branched at the ends.

The specimens taken by the "Albatross" range from 23 to 75 mm. in diameter. The smallest is dull purplish with an evident greenish tinge abactinally, while the spines are more or less greenish. There are *six* pairs of pores in each arc in the mid-zone but the uppermost arcs contain *seven* as a rule. In the larger specimens, the color is uniformly dark reddish brown with no trace of green. In the largest specimen, there are *six* pairs of pores in each arc at the ambitus, but just above, there are a few arcs with seven; then follow a few with six and the uppermost have only five, indicating a senescent change.

The "Albatross" collected this species at the following stations: —

Station 4807. Between Hakodate and Sado Island, Japan, 41° 36′ 12″ N., 140° 36′ E. Bott. temp. ? 44–47 fathoms. Sh., crs. g.

Station 5018. Off Cape Tonin, Saghalin Island, Japan. 46° 41′ 30″ N., 143° 57′ 40″ E. Bott. temp 30.4°. 100 fathoms. Br. m., bk. s., p.

Hakodate.

Seven specimens.

ECHINOMETRIDÆ Gray.

General Considerations.

There can be little question that this family includes the most highly specialized of the recent regular Echini, for the elongation of one axis, when combined with highly developed ambulacra, indicates an unusual complexity of structure. And yet in the characters of the abactinal system and the globiferous pedicellariæ, the more specialized Echinidæ, such as Tripneustes, are apparently more advanced than any of the Echinometridæ, and it is therefore merely a matter of opinion whether Tripneustes or Heterocentrotus is considered the "highest" of the regular Echini. They represent different lines of development and cannot properly be considered competitors. Since, however, the ambulacra are held to be the most important structures of an echinoid and the multiplication of ambulacral elements the best evidence of increasing specialization, we do not hesitate to rank the Echinometridæ as the last and highest of the families of Regulares. In addition to the characters already mentioned, Jackson (1912, Mem. Boston Soc. Nat. Hist., VII) has brought out the interesting fact that in the Echinometridæ, ocular V is the first to become insert instead of ocular I as in the Echinidæ and Strongylocentrotidæ. This seems a very significant fact when taken in connection with the small size of the abactinal system.

The family is confined to the tropics and is made up entirely of reef-dwelling, littoral species. With the exception of the two West Indian Echinometras, none of the family are found outside of the Indo-Pacific region. It is interesting to note that with only two exceptions, there are no localities north or south of 30° latitude, where members of the family are known to occur. One of these exceptions is the Bermuda Islands, which are north of 30° N., where *Echinometra lucunter* is common, and the other exception is Lord Howe Island, which is south of 30° S., where *Echinometra mathæi* occurs. The old record of the occurrence of the latter species at the Cape of Good Hope has not been confirmed by later collecting and is doubtless erroneous, while the reported occurrence of an Echinometra in New Zealand waters (Index Faunæ Novæ Zealandiæ, p. 288), supposedly based on the collections of the "Challenger," is obviously erroneous, as the "Challenger" collected no shallow water Echini whatever, in that region.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plate 95, figs. *1–15*.

In no other family do the spines reach such a degree of specialization as they do in the Echinometridæ. While Parasalenia and Echinometra are not remarkable in this respect, the remaining genera are extraordinary. In Heterocentrotus, the primary spines have become so long and stout, as to give the animal a very heavy appearance, while the secondaries, though not lengthened are greatly thickened. In Colobocentrotus and Podophora on the other hand, the spines are all reduced to a uniform length abactinally and being correspondingly thickened, they have come to form a close, smooth covering over the whole upper surface. Although little is known of the habits of the species, contained in these three genera, it can hardly be doubted that these remarkable modifications of the spines are due to the conditions under which they live on surf-exposed reefs. Even in Echinometra, a tendency for the abactinal secondary spines to become modified in a manner somewhat similar to that shown by Podophora is found.

The pedicellariæ of the Echinometridæ are not sufficiently different from those of the Strongylocentrotidæ to warrant any extended description. The valves of the *globiferous* have as a rule, a single lateral tooth on the left side but this is wanting in Parasalenia and there is considerable diversity, in Podophora, the lateral tooth sometimes occurring on the right side, and occasionally either it or the terminal tooth is paired (see A. Agassiz, 1908, Mem. M. C. Z., XXXIX, Pl. 5, figs. *10–13*). As a rule, these pedicellariæ are smaller than in the Echinidæ and Strongylocentrotidæ, but in some species they are well developed. The *ophicephalous*, *tridentate*, and *triphyllous* pedicellariæ are commonly present in large numbers and reveal great diversities of form, even within a single species. As they have been very fully illustrated for Colobocentrotus and Podophora (A. Agassiz, 1908, l. c.), it would be quite superfluous to figure or discuss them in detail here. The tridentate in spite of their diversity sometimes furnish excellent specific characters.

The sphæridia occur as in the related families on the actinal portion of each ambulacrum. There are commonly 4–6 in each area but there may be 8 or even more. They show great diversity in form, as has been very fully shown recently, for Colobocentrotus and Podophora (A. Agassiz, 1908, Mem. M. C. Z., XXXIX, Pls. 31 and 32).

The calcareous spicules of the pedicels, show an unusual diversity. They are most commonly bihamate but in Echinometra they are often triradiate. In Parasalenia, they are very peculiar in having two little projections on the concave side, quite unlike anything seen in other Echini.

The Genera and Species of Echinometridæ.

Generic distinctions in this family are quite sharp and it is easy to distinguish the five which seem valid. Specific distinctions are on the contrary remarkably ill-defined and except in Podophora, it is a matter of difficulty to decide just how many species ought to be recognized. Döderlein's attempt to distinguish *Echinometra oblonga* as the type of a new genus seems peculiarly unfortunate, not merely because the character is microscopic but because it is very variable and is not distinctive. Triradiate spicules occur in the pedicels of *Echinometra picta*, *Van Brunti*, and especially *viridis*, as well as in those of *oblonga*. It is true that some specimens of *oblonga* have a much greater development of such spicules than are ever seen in any other species, but there is great individual diversity; I have never seen a specimen with nearly as many as those photographed by Döderlein appear to have possessed, while on the other hand, some specimens have very few. Far from considering *oblonga* as worthy of generic rank, de Meijere's view that it is simply an extreme form of *mathæi* seems much more probable, for a considerable number of specimens have been seen which could be assigned to one species or the other only quite arbitrarily.

The characters which are of most service in distinguishing the genera of this family, are the position of the long axis, the structure of the ambulacra, the covering of the periproct, and the character of the spines.

The following table will show how these are grouped in the different genera here recognized: —

Long axis through IIIb–5b; ambulacral plates of 3 elements; periproct covered by 4 subequal plates; spines not peculiar . . . . *Parasalenia.*

Long axis to the left of IIIb–5b; ambulacral plates of more than 3 elements; periproct with numerous plates.

- Long axis through 3–1; ambulacral plates of 4–8 elements; spines not peculiar *Echinometra.*
- Long axis through IVb–1b or 4a–IIa; ambulacral plates of 9–19 elements; spines extraordinarily modified.
  - Primary spines very short, thick and flat-topped, forming a smooth abactinal pavement.
    - Primary tubercles very large, at least in mid-zone, 3–6 in an irregular horizontal row on each interambulacral plate . . . . *Podophora.*
    - Primary tubercles moderate, in mid-zone 10–12 in two horizontal series on each interambulacral plate . . . . *Colobocentrotus.*
  - Primary spines remarkably long, stout, heavy . . . . *Heterocentrotus.*

PARASALENIA.

A. Agassiz, 1863. Bull. M. C. Z., I, p. 22.
Type-species, *Parasalenia gratiosa* A. Agassiz, 1863, l. c.

This is a very interesting genus and its affinities are by no means clear. The ambulacra are echinoid, the anal plates are like Arbacia, while the form of the test is like Echinometra. The spines are externally like Echinometra and the differences internally are hardly as important as McIntosh and Mortensen seem to think. When compared with Echinometra-spines of the same size, those of Parasalenia are not essentially different. The lantern, teeth, and auricles are like those of small Echinometras, except that there are apparently no projections on the epiphyses for the support of the teeth. It is clear from these important structures about the mouth, that there is no near relationship to Arbacia, and the pedicellariæ confirm this conclusion. Except that the lateral tooth is lacking on the left side of the narrow blade, there is nothing about the globiferous pedicellariæ to distinguish them from those of Echinometra, and the other forms are even less peculiar. The calcareous spicules in the pedicels of Parasalenia are very characteristic but they do not indicate relationship to any other group. On the whole it seems that Parasalenia is an isolated offshoot from the echinid stock from which the Echinometridæ have sprung and that it is not properly a part of that family from the phylogenetic point of view, but as a matter of convenience it may be placed therein.

Whether the genus contains more than one valid species seems uncertain. Owing to insufficient material the status of *Pöhlii* is doubtful. Typical specimens of the two nominal species are very different but as is so often the case, there are certain specimens which are perfectly intermediate at least in many ways. The red coloration of *Pöhlii* is very noticeable and extends even to the calcareous matter in the pedicellariæ but specimens of *gratiosa* are sometimes quite red, especially when young. The primary spines of *gratiosa* are sometimes banded and if such specimens are also more or less red, the resemblance to *Pöhlii* is very marked. In our specimens of *Pöhlii*, genital 3 is excluded from contact with the periproct, by the meeting of genitals 2 and 4, but whether this is a constant specific character, is not known; if it is, it is an excellent one. In our specimens, globiferous pedicellariæ are extremely rare, and tridentate fairly common in *gratiosa*, while in *Pöhlii*, the globiferous are abundant while the tridentate are very rare; but it may be doubted if this difference holds thoughout the species.

What seem to be the real specific differences may be stated as follows: —

Periproct moderately large, its long diameter about $\frac{1}{3}$ that of the long diameter of the abactinal system; each genital plate with at least one well-developed tubercle *gratiosa*.
Periproct very small, its long diameter less than $\frac{1}{4}$ that of the long diameter of the abactinal system; genital plates without tubercles . . . . *Pöhlii*.

Parasalenia gratiosa A. Ag.

Parasalenia gratiosa A. Agassiz, 1863. Bull. M. C. Z., I, p. 22.

The coloration of adult specimens of this species is very striking for the test and spines are very dark, more or less nearly black, while the milled ring of each primary spine, is pure white, in marked contrast. Half grown specimens are much lighter, usually a sort of reddish brown. In really young specimens, the shade is often very nearly red, and the spines are more or less banded. The only specimen brought home by the "Albatross" has the long axis 11 mm. and the short one, 8 mm. It has a distinctly roseate tinge and the primary spines are banded, though not with red and white. The secondary spines, and the bases and tips of the primaries are dull pink; the remainder of each primary is light greenish brown with three indistinct bands of a much lighter shade; the milled rings are pearly white. The long diameter of the abactinal system is 4 mm. and that of the periproct is almost 2. All of the genital plates are in contact with the periproct but not one of them has even a minute tubercle! Such a specimen renders the distinctness of *Pöhlii* doubtful.

Makemo, Paumotus, Oct. 21, 1899.

Parasalenia Pöhlii Pfeff.

Parasalenia Pöhlii Pfeffer, 1887. Verhandl. Ver. Naturw. Unterh. Hamburg, VI, p. 110.

Plate 95, figs. *1–5*.

It has seemed desirable to give a few figures illustrating the pedicellariæ of this species, for the purpose of making easy, comparison with those of Echinometra. Only one *tridentate* was found (Pl. 95, fig. *1*); it had an exceedingly long neck and slender valves about a millimeter long, and is not essentially different from those of *gratiosa* and Echinometra. The *globiferous* are abundant, usually with glands (Pl. 95, fig. *3*) but occasionally without (Pl. 95, fig. *2*); they vary much in size, the valves (Pl. 95, fig. *4*), which lack a lateral tooth on the blade (Pl. 95, fig. *5*), ranging from .30 to .60 mm. The *ophicephalous* and *triphyllous* are small but fairly common, and the former have the calcareous matter in the valves distinctly red. In other respects, these pedicellariæ cannot be distinguished from those of *gratiosa* and Echinometra.

Echinometra.

Gray, 1825. Ann. Phil., XXVI, (n. s. X), p. 426 (4 of reprint).
Type-species, *Echinus lucunter* Linné, 1758. Syst. Nat., ed. 10, p. 665.

Although this genus is so well characterized, one occasionally meets with a specimen, usually young, in which the long axis is so little longer than the short one, that it is necessary to measure the specimen to determine which is the long axis. Such specimens have very naturally a close resemblance to individuals of Heliocidaris and Strongylocentrotus, but they can usually be distinguished without difficulty by the flatness of the test, which is generally very marked, and by the large size of the auricles.

The number of valid species of Echinometra is far from being satisfactorily determined. There are few Echini so variable in form and color as *E. Mathæi* and it may well be doubted whether *oblonga* is anything more than an extreme form of that species, and *picta* is probably not specifically distinct. Both these species are retained however, that the points in which they differ from *Mathæi* may be emphasized, in the hope that some zoölogist who has a favorable opportunity, such as the Hawaiian Islands afford, may make a careful study of the diversity shown by the Indo-Pacific Echinometras. The American species, *lucunter* and *Van Brunti*, are quite easily distinguished from the others by the large number of pore-pairs in each arc, but they are not so easily distinguished from each other. The difference in the auricles however is surprisingly constant and will separate all but very young specimens. The differences in the shape of the test, the length of the primary spines, and the character of the tridentate pedicellariæ seem to be less constant, though they are all useful. *Ellipsechinus macrostomus* Ltk. seems to be only a large specimen of *Echinometra lucunter* from the eastern Atlantic Ocean. Large specimens from the Cape Verde Islands have 8 pore-pairs in many of the arcs and answer well to Lütken's description, except for the position of the long axis. Dr. Mortensen has however reëxamined Lütken's type and has kindly assured me that the long axis is erroneously given in the description, and that it really coincides with that of Echinometra. The specimens brought home by the "Albatross" from Easter Island have proven very interesting, for their superficial appearance is so much like that of *Van Brunti*, it was not until the ambulacra were examined that their nearer relationship to *Mathæi* became evident. The difference from *Mathæi* is however so constant as to require a new species, *insularis*, for this interesting form. Jackson (1911, Mem. Boston Soc. Nat. Hist., VII, p. 147) has shown that *lucunter* and *Van*

Brunti differ from the other members of the genus, in that ocular V is insert in the great majority of specimens, whereas in all of the others the oculars are usually all exsert. It is interesting to note that in *Van Brunti,* which is most progressive as regards number of elements in an ambulacral plate, we find the most progressive abactinal system, oculars V and I being insert in nearly three quarters of the specimens.— The largest Echinometras seen are from Bermuda and the Abrolhos Reefs, Brazil. They measure from 85–95 mm. in length and are about 75–85 mm. wide and 42–48 mm. high. Great diversity is shown in the genus in the relative length, breadth, and height of the test. The breadth ranges from .75 to .96 of the length; when it is as much as .95, small specimens of course appear to be circular in outline. The height ranges from .40 to .63 of the length; as a rule low specimens are wide and high specimens are narrow.

In distinguishing the seven species herein recognized, the number of pore-pairs in an arc is considered of first importance, for while there is more or less variation from the normal number, yet in the mid-zone and above, the variation is slight, until one approaches the ocular; of course in young specimens, the largest number of pores will be above the mid-zone. The form of the test, the structure of the auricles and the character of the primary spines prove to be more or less useful points in most of the species. The pedicellariæ are of little use, though the tridentate have a characteristic form in at least one species. In some cases, color may be of use for distinguishing a given species but it is very unreliable and in *Mathœi* at least is almost useless. The size and tuberculation of the abactinal system and even the form of the abactinal secondary spines are useful characters in recognizing some species.

The following table shows how the seven species may be distinguished: —

Pore-pairs, at or above ambitus, 4 or 5 in each arc, and not rarely 6.
  Pore-pairs in arcs of 4, not rarely 5.
    Color very rarely black; primary spines variable but usually pointed and their thickness generally much less than ten per cent of their length.
      Height of test usually .55–.63 of length; abactinal system .15–.25 of test-length; usually 3 or more secondary tubercles on each genital plate; color of primary spines very variable, often dark purplish or reddish, frequently tipped with yellow or red . . . . *Mathœi.*
      Height of test less than half the length; abactinal system .20–.30 of test-length; seldom more than one secondary tubercle on each genital plate; primaries usually light fawn-color or greenish, but sometimes dark with light tips . . . . *picta.*
    Color usually black, rarely dull purplish gray or even dull red; primary spines short, stout, and usually blunt, their thickness .12–.22 of their own

length; primary tubercles correspondingly big, especially noticeable abactinally; height of test usually .55–.60 of its length . . . . *oblonga.*

Pore-pairs in arcs of 5, not rarely 6.

Primary spines deep purplish or reddish; abactinal system with numerous secondary and miliary spines, many of which are low, thick and truncate, or capitate; ambulacra petaloid actinally . . . . . *insularis.*

Primary spines light brownish, more or less extensively green distally, usually purple-tipped; abactinal system remarkably free from spines; ambulacra not petaloid actinally . . . . *viridis.*

Pore-pairs, at or above ambitus usually 7 or 8 in each arc, rarely only 6.

Auricles stout with conspicuous supplementary "tags," arising vertically from their united ends; few, sometimes none, of the arcs of pores with more than 6 pairs; test usually more than half as high as long with the width usually about .85 of the length; primary spines usually much shorter than width of test; valves of tridentate pedicellariæ narrow at tip, in contact for most of their length . . . . *lucunter.*

Auricles slender without conspicuous "tags"; pore-pairs usually 7 or 8; test about half as high as long or less; width generally .90–.95 of length; primary spines nearly equal to short diameter of test; valves of tridentate pedicellariæ widened at tip and in contact only distally . . . . *Van Brunti.*

Echinometra Mathæi Bl.

Echinus Mathæi de Blainville, 1825. Dict. Sci. Nat., XXXVII, p. 94.
Echinometra Mathæi de Blainville, 1830. Dict. Sci. Nat., LX, p. 206.

The specimens of this very common and wide spread sea-urchin, which the "Albatross" collected from various parts of the Pacific, reveal the usual diversities of color and form. Some of them are very fine examples of the typical form, except that there are none in which the color is at all green. The finest specimens are from Laysan and Manga Reva. The former have the test dark brown, with the spines light pinkish fawn-color; the largest is 64 mm. long, 53 wide and 40 high. Those from Manga Reva are not so large but are much more handsomely colored as the spines are light purplish gray abruptly tipped with cream-color.

The following are the places, whence specimens were collected: —

Station 3959. Near Laysan Island, Hawaiian Islands, 10 fathoms. Wh., s., co.

Laysan Island, H. I.
Necker Island, H. I.
Kamalina Bay, Niihau, H. I.
Honolulu Reef, Oahu, H. I.
Waikiki Beach, Oahu, H. I.
Hilo, Hawaii, H. I.
Bora-bora, Society Islands.
Fakarava, Paumotu Islands.
Makemo, Paumotu Islands.
Rangiroa, Paumotu Islands.
Manga Reva, Paumotu Islands.

Forty-nine specimens.

Echinometra picta A. Ag. and Cl.

Echinometra picta A. Agassiz and Clark, 1907. Bull M. C. Z., L, p. 241.

Plates 95, figs. *6–12;* 114, figs. *5, 6.*

The more the specimens on which this species is based are studied the more doubtful it seems whether it is really distinct from *Mathœi,* but the figures of typical specimens, as well as of the pedicellariæ, will enable other zoölogists to recognize the form to which attention is called. In such specimens, the test is distinctly flattened and wider than usual, the height being less than one half the length, while the shorter diameter is about .85–.90 of the longer. The spines seem to be less crowded and are somewhat more slender than in *Mathœi,* and are much less numerous on the abactinal system. The latter is distinctly larger than in that species, its diameter sometimes nearly equalling one third of the test-length. The color is dark brown for the test and light fawn-color for the spines. Such specimens as these occur only in material from the Hawaiian, Society, and Philippine Islands. They intergrade with *Mathœi* in each one of these characters taken by itself, more or less fully, but are usually easily distinguished by their general appearance resulting from the combination of all five. The pedicellariæ (Pl. 95, figs. *6–12*) show no characteristic peculiarities, but the various forms illustrative of the genus are figured.

The "Albatross" collected *picta* at the following places: —

Station 3881. Napili Harbor, Maui, Hawaiian Islands.

Station 3975. Off Necker Island Shoal, H. I. 16–171 fathoms. Crs. S., co., sh.

Necker Island, H. I.
Kamalina Bay, Niihau, H. I.
Waianae, Oahu, H. I.
Honolulu Reef, H. I.
Puako Bay, Hawaii, H. I.
Hilo Bay, Hawaii, H. I.
Fakarava, Paumotu Islands.

Thirty-four specimens.

Echinometra oblonga Bl.

Echinus oblongus de Blainville, 1825. Dict. Sci. Nat., XXXVII, p. 95.
Echinometra oblongus de Blainville, 1830. Dict. Sci. Nat., LX, p. 206.

Plate 114, figs. *1, 2.*

As this interesting form has never been figured, so far as known, it has seemed desirable to give an illustration showing its general appearance. The reasons for not accepting the new genus proposed by Döderlein, of which *oblonga* is the type are given above (p. 367). The series of specimens at hand is most perplexing, so great is the individual diversity shown. On the one hand, there are from Clarion Island, black specimens with high, compressed test, big abactinal tubercles, and small abactinal system with all the oculars completely excluded from the periproct, but with spines tapering to a point and not nearly as thick as they should be in *oblonga*. And on the other hand there are specimens from Makemo in the Paumotus, which have the characteristic spines of *oblonga* but show a remarkable diversity in color; some are deep purple, some grayish lavender, and one is dull purplish red. In the presence of these puzzling specimens, much sympathy is felt with de Meijere's remark, apropos of *oblonga*, "Dass letztere eine gute Art ist, glaube ich kaum."

Mortensen first called attention to the curious fact that the globiferous pedicellariæ of *oblonga* have a jointed stalk. Examination of a considerable amount of material shows that this peculiarity exists in less than half the globiferous pedicellariæ; at least, more than half of those examined did not show it. Such a joint in the stalk of the pedicellariæ is not known in any other echinoid, although it is easy to see how it might be of real use.

The "Albatross" obtained specimens of *oblonga* from the following stations: —

Laysan, Hawaiian Islands.
Necker Island, H. I.
Lanai, H. I.
Kamalina Bay, Niihau, H. I.
Hanalei, Kauai, H. I.
Waianae, Oahu, H. I.
Honolulu Reef, Oahu, H. I.
Hilo, Hawaii, H. I.
Puako Bay, Hawaii, H. I.
Rangiroa, Paumotu Islands.
Makemo, Paumotus.
Fakarava, Paumotus.
Clarion Island, Mexico.

Sixty-seven specimens.

Echinometra insularis,[1] sp. nov.

Plates 95, figs. *13–15;* 114, figs. *3, 4*.

On first examination the Echinometras from Easter Island showed considerable resemblance to *Van Brunti*, but further study soon proved that they are more nearly related to *Mathæi*. The test is rather wide and flat, the width being .85–.95 of the length and the height about half the length or a trifle less. The

[1] *Insularis* = pertaining to an island.

abactinal system is about .20 of the length. The largest specimen is 45 mm. long, without including the spines, which are long and slender as in *Van Brunti*, and may exceed the short diameter of the test. There are 10–14 primary interambulacral plates in each column. The pore-pairs are generally in arcs of five at the ambitus but some of the abactinal arcs usually have six and in one or two specimens most of the abactinal arcs have six. The ocular plates are all broadly excluded from the periproct in the ten normal specimens examined. The small spines abactinally, particularly on the abactinal system, are distinctly capitate and many of them are remarkably low and stout (Pl. 95, fig. *13*). Actinally the ambulacra become somewhat widened but they are not quite so distinctly petaloid as in *Van Brunti*. The tridentate pedicellariæ have rather narrow valves (Pl. 95, fig. *15*) as in most Echinometras and they are not widened at the tip as in *Van Brunti*. The pedicellariæ of all kinds are rather rare and small; the valves of the globiferous (Pl. 95, fig. *14*) are about .30 mm. or less, while those of the tridentate and ophicephalous are only .30–.40 mm. No spicules whatever were found in the tube-feet. The color of all the specimens is uniformly deep purple or brownish red.

Not having seen this species previously, it was supposed to be peculiar to Easter Island, and it was therefore rather surprising to find that the Echinometras which the "Albatross" collected in March, 1889, at Socorro Island, must be referred to the same form. One would naturally have expected Mexican species in the Revilla Gigedo Islands, and it is therefore interesting to find no specimens of *Van Brunti*, but instead *oblonga* at Clarion Island and *insularis* at Socorro.

The material consists of the following lots: —

Socorro, Revilla Gigedo Islands, Mexico, March, 1889.

Easter Island, southeastern Pacific Ocean, Dec. 1904.

Twenty-eight specimens.

Echinometra Van Brunti A. Ag.

Echinometra Van Brunti A. Agassiz, 1863. Bull. M. C. Z., I, p. 21.

There are three fine specimens of this species before us, taken by the "Albatross" in May, 1888. One of them is the largest example of this species seen, measuring 73 mm. in length by 70 mm. in width, regardless of the spines, some of which are 40 mm. long.

Santa Margarita Island, Lower California, Mexico.

Three specimens.

Podophora.

L. Agassiz, 1840. Cat. Syst. Ectyp. Echinod., p. 19.
Type-species, *Echinometra atrata* de Blainville, 1830. Dict. Sci. Nat., LX, p. 206.

As this genus and the following have been so fully discussed in a recent Monograph (A. Agassiz, 1908, Mem. M. C. Z., XXXIX), it would be quite superfluous to go into any details here. There are two distinct species in the genus, one of which (*atrata*) is wide spread in the Indo-Pacific region, ranging from Zanzibar to Hawaii, while the other (*pedifera*) is confined, so far as known, to the southeastern Pacific.

The two species are readily distinguished from each other as follows: —

Color abactinally, usually deep purple, rarely greenish; marginal primary spines with rounded, sometimes swollen ends, not forming a close-set, even margin; actinal petaliferous areas of ambulacra moderately developed, not abruptly constricting the interambulacral spaces; pore-pairs at ambifus in arcs of 9 or 10 . . . . . . *atrata*.

Color, abactinally olive-green; marginal primary spines with flattened, chisel-like tips, forming a close-set, even margin; actinal petaliferous ambulacral areas greatly developed, abruptly constricting the interambulacral spaces; pore-pairs at ambitus in arcs of 10–12 . . . . *pedifera*.

Podophora atrata Agass.

Echinus atratus Linné, 1758. Syst. Nat., ed. 10, p. 655.
Podophora atrata L. Agassiz, 1840. Cat. Syst. Ectyp. Echinod., p. 19.
"**Colobocentrotus Quoyi** Brandt," A Agassiz and Clark, 1907. Bull. M. C. Z., L, p. 240.

This appears to be one of the common and characteristic sea-urchins of the Hawaiian Islands, and was found by the "Albatross" in considerable numbers particularly at Puako Bay, Hawaii. A collector's note with a jar of specimens from this place reads as follows: —

"Common on rocks along shore. Live in little depressions, the border spines acting as the edge of a sucking disk. Dorsal surface very deep Indian purple or prune-purple when in the water. By reflected light, out of water, almost black. Underside of big spines, mauve. Circumoral membrane and membrane between clumps of small spines and tubefeet, orange-red. Small spines and tube-feet, light brownish, occasionally red or purple."

Necker Island, Hawaiian Islands.

Kamalino Bay, Niihau, H. I.

Napili Harbor, Maui, H. I., "Albatross" St. 3881.

Napili, Maui, H. I.

Lanai, H. I.
Hilo, Hawaii, H. I.
Puako Bay, Hawaii, H. I.
One hundred and twenty-eight specimens.

Podophora pedifera Agass. and Des.

Echinus pedifer de Blainville, 1825. Dict. Sci. Nat., XXXVII, p. 97.
Podophora pedifera Agassiz and Desor, 1846. Ann. Sci. Nat., (3), VI, p. 374.

This species has been confused with the preceding but the large series collected by the "Albatross" in the Paumotus shows clearly that it is quite distinct and that its specific characters are well marked and constant. They need not be discussed here however as they are fully dealt with in the monograph on the genus, already referred to.

The specimens brought home by the "Albatross" were collected on the reefs of

Rangiroa, Paumotu Islands.
Fakarava, Paumotu Islands.
One hundred and eleven specimens.

Colobocentrotus.

Brandt, 1835. Prodrom. desc. Anim., p. 266 (or 66).
Type-species, *Colobocentrotus Mertensii* Brandt, 1835, l. c.

It is a curious fact that so far as any reliable records show this genus is confined to the Bonin Islands, and few specimens have found their way into collections. There is some doubt as to whether all the known specimens should be referred to a single species (*Mertensii* Brandt) or not, but there seems to be a second (*Stimpsoni* A. Ag.).

The two are distinguished as follows: —

Short diameter of test more than .90 of long diameter so that ambitus is nearly circular . . *Mertensii.*
Short diameter of test less than .90 of long diameter so that ambitus is elliptical . . *Stimpsoni.*

Heterocentrotus.

Brandt, 1835. Prodrom. desc. Anim., p. 265 (or 65).
Type-species, *Echinus mammillatus* Linné, 1758. Syst. Nat., ed. 10, p. 667.

There seems to be general agreement that this well-known genus contains two, and only two, species, and an examination of all the available material confirms the opinion. But this examination also shows that the primary spines are of no value whatever as a means of distinguishing the species, few Echini showing so great variability in this respect. The secondary spines are of more use, though they cannot be absolutely relied on. The best specific character is found in the arcs of pores, the difference in this respect being remarkably constant. A rather marked difference in the tridentate pedicellariæ has been noticed by Mortensen, but I have made no attempt to determine how constant this is.

By the use of these various characters, the two species may be distinguished as follows:—

Pore-pairs, in mid-zone, in arcs of 11 (10–12); secondary spines, short, flaring, and truncated at tip; no large primary tubercles in abactinal part of ambulacra; valves of tridentate pedicellariæ somewhat curved, widened at tip where alone they are in contact . . . . *mammillatus.*

Pore-pairs, in mid-zone, in arcs of 15 (14–19); secondary spines, short, usually tapering and pointed at tip; normal primary tubercles in abactinal part of ambulacra; valves of tridentate pedicellariæ bluntly pointed, in contact for most of their length . . . . *trigonarius.*

Heterocentrotus mammillatus Br.

Echinus mammillatus Linné, 1758. Syst. Nat., ed. 10, p. 667.
Heterocentrotus mammillatus Brandt, 1835. Prodrom. desc. Anim., p. 266 (or 66)

Plates 115–117.

The specimens of Heterocentrotus in the "Albatross" collection are divisible, at a glance, into two groups on account of their color. In one group, the general coloration is brown, the secondaries lighter than the primaries and usually light fawn- or even cream-color; these specimens are all *mammillatus* and are all from the Hawaiian Islands. In the other group the general coloration is deep purple and there is little difference in shade between primaries and secondaries; these specimens are all *trigonarius* and are from the Paumotus. So far as known *trigonarius* does not occur in the Hawaiian Islands, nor *mammillatus* in the Paumotus. Indeed the latter seems to be confined to the North Pacific and Indian Oceans; the M. C. Z. has good series from Mauritius, the Bonin Islands, and the Hawaiian Islands, but only one specimen from south of the equator in the Pacific, and that one is a young individual from Jarvis Island (which is less than 23′ S.), the identification of which admits of some doubt. So far as our material is concerned, *mammillatus* is often very light colored, and never shows any indication of purple; when dark colored, the shade is always a rich chocolate-brown.

The "Albatross" material is from the following places: —

Laysan, Hawaiian Islands.

Honolulu Market, Oahu, H. I.

Puako Bay, Hawaii, H. I.

Twenty-six specimens.

Heterocentrotus trigonarius Br.

Echinus trigonarius Lamarck, 1816. Anim. s. Vert., III, p. 51.

Heterocentrotus trigonarius Brandt, 1835. Prodrom. desc. Anim., p. 266 (or 66).

Plates 118–120.

This species shows much greater diversity in every feature than *mammillatus* does, but the number of pore-pairs in at least one arc appears to be always more than 12, even in specimens, whose test does not exceed 20 mm. in length. In specimens only half grown there is almost always at least one arc with 15 pairs, but occasionally 14 is the maximum. The primaries range in form from long, tapering, acute, trigonal spines to short, club-shaped spines with very thick blunt tips. The actinal spines are of course more or less flattened, but the amount of flattening and the number of primaries involved shows great diversity. The secondaries show nearly as great diversity, for while they are usually more or less acutely pointed, we have a number of specimens in which they are as thick and truncate at tip as in any *mammillatus*. The color is also variable, and in this particular there is a suggestion of local differences; specimens from Mauritius are brown with distinct shades of green and orange-red on the primaries, while specimens from the Paumotus are deep purple, with very little variation except in shade. Specimens from intermediate localities connect the two extremes, which will probably at some future time be designated as subspecies.

Apparently *trigonarius* is more widely distributed or at least, more generally distributed than *mammillatus*. Specimens are at hand from Mauritius, the Philippines, New Guinea, the Carolines, the Gilberts, the Marshalls, the Fijis, Baker's Island, Tongatabu, the Society Islands, and the Paumotus. As the two species are so easily confused with each other, the published records especially if they date back half a century or more are unreliable so that the question of the geographical distribution of the two species of Heterocentrotus is still an open one. The evidence however indicates that *mammillatus* is a northern species ranging from the Red Sea (eastern Mediterranean?) to Hawaii, while *trigonarius* is southern, ranging from Zanzibar to the Paumotus. The two occur together in abundance at Mauritius and probably in the East Indies, but just where and to what extent their ranges overlap is as yet unknown.

The "Albatross" specimens of *trigonarius* come from the following place: —

Fakarava, Paumotus, Oct., 1899.

Sixteen specimens.

ADDENDA.

On p. 73 the genus Podocidaris is stated to be monotypic, but after that statement was published, Dr. W. K. Fisher sent me a single specimen of a Podocidaris which was found by him among the starfishes collected by the "Albatross" at the Hawaiian Islands. As it seems to be distinct from the West Indian species, it may be described as

Podocidaris ornata,[1] sp. nov.

Plate 102, fig. *1*.

Test flattened, the height only 4 mm. while the horizontal diameter is 9 mm. The abactinal system is 4.5 mm. across and the actinostome about half a millimeter more. The periproct is 2 mm. in diameter and is completely covered by four equal plates. The primary spines are confined to the region below the ambitus, as is characteristic of the genus, and are very flat, as seen from below, but on the upper side are distinctly keeled along the median line. The longest spines are not quite equal to half the diameter of the test, but they are very broad, the width, half way between the middle and the tip, being equal to one fourth of the length. Each spine ends in an enamel hoof, as usual in the family, but this is scarcely noticeable from above. The "non-articulated spines" or better, "cylindrical tubercles," of the abactinal half of the test are slenderer and less conspicuous than in *sculpta;* they also form less regular series, many of them remaining very imperfectly developed. They are present in some numbers on the genital and ocular plates and their arrangement there in two or three series parallel to the distal margins of the genital plates, gives the abactinal system a very ornamented appearance, quite different from that of *sculpta*. The pedicellariæ of *ornata* show no special peculiarities excepting that they are more slender than in *sculpta* and the ophicephalous are smaller. The tridentate have the valves about .30 mm. long but the blade where widest, near tip, is less than .06 mm. broad; in *sculpta*, the blade is more than one fourth as wide as the length of the valve. In the ophicephalous pedicellariæ of *ornatus* the valves are only .15–.20 mm. long. The spicules of the tube-feet are not distinguishable from those of *sculpta* except in being rather more slender. The sphæridia are like those of *sculpta* in form, but there seem to be *two* in each ambulacrum, one

[1] *ornatus* = ornamented.

distal to the other. The test is dull olive, brown on the abactinal system, but distinctly greenish in the mid-zone. The spines are almost white but have more or less dusky tips, and the bases show a trace of green or reddish brown.

In view of the occurrence of *Habrocidaris argentea* in the Hawaiian region, it is most interesting to have the closely related genus Podocidaris discovered there. It is a very peculiar fact in the geographical distribution of Echini that these two genera of Arbaciadæ, each of which was discovered in the West Indies, should occur in the Hawaiian region, and so far as now known nowhere else in the world, except perhaps the East Indies, where the "Siboga" collected two specimens of what is probably a true Podocidaris. The genus Trigonocidaris (see p. 295) shows a very similar distribution but otherwise it appears to be unique among Echini. In these three cases, the Hawaiian species is identical with or very closely related to the West Indian and it seems impossible to doubt that it has sprung from that stock, and the lack of marked specific differentiation would indicate that it was at no very distant date. Possibly the East Indies were stocked from the Hawaiian Islands.

The Hawaiian Podocidaris was taken by the "Albatross" only at the following station: —

Station 3919. Off Diamond Head, Oahu, Hawaiian Islands. Bott. temp. 45.6°. 220–257 fathoms. Gy. s.

As it seems most probable that the species designated as *Podocidaris sp.?* by de Meijere ("Siboga" Ech., p. 68) is quite different from any of its near allies, it may be named *cincta,* since the banded spines are its most striking character.

The three species of Podocidaris may then be distinguished as follows: —

Spines not banded . . . .
  Tubercles on abactinal system few, low and not arranged according to any very definite pattern . . . . *sculpta.*
  Tubercles on abactinal system, rather numerous, arranged in series parallel to the distal margins of the genital plates . . . . *ornata.*
Spines banded with carmine-red . . . . *cincta.*

Yoshiwara's Echini.

Through the kindness of Professor Seitaro Goto, the Imperial University at Tokyo has entrusted to me the type-specimens of the ten species of Echini described as new by Yoshiwara in 1897 (Ann. Zool. Jap., II, p. 57–61). In the preceding pages reference has been made to four of these species, noting that "*Echinus multicolor*" is a valid species of Nudechinus, that "*Mespilia laevituber-*

culatus" and "*Salmacopsis pulchellimus*" are synonyms of *Mespilia globulus*, and that "*Echinostrephus pentagonus*" is a synonym of *Echinostrephus molaris*. Of the other six species, three are clypeastroids and will be discussed in part 5 of the present work. The three remaining species are cidarids and a few comments on them may be given here.

Cidaris (*Stereocidaris*) *tenuispinus* Yoshiwara. Examination of the type and a cotype of this species leaves no doubt that the conclusion reached in 1907 that it is identical with Döderlein's *Dorocidaris japonica*, is correct. For a full discussion of the matter, see A. Agassiz and Clark, 1907, Bull. M. C. Z., LI, p. 112–114.

Cidaris (*Stereocidaris*) *microtuberculatus* Yoshiwara. Examination of the type-specimen confirms the validity of this species, which has already been diagnosed and figured (1907, Bull. M. C. Z., LI, p. 220, pls. 1 and 2).

Cidaris (*Porocidaris*) *misakiënsis* Yoshiwara. The most striking feature of the beautiful specimen on which this species is based is found in the primary spines, which are more like those of some species of Cidaris (*rugosa* H. L. C. for example) than they are like those of the other species of Porocidaris. They are thickest not far from the base and then taper steadily to a blunt point. They are longitudinally striated with about 28 series of minute, sharp prickles, much as in *P. Sharreri*. The longest spines are 95–100 mm. in length and 5 mm. in diameter, 10–12 mm. above the base. The primaries are pure white, while the secondaries, pedicellariæ, and test are white with a tinge of yellow. Yoshiwara says the test, especially abactinally, and the collar of the primaries is "deep brown" and the secondary spines "brownish." Evidently the specimen has become completely bleached in alcohol. The abactinal system is .40 h. d. in diameter. The pedicellariæ are similar to those of *P. variabilis* and some of the large ones have valves 5 mm. long.— There is no doubt that *misakiënsis* is quite distinct from *elegans* and it appears to be equally different from *variabilis*, but it is very close to *Sharreri* and so far as our material shows, the form of the primary spines is the only difference worthy of mention. The specimen, described and figured by de Meijere ("Siboga" Ech., p. 27, Pl. 2, figs. *15, 16*) as *misakiënsis*, does not agree well with the type, and it is doubtful if it is the same species. It may be, as de Meijere suggests, only a form of *elegans* or it may possibly be *variabilis*. The specific differences in the genus are very intangible and much more material is necessary, from both the East and West Indies, before the species already described can be satisfactorily known.

EXPLANATION OF THE PLATES.

Wherever the nature of the figure permits, the anterior ambulacrum (III) is placed uppermost.

PLATE 90.

Plate 90.

Showing the Arrangement of the Digestive and Reproductive Organs, and the Structure of the Lantern, and Auricles.

1–4. **Cænopedina hawaiiensis**, nom. nov.

1. Interior view of actinal half of test with organs in place. × 1.5.
2. Interior view of abactinal half. × 1.5.
3. Exterior view of a pyramid from lantern. × 4.
4. Side view of same. × 4.

5–10. **Glyptocidaris crenularis** A. Ag.

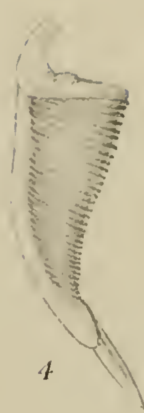
5. Interior view of actinal half of test with organs in place. Slightly enlarged.
6. Interior view of abactinal half. Slightly enlarged.
7. Side view of lantern. × 2.
8. Top view of lantern. × 2.
9. Side view of a single pyramid (tooth-supporting process broken off). × 2.
10. Part of base of corona, with auricles and apophyses. × 2.

11, 12. **Stomopneustes variolaris** Agass.

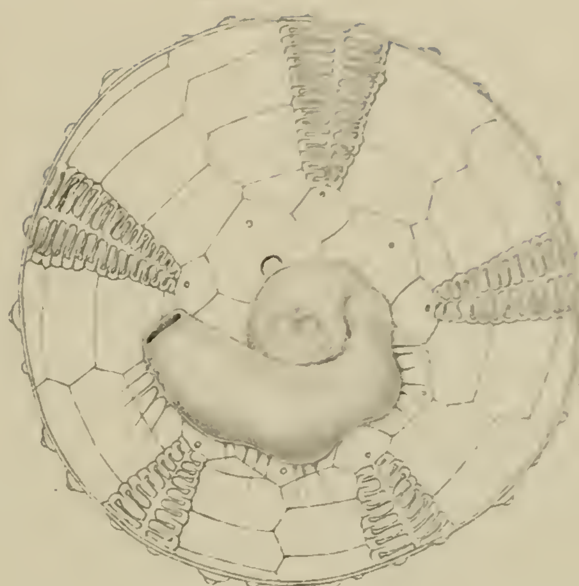
11. Interior view of actinal half of test with organs in place. Slightly reduced.
12. Interior view of abactinal half. Slightly reduced.

1

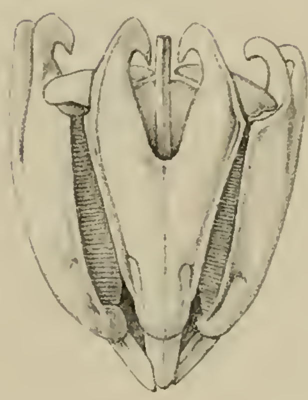
3



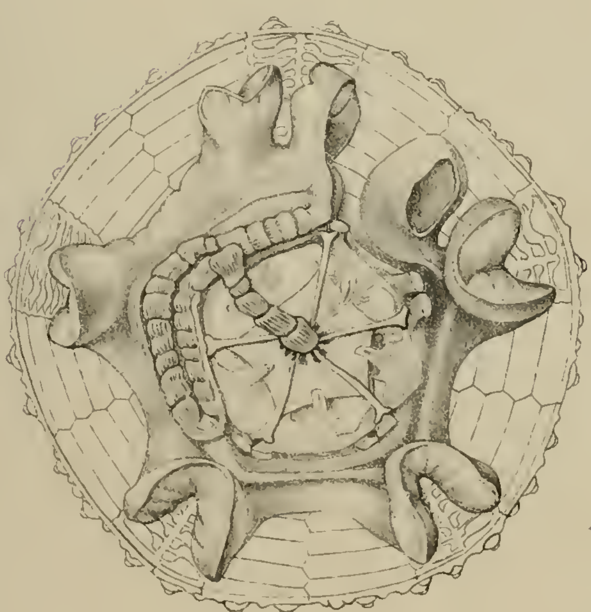
4



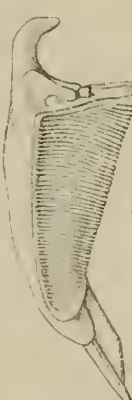
2



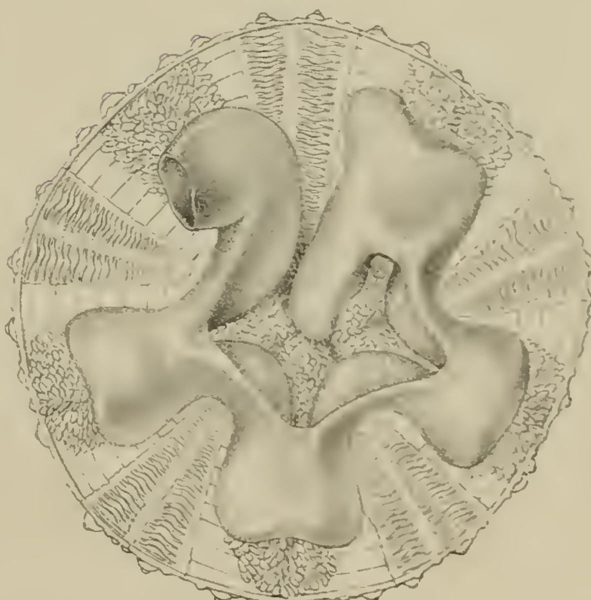
7



5



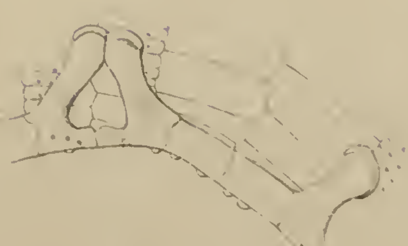
9



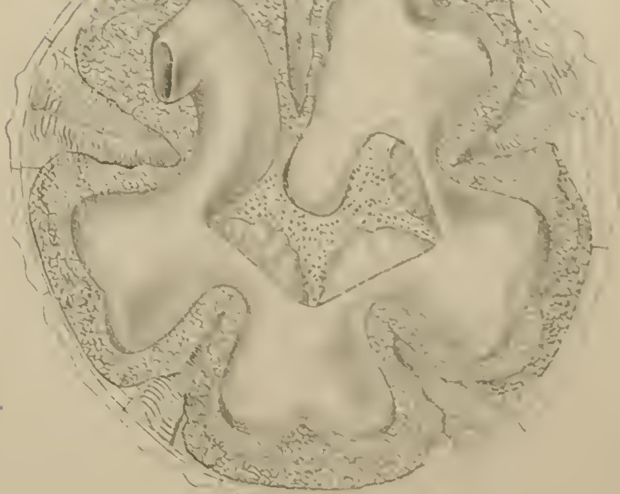
6

8

11



10



12

A. M. Westergren del.

B. Meisel lith.

PLATE 91.

Plate 91.

1–13. **Cænopedina hawaiiensis,** nom. nov.

1. Large tridentate pedicellaria. × 70.
2. Side view of valve of same. × 70.
3. Interior view of same valve. × 70.
4. Slender tridentate pedicellaria. × 70.
5. Another slender tridentate pedicellaria. × 10.
6. Another slender tridentate pedicellaria. × 10.
7. Valve of ophicephalous pedicellaria. × 70.
8. Valve of triphyllous pedicellaria. × 70.
9. Peculiar, incomplete large tridentate pedicellaria. × 70.
10. Globiferous pedicellaria. × 70.
11. Side view of tip of valve of same. × 70.
12. Interior view of tip of same valve. × 70.
13. Sphæridium. × 70.

14–17. **Cænopedina mirabilis** Mrtsn.

14. Valve of ophicephalous pedicellaria. × 70.
15. Valve of another ophicephalous pedicellaria. × 70.
16. Valve of globiferous pedicellaria. × 70.
17. Side view of tip of valve of same. × 150.

18–22. **Cænopedina pulchella,** comb. nov.

18. Side view of valve of globiferous pedicellaria. × 70.
19. Valve of tridentate pedicellaria. × 70.
20. Valve of ophicephalous pedicellaria. × 70.
21. Calcareous plate from pedicel. × 300.
22. Sphæridium. × 70.

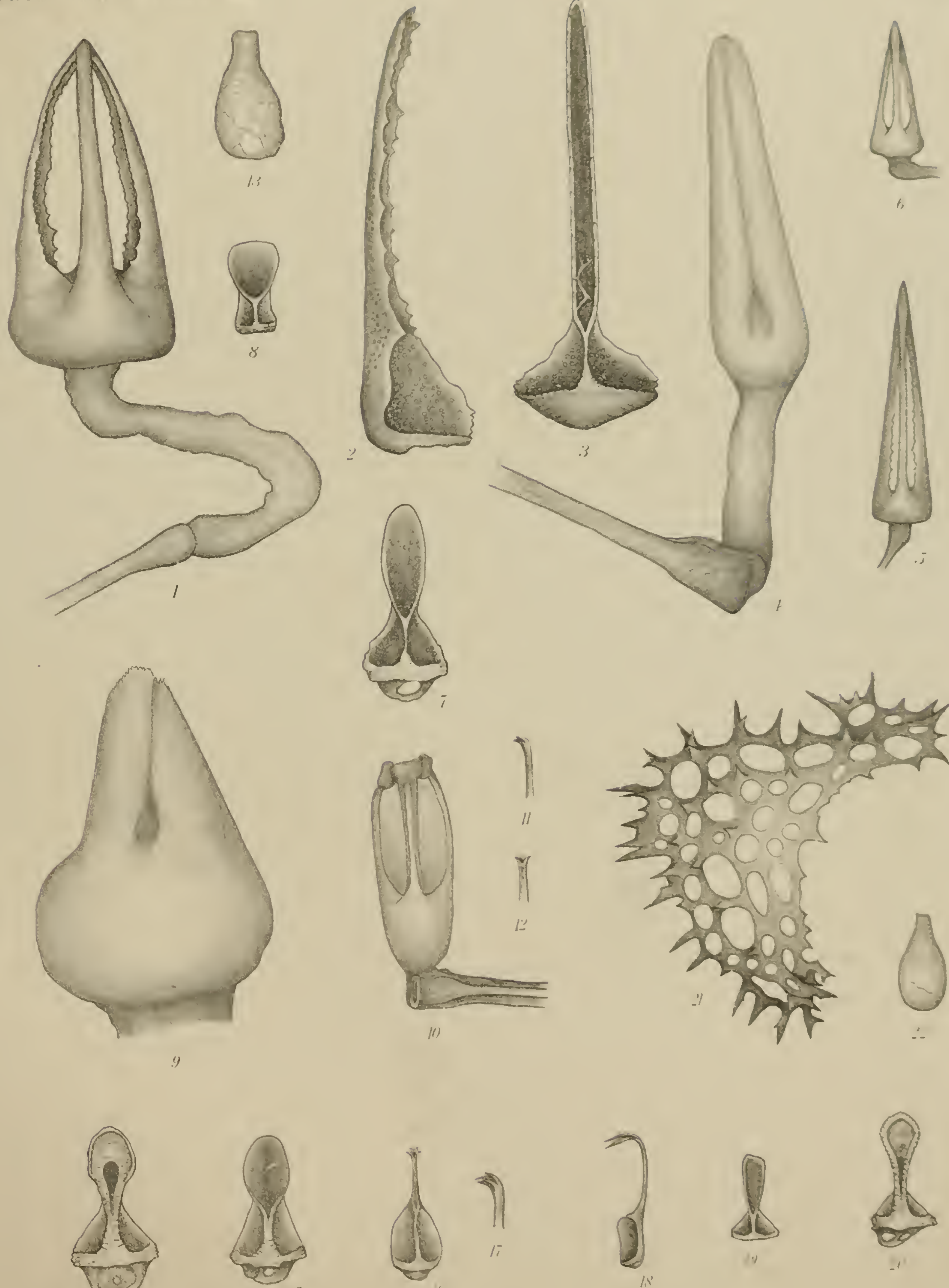

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 92.

PLATE 92.

1–11. **Glyptocidaris crenularis** A. Ag.

1. Globiferous pedicellaria. × 30.
2. Tridentate pedicellaria. × 30.
3. Ophicephalous pedicellaria. × 30.
4. Triphyllous pedicellaria. × 30.
5. Valve of tridentate pedicellaria. × 30.
6. Valve of globiferous pedicellaria. × 70.
7. Side view of tip of same. × 70.
8. Valve of triphyllous pedicellaria. × 70.
9. Valve of ophicephalous pedicellaria. × 70.
10. Sphæridium. × 70.
11. Spicules from pedicels. × 70.

12–18. **Pseudoboletia indiana** A. Ag., juv.

12. Large globiferous pedicellaria. × 30.
13. Small globiferous pedicellaria, with glands on the stalk. × 70.
14. Slender tridentate pedicellaria. × 70.
15. Valve of globiferous pedicellaria. × 70.
16. Side view of tip of same. × 70.
17. Valve of broad tridentate pedicellaria. × 70.
18. Sphæridium. × 70.

H. L. Clark del.

Plate 93.

1. **Nudechinus stictus**, sp. nov.

1. Valve of globiferous pedicellaria. × 70.

2, 3. **Echinus euryporus**, sp. nov.

2. Valve of globiferous pedicellaria. × 70.
3. Side view of tip of same. × 70.

4, 5. **Lytechinus euerces**, sp. nov.

4. Valve of globiferous pedicellaria. × 70.
5. Valve of tridentate pedicellaria. × 70.

6, 7. **Toxopneustes chloracanthus**, sp. nov.

6. Side view of tip of valve of globiferous pedicellaria. × 70.
7. Valve of tridentate pedicellaria. × 70.

8, 9. **Echinus anchistus**, sp. nov.

8. Valve of globiferous pedicellaria. × 70.
9. Side view of tip of same. × 70.

10. **Lytechinus dyscritus**, sp. nov.

10. Valve of globiferous pedicellaria. × 70.

11–15. **Echinus tylodes**, sp. nov.

11. Valve of triphyllous pedicellaria. × 70.
12. Valve of ophicephalous pedicellaria. × 70.
13. Valve of globiferous pedicellaria. × 70.
14. Side view of tip of same. × 70.
15. Valve of tridentate pedicellaria. × 70.

16, 17. **Genocidaris apoda** A. Ag. and Cl.

16. Valve of globiferous pedicellaria. × 70.
17. Valve of ophicephalous pedicellaria. × 70.

18–21. **Goniopneustes pentagonus** Duncan.

18. Valve of ophicephalous pedicellaria. × 70.
19. Valve of globiferous pedicellaria. × 70.
20. Side view of tip of same. × 70.
21. Valve of triphyllous pedicellaria. × 70.

22, 23. **Gymnechinus epistichus**, sp. nov.

22. Valve of globiferous pedicellaria. × 70.
23. Valve of tridentate pedicellaria. × 70.

24–26. **Prionechinus sculptus** A. Ag. and Cl.

24. Valve of globiferous pedicellaria. × 350.
25. Valve of tridentate pedicellaria. × 70.
26. Sphæridium. × 70.

27–31. **Orechinus monolini** Död.

27. Valve of globiferous pedicellaria. × 70.
28. Side view of tip of same. × 70.
29. Valve of tridentate pedicellaria. × 70.
30. Side view of same. × 70.
31. Sphæridium. × 70.

32. **Echinus Wallisii** A. Ag.

32. Globiferous pedicellaria, with entire stalk. × 30.

33. **Salmacis Dussumieri** Agass. and Des.

33. Base of valve of globiferous pedicellaria. × 70.

34. **Salmacis erythracis**, sp. nov.

34. Base of valve of globiferous pedicellaria. × 70.

35. **Salmacis Belli** Död.

35. Base of valve of globiferous pedicellaria. × 70.

36. **Salmacis bicolor** Agass.

36. Base of valve of globiferous pedicellaria. × 70.


1
3
4
5
6
2
7
14
17
12
16
13
9
10
21
20
19
8
11
15
18
22
23
31
25
28
24
27
29
30
26
32
33
34
35
36

H. L. Clark del.

Plate 94.

1–6. **Pachycentrotus australiæ**, comb. nov.

1. Valve of globiferous pedicellaria. × 70.
2. Side view of tip of same. × 70.
3. Valve of tridentate pedicellaria. × 70.
4. Side view of a similar valve. × 70.
5. Valve of ophicephalous pedicellaria. × 70.
6. Valve of triphyllous pedicellaria. × 70.

7, 8. **Heliocidaris crassispina**, comb. nov.

7. Valve of globiferous pedicellaria from a specimen 18 mm. h. d. × 70.
8. Side view of tip of same. × 70.

9. **Strongylocentrotus franciscanus** A. Ag.

9. Valve of globiferous pedicellaria. × 70.

10, 11. **Paracentrotus Gaimardi** Mrtsn.

10. Valve of globiferous pedicellaria. × 70.
11. Side view of same. × 70.

12. **Paracentrotus lividus** Mrtsn.

12. Side view of tip of valve of globiferous pedicellaria. × 70.

13–16. **Strongylocentrotus echinoides** A. Ag. and Cl.

13. Tridentate pedicellaria. × 20.
14. Valve of ophicephalous pedicellaria. × 70.
15. Base of valve of globiferous pedicellaria. × 70.
16. Side view of tip of same valve. × 70.

17–23. **Strongylocentrotus nudus** A. Ag.

17. Valve of ophicephalous pedicellaria. × 70.
18. Valve of globiferous pedicellaria. × 70.
19. Side view of tip of same. × 70.
20. Valve of triphyllous pedicellaria. × 70.
21. Valve of small tridentate pedicellaria. × 70.
22. Blade of valve of large tridentate pedicellaria, from specimen taken at Station 5018. × 70.
23. Valve of large tridentate pedicellaria, from same specimen, with tip directed towards observer. × 70.

24–27. **Strongylocentrotus pulchellus** A. Ag. and Cl.

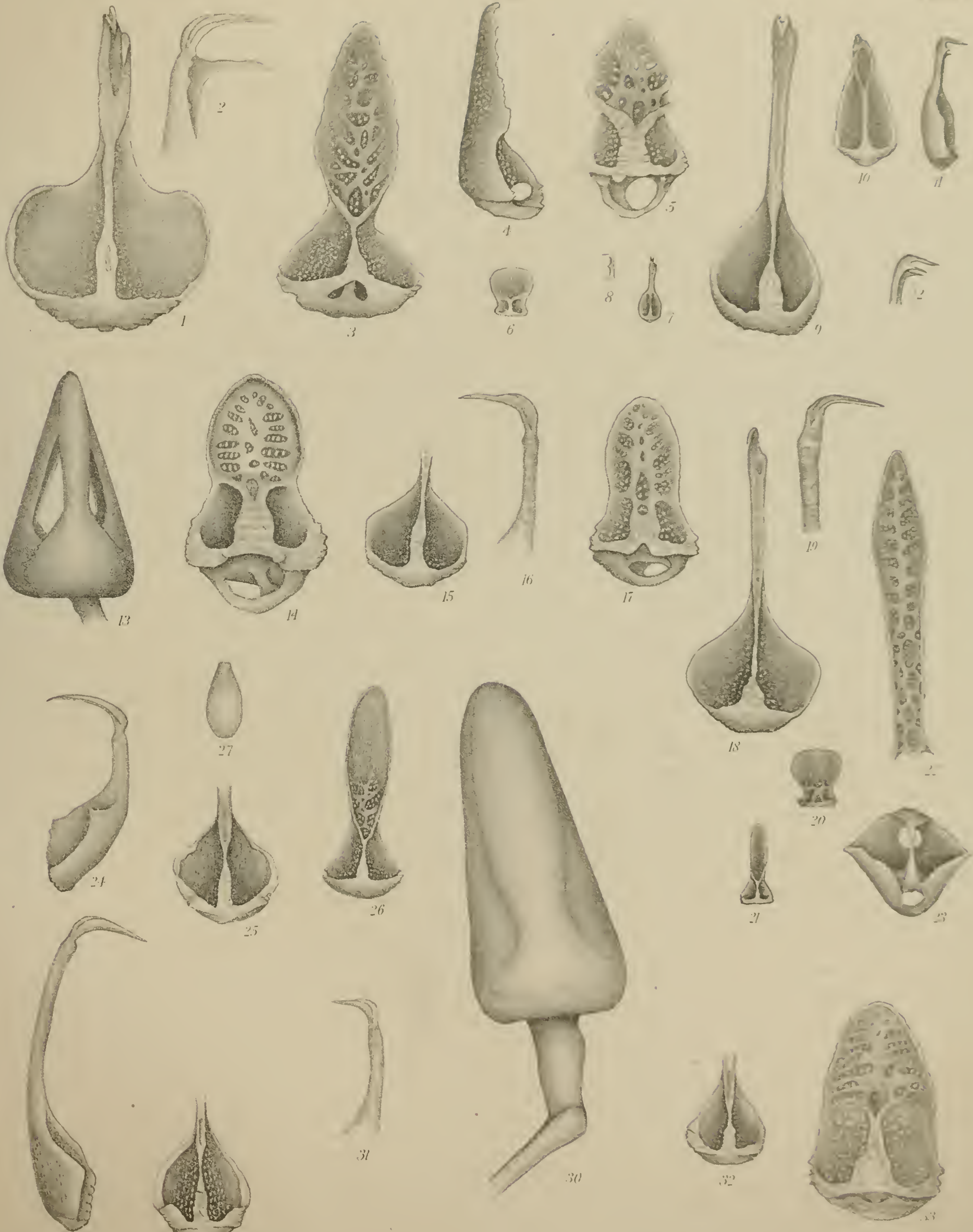
24. Side view of valve of globiferous pedicellaria. × 70.
25. Base of same. × 70.
26. Valve of tridentate pedicellaria. × 70.
27. Sphæridium. × 70.

28, 29. **Strongylocentrotus fragilis** Jackson.

28. Side view of valve of globiferous pedicellaria. × 70.
29. Base of same. × 70.

30–33. **Strongylocentrotus polyacanthus** A. Ag. and Cl.

30. Tridentate pedicellaria. × 70.
31. Side view of blade of valve of globiferous pedicellaria. × 70.
32. Base of a similar valve. × 70.
33. Valve of ophicephalous pedicellaria. × 70.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

H.L.Clark del.

PLATE 95.

Plate 95.

1–5. **Parasalenia Pöhlii** Pfeff.

1. Head and neck of tridentate pedicellaria. × 70.
2. Globiferous pedicellaria. × 70.
3. Globiferous pedicellaria with evident glands on the valves. × 70.
4. Valve of globiferous pedicellaria. × 70.
5. Side view of tip of same. × 70.

6–12. **Echinometra picta** A. Ag. and Cl.

6. Valve of globiferous pedicellaria. × 70.
7. Side view of same. × 70.
8. Valve of slender tridentate pedicellaria. × 70.
9. Side view of tip of same. × 70.
10. Blade of valve of stout tridentate pedicellaria. × 70.
11. Valve of ophicephalous pedicellaria. × 70.
12. Valve of triphyllous pedicellaria. × 70.

13–15. **Echinometra insularis**, sp. nov.

13. Abactinal secondary spines. × 10.
14. Side view of valve of globiferous pedicellaria. × 70.
15. Valve of tridentate pedicellaria. × 70.

16, 17. **Cænocentrotus gibbosus**, comb. nov.

16. Valve of globiferous pedicellaria. × 70.
17. Side view of tip of same. × 70.

18–22. **Heliocidaris stenopora**, nom. nov.

18. Valve of globiferous pedicellaria. × 70.
19. Side view of tip of same. × 70.
20. Valve of ophicephalous pedicellaria. × 70.
21. Valve of tridentate pedicellaria. × 70.
22. Valve of triphyllous pedicellaria. × 70.

23, 24. **Echinostrephus aciculatus** A. Ag.

23. Globiferous pedicellaria. × 70.
24. Side view of tip of a valve of globiferous pedicellaria with a lateral tooth on each side. × 70.

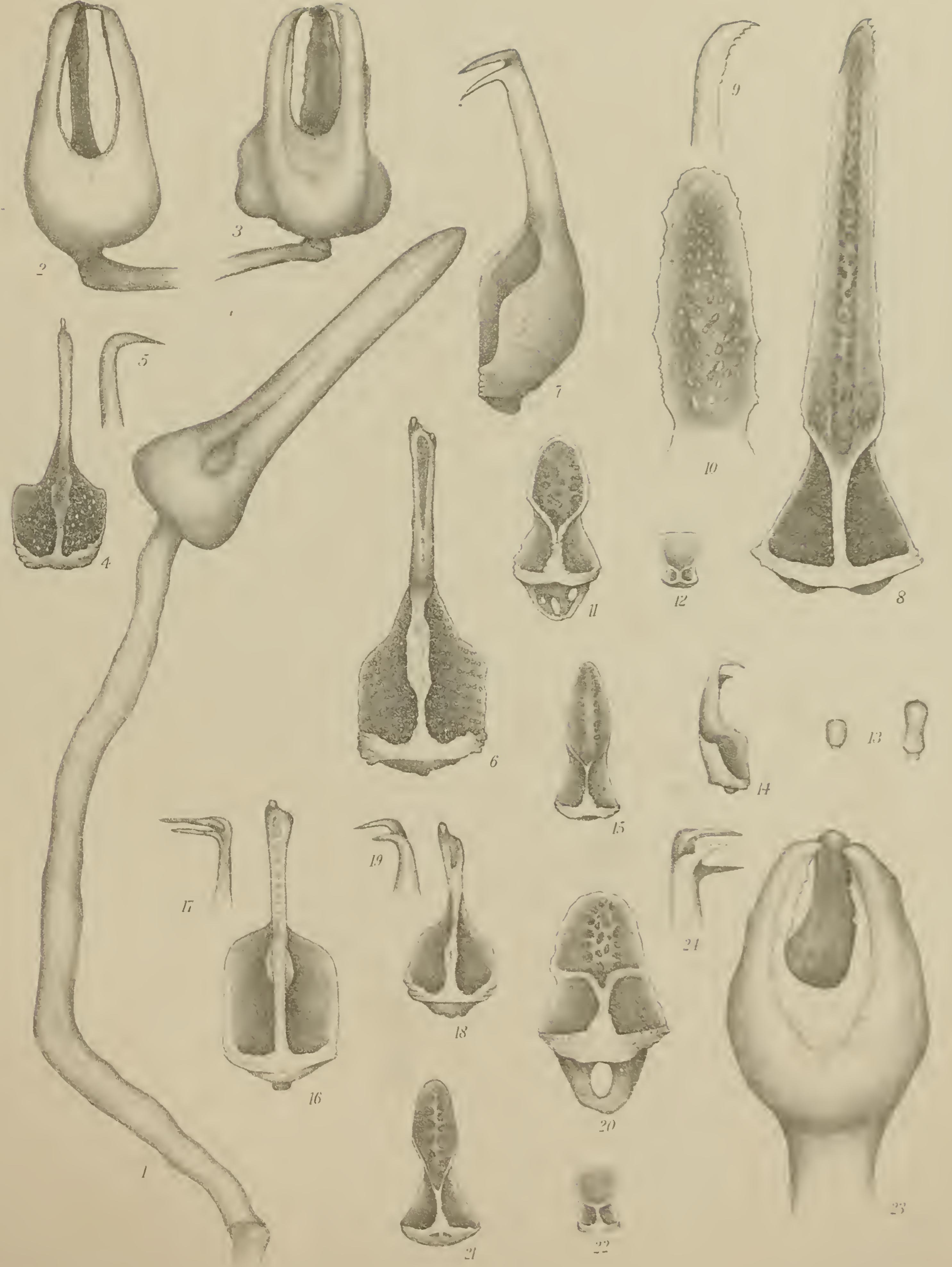

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PLATE 96.

Plate 96.

1–3. **Lytechinus dyscritus**, sp. nov.

1. Side view. × 5.
2. Actinostome and base of corona. × 8.
3. Abactinal system. × 8.

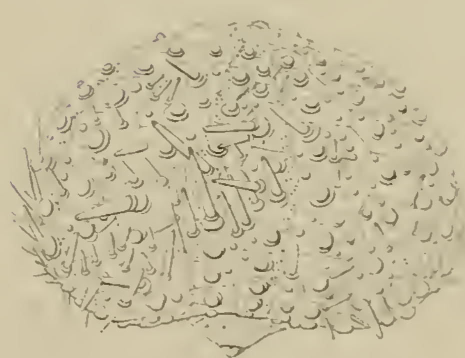
4–6. **Lytechinus callipeplus**, sp. nov.

4. Side view. × 5.
5. Actinostome and base of corona. × 7.
6. Abactinal system. × 8.

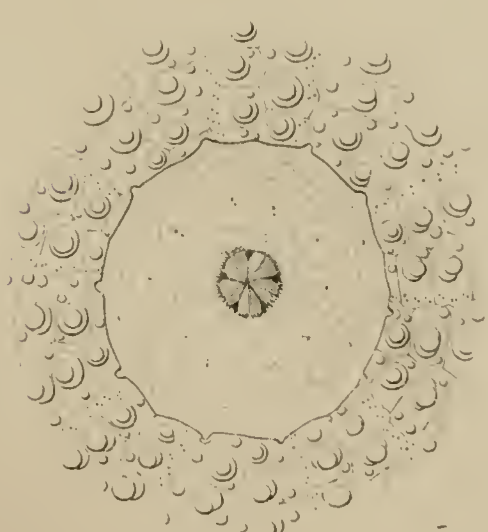
3

2

1



1



5

6

PLATE 97.

Plate 97.

1–3. **Nudechinus stictus**, sp. nov.

1. Side view. × 8.
2. Actinostome and base of corona. × 9.
3. Abactinal system. × 12.

4–6. **Nudechinus scotiopremnus**, sp. nov.

4. Side view. × 3.
5. Actinostome and base of corona. × 6.
6. Abactinal system. × 8.

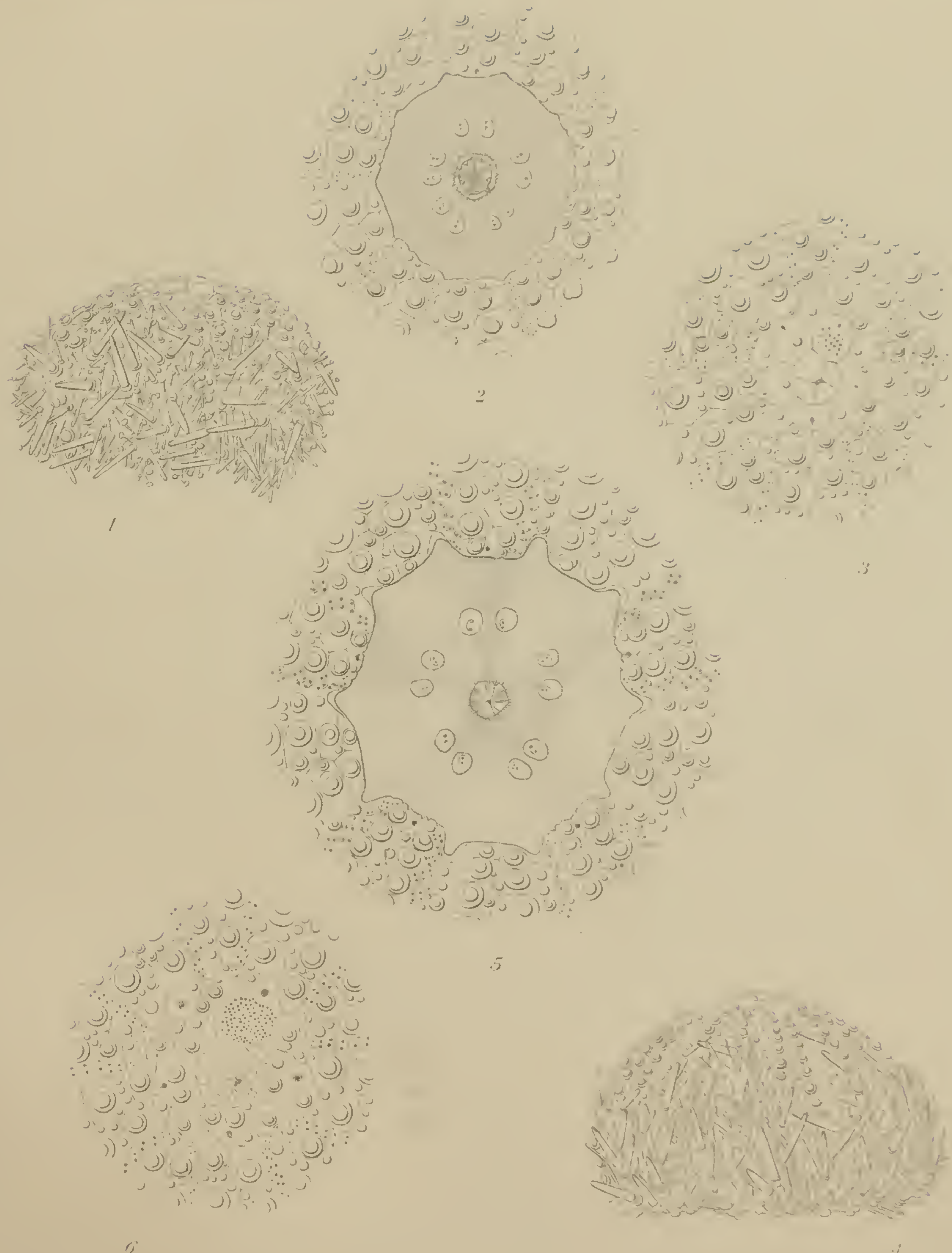

1
2
3
4
5
6

PLATE 98.

Plate 98.

1, 2. **Strongylocentrotus pulchellus** A. Ag. and Cl.

1. Part of actinostome and base of corona. × 8.
2. Abactinal system. × 8.

3, 4. **Lytechinus euerces**, sp. nov.

3. Part of actinostome and base of corona. × 5.
4. Abactinal system. × 5.

5–8. **Pachycentrotus australiæ**, comb. nov.

5. Part of actinostome and base of corona. × 5.
6. Abactinal system. × 5.
7. Two ambulacral plates from mid-zone, showing 5 elements in one. × 5.
8. The same seen from within the test. × 5.

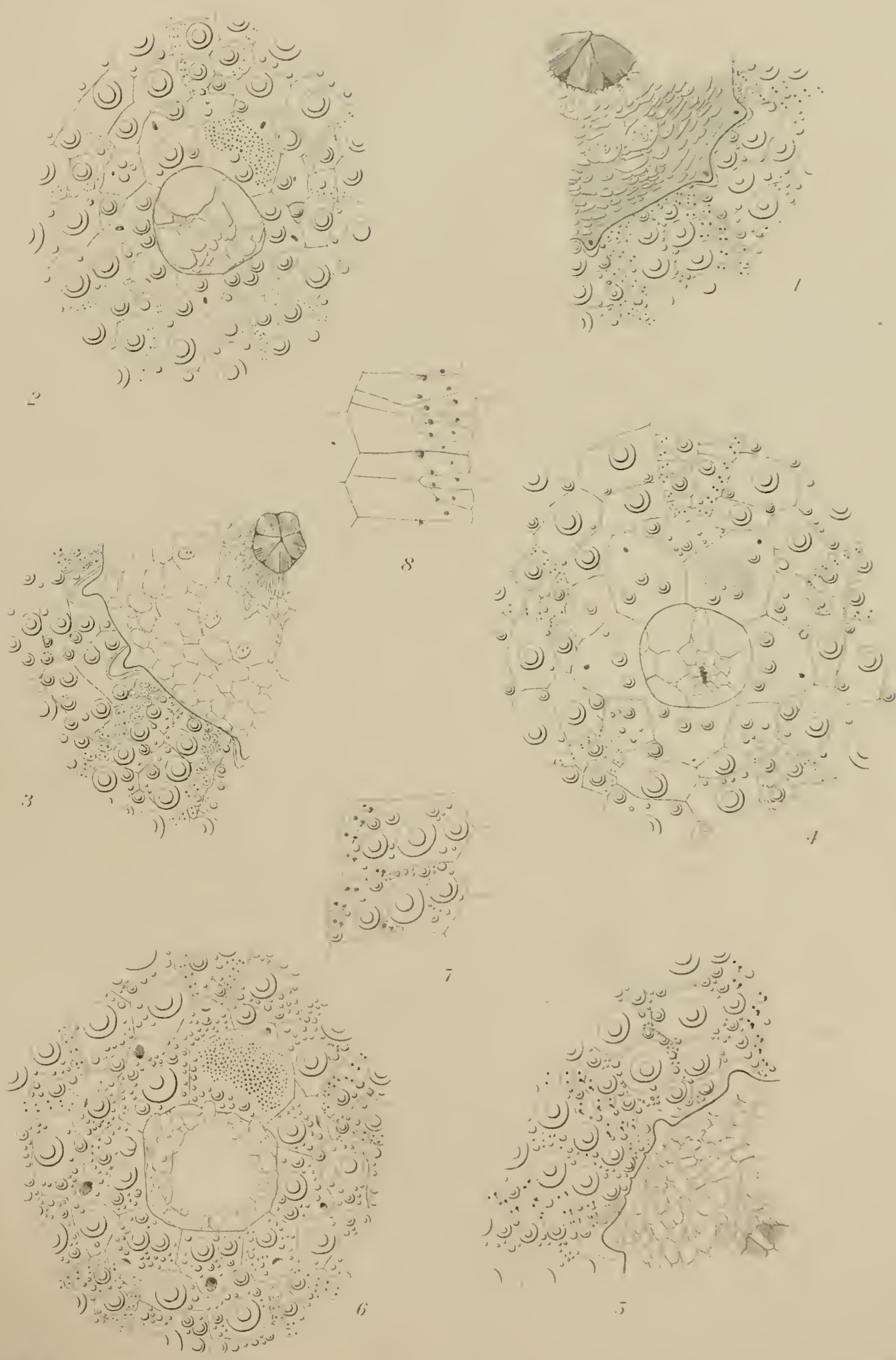

2
1
8
3
4
7
6
5

PLATE 99.

Plate 99.

1–3. **Temnotrema hawaiiensis**, comb. nov.

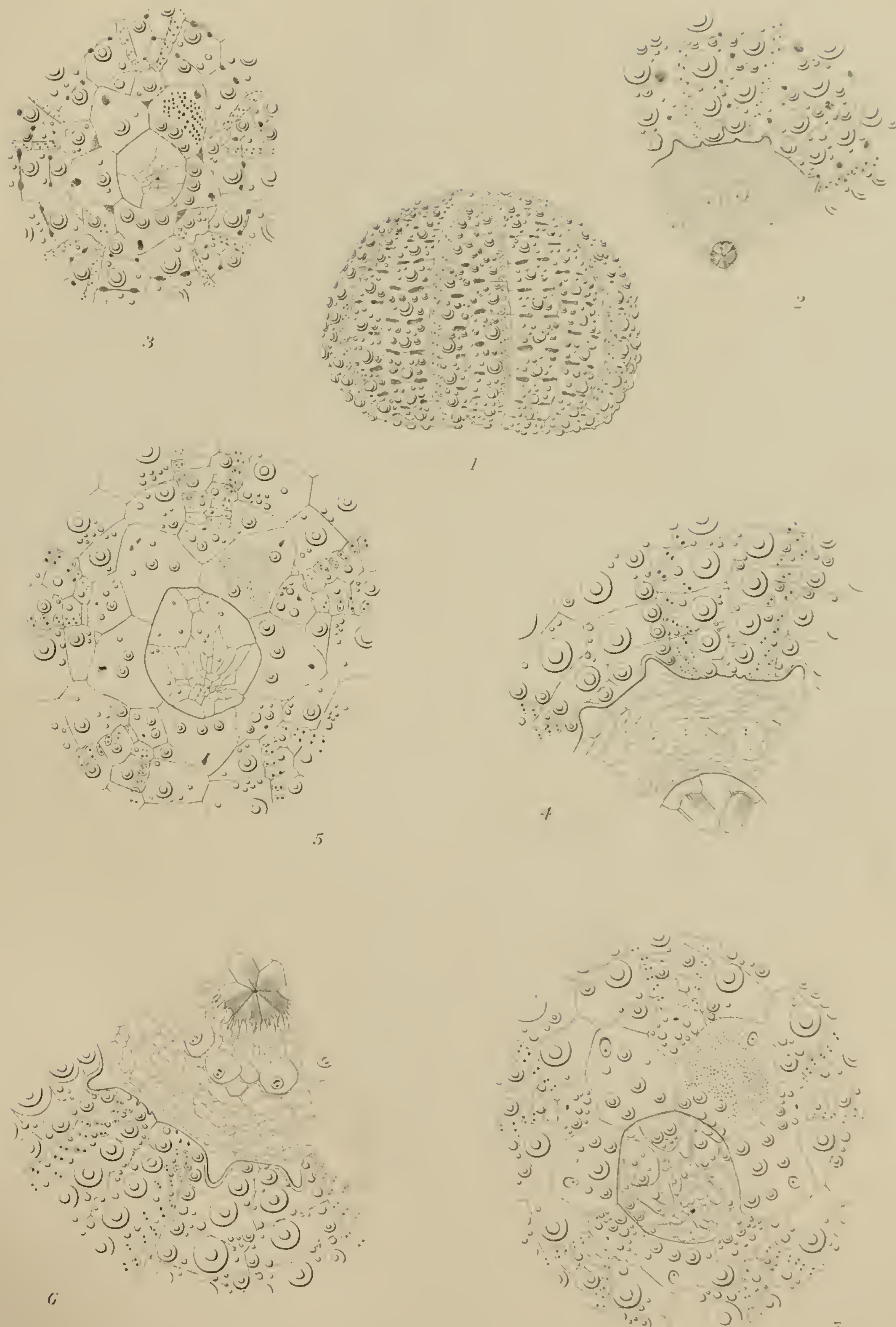
1. Side view of denuded test. × 6.
2. Part of actinostome and base of corona. × 8.
3. Abactinal system. × 10.

4, 5. **Lytechinus anamesus**, sp. nov.

4. Part of actinostome and base of corona. × 5.
5. Abactinal system. × 5.

6, 7. **Lytechinus pictus**, comb. nov.

6. Part of actinostome and base of corona. × 4.
7. Abactinal system. × 4.



3 2 1 5 4 6 7

A. M. Westergren del. B. M[illegible]

PLATE 100.

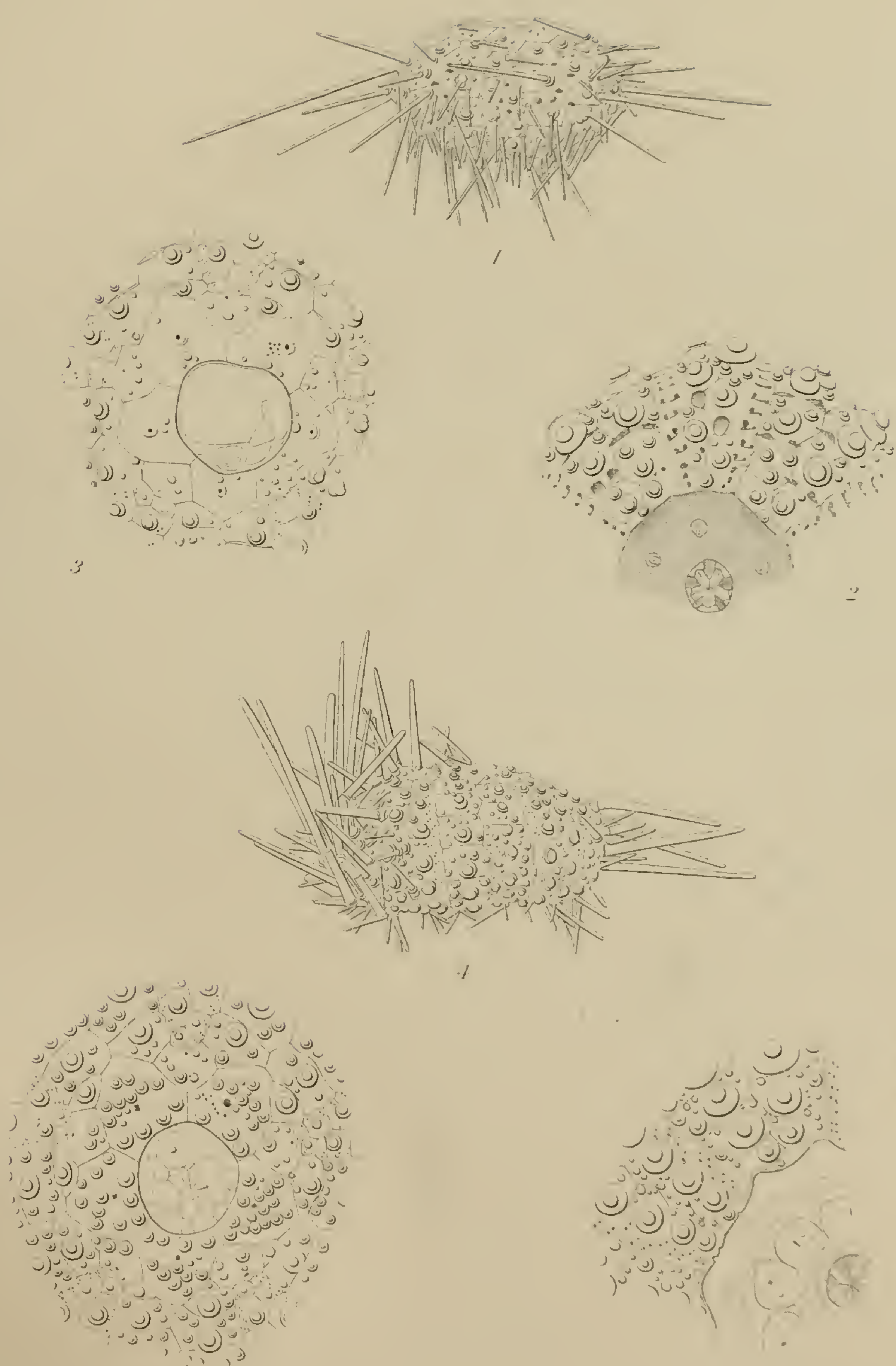
Plate 100.

1–3. **Genocidaris apoda** A. Ag. and Cl.

1. Side view. × 5.
2. Part of actinostome and base of corona. × 9.
3. Abactinal system. × 7.

4–6. **Prionechinus ruber** A. Ag. and Cl.

4. Side view. × 5.
5. Part of actinostome and base of corona. × 8.
6. Abactinal system. × 7.



1

3

2

4

6

5

PLATE 101.

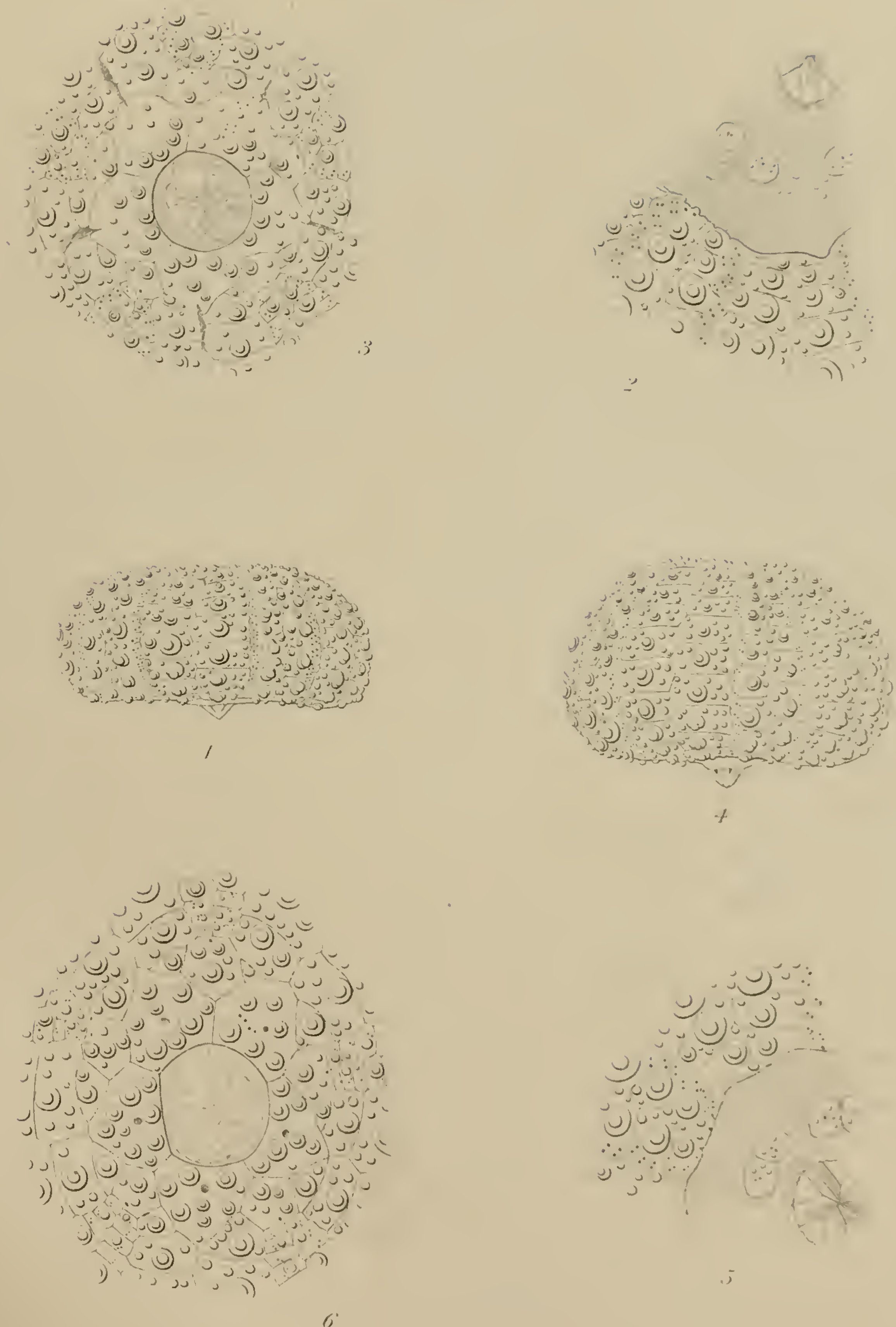
Plate 101.

1–3. **Prionechinus depressus** A. Ag. and Cl.

1. Side view of denuded test. × 5.
2. Part of actinostome and base of corona. × 10.
3. Abactinal system. × 7.

4–6. **Prionechinus sculptus** A. Ag. and Cl.

4. Side view of denuded test. × 5.
5. Part of actinostome and base of corona. × 10.
6. Abactinal system. × 10.



M. Westergren del

PLATE 102.

Plate 102.

1. **Podocidaris ornata**, sp. nov.

1. Abactinal view. $\times$ 6.

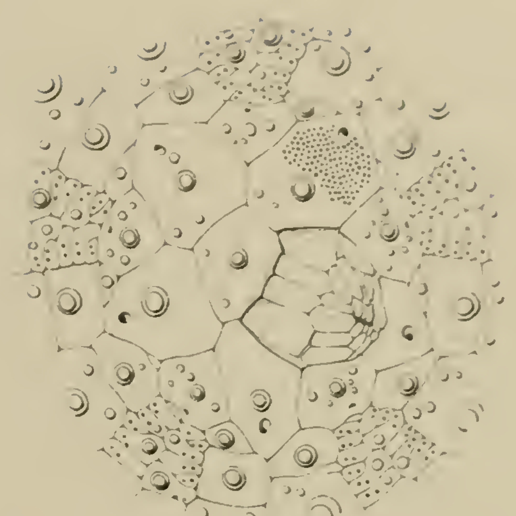
2, 3. **Gymnechinus megaloplax**, sp. nov.

2. Part of actinostome and base of corona. $\times$ 5.
3. Abactinal system. $\times$ 6.

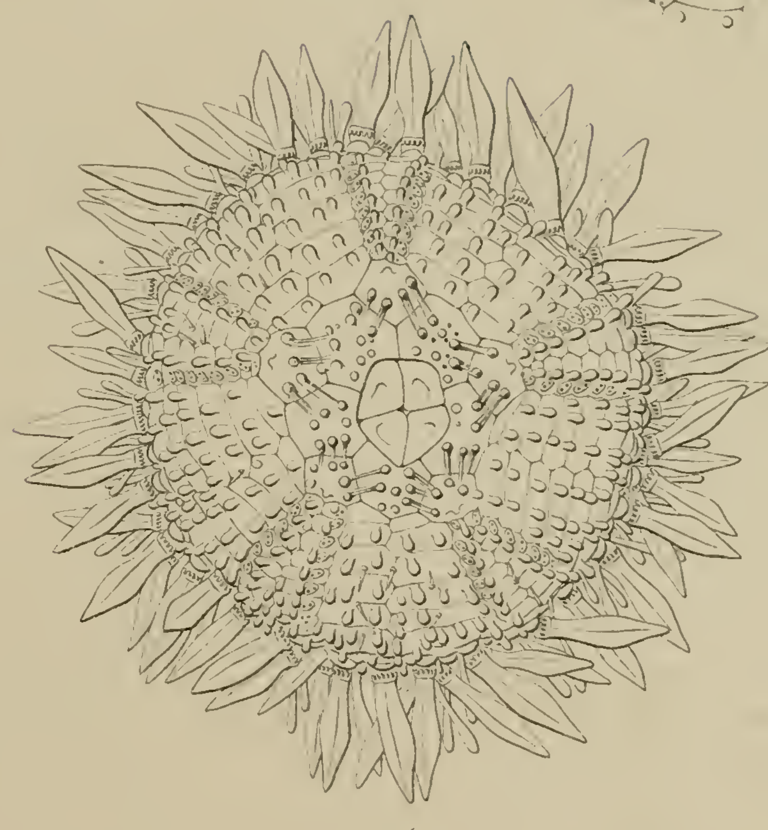
4, 5. **Gymnechinus epistichus**, sp. nov.

4. Part of actinostome and base of corona. $\times$ 5.
5. Abactinal system. $\times$ 5.5.

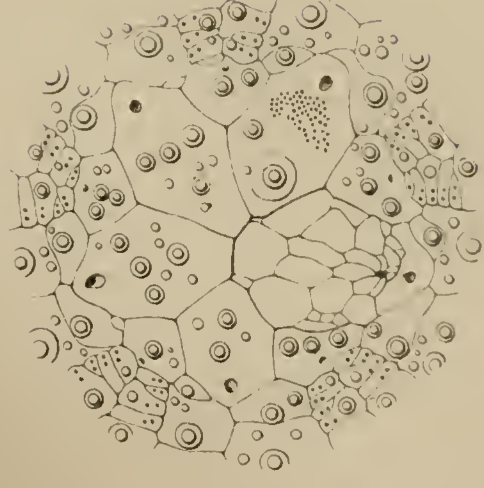
2



3



1



5

4

A M Westergren del.

PLATE 103.

Plate 103.

1–3. Cænopedina pulchella, comb. nov.

1. Abactinal system. × 5.
2. Part of actinostome and base of corona. × 8.
3. Two ambulacral plates at mid-zone. × 8.

4, 5. Echinus anchistus, sp. nov.

4. Abactinal system. × 6.
5. Part of actinostome and base of corona. × 6.

6, 7. Salmacopsis olivacea Död.

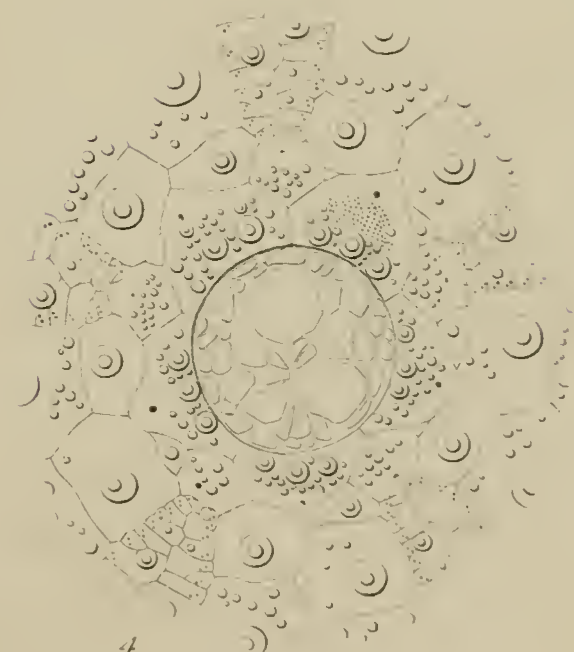
6. Abactinal system. × 5.
7. Part of actinostome and base of corona. × 4.

1

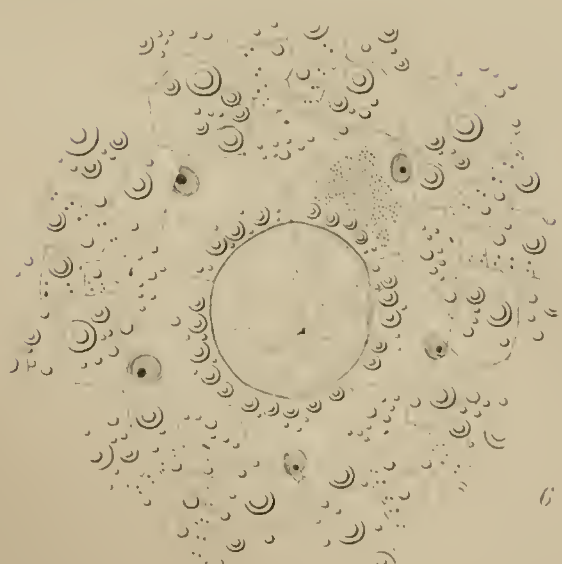
2

3

5



4



6

7

PLATE 104.

Plate 104.

1–3. **Heliocidaris stenopora**, nom. nov.

1. Abactinal system. × 4.
2. Part of actinostome and base of corona. × 3.
3. Part of ambulacrum at ambitus, showing vertical arrangement of outer pore-pairs. × 5.

4. **Holopneustes pycnotylus**, sp. nov.

4. Part of ambulacrum and interambulacrum, showing relative width, arrangement of pore-pairs, and tuberculation. × 5.

5. **Amblypneustes triseriatus**, sp. nov.

5. Part of ambulacrum and interambulacrum, showing relative width, arrangement of pore-pairs, and tuberculation. × 9.

6. **Amblypneustes pachistus**, sp. nov.

6. Part of ambulacrum and interambulacrum, showing relative width, arrangement of pore-pairs, and tuberculation. × 5.

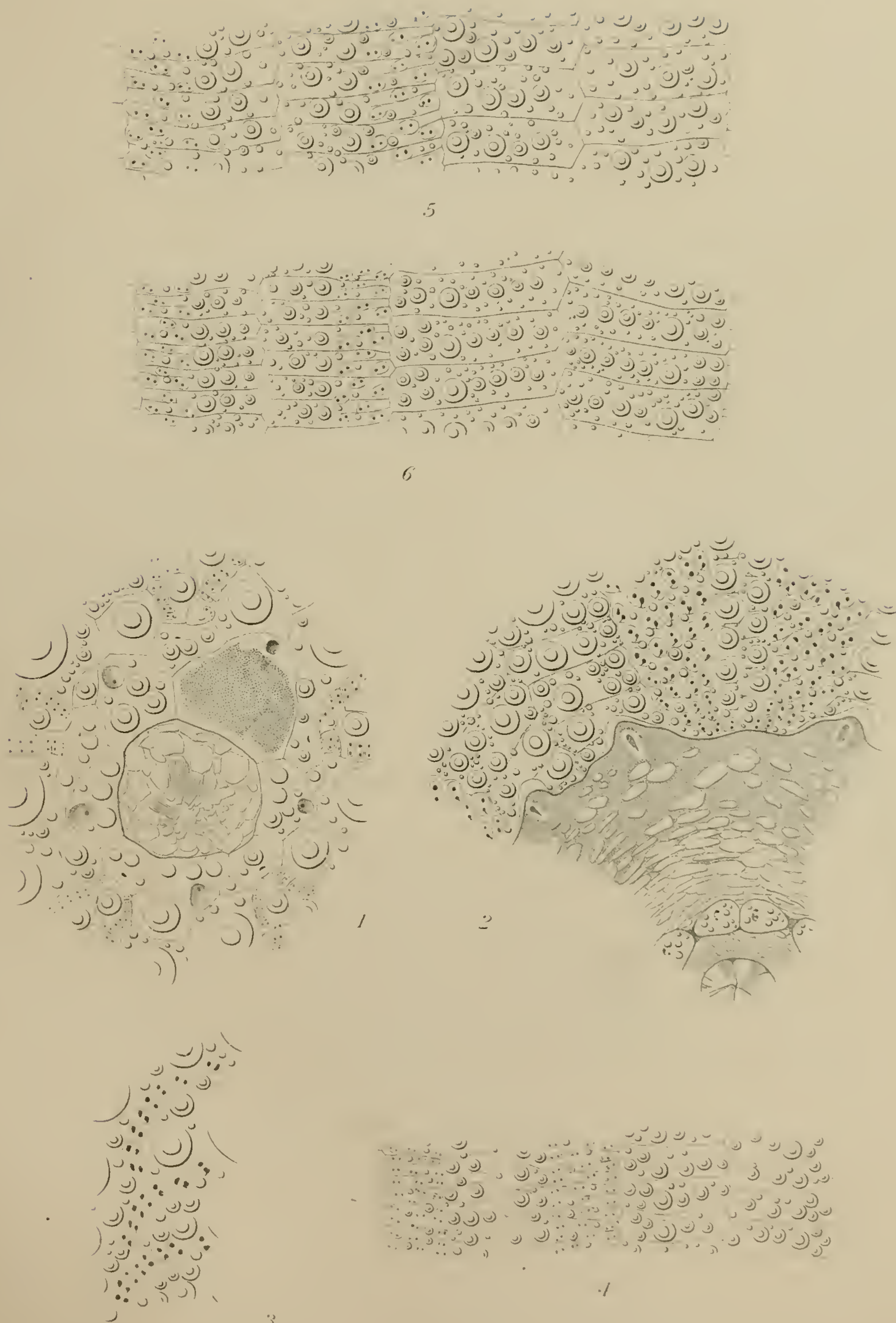

5
6
1
2
3
4

PLATE 105.

Plate 105.

1–5. **Cænopedina hawaiiensis**, nom. nov.

1. Abactinal view.
2. Side view.
3. Abactinal view of denuded test.
4. Side view of same.
5. Actinal view of same.

6, 7. **Cænopedina pulchella**, comb. nov.

6. Side view of partly denuded specimen.
7. Abactinal view of same.

8. **Cænopedina mirabilis** Mrtsn.

8. Abactinal view.

9. **Echinostrephus aciculatus** A. Ag.

9. Side view of unusually fine specimen; Laysan, H. I.

10, 11. **Echinostrephus molaris** A. Ag.

10. Side view of denuded test; Mauritius.
11. Abactinal view of same.

All figures natural size.

Heliotype Co Boston

PLATE 106.

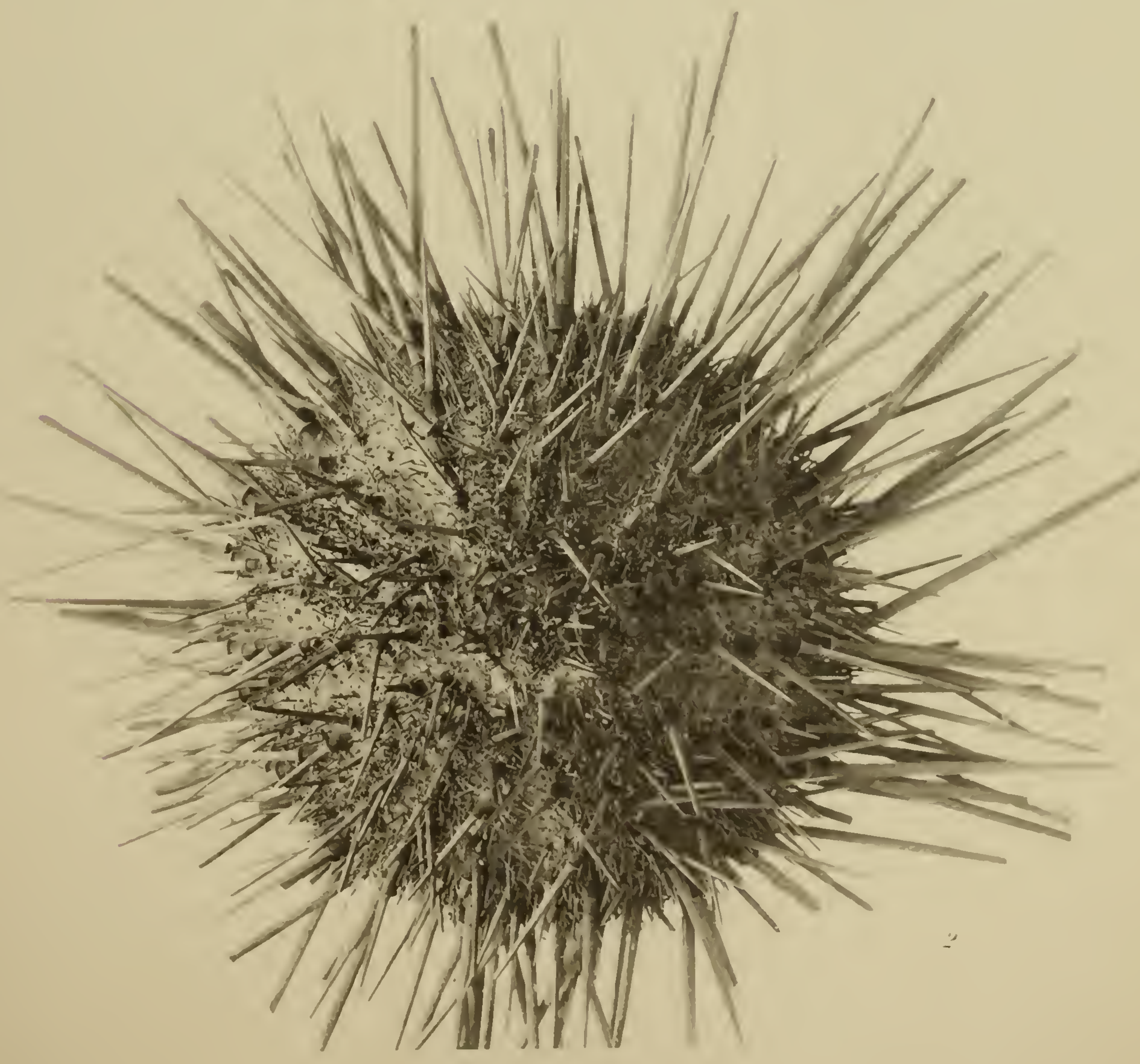
PLATE 106.

1, 2. **Glyptocidaris crenularis** A. Ag.

1. Side view of unusually fine specimen; Kinka San Light, Japan.
2. Abactinal view of same.

Both figures natural size.

1



2

Heliotype Co Boston

PLATE 107.

PLATE 107.

Plate 107.

1–3. **Echinus lucidus** Död.

1. Side view of high, short-spined specimen.
2. Side view of long-spined specimen.
3. Side view of low, short-spined specimen.

4–6. **Lytechinus euerces**, sp. nov.

4. Abactinal view of type-specimen, partly denuded.
5. Side view of same.
6. Actinal view of same.

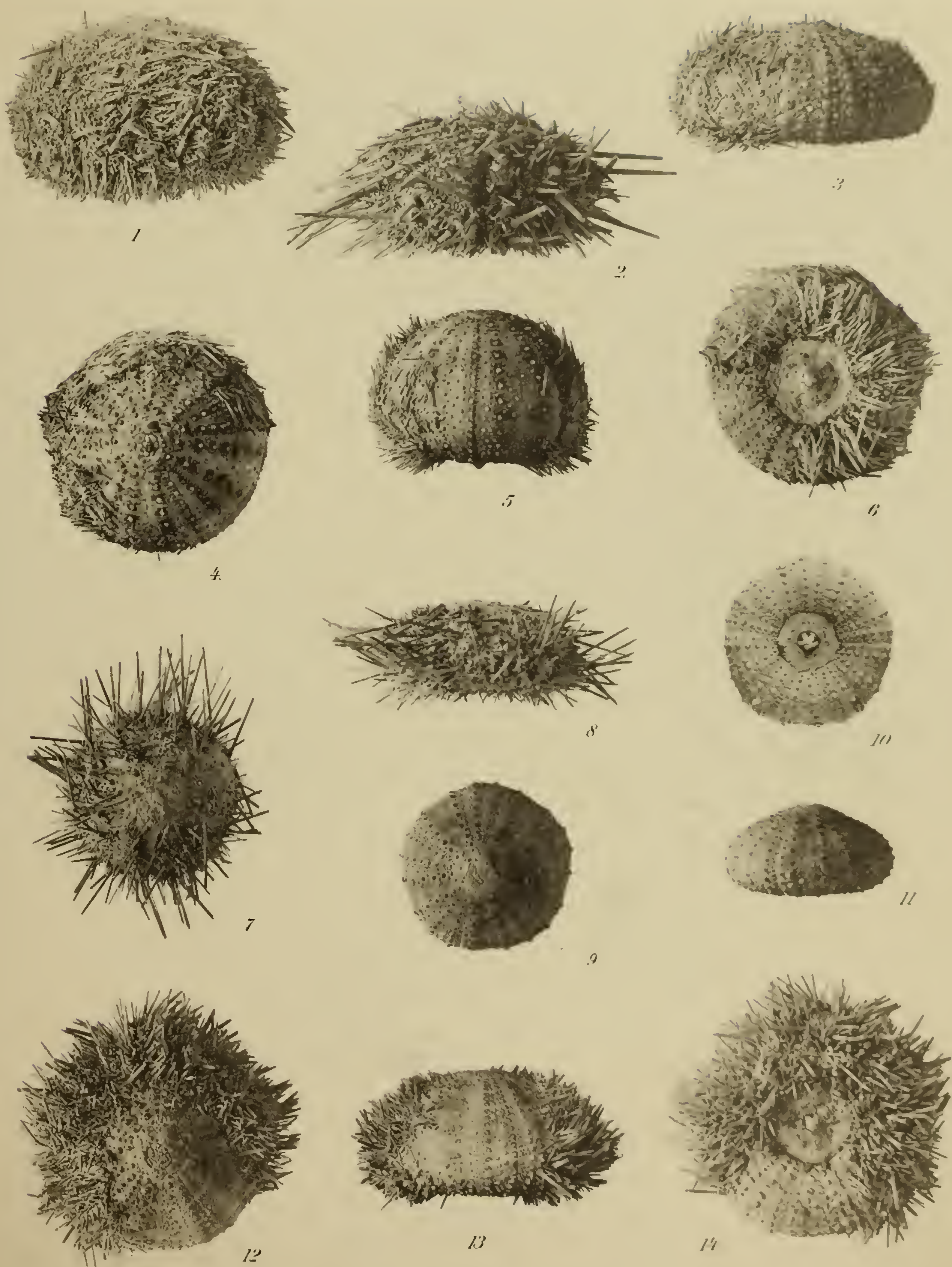
7–11. **Lytechinus anamesus**, sp. nov.

7. Abactinal view.
8. Side view.
9. Abactinal view of denuded test.
10. Actinal view of same.
11. Side view of same.

12–14. **Lytechinus pictus**, comb. nov.

12. Abactinal view of partly denuded specimen.
13. Side view of same.
14. Actinal view of same.

All figures natural size.



Heliotype Co Boston

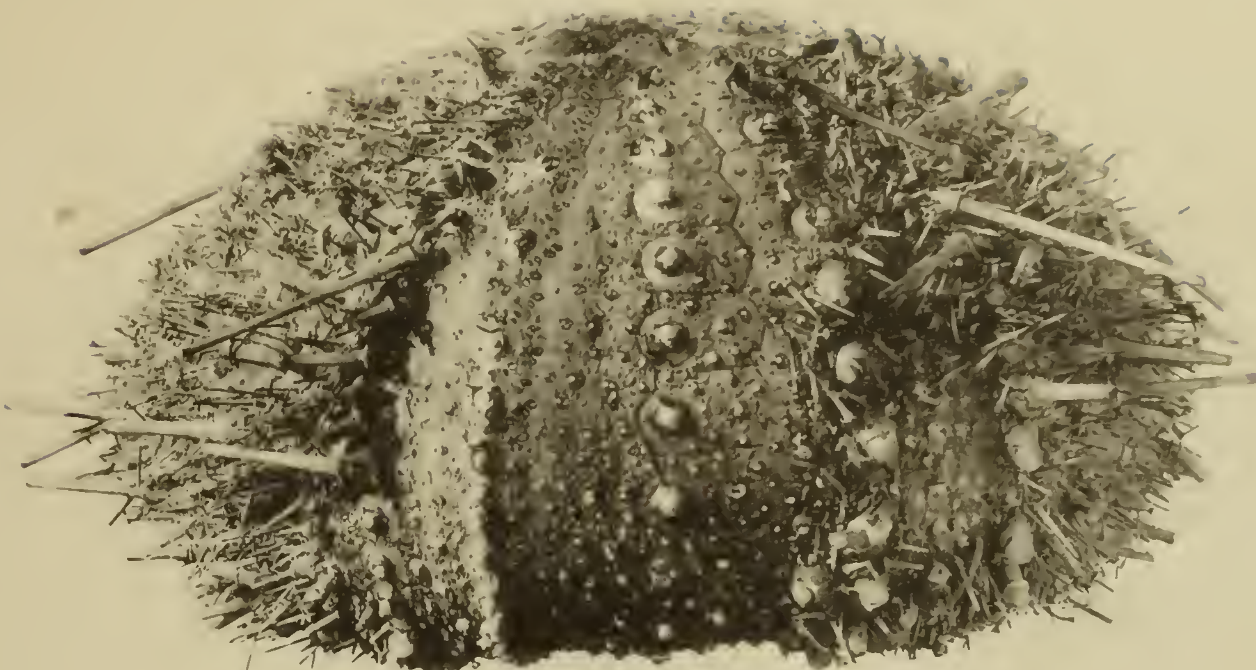
PLATE 108.

Plate 108.

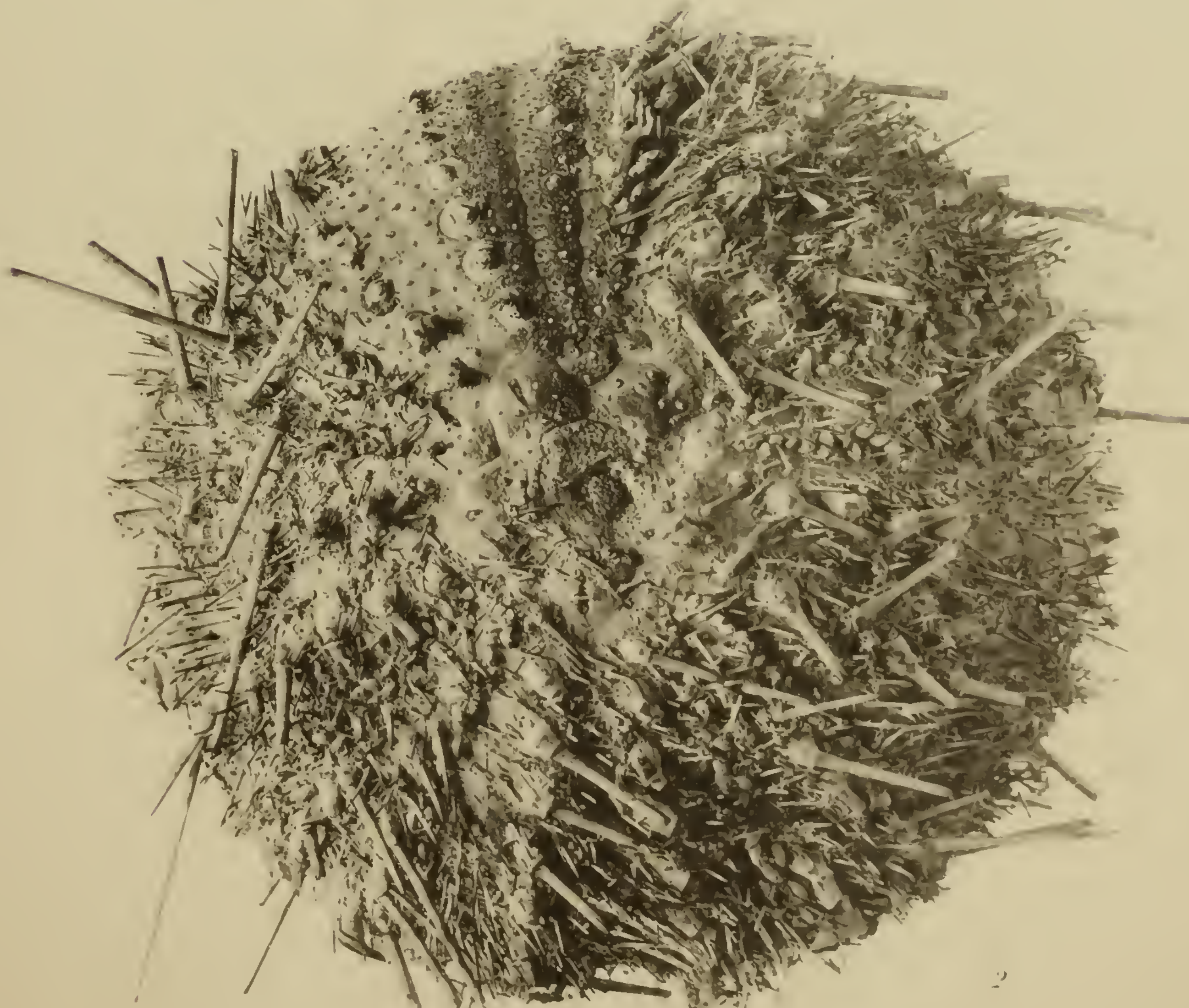
1, 2. **Echinus Wallisii** A. Ag.

1. Side view of partly denuded, very large specimen.
2. Abactinal view of same.

Both figures natural size.



1



2

Heliotype Co. Boston

Plate 109.

Plate 109.

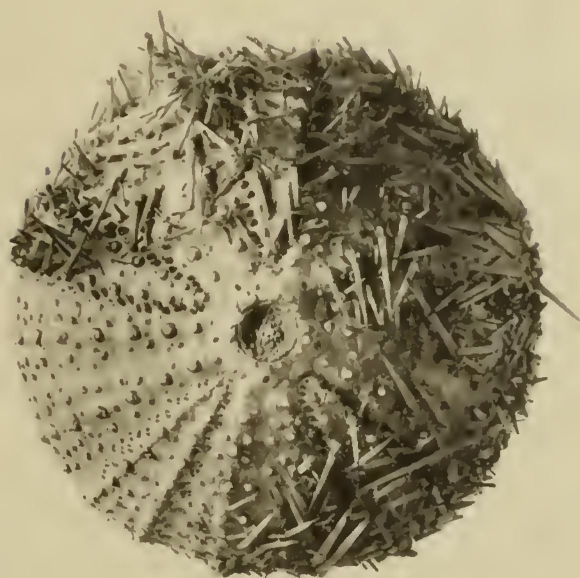
1–3. **Echinus tylodes**, sp. nov.

1. Abactinal view of type-specimen partly denuded.
2. Side view of same.
3. Actinal view of same.

4–6. **Echinus euryporus**, sp. nov.

4. Abactinal view of type-specimen partly denuded.
5. Side view of same.
6. Actinal view of same.

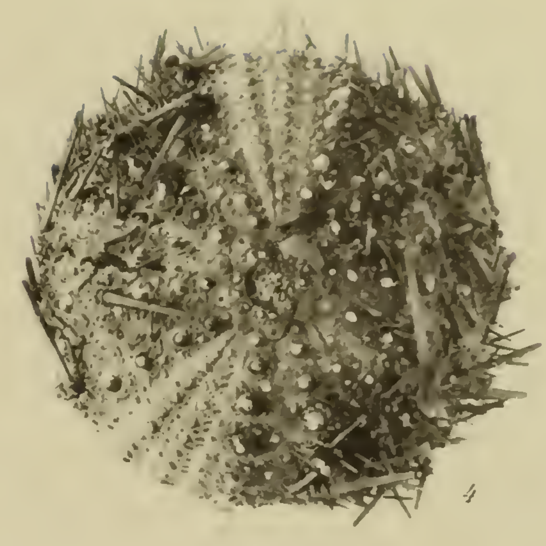
All figures natural size.



1

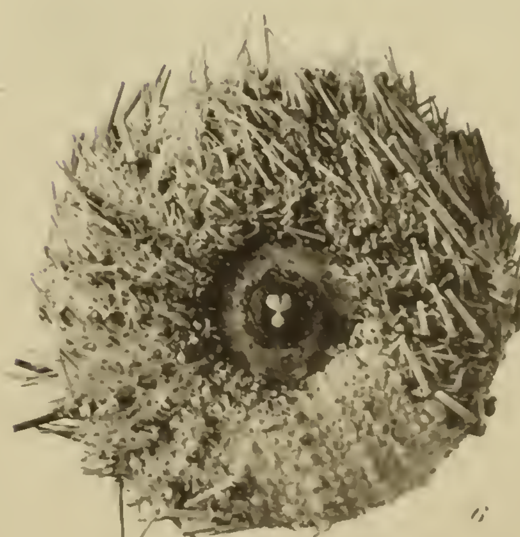
2

3



4

5



6

Heliotype Co Boston

Plate 110.

Plate 110.

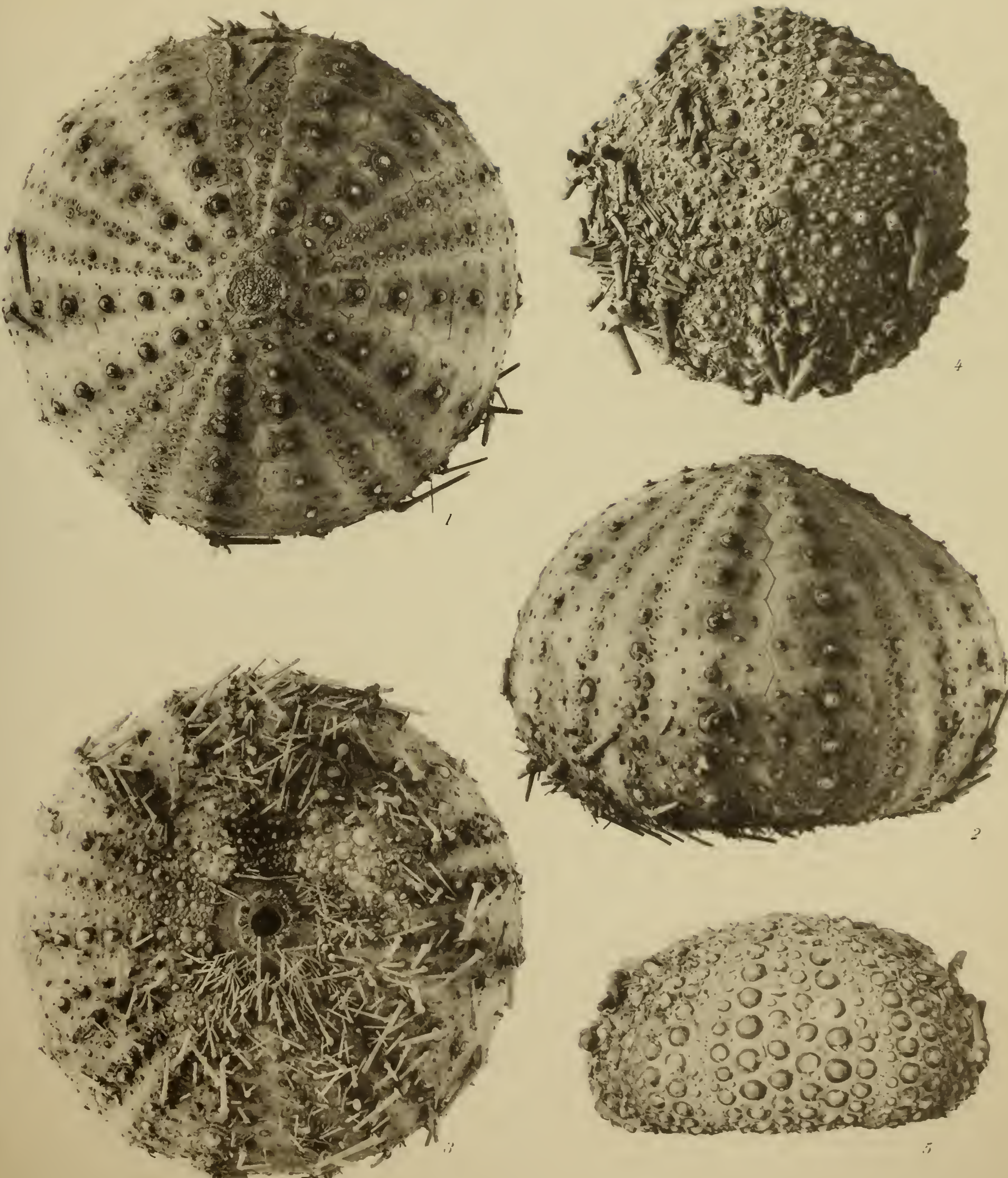
1–3. **Echinus atlanticus** Mrtsn.

1. Abactinal view of unusually fine specimen; Ascension Island.
2. Side view of same.
3. Actinal view of same.

4, 5. **Heliocidaris stenopora**, nom. nov.

4. Abactinal view of A. Agassiz's type of *Toxocidaris mexicanus*, partly denuded.
5. Side view of same.

All figures, natural size.



Heliotype Co. Boston.

PLATE 111.

Plate 111.

1–3. **Echinus anchistus**, sp. nov.

1. Abactinal view of type-specimen, partly denuded.
2. Side view of same.
3. Actinal view of same.

4–6. **Salmacis erythracis**, sp. nov.

4. Abactinal view of type-specimen, partly denuded.
5. Side view of same.
6. Actinal view of same.

7, 8. **Nudechinus multicolor**, comb. nov.

7. Side view of Yoshiwara's type-specimen, partly denuded.
8. Abactinal view of same.

9, 10. **Strongylocentrotus pulchellus** A. Ag. and Cl.

9. Side view of type-specimen, partly denuded.
10. Abactinal view of same.

All figures natural size.

Heliotype Co. Boston.

PLATE 112.

Plate 112.

1, 2. **Temnotrema sculpta** A. Ag.

1. Abactinal view of type-specimen, now a denuded test.
2. Side view of same.

3, 4. **Salmacopsis olivacea** Död.

3. Side view of large specimen.
4. Abactinal view of same.

5. **Amblypneustes triseriatus**, sp. nov.

5. Side view of denuded test.

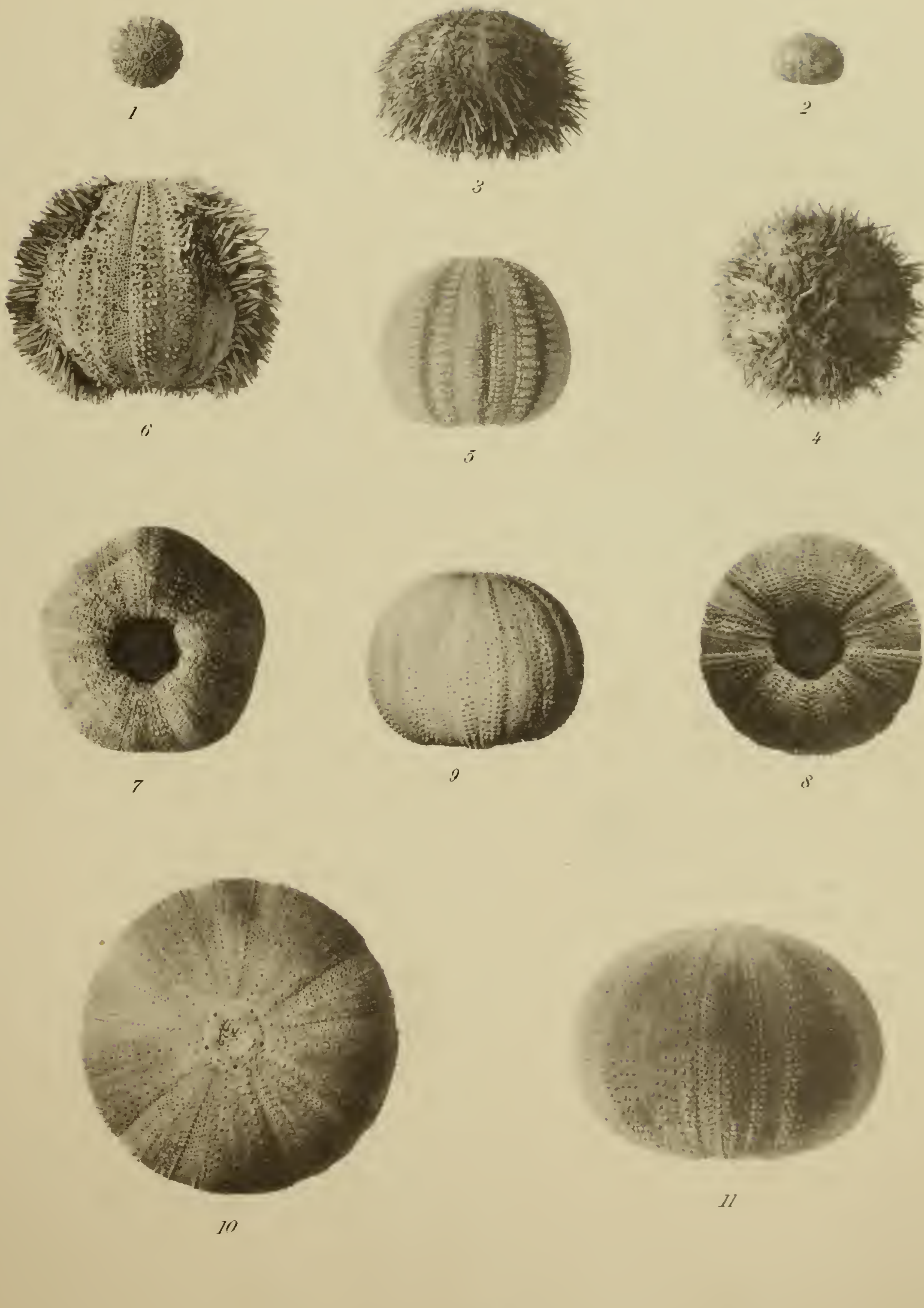
6–9. **Holopneustes pycnotylus**, sp. nov.

6. Side view of type-specimen, partly denuded.
7. Actinal view of denuded test, with pentagonal outline.
8. Actinal view of denuded test, with circular outline.
9. Side view of same.

10, 11. **Amblypneustes pachistus**, sp. nov.

10. Abactinal view of a large, denuded test.
11. Side view of same.

All figures natural size.



Heliotype Co Boston

PLATE 113.

Plate 113.

1. **Strongylocentrotus echinoides** A. Ag. and Cl.

1. Side view of partly denuded specimen.

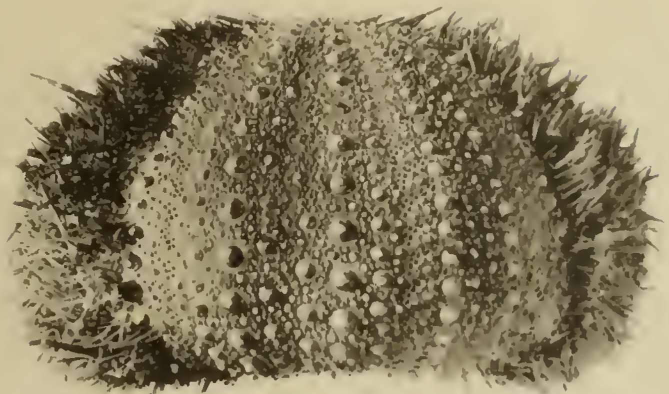
2. **Strongylocentrotus polyacanthus** A. Ag. and Cl.

2. Side view of type-specimen, partly denuded.

3–6. **Strongylocentrotus fragilis** Jackson.

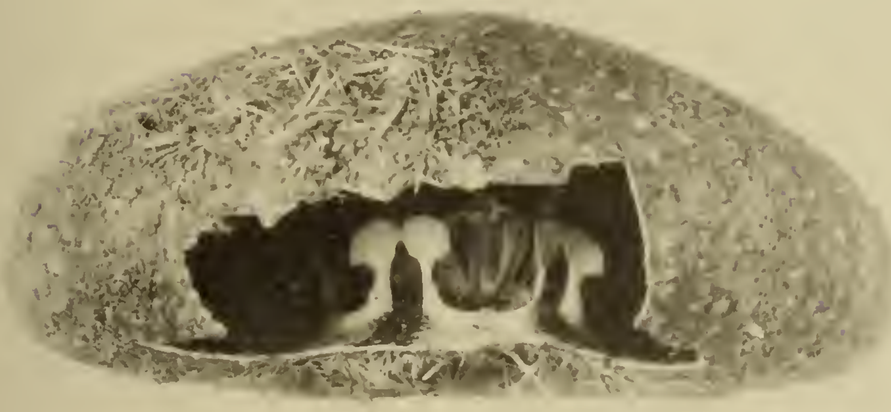
3. Side view of type-specimen; test broken, showing auricles.
4. Abactinal view of same.
5. Side view of a smaller specimen.
6. Abactinal view of same.

All figures natural size.



1

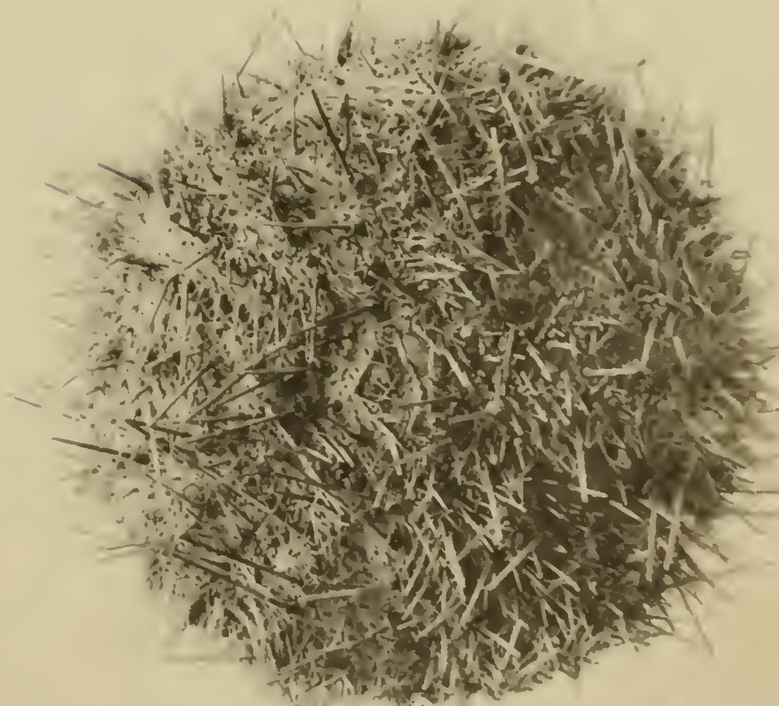
2



3

5

4



6

Heliotype Co. Boston.

PLATE 114.

PLATE 115.

PLATE 115.

Heterocentrotus mammillatus Br.

Abactinal view of specimen from Mauritius.
Natural size.

Heliotype Co Boston.

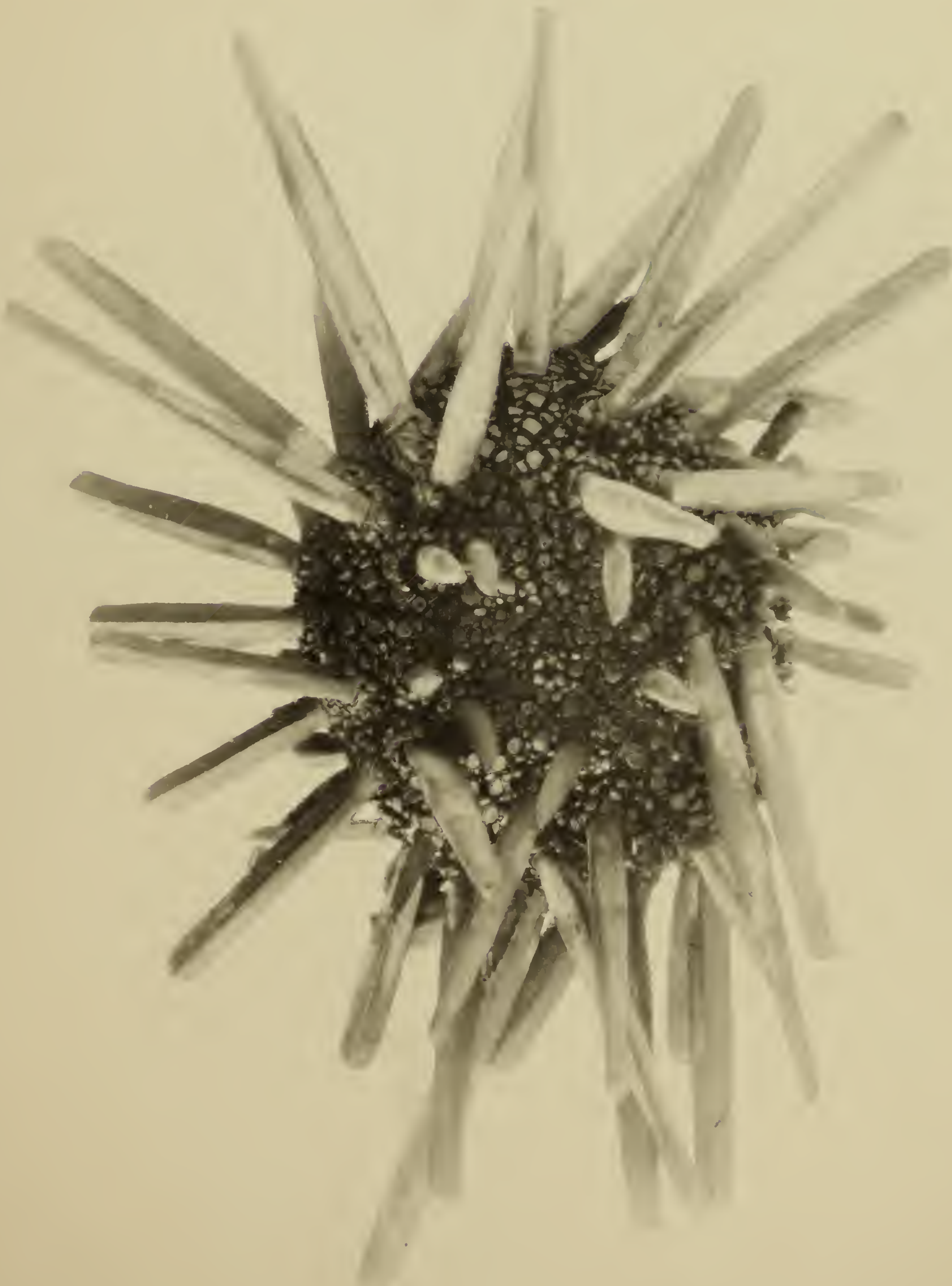
PLATE 116.

Plate 116.

Heterocentrotus mammillatus Br.

Abactinal view of specimen from Laysan, H. I.

Natural size.



Heliotype Co. Boston

PLATE 117.

PLATE 117.

1, 2. **Heterocentrotus mammillatus** Br.

1. Abactinal view of specimen from Hawaiian Islands.
2. Actinal view of same.

Both figures natural size.

2

1

Heliotype Co. Boston

PLATE 118.

Plate 118.

Heterocentrotus trigonarius Br.

Abactinal view of a specimen from Mauritius.
Natural size.

Heliotype Co Boston.

PLATE 119.

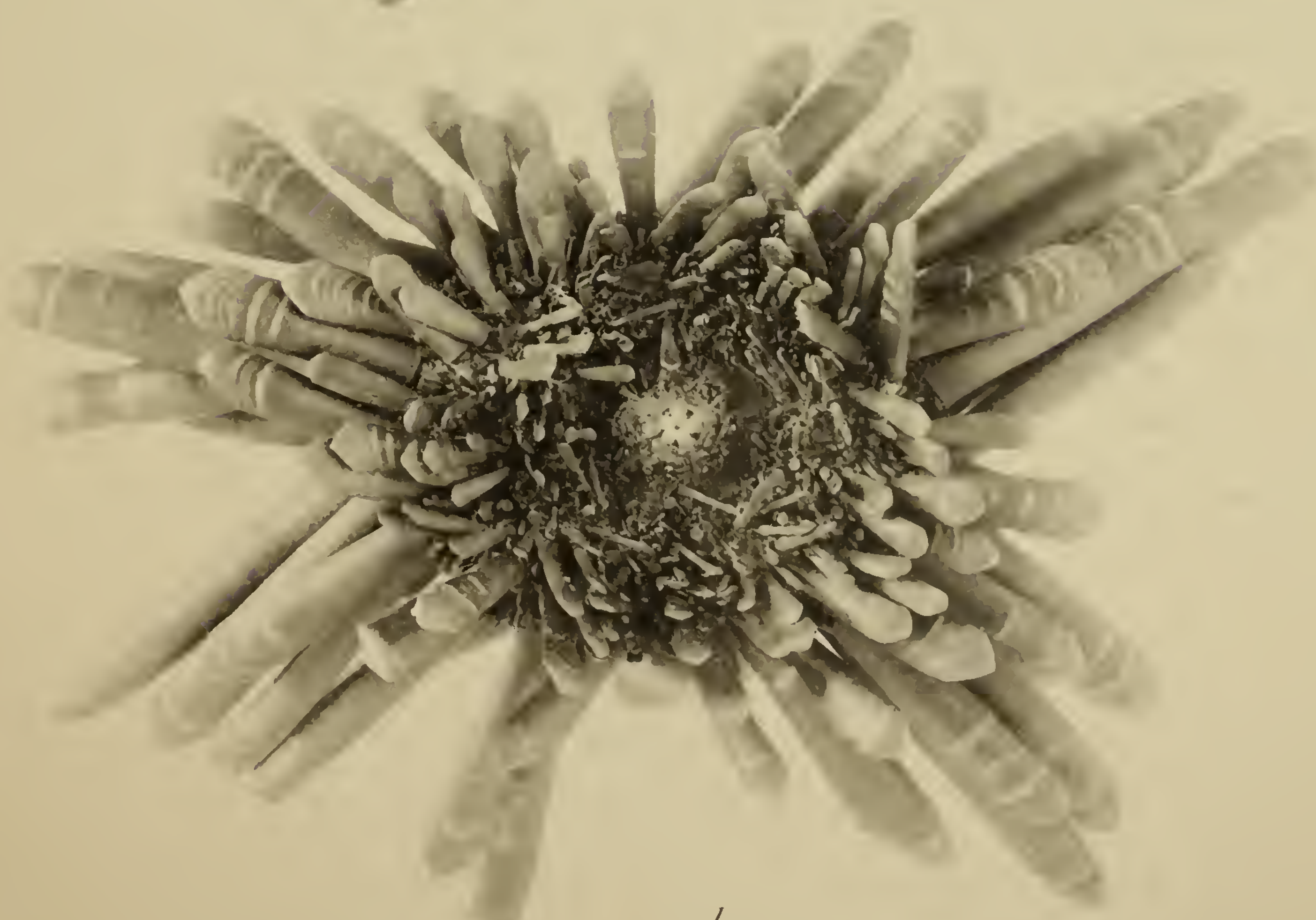
Plate 119.

1, 2. **Heterocentrotus trigonarius** Br.

1. Actinal view of a specimen from Fakarava, Paumotu Islands.
2. Abactinal view of same.

Both figures natural size.

2



1

PLATE 120.

Plate 120.

1, 2. **Heterocentrotus trigonarius** Br.

1. Actinal view of a specimen from Society Islands.
2. Abactinal view of same.

Both figures natural size.

Heliotype Co Boston.

PLATE 121.

Plate 121.

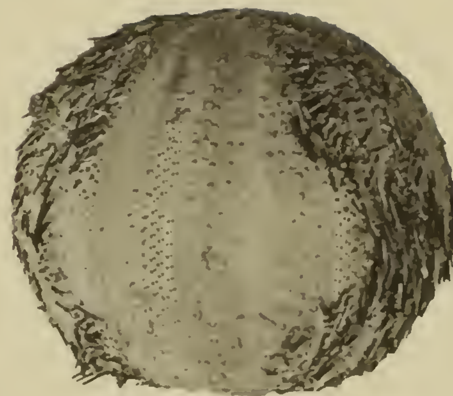
1–3. **Amblypneustes pachistus**, sp. nov.

1. Abactinal view of type-specimen, partly denuded.
2. Side view of same.
3. Actinal view of same.

4–6. **Amblypneustes grandis**, sp. nov.

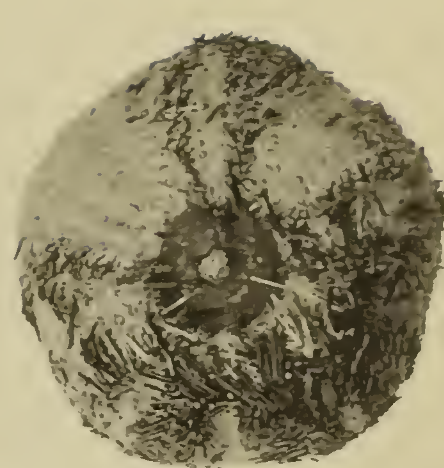
4. Abactinal view of type-specimen, partly denuded.
5. Side view of same.
6. Actinal view of same.

All figures natural size.

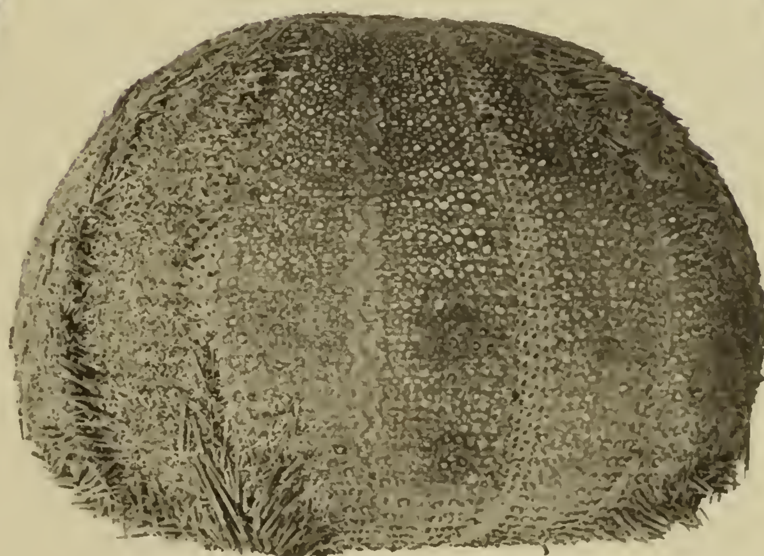


2.

1.



3.



5.

4.

6.

PUBLICATIONS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT HARVARD COLLEGE.

There have been published of the BULLETIN Vols. I. to LII.; of the MEMOIRS, Vols. I. to XXIV., and also Vols. XXVI. to XXIX., XXXI. to XXXIV., XXXVII., XXXVIII., and XLI.

Vols. LIII. to LV. of the BULLETIN, and Vols. XXV., XXX., XXXV., XXXVI., XXXIX., XL., XLII. to XLVII., of the MEMOIRS, are now in course of publication.

A price list of the publications of the Museum will be sent on application to the Director of the Museum of Comparative Zoölogy, Cambridge, Mass.