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.

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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 together. 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 varicgatus*) 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 *magellànicus*, 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] ἐυερκής = 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 interrelationships 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 respec-

tively. 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] ἐυρύς = 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 *Evechinus* 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 determin-

ing 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] μέχας (μεχάλ) = 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 Saleniidæ 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 speci-

men 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_1 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 $\frac{1}{3}$ to $\frac{1}{2}$ as wide as interporiferous; coronal plates conspicuously sculptured around primary tubercles . . . . . *scillæ.*
      - Spines smooth; primaries often swollen at tip; poriferous area $\frac{1}{4}$ to $\frac{1}{3}$ 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 porifcrous 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 . . . . . *drōbachiensis.*

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 mathœi* 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 Zealandæ, 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–I; 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 *Mathæi* 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 . . . . . *Mathæi.*
    - 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.	Hilo, Hawaii, H. I.
Necker Island, H. I.	Puako Bay, Hawaii, H. I.
Lanai, H. I.	Rangiroa, Paumotu Islands.
Kamalina Bay, Niihau, H. I.	Makemo, Paumotus.
Hanalei, Kauai, H. I.	Fakarava, Paumotus.
Waianae, Oahu, H. I.	Clarion Island, Mexico.
Honolulu Reef, Oahu, H. I.	

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 *Mathœi*. 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 ambitus 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, "cyclindrical 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.

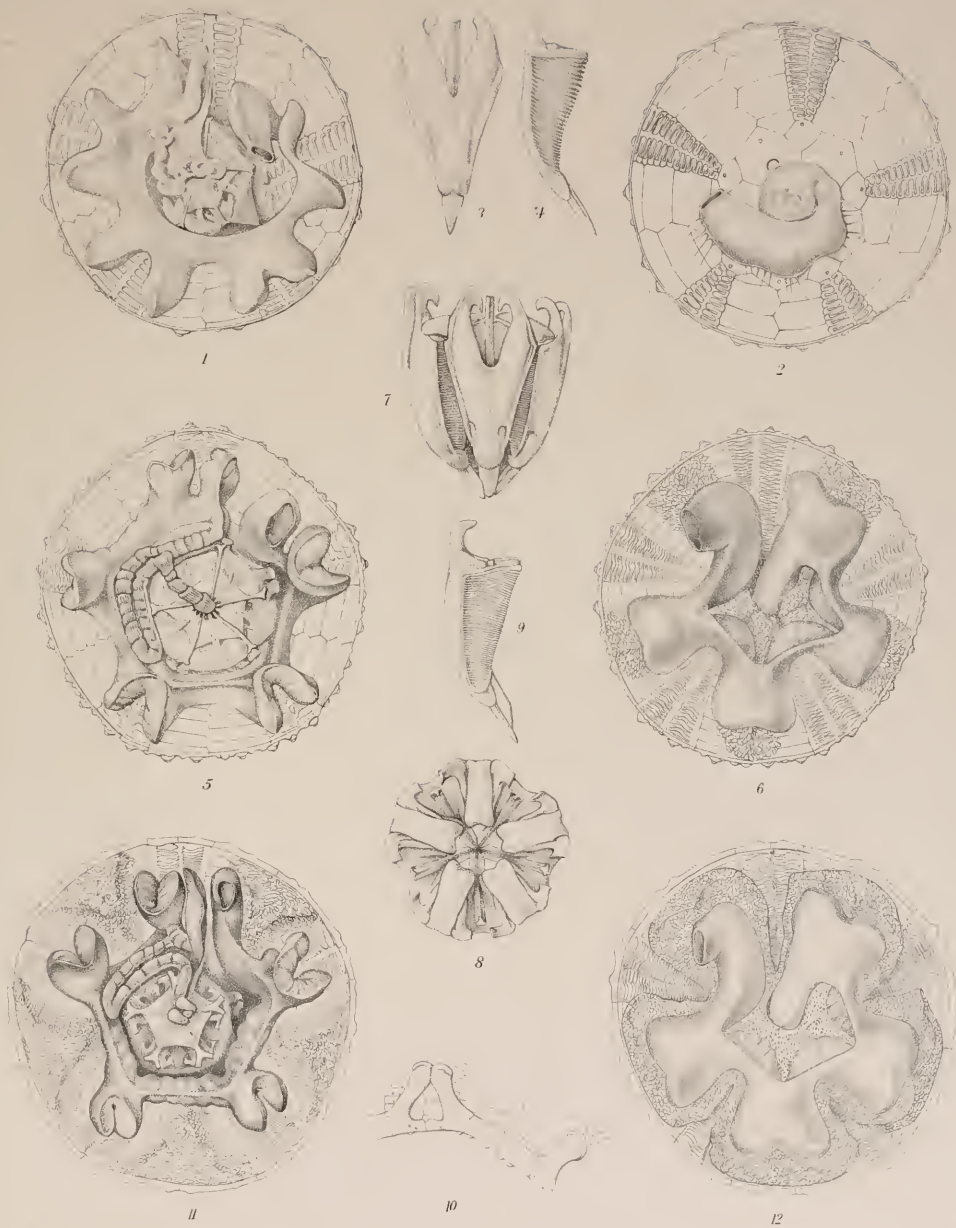
1. Interior view of actinal half of test with organs in place. × 1.5.
2. Interior view of abactinal half. × 1.5.
3. Exterior view of a pyramid from lantern. × 4.
4. Side view of same. × 4.

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.



A. M. Westergren del. B. Mas[illegible]

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.

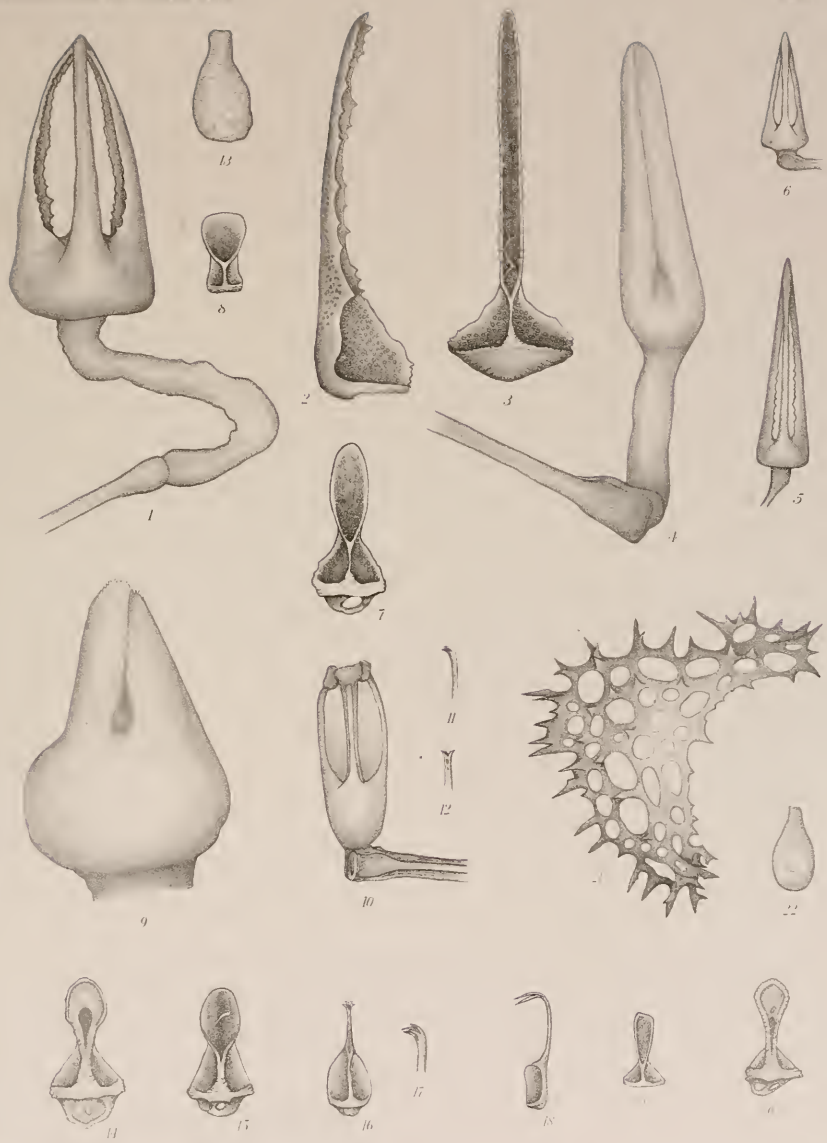

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PLATE 92.

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.

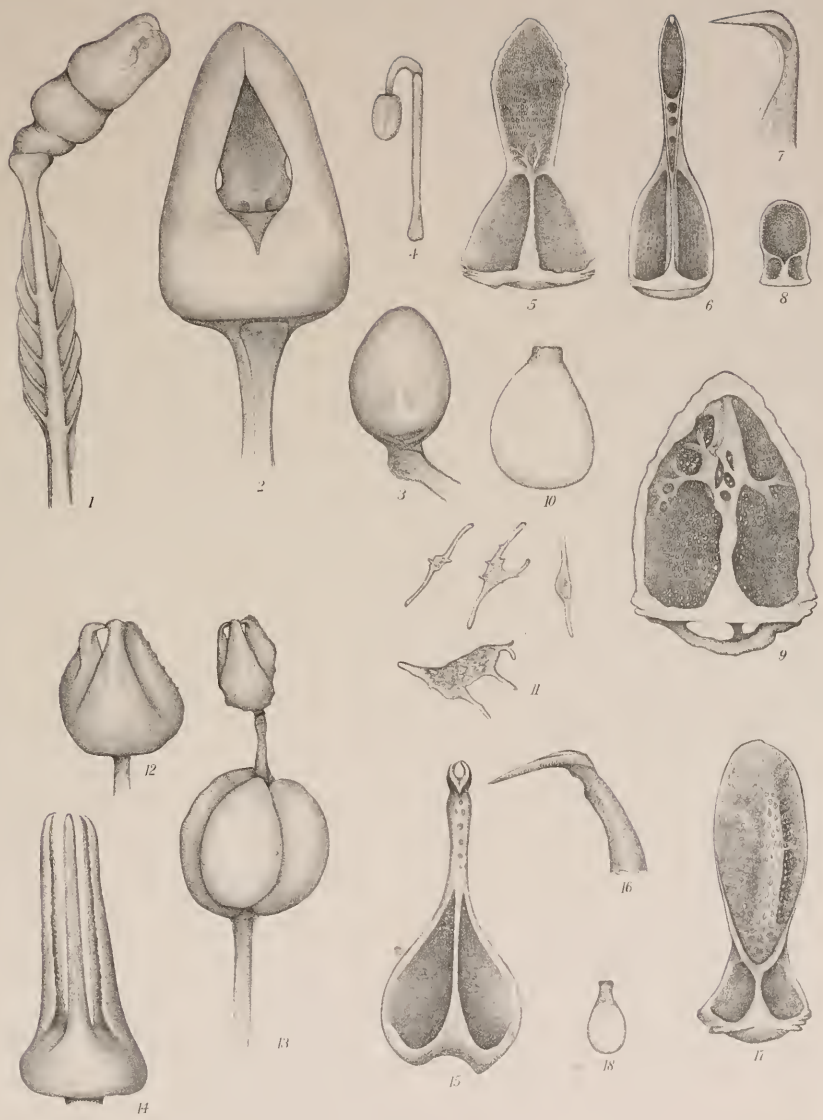
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Plate 93.

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.


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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.

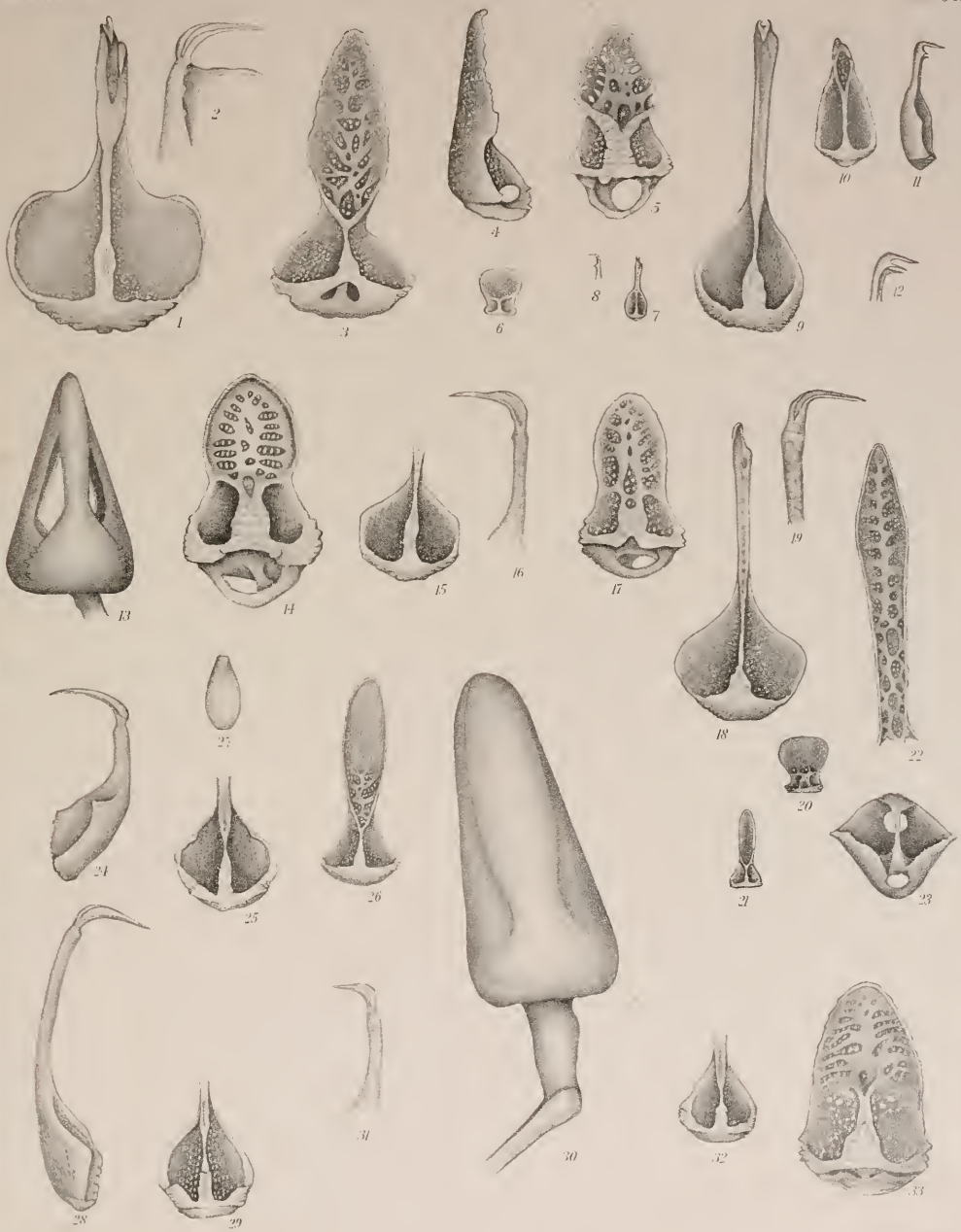
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PLATE 95.

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.

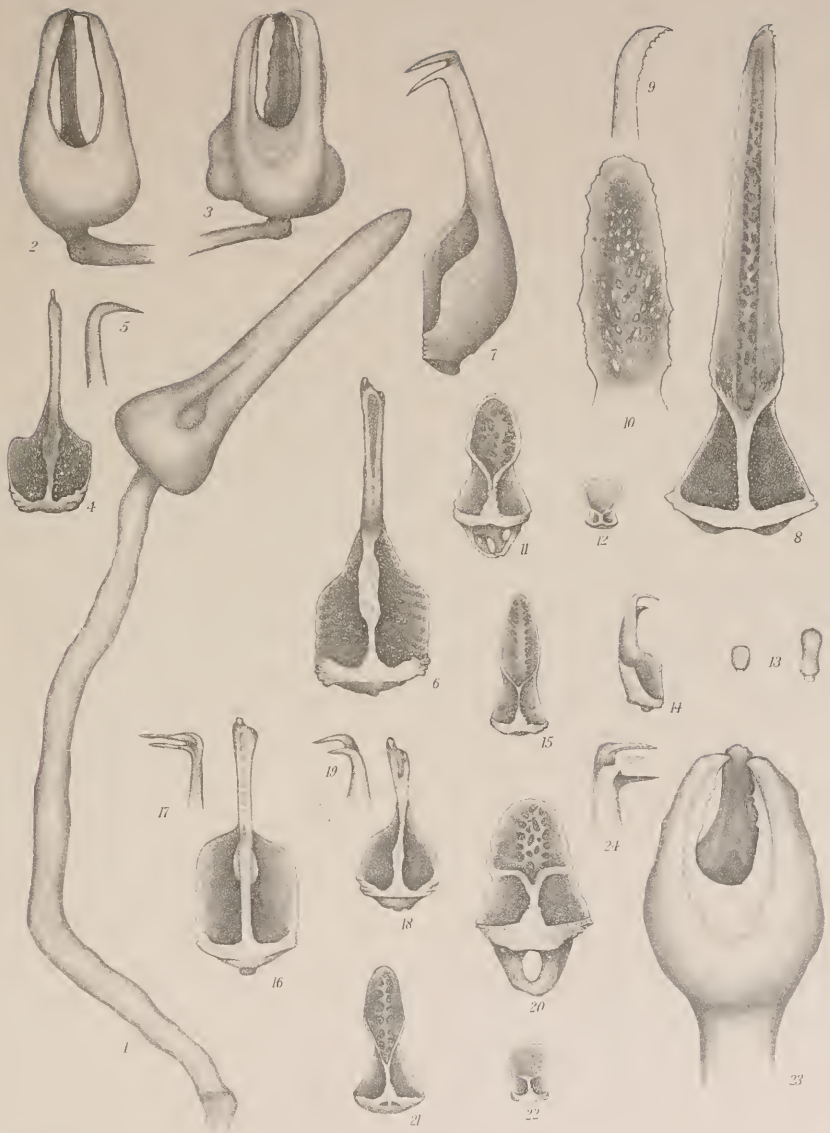
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PLATE 96.

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.

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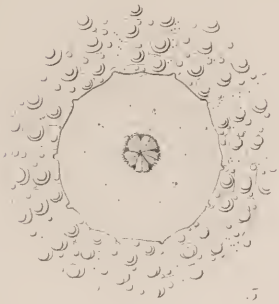

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PLATE 97.

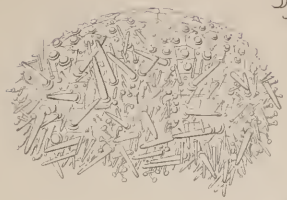
PLATE 97.

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.



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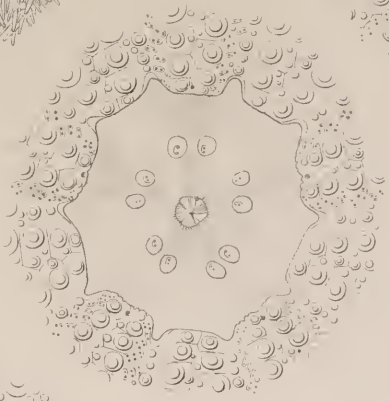

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PLATE 98.

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.


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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.

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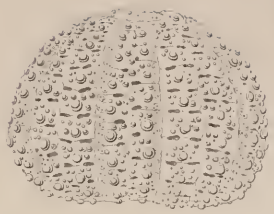

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PLATE 100.

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.

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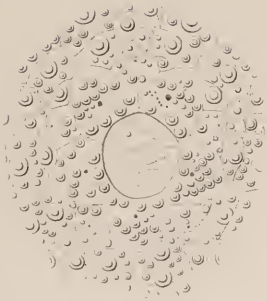

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PLATE 101.

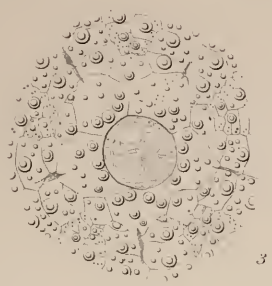
Plate 101.

1–3. **Prionechinus depressus** A. Ag. and Cl.

1. Side view of denuded test. × 5.
2. Part of aetinostome and base of corona. × 10.
3. Abaetinal 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. Abaetinal system. × 10.



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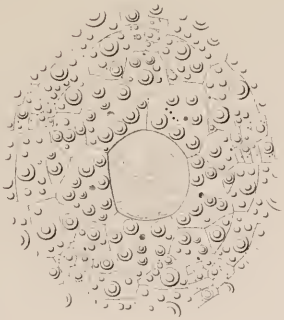

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A. Agassiz del. et lith. del. S. Wilson, lith. Berlin.

PLATE 102.

Plate 102.

1. **Podocidaris ornata**, sp. nov.

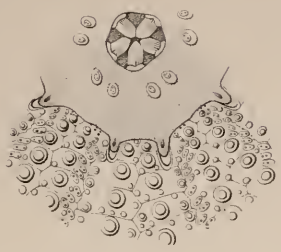
1. Abactinal view. × 6.

2, 3. **Gymnechinus megaloplax**, sp. nov.

2. Part of actinostome and base of corona. × 5.
3. Abactinal system. × 6.

4, 5. **Gymnechinus epistichus**, sp. nov.

4. Part of actinostome and base of corona. × 5.
5. Abactinal system. × 5.5.



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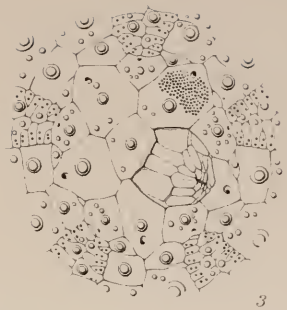

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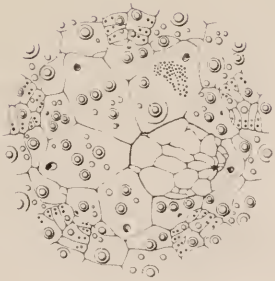

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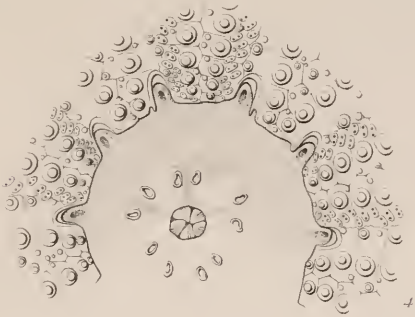

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M. Mosenthal del. B. M. Isel lith. Bonn

PLATE 103.

Plate 103.

1–3. **Cænopedina pulchella**, comb. nov.

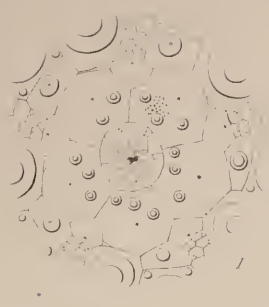
1. Abactinal system. × 5.
2. Part of actinostome and base of corona. × 8.
3. Two ambulacral plates at mid-zone. × 8.

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.



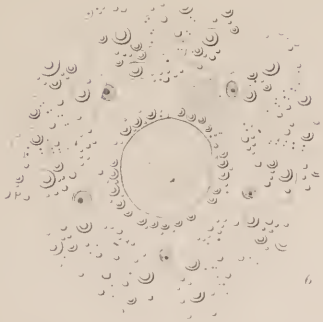


PLATE 104.

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.

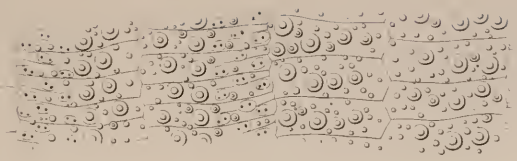


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PLATE 105.

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.


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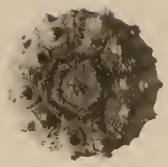
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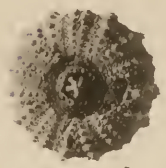
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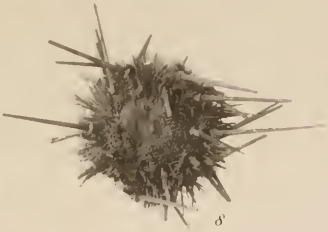
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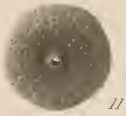
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Heliotype Co. Boston.

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.

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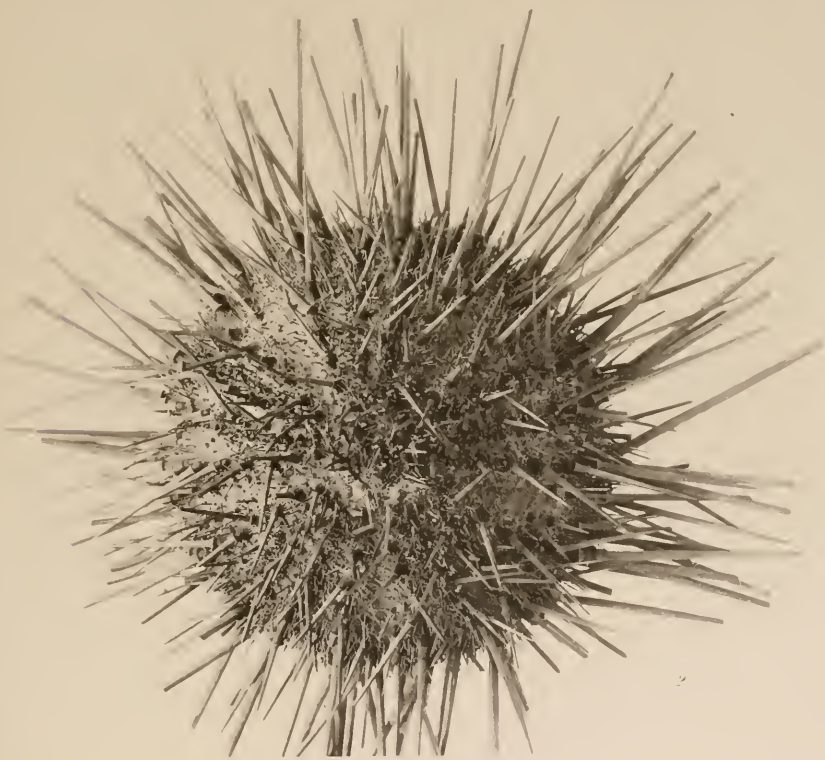

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PLATE 107.

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.


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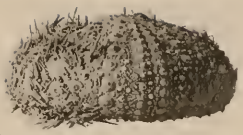
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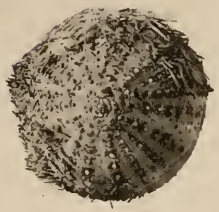
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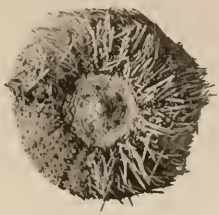
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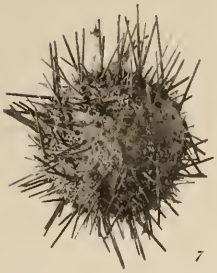
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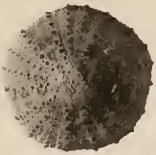
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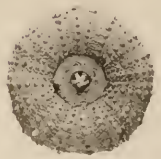
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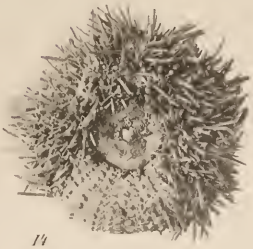

14

Heliotype to face

PLATE 108.

PLATE 108.

1, 2. **Echinus Wallisii** A. Ag.

1. Side view of partly denuded, very large specimen.
2. Abaetinal view of same.

Both figures natural size.

1

2

Heliotype of Boston

Plate 109.

1–3. **Echinus tylodes**, sp. nov.

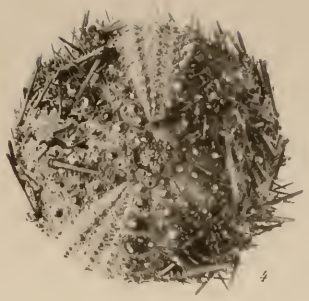
1. Abactinal view of type-specimen partly denuded.
2. Side view of same.
3. Actinal view of same.

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



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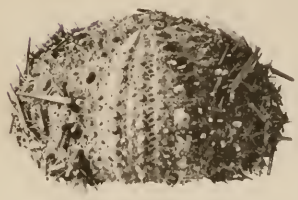

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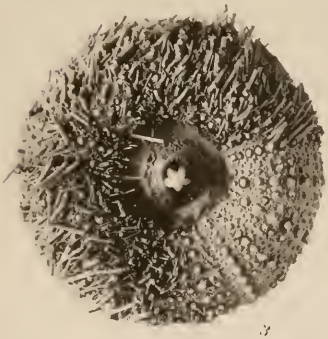

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Heliotype Co Boston

Plate 110.

Plate 110.

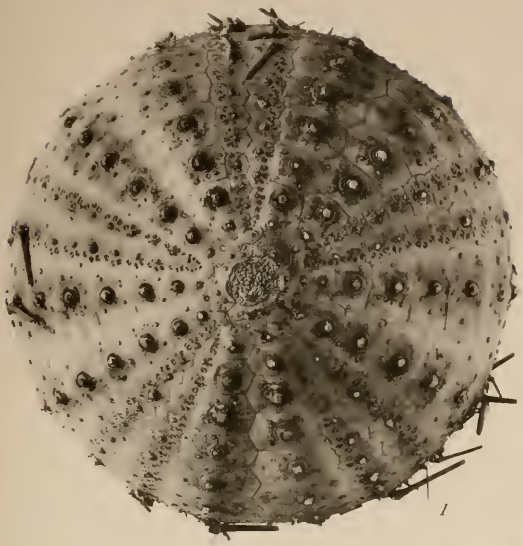
1–3. **Echinus atlanticus** Mrtsn.

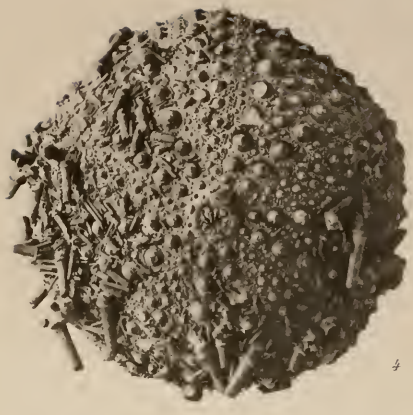
1. Abactinal view of unusually fine specimen; Ascension Island.
2. Side view of same.
3. Actinal view of same.

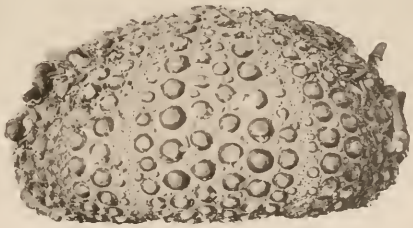
4, 5. **Heliocidaris stenopora**, nom. nov.

4. Abactinal view of A. Agassiz's type of *Toxocidaris mexicanus*, partly denuded.
5. Side view of same.

All figures, natural size.







Phototype 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.

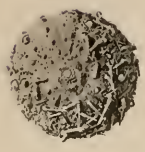
7, 8. **Nudechinus multicolor**, comb. nov.

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.



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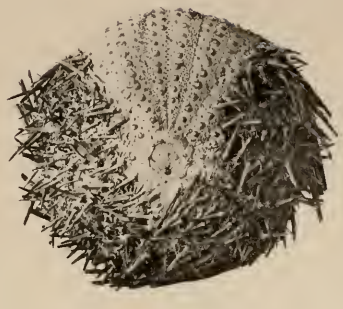

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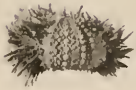

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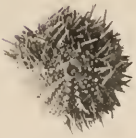

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Heliotype Co. Boston.

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.

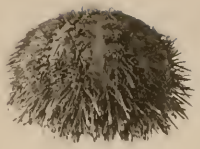
6. Side view of type-specimen, partly denuded.
7. Actinal view of denuded test, with pentagonal outline.
8. Actinal view of denuded test, with circular outline.
9. Side view of same.

10, 11. **Amblypneustes pachistus,** sp. nov.

10. Abactinal view of a large, denuded test.
11. Side view of same.

All figures natural size.

1



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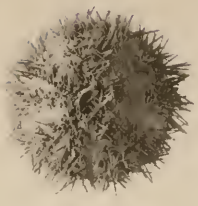

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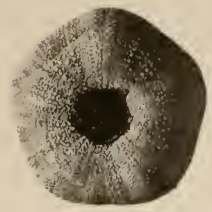

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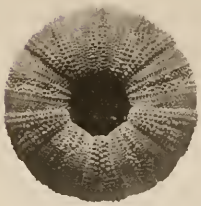

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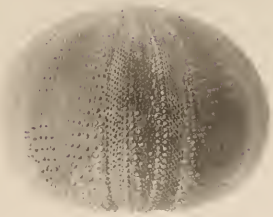

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Heliotype Co Boston

PLATE 113.

Plate 113.

1. **Strongylocentrotus echinoides** A. Ag. and Cl.

1. Side view of partly denuded specimen.

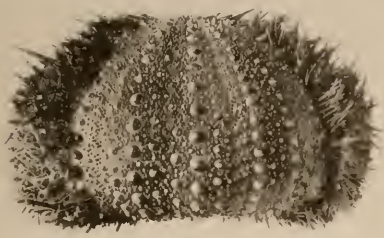
2. **Strongylocentrotus polyacanthus** A. Ag. and Cl.

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.



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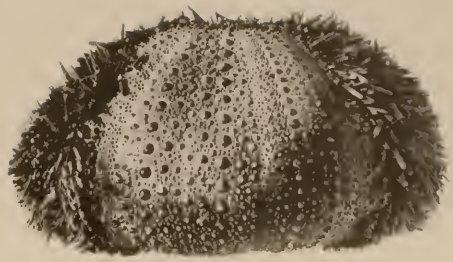

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Heliotype Co Boston.

PLATE 114.

Plate 114.

1, 2. **Echinometra oblonga** Bl.

1. Side view of an unusually fine specimen; Laysan, H. I.
2. Side view of a slender-spined specimen; Clarion Island.

3, 4. **Echinometra insularis,** sp. nov.

3. Side view of specimen from Easter Island.
4. Abactinal view of another Easter Island specimen.

5, 6. **Echinometra picta** A. Ag. and Cl.

5. Side view of a small specimen.
6. Abactinal view of same.

All figures natural size.


1


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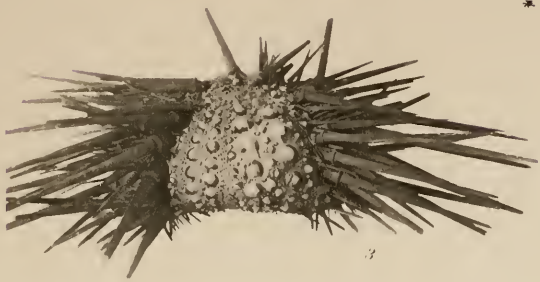
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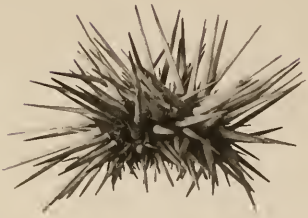
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Phototype Co. Boston

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.

Heliocidaris tuberculata

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

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

Heliotype Co. Boston.

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.

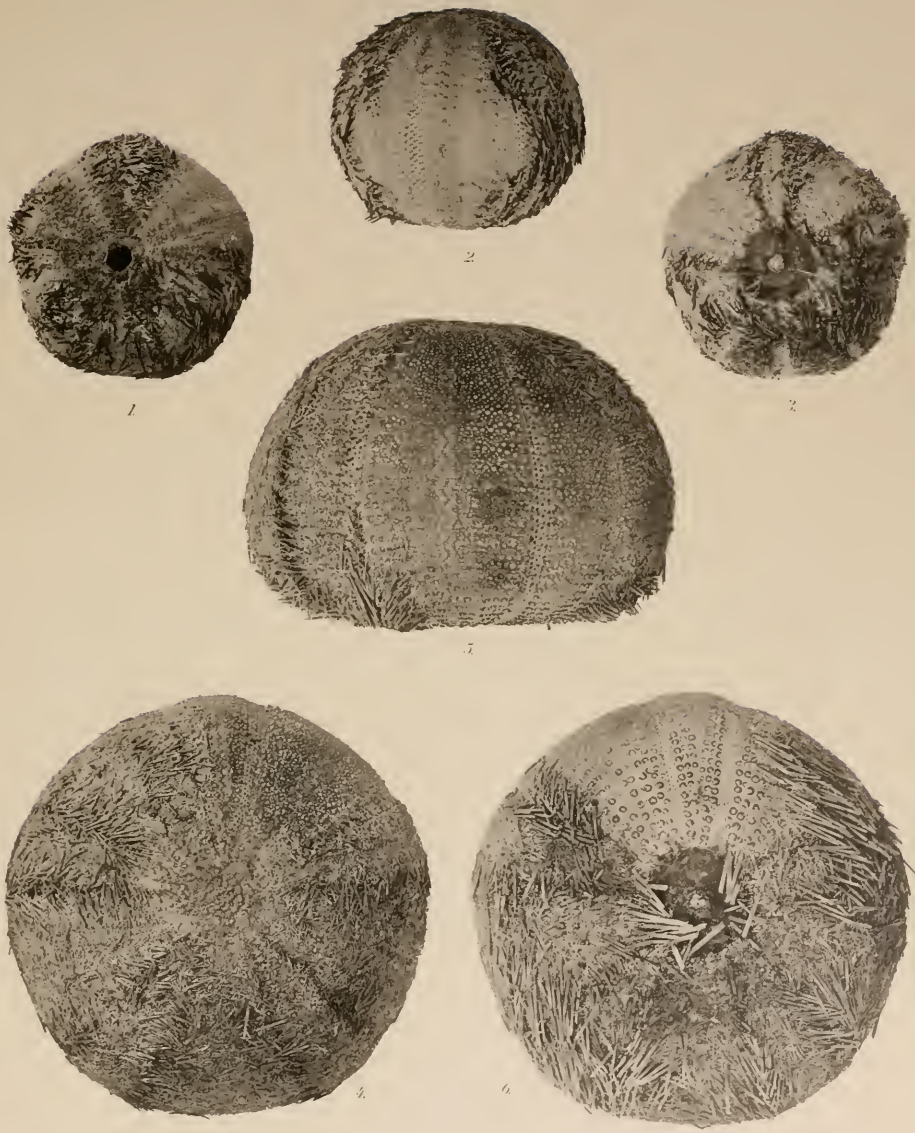
1–3. **Amblypneustes pachistus**, sp. nov.

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.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OF THE

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