MEMOIRS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT

HARVARD COLLEGE.

VOL. XXXI.

CAMBRIDGE, U.S.A.
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1904.

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CONTENTS.

Memoirs of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. XXXI.

REPORTS ON AN EXPLORATION OFF THE WEST COASTS OF MEXICO, CENTRAL AND SOUTH AMERICA, AND OFF THE GALAPAGOS ISLANDS, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," DURING 1891, LIEUT. COMMANDER Z. L. TANNER, U. S. N. COMMANDING.

XXXII.

THE PANAMIC DEEP SEA ECHINI.

BY ALEXANDER AGASSIZ.

ONE VOLUME TEXT,

WITH ONE HUNDRED AND TWELVE PLATES,

INCLUDING A CHART OF THE ROUTE, AND 319 FIGURES IN THE TEXT.

TEXT.

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CONTENTS.

* Panamic species collected by the "Albatross."

INTRODUCTION.

In connection with the collection made by the "Albatross" Expedition of 1891, I intended to take up the anatomy of the most prominent types of the Deep Sea Echini, combining with it species from the collections made by the "Blake," the "Hassler," and other "Albatross" Expeditions. Considerable material had been brought together to elucidate the structure of the pedicellariæ, of the spines, the jaws, the auricles, and internal anatomy of groups represented by deep-sea species. Unfortunately my frequent and prolonged absences in the interest of Thalassographical investigations have interfered to such an extent with this work that I am again compelled to postpone that part of my Report to another occasion. Having associated with this investigation Professor Hubert Lyman Clark, of Olivet, Michigan, I hope to incorporate this material in a Report on the Echini collected by the "Albatross" among the Hawaiian Islands which we are preparing for the United States Fish Commission.

The present Report on the Echini of the "Albatross" Expedition of 1891, the greater part of which was written in 1898, is therefore published without the studies mentioned above, and limited principally to the morphological study of the tests of the species discovered. I regret the delay of the publication of the details; the more so as two Memoirs[1] have lately been published which deal with the classification of the Echini essentially from the study of the pedicellariæ. These Memoirs are both very radical in their conclusions, and are likely, if adopted without further criticism, to increase the confusion already existing in the classification of Echini, which the authors attempt to rectify.

The Monographs are both by new-comers into the field of Echinology, enthusiastic in their cause, and showing but little appreciation of the work of those who have preceded them. Dr. Mortensen practically rejects all

[1] The Danish "Ingolf" Expedition. Vol. IV. 1, Echinoidea, Part I, by Th. Mortensen, 1903. Siboga-Expeditio. Die Echinoidea der Siboga-Expedition, v. J. C. H. De Meijere. 1904.

the work of his predecessors, and challenges it all as worthless because it is not based upon his methods for the solution of all Echinological problems. Like all classifications based upon a single character, the results obtained culminate in such impossible associations that we are loath to follow his lead. But as the material at my disposal has only been partly worked up, I do not propose to discuss at present the questions raised by Dr. Mortensen beyond calling attention to some points suggested by the study of the few genera involved in this Report; others I hope to take up in a subsequent Memoir.

I must protest against the temper and style of criticism adopted by Dr. Mortensen; even if he were right, his assumption of omniscience is offensive to the utmost, and his personal remarks are entirely out of place in a scientific memoir.

I am tempted to quote, *mutatis mutandis*, from an article in a New York newspaper summing up the arguments against old fogies' views propounded by an ardent reformer: "The results should diminish the patronizing certainty of 'knowing it all' which distinguishes Dr. Mortensen's work, and forbids us, his predecessors, to discuss matters of which we must be, in the nature of the case, wholly ignorant"!

To faciliate references to the plates, I have intercalated in the text a large number of figures, on which I have adopted, for the sake of brevity, Lovén's nomenclature of the plates of the test of Echini. I wish, however, to repeat that in doing so I do not accept the theoretical conclusions attached by Lovén to his nomenclature. My reasons for doing so have been fully stated in the "Challenger" Echinoidea Report, p. 4.

I have specially to thank Mr. A. M. Westergren for the great care he has taken in preparing the drawings for the lithographic plates which accompany this Memoir. I am also under great obligations to him for his general superintendence of the execution of the plates.

NEWPORT, R. I., August, 1904.

PANAMIC DEEP SEA ECHINI.

DESMOSTICHA Haeckel.

CIDARIDÆ Muller.

In describing the shape of the test of the Cidaridæ, certain points of general interest are brought out from the comparison of different stages of growth.

If we place the odd anterior ambulacrum forward, the pentagon formed by the abactinal system will have its odd face forward, Fig. 1, while that of the anal system will have its odd side toward the posterior extremity. With the pentagons of the actinal system and of the teeth the opposite is the case, Fig. 2. The outline of the test may similarly be pentagonal with the odd face either anterior or posterior. When the odd face is posterior, the interambulacral areas do not bulge out as they do when the odd face is anterior, Figs. 1, 2. Intermediate conditions will give the test a more or less circular equatorial outline, as in *Dorocidaris panamensis*, Fig. 3; *Centrocidaris Doederleini* and *Porocidaris Cobosi*, Fig. 4, have an anterior odd pentagonal face, and *P. Milleri*, Fig. 6, an odd posterior face.

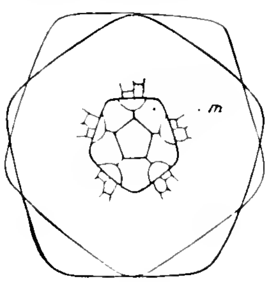


Fig. 1.

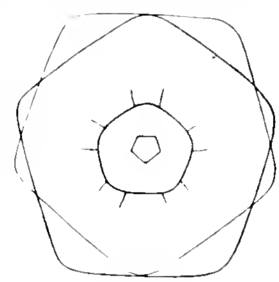
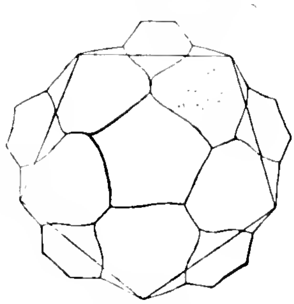
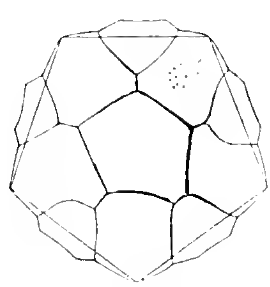


Fig. 2.



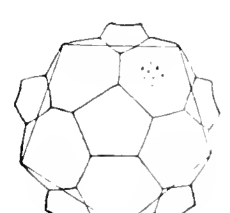
30 mm.

Fig. 3. Dorocidaris panamensis.



35 mm.

Fig. 4. Porocidaris Cobosi.



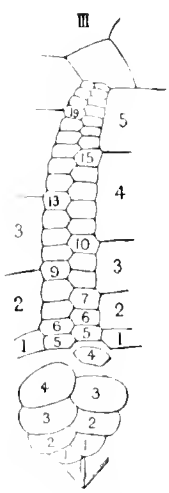
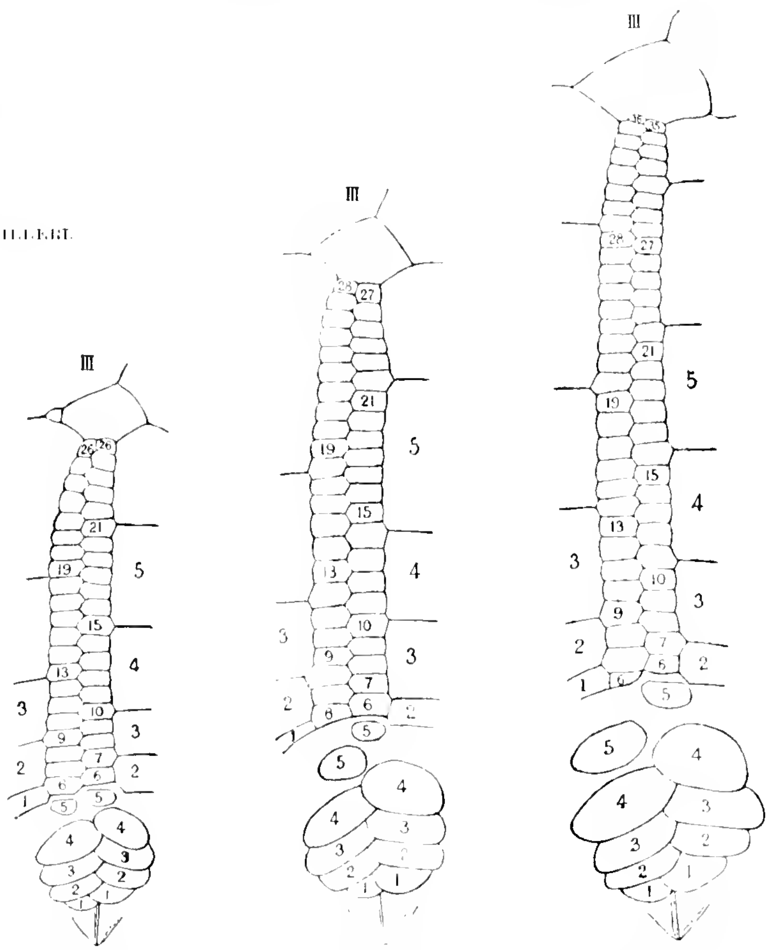
8 mm.

Fig. 5.

This holds good mainly for older specimens. In younger stages the outline of the test is modified by the projecting ocular plates, due to the great development of the abactinal system in younger stages, Figs. 5, 6. The ratio of increase of the ambulacral and interambulacral zones does not vary greatly with age.

In a young specimen of *Porocidaris Milleri* of 14 mm., Fig. 7, taking the odd anterior ambulacrum for comparison, interradial plate 2 covers one

14 mm.
FIG. 6. POROCIDARIS MILLERI.

14 mm. FIG. 7. 18 mm. FIG. 8. 20 mm. FIG. 9. 28 mm. FIG. 10.

FIGS. 7–10. POROCIDARIS MILLERI.

whole plate and two half plates, 3 covers two whole and two half plates, 4, four whole and two halves, while 5 covers six and a half plates. We find practically the same conditions in the odd ambulacra of specimens of 18 and 20 mm., Figs. 8, 9. Even when compared to a specimen of 28 mm., Fig. 10, the number of ambulacral plates corresponding to the fifth interambulacral plate has only increased by one plate.

In specimens of *P. Milleri* of very different size, Fig. 11, the ratio between the actinal system and the diameter of the test does not differ. It is reduced to a trifle less than half in *D. panamensis*, Fig. 12. In *P. Cobosi*, Fig. 13, the actinal system is not more than one third the diameter of the test.

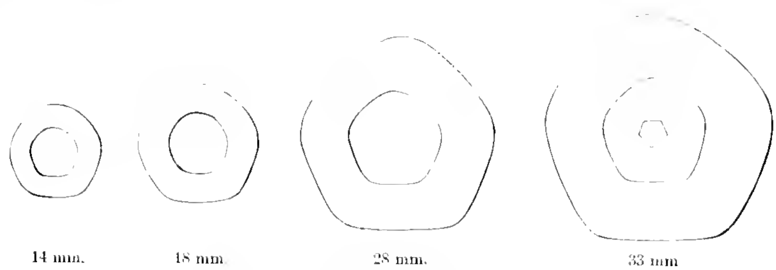


FIG. 11. POROCIDARIS MILLERI.

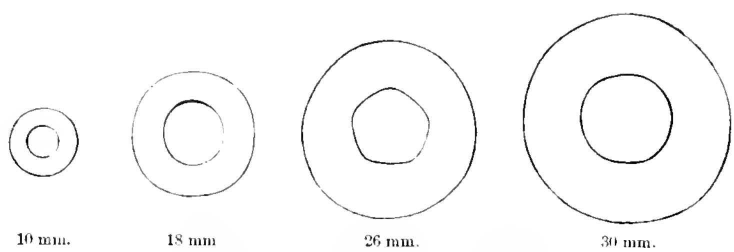


FIG. 12. DOROCIDARIS PANAMENSIS.

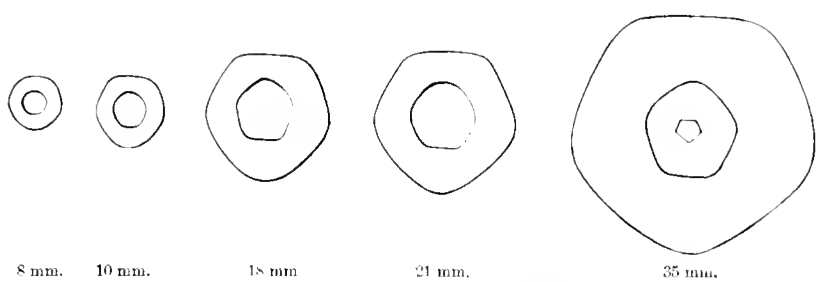


FIG. 13. POROCIDARIS COBOSI.

According to Lovén[1] the anal system in the young stages of *Goniocidaris* is covered with a single plate (the dorso-central disk). In a young *Dorocidaris* (Pl. 13, fig. 5) of 2.8 mm., dredged by Pourtalès off Key West in 138 fathoms the anal system was covered with five anal plates, Fig. 14. This is contrary to what is known of the young of Echinidæ proper, in which the anal system is

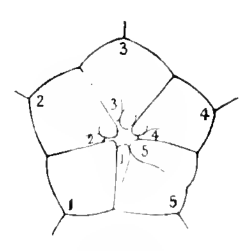


FIG. 14. DOROCIDARIS PAPILLATA.

[1] Echinologica. Pls. I. fig. 2; II. figs. 5, 7.

at first closed by a single plate with additional plates formed along its edge,—an embryonic condition which remains permanent in the Saleniæ. In the Arbaciadæ there are four primordial anal plates, these vary in number in the family, but are never as numerous as in the Echinidæ,

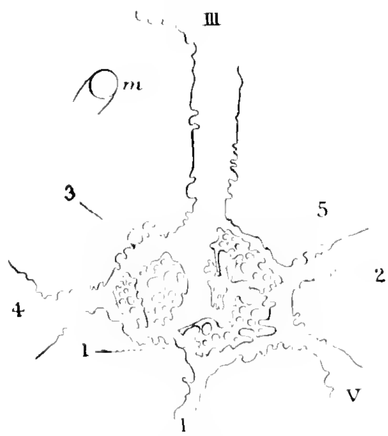


FIG. 15. GONIOCIDARIS CANALICULATA.

Cidaridæ or the majority of the genera of the order. In one of Lovén's figures (Echinologica, Pl. II. fig. 6) there seems to be an agglomeration of plates, forming the dorso-central disk of *Goniocidaris canaliculata*;[1] a

[1] Dr. Mortensen (Ingolf Exped.) distinguishes *Goniocidaris nutrix* (Pl. X. figs. 3, 4; 12, 14; 24) from *Goniocidaris canaliculata* (Pl. VIII. figs. 6, 8, 32) by the pedicellariæ. The figures he gives of the large globiferous pedicellariæ of *G. nutrix* differ from one another more than do the globiferous pedicellariæ which he gives as characteristic of each species. It is not inconceivable, as Dr. Mortensen thinks, that the young should be carried in a marsupium composed of either the actinal or abactinal spines. The fact that Thomson describes the former method and I have figured the latter does not imply any pre-eminent structural difference. Surely Dr. Mortensen does not pretend to imply that the eggs or the young are hatched round the actinal surface, because at some time in their development they have found their way there. That they are retained in a marsupium of the spines either of the actinal or abactinal areas does not seem to be an important physiological character; it may depend upon local conditions tending to the greater or less growth of the spines of either area.

Dr. Mortensen refers *G. canaliculata* to *Stereocidaris*, though Doederlein thinks they are more closely related to *Dorocidaris*. I can hardly think it advisable to refer such a variable species to either of these genera, though, as I have stated in my "Challenger" Report, the characteristic *Goniocidaris* features are frequently greatly obliterated. The great bathymetrical range of the species, as I understand it, is not, as Dr. Mortensen imagines, *prima facie* evidence that the very variable specimens found at the extremes of the range must belong to different species. Surely the bathymetrical lists I have given in the "Challenger" and "Blake" reports show a number of cases in which the range is fully as great as the objectionable range of this species. I have on several occasions called attention to the great bathymetrical range of many species of Echini, and it is not necessary to call attention to it every time they are mentioned. Dr. Mortensen will find on pp. 46 and 209 of the "Challenger" Echini a list of the localities at which I stated *G. canaliculata* to occur, —stations ranging in depth from 5 to 1975 fathoms. I may be mistaken in referring all these specimens to *G. canaliculata*, but their range is indicated, and I have not suppressed it, as is stated by Dr. Mortensen.

renewed examination of the anal plates of a young *Goniocidaris canaliculata* of 1.5 mm., Fig. 15, which I owe to Sir Wyville Thomson, shows that in the youngest stages, about the size of that examined by Lovén, there are already five anal plates (Pl. 13, fig. *6*).

Doederlein[1] has figured a young specimen of *D. canaliculata* showing the primordial interambulacral plates. He[2] has also figured a young specimen of *L. verticillata* showing the five primary anal plates with one intercalated plate. In a young specimen of *Porocidaris Milleri* of 14 mm. (Pl. 7, fig. *5*) there are five large anal plates in the angles of their respective pentagons, Fig. 16. Three of these are in contact and occupy the left part of the

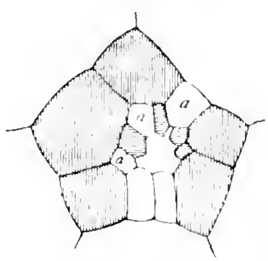


FIG. 16. POROCIDARIS MILLERI.

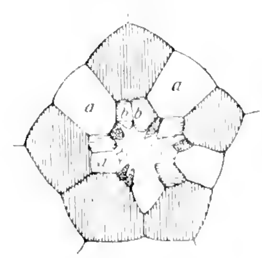


FIG. 17. POROCIDARIS MILLERI.

anal system, — the anterior plate and the left lateral plates. The two right lateral plates are also in contact, but are separated from the next anal plates by one and by two secondary anal plates which have reached the genital ring, while three small plates have barely obtained a foothold between the other anal plates. The plates of the third series are only three in number.

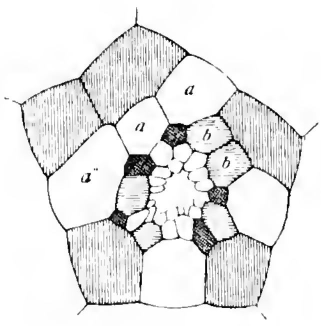
The order of appearance of the second and third series does not seem to be regular, as is clearly seen in other specimens of *P. Milleri* of 18 and 28 mm. In a specimen of 18 mm. (Pl. 7, fig. *4*) the three primitive anal plates which are connected are not the same as those of the younger stage just described, Fig. 17. They are in this larger specimen the two posterior plates and the left anterior, while the odd anterior and the right anterior are separated by single plates from the next adjacent series of anal plates (Pl. 7, fig. *4*).

Even in specimens of the same size the primitive anal plates and the secondary anal plates which separate them and have reached the genital ring are not the same. In a male of 28 mm. (Pl. 7, fig. *1*) the odd anterior

[1] Japanische Seeigel Pl. IX. fig. 6.

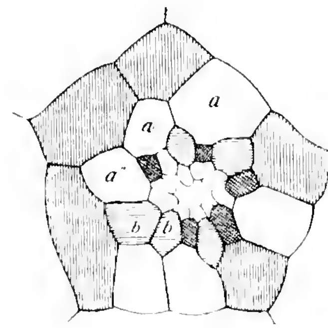
[2] Japanische Seeigel, Pl. IX. fig. 8 *a*.

and the left anterior alone are connected; the three others are separated by the next series of anal plates, — large plates of the second series which have reached the genital ring, Fig. 18. In a female of 28 mm. there are



28 mm. ♂

Fig. 18. Porocidaris Milleri.

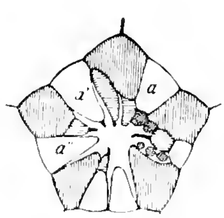


28 mm. ♀.

Fig. 19. Porocidaris Milleri.

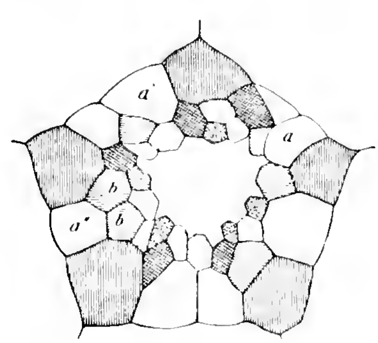
again three of the primitive anal plates connected, the anterior and the two left lateral plates (Pl. 7, fig. *2*), as in the youngest specimen of 14 mm.; but the right lateral plates are not in contact. They are separated by large anal plates of the second series, and the posterior plates are separated by two secondary anal plates, Fig. 19. But in spite of the irregularity of position of the five plates of the second series, it is easy to recognize them, as well as those of the third and fourth series, in all the stages we have described.

In *Porocidaris Cobosi* the plates of the second series seem to force their way to the genital ring in a more regular manner, as is easily seen in com-



8 mm.

Fig. 20. Porocidaris Cobosi.

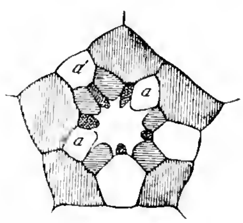


35 mm.

Fig. 21. Porocidaris Cobosi.

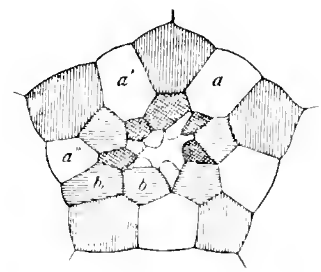
paring the anal plates of a young *P. Cobosi* of 8 mm., Fig. 20 (Pl. 12, fig. *1*), with those of one of 35 mm., Fig. 21 (Pl. 11, fig. *6*). With the exception of the splitting of two of the plates of the second series which have reached the genital ring, the plates of the different series present a remarkable uniformity.

In *Dorocidaris panamensis* we have, as in *P. Cobosi*, quite regular stages in the growth of the second and third cycles of anal plates. In a young specimen of 10 mm., Fig. 22 (Pl. 3, fig. *1*), we have the five large primitive



10 mm.

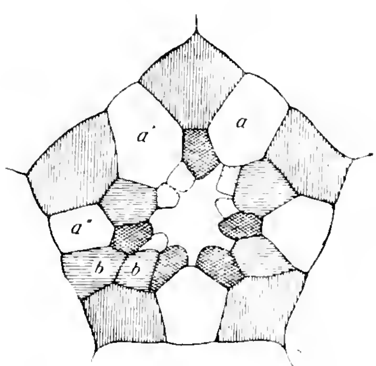
Fig. 22. Dorocidaris panamensis.



18 mm.

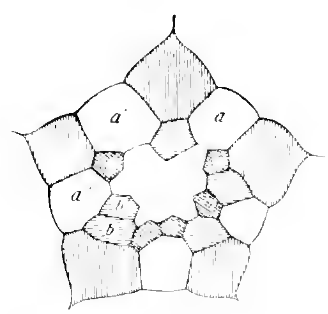
Fig. 23. Dorocidaris panamensis.

anal plates in the sutures leading to the ocular plates; two of the plates are separated by large secondaries; the others are merely somewhat wedged apart by the secondaries near the anal opening. In a somewhat older specimen of 18 mm., Fig. 23 (Pl. 3, fig. *2*), the primary plates are separated



30 mm.

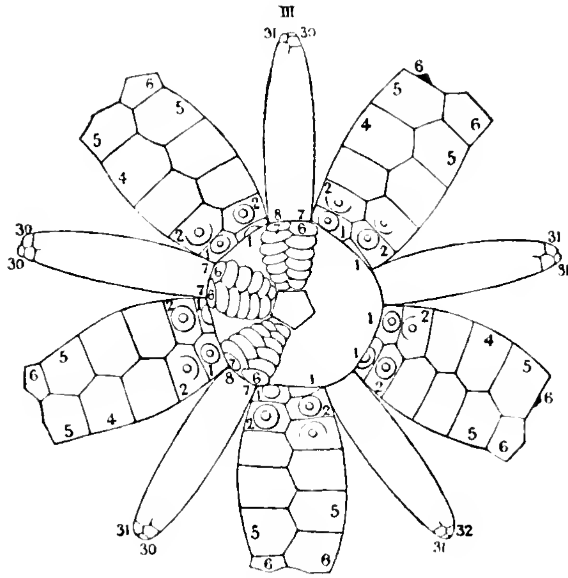
Fig. 24. Dorocidaris panamensis.



28 mm.

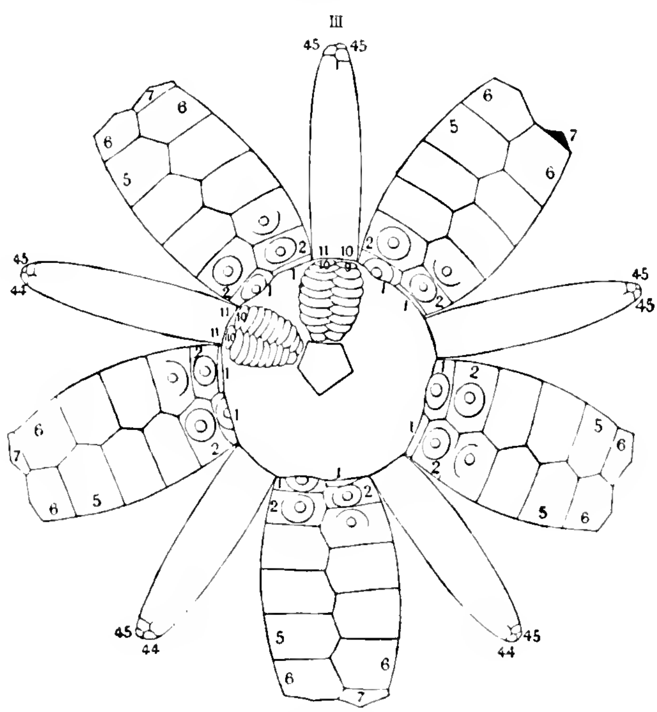
Fig. 25. Centrocidaris Doederleini.

by secondaries all of nearly uniform size, one of the plates of the third cycle having also reached the genital ring. In a specimen of 30 mm. (Pl. 3, fig. *3*) the arrangement of the anal plates is not materially different. Fig. 24. The arrangement of the anal plates is the same in a specimen of *Centrocidaris Doederleini* of 28 mm., Fig. 25 (Pl. 5, fig. *4*).



10 mm.
FIG. 26. DOROCIDARIS PANAMENSIS.

The rudimentary interambulacral plates always make their appearance against the face of the adjoining ocular (Pl. 3, fig. 3), while the new ambulacral plates are formed between the ocular plate and the last



18 mm.
FIG. 27. DOROCIDARIS PANAMENSIS.

ambulacral plate; this is well seen in interior views of the ocular and the adjoining abactinal ambulacral plates (Pls. 8, figs. *1–4*; 12, fig. *8*). The young abactinal interambulacral plates, at first wedged in between the oculars and genitals, are more or less connected with them by elongated calcareous threads (Pl. 4, fig. *5*) covered by compact shining nodules.

In *Dorocidaris panamensis*, where the number of coronal plates is smaller, the addition of new interambulacral plates takes place more slowly than in

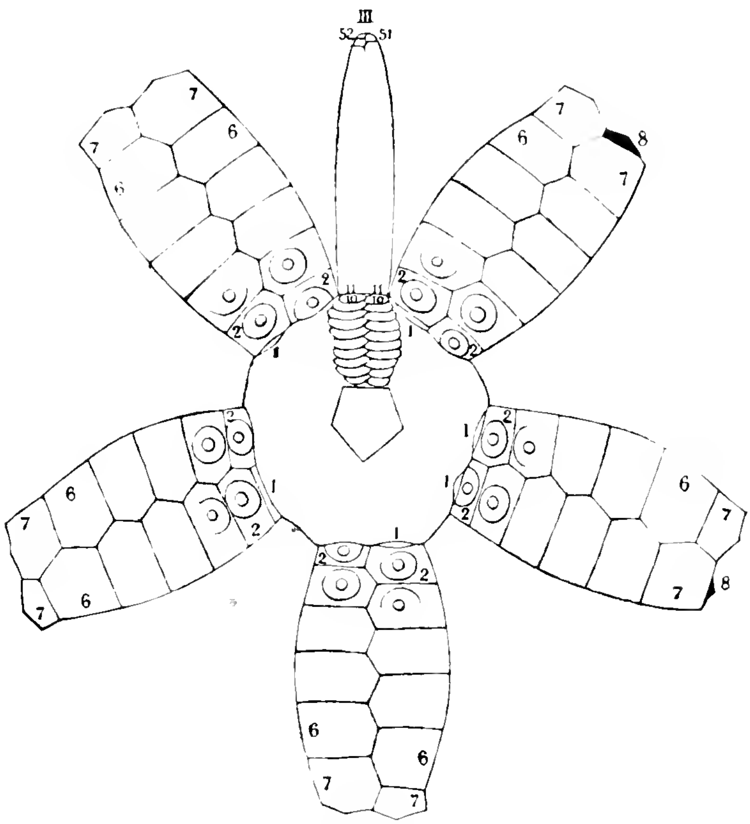
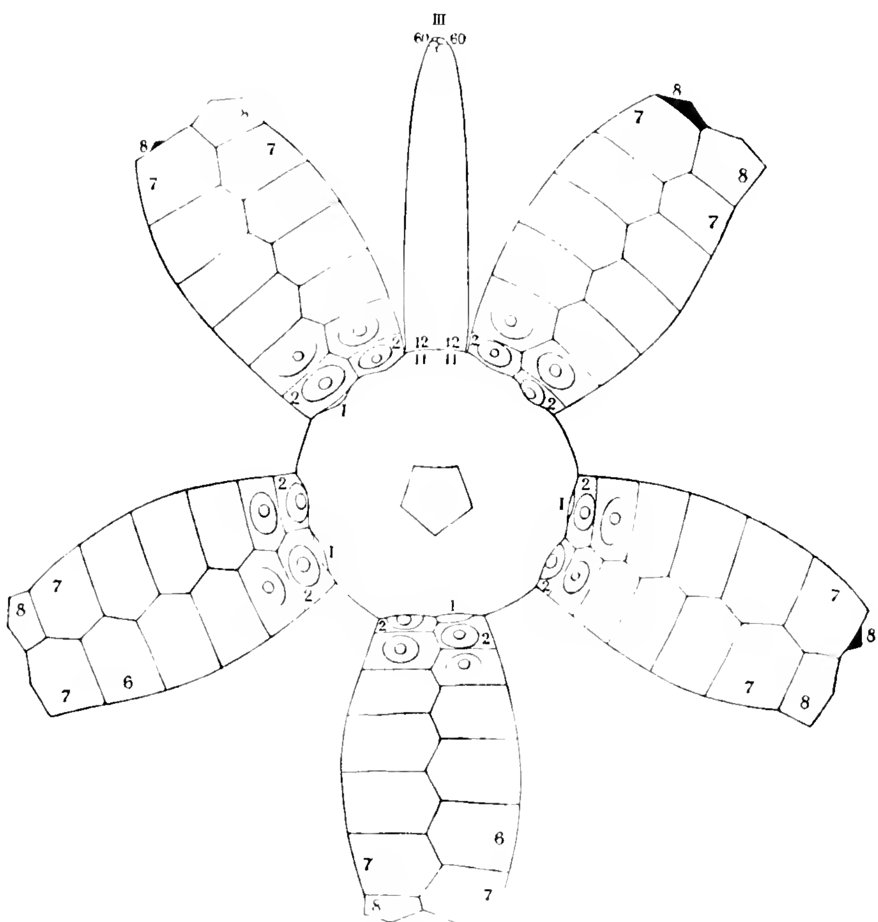


FIG. 28. DOROCIDARIS PANAMENSIS.

Porocidaris. In a specimen of 10 mm., Fig. 26, with six and seven rows of buccal plates, the primordial plates have disappeared, and the first set of interambulacral plates are adjacent to the actinal system in all the interambulacra (Pl. 3, fig. *1*). There are thirty to thirty-two pairs of ambulacral plates, and five pairs of interambulacral plates, the sixth being more or less developed in all the ambulacra, the least in the left posterior interambulacrum. In a specimen of 18 mm. (Pl. 3, fig. *2*) with ten rows of buccal plates and forty-five pairs of ambulacral plates, Fig. 27, the sixth pairs of interambulacral plates have become fully developed, and the seventh are indicated in all the interambulacral areas except the left posterior one. The first pairs of interambulacral plates are still in contact with the actinal system, although all greatly diminished in size since the preceding stage.

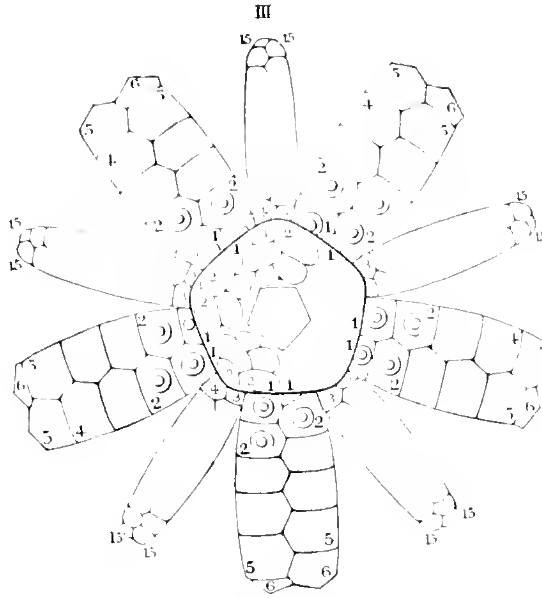
In a specimen of 25 mm., Fig. 28, the first pairs of interambulacral plates are adjacent to the actinal system only in the left posterior interambu-



30 mm.

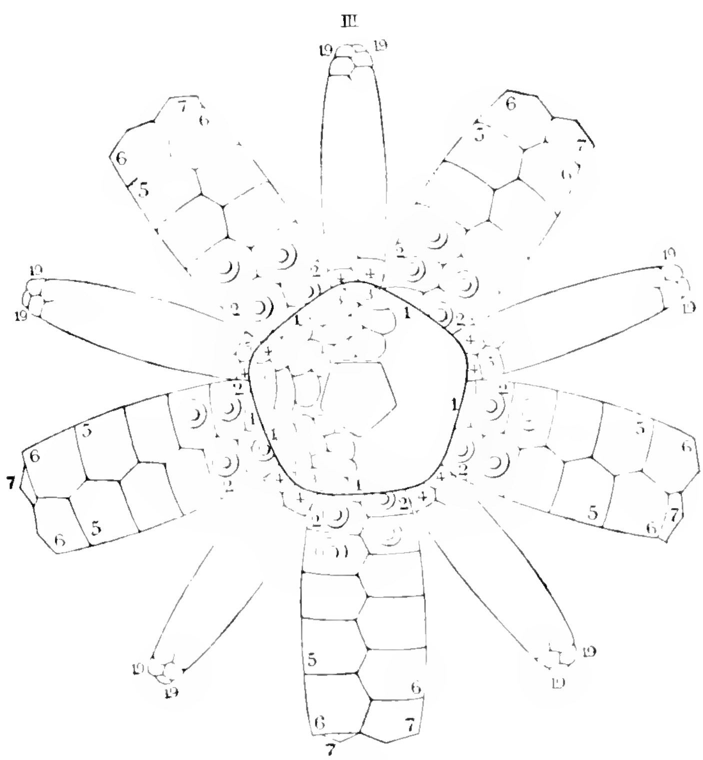
FIG. 29. DOROCIDARIS PANAMENSIS.

lacrum; in all the other interambulacra one of the second plates has reached the actinal system, and the first plate left is reduced to a mere thread. The sixth and seventh interambulacral pairs of plates are now fully developed, and the eighth is indicated in the left lateral interambulacra.



8 mm.

Fig. 30. Porocidaris Cobosi.

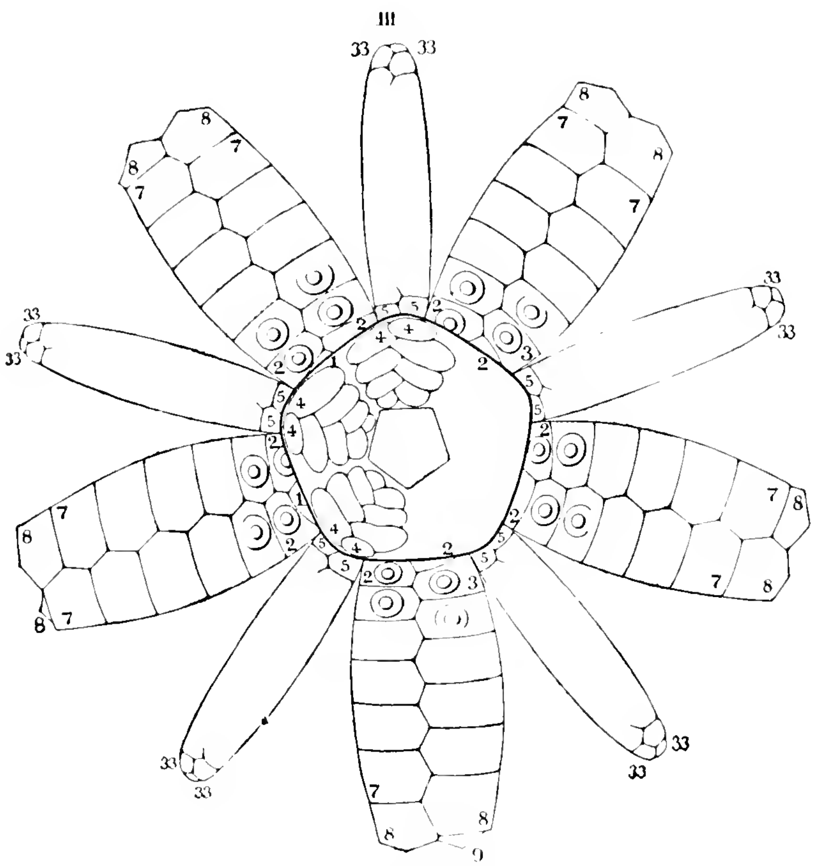


10 mm.

Fig. 31. Porocidaris Cobosi.

In a specimen of 30 mm., Fig. 29, the position and proportions of the actinal interambulacral plates is about as in the previous stage. The seventh pairs of plates are fully developed, and the eighth pairs are much more advanced than in the preceding stage.

As *Goniocidaris canaliculata* and *Dorocidaris papillata* have been shown to have interambulacral primordial plates in very young stages, we may safely



18 mm.

FIG. 32. POROCIDARIS COBOSI.

assume that they have already been resorbed in a young specimen of *P. Cobosi* of 8 mm., Fig. 30, and that parts of the first and second interradial plates have likewise disappeared (Pls. 10, figs. *4, 5*; 12, figs. *1, 2*). Comparing this stage, having fifteen pairs of ambulacral plates, one of the sixth pair of interambulacral plates in each area, and two series of buccal plates with a somewhat older one, Fig. 31, of 10 mm. (Pl. 12, fig. *10*), having three series of buccal plates, we can trace the extent of the resorption which has taken place. In the younger specimen, beginning with the right anterior interambulacrum, the actinal plates were 1, 1 in all the interambulacral areas, the plates of the right zones being the smallest in all cases, except in the odd interambulacrum. In the stage of 10 mm. the second plate of the right ambulacral zone has reached the actinal system, and only a small part of the largest of the first plates has not been

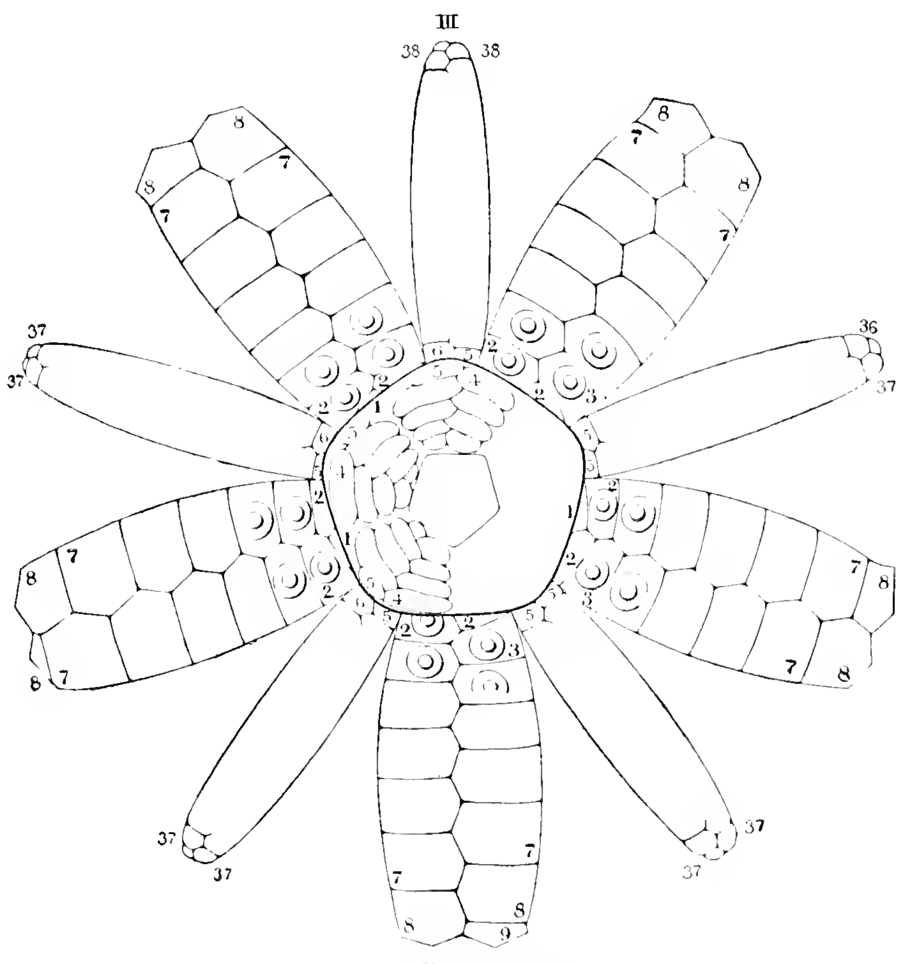
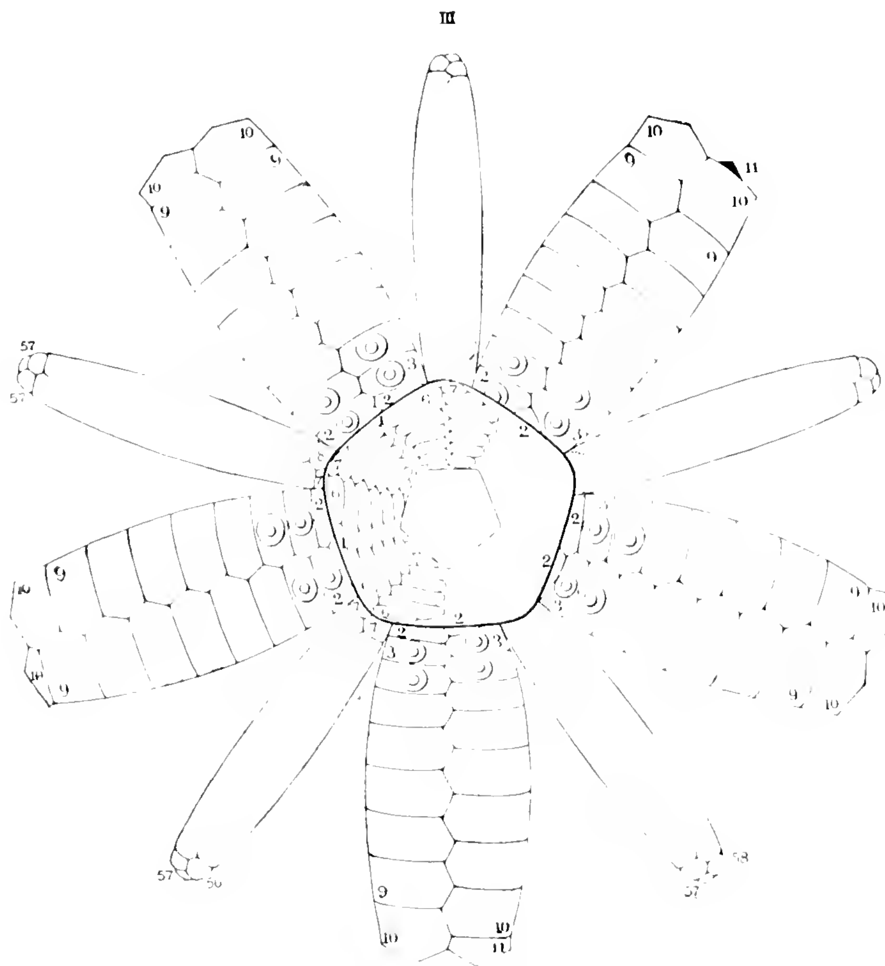


Fig. 33. Porocidaris Cobosi.

resorbed, the interambulacral plates having increased also from six to seven plates. In the larger stage, having nineteen pairs of ambulacral plates, the sixth pairs of interambulacral plates barely indicated in the preceding stage, have become fully grown plates, and the seventh pairs are indicated.

In a specimen of 18 mm., Fig. 32, only a small triangular part of the first plate remains in the left lateral interambulacra, and the second plates reach the actinal system in all the interambulacra, but all greatly reduced in size. There are in this stage four rows of buccal plates, thirty-three ambulacral and eight pairs of interambulacral plates, with a ninth in the odd interambulacral area; not only the seventh pairs of the preceding stage but the eighth have become fully developed, and the ninth are indicated.

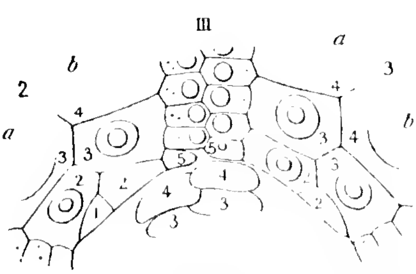


35 mm.

FIG. 34. POROCIDARIS COBOSI.

In a specimen of 21 mm., Fig. 33, there are thirty-six to thirty-eight pairs of ambulacral and eight to nine of interambulacral plates, with four rows of buccal plates, the plates at the actinal system being in about the same stage of resorption as the preceding stage.

In a specimen of 35 mm., Fig. 34, with six and seven rows of buccal plates, there are fifty-six, fifty-seven and fifty-eight ambulacral plates, with ten pairs of interambulacral plates, and one plate of the eleventh in the left anterior and the odd interambulacral area. The actinal plates have scarcely changed their size, showing that in *Porocidaris Cobosi* the resorption of the actinal interambulacral plates is limited to that of the primordial, of the first and part of the second plates. The ninth pairs of interambulacral plates indicated in the preceding stage have become fully developed,



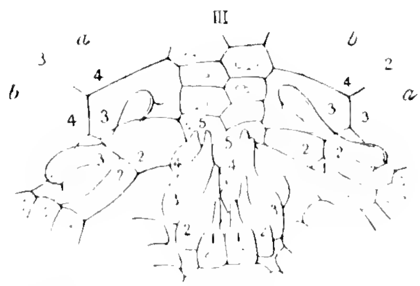


Fig. 35. Porocidaris Cobosi. Fig. 36.

as well as the tenth pairs. The eleventh pair of plates is indicated in the odd posterior and the left anterior ambulacra.

In the resorption of the actinal interambulacral plates, one of the plates becomes triangular, Fig. 35, and disconnected from the adjoining ambulacrum (Pl. 11, figs. *2*, *3*), though when seen from the interior, Fig. 36, it is rectangular (Pl. 11, fig. *4*) and extends into the auricle, Fig. 37.

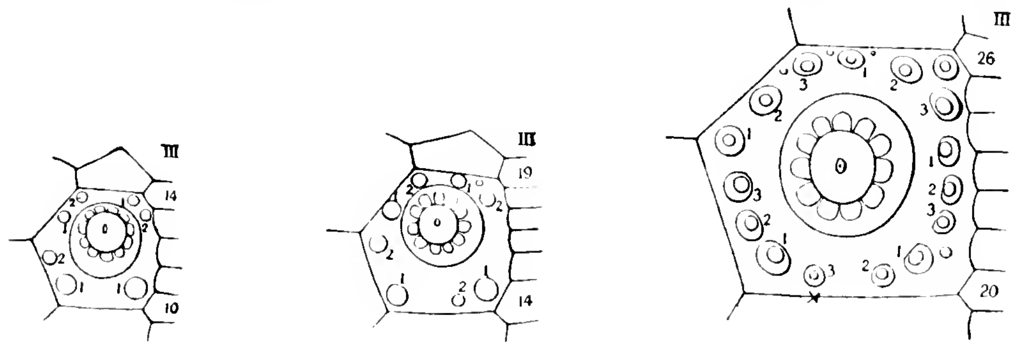
With the resorption of the interambulacra and the flow of the ambulacra towards the actinostome, some of the primary tubercles naturally disappear and become resorbed as the ambulacral plate and its pore passes over to the actinal system (Pl. 12, fig. *5*), or the interambulacral plate becomes resorbed

Fig. 37. Porocidaris Cobosi.

and gradually cuts off a part of the primary tubercle (Pl. 12, fig. *6*). In a still later stage (Pl. 12, fig. *7*) the primary tubercles are moving towards the actinal system.

With the increasing age and size of the actinal system the number of ambulacral plates to be liberated and flow over on the actinal system gradually diminishes, as well as the addition of the irregular interambulacral plates which do not reach the actinostome.

A comparison of the shape of the coronal plates of *P. Cobosi* of specimens of different stages of growth shows that with increasing size the coronal interambulacral plates — let us take the fifth plate of the left



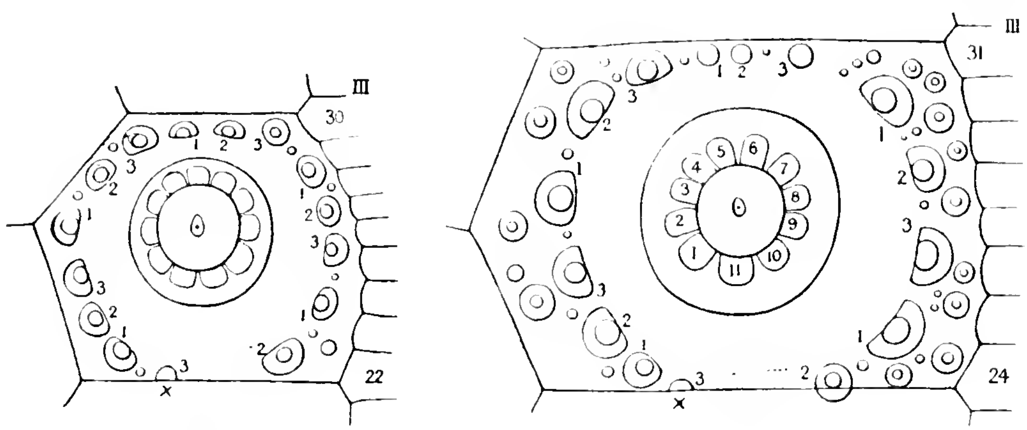
8 mm. Fig. 38.

10 mm. Fig. 39.

18 mm. Fig. 40.

Figs. 38–40. Porocidaris Cobosi.

anterior interambulacrum adjoining the odd ambulacrum — become gradually wider; in a young specimen of 8 mm., Fig. 38, the fifth plate is high, slightly narrowed at the abactinal suture (Pl. 10, fig. *4*), the primary tubercle occupying nearly the whole of the plate which carries but three secondaries and three miliaries. In a specimen of 10 mm., Fig. 39, the plate has become less high compared to its width, and carries only one additional miliary. In a somewhat older stage, 18 mm., Fig. 40, the area

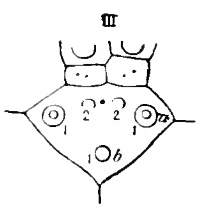


21 mm. Fig. 41.

Porocidaris Cobosi.

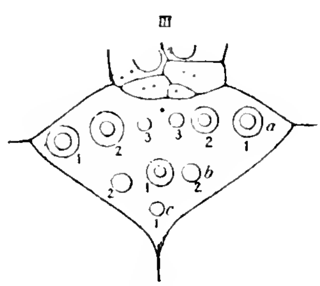
35 mm. Fig. 42.

on the ambulacral side of the primary tubercle has become still wider, and the secondaries seem to be arranged in sets of threes, not only in this stage, but also in a specimen of 21 mm., Fig. 41 (Pl. 10, fig. *7*), and one of 35 mm., Fig. 42 (Pl. 10, fig. *9*). The independence of the growth of the ambulacral and interambulacral areas is well shown on comparing the number of the ambulacral plates which are opposite the actinal suture of the fifth plate. In a specimen of 8 mm. (Pl. 10, fig. *4*) it is the tenth ambulacral plate which faces the suture, and the fourteenth which faces the upper suture. In a specimen of 10 mm. it is the fourteenth and the nineteenth which face the sutures. In a specimen of 18 mm. it is the twentieth and the twenty-sixth. In one of 21 mm. it is the twenty-second and the thirtieth (Pl. 10, fig. *7*), and in one of 35 mm. it is the twenty-fourth and the thirty-first (Pl. 10, fig. *9*). The action of the muscular fibres attached to the scrobicular circle, in destroying the mamelon and mammary boss of the secondaries, is already indicated in a specimen of 18 mm., Fig. 40. In the earlier stages (Pl. 10, fig. *4*) the scrobicular circle of the secondaries is not indicated. It becomes still better limited in specimens of



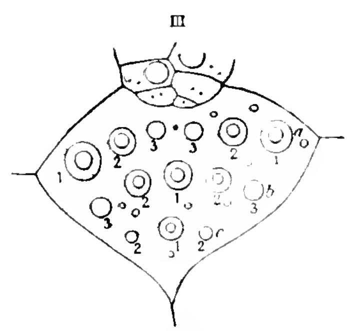
10 mm.

FIG. 43.



26 mm.

FIG. 44.



30 mm.

FIG. 45.

FIGS. 43–45. DOROCIDARIS PANAMENSIS.

21 mm. (Pl. 10, fig. *7*) and of 35 mm. (Pl. 10, fig. *9*). The crenulation of the fifth plate is only to be seen in a specimen of 35 mm. (Pl. 10, fig. *9*); it is not developed in earlier stages of growth.

In the fifth plate of a specimen of 21 mm., the area on the two sides of the primary tubercle is nearly the same; the upper suture is but little shorter than the lower (Pl. 10, fig. *7*). In the next stage (Pl. 10, fig. *9*) the two sutures are of nearly equal length, the mamelon and its mammary boss are in the centre of the plate, miliaries and smaller secondaries have developed outside of the row of the secondaries edging the scrobicular circle (Pl. 10, fig. *9*).

It is quite feasible to follow the order of appearance of the miliaries and secondaries. For instance, we can readily trace the order in which the miliaries have been formed on the ocular plates of *Dorocidaris panamensis* from the stage represented on Pl. 3, fig. 7, in the ocular of the odd anterior ambulacrum of a specimen of 10 mm., Fig. 43, as they have increased on the ocular plate of the same ambulacrum in a specimen of 26 mm., Fig. 44 (Pl. 3, fig. 2), to pass into the still more numerous miliaries regularly arranged on the same ocular of a specimen of 30 mm., Fig. 45 (Pl. 3, fig. 5); additional miliaries being constantly added between the older miliaries and the ocular pore, and in the following rows on the sides of the first-formed miliaries.

In the Cidaridæ, according to Dr. Mortensen, the small pedicellariæ "are highly similar in almost all species, but they may vary very much in the separate individuals. The tridentate ones are better, but they are also highly variable in the separate individuals. Most applicable for the classification are the large globiferous pedicellariæ."

Doederlein, basing his conclusions on his careful researches regarding the Cidaridæ, states that in that family the pedicellariæ offer no characters to distinguish natural groups within the family, and that very closely allied forms of pedicellariæ are found in species only distantly related. Dr. Mortensen comes to a radically opposite conclusion, and suggests that species having the same kind of pedicellariæ proves them to be nearly related; so that *Cidaris metularia* and *Cidaris verticillata* should be united in one genus, — two species which are more readily distinguished by the characters of the spines and tests than any other species of the family. Dr. Mortensen also adds *Cidaris baculosa* to the same genus. I have never seen any specimens of this species the spines of which show the arrangement of the thorns recalling that of *C. verticillata*.

M. de Meijere has adopted the infinitesimal classification of Dr. Mortensen, and appears as its ardent supporter; and yet in spite of this the new classifying tool does not seem to do its work properly in all cases, as M. de Meijere returns to Duncan's classification of Cidaris,[1] and rejects all the genera based on the structure of the pedicellariæ proposed by Dr. Mortensen, as well as all others hitherto proposed, for the very reasons which have satisfied Dr. Mortensen of the correctness of his views.

Dr. Mortensen harps on the fact that a great many species of Cidaris as well as other Echinoids have been proved by him to belong to other genera than those to which they were referred by others, and thus he

[1] "Siboga" Echinoidea, p. 204.

constantly finds "a fine demonstration of the trustworthiness of the statements hitherto found in the literature with regard to the occurrence and distribution of these animals"! Once given his genera, the rest naturally follows, and we have nothing left of what has preceded.

It appears childish to be constantly lamenting, as do Dr. Mortensen and M. de Meijere, the loss of a specimen, if examined by the old methods, necessary for the examination of the test, and of the actinal and abactinal systems. Surely we cannot welcome a method which deliberately saves a specimen in order to remain ignorant of its structure, or which would necessitate the definition of an Echinoid to be that of an animal consisting of a number of pedicellariæ of variable forms, with which are connected a test covered with spines, tubercles, and all the other useless and supernumerary structures which have thus far been studied in the classification of the Echinoids, to the great detriment of the pedicellariæ.

When a living species is referred to a fossil genus, Dr. Mortensen on principle denies the accuracy of such a proceeding, and demands the adoption of synonyms, as in the case of *Glyptocidaris*, *Cœnopedina*, and of *Goniocidaris* and others. But he is not consistent in this general rejection of generic names of fossil Echini, as he retains *Arbacina*, *Porocidaris*, *Stereocidaris*, and others, for no apparent reasons.

As M. de Meijere well says, Dr. Mortensen's methods naturally lead to an infinitesimal splitting up of the older genera, to the establishment of genera based on a single structural feature, and to the loss of the relationship of the species they contain.

It does not occur to Dr. Mortensen that differences of opinion are possible, that points of view other than his own have any value, and that perhaps the last word has not been said regarding the affinities of the Echinoids. The height of absurdity is finally reached when we are told that nothing can be said of the affinities of species of which pedicellariæ have not been examined (by him).

GONIOCIDARIDÆ Haeckel.

Dorocidaris A. Ag.

Dorocidaris panamensis A. Ag.

Dorocidaris panamensis A. Ag., Bull. M. C. Z. XXXII, No. 5, p. 73, Plates I; II, fig. 1, 1898.

Plates 1–4.

This is the Pacific representative of *D. papillata*, from which it is distinguished by its pentagonal anal system, the flattened test, the closer granulation of the plates of the apical system, while the secondary tuberculation of *D. panamensis* is closer than that of *D. papillata*. In the largest specimen examined, measuring 36 mm. in diameter, the primary radioles attained a length of only 50 mm. (Pl. 1, figs. *1*, *2*), and in many specimens the radioles were not longer than the diameter of the test. The radioles are more slender than those of *D. papillata*, and their granulation coarser (Pl. 4, figs. *9*, *12*), resembling as a whole more those of *Goniocidaris canaliculata*. The test of this species is depressed (Pl. 2, figs. *3*, *4*); the miliary spines are reddish-brown, giving the test when alive a general chestnut coloring. The shorter primary radioles of the actinal side are marked for their proportionally slender shaft (Pls. 1, figs. *2*, *4*; 2, fig. *2*); they are fairly smooth, delicately striated. The coronal primary radioles vary greatly in ornamentation, from a delicate striation to a serration formed of short blunt spines passing into a granular structure (Pl. 4, figs. *9–11*).

In a specimen measuring 30 mm. in diameter, with seven primary interambulacral plates (Pl. 3, figs. *5*, *6*), the actinal system is only 10 mm. in diameter (Pls. 2, fig. *2*; 3, fig. *4*). The abactinal system of the same specimen measured 15 mm. in greatest diameter, with two rows of eleven ambulacral buccal plates and two pairs of pores detached from the actinal extremity of the ambulacra, and five interambulacral buccal plates in each interradial space (Pl. 3, fig. *3*). The secondary tubercles and miliaries are crowded on the actinal side of the older buccal plates. (Pl. 3, fig. *4*). The test as well as the actinal and abactinal systems are crowded with short-headed, long-stemmed, tridentate pedicellariæ. The secondary tubercles and miliaries of the interambulacral areas (Pl. 3, fig. *6*) are smaller than those of *D. papillata*. In the ambulacral areas the outer row of primary tubercles consists of larger and more prominent tubercles than the secondary ones of the interambulacral areas (Pl. 3, fig. *5*). This row of primary ambulacral tubercles is flanked by an inner irregular row of small miliaries, single near the actinal and abactinal extremities and double along the equatorial region of the test. The primary interambulacral tubercles are surrounded by a row of secondaries placed close to the scrobicular area; the rest of the primary plate is closely packed by smaller secondaries and miliaries (Pls. 3, fig. *6*; 4, figs. *6*, *7*).

The structure of new interambulacral plates is shown in Pl. 4, figs. *1*, *2*. In fig. *1* the eighth primary plate of the left interambulacral area is triangular, and has only a single rudimentary primary tubercle, showing the radiating and circular arrangement of the limestone cells of the plate. In fig. *2* the eighth primary plate of the odd interambulacrum has assumed a pentagonal shape. In addition to the rudimentary primary tubercle it has three fairly developed secondary tubercles and one less advanced. The arrangement of the cells of the plate is more irregular than that of the younger plate; their arrangement in radiating ridges is better seen in an older plate (Pl. 4, fig. *5*), the sixth from the actinostome.

Considerable changes take place in the abactinal system during growth. In a small specimen measuring 10 mm. in diameter (Pl. 3, fig. *1*), the genital and ocular plates as well as the outlines of the anal system are marked for their sharp angular outlines. In a somewhat older specimen, 18 mm. in diameter (Pl. 3, fig. *2*), the angles of these plates have become slightly rounded, and in a still larger specimen, 30 mm. in diameter (Pl. 3, fig. *3*), the sides of the genital plates are convex or concave, with rounded points. The dividing lines between the genital plates are greatly reduced in length, the cusps of the anal system and of the ocular plates almost connecting. In young specimens (Pl. 3, fig. *1*) only a few verrucæ are found on the plates of the abactinal system. In somewhat older specimens they are found only on the anal edge of the genital plates; the rest of the plate is covered by small secondary tubercles and miliaries. In still older specimens (Pl. 3, fig. *3*) both genital and ocular plates are covered by a regular granulation of small secondary tubercles, with a few miliaries in the central part of the plates. The genital pores are not pierced in the smallest specimen figured (Pl. 3, fig. *1*). They appear in older stages, and are well developed in a specimen 18 mm. in diameter (Pl. 3, fig. *2*); they are fully as well marked as in a still older specimen (Pl. 3, fig. *3*).

A number of madreporic pores are found in a specimen of 10 mm. in diameter (Pl. 3. fig. *1*); they cover proportionally as large an area in the next stage (Pl. 3. fig. *2*) as in the oldest stage figured (Pl. 3, fig. *3*). An enlarged part of the madreporic body seen from the exterior is given in Pl. 4, fig. *4*.

In a specimen 14 mm. in diameter one of the genital plates showed a number of irregular genital openings covered by minute plates (Pl. 4, fig. *6*).

In the youngest specimen figured (Pl. 3, fig. *1*), the five original anal plates can still be seen occupying the angles of the anal system. In the faces of the left anterior, the odd and right posterior interambulacrum a second plate has become intercalated, and the third and fourth sets of plates have made their appearance. In the next stage (Pl. 3, fig. *2*) there are two intercalated plates on the face of the left posterior interambulacrum, and one on each of the other faces of the anal system; the intercalated plates and the five original plates forming, as it were, a primary outer cycle with a secondary one of nine plates and a third series of six plates round the anal opening, intercalated in the anal angles of the second row of plates. In the next stage (Pl. 3. fig. *3*) the proportions between the anal plates have only slightly changed, those of the second row being proportionally large; otherwise they occupy relatively the same position.

Dr. Mortensen[1] revises the classification of the Cidaridæ, radically changing the position of the species among the genera hitherto recognized, and introducing a number of new genera based upon minute differences in the pedicellariæ, and with utter disregard of other characters of the species he groups together.

As one of the results of his classification, *Cidaris affinis* and *Dorocidaris papillata*, which had been considered as most closely allied, if not identical species, are now placed in separate genera. There is nothing in the figures of the pedicellariæ given by Mortensen to warrant such a transposition. Compare his figs. 1 and 7, Pl. IX., 21, 23 and 25, 27, for the tridentate pedicellariæ. It seems to be an enormous overestimate of details to consider the differences between the globiferous pedicellariæ as of generic value. Compare his figs. 17 and 20, Pl. IX., figs. 3, 5 and 5, 9; figs. 8, 11 and 13, 15, for the globiferous pedicellariæ. The genus *Petalocidaris* (*G. florigera* pars) is based upon the small opening of the point of the large globiferous pedicellariæ (Pl. X. figs. 23, 30; 22, 31; 10, 11). Only one of the small globiferous pedicellariæ of the genus is figured (Pl. X.

[1] "Ingolf" Echinoidea, p. 11.

fig. 16), it does not show plainly the greater size of the opening mentioned by Mortensen. The projection of calcareous ridges on the stalk of the globiferous pedicellariæ (Pl. IX. fig. 4) can hardly be considered a generic character; see Pl. IX. fig. 12.

This genus is established in spite of the fact that Doederlein had already grouped together as *Discocidaris* certain species of *Goniocidaris*, among which he included *Goniocidaris florigera* (Chall. Pl. I. fig. 11), and for reasons far more satisfactory than those assigned by Mortensen for establishing *Petalocidaris*.

The association of *Dorocidaris bracteata* A. Ag.[1] with *Stephanocidaris bispinosa* is most unfortunate. The abactinal system of the genus is so entirely unique among the Cidaridæ that there is no excuse for associating with it a species with the abactinal system of the species of Dorocidaris.

Mortensen also states that *Dorocidaris panamensis* is scarcely a *Dorocidaris*[2] because *he supposes* that species to have the form of pedicellariæ figured by him on Pl. IX. figs. 9, 22, 24 for *C. affinis*, — a form of pedicellariæ occurring also, as Mortensen says, in *C. tribuloides* and *galapagensis*, *metularia*, *verticillata*, and *baculosa*, as well as *P. imperialis* and *Goniocidaris florigera*. Surely a sufficiently varied series of forms to show how little practical use this special type of pedicellariæ must be; and for this heterogeneous group he retains the name of *Cidaris* (excluding *P. imperialis* and *G. florigera*).

Station 3367, off Cocos Island, 100 fathoms. Lat. 5° 31′ 30″ N.; Long. 86° 52′ 30″ W. Bottom temperature 57°.1. Rocky.

Station 3368, off Cocos Island, 66 fathoms. Lat. 5° 32′ 45″ N.; Long. 86° 54′ 30″ W. Bottom temperature 58°.4. Rocky.

Station 3378, off Galera Point, 112 fathoms. Lat. 3° 58′ 20″ N.; Long. 81° 36′ W. Bottom temperature 55°.9. Brk. sh.

Station 3397, off Galera Point, 85 fathoms. Lat. 70° 33′ N.; Long. 78° 34′ 20″ W. Bottom temperature 57°.3. Stf. gn. M. brk. sh.

Bathymetrical range 66–112 fathoms. Range in temperature 58°.4–55°.9.

[1] Not Ag. as marked by Mortensen.

[2] This will be examined in the Report on the Hawaiian Echini.

Porocidaris Des.

Studer has limited the genus *Porocidaris* and associated with it some fossil species which would eliminate from the genus not only *Porocidaris Sharreri*, as he suggests, but also the new species of *Porocidaris* discovered by the "Albatross" off the Panamic coast. Studer inclines to associate *P. Sharreri* with *Pleurocidaris* of Pomel, which contains both Jurassic and Tertiary types, with miliaries arranged in horizontal rows separated by fine furrows in the interambulacral area, but with smooth noncrenulated tubercles.

In *P. Cobosi* the tubercles are crenulated and perforated. In *P. Milleri* they are smooth and perforated, while the general arrangement of the miliary interambulacral tubercles is the same in both, and does not recall in any way their arrangement in horizontal rows, as in *P. Sharreri*. In *P. elegans* the miliaries are irregularly arranged and occupy only a small part of the interambulacral plates, which is nearly all taken up by the scrobicular area of the primary tubercle; they are more closely packed, and there is but a step from this to the linear arrangement of the miliaries in *P. Sharreri*, with primary tubercles having a comparatively smaller scrobicular circle defined by a single row of secondaries rising almost like a ridge round it,[1] which remind us more of such Cidaridæ as *Chondrocidaris*.

Oppenheim[2] is of the opinion that the recent species of *Cidaris* referred to *Porocidaris* by Thomson and myself are hardly to be placed in the genus as originally defined by Desor.[3] While the recent and fossil species both have peculiar toothed spines on the actinal surface, yet the recent species do not possess the furrowed grooves of the scrobicular area which Desor regarded as characteristic of the genus, the systematic value of which is most problematical.

On the strength of such slight characters Dr. Mortensen asserts that *Porocidaris elegans* has no relation to *Porocidaris purpurata*, and suggests the name of *Histocidaris* for the reception of *Porocidaris elegans*. The ground for this it is impossible to conceive, unless it be that the characters of a single valve of a small globiferous pedicellaria, which he figures

[1] "Blake" Echini, Pl. IV. fig. 1.

[2] Oppenheim, P. Revision d. Tertiären Echiniden Venetiens u. v. Trentino. Zeitschr. d. deutsch. geol. Ges., 54 (1902), p. 174.

[3] Desor, Synopsis, p. 47.

as perhaps belonging to that species, is sufficiently characteristic for such a generic separation.

Dr. Mortensen names as *Dorocidaris micans* specimens of a Cidaris which he received from the U. S. National Museum, Washington, labelled as *Porocidaris Sharreri* ("Albatross," 1885, St. 2415), and also from the U. S. Fish Commission ("Albatross," 1885, St. 2315) under the same name. I beg to call Dr. Mortensen's attention to the fact that the publication of the "Blake" Echini dates back to 1883, that my specimens came from Nevis and the Barbados, and that I was in no way concerned in making the collection of the "Albatross" in 1885, or with the identification of the Echinoids then collected. Dr. Mortensen's statements[1] in regard to *Porocidaris Sharreri* are gratuitous misrepresentations of facts. Other specimens have also been received by him from Washington of collections made by the "Albatross" which come under the same conditions.

Porocidaris Milleri A. Ag.

Porocidaris Milleri A. Ag., Bull. M. C. Z. XXXII, No. 5, p. 74, Plate IV, 1898.

Plates 6–8; 10, figs. *1–3*.

This species, Pl. 6, is closely allied to *P. elegans* A. Ag., collected by the "Challenger";[2] it is readily distinguished from *P. elegans* by the great irregularity in shape of the genital plates (Pl. 7, figs. *1, 2*) and the scant development of the ambulacral buccal plates (Pls. 7, fig. *6*; 8, fig. *5*). Its primary radioles also differ from those of *P. elegans* in being less tapering and having finer serrations (Pls. 6; 10, fig. *3*). The external appearance of the primary radioles varies greatly both in different specimens from the same locality or in the same specimen (Pl. 6). In three of the specimens from Station 3381 annelid tubes were found attached to the radioles. In the long cylindrical radioles there are often as many as six or seven longitudinal rows of blunt lamellar spines or sharp spinules; and in the same specimen we find all possible gradations between them and radioles merely finely striated or with here and there remnants of a spinule or of a lamellar protuberance. In the smaller, flattened, spear-shaped, and laterally serrated primary spines of the actinal side a third row of spinules often develops on the convex side.

[1] Mortensen, l. c., pp. 22, 23.

[2] "Challenger" Echinoidea, Pl. III, p. 40.

The primary radioles and other spines early attain nearly their full growth, specimens of 13 mm. in diameter already having radioles 51 mm. in length. In the largest specimen examined, 30 mm. in diameter, the longest radiole was 75 mm.; the longest of the serrated radioles on the actinal side was 26 mm.; those immediately surrounding the actinal edge of the interambulacral area varied in length from 5 to 12 mm. In the same specimen (30 mm. in diameter) the greatest diameter of the abactinal system was 19 mm.; the sides of the anal pentagon varied from 5 to 6 mm. There were six and five primary interambulacral tubercles. In a specimen of 10 mm. there are already four, with traces of a fifth; in a specimen of 14 mm. there are four, with a fifth well advanced; in one of 18 mm. there are five, with traces of a sixth; in one of 23 mm. there are six and five, as in the older specimens.

The abactinal system (Pl. 7, figs. *1–3*) is crowded with small secondary tubercles carrying papillæ ranging in length from 1.5 mm. to 4 mm. They are smallest on the anal system. They only differ from the secondary spines of the interambulacra in length, those being at least 5 mm. long in the equatorial region of the corona. Toward the actinal system they become more spathiform and shorter, both in the ambulacral and interambulacral areas above the ambitus. As a whole, the ambulacral papillæ are shorter than those of the interambulacral areas.

In none of the specimens examined are the primary tubercles crenulate (Pls. 8, fig. *7*; 10, figs. *1*, *2*.) but they all carry the characteristic smaller, flattened, spear-shaped, serrated, primary actinal radioles characteristic of the genus both in the fossil and recent species (Pl. 6, fig. *1*). The angle of the plates along the median interambulacral suture is usually bare of miliaries. The scrobicular circle is surrounded by a row of secondary tubercles alternating with miliaries (Pls. 8, fig. *7*; 10, fig. *2*), and the angular spaces of the interambulacral plates, when not bare along the median line, are filled with small secondaries and miliaries irregularly arranged. The secondaries forming the median vertical row of the ambulacral system are arranged in a single vertical line close to the median line of the ambulacrum; in the equatorial region of the test the ambulacral plates carry in addition one or two miliaries below the secondary tubercle (Pl. 10, fig. *1*).

The actinal system of this species presents some marked peculiarities (Pls. 7, fig. *6*; 8, fig. *5*); we find the ambulacral buccal plates clustered round the actinostome, separated by a wide zone from the ambulacral plates of the corona (Pls. 7, fig. *6*; 8, fig. *5*), in which one or two isolated ambulacral plates are situated, the last to become separated from the ambulacral zone. The interambulacral space is covered with numerous, ill-defined, calcareous plates (Pl. 7, fig. *6*), reminding us of the irregular pavement of the Echinidæ proper, formed of thin plates rather than of the row of solid, interambulacral, buccal plates characterizing the Cidaridæ. In other species of Porocidaris (*P. elegans*,[1] *P. Cobosi*[2]) the actinal system is exclusively covered by the buccal ambulacral plates, with the exception of a small area at the base of the interambulacral areas, which may be bare or carry one or more small, ill-defined, calcareous plates.

It is possible that the extraordinary resorption of the actinal interambulacral plates, due to the great growth of the auricles, is the cause of the anomalous development of the buccal plates of this species. It is interesting to compare the figures of the auricles of a specimen of *P. Milleri* 28 mm. in diameter seen facing the auricles from the exterior (Pl. 8, fig. *9*), from the actinal side (Pl. 7, fig. *7*), and from the interior (Pl. 8, fig. *8*) with the corresponding figure of the small auricles of *P. Cobosi* of a specimen 18 mm. in diameter (Pl. 11, fig. *4*), and in which the buccal plates cover the whole of the actinal system (Pl. 11, figs. *1–3*).

Small, short-stemmed pedicellariæ are found on all the plates of the abactinal system and in the abactinal part of the ambulacral area. Longer and larger stemmed pedicellariæ are found arranged round the primary tubercles.

The abactinal system of this species is most prominent, the genital plates appear as if rising above the general level of the test (Pl. 6, figs. *3*, *4*) both in the males and females; they are readily distinguished even when no larger than 18 or 20 mm. (Pl. 7, figs. *3*, *4*); in larger specimens, probably full-grown, of 28 to 30 mm. the difference in the size of the genital openings is very marked (Pl. 7, figs. *1*, *2*). The anal system in the larger specimens is usually larger in the males than in the females. In the larger males the occurrence of two or more genital openings in the same plate is not uncommon (Pl. 7, figs. *1*, *4*). The genital openings in the females are placed nearer the interambulacral sutures than in the males. In the youngest specimen examined, 10 mm. in diameter, no genital openings could be traced. The genital plates of the larger specimens are most irregular in shape (Pl. 7, figs. *1–5*), the anal system

1 "Challenger" Echinoidea, Pl. III, fig. 3.

2 See Pl. 11, figs. *1*, *2*.

varying greatly in outline and even in its general trend, being often irregularly pentagonal. The madreporic body is prominent in early stages and is usually placed towards the anterior edge of its genital plate. In all the specimens examined the primary anal plates retain their predominance and can readily be traced.

The great thickness of the genital and ocular plates is well seen in Pl. 8, fig. *6*, which shows the abactinal system from the interior of the test. It will be seen that the right posterior genital plate is divided into two plates, and that the madreporic genital plate also shows a suture half-way across the plate. The uniform and close granulation of the abactinal system of *P. Milleri* recalls that of the typical cretaceous Stereocidaris. The whole abactinal system is covered with secondaries of nearly uniform size (Pl. 7, figs. *1–5*), with but few miliaries in the central part of the genitals. An enlarged view of these is shown on the ocular plate of the odd ambulacrum (Pl. 8, fig. *4*); this also shows the young poriferous plate forming between the ocular plate and the uppermost ambulacral plate. Plate 8, fig. *1*, shows the same seen from the interior of the test. Pl. 8, figs. *2* and *3*, show from the interior the ocular plates and adjoining ambulacral plates of the right anterior and the left posterior ambulacra.

Station 3359, off Cape Mala, 465 fathoms. Lat. 6° 22′ 20″ N.; Long. 81° 52′ W. Bottom temperature 42°. Rocky.

Station 3360, off Cape Mala, 1672 fathoms. Lat. 6° 17′ N.; Long. 82° 5′ W. Bottom temperature 36°.4. Fine blk. drk. gr. S.

Station, 3381 off Malpelo Isd., 1772 fathoms. Lat. 4° 56′ N.; Long. 80° 52′ 30″ W. Bottom temperature 35°.8. Gn. M.

Station, 3399 off Galera Point, 1740 fathoms. Lat. 1° 7′ N.; Long. 81° 4′ W. Bottom temperature 36°. Gn. ooze.

Station, 3415 off Acapulco. 1879 fathoms. Lat. 14° 46′ N.; Long. 98° 40′ W. Bottom temperature 36°. Bn. M. Glob. Ooze.

Bathymetrical range, 465–1879 fathoms. Range in temperature, 42°–35°.8.

Porocidaris Cobosi A. Ag.

Porocidaris Cobosi A. Ag. Bull. M. C. Z., 1898, XXXII, No. 5, p. 74, Plate III, figs. 2–5.

Plates 9; 10, figs. *4–9*; 11; 12; 13, figs. *1–4*.

This species is characterized by its small actinal and abactinal systems (Pl. 9, fig. *4*), its stout primary radioles (Pl. 9, figs. *1–3*); the primary tubercles are perforate and crenulate (Pl. 10, figs. *6–9*) in older specimens, but are not crenulate in a specimen 8 mm. in diameter (Pl. 10, figs. *4*, *5*). In the largest specimen examined, a female 35 mm. in diameter (Pl. 11, fig. *6*), the abactinal system is only 14 mm. in diameter. The genital plates are quite regular in outline compared with those of *P. Milleri*, and they as well as the ocular plates are covered by larger, coarser, and more distant secondary tubercles, with still fewer miliaries than in that species. In a younger specimen, a male 21 mm. in diameter, the secondaries on the genitals are reduced to a single row of three on the anal edge of the plates and to two or three miliaries in the centre of the distal part; on the oculars an arc of four or five miliaries is found round the ocular pore (Pl. 11 fig. *5*). In this specimen the anal system is isolated from the oculars, and the larger of the anal plates carry a miliary. In the larger specimen the anal system reaches the right posterior ambulacrum, and the larger anal plates carry from two to four secondaries and miliaries. The genital plates of this species are more elongate than in *P. Milleri*, and the ocular plates are much larger. Compare Pls. 11, figs. *5*, *6*; 12, fig. *1*, with Pl. 7, figs. *1–5*.

Plate 12, fig. *8*, shows, seen from the inside, the abactinal plates of the right posterior ambulacrum, with the newly formed ambulacral plate adjoining the ocular plate. The ocular pore is, as is seen in Pls. 11, figs. *5*, *6*; 12, fig. *8*, placed at a considerable distance from the ambulacral edge of the plate.

In older specimens we find the usual difference in the size of the genital openings of the males (Pl. 11, fig. *5*) and females (Pl. 11, fig. *6*).

In the youngest specimen found, 8 mm. (Pl. 12, fig. *1*), the genital openings are covered by lamellæ forming wart-like protuberances (Pl. 12, figs. *9*, *10*), and the granulation of the abactinal plates is reduced to two to four miliaries on the genitals and to two on the oculars. The symmetrical outline of the plates of the abactinal system is well seen in this young specimen.

The anal plates are, however, more characteristic of an older stage than is usual in such a young specimen, the plates intercalated between the primary anal plates equalling in size several of those of the primary ones. In the oldest anal system figured (Pl. 11, fig. *6*) the second row of plates have all become intercalated between the primary ones, as is already the case in a younger specimen (Pl. 11, fig. *5*), the primary plates being only slightly more prominent than the secondary ones.

The primary radioles are cylindrical, finely striated (Pl. 12, fig. *12*), they early lose all trace of the delicate serration seen in the spines of the ambitus and in younger specimens. In a small specimen 8 mm. in diameter there are five primary tubercles, in one 23 mm. we find six, and in a specimen of 35 mm. there are eight. The radioles of a specimen 11 mm. are 31 mm. long; of one 35 mm. they are 105 mm.

In a specimen with eight primary tubercles the scrobicular area of the larger tubercles joins the sutures of the plate below it, and is thus surrounded by an imperfect circle of secondaries and miliaries (Pls. 9, figs. *5*, *6*; 10, fig. *9*; 13, fig. *2*), the rest of the plate being thickly covered with secondaries and miliaries irregularly arranged. In a somewhat younger specimen (Pl. 10, fig. *7*) there are as yet but few miliaries on the coronal plates except on the older ones near the actinal system (Pl. 10, figs. *2*, *3*). In still younger specimens the coronal plates are comparatively bare, and carry only a single miliary at each angle of the interambulacral plates (Pl. 10, figs. *4*, *5*).

Part of the base of the secondary tubercles is frequently cut off by the extension of the muscular attachment of the radiole beyond the scrobicular area (Pl. 13, fig. *1*).

In the ambulacral areas each plate has at first but a single secondary tubercle (Pl. 10, fig. *4*); even in older specimens we find the same structure (Pl. 10, fig. *6*) It is only in somewhat older specimens (Pl. 10, fig. *8*) that we occasionally find an additional miliary in the equatorial region of the corona (Pl. 9, figs. *5*, *6*). The secondary ambulacral tubercles are neither perforated nor crenulated.

The actinal system is completely covered by the ambulacral buccal plates, which spread laterally so as to unite, except near the last actinal interambulacral plates, where a narrow space is left bare or is partly filled by a single buccal interambulacral plate (Pl. 10, figs. *1*, *2*, *3*).

In young specimens of 8 and 10 mm. in diameter the buccal plates, even when there are not more than two or three pairs, have already become, in great part, joined laterally. On the buccal plates a single row of secondary tubercles, separated by miliaries irregularly arranged, extends along their actinal edge, leaving the rest of the plate bare (Pl. 11, figs. *1*, *2*). In young specimens two or three miliaries only are found on each plate (Pl. 12, figs. *2*, *3*).

The separation of the actinal ambulacral plates and their migration upon the actinal system is well seen in Pl. 12, figs. *4*, *5*. In one case (Pl. 12, fig. *5*), the ambuleral plate has become separated as a whole; in the other (Pl. 12, fig. *4*) the ambulacral plate has been torn off in such a way as to carry with it a part of the next ambulacral plate as well as a part of the adjoining interambulacral plate. In Plate 12, figs. *6* and *7*, is seen the actinal edge of the odd interambulacrum, showing the extent to which the actinal plates have been resorbed, and indicating (Pl. 12, fig. *7*) the minute calcareous plates which have filled the space left between the distal ambulacral buccal plates.

In Plate 11, figs. *3*, we have the actinal plates of the odd ambulacrum and the adjoining interambulacra seen from the actinal side; Plate 12, fig. *4*, shows the same ambulacrum seen from the interior to show the auricles and the remarkable processes extending from the abactinal side of the ambulacral buccal plates.

Thomson[1] has figured for *Porocidaris purpurata* the peculiar curved spines into which the buccal ambulacral plates rise on each side of the median line as seen from the interior of the test. I do not know similar plates in other Cidaridæ.

Thomson also speaks[2] of the two-valved pedicellariæ of Porocidaris as unique among the Echinoideans. They occur in Clypeastroids and Spatangoids.

Station, 3404, off Chatham Id. (Galapagos), 385 fathoms, Lat. 1° 3′ S.; Long. 89° 28′ W. Bottom temperature, 43°.2. Rocky.

[1] Thomson, Wyville, Echinoidea of the "Porcupine" Deep Sea Dredging Expedition. Trans. R. S. London. Vol. 164, Pt. 2, p. 728, fig. 2.

[2] Loc. cit., p. 727.

Centrocidaris A. Ag.

In his important paper on the Cidaridæ of Japan,[1] Doederlein very properly objects to the position of *Goniocidaris canaliculata* in the genus Goniocidaris, which he would place in a remote section of Dorocidaris, if we limit it to species in which the bare ambulacral and interambulacral spaces are found at the angles of the median lines of these plates. The discovery of a species of Cidaris allied to *G. canaliculata* leads me to suggest that it, as well as the species here described, be transposed to a new subgenus, Centrocidaris, including it and *G. canaliculata*;[2] the species all being characterized by the broad bare space in the ambulacral and interambulacral areas. This would seem to indicate the affinities of Goniocidaris to be more remote from the Dorocidaris group and more closely related to the type of *Goniocidaris canaliculata*, and finally with the limitation of the bare pits to the angles of the plates we come upon the genus Goniocidaris proper.

Doederlein has in his interesting account attempted to subdivide the recent and fossil Cidaridæ into a number of groups, many of which have been based either upon the study of recent species or of fossils alone. He has succeeded in making an excellent classification. Perhaps the most interesting of his observations are those relating to the existence of furrows on the outer edge of the ambulacra of some of the Jurassic Echini. This feature recalls a similar structure in the plates of the Eocidaridæ. It must have rendered the test of these genera more or less flexible. This flexibility was attained in a very different way from that of the Echinothuriæ; in the Cidaridæ it was lateral, in the Echinothuriæ to great extent vertical.

I can see no reason for referring *G. canaliculata* to *Stereocidaris*, as has been suggested by Dr. Mortensen.[3] Referring a living species to genera established for fossil species is so contrary to Mortensen's principles that I cannot understand his reasons for referring to *Porocidaris*, *Stereocidaris*, and *Arbacina* some living species, and rejecting other similar references merely because they were based upon fossil species. But to Mortensen affinities as usually recognized by most writers on Echini have no interest and have no value when not based on the pedicellariæ.

[1] Japanische Seeigel, loc. cit., p. 16.

[2] I had, in 1863, when describing *G. canaliculata*, originally placed it in the genus Temnechinus, a name preoccupied by Cotteau (Bull. M. C. Z., I. p. 18).

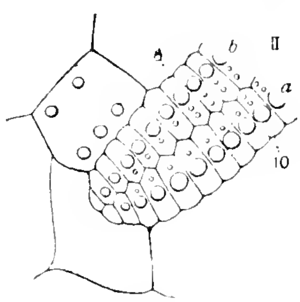
[3] "Ingolf" Echinoidea, p. 29.

Centrocidaris Doederleini A. Ag.

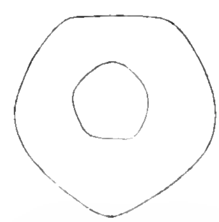
Goniocidaris Doederleini A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 73. Plate III, fig. 1.

Plates 5; 14, figs. *1, 2*.

Only a single specimen of this interesting species was collected. It is allied to *G. canaliculata*, but can at once be distinguished from it by the flatness of the test and the very slender primary radioles; they are cylindrical, finely striated, slightly tapering at the distal extremity, where they are slightly fluted (Pl. 14, figs. *1, 2*). The ambulacral secondary spines are elongated, sharp, slender, slightly fluted; those of the interambulacral areas are longer and broader. When denuded, the bare interambulacral area is seen to be shallow (Pls. 5, figs. *1, 4*; 14, figs. *1, 2*). The scrobicular area of the primary tubercles is surrounded by a prominent row of secondary tubercles, with a few secondary tubercles and miliaries irregularly scat-



26 mm.



26 mm. showing ratio of test to actinal syst.

Fig. 46. CENTROCIDARIS DOEDERLEINI. Fig. 47.

tered outside of it. The primary ambulacral tubercles run in two vertical, slightly undulating lines, with two inner rows of miliaries between the outer row and the bare median line (Pl. 5, figs. *1–3*) extending along the equatorial zone of the ambulacrum, and single rows at the actinal and abactinal extremities of the ambulacral areas (Pl. 5, figs. *1–3*).

The first six pairs of ambulacral plates (after the upper pair) carry two tubercles, Fig. 46, and subsequently three, one in each case being a secondary tubercle, the others miliaries (Pl. 5, fig. *2*).

The poriferous zone is characterized by its great width (Pl. 5, fig. *3*); it is as broad as the median ambulacral space between the vertical rows of primary ambulacral tubercles, and by the depth of grooves connecting the ambulacral pores. In the specimen figured, 26 mm. in diameter, there were eleven plates in each ambulacral series of the actinal system and four in each interambulacral area, except in the right, posterior, interambulacral area, where a small fifth plate had developed. In our specimen, measuring 26 mm. in diameter, the actinal system is 9 mm. in diameter, Fig. 47. The arrangement of the small secondary tubercles on the buccal plates is shown on Pl. 5, fig. *1*; these are few in number and are limited to the actinal side of the plates.

The abactinal system is 8.5 mm. in greatest diameter (Pl. 5, fig. *2*). It is nearly bare of miliaries; these are widely separated and arranged along the edges of the genital plates, with two or three in the centre of the plates and round the genital pores. Along the distal side of the ocular plates extends one line of secondaries and miliaries.

The madreporic body is well developed in the central part of the genital plate. The anal plates, like the other plates of the abactinal system, are bare, with from one to three miliaries on each anal plate. The arrangement of the older plates of the anal system is quite regular (Pl. 5, fig. *2*). The oldest plates occupy the angles of the pentagonal anal system.

The genital plates are elongate with concave sides flanking the oculars, which nearly join the anal system, and with convex sides against the interambulacral plates.

When alive the bare spaces of the median interambulacral area are of a deep brownish violet (Pl. 14, figs. *1*, *2*), the primary radioles are reddish, the secondary and miliary spines greenish with brownish longitudinal bands. The sutures between the genital and ocular plates, as well as in the anal system, are marked by a sharp violet line (Pl. 14, fig. *2*).

Station 3369, off Cocos Island, 52 fathoms. Lat. 5° 32′ 45″ N.; Long. 86° 55′ 20″ W. Bottom temperature 62°.2′. Nullipore and rocky.

SALENIDÆ Agass.

The discovery of a number of new species of Salenia by the "Challenger" and "Blake" has somewhat modified our ideas of the relationship of the genus to the Cidaridæ. The study of the additional species collected by the "Albatross" in 1891 has only emphasized the view of Duncan[1] and Sladen[2] and of Doederlein[3] of their relationship to the Echinidæ. Although the simple structure of the ambulacra, the solid genital and ocular plates,

[1] Ann. and Mag. N. H., 1877. Ser. 4, Vol. XX, p. 70.
[2] Ann and Mag. N. H., 1887. Ser. 5, Vol. XIX, p. 132.
[3] Japanische Seeigel, p. 53.

the small number of primary coronal plates, the structure of the radioles and secondary spines, are Cidaridean features of considerable importance, yet the structure of the plates of the buccal membrane, the gill slits of the actinal interambulacral plates, the presence of ophicephalous pedicellariæ, the disconnected ambulacral auricles, their low, wide, interambulacral ridges, the presence of a deep foramen in the pyramid of the jaws, which are not almost solid, as in the Cidaridæ, are all features of the Echinidæ far outweighing the Cidaridean characters which had originally led me to consider them as more closely allied to the Cidaridæ. In addition, the existence of demiplates in the actinal region of the ambulacra and the slight crowding of the actinal ambulacral plates are important features allying them to the Echinidæ. To group together the Salenidæ and the Aspidodiadematidæ as Diadematoida, as is suggested by M. de Meijere, can only bring endless confusion.

It has become evident from the abundant material of Saleniæ collected since the first recent species was described,[1] that the typical *Salenia varispina* was only a very young specimen from which but few of the characters of the modern Saleniæ could be ascertained. As *Salenia varispina* was not as fully figured as other species, I have added for the sake of comparisón not only additional figures of *S. varispina* (Pl. 21), but also a few figures of *S. Pattersoni* (Pl. 20, figs. 5–7) and of *S. hastigera* (Pl. 20, fig. 8) to assist the identification of these species.

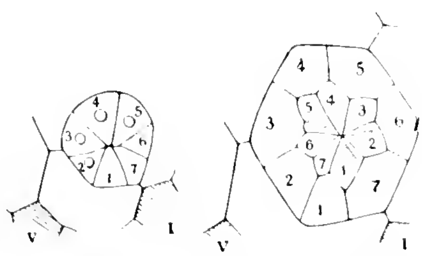
The original *S. varispina* measured only 1.9 mm. in diameter. The abactinal system covered nearly the whole of the upper part of the test (Pl. 21, fig. 4), and was much larger in proportion than in a small *S. miliaris* of 5 mm. in diameter, in which the coronal plates formed a wide zone round it.

The genital and ocular plates are striated diagonally (Pl. 21, fig. 8), and a few sessile verrucæ edge these plates, with one or two near the edge of the anal system. Those of the madreporic genital are seen more magnified (Pl. 21, fig. 7) from the exterior, and the same plate is seen from the interior (Pl. 21, fig. 8) to show the accumulation of limestone cells forming the madreporic body. Both figures show the character of the striation of the apical plates; it does not pass from one plate to the adjoining one, the striæ butt against the sutures. This diagonal striation, towards the actinal suture in the younger coronal plates and towards the abactinal suture in older plates, seems to give us the explanation of the movement of the

[1] Salenocidaris varispina A. Ag., 1869, Bull. M. C. Z p. 254. Revision of the Echini, p. 261.

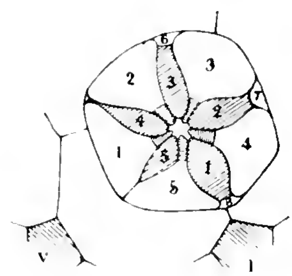
primary and other tubercles across adjoining sutures or over adjoining smaller tubercles and miliaries.

It is probable that in an earlier stage the anal system was only covered by five plates. The specimen of 1.9 mm., Fig. 48, had seven triangular plates, five of equal size, four of which carried miliaries, and two slightly smaller (Pl. 21, fig. *2*). In an older specimen 5 mm. in diameter, Fig. 49, the anal system is hexagonal (Pl. 21, fig. *9*), with an outer row of seven large plates which have lost their triangular shape and have become mainly hexagonal, with an inner row of seven elongate pointed small plates in the angles of the primary anal plates and three smaller, narrow plates. In a



1.9 mm. 5 mm.

FIG. 48. SALENIA VARISPINA. FIG. 49.



5 mm.

FIG. 50 SALENIA MILIARIS.

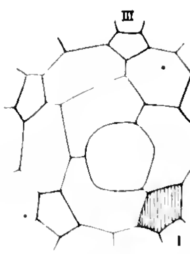
specimen of *S. miliaris*, also measuring 5 mm. in diameter, Fig. 50, the anal plates are more regularly arranged (Pl. 16, fig. *2*), there being five large primary anal plates, an inner row of five smaller ones intercalated between the primary plates, and a third set of still smaller, narrow, elongate plates in the actinal angles of the second set of plates. So that it appears that the anal system of Salenia, as of Cidaris, was originally covered by five plates.

The buccal ambulacral plates (Pl. 21, fig. *1*) occupy nearly the whole of the actinal system. They touch laterally, and are separated from the actinostome by a belt of two or three rows of calcareous plates, slightly imbricating, irregularly arranged (Pl. 21, figs. *1*, *4*). The plates of the actinal system are made up of an open network of cells. The ambulacral pores are not as yet equally developed (Pl. 21, figs. *1*, *4*), five of the suckers being more prominent than the others, the pores being scarcely visible on the other buccal plates.

The *Salenia Goesiana* figured by Lovén[1] has unfortunately lost its actinal and anal plates, as well as radioles, so that we can only compare the test to

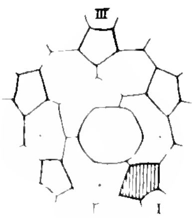
[1] Lovén, Echinoidées, p. 27, Pl. XIX.

S. varispina. The specimen is also intermediate in size between the specimens of *S. varispina* collected. The arrangement of the ambulacral plates as far as we can judge from the figures of Lovén,[1] is similar to that of *Salenia Pattersoni* (Pl. 20, fig. *5*).



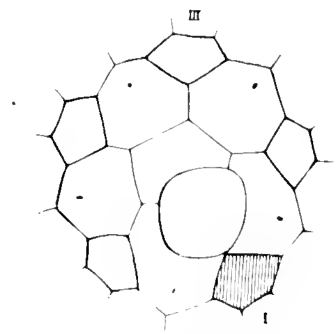
1.9 mm.

FIG. 51. SALENIA VARISPINA.



5 mm.

FIG. 52. SALENIA MILIARIS.

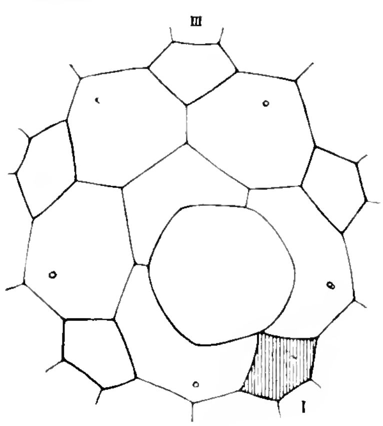


13 mm.

FIG. 53. SALENIA PATTERSONI.

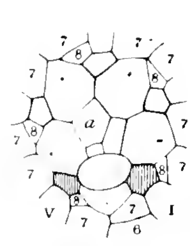
In Pl. 21, fig. *1*, we can see a small triangular plate at the actinostome in the median interambulacral zone, — very probably the remnant of the primitive primordial plate. No trace of primordial plates could be traced in *Salenia miliaris*.

In none of the young stages of *Salenia varispina*, Fig. 51; *miliaris*, Fig. 52; *Pattersoni*, Fig. 53, and *hastigera*, Fig. 54, do any of the ocular plates come

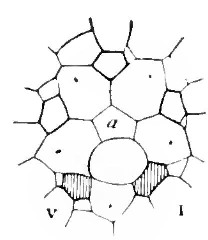


13 mm.

FIG. 54. SALENIA HASTIGERA.



7.3 mm.



9 mm.

FIG. 55. ACROSALENIA SPINOSA. FIG. 56.

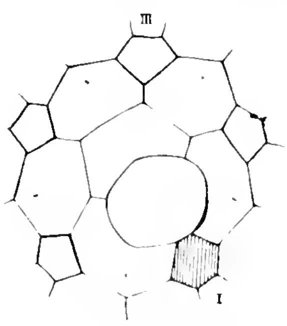
in contact with the anal system, while in the young *Acrosalenia spinosa*, Fig. 55, of 7, and Fig. 56, of 9 mm., the ocular plate of the right posterior ambulacral is well in contact by one of its sides with the anal system (Pl. 22, fig. *5*). Compare this with the figures of the apical system of a

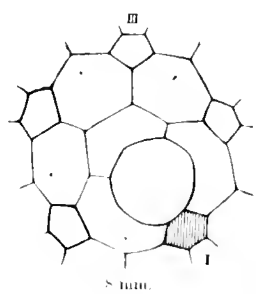
[1] Lovén, Echinoïdées, Pl. XIX, figs. 162, 165.

young *Salenia varispina*, Fig. 51, of 1.9 mm. (Pl. 21, fig. *2*), and one of a young *S. miliaris* of 5 mm. (Pl. 16, fig. *2*), Fig. 52.

In Acrosalenia, the ocular plate of the left posterior ambulacrum has also come in contact by one of its sides with the anal system. Figs 55, 56.

The movement of the same pentagonal ocular plate in the right posterior ambulacrum towards the anal system can be readily followed in its successive stages in *S. miliaris*. In the youngest stage (Pl. 16, fig. *2*) it is pentagonal and well separated from the anal system; when 8 mm. in diameter, Fig. 58, the ocular plate has become truncated and hexagonal, and is now in contact by one of its sides with the anal system. In a





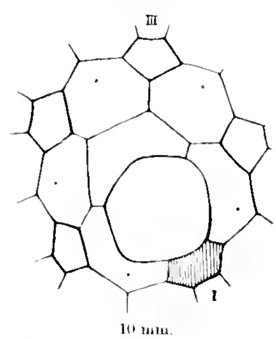


FIG. 57. SALENIA VARISPINA. FIG. 58. SALENIA MILIARIS. FIG. 59.

specimen of 10 mm., Fig. 59, the side of the ocular plate in contact with the anal system is still longer (Pl. 16, fig. *6*). It has become somewhat indented in a specimen of 13 mm., Fig. 60 (Pl. 17, fig. *2*), and in an older specimen of 16 mm., Fig. 61, the side of the hexagon in contact with the anal system is still longer and quite deeply concave (Pl. 17, fig. *3*).

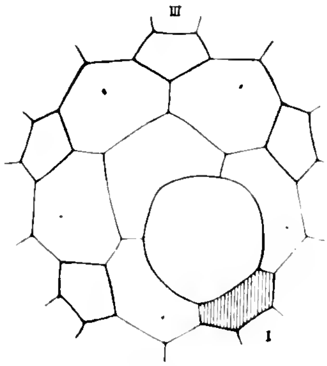
In a *Salenia Pattersoni* of 10 mm., Fig. 62, and 13 mm. Fig. 53, this same ocular plate of the right posterior ambulacrum is in one case, "Blake" Echini, Pl. IV., Fig. 18, still pentagonal, its apex barely truncated by the anal system, and in the other, "Blake" Echini, Pl. IV., fig. 3, somewhat more truncated, but less than in a specimen of similar size of *S. miliaris*. A specimen of *S. hastigera*, "Challenger" Echini, Pl. IV. figs. 6, 10, 12, of 13 mm. Fig. 54, shows the ocular plate only slightly truncated, much as in the specimen of the same size of *S. Pattersoni*, Fig. 53.

M. de Meijere[1] refers a small Salenia obtained by the "Siboga" to *S. Pattersoni*. It is more likely to be the Panamic *S. miliaris* or *S. pacifica*, a Japanese species, than the West Indian species. But as he gives no

[1] "Siboga" Echinoidea, p. 13.

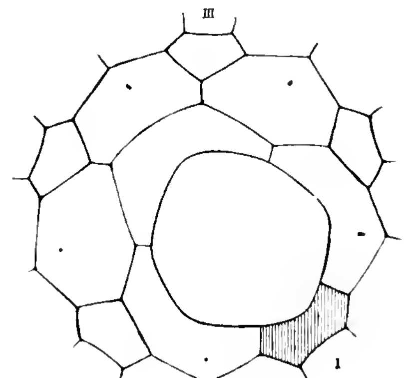
details or available figures, nothing more definite can be stated regarding his specimen.

In the Report on the "Challenger" Echini[1] the detailed drawings of the abactinal system have not been uniformly placed in their correct theo-



13 mm

FIG. 60.

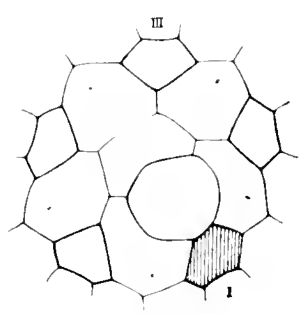


17 mm.

FIG. 61.

SALENIA MILIARIS.

retic position, with the axis passing through the anterior ambulacrum pointing upward so as to bring the madreporic body on the right of the odd anterior ambulacrum. This has misled Duncan in assuming that I placed the madreporic plate of Salenia in a posterior position and to the left of the anterior axis. This is most unfortunate, as I am the last



10 mm.

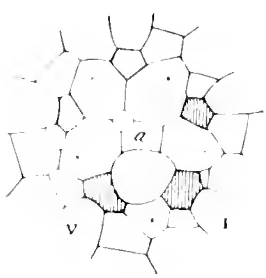
FIG. 62. SALENIA PATTERSONI.

to suggest any other position for the madreporic body than that I have always recognized with Desor, Cotteau, Lovén, Duncan, and others.

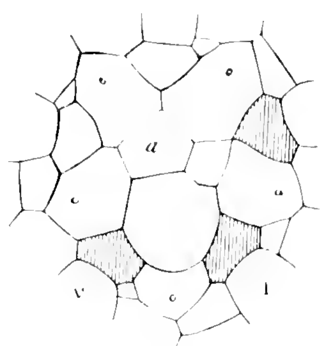
Although the suranal plate of Salenia recalls the large anal plate of very young Echini, yet it never becomes a part of the anal system proper. It seems more to be the remnant of one of the suranal plates of Acrosalenia or of Gauthieria.

[1] A. Agassiz, "Challenger" Echinoidea, Pl. IV.

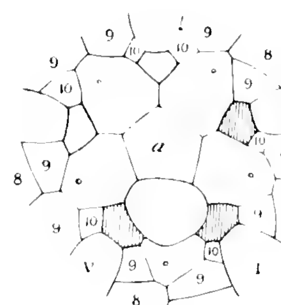
In Acrosalenia the suranal plate is not always single (Pl. 22, figs. *4*, *6*, *8*), and some of the species indicate a transition between the single suranal plate of Salenia to the numerous plates of the anal system of Echinidæ proper, in which no prominent suranal plate exists in the adult. It is seen only in very young specimens of some genera, as those of Strongylocentrotus Temnechinus, Echinus, Toxopneustes, Trigonocidaris, and others, and it is in no way to be distinguished in older stages from the ordinary anal plates filling a part of the anal system, while in Salenia and Acrosalenia the suranal plate is an intercalated one, outside of the anal system (Pl. 22, figs. *5*, *7*), and never becomes a part of the anal system of plates, even when as in Acrosalenia, the suranal plate is not single, and there are two or three or more suranal plates (Pl. 22, figs. *4*, *6*, *8*), Figs. 55, 62 a, 63, which do not hold



11 mm.
FIG. 62 a.



20 mm.
FIG. 63.



13 mm.
FIG. 64.

FIGS. 62 a–64 ACROSALENIA SPINOSA.

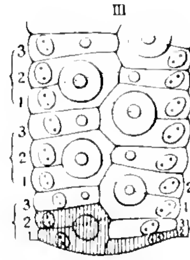
a definite relation to the primary suranal plate, and may be part of the suranal system either in the direction of the right posterior (Pl. 22, fig. *4*), the right anterior (Pl. 22, fig. *8*), or the left anterior ambulacra (Pl. 22, fig. *6*); or the suranal plate may remain single, Fig. 64 (Pl. 22, figs. *5*, *7*), holding to the anal system the same relation it holds in some of the Saleniæ.

In Gauthieria[1] the central part of the apical system is occupied by large hexagonal plates surrounding a central suranal plate, the anal opening is excentric and the posterior genital reduced to a mere narrow shank. As Lambert well says, this is a most unusual structure in Echinidæ. The only thing which at all suggests such a structure in recent Echini is the anal system of Aspidodiadema and Dermatodiadema (Pl. 28, figs. *3*, *4*), which is

[1] Lambert, Bull. Soc. des Sc. hist. et nat. de l'Yonne, September, 1888.

in certain stages covered by a few large anal plates of uniform size; but they are disconnected as compared with the solid pavement formed by the plates of the anal system of Gauthieria.

In the ambulacral system of Acrosalenia primary ambulacral plates are split into two, and an intercalated plate, carrying only a small tubercle or miliaries (Pl. 22, figs. *2, 3*), is found between the primary plates with two pairs of ambulacral pores, as in Salenia Pattersoni, Figs. 76, 77. Near the



8.8 mm.

FIG. 65. ACROSALENIA SPINOSA.

actinal system the ambulacral plates become resorbed and crowded together and this arrangement is entirely lost (Pl. 22, figs. *1–3*), though it reappears again, and is followed as far as the apical system by a single line of small plates, Fig. 65.

In the abactinal system of the youngest Acrosalenia examined of 7.3 mm., (Pl. 22, fig. *4*), the two ocular plates of the posterior lateral ambulacra are hexagonal and in contact with the anal system by one of their sides, but the ocular of the left posterior ambulacrum is the smallest, and it seems to be that plate which reaches the anal system last of the two (Pl. 22, figs. *4, 5*), the ocular of the right posterior reaching it evidently first (Pl. 22, fig. *5*), as it does in Salenia miliaris.

SALENIA Gray.

Salenia miliaris A. Ag.

Salenia miliaris A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 74, Pl. II, figs. 2–4.

Plates 14, figs. *3–11*; 15, figs. *1, 2*; 16–19; 20, figs. *1–4*.

This species can at once be distinguished from its congeners by the great size of the anal system (Pls. 16, figs. *2, 4, 6*; 17, figs. *2, 3*), which is irregularly hexagonal and covered by a larger number of plates than in *S.*

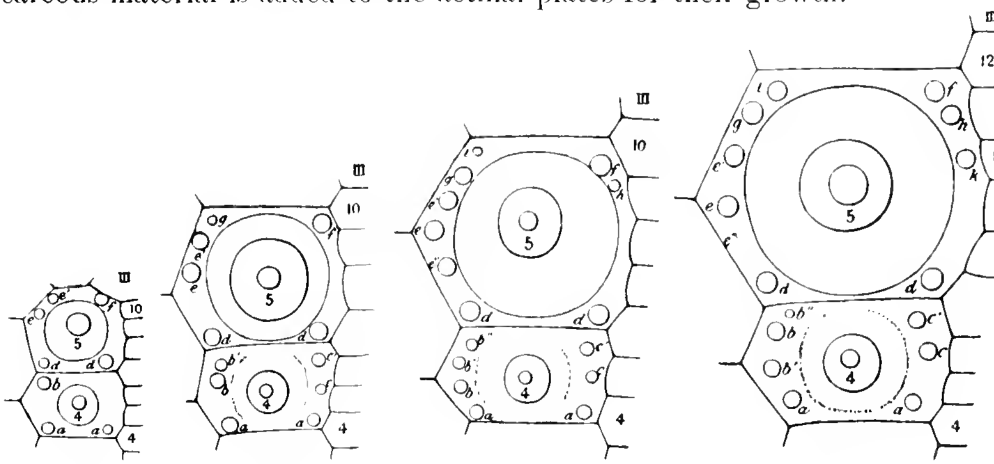
hastigera, *varispina*, and *Pattersoni*. As in *Salenia Pattersoni*[1] the right posterior ocular plate forms with the right posterior genital, the odd genital, and the suranal plate a part of the ring of plates surrounding the anal system, while in *S. hastigera*[2] and *varispina*[3] (Pl. 21, figs. *2*, *9*) the right posterior ocular is excluded from the anal system. In *Salenia miliaris*, however, the anal system as well as the other plates of the abactinal system are not symmetrically placed as in *S. Pattersoni*; and in *S. miliaris*, in the youngest specimen examined, 5 mm. in diameter (Pl. 16, fig. *2*) the right ocular is excluded from the anal system, Fig. 52, but in a specimen of 8 mm., Fig. 58, that plate again forms a part of the plates surrounding the anal system (Pl. 16, fig. *4*). A few of the larger plates near the anal opening carry large papillæ similar to those of *S. pacifica* figured by Doederlein;[4] the other anal plates carry smaller more slender papillæ similar to those of the median ambulacral area (Pl. 15, fig. *2*). All the plates of the abactinal system, exclusive of the anal system, are covered with fixed verrucose papillæ irregularly arranged on these plates (Pls. 16, figs. *2*, *4*, *6*; 17, figs. *2*, *3*), but far less crowded than in *S. hastigera*, and showing no trace of the radiating arrangement of the verrucæ so characteristic of *S. Pattersoni*. The ocular plates are in the older stages more elongate (Pl. 17, figs. *2*, *3*) than those of *S. hastigera*, *Pattersoni*, or *varispina*. The madreporic body is but slightly developed (Pls. 16, figs. *2*, *4*, *6*; 17, figs. *2*, *3*). The genital openings are small, placed nearly in the centre of the larger genital plates, and they cannot be traced in young specimens (Pl. 16, figs. *2*, *4*, *6*). *Salenia miliaris* is marked for its huge curved spines (Pl. 15, figs. *1*, *2*) and the great variation in the height of the test (Pl. 14, figs. *5*, *8*, *11*); the great length of the primary radioles is very striking; in a specimen 12 mm. in diameter, the longest primary radioles are over 60 mm. in length; in a specimen 16 mm. in diameter they attained a length of 75 mm.

A comparison of the fourth and fifth plates of the right anterior interambulacrum in specimens varying from 5 to 13 mm. in diameter seems to show a regular order in the appearance of the miliaries in the angles of the primary coronal plates. In a specimen of 5 mm., Fig. 66, there are three and five miliaries (Pl. 17, fig. *5*); in one of 8 mm., Fig. 67, there are six and six in the same plates (Pl. 17, fig. *7*); in the next stage of 10 mm.,

[1] "Blake" Echini, Pl. IV, figs. 3, 15, 18.
[2] "Challenger" Echinoidea, Pl. IV, figs. 6, 10, 12.
[3] Revision of the Echini, Pl. III, fig. 11.
[4] Doederlein, Jap. Seeigel, Pl. XI, fig. 9.

Fig. 68, we find seven and nine (Pl. 18, fig. *2*); and in one of 13 mm., Fig. 69 (Pl. 18, fig. *4*) there are seven and ten, new miliaries being formed in the upper angles of the plates.

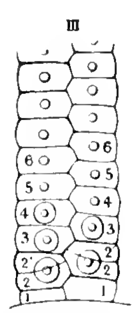
The small size of the auricles of Salenia and other genera is undoubtedly due to the fact that in Salenia and others the coronal plates supply but little calcareous material to the actinal system owing to its relative constant size, and the primordial plate having been resorbed, little or no fresh calcareous material is added to the actinal plates for their growth.



5 mm. FIG. 66. 8 mm. FIG. 67. 10 mm. FIG. 68. 13 mm. FIG. 69.

FIGS. 66–69. SALENIA MILIARIS.

The primary ambulacral tubercles are small, placed near the median line, and in older specimens they are separated by miliaries which separate the two vertical rows (Pl. 20, figs. *3*, *4*); they, however, have the same Hemi-

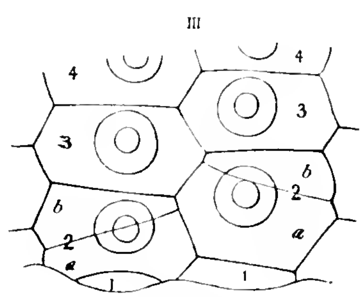


5 mm.

FIG. 70. SALENIA VARISPINA.

cidaris arrangement which has been observed in other species of the genus, tapering gradually (Pl. 18, figs. *1*, *3*, *5*), Fig. 70, and stopping abruptly at the fourth or fifth plate, where they are followed by large miliaries or small secondaries (Pls. 18, figs. *1, 3, 5*; 20, figs. *1–4*). The pairs of pores are small and occupy a small corner of the ambulacral plate (Pl. 20, figs. *1–4*), while in *S. Pattersoni* the pores are large, distant, and occupy the whole side of the ambulacral plate adjoining the interambulacral area (Pl. 20, figs. *6, 7*), and in *S. hastigera* the size of the pores is intermediate between the two (Pl. 20, fig. *8*). In *S. varispina* the ambulacral pores are still smaller, and take up but a fractional part of the ambulacral plate (Pl. 21, figs. *5, 6*). Three of the actinal ambulacral tubercles are somewhat larger than the others (Pl. 20, figs. *1–4*), showing a Hemicidaris-like arrangement, while the others are uniform in size, decreasing only in dimensions at the last plates near the abactinal system. The larger tubercles are often crenulated (Pl. 19, fig. *1*).

There is one important feature in the structure of the ambulacra which gives us the measure of the amount of resorption which has taken place at the junction of the ambulacra with the actinal system. The resorption of the actinal plates does not seem to be sufficient to absorb wholly any of the ambulacral plates, though in a specimen of *Salenia miliaris* of 13 mm. the first ambulacral plate of the right zone of the odd anterior ambulacrum,

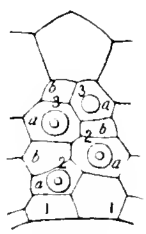


13 mm.

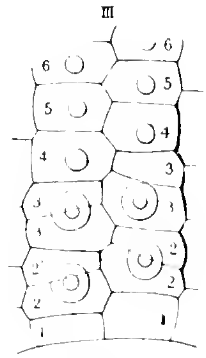
FIG. 71. SALENIA MILIARIS.

Fig. 71, has nearly disappeared (Pl. 20. fig. *3*), and there is no trace of the interambulacral primordial plates in any of the young of Salenia I have examined except in a very young *S. varispina* of less than 2 mm. This corresponds to what takes place in the Cidaridæ, in which the primordial plates have been observed only in the very youngest stages.

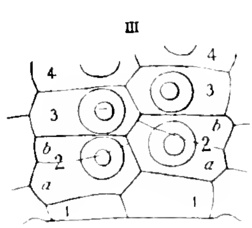
The stress of the coronal ambulacral plates against the edge of the actinal system produces an asymmetry (Pl. 20, fig. *2*), as in Dermatodiadema and other Echinoids in which there are but few calcareous plates sloughed off onto the actinal system from the adjoining coronal plates, a slight thickening of the actinal lips (Pl. 20, fig. *3*), and retrogression to form on the sides of the ambulacral areas the notches for the gills (Pl. 20, figs. *2*, *3*), one of the zones extending further into the actinal system than the other (Pl. 20, fig. *3*); while in very young specimens of 5 mm. the outline of the actinal system is symmetrical.


1.9 mm
Fig. 72.

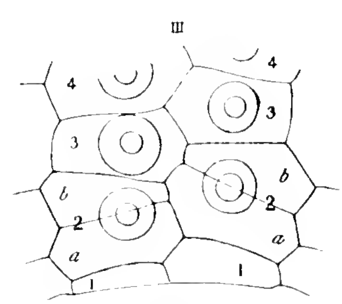
Salenia varispina.


5 mm.
Fig. 73.

In the different species of Salenia one or more plates are double, the ambulacral tubercle extending across adjoining plates, each of which has a pair of pores. In *Salenia varispina*, Fig. 72, it is the second and third plates which are thus constructed (Pl. 21, fig. *6*.) In a specimen measuring only 1.9 mm. it is the second plate, and in that specimen the plate appears as an intercalated one (the third), the primary tubercle of the second plate not having as yet encroached upon the third plate (Pl. 21, fig. *5*). In the older specimen (Pl. 21, fig. *6*) the tubercles of the second and third plates have encroached upon the intercalated plates. Fig. 73, on one side of the ambulacrum, while on the other the tubercle of the second plate has gone over the intercalated plate and that of the third plate has not yet encroached upon the intercalated plate.

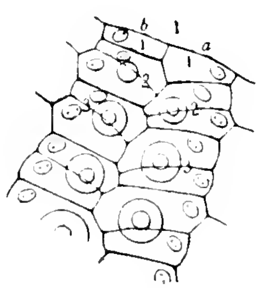

8 mm.
Fig. 74.

Salenia miliaris


10 mm.
Fig. 75.

In a young *S. miliaris* (Pl. 20, fig. *1*) it is the second which is a double plate, Fig 74. In older specimens the actinal plates have been partly resorbed, Fig. 75, and as they become older and the first formed actinal ambulacral plates are more or less resorbed (Pl. 20, figs. *2*, *3*) they become smaller, and the double plates are brought close to the actinostome (Pl. 20, fig. *4*).

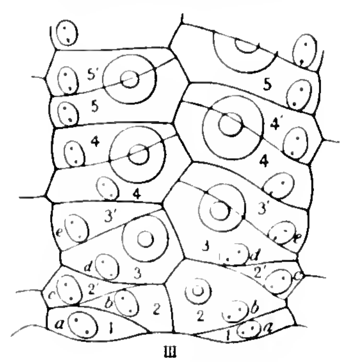
In *Salenia hastigera* (Pl. 20, fig. *8*) the double plates have the same position as in *S. miliaris* (Pl. 20, fig. *3*). In *Salenia Pattersoni* nearly all the ambulacral plates are double plates and may become so up to the abactinal system. In a specimen 13 mm., Fig. 77, there are intercalated plates above the sixteenth plate, which is a double one. In a specimen of 5 mm., Fig. 76, all eight of the ambulacral plates are double except the youngest



5 mm

FIG. 76.

SALENIA PATTERSONI



13 mm.

FIG. 77.

plate, which on one side is a single, on the other an intercalated plate (Pl. 20, fig. *5*). Lovén has indicated this structure for *S. Goesiana* by calling attention to the alternate position of the ambulacral pores in the plates nearer the actinal system.[1]

Large tridentate pedicellariæ are found in both the ambulacral and interambulacral areas below the ambitus as well as on the actinal system. On the latter round the actinal tentacles are found clustered small short-stemmed pedicellariæ. On Pl. 19, fig. *2*, are figured spheridia at the actinal extremity of the left posterior ambulacrum.

In a specimen 16 mm. in diameter (Pl. 14, figs. *3–5*) the coronal plates are 10 mm. in height, the abactinal system rising 4 mm. above that (Pl. 14, fig. *5*); the abactinal system measured 11 mm. across (Pl. 17, fig. *3*), the greatest width of the anal system being 5 mm. and that of the actinal system 8 mm. in diameter (Pl. 19, fig. *1*). In a specimen 17 mm. in diameter there are seven primary tubercles and five ambulacral plates to each of the largest interambulacral plates (Pl. 18, figs. *5*, *6*).

[1] Lovén, Echinoidées, Pl. XIX, figs. 162, 165.

The scrobicular areas of the primary tubercles are already connected in specimens 10 mm. in diameter; in younger specimens the areas of the principal plates are still isolated (Pl. 17, figs. *4–6*). The scrobicular areas (Pl. 19, fig. *3*) of the larger primary tubercles are flanked on each side by five to six secondaries with one or two miliaries in the narrow space between these and the ambulacra (Pl. 18, figs. *5, 6*), while in the wide median interambulacral area the miliaries are more numerous. The larger primary tubercles are crenulated, but those nearer the actinal system are not.

The radial and concentric mode of growth of the coronal plates is well shown in Pl. 19, figs. *3, 4, 5*; figs. *4* and *5* illustrate specially the independent growth of the interambulacral and ambulacral plates by the

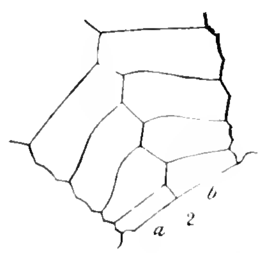


FIG. 78. SALENIA VARISPINA.

gradual intercalation of additional calcareous material in the connecting angles of the plates. In fig. *5* there are five ambulacral on the side of the interambulacral plate, while there are only three and two halves in fig. *4*. Towards the actinal edge, Fig. 78, the sutures of the actinal interambulacral coronal plates are somewhat curved, the sloping plates contrasting greatly to the rectangular plates which follow (Pl. 16, fig. *5*).

In all the Saleniæ thus far known the actinal system (Pl. 19, fig. *1*) is covered by small elongated imbricating plates irregularly arranged occupying the whole space between the ten ambulacral buccal plates and the coronal plates. In young specimens the ten ambulacral buccal plates occupy the greater part of the actinal system (Pl. 16, fig. *1*). With increasing age the buccal plates become larger (Pl. 16, figs. *3, 5*), and the other actinal plates increase greatly in number, though without showing any regular arrangement (Pl. 17, fig. *1*). In *Salenia miliaris* the actinal plates show but little trace of imbrication. The ratio between the actinal system and the diameter of the test does not change with age, Fig. 79; in specimens of 16 mm. where the outline of the actinal system is decagonal it remains about one half that of the test, as in a specimen of 5 mm.

In a specimen 16 mm. in diameter (Pl. 14, figs. *6–8*) the height of the coronal plates was 12 mm. and the apical system rose fully 4 mm. above that. There were seven and eight primary interambulacral plates.

In a specimen 13 mm. in diameter (Pls. 14, figs. *9–11*; 18, figs. *3*, *4*; 17, figs. *1*, *2*; 20, fig. *3*) the coronal plates rose to a height of 7.75 mm. and the abactinal system 2.5 mm. above that. There were six and seven primary tubercles differing from the older ones only in the smaller number of miliaries surrounding the scrobicular area. The abactinal system measured 8 mm. in diameter, the anal system 3.25, and the actinal system 6 mm.

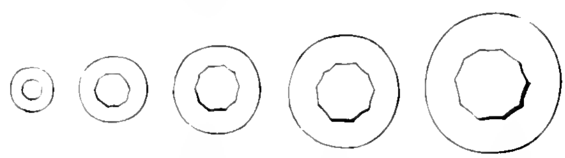
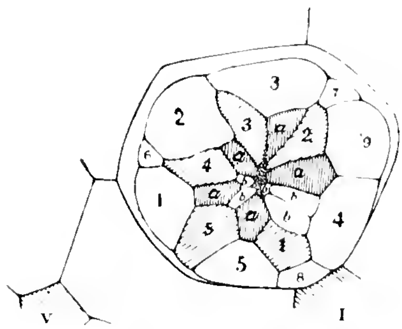


Fig. 79. Salenia miliaris.

In a specimen 10 mm. in diameter (Pl. 18, figs. *1*, *2*) the five and six coronal plates rose to 8 mm. and the abactinal system was far less prominent than in older specimens, rising only 1 mm. above that; it measured 7 mm. across (Pl. 16, fig. *6*), and was more circular, — the anal plates with diminishing size becoming proportionally larger as they decrease in number. Compare Pl. 16, figs. *2*, *4*, *6* and Pl. 17 figs. *2*, *3*. The actinal system (Pl. 16, fig. *10*) of the same specimen measured 5.5 mm. in diameter.

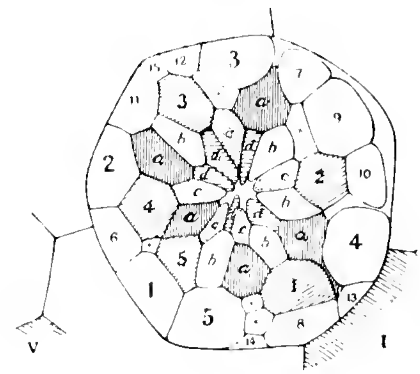
In a somewhat younger specimen, 8 mm. in diameter (Pls. 16, figs. *3*, *4*; 17, figs. *6*, *7*; 20. fig. *2*), the abactinal system measured 6 mm. across, the anal system 2.2 mm. in diameter, the actinal system 4 mm.; the height 7 mm. including the abactinal system; there were six and seven primary tubercles, Fig. 83. In the youngest specimen collected, 5 mm. in diameter, Fig. 82 (Pls. 16, figs. *1*, *2*; 17, figs. *4*, *5*; 20, fig. *1*), the test is much flatter, the height, including the abactinal system, is only 3 mm., the diameter of the apical system 3.9 mm., of the anal system 1.5 mm., with only five large primary plates and the points of the smaller second set intercalated between them; the actinal system 2.2 mm. in diameter and the longest radiole 25 mm. in length.

The anal system of *Salenia miliaris* would seem to have started in the youngest stage with five anal plates. They are still predominant in a specimen of 5 mm., Fig. 50 (Pl. 16. fig. *2*). in which the second set of anal plates has found its way between the original plates, and the third set between those of the second. In a somewhat older specimen. 8 mm., Fig. 80 (Pl. 16. fig. *4*) the third set of plates has greatly increased in size, and a



8 mm.

FIG. 80.

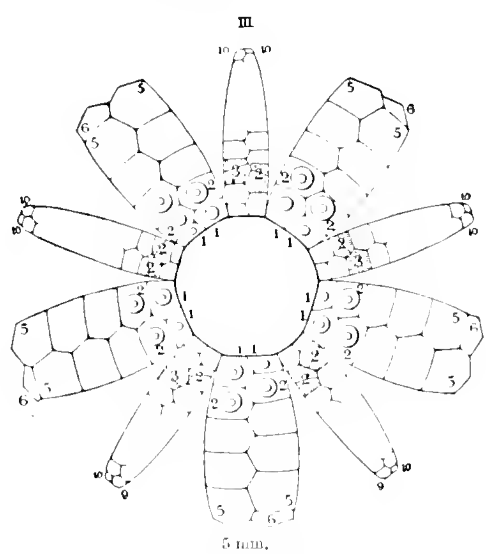


10 mm

FIG. 81.

SALENIA MILIARIS.

fourth set has made its appearance. In a specimen of 10 mm. (Pl. 16. fig. *6*) a fifth set of plates has been added, and the five primary anal plates are now separated by plates nearly as large as they are. Fig. 81. The plates of the different series do not always push their way through the preceding



5 mm.

FIG. 82. SALENIA MILIARIS.

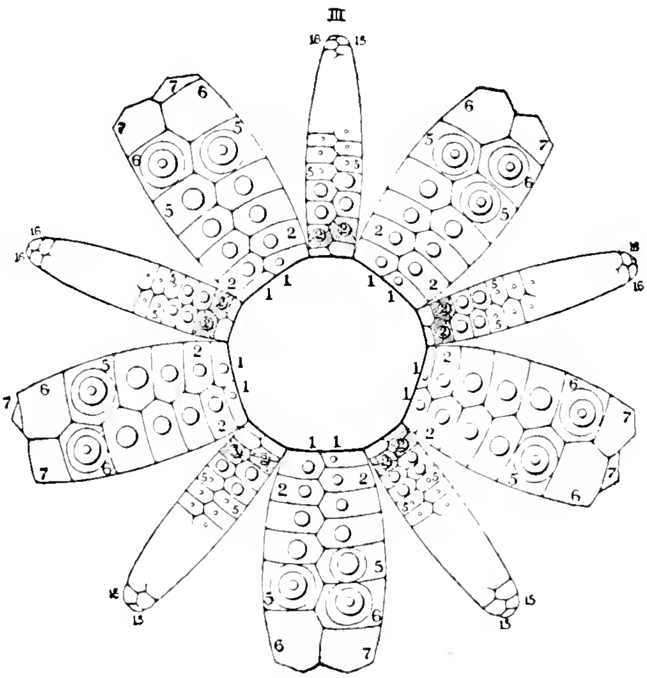
series; they are frequently split, and thus odd, intercalated, small plates break the uniformity of the arrangement.

The actinal system has originally ten large buccal plates arranged in pairs (Pl. 16, fig. *1*) occupying, in a young specimen of 5 mm., the greater

4

part of the actinal system. In still younger specimens, as in *S. varispina*, these plates cover the whole actinal system (Pl. 21, fig. *1*). The rest of the actinal system is covered with plates irregularly shaped and irregularly arranged (Pl. 16, figs. *3*, *5*).

The primary radioles are usually cylindrical, marked for the great development of the milled ring (Pl. 19, fig. *7*) forming a deep groove round the base of the larger radioles; these vary greatly in appearance: some of them are covered with flat, sharp spinules arranged in irregularly concentric rings round the shaft (Pl. 19, fig. *7*), which has an exceedingly fine

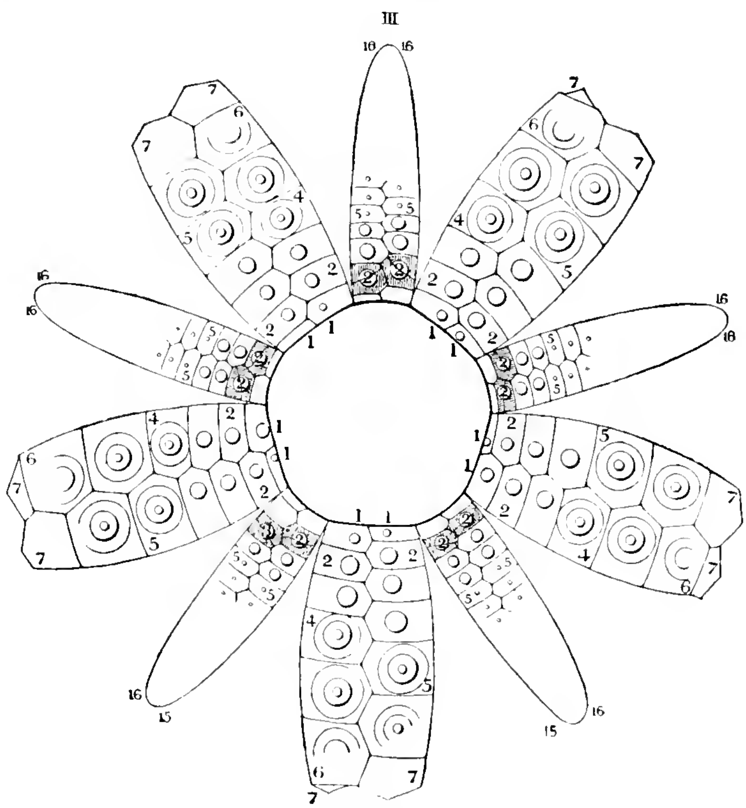


6 mm.

FIG. 83. SALENIA MILIARIS.

longitudinal striation; in others the radioles have lost the spinules, and the whole shaft retains only its delicate longitudinal lines; while again the striations may coalesce, forming a coarser fluting with traces on the sides of the lines of sharp spinules which characterize some of the more flattened radioles (Pl. 19, fig. *8*). The radioles on the actinal side are often flattened, even spear-shaped, somewhat concave, with larger serrations on the edges, and recalling to a certain extent the serrated actinal spines of Porocidaris. This tendency to become spathiform at the extremity is also seen in some of the largest primary radioles. The longest radiole observed was 85 mm. long in a specimen of 18 mm. in diameter. In younger specimens the serrations and spinules of the primary radioles are proportionally very large as compared to the diameter of the shafts.[1]

In a specimen of 5 mm. (Pls. 16, figs. *1, 2*; 17, figs. *4, 5*) the primordial plates have been resorbed and the first pairs of plates are in contact with the actinal system in all the interambulacra, Fig. 82. There are nine to ten pairs of ambulacral plates with five to six pairs of interambulacral plates, the sixth being a small plate or merely indicated in the interambulacral areas.



10 mm.

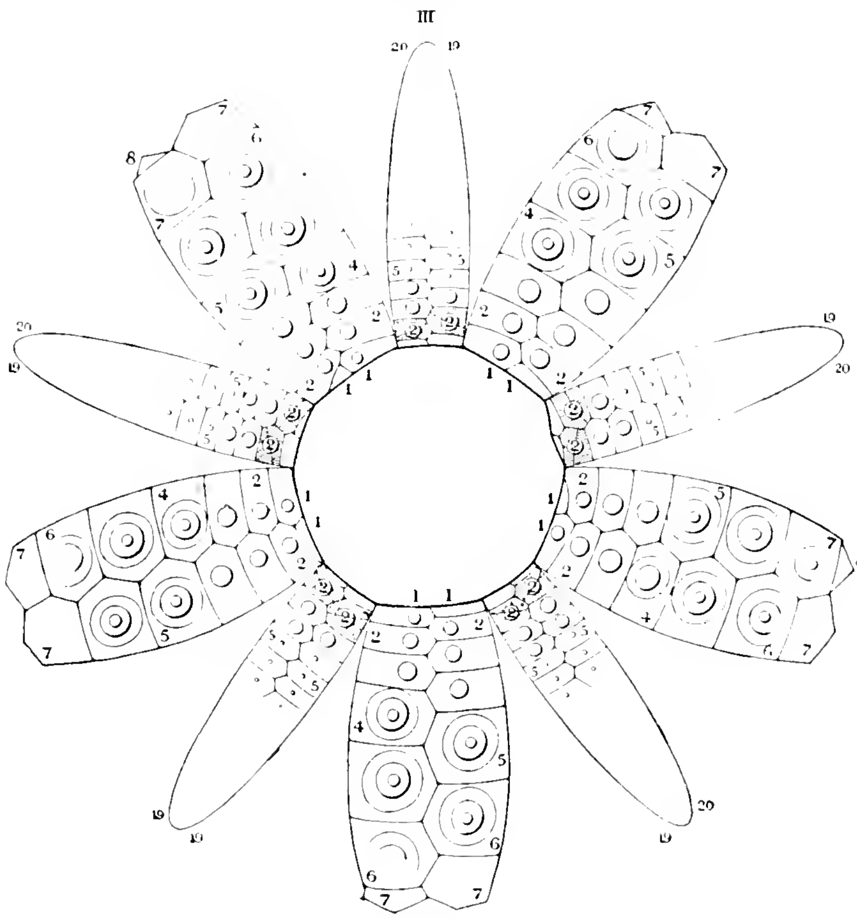
FIG. 84. SALENIA MILIARIS.

In a specimen of 8 mm. (Pls. 16, figs. *3, 4*; 17, figs. *6, 7*), with fifteen to sixteen pairs of ambulacral plates, the first interambulacral plates are still in contact with the actinal system, Fig. 83, the sixth pairs of interambulacral plates are fully developed, and the seventh is composed of smaller plates in all the interambulacra.

In a specimen of 10 mm., Fig. 84, the conditions since the preceding stage have changed but slightly (Pls. 16, figs. *5, 6*; 18, figs. *1, 2*), the seventh pair of interambulacral plates being somewhat more advanced.

[1] See the fimbriated spines of a young *S. varispina*, "Blake" Echini, Pl. VI. fig. 1.

In a specimen of 13 mm. (Pls. 17, figs. *1*, *2*; 18, figs. *3*, *4*) the seventh pairs of interambulacral plates are fully developed in all the areas except the left anterior, and the eighth pair is indicated in two of the interambulacra, Fig. 85. The first pairs of actinal interambulacral plates are still in contact with the actinal system, but of course they have become greatly reduced in size from the early stages examined (Pl. 16, figs. *1*, *2*) when the



13 mm.
FIG. 85. SALENIA MILIARIS.

first actinal interambulacral plates were of full size. The first ambulacral plates not flowing continuously, but having only a most limited resorption, are only gradually somewhat reduced in size in the successive stages of growth.

This species is, like most Saleniæ I have seen alive, brilliantly colored, though not as strikingly as *S. Pattersoni*. In *S. miliaris* the papillæ of the test are a dark violet, while the primary radioles are a brilliant white enamel. On the apical system the sessile verrucæ are light claret color.

Station 3357 off Mariato Point, 782 fathoms. Lat. 6° 35′ N.; Long. 81° 44′ W. Bott. temp. 38°.5. Modern greensand.

Station 3360, on way to Cocos Isd., 1672 fathoms. Lat. 6° 17′ N.; Long. 82° 5′ W. Bott. temp. 36°.4. Fine blk. drk. gn. S.

Station 3361 on way to Cocos Isd., 1471 fathoms. Lat. 6° 10′ N.; Long. 83° 6′ W. Bott. temp. 36°.6. Gn. ooze.

Station 3362 on way to Cocos Isd., 1175 fathoms. Lat. 5° 56′ N.; Long. 85° 10′ 30″ W. Bott. temp. 36°.8. Gn. M. S. Rocky.

Station 3376 south of Malpelo Isd., 1132 fathoms. Lat. 3° 9′ N.; Long. 82° 8′ W. Bott. temp. 36°.3. Gy. glob. ooze.

Station 3380, off Malpelo Isd., 899 fathoms. Lat. 4° 3′ N.; Long. 81° 31′ W. Bott. temp. 37°.2. Rocks.

Station 3407, Galapagos Isds., 885 fathoms. Lat. 0° 4′ S. Long. 90° 24′ 30″ W. Bott. temp. 37°.2. Glob. ooze.

Station 3411, Galapagos Isds., 1189 fathoms. Lat. 0° 54′ N.; Long. 91° 9′ W. Bott. temp. 36°.2. Yellow glob. ooze.

Station 3413, Galapagos Isds., 1360 fathoms. Lat. 2° 34′ N.; Long. 92° 6′ W. Bott. temp. 36°. Glob. ooze dk. sp.

Bathymetrical range, 782 fathoms to 1672 fathoms. Extremes of temperature, 38°.5 to 36°.

ARBACIADÆ Gray.

It has been impossible thus far to trace the development of the coronal plates in the stages immediately following that of the free swimming Pluteus.

Lovén [1] has figured a young Echinid of 0.6 mm. immediately after the resorption of the Pluteus and its appendages, in which he shows the ten primitive buccal plates and traces of the five single actinal primordial interambulacral plates. He has also figured [2] a much older specimen of a *Strongylocentrotus dröbachiensis* of 1.2 mm. showing the single interambulacral primordial plates for the greater part intact, and in a still larger specimen of *Echinus miliaris* of 2.5 mm. Lovén figures the single primordial interambulacral plates as almost resorbed, only a fragment of each remaining. [3] But these specimens and the young of *Goniocidaris canaliculata* figured by Lovén and myself give us no indication of the mode or order of formation of the coronal plates of intermediate stages.

[1] Études, Pl. XVII. fig. 149.

[2] Lovén, Echinologica, Pl. IV. figs. 25, 26.

[3] Lovén, Echinologica, Pl. V, fig. 29.

In young Saleniæ there are also traces of the single primitive interambulacral plates, as in the small *S. varispina* of 1.9 mm. (Pl. 21, fig. *1*).

On several occasions I attempted to obtain information regarding the succession of the coronal plates, but have been unsuccessful both with Strongylocentrotus[1] and Arbacia.[2] For many years at Newport the pluteus of Arbacia was raised until well after the formation of the Echinid, and although one stage of the young Arbacia (Pl. 54, fig. *1*) attained 1.5 mm. in diameter, I was unable even in that specimen to define the coronal plates. It is only in a young specimen of 3.6 mm. that the primary tubercles are fully developed, the arrangement of the coronal plates easily made out, and the plates of the apical system sharply defined (Pls. 53, fig. *9*; 54, fig. *2*), though in the younger specimen of 1.5 mm. the number of the tentacles and of the primary spines would indicate the probable number of the ambulacral as well as interambulacral plates.

Arbacia, as one of the few regular Echinid genera in which the single primordial interambulacral plates are not resorbed (Pl. 54, figs. *5*, *6*), naturally formed an interesting genus in which to trace the development of the coronal plates. Unfortunately the existence in very early stages of huge pigment spots renders the detection of minute calcareous plates most difficult. In a young specimen of Arbacia only 0.4 mm. in diameter exclusive of the spines, and 0.8 mm. including them (Pl. 53, figs. *1–5*), there were no traces of coronal plates. The larval envelopes still surround the whole animal. There are fifteen large club-shaped radioles dotted with pigment; they are arranged in sets of three, and between them are placed the five ambulacral suckers, one of which, the terminal one, is much larger than the others and provided with a powerful disk (Pl. 53, figs. *2–5*). It bends toward the actinal system, as is the case also with other larval Echini (Strongylocentrotus and Goniocidaris). The abactinal side is greatly swollen (Pl. 53, fig. *3*), with five large plates, presumably the oculars, on the abactinal side of the large odd terminal sucker. Above the ambitus four diminutive spines have made their appearance. Seen from the actinal side (Pl. 53, fig. *5*) the five actinal plates which have appeared may be the first trace of the teeth.

In the stage of 0.4 mm. the five ambulacral suckers correspond to the five embryonic folds of the water system, showing that in the earliest stages of Arbacia as in other young Echini there can be only four ambulacral

[1] Embryol. of Echinod., Mem. Am. Acad. 1864, IX, Pl. 1; Revision of the Echini, p. 709 (Pl. IX, fig. 1; Pl. X, figs. 1-4).

[2] Revision of the Echini, p. 731, figs. 68, 69.

plates and one ocular pore, and the spines would similarly indicate in the interambulacrum area one primordial plate and a row of two plates above it. In the next stage of 1.5 mm. (including the spines) (Pls. 53, fig. *6*; 54, fig. *1*) an additional primary spine has been added to each ambulacrum (Pls. 53, fig. *6*; 54, fig. *1*). These spines (Pl. 53, fig. *7*) are larger than those of the interambulacral areas (Pl. 53, fig. *6*), and already have a well developed milled ring. In this stage there are three pairs of ambulacral suckers below the ambitus and as many above it, with a spherid at the actinal edge of the ambulacrum. In this stage (1.5 mm.) it is difficult to decide if the anus is covered with four anal plates. The keel of verrucæ surrounding the anal system is somewhat irregular; from the angles run branches extending over the genital plates.

The design of the abactinal system becomes quite regular in a somewhat older stage of 2 mm. (Pl. 54, fig. *4*); the four plates of the anal system are clearly defined and the radiating structure of the genital and ocular plates is the same as that of an older specimen of 3.6 mm. (Pl. 54, fig. *3*). The madreporic body and two of the genital pores of the trivium are fully developed, while no trace could be seen of either in the specimen of 2 mm.

The crowding of the interambulacral plates against the single actinal primordial plates and its gradual diminution in height with increasing age is well shown by comparing a part of the actinal system of a young Arbacia of 3.6 mm. (Pl. 54, fig. *2*) with its large pentagonal single actinal primordial plates with a specimen of 16 mm. in which the second set of two plates has been almost resorbed by the narrow primordial plate (Pl. 54, figs. *5*, *6*); the extent of the pressure of the ambulacral plates in forming the multiporous rows of ambulacral plates next to the actinal system is well seen on Pl. 54, figs. *2* and *5*.

Dialithocidaris A. Ag.

Dialithocidaris A. Ag., Bull. M. C. Z. 1898, XXXII. No. 5, p. 75.

The genus is marked by the great size of the genital and ocular plates, the great width of the interambulacral areas, the linear arrangement of the miliaries and sessile verrucæ along the median line parallel with the horizontal sutures of the upper interambulacral plates. The interambulacral plates carry each two primary tubercles, the ambulacral, one. The sutures of the abactinal interambulacral coronal plates are somewhat sunken and bare. It has four anal plates like Cœlopleurus.

Dialithocidaris gemmifera A. Ag.

Dialithocidaris gemmifera A. Ag., Bull. M. C. Z. 1898, XXXII. No. 5, p. 75, Plate V. figs. 1, 2.

Plates 15, figs. *3–5*; 23.

A single specimen of this species was dredged in nearly 1800 fathoms about seventy miles southeast of Mariato Point. It is interesting from its size (Pl. 15, figs. *3–5*), 21 mm., which is nearly twice that attained by species of the genus most closely allied to it (Podocidaris). The abactinal system is noted for the great size of the ocular plates; these are pentagonal, broader on the genital faces, elongate, tapering to a small face at the ambulacra (Pl. 23, fig. *2*). The ocular plates are excluded from the anal system (Pl. 15, fig. *4*). The genital plates are heptagonal. In the specimen collected there were, as in Cœlopleurus, only four bare anal plates, while the other plates of the apical system are well covered with irregularly arranged sessile verrucæ varying in form from globular to club shape. The madreporic body is well developed, but the genital openings cannot be traced from the exterior in the clusters of verrucæ and miliaries.

The primary interambulacral tubercles extend only to the fourth or fifth plate from the abactinal system, those of the ambulacral rows somewhat higher (Pls. 15, figs. *4*, *5*; 23, figs. *2*, *3*). The interambulacral primaries (Pl. 23, fig. *12*) are placed at each extremity of the plate, the greater part of the remainder of the plate being covered by irregularly arranged miliaries (Pl. 23, figs. *1*, *3*). In the third and fourth plates above the ambitus the interambulacral primaries become smaller (Pl. 23, fig. *3*); sessile verrucæ (Pl. 23, fig. *11*) are found between them in addition to the miliaries. In the following plates the inner primary disappears, the verrucæ increase in number, and are arranged in a line parallel to the sutures along the central part of the plates. In the last three and four abactinal plates they extend the whole length of the plate, the lower part of which is bare and slightly sunken; the upper, above the verrucæ, is covered with miliaries.

The ambulacral plates carry but a single primary tubercle, fully as large as the adjoining primary interambulacral ones. Fig. 86. The primary tubercles gradually disappear on the abactinal parts of the ambulacrum to be replaced by one or two sessile verrucæ and large miliaries.

The ambulacral pores form a vertical line with the pairs of pores placed obliquely at the outer edge of the plates, Fig. 86 (Pl. 23, fig. *3*), except on the actinal plates, where the lower pair of pores is pushed toward the median line, Fig. 87 (Pl. 23, figs. *1*, *4*). There are three pairs of pores to each ambulacral plate.

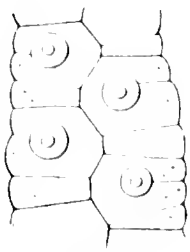


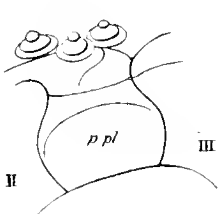
FIG. 86 DIALITHOCIDARIS GEMMIFERA. FIG. 87.

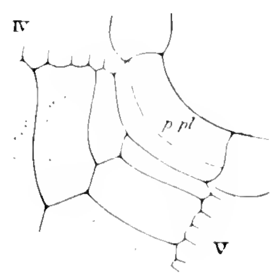
The actinal system is marked by the existence of five large elongate areas composed of minute calcareous plates placed between the actinal extremity of the ambulacra and the ring of ten perforate ambulacral buccal plates; these plates are thickly covered with miliaries and long-stemmed pedicellariæ similar to those of the abactinal system.

The gills are large (Pl. 23, fig. *1*), forming a prominent loop or separate clusters.

The largest primary radioles observed are 8 mm. in length; they are flattened, fluted (Pl. 15, fig. *3*), and serrate on the edges (Pl. 23, fig. *13*).

The primary tubercles are imperforate. The scrobicular circle is slightly raised from the surface of the test.





21 mm.
Int. 2, actinal side.
FIG. 88.

DIALITHOCIDARIS GEMMIFERA.

Int. 2, inside.
FIG. 89.

When alive the general coloring of this species is yellowish brown.

The apical system is thickly covered with short-headed long-stemmed pedicellariæ seated upon the minute miliaries scattered in the space between the sutures and that covered with verrucæ. Over the whole test are found many small pedicellariæ somewhat similar to those of the apical system. Each coronal plate also carries from four to six large tridentate pedicellariæ.

In the figures of the auricles (Pl. 23, figs. *5*, *6*) a faint horizontal line divides the auricle into two plates, one of which is probably the primordial plate, Figs. 88, 89.

Station 3382, southeast of Mariato Point, 1793 fathoms. Lat. 6° 21′ N.; Long. 80° 41′ W. Bott. temp. 35°.8. Gn. M.

ASPIDODIADEMATIDÆ Duncan.

Dermatodiadema A. Ag.

Dermatodiadema A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 76.

This genus holds to Aspidodiadema the same relation which Echinothrix holds to Diadema. It differs from it in having only small secondary tubercles and miliaries in the ambulacral areas, Fig. 93, as in Cidaris, while in Aspidodiadema the ambulacral plates of the actinal region carry large primary tubercles, as in Hemicidaris; in *D. globulosum* there are also in addition to the miliaries distant small secondary tubercles, but they have not the Hemicidaris arrangement.

Two species of the genus have been dredged in the Panamic area. Their representative in the West Indian area is *Aspidodiadema antillarum* collected by the "Blake," which should be referred to Dermatodiadema, it having the miliary and secondary ambulacral tubercles on the actinal plates as in that genus. *A. Jacobyi*[1] and *A. tonsum*[2] are characteristic Aspidodiadematidae, while *A. microtuberculatum*[3] as well as *A. antillarum*[4] are to be referred to Dermatodiadema.

I did not find in either species of Dermatodiadema the sheathed pedicellariæ so characteristic of the West Indian species.

In the genital ring of Aspidodiadema and Dermatodiadema the oculars not only all reach the anal system, but they are of nearly uniform size with the genitals. We find in Centrostephanus a very similar genital ring,

[1] "Blake" Echini, Pl. IX^a, figs. 3, 7, 10, 15, 18.
[2] "Challenger" Echinoidea, Pl. VIII, figs. 5, 9.
[3] "Challenger" Echinoidea, Pl. VIII, figs. 11, 12, 16.
[4] "Blake" Echini, Pl. IX, figs. 3, 4, 6, 8.

while in the other Diadematidæ the oculars, though in contact with the anal system, yet are small compared to the large triangular genital plates of the family.

The auricles are most irregularly developed. They are either wanting or mere projections, slightly raised.

Since the publication, in 1898, of the Preliminary Report of the Echini of the 1891 "Albatross" Expedition, my attention has been called by a synonym in Duncan's Revision of the Genera of the Echinoidea, p. 56, to the fact that Pomel in 1883 separated *Aspidodiadema microtuberculatum* from *A. tonsum*, and suggested a new generic name, Plesiodiadema, differing from Aspidodiadema in having, according to Pomel, a double row of small ambulacral tubercles, while *A. tonsum* has only granules, as in Cidaris. Unfortunately the reverse is the case, and I may be pardoned in rejecting a name which is evidently based upon a misunderstanding or a gross error in quotation, as has also been noticed by Lambert, l. c. p. 14.

When *Aspidodiadema antillarum* was described, there were included with it in the genus Aspidodiadema other species not having the peculiar Hemicidaris arrangement of the actinal ambulacral primary tubercles. Their absence was considered as due to the small size of the specimens then available. The material of the genus collected in the Panamic realm shows that *A. antillarum* of the "Blake" as well as *A. microtuberculatum* of the "Challenger" collection belong to the genus Dermatodiadema, as here limited, in which the actinal secondary tubercles are small, hardly larger than the miliaries.

The genus Dermatodiadema in the Pacific seems to be characteristic of deep water. The least depth at which either species has been dredged is over 900 fathoms, and the deepest point, north of Malpelo Island, is nearly 1800 fathoms. *A. antillarum* has a range of about 400 to nearly 1600 fathoms, and the other species of Dermatodiadema range from 400 to over 2200 fathoms, while Aspidodiadema as now restricted[1] has a range starting from much shallower waters, — about 100 fathoms.

[1] *A. Jacobyi*, *A. tonsum*.

Dermatodiadema globulosum A. Ag.

Dermatodiadema globulosum A. Ag. Bull. M. C. Z. 1898. XXXII. No. 5, p. 76, Pl. V. figs. 3, 4, 5.[1]

Plates 24. figs. *1–3*; 26. fig. *2*; 28. figs. *3, 4*; 29. figs. *5–7*.

This species is readily distinguished by its high test (Pl. 24. fig. *3*), the row of large plates surrounding the anal opening (Pls. 24, figs. *1, 2*; 28, figs. *3, 4*), with an outer circle of smaller irregularly arranged plates, which with the large plates cover the greater part of the anal system. The anal plates are covered with long slender miliary spines similar to those of the ambulacral and interambulacral areas. *D. globulosum* is also noted for its wide ambulacral area.

A specimen of 22 mm. in diameter was 19 mm. in height, the apical system 12.5 mm. in diameter, the anal system 8 mm. in diameter, the actinal system 8 mm. in diameter, the greatest width of the ambulacral system 3 mm., the longest radiole 40 mm. The radioles of *D. globulosum* are much stouter than those of *D. horridum* and are covered with coarser verticillations. There were four ambulacral plates to each interambulacral plate in the equatorial region of the test. The scrobicular areas of the primary interambulacral tubercles are marked for the deep furrows to which are attached the muscular bundles of the base of the radioles.

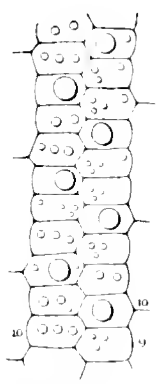
In a specimen 25 mm. in diameter there are eight primary interambulacral tubercles with a large elliptical scrobicular area connected at the sutures of adjoining plates (Pl. 29, fig. *6*). Closely packed miliaries cover the interambulacral plates in the median space between the primaries, and similar less crowded miliaries separate the scrobicular area from the ambulacral areas. The primary tubercles are perforate, and the larger ones crenulate.

In the ambulacral area, Fig. 90, the small secondary tubercles (Pl. 29, figs. *5, 7*) are separated by one or two plates which carry only a few miliaries; they occur in two irregular vertical rows, and contrast with the regular arrangement of the large miliaries in *D. horridum*. The pairs of pores are small. Fig. 91, and occupy a much smaller proportion of the ambulacral plates than in *D. horridum* (Pl. 29, figs. *1, 2*).

[1] In the "Preliminary Report" this figure was by mistake quoted as *D. horridum*.

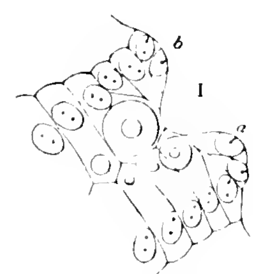
In a specimen 30 mm. in diameter the ten buccal plates are connected for their whole length and cover a relatively greater part of the actinal system (Pl. 26, fig. *2*), more as we find them in young specimens of *D. horridum* (Pl. 25, figs. *1, 2*); the plates are rounded at the proximal extremity, the ambulacral pore is protected distally by a prominent lip, the distal part of the buccal plates is covered with miliaries and secondary tubercles. The narrow belt left between the outer faces of the buccal plates and the edge of the actinal system is filled with small narrow elongate actinal plates irregularly arranged.

In a specimen of 25 mm. (Pl. 28, fig. *3*) the ocular plates are flat pentagons, with rounded corners, leaving large cuts between them and the adjoin-



25 mm.

FIG. 90. DERMATODIADEMA GLOBULOSUM.



30 mm. (fragment).

FIG. 91. DERMATODIADEMA GLOBULOSUM.

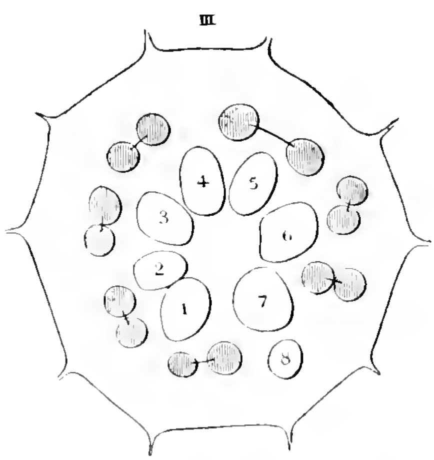
ing rectangular genital plates. The ambulacral base of the ocular plates is longer than the base of the genitals, which project slightly further than the oculars into the anal system. The genitals and oculars are covered with miliaries. The oculars carry in addition one or two secondary tubercles on the anal edge.

In a specimen of 30 mm. in diameter the proportions between the oculars and genitals are somewhat different. The oculars have nearly twice the base of the genitals, and three of them (Pl. 28, fig. *4*), the odd and the right and left anterior oculars, have split into two plates which appear like plates intercalated between the genitals and oculars, reaching in one case the anal system. These plates look much as if interambulacral plates had forced their way to the anal system and were to separate, as in some Spatangoids, the bivium and the trivium. In this older specimen the anal edges of all the apical plates carry an outer line of secondaries.

The genital openings are large; their position varies somewhat, though it is generally central. The ocular pores are usually placed close to the terminal ambulacral plates.

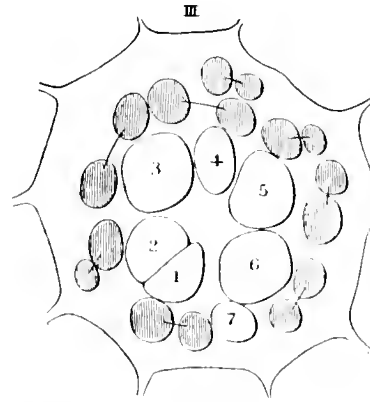
The madreporic body is well defined in both the above-mentioned specimens, occupying nearly one half of their respective genital plates.

In *D. globulosum* of 30 mm., Fig. 92, there are eight primary anal plates (Pl. 28. fig. 4) and an outer circle of seven pairs of secondaries. In a specimen of 25 mm., Fig. 93, there are only seven primary anal plates and an



30 mm.

FIG. 92.



25 mm.

FIG. 93.

DERMATODIADEMA GLOBULOSUM.

outer circle of eight pairs of secondary plates.

Both in *D. globulosum* and *D. horridum* the ratio between the actinal system and the diameter of the test seems to change but little with increasing size.

The color of the test when alive is of a dark violet with lighter colored primary radioles and still lighter colored, almost pinkish, miliary spines.

Station 3381, north of Malpelo Isd., 1772 fathoms. Lat. 4° 56′ N.; Long. 80° 52′ 30″ W. Bott. temp. 35°.8. Gn. M.

Station 3398, off Galera Point, in 1573 fathoms. Lat. 1° 7′ N.; Long. 80° 21′ W. Bott. temp. 36°. Gn. ooze.

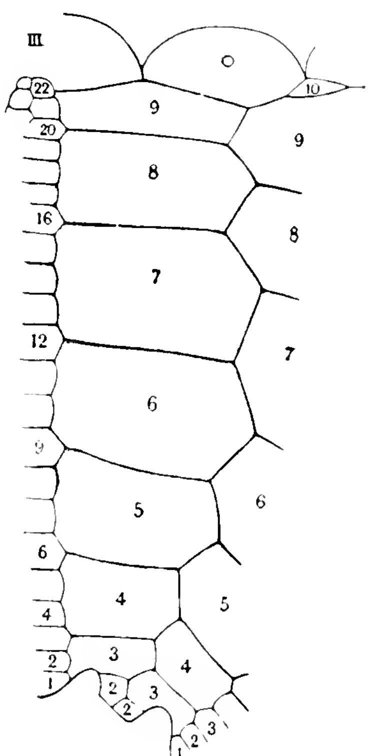
Bathymetrical range, 1573–1772 fathoms. Temperature range, 36° to 35°.8.

Dermatodiadema horridum A. Ag.

Dermatodiadema horridum A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 76; Plate V, figs. 6, 7.

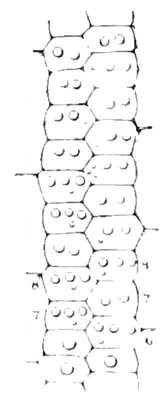
Plates 24, figs. *4–12*; 25; 26, figs. *1, 3, 4*; 27; 28, figs. *1, 2*; 29, figs. *1–4*.

D. horridum is comparatively flat (Pl. 24, fig. *8*) with a large apical system (Pl. 24, fig. *9*). The anal system is covered by a number of small plates (Pl. 24, fig. *9*). Those immediately surrounding the anal opening are



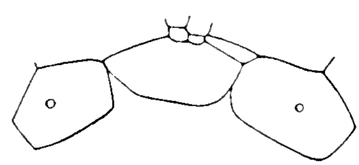
20 mm.

FIG. 94.



20 mm.

FIG. 95. D. HORRIDUM.



20 mm.

D. HORRIDUM. FIG. 96.

elongate and somewhat larger than the others (Pls. 27; 28, figs. *3, 4*), which are irregularly arranged in concentric rows or dotted over the surface of the anal system. The anal plates are covered with miliary spines. Those near the anal opening are fully as large and long as any of the miliary spines of the test.

The greater number of the specimens collected were about 20 mm. in diameter. When alive the test is claret-colored. The suckers and gills are somewhat darker and stand out prominently among the lighter-colored miliary spines. The primary radioles are of a still lighter tint, somewhat pinkish.

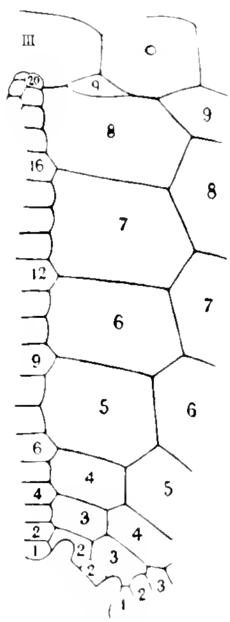
In a specimen 20 mm. in diameter the apical system measured 14 mm. in diameter (Pl. 28, figs. *1*, *2*) and the anal system 10 mm. The genital and ocular plates are more elongate than those of *D. globulosum*, in which the genital plates specially project further into the anal system than in *D. horridum*: compare Plate 28, figs. *1*, *2* with Plate 28, figs. *3*, *4*. The greatest width of the ambulacral system, 2.3 mm., is found nearer the ambitus than to the equatorial zone. The actinal system (Pl. 26, fig. *1*) is 6 mm. in diameter; the height of the test is 12 mm. At that stage of growth there are nine primary interambulacral tubercles, Fig. 94, with a tenth rudimentary plate (Pl. 26, fig. *4*).

There are four ambulacral plates to each of the larger interambulacral plates (Pl. 29, fig. *4*). The muscular furrows of the scrobicular area are well developed. An irregular row of two or three miliaries occupies the upper part of each ambulacral plate, Fig. 95 (Pl. 29, fig. *3*); these become small secondary tubercles on the older plates (Pl. 26, fig. *4*). The miliaries along the sides of the median interambulacral line are irregularly arranged, filling the spaces between the scrobicular circles; these unite at the sutures. A similar belt of miliaries fills the angles between the scrobicular areas and the ambulacra. The miliaries of the interambulacra are more uniform in size than those of the ambulacra.

The genital plates are elongate, Fig. 96, pentagonal, with slightly rounded corners; they are covered with miliaries and pierced by large genital openings placed in the centre of the plate (Pl. 28, figs. *1*, *2*). The ocular plates are even more elongate than the genitals; the rounded corners of adjoining plates leaving a slight notch between the genitals and oculars. The ocular pore is on the edge of the plate close to the terminal ambulacral plates.

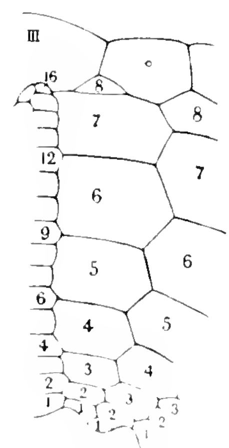
The ten buccal ambulacral plates (Pl. 26, fig. *1*) are smooth, irregularly triangular, they join along their whole length; the outer face is slightly concave. The proximal extremity is cut off to form the dental pentagon; at the junction of the teeth with the actinal membrane it is strengthened by a number of filaments carrying minute calcareous plates. The tentacular pores are placed in the distal third of the plate; in younger specimens they are nearer the distal sides (Pl. 25). The actinal membrane between the buccal plates and the coronal plates (Pl. 26, fig. *1*) is thickly covered by irregularly shaped minute calcareous plates varying in outline from circular to very narrow elongate plates.

In a specimen of 18 mm. in diameter with nine primary interambulacral plates, Fig. 97, the height was 11.5 mm. and the apical system 13.5 mm. It differed mainly in size from the specimen just described. The anal system, however, had larger plates round the anal opening, eight in number, and somewhat comma-shaped; the larger anal plates are covered with small miliaries. In a specimen of 19 mm. in diameter there were



18 mm.

FIG. 97. D. HORRIDUM.



10.5 mm.

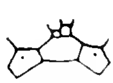
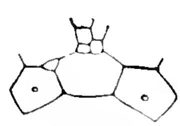
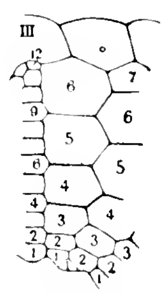
FIG. 98. D. HORRIDUM.

seven and eight primary tubercles, as in the larger and the smaller specimen alluded to above. The longest radioles of specimens of 19 to 20 mm. in diameter, taken on the third or fourth largest interambulacral plates, measured about 40 mm. in length; they are very brittle and delicate and rarely found unbroken at the tip.

In a specimen of 14 mm. in diameter (Pl. 24, figs. *10–12*) the longest radiole was 26 mm., the apical system 8.2 mm. in diameter, the anal system 6.1 mm., the height of the test 10 mm., the greatest width of the ambulacral system 2.2 mm., the diameter of the actinal system 5.1 mm., and the number of primary interambulacral tubercles six and seven. In this stage of growth there are but two miliaries to each ambulacral plate. Along the median interambulacral line the miliaries are placed in the median edge of each plate, thus forming an irregular vertical median line of two rows of miliaries. In the outer edge of the interambulacral plates there are only two or three small miliaries at the junction of the ambulacral and interambulacral plates. The primary interambulacral tubercles are perforate and crenulate (Pl. 29, figs. *2, 4*).

In a smaller specimen 12 mm. in diameter and 7 mm. in height the apical system was 6.2 mm. in diameter (Pl. 27, fig. *4*), the anal system 4 mm., and the actinal system 4.5 mm. It had six and seven primary interambulacral tubercles with three ambulacral plates to each of the largest coronal plates. The longest radiole was 16 mm.

In a smaller specimen, 10.5 mm. in diameter and 6 mm. in height, there are already eight and eight interambulacral plates, Fig. 98, as many as in older specimens of nearly twice the size, though the primary tubercles are only developed to their full size on the coronal plates above the ambitus (Pl. 29, fig. *2*). There are three ambulacral plates to the larger coronal plates. In the median interambulacral belt the miliaries are few in number, forming almost a single, angular, vertical line along the median zone. On the outer edge only two to three miliaries are found in the space separating the scrobicular area from the ambulacra.

7.3 mm. 10.5 mm. 7.3 mm.

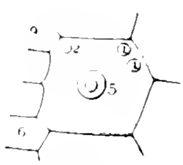
FIG. 99. D. HORRIDUM. FIG. 100. FIG. 101. D. HORRIDUM.

In the younger specimens examined (Pl. 27, figs. *1–4*) the genital and ocular plates are nearly of the same height, the ocular plates gradually becoming more elongate than the genitals, Figs. 99, 100.

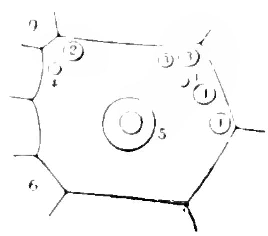
In the smallest specimen collected, 6 mm. in diameter and 4 mm. in height, there are five and six primary tubercles and three ambulacral plates to each of the larger interambulacral plates. Usually there is only a single miliary to each ambulacral plate; the median interambulacral miliaries are limited to a cluster of two or three in the median angle of each plate.

The apical system (Pl. 27, figs. *1, 2*) measured 4 mm. in diameter, the anal 2.75. The plates of the genital ring (Pl. 27, fig. *1*) are higher in proportion than in older specimens (Pl. 27, figs. *5*, *6*). The plates immediately surrounding the anus are placed on edge and send out long calcareous threads (Pl. 27, fig. *1*).

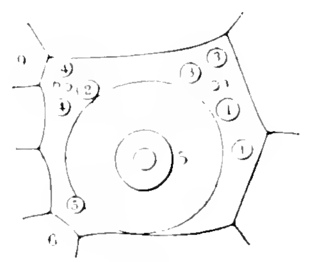
The buccal plates of the actinal system occupy a proportionally greater space of the actinal system in young specimens than in older ones. In a specimen of 7.3 mm. in diameter with six and seven interambulacral plates, Fig. 101, there is only a narrow belt between the distal edge of the buccal and the coronal plates (Pl. 25, fig. *1*) filled with small irregularly shaped calcareous plates. In somewhat older specimens 10 and 10.5 mm. in



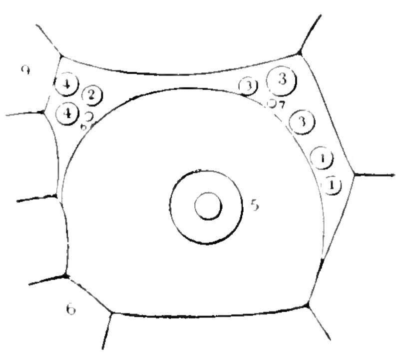
7.3 mm.
Fig. 102.



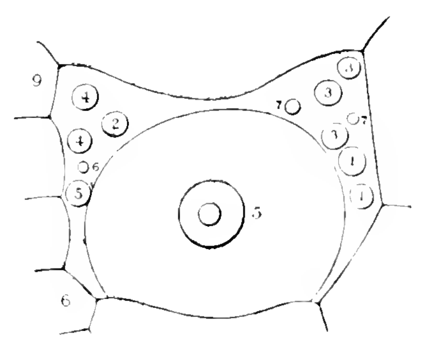
10 mm.
Fig. 103.



10.5 mm.
Fig. 104.



15 mm.
Fig. 105.



20 mm.
Fig. 106.

Figs. 102–106. D. horridum.

diameter the belt of small plates had increased in width (Pl. 25, figs. *2*, *3*, *4*), and still more in larger specimens (Pls. 25, fig. *5*; 26, fig. *1*). The ambulacral pores also assume with increasing size a more central position in the buccal plate.

There seems to be a regular sequence in the order of appearance of the miliaries in the angles of the interambulacral plates, as is shown in the accompanying figures of the fifth interambulacral plate from the actinal system in specimens varying in size from 7.3 mm. to 20 mm. Figs. 102–106.

The largest specimen collected, 30 mm. in diameter, was somewhat crushed. The apical system measured 19 mm. in diameter, the anal 14, the actinal 10 mm. In this large specimen the buccal actinal plates were somewhat irregular in shape, much as in the actinal system of a large specimen of *D. globulosum* (Pl. 26, fig. *2*). In younger specimens (Pl. 25) they are marked for their great regularity of size. In a specimen 20 mm. (Pl. 26, fig. *1*) they show a tendency to irregularity, and one of the plates is split into two near the distal side. There are in this specimen eight and nine primary tubercles, with five ambulacral plates to each large interambulacral plate. The milled ring of the primary radioles often spreads at the base of the spines to a breadth of twice the diameter of the shaft (Pl. 25, fig. *5*).

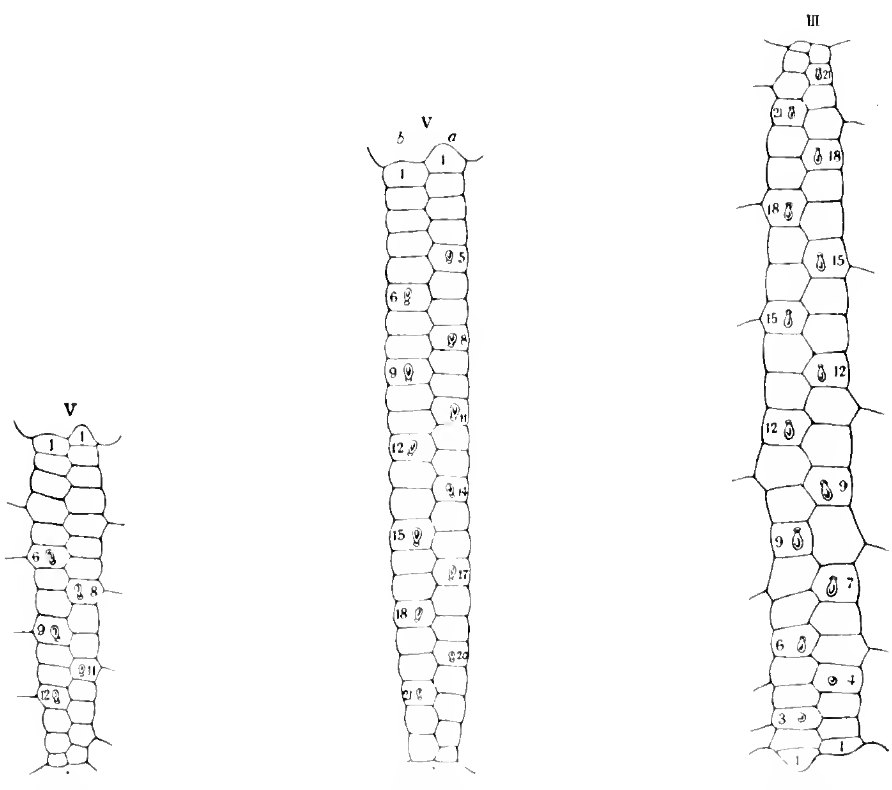


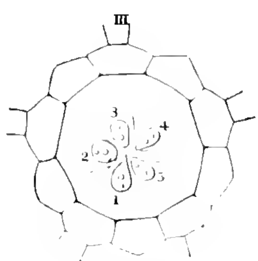
FIG. 107. FIG. 108. FIG. 109.

FIGS. 107–109. DERMATODIADEMA HORRIDUM.

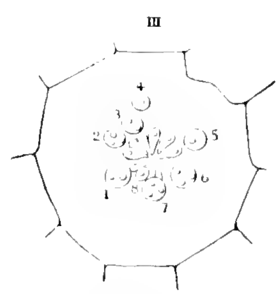
In younger stages (Pl. 27, fig. *2*) the genital plates are uniform in size, and remain so in older stages, with the exception of the madreporic genital, which early develops into a larger plate (Pls. 27, fig. *3*; 28, figs. *1*, *3*, *4*), the right anterior interambulacrum thus being wider than the others.

In a young specimen of *D. horridum* of 7.3 mm. the anterior pores of the left and of the right posterior ambulacra, the posterior pore of the right anterior and the left anterior ambulacra slant obliquely toward the actinostome (Pl. 25, fig. *1*). In this stage the indentations of the gills are symmetrical, but with advancing age the gill slits become asymmetrical (Pl. 25, fig. *3*) from the extension of one of the poriferous zones (Pl. 26, figs. *1*, *4*), and in a specimen of *D. globulosum* of 30 mm., Fig. 91, the ambulacral plates have been pushed towards the actinal system so as to distort and crowd the poriferous plates into a long tongue (Pl. 26, fig. *2*), of which the outer plates are ready to pass over on to the actinal membrane.

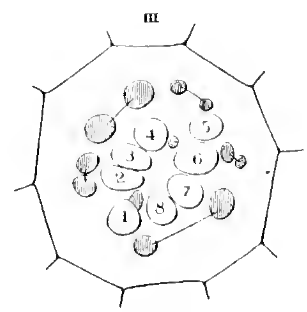
Spheridia occur in young specimens of 9 mm. (Pl. 26, fig. *3*) on the sixth and eighth ambulacral plates, Fig. 107. In other Echinids they usually make their first appearance on the first ambulacral plates. The



6.8 mm
FIG 110.



10 mm.
FIG. 111.



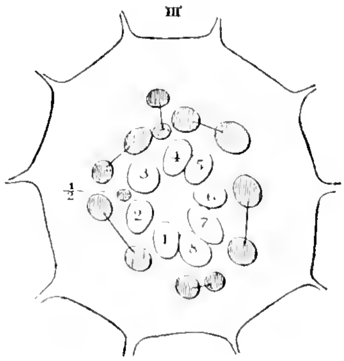
12 mm
FIG. 112.

FIGS. 110–112. DERMATODIADEMA HORRIDUM.

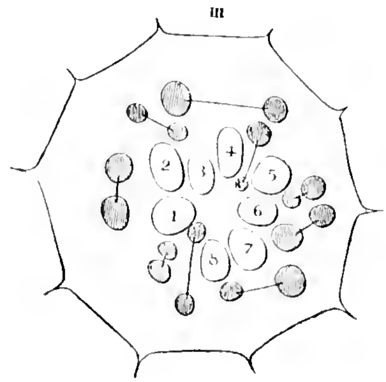
spheridia extend the whole length of the ambulacrum. In the young specimen mentioned above there are three in one zone and two in the other, separated by two plates. In an older specimen of 19 mm., Figs. 108, 109, the spheridia are also separated by two ambulacral plates (Pl. 26, fig. *4*), there being six and seven in each ambulacral zone. It is interesting to notice that in Dermatodiadema the spheridia point toward the actinostome and not toward the abactinal pole as is the case in other Echinoids where spheridia have been observed.

The splitting of one of the anal plates of *D. globulosum* (Pl. 28, fig. *3*) in a specimen of 25 mm., Fig. 93, seems to indicate the manner in which eight or more plates may arise from the five primitive anal plates such as are found in a specimen of *D. horridum* of 6.8 mm. (Pl. 27, fig. *2*), Fig. 110. In a somewhat older specimen of 10 mm., Fig. 111, there are eight large anal plates (Pl. 27, fig. *3*), and the anal opening is covered by six or seven new plates. The same larger anal plates exist in a somewhat older specimen (Pl. 27, fig. *4*) of 12 mm., Fig. 112, with an outer circle of ten secondary plates arranged in pairs.

In the next stage of 14 mm. the eight anal plates, Figs. 113, 114, still



14 mm.
FIG. 113.



14 mm.
FIG. 114.

D. HORRIDUM.

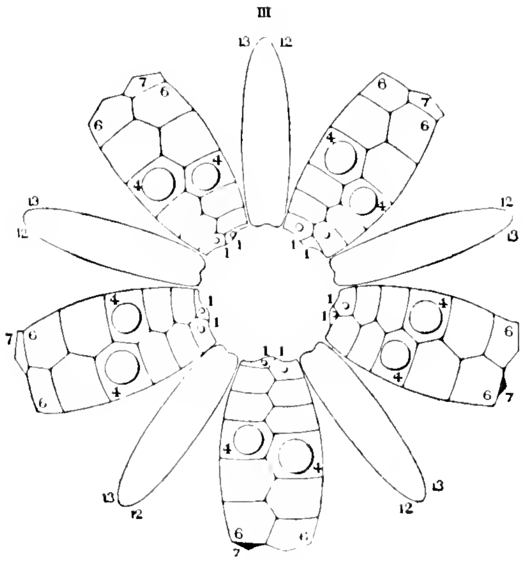
persist, as they do to 30 mm. in diameter, but they are more or less disturbed in their arrangement, and we find (Pl. 27, figs. *5*, *6*) an outer circle of seven and nine pairs of plates. In a specimen of 20 mm. in diameter, Fig. 115, there are twenty-five pairs of outer secondary anal plates (Pl. 28, fig. *1*), and in another specimen of the same size, Fig. 116, there are no less than forty-six pairs of secondary anal plates (Pl. 28, fig. *2*).

20 mm.
FIG. 115.

20 mm.
FIG. 116.

D. HORRIDUM.

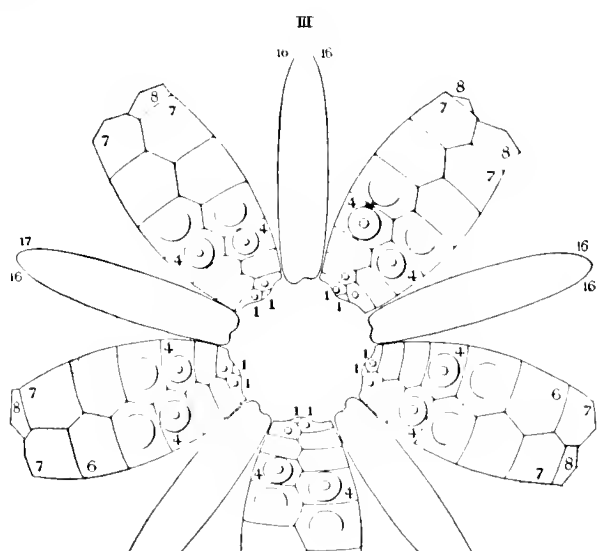
In Dermatodiadema, where the ambulacral plates play but an insignificant part in supplying the actinal system with calcareous plates some of the first actinal plates remain in contact with the actinal system in quite



7.3 mm

FIG. 117. D. HORRIDUM.

advanced stages of growth (Pls. 26, fig. *1*; 28, fig. *1*; 29, figs. *3*, *4*). In a young specimen of 7.3 mm., Fig. 117, the primordial plates have been resorbed, and the first pair of interambulacral plates are in contact with the actinal system. There are twelve to thirteen ambulacral plates, six



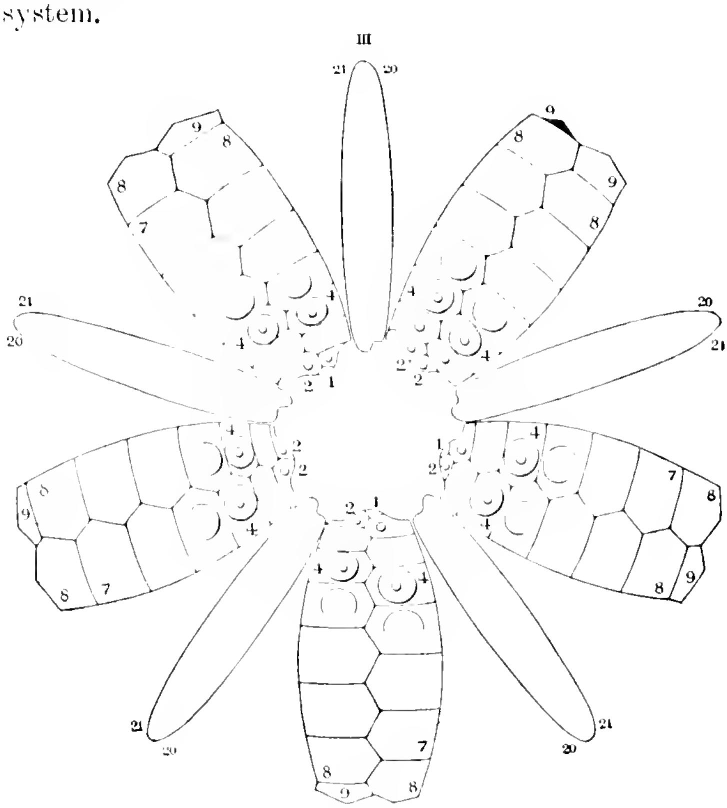
10.5 mm.

FIG. 118. D. HORRIDUM.

pairs of interambulacral plates, with one plate of the seventh in each interambulacral area (Pl. 25, fig. *1*).

In a somewhat older specimen of 10.5 mm., Fig. 118, the first pairs of interambulacral plates are but slightly reduced in size. There are sixteen to seventeen pairs of ambulacral plates. The seventh pairs of interambulacral plates are fully developed, with the eighth indicated in each interambulacrum (Pl. 25, figs, *3*, *4*; 29, figs. *1*, *2*).

In a specimen of 15 mm., Fig. 119, the first pairs of actinal interambulacral plates have been resorbed in all the interambulacra except the left posterior, the right anterior, and the odd interambulacral area, where one plate is left, the second pairs of plates now being elsewhere in contact with the actinal system.

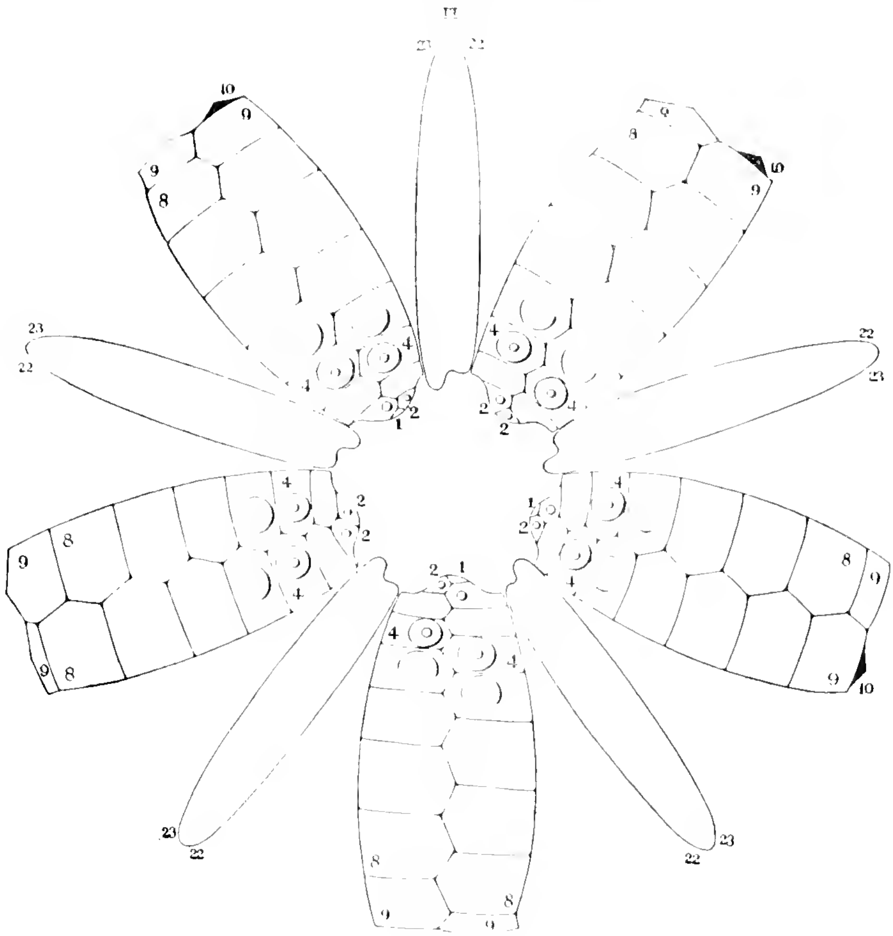


15 mm.

FIG. 119. D. HORRIDUM.

There are twenty and twenty-one ambulacral plates. The eighth pairs of interambulacral plates are fully developed, and the ninth pairs are indicated in all the ambulacra (Pl. 25).

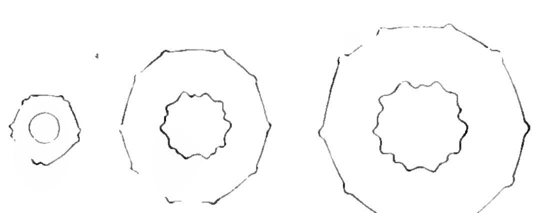
In a specimen of 20 mm. (Pls. 26, fig. *1*; 28, fig. *1*; 29, figs. *3*, *4*), with twenty-two to twenty-three ambulacral plates, Fig. 120, the actinal inter-



20 mm.

FIG. 120. D. HORRIDUM.

ambulacral plates have retained nearly the same size as in the preceding stage; they, however, are rounded off and project somewhat into the actinal system, forming slight gill cuts more marked than in the preceding stage. The ninth pairs of interambulacral plates have fully developed, and the tenth pairs are indicated in the anterior interambulacra and the left pos-

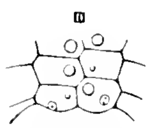


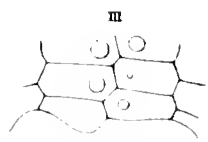
7.5 mm 15 mm. 20 mm.

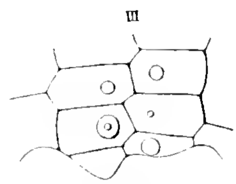
FIG. 121. D. HORRIDUM.

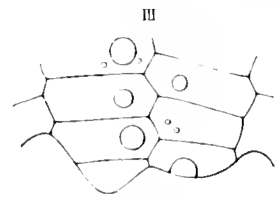
terior one. The relative proportions of the actinal system and of the test do not vary materially in the different stages of growth, Fig. 121.

Although the ambulacral plates of the Aspidodiadematidæ are small and of nearly uniform size (Pls. 25. figs. *1*, *3*; 26. figs. *1*, *4*), much as in the Cidaridæ, yet in older specimens the actinal plates become slightly petaloid


7.3 mm
FIG. 122.


10 mm
FIG. 123.

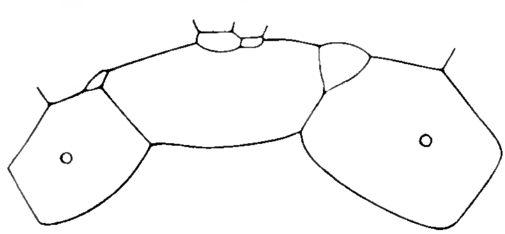

15 mm.
FIG. 124.


20 mm.
FIG. 125.

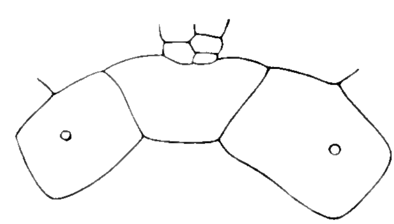
FIGS. 122–125. D. HORRIDUM.

crowded and pushed inward (Pl. 26, fig. *2*), as in the Echinidæ, and the actinal plates pass from simple plates extending across the ambulacrum, Fig. 122, to small intercalated plates reaching but little beyond the median line of each ambulacral zone, Fig. 91. In the younger stages, Fig. 122, the ambulacral plates are symmetrical at the actinostome; with increasing age, they become more and more asymmetrical, Figs. 123, 124, 125, as the gill cuts become more prominent.

In both the species of Dermatodiadema here described the plates of the genital ring are of equal size in young stages (Figs. 99, 100); with increasing age the madreporic plate becomes longer, Figs. 126, 127. This is


30 mm.
FIG. 126.

D. GLOBULOSUM.


25 mm.
FIG. 127.

already seen in a specimen of 20 mm. in diameter, Fig. 96. In *D. globulosum* the anterior ocular plate sometimes increases in length but not in width with the growth of the madreporic plate, Fig. 126. In *D. horridum* the odd ocular shows gradual increase in length in young stages of 10.5 mm. in diameter, Fig. 100, and the increase in size of this plate keeps pace with that of the madreporic plate, Fig. 96, while in *D. globulosum* the madreporic plate sometimes increases alone in width and length beyond the other plates of the genital ring, Fig. 127. In *D. horridum* Figs. 96, 100, and in *D. globulosum*, Fig. 125, the youngest interambulacral plates push their way between the oculars and genitals.

The characters of the genital ring of the Aspidodiadematidæ are eminently archaic. It is only in the Melonitidæ and Bothriocidaridæ and in some of the older Cidaridæ that we find the genitals and oculars all in contact with the anal system.

Station 3362 between Cocos Isd. and the mainland, 1175 fathoms. Lat. 5° 56′ N.; Long. 85° 10′ 30″ W. Bott. temp. 36°.8. Gn. m. s. Rocky.

Station 3363 between Cocos Isd. and the mainland, 978 fathoms. Lat. 5° 43′ N.; Long. 85° 50′ W. Bott. temp. 37°.5. Wh. glob. ooze.

Station 3364 between Cocos Isd. and the mainland, 902 fathoms. Lat. 5° 30′ N.; Long. 86° 8′ 30″ W. Bott. temp. 38°. Yel. glob. ooze.

Station 3375 south of Malpelo Isd., 1201 fathoms. Lat. 2° 34′ N.; Long. 82° 29′ W. Bott. temp. 36°.6. Gy. glob. ooze.

Station 3376 near Malpelo Isd., 1132 fathoms. Lat. 3° 9′ N.; Long. 82° 8′ W. Bott. temp. 36°.3. Gy. glob. ooze.

Station 3381 north of Malpelo Isd., 1772 fathoms. Lat. 4° 56′ N.; Long. 80° 52′ 30″ W. Bott. temp. 35°.8. Gn. M.

Station 3398 off Galera Point, 1573 fathoms. Lat. 1° 7′ N.; Long. 80° 21′ W. Bott. temp. 36°. Gn. ooze.

Station 3400 from Galera Point to the Galapagos, 1322 fathoms. Lat. 0° 36′ S.; Long. 86° 46′ W. Bott. temp. 36°. Lt. gy. glob. ooze.

Station 3413 northwest of Culpepper Isd., Galapagos, 1360 fathoms Lat. 2° 34′ N.; Long. 92° 6′ W. Bott. temp. 36°. Glob. ooze, drk. sp.

Bathymetrical range, 902 fathoms to 1772 fathoms. Extremes of temperature, 38°–35°.8

ECHINOTHURIDÆ Wyv. Thom.

We may be justified in assuming that the anal system is in the Echinothuridæ, as in the Cidaridæ, covered by five small anal plates; but in none of the young specimens I have had occasion to examine was it possible to determine their primitive grouping, though in a young specimen of *Ph. placenta* of 7 mm. (Pl. 43, fig. 2) there seem to be five plates in the angles of the anal pentagon somewhat larger than the others. Their development is evidently quite irregular, as is seen in a somewhat older stage of the same species of 9 mm., where there were fewer anal plates (Pl. 43, fig. *4*). The position of the anus, which is central in these young specimens, seems to trend to one side, as will be noticed on examining the figures of the apical system of *P. hispidum* (Pls. 39, 40). In *Asthenosoma coriaceum* it has retained its central position (Pl. 52, fig. *1*).

A similar movement in the anal system of Saleniæ is suggested by the gradual greater encroachment, due to age, of the right posterior ocular plate upon the anal system (Pl. 16, figs. *2, 4, 6*,) and in Acrosalenia (Pl. 22, figs. *5, 6, 7, 8*).

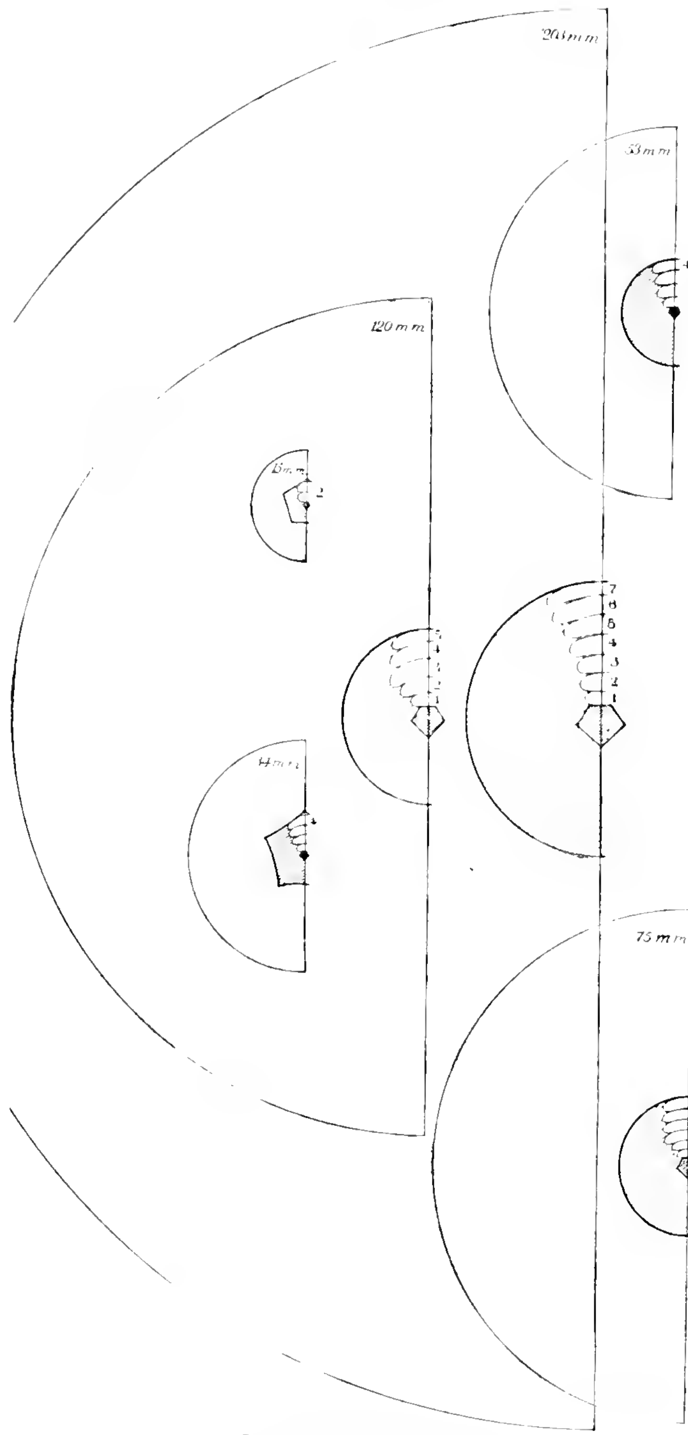
When about 30 mm. in diameter the genital and ocular plates, which had thus far formed a closed ring, begin to separate, the madreporic genital remaining longer in contact with the odd ocular than the other genitals do with their correlated oculars (Pls. 39, 40).

In Phormosoma (Pl. 40, fig. *2*) and Asthenosoma (Pl. 51, fig. *6*) the genital pores are rarely in the genital plates; they are usually situated in the triangular extension of the dermal tissue which separates the abactinal region of the interambulacral zones. The genital pores open in a small conical plate isolated from the components into which the genital plates have become broken up (Pl. 39). In most of the species of Phormosoma the anal opening is surrounded by a series of elongated conical plates radiating from it.

In the Echinothuriæ the proportions between the actinal system and the diameter of the test vary with age. In smaller specimens of 15 mm. and 34 mm., Fig. 128, the actinal system is about one third that of the test; in specimens of 53 and 75 it is less than a third; and in specimens of 120 to 200 mm. the actinal system is only a fifth of the diameter of the test.

The interambulacral primordial plate is very prominent in the young of Phormosoma (Pl. 43, figs. *1, 3, 5*), though very different in shape in the different species, it is nearly square in *P. hispidum* (Pl. 43, fig. *5*), while it is very elongated in *P. placenta* (Pl. 43, figs. *1, 3*). It is deeply indented in *Asthenosoma zealandiæ* (Pl. 51, fig. *1*), and quite asymmetrical in *A. pellucidum* (Pl. 51, fig. *5*), and very large, somewhat polygonal in Kamptosoma (Pl. 50, fig. *1*). In a specimen of *P. hispidum*, of 34 mm., the primordial plates are split in two by a vertical suture (Pl. 43, fig. *6*).

On the buccal plates the first miliaries to appear are those adjoining the sutures of contiguous ambulacra. The growth of the ambulacral plates on the actinal system does not in the Echinothuriæ any more than in other

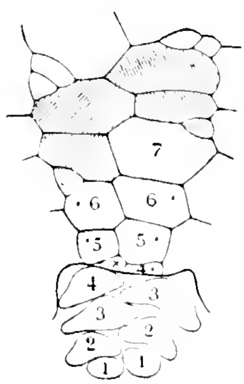


Ratio of Actinostome to test.

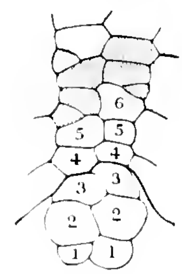
FIG. 128. PHORMOSOMA HISPIDUM.

regular Echinidae, take place at or near or under the peristome as is suggested by Jackson for Melonites. But in the Spatangidæ that is not the case; the plates of the actinostome are limited to an area which increases but little in size. Early in the development it is covered with plates which increase in number from the interior of the outer row of peristome plates between it and the actinostome; these plates increase in size in all directions.

In the Echinothuriæ it is easy to follow the migration of the pores from the coronal ambulacral plates on to the actinal system. In a specimen of *Phormosoma zealandiæ* of 24 mm. (Pl. 51, fig. *1*) and one of *P. hispidum* (Pl. 43, fig. *5*) the third plate (counting from the teeth) is in each case in



24 mm.
FIG. 129. P. ZEALANDIÆ.



15 mm
FIG. 130. P. HISPIDUM.

the process of passing from the corona to the actinal system, they are not quite free but are still held together by connecting calcareous tissue. The ambulacral plates are single up to the sixth pair, Figs. 129, 130, where the intercalated half plates begin and the ambulacral plates are clustered in rows of three. On reaching the actinal system the ambulacral buccal plates extend rapidly laterally, principally toward the interambulacral areas, and overlap.

The first pair of buccal ambulacral plates is formed on the actinal membrane, Figs. 131, 132; the second pair of buccal plates is the first to become detached from the ambulacral coronal plates (Pl. 43, figs. *1*, *3*).

In Phormosoma and Asthenosoma the ambulacral pores are placed near the upper sutures (Pl. 48), while in the regular Echinoidea they are generally near the lower suture or in the suture itself. The secondary suture, such as occurs across the primordial plate of *P. hispidum* (Pl. 43, fig. *6*), is the first indication of an extensive network of secondary sutures which extends over the coronal plates and gives them additional flexibility (Pl. 45, figs. *13*, *14*) in older stages of growth.

From the great length of the genital plates in old and large specimens of Phormosoma we find from three to three and a half interambulacral plates butting against their sides — a feature already existing in Palæchinidæ. It is well seen in a specimen of *Oligoporus missouriensis* Jack. from Webb City, Mo., where there are three and two and a half interambulacral plates in contact with the genitals, and no less than four in a specimen of *Lepidechinus imbricatus* Hall, from Burlington, Iowa. An odd triangular plate is also barely in contact with the outer edge of the genital plate. Between the sixth and seventh plates of the two abactinal rows of interambulacral plates two small rhomboidal plates are intercalated, the youngest plates of the third

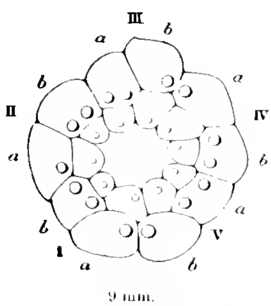


FIG. 131. P. PLACENTA.

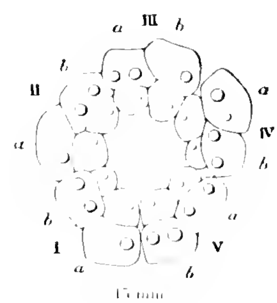


FIG. 132. P. HISPIDUM.

row of interambulacral plates appearing near the abactinal system, much as they do in the abactinal interambulacral region, where its plates separate the bivium from the trivium.

One cannot fail to be struck with the Bothriocidarid structure of the actinal system of young Phormosoma (Pl. 43, figs. 3, 5), in which the interambulacral plates are excluded from the actinostome, Figs. 131, 132, as in Bothriocidaris,[1] if we look upon the second and third plates of the ambulacral areas, which form a closed ring, as still a part of the coronal plates, a condition of things not uncommon in certain Clypeastroids and Spatangoids.

I cannot understand Gregory's[2] statement that in Asthenosoma the apical system is reduced to ten rudimentary plates of no functional importance, or are altogether absent.

The genital ring of Bothriocidaris as well as of the Palæchinidæ is much like that of the recent Echinids, only in the former the ocular plates are far larger than the small plates corresponding to the genitals.

[1] Schmidt, F., Mem. Acad. St Petersburg, XXI, No. 11 (1874).
[2] The Echinoidea, p. 294. In Bather, Gregory and Goodrich, The Echinoderma. 1900.

The anal system of *Bothriocidaris globulus* Eichw. as figured by Jaeckel[1] shows, as in the very young Cidaridæ, five anal plates in the angles of the ocular plates, with secondary smaller and intercalcated plates. The mode of growth of the ambulacral zones is well shown in his figures, from the position and size of the abactinal plates, and does not differ in any way from that of recent Echinidæ. It is natural that there should be no difference from the mode of growth, in the pluteus of Echini and following postembryonic stages, of succeeding pairs of tentacles immediately at the base of the odd terminal tentacle. The difference in the number of interambulacral plates in the several rows is not more marked than in the Cidaridæ, where they vary from one to two plates, according to their position with reference to the youngest interambulacral abactinal plate.

It is by no means certain that the plate indicated as madreporic by Schmidt and Jaeckel is to be considered as such. It is true that in Echini the madreporic body is not always in a definite plate. It is not so placed in Clypeastroids, and in many Spatangoids and in Echinothuriæ we see it encroaching upon the ocular plates.

The existence of an interambulacral zone composed of a single row of plates does not give us any clue to the mode of formation of the Palæchinid type of interambulacra with its manifold rows of plates.

An examination of specimens of *Oligoporus missouriensis* Jackson, from Webb City, Mo., and of *Lepidechinus imbricatus* Hall, from Burlington, Iowa, shows that young plates are added in the interambulacral area in the abactinal region adjoining the ocular plates, forcing their way down on each side of the genital plates and pushing the older plates towards the centre of the interambulacral area.[2] But the exact mode of formation of new vertical rows cannot be determined until very young specimens are available. That they are formed at the apical system in the oldest known Echinids is clearly shown by Jaeckel and Schmidt's figures.

In Bothriocidaris the interambulacral zone stops short of the actino-

[1] Jaeckel, Otto, Über die älteste Echiniden-Gattung Bothriocidaris, Sitzungs-Ber. d.Ges. f. naturf. Freunde zu Berlin, Dec. 18, 1891 fig. 1, p. 245.

[2] The abactinal system of Melonites figured by Keyes (Iowa Acad. of Sc., Pl. XX, fig. 1b) shows plainly that new abactinal interambulacral plates are formed adjoining the genital plates. They form a loop of six plates, the oldest in the centre. Immediately below there is a band of only four or five plates; there are eight rows in the sixth belt, and the same number in the equatorial region and beyond the ambitus towards the actinal system. Unfortunately there are no figures of the abactinal part of the ambulacral areas, or specimens available to enable us to obtain an idea of the mode of formation of the polyporous plates of the ambulacral system.

stone; in the Palæchinidæ it is probable that the vertical rows stop in a similar manner at certain points of the test, being excluded from the lower part by the crowding of the older plates. But the lowest plates of each row are certainly the oldest and not the youngest, if we are to judge by analogy from the whole Echini group. In the young of *Goniocidaris canaliculata* the interambulacral plates are also excluded from the buccal membrane, as well as in Salenia and Strongylocentrotus.

The disappearance of ocular plates in Pourtalesiæ, and that of some of the genital plates and their scattered position in such groups as the Holasteridæ, Ananchytidæ, Pourtalesiæ, and other Spatangoids as well as in other groups of Echini shows how great may be the variation in the position of the plates composing the apical system.

The zones of interambulacral plates in recent Echini may in reality be said to form in their earliest stages, single, irregular, zigzag, vertical lines of five plates.[1] Although the formation of these plates has not been determined in the youngest postembryonic stages, yet in the earliest stages the interambulacral plates are not as yet united, but form calcified areas arranged in a quincunx manner, the oldest of which are alternately on the right or left, and finally appear to form two distinct vertical rows from the disappearance of the primordial actinal plate, and the lateral crowding of the older plates with their increase in number.

That we have more than one primordial interambulacral plate followed by the older interambulacral plates is evident from the earlier stages of Echini figured by Müller,[2] and by Theel[3] on the development of Echinocyamus, where there seem to be five interambulacral plates formed at the same time.

In the Echinothuriæ we have some data, as in the genus Sperosoma,[4] showing the manner in which four vertical rows of ambulacral plates may be developed on the actinal side from such simple primordial rows as still exist in the Cidaridæ and many of the Clypeastroids and Spatangoids. The passage is quite abrupt from four plates to two on the abactinal side, so that no clear idea can be formed of the mode of origin of the four plates on the actinal side. Dr. Mortensen describes a young Sperosoma of 27 mm.

[1] Bury, Q. J. Mic. Sci., Vol. 38 (1895–96), Pls. 7, fig. *34*; 8, fig. *36*.
[2] Larven u. Met. d Oph. u. Seeigel Erste Abhandl., Pl. VII and 7te Abhandhl., Pl. VIII, fig. 11.
[3] Nova Acta Reg. Soc. Sc. Upsala, 1892, p. 50.
[4] Koehler, R., Pl III, figs. *3*, *4*, Fascicule XII, Échinides et Ophiures. Résultats des Campagnes scientifiques du Prince de Monaco. 1898.

diameter, but gives no detailed figures of the ambulacral areas of that stage.

The figures given by Cotteau[1] of Tetracidaris do not include the abactinal plates of the interambulacral area. The passage between the two pairs of interambulacral plates to the usual type of interambulacral plates is abrupt and gives us no clue of their origin. We may notice that the outer suture of the inner plates is not in the median line, but in the lower part of the inner plate, the outer plates being pentagonal, the inner plates hexagonal.

Lysechinus,[2] although it has three rows in two sets above the second row, yet gives no indication of how the third median row has originated any more than Tiarechinus, which has three plates immediately above the primordial.

After Dr. Mortensen's criticisms[3] of the chapter on the Echinothuriæ of the "Challenger," it was natural to expect that in the arrangement of his figures we should have a model to follow. It was essential, if he wished to persuade his readers of the value of his identifications, that every effort should be made to ensure ready comparison of the pedicellariæ of allied species. Quoting from Dr. Mortensen, "it was almost enough to drive one to despair" to make such an attempt with his plates, without a guide or key to their arrangement.

In dwelling upon the many points of relationship between Phormosoma and Asthenosoma I drew attention to the difficulties of describing the species of these genera owing to the changes due to growth. On the strength of this remark Dr. Mortensen assumes that I have stated that the two genera cannot be distinguished,[4] and proceeds to ignore all that has been said of the different species of Echinothuriæ relating to the actinal and abactinal systems and the spines, because he thinks the Echinothurids are not adapted for examination in the dry state. But he claims to give a perfect classification based, first, upon the characters of the spines, as if his predecessors had not mentioned them in any way; next, upon pedicellariæ, tube feet, pores and spicules, the last of which he has previously informed us were of no systematic value! Having stated that the genera Phormosoma

[1] Bull. Soc. Geol. de France, 3e Ser. I, Pl. III, p. 258. March 17, 1873.

[2] On Lysechinus, a new genus of fossil Echinoderms from the Tyrolese Trias. J. W. Gregory, Proc. Zool. Soc London, Dec. 15, 1896, p. 1000, Pl. LI.

[3] Mortensen, l. c. p. 43.

[4] Mortensen, l. c. p. 43.

and Asthenosoma cannot be distinguished, he then establishes a number of new genera based wholly upon the structure of the triphyllous and tridentate pedicellariæ.[1] The latter show "a great variety of forms, and are of great systematic importance;" while the former have little systematic importance in Echinidæ, they are considered by Dr. Mortensen of value for the determination of the Echinothuriæ.

Dr. Mortensen has given a number of plates of most admirably drawn pedicellariae and colored figures of several species of Echinoids. He is most outspoken regarding the quality of the illustrations of many of his predecessors. Surely we might call his attention to a number of figures on Plates IV, V, VI, VII, XV of the "Ingolf" Echinoidea, and refer them to his benevolent criticisms. When such minute characters as those of pedicellariae are to be illustrated, it is important that we should know their size and kind, but in a great many of his figures the explanation of the plates gives us no information on the subject. Surely he cannot expect his readers to calculate the enlargement of his figures from the data of the oculars and objectives used in drawing them.

It seems rather hazardous to state, as is done by Dr. Mortensen, that the tetradactyle pedicellariae described by Thomson for *Asthenosoma fenestrata* are only found in the two species for which he has established the genus Aræosoma.[2] No one who has dredged Echinothuriæ from great depths can have failed to notice how frequently the tests come up more or less injured, with their appendages completely worn off. Should the same tetradactyle pedicellariæ be found in other Echinothuriæ they would, according to Dr. Mortensen, have to be referred to the genus Aræosoma, even if the tridentate pedicellariæ were different; for certainly the differences in the tridentate pedicellariæ of *Asthenosoma fenestrata* and of *Asthenosoma hystrix*, figured by Dr. Mortensen (Pl. XIV, figs. 8, 17, 18, 24, 32, and Pl. XIII, figs. 17, 18, Pl. XIV, fig. 26) cannot be regarded as sufficient to separate them generically.

Ophicephalous pedicellariæ occur not only in *Tromikosoma Koehleri* (Mortensen, Pl. XIV, figs. 19, 23), but also in *Phormosoma luculentum* (I have figured them, "Challenger" Echinoidea, Pl. XLIV, fig. 27). Dr. Mortensen refers that species with some hesitation to his genus Hygrosoma on account of the thick broad blades of a peculiar kind of tridentate pedicellariæ (Mortensen, Pl. XIII, fig. 16). I take it they are the pedicellariæ of which I have given

[1] Mortensen, l. c. p. 9. [2] Mortensen, l. c. p. 53.

a sketch ("Challenger" Echinoidea, Pl. XLIV, figs. 25, 26). *Phormosoma hoplacantha* also has tridentate pedicellariæ clearly resembling those of *Asthenosoma fenestrata* and of *Asthenosoma hystrix* ("Challenger" Echinoidea, Pl. XLIV, figs. 29, 29', 30).

Dr. Mortensen[1] proposes to retain the name Calveria of Thomson as a generic appellation of *A. hystrix*, *varium*, and *A. Grubei*, of which he says the former species "has unjustly been deprived." The name of Calveria was dedicated to Captain Calver, and originally given by Carpenter, Jeffreys, and Thomson in 1869 to "a very singular Asterid allied to Pteraster which is covered with a regular brush of long paxillæ. . . . We propose to give the generic name *Calveria* to the latter (Pteraster) with the specific designation *hystrix*" (Proc. R. S. London, No. 121, Vol. XVIII, January, 1869, p. 445), and only afterwards did Thomson apply the same name to a species of Asthenosoma.[2]

Having stated in one part of the "Challenger" Report that I considered[3] some young specimens from Stations 184 and 219 as perhaps not belonging to *A. gracilis*, I am corrected for not repeating this every time I mention *A. gracilis!* These specimens Dr. Mortensen examined, and also considers as very different from *A. gracilis*.

Dr. Mortensen states that *Asthenosoma varium* and *A. Grubei* are distinct species. He gives no figures of pedicellariæ to settle the question, as his figures of pedicellariæ of *A. Grubei* are not comparable to those of *A. varium*.

According to Dr. Mortensen I have wasted my time in describing the differences between *Ph. bursarium* and *Ph. luculentum*, which are so evidently distinct according to the figures I have given in the Challenger Echini, while I have not observed that *Ph. bursarium* is very similar to *Ph. placenta*, and have not informed my readers of the characters which distinguish the two. I beg to refer Dr. Mortensen to the figures of *Ph. placenta* published in the "Blake" Report and those of *Ph. bursarium* published in the "Challenger" Report.

If we compare the differences between the pedicellariæ of *A. hystrix* and those of *A. fenestratum* and *A. coriaceum* as figured by Dr. Mortensen, we find them so slight that they certainly cannot be considered of generic value as is maintained by him. We can only wonder at his constant amazement concerning the affinities of the various species of Echinothuriæ sug-

[1] Mortensen, l. c. p. 52.

[2] Depths of the Sea, p. 157, 1873. Trans R. S. Lond., 1874, p. 737.

[3] "Challenger" Echinoidea, p. 91.

gested in the "Blake" and "Challenger" Reports. There is not one, according to him, of any value, because they are not based upon the pedicellariæ.

Dr. Mortensen thinks I am wholly mistaken in suggesting any affinity between *A. pellucidum* and *A. coriaceum* and *A. tessellatum*, because he has suggested a new genus, Hoplosoma, for *A. pellucidum*, based entirely upon the structure of the pedicellariæ (Pl. XIII, figs. 20, 24, 25); they are certainly very peculiar, but may be embryonic conditions of unknown pedicellariæ similar to those he figures for *Ph. placenta* (Pl. XII, figs. 15, 24, 30). As for his remarks on *Phormosoma tenue*,[1] I would suggest to Dr. Mortensen that the Report on the "Challenger" Echini was issued in 1881, and that his Memoir was published in 1903; he can hardly expect genera proposed in 1903 to have received any recognition in 1881.

I have nothing to say regarding Dr. Mortensen's sneers at descriptions of pedicellariæ[2] because they do not fit with his classification. I have no doubt that in the mass of material collected by the "Challenger" which passed through my hands I must have failed to distinguish all the species. I was frequently in doubt as to the identification of certain specimens. That doubt was usually indicated on the labels accompanying them, but Dr. Mortensen[3] has no words to express his horror at such a proceeding. It is therefore somewhat surprising that he should, without any examination of the pedicellariæ, refer *Phormosoma hoplacantha* to the genus Hygrosoma which he has established for *Ph. Petersii*, described in the Preliminary Report of the "Blake" Echini, and which I subsequently considered to be *Ph. uranus* Wyv. Thom. in the final Report.

Dr. Mortensen holds me responsible for the identification of specimens of *Ph. uranus* and *Ph. Petersii* sent by the Smithsonian (National Museum) to the Copenhagen Museum and to Professor Koehler. I must repeat again that I know nothing of the specimens collected by the "Albatross" in the Atlantic after the publication of the "Challenger" Echini. As the Report on the "Challenger" Echini was published in 1881, and the "Albatross" was not launched until 1883, I cannot have had in 1881 any opinion regarding the identity or difference between the specimens of *Ph. uranus* and *Ph. Petersii* on which he establishes the genus Hygrosoma. There are no indications in the figures of the pedicellariæ of *Ph. placenta*

[1] "Ingolf" Echinoidea, p. 55.
[2] Loc. cit. p. 57.
[3] Loc. cit. p. 57.

or among those of Hygrosoma available for comparison showing reasons for the adoption of Hygrosoma as contrasted to Phormosoma.

It is with a sigh of relief that Dr. Mortensen[1] comes to *Ph. asterias*, "the last of the Echinothurids described from the 'Challenger'"; to be exact I beg to call his attention to the fact that it is not the last species described. Of course he finds the description useless. Fortunately some of the figures meet his approval, and a new genus is established for the species based on characters which to me appear most trivial.

PHORMOSOMA Wyv. Thom.

Phormosoma hispidum, A. Ag.

Phormosoma hispidum, A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 77. Plates VI, VII.

Plates A; B, fig. *1*; 30–42; 43, figs. *5*, *6*; 44–47; 48, figs. *2–6*; 49.

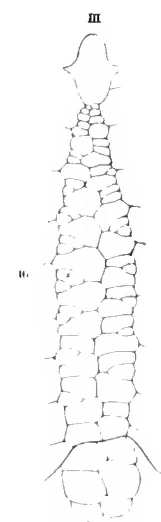
This species is the Pacific representative of the Caribbean and Northern Atlantic *Ph. uranus*. It has like it an extensive geographical distribution from the Panamic to the South Californian district, but in comparatively deeper water. Its range is from about 1000 to over 1300 fathoms, while the Atlantic species has been found at a much less depth (399 fathoms). An excellent series of specimens of this species was collected, varying from 15 mm. to 203 mm. in diameter (Pls. 30–38), the greater number being from 120 to 130 mm. in diameter (Pls. 31, fig. *3*; 32; 33, fig. *3*; 34, fig. *1*; 35; 36). In the largest specimen, 203 mm. in diameter (Pls. 37; 38) the actinal system was 44 mm. in diameter (Pl. 41, fig. *2*) and the apical 44 mm. (Pl. 39, fig. *3*). The test is marked by the great width of the ambulacral system, which at the ambitus is no less than 57 mm., — nearly of the same width as the interambulacral area at the corresponding edge.

It will be simpler to describe first the youngest specimens collected, and trace the changes taking place with increasing size, until we reach the largest specimens dredged by us.

The young stages of Phormosoma are less globular, more flattened, like Diadema, than the older stages (Pl. 30). The youngest specimen collected (Pl. 30, figs. *1*, *2*) measured 15 mm. in diameter, Fig. 133; the actinal system 5 mm. in diameter (Pls. 43, fig. *5*; 44, fig. *1*; 48, fig. *2*), with three

[1] "Ingolf" Echinoidea, p. 60.

pairs of ambulacral buccal plates, and three to four ambulacral plates to each interambulacral plate at the ambitus, and four and five above (Pls. 48, fig. *2*; 49, fig. *1*), and two to four in the actinal plates above the primordial plate. There are three and four interambulacral plates from the primordial plate to the ambitus and five and six to the abactinal system. The interambulacral plates each carry a primary tubercle (Pl. 49, fig. *1*). The primordial plate has a second small one; these are, below the ambitus, placed near the ambulacral edge, above the ambitus, in the central part of the plate. In addition, on the actinal side, each plate carries from one to three miliaries on the inner side of the primary. On the abactinal side the three plates nearest the ambitus carry, parallel to the sutures, one or two small primaries in addition to the two or three miliaries. The two last ambulacral plates carry only a single miliary.



15 mm.
FIG. 133. PH. HISPIDUM.

In the odd anterior ambulacral area (Pl. 48, fig. *2*) the first four and three abactinal ambulacral plates, Fig. 133, are arranged in a linear series; the fifth and fourth are much larger, and are followed by two smaller plates reaching to the median line. The next large plate is followed by one reaching the median line and one which is excluded; and then, as far as the ambitus, of the succeeding three plates only the larger reaches the ambitus; the others are excluded. Below the ambitus, of the three plates which go to form the ambulacral system, the third plate only is excluded, the second plate reaching the median line (Pl. 48, fig. *2*). Nearly all the larger ambulacral plates which extend from the interambulacral edge to the median line carry a primary tubercle or a large miliary, and six of the excluded secondary plates carry similarly a small miliary. Of the younger series of abactinal ambulacral plates only the fourth has a miliary. Of the buccal plates the two oldest plates carry one or two miliaries.

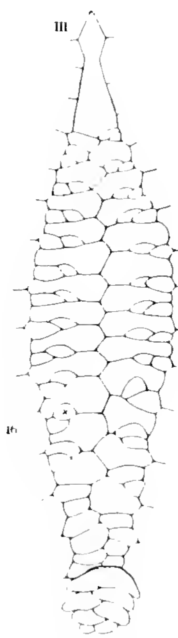
The abactinal system is 6 mm. in diameter (Pl. 40, fig. *1*). At this stage the ring of genital and ocular plates is closed, excluding the anal system from the interambulacral plates. The madreporic genital is somewhat larger than the others, and carries but two miliaries, it is more rounded than the others, which are irregularly pentagonal, and carry in the central part a vertical line of two or three small secondaries with a single miliary. No trace can be found of the genital pores.

The ocular plates are larger than the genitals; from their junction with the genitals their outline forms a re-entering angle along the ambulacral side of the abactinal interambulacral plates, its sides extending nearly parallel, as far as the middle of the second plate. At their junction with the abactinal ambulacral plates the oculars are cut off at right angles. The ocular pore is placed near the ambulacral edge. The oculars carry a single secondary tubercle in the centre of the anal side, with five to six miliaries in two vertical rows occupying the distal part of the plate. The anal plates carry no miliaries; their number is already so great that, even in the outer row of larger plates, we can no longer trace the original anal plates. Inside of the irregular row of outer plates there are two other rows of smaller plates filling irregularly the central part of the anal system.

In a specimen of 15 mm. in diameter the three buccal plates already show, seen from the interior of the test, the reverse imbrication characteristic of the actinal system (Pl. 44, fig. *1*), and the fourth ambulacral plate shows a small club-shaped prominence, the base of the arch of the auricle. See Fig. 136.

In a specimen measuring 34 mm. in diameter (Pl. 30, figs. *3, 4*) there are five and five interambulacral plates between the primordial plate and the ambitus, and nine and nine between the ambitus and the genital plate (Pl. 49, fig. *2*). The position of the primary interambulacral tubercles has not changed from that observed in the preceding stage described, but with the extension of the interambulacral plates laterally, additional miliaries and small secondaries have formed upon the plates. The left side of the primordial, in addition to its two small secondaries, is well covered with miliaries. On the other plates below the ambitus the miliaries have increased in number along the ambulacral edges of the interambulacral plates. A small additional secondary tubercle is found on the inner part of the plate; the miliaries, however, have not increased in number along the median line. On the plates above the ambitus additional miliaries occur arranged horizontally along the middle line of the plate.

The changes which have taken place in the ambulacral system of a specimen 34 mm. in diameter, compared to one only 15 mm., are much greater than those occurring in the interambulacral zones. We cannot fail to observe the great width already attained by the ambulacral system at the ambitus in this specimen (Pl. 48, fig. *3*) as compared with the younger specimen (Pl. 48, fig. *2*). There are fourteen and fifteen ambulacral plates between the buccal plates and the ambitus, and twenty-seven and twenty-eight between the ambitus and the ocular plates. It is only at the abactinal and actinal parts of the ambulacrum that we can still trace the embryonic arrangement of the plates. From the ambitus towards the abactinal pole, with the great lateral extension of the larger ambulacral plate, the second plate has been excluded from the outer edge and the third component plate alone reaches the edge. Four of the abactinal plates are in lineal succession of equal size, and are then followed by three larger plates, each with its two smaller poriferous plates reaching the outer edge, where they are followed by plates having the arrangement characteristic of the older specimens.



120 mm.
FIG. 134. PH. HISPIDUM.

Below the ambitus (Pl. 48, fig. *3*) on the actinal side, in two of the plates nearest the ambitus are the third plates excluded from the outer edge; between these and the fifth plate from the actinal system, the second plate being pushed back of the third plate, the second and third component plates reach the outer edge; the last five actinal plates, being nearly equal in size, all reach the outer edge as well as the median line, and alone retain the embryonic arrangement of the younger stage.

In a specimen of 75 mm. the thirteenth plate in the right zone of the odd anterior ambulacrum is enclosed (Pl. 48, fig. *5*), while in specimens of 120 and 203 mm. it is the sixteenth from the actinostome. Fig. 134.

It will be noticed how interesting is this structure of the ambulacral system of the Echinothuriæ. Nearly all the plates of the actinal part of the ambulacrum below the ambitus retain the Cidarid arrangement of equal ambulacral plates one above the other; while from the ambitus toward the abactinal system these plates form combinations of three, each with a pair of pores, one of the plates being much larger than the others; thus imitating the composite plate of Strongylocentrotus with its pairs of pores, but formed in a very different way, the component plates of Strongylocentrotus being cut through the original plate, while in the Echinothuriæ each of the component plates begins as an independent plate for the whole length of the ambulacral zone. In Strongylocentrotus the single primary plates are the uppermost of the abactinal plates.

In this larger specimen (34 mm.) the primary tubercles have increased in number with the increase of the ambulacral plates, and from one to three small miliaries have been added to the outer part of the larger component plate. The buccal plates also have become thickly covered with secondaries and miliaries. A comparison of figs. *2* and *3*, Plate 48, will readily show the nature of the changes which have taken place in the tuberculation of the ambulacral system.

In the larger specimens eight or nine interambulacral plates carry on the actinal side a single, primary tubercle; it increases in size as it approaches the ambitus. The sixth, seventh, and eighth plates carry two primaries; the second appears in specimens of about 100 mm. On the abactinal side the primary tubercles become greatly reduced in size, occurring in a single row in small specimens; subsequently there are two and three or four at the ambitus. The scrobicular area of the larger tubercles frequently spreads over the adjoining miliaries, which are thus resorbed (Pl. 45, fig. *15*). The miliaries covering the test are in all stages of growth. The first appearance of the tubercles is indicated by a concentration of the open reticulation (Pl. 46, fig. *2*) growing round the areola, which is thus lifted above the general network (Pl. 46, figs. *5*, *6*).

In the abactinal system of a specimen of 34 mm. (Pl. 40, fig. *2*) very marked changes have taken place. The genital and ocular plates no longer form a closed ring. Four of the genitals are separated from their adjoining oculars by elongate anal plates which have forced their way between them, and connect with the youngest abactinal interambulacral plates of the odd posterior, the left anterior, and the two posterior lateral interambulacra. The odd ocular is not yet separated from its adjoining genitals, and the madreporic genital only partly so by the intrusion of a wedge-shaped anal plate. Genital pores have developed in all the genital plates except the odd posterior one. The tuberculation of the genital and ocular plates is less prominent than in the younger specimens (Pl. 40, fig. *1*). On the contrary, many of the larger anal plates carry a single secondary or large miliary tubercle. The madreporic body also covers the greater part of its genital.

The actinal system measures 12 mm. in diameter and has four rows of buccal plates (Pl. 43, fig. *6*). They do not fill quite as completely the actinal system as in an earlier stage (Pl. 43, fig. *5*), but leave a small open area in the interambulacral angle between the buccal plates. An interesting feature of this specimen is the splitting of the primordial plate into two. This splitting of the plates is carried on in older stages both in the ambulacral and interambulacral areas. That of the primordial plate occurs also in older specimens (Pl. 41, fig. *2*) in the right anterior and right posterior interambulacra. In the right posterior interambulacrum (Pl. 43, fig. *6*) the second plate is abnormal; one of the second plates is reduced to a small intercalated triangular plate.

In specimens measuring 43 mm. in diameter there are five rows of buccal plates (Pl. 44, fig. *2*), in those of 64 mm. there are six (Pl. 44, fig. *3*), and in one 137 mm. we find seven. With increasing size the buccal plates become more elongate, the row immediately at the teeth alone retain more or less their circular outline (Pl. 44). In the specimens of 43 and 137 mm. the bare interambulacral area adjoining the primordial plate is covered with a few minute, elongate, irregularly arranged plates, which correspond to the interradial buccal plates of Cidaris.

In a specimen of 53 mm. in diameter (Pl. 30, figs. *9*, *10*) it will be seen that on the actinal side there is no greater number of interambulacral plates (Pl. 49, fig. *3*) than in a specimen not much more than half the size (Pl. 49, fig. *2*). The position of the primary tubercles in the plate indicates that it has grown fairly uniformly in all directions. The scrobicular circle has become well-defined in some of the plates, and they are much more closely covered by small miliaries than in the previous stage. Between the ambitus and the genital plates, however, there have been four additional plates formed; there are thirteen in place of nine, differing in length and in the greater number of small miliaries found in the plates.

In a somewhat smaller specimen of 47 mm. the arrangement and number of the actinal and abactinal plates of the corona are similar to the larger one.

In a specimen 120 mm. in diameter (Pls. 31; 32, fig. *3*; 49, fig. *4*) there are fifteen plates above the ambitus and seven below, above the primordial plate. There are only eight on the actinal side of a specimen measuring 203 mm. in diameter (Pls. 37; 49, fig. *5*) between the ambitus and the genitals (Pl. 38), showing that the increase in size takes place on the actinal side mainly by the growth of existing plates in all directions, while on the abactinal side the coronal plates increase somewhat in size, but greatly in number also.

In the specimen of 53 mm. in diameter the position of the original vertical row of primary tubercles is well shown (Pl. 49, fig. *3*). The actinal system measured 16 mm. in diameter, with five rows of buccal plates covering the whole actinal system, and leaving but a slight bare interambulacral area between the buccal plates; these have become greatly elongate, compare Pl. 42, fig. *1* and Pl. 43, fig. *6*.

The ambulacral area of this specimen (Pl. 48, fig. *4*) has proportionally also greatly increased in width from above the ambitus to the fourth or fifth plate beyond it. The increase in width is due to the lateral growth of the median ambulacral space between the poriferous zones. Above the ambitus the large primary ambulacral plates now form a very regular vertical series, while on the actinal side, owing to the great height of the primary plates, the inner angle of each plate projects beyond the median line. In the ambulacral plates immediately above and below the ambitus the primary plates are excluded from the interambulacral edge, owing to the great increase in height of the third poriferous plates (Pl. 48, fig. *4*). This great irregularity in the arrangement of the poriferous zone is characteristic of all Echinothuriæ.

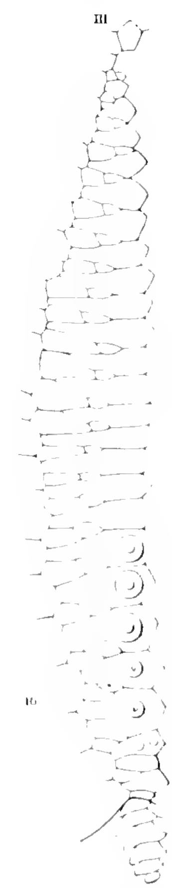
In a specimen 75 mm. in diameter (Pls. 48, fig. *5*; 31, figs. *1*, *2*) above the ambitus a very narrow side of the primary plate again reaches the interambulacrum, the third plate being higher than the primary, and the second pushed back of the third. Much the same proportions exist in the arrangement of the ambulacral plates of a specimen of 120 mm. in diameter (Pls. 48, fig. *6*; 31, fig. *3*).

In the specimen of 53 mm. (Pl. 48, fig. *4*) the vertical rows of primary tubercles are not readily traced; they are fairly distinct on the actinal side, where the primary tubercles are larger; on the abactinal side, on the central part of the median interambulacral belt plates, are found a few large miliaries arranged in horizontal rows, and a few miliaries on the outer edge of the poriferous zone. But in larger specimens the primary vertical rows again become prominent, as in a specimen of 75 mm. in diameter (Pls. 48, fig. *5*; 31, figs. *1*, *2*), and in a specimen of 120 mm. (Pls. 48, fig. *6*; 31, fig. *3*); but in both, the primaries are larger on the actinal side. This contrast between the primaries of the actinal and abactinal sides is still more marked in the interambulacral areas, where with increasing size the scrobicular areas become well limited (Pl. 49; see also Pls. 30; 31; 35–38).

In a specimen of 53 mm. the apical system measured 12.5 mm. in diameter (Pl. 40, fig. 3). It differs from the preceding stage by the elongation of the genital plates, the great increase in size of the madreporic genital, and the presence of anal plates intercalated between some of the genitals and oculars. Though this specimen is so much larger than the one just described, the genital openings are not visible; nor can they be seen in a still larger specimen of 75 mm. (Pl. 40, fig. 4). In this there are two anal plates intercalated between the left posterior ocular and the odd genital, and between the right posterior genital and ocular. The other genitals and oculars are separated by a single plate (Pl. 40, fig. 4), with the exception of the right and left anterior genitals and oculars.

In specimens 120 mm. in diameter (Pls. 31; 33, fig. 3; 48, fig. 6), the rows of interambulacral primaries on the actinal side are arranged much as in the largest specimens collected; there are, however, two plates less on the actinal side, so that the second row of primaries is limited to two plates.

In a somewhat larger specimen 131 mm. in diameter (Pls. 35; 36) the primary tubercles are arranged as in the specimen measuring 203 mm. The arrangement of the miliaries and secondaries in specimens more than 120 mm. in diameter does not differ from that of the larger specimens. Above the ambitus, specimens of 120 mm. in diameter show a greater number of secondary tubercles to each interambulacral plate (Pl. 49, fig. 4) than in the oldest specimen, in which the interambulacral plates carry a much greater proportion of miliaries. The ambulacral system (Pl. 48, fig. 6) has increased in width; there are three and two elongated primary plates on the actinal side of the ambitus. Above the ambitus on one side, four of the primary plates are excluded from the interambulacral edge, while on the other — the right when seen from above, Fig. 135 — only two are thus shut off, thus completely changing the position and arrangement of the poriferous zone, the normal arrangement of which is an outer pair of pores with two pairs immediately below, arising from the original linear arrangement and the subsequent crowding back of the second ambulacral plate.



120 mm.

FIG. 135. PH. HISPIDUM.

In a specimen of 120 mm. (Pl. 48, fig. *6*) secondaries and miliaries occupy the part of the plate between the poriferous zone and the interambulacral edge, and the median vertical rows of primary tubercles are prominent on the actinal side; they continue somewhat smaller on the abactinal side. Along the median space miliaries are arranged in irregular horizontal lines, and on the actinal side the large primary plates are covered with small secondaries.

The buccal ambulacral plates are elongate, arranged in six rows (Pls. 41, fig. *1*; 48, fig. *6*), leaving but a narrow bare space in the interambulacral area. The buccal plates are, from the earliest stage examined, all perforate by a pair of pores, and carry a horizontal row of three to six small secondaries on the actinal edge of the plate according to its length, with here and there a miliary.

The abactinal system of a specimen 120 mm. in diameter has undergone great changes (Pl. 39, fig. *1*) from that of a specimen 75 mm. in diameter (Pl. 40, fig. *4*). The abactinal median interambulacral area is occupied by a triangular membraneous extension of the genital plate which reaches to the third or fourth interambulacral plate from the summit, and in these membraneous spaces are situated the genital openings. The calcareous part of the genital plates is more or less elliptical. The left anterior genital appears made up of the original genital and of an intercalated anal plate, while the madreporic genital is made up of two primary genital plates surrounded by an arc of eight anal plates, on seven of which the madreporite has encroached. The madreporic genital is the only one still partly in contact with an ocular (the odd anterior ocular plate). The anal plates have forced their way to such an extent between the oculars and genitals that it is difficult to say where the interambulacral system ends or the anal begins. Pl. 40, fig. *5* shows the madreporic genital with the adjoining anal and other plates of the abactinal system as seen from the interior of the same specimen.

In another specimen somewhat larger (a fragment) of 130 mm. in diameter (Pl. 39, fig. *2*) the genitals and oculars are all well separated by anal plates which in some of the interambulacra have forced their way on both sides of the median interambulacral space as far as the third interambulacral plate. The abactinal interambulacral plates are thus forced to the sides, spread open at the summit to allow the further invasion of the anal plates. This has changed the point of origin of the new interambulacral plates; they now arise, even in the specimen 120 mm. in diameter, from the flanks of the ocular plates and not from the genitals (Pl. 39, fig. *1*). In the older specimen (Pl. 39, fig. *2*) the intrusion of the anal plates within the interambulacral area has greatly disturbed the regular arrangement of the older plates and the mode of growth of the new plates. In the specimen of 130 mm. (Pl. 39, fig. *2*) bare spaces in addition to those in continuation of the genital plates have developed so as to separate the madreporic genital[1] from the odd anterior ocular, the left anterior and left posterior oculars from the adjoining interambulacral zone. The right posterior ocular is separated from the adjoining interambulacrum so that one of the intercalated anal plates occupies the position of a newly formed interambulacral plate (Pl. 39, fig. *2*).

When we examine the apical system of the largest specimen collected, 203 mm. in diameter (Pl. 39, fig. *3*), we find the narrow elongated triangular extension of the membraneous part of the genitals extending along the median interambulacral line as far as the fourth plate, so that the abactinal parts of the interambulacral zones are widely separated. As in the specimen of 130 mm. (Pl. 39, fig. *2*), bare membraneous spaces occur between many of the anal plates in the anterior part of the apical system, on the anal side of the anterior genital plates, of the odd posterior genital and the right posterior ocular plate. The madreporic genital is joined with the odd anterior ocular plate; the madreporite occupies only the madreporic genital, which is polygonal and much larger than any other genital. In fact, the other genitals, with the exception of the left anterior one, have lost their great size as compared to that of the anal plates. Many of the latter are now nearly as large as the former, carrying secondaries and miliaries. Otherwise all the genitals and oculars are widely separated, the intercalated anal plates abutting on the abactinal part of each of the two interambulacral zones to such an extent that in some interambulacra it is almost impossible to determine which is the terminal interambulacral plate or the intercalated anal plate.

It is this extraordinary change in the anal system which I had observed in the abactinal part of the test, which has prompted Dr. Mortensen[2] to credit me with the most extraordinary ignorance of the rudimentary embryological data, many of which I was the first to discover. That this remarkable intercalation exists there is not the least doubt, and it naturally suggests

[1] The madreporite extends over one of the adjoining anal plates. [2] Mortensen, l. c. p. 175.

in old specimens a flow of the anal plates into the interambulacrum, similar to the flow of the ambulacral plates of the corona onto the buccal plates of the actinal system. The figures which I here give of the young of *Phormosoma hispidum* show plainly that I was mistaken in my observations on the mode of formation of the buccal plates of the actinostome of Echinothuriæ. I wish here to state that the plates illustrating this point were drawn and printed several years before Dr. Mortensen[1] called attention to the error.

In the largest specimen collected, 203 mm. in diameter (Pls. 37; 38), the abactinal system (Pl. 39, fig. *3*) was 44 mm., and the actinal system (Pl. 41, fig. *2*) 46 mm. The three interambulacral plates nearest the ambitus (Pl. 49, fig. *5*) carry two large primary tubercles occupying each nearly the whole width of the inner and outer parts of the plate; the next plates have only one much smaller primary tubercle on the outer part of the plate. The rest of the interambulacral plates is fairly covered by secondaries and miliaries; they are more closely packed in the plates above the primordial one. In the actinal system (Pl. 41, fig. *2*) there are seven rows of buccal plates well covered by an actinal row of secondaries with a few intercalated miliaries.

The large, primary radioles near the ambitus on the actinal side are slightly curved, and end with a shoe-shaped bevelled tip having a slightly curved edge (Pl. 45, figs. *16–18*). The radioles of the abactinal side are straight, somewhat pointed. The difference in the size of the primary radioles of the abactinal and actinal sides of the test near the ambitus becomes very apparent in specimens of 75 mm. (Pl. 31, figs. *1, 2*). In specimens of 120 mm. and over the contrast is still greater (Pls. 31, fig. *3*; 35; 36), and in those of 134 mm. fully as marked as in the largest specimens collected, 203 mm. in diameter (Pls. 37; 38).

The breaking up of the interambulacral and larger ambulacral plates can be seen in Plates 37 and 38. The general aspect of this breaking up is also shown in Plate 38 on the plates nearest the ambitus of the lower part of the figure. The splitting of the plates already occurs in specimens of 40 mm. (Pl. 30, fig. *8*), and is well seen in Plate 30 fig. *10* in the left interambulacral areas of a specimen 55 mm. in diameter. On Plate 32, fig. *1*, the breaking up of the plates of the odd and left posterior interambulacra, seen from the abactinal side, is very distinctly shown. In

[1] Mortensen, l. c. p. 174.

a view from the interior of the same interambulacra (Pl. 32, fig. *2*) the split and subdivided plates of the ambulacral area are specially marked. The subdivision of the interambulacral plates is better shown from the abactinal side (Pl. 32, fig. *1*), though it is very striking also in an interior view of the test of a specimen 110 mm. in diameter (Pl. 34, fig. *1*). The characteristic lapping of the interambulacral plates of the Echinothuriæ is well shown.

The breaking up of the plates of a part of the right posterior interambulacrum and the adjoining right posterior ambulacrum of a specimen 203 mm. in diameter is shown on Plate 45, figs. *13*, *14*. The outline of the original plates is still very distinct, while the interior of each of the larger plates is broken up into a number of smaller plates apparently without any regularity. In the actinal plates of the left anterior ambulacrum (Pl. 45, fig. *8*) the first trace of the breaking up of the ambulacral plates is shown from the exterior, and in Plate 45, fig. *9*, the same plates are seen from the interior.

In Plate 32, fig. *2* the reverse imbrication of the ambulacral plates is not as distinctly seen as in the interior view of a somewhat smaller specimen (Pl. 34, fig. *1*), which also shows the crowding past the auricles, under their arches, of the ambulacral plates as they pass over onto the actinal area. The same figures also show the imbrication of the plates of the actinal system, that is always best seen from the interior, where the regular tile-like arrangement of the successive rows of buccal plates is very prominent (Pls. 33, fig. *2*; 34, fig. *3*). Compare these figures to those of the actinal system seen from the exterior of the test (Pls. 33, fig. *1*; 34, fig. *2*).

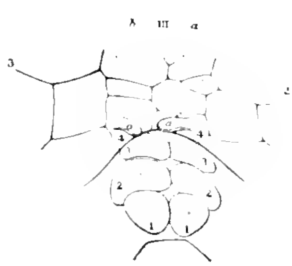
The extent of the imbrication of the buccal plates is shown on Plate 45, fig. *10*, which represents the successive actinal plates of the right zone of the odd ambulacrum. The oldest plate is at the bottom of the figure; the shaded and tuberculated parts of the figure represent the portion not covered by the lapping of the two younger plates above it.[1] The third and fourth plates are also figured from the opposite side; the youngest plate is shown from the interior and in profile (Pl. 45, fig. *11*), and one of the plates of the left zone of the left posterior ambulacrum is figured on Pl. 45, fig. *12*.

The primary tubercles near the ambitus are usually crenulated, and the scrobicular area is frequently slightly raised (Pl. 45, fig. *15*), the edge

[1] One of its own ambulacrum, the other of the one next to it.

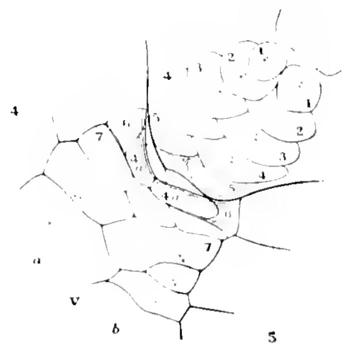
still showing the cellular structure of the outer part of the circle. The miliaries and secondaries also show this cellular structure. (Pl. 46, figs. *5–7*).

I have given a number of figures (Pls. 44; 45, figs. *1–6*) showing the first formed auricular knobs (Pl. 45, fig. *1*), Fig. 136, still well sepa-



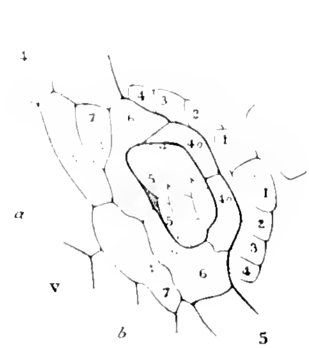
15 mm.

FIG. 136.



43 mm.

FIG. 137.

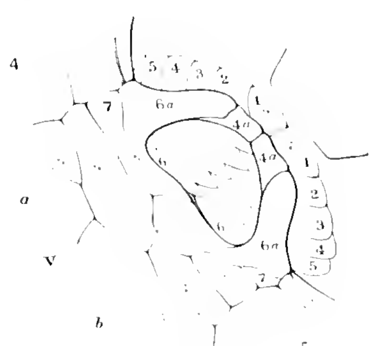


43 mm.

FIG. 138.

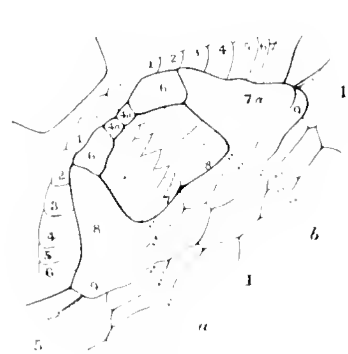
FIGS. 136–138. PHORMOSOMA HISPIDUM.

rated, with two ambulacral plates passed over onto the actinal system; next a somewhat older stage (Pl. 45, fig. *2*), in which the arch of the auricles has become closed, Figs. 137, 138, with five ambulacral plates beyond the auricles; and still older stages (Pl. 45, figs. *3–5*) showing the flow of the ambulacral plates, Figs. 139, 140, under the arch of the auricle,



69 mm

FIG. 139. PHORMOSOMA HISPIDUM.



137 mm.

FIG. 140. PHORMOSOMA HISPIDUM.

by the breaking up of the ambulacral plates into a median and exterior part, the median carrying the pores beyond the auricle; the outer part left behind is crowded against the base of the auricles (Pls. 44, fig. *3*; 45, figs. *5*, *6*). The suture of one of these plates can be seen at the base of the auricles (Pl. 45, figs. *4*, *5*). Seen from the exterior the crowding of the right anterior ambulacral plates is shown on Pl. 45, fig. *6*, and the corresponding view of the actinal plates of the left posterior ambulacrum on Pl. 45, fig. *7*.

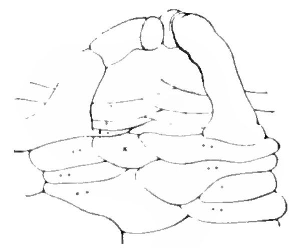
The auricles first appear on the fourth plate (Pl. 44, fig. *1*); the open gap between them has become closed in a specimen of 43 mm. (Pl. 44, fig. *2*), in which the auricles are now on the sixth pair. In a specimen of 64 mm. they are partly on the seventh and partly on the eighth pair, and in a

53 mm.

FIG. 141.

64 mm.

FIG. 142.



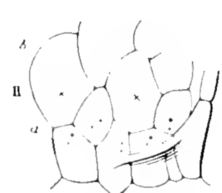
203 mm.

FIG. 143.

FIGS. 141–143. PHORMOSOMA HISPIDUM.

specimen of 137 mm. (Pl. 44, fig. *4*) they are on the ninth pair, except in the anterior zone of the right anterior ambulacrum, in the right zone of the odd ambulacrum, and in the posterior zone of the left posterior ambulacrum, where they are on the eighth pair. The movement of the ambulacral coronal plates cannot be better illustrated than by this difference, due to growth, in the position of the auricles, and by the difference in the size of the plates in front of and behind the auricles. From three to four plates of each ambulacrum have slipped under the auricle thus forming its component parts.

When passing onto the actinostome under or by the auricles, the inner part of some of the larger ambulacral plates is left behind; thus a plate without pores remains in the ambulacral series; it is marked with a cross on Figs. 141–144, taken from specimens of 53, 64, and 203 mm. in diameter, see also Fig. 129. From the part of that plate which borders the interambulacrum rises a ridge extending to the adjoining plates and uniting with the auricles, Fig. 144.



64 mm.

FIG. 144. PHORMOSOMA HISPIDUM.

Lovén[1] has described the changes taking place in the actinal plates of the ambulacra of *Asthenosoma varium* as they flow Cidaris-like onto the actinal system. It is probable that the absence of interradial buccal plates in the Echinothuriæ is due to the persistence of the primordial interambulacral plate; in Cidaridæ the primordial pair is resorbed[2] and the interambulacral zone comes under the same conditions as in the Echinidæ, where there is a constant flow of the coronal plates onto the actinal system more rapid in the ambulacral zone than in the interambulacral area, though it may often be difficult, if not impossible, to detect the formation of the minute actinal plates as coming from the disintegration of either the ambulacral or interambulacral areas.[3]

On Plate 33, fig. *3* is given an abactinal view of the pyramid of a *Phormosoma hispidum* 120 mm. in diameter, and on Pl. 46, fig. *1* that of a large specimen, 203 mm. in diameter, seen from the same point of view, with a slightly oblique view of the same (Pl. 46, fig. *3*) showing the position of the compass with reference to the auricles. The dental system of Asthenosoma has been figured and described by Lovén.[4] That of Phormosoma differs in some essential points from that of Asthenosoma. Seen in profile the pyramid of the former is more slender and drawn out at the actinal extremity (Pl. 47, figs. *1*, *3*). See Thomson, loc. cit. p. 735, Pl. LXIII.

Station 3362, east of Cocos Isd., 1175 fathoms. Lat. 5° 56′ N.; Long. 85° 10′ 30″ W. Bott. temp. 36°.8. Gn. M. S. rocky.

Station 3375, south of Malpelo Isd., 1201 fathoms. Lat. 2° 34′ N.; Long. 82° 29′ W. Bott. temp. 36°.6. Gy. glob. ooze.

Station 3376, south of Malpelo Isd., 1132 fathoms. Lat. 3° 9′ N.; Long. 82° 8′ W. Bott. temp. 36°.3. Gy. glob. ooze.

Station 3392, southwest of Cape Mala, 1270 fathoms. Lat. 7° 5′ 30″ N.; Long. 79° 40′ W. Bott. temp. 36°.4. Hard.

Station 3400, about 30 miles east of Chatham Isd., Galapagos, 1322 fathoms. Lat. 36′ S.; Long. 86° 46′ W. Bott. temp. 36°. Lt. gry. glob. ooze.

Station 3413, north of Culpepper Isd. Galapagos, 1360 fathoms. Lat. 2° 34′ N.; Long. 92° 6′ W. Bott. temp. 36°. Glob. ooze dk. sp.

Station 3431, off Altata, Gulf of Califa., 995 fathoms. Lat. 23° 59′ N.; Long. 108° 40′ W. Bott. temp. 37°. Lt. br. m. glob.

[1] Lovén, Echinologica, p. 26.
[2] Doederlein, Japanische Seeigel, p. 32, Pl. IX, fig. 6.
[3] Lovén, Echinologica, pp. 31–34, Pl. XII.
[4] Echinologica, pp. 52, 53, Fig. 4.

Station 3432, off Altata, 1421 fathoms. Lat. 24° 22′ 30″ N.; Long. 109° 3′ 20″ W. Bott. temp. 37°.8. Br. m. blk. sp.

Bathymetrical range, 995–1421 fathoms. Temperature range, 37°.8–36°.

Phormosoma panamense A. Ag.

Phormosoma panamense A. Ag., Bull. M. C. Z. 1898, XXXII. No. 5, p. 77.

Only three specimens of this species were collected, all in poor condition, measuring from 130 to about 160 mm. in diameter, having lost all but a few broken shafts of their spines. It, as well as its ally *Ph. tenue*, is noted for the great elongation of the abactinal plates of the test, much as in Asthenosoma, though they are not bordered by the bare spaces which leave a central limestone ridge in the interambulacral plates, so characteristic of Asthenosoma. The primary tubercles of the interambulacral plates are arranged in three or four vertical rows; the remainder of the plate is dotted with deeply sunken miliaries.

The apical system of a specimen 130 mm. in diameter is 25 mm. in diameter. The arrangement of the ambulacral pores recalls that of *Ph. luculentum*.[1]

Dr. Mortensen is distressed because I have as yet (1903) given no figures, nor complete information, regarding *Ph. panamense*, a species which is only mentioned in the Preliminary Report on the Echini of the "Albatross" Expedition of 1891,[2] and he finds it impossible to find a place for this species among his genera; he limits the genus Phormosoma to species with skin-covered spines. I have stated that I thought this character of no great systematic importance.[3] Dr. Mortensen[4] is of a contrary opinion.

The color of the fragments of the test which came up in the trawl were light pinkish brown. At the ambitus the width of the ambulacra is greater than that of the interambulacra. Comparing a specimen of this species of 130 mm. in diameter with one of *Ph. hispidum* 140 mm. in diameter, we find the interambulacral plates of the actinal side of the former quite thickly covered with miliaries, while in the latter the miliaries are quite scattered. There is also a line of six and eight primary tubercles with

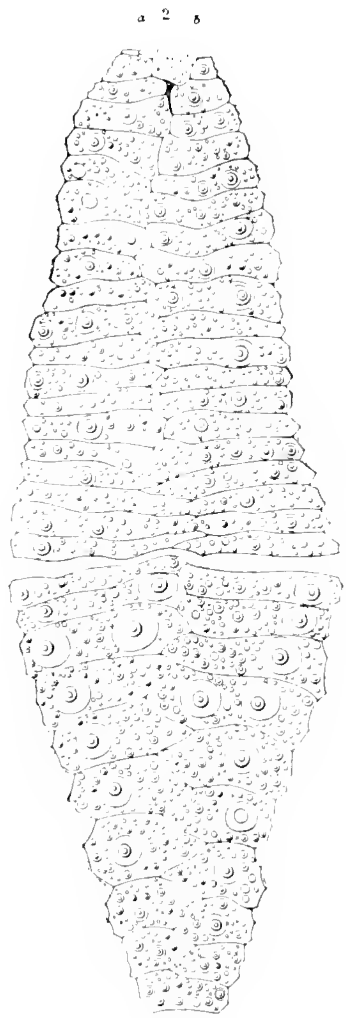
[1] "Challenger" Echinoidea, Pl. IX^a, fig. 2.

[2] Bull. M. C. Z. 1898, XXXII, p. 77.

[3] "Challenger" Echinoidea, p. 101.

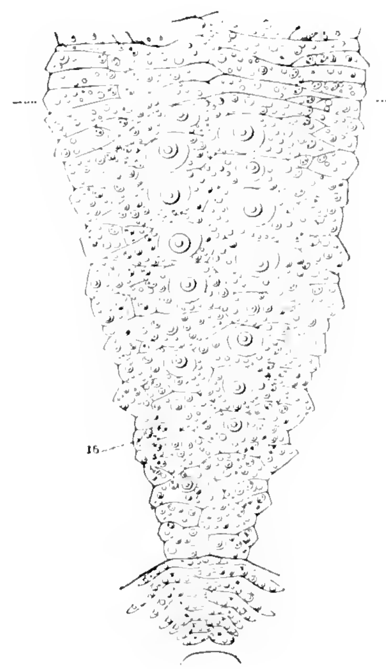
[4] Mortensen, loc. cit. p. 48.

large scrobicular areas on the outer edge of the plates in *Ph. panamense*, while there are but five and six in *Ph. hispidum*. A similar difference in the number of the miliaries exists on the abactinal side, Fig. 145. The interambulacral plates are also more elongated in *Ph. panamense;* there are nineteen and twenty plates from the ambitus to the abactinal system, having



140 mm.

FIG. 145. PHORMOSOMA PANAMENSE.



140 mm frgt.

FIG. 146. PHORMOSOMA PANAMENSE.

a primary tubercle with a small scrobicular area on alternate plates, and with a few secondaries near the outer and inner edges of the plates, while there are only fifteen and fourteen in a specimen of *Ph. hispidum* of 140 mm. In *Ph. hispidum* there are no large primaries on the abactinal side, but two to three large secondaries on each interambulacral plate.

On the actinal side the ambulacral area is marked for the large size of the outer poriferous plates, Fig. 146, which, towards the ambitus, exclude several of the larger ambulacral plates from the outer edge of the am-

FIG. 147. PHORMOSOMA PANAMENSE.

bulacral area. The small poriferous plates form a wedge-shaped area, while in *Ph. hispidum* these plates form an irregularly rectangular area. The row of large primary tubercles, with large scrobicular areas, consists of six and eight tubercles in *Ph. panamense*, while there are but three and five in

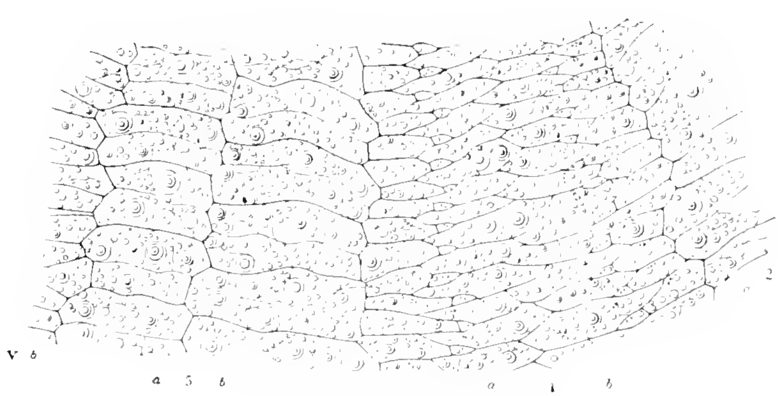


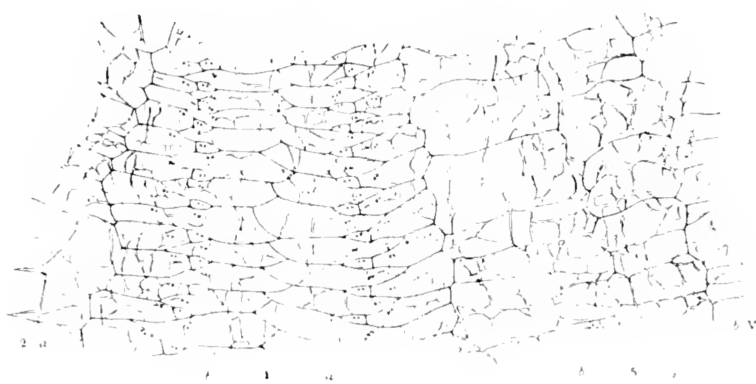
FIG. 148. PHORMOSOMA PANAMENSE.

Ph. hispidum. The miliaries are, as in the interambulacra, far more numerous on the actinal ambulacral plates of *Ph. panamense* than in *Ph. hispidum.*

The buccal plates of *Ph. panamense* are in striking contrast with those of *Ph. hispidum*; the former are narrow elongate, Fig. 147, as compared with the broad, high, ambulacral buccal plates of the latter.

Above the ambitus, Fig. 148, the greater number of the large ambulacral plates are excluded from the outer edge; this is formed by the larger of the smaller ambulacral plates. The inner poriferous plates are small, triangular, and separated by a tongue of the larger excluded primary ambulacral plate. In a *Ph. hispidum* of about the same size not more than five or six primary ambulacral plates above the ambitus are thus excluded from the outer edge; in *Ph. panamense* there are from nineteen to twenty.

There is no species of Phormosoma which shows to such an extent the splitting up of the primary plates both in the ambulacral and interambula-



130 mm

FIG. 149. PHORMOSOMA PANAMENSE.

cral areas. While this can be seen to a certain extent from the exterior by the fine irregular lines crossing the primary plates, in Fig. 148, in all directions, it is best seen from the interior, Fig. 149, where the secondary plates lap more or less and their edges are raised. The splitting up extends to the larger secondary ambulacral plates.

The abactinal system of *Ph. panamense*, Fig. 150, is marked for the elongated outline of the ocular plates, which in *Ph. hispidum* are quite pentagonal. The genital plates are also smaller than those of *Ph. hispidum*, and the genital pore is placed in the upper part of a narrow membraneous slit which separates the second or third interambulacral plates. The madreporic genital exceeds greatly in size the other genitals, and the madreporite extends over two of the adjoining anal plates.

There are from three to four concentric rows of small polygonal anal plates carrying from one to two miliaries according to the size of the plates.

The genitals and oculars as well as the large outer anal plates carry small secondaries.

Station 3374. southwest of Malpelo. 1823 fathoms. Lat. 2° 35′ N.; Long. 83° 53′ W. Bott. temp. 36°.4. Green ooze.

130 mm

Fig. 150. Phormosoma panamense.

Phormosoma zealandiæ A. Ag.

Asthenosoma gracile A. Ag. (pars) "Challenger" Echinoidea, p. 89.

Plate 51, figs. 1–4.

In the "Challenger" Echinoidea [1] when describing *A. gracile*, of which there was only a single large specimen, I expressed considerable doubt regarding the determination as *A. gracile* of certain small specimens collected by the Expedition at Stations 184, 219. Having made that statement, I am taken to task by Dr. Mortensen [2] for having made a statement in one place and not having repeated it somewhere else; "this way of proceeding is very objectionable."

Dr. Mortensen thinks that the pedicellariæ can be described in terms of a different degree of precision from those which his predecessors have

[1] "Challenger" Echinoidea, p. 89. [2] Mortensen, l. c. p. 52.

employed in describing the "pores, spines, tubercles, the mouth slits, the lining of the buccal membrane with larger or smaller plates, and the calycinal area. . . . But most frequently they (these structures) are so relative that it is exceedingly difficult or impossible by means of these structures to decide whether a specimen in hand belongs to one species or another. . . . It may be simply irritating to read the descriptions of these in different species that are to be compared." To remedy this uncertainty, Dr. Mortensen planned what he modestly calls "a profound and careful attempt at penetrating into the mysteries of the relationship of the Echinoids," based upon a study of the pedicellariæ.

It is undoubtedly true that nearly all the characters which have been employed to distinguish species vary with age, and the same is the case with pedicellariæ. They form no exception, and do not appear fully fledged in the embryos and young specimens, in spite of Dr. Mortensen's statement to the contrary; though he acknowledges[1] that "there is in literature next to no more exact accounts of the development of the pedicellariæ of Echinoids."

Certainly before making such a sweeping use of the minute and often infinitesimal characters supplied by pedicellariæ for classification, it would have been instructive to trace the development of the several kinds of pedicellariæ, and obtain some data regarding the extent and nature of the variation of pedicellariæ during their growth. The only addition made by Dr. Mortensen to our knowledge of the development of pedicellariæ is shown on Figs. 15, 24, 30, Pl. XII, of the "Ingolf" Echinoidea, giving three stages of a triphyllous pedicellaria of *Phormosoma placenta.* As long as we know so little regarding the nature of the relations of the large and the small pedicellariæ of the same kind to one another, it seems useless to speculate "on the improbability . . . of the rearrangements" which must "take place in the calcareous mass to make a small fully formed pedicellaria become a larger one." Every student of Echini is fully aware of the immense amount of resorption and rearrangement constantly taking place in the actinal and abactinal parts of the coronal plates, in the interambulacral areas, and in the actinal and abactinal systems — changes that are far greater than those referred to above can be.

No one has ever questioned that it is desirable to employ in the definition of systematic characters all the data possible from whatever source, which

[1] Mortensen, l. c., p. 5.

may throw any light on the subject. But we cannot expect this to be done at once. The demands of modern systematists must of necessity be met gradually, and one's predecessors are not to be unhesitatingly condemned because they have not included in their work some more modern point of view.

The study of pedicellariæ has only added a new factor differing in no way in its potentiality from those formerly in use. I may quote again from Dr. Mortensen:[1] "When no pronounced difference is found between large and small pedicellariæ, it may in fact be impossible to decide whether a certain specimen is to be regarded as a large or a small form." Surely this acknowledgment that the pedicellariæ cannot be classified may throw some doubt on the statement that "the pedicellariæ give absolutely excellent systematic characters."

Dr. Mortensen recognizes only such affinities as are indicated by the structure of the pedicellariæ. Affinities indicated by other structural features have little or no interest for him, or are entirely erroneous. It will be a great saving hereafter if illustrations of Echini are limited, as he would have us limit them, to figures of pedicellariæ.

Dr. Mortensen says,[2] "even if the structure of the tests were identical, we cannot be warranted in classing them together; for, as has constantly been shown by these examinations, identical structure of the test is no proof of near relationship." We are perfectly justified in retorting that similarity of the pedicellariæ is no proof of relationship as shown by the structure of the test, and we are not warranted in classifying together forms which agree only in the structure of the pedicellariæ, and differ in the structure of the test.

Dr. Mortensen[3] does not fail to perceive that pedicellariæ are not likely to be of frequent use in the determination of fossil forms, and for that reason condemns the classification of all fossil forms, and, in passing, of the Irregular Echinoids. It certainly would be most valuable to be able to determine fossil Echinoids with all the data available for their modern representatives, for the present we must be satisfied to acknowledge the limitations of our work. Even among the living Echinoids we have not as yet a monographic description of the principal types of the Desmosticha and Petalosticha, to which we may refer the many new species which have been described from the collections of recent deep-sea explorations. There is still

[1] Mortensen, l. c. p. 9. [2] Mortensen, l. c. p. 85. [3] Mortensen, l. c. p. 8.

in many directions an immense amount of work to be completed before we have a trustworthy guide to the classification of the Echini.

Among the specimens left at Cambridge, I had occasion to examine a specimen (*A. gracile?*) from "Challenger" Station 169, and am able to give some details and figures of this specimen, plainly showing that it is not an Asthenosoma, but a new species of Phormosoma allied to *Ph. hispidum*. This specimen measured 24 mm. in diameter, the actinal system 9 mm., and the abactinal 7 mm., with thirteen primary interambulacral plates, five on the actinal side of the ambitus.

The actinal system (Pl. 51, fig. 1) is characterized by the depth of the gill cuts, which are usually barely indicated in many of the Echinothuriæ. There are three and four rows of large actinal plates occupying the whole of the actinal system. The ten primitive buccal plates are more or less elliptical with two to three small secondaries along the actinal edge of the plates, with a couple of minute miliaries adjoining the pores. The primordial interambulacral plate is large, with a projecting lip, on each side of which, adjoining the ambulacra, are the gill cuts; the primordial plates carry from two to three small primary tubercles with the same number of miliaries crowded together in the centre of the actinal part.

In the abactinal system (Pl. 51, fig. 2) the proportion of the ocular plates to the genitals is much like that in specimens of *Ph. hispidum* of the same size (Pl. 40, fig. 2). The ocular plates extend somewhat lower along the corona than do the genitals, and the anal plates have only separated the odd posterior genital from the left posterior ocular. The genitals are elongate, pentagonal, the madreporic somewhat larger than the others. None of them are as yet pierced by genital openings. They carry in the center of the plate two or three secondary tubercles irregularly placed, while on the oculars, two or three secondaries, with one or two miliaries, are arranged vertically along the central line.

The anal system is pentagonal and covered with four or five irregular rows of plates. The larger outer rows are more or less rectangular. The miliary and secondary tuberculation of the ambulacra is coarser than in *Ph. hispidum* (Pl. 51, fig. 3), the scrobicular area of the actinal primaries of this small specimen already occupying the whole height of the plate. The greatest width of the ambulacral area is below the ambitus.

For the sake of a ready comparison of the ambulacra of a Phormosoma and of an Asthenosoma, I have given on Plate 51 figures of *Asthenosoma pellucidum* and of *Ph. zealandiæ*.

Phormosoma placenta Wyv. Thom.

Phormosoma placenta Wyv. Thom., Trans. R. S. London, Vol. 164, Part 2, 1874, p. 719.

Plate 43, figs. *1–4*; figs. *1–2*, "Blake" Station 150, off Nevis, 375 fathoms; figs. *3–4*, "Blake" Station 29, off the Tortugas, 955 fathoms.

Plate 48, fig. *1*, "Blake" Station 150.

In a young *Phormosoma placenta* 7 mm. in diameter (Pl. 43, fig. *2*) the genital ring is composed of pentagonal genital plates, the madreporite genital and the left anterior are somewhat larger than the others and carry from one to three large miliaries; the madreporic body can barely be detected.

The ocular plates are hexagonal, they extend between the interambulacral zones to the level of the second abactinal plate; they project much less along the coronal plates than they do in a somewhat older stage (Pl. 43, fig. *4*), 9 mm. in diameter, in which the proportions between the oculars and genitals, joined on smaller sides, are similar to those of a somewhat older stage of *Phormosoma hispidum* (Pl. 40, fig. *1*). The anal system of each of these stages (Pl. 43, figs. *2, 3*) is pentagonal and covered with rows of plates very irregular in size and shape.

The actinal system of the specimen 7 mm. in diameter is marked for the great size and elongated shape of the ten original buccal plates at a time when there are only three rows of actinal plates. The great depth of the primordial plate is also characteristic as compared with that of stages of other species only slightly older (Pl. 43, fig. *5*). In a somewhat older stage the first row of buccal plates has lost its great preponderance (Pl. 43, fig. *3*), and the second row is now by far the most prominent. On the same figure a number of spheridia are figured both on the ambulacral and actinal plates.

In the young specimen of *Ph. placenta* of 7 mm. there are eight interambulacral plates (Pl. 48, fig. *1*). All the ambulacral plates reach the interambulacral edge. On the actinal side all the primary plates, except one, reach the median line, while on the abactinal side the second and third component plates occupy but a small angle in the first primary plate, until we come to the primary abactinal plates of the ambulacrum where they again all reach the median interambulacral line.

Young specimens of 9 mm. carry spheridia on the second buccal plate (Pl. 43, fig. *3*). Spheridia are usually found on the actinal coronal plates in *Ph. placenta;* in an *Asthenosoma pellucidum* of 34 mm. we find spheridia on the ambulacral plates in process of passing over to the actinal system (Pl. 51, fig. *5*). In addition, on the actinal surface nearly to the ambitus the half plates all carry spheridia (Pl. 51, fig. *7*). In *Asthenosoma coriaceum* spheridia are found nearly up to the ocular plate on the posterior zone of the left posterior ambulacrum (Pl. 52, fig. *1*).

KAMPTOSOMA Mort.

Kamptosoma Mortensen, The Danish "Ingolf" Expedition. Echinoidea, Part 1., p. 60, 1903.

A few specimens of Echini collected by the "Challenger," were left in Cambridge, and were not returned to Sir Wyville Thomson with the rest of the collection, owing to my ill health and the death of Count Pourtalès. Among them was a specimen labelled "*Ph. tenue?*" from Station 272.[1] The peculiar features presented by this specimen led me to examine it again. I soon discovered that it differed greatly from *Phormosoma tenue*, and that it, as well as *Ph. asterias*, should form a new genus of Echinothuriæ. I came to this conclusion in 1898, at the time I was writing the Preliminary Report of the Echini of the "Albatross" Expedition of 1891; at that time the sketch notes, which have since been drawn out carefully by Mr. Westergren, were made (Pl. 50). In 1903 Dr. Mortensen published the results of an examination he made of another specimen of *Ph. tenue?* from the same locality, and called attention to the interesting structure of the ambulacral system of *Ph. tenue* and of *Ph. asterias*,[2] and proposed for these two species the genus *Kamptosoma*.

Kamptosoma indistinctum A. Ag.

Phormosoma tenue A. Ag. pars., "Challenger" Echinoidea, 1881, p. 91.

Plate 50.

In a specimen of 42 mm. in diameter, from "Challenger" Station 272, the actinal system (Pl. 50 fig. *1*), measured 9 mm. in diameter, and the abactinal system 12 mm. In no genus of Echinothuriæ is the contrast

[1] In 2600 fathoms, in Lat. 3° 18′ S. and Long. 152° 56′ W., east of Malden Isd.; bott. temp. 1° C.
[2] "Challenger" Station 299. On the way to Valparaiso from Juan Fernandez, in 2160 fathoms.

between the actinal and abactinal sides so marked. In the ambulacral area, from the actinostome to the ambitus (Pl. 50, fig. *3*) the primary plates, ten in number, are irregular in outline, quadrangular, pentagonal, becoming somewhat elongated towards the ambitus, with two wedge-shaped poriferous plates between the second and third and the fourth and fifth plates on one side, and between the fourth and fifth and sixth and seventh on the other side. Between the seventh and the eighth and ninth, small perforated lozenge-shaped plates appear near the interambulacral edge; these tend towards the centre of the two rows of elongated plates[1] which extend from the ambitus towards the ocular plates, becoming gradually higher as they approach it (Pl. 50, fig. *3*). There we find a series of pairs of small plates each with a single pore, as have all the primaries and secondaries except the four primary actinal plates, which have two disconnected pores (Pl. 50, figs. *1*, *3*). As the plates increase in number these pairs of small plates are forced down at the junction of two primary plates, Fig. 151, the larger of the small plates finally occupying the central part of the division line between the large ambulacral plates; the smaller plate is pushed into the adjoining primary, and its outline is lost between the fourth and fifth plates, to become the single pore of the larger elongated primary plates. The position of the wedge-shaped poriferous plates on the actinal side would seem to indicate that the small persistent poriferous plate of the abactinal side is in its turn, with one or two exceptions, sloughed off and resorbed on the actinal side. In a specimen of this size, 42 mm., there are a large number of primary interambulacral plates, — no less than eight from the actinal system to the ambitus, and nine on the abactinal side (Pl. 50, fig. *3*). On the actinal side the primary ambulacral plates carry only one or two secondaries with a few miliaries irregularly placed. As the plates elongate, and for four plates beyond the ambitus, they carry three to four secondaries arranged in a horizontal row parallel to the sutures, with one or two intercalated miliaries. As the plates become higher nearer the ocular they carry only one or two secondaries and as many miliaries.

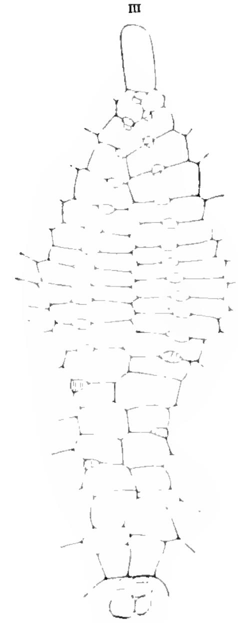


FIG. 151. KAMPTOSOMA.

[1] Wholly different in shape from any other ambulacral plates in Echinothuriæ.

Seen from the interior (Pl. 50, fig. *5*), the ambulacral tube gives off one branch to each plate, which evidently terminates in a blind sac, as no trace of its pore can be seen from the exterior.

The point of disappearance of the second small plate is shown on Plate 50, fig. *4*,[1] where the two small plates are shown at the suture of the lowest plates, while in the older plates the outline of the second small plate has disappeared, and its pore alone is left close to the poriferous plate, gradually to move in older plates to a more central position (Pl. 50, fig. *3*) with the extension of the poriferous plate along the suture. This figure also shows the tentacle of the lozenge-shaped poriferous plate. A number of spheridia are shown on Plate 50, figs. *1*, *3* at various points of the ambulacral area.

The exclusion of the young abactinal ambulacral plates from the outer edge of their respective ambulacral zones is quite unknown in the regular Echinidæ, and forms a marked exception in Kamptosoma, where the new embryonic half-plates originate along the median ambulacral line and are at once pushed along the middle part of the principal ambulacral plates (Pl. 50, fig. *3*). The large ambulacral plates are imperforate (Pl. 50, fig. *3*) when seen from the exterior, when examined from the interior the main ambulacral tube is seen to send a branch to each of the larger primary plates, but it ends in a blind extremity and does not pass through the large plates.

On the actinal side the fifth or sixth pair of interambulacral plates carry two primary tubercles; on the abactinal side these plates carry secondary tubercles, grouped by twos, three to four to each plate, half way to the ocular plate.

The actinal system measures only 9 mm.; it is smaller compared to the size of the test than in other Echinothurids (Pl. 50, fig. *1*), and has retained the embryonic feature of having the ten primitive bare buccal plates entirely out of proportion to the size of the second row of actinal plates and occupying the greater part of the actinal system,[2] with the exception of the narrow belt in which is placed the second row of actinal plates, as well as the minute irregular elongate calcareous plates which separate it from the ten original plates.

In this species, as in older stages of *Ph. hispidum*, we find a few of the same irregular elongate interambulacral plates which in the Cidaridæ are

[1] The lower plates are the abactinal plates.

[2] As in *Ph. placenta* (Pl. 13, fig. *7*).

as well and as regularly developed as the ambulacral buccal plates. The structure of the actinal system is essentially Echinid. The primordial interambulacral plates are large for the size of the test (Pl. 50, fig. *1*). From the irregularity and great size of the actinal ambulacral plates it is difficult to trace the limits of these areas. The actinal plates of both systems are fairly well covered by prominent secondaries placed close together (Pl. 50, fig. *1*). Between many of the plates linear or polygonal spaces are left bare; this adds greatly to the apparent irregularity of their arrangement.

The abactinal system measures 12 mm. in diameter (Pl. 50, fig. *2*). The anal system is irregularly polygonal, and is characterized by the small number of its comparatively large, widely separated, and disconnected plates, several of which are nearly as large as the smaller genital plates, and carry one to two miliaries. It would seem as if some of the anal plates were derived from the breaking up of the anal edge of the genital plates. The ocular plates (Pl. 50, figs. *2*, *3*) are remarkable for their great elongation, they are practically rectangular, carrying an accumulation of miliaries near the anal extremity. They are widely separated from their adjoining genitals by two to three intercalated anal plates, and also separated by bare spaces; with the exception of the two young interambulacral plates adjoining the odd anterior ocular and the right posterior, it would be difficult to distinguish the more recently formed interambulacral plates from the intercalated anal plates of the other areas. The madreporic genital is somewhat heart-shaped, well developed, with a small genital opening. The other genitals are small, irregular in shape, either triangular or even rectangular.

ASTHENOSOMA Grube.

Asthenosoma pellucidum A. Ag.

Asthenosoma pellucida A. Ag. 1879, Proc. Am. Acad. Vol. XIV, p. 200.

Asthenosoma pellucidum A. Ag., "Challenger" Echinoidea, p. 85, 1881.

Plate 51, figs. *5–13*.

In a small specimen of *A. pellucidum* from "Challenger" Station 192, 34 mm. in diameter, the actinal system measured 9.5 mm. and the abactinal 9 mm. The smaller specimens of this species are interesting as showing, with the increase in size, the gradual extension from the actinal system towards the ambitus of the bare spaces separating the interambulacral plates (Pl. 51, figs. *5, 7*), while on the abactinal side the calcified parts of the coronal plates are still united along the whole length of the sutures (Pl. 51, figs. *6, 7*). In this specimen there are five and six rows of actinal plates (Pl. 51, fig. *5*), leaving a narrow bare belt next to the coronal plates partly filled in the interambulacral area with small very narrow elongate calcareous plates. The buccal plates are edged with a horizontal actinal row of from three to five large miliaries. The primordial interambulacral plates have already been somewhat reduced in size by the resorption of their actinal edge (Pl. 51, fig. *5*). A number of spheridia are shown on the actinal surface of the ambulacra.

In the genital ring the genital plates are polygonal, larger than the oculars (Pl. 51, fig. *6*), which are more elongate toward the anal system; their distal extremity narrows to a rectangular outline; it extends no farther along the interambulacral plates than do the genitals. The madreporic genital is larger than the others, the madreporite occupies a part of the centre of the plate; the madreporic and the odd posterior genital are perforated by a large genital pore. The plates of the genital ring are nearly bare; they carry only one small secondary and one to two small miliaries placed in the anal part of the plates. The anal system is polygonal, with one outer row of well marked larger plates of irregular shape enclosing an inner space filled with much smaller elongate plates. The larger plates carry a single secondary or miliary tubercle and sometimes a second smaller miliary. The genital ring is closed.

In this specimen there are nine interambulacral plates between the actinal system and the ambitus and twelve between it and the genital ring (Pl. 51, fig. *7*). The abactinal part of the ambulacral zone (Pl. 51, figs. *7, 13*) clearly shows the small primary ambulacral plates adjoining the oculars, their crowding from the outer edge of the second and third pair of pores toward the median line (Pl. 51, figs. *12, 13*), and finally their exclusion from the outer edge (Pl. 51, figs. *10, 11*) in the third or fourth plate above the ambitus, and their position inside of the pores of the large primary plate, until near the actinal system the pairs of pores again reach the outer edge (Pl. 51, fig. *9*).

The tentacles at the coronal edge of the actinal system have no well developed disk. The tuberculation of the plates of the ambulacral system is quite prominent on the two sides of the test near the ambitus, where the primary plates carry along the central line a horizontal row of three to five prominent secondary tubercles with an occasional intercalated miliary. Towards both the abactinal and actinal extremities the secondary tubercles gradually decrease in number, as well as in prominence, leaving the median part of the plates of the ambulacral zone bare of tubercles and miliaries.

Asthenosoma coriaceum A. Ag.

Asthenosoma coriaceum A. Ag. 1879, Proc. Am. Acad. Vol. XIV, p. 201.
Asthenosoma coriaceum A. Ag. 1881, "Challenger" Echinoidea, p. 88.

Plate 52.

As there is no very detailed figure of the abactinal system of an Asthenosoma, I have given on Pl. 52, fig. *1*, a figure of the abactinal system and adjoining coronal plates of *A. coriaceum* from a "Challenger" specimen (fragment from 310 to 315 fathoms, "Challenger" Station 173, off the Fiji islands) of 125 mm. in diameter. The abactinal specimen measured 38 mm.

In none of the Echinothuriæ I have examined are the plates of the abactinal system so greatly subdivided as in *A. coriaceum.* The ocular plates alone are readily isolated; they are crescent-shaped with truncated horns, the ambulacral system entering deeply into the crescent of the plate. The ocular plates vary considerably in size; the odd anterior ocular, the largest, is nearly twice as large as the smallest ocular, — the right posterior. The oculars and genitals are separated by anal plates with the exception of the madreporic genital, which is connected with the adjoining oculars, and the right posterior one, which has a point of contact with the odd posterior genital. The genitals are triangular, longer than broad, extending in the median line to the third interambulacral plate. The position of the genital opening also varies considerably. In the odd posterior genital it is in a bare space near the anal base of the plate; in the madreporic genital, at the very tip of the genital plate and in the others, in a bare space in the distal part of the plate (Pl. 52, fig. *1*). All the genital plates are greatly broken up into distinct plates — so much so that it is impracticable to distinguish the original anal plates from those which may have been split off from the anal edge of the genitals (Pl. 52, fig. *1*). The genital openings all open in a small bare part of the genital plate; here and there we also find small bare spaces between the sutures of the anal plates. The anal opening is large, a funnel-like projection of a thick skin, the edges strengthened by long narrow slender plates, followed by an irregular second row of larger elongated plates, and then by two to three rows of most irregularly arranged polygonal plates covered with distinct small secondaries and miliaries.

The madreporite occupies four plates. It is difficult to say if the two outer plates belong to the genital plate, or are anal plates which have forced their way between the adjoining oculars and the right anterior genital. The plates of the genital ring are comparatively bare. The oculars carry but one or two small secondaries with four or five small miliaries. On the component plates of the genitals the tuberculation is somewhat closer, but a great part of the plates is also bare.

The interambulacral plates become quite early separated by a bare horizontal belt free from calcareous tissue. In the odd posterior interambulacrum (Pl. 52, fig. *1*) the first, second, and third of the abactinal interambulacral plates are connected along the whole length of the horizontal suture, the third and fourth plates are slightly separated by a bare space, while between the next plates the calcified part of plates occupies already the proportions of the interambulacral area of older plates near the ambitus.

A part of the abactinal system,[1] when seen from the interior of the test (Pl. 52, fig. *2*), shows the extraordinary splitting up of the calcareous plates into ossicles almost like those of the abactinal surface of starfishes, not only of the interambulacral but to a certain extent of the ambulacral area, as also of the anal plates, of the genitals and oculars. The extent to which the interambulacral ossicles overlap laterally with the ambulacral ones is well seen on Plate 52, figs. *3*, *4*, taken not far from the ocular plate; fig. *3* showing this overlapping as seen from the exterior, and fig. *4* from the interior. The dermal membrane separating longitudinally the interambulacral and ambulacral plates is shown in Plate 52, fig. *2*.

The interambulacral plates are made up of a series of short joints, from five to six in the larger plates, and the confusion arising from this breaking up and the forcing of the anal plates through the median line of the interambulacral system is well seen in Plate 52, fig. *2*, in the space between the oculars and genitals, — a confusion of plates which is even worse than when

[1] The right posterior ocular and genital.

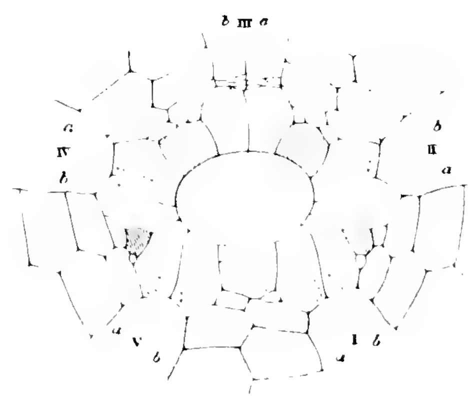
they are examined on the abactinal side (Pl. 52, fig. *1*). The intrusion or flow of the anal plates into the interambulacral system of the Echinothuriæ is well illustrated in *A. coriaceum*. Though this seems so absurd to Dr. Mortensen, yet Lovén[1] has suggested something of the same kind as possible when comparing a Collyrites to a Culcita-like starfish.

PETALOSTICHA Haeckel.

CASSIDULIDÆ Agass.

NUCLEOLIDÆ Agass.

Among the Cassidulidæ the primordial plates are actinal in Echinolampas, (Pl. 65, fig. *2*), Fig. 155, Rhynchopygus,[2] and Neolampas (Pl. 64, fig. *6*) Fig. 156; they are only partly so in Echinonëus, where, perhaps owing to the obliquity of the test, the primordials have been pushed to one side in the right anterior and the left posterior interambulacrum. In Conolampas[3] (Pl. 65, fig. *6*), the primordial plates in the posterior lateral interambulacra, Fig. 152, are excluded from the actinal system by the intrusion in front of them of the actinal plates of the lateral posterior ambulacra. These leave visible but a small triangular slice of the primordial plates in the angle of the adjoining ambulacral plates. The other interambulacral areas are also much disturbed at the actinal system from the crowding of the primordial plates by the coronal plates, which tend to be resorbed and to pass into the



30 mm.

FIG. 152. CONOLAMPAS SIGSBEI.

[1] Lovén, Échinoidées, p. 85.

[2] Lovén, Études, Pls. VII, fig. 67; XXII, fig. 179.

[3] In the list of known species of Echini given in the Report on the "Challenger" Echinoidea (p. 217), I retained the original name *Conoclypus Sigsbei* given to this remarkable Cassiduloid in the Preliminary Report of the "Blake" Echini (Bull. M. C. Z. V, No. 9, pp. 187, 190). In the Report on the "Blake" Echini (Mem. M. C. Z. X, No. 1, p. 18) I suggested the name Conolampas for this species, and gave my reasons for it. Loriol (Catal. Rais. des Échinod. de l'Isle Maurice. Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève, XXVIII, No. 8, p. 41, 1883) says that *Conoclypus Sigsbei* is an Echinolampas. Surely the details I have given in the "Blake" Report and the additional figures here given do not warrant such an association, even though it may be difficult in the very youngest stages to distinguish the young of Echinolampas and of Conolampas.

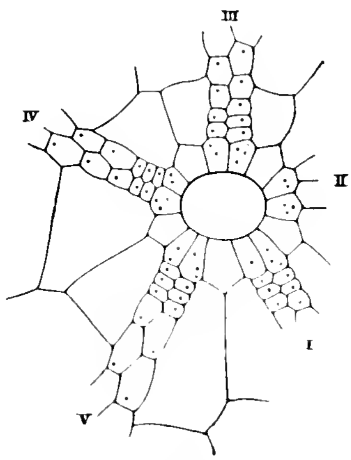
primordials and form part of the ridge surrounding the actinal system (Pl. 65, fig. *6*), a rudimentary auricle perhaps, which is greatly developed in some fossil species of the group, and has led to the supposition that they might be provided with teeth.

This crowding results in part from the exclusion of the posterior lateral primordial plates from the actinostome by the adjoining posterior lateral ambulacral plates in Conolampas (Pl. 65, fig. *6*), thus forming a striking contrast to the arrangement of the primordial plates in Echinolampas (Pl. 65, fig. *2*). In Echinolampas the bourrelets are less crowded with tubercles.

The extent of the crowding of the actinal plates by the coronal plates is well seen from the great height of the actinal ambulacral plates and the disappearance of the pairs of pores of the older plates and the great irregularity of the ambulacral plates (Pl. 65, fig. *6*), which have been twisted and pushed out of place and broken into numerous intermediate plates by this great thrust. The irregularity of the phyllodes thus formed in Conolampas is very apparent when seen from the exterior; the pores are placed in all possible positions (Pl. 65, fig. *5*), only forming most irregular pairs of lanceolate lines which extend towards the ambitus until the ambulacra again assume their normal structure.

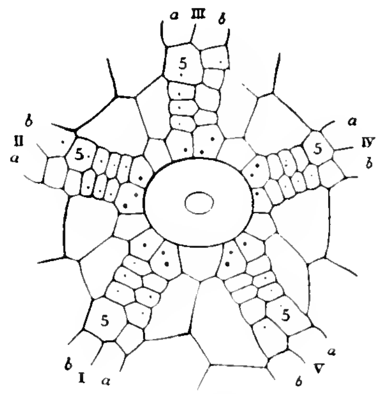
This irregularity is less pronounced in Echinolampas, as can be seen (Pl. 65, figs. *1*, *2*) from the more distant position of the pores and the comparative regularity in the ambulacral plates even at the phyllodes. The greater crowding of the coronal plates in Conolampas (Pl. 65, fig. *6*) is also accompanied by the greater development of the bourrelets and the dense packing of the secondary tubercles on the actinal face of the primordial plates; in Neolampas (Pl. 64, fig. *6*) the bourrelets are practically in an embryonic stage, being only slightly accentuated by the packing of the secondary tubercles on the primordial plates and by the formation of very rudimentary phyllodes which do not extend further than to the fourth ambulacral plate, while in Echinolampas, in a specimen of 50 mm. they extend to the sixteenth or seventeenth plate, and in a Conolampas of 90 mm. they extend as far as the fortieth ambulacral plate. In *Rhynchopygus pacificus* the oldest actinal ambulacral plates are quite large and have only one pair of pores.

In a young specimen of Echinolampas of 4 mm. (Pl. 64, figs. *2*, *3*) the actinal ambulacral plates have only two pairs of pores, and are formed by the ankylosis of the two oldest of the ambulacral plates; a trace of the original suture is still visible in Fig. *3*, Plate 64; even in this young stage the effect of the thrust of the coronal plates on the actinal plates is visible in the low ridge surrounding the actinal system (Pl. 64, fig. *2*).



inside.

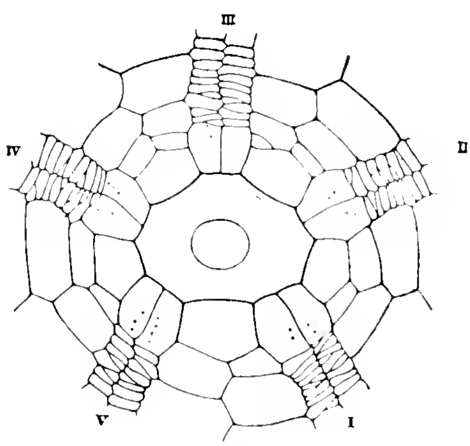
FIG. 153. RHYNCHOPYGUS CARIBÆARUM.



outside.

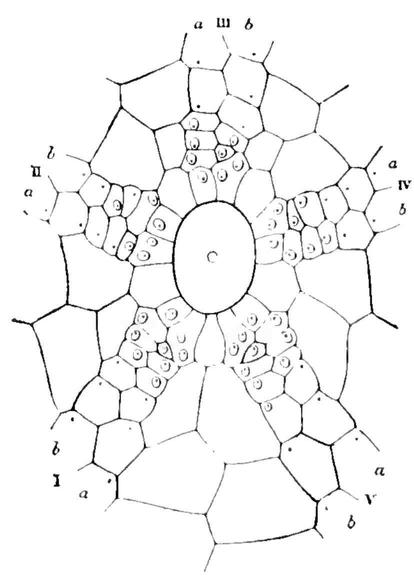
FIG. 154. RHYNCH CARIBÆARUM. AFTER LOVÉN.

In Rhynchopygus, Figs. 153, 154, the primordial plates are all actinal, but elongate and much narrower than in Echinolampas, Fig. 155. In Neolampas, Fig. 156, the primordial plate of the odd ambulacrum is still more drawn out by the crowding of the adjoining plates of the posterior lateral ambulacra.



50 mm.

FIG. 155. ECHINOLAMPAS DEPRESSA.



10 mm.

FIG. 156. NEOLAMPAS ROSTELLATA.

The abactinal systems of Echinolampas, Conolampas, Neolampas, Rhynchopygus, and Echinonëus are very similar. The genital openings in all encroach largely upon the abactinal plates of the interambulacral areas, Figs. 157, 158 (Pls. 64, figs. *7, 8*; 65, figs. *4, 7*), and all have a stone canal occupying the greater part of the single central plate of the abactinal system, in which no trace of the separate genitals can be detected. Neolampas (Pl. 64, figs. *7, 8*) has but three genital pores; the left anterior one is atrophied, Fig. 157. In a young Echinolampas of 4 mm. the central apical plate is well defined when seen from the exterior. The madreporic body is already slightly indicated (Pl. 64, fig. *5*), but there are no traces as yet of any genitals. The stone canal is prominent (Pl. 64, fig. *4*) seen from the interior of the test.

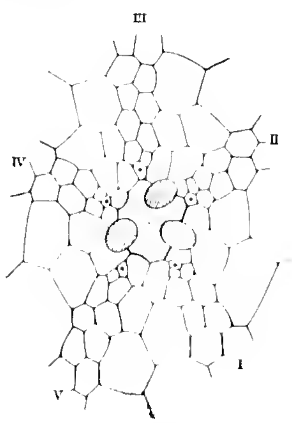


FIG. 157. NEOLAMPAS ROSTELLATA.

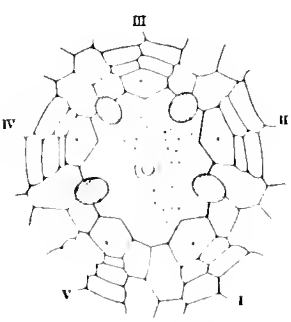


FIG. 158. CASSIDULUS EUGENIÆ. AFTER LOVÉN.

The ocular pores in all the Cassidulids are prominent, and the ocular plates sharply defined (Pls. 64, fig. *7*; 65, fig. *7*). In Neolampas (Pl. 64, fig. *6*) there are clusters of four or five spheridia in the ambulacra near the actinal system. In a young Echinolampas of 4 mm. (Pl. 64, fig. *3*) there was only one on the second row of ambulacral plates. In Neolampas the spheridia stand out freely from the test, while in Rhynchopygus they are placed in cavities. The abactinal ambulacral plates in this young stage (Pl. 64, figs. *4, 5*) have but one pore, as in Neolampas (Pl. 64, figs. *7, 8*), and not the double pores characteristic of the older Echinolampas (Pl. 65, fig. *4*) of Conolampas (Pl. 65, fig. *7*), and Echinonëus.

The membrane of the actinal system of Neolampas and of Echinolampas is packed with minute calcareous plates of nearly uniform size. The actinal system of Neolampas is longitudinally elliptical (Pl. 64, fig. *6*), while that of Echinolampas, Rhynchopygus, and Conolampas is transverse (Pls. 64, fig. *2*; 65, figs. *2, 6*); Figs. 153–156.

In Echinolampas (Pl. 64, fig. *5*) and Conolampas the central plate of the apical system rises like a button above the general level of the test, it is thickly covered with small tubercles, many of which are glassy as in Echinonëus.

The ambulacra of Neolampas show the first trace of the wedging of the ambulacral plates (Pl. 64, fig. *6*), one plate in each ambulacrum only, which is carried to such an extreme in Conolampas, Rhynchopygus, and Echinolampas as to obliterate the primitive regular arrangement of the ambulacral plates as it still exists in Neolampas and in the young of Rhynchopygus.[1] The smaller wedge-shaped plate is the only indication of a phyllodic expansion, as in Rhynchopygus,[2] while in Echinolampas the ambulacra are not thus expanded (Pl. 65, fig. *3*), but the two sides merely diverge towards the ambitus in straight lines, though externally the pores expand in Conolampas (Pl. 65, fig. *5*) and Echinolampas (Pl. 65, fig. *1*) into a somewhat phyllodic outline. In the Pacific species of the genus (*R. pacificus*) one of the first pair of plates of each ambulacrum, though large, carries only a single pore, the ankylosis of the other plates showing it to be composed of two plates.

SPATANGIDÆ Agass.

POURTALESIÆ A. Ag.

It is interesting to trace the gradual modifications in the odd posterior interambulacrum from the simple conditions such as exist in Urechinus (Pl. 73, fig. *1*), where the primordial interambulacral plates all reach the actinal system, Fig. 159, but in which the sternum consists of a single elongate polygonal plate following the primordial, the labium differing in no way except in size from the single plate following the primordial of the other interambulacral areas. We may thus look upon Urechinus, in which the plate next to the primordial is single in all the interambulacral areas, as showing us the probable origin of the single sternal plate in some Spatangoids, while in the Spatangoid types such as Collyrites, Echinonëus, and the Cassidulids, in which the primordial plate is followed by two plates in all the interambulacral areas, we have the prototype of the sternum made up of two plates which, from the great extension of the posterior

[1] Lovén, Études Pl. VII, fig. 61.

[2] Lovén, Études, Pl. VII, fig. 67.

extremity, develop to an extraordinary extent in such recent Spatangoids as Metalia, Schizaster, Desoria, Brissopsis, and others. It is interesting to note that already in Hemiaster and Micraster of the Chalk we find the same excessive development of the sternum; while in Holaster the labium is

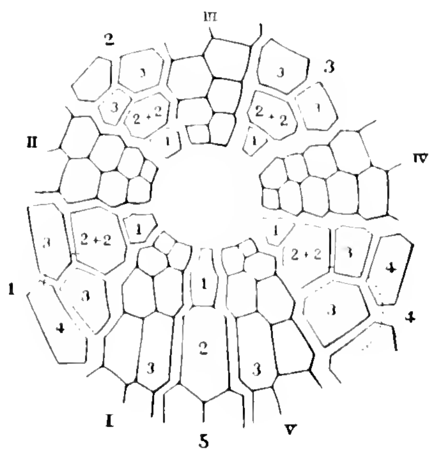
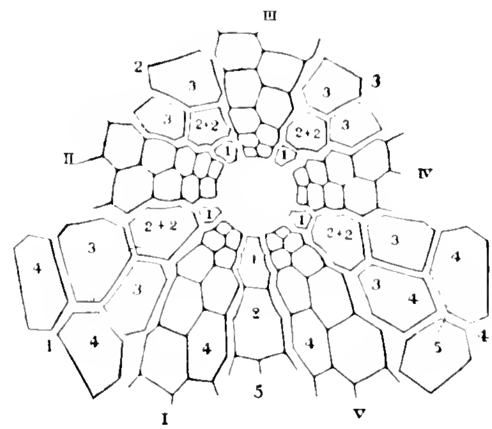


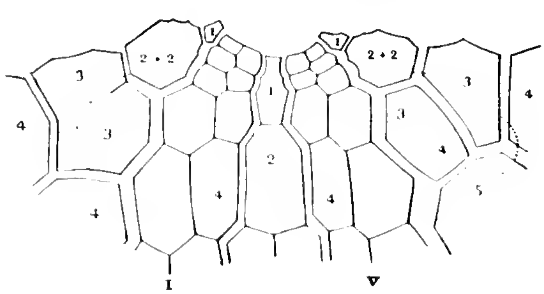
FIG. 159. URECHINUS NARESIANUS. AFTER LOVÉN.



83 mm.
FIG. 160. CYSTECHINUS LOVENI.

followed by a sternum made up of a single rectangular plate as in Ananchytes, though the other actinal primordial interambulacral plates are followed by two plates.

A single plate follows the interambulacral primordial plates not only in Urechinus but also in Plexechinus (Pls. 58, fig. *1*; 59, fig. *3*), in *Cystechinus Loveni* (Pls. 77, fig. *1*; 78, fig. *3*), Figs. 160, 161, in *C. Wyvillii* (Pl. 80, fig. *2*), Fig. 161[a], and in *P. Rathbuni* (Pls. 83, fig. *1*; 85, figs. *1*, *2*), Fig. 164. In Spatagocystis (Pl. 71, fig. *6*) the primordials are excluded from the actinal system in the lateral posterior ambulacra, Fig. 162. The small labium is separated from the sternum by the second and third set of plates of the posterior lateral ambulacra, and the second set of the lateral interambulacra, Fig. 175.



85 mm. ?
FIG. 161. CYSTECHINUS LOVENI.

In *Cystechinus Wyvillii* there is also some difference in the arrangement of the plates around the actinal system between older and younger specimens of 13, Fig. 161^{a}, and 18 mm. (Pl. 80, fig. *1*); in the latter the primordial plates of the right lateral interambulacra are excluded from it, which is not the case in the older specimen of 56 mm. (Pl. 80, fig. *2*), Fig. 163.

In the odd interambulacrum of Plexechinus a well developed hexagonal sternum consisting of a single plate is separated from a small lanceolate labium by the second plates of the posterior lateral ambulacra; this sternum is only an emphasized single second plate such as exists in the other interambulacral areas of the genus.

The sternum of *Cystechinus Loveni* (Pls. 77, fig. *1*; 78, fig. *3*), Fig. 160, is connected with the labium, but otherwise represents a somewhat specialized single second interambulacral plate of the other interambulacral areas.

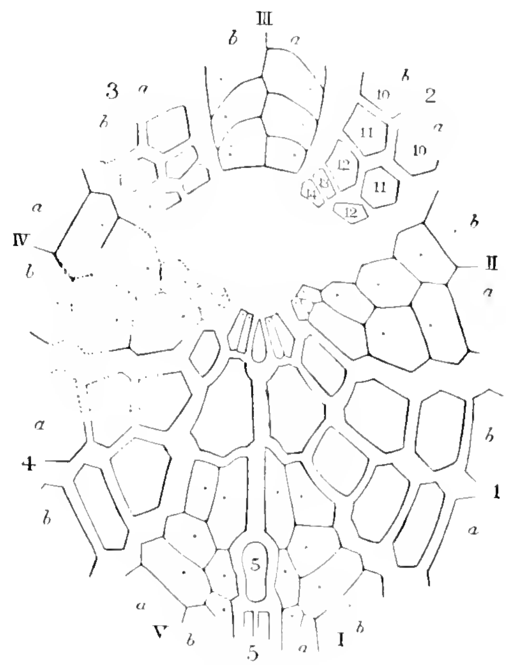


FIG. 162. SPATAGOCYSTIS CHALLENGERI.

In *Cystechinus Wyvillii* (Pl. 80, figs. *1*, *2*) the sternum holds the same relations to the labium and to the single interambulacral plates which follow the primordials, Fig. 161^{a}, as in *C. Loveni*. In the younger specimens the sternum holds to the labium the same relation which the second plate holds to the primordial interambulacral plates.

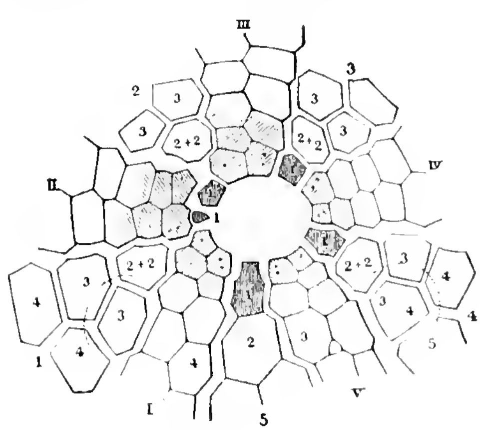


FIG. 161^{a}. CYSTECHINUS WYVILLII.

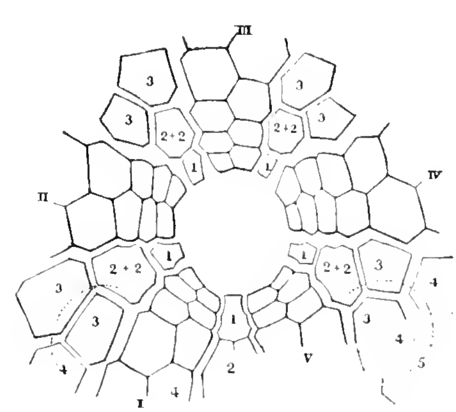
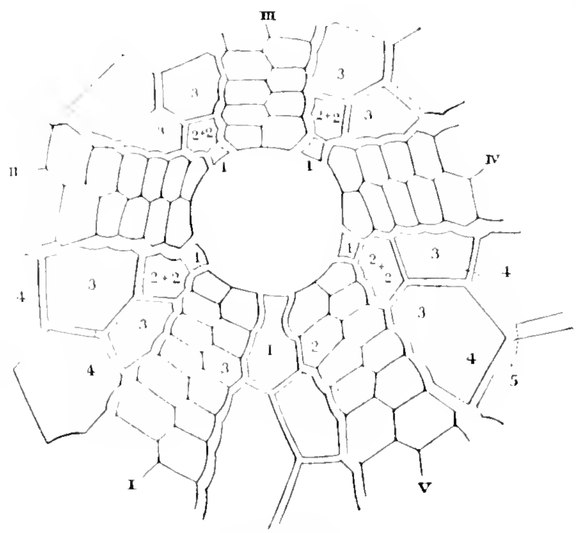


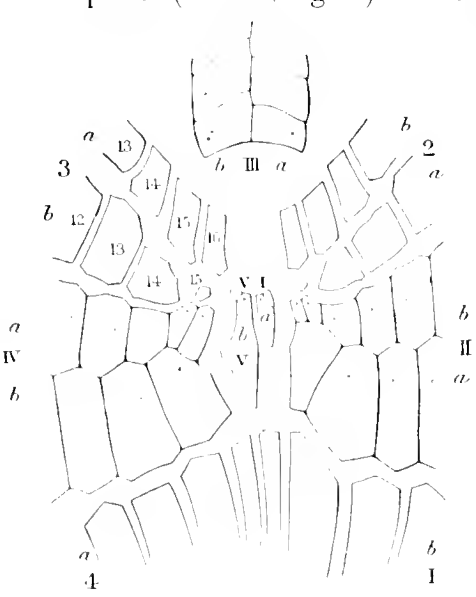
FIG. 163. CYSTECHINUS WYVILLII.

In *Pilematechinus Rathbuni* (Pl. 85, figs. *1, 2*), Fig. 164, the labium is followed as in the younger C. *Wyvillii* by two plates and the sternum is absent. This anomalous condition is readily explained by comparing the labium and the two plates with the primordial plate and the plates succeeding it in the other interambulacra.



85 mm.
FIG. 164. PILEMATECHINUS RATHBUNI.

In Echinocrepis, Fig. 165, the anterior interambulacral primordials alone reach the actinal system; there is no labium.[1] The sternum consists of one plate followed by two episternal plates, Fig. 167, and further separated from the anal system by three pairs of small plates (Pl. 68, fig. *1*). The sternum is separated from the actinal system by both rows of the posterior lateral ambulacra, Fig. 168, and the anterior zone of the lateral posterior interambulacra, which extend beyond the sternum, the first plates of which are in contact with the actinostome as well as the anterior lateral interambulacra (Pl. 68, fig. *1*).



92 mm.
FIG. 165. ECHINOCREPIS SETIGERA.

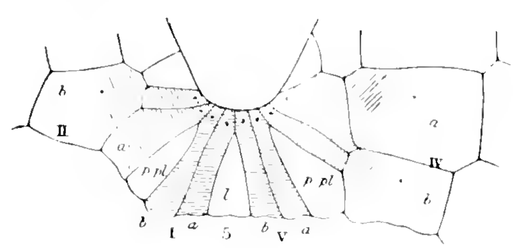
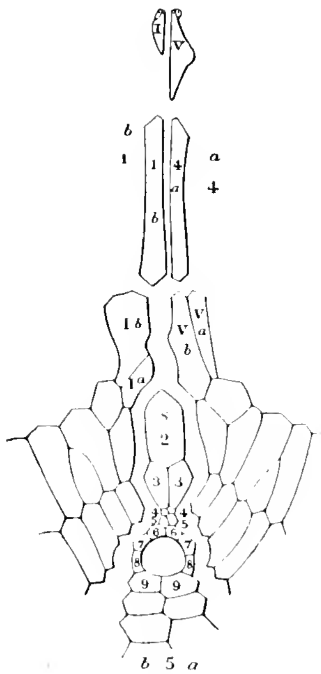


FIG. 166. E. CUNEATA. AFTER LOVÉN.

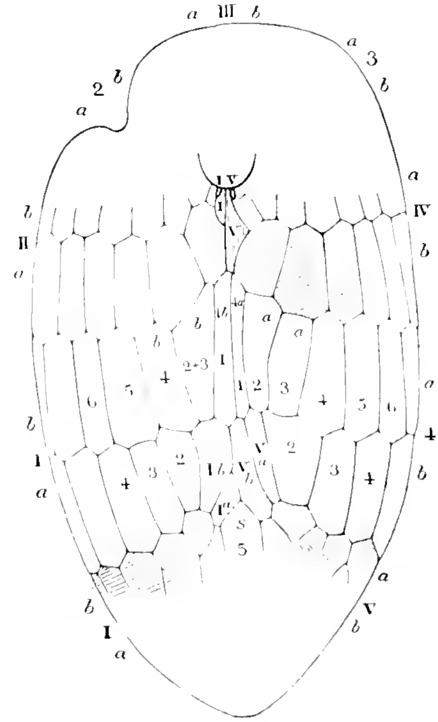
In the Pourtalesiæ there is not only an unexampled extension of the posterior extremity, in which a prominent anal snout is formed, but also

[1] Though Lovén, Pourtalesia, Pl. VII, figures one in *P. cuneata*, Fig. 166, its absence in *E. setigera* is not remarkable, as in *P. Tanneri* we find the same discrepancies.



92 mm.

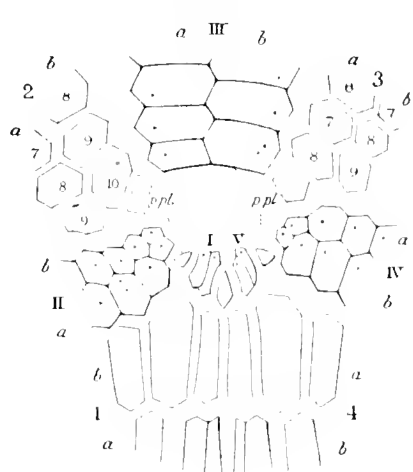
FIG. 167. ECHINOCREPIS SETIGERA.



92 mm.

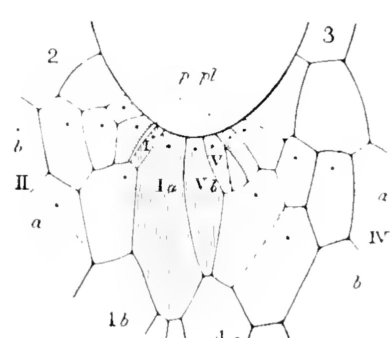
FIG. 168. ECHINOCREPIS SETIGERA.

a deep and long actinal groove in the extension of the anterior extremity of the test. It is natural that with such extensive movements in the coronal plates of the test we should find, as we do, such great differences in the final position of the coronal plates in the Pourtalesiæ as contrasted to all other Echinoidea.



16 mm.

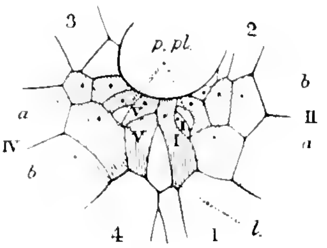
FIG. 169. POURTALESIA TANNERI.



17 mm.

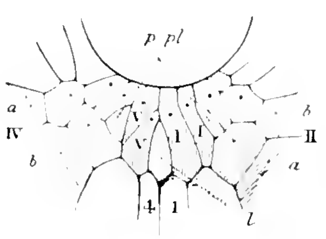
FIG. 170. POURTALESIA TANNERI.

In *Pourtalesia Tanneri* (Pl. 57, figs. *1*, *5*) there is a small labium, Fig. 169, which is wanting in some specimens (Fig. 170); it is excluded from the actinostome, and is separated from the large elongated hexagonal sternum followed by two episternal plates, Fig. 171, by the anterior zone of the posterior lateral interambulacra (Pl. 56, fig. *1*), and the second pair of plates of the posterior lateral ambulacra (Pl. 57, fig. *5*), the first plates of which reach the actinostome.



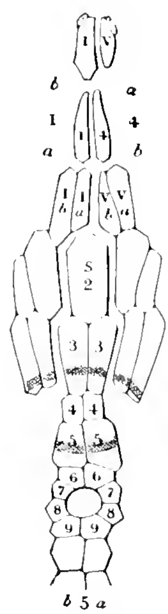
16 mm

FIG. 172. POURTALESIA TANNERI.



16 mm.

FIG. 173. P. TANNERI.



17 mm.

FIG. 171.
POURTALESIA TANNERI.

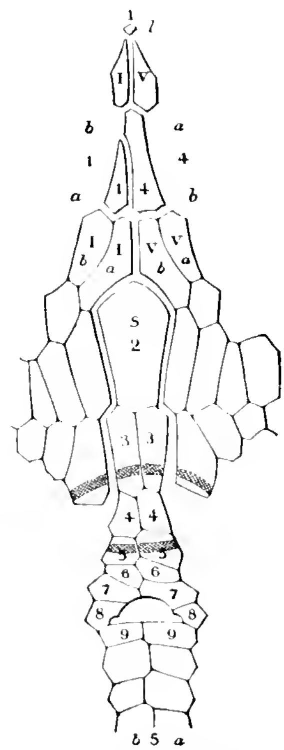


FIG. 174. P. JEFFREYSI.
AFTER LOVÉN.

The lateral posterior interambulacral primordials are diminutive, *p. pl.* Figs. 172, 173; they do not reach the actinal system (Pl. 57, figs. *1*, *5*), as do the larger primordials of the anterior lateral interambulacra (Pl. 57, fig. *5*). In *P. Jeffreysi* the arrangement of the plates is somewhat different.[1] The posterior interambulacral primordials are excluded from the actinostome, the labium is actinal, Fig. 174, and is separated from the sternum by the same set of plates, both ambulacral and interambulacral, as in *P. Tanneri*.

In Spatagocystis, Fig. 175, the labium is separated from the sternum,

[1] Lovén, Pourtalesia, Pl. II.

which is narrow, small, elongate (Pls. 70, fig. *4*; 71, fig. *6*), by large composite double plates of the lateral anterior interambulacra and by the second rows of plates of the lateral posterior ambulacra extending along the sternum, which also separate the actinal plates of the lateral posterior ambulacra from the actinal plates.

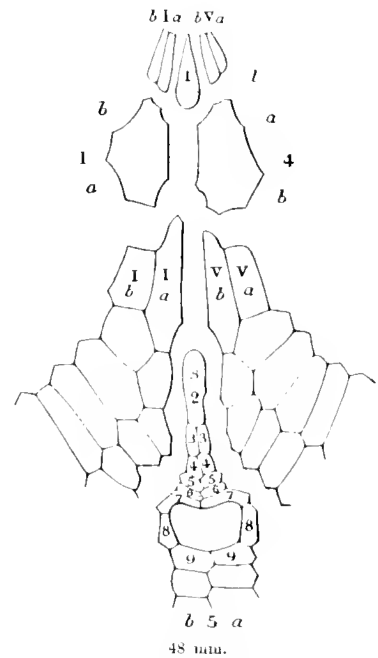


Fig. 175. Spatagocystis Challengeri.

The position of the anal system on the actinal side in Echinocrepis and Spatagocystis materially alters the proportion of the actinal plates of the odd interambulacrum from those of Pourtalesia proper and Plexechinus, in which the anus is in a sunken groove at the base of a well developed anal snout, round which a fasciole is developed. Compare Figs. 167, 175 to Figs. 171, 174.

The shape of the actinal system of *Pourtalesia Tanneri*, Fig. 176, differs considerably from that of *P. Jeffreysi*,[1] and of *P. carinata*.[2] It is round in the former (Pl. 57, fig. *3*), somewhat rectangular in

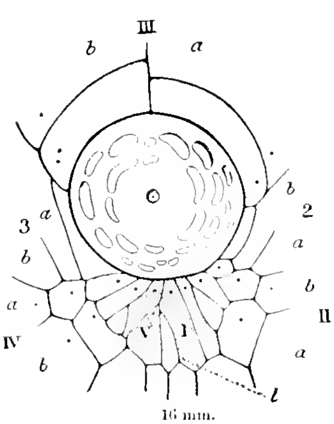


Fig. 176. Pourtalesia Tanneri.

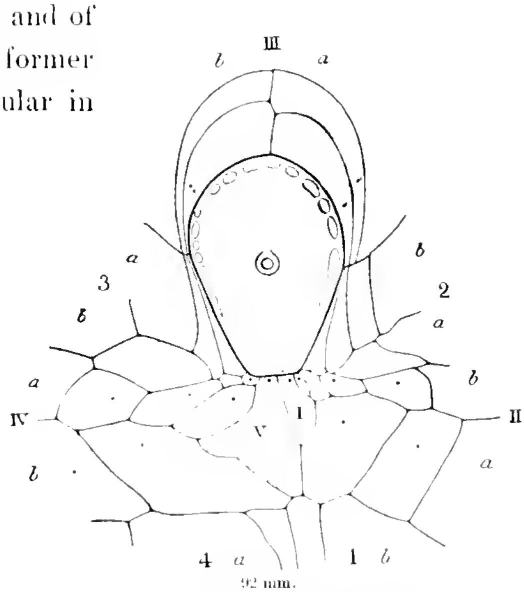


Fig. 177. Echinocrepis setigera.

the second, and oval in the third. In *E. setigera* the actinal system is pear-shaped, Fig. 177, and pointed abactinally in *Sp. Challengeri*, Fig. 177^{a}.

[1] Lovén, Pourtalesia, Pl. IV, fig. 18. [2] "Challenger" Echinoidea, Pl. $\mathrm{XXVIII^{a}}$, fig. 9.

There are great differences in the number of plates of the odd anterior ambulacrum: in *P. Jeffreysi* we find thirteen to fifteen pairs, Fig. 178; in *P. Tanneri* twelve, Fig. 179; in other genera of Pourtalesiæ, as in

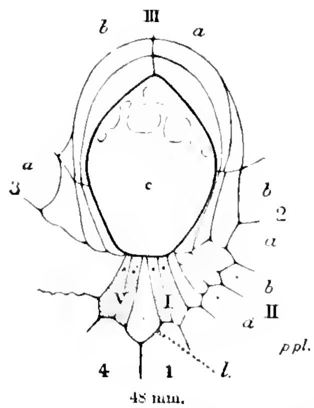


FIG. 177[a]. SPATAGOCYSTIS CHALLENGERI.

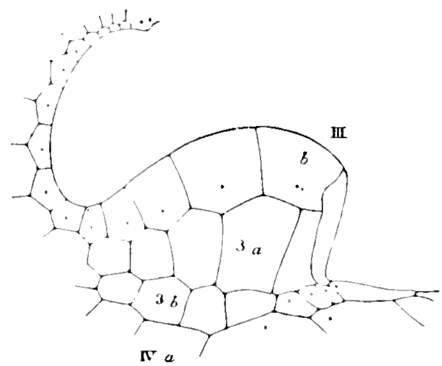


FIG. 178. POURTALESIA JEFFREYSI. AFTER LOVÉN.

Echinocrepis, there are twenty-one to twenty-two, Fig. 180; and in Spatagocystis, sixteen pairs, Fig. 181. The number of the plates is due mainly to the length of the actinal pouch in those genera. These differences are well shown on comparing the profiles of the actinal pouches of *P. Jeffreysi*,[1] of *P. carinata*,[2] Fig. 182, of *P. Tanneri* (Pl. 57, fig. 2), of *P. hispida*,[3] of

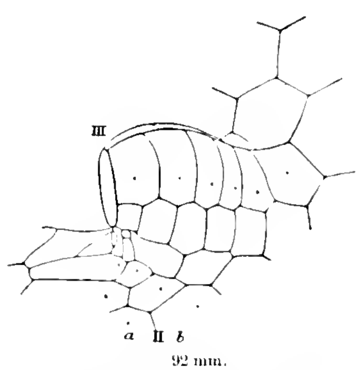


FIG. 180. ECHINOCREPIS SETIGERA.

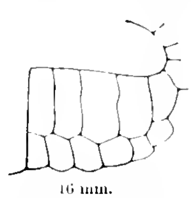


FIG. 179. P. TANNERI.

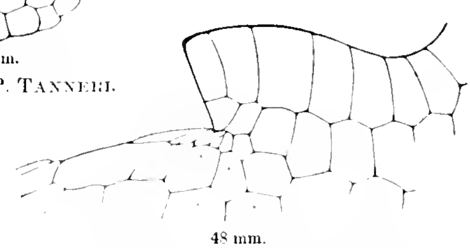


FIG. 181. SPATAGOCYSTIS CHALLENGERI

P. ceratopyga,[4] of *Echinocrepis setigera* (Pl. 69, fig. 2), and *Spatagocystis Challengeri* (Pl. 71, fig. 2). These profiles differ greatly in outline, especially in the angle formed by the groove with the actinal system, as well as

[1] Lovén, Pourtalesia, Pl. III, fig. 12.

[2] Lovén, Pl. VI, fig. 45; "Challenger" Echinoidea, Pl. XXVIII[a], fig. 11.

[3] "Challenger" Echinoidea, Pl. XXII, fig. 8.

[4] "Challenger" Echinoidea, Pl. XXVIII, fig. 5.

in the number and size of the ambulacral plates which go to make up the sunken ambulacral actinal grooves of these genera. Views of these genera seen from the actinal side show the proportional extent which the

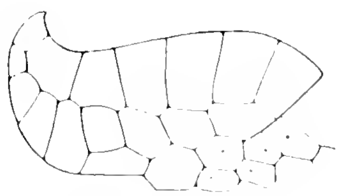


Fig. 182. P. carinata.

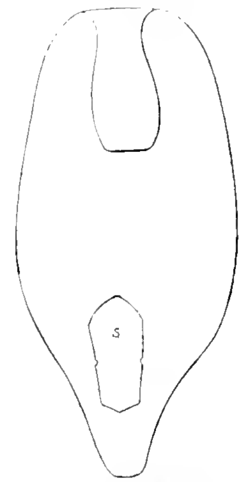
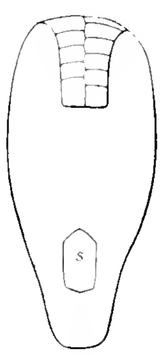


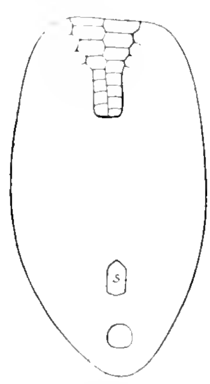
Fig. 183. Pourtalesia Jeffreysi. After Lovén.

actinal groove bears to the whole test, as well as their general outline. In *P. Jeffreysi*,[1] Fig. 183, it occupies nearly one third the length of the test, and is nearly half as broad as the test. In *P. Tanneri* (Pl. 56, fig. *1*), Fig. 184, it occupies about a fourth of the actinal side, flaring out laterally



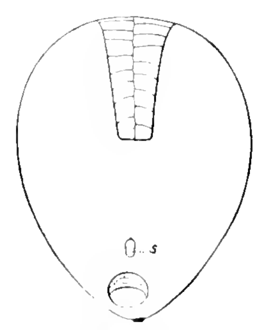
17 mm.

Fig. 184. P. Tanneri.



92 mm.

Fig. 185. Echinocrepis setigera.



48 mm.

Fig. 186. Spatagocystis Challengeri.

and not having a re-entering curve as in *P. Jeffreysi*. This form of actinal groove is still more marked in *Pourtalesia phiale* W. Th.,[2] while in *Pourtalesia laguncula*[3] it has more the shape of that of *P. Tanneri*; that of *P. hispida*[4]

[1] Lovén, Pourtalesia, Pl. III, fig. 10.

[2] "Challenger" Echinoidea, Pls. XXII, fig. 1; XXII[a], fig. 2.

[3] Id. Pl. XXII[a], fig. 9.

[4] Id. Pl. XXII[a], fig. 8.

is more like the groove of *P. Jeffreysi.* In *Echinocrepis setigera*, Fig. 185, the groove is over a fourth of the test (Pl. 66, fig. *1*), as in *E. cuneata*[1] also, and in *Spatagocystis Challengeri*[2] it is nearly half the length, Fig. 186.

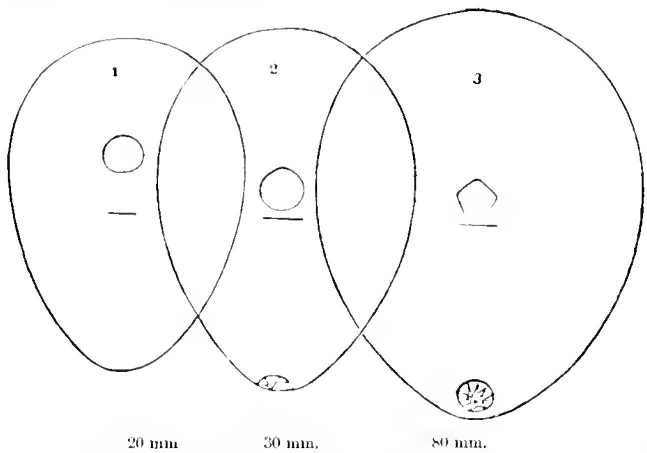


FIG. 187. 1 PLEXECHINUS CINCTUS. 2 URECHINUS NARESIANUS. 3 U. GIGANTEUS.

The position of the actinostome in the Urechinidæ is more central than in the Pourtalesiæ, even than in such a genus as Plexechinus, Fig. 187, 1; in *Cystechinus Wyvillii* and *C. Loveni* the actinostome is also more excentric than in *Pilematechinus Rathbuni*, Fig. 188, 3.

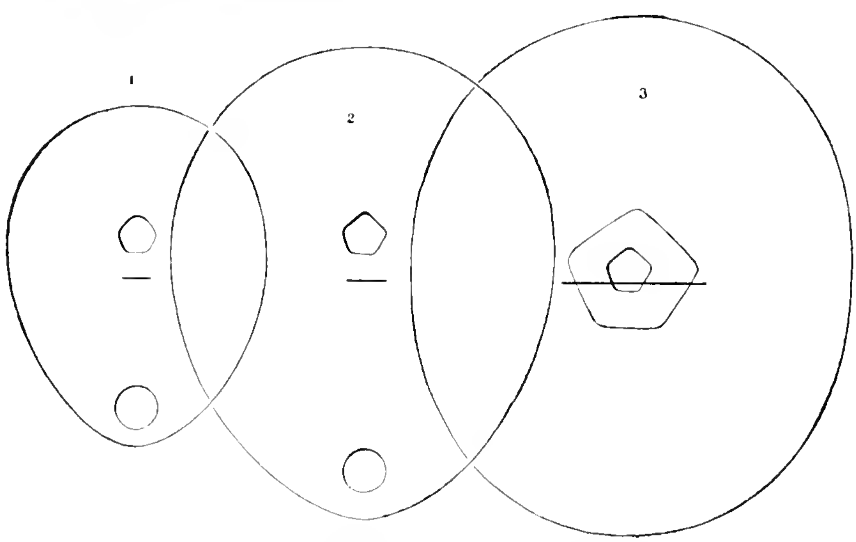


FIG. 188. 1 CYSTECHINUS WYVILLII. 2 C. LOVENI. 3 P. RATHBUNI.

Is there not in the Clypeastroids something analogous to the intrusion of the lateral posterior interambulacra between the labium and sternum

[1] "Challenger" Echinoidea, Pl. XXXV^a, fig. 10.

[2] Id. Pl. XXVI^a, fig. 2.

of the Pourtalesiæ in the isolation of the second row of plates of all the interambulacra from the actinal primordial interambulacral plates by the intrusion of the second row of ambulacral plates of all the zones. They connect laterally in Arachnoides, Echinarachnius, Clypeaster, and Encope, while the ambulacral and interambulacral zones are perfectly symmetrical in Echinocyamus, Laganum, and Mellita; the latter genera holding to the former much the same relation which the recent Ananchytids hold to the modern Spatangoïds.

The discovery of so many recent Ananchytid-like Spatangoids would seem to warrant the establishment of subfamilies including on the one side, as Urechinidæ: Urechinus, Cystechinus, Pilematechinus, and Calymne; and on the other as Paleopneustidæ: Paleopneustes, Linopneustes, Homolampas, Phrissocystis, Argopatagus, Genicopatagus, Palæotropus, and Palæobrissus. This would exclude from the Pourtalesiæ a few genera at one time associated with them, and limit the Pourtalesiæ to Pourtalesia, Echinocrepis, Spatagocystis, Plexechinus, and Sternopatagus. But the Pourtalesiæ can hardly be considered, from what has been said here, as a group equivalent to the Clypeastroids and Cassidulids, as has been suggested by Lovén.

Among the Spatangoids a new genus of Pourtalesiæ has been described from the collection of the "Siboga" Expedition under the name of Sternopatagus,[1] differing in shape from that of any other Pourtalesia. It has the marginal fasciole of Calymne, the abactinal system of Cystechinus (*C. Loveni*) though there are four genitals in Sternopatagus and only three in *C. Loveni*. The labium is separated from the sternum much as it is in Plexechinus, which, however, has the compact abactinal system of Pourtalesia proper. If the figures of M. De Meijere are correct, its sternum has nothing in common with that of Urechinus, as he states, the labium of the former being separated from the sternum, which is not the case in Urechinus. The abactinal system of Sternopatagus is entirely different from that of the Pourtalesiæ; the bivium is not separated from the trivium by the posterior lateral interambulacra, its apical system as well as that of Sternopneustes is quite that of Holaster and of the Ananchytidæ, and it also has its anus on the lower side as Echinocrepis.

The plates of the apical system of Echinocrepis are not as they have been described by M. de Meijere; those of the bivium are well separated by the

[1] Sternopatagus Sibogæ De Meijere. Die Echinoidea der Siboga-Expedition, p. 151.

posterior lateral interambulacra from those of the trivium. There are the two posterior ocular plates, and the anterior ones are ankylosed, the oculars of the trivium being lost and occupied by the madreporite. (Pls. 67, fig. *2*; 69, figs. *3*, *4*.)

No Pourtalesia has the marginal fasciole of Sternopatagus. It has the labium and sternum of Plexechinus separated by the posterior lateral interambulacra, although the actinal plate of the left posterior interambulacrum cannot be traced in M. de Meijere's figure, and the structure of the odd interambulacrum is entirely different from that of any Pourtalesia. M. de Meijere considers Sternopatagus[1] an intermediate form between Ananchytidæ and the Pourtalesiæ. It looks to me far more Ananchytid than Pourtalesian.

Pourtalesia A. Ag.

Pourtalesia Tanneri A. Ag.

Pourtalesia Tanneri A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 77; Pl. VIII, figs. 1, 2.

Plates B, fig. *2*; 55, figs. *1*, *2*; 56; 57.

This species (Pl. 55, figs. *1*, *2*) is closely allied to *P. laguncula* A. Ag.[2] It differs from it in the shape of the test, which is more elongate (Pl. 56, fig. *1*), less bottle-shaped, more like the younger specimens of *P. laguncula* A. Ag.,[3] and consequent greater length of the coronal plates, especially in the left posterior ambulacral and interambulacral areas; compare[4] Chall. Ech. Pl. XXII a, figs. *7*, *9* with Pl. 56, figs. *1*, *3*; the anterior extremity of the test is higher (Pl. 56, fig. *4*); the larger primary tubercles are concentrated on the sides of the test in a triangular space (Pl. 56, figs. *2*, *3*) extending from the anal system to the junction of the ambitus with the anterior edge of the posterior ambulacra. The primary radioles on the flanks of the test are also longer, while in *P. laguncula* and *P. miranda* they are somewhat spathiform.

[1] I am blamed by M. de Meijere for not putting on one plate the figures belonging to one species. We do not find in M. de Meijere's Report any greater concentration of figures belonging to one species than is the natural result of one's inability to put a gallon into a pint measure. I would refer to the position of M. de Meijere's figures of Sternopatagus on three widely separated plates, of Sternopneustes on the same number, and others, which do not seem to show that regard for the reader the lack of which is so blameworthy in others.

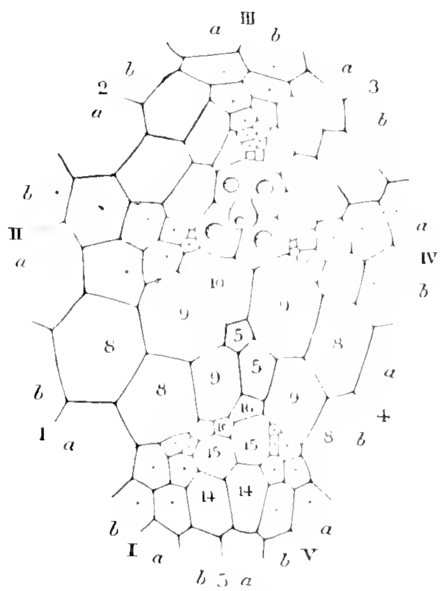
[2] "Challenger" Echinoidea, p. 137, Pls. XXII a, figs. 7–9; XXXI, figs. 1–11.

[3] "Challenger" Echinoidea, Pl. XXXI, figs. 10, 11.

[4] See also Lovén, Pourtalesia, Pl. VI, figs. 37, 38.

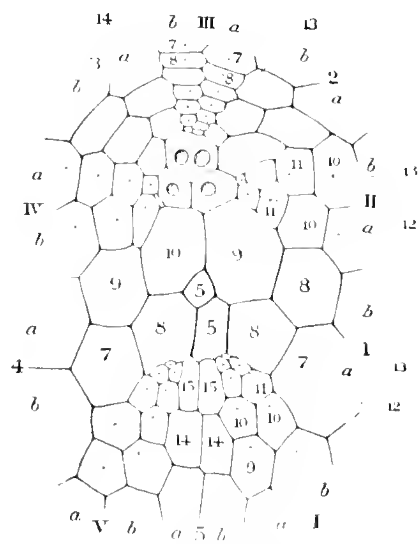
The actinal side of *P. Tanneri* is also somewhat flatter than that of *P. lagunenla.* The smallest specimen of *P. Tanneri* collected measured 12 mm. in length; as in small specimens of *P. lagunenla*, the test is more pointed posteriorly and the proboscis less developed than in larger specimens. The largest specimen collected measured 17 mm. in length, 9 mm. in greatest height, and 8 mm. in greatest width, somewhat posteriorly of the actinal groove.

There was nothing either in the youngest or the largest specimen examined, Figs. 189, 190, to show conclusively that the intercalated plates in the interambulacral belt separating the trivium from the bivium belonged



16 mm.

FIG. 189. POURTALESIA TANNERI.



17 mm.

FIG. 190. POURTALESIA TANNERI.

to the odd interambulacral area rather than to the posterior interambulacra. These plates are marked by Lovén as belonging to the odd interambulacrum in *Pourtalesia Jeffreysi*, Fig. 200.

From the remarkable belt-like arrangement of the interambulacra which is so well seen in an actinal view of Pourtalesia (Pl. 56, fig. *1*), Figs. 162, 191, 191[a], Lovén[1] has suggested that the actinal groove of the Pourtalesiæ may have developed from the invagination of a similar belt at the anterior area of the test.[2] It seems to me more natural to trace the course of this

[1] Lovén, Pourtalesia, p. 30.

[2] The separation of the plates composing the sternum from the labium, so characteristic of the Pourtalesiæ, also occurs in some of the Clypeastroids, as in Encope, Clypeaster, Echinarachnius, and Arachnoides.

invagination to a process similar to that forming the deep sunken ambulacra in Moira, between them and the flush or slightly sunken ambulacra we find nearly all stages of intermediate depression, or to the formation of the slight groove of the odd anterior ambulacrum in so many Spatangoids, without of course hinting at a genetic connection between the two.

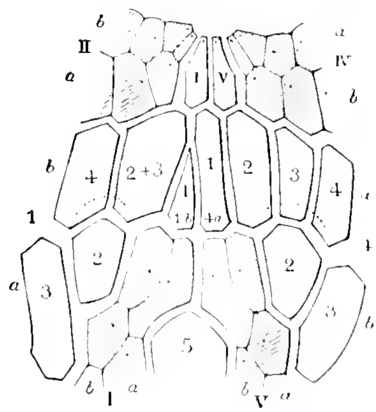
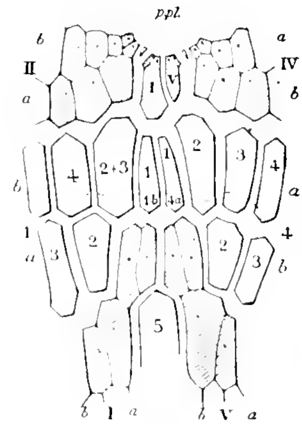


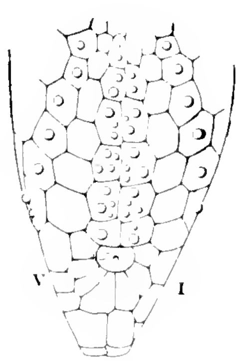
FIG. 191. POURTALESIA JEFFREYSI. AFTER LOVÉN.



17 mm.

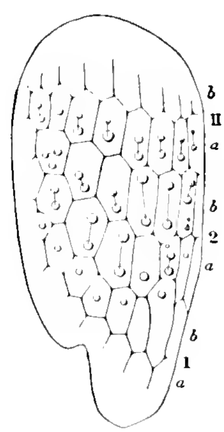
FIG. 191[a]. P. TANNERI.

The color of the test when brought up in the trawl was bright pink, with a violet tinge round the base of the primary tubercles; the radioles were white.



17 mm.

FIG. 192. POURTALESIA TANNERI.



17 mm.

FIG. 193. POURTALESIA TANNERI.

The proboscis of *Pourtalesia Tanneri* (Pl. 56, fig. 3) slopes off more gradually from the anal opening than in *P. laguncula*,[1] in which it also expands laterally, while in *P. Tanneri* it is somewhat pointed and projects considerably beyond the subanal fasciole, Fig. 192.

[1] "Challenger" Echinoidea, Pl. XXII[a], figs. 7, 9.

The edge of the actinal groove and the apical system are both placed more towards the anterior extremity than in *P. laguncula*. On the abactinal side the plates of the ridge formed by the odd posterior interambulacrum are covered by two to four large primary tubercles and minute miliaries, Fig. 192, (Pl. 56, fig. *2*). On the central part of the sides of the test, Fig. 193, the primary tubercles are arranged in pairs, with distant miliaries on the rest of the plate. *P. Tanneri* is also marked for the small number of large primary tubercles found on the sides of the test (Pl. 56, fig. *3*).

On the actinal side the prominent primary tuberculation of the sternum and of the actinal plates of the posterior interambulacra and the anterior ambulacra (Pl. 56, fig. *1*) is in marked contrast with the few primary tubercles of the actinal face of *P. laguncula*.[1] The great length of the sternum is also a characteristic feature of *P. Tanneri*, Fig. 194. The sternum of *P. Jeffreysi* is broader anteriorly Fig. 195.

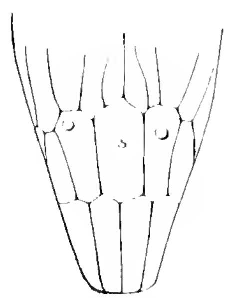


FIG. 194. POURTALESIA TANNERI.

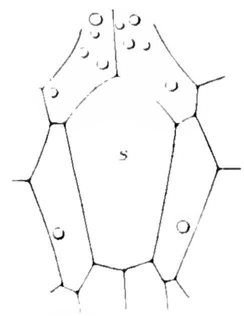


FIG. 195. P. JEFFREYSI. AFTER LOVÉN.

An important structural difference between these two species is the existence of a well developed labium in *P. laguncula*,[2] varying greatly in outline, its narrow edge barely reaching the actinal edge, and the exclusion of the primordial plates of the posterior interambulacra from the actinal system. In *P. Tanneri* the labium is excluded from the actinal edge, Figs. 172, 173; it is reduced to a diminutive pointed elliptical plate (Pl. 57, figs. *1*, *2*), or is represented by a minute plate surrounded by the actinal posterior lateral ambulacral plates. In another specimen it cannot be traced, and the small primordial plates of the posterior ambulacra can be seen at the actinal edge between the long narrow actinal ambulacral plates of the lateral ambulacra, Fig. 196 (Pl. 57, figs. *1*, *2*, *5*), while the actinal primordials of the

[1] "Challenger" Echinoidea, Pl. XXII^a, fig. 9. [2] Lovén, Pourtalesia, Pl. VI, figs. 37–40.

anterior interambulacra are larger (Pl. 57, fig. *5*). In this respect *P. Tanneri* is more closely allied to *P. carinata*, Fig. 197, in which, according to Lovén,[1] the primordial plates of the posterior interambulacra and the labium occupy much the same position they do in *P. Tanneri.* A similar arrangement is found in *P. ceratopyga* and *E. cuneata.*[2]

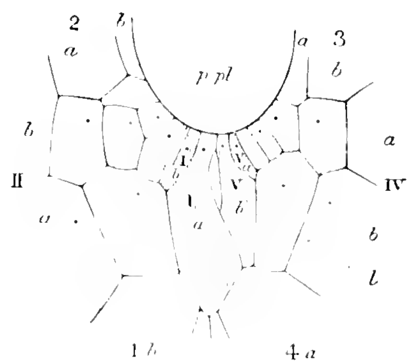


FIG. 196. POURTALESIA TANNERI.

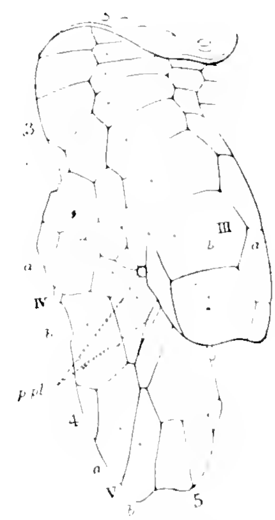


FIG. 197. P. CARINATA. AFTER LOVÉN.

The actinal system of *P. Tanneri*, Fig. 176, is circular (Pls. 56, fig. *4*; 57, figs. *2*, *3*); the outer belt is covered by delicate elongated plates forming three or four irregularly concentric rows. The central part of the actinal system is bare. The course of the odd anterior ambulacrum (Pls. 56, figs.

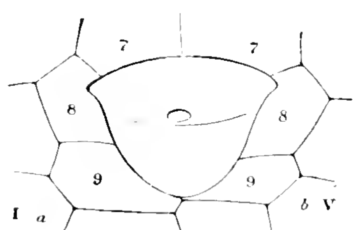


FIG. 198. POURTALESIA JEFFREYSI. AFTER LOVÉN.

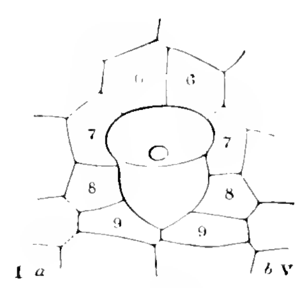


FIG. 199. P. TANNERI.

1–4; 57, fig. *2*) is specially well seen from the interior view of the test (Pl. 57, fig. *2*), which shows the rapid widening and arching of the ambulacral plates to form the deep anterior actinal ambulacral groove. The

[1] Lovén, Pourtalesia, Pl. VI, figs. 42–44.

[2] Id., Pl. VII, figs. 48, 53.

circular shape of the actinal system of *P. Tanneri* is in great contrast to its elongate elliptical outline in *P. Jeffreysi*.[1] Yet, in spite of this apparent difference in outline, the number of coronal plates in the different ambulacra or interambulacra does not vary perceptibly.

The anal system of *P. Tanneri* is, on the contrary, much less flattened than that of *P. Jeffreysi*;[2] Figs. 198, 199. The posterior edge of the lower part of the anal system is strengthened by a low ridge running along the inner part of the surrounding plates (Pl. 57, fig. *4*). The anal system is divided into two parts, the lower somewhat pointed; below the circular anal opening it is covered by irregularly arranged plates larger than those of the upper part, which is flattened, with rounded top and re-entering sides, and is strengthened by more numerous smaller plates increasing in size towards the anterior edge.

An enlarged view of the abactinal system (Pl. 56, figs. *5*, *6*) of two specimens nearly of the same size, 16 and 17 mm. in length, Figs. 189, 190, shows that the ocular plates have all disappeared, the ambulacra abutting in the trivium against the genital plates, and in the bivium against the abactinal plates of the posterior interambulacra. There are four large genital pores in the central disk, but only three genital plates could be distinguished; there are four in *P. laguncula*.

The bivium and trivium are separated by the abactinal plates of the posterior interambulacra, and in addition by two plates placed one in front of the other in the extension of the abactinal plates of the odd posterior interambulacrum (Pl. 56, fig. *5*). In another somewhat younger specimen (Pl. 56, fig. *6*) the arrangement and number of the intercalated plates is very different; at the abactinal extremity of the paired plates of the odd interambulacrum there are no less than three small plates, the largest of which connects with two plates having much the same relation to the posterior interambulacral plates which they held in the other specimen (Pl. 56, fig. *5*), so that we might really consider all these plates as the irregular extension of the abactinal plates of the odd interambulacrum. Yet this may not be the case, as in *P. Jeffreysi* the three additional plates are not joined with the odd interambulacrum, as in *P. Tanneri* (Pl. 56, fig. *6*), but are placed next to the genitals,[3] and the two intermediate plates are isolated from the single plate adjoining the extremity, Fig. 200, of the

[1] Lovén, Pourtalesia, Pl. IV, figs. 18, 20.
[2] Id., Pl. I, fig. 4.
[3] Id., Pls. I, fig. 1; V, figs. 25–28.

odd posterior ambulacrum, and stand surrounded by the abactinal plates of the odd ambulacrum.

The arrangement of these abactinal plates in other genera of Pourtalesiæ does not seem to give us definite conclusions regarding their character, and thus far no very young Pourtalesiæ have been examined with reference to this point. In *Echinocrepis cuneata*[1] the odd interambulacrum is excluded from the genital plate by the oculars of the posterior ambulacra, which are in contact with it, in all the other interambulacra the two abactinal plates touch the genital. The oculars of the trivium are wanting. A very different condition of things exists in *E. setigera*, as will be seen later.

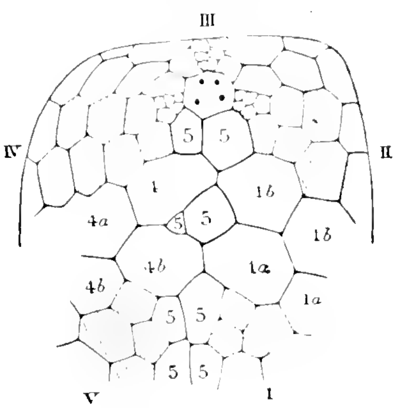
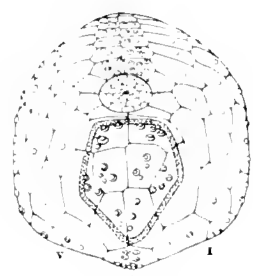


Fig. 200. Pourtalesia Jeffreysi. After Lovén.



15 mm.

Fig. 201. Pourtalesia Tanneri.

P. Tanneri, although not more than 16 or 17 mm. in length, is evidently an adult, while *P. Jeffreysi* is fully 45 mm. long.

The subanal fasciole of *P. Tanneri* is, when seen facing the anal extremity, somewhat pentagonal, Fig. 201; it is mainly limited to the plates of the odd interambulacrum and does not extend laterally so as to include in the subanal plastron any large part of the plates of the adjoining ambulacra, as is the case in many Spatangoids, in which narrow parts of the outer edge of the ambulacral plates extend far into the plastron, as in Brissus, Spatangus, Echinocardium, Breynia, Maretia, Paleopneustes, and others, showing a tendency to the formation of a subanal snout. In Cionobrissus the subanal snout is, as in *P. Tanneri*, bound by a subanal fasciole restricted in great part to the odd interambulacral plates. In Plexechinus the subanal fasciole surrounding the snout is, with the exception of one ambulacral

[1] Lovén, Pourtalesia. Pl. VII, fig. 54.

plate, also limited to the plates of the odd interambulacrum (Pls. 58, fig. *4*; 59, fig. *3*).

Station 3411, between Bindloe and Wenmam Isds., Galapagos, in 1189 fathoms. Lat. 54′ N.; Long. 91° 9′ W. Bott. temp. 36°.2. Yell. glob. ooze.

Station 3431, off Altata, Gulf of California, in 995 fathoms. Lat. 23° 59′ N.; Long. 108° 40′ W. Bott. temp. 37°. Light br. m. glob.

Bathymetrical range, 995–1189 fathoms. Temperature range, 37°–36°.2.

Pourtalesia miranda A. Ag.

Pourtalesia miranda A. Ag.[1] Bull. M. C. Z. 1869, I, No. 9, p. 272.
Pourtalesia miranda A. Ag. Rev. Echini, 1872, p. 345, Pl. XVIII.

In 1878–79 the "Blake" collected at two localities fragments of *Pourtalesia miranda*[2] from which it has been possible to give details of the species and compare it with the other species of the genus.

Owing to the small size of the *P. miranda* collected by Pourtalès, 3.5 mm. in length, it was quite possible that it might turn out to be the young of P. *Jeffreysi* Wyv. Thom. collected by the "Porcupine." The specimens of *P. miranda* collected by the "Blake" in 1878–79 off Grenada in 576 fathoms, with the fragments collected off Barbados, show that this is not the case. The figures of *P. Jeffreysi* given by Lovén[3] show that *P. Jeffreysi* is proportionally much broader, and has a shorter anal snout than *P. miranda*. The odd actinal sunken groove in *P. miranda* is longer than in *P. Jeffreysi*, the sternum of the former is hexagonal, elongated, while that of the latter species is wider.

In a specimen of *P. miranda* 18 mm. in length the test is more elongate than in *P. Jeffreysi*, *P. laguncula*, or in the young specimen figured on Pl. XVIII. in the Revision of the Echini. The arrangement of the plates of the test is not shown in those figures. The apical system of *P. miranda* is compact, Figs. 202, 205. The sutures between the genital plates cannot be made out, Fig. 205. The apical system varies greatly, as in other Pourtalesiæ; Lovén figures that of two specimens of *P. Jeffreysi*[4] in which

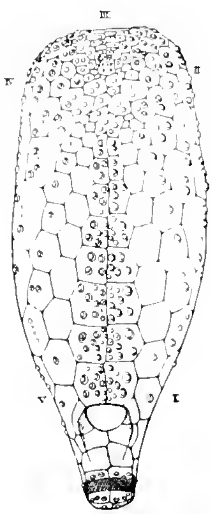
[1] On p. 169 of the Revision, this reference is not correctly given.

[2] The single original specimen of *P. miranda* collected by Pourtalès off the Tortugas in 319 fathoms was sent to Professor Lovén for examination, and unfortunately crushed in transmission on its return.

[3] Lovén, Pourtalesia, Pls. I–V.

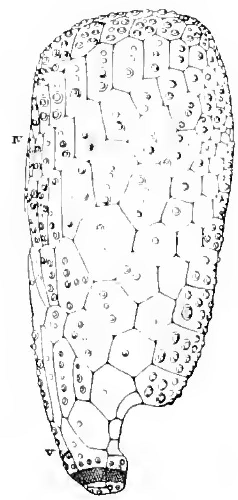
[4] Loc. cit. Pl. V, figs. 25–28.

the genital plates are ankylosed in one, and distinct in the other. The bivium is separated from the trivium by the posterior interambulacra, as



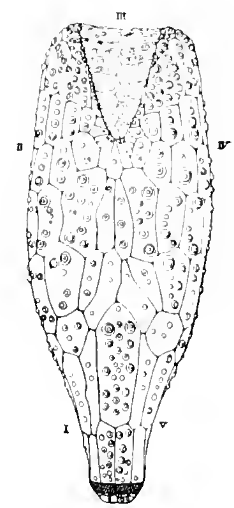
18 mm

FIG. 202.



18 mm

FIG. 202 a.



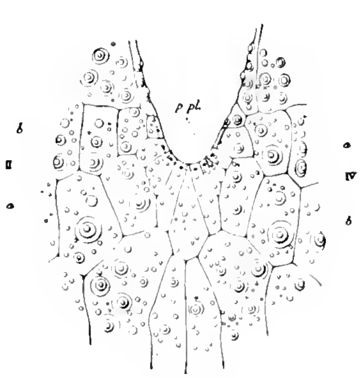
18 mm.

FIG. 203.

FIGS. 202, 202 a, 203. POURTALESIA MIRANDA.

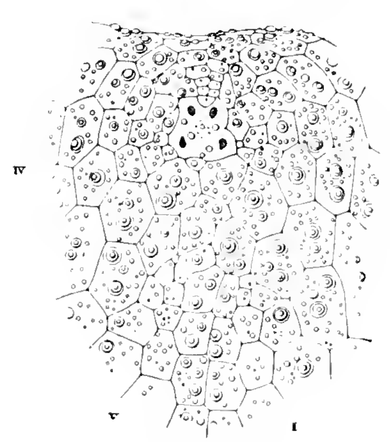
is the case in *P. Jeffreysi*, *P. laguncula*, *P. Tanneri*, and *P. ceratopyga*. The ocular plates can be traced in the posterior ambulacra, Fig. 205.

Seen from the actinal side the labium and the sternum are separated by the anterior row of the posterior ambulacra, Figs. 203, 204, and by the pos-



18 mm.

FIG. 204. P. MIRANDA.



18 mm.

FIG. 205. P. MIRANDA.

terior ambulacra which unite on the median line, as in *P. Jeffreysi* and the species named above. The labium of *P. miranda* is, like that of *P. laguncula* and *P. Tanneri*, in contact with the actinostome, Figs. 203, 204, and the primordial plates of the paired anterior interambulacra are small, wedge-shaped, elongate plates separating at the actinostome the anterior from the posterior pair of ambulacra. The sternum of both is followed by two long episternal plates, larger in *P. miranda* than in *P. Jeffreysi*. It is, however, in profile that the great differences in the outline of the test are best seen; the actinal face of *P. miranda* is quite flat, compared to its arched outline in *P. Jeffreysi*. The vertex of *P. miranda*, Figs. 202, 202^a, coincides with the position of the abactinal system; in *P. Jeffreysi* the vertex is placed in the centre of the highly arched abactinal side. The coronal plates carry a greater number of primary tubercles in *P. Jeffreysi* than in *P. miranda*, though the odd interambulacrum of the latter is more closely covered by small primaries than in the former.

The striking differences found in the various groups of species of Pourtalesiæ would seem to warrant the splitting up of the genus Pourtalesia into subsections. We might retain the name of the genus, Pourtalesia, for the bottle-shaped types allied to *P. miranda*, such as *P. Tanneri*, *P. laguncula*, *P. Jeffreysi*, and form a section of the genus for the elongate *P. phiale* and another for the stout-tested *P. ceratopyga* and *P. rosea*. *P. hispida* may yet be found to belong to a special genus.

Spatagocystis A. Ag.

Spatagocystis Challengeri A. Ag.

Spatagocystis Challengeri A. Ag., Proc. Am. Acad. Vol. XIV, 1879, p. 206.
Spatagocystis Challengeri A. Ag., "Challenger" Echinoidea, 1881, p. 141.

Plates 70; 71.

From a specimen of *Spatagocystis Challengeri* among the species left in Cambridge I am able to give some additional details which were not sufficiently brought out in the "Challenger" illustrations. A view from the actinal side (Pl. 70, fig. *1*) of a specimen 48 mm. in length shows the plates of the test far better than they are shown from the fragments figured on Plate XXVI^a "Challenger" Echinioidea. An enlarged figure of the plates surrounding the actinal system (Pl. 70, fig. *4*) shows the comma-shaped labium Fig. 206, and on one side what is probably the remnant of a primordial plate enclosed in the right posterior ambulacrum, see also Fig. 177^a

(Pl. 71, figs. *1*, *6*). The actinal plates of the anterior lateral ambulacra are probably primordial plates. Fig. 162. The labium (Fig. 162) is, as in Pourtalesiæ, separated from the sternum (Pl. 70, figs. *1*, *2*, *4*; 71, fig. *6*) by the plates of the anterior zone of the lateral posterior interambulacra and by the pair of plates of the lateral posterior ambulacra, which are separated from the actinal plates by the interambulacral zone. The sternum is remarkable for its small size (Fig. 175) and prominent tuberculation (Pls. 70, figs. *1*, *2*, *4*, *5*; 71, fig. *6*), which forms the extension of the actinal keel on the line of the odd posterior interambulacrum. Seen from

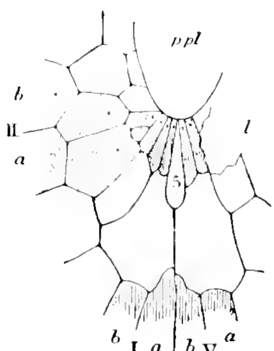

48 mm.

FIG. 206. SPATAGOCYSTIS CHALLENGERI.

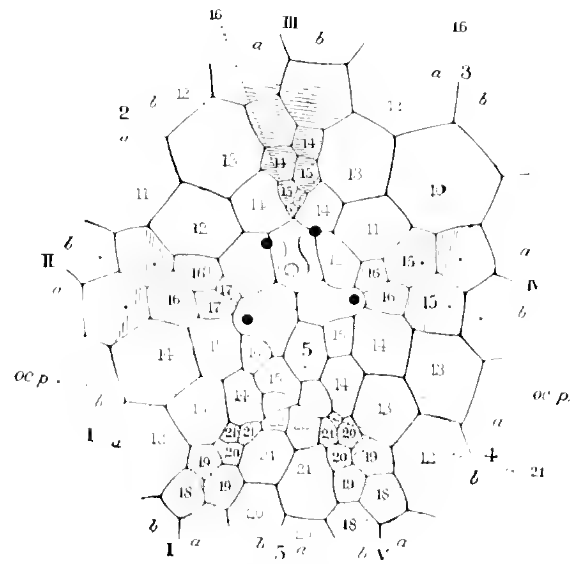

48 mm.

FIG. 207. SPATAGOCYSTIS CHALLENGERI.

the interior of the test, Fig. 207 (Pl. 70, fig. *3*), one is struck with the great uniformity in the size of the coronal plates forming the bivium on the abactinal part of the test. Above the ambitus the posterior lateral ambulacral plates are much elongated. Similarly the plates of the actinal side, except those surrounding the anal system and composing the odd interambulacrum, are quite uniform in size. The odd interambulacrum is reduced on the actinal side, beyond the anal system, to five small pairs of plates on the actinal edge of the anal system, to the small sternum, and the still smaller labium (Pl. 70, figs. *1*, *2*, *5*). The position and shape of the plates of the odd interambulacrum and round the anal system is well seen in an interior view of the anal system, Fig. 208, extending from the ambitus to the sternum and beyond (Pl. 71, fig. *5*).

The anal system is somewhat heart-shaped (Pl. 70, fig. *1*), situated in a deep re-entering pocket formed by an overhanging hood of the upper part of the test and the sharp extension of the actinal side into a kind of beak. The anal opening extends the whole length of the rounded anterior lip formed by stouter irregular polygonal plates than the numerous small plates which cover the rest of the anal system. These are larger toward the posterior edge of the anal system, gradually diminishing in size toward the anal slit, where they are quite minute.

The actinal system is elliptical (Pl. 71, fig. *1*), slightly pointed, Fig. 177[a]; it is covered on the anterior edge with a few large irregular plates; the rest of the membrane is bare. The actinostome is subcentral, placed near

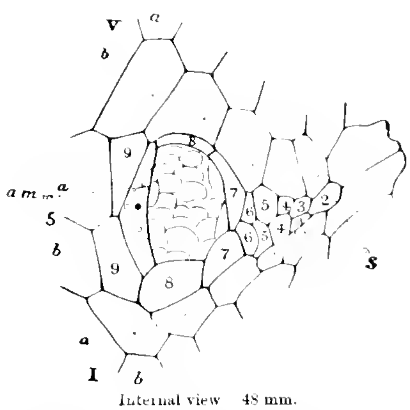


FIG. 208. SPATAGOCYSTIS CHALLENGERI.

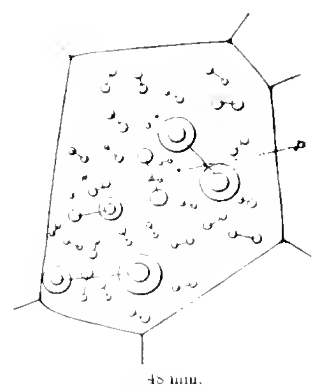


FIG. 209. SPATAGOCYSTIS CHALLENGERI.

the labium. The extent of the odd ambulacral fossa is seen in Plate 71, fig. 2, showing the odd ambulacrum in profile from the actinostome to the ambitus, Fig. 181.

The apical system of the specimen here figured differs from that figured in the "Challenger" Echinoidea (Pl. XXVI[a], fig. *8*) in having four instead of three genital openings. The anterior pair of genital openings encroach upon four adjoining plates, though the madreporic body covers only the genital plate (Pl. 71, figs. *3*, *4*) corresponding to the single anterior genital figured in the "Challenger." The right posterior genital opening is also placed on the suture of two plates. The bivium is separated from the trivium by the anterior zone of the posterior lateral ambulacra (Pl. 71, figs. *3*, *4*).

Two of the intercalated plates at the apex of the posterior lateral ambulacra may possibly be oculars, as they have slight indications of perforations (Pl. 70, fig. *3*).

The tuberculation of one of the anterior lateral ambulacral plates at the ambitus is shown on Plate 71, fig. 7; Fig. 209.

Station 147, "Challenger" Expedition, December 30, 1873. Lat. 46° 16′ S.; Long. 48° 27′ E., 1600 fathoms. Bottom temperature 0°.8 C. Globigerina ooze.

ECHINOCREPIS A. Ag.

Echinocrepis setigera A. Ag.

Echinocrepis setigera, A. Ag. Bull. M. C. Z. 1898, XXXII, No. 5, p. 78, Plate XIII.

Plates 66–69.

A number of fragments of this species were collected, but only a single fairly complete specimen (Pls. 66; 67) was obtained from Station 3399. It measured 92 mm. in length, 51 mm. in greatest width somewhat posteriorly to the bivium; at the apex, which is also the position of the abactinal junction of the trivium, the test is 52 mm. in height about a third of the length of the test from the anterior extremity. When alive the test is chocolate color, or sometimes deep claret. The primary spines, which are not numerous (Pls. 66, 67), are from 20 to 22 mm. long, of a pinkish color, and stand out prominently against the dark color of the test (Pl. 66).

The posterior edge of the deep fossa is about 23 mm. from the anterior edge of the test, and 20 mm. at its greatest width.

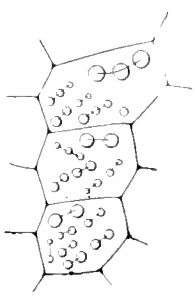
This species is at once distinguished from *E. cuneata* A. Ag.[1] by the great elongation of the posterior part of the test, the slightest indentation at the ambitus at the junction of the anterior ambulacral areas and of the posterior interambulacral region (Pl. 67, figs. *1, 2*), instead of the deep re-entering angle formed at the same place in *E. cuneata*.[2]

The outline of this species is also more rounded (Pls. 66, figs. *1, 2*; 67, figs. *1, 2, 4, 5*), less angular than *E. cuneata*. The odd anterior ambulacrum is but slightly depressed below the actinal surface (Pl. 67, figs. *1, 4*). The actinal pouch is entirely on the oral surface (Pl. 67, fig. *1*). The anterior extremity of the test when seen from above is barely indented at the odd ambulacrum (Pl. 67, figs. *1, 4*), and does not form, as in *E. cuneata*, a deep groove passing into the deep angular notch of the anterior extremity, which

[1] "Challenger" Echinoidea, Pl. XXVII.
[2] "Challenger" Echinoidea, Pl. XXV[a], figs. 9, 10.

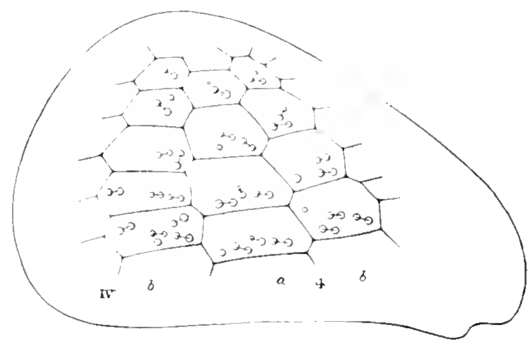
loses itself on the abactinal side toward the ambitus.[1] The short size of the actinal pouch is well seen in Pl. 69, figs. *1*, *2* on comparing it with the long fossa of *Pourtalesia Tanneri* (Pl. 57, fig. *2*), which extends the greater part of the length of the odd ambulacrum.

The primary tubercles on the abactinal part of the test are but few in number, only from one to three on each plate, Fig. 210, and even these are sometimes wanting. Many of the plates on both surfaces only carry one tubercle, and most of the anterior ambulacral plates are bare, or only thickly covered with diminutive miliaries (Pl. 67, fig. *4*), as are all the



III b. 92 mm.

FIG. 210. ECHINOCREPIS SETIGERA.



92 mm.

FIG. 211. E. SETIGERA.

plates of the test (Pls. 67; 68, fig. *5*). As the coronal plates approach the ambitus, they carry a greater number of primaries, five to seven, usually placed near the lower part of the plate, Fig. 211. At the ambitus the narrowing of the plates is also accompanied by a more crowded and smaller tuberculation which extends to all the plates of the actinal side (Pl. 67, figs. *1–5*).

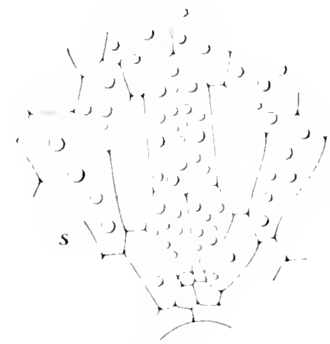
The plates of the anterior interambulacra on the actinal side are crowded with small primaries which extend to the ambitus (Pl. 67, fig. *1*). The great variation in the distribution and size of the primary tubercles is in marked contrast with the uniform tuberculation which extends over the test of *E. cuneata*.[2] In the fragment of another specimen the arrangement of the primary tubercles above the ambitus was most irregular, the plates carrying from one to five tubercles or being bare. Near the apical system the primary tubercles were closely packed; this is also well seen in the odd anterior ambulacrum, Fig. 210. On the sides of the test the secondaries run in slanting lines (Pl. 67, fig. *3*).

[1] "Challenger" Echinoidea, Pl. XXXV^a, figs. 9, 10, 12.

[2] "Challenger" Echinoidea, Pl. XXXV^a, figs. 9–12.

The sternum and adjoining episternal plates (Pl. 68, fig. *3*) of the odd posterior interambulacrum are thickly packed with primary tubercles, Fig. 212; these plates form a slight keel on the actinal side when the test is seen facing the anal extremity (Pl. 67, figs. *1*, *5*).

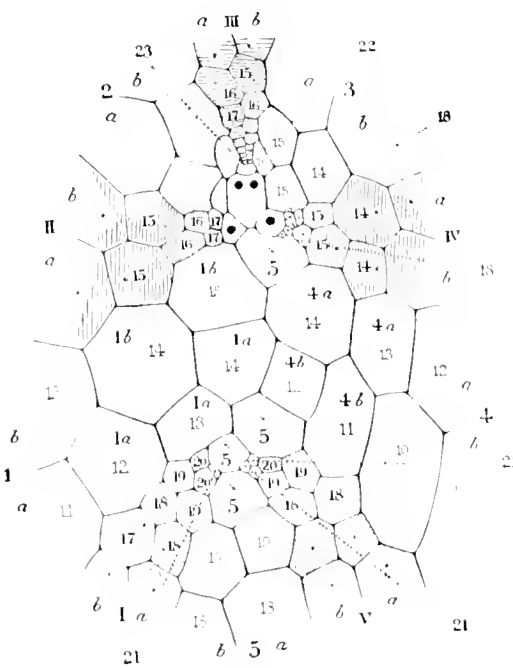
As in Pourtalesia the trivium is separated from the bivium, Fig. 213, by the abactinal plates of the lateral posterior ambulacra (Pls. 67, fig. *2*; 68. figs. *2*, *4*; 69, figs. *3*, *4*), and by additional intercalated plates, all of which are larger than the abactinal terminal plates of the odd interambulacrum.



92 mm.

Fig. 212. Echinocrepis setigera.

There are four genital openings; the madreporite extends over two of the plates which have become soldered, and carries the anterior genitals. Against this, the intercalated plates (Pl. 69, figs. *3*, *4*), the ambulacra, and interambulacra of the trivium abut. The four genital organs form small clusters hanging from a tube perhaps 15 mm. in length. As is seen in *E. cuneata*, four of the genitals have united and are covered by the madreporic body.[1]



92 mm.

Fig. 213. Echinocrepis setigera.

The ocular plate can only be traced in the odd anterior ambulacrum (Pl. 69, figs. *3*, *4*). In the crowding due to the intrusion of the intercalated and interambulacral plates between the bivium and the trivium they have been pushed out of place or resorbed. The fragments of the abactinal system showed great irregularity in the number and position of the interambulacral and intercalated plates separating the bivium and the trivium. See also those of *E. cuneata*,[2] where the separation is made by one plate, which differs from any I have seen in *E. setigera*.[3]

[1] Lovén, Pourtalesia, Pl VII, fig 54.

[2] Loven, Pourtalesia, Pl. VII, fig. 54.

[3] "Challenger" Echinoidea, Pl. XXVII, fig. 9.

The anal system is slightly pyriform (Pl. 68, fig. *3*); it is covered by five or six concentric rows of small irregularly shaped polygonal plates with a subcentral anal opening, Fig. 177. The outer row of plates are larger and carry miliaries.

The actinal system is pyriform, truncated at the posterior extremity (Pl. 69, fig. *1*). The actinal membrane is flexible, bordered only on the edges with a row of larger elongate plates on one side, broken into two or three rows of much smaller plates on the other side. There are no primordial plates and no labium to be seen, Fig. 165, unless the small plates facing the anterior lateral ambulacra are to be considered as such. As in Pourtalesia the whole width of the posterior lateral interambulacra separates the bivium from the trivium (Pls. 67, fig. *1*; 68, fig. *1*). The sternum is separated from the actinal pair of the posterior ambulacra, by the whole width of these interambulacra as well as by the actinal plates of the anterior lateral ambulacra and the antisternal plates of the posterior ambulacrum (Pl. 67, fig. *1*; 68, fig. *1*; 69, figs. *1*, *5*).

The primary radioles are long, slender, pointed, slightly curved (Pl. 66); they are longer upon the abactinal side (Pl. 66 figs. *2*, *3*) than upon the actinal side, where they are also less curved, or quite straight. The small, slender, and short miliary spines resemble the primaries in every respect except size.

The arrangement of the actinal plates of *Echinocrepis cuneata*, Fig. 166, is, according to Lovén,[1] much like that of *Spatagocystis Challengeri*, with two long slender plates in the lateral posterior ambulacra, and a pointed labium excluded from the actinal system.

Some of the pedicellariæ are brilliant glassy heads standing out like miniature spheres on the dark test.

Station 3398, fragments, off Galera Point, 1573 fathoms. Lat. 1° 7′ N.; Long. 80° 21′ W. Bottom temperature, 36°. Gn. ooze.

Station 3399, one specimen off Galera Point, 1740 fathoms. Lat. 1° 7′ N.; Long. 81° 4′ W. Bottom temperature, 36°. Gn. ooze.

Station 3415, many fragments, off Acapulco, in 1879 fathoms. Lat. 14° 46′ N.; Long. 98° 40′ W. Bottom temperature, 36°. Br. m. glob. ooze.

Bathymetrical range, 1573–1879 fathoms. Temperature range, 36°.

[1] Pourtalesia, Pl. VII, fig. 53.

PLEXECHINUS A. Ag.

Plexechinus A. Ag., Bull. M. C. Z. 1898, XXXII. No. 5, p. 76.

This genus combines features of the Ananchytid genera Urechinus and Palæotropus, while possessing also striking features of the Pourtalesiæ. It has, like Urechinus, a long hexagonal plastron, a flush actinostome, with the primordial and actinal ambulacral plates in the same position as in that genus, Fig. 214, rudimentary phyllodes, and a well developed subanal fasciole surrounding the proboscis; in Urechinus the fasciole is rudimentary, the general arrangement of the tubercles both on the actinal and abactinal sides is similar to that of Palæotropus. We may look upon the slightly sunken anal system and the protrusion of the anal rostrum surrounded by its fasciole as

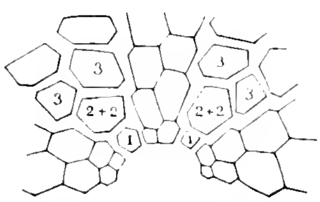


FIG. 214. PLEXECHINUS CINCTUS.

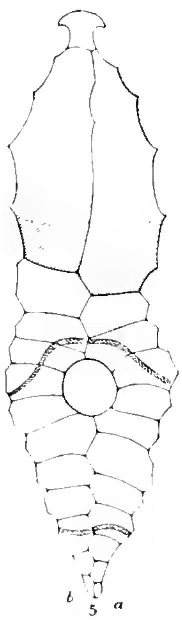


FIG. 215. SCHIZASTER FRAGILIS. AFTER LOVÉN.

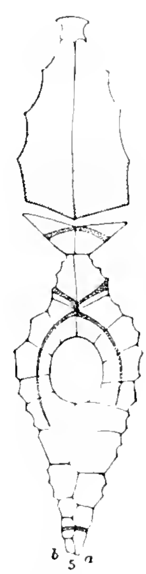
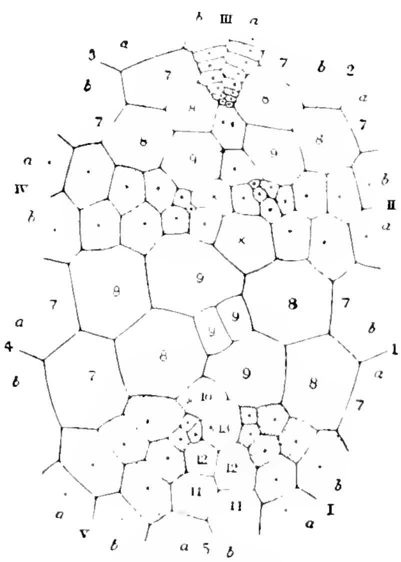


FIG. 216. ECHINOCARDIUM CORDATUM. AFTER LOVÉN.

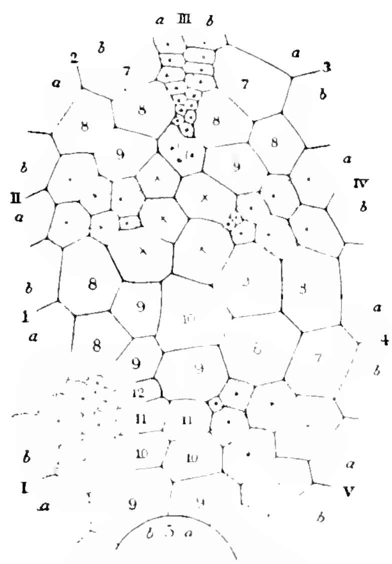
an early stage in the formation of the prominent anal snout so greatly developed in Pourtalesia.

The formation of an anal snout in Spatangoids, varying from such rudimentary ones as in Brissus and the like, to such exaggerated types as the snout of Pourtalesia, is connected with the constriction of the subanal plastron taking place between the episternal plates and plates 4 of the odd interambulacrum. Where no subanal plastron, or only an anal fasciole exists, this constriction does not take place and the plates of the odd interambulacrum extend laterally so that the outline of the anal part of the test becomes more or less cylindrical. An excellent example of this can be seen on comparing the odd interambulacrum of *Schizaster fragilis*, Fig. 215, with that of *Echinocardium cordatum*, Fig. 216, the former having an anal fasciole, the latter a subanal plastron. The effect of this constriction to form the extreme development of the snout, as in *P. Jeffreysi* and *P. Tanneri*, is shown in Figs. 171, 174. The reduction of the sternum



Outside view. 20 mm.

FIG. 217. PLEXECHINUS CINCTUS.



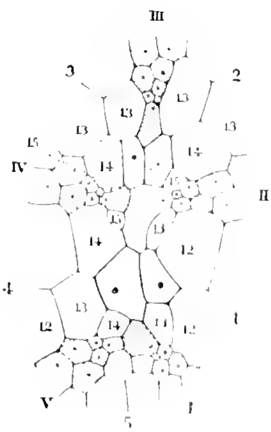
Inside view. 20 mm. ? (fragment).

FIG. 218. P. CINCTUS.

and of the plates of the odd interambulacrum to a diminutive size, as in *Echinocrepis setigera* and *Spatagocystis Challengeri*, Figs. 167, 175, reduces the snout to a mere point.

The abactinal system, Figs. 217, 218, is much like that of *P. Tanneri* and *P. lagunculа*, both the zones of the posterior interambulacra separating completely the trivium from the bivium, with a number of intercalated plates, Fig. 217, which may belong to the odd interambulacrum, while in Urechinus, Fig. 219, and Calymne the bivium and trivium are only separated by the anterior zone of the posterior interambulacra, and in Palæotropus, Figs. 245, 246, 247, the abactinal plates of all the interambulacra abut against the single central genital plate.

The labium is separated from the sternum by the posterior zone of the posterior ambulacra (Pls. 58, fig. *1*; 59, figs. *1*, *3*). As in Urechinus the primordial plates are all in contact with the actinal system (Pls. 58, fig. *1*; 59, figs. *1*, *3*).



Out side view.

FIG. 219. URECHINUS NARESIANUS. AFTER LOVEN

It is interesting to trace the changes between Pourtalesia proper with its bottle-shaped outline, deeply sunken actinal and anal grooves, its well developed anal proboscis, and such a type as Plexechinus, in which the Pourtalesian features have almost disappeared, to pass into a more Ananchytid type represented by Urechinus and Cystechinus. In the further development the rudimentary phyllodes and labium become specialized in Genicopatagus, Argopatagus, and Homolampas. Next Ananchytid petals like those of Paleopneustes, Linopneustes, lead us gradually to the petaloid type of the recent Spatangoids.

The recent Ananchytid Spatangoids might thus naturally be subdivided into three families: the Urechinidæ, with such types as Urechinus, Cystechinus, Pilematechinus, and Calymne; a second group containing the Paleopneustidæ, containing genera like Linopneustes and Paleopneustes, — all types more closely allied to the recent Spatangoids; with perhaps a third group containing Argopatagus, Genicopatagus, Homolampas, and Palæotropus, though for the present the third group may remain united with the Paleopneustidæ.

Plexechinus cinctus A. Ag.

Plexechinus cinctus A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 76, Pl. VIII, figs. 3, 4.

Plates 55, figs. *3–5*; 58, figs. *1–4*; 59; 60, figs. *1–3*.

Only two slightly broken specimens of this interesting species were collected, at Station 3424. The smaller of the two specimens measured 21 mm. in length, 15.5 mm. in width at the anterior part of the posterior lateral interambulacra, and 11 mm. in height immediately in front of the anal system. Seen in profile (Pls. 55, fig. *5*; 58, fig. *3*) the test slopes very gradually from the highest point in front of the anal system towards the rounded anterior extremity. The posterior extremity is scooped out for the anal system above the broad anal proboscis, which is rounded posteriorly, and gradually lost in the keel of the actinal surface. The anal proboscis is bound by a wide fasciole (Pl. 58, figs. *1–4*) well beyond the posterior edge of the anal system (Pl. 59, figs. *2, 3*) and sloping toward the anterior extremity. The fasciole stands out very prominently, as the ambulacral plates both on the actinal side and the side of the test flanking the posterior extremity are bare, while the odd interambulacral plates enclosed by the fasciole are closely tuberculated with small primaries and minute miliaries, as is also the whole abactinal part of the test. The actinal plates of both the ambulacral and interambulacral areas adjoining the ambitus as well as the plastron are covered with larger primary tubercles, while the posterior zone of the posterior ambulacra as well as the actinal plates of the ambulacra are bare or carry but few miliaries (Pl. 59, fig. *1*).

The actinal system is circular, strengthened by an outer row of plates, largest on the anterior edge, gradually becoming smaller towards the posterior edge. The central part of the actinal system is covered by minute elongated plates radiating from the actinostome (Pls. 58, fig. *1*; 59, fig. *2*).

The anal system is transversely elliptical (Pls. 58, fig. *4*; 59, fig. *3*); an outer row of larger irregularly shaped plates surrounds the small elongated central plates.

These specimens are evidently young stages, as no trace of genital openings could be seen, unless one of the openings seen on the large interambulacral madreporic plate in continuation of the odd interambulacrum be a genital pore (Pl. 60, figs. *1–3*).

As in Pourtalesia the ocular plates are not present or could not be traced; and not only is the bivium separated from the trivium by the abactinal plates of the lateral posterior interambulacra and some intercalated plates (Pls. 58, fig. *2*; 60, figs. *1, 2*), but the ambulacra of the trivium are also disconnected by the intrusion of the lateral anterior interambulacra, and those of the bivium by that of the odd posterior interambulacrum. Figs. 217, 218. It will be seen that there is great variation in the position of the intruding interambulacral plates and intercalated plates. In Plate 60, fig. *2*, the intruded plates seem to belong without doubt to the odd and posterior lateral interambulacra, while in Plates 58, fig. *2*; 60, fig. *1*, the relation of the intruding interambulacral plates and the intercalated ones is by no means so simply traced, reminding us more of the arrangement of the abactinal plates of *P. Tanneri* and *P. laguncula*. There seems to be some difficulty, owing to the great size of the intercalated or intruding interambulacral plates, in considering them as the abactinal plates of a smaller series preceding them.

The primoridial interambulacral plates in contact with the actinostome vary but little in size, Fig. 214. The labium is, owing to its isolation from the sternum, lanceolate.

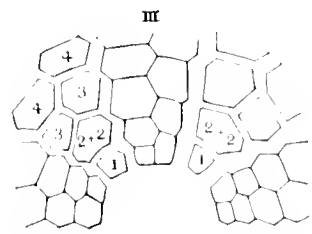


FIG. 220. URECHINUS NARESIANUS. AFTER LOVÉN.

In Plexechinus (Pl. 59, fig. *3*), as in Urechinus (Pls. 58, fig. *5*; 73, fig. *1*), the second plate of the lateral ambulacra is a double plate.

The Urechinid type of the odd anterior ambulacrum and of the adjoining interambulacra of Plexechinus is well seen on comparing Fig. 214 and Fig. 220, which represent the odd ambulacrum of *Pl. cinctus* and *U. Naresianus*, with the odd interambulacrum of other Urechinids, such as *Cystechinus Loveni*, with Spatagocystis, Echinocrepis, and Pourtalesia, Figs. 162, 165, and 169. In the Urechinids the second plates of the paired interambulacra are double, while they are single in the Pourtalesiæ.

Station 3424, off Tres Marias, Gulf of California, in 676 fathoms. Lat. 21° 15′ N.; Long. 106° 23′ W. Bottom temperature, 38°. Gy. s. blk. s. blk. sp. glob.

ANANCHYTIDÆ Alb. Gras.

URECHINIDÆ Lambert (emend.)

URECHINUS A. Ag.

Urechinus giganteus A. Ag.

Urechinus giganteus A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 79, Pl. VIII, figs. 7, 8.

Plates 72; 73; 74, figs. *1–5*.

From Station 3431 two large specimens of Urechinus were collected (Pl. 72), far larger than any specimens of the genus hitherto obtained by the "Challenger" or the "Blake." The smaller specimen measured 80 mm. in length, 63 mm. in width slightly posterior to the apical system, and 37 mm. in greatest height. The larger specimen measured 93 mm. in length, 80 mm. in width, and 39 in height. The outline as seen from above or below is ovoid (Pl. 72, figs. *1*, *2*); the larger specimen is proportionally flatter. On the actinal side the odd anterior ambulacrum is slightly sunken near the actinostome, much less so than in the other species of the genus. There is a mere rudimentary subanal fasciole in some specimens of *U. Naresianus*[1] (Pl. 74, fig. *8*), in others it is well developed. No trace of such a fasciole could be detected in this species (Pl. 73, fig. *3*).

Seen in profile (Pl. 72, fig. *3*) the outline is regularly arched both towards the anterior and posterior extremity, somewhat more gibbous at the anterior extremity. The abactinal side passes most gradually into the ambitus and actinal side. At the junction of the posterior interambulacrum and lateral ambulacra the test forms a slight re-entering curve when seen in profile.

This species is remarkable for the great length of the primary radioles above the ambitus (Pl. 72, fig. *2*); in proportion to the size of the test they are nearly as long as in Linopneustes and Paleopneustes. When covered with spines, this species of Urechinus must have recalled small specimens of Linopneustes; the spines do not increase in length with the larger specimens. In the smaller specimen the length of the primary radioles on the abactinal side along the sides of the test varied from 21 mm. to 8 or 9. They are very slender, sharp-pointed, and curved. On the actinal side the radioles are shorter, usually straight, and do not exceed 10 mm. in length, the majority being from 4 to 6 mm. long.

Above the ambitus the whole test is covered by minute miliaries (Pl. 73, figs. *2*, *3*) scattered uniformly over the surface of the coronal plates except on the posterior interambulacra, where they are more closely crowded. The miliary tubercles carry either minute cylindrical spines or round-headed pedicellariæ on stems of about $\frac{3}{4}$ mm. in height. The primary tubercles are placed pretty uniformly on the abactinal part of the test (Pl. 72, figs. *2*, *3*). Both on the ambulacral and interambulacral areas there are from three to seven primary tubercles on each plate; they are more numerous and more closely crowded together toward the ambitus (Pl. 73, figs. *2*, *3*). In the interambulacral areas of the actinal side the primaries become somewhat smaller and are crowded on the plates (Pls. 72, fig. *1*; 73, fig. *4*), forming a close pavement; this is specially the case in the odd posterior interambulacrum (Pls. 72, fig. *1*; 73, fig. *1*). We find in Urechinus as in Cystechinus bare circular spots (Pls. 73, figs. *2*, *3*; 74, fig. *5*) which represent primaries and miliaries that have been resorbed and have disappeared, having been dissolved as other carbonate of lime organisms dissolve at great depths.

[1] "Challenger" Echinoidea, Pls. XXX, fig 19; XXX^a, fig. 10^a.

The ambulacral areas are bare where the phyllodes are developed, about half-way from the actinostome to the ambitus (Pls. 72, fig. *1*; 73, fig. *1*); beyond that point they are covered with small secondaries as in the interambulacral plates (Pl. 72, fig. *1*). Round the anal system (Pl. 73, fig. *5*) the tuberculation is coarse like that of the interambulacral plastron. The anal system is partly on the actinal side and partly on the ambitus. It is longitudinally slightly elliptical (Pl. 73, fig. *5*), covered with concentric rows of trapezoidal plates; the outer row is composed of larger plates, they all carry small tubercles. The anal opening is subcentral towards the actinal edge.

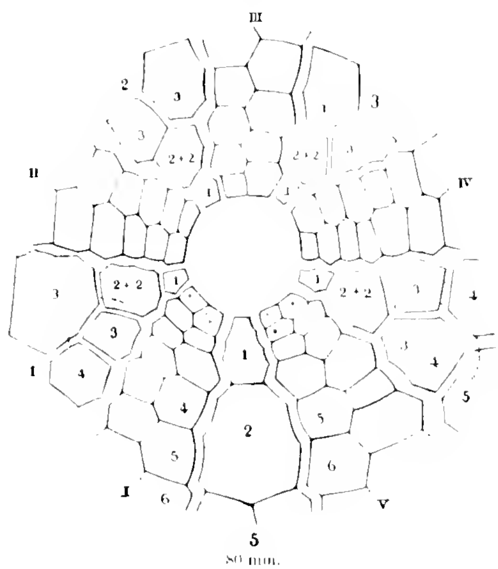


FIG. 221. URECHINUS GIGANTEUS.

The sternum of *U. giganteus* is polygonal, narrower towards the actinostome, Fig. 221, and proportionally much larger than the elongate heptagonal sternum of *U. Naresianus*,[1] Fig. 223, which is followed by large episternal plates, Fig. 222.

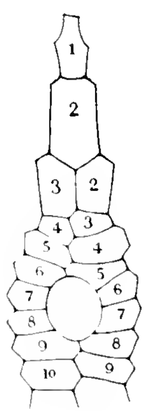


FIG. 222. URECHINUS NARESIANUS. AFTER LOVÉN.

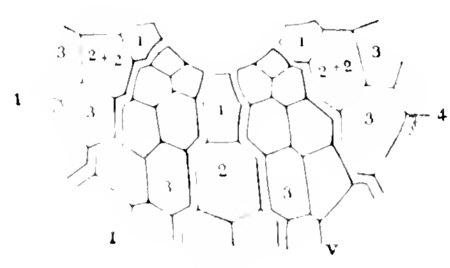


FIG. 223. U. NARESIANUS.

The actinostome is circular, depressed (Pls. 72, fig. *1*; 73, fig. *1*), covered with an outer row of large triangular plates with smaller elongated plates between these and the actinal opening. In this large specimen the rudi-

[1] In Calymne the plastron is like that in Urechinus, the labium is small, followed by a single plate and then by the double plates. This corresponds to the first and second interambulacral plates of Cystechinus.

mentary phyllodes include six to seven pairs of pores towards the ambitus (Pls. 72, fig. *1*; 73, fig. *1*). In a small specimen of *U. Naresianus* of 13 mm. there are but two pairs of pores (Pl. 74, fig. *6*) representing the phyllodes.

It is interesting to note that the actinal edge of the primordial interambulacral plates forms with its close tuberculation a rudimentary bourrelet (Pl. 73, fig. *1*) separating the ambulacral areas, a character greatly developed in such genera as Conolampas, Conoclypus, Echinolampas, and the like.

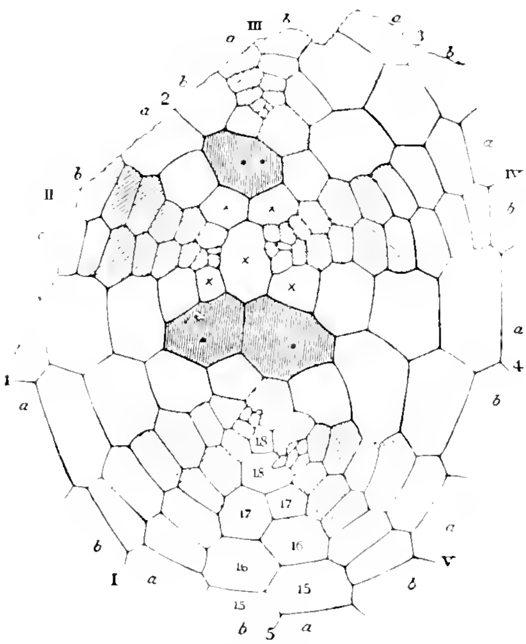

93 mm.

FIG. 224. URECHINUS GIGANTEUS.

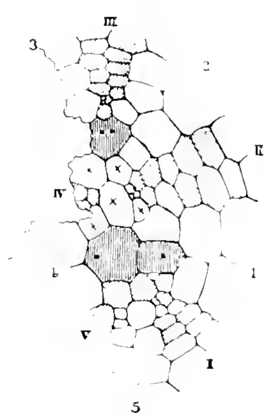

80 mm.

FIG. 225. U. GIGANTEUS.

On the abactinal side of the test (Pl. 74, fig. *2*) the pores are placed towards the lower side of the ambulacral plates.

In the abactinal system the anterior genital plates (Pl. 74, figs. *1*, *2*) are united in a single plate which also carries the madreporic body, Figs. 224, 225. The odd anterior ocular plates abut against this composite genital; the anterior lateral ambulacra are separated by an elongated intercalated central plate which abuts on the anterior side against the abactinal plates of the anterior lateral interambulacra, and on the other against the posterior genitals, which with an intercalated plate separate the bivium from the trivium, against which abuts the ocular of the right posterior ambulacrum. There are no anterior lateral oculars. The ambulacral tube of the odd anterior ambulacrum does not pierce the odd ocular plate (Pl. 74, fig. *4*).

To which of the series the intercalated plates belong, it seems impossible to determine. By analogy we might take this central plate to represent the two contiguous ocular plates of Cystechinus (Pl. 79, fig. *3*), or of the specimen of *U. Naresianus* figured by Lovén,[1] which has two oculars, Fig. 226, occupying the place of the single central plate in *U. giganteus*.

In *Urechinus Naresianus*, Pl. 74, fig. *7*, the oculars of the trivium together with the madreporic genital form a connected series separated from the bivium

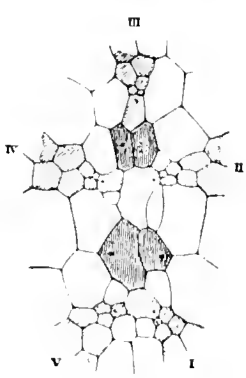
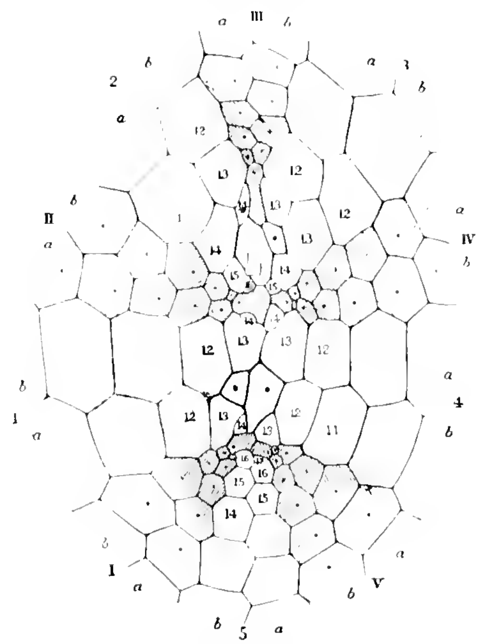


Fig. 226. U. Naresianus.
After Lovén.



Inside view. 30 mm.
Fig. 227. Urechinus Naresianus.

by four small intercalated plates and the two posterior lateral genitals, which in the specimen of 13 mm. are not perforate. In a still older specimen 30 mm. in length, Fig. 227 (Pl. 60, figs. *4*, *5*), the abactinal plates of the anterior zones of the posterior pair of interambulacra separate the bivium from the trivium, as well as a couple of small intercalated plates adjoining the central ocular plates and those of the bivium, the position of which is doubtful. The great size of the posterior genitals of *U. giganteus*, Fig. 224, is in marked contrast to the small genital plates of *U. Naresianus*.[2]

[1] Pourtalesia, Pl. XXI, fig. 242.

[2] M. de Meijere has figured an interesting Ananchytid: Sternopneustes (*Sternopneustes relictus* de Meijere, l. c. p. 117); it has much the outline of *Paleopneustes cristatus*, the abactinal system and sternum of Urechinus, but its actinal system is more like that of Homolampas, with a slightly

There is considerable variation in *U. Naresianus* in the manner in which the bivium is separated from the trivium by the plates intercalated between the posterior genitals and the anterior lateral ambulacra (Fig. 227). When the right anterior genital is greatly developed it comes in contact with the posterior genitals so that the belt of intercalated interambulacral plates does not extend across the abactinal system. Similar variation in the arrangement of the abactinal plates (Fig. 219) has been observed in *Pilematechinus Rathbuni* (Figs. 238, 239).

Station 3431, off Altata, Gulf of California, in 995 fathoms. Lat. 23° 59′ N.; Long. 108° 40′ W. Bottom temperature 37°. Lt. br. m. glob.

Cystechinus A. Ag.

Gregory has described a species of Cystechinus[1] (*C. crassus*) from the Radiolarian marls of Barbados. "The specimen is unfortunately in a very imperfect state of preservation, as the actinal side is not shown, and the structure of the apical system can only be inferred. Even on the abactinal side many of the plates have been lost." Mr. Gregory further states that none of the "Challenger" collections of Cystechinus in the Natural History Museum are more perfect, except a couple of very young specimens of *C. Wyvillii*, and that the specimen is in better preservation than the collection of scattered plates that forms the type of *C. clypeatus*. The great thickness of the plates of *C. crassus* and the resemblance to those of the Palæchinidea would seem to preclude the association of this species with Cystechinus, especially as we know nothing of its shape, of its actinal face, or abactinal system.[2] Only one of the species of Cystechinus described from the "Challenger" collection (*C. vesica* A. Ag.) possesses a flexible test,[3] and not others as is suggested by Gregory; the others, though having a thin test, were rigid.

It is hardly correct to say that none of the "Challenger" specimens of Cystechinus were in a better condition than the fragment figured by Gregory, since it has been possible to make such drawings of *C. vesica*, *C. Wyvillii*, and *C. clypeatus*[4] as we have given in the "Challenger" Echinoidea. The com-

prominent lower lip and an elliptical crescent-shaped actinostome. It has also a well developed subanal fasciole, as in some specimens of *Urechinus Naresianus* ("Challenger" Echinoidea, Pl. XXX a, figs. 10, 10 a, 12, 13).

[1] Quart. J. Geol. Soc. London, 1889, Vol. XLV. p. 640.

[2] It is true that the plates of the test of deep sea species vary somewhat, but not to the extent assumed by Gregory in uniting *C. crassus* to Cystechinus.

[3] A. Agassiz, "Challenger" Echinoidea, p. 151.

[4] "Challenger" Echinoidea, Pls. XXIX, XXIX a, XXIX b, XXXV, XXXV a, figs. 5–8.

parison of Gregory's figures will show the incorrectness of the statement. Even the plates and fragments of *C. clypeatus* showed plainly the abactinal system and the surrounding coronal plates and the anal system (Pl. XXXV b, figs. 10, 11). These characters cannot be studied in the specimen described by Gregory, and it seems to me a very hazardous identification.

I do not see why Neumayer should be quoted as mentioning Cystechinus as one never found above the 1000 fathom line. All the information we had on the subject at the time Mr. Gregory wrote his article was derived from the data given in the Reports of the "Challenger."

As regards the statements made on the subject of Calymne in the Report of the "Challenger" Echinoidea, the single specimen sent to me was marked "'Trawl,' 2650 fms. May 27. 1873." The "Trawl" was so indistinctly written as to be mistaken for Fayal. It was not until after the Report had been printed that my mistake was discovered.

Gregory[1] is mistaken in stating that at the time he described *C. crassus* the genus was only known from the Antarctic and China Sea. See "Challenger" Echinoidea, p. 218. He also speaks with some doubt of the genus Cystechinus having been dredged by me in deep water off the western coast of Central America. While it is true that my remarks on the two species collected (*C. Loveni* A. Ag. and *C. Rathbuni* A. Ag.) are short, I must insist that the photographs given of the species[2] are sufficient to denote their affinities to *C. Wyvillii* and *C. vesica*. But like many of the criticisms directed against short preliminary notices, they lose their value if the accompanying illustrations are taken into account, and not ignored, as is usually the case.

Cystechinus Loveni A. Ag.

Cystechinus Loveni A. Ag., Bull. M. C. Z. 1898, XXXII. No. 5, p. 79, Plate IX.

Plates B, fig. 3; 75–79.

This species is closely allied to *Cystechinus Wyvillii* A. Ag.[3] It can be distinguished from it by its comparatively stout test, its circular or pyriform anal system (it is transverse in *C. Wyvillii* and *C. clypeatus*), the great size of the actinal plastron, and by the marked differences in the

[1] Gregory, Relations of Echinid Faunas. Bull. Geol. Soc. of Am., Vol. 3, 1891, p. 10.
[2] Bull. M. C. Z. 1898, XXXII. No. 5, p. 79, Pls. IX. X.
[3] "Challenger" Echinoidea, Pl. XXIX b.

shape of the plates of the apical system. In *C. clypeatus* A. Ag.[1] the posterior genitals are characterized by their lateral elongation and, as in *C. Wyvillii*, by the great size of the posterior lateral ocular plates (Pl. 80, figs. *5*, *6*), Fig. 234.

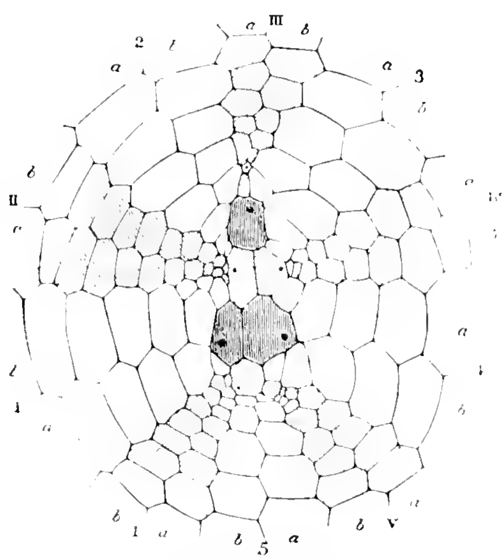
The test when seen from the actinal or abactinal side (Pl. 75, figs. *1*, *2*) is somewhat more pointed than in *C. Wyvillii*, A. Ag.[2] Seen in profile (Pls. 76, fig. *1*; 77, fig. *3*) the shorter anterior extremity, and the slight re-entering outline of the sides of the test are in marked contrast with the gibbous outline of the test above the ambitus, the deep re-entering curve, and the extension of the anterior extremity of the test of *C. Wyvillii*.[3] The more conical and gibbous outline of *C. Wyvillii*,[4] as contrasted with *C. Loveni* (Pl. 76, fig. *2*) is well seen on comparing the two figures here quoted. The coronal plates are proportionally higher in *C. Wyvillii* than in *C. Loveni*. In a specimen of the former of 88 mm. in length there are eleven plates in the odd anterior ambulacrum from the apex to the ambitus, while in the latter, in a specimen of the same size there are thirteen plates in the odd anterior ambulacrum and nine in the odd interambulacrum. The most prominent character of the test is the greater number of the fine primary tubercles in *C. Loveni* (Pl. 77) as compared with the coarser and more distant primaries of *C. Wyvillii*.[5] The miliaries are also finer and more crowded in *C. Loveni* (Pl. 77).

The size of the actinal plastron of *C. Loveni* (Pls. 77, fig. *2*; 78, fig. *3*) is large as compared with that of *C. Wyvillii*.[6] The rudimentary phyllodes occupy five or six of the actinal ambulacral plates in the anterior lateral ambulacra, three or four in the posterior ambulacra, and four or five in the odd anterior ambulacrum (Pls. 76 figs. *4*, *5*; 78, fig. *3*). There is a marked thickening of the actinal plates adjoining the actinostome (Pls. 76, fig. *5*; 78, fig. *5*), forming a low ridge much as it occurs in Echinolampas (Pl. 64, fig. *5*) and Conolampas (Pl. 65, fig. *6*). The labium is by far the largest of the primary interambulacral plates (Pls. 77, fig. *1*; 78, fig. *3*). The ambulacral plates of the actinal side are comparatively bare; towards the ambitus they become like the interambulacral plates thickly covered with primary tubercles (Pl. 77, fig. *1*).

I have already, when speaking of *Urechinus giganteus*, alluded to the bare spaces occasionally occurring on the coronal plates, which would seem

[1] "Challenger" Echinoidea, Pl. XXXV^b, fig. 10.
[2] Id., Pl. XXIX^b, fig. 2.
[3] Id., Pl. XXIX^b, fig. 3.
[4] Id., Pl. XXIX, fig. 4.
[5] Id., Pl. XXIX^b, figs. 1–4.
[6] Id., Pl. XXIX^b, fig. 2.

to indicate a partial resorption of a part of the tubercles. This is still further elucidated in specimens of *C. Loveni.* When coming up in the trawl most of them appeared as if patches of the test had been badly rubbed; they had lost their purple color, and the tubercles seemed broken off (Pls. 75, fig. *2*; 76, figs. *1–3*). A closer examination of these white patches (Pls. 77, figs. *2–4*; 78, fig. *2*) showed that they consisted of bare areas where the miliaries as well as many of the primaries had disappeared. In other parts of the test the scrobicular areas alone remained to show the position of the small primaries, the mammelon and primary boss having disappeared (Pl. 77, figs. *2, 3*). This is well seen in the actinal plates of the odd interambulacral area (Pl. 77, fig. *1*) and on the sides of the test near the ambitus (Pl. 77, figs. *3, 4*). Nothing, it seems to me, can show more plainly the constant struggle that must exist for the deposition of the needed carbonate of lime even for such thin tests as those of *C. Loveni* or the shells of the delicate deep-sea mollusks associated with them, the least disorder in the growing tissue of any part of the test evidently affecting at once the active deposition of the carbonate of lime of that region.

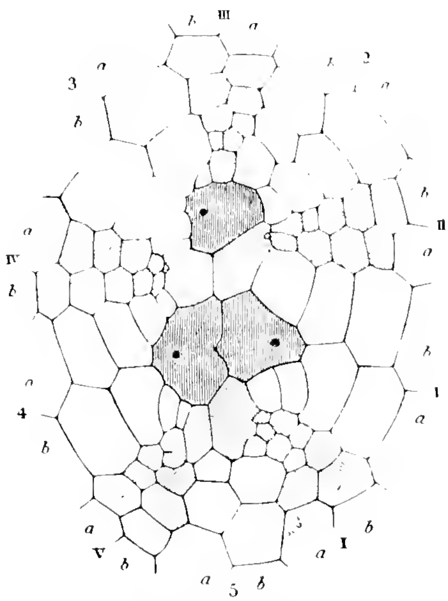


Inside view 80 mm ?

FIG. 228. CYSTECHINUS LOVENI.

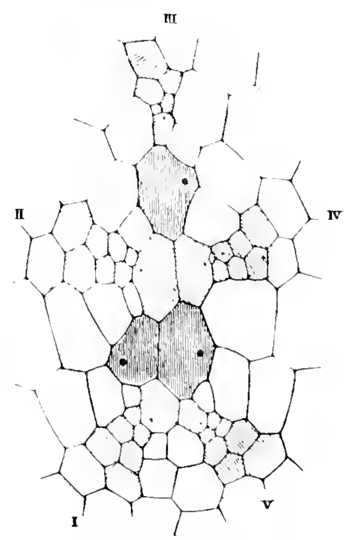
In the apical plates of Cystechinus, Fig. 228, the odd anterior ocular is followed by the madreporic genital plates, composed of the anterior genitals followed by the large lateral anterior adjoining oculars and the elongate posterior genitals against which abut the large lateral posterior oculars (Pl. 79, figs. *1–3*).

In the three larger specimens of which we examined the apical system, Fig. 229, there was considerable variation in the shape of the apical plates. In one case (Pl. 79, fig. *1*) the plates of the abactinal lateral interambulacra of both the zones abutted against the sides of the anterior madreporic genital, in the others (Pl. 79, figs. *2, 3*) the plates of the posterior zones terminated against the anterior lateral oculars. These, as well as the posterior genitals and the posterior oculars, also varied greatly in outline and size, Fig. 230 (Pl. 79, figs. *1–3*). In Cystechinus the ocular plates are not



Outside view. 88 mm.

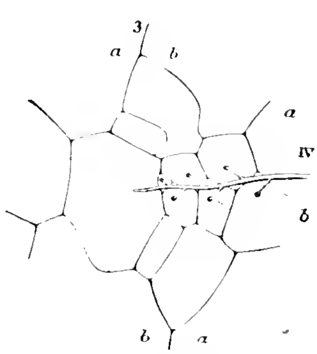
FIG. 229. C. LOVENI.



Inside view 85 mm. ?

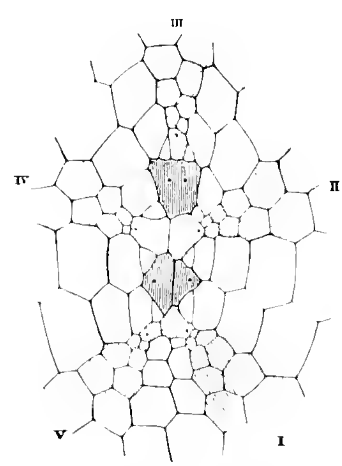
FIG. 230. CYSTECHINUS LOVENI.

infrequently imperforate in older specimens (Pl. 78, fig. *6*), Fig. 231. In a smaller specimen of 20 mm. the abactinal system (Pl. 79, fig. *4*) resembles somewhat that of Urechinus, Fig. 232.



88 mm.

FIG. 231. C. LOVENI.



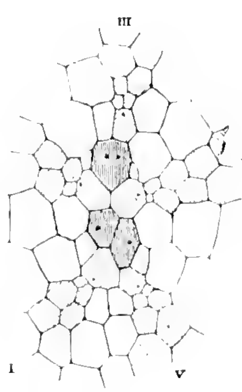
Outside. 20 mm. ?

FIG. 232. C. LOVENI.

The actinal system is elliptical, the actinostome is subcentral placed towards the posterior edge (Pl. 79, figs. *3*, *5*). The anterior part of the actinal membrane is covered with an outer row of large triangular plates becoming smaller towards the posterior edge. The rest of the actinal membrane is covered with irregular rows of small elongate plates radiating from the actinostome.

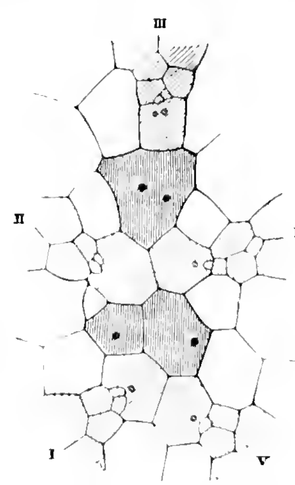
The anal system is circular or slightly pyriform (Pls. 75, fig. *1*; 78, fig. *4*); it is covered by five to six irregular rows of concentric and radiating small polygonal plates, a few of which are somewhat larger on the outer margin of the actinostome; all the plates except those radiating from the actinostome carry small miliaries.

A re-examination of two stages of *C. Wyvillii*, Figs. 233, 234, collected by the "Challenger," one of 18 mm. in length (Pl. 80, figs. *3*, *4*), the



Inside. 18 mm.

FIG. 233. CYSTECHINUS WYVILLII.



Inside. 56 mm.

FIG. 234. CYSTECHINUS WYVILLII.

other 56 mm. (Pl. 80, figs. *5*, *6*), shows no great differences between it and *C. Loveni* in the arrangement of the apical plates. The increase in the size of the genital pores is marked in the larger specimen (Pl. 80, figs. *5*, *6*); they are barely visible in the smaller specimen (Pl. 80, figs. *3*, *4*). With increasing size the slightly elliptical actinal system of *C. Wyvillii* (Pl. 80, fig. *1*) becomes pentagonal (Pl. 80, fig. *2*). The phyllodes are found on a larger number of ambulacral plates (Pl. 80, figs. *1*, *2*). The primary tuberculation is limited to two or three tubercles on each coronal plate, and the miliaries are more distant (Pl. 80, figs. *1*, *3*). In the larger specimen the primary tubercles as well as the miliaries have increased in number, so that, compared to the younger stage, they now cover the coronal plates quite uniformly (Pl. 80, figs. *5*, *7*). In these two specimens of *C. Wyvillii* the anal system is already longitudinally elliptical (Pl. 80, figs. *1*, *7*). In the smallest it is covered with three to four concentric rows of polygonal plates of nearly uniform size, the outer row being somewhat larger, with an inner row of small elongated plates round the actinostome (Pl. 80, fig. *1*). In the larger specimen the anal system has become greatly elongated with a prominent outer row of pentagonal plates, the central part being covered by smaller polygonal and elongated plates, all except those near the anal opening carrying a number of miliaries (Pl. 80, fig. *7*). The plates of the anal system have not yet assumed the imbricating arrangement they take in older stages ("Challenger" Echinoidea, Pl. XXIX^a, fig. 20) or in *C. clypeatus* (Pl. XXXV^b, fig. 11).

Station 3415, off Acapulco, 1879 fathoms. Lat. 14° 46′ N.; Long. 98° 40′ W. Bottom temperature 36°. Br. m. glob. ooze.

PILEMATECHINUS A. Ag.

Cystechinus pars A. Ag. Bull. M. C. Z. 1898, XXXII, No. 5, p. 79.

In the preliminary Report on the Echini of this Expedition, I referred the extraordinary sea urchin described as *Cystechinus Rathbuni* to the genus Cystechinus. Subsequent examination has led me to propose a new genus for this interesting species, for the following reasons.

The primary coronal plates adjoining the actinal system are smaller than the labium, Fig. 235, and are followed by a single plate. It is possible that the labium is made up of two plates and then followed by the regular succession of plates belonging to the right and left odd interambulacral zones (Pl. 85, figs. *1*, *2*). Both in *C. Wyvillii* (Pl. 80, fig. *1*) and *C. Loveni* Fig. 237 (Pl. 78, fig. *3*) a single sternal plate follows the labium, Fig. 236, as in Urechinus (Pl. 74, fig. *6*); while in *C. Rathbuni* the labium is followed by the plates of the two zones of the odd interambulacrum (Pl. 85, figs. *1*, *2*).

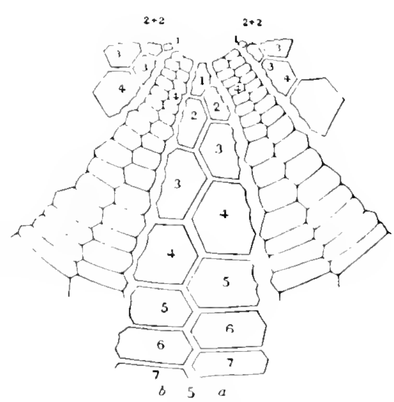
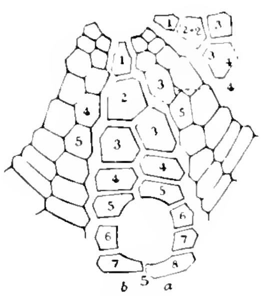


FIG. 235. PILEMATECHINUS RATHBUNI.

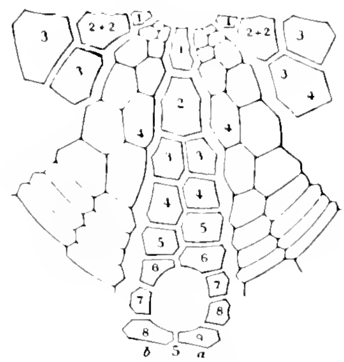
So radical a difference may justify us in separating generically, as Pilematechinus, *C. Rathbuni* from *C. Loveni* and associating it in a new genus with *C. vesica*, in which the structure of the plastron is like that of *C. Rathbuni*, it having a high thin test and the anus well above the ambitus.

If the labium consisted of two plates the sternum would be constructed like that of Offaster, but from analogy of the young of Abatus it has the rudimentary embryonic meridosternum of Spatangoids, though the size of the plates is reversed. In Abatus, *a* 2 is the larger as in Hemipneustes, in Echinospatagus, Dysaster, and Spatangoids generally, while in Pilematechinus, *b* 2 is the larger, as is the case in Offaster, Micraster, and Hemiaster.[1] In Holaster, Collyrites, Echinolampas, Cassidulus, the plates *b* 2 or *a* 2 are sometimes the larger. In Cardiaster Peroni there are five single plates, one above another. In the plastron of Stegaster,[2] though a meridosternal one, the labium, like that of Plexechinus, is separated from the sternum by the posterior lateral ambulacra. In *Cardiaster tenuiporus* the plates alternate below the labium.



18 mm.

FIG. 236. C. WYVILLII.



83 mm.

FIG. 237. C. LOVENI.

It seems to me as if Lambert himself had given us the best possible proof of the accuracy of Lovén's view of the development of the amphisternal from the meridosternal plastron. The development of the adult amphisternal Abatus from a meridosternal young (Pl. 99, figs. *1–5, 8*) seems to settle this question in favor of Lovén's view. In the young Echinocardium (1.7 mm.) figured by Lovén[3] the plastron is already amphisternal. In the young Abatus there is no difference in the interambulacra; the primordial plate is followed in each by two plates differing greatly in size.

While in the odd interambulacrum of the recent Spatangoids the primordial plate, the labium, is followed by the amphisternal plastron, in the older Spatangoids, as in Collyrites, Ananchytes, and in the Nucleolidæ or Clypeastroids there is no marked difference in the order and arrangement of the interambulacral plates in any of the interambulacra; though in the latter the order of the interambulacral plates is often interrupted by the lateral encroachment of the ambulacral plates.

[1] These data are taken from Lambert's interesting paper on the Plastron of Spatangoids. Bull. Soc. des Sc. hist. et nat. de l'Yonne. 2e semestre, 1892.

[2] See Lambert, l. c. p. 6

[3] Pourtalesia, Pl. XV, figs. 172, 173.

Pilematechinus Rathbuni A. Ag.

Cystechinus Rathbuni A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 79, Plate X.

Plates 81–86.

A number of specimens in excellent condition came up in the trawl from the two stations at which this species was procured. While the test of some of the specimens came up more or less indented, yet a few preserved their shape. and none showed such extremes of flexibility as in *C. vesica*;[1] we are thus able to give figures of the outline of the group of Cystechinus to which this species (Pls. 81; 82) and *C. vesica* belong. The test of *P. Rathbuni* is much thinner than that of *C. Loveni*, but somewhat thicker than that of *C. vesica*. The coronal plates are frequently split by longitudinal or transverse cracks due to the sharp folds of the sides of the test (Pls. 82; 85, fig. *5*) or differences in the thickness during the growth of the plates (Pl. 86, fig. *4*).

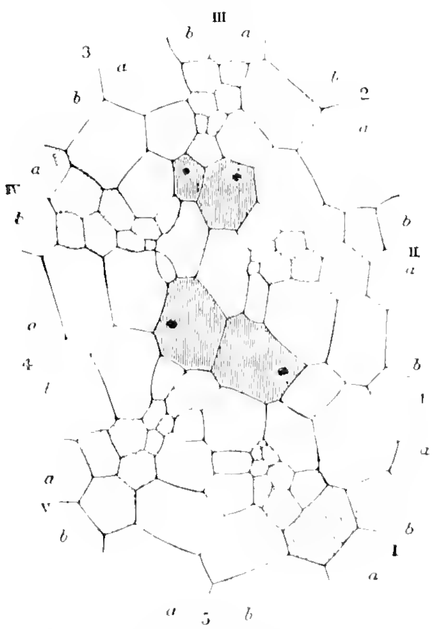
Pilematechinus Rathbuni is a most striking sea-urchin. Its enormous height compared to its diameter is unique among recent Spatangoids. When alive the specimens varied from a brilliant dark violet to a light claret color. The specimens collected were nearly of the same size: 95 mm. in greatest length, 82 mm. in height, and 75 mm. at its greatest diameter (Pls. 81; 82). It is interesting to note that among the deep-sea types of Echini we find also the extreme elongated forms of Pourtalesia and Aërope and the flattened Echinothuriæ. Seen from above (Pl. 81, fig. *2*) the outline is but slightly elliptical, with blunt anterior and posterior extremities. The straight edges of the coronal plates give it an angular outline at the ambitus. The actinal side (Pl. 81, fig. *1*) is quite flat having a somewhat pentagonal depression around the actinostome, a sharply rounded ambitus (Pl. 82) and a depressed subcentral actinal system. The actinostome is about 40 mm. from the anterior edge of the test, and 55 from the posterior extremity.

The whole actinal side is thickly covered with small primary tubercles (Pls. 81, fig. *1*; 83, fig. *1*), though many of the plates near the ambitus show only traces of the former primary tuberculation. On the actinal side the plates are thickly covered with small miliaries. The prominent actinal tuberculation is in marked contrast with that of the abactinal part of the test, where the coronal plates carry a less crowded pavement of small

[1] "Challenger" Echinoidea, Pl. XXXV, figs. 1–4.

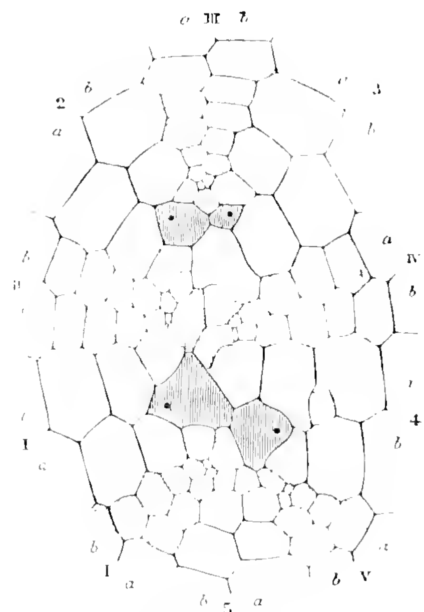
miliaries, and by far the greater number of them only traces of the primaries (Pls. 81, fig. *2*; 82; 83, fig. *2*; 84). When seen in profile (Pl. 84, fig. *2*) there are not more than fifteen to sixteen prominent primary tubercles; all the others as well as many of the miliaries have been resorbed. Seen facing the anal system (Pl. 84, fig. *1*) there are fifteen to sixteen irregularly scattered in the odd posterior interambulacrum.

An enlarged figure of a part of the ambitus and of the adjoining coronal plates (Pl. 86, fig. *1*) shows the contrast between the primary and miliary



Outside. 95 mm.

FIG. 238. PILEMATECHINUS RATHBUNI.



Inside. 85 mm.

FIG. 239. PILEMATECHINUS RATHBUNI.

tuberculation of the former and that of the latter, on the plates of which we find patches of miliaries only, large bare areas, and parts of the scrobicular ring or indications of its former existence, or parts of the mammary boss in all stages of resorption. This is still better shown in Plate 86, fig. *2*, on the fifth and sixth right anterior interambulacral plates from the actinostome and on the seventh plate of the right posterior interambulacrum.

This resorption of the primary tubercles seems to be quite general among many of the abyssal species of Spatangoids. See also *Paleopneustes cristatus* (Pls. 95; 96, fig. *5*), *Paleopneustes hystrix* (Pl. 97, fig. *1*), and Linopneustes (Pl. 93, fig. *1*).

Seen in profile (Pls. 82, fig. *1*; 84, fig. *2*) the anterior extremity slopes quite regularly between the rounded abactinal part of the test and the somewhat sharper curve at the ambitus. The posterior extremity slopes at a sharper angle (Pls. 82, fig. *1*; 84, fig. *2*), and is truncated at the anal system.

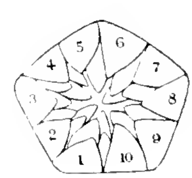
Seen facing the anal system and odd posterior interambulacrum (Pls. 82, fig. *1*; 84, fig. *2*) the ambital curve is sharper on the sides of the test than at the anterior and posterior extremities, and the slope of the sides of the test much steeper than those of the extremities.

The extended apical system, which is also at the apex, Figs. 238, 239, occupies about the central part of the abactinal part of the test (Pl. 83, fig. *2*). The apical system of *P. Rathbuni* (Pls. 83, fig. *2*; 85, figs. *3*, *4*), greatly resembles that of *Urechinus Naresianus*, Fig. 227, its anterior genital plates are distinct, and not united as in *C. Wyvillii* and *C. Loveni*, but the madreporic body extends over both and part of the adjoining anterior ocular plates. The posterior zones of the lateral anterior interambulacra unite between the anterior genitals, and the anterior lateral oculars, Fig. 239, which are thus isolated from the odd anterior ambulacrum, as in Urechinus, Fig. 224, and do not adjoin the anterior genitals as in *C. Wyvillii* and *C. Loveni*.

Between the trivium and bivium the posterior genitals are placed diagonally, so that the anterior zone of the left posterior interambulacrum separates the posterior genital from the anterior ocular, while the posterior zone of the corresponding interambulacrum separates the posterior genital from the posterior ocular.

There are, however, important variations in the apical system of *Pilematechinus Rathbuni*, the specimen of 95 mm., Fig. 238, having an apical system much like that of Cystechinus as here limited, while in the smaller specimen, Fig. 239, the arrangement of the apical plates is more like that of *U. giganteus*, Fig. 224.

The anal system is large, longitudinally elliptical (Pls. 82, fig. *2*; 84, fig. *1*; 86, fig. *5*), placed well above the ambitus; while in *C. Wyvillii*, *C. Loveni*, and *C. vesica* the anal system is on the actinal side of the ambitus. It is covered by an outer row of large irregularly pentagonal plates, largest at the abactinal edge.



85 mm.

FIG. 240. PILEMATECHINUS RATHBUNI.

The miliaries of the test all carry minute spines. The few primary spines left on the test were slender, cylindrical, rather short. Small, short-headed pedicellariæ were found scattered irregularly among the miliary spines.

The actinal system of *P. Rathbuni* (Pls. 81, fig. *1*; 83, fig. *1*; 85, figs. *1*, *2*) is somewhat pentagonal, Fig. 240, placed in the centre of a similarly shaped depression which extends to the fourth or fifth ambulacral plate (Pls. 83, fig. *1*; 85, fig. *1*). The actinostome is subcentral, nearer the ambital edge, and surrounded by a couple of inner rows of irregularly shaped polygonal or elongated plates covered by miliaries, while on the outer edge are ten large pointed pentagonal plates which form a closed circle, recalling the buccal plates of Palæostoma (Pl. 85, figs. *1*, *2*). Seen from the inside the edge of the actinostome is strengthened by a circular keel forming the edge of the actinal plates of the corona.

The rudimentary phyllodes extend to the eighth or ninth ambulacral plate.

Station 3360, southwest of Mariato Point, in 1672 fathoms. Lat. 6° 17′ N.; Long. 82° 5′ W. Bottom temperature 36°.4. Fn. bk. drk. gn. s.

Station 3374, southwest of Malpelo Island, in 1823 fathoms. Lat. 2° 35′ N.; Long. 83° 53′ W. Bottom temperature 36°.4. Gn. ooze.

Bathymetrical range, 1672–1823 fathoms. Temperature, 36°.4.

PALEOPNEUSTIDÆ A. Ag.

Palæotropus Lov.

Palæotropus Loveni A. Ag.

Palæotropus Loveni A. Ag., Proc. Am. Acad. 1879, Vol. XIV, p. 204.
Palæotropus Loveni A. Ag., "Challenger" Echinoidea, 1881, p. 158, Pl. XXI, figs. 3–16.

Plate 87.

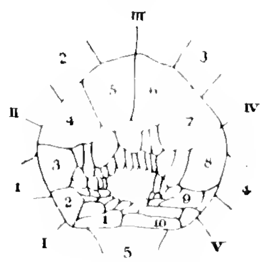
The figures of this species given in the "Challenger" Echinoidea are scarcely distinct enough to give them sufficient accuracy. In order better to characterize this genus, which has affinities to so many of the ancient types of the deep-sea genera, and also to many well-known recent Spatangoids, I have given on Plate 87 a number of figures of *Palæotropus Loveni* which will materially assist in following the description of the genus and species given in the "Challenger."

Seen from the actinal side (Pl. 87, fig. *1*), the contrast between the bare ambulacra, especially the broad posterior lateral ambulacra, and the interambulacra, closely tuberculated except towards the actinal system, is most marked.

The rudimentary phyllodes extend only for two or three ambulacral plates (Pl. 87, figs. *1*, *5*).

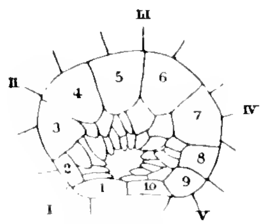
The actinal system varies in outline, but the general system of plating covering it seems to be quite uniform, the number of the larger plates being the same in the three specimens figured Figs. 241, 242, 243 (Pl. 87, figs. *8*, *10*, *11*). The same is the case with the anal system, Fig. 244 (Pl. 87, fig. *9*).

The ambital plates of the lateral posterior ambulacra extend towards the centre of the plastron, they are enclosed by the subanal fasciole to such



23 mm.

Fig. 241. Palæotropus Loveni.

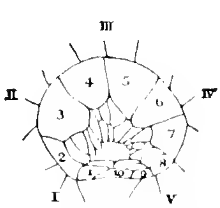


21 mm.

Fig. 242. Palæotropus Loveni.

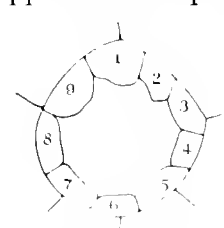
an extent as almost to join across the median interambulacral plates and leave them but a narrow connecting line (Pl. 87, figs. *1*, *4*).

Seen in profile (Pl. 87, fig. *3*) the bare posterior ambulacral plates extend as far as the level of the anal system, but the rest of the test carries the same general tuberculation characteristic of the ambital tract on the actinal side. Seen from above (Pl. 87, fig. *2*), it is seen that the tuberculation becomes more distant and less prominent as we approach the apical system,



17 mm.

Fig. 243. Palæotropus Loveni.



23 mm.

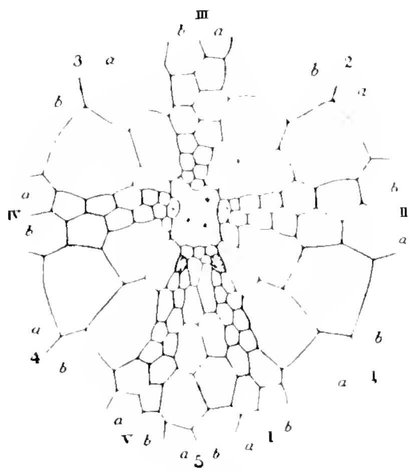
Fig. 244. Palæotropus Loveni.

and that the abactinal ambulacral plates become greatly reduced in size as they approach the apical system, Fig. 245 (Pl. 87, fig. *6*).

The apical system (Pl. 87, figs. *6*, *7*) closely resembles that of a young Echinocardium figured by Lovén.[1] The genital plates are ankylosed, forming a single central plate, Figs. 245, 246, pierced by three genital openings, with a small madreporite in the anterior part of the plate. The prominent

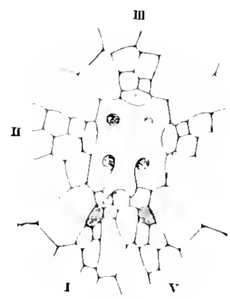
[1] Pourtalesia, Pl. XVII, fig. 200.

oculars occupy notches in this central plate. The apical system is also very similar to that of *Phrissocystis aculeata*, Fig. 276, of Argopatagus, Fig. 252, and Homolampas, Fig. 258; in Palæotropus there are, however, only three genital pores.



23 mm.

FIG. 245. PALÆOTROPUS LOVENI.



23 mm.

FIG. 246. PALÆOTROPUS LOVENI.

Koehler[1] has called attention to the relations of *P. Hirondellei* to the other species of the genus. We may add the following to his notes.

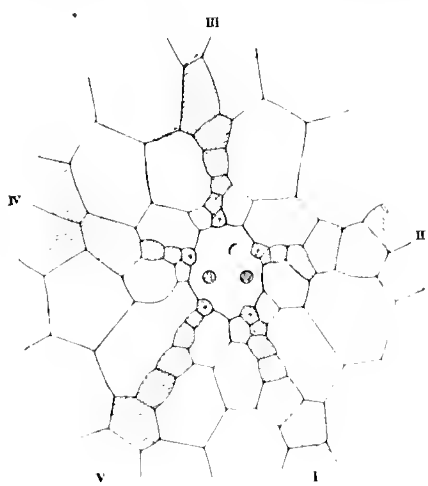
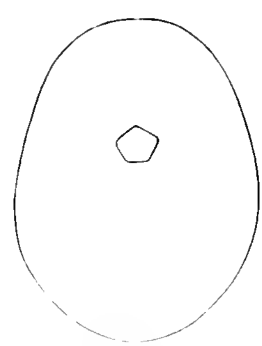


FIG. 247. PALÆOTROPUS JOSEPHINÆ. AFTER LOVÉN.



23 mm.

FIG. 248. PALÆOTROPUS LOVENI.

Palæotropus Hirondellei Koehler[2] differs from *P. Josephinæ*[3] and *P. Loveni* by its coarse tuberculation, the splitting up of the central plate into its

[1] Campagnes Scientifiques du Prince de Monaco. Fasc., XII. Échinides et Ophiures du Yacht l'Hirondelle, par R. Koehler. 1898, p. 29.

[2] Koehler, loc. cit. Pls. V, figs. 12–14; VI, figs. 27, 28.

[3] Koehler inadverently mentions *P. Josephinæ* as described by me. It should be referred to Lovén, who established the genus, and who described the first species of the genus; Lovén, Études, p. 17, Pl. XIII, figs. 108–113.

genital components, the presence of two genital pores, as in *P. Josephinæ*, Fig. 247 (*P. Loveni* has three, Fig. 246). The outline of the test of *P. Loveni* and of *P. Josephinæ* is very different; in the former the anterior part is narrow while the posterior extremity is wide, the reverse being the case in *P. Josephinæ*, Fig. 249, but as *P. Josephinæ* is only known from young specimens this difference may be due to age. The shape of the episternal plates is very different in the two species; in *P. Loveni* the fourth pair is triangular, Fig. 250, the point turned anteriorly, while in *P. Josephinæ* their position is reversed and they reach the anal system, Fig. 251.

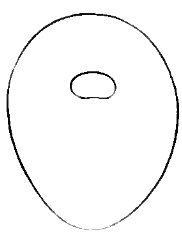


Fig. 249. P. Josephinæ. After Lovén.

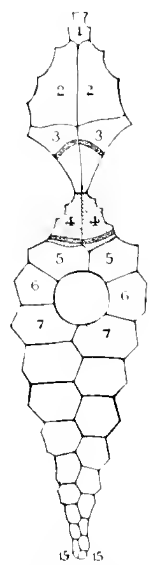


Fig. 250. Palæotropus Loveni.

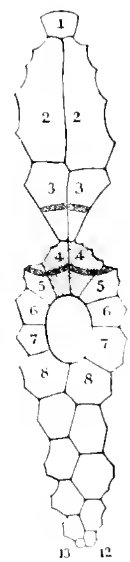


Fig. 251. P. Josephinæ After Lovén.

The species of Palæotropus described by Koehler[1] differs strikingly from the other species of the genus. The sternum differs radically from that of the other species; the genital plates are distinct, and the arrangement of the apical plates does not resemble that of either *P. Josephinæ* or *P. Loveni*. The small number and proportionally great size of the primary tubercles give *P. Hirondellei* a very striking appearance.

"Challenger" Expedition Station 201, January 25, 1875. Lat. 9° 26′ N.; Long. 123° 45′ E.; 375 fathoms. Bottom temperature, 12°. 2. Mud.

[1] Koehler, loc. cit. Pl. V, figs. 12–14.

Argopatagus A. Ag.

Argopatagus vitreus A. Ag.

Argopatagus vitreus A. Ag., Proc. Am. Acad. 1879, Vol. XIV, p. 209.
Argopatagus vitreus A. Ag., "Challenger" Echinoidea, 1881, p. 160.

Pls. XXXII, figs. 1–6; XXXVIII, fig. 25; XXXIX, fig. 18; XLI, figs. 32–35.
Plate 91, figs. 1–3.

Genicopatagus A. Ag.

Genicopatagus affinis A. Ag.

Genicopatagus affinis A. Ag., Proc. Am. Acad. 1879, Vol. XIV, p. 210.
Genicopatagus affinis A. Ag., "Challenger" Echinoidea, 1881, p. 163.

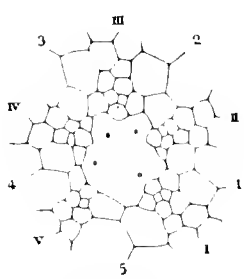
Pls. XXXI, figs. 12–22; XXXV a, figs. 1–4; XXXIX, fig. 20; XLI, figs. 38–39; XLIII, fig. 13; XLV, figs. 20–24.
Plate 91, figs. 4–7.

The figures of these species given in the Echinoidea of the "Challenger" hardly bring out sufficiently clearly their relationship and the characters allying them with Palæotropus, Homolampas, and Phryssocystis. Of these genera, Argopatagus and Palæotropus have simple ambulacral zones with rudimentary phyllodes, as have also Homolampas and Genicopatagus. Homolampas, Phrissocystis, and Genicopatagus (Pl. 91, fig. *5*) have ill-defined petaloid ambulacra, merely indicated by the sudden widening of the ambulacral zones above the ambitus.

Homolampas (Pl. 63, figs. *2*, *5*) has a peripetalous fasciole as well as a subanal fasciole, as have also Argopatagus and Palæotropus. With the exception of Palæotropus, in which the labium is flat and the actinostome pentagonal, the other genera mentioned above all have a prominent labium and a more or less elongate actinostome with a re-entering labium; this attains its maximum in Phrissocystis (Pl. 88, fig. 4), in which the projection of the apex of the labium narrows the actinostome to a marked extent. The labium of Palæotropus (Pl. 87, figs. *5*, *8*, *10*) is quite short; it is flanked by only one of the actinal posterior ambulacral plates. In Argopatagus (Pl. 91, fig. *2*) it is flanked by two, and probably also in Phrissocystis (Pl. 88, fig. *4*); in Homolampas by two and a half, and in Genicopatagus by no less than four (Pl. 91, fig. *4*). In Homolampas (Pl. 63, figs. *2*, *4*) and Palæotropus (Pl.

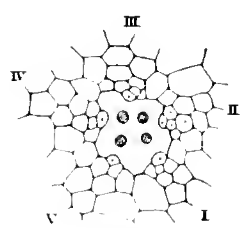
87, figs. *1–3*) the left posterior interambulacral plates attain a great width. In Phrissocystis (Pls. 88, figs. *1, 2*; 89, fig. *2*), Argopatagus (Pl. 91, fig. *1*), and specially in Genicopatagus (Pl. 91, figs. *4, 5*) the interambulacral and the ambulacral plates are of more uniform size, the latter increase very gradually in size towards the ambitus; in Argopatagus alone the posterior ambulacral plates on the actinal side increase rapidly at the ambitus towards the actinostome (Pl. 91, fig. *2*). In Argopatagus, as will be seen on Plate 91, fig. *2*, the second plates of the posterior zone of the posterior lateral ambulacra almost separate the labium from the sternum, as in Plexechinus; this is an indication of the affinities of the genus to the Pourtalesiae.

As regards the abactinal system, that of Palæotropus, Figs. 245, 247 (Pl. 87, fig. *6*), of Argopatagus (Pl. 91, fig. *3*), Fig. 252, of Phrissocystis (Pl. 89, fig. *3*), Fig. 276, and of Homolampas, Fig. 253 (Pl. 63, fig. *3*) all belong to



48 mm. ?

Fig. 252. Argopatagus vitreus.



32 mm.

Fig. 253. Homolampas hastata.

the same type; the genital plates are ankylosed in the midst of the madreporic body, which covers the greater part of the central plate formed by the genitals. While in the abactinal system of Genicopatagus (Pl. 91, fig. *6*) three of the genital plates are well developed; the fourth, carrying no genital opening, is ankylosed with the madreporite plate, it extends from the right anterior interambulacrum to the odd interambulacrum and separates the left genital plates from the right posterior plate, Fig. 254, — a type of abactinal system belonging to Schizaster (Figs. 297, 301), far more recent than that of the other genera just named, though as a whole the other features of the test of Genicopatagus are more antique. The Palæotropus type of abactinal system is also found in Agassizia Fig. 287 (Pl. 108, fig. *7*), perhaps in Spatagodesma (Pl. 106, fig. *2*), Fig. 289, and in Neolampas (Pl. 64, figs. *7, 8*); it may to a certain extent be called Echinolampid, occurring as it does in Echinolampas and Conolampas (Pl. 65, figs. *4, 7*).

In Palæobrissus[1] the ambulacral plates widen very regularly from the apex to the ambitus, as in Argopatagus, without the break forming the ill-defined petaloids of Genicopatagus. The pores, however, form diverging lines and increase regularly in size, much as they do in Paleopneustes. In the apical system of Palæobrissus the anterior genitals are united in one plate carrying the madreporic body, and the posterior genital plates are distinct, though in contact, — a combination which has not been noticed in other Spatangoids.

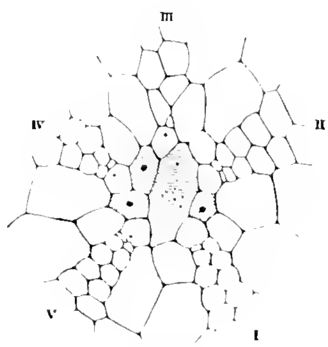


FIG. 254. GENICOPATAGUS AFFINIS.

From the position of the anal system and the structure of the actinostome, Genicopatagus has somewhat the facies of Paleopneustes, while the outline of Phrissocystis and Argopatagus are quite similar, Fig. 255.

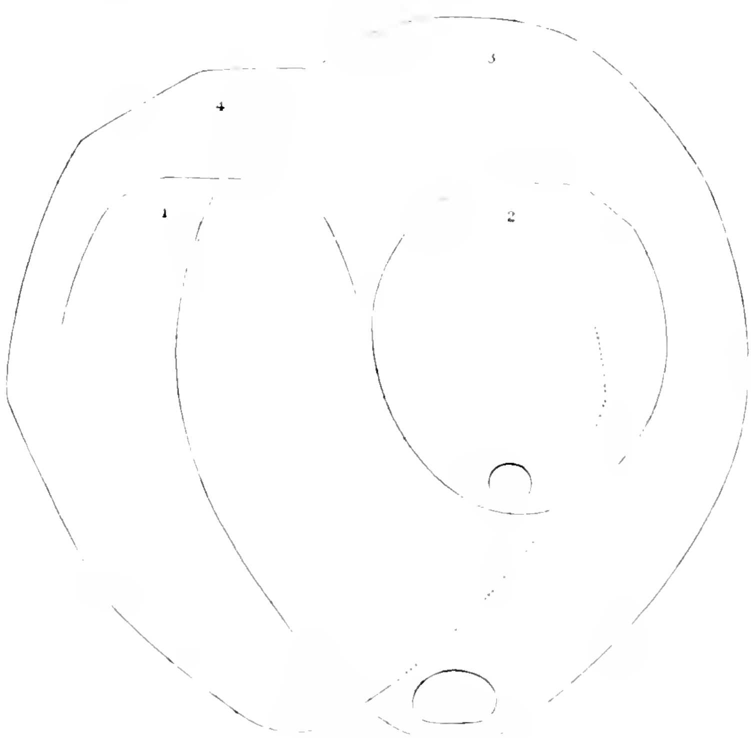


FIG. 255.

1 ARGOPATAGUS VITREUS. DORSAL. 48 mm.? 2 GENICOPATAGUS AFFINIS. DORSAL. 37 mm.
3 PALEOPNEUSTES HYSTRIX. VENTRAL. 153 mm. 4 PHRISSOCYSTIS ACULEATA. DORSAL. 120 mm.

[1] "Blake" Echini, Pl. XXIV, figs. 10–12.

Homolampas A. Ag.

Homolampas hastata A. Ag.

Homolampas hastata A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 81, Pl. XI, fig. 1.

Plates 55, figs. *9*[a], *10*; 63; 64, fig. *1*.

The specimens collected were nearly of the same size, about 30 mm. in length, 22 in width, and 10.5 in height. This species is not as heart-shaped as *H. fulva*,[1] nor has it the pointed posterior extremity of *H. fragilis*.[2] Fig. 256. 3. It is marked by the great distinctness and sharpness of its angular peripetalous fasciole (Pl. 63, figs. *1*, *2*); it is somewhat irregularly pentagonal in outline and surrounds the few primary tubercles found near the apical extremity of the interambulacral areas (Pl. 63, fig. *1*). On the abactinal side of the anterior interambulacra the primary tubercles with the exception of one or two are small, and are arranged in irregular vertical rows along the rounded ridges on both sides of the median anterior ambulacral furrow. In the other interambulacra the primaries are limited to one large primary tubercle in each zone near the abactinal extremity of the interambulacral areas within the peripetalous fasciole (Pl. 63, fig. *1*) These primaries carry long Lovenia-like spines. The scrobicular areas of the large tubercles are sunken, and they as well as the sunken areas of the smaller tubercles of the anterior lateral interambulacra form small rudimentary processes projecting into the interior of the test, but by no means so greatly developed as are the corresponding processes of *Homolampas fulva*[3] or of *H. fragilis*.[4]

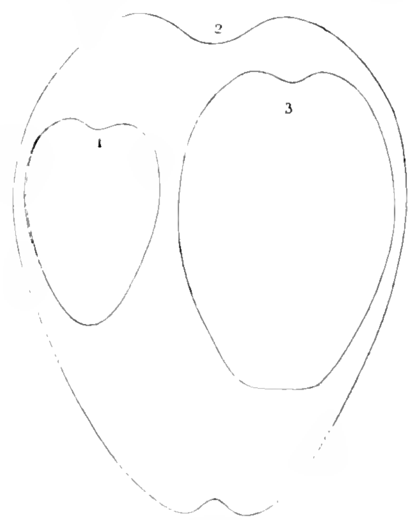


Fig. 256.
1 Homolampas fragilis. 93 mm.
2 " fulva. 95 mm.
3 " hastata. 32 mm.

[1] "Challenger" Echinoidea, Pl. XXIV, figs. 2, 3.

[2] Revision of the Echini, Pl. XVII, figs. 13–15.

[3] "Challenger" Echinoidea, Pl. XXIV, fig. 8.

[4] Revision of the Echini, Pl. XVII, figs. 13–15. M. de Meijere describes a species of Homolampas from the "Siboga" Expedition. From his sketches (Pl. XXIII, figs. 489–491) it is not possible to make out the genus to which his species belongs. The dorsal position of the anus, the course of the

The uniform size of the plates of the bivium and the included odd interambulacrum is most characteristic when seen from the abactinal side of the test (Pl. 63, fig. *1*).

Both the ambulacral and interambulacral plates of the upper part of the test are crowded with small miliaries (Pl. 63, figs. *1*, *2*), arranged, in some of the wider lateral interambulacral plates, in horizontal rows more or less parallel with the sutures. In the other species of the genus this miliary tuberculation is far more distant.

The posterior extremity is vertically truncated and its height is very considerable in proportion to that of the test (Pl. 63, fig. *2*), while in *H. fulva*[1] the height of the obliquely truncated posterior extremity is small compared to that of the test; the anal groove (Pl. 63, fig. *1*), is also very slight compared to the deep narrow cut of *H. fulva*.[2] The anal system is slightly pyriform; its greatest diameter is horizontal (Pl. 63, fig. *5*); while in *H. fulva*[3] the anal system is longitudinally elliptical. This difference in outline may, however, be partly due to differences in age. The anal system (Pl. 63, fig. *5*) is covered with large irregularly pentagonal plates becoming smaller towards the central anal opening; above it the plates are small; they all carry a few miliaries.

The subanal fasciole (Pl. 63, fig. *5*) is intermediate in outline between that of *H. gracilis*,[4] which is elliptical, and that of *H. fulva*,[5] which has a very angular pentagonal outline.

On the actinal side (Pl. 55, fig. *9*) this species is marked by the great width of the bare posterior lateral ambulacra and the length of the actinal plastron; this as well as the outer edge of the bare lateral ambulacra are flanked by large secondaries (Pl. 64, fig. *1*) with sunken scrobicular areas (Pl. 63, fig. *7*) elongated towards the ambitus, the boss sloping in the opposite direction. In *H. fulva* the tuberculation of the plastron and of the

peripetalous fasciole, the existence of a rostrum surrounded by a fasciole — all these are characters which do not exist in any of the species of Homolampas thus far described.

M. de Meijere, in his Memoir on the Echinoidea of the "Siboga" Expedition, follows Dr. Mortensen in his criticisms regarding the execution and arrangement of a number of the "Challenger" Echini plates. These criticisms come with little grace from an author who gives his readers such caricatures of Echini as Figs. 303, 313, 310, 369, 370, 372, 373, 381, 385, 459, 460, 489 to 491, and whose figures of the same species are far more scattered, and for no apparent reason, than those he condemns.

1 "Challenger" Echinoidea, Pl. XXIV, fig. 1.

2 Id. Pl. XXIV, fig. 2.

3 Id. Pl. XXIV, fig. 4.

4 Revision of the Echini, Pl. XVII, fig. 10.

5 "Challenger" Echinoidea, Pl. XXIV, fig. 4.

anterior part of the test is quite uniform over the whole actinal side. On the greater part of the interambulacral plates the large secondaries apparently run in parallel lines. On the edge and in the angles of the plates the secondaries are arranged on independent parallel lines, Fig. 257.

The actinal system (Pl. 63, fig. *6*) is flattened posteriorly; the actinostome is close to the posterior edge. The anterior part is covered with an outer row of large irregularly polygonal plates, immediately at the actinostome they form a pavement of diminutive plates; the central part of the actinal system is covered with irregular plates; the larger plates only carry miliaries.

The phyllodes extend as far as the third of the anterior ambulacral plates, and are found only on the actinal pair of the posterior lateral ambulacra. The actinal ambulacral plates are bare; the actinal interambulacral plates

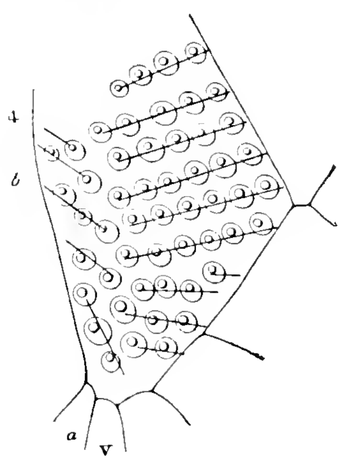


FIG. 257. HOMOLAMPAS HASTATA.

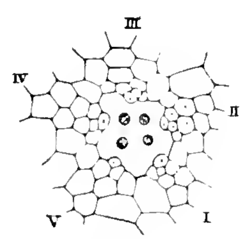


FIG. 258. HOMOLAMPAS HASTATA.

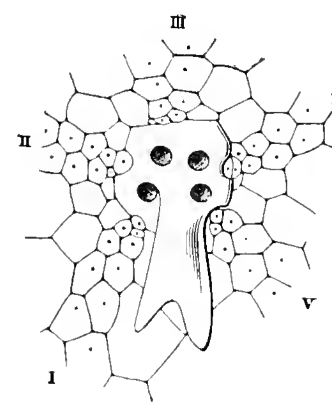


FIG. 259. H. HASTATA.

(the primordials) carry three to five or six minute secondary tubercles, and all the bare plates round the actinal system are scantily covered by distant miliaries. The actinal region is noted for the length of the labium, which reminds us of that of Linopneustes (Pl. 92).

The structure of the apical system Figs. 258, 259, recalls that of Palæotropus (Pl. 87, fig. *6*). The genital plates are ankylosed into a central plate, with four genitals, the madreporic body is found on its posterior part; the oculars are small but prominent, notched in the central plate (Pl. 63, fig. *3*). Five to six of the abactinal ambulacral plates are perforated by double pores; they and three or four plates with single pores are enclosed by the peripetalous fasciole Pl. 63, fig. *1*). The stone canal, Fig. 259, extends posteriorly as a ridge nearly twice the length of the central plate (Pl. 63, fig. 4). When examined from the interior of the test, the genital openings are seen to be deeply sunken in the thick central plate.

The primary spines (Pl. 63, figs. *8–11*) are quite flattened, covered with coarse serrations on the edge, and have a sharp terminal spine.

Station 3363, northeast of Cocos Island, in 978 fathoms. Lat. 5° 43′ N.; Long. 85° 50′ W. Bottom temperature, 37°.5. Wh. glob. ooze.

Station 3365, northeast of Cocos Island, in 1010 fathoms. Lat. 5° 31′ N.; Long. 86° 31′ W. Bottom temperature, 37°. Y. glob. ooze.

Station 3376, south of Malpelo, in 1132 fathoms. Lat. 3° 9′ N.; Long. 82° 8′ W. Bottom temperature, 36°.3. Gy. glob. ooze.

Bathymetrical range, 978–1132 fathoms. Temperature range, 37°.5–36°.3.

PALEOPNEUSTES A. Ag. and LINOPNEUSTES A. Ag.

Pls. 92–97.

The genus Amphipneustes has been established by Koehler[1] for a Spatangoid collected by the "Belgica" in Lat. 70° 33′ S., Long. 89° 22′ W., in 600

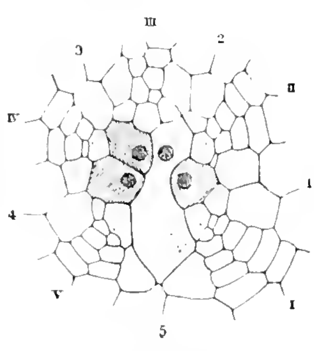


FIG. 260. LINOPNEUSTES LONGISPINUS.

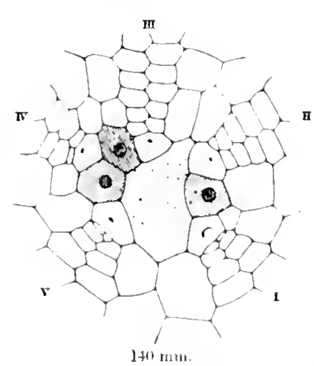
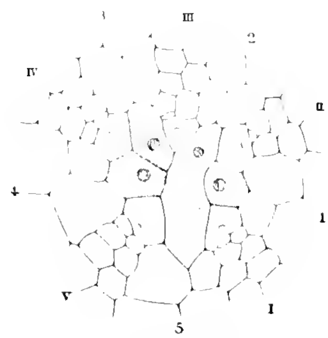


FIG. 261. PALEOPNEUSTES CRISTATUS.

metres. It is allied to Paleopneustes and Linopneustes, but is marked for its anterior ambulacrum flush with the test, with pores like those of the lateral ambulacra, and a tendency in the lateral ambulacra to become petaloid even more than in *Linopneustes Murrayi* and *L. longispinus* (Pl. 93, fig. *1*). In the apical system there are four distinct genital plates, the madreporic plate does not extend into the median interambulacral area as in Schizaster or Linopneustes, Fig. 260, and Paleopneustes, Figs. 261, 262, in both of which also the right anterior genital forms a single plate with the madreporic plate (Pls. 93, fig. *1*; 94, fig. *7*; 96, fig. *3*; 97, fig. *2*), but in

[1] Résultats du Voyage du S. Y. Belgica. Zoologie. 1902. Échinides et Ophiures, par R. Koehler, p. 11, Pl. VI, figs. 42, 43.

the former there are always four genital pores, in the latter sometimes three, Fig. 261. Amphipneustes, like Paleopneustes, has no subanal fasciole. Koehler also says[1] it has no marginal fasciole. The swollen coronal plates, as in Stenonia, are a most interesting feature of the genus. No trace of this is apparent in either Paleopneustes or Linopneustes. Something of the kind is found among the Brissinae in Hemiaster. Amphipneustes is also marked for the great development of the phyllodes:[2] they are as well defined as in *Paleopneustes cristatus*.

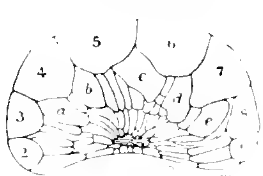


135 mm.

FIG. 262. PALEOPNEUSTES HYSTRIX.

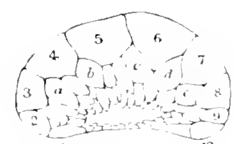
The genera Phrissocystis, Paleopneustes, Linopneustes, and Amphipneustes are interesting from the combination of structural features they possess, showing in one direction quite recent Spatangoid characters, like those of the laterally elongate actinostome, Figs. 263, 264, with a powerful labium (Pls. 92, 95, 96, 97), the great development of the phyllodes, broad actinal lateral ambulacral zones, a well developed plastron, especially in Linopneustes, and a compact apical system (Pls. 93, fig. *1*; 94, fig. *7*), while the structure of the abactinal part of the ambulacra is related to more ancient types with which is associated also a more primitive arrangement of the plates surrounding the actinal system.

We may look upon the presence of a marginal fasciole (Pl. 94, fig. *1*), as an early or rudimentary peripetalous fasciole of a stage of development in



110 mm.

FIG. 263. LINOPNEUSTES LONGISPINUS.



82 mm.

FIG. 264. LINOPNEUSTES LONGISPINUS.

which the petals are not as yet defined as in the more recent Spatangoids; while the presence of a well defined subanal fasciole in Linopneustes (Pl. 92) is an additional link connecting it with the more recent Spatangoids.[3]

[1] Koehler. "Belgica" Échinides et Ophiures, p. 11.

[2] Koehler, loc. cit. Pl. V, fig. 36.

[3] The classification of the Spatangoids according to the presence or absence of the subanal fasciole does not seem to me fortunate; it brings together such divergent types as Agassizia and Moira, and again Nacospatangus and Linopneustes.

Paleopneustes spectabilis de Meij. has, like the West Indian species *P. cristatus*, a very prominent marginal fasciole.[1] These reciprocal relations extend to the character of the tuberculation and of the spines. The coarse tuberculation of Paleopneustes, its extension over the actinal surface, both in the ambulacral and interambulacral areas (Pls. 95; 97), are features characteristic of embryonic stages already partly lost in Linopneustes, the actinal surface of which is eminently Spatangoid, Fig. 294 (Pl. 92), while the abactinal surface (Pl. 93) has the coarse tuberculation of Paleopneustes, with a subanal plastron into which the posterior lateral ambulacral plates have extended, restricting the odd interambulacral plates to a narrow zone in front of the

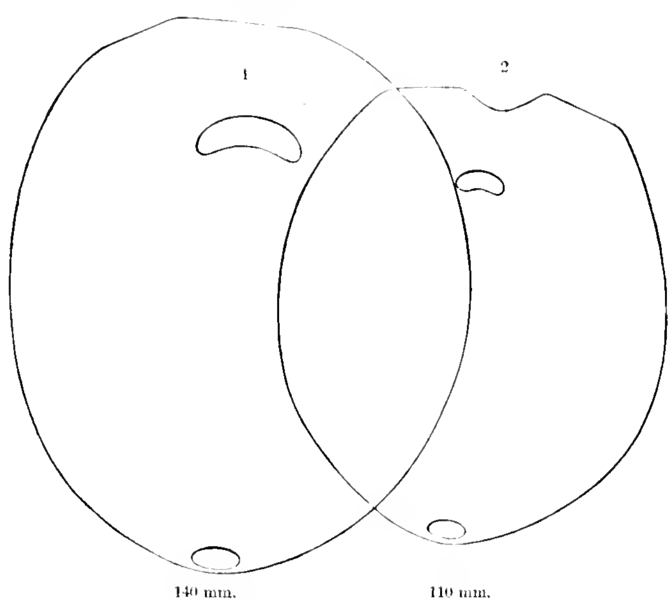


FIG. 265. 1 PALEOPNEUSTES CRISTATUS. 2 LINOPNEUSTES LONGISPINUS.

anal system (Pl. 92, fig. 2); in Paleopneustes the plates of the odd interambulacral zone extend of uniform width past the anal system (Pls. 95; 97). Linopneustes (Pls. 92, fig. *1*; 93) also has a slightly re-entering odd ambulacral area extending from the apical system to the ambitus, where it becomes more re-entering with increasing size (Pl. 92), and extends to the actinostome. This gives to Linopneustes a more angular outline than to Paleopneustes, Fig. 265, the latter is more ovoid (Pl. 97) and has no sunken anterior ambulacral groove either on the actinal or the abactinal side.

It is true that the outline of *Paleopneustes cristatus* is more rectangular and angular (Pl. 95) than that of *P. hystrix* (Pl. 97), but in both there is no

[1] "Siboga" Echinoidea, Pl. VIII, fig. 87.

anterior ambulacral groove, the test is not indented at the ambitus, and above it the anterior ambulacrum is flush with the test, but not slightly petaloid as are the other ambulacra. It would also seem as if in *P. cristatus* the wide bare posterior lateral ambulacra on the actinal side (Pl. 95) were more similar to those of Linopneustes (Pl. 92) than to the tuberculated actinal ambulacra of *P. hystrix* (Pl. 97).

On examining the actinal surface of the specimen of *P. cristatus* figured on Plate 95, we find the interambulacra of the whole posterior part of the test and a part of the anterior actinal surface covered with the remnants of scrobicular areas of tubercles which once occupied their place and which have

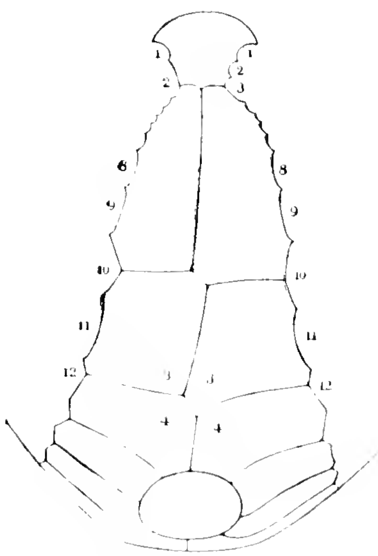


FIG. 266. PALEOPNEUSTES HYSTRIX.

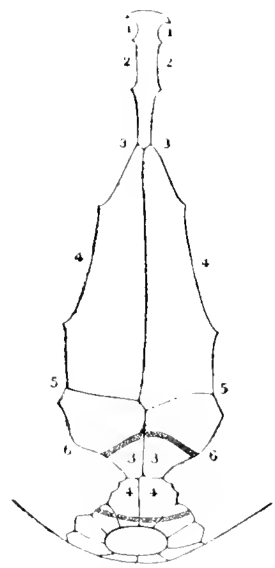


FIG. 267. LINOPNEUSTES LONGISPINUS.

been resorbed. The ambulacra have suffered to the same extent, as can be seen from the empty scrobicular circles of the plates of the anterior lateral ambulacra and from the posterior part of the lateral posterior ambulacra, as well as from the two narrow bands of primary tubercles still remaining unaffected on the two sides of those ambulacra. In *P. hystrix* we find a few of the same empty scrobicular circles on the actinal surface in both areas, but in this species they are not found to such an extent as to affect the general appearance of the test (Pl. 97) as they do in *P. cristatus* (Pl. 95), in which, when the primary tuberculation has gone, they cover the actinal surface with bare blotches, more extended and connected on the posterior lateral ambulacra. In *Paleopneustes Hemingi And.* similar traces of the primary tubercles are figured by Alcock.[1]

The shapes of the odd interambulacral plates of the actinal side of the test of Linopneustes and Paleopneustes are strikingly different. Those of Paleopneustes, Fig. 266, are more Ananchytid, that is, more regular in size, and although in Paleopneustes the plates of the actinal plastron and the first pairs of plates of the lateral posterior interambulacra are large and somewhat Spatangoid (Pls. 95, 97), yet they have not attained the great size of the corresponding plates of Linopneustes, Fig. 267, where the first pair of plates of the posterior lateral ambulacra occupies nearly the whole area between the posterior lateral ambulacral zones and the ambitus (Pl. 92). On these plates, as well as on the sternum, the radiating arrangement of the zones of the large primary tubercles has quite assumed the aspect of recent Spatangoids and has not retained the more primitive arrangement of the interambulacral primaries existing in Paleopneustes (Pls. 95; 97).

In Linopneustes the primordial lateral interambulacral plates are small and have also been greatly distorted, Figs. 271, 275, from the excessive development of the first pair of plates following it (Pl. 92); the primordials are comparatively large and regular in Paleopneustes (Pls. 95; 97), though excluded from the actinal system in *P. cristatus* in the older stages of growth examined (Pl. 96, figs. *1, 2*).

The primordial plates of the posterior lateral interambulacra are excluded from the actinal system only in a few Spatangoid genera, such as Moira, Faorina, and Micraster; in the other Spatangoids they reach the actinal system, though these plates are often reduced to the merest narrow slips wedged in between the ambulacra.

The phyllodes are perhaps better developed in Paleopneustes (Pls. 95; 97) than in Linopneustes (Pl. 92). They are specially prominent in *P. hystrix*, where they are as prominently petaloidal as in many of the regular Spatangoids, in which the actinal system is greatly developed laterally and quite crescent-shaped (Pls. 95; 97) compared to the shorter and broader actinal system of Linopneustes (Pls. 92; 94, figs. *2, 3*).

The shape of the labium gives us excellent characters to distinguish the Spatangoids allied to Linopneustes and Paleopneustes. In Linopneustes, Fig. 268, the labium is long, very narrow, the greater part of it flanked by the lateral ambulacral plates 2 and 3 (Fig. 267). In Paleopneustes, Figs. 269,

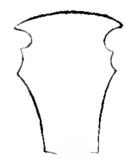
[1] A Naturalist in the Indian Seas, 1902, fig. 22, p. 168.

270, the labium is quite broad. In *P. cristatus*, the third plate occupies nearly its whole flank, Fig. 269, while in *P. hystrix*, Figs. 266, 270, in which it is shorter and more arched, the sides of the labium are flanked by the first, second, and third ambulacral plates which are quite small. In Phrissocystis the labium is deeply indented by the first plate, Fig. 271. In Argopatagus, Fig. 272, it resembles somewhat that of Phrissocystis, and is

110 mm.

FIG. 268.

LINOPNEUSTES LONGISPINUS.



140 mm.

FIG. 269.

PALEOPNEUSTES CRISTATUS.

135 mm.

FIG. 270.

PALEOP. HYSTRIX.

flanked for nearly its whole length by the first and second plates. In Genicopatagus, Fig. 273, the labium is more like that of the Urechinidæ.

In *Linopneustes Murrayi*[1] the labium is small, followed by a long narrow single plate, while in the West Indian Linopneustes the labium is not thus subdivided (Pl. 92). *Linopneustes excentricus* de Meijere[2] has the elongate narrow labium characteristic of the West Indian *Linopneustes longispinus* (Pl. 92, figs. *1, 2*).

The sternum of *Plesiozonus hirsutus* of M. de Meijere[3] with its short labium is very similar to that of *Paleopneustes cristatus* (Pl. 95). Plesiozonus differs

120 mm. ?

FIG. 271.

PHRISSOCYSTIS ACULEATA.

4 mm. ?

FIG. 272.

ARGOPATAGUS VITREUS.

37 mm.

FIG. 273.

GENICOPATAGUS AFFINIS.

from Linopneustes and Paleopneustes by its small ambulacral plates alternating near the extremity of the petals with the larger plates. The labium of *Paleopneustes spectabilis* and of *P. fragilis*, as figured by M. de Meijere,[4] recalls more the labium of Linopneustes than of Paleopneustes.

At the ambitus of Linopneustes (Pls. 92; 93; 94, fig. *1*), as in Phrissocystis (Pls. 88, figs. *1, 2*; 90, figs. *1, 3*), there are a number of very narrow

[1] "Challenger" Echinoidea, Pl. XXV, figs. 2, 7.

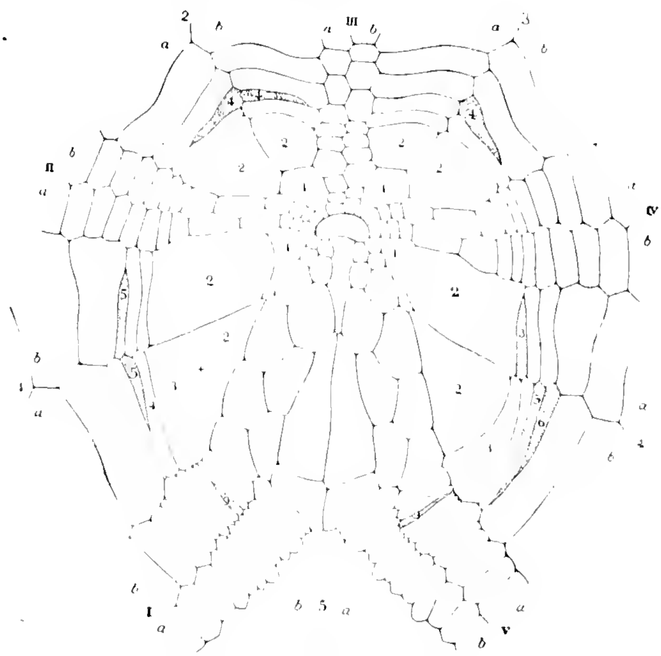
[2] "Siboga" Echinoidea, Pl. XXII, fig. 451.

[3] Id. Pl. XXII, fig. 441.

[4] Id. Pl. XXI, figs. 422, 427.

plates both in the ambulacral and interambulacral areas. How these are formed I have been unable to observe; they evidently greatly strengthen the ambital edge of the test, Figs. 274, 275.

The drawing out laterally of the interambulacral and ambulacral plates at the ambitus of Spatangoids is characteristic of those recent genera in which the actinal surface of the test is, in the interambulacral areas, occupied by not more than three large plates.



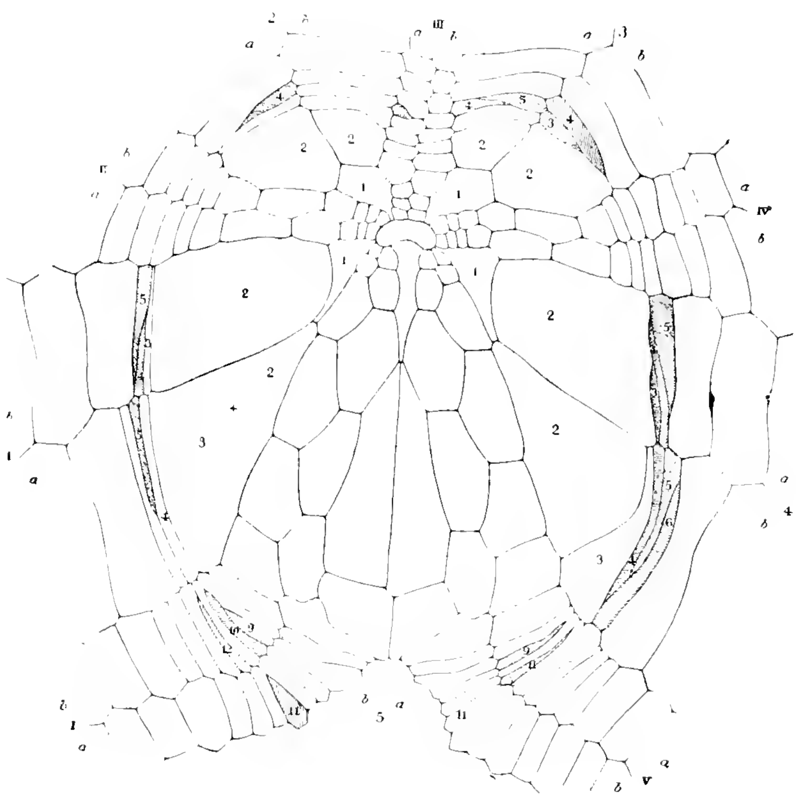
82 mm

FIG. 274. LINOPNEUSTES LONGISPINUS.

In the Ananchytids the differences between the actinal, ambital, and abactinal plates are slight; they become somewhat marked in Cassidulids. In Micraster, the lengthening of the ambulacral plates at the anal plastron is very decided, as it is in all recent Spatangoids where the anal plastron is well developed, except the Ananchytidæ or Pourtalesiæ. The lengthening of the ambital plates takes a great development in such genera as Maretia, Metalia, Breynia, Lovenia, and the like, where the junction of the abactinal and actinal areas forms a sharp angle, somewhat as in Homolampas and Phrissocystis, but to a less extent. In these genera the formation of a sharp angle at the ambitus is due to the excessive elongation of two or three of the ambital plates in all the ambulacral and interambulacral areas except the anterior ambulacrum.[1]

[1] Lovén, Études, Pls. IV, figs. 41, 42; XXXII.

According to Jackson,[1] such wedge-shaped plates, which are little by little pushed back from the radial or interradial line of junction by the constant movement of the plates of the test, are considered as being newly intercalated plates in Melonites. Certainly in Linopneustes and Phrissocystis their shape is due to the pressure of the coronal plates at the sharp angle of the ambitus, both from the actinal and abactinal side, which prevents their regular expansion.



110 mm.

FIG. 275. LINOPNEUSTES LONGISPINUS.

The apical systems of Linopneustes and of Paleopneustes, Figs. 260, 261, differ but slightly. The genital plates in Linopneustes (Pl. 94, fig. 7) are much less elongated than those of Paleopneustes (Pl. 97, fig. *2*), and in the former the genital openings are closer together or vary in number as mentioned above. The ocular plates of Paleopneustes are also larger and more triangular than those of Linopneustes. The primary radioles of Paleopneustes (Pl. 97, figs. *4*, *5*) resemble greatly those of the regular Echinidæ.

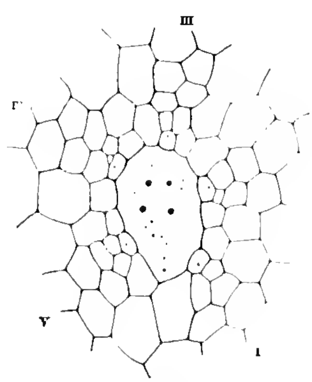
[1] Bull. Geol. Soc. Am. 1896, Vol. 7, pp. 152, 196.

Mr. Gregory[1] has established the genus Archeopneustes, with *Paleopneustes hystrix* A. Ag. as type, to include an interesting Spatangoid from Bissex Hill, Barbados, from the uppermost limestone of the Oceanic Series. Mr. Gregory is in error in stating that in *P. hystrix* the petals reach the ambitus. They fall short of the ambitus, there being in the anterior ambulacra four to five ambulacral plates between the ambitus and the termination of the petals, and a larger number in the posterior ambulacra, which are still shorter. As there is no profile figured of *P. hystrix*, Mr. Gregory was misled by the figures seen from the abactinal side. The structure of the petals of *P. hystrix* is quite like that of *P. cristatus*, and has nothing in common with those of the fossil Archeopneustes of Gregory. His genus Archeopneustes seems to me more closely allied to Amphipneustes of Koehler.[2]

PHRISSOCYSTIS A. Ag.

Phrissocystis A. Ag., Bull. M. C. Z. 1898, XXXII. No. 5, p. 80.

This genus is allied to Palæotropus and Palæobrissus in having, like the latter, pairs of pores piercing the abactinal ambulacral plates, they are, however, limited to the four or five or six uppermost plates, where the pores become simple, and where the ambulacra are all equally developed, as in Palæotropus and the Ananchytid genera Cystechinus, Calymne, Urechinus, and the like, while in Palæobrissus the small narrow ambulacral plates with pairs of pores extend well towards the ambitus. The actinostome, however, is eminently Spatangoid, the labium and the phyllodes take a great development, much as they do in Paleopneustes and Linopneustes. The apical system is compact, Fig. 276, as it is in the last named genera, and the long curved primary spines recall those of the same genera. The tuberculation both of the ambulacral and interambulacral areas recalls that of Paleopneustes. On the actinal side the posterior plastron is greatly developed.



1.20 mm.

FIG. 276. PHRISSOCYSTIS ACULEATA.

[1] Q. J. Geol. Soc. London, May, 1892, XLVIII, p. 163.

[2] Echinides . . . du S. Y. "Belgica," p. 12, Pls. V, fig. 37; VI, figs. 42, 43.

carrying curved spathiform spines, and separated by the wide posterior ambulacral areas from the lateral interambulacral ambital plastrons.

The coronal plates are distinctly imbricating. The ambulacral plates lap in one direction, the interambulacral in the other, as has been observed by Ludwig[1] and Lovén for other Spatangoids (Spatangus, Brissopsis, and Echinocardium).

M. de Meijere describes a species of Phrissocystis,[2] but as there are no details figured it is impossible to decide if his species belongs to the genus or not. He speaks of a subanal fasciole. There is no such fasciole in the Panamic species. His description of the coronal plates agrees well with those of Phrissocystis, but he does not speak of the remarkable elongated coronal ambital plates. It must be a mistake to say that the vertex and apical system lie in the middle. From his figure 99, Pl. X., it has all the appearance of being anterior; and surely figure 495, Pl. XXIII., cannot be a peripetalous fasciole of Phrissocystis, as M. de Meijere states in the Explanation of the Plates.

Phrissocystis aculeata A. Ag.

Phrissocystis aculeata A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p 80, Plate XII, figs. 1-7.

Plates 88–90.

At Station 3366, from a depth of 1067 fathoms, a large number of fragments of this species came up in the trawl. Though we did not obtain a single whole specimen, yet the pieces and fragments were sufficiently large and numerous to enable me to reconstruct quite accurately this interesting Spatangoid (Fig. 255). In general appearance this species must have resembled Linopneustes and Paleopneustes. The test is covered with large primary radioles arranged in distant clusters on the coronal plates (Pls. 88, figs. *1*, *2*; 89, figs. *1*, *2*; 90); the radioles are of uniform size; those above the ambitus are sharp, curved, from 30 to 40 mm. in length, with secondary small sharp spines scattered along the shaft. There are but few secondary radioles above the ambitus; they are more thickly clustered along the ambitus (Pl. 88, figs. *1*, *2*).

[1] Ludwig, Morpholog. Studien, and Lovén, Études, Pls. XXXV, fig 208; XXXVII, fig. 213; XXXIX, fig. 222.

[2] "Siboga" Echinoidea, p. 198.

The test of this species is thin and most brittle. It must have been somewhat conical, the apex slightly excentric posteriorly, with an angular outline, Fig. 255. The oral plastron is very prominent, and separated from the posterior interambulacra by wide, bare ambulacral zones; it is crowded by primaries closely packed carrying long, slender spathiform radioles turned up at the extremity. The actinal lip of the labium is wide at the base, triangular, and extends well into the actinostome (Pl. 88, fig. *4*).

The apical system is compact (Fig. 276.) The genital plates are all ankylosed to form an irregularly elliptical central plate (Pl. 89, figs. *1*, *3*), against which abut the small polygonal ocular plates as well as the abactinal plates of all the interambulacra. There are four large genital openings near the anterior part of the central plate; the anterior pair of genitals are twice as close as the posterior ones. The madreporic openings cover the whole of the posterior part of the central plate and extend beyond the genitals so as to cover the greater part of its anterior extremity. The ocular plates are small but most prominent (Pl. 89, fig. *3*), with large ocular pores and well separated by the intervening apical interambulacral plates. With the exception of there being four genital openings, the structure of the apical system is that of Palæotropus.

When seen from the interior of the test (Pl. 89, fig. *4*) the genital openings form, as in Homolampas, deep pits in the outside walls of the stone canal; this projects fully 8 mm. from the level of the central apical plate. The genital clusters resemble those of Homolampas.[1]

The smaller plates of the abactinal part of the ambulacra are bare for a distance from the apex (Pls. 89, figs. *1*, *2*; 90, figs. *1*, *2*); with increasing size the plates carry first a single primary tubercle, then a primary with two or three secondaries placed near the centre of the ambulacral plate. Succeeding plates carry two, three, or more primaries with a few secondaries, and at the ambitus from six to eight or nine distant primaries according to the size of the specimen. The ambital plates are also comparatively thickly covered with secondary tubercles.

In the odd anterior ambulacrum (Pl. 89, fig. *2*) the plates are smaller than those of either of the lateral ambulacra (Pls. 88, fig. *2*; 90, fig. *2*), in both of which they take a great lateral development towards the ambitus. The anterior and posterior as well as the odd interambulacral areas are quite regularly tuberculated (Pl. 88, fig. *2*; 89, figs. *1*, *2*; 90, figs. *1*, *2*, *4*).

[1] "Challenger" Echinoidea. Pl. XXIV, figs. 6, 7, 12.

The primary interambulacral tubercles increase gradually in number from the apex towards the ambitus, there are at first one or two to three or four, the intertubercular spaces being filled with secondaries (Pl. 88, figs. *1*, *2*). The secondaries also increase in number with the primaries, but on the whole the interambulacral coronal plates above the ambitus are comparatively bare, the tuberculation occupying but a part of the central area of the plates.

In the odd interambulacrum a slight median furrow extends from the apex towards the ambitus to the anal system. The plates of the odd interambulacrum (Pl. 90, figs. *1*, *4*), except those near the apex, carry a larger number of primaries, from six to ten, than those of the lateral interambulacra, they are also closely clustered in the central part of the plates, and towards the anal system (Pls. 88, fig. *5*; 90, fig. *3*). The whole test is covered with minute distant miliaries scattered irregularly over the coronal plates (Pls. 88–90).

The anal system is irregularly circular (Pl. 90, fig. *3*), covered with elongated polygonal plates gradually decreasing in size from the outer edge of the anal system to the anal opening; each plate carries a few small miliaries. The anal system is on the truncated edge of the ambitus (Pl. 88, fig. *5*); it is circular, covered with small polygonal plates.[1] The ambitus makes a sharp angle with the floor of the actinal surface, and, owing probably to the pressure from the actinal and abactinal sides, both the interambulacral and ambulacral plates become very greatly elongated (Pls. 88, figs. *1*, *2*, *3*, *5*; 90, figs. *3*, *4*), five to six of these long narrow ambital plates occupying no greater height than that of a single plate above the ambitus (Pl. 88, figs. *1*, *2*, *5*), much as in Linopneustes.

In one of the larger fragments the phyllodes are greatly developed. There are six or seven pairs of pores in the anterior lateral ambulacra.

It is difficult to determine from the fragments the exact shape of the actinal plastron, it may be like that of Linopneustes and have a long slender labium, or a short labium (Pl. 88, fig. *4*) more like that of Paleopneustes.

This species is marked by the great width of the posterior interambulacral area at the ambitus (Pl. 88, fig. *1*). The outline of the test seen from above must have been much like that of Linopneustes, only with a more angular outline (Fig. 255) at the ambitus, owing to the re-entering angles in the median interambulacral area at the ambitus (Pl. 88, figs. *1*, *2*).

[1] Bull. M. C. Z. XXXII, No. 5, Pl. XII, fig. 6.

On the actinal side the interambulacral plates are very large, expanding into irregularly shaped plates forming the anterior and posterior lateral ambulacra. As in *Paleopneustes cristatus* (Pl. 95) the primordial plates of the lateral posterior ambulacra are excluded from the actinal system (Pl. 88, fig. *4*) though in young stages of both genera they abut on the actinal system the whole width of the primordial plate.[1] In *Paleopneustes hystrix* a thin, narrow prolongation of these plates extends to the actinal system (Pl. 97, fig. *1*), as in *Linopneustes longispinus* (Pl. 92).

Judging from the fragments, the largest specimens must have been at least 50 mm. in height and over 100 mm. in length, with a greatest width across the anterior half of the posterior interambulacra of from 80 to 90 mm. When alive the color of the test was yellowish brown with darker reddish brown primary and secondary tubercles. Its coloring was much that of *Linopneustes Murrayi*.

Station 3366, east of Cocos Island in 1067 fathoms. Lat. 5° 30′ N.; Long. 86° 45′ W. Bott. temp. 37°. Y. glob. ooze.

BRISSINA Gray.

Brissopsis Agass.

Brissopsis columbaris A. Ag.

Brissopsis columbaris A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 82.

Pls. 100, figs. *6*, *7*; 102, figs. *5–9*; 103, figs. *1*, *2*.

Brissopsis columbaris adds another representative species to those found on the two sides of the Isthmus. The changes due to growth are similar to those of the Atlantic species, to which I have called attention in the Revision of the Echini. The petals, flush with the test in young stages, gradually become more sunken (Pls. 100, figs. *6*, *7*; 102, fig. *5*; 103, figs. *1*, *2*). The regular elliptical outline of the fasciole becomes indented in older specimens. The subanal fasciole sends out no branches in the younger stages, which are globular and truncated at the extremity, while the outline becomes indented and covered with a closer tuberculation in older specimens.

[1] "Blake" Echini, Pl. XXI, figs. 11, 13.

The Panamic Brissopsis[1] is readily distinguished from the Atlantic species by the greater length of the posterior lateral ambulacra (Pl. 103, fig. *2*), the flatness of the test (Pl. 100, figs. *6*, *7*), and the great width of the area enclosed by the subanal fasciole (Pls. 100, fig. *7*; 103, fig. *1*). The anal extremity of the test is more sloping (Pl. 100, fig. *6*) than in the Atlantic species, and is characterized by the great size of the anal opening (Pl. 100, fig. *7*); in older specimens the anal system increases rapidly in size. The Panamic species is noted for a marked indentation of the test at the lateral anterior ambulacra when seen from the actinal or abactinal side (Pl. 103, figs. *1*, *2*); the great width of the posterior lateral ambulacra

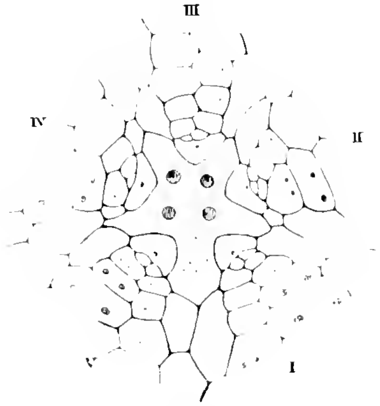


FIG. 277. BRISSOPSIS COLUMBARIS.

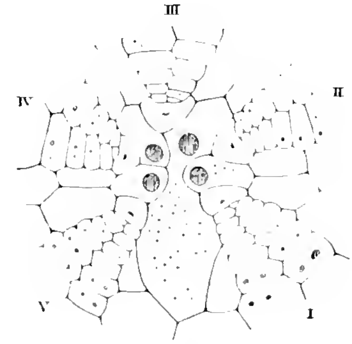


FIG. 278. B. LYRIFERA. AFTER LOVÉN.

and the large size of the ambulacral plates as compared with those of the Atlantic species are striking features of the Panamic species.

The apical systems of the Atlantic and Panamic species of Brissopsis differ materially, that of *B. lyrifera*, Fig. 278, is more like that of *Toxobrissus pacificus*, both showing the sutures of the genital plates, while in *B. columbaris*, Fig. 277, the sutures cannot be made out, and the madreporic genital extends but little into the median odd interambulacrum, Fig. 277, scarcely beyond the second apical ambulacral plate. In *B. lyrifera* it reaches to the level of the seventh plate, Fig. 278, and in *T. pacificus* to that of the fifth, Fig. 279.

[1] In the elongated and globular specimens of the West Indian *Brissopsis lyrifera* the structure of the odd interambulacrum of the two types is identical, as well as that of the abactinal system. Though there is a confluence of the posterior lateral ambulacra, the structure of the odd ambulacrum is not modified as in the case of the Panamic Toxobrissus. So that, in spite of the elongated form and confluent ambulacra of some of the West Indian specimens of Brissopsis, they cannot be referred to Toxobrissus.

M. de Meijere calls attention to the great difference in outline of specimens of *Brissopsis luzonica*. It seems incredible that his figures[1] should belong to the same species.

Station 3353, off Mariato Point, 695 fathoms. Lat. 7° 6′ 15″ N.; Long. 80° 34′ W. Bottom temperature, 39°. Gn. m.

Station 3356, off Mariato Point, in 546 fathoms. Lat. 7° 9′ 30″ N.; Long. 81° 8′ 30″ W. Bottom temperature, 40°.1. Sft. bl. m.

Station 3382, off Point Mala, in 1793 fathoms. Lat. 6° 21′ N.; Long. 80° 41′ W. Bottom temperature, 35°.8. Gn. m.

Station 3394, Panama Bay, in 511 fathoms. Lat. 7° 21′ N.; Long. 79° 35′ W. Bottom temperature, 41°.8. Dk. gn. m.

Bathymetrical range, 511–1793 fathoms. Temperature range, 41°.8–35°.8.

Toxobrissus, Des.

Toxobrissus pacificus A. Ag.

Toxobrissus pacificus A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 83, Plate XI, figs. 4, 5.

Plates 103, figs. *3, 4*; 105, figs. *4–6*.

Confronted with the same difficulties in determining the Pacific species of Brissopsis as was the case with the West Indian types, I am inclined to refer to the genus Toxobrissus of Desor a number of specimens allied to *Brissopsis columbaris* dredged off Point Mala at Stations 3355 in 182 fathoms and 3357 in 782 fathoms.

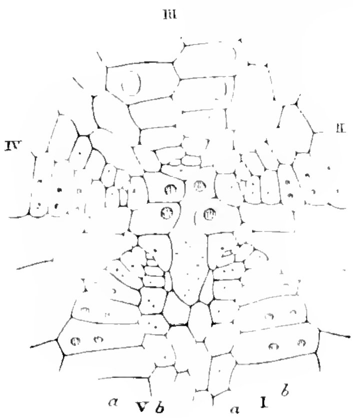
This species is marked for the flatness of the test, the confluence of the posterior lateral ambulacra along the median line for nearly half their length, Fig. 279 (Pls. 103, fig. *4*; 105, fig. *5*), the width of the posterior extremity of the test, the narrow and uniform size of the bare posterior ambulacral plates on the actinal side of the test (Pl. 105, fig. *4*), and the small size of the actinal plastron (Pl. 103, fig. *3*), the small size of the anal system (Pl. 105, fig. *6*), with an outer row of large rectangular plates, and the elongated subanal fasciole, broad under the anus and gradually becoming narrower at the actinal loop.

The apical system (Pl. 105, fig. *5*) has four large genital pores, Fig. 279; the right anterior genital plate, separating the posterior genital from the left genitals, extends as a madreporic plate far into the odd interambu-

[1] "Siboga" Echinoidea, Pl. XXIII, figs. 469, 470.

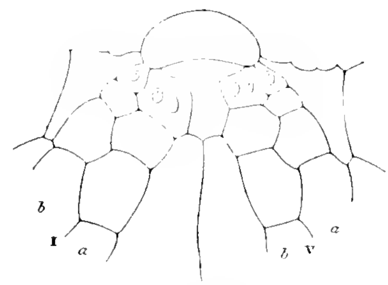
lacrum, the fourth abactinal series of which is reduced to a single plate (Pl. 105, fig. 5). The oculars are irregularly pentagonal; the odd ocular is far the smallest. The anterior pair of oculars are in the angle separating the lateral genital plates. The posterior pair abut against the posterior genitals and flank a part of the madreporite (Pl. 105, fig. 5).

The actinostome is covered by an upper row of large polygonal plates with two or three rows of smaller ones. The labium is T shaped, it is wide near the actinostome. Fig. 280.



50 mm.

FIG. 279. T. PACIFICUS.



50 mm.

FIG. 280. TOXOBRISSUS PACIFICUS.

Toxobrissus differs from Brissopsis in the structure of the apical system, the genitals of the last genus extending into the interambulacral areas (Pl. 102, fig. 7). The extremities of five of the ambulacral plates are included in the anal fasciole of Toxobrissus (Pl. 105, fig. 6), while only four are so included in Brissopsis (Pl. 102, figs. 8, 9). The labium of Brissopsis (Pl. 102, fig. 6) is also shorter and more T-shaped than in Toxobrissus.

The apical system belongs to the type of *Brissopsis lyrifera*, Fig. 278, rather than to that of *B. columbaris*, but the arrangement of the apical interambulacral plates of the odd interambulacrum shows at once the radical difference existing between Toxobrissus and Brissopsis.

From the above it is clear that Bittner[1] is correct in stating that Toxobrissus and Brissopsis are not identical, as I had suggested, and that we are justified, taking into account some recent and some of the younger geological forms, in establishing genera based upon the coalescence of ambulacra. Dames,[2] on the contrary, goes so far as to substitute Metalia, as being the oldest name, for Brissopsis and Toxobrissus, owing to the confluence of the lateral posterior ambulacra.

[1] Bittner, Verhandl. d. K. K. Geol. Reichsanstalt, 1891, p. 103.

[2] Dames, Palæontog. XXV, 1878, p. 67.

Station 3355, off Point Mala, 182 fathoms. Lat. 7° 12′ 20″ N.; Long. 80° 55′ W. Bottom temperature, 54°.1. Bk. glob. sh.

Station 3357, southwest of Mariato Point, 782 fathoms. Lat. 6° 35′ N.; Long. 81° 44′ W. Bottom temperature, 38°.5. Modern green sand.

Bathymetrical range, 182–782 fathoms. Temperature range, 54°.1–38°.5.

Aërope Wyv. Thom.

Aërope fulva A. Ag.

Aërope fulva A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 81, Plate VIII, figs. 5, 6.

Plates 55, figs. *6–8*; 61; 62.

This species is readily distinguished from *A. rostrata* Wyv. Thom.[1] by its proportionally greater length compared to its width, the lateral flattening of the test, and the pointed anal rostrum (Pls. 55, figs. *6–8*; 61, figs. *1–*). It has more the outline of the larger specimen figured on Pl. XXXIII, figs. 1–5 of the "Challenger" Echinoidea, which is of the same size as that here figured (Pl. 55, figs. *6–8*). The differences in outline of the specimen figured on Pl. XXXIII, of the "Challenger" Echinoidea are, however, all compatible with differences due to age. The primary tuberculation is most uniform over the test, within the peripetalous fasciole, and over the actinal floor, excepting the bare ambulacra; it is also much closer (Pls. 61, figs. *1–3*; 62, figs. *6–8*) than in the species described by Thomson; the primary radioles are quite slender (Pl. 62, figs. *10–12*) compared with the stouter radioles of *A. rostrata*.[2]

The vertex of *Aërope fulva* is at the apical system, well anterior of the peripetalous fasciole (Pl. 61, fig. *3*), while in the "Challenger" species, even in the larger specimens, the vertex is at the abactinal pole of the peripetalous fasciole in a position far posterior to that it occupies in *A. fulva*. The posterior extremity of *A. fulva* also tends to turn up somewhat snout-shaped for the reception of the anal system (Pl. 61, fig. *3*), while the posterior extremity of *A. rostrata* slopes quite gradually to meet the rounded anal extremity.

The actinal plastron is elongate, triangular, consisting of two plates; it is closely packed with primaries, specially near the posterior edge (Pl. 61,

[1] "Challenger" Echinoidea, Pls. XXXIII, figs. 8–12; XXXIII a, figs. 8, 9.

[2] "Challenger" Echinoidea, Pl. XXXIII, figs. 1–3.

fig. *1*). Near the actinostome the posterior lateral ambulacra are nearly bare (Pl. 61, fig. *6*), they are only covered with a few miliaries and a few small secondary tubercles, except near the ambitus (Pl. 62, fig. *8*), where the plates become as closely tuberculated as are the interambulacral plates on the actinal side (Pls. 61, figs. *1*, *2*; 62, fig. *7*). The labium is very narrow, lozenge-shaped, with five primary tubercles in the anterior half of the plate. The anterior lateral primordial plates are pentagonal, short, and carry two primary tubercles. The lateral posterior primordials are turned backwards at a right angle, extending posteriorly more than the whole length of the first actinal plate of the posterior lateral ambulacra (Pl. 61, figs. *1*, *6*). The actinostome is longitudinally elliptical with rounded edges, the phyllodes are limited to the first actinal ambulacral plate (Pl. 61, figs. *1*, *6*). The coronal plates are slightly imbricated towards the actinostome in the ambulacra, and away from it in the interambulacra.

The peripetalous fasciole (Pl. 61, figs. *1–3*) is not as broad as that of *A. rostrata*; it forms an angle in the median anterior interambulacrum, near the ambitus, passing then nearly vertically round to the actinal side of the test (Pl. 61, fig. *1*), and crossing the anterior part of the odd anterior ambulacrum in a straight line.

The lateral anbulacra do not differ except in length; their plates are remarkably uniform in size inside of the peripetalous fasciole (Pl. 61, fig. *2*), and above the ambitus as far as the anal system, though on the actinal side the plates of the odd ambulacrum and of the posterior lateral ambulacra become very elongated (Pl. 61, fig. *1*), those of the anterior lateral ambulacra being less so, and those of the posterior lateral ambulacra attain the greatest longitudinal extension; they increase gradually towards the ambitus, those of the posterior extremity of the posterior lateral ambulacra are much larger along the sides of the test as they pass from the ambitus to the actinal side. The plates of the odd ambulacrum are wider and narrower than those of the other ambulacra.

There are three genital plates with four large genital pores (Pls. 61, fig. *2*; 62, figs. *1*, *3*); all of these in one case (Pl. 62, fig. *1*) encroach upon adjoining plates, Fig. 281, in the other upon three and upon one of the anterior oculars (Pl. 62, fig. *2*). The madreporic body extends over one genital plate, and the stone canal, when seen from the interior, Fig. 282, projects like a hood well over the adjoining genitals, ending on the right posterior ocular (Pl. 62, fig. *3*).

In another specimen there are only two genital pores, Fig. 283, which both encroach upon the sutures not only of the genital, but also of the posterior ocular plates.

The abactinal system of *Aërope fulva* varies greatly, Figs. 281–283. The position of the genital pores is by no means fixed, and young apical inter-

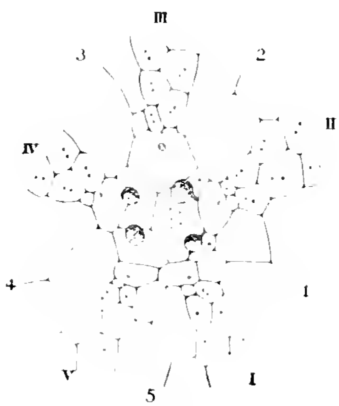


FIG. 281. AËROPE FULVA.

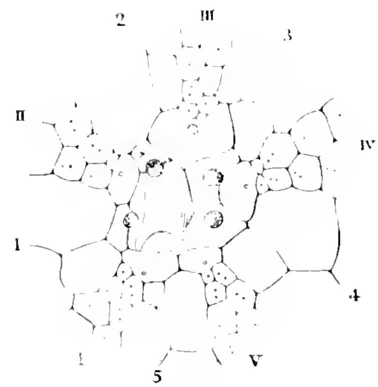


FIG. 282. AËROPE FULVA.

ambulacral plates marked × on the figures come within the abactinal system. In another and larger specimen there are but two large genital openings (Pl. 62, fig. *2*); the anterior pair are wanting. The madreporic body occupies the anterior parts of the right anterior genital, upon which the right posterior genital opening encroaches, as well as upon the right anterior ocular. The left posterior genital pore encroaches upon both the adjoining ocular plates as well as slightly upon the left anterior genital plate. The ocular plates are large, irregularly pentagonal; the odd anterior ocular is more regular in outline and far larger than any of the others (Pl. 62, figs. *1–3*).

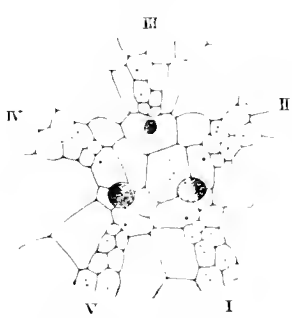


FIG. 283. AËROPE FULVA.

The pairs of simple pores perforating the abactinal ambulacral plates enclosed by the peripetalous fasciole are seen on Plate 62, figs. *1–3*. The spines within the fasciole are slightly curved towards the anterior extremity. Those above the ambitus outside of the fasciole trend towards the posterior extremity, and are frequently spathiform, terminating in a hook (Pl. 62, figs. *10, 12, 13*). The miliary spines are fine, straight, and thickly crowded on both sides of the anterior ambulacral area. On the sides of the test the radioles are somewhat stouter than those within the peripetalous fasciole; at the ambitus they are not only longer but more uniformly spathiform, as also on the actinal and anal plastrons.

The longitudinally elliptical actinal system (Pl. 62, fig. *4*) is almost bare; it is covered with but few and insignificant elongated plates. The anal system is elongate, angular in outline. The anal opening is subcentral nearer the posterior edge; it is covered by small concentrically arranged irregularly shaped plates, the anterior of which carry a few miliaries with an inner row of elongated plates radiating from the actinostome.

On coming up in the trawl the specimens are of a dark yellowish brown color.

In the "Challenger" Report,[1] Aërope was placed among the Brissina, and the same position was assigned to it in the Preliminary Report on the Echini of this expedition.[2] This is evidently not quite correct. A closer analysis shows Aërope to be allied to the Ananchytidæ as well as to the Brissina; it is more closely related to Homolampas than to the Brissina proper. In spite of its prominent peripetalous fasciole, so similar to that of the young of Hemiaster and of Brissopsis and its rudimentary petaloid system, it has the actinal system of the Ananchytidæ, a peripetalous fasciole as in Homolampas, and the double-pored primitive ambulacral petals of Phrissocystis and Palæobrissus, but enclosed in a peripetalous fasciole; this is specially well developed in the odd anterior ambulacrum of Aërope (Pl. 61, fig. *4*). Aërope has also the cylindrical outline which characterizes Pourtalesia and the young Brissinæ; on the whole, while retaining Aërope among the Brissina, we should not neglect to recognize its Ananchytid affinities.

Station 3361, on the way to Cocos Island from Mariato Point, in 1471 fathoms. Lat. 6° 10′ N.; Long. 83° 6′ W. Bottom temperature 36°.6. Gn. ooze.

Station 3362, on the way to Cocos Island from Mariato Point, in 1175 fathoms. Lat. 5° 56′ N.; Long. 85° 10′ 30″ W. Bottom temperature 36°.8. Gn. m. S. rocky.

Station 3381, north of Malpelo Island, in 1772 fathoms. Lat. 4° 56′ N.; Long. 80° 52′ 30″ W. Bottom temperature. 35°.8. Gn. m.

Station 3398, off Galera Point, in 1573 fathoms. Lat. 1° 7′ N.; Long. 80° 21′ W. Bottom temperature 36°. Gn. ooze.

[1] "Challenger" Echinoidea, p. 190.

[2] Bull. M. C. Z. XXXII. No. 5, p. 81.

Station 3399, off Galera Point, in 1740 fathoms. Lat. 1° 7′ N.; Long. 81° 4′ W. Bottom temperature, 36°. Gn. ooze.

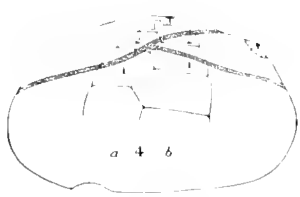
Bathymetrical range, 1175–1772 fathoms. Temperature range, 36°.8–35°.8.

SPATAGODESMA A. Ag.

Spatagodesma A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 83, Plate XII, fig. 8.

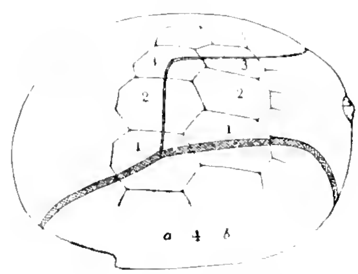
During the voyage of the "Albatross" from New York to San Francisco (1887 to 1888) there were obtained from Station 2769 a few specimens of a small Spatangoid (Pl. 107, fig. *6*) with a peculiar apical fasciole differing widely from that of any Spatangoid known to me, Fig. 284.

A broad elliptical fasciole encircles both the ambulacra and the anal system (Pl. 107, fig. *2*). A transverse band, convex posteriorly, divides the fasciole into two areas, one enclosing the anal system (Pl. 107, figs. *2*, *5*), but not in any way corresponding in shape or position to an anal fasciole, the other becoming a peripetalous fasciole.



5.3 mm

FIG. 284. SPATAGODESMA.



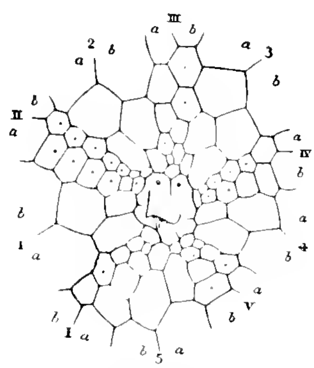
16 mm.

FIG. 285. A. EXCENTRICA.

The nearest approach to the fasciole of this genus is found in Agassizia (Pl. 108). To facilitate the comparison between these genera I have given figures of the young of two specimens of Agassizia; one 5 mm. in length (Pl. 108, figs. *1–5*), and the other 16 mm. (Pl. 108, figs. *6–9*).[1] It will be noticed that in the smaller Agassizia the ambulacral plates within the fasciole do not yet possess double pores (Pl. 108, figs. *2*, *3*, *5*), and that the phyllodes are not yet developed round the actinal system (Pl. 108, fig. *1*), though in this small specimen, the course of the lateral fasciole and its peripetalous branch (Pl. 108, figs. *1–4*) shows but slight variation from that of an older specimen of 16 mm. in length, Fig. 285 (Pl. 108, figs. *6–8*), the principal difference being in the course of the subanal branch of the lateral fas-

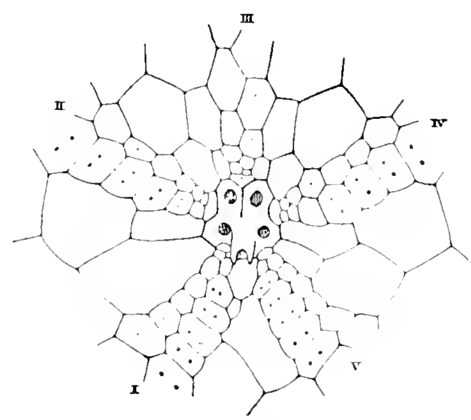
[1] "Blake," 1878–79, St. 231 off St. Vincent, 95 fathoms.

ciole, which has passed down to the actinal surface (Pl. 108, fig. *6*), while in the younger specimen it runs close to the anal system (Pl. 108, figs. *3*, *4*). In the larger Agassizia, however, important changes have taken place in the ambulacral system. On the actinal side the phyllodes have become developed on from two to three pairs of actinal ambulacral plates (Pl. 108, fig. *6*). The odd anterior ambulacrum alone has retained its simple pores; the posterior lateral ambulacral plates are, within the fasciole, perforated by two pairs of pores, while in the anterior lateral ambulacra only the posterior zone is thus perforated, the plates of the anterior zone retaining, as is characteristic of this genus, the primitive single pore of the younger stages (Pl. 108, figs. *7*, *8*, *9*). The actinal system even in the younger stage is



5 mm.

Fig. 286. Agassizia excentrica.



10 mm.

Fig. 287. Agassizia excentrica.

already transversely elliptical (Pl. 108, fig. *1*), slightly heart-shaped from the development of the labium, and becomes still more so in the older stage (Pl. 108, fig. *6*), where the labium is well marked. In both stages the actinostome is covered with few large plates.

It is interesting to note the gradual accumulation of secondaries and primaries along the line (and below it) of the peripetalous fasciole (Pl. 108, figs. *2*, *3*, *6*, *7*, *8*). In the youngest Agassizia the central apical plate, with two indefinite sutures indicating two genital and one interambulacral plate, is made up of the ankylosed genital plates and shows no traces of genital openings or of the madreporic body from the exterior (Pl. 108, fig. *2*), but from the interior of the test, Fig. 286 (Pl. 108, fig. *5*) two well developed genital openings are seen as well as the base of the stone canal and indications of the sutures of the four genital plates. In the older stages there are four genital openings, Fig. 287, piercing the central apical plate (Pl. 108, fig. *7*).

The madreporic body has developed between the two posterior genital openings. The stone canal is prominent when seen from the interior of the test (Pl. 108, fig. *9*), and there are also traces of the suture between two of the genitals visible from that side.

In Agassizia the change of position of the fasciole with age is very marked; though it is on the same plates in the anterior part of the test, yet it is almost on the ambitus when seen from the actinal side (Pl. 108, figs. *1*, *6*). At the anal extremity the fasciole is close to the anus in a specimen of 5 mm. (Pl. 108, fig. *4*), while in a specimen of 16 mm. it forms a sharp angle and crosses the odd posterior interambulacrum on the second plates from the sternum (Pl. 108, figs. *6*, *8*).

There are several genera in which the anterior poriferous zone of the petaloid anterior ambulacra is modified or partly atrophied. Among the tertiary types Lambertia[1] and Atelospatangus,[2] related to Maretia and Hemipatagus, have, as in the recent Agassizia, and Nacospatangus, a rudimentary or totally absent anterior zone. In Agassizia and Nacospatangus the lateral ambulacra are barely petaloid, while in the tertiary genera they are petaloid. Oppenheim[3] has called attention to the existence of this whole or partial atrophism in Hemipatagus and Parabrissus.[4] In Maretia and Lovenia the distal pores are part of the petals, they disappear or are rudimentary at the abactinal pole. In Nacospatangus the distal pores disappear; in Agassizia the anterior zone only of the anterior lateral ambulacra is absent.

Spatagodesma Diomedæ A. Ag.

Spatagodesma Diomedæ A Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 83, Pl. XII. fig. 8.

Plates 106 : 107.

The general aspect of Spatagodesma shows that it is an embryonic stage, yet the development of the fimbriated tentacles of the phyllodes (Pl. 107, fig. *7*) of the double pores on the plates of the anterior ambulacral system (Pls. 106, fig. *4*; 107, fig. *4*) would seem to indicate, judging by analogy with Agassizia, that it possessed the principal characters of the adult.

[1] Lambertia, Palæontog. 17, Pl. 10, fig. 3 1900, p. 112.

[2] Koch, A., Die Alttertiaren Echiniden Siebenburgens. Jahrb. d. K. Geol. Anstalt, VII, 1885, Pl. VII, fig. 4, p. 115.

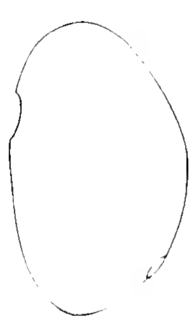
[3] Oppenheim, P., Protok. d. März Sitzung. Zeits. d. deutsch. Geol. Ges. 1899, 51, p. 28.

[4] Parabrissus is a Brissoid having only the posterior zone of the anterior lateral ambulacra developed. See Bittner, A., Verhandl. d. K. K. Geol. Reichsanstalt, 1891, p. 133, fig. p. 135.

The existence of simple pores in the anterior zones of Agassizia has usually been looked upon as an abortion of the second pore of the pair, and not as a character indicating its Ananchytid relations.

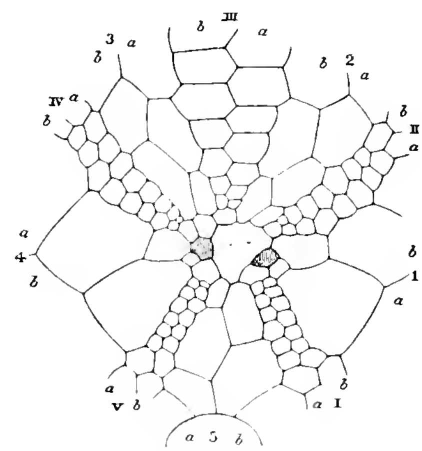
The actinostome is near the labium. The actinal system is pentagonal with rounded corners; the plates covering it are barely indicated; they are large and few in number, much as in Agassizia (Pl. 107, fig. *7*). There is a single spheridium in the actinal plate of each ambulacral area. Seen from the actinal side (Pl. 107, fig. *1*) the ambulacra are bare; the interambulacral areas alone are covered by large primaries. Seen in profile (Pl. 107, fig. *3*) the lateral ambulacra continue bare along the sides of the test and as far as the apical system; within the peripetalous fasciole (Pl. 107, fig. *2*) the interambulacra alone carry primary tubercles.

The spines of the abactinal side trend towards the anterior extremity; those of the ambitus towards the posterior part of the test. On the sternum the primary radioles of the test are fluted, spatulate, rounded at the extremity, covered with sharp lateral spines, (Pl. 107, figs. *8*, *9*); those of the fascioles are short, straight, carinate, slightly expanded at the extremity (Pl. 107, fig. *10*).



5.3 mm.

FIG. 288. S. DIOMEDÆ.



5.3 mm.

FIG. 289. SPATAGODESMA DIOMEDÆ.

The anal system is slightly pointed, covered with irregular elliptical plates, largest at the abactinal edge and decreasing in size towards the anal opening, which is close to the actinal edge of the anal system (Pl. 106 fig. *3*).

The general outline of the test as seen from the actinal side (Pl. 107, fig. *1*) is elliptical, slightly truncated anteriorly, somewhat indented; the actinal side is arched both laterally and longitudinally (Pl. 107, figs. *3–5*).

Seen in profile (Pl. 107, fig. *3*), the apex is posterior, Fig. 288, nearer the transverse fasciole. Anteriorly the test slopes somewhat more gradually towards the ambitus than towards the posterior extremity, which is slightly indented at the anal system, the anus is placed almost half-way from the ambitus to the vertex.

As in Agassizia, there is a central apical plate, Fig. 289, composed of the four ankylosed genitals. The genital pores are not as yet developed (Pl. 106, figs. *2*, *4*), and the madreporic body can barely be detected from the exterior (Pl. 106, fig. *2*). Seen from the interior the base of the stone canal projects prominently from the level of the central plates.

The ocular plates are large, irregularly hexagonal, they abut against the central genital plate, except the left anterior, which is separated from it by the intercalation of a row of lateral interambulacral plates (Pl. 106, figs. *2*, *4*).

The primary actinal interambulacral plates and those of the odd and of the posterior interambulacra are nearly of the same size; the labium is somewhat larger (Pl. 106, fig. *1*).

The tentacles of the odd anterior ambulacrum are large with prominent disks (Pl. 107, fig. *6*).

Station 2769, "Albatross" Exp. New York to San Francisco, off Cape Dos Bahias, in 51 fathoms. Lat. 45° 22′ S.; Long. 64° 20′ W

NACOSPATANGUS A. Ag.

Nacospatangus gracilis A. Ag.

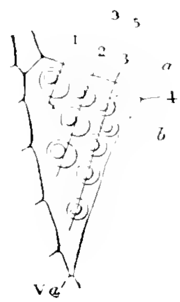
Nacospatangus gracilis A. Ag., Bull. M. C. Z. 1873, III, p. 189.
Nacospatangus gracilis A. Ag., "Hassler" Exped. Echini, p. 18, Ill. Cat. M. C. Z. 1874, No. VIII.

Plate 98.

Although I have given photographic figures of Nacospatangus,[1] yet as they do not bring out sufficiently clearly the important characters of this interesting genus, I have given on Plate 98 additional figures which will show more in detail the specific and generic characters described in the "Hassler" Echini, and bring out its distant relationship to Agassizia and Spatagodesma.

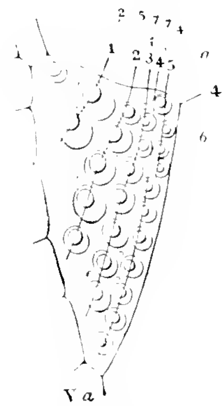
[1] Ill. Cat. M. C. Z. No. VIII, Pl. II, figs. 3–5.

Seen from above (Pl. 98, fig. *3*) a denuded specimen 17 mm. in length[1] shows the broadly petaloid posterior ambulacra, the semipetaloid anterior



6.5 mm.

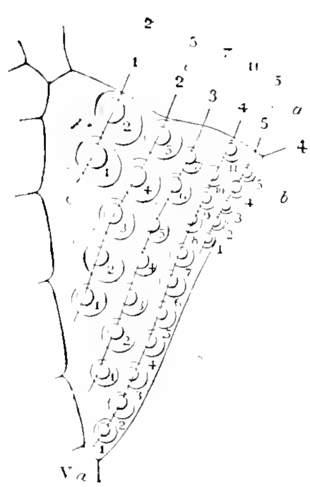
Fig. 290. Nacospatangus gracilis.



9 mm.

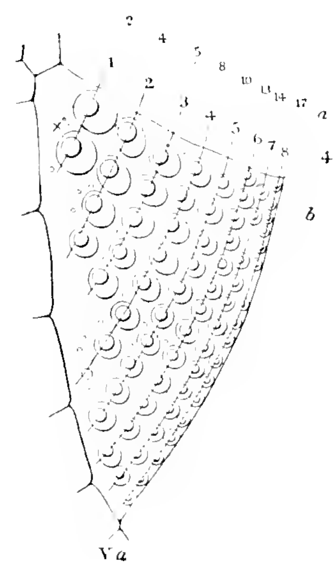
Fig. 291. Nacospatangus gracilis.

pair with the anterior zone composed of simple pores and the simple anterior ambulacrum. The uniform tuberculation of the coronal plates is very marked, extending over the interporiferous zone of the lateral ambulacra.



11 mm.

Fig 292. Nacospatangus gracilis.



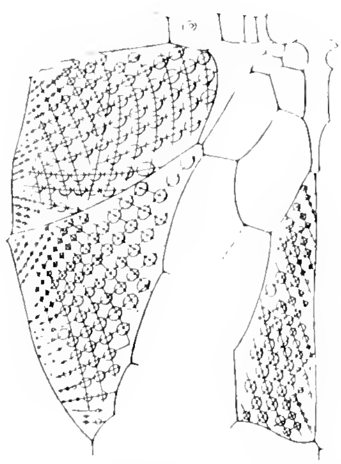
17 mm.

Fig. 293. Nacospatangus gracilis.

The great width of the posterior row of the posterior lateral ambulacra is very striking, as well as the size of the anterior interambulacral plates compared to those of the ambulacral zone.

[1] "Hassler" Echini, Pl. II, fig. 4.

A profile view[1] as well as a view from the abactinal side (Pl. 98, figs. *2, 4*) shows the abrupt passage, near the ambitus, of the small tubercles of the abactinal part of the test to the large tuberculation of the second pair of plates of the interambulacral areas (Pl. 98, fig. *2*). This is also shown in Pl. 98, figs. *8–11*, where the large tubercles are arranged in rows parallel to the ambital suture of the second posterior plate of the right posterior lateral interambulacrum. The specimens figured on Pl. 98, figs. *8–11*, range in size from 6.5 to 17 mm.



110 mm.

FIG. 294. LINOPNEUSTES LONGISPINUS.

Among the Spatangoids we find a great diversity in the arrangement of the primary and secondary tubercles in the large interambulacral plates of the actinal side. This leads to most characteristic patterns which have not as yet been used either for generic or specific characters. A comparison of the patterns of some of these actinal plates, Figs. 257, 290–294, shows in a striking way how important these characters are among the Spatangoids. The earliest indications of such designs are found among the Cassidulidæ. The patterns take their greatest development among such forms as Metalia, Lovenia, Maretia, Rhynobrissus, and are in striking contrast with the simple patterns of Brissus, Meoma, Brissopsis, Echinocardium, and others.

On the actinal plastron the tuberculation is coarse towards the labium, and quite small and crowded towards the subanal plastron. On the actinal surface, the ambulacral zones, composed of large plates, are broad and bare as well as the adjoining edges of the interambulacral areas, forming a striking contrast to the narrow ambulacral zones of the abactinal surface with their small and diminutive plates.

The actinostome is somewhat pentagonal, with the actinal edge of the labium slightly raised.

A young specimen of only 6.5 mm. in length (Pl. 98, fig. *1*) seen from the actinal side does not show any marked differences from older specimens. The abactinal system of a specimen of 6.5 mm. (Pl. 98, fig. *5*) has only three genital plates, no genital pores, Fig. 296, and a few madreporic

[1] "Hassler" Echini, Pl. II, figs. 3, 5.

openings. The two anterior genital plates, Fig. 296, are ankylosed and carry the madreporite. In a large specimen (Pl. 98, figs. *3*, *6*) there are three genital pores. The right anterior genital pore is wanting, Fig. 295. The left anterior and the two posterior pores are large. The right anterior and posterior genital plates are ankylosed (Pl. 98, figs. *3*, *6*).

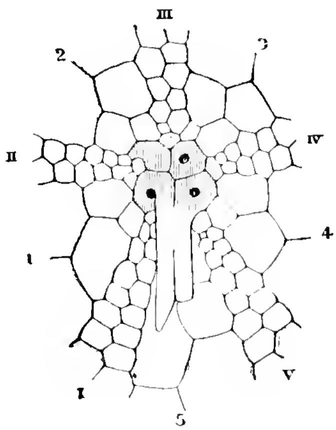


FIG. 295. NACOSPATANGUS GRACILIS.

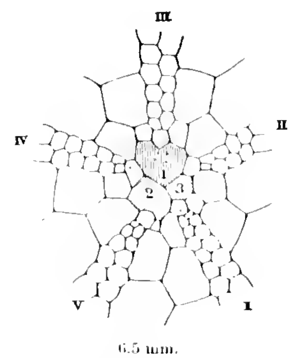


FIG. 296. NACOSPATANGUS GRACILIS.

In Agassizia there are four genital pores. Three genital plates are faintly indicated in young specimens of 5 mm. (Pl. 108, figs. *2*, *5*). In larger specimens (16 mm.) there is a faint longitudinal suture to be seen on the interior of the test (Pl. 108, fig. *9*). On the whole the abactinal system of the two genera are very similar.

Nacospatangus gracilis was dredged by the "Hassler" in 65 fathoms off Juan Fernandez.

SCHIZASTER Agass.

Schizaster latifrons A. Ag.

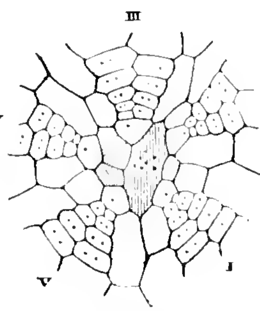
Schizaster latifrons A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 81, non Pl. XI, figs. 2, 3.

Plate 102, figs. *1–4*.

At Station 3431, in 995 fathoms, were collected specimens of a species of Schizaster remarkable for the great development of the anterior extremity, the breadth of the odd anterior ambulacrum (Pl. 102, fig. *2*), and the short posterior pair of lateral ambulacra. The subanal fasciole is delicate, does not join the peripetalous fasciole (Pl. 102, fig. *4*). The actinal plastron is well marked by the two large plates which occupy nearly the whole length of the odd posterior actinal interambulacrum.

This species belongs to the group of Schizaster of which *S. Philippii* is a well known representative, though its anterior odd ambulacrum is far less sunken (Pl. 102, fig. *2*).

In a specimen 17 mm. in length (Pl. 102, figs. *2*, *3*), Fig. 297, there are as yet no genital pores. The apical system is very similar to that of *S.*



17 mm.

Fig. 297. S. latifrons.

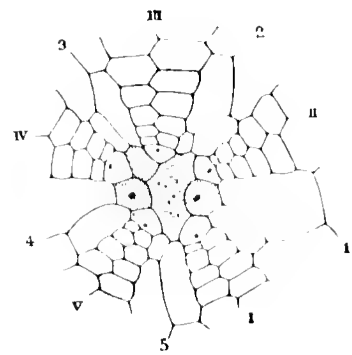
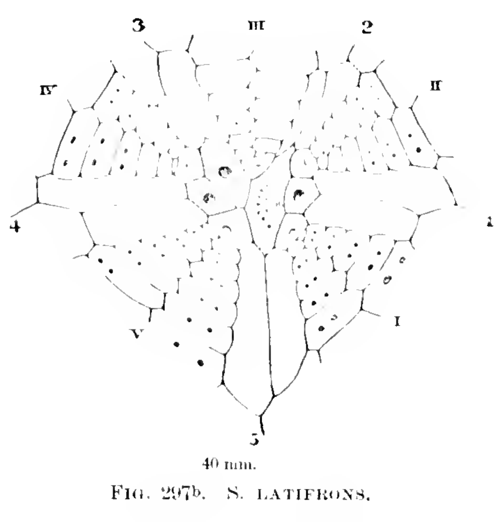


Fig. 297^a. Schizaster Philippii.
After Lovén.

Townsendi (Pl. 101, fig. *3*) and of *S. Philippii*, Fig. 297^a, though the ocular plates are rectangular or pentagonal in *S. latifrons* and triangular in *S. Townsendi*. Fig. 301. In a young specimen of *S. Townsendi* of not more



40 mm.

Fig. 297^b. S. latifrons.

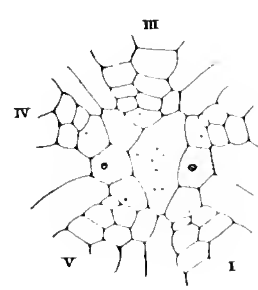


Fig. 298. Schizaster Philippii.
After Lovén.

than 10 mm. in length (Pl. 101, figs. *7*, *8*) there are three genital openings as in larger specimens (Pl. 101, figs. *2*, *3*), but with only a few madreporite pores.

There is great similarity in the structure of the apical system of *Schizaster Townsendi*, Fig. 301, *S. latifrons*, Fig. 297^b, *S. Philippii*, Fig. 298, *S. fragilis*,

Fig. 299, and *S. canaliculata*, Fig. 300, with only slight variations in the dimensions of the right anterior genital, the madreporite, or in the atrophy of one or more genital pores.

Station 3431, off Altata, Gulf of California, 995 fathoms. Lat. 23° 59′ N.; Long. 108° 40′ W. Bottom temperature, 37°. Lt. br. m. glob.

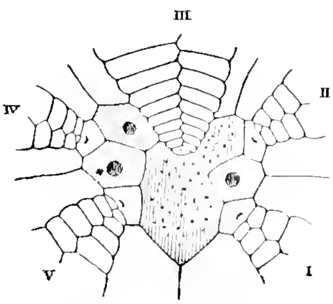


FIG. 299. S. FRAGILIS.
AFTER LOVÉN.

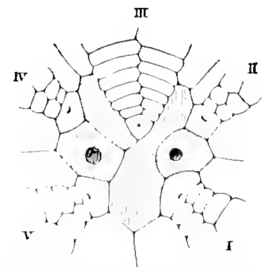


FIG. 300. S. CANALICULATA.
AFTER LOVÉN.

Schizaster Townsendi A. Ag.

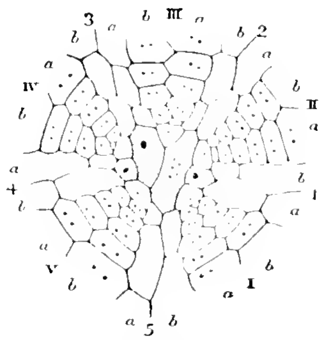
Schizaster Townsendi A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5. p. 82, Pl. XI, figs. 2, 3.[1]

Plates 100, figs. *1–5*; 101.

In young specimens the apical system is comparatively more distant from the posterior extremity than in older specimens. In two specimens, measuring 10 and 11 mm. in length (Pls. 100, fig. *1*; 101, fig. *7*), the apical system was central. In a somewhat larger specimen, 15 mm. long, the apical system was 6 mm. from the posterior edge, showing that the anterior extremity develops more rapidly with age than the posterior, the lateral anterior ambulacra soon far outstripping in length the posterior ones. In a specimen of 22 mm. in length the centre of the apical system was 8 mm. from the posterior extremity. In a specimen of 32.5 mm. the centre of the apical system was 13 mm. from the posterior extremity, 14 mm. in a specimen of 36 mm. in length, and 15 mm. in the largest specimen collected, of 49 mm. A distinct thin anal fasciole extends across the posterior interambulacrum (Pl. 101, fig. *7*). This species is marked by the flatness of the test (Pl. 100, figs. *4*, *5*), the great width of the lateral ambulacra (Pls. 100, fig. *3*; 101, fig. *2*), the small size of the anal system (Pl. 100, fig. *5*; 101, figs. *2*, *7*), the close primary tuberculation of the actinal plastron, which is in striking contrast to the bare actinal surface (Pls. 100, fig. *2*; 101, fig. *1*).

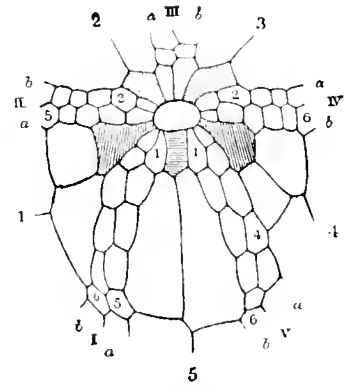
[1] Referred to *S. latifrons* by mistake in Bull. M. C. Z. 1898, XXXII, No. 5, p. 81.

In the apical system of a young specimen of 10 mm. the left posterior genital is excluded from the madreporite by the left anterior genital, Fig. 301. The genital pores are already well developed in so small a



10 mm.

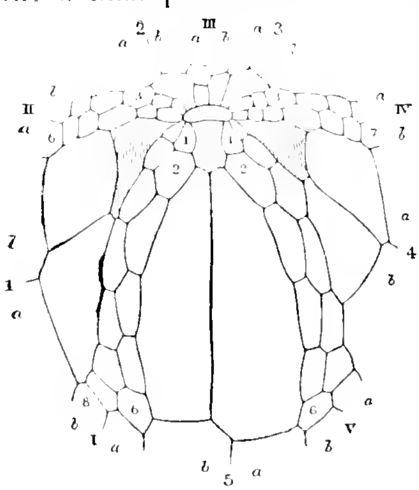
FIG. 301. SCHIZASTER TOWNSENDI.



10 mm.

FIG. 302. SCHIZASTER TOWNSENDI.

specimen. The labium of *S. Townsendi*, Fig. 302, is in contact with only one actinal ambulacral plate; in *S. latifrons*, Fig. 303, it is in contact with the actinal part of the second plate. On comparing Figs. 302 and 303 striking differences will be noticed in the relative positions of plates 1, 2, 4, and 6 in the lateral posterior ambulacra, and of plates 2, 3, 5, 6 and 7 in the lateral anterior ambulacra.



40 mm.

FIG. 303. S. LATIFRONS.

Station 3394, Gulf of Panama, 511 fathoms. Lat. 7° 21′ N.; Long. 79° 35′ W. Bottom temperature, 41°.8. Dk. gn. m.

Station 3419, off Acapulco, 772 fathoms. Lat. 16° 34′ 30″ N.; Long. 100° 3′ W. Bottom temperature, 39°.6. Gn. m. bk. sp.

Station 3424, off Tres Marias, Gulf of California, 676 fathoms. Lat. 21° 15′ N.; Long. 106° 23′ W. Bottom temperature, 38°. Gy. s. bk. sp. glob.

Station 3425, off Tres Marias, 680 fathoms. Lat. 21° 19′ N.; Long. 106° 24′ W. Bottom temperature, 39°. Gn. m. s.

Station 3426, off Tres Marias, 146 fathoms. Lat. 21° 21′ N.; Long. 106° 25′ W. Bottom temperature, 51°.2. Rocky.

Station 3431, off Altata, Gulf of California, 995 fathoms. Lat. 23° 59′ N.; Long. 108° 40′ W. Bottom temperature, 37°. Lt. br. m. Glob.

Station 3436, south of Guaymas, 905 fathoms. Lat. 27° 34′ N.; Long. 110° 53′ 40″ W. Bottom temperature, 37°.2. Br. m. bk. sp.

Station 3437, 50 miles south of Guaymas, 628 fathoms. Bottom temperature, 40°. Bn. m. bk. sp.

Bathymetrical range, 146–995 fathoms. Temperature range, 51°.2–37°.

PERIASTER D'Orb.

Periaster tenuis A. Ag.

Periaster tenuis A. Ag., Bull. M. C. Z. 1898, XXXII, No. 5, p. 82, Pl. XI, figs. 6, 7.

Plates 103, figs. *5–7*; 104; 105, figs. *1–3*.

This species is much flatter and less cylindrical (Pl. 104, fig. *3*) than *P. limicola* from the Gulf of Mexico. It has no anal fasciole. The peripetalous fasciole is wide (Pls. 103, fig. *6*; 104, figs. *2*, *5*; 105, fig. *2*), covered by prominent miliaries. The actinal plastron is elongated (Pls. 104, figs. *1*, *4*; 105, fig. *1*), and the tuberculation of the test is close (Pl. 104, fig. *3*).

On coming up in the trawl the color of the test is light brown, though it is found at considerable depths, nearly 1800 fathoms, depths at which the prevailing tints and colors of the Echini found there are pinkish to dark violet. Aërope and Phrissocystis are similar exceptions: they are both yellowish and brown, and are found, the one at over 1000 fathoms, the other to nearly 1800 fathoms.

Seen from the abactinal side the Panamic species is only slightly elongate, the labium narrow and very prominent (Pls. 104, figs. *1*, *4*; 105, fig. *1*). The apical system is slightly anterior, the petals broad, sharply constricted at the peripetalous fasciole (Pl. 105, fig. *2*), the odd anterior ambulacrum narrow. The vertex is near the anterior line of the peripetalous fasciole (Pl. 104, fig. *3*); from this the test slopes very gradually to the anterior extremity, which is rounded, the ambitus passing gradually to the actinal surface (Pl. 104, fig. *3*). The posterior extremity of the test is truncated, sloping sharply from the vertex to the ambitus, where it forms a rudimentary posterior snout (Pl. 104, fig. *3*).

The labium and sternum of this species (Pl. 105, fig. *1*) are much longer and narrower than in *P. limicola*, and the bare ambulacra flanking the sternum fully twice as wide as in the Mexican species.

The anal system is cut out of only three interambulacral plates (Pl. 105, fig. *3*).

The apical system of *P. tenuis*, Fig. 305, is very similar to that of *Hemiaster bufo*, Fig. 304; it has four genital plates in contact with four

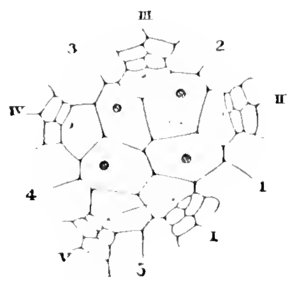


FIG. 304. HEMIASTER BUFO.
AFTER LOVÉN.

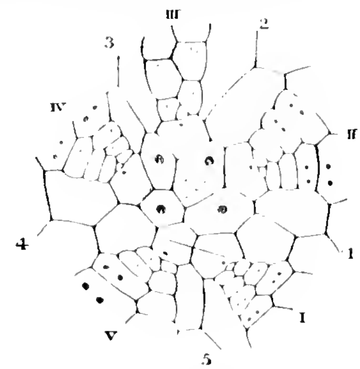


FIG. 305. PERIASTER TENUIS.

genital openings, with a madreporite limited to the right anterior genital (Pl. 105, fig. *2*), though it extends so as to come in contact with the left posterior genital plate.

The actinostome is paved by numerous longitudinal rows of small plates radiating irregularly towards the labium (Pl. 105, fig. *1*). The anal system is bordered on the upper edge by four large polygonal plates; those covering the rest of the anus are smaller.

There must have been some mistake in the identification of the Schizasterid collected by the "Challenger" (Pl. XXXV^{b}, figs. 1–4) as *Periaster limicola*. A comparison of the figures on Pl. XXXV^{b}, of the "Challenger" Echinoidea with those collected by the "Blake" off the mouth of the Mississippi[1] shows great differences in outline both in profile and from above. In profile the species from the Gulf of Mexico (Pl. III, fig. 1)[1] is seen to be quite rectangular in outline, and posteriorly vertically truncated, with a rounded anterior extremity; while the "Challenger" specimens (Pl. XXXV^{b}, fig. 3) are more rounded anteriorly, and the posterior extremity slants from the anal system towards the actinal side.

Seen from above the original *P. limicola* is quite circular, slightly indented at the ambulacral areas (Pl. III, figs. 2, 3)[1] while the "Challenger" specimens are ovoid (Pl. XXXV^{a}, figs. 1, 2). But by far the most important differences are those shown by the short labium, the wide sternum,

[1] Bull. M. C. Z. 1878, No. 9, Vol. V, p. 193, Pl. III.

and the narrow ambulacral areas of the actinal side (Pl. XXXV[b], fig. 2) as contrasted to the broad ambulacral areas of *P. limicola* from the Gulf of Mexico (Pl. III. fig. 4).[1]

The Mexican species is far more closely allied to the Panamic species than to the Schizaster-like specimens collected by the "Challenger." The abactinal system of the latter resembles that of Schizaster, while that of *P. limicola* and *P. tenuis* are Hemiaster-like, though that of *P. limicola* has only two genital pores.

Station 3381, off Galera Point, 1772 fathoms. Lat. 4° 56′ N.; Long. 80° 52′ 30″ W. Bottom temperature, 35°.8. Gn. m.

Station 3398, off Galera Point, 1573 fathoms. Lat. 1° 7′ N.; Long. 80° 21′ W. Bottom temperature, 36°. Gn. ooze.

Station 3399, off Galera Point, 1740 fathoms. Lat. 1° 7′ N.; Long. 81° 4′ W. Bottom temperature, 36°. Gn. ooze.

Bathymetrical range, 1573–1772 fathoms. Temperature range, 36°–35°.8.

Abatus Trosch.

Abatus cavernosus Trosch.

Tripylus cavernosus, Phil. Wieg. Arch. 1845, XI, p. 345.
Abatus cavernosus, Trosch. Wieg. Arch. 1851, XVII, p. 72.

Plate 99.

The Echinid-like type of young Spatangoids has been known since 1848 from Müller's figures. Subsequently I figured a number of post-embryonic stages of young Spatangoids in the Revision of the Echini (1874), the "Challenger," and "Blake" Echini. In 1883 Lovén carefully described and figured the young of *Abatus cavernosus* and of Echinocardium,[2] while we owe to Fewkes and Theel more recent figures of very early Echinid stages of Echinarachnius and Echinocyamus. In Lovén's figures of a young Echinocardium[3] of 1.7 mm. in length the coronal plates of the young Spatangoid are drawn and the fascioles are indicated. In his figures of a young Abatus of 2.3 mm. the plates near the actinostome are figured,[4] as well as those of the abactinal system and part of those of the ambulacral system. The interambulacral plates are not shown.

[1] Bull. M. C. Z. 1878, No. 9, Vol. V, p. 193, Pl. III.
[2] Pourtalesia, p. 24, Pls. XIV, XV.
[3] Pourtalesia, Pl. XV, figs. 172, 173.
[4] Pourtalesia, Pl. XIV, figs. 166, 167.

I am able to give figures of the plates of young Abatus 1.6 mm. in length kindly sent me by Mr. Rathbun of the Smithsonian. They are perhaps the most Echinid-like post-embryonic stages as yet figured of any Spatangoid. Figs. 306–308 (Pl. 99, figs. *3–7*).

In the young Echinocardium figured by Lovén the anal system is fully developed in the abactinal part of the posterior ambulacrum, and the actinal sternum has already assumed the characters of the adult sternum. This is in great contrast to the stages of Abatus I am able to describe. The young, when seen from above or below, is but slightly elliptical (Pl. 99, figs. *3*, *4*), the actinostome is pentagonal, somewhat excentric, the interambulacra are all in contact with it, though in older specimens (Pl. 99, fig. *8*) the posterior lateral ambulacra are excluded from the actinostome. The sternum consists of two plates of very different dimensions forming almost a true meridosternum (Pl. 99, figs. *3*, *5*), which in the adult becomes amphisternal (Pl. 99, fig. *8*).

The anal system of the young Abatus, Fig. 306, is not as yet separated from the abactinal system by the abactinal plates of the odd interambulacral area (Pl. 99, fig. *5*). The two systems are enclosed in the same area within the circle of the ocular plates (Pl. 99, figs. *4*, *6*, *7*), as has already been figured by Lovén.[1] Lovén's figures are from a specimen somewhat larger than mine; the interambulacral plates are not quite as far advanced. The fascioles are more marked in my figures (Pl. 99, figs. *2*, *4*, *5*), the interambulacral spines somewhat larger, and the suckers more prominent (Pl. 99, fig. *1*). Only few of the spines are curved as they appear in somewhat older specimens[2] which I figured on a former occasion.[3]

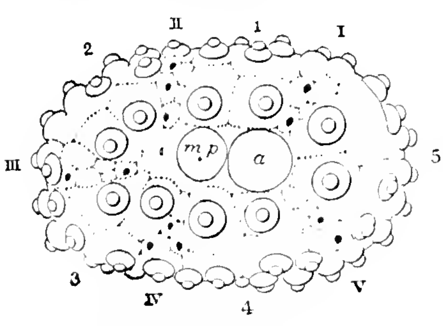


FIG. 306. ABATUS CAVERNOSUS.

In the smallest Abatus (Pl. 99, figs. *4*, *6*), Fig. 307, the anal system is indicated by a nearly bare membrane, while in a somewhat older specimen 1.9 mm. in length, Fig. 308, the anal system appears towards the posterior edge of the abactinal area surrounded by a row of radiating plates (Pl. 99, fig. *7*) identical in number with those of the adult (Pl. 99, fig. *10*), Fig. 309.

[1] Pourtalesia, Pl. XIV, fig. 164.
[2] "Challenger" Echinoidea, Pl. XX[a], fig. 8.
[3] Proc. Am. Acad. 1876, p. 231.

There are five spheridia near the actinostome, one in each ambulacral area (Pl. 99, fig. *1*).

Each interambulacrum has one actinal plate followed by four and a half coronal plates carrying on each plate from one to six primary and secondary tubercles. The ambulacral areas are bare. In older specimens[1] 3 mm. in length there is a miliary in each ambulacral plate.

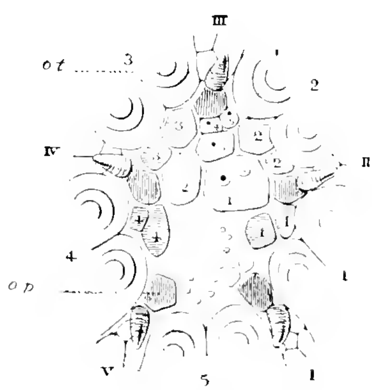


FIG. 307. A. CAVERNOSUS.

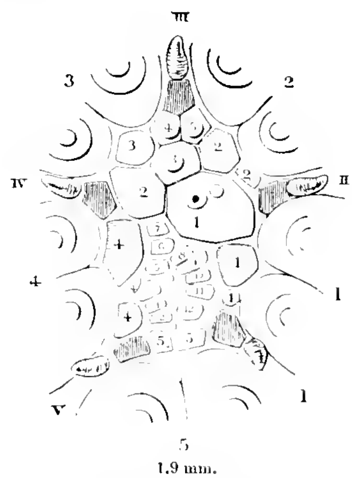


FIG. 308. A. CAVERNOSUS.

Lovén is right in objecting to the association of *Abatus cavernosus* Trosch. with Hemiaster.[2] The structure of the abactinal system of Hemiaster is

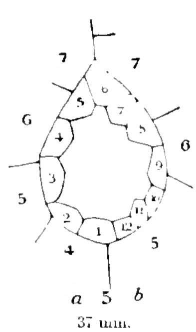


FIG. 309. A. CAVERNOSUS.

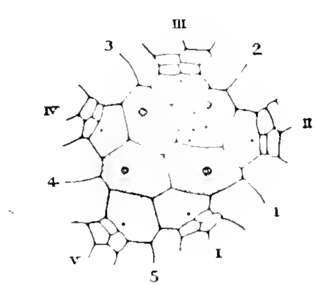


FIG. 310. HEMIASTER BUFO. AFTER LOVEN.

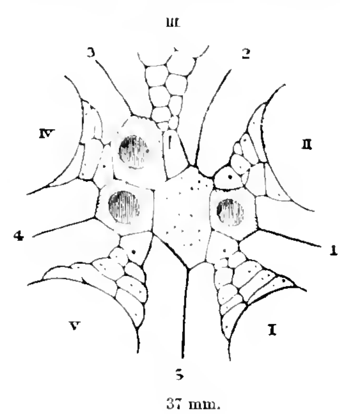


FIG. 311. ABATUS CAVERNOSUS.

of an ancient type, Fig. 310, while that of Abatus is eminently Schizasteroid, Fig. 311 (Pl. 99, fig. *9*), but neither Troschel nor myself had noticed the difference in the structure of the abactinal system of Abatus and Hemiaster first detected by Lovén.

[1] "Challenger" Echinoidea Pl. XX^{a}, figs. 9, 10.

[2] Pourtalesia, p. 72.

MOIRA A. Ag.

Moira clotho A. Ag.

Moera clotho Mich. Rev. et Mag. Zool. 1855. p. 247.
Moira clotho A. Ag. Revision, p. 147.

Plate 109.

During the voyage from New York to San Francisco the "Albatross" collected a few young specimens varying in size from 7 to 34 mm., at Stations 2800 and 2801. Unfortunately they came badly broken, but the fragments sufficed to show that in the smallest specimen the adult features are already developed. The test is perhaps less angular than in old specimens, but the sunken ambulacra, both the lateral and odd anterior, are fully as developed as in larger specimens. The radioles of the different parts of the test are as well differentiated as in larger specimens, and in the younger stages both the peripetalous fasciole and its subanal branch follow the same course as in full grown specimens, passing at a considerable distance under the anus. The large suckers of the anterior ambulacra are quite as marked as those of the deep-sea genera Aceste and Aërope. In fact we might look upon Moira as a further stage in the development of sunken ambulacra; Abatus having lateral ambulacra greatly developed, while Cionobrissus and Aërope have a wide anterior ambulacrum more like that of the Schizasteridae.

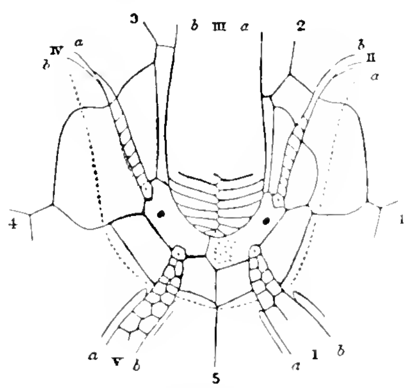


FIG. 312. MOIRA CLOTHO.

Among the Spatangoids with deeply sunken ambulacra like Abatus, Aceste, Moiropsis, and Moira, the last is specially noted for the modifications produced on the abactinal system by the great width of the deeply sunken anterior ambulacrum and the deeply sunken petals of the adjoining lateral anterior ambulacra (Pl. 109, figs. *2*, *4–6*). The apical system, Fig. 312, consists of two narrow elongated plates, which are united along the medium suture of the odd posterior line of the interambulacrum and form an arc extending from the anterior oculars. There are two large genital pores corresponding to the posterior interambulacral areas. The narrow polygonal genital plates are deeply notched to receive the four lateral oculars (Pl. 109, figs. *2*, *4*, *5*), the posterior pair cutting into the centre of the genitals, the anterior pair being notched into the narrow extremity of the genital plates; they extend a short distance on each side of the anterior ocular plates (Pl. 109, figs. *4*, *5*). The right genital carries the madreporite, which covers the greater part of the plate adjoining the odd interambulacrum (Pl. 109, fig. *4*). The odd ocular plate fits into the inner curved edge of the genital plates at their junction.

Seen from the interior (Pl. 109, fig. *5*) there is no trace of the suture of the anterior genitals, and only a mere line to indicate the junction between the two genitals so well seen from the outside. The extension of the stone canal on the right genital is very prominent (Pl. 109, fig. *5*).

The expansion of the ambulacra in the interior of the test has quite hidden the abactinal anterior interambulacral plates. They are already quite narrow when seen from the outside of the test (Pl. 109, fig. *4*), but when seen from the interior (Pl. 109, fig. *5*) only two very slender plates are visible in the space between the odd and the anterior ambulacra. It is interesting to note that the central angular sutures are curved, following more or less the general curve of the sunken ambulacral plates.

The internal fasciole is very irregular in its development, often merely marked by a bare space covered with most minute tubercles along the bevelled edge of the petals where they join the ambulacra (Pl. 109, fig. *2*), or with intermittent tubercles apparently worn from an edge formerly well covered, as is indicated on Plate 109, fig. *6*, which represents the internal fasciole on the edge of the petal of the third interambulacral plate from the genital plate.

When seen in profile (Pl. 109, fig. *3*) the anterior part of the test makes a sharp indentation at the point where the anterior petals turn sharply towards the apical system, near the point where the peripetalous fasciole follows on both sides the edge of the anterior petals to their extremity. Nearly from the same point on the anterior edge the fasciole strikes across the test to the extremity of the odd anterior petal, where it crosses the odd ambulacral area (Pl. 109, fig. *2*). The inner fasciole follows the edge of the lateral petals, and the anterior part forms a part of the peripetalous fasciole which branches off from the anterior petals and runs diagonally down the side of the test towards the anal system.

As there are no detailed figures of Moira, I have given the principal features of *Moira clotho*, the Pacific representative of the genus. This species is very regularly oval when seen from above (Pl. 109, fig. *2*). The odd anterior ambulacrum is bare, covered with minute miliaries, slightly sunken at the ambitus; it is somewhat dumb-bell shaped, deeply sunken towards the abactinal pole. The abactinal plates are narrow and increase rapidly in size toward the ambitus, where it is crossed by the peripetalous fasciole.

The ambulacral plates of the sunken petals are quite uniform in size; at the extremity of the petals they pass suddenly into horizontally elongate plates, which in their turn pass on the actinal side into bare, longitudinally elongated plates.

The coronal plates are covered with rather small tubercles very uniform in size, arranged in diagonal rows across the plates. In the larger interambulacral and ambulacral plates of the sides of the test the lines of tubercles are interrupted by bare spaces (Pl. 109, figs. *2*, *3*).

On the actinal side (Pl. 109, fig. *1*) the tubercles are much larger, especially on the plastron towards the actinostome and on the interambulacral areas along the bare ambulacral areas. The left plate of the sternum is larger than the right (Pl. 109, fig. *1*), the labium is very prominent (Pl. 109, fig. *3*), with the actinal sternum forming a very marked keel; the primordial plates of the posterior interambulacra are irregularly triangular and in contact with the actinostome by a mere point. Those of the anterior interambulacra are L-shaped and are in contact with the actinostome by a broader face (Pl. 109, fig. *1*).

The actinostome is transverse ,with a convex labium (Pl. 109, fig. *7*); the anterior edge is bordered by eight large irregularly rectangular plates with an inner row of smaller plates and a third still smaller row adjoining the labium.

The anal system is longitudinally elliptical (Pl. 109, fig. *8*), flanked by an outer row of eight large polygonal plates and two irregular rows of smaller plates radiating from the anal opening.

We may note that M. de Meijere[1] mentions a species of Moira from the East Indian Archipelago. The profile and abactinal views given by him[2] are said to be from the same specimen; they are drawn on a different scale. This may be a young specimen of the species of Moira (*M. stygia*) said to inhabit the Red Sea and to be found on the east coast of Africa (Zanzibar).

[1] "Siboga" Echinoidea, p. 183. [2] Id. Pl XXII, figs. 459, 460.

It is interesting to trace the gradual specialization of the odd anterior ambulacrum from the time of the Chalk; Holaster, Hemipneustes, Cardiaster, Toxaster, all have lateral ambulacra flush with the test or nearly so, features still retained among the recent Spatangoids in Aërope and Aceste; while in Hemiaster, Periaster, Prenaster, and Schizaster, in addition to the specialized odd ambulacrum, the lateral ambulacra become somewhat sunken, and culminate in such sunken lateral ambulacra as those of Abatus and some species of Schizaster, and finally in Moiropsis and Moira, in which all the ambulacra are sunken. These genera have been preceded by such types as Linthia with ambulacra all equally but slightly sunken within a peripetalous fasciole, while in Brissus, Meoma, Metalia, and the like we have stages of development representing the growth of the sunken lateral ambulacra in *Abatus cavernosus*.[1] In Moira we find the greatest development in the sunken ambulacra, not only of the lateral pairs but also of the odd anterior ambulacral pouch, which is more sunken [2] than that of the lateral pairs (Pl. 109, figs. 2, 5).

Moira clotho differs from *M. atropos* in having the abactinal system more excentric, and in being more elliptical in outline. In *M. clotho* the fasciole passing under the anal system crosses the plates in contact with the anal system, while in *M. atropos* it cuts across the posterior extremity of the set of plates next to the sternum. In *M. atropos* the posterior extremity of the sternum at the ambitus is much narrower than in *M. clotho*. In *M. clotho* the anal system is cut out of five interambulacral plates; in *M. atropos* from four only.

Station 2800. Lat. 8° 51′ N.; Long. 79° 31′ 30″ W. 7 fathoms. Bottom temperature, 77°. Gn. m.

Station 2801. Lat. 8° 38′ N.; Long. 79° 29′ 30″ W. 14 fathoms. Bottom temperature, 78°. Gn. m.

Both Stations in the Bay of Panama (Voyage of the "Albatross" from New York to San Francisco, 1887–1888).

Bathymetrical range, 7–14 fathoms. Temperature range, 78°–77°.

[1] "Hassler" Echini, Pl. IV, figs. 4–8.
[2] Revision of the Echini, Pl. XXIII, figs. 3, 5.

BATHYMETRICAL AND GEOGRAPHICAL RANGE OF THE PANAMIC AND WEST INDIAN ECHINID FAUNÆ.

In 1895 Koehler[1] called attention to the small number of new and striking forms of Echini collected by the more recent deep-sea expeditions as compared to the many new types collected by the "Challenger" and the "Blake." The material of the "Travailleur" and "Talisman" has not as yet been published, but the number of species is known to be small, and perhaps the limited field explored by the French expeditions may account for this dearth. The same is true of the "Valdivia" Expedition in the Indian Ocean and the Antarctic expedition of the "Belgica." The "Siboga" expedition, however, which explored a region with one of the richest Echinid faunæ, collected no less than thirty-one new species of Echini, forming quite a percentage of the known species, of which M. de Meijere says twenty-four are deep-sea species. The most interesting species are four allied to such genera as Paleopneustes, Linopneustes, and Amphipneustes, one of the Pourtalesiæ, and one of the Ananchytidæ allied to Urechinus. We can hardly call twenty-four of them deep-sea species, as no species has been obtained at a greater depth than 1000 fathoms, and only thirteen species below a depth of 500 fathoms. Still the range of many of the genera collected by the "Siboga" has been shown to vary between much shallower depths than was supposed to be the case. From the physical conditions of the region explored it was natural that the characteristic Echini collected should belong to the continental slope.

The "Albatross" expedition of 1891, trawling along and beyond a continental range, but in deeper water than the "Siboga," collected in the limited area explored a large number of deep-sea types, no less than twenty-five species, — six species within the 400-fathom line; one species within the 700-fathom line; two species within the 1000-fathom line; two species within the 1200-fathom line; the other fourteen within the 1900-fathom line.

No collections of Echini were made in shallow waters, except on the reef at Panama Harbor, where a few specimens of *Arbacia stellata* and of *Cidaris Thouarsii* were obtained.

In a chapter on the Origin of the West Indian Echinid Fauna[2] I have

[1] Note prél. sur les Échinides recueillis pendant les Campagnes de l'Hirondelle. Bull. Soc. Zool. de France, 1895, p. 22.

[2] "Blake" Echini, p. 79.

given my views of the effects of oceanic currents on the distribution of Echini.

As regards the distribution of Echini in the Pacific, we have at the present day a condition of things very similar to that which must have prevailed in the Atlantic when the species of Echini living in the Crag and in the Maltese beds had their representatives in the West Indies; having, as has been suggested by Gregory, found their way from the Mediterranean along the shores of an ancient continent. Some of the species living on the west coast of Central America have a very extended geographical distribution in the Pacific, and yet no one claims that this great range has been brought about by their migration along the shores of a continent or continental islands existing between Panama and the Sandwich Islands or the Marquesas.

The great equatorial current gives us a cause fully sufficient to effect such a wide distribution, and that in a comparatively short time. While undoubtedly many of the species of Echini have no pelagic plutei, and are so to speak viviparous, or carry their young for a considerable period, yet we should remember that young Echini, even after they have assumed the characters of the adult, are capable of floating and of being transported long distances by currents. It is not an uncommon thing to find the young of Arbacia, of Strongylocentrotus, and of Echinarachnius floating about on our coasts, and they are not unfrequently caught in the surface tow-net. The same holds good for many species of Starfishes and of Ophiurans, as well as of Holothurians. In Florida I have caught in the same way the young of Cidaris, of Hipponoë, of Toxopneustes, and of many species of Starfishes and Ophiurans, during the period in which they still have the huge embryonic tentacles characteristic of their younger stages, when the ambulacral feet are entirely out of proportion in size to the rest of the test, and the young thus possess a great floating capacity when their suckers are expanded.

They retain these suckers for a considerable period of time, during which they can be transported very great distances. There is no other explanation needed to account for the identity of the littoral marine fauna of the Bermudas and the West Indies. The young and embryos of the Echinoderms and Polyps of the West Indies have been carried fully six hundred miles northward by the Gulf Stream at a rate of from one to three miles a day, and have finally settled in the Bermudas.

We can well imagine an equatorial current during Miocene and Eocene periods taking the young of the Echini flourishing in the Crag, and in the Mediterranean, and in the southern extension of that fauna perhaps as far as the Cape Verde Islands, and bringing them to the shores of northern South America or into the Caribean Sea. That stretch is but little longer than the stretch which we know to be annually traversed by Acalephs, Pteropods, Fishes, and Annelids along the course of the Gulf Stream from the Straits of Florida to Narragansett Bay, and to the southern shores of Cape Cod and the adjacent islands.

In discussing the relations of the West Indian and Mediterranean Echinoid faunas Gregory maintains that a shallow water connection is essential. There are a number of species of recent Echini which are common to the Mediterranean and West Indies, and which have not worked their way from one area to the other round the northern shallow water connection of the present day or those of a mid-atlantic land of a former period. They are found in deep water, have a wide geographical distribution, and, though some of them have pelagic plutei, others have not, and are viviparous. While the "Challenger," as is stated by Gregory,[1] did not collect any plutei, yet there have been many Echinid and Actinid plutei collected by other expeditions at a great distance from land.

As regards the statement that Temnechinus was "probably viviparous," we know nothing on the subject, and there is no proof that either *S. Parkinsoni* or *S. Scillæ* were viviparous. The number of recent Echini which are known to be viviparous is not "many." There are only two Cidaridæ, Hypsechinus, Anochanus, and Abatus.[2] Ludwig enumerates as viviparous thirteen Holothurians, five Echinoidea, twelve Ophiurans, seventeen Starfishes, and one Crinoid, — certainly not a large percentage of viviparous Echinoderms.

The migration of Echinoderms is not limited to the range of their plutei. Young Echini, Starfishes, Holothurians, and Ophiurans are to be met with floating on the surface at great distances from shore, so that the young of viviparous Echinoderms play an important part in extending their geographical range.

The existence of a continent or of intervening islands does not seem to me necessary to explain the similarity of the Echinid fauna of former times

[1] Loc. cit. p. 106.

[2] Ludwig, H., Zool. Jahrb. 1904, Suppl., VII, p. 690.

on both sides of the Atlantic or Pacific. The causes now at work appear sufficient to explain their relationship, when we take into account what is known of the efficient transporting agency of equatorial or other oceanic currents for the pluteus or the young stages of Echini during a considerable period of their post-embryonic life. We should also remember that, even with our imperfect knowledge of the bathymetrical range of Echini, the range in depth of many genera is known to be very great, as will be seen from an examination of the lists given in the "Challenger" Report and from the depths obtained by this Expedition. Among them I may mention those having a wide geographical distribution as well as a great bathymetrical range.[1] This will serve to show the extent to which many species can slowly migrate upon the bottom, even at a very considerable distance from land or continental or insular slopes, when living in the track of a great equatorial current which brings them a constant and abundant supply of food.

Doederlein[2] has also called attention to the extensive geographical distribution of many species of Echini in the Indo-Pacific realm,[3] — a huge realm extending from the Red Sea to the Sandwich Islands and from the Paumotus to Mozambique; so that it is natural to expect to find local varieties due to the limited migration of many of the species, in spite of the extensive migration of others during their pluteus existence. He enumerates the Red Sea, Western India with the east coast of Africa, Mauritius and the Seychelles, the Indo-Malay district from New Guinea to Ceylon, and the east coast of Australia as four somewhat independent realms of the great

[1] Genera.	Range in fathoms.	Genera.	Range in fathoms.
Dorocidaris	874	Fibularia	950
Porocidaris	1444	Pourtalesia	2550
Centrocidaris	1975	Homolampas	1600
Salenia	1850	Maretia	800
Podocidaris	1075	Echinocardium	2675
Coelopleurus	1323	Hemiaster	400
Aspidodiadema	1800	Brissopsis	2435
Dermatodiadema	800	Aërope	600
Phormosoma	1100	Cystechinus	900
Temnechinus[4]	600	Pilematechinus	1825
Trigonocidaris	460	Urechinus	600
Echinus	2100	Periaster	1800
Sphærechinus	400	Schizaster	1400
Hipponoe	451		

[2] Bericht über die von Herrn Professor Semon bei Amboina und Thursday Island gesammelten Echinoidea. Jena, 1902. Aus Semon, Zoologische Forschungsreisen in Australien und dem Malayischen Archipel.

[3] See A. Agassiz, Revision of the Echini, 1872, Plates A–G, pp. 205–212.

[4] Genocidaris.

central tropical Pacific realm, of which the Sandwich Islands, the Panamic, the Paumotus, Samoan, and the Fijian may be similar primary subdivisions.

None of the trawl hauls made by this Expedition were at a great distance from shore. Our stations, centring as they did at the Galapagos, always had that group as oceanic terminus. From Galera Point to the Galapagos (Chatham Island) the distance is about six hundred miles, and though our line from the Galapagos to Acapulco measured 1200 miles, the greatest distance normal from the shore was not more than 900 miles, and no point on our lines inside of the Galapagos was more than 300 miles from the shore. See Plate 110.

There was hardly a station at which a considerable amount of vegetable matter was not brought up in the trawl, derived either from the nearest part of the mainland or from Cocos Island or the Galapagos. This vegetable deposit dropping from the surface plainly shows the extent of the area which may thus be supplied with food by the prevailing currents. The distance of our stations from land was not great enough to have modified to any extent the abundance of the abyssal fauna; for although Echini were brought up in the trawl at only forty-one stations, there was not a single haul of the trawl made which did not bring up abundant animal life, so that representatives of either fishes, crustacea, mollusks, annelids, alcyonarians, or other groups were always represented, according to the nature of the bottom. On the track from Panama to Cocos Island and eastward toward Galera Point, then to Malpelo and to Panama, as well as from Galera Point to Chatham Island, Echini were found at nearly every station. We found them more abundant immediately off Mariato Point, around Cocos and Malpelo, Galera Point; but between Culpepper to off Acapulco they only occurred near Culpepper and about seventy miles off Acapulco in deep water at the foot of the continental slope. We found Echini again along our line from Cape Corrientes into the Gulf of California as far as Guaymas, where the distances from shore were inconsiderable.

As will be seen by the chart of our route, Pl. 110, the continental slope of the Panamic district is steep, the 1500 and 2000 fathom lines both running generally parallel to the coast line at a distance of from thirty to ninety miles, except where the 2000-fathom line bulges out to sea to enclose the Galapagos.

The dredgings made by the "Albatross" in 1891[1] were not sufficiently

[1] See List of Stations, p. 242.

numerous to give us any idea of the association of the deep-water species at any locality. The adjoining Table gives the range of the different species on the Panamic side of the Isthmus, as far as it can be given from the collections made by the "Albatross" in 1891.

BATHYMETRICAL RANGE OF THE PANAMIC SPECIES OF ECHINI.

Name.	Depth in fathoms	Name.	Depth in fathoms.
Moira clotho A. Ag.	7	Salenia miliaris A. Ag.	1175
Moira clotho A. Ag.	14	Phormosoma hispidum A. Ag.	1175
Centrocidaris Doederleini A. Ag.	52	Aërope fulva A. Ag.	1175
Dorocidaris panamensis A. Ag.	66	Salenia miliaris A. Ag.	1189
Dorocidaris panamensis A. Ag.	85	Pourtalesia Tanneri A. Ag.	1189
Dorocidaris panamensis A. Ag.	100	Phormosoma hispidum A. Ag.	1201
Dorocidaris panamensis A. Ag.	112	Dermatodiadema horridum A. Ag.	1201
Schizaster Townsendi A. Ag.	146	Phormosoma hispidum A. Ag.	1270
Toxobrissus pacificus A. Ag.	182	Phormosoma hispidum A. Ag.	1322
Porocidaris Cobosi A. Ag.	385	Dermatodiadema horridum A. Ag.	1322
Porocidaris Milleri A. Ag.	465	Phormosoma hispidum A. Ag.	1360
Brissopsis columbaris A. Ag.	511	Salenia miliaris A. Ag.	1360
Schizaster Townsendi A. Ag.	511	Dermatodiadema horridum A. Ag.	1360
Brissopsis columbaris A. Ag.	546	Phormosoma hispidum A. Ag.	1421
Schizaster Townsendi A. Ag.	628	Salenia miliaris A. Ag.	1471
Schizaster Townsendi A. Ag.	676	Aërope fulva A. Ag.	1471
Plexechinus cinctus A. Ag.	676	Echinocrepis setigera A. Ag.	1573
Schizaster Townsendi A. Ag.	680	Periaster tenuis A. Ag.	1573
Brissopsis columbaris A. Ag.	695	Dermatodiadema globulosum A. Ag.	1573
Schizaster Townsendi A. Ag.	772	Dermatodiadema horridum A. Ag.	1573
Toxobrissus pacificus A. Ag.	782	Aërope fulva A. Ag.	1573
Salenia miliaris A. Ag.	782	Porocidaris Milleri A. Ag.	1672
Salenia miliaris A. Ag.	885	Salenia miliaris A. Ag.	1672
Salenia miliaris A. Ag.	899	Pilematechinus Rathbuni A. Ag.	1672
Dermatodiadema horridum A. Ag.	902	Porocidaris Milleri A. Ag.	1740
Schizaster Townsendi A. Ag.	905	Echinocrepis setigera A. Ag.	1740
Dermatodiadema horridum A. Ag.	978	Periaster tenuis A. Ag.	1740
Homolampas hastata A. Ag.	978	Aërope fulva A. Ag.	1740
Phormosoma hispidum A. Ag.	995	Dermatodiadema globulosum A. Ag.	1772
Schizaster Townsendi A. Ag.	995	Dermatodiadema horridum A. Ag.	1772
Schizaster latifrons A. Ag.	995	Aërope fulva A. Ag.	1772
Pourtalesia Tanneri A. Ag.	995	Porocidaris Milleri A. Ag.	1772
Urechinus giganteus A. Ag.	995	Periaster tenuis A. Ag.	1772
Homolampas hastata A. Ag.	1010	Dialithocidaris gemmifera A. Ag.	1793
Phrissocystis aculeata A. Ag.	1067	Brissopsis columbaris A. Ag.	1793
Phormosoma hispidum A. Ag.	1132	Phormosoma panamense A. Ag.	1823
Homolampas hastata A. Ag.	1132	Pilematechinus Rathbuni A. Ag.	1823
Salenia miliaris A. Ag.	1132	Porocidaris Milleri A. Ag.	1879
Dermatodiadema horridum A. Ag.	1132	Echinocrepis setigera A. Ag.	1879
Dermatodiadema horridum A. Ag.	1175	Cystechinus Loveni A. Ag.	1879

At Station 3394 in 511 fathoms, we obtained in Panama Bay Brissopsis columbaris and Schizaster Townsendi.

At Station 3363 in 978 fathoms, N. E. of Cocos Island, we obtained Dermatodiadema horridum and Homolampas hastata.

At Station 3431 in 995 fathoms, Gulf of Panama, we dredged Phormosoma hispidum, Schizaster Townsendi, Pourtalesia Tanneri, Schizaster latifrons, Urechinus giganteus.

At Station 3376 in 1132 fathoms, south of Malpelo, we obtained Salenia miliaris, Homolampas hastata, Phormosoma hispidum, Dermatodiadema horridum.

At Station 3362 in 1175 fathoms, Mariato Point to Cocos Island, we obtained Salenia miliaris, Phormosoma hispidum, Dermatodiadema horridum, Aërope fulva.

At Station 3411 in 1189 fathoms, between Bindloe and Wenman Islands, we obtained Salenia miliaris and Pourtalesia Tanneri.

At Station 3375 in 1201 fathoms, south of Malpelo, and at Station 3400 in 1322 fathoms, Galera Point to Galapagos, we obtained Phormosoma hispidum and Dermatodiadema horridum.

At Station 3413 in 1360 fathoms, northwest of Culpepper Island, we obtained the same species, and in addition, Salenia miliaris.

At Station 3361 in 1471 fathoms, from Mariato Point to Cocos Island we obtained Salenia miliaris and Aërope fulva.

At Station 3398 in 1573 fathoms, off Galera Point, we obtained Dermatodiadema globulosum, D. horridum, Echinocrepis setigera, Periaster tenuis and Aërope fulva.

At Station 3360 in 1672 fathoms, southwest of Mariato Point, we obtained Porocidaris Milleri, Salenia miliaris and P. Rathbuni.

At Station 3399 in 1740 fathoms, off Galera Point, we obtained Porocidaris Milleri, Aërope fulva, Echinocrepis setigera and Periaster tenuis.

At Station 3381 in 1772 fathoms, off Galera Point, we obtained Dermatodiadema globulosum, D. horridum, Aërope fulva, Porocidaris Milleri and Periaster tenuis.

At Station 3382 in 1793 fathoms, off Point Mala, we obtained Dialithocidaris gemmifera and Brissopsis columbaris.

At Station 3415 in 1879 fathoms, off Acapulco, we obtained Porocidaris Milleri, Echinocrepis setigera and Cystechinus Loveni.

Out of forty-one stations at which Echini were collected, at twenty-five stations only one species was found, and at sixteen more than one: viz., at six stations, two species; at three stations, three species; at five stations, four species; at two stations, five species.

On the West Indian side Echini were collected at one hundred and seventy-eight stations. At ninety-eight stations only one species was found; at twenty-nine, two species; at twenty-four, three species; at seven, four species; at ten, five species; at four, six species; at five, seven; and at one station thirteen species. In the West Indies by far the greatest number of the hauls were made along the continental slope, and comparatively few in the abyssal region; while in the Panamic district comparatively few hauls were made along the continental slope, a larger proportion being made in the abyssal region. So that the comparisons here made will probably be somewhat modified after a more extended survey of the Panamic continental slope has been made.

The following lists taken at characteristic points will give an idea of the association of the species of Echini on the West Indian continental slope.

STATION 155, OFF MONTSERRAT, 88 FATHOMS.

Dorocidaris Bartletti.
D. papillata.
Genocidaris maculata.
Conolampas Sigsbei.
Agassizia excentrica.

STATION 269, OFF ST. VINCENT, 124 FATHOMS.

Coelopleurus floridanus.
Trigonocidaris albida.
Toxopneustes variegatus.
Clypeaster subdepressus.
Palæotropus Josephinæ.

OFF HAVANA, 250 FATHOMS.

Dorocidaris papillata.
Dorocidaris Blakei.
Salenia Pattersoni.
Podocidaris scutata.
Coelopleurus floridanus.
Trigonocidaris albida.
Echinocyamus pusillus.
Conolampas Sigsbei.
Pourtalesia miranda.
Palæotropus Josephinæ.
Paleopneustes cristatus.
Rhynobrissus micrasteroides.
Brissopsis lyrifera.
Agassizia scrobiculata.

STATION 157, OFF MONTSERRAT, 120 FATHOMS.

Dorocidaris Bartletti.
D. papillata.
Salenia Pattersoni.
Genocidaris maculata.
Paleopneustes cristatus.
Paleopneustes hystrix.

STATION 274, OFF BARBADOS, 209 FATHOMS.

Asthenosoma hystrix.
Echinocyamus pusillus.
Linopneustes longispinus.
Macropneustes spatangoides.
Agassizia excentrica.
Schizaster orbignyanus.

STATION 300, OFF BARBADOS, 82 FATHOMS.

Coelopleurus floridanus.
Echinolampas depressa.
Palæotropus Josephinæ.
Paleopneustes cristatus.

The stations occupied off Havana, varying in depth from 120 to 400 fathoms off Morro Light, were all wonderfully rich in species not only of Echini, but of Corals and Ophiurans.

In my Report on the "Blake" Echini[1] I called attention to the interesting comparisons to be made between the abyssal Echinid fauna of the West Indian and of the Panamic regions when the material became available. The Echini collected by the "Albatross" Expedition of 1891[2] in the Panamic region comprise twenty-four species, only three of which belong to the continental slopes; the others are deep-sea types, such as Porocidaris, Salenia, a new abyssal genus of Arbaciadæ, Dermatodiadema, Phormosoma, three Pourtalesiæ: Pourtalesia, Plexechinus, and Echinocrepis; four species of Urechinidæ belonging to Urechinus, Cystechinus, Pilematechinus; two Paleopneustidæ: Phrissocystis, and Homolampas; and among the Spatanginæ and Brissina, Aërope, Schizaster, Periaster, Brissopsis, and Toxobrissus, all of which have abyssal representatives among the West Indian Echinoidea. The discovery of these species only increases the great similarity already known to exist between the littoral and continental species of the two sides of the Isthmus of Panama.

I have given in the "Blake" Echini[3] a Table showing the West Indian species of Echini which have representatives in the Panamic area. This Table is here reproduced with the addition of the bathymetrical range of both the West Indian and Panamic species as far as it is known. I have not repeated the list of the nearest representatives in post-Cretaceous and Cretaceous times, as but few additions have been made to the fossil species of American Echini. The principal additions are found in Clark's Revision of the Cretaceous Echinoidea of North America.[4] They consist in additions to my list of two species of Cretaceous Cidaris, of three species of Salenia from the Cretaceous of Texas, of a species of Goniopygus, of Cyphosoma, and of Psammechinus, also from Texas, of two species of Scutella and Echinobrissus from Alabama and Texas, of three species of Cassidulus, of a Periaster, of additional species of Hemiaster, and a Linthia. With the exception of Salenia, Goniopygus, Periaster, and Linthia, no genera not included in my list have been added to the Table. Other interesting additions have also been made by Professor Gregory, who has described two species of fossil Echini

[1] Mem. M. C. Z. 1883, X, No. 1, p. 82.
[2] Bull. M. C. Z. 1898, XXXII, No. 5, p. 71.
[3] "Blake" Echini, p. 85.
[4] W. B. Clark, Johns Hopkins University Circulars, No. 86, 1891.

from the Oceanic Series of Barbados, *Archeopneustes abruptus*[1] and *Cystechinus crassus*.[2]

From the list of the species found in the East Indian Archipelago, given by M. de Meijere, and by the "Valdivia" in the Indian Ocean, we have collated the genera or their representatives which had not thus far been noticed to extend over the Indo-Pacific realm. From the Echinoidea of the "Valdivia" and "Siboga" Expeditions and other sources we may add the following genera which have not been recorded before as extending from the Panamic to the East Indian realm: Phormosoma, Salenia, Aspidodiadema, Dermatodiadema, Neolampas, Homolampas, Phrissocystis and Moira.

The number of Clypeastroids collected from shallow water by the "Siboga" Expedition is remarkable. With the exception of the species of Echinocyamus and Fibularia, the first of which extends to 1886 metres and the last to 522 metres, the Clypeastroids range from littoral to 350 metres, the majority to less than 200 metres.

I have before called attention to the absence of Clypeasteridæ in the deeper waters of the West Indian area and off the southern coasts of the United States, where Clypeastroids are common littoral forms. The same is the case in the Gulf of California and off the Pacific Mexican and Central American coasts.

The "Blake" dredged Echinocyamus to a depth of 850 fathoms, and the "Challenger" obtained Fibularia to a depth of 950 fathoms. This agrees with the deeper range of these genera in the East India Islands.

[1] Q. J. Geol. Soc. London, 1892, Vol. XLVIII, p. 163.
[2] Id. 1889, Vol. XLV, p. 640.

GEOGRAPHICAL AND BATHYMETRICAL RANGE OF THE CARIBEAN AND PANAMIC ECHINI.

(Caribean) West Indian Echini.	Bathymetrical Range, Depths in Fathoms.	Principal Localities.	Panamic Echini, West Coast of Central America.	Bathymetrical Range, Depths in Fathoms.	Principal Localities.
DESMOSTICHA Haeckel.					
CIDARIDÆ Muller.					
Goniocidaridæ Haeckel.					
Cidaris Klein.		Tropical Atlantic, Indo-Pacific, Red Sea.			
C. tribuloides Bl.	—250	So. Carolina, Brazil, Cape Palmas.	C. Thouarsii Val.		Panama, Gulf of California, Galapagos.
Dorocidaris A. Ag.		Atlantic, Indo-Pacific.	C. Galapagensis Doed.		Galapagos
D. Bartletti A. Ag.	76–398	West Indies.			
D. Blakei A. Ag.	158–450	West Indies.			
D. papillata A. Ag.	—874	Norway, Mediterranean, Canaries, Florida, St. Paul Rocks, West Indies, La Plata, Philippines.	D. panamensis A. Ag.	66–112	Panamic. (Includes the district explored by the "Albatross" in 1891, see Pl. 110.)
Porocidaris Des.		Tropical and temperate Atlantic and Pacific.			
P. Sharreri A. Ag.	122–356	West Indies.	P. Cobosi A. Ag.	385	Panamic.
			P. Milleri A. Ag.	465–1879	Panamic.
			Centrocidaris A. Ag.		Indian Ocean, Patagonia, Australia, Tasmania, Antarctic.
			C. Doederleini A. Ag.	52	Panamic.
SALENIDÆ Agass.					
Salenia Gray.		Atlantic, Tropical Pacific, East India Isds.			
S. Goesiana Lov.	180	West Indies.			
S. Pattersoni A. Ag.	51–314	West Indies.	S. miliaris A. Ag.	782–1672	Panamic.
S. varispina A. Ag	288–1200	West Indies, Brazil, Ascension, Canaries.			
ARBACIADÆ Gray.					
Arbacia Gray.		Atlantic, Pacific, East India Isds.?			
A. punctulata Gray.	—125	Long Island Sound to Yucatan.	A. stellata Gray.		Panama, Gulf of California.
A. pustulosa Gray.		Mediterranean, Liberia, Brazil.			
Podocidaris A. Ag.		Philippines, New Guinea, Straits of Florida, East India Isds., Caribean Isds.			
P. sculpta A. Ag.	250–400	West Indies.			(P. sp. East India Isds., Indian Ocean.)
P. scutata A. Ag.	580	West Indies.			
Coelopleurus Agass.		Tropical Atlantic, Indian Ocean, East India Isds.			
C. floridanus A. Ag.	56–1323	West Indies.			C. Maillardi A. Ag., Indian Ocean, East India Isds.

DIADEMATIDÆ Peters.			**Dialithocidaris** A. Ag.		
			D. gemmifera A. Ag.	1793	Panamic.
Diadema Schynv.		Tropical Atlantic, Indo-Pacific.			
D. setosum Gray.	—115	West Indies, Cape St. Lucas? Cape Verde Isds., Indian Ocean, Pacific, East India Isds	D. mexicanum A. Ag.		Acapulco, Cape St. Lucas, Galap.
			Astropyga Gray.		East India Isds., Indo-Pacific.
			A. pulvinata Agass.		Panama, Sandwich Isds.
Centrostephanus Peters.		West Coast Central Am., Mediterranean, Australia.			
C. longispinus Pet.		Palermo, Canary Isds.	C. coronatus A. Ag.		Cape St. Lucas.
Aspidodiadematidæ Duncan.					
Aspidodiadema A. Ag.		East and West Coast S. Am., Indian Ocean, Tropical Atlantic and Pacific, East India Isds.			
A. Jacobyi A. Ag.	95–297	West Indies.			
Dermatodiadema A. Ag.		West Indies, Philippines, East India Isds., Kermadec, No. Brazil.			D. sp., East India Isds.
D. Antillarum A. Ag.	451–1568	West Indies.			
			D. globulosum A. Ag.	1573–1772	Panamic.
D. microtuberculatum A. Ag.	356–2225	Macio, No. Brazil, Chile.	D. horridum A. Ag.	902–1772	Panamic.
D. tonsum A. Ag.	100–1700	Macio, Philippines, Kermadec.			
ECHINOTHURIDÆ Wyv. Thom.					
Asthenosoma Grube.		No. Atlantic, Tropical Pacific. East India Isds.	No species of Asthenosoma has as yet been dredged in the Panamic District.		
A. hystrix A. Ag.	103–373	Florida, West Indies, Eastern No. Atlantic.			(A. sp. East India Isds.)
Phormosoma Wyv. Thom.		Atlantic, Pacific, Indian Ocean.			
P. placenta Wyv. Thom.	120–1242	West Indies, N. E. Atlantic, E. coast U. S.	P. hispidum A. Ag.	995–1421	Panamic.
P. uranus Wyv. Thom.	399–1221	W. Indies, Atlantic coast, So. and Middle States, N. E. Atlantic.	P. panamense A. Ag.	1825	Panamic.
ECHINOMETRADÆ Gray.					
Echinometra Rond (Breyn.)		Tropical Atlantic, Indo-Pacific.			
E. subangularis Desml.	—250	Senegal, Ascension, West Indies, Brazil.	E. Van Brunti A. Ag.		Peru, Panama, Gulf Califa.
E. viridis A. Ag.	—250	West Indies.			
Strongylocentrotus Br.					
S. Drobachiensis A. Ag.	—78	N. E., N. W. Atlantic and E. coast of U. S., North Pacific.	S. gibbosus A. Ag.	—45	Galapagos, Chile.
S. Gaimardi A. Ag.		Brazil.	S. franciscanus A. Ag.		San Diego.
			S. mexicanus A. Ag.		Gulf of California.
			S. tuberculatus A. Ag.		Galapagos? Japan, Australia.

GEOGRAPHICAL AND BATHYMETRICAL RANGE OF THE CARIBEAN AND PANAMIC ECHINI. — *Continued.*

(Caribean) West Indian Echini.	Bathymetrical Range, Depths in Fathoms.	Principal Localities.	Panamic Echini, West Coast of Central America.	Bathymetrical Range, Depths in Fathoms.	Principal Localities.
ECHINIDÆ Agass.					
Temnopleuridæ Des.					
Genocidaris A. Ag.		Tropical Atlantic, East India Isds., Mediterranean.			
G. maculata A. Ag.	30–229	Azores, Florida, West Indies, Josephine Bk.			(G. sp. East India Isds.)
Trigonocidaris A. Ag.		East Atlantic, East India Isds. West Indies.			(T. albida A. Ag. East India Isds.)
T. albida A. Ag.	40–450	Josephine Bk., Florida, West Indies.			
Triplechinidæ A. Ag.					Two species of Prionechinus occur in the East India Isds.
Hemipedina Wright.		Tropical W. Atlantic, East India Isds.			
H. cubensis A. Ag.	138–270	Straits of Florida.	H. indica de Meij.		East India Isds.
			Phymosoma Haime.		Japan.
			P. crenulare A. Ag.		Japan.
Echinus Rond. (Linn.)		Atlantic, Indo-Pacific, N. E. Atlantic, Medit., W. Indies, Halifax to N. Y., Kermadec Isds.?			
E. elegans Dub. & Kor.	80–1350	N. E. Atlantic, Medit., Halifax to N. Y., Tristan d'Acunha, Papua? W. Indies?	Thus far no species of Echinus has been found in the Panamic District.		
E. gracilis A. Ag.	93–200	Straits of Florida, West Indies, No. E. Atlantic.			
Toxopneustes Agass.		Tropical Pacific and Indian Ocean, East India Isds., Tropical W. Atlantic.			
T. variegatus A. Ag.	—300	Bermudas, So. Carolina, Florida, West Indies, Brazil.	T. semituberculatus Agass		Galapagos, W. Coast Cent. Am., Gulf Califa.
			T. pileolus Agass.	—10	Panama, Fiji, New Caledonia, East India Isds.
Hipponoë Gray.		Tropical Western Atlantic, Indo-Pacific.			
H. esculenta A. Ag.	—451	Bermudas, Florida, West Indies, Surinam.	H. depressa A. Ag.		Gulf of California, Galapagos.

CLYPEASTRIDÆ Agass.			According to the "Siboga" Ex. the East India Islands are noted for the number of species of Laganidæ, Scutellidæ, and Fibularidæ, all genera which do not exist in the Panamic District.		
ECHINOCONIDÆ D'Orb.					
Pygastrides Lov.		W. Indies.			
P. relictus Lov.	180	W. Indies.			
EUCLYPEASTRIDÆ Haeck.					
Fibularina Gray.					
Echinocyamus Van Phels.		North Atlantic, East India Isds.			
E. pusillus Gray.	—805	No. Atlantic, Medit., Azores, Florida, West Indies.			Three species of Echinocyamus, occur in the East Indian Archipelago; none in the Panamic District.
Echinanthidæ A. Ag.					
Clypeaster Lamk.		Tropical Atlantic, Indo-Pacific.			
C. latissimus A. Ag.	88–248	West Indies, No. Brazil.			
C. Ravenellii A. Ag.	—84	So. Carolina, W. Indies.	C. rotundus A. Ag.		Panama, San Diego, Galapagos.
C. subdepressus A. Ag.	—1952	W. Coast of Africa, So. Carolina, Florida, Brazil, W. Indies.			
Echinanthus Breyn.		Tropical Atlantic and Pacific, East India Isds.			
E. rosaceus Gray.	—118	West Indies, Florida, So. Carolina.	E. testidunarius Gray.	—120	Gulf of Califa., Sandwich Isds., Japan, Australia.
Scutellidæ Agass.					
Mellita Klein.		American Tropical Atlantic and Pacific.			
M. sexporis A. Ag.	—270	So. Carolina, Bermudas, West Indies, Brazil.	M. pacifica Verr.		Peru.
M. testudinata A. Ag.	—7	Nantucket — Brazil.	M. longifissa Mich.		Panama, Gulf of Califa.
Encope Agass.		American Tropical Atlantic and Pacific.	M. Stokesii A. Ag.		Panama, Galap.
E. emarginata Agass.	—7	So. Ca., Florida, Yucatan, West Indies, Brazil.	E. californica Verr.		Gulf of California.
E. Michelini Agass.	—14	Yucatan, Florida.	E. micropora Agass.		Gulf of California, Galapagos.
			E. grandis Agass.		Gulf of Califa., Panama.
PETALOSTICHA Haeckel.					
CASSIDULIDÆ Agass.					
Echinoneidæ Agass.					
Echinonëus Van Phels.		Tropical W. Atlantic and Indo-Pacific, East India Isds.			
E. semilunaris Lamk.	—80	West Indies.			
Nucleolidæ Agass.					
Neolampas A. Ag.		E. India Isds., Florida, West Indies, N. E. Atlantic, East India Isds.			(E. cyclostomus South Sea Islands, East Indian Archipelago).
N. rostellata A. Ag.	100–690	Florida, West Indies, N. E. Atlantic.			(N. sp. East India Isds.)
Echinolampas Gray.		Tropical Atlantic, Indo-Pacific, East India Isds.			
E. depressa Gray.	—160	Straits of Florida. West Indies			

GEOGRAPHICAL AND BATHYMETRICAL RANGE OF THE CARIBEAN AND PANAMIC ECHINI.— *Continued.*

(Caribean) West Indian Echini.	Bathymetrical Range, Depths in Fathoms.	Principal Localities.	Panamic Echini, West Coast of Central America.	Bathymetrical Range, Depths in Fathoms.	Principal Localities.
Conolampas A. Ag.		Tropical W. Atlantic.			
C. Sigsbei A. Ag.	76–450	Yucatan, Straits of Florida.			
Rhynchopygus D'Orb.		Tropical American Atlantic and Pacific.			
R. caribæarum Lutk.	—106	West Indies.	R. pacificus A. Ag.		Galapagos, Panama, Gulf of Califa.
SPATANGIDÆ Agass.					
Pourtalesiæ A. Ag.					
Pourtalesia A. Ag.		Atlantic, Indo-Pacific, East India Isds., Antarctic, Arctic.			
P. miranda A. Ag.	242–1215	Shetland Channel, Straits of Fla., W. Indies.	P. Tanneri A. Ag.	995–1189	Panamic.
			P. carinata A. Ag.	2225	Juan Fernandez — Chile.
			P. ceratopyga A. Ag.	1950–2225	Juan Fernandez — Chile. (Sternopatagus Sibogæ de Meij is found in the East Indian Archipelago, 2050 metres.)
Spatagocystis A. Ag.		So. Pacific, Caribean.			
S. sp. A. Ag.	576	West Indies.			
			Echinocrepis A. Ag.		South Pacific, Panamic.
			E. setigera A. Ag.	1573–1879	Panamic.
ANANCHYTIDÆ Alb. Gras.			**Plexechinus** A. Ag.		
Urechinidæ Lamb. (emend. A. Ag.)			P. cinctus A. Ag.	676	Panamic.
Urechinus A. Ag.		Antarctic, So. Indo-Pacific, So. Pacific, W. Indies, S. W. Coast of S. Am.			
U. Naresianus A. Ag.	422–1800	Marion to Kerguelen, to Australia, Cape Gd. Hope, Juan Fernandez, Straits of Magellan. W. Indies.	U. giganteus A. Ag.	995	Panamic.
Cystechinus A. Ag.		So. West Atlantic, W. Indies, Philippines, East India Isds.			
C. clypeatus A. Ag.	1050–1915	Philippines, W. Indies, Tristan d'Acunha, Bahia, Buenos Ayres.	C. Loveni A. Ag.	1879	Panamic.
			C. Wyvillii A. Ag.	2160	Juan Fernandez — Chile.
			Pilematechinus A. Ag.		So. Pacific, Juan Fernandez — Chile, Antarctic.
			P. Rathbuni A. Ag.	1672–1823	Panamic.
			P. vesica A. Ag.	2225	Juan Fernandez — Chile.

Paleopneustidæ					
Palæobrissus A. Ag		West Indies.			
P. Hilgardi A. Ag.	82–185	West Indies.			
Palæotropus Lov.		East India Isds., Tropical Atlantic, W. Indies.			
P. Josephinæ Lov.	82–250	West Indies, Azores.			(P. sp. East India Isds.)
P. Thomsoni A. Ag.	233	Atlantic Coast of U. S., S. C.			
Homolampas A. Ag.		Tropical Atlantic and Pacific. East India Isds.			
H. fragilis A. Ag.	300–1920	Florida, Brazil, Josephine Bk.	H. hastata A. Ag.	978–1132	Panamic.
Paleopneustes A. Ag.		Tropical W. Atlantic. East India Isds.			
P. cristatus A. Ag.	56–450	Straits of Florida, W. Indies.			(P. sp. Indian Ocean)
P. hystrix A. Ag.	21–208	Caribean Isds.			
Linopneustes A. Ag.		Tropical Atlantic and Pacific. E. India Isds.			(L. sp. East India Isds.)
			Phrissocystis A. Ag.		Panamic. East India Isds., W. Indies.
L. longispinus A. Ag.	38–298	W. Indies.			
			P. aculeata A. Ag	1067	Panamic.
SPATANGINA Gray.					
Macropneustes Agass.		Tertiary.			
M. spatangoides A. Ag.	82–373	West Indies	**Nacospatangus** A. Ag.		
Echinocardium Gray.		East Indies, China, Japan, Australia, Atlantic.	N. gracilis A. Ag.	65	Juan Fernandez.
					E. australe Gray.
E. cordatum Gray.	—85	Norway, Mediterranean. N. C. to Brazil.			East India Isds., Japan, China Sea, Australia, Mozambique —2675.
E. flavescens A. Ag.	—150	Norway, Cape Good Hope, South Carolina, Florida.			
E. pennatifidum Norm.	79–121	Shetland Isds., Straits of Fla.			
BRISSINA Gray.					
Hemiaster Des.		Southern Ocean, So. Pacific and Atlantic. Tropical Atlantic.	**Abatus** Trosch.		Strs. Magellan, La Plata.
H. expergitus Lov.	164–185	West Indies, East No. Atlantic.	A. Cavernosus Trosch.		Patagonia, Chile, Kerguelen. Heard Isds.
H. Mentzi A. Ag.	170–626	West Indies.			
H. zonatus A. Ag.	620–750	Bahia, No. Brazil, Canary Isds.			(H. Gibbosus A. Ag., East India Isds.)
Rhynobrissus A. Ag.		Pacific, China, West Indies.			
R. micrasteroides A. Ag.	175–233	Caribean Isds	R. hemiasteroides A. Ag.	20	Tahiti
			Lovenia Des.		East India Isds., Indo-Pacific, Japan. Gulf of Califa., West Coast No. and So. Am.
			L. cordiformis Lutk.		Guyaquil, Gulf of California
Brissopsis Agass.		Atlantic, Pacific, East India Isds.			
B. lyrifera Agass.	—2435	Norway, Greenland, Mediterranean, Cape Good Hope, West Indies.	B. columbaris A. Ag.	511–1793	Panamic.

GEOGRAPHICAL AND BATHYMETRICAL RANGE OF THE CARIBEAN AND PANAMIC ECHINI. — *Continued.*

(Caribean) West Indian Echini	Bathymetrical Range, Depths in Fathoms	Principal Localities.	Panamic Echini West Coast of Central America	Bathymetrical Range, Depths in Fathoms	Principal Localities.
			Toxobrissus Des.		
			T. pacificus A. Ag	182	Panamic.
Aërope Wyv. Thom.		No. Atlantic, E. coast of U. S. Arafura Sea, Panama, E. India Isds.			
A. rostrata Wyv. Thom.	800–1750	Arafura Sea, Bay of Biscay, Davis Straits, Martha's Vineyard, E. India Isds.	A. fulva A. Ag.	1175–1740	Panamic.
Aceste Wyv. Thom.		Central Pacific, East India Isds., So. Atlantic, Canary Isds.			
A. bellidifera Wyv. Thom.	620–2600	Sandwich Isds, Low Archipelago, Buenos Ayres to Tristan d' Acunha, Canary Isds., East India Isds.			
Agassizia Val.		Tropical American Atlantic and Pacific.			
A. excentrica A. Ag.	73–391	W. Indies.	A. scrobiculata Val.		Peru, Panama, Gulf of Califa.
Brissus Kl.		Tropical Atlantic, Indo-Pacific.			
B. Damesi A. Ag.	120–450	No. Brazil, Azores.	B. obesus Verr.		Panama, Gulf of California.
B. unicolor Kl.	—7	West Indies, Cape Verde Isds., Mediterranean.			
Metalia Gray.		Tropical Pacific, Indo-Pacific, West Indies.			
M. pectoralis A. Ag.	—156	West Indies, Brazil.	M. maculosa A. Ag.		Panama, Gulf of Califa., Samoa, Sandwich Isds., Australia, Mauritius, Arafura Sea, East India Isds.
Meoma Gray.		American tropical Atlantic and Pacific.			
M. ventricosa Lütk.	—242	West Indies.	M. grandis Gray.	—28	Acapulco, Gulf of California.
Schizaster Agass.		Atlantic, Indo-Pacific, Sub-Antarctic.			
S. fragilis Agass.	71–955	Norway, E. coast of U. S., West Indies, Cape Good Hope.	S. latifrons A. Ag.	995	Panamic.
S. Orbignyanus A. Ag.	92–1507	West Indies, Martha's Vineyard.	S. Townsendi A. Ag.	511–995	Panamic.
Periaster D'Orb.		West Indies, Panamic, Arafura Sea			
P. limicola A. Ag.	28–118	West Indies, Arafura Sea.	P. tenuis A. Ag.	1573–1772	Panamic.
Moira A. Ag		American tropical Atlantic and Pacific, Gulf of California.			
M. atropos A. Ag.	—80	North Carolina, West Indies Straits of Florida.	M. clotho A. Ag.	7–14	Gulf of Califa., Bay of Panama.

An analysis of the representative species at different depths on both sides of the Isthmus of Panama shows a surprising similarity. Since the publication of the "Blake" lists.[1] the number of representative species has been markedly increased by the discoveries of the "Albatross" in 1891. The littoral species with a range of something beyond 100 fathoms, and some of the species having an abnormal range extend into the Continental slope or even beyond to the abyssal region; these number no less than thirty-four species on the Caribean side. With the exception of Cidaris they belong to tertiary genera of comparatively recent periods. On the Panama side they are represented by twenty-seven species. Of these, two are genera (Lovenia and Astropyga) not represented on the West Indian side; while of the thirty-four West Indian species Echinus, Echinocyamus, Pygastrides, Echinonëus, Echinolampas, and Echinocardium are not found on the Pacific side. The other genera are represented on both sides by closely allied species, which may be regarded as strictly representative species.

Many of the West Indian littoral genera have a wide geographical distribution both in the Atlantic and Pacific. Some of the genera are strictly American, or on the Pacific side of the Isthmus there are some American and a few Indo-Pacific genera. They are: Cidaris, Dorocidaris, Diadema, Echinometra, Echinus, Strongylocentrotus, Echinocardium, Brissopsis, Brissus and Schizaster.

The following genera are West Indian and Atlantic and have not been found on the Panama side, but occur in the East Indian Archipelago and Western Pacific: Echinus, Echinocyamus, Echinonëus, Echinolampas.

The following are West Indian. Panamic, and Indo-Pacific: Toxopneustes, Hipponoë, Echinanthus, Metalia, Periaster.

The following genera occur on both sides of the Isthmus, and are eminently American: Mellita, Encope, Agassizia, Moira. Arbacia is American and Atlantic; Astropyga is Panamic and Indo-Pacific.

When we come to the continental slope, the dredgings of the "Blake" were far more numerous in that region than those of the "Albatross," no less than 316 Stations having been occupied by the "Blake" in the continental area of the West Indies, which is also one of the richest regions of its kind, not only for Echini but also for all classes of invertebrates.

On the West Indian side there are thirty-three species of Echini representing twenty-four genera. On the Panamic side we have only nine

[1] "Blake" Echini, p. 84.

species belonging to eight genera, all of which are represented in the West Indies. Of the twenty-four West Indian continental genera thirteen are not found in the Panamic district, though of these thirteen no less than eleven are found on the continental slope of the East Indian Archipelago. Of the Panamic genera only three are not found in the West Indies.

When we come to the abyssal realm in the West Indian area there are six species belonging to as many genera; on the Panamic side there are 13 species representing ten genera; of these only five are also found in the abyssal West Indian realm, though two of the Panamic abyssal genera occur on the continental West Indian slope.

It must be noticed that two of the genera occurring in the continental slope of the West Indies are, as thus far known, abyssal genera in the Panamic realm. They are Dermatodiadema and Phormosoma.

Such a close correspondence in the distribution of the species on the two sides of the Isthmus of Panama would seem to indicate, between the West Indian and Panamic realms, a very free communication in comparatively recent geological times down to a depth of about 100 fathoms, the representative species on the two sides of the Isthmus belonging to genera with a limited bathymetrical range.

The species of the continental slope belong to genera with a more extended bathymetrical range, many dating back to the Cretaceous and Jurassic periods. Of the twenty-three West Indian genera only six, Dorocidaris (Centrocidaris), Porocidaris, Salenia, Linopneustes, Brissus, and Periaster, occur also on the Panamic side, though two additional genera are abyssal Panamic while they are continental West Indian: Dermatodiadema, Phormosoma.

The number of West Indian continental genera also found in the East Indian Archipelago is very striking. They are Porocidaris, Coelopleurus, Asthenosoma, Genocidaris, Trigonocidaris, Hemipedina, Palæotropus, Linopneustes, Neolampas, Hemiaster, Rhynobrissus.

Nacospatangus and Plexechinus are Panamic.

The nine continental genera indicate a connection across the Isthmus of at least 250 fathoms in depth.

When we take the abyssal genera, the allies of which date back to the Jurassic period, there are five of the six West Indian abyssal genera, Pourtalesia, Urechinus, Cystechinus, Homolampas, and Aërope, which are also found on the Panama side, the sixth, Spatagocystis, being an East Indian Archipelago and Western Pacific genus.

On the Panamic side we have three genera, Dialithocidaris, Echinocrepis, and Pilematechinus, which are not represented in the West Indian fauna. Dialithocidaris may be said to represent the continental West Indian Podocidaris; Echinocrepis and Pilematechinus being Southern Ocean genera; Dermatodiadema and Phormosoma are Panamic abyssal, they are also West Indian continental genera.

LITTORAL SPECIES.[1]

West Indian.	Panamic.
Cidaris tribuloides Bl.	Cidaris Thouarsii Val.
Dorocidaris papillata A. Ag. 21–812 fathoms.	Dorocidaris panamensis A. Ag. 66–112 fathoms
Arbacia Gray.	
A. punctulata Gray.	A. stellata Gray.
Diadema Schynv.	
D. setosum Gray.	D. mexicanum A. Ag.
	Astropyga Gray.
	A. pulvinata A. Ag.
Echinometra Rond.	
E. subangularis Desml. —250.	E. Van Brunti A. Ag.
E. viridis A. Ag. —250.	
Strongylocentrotus Br.	
S. Drobachiensis A. Ag. —78.	S. mexicanus A. Ag.
Echinus Rond.	
E. elegans Düb. & Kor. 80–1350.	
E. gracilis A. Ag. 92–200.	
Toxopneustes Agass.	
T. variegatus A. Ag. —300.	T. semituberculatus A. Ag.
	T. pileolus Agass. —10.
Hipponoë Gray.	
H. esculenta A. Ag. —151.	H. depressa A. Ag.
Echinocyamus Gray.	
E. pusillus Gray. —805.	(E. sp. East India Islands.)
Clypeaster Lamk.	
C. latissimus A. Ag.	
C. Ravenellii A. Ag.	
C. subdepressus Agass. —120.	C. rotundus A. Ag.
Echinanthus Breyn.	
E. rosaceus Gray. —118.	E. testudinarius Gray. —120.
Mellita Kl.	
M. sexporis A. Ag. —270.	M. pacifica Verr.
M. testudinata Kl. —7.	M. longifissa. Mich.
	M. Stokesii A. Ag.

[1] The figures indicate the depths in fathoms; 21–812 gives the bathymetrical range; —50 shows that the range is littoral to 50 fathoms.

LITTORAL SPECIES — *Continued.*

West Indian.	Panamic.
Encope Agass.	
E. emarginata Agass. —70.	E. californica Verr.
E. Michelini Agass. —11.	E. micropora Agass.
	E. grandis Agass.
Echinonëus Van Phels.	
E. semilunaris Lamk.	(E. cyclostomus Leske. East India Islands South Sea Islands).
Echinolampas Gray.	
E. depressa Gray.	(E. sp. East India Islands).
Rhynchopygus D'Orb.	
R. caribæarum Lutk. —106.	R. pacificus A. Ag.
	Lovenia Gray.
	L. cordiformis Lutk.
Echinocardium Gray.	
E. cordatum Gray —85.	(E. australe Gray. —2675. East Indian Islands.)
E. pennatifidum Norm. 79–121.	
E. flavescens A. Ag. 150.	
Brissopsis Agass.	
B. lyrifera Agass. —2475.	B.[1] columbaris A. Ag. 511–1793.
Agassizia Val.	
A. excentrica A. Ag. 36–391.	A. scrobiculata Val.
Brissus Kl.	
B. unicolor Kl. —7.	B. obesus Verr.
Metalia Gray.	
M. pectoralis A. Ag. —156.	M. maculosa A. Ag. —28.
Meoma Gray.	
M. ventricosa Lutk. —242.	M. grandis Gray.
Schizaster Agass.[2]	
S. fragilis Agass. 71–955.	S. latifrons A. Ag.[1] 995.
S. Orbignyanus A. Ag. 92–1507.	S. Townsendi A. Ag. 146–995
Moira A. Ag.	
M. atropos A. Ag. —60.	M. clotho A. Ag. 7–14.

CONTINENTAL SPECIES.

West Indian.	Panamic.
Dorocidaris A. Ag.	Centrocidaris A. Ag.
D. Bartletti A. Ag. 88–398.	C. Doederleini A. Ag. 52.
D. Blakei A. Ag. 158–450.	
Porocidaris Des.	
P. Sharreri A. Ag. 122–356.	P. Cobosi A. Ag. 385.
	P. Milleri A. Ag. 465–1879.

[1] By analogy placed in the Littoral Fauna.
[2] Great range not characteristic of abyssal, but of continental area.

CONTINENTAL SPECIES. — *Continued.*

West Indian.	Panamic.
Salenia Gray.	
S. goesiana Lov. 360.	S. miliaris A. Ag. 782–1471.
S. Pattersoni A. Ag. 51–314.	
S. varispina A. Ag. 288–1200.	
Podocidaris A. Ag.	
P. sculpta A. Ag. 250–400.	(Podocidaris sp. East Indian Archipelago, Indian Ocean.)
P. scutata A. Ag. 580.	
Coelopleurus Agass.	
C. floridanus A. Ag. 56–1323.	(C. Maillardi A. Ag. Indian Ocean.)
Aspidodiadema A. Ag.	
A. Jacobyi A. Ag. 95–287.	
Dermatodiadema A. Ag.	
D. antillarum A. Ag. 151–1200.	See Abyssal species.
D. microtuberculatum A. Ag. 356–1568.	
Asthenosoma Grube.	
A. hystrix A. Ag. 100–115.	(Asthenosoma sp. Philippines and East India Islands.)
Phormosoma Wyv. Thom.	
P. placenta Wyv. Thom. 120–1242.	
P. uranus Wyv. Thom. 399–1525.	
Genocidaris A. Ag.[1]	
G. maculata A. Ag. 30–600.	(Genocidaris sp. East India Islands.)
Trigonocidaris A. Ag.	
T. albida A. Ag. 60–450.	(T. albida A. Ag. East India Islands.)
Hemipedina Wright.	
H. cubensis A. Ag. 138–270.	(H. indica de Meij. East India Islands.)
Pygastrides Lov.	
P. relictus Lov. 200–300.	
Neolampas A. Ag.	
N. rostellata A. Ag. 100–690.	(N. sp. de Meijere. East India Islands.)
Conolampas A. Ag.	
C. Sigsbei A. Ag. 84–450.	
	Plexechinus A. Ag.[2]
	P. cinctus A. Ag. 676.
Palæobrissus A. Ag.	
P. Hilgardi A. Ag. 82–185.	
Palæotropus Lov.	
P. Josephinæ Lov. 82–250.	(P. sp. East India Islands.)
P. Thomsoni A. Ag. 233.	
Paleopneustes A. Ag.	
P. cristatus A. Ag. 56–150.	

[1] Dr. Mortensen is correct in not referring this species to Temnechinus, as I was inclined to do.

[2] May be an abyssal species.

CONTINENTAL SPECIES. — *Continued.*

West Indian.	Panamic.
P. hystrix A. Ag. 21–208.	(P. sp. East India Islands.)
Linopneustes A. Ag.	
L. longispinus A. Ag. 28–298.	(L. sp. East India Islands.)
	Phrissocystis A. Ag.
	P. aculeata A. Ag. 1067.
	Nacospatangus A. Ag.
	N. gracilis A. Ag. 65.
Macropneustes Agass.	
M. spatangoides A. Ag. 82–373.	
Hemiaster Des.	
H. expergitus Lov. 461–485.	(H. gibbosus A. Ag. East India Islands.)
H. zonatus A. Ag. 620–750.	
H. Mentzi A. Ag. 170–576.	
Rhynobrissus A. Ag.	
R. micrasteroides A. Ag. 175–212.	(R. hemiasteroides A. Ag. Tahiti.)
Brissus A. Ag.	
B. Damesi A. Ag. 120–150.	
Periaster d'Orb.	
P. limicola A. Ag. 28–118.	P. tenuis A. Ag. 1573–1772.

ABYSSAL SPECIES.

West Indian.	Panamic.
	Dialithocidaris A. Ag.
	D. gemmifera. 1793.
	Dermatodiadema A. Ag.
	D. globulosum A. Ag. 1573–1772.
	D. horridum A. Ag. 902–1573.
	Phormosoma Wyv. Thom.
	P. hispidum A. Ag. 1132–1421.
	P. panamense A. Ag. 1823.
Pourtalesia A. Ag.	
P. miranda A. Ag. 242–1215.	P. Tanneri A. Ag. 995–1189.
	P. carinata[1] A. Ag. 1950–2225.
Spatagocystis A. Ag.	P. ceratopyga[1] A. Ag. 1950–2225.
S. sp. 576.	
	Echinocrepis A. Ag.
	E. setigera A. Ag. 1573–1879.
Urechinus A. Ag.	
U. Naresianus A. Ag. 1200–1800.	U. giganteus A. Ag. 995.

[1] Juan Fernandez.

ABYSSAL SPECIES. — *Continued.*

West Indian.	Panamic.
Cystechinus A. Ag.	
C. clypeatus A. Ag. 1080–1950.	C. Loveni A. Ag. 1879.
	Pilematechinus A. Ag.
	P. Rathbuni A. Ag. 1672–1823.
Homolampas A. Ag.	
H. fragilis A. Ag. 300–1920.	H. hastata A. Ag. 978–1132.
Aërope Wyv. Thom.	
A. rostrata Wyv. Thom. 800–1750.	A. fulva A. Ag. 1175–1740.

RECORD OF DREDGING AND TRAWLING STATIONS OF THE UNITED STATES FISH COMMISSION STEAMER "ALBATROSS" IN THE PANAMIC DISTRICT.

Serial Number.	Date.		Time.	Position. Latitude North.	Position. Longitude West.	Temperatures. Surface.	Temperatures. Bottom.	Depth in Fathoms.	Character of Bottom.	Remarks.
	1891		h m	° ′ ″	° ′ ″	°	°			
	Feb.	22	8 0 P.M.	. . .	. . .	. .	. . .	. . .	. . . .	
3353*	"	23	8 56 A.M.	7 6 15	80 34 0	73	39.0	695	gn. M.	Surface tow-net.
3354	"	23	1 25 P.M.	7 9 45	80 50 0	78	46.0	322	gn. M.	
3355*	"	23	3 1 P.M.	7 12 20	80 55 0	81	54.1	182	bk. G. Sh.	
3356*	"	23	7 30 P.M.	7 9 30	81 8 30	83	40.1	546	sft. bl. M.	Surface tow-net. 15 miles from Mariato Point.
3357*	"	24	6 17 A.M.	6 35 0	81 44 0	83	38.5	782	gn. S.	Surface tow-net.
3358	"	24	11 38 A.M.	6 30 0	81 44 0	83	40.2	555	gn. S.	
3359*	"	24	2 4 P.M.	6 22 20	81 52 0	83	42.0	465	rky.	
3360*	"	24	5 20 P.M.	6 17 0	82 5 0	83	36.4	1672	fne. bk. dk. gn. S.	Surface tow-net.
3361*	"	25	7 33 A.M.	6 10 0	83 6 0	82	36.6	1471	gn. Oz.	
3362*	"	26	7 20 A.M.	5 56 0	85 10 30	84	36.8	1175	gn. M. S. rky.	Intermediate net of Chun and Petersen.
3363*	"	26	4 37 P.M.	5 43 0	85 50 0	83	37.5	978	wh. glob. Oz.	Surface tow-net.
3364*	"	27	6 58 A.M.	5 30 0	86 8 30	81	38.0	902	yl. glob. Oz.	
3365*	"	27	4 30 P.M.	5 31 0	86 34 0	85	37.0	1010	yl. glob. Oz.	Surface tow-net.
3366*	"	27	8 4 P.M.	5 30 0	86 45 0	84	37.0	1067	yl. glob. Oz.	
3367*	"	28	6 38 A.M.	5 31 30	86 52 30	82	57.4	100	rky.	
3368*	"	28	7 21 A.M.	5 32 15	86 54 30	82	[illegible]8.4	66	rky.	Surface tow-net.
3369*	"	28	8 7 A.M.	5 32 45	86 55 20	82	62.2	52	Nullipore or rky.	
3370	"	28	10 3 A.M.	5 36 40	86 56 50	84	54.8	134	rks. & S.	At Cocos Island. Surface tow-net at night.
3371	March	1	7 49 A.M.	5 26 20	86 55 0	82	39.0	770	glob. Oz.	
3372	"	1	5 51 P.M.	4 49 0	86 11 20	81	38.8	761	gy. glob. Oz.	8 P.M. Surface tow-net.
3373	"	2	10 33 A.M.	4 2 0	84 58 0	82	36.6	1877	br. M. bk. sp.	
3374*	"	3	10 35 A.M.	2 35 0	83 53 0	80	36.4	1823	gn. Oz.	
3375*	"	4	6 36 A.M.	2 34 0	82 29 0	77	36.6	1201	gy. glob. Oz.	Surface tow-net.
3376*	"	4	4 27 P.M.	3 9 0	82 8 0	78	36.3	1132	gy. glob. Oz.	
3377	"	5	8 38 A.M.	3 56 0	81 40 15	77	38.0	764	M.	
3378*	"	5	11 45 A.M.	3 58 20	81 36 0	78	55.9	112	brk. sh.	
3379	"	5	2 15 P.M.	3 59 40	81 35 0	78	. . .	52	rks.	
3380*	"	5	4 51 P.M.	4 3 0	81 31 0	79	37.2	899	rks.	
3381*	"	6	8 38 A.M.	4 56 0	80 52 30	77	35.8	1772	gn. M.	
3382*	"	7	10 46 A.M.	6 21 0	80 41 0	75	35.8	1793	gn. M.	Submarine tow-net. 8.30 P.M., surface tow-net.
3383	"	8	6 51 A.M.	7 21 0	79 2 0	74	36.0	1832	gn. glob. Oz.	
3384	"	8	1 20 P.M.	7 31 30	79 14 0	74	42.0	458	gn. S.	
3385	"	8	3 7 P.M.	7 32 36	79 16 0	72	45.9	286	gn. M.	
3386	"	8	4 54 P.M.	7 33 12	79 17 15	73	48.0	242	fne. gy. S.	
3387	"	8	7 21 P.M.	7 40 0	79 17 50	74	56.1	127	fne. gy. S.	Surface tow-net.
3388	"	9	6 41 A.M.	7 6 0	79 48 0	73	36.2	1168	gn. glob. Oz.	Submarine tow-net.
3389	"	9	2 10 P.M.	7 16 45	79 56 30	74	48.8	210	gn. M.	
3390	"	9	4 25 P.M.	7 26 10	79 53 50	74	62.6	56	fne. gy. S. G.	
3391	"	9	7 15 P.M.	7 33 40	79 43 20	73	55.8	153	gn. M.	
3392*	"	10	6 30 A.M.	7 5 30	79 40 0	73	36.4	1270	hard.	Rhabdamina bottom.
3393	"	10	1 21 P.M.	7 15 0	79 36 0	74	36.8	1020	gn. M.	
3394*	"	10	5 43 P.M.	7 21 0	79 35 0	73	41.8	511	dk. gn. M.	
3395	"	11	2 20 P.M.	7 30 36	78 39 0	70	38.5	730	rky.	
3396	"	11	5 15 P.M.	7 32 0	78 36 30	70	47.4	259	hrd. gy. M. S.	

* Stations at which Echini were collected.

RECORD OF DREDGING AND TRAWLING STATIONS OF THE UNITED STATES FISH COMMISSION STEAMER "ALBATROSS" IN THE PANAMIC DISTRICT. — *Continued.*

Serial Number.	Date.	Time.	Position. Latitude North.	Position. Longitude West.	Temperature. Surface.	Temperature. Bottom.	Depth in Fathoms.	Character of Bottom.	Remarks.
	1891	h. m.	° ′ ″	° ′ ″					
3397*	March 11	6 32 P.M.	7 33 0	78 34 20	71	57.3	85	stf. gn. M. brk. sh.	Surface tow-net.
3398*	" 23	3 16 P.M.	1 7 0	80 21 0	84	36.0	1573	gn. Oz.	Surface tow-net, off Galera Point.
3399*	" 24	6 37 A.M.	1 7 0	81 4 0	80	36.0	1740	gn. Oz.	Surface tow-net.
			South.						
3400*	" 27	6 10 A.M.	0 36 0	86 46 0	81	36.0	1322	lt. gy. glob. Oz.	Surface tow-net.
3401	" 28	1 45 A.M.	0 59 0	88 58 30	82	44.0	395	glob. Oz.	
3402	" 28	7 13 A.M.	0 57 30	89 3 30	82	42.3	421	R. glob. Oz.	
3403	" 28	10 19 A.M.	0 58 30	89 17 0	82	43.3	384	fne. gy. S. bk. sp.	
3404*	" 28	1 16 P.M.	1 3 0	89 28 0	83	48.2	385	R.	
3405	" 28	3 42 P.M.	0 57 0	89 38 0	83	60.0	53	R. Co. Sh.	Tangles.
3406	April 3	6 47 A.M.	0 16 0	90 21 30	81	41.3	551	R.	
3407*	" 3	10 48 A.M.	0 4 0	90 24 30	81	37.2	885	glob. Oz.	Tangles.
			North.						
3408	" 3	4 7 P.M.	0 12 30	90 32 30	83	39.5	684	glob. Oz.	Tangles.
3409	" 3	7 24 P.M.	0 18 40	90 34 0	82	42.3	327	bk. S.	Tangles. Surface tow-net. Off Bindloe Island, 4 miles west.
3410	" 3	8 48 P.M.	0 19 0	90 34 0	82	44.2	331	bk. S.	
3411*	" 4	7 35 A.M.	0 54 0	91 9 0	82	36.2	1189	yl. glob. Oz.	
3412	" 4	6 11 P.M.	1 23 0	91 13 0	82	38.0	918	R.	9 P.M., surface tow-net, 5 miles off Wenman Islands.
3413*	" 5	8 24 A.M.	2 34 0	92 6 0	82	36.0	1360	glob. Oz. dk. sp.	At noon, surface tow-net.
3414	" 8	11 14 A.M.	10 14 0	96 28 0	82	35.8	2232	gn. M.	Submarine tow-net and surface tow-net.
3415*	" 10	9 30 A.M.	14 46 0	98 40 0	82	36.0	1879	br. M. glob. Oz.	
3416	" 11	9 16 A.M.	16 32 30	99 42 40	81	40.5	419	fne. br. M.	
3417	" 11	11 44 A.M.	16 32 0	99 48 0	82	40.6	493	gn. M.	
3418	" 11	2 57 A.M.	16 33 0	99 52 30	82	39.0	660	br. S. bk. sp.	
3419*	" 11	5 59 P.M.	16 34 30	100 3 0	81	39.6	772	gn. M. bk. sp.	Surface tow-net.
3420	" 12	7 48 A.M.	16 46 0	100 8 20	82	39.6	664	dk. gn. M.	
3421	" 12	11 32 A.M.	16 17 20	100 0 10	82	42.9	388	dk. gn. M.	
3422	" 12	12 35 P.M.	16 47 30	99 59 30	83	53.5	141	gn. M.	
3423	" 12	1 31 P.M.	16 47 30	99 59 20	83	56.0	94	gn. M.	
3424*	" 18	11 18 A.M.	21 15 0	106 23 0	76	38.0	676	gy. S. bk. Sp. glob.	
3425*	" 18	2 14 P.M.	21 19 0	106 24 0	76	39.0	680	gn. M. & S.	
3426*	" 18	3 45 P.M.	21 21 0	106 25 0	76	51.2	146	rky.	
3427	" 18	4 3 P.M.	21 22 15	106 25 0	75	51.2	80	rky.	Tangles.
3428	" 18	6 40 P.M.	21 36 30	106 25 0	76	48.4	238	dk. gy. S. glob.	
3429	" 19	5 39 A.M.	22 30 30	107 1 0	73	37.0	919	gn. M. glob. Oz.	
3430	" 19	3 27 P.M.	23 16 0	107 31 0	73	37.9	812	bk. S.	
3431*	" 20	6 33 A.M.	23 59 0	108 40 0	70	37.0	995	lt. brn. M. glob.	
3432*	" 20	2 38 P.M.	24 22 30	109 3 20	70	37.8	1421	br. M. bk. sp.	
3433	" 21	6 31 A.M.	25 26 15	109 48 0	69	36.5	1218	br. M. bk. sp.	
3434	" 21	10 14 A.M.	25 29 30	109 48 0	70	36.4	1588	br. M. bk. sp.	Surface tow-net.
3435	" 22	8 56 A.M.	26 48 0	110 45 20	70	37.3	859	br. M. bk. sp.	
3436*	" 22	3 10 P.M.	27 34 0	110 53 40	72	37.2	905	br. M. bk. sp.	Submarine tow-net and surface tow-net.
3437*	" 23	5 4 A.M.	. . . . .	. . . . .	70	40.0	628	br. M. bb. sp.	Submarine tow-net dragged on the bottom. About 50 miles south of Guaymas.

* Stations at which Echini were collected.