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ON VIVIPAROUS ECHINI FROM THE KERGUELEN ISLANDS.

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THE function of the deeply sunken petaloid ambulacra of several genera of Spatangoids, such as *Moira*, *Schizaster*, *Hemiaster*, and the like, has thus far remained unknown. Philippi, in 1845, while describing some South American Spatangoids, found in the deeply sunken posterior ambulacra of *Hemiaster cavernosus* minute Echini, which he regarded as the young of the species, though they differed widely from the adults, and seemed, from their shape and the nature of their spines, to approach nearer the regular Echini than the Spatangoids. The Echini of this genus being but rarely found in collections, no opportunity occurred of verifying the observations of Philippi. A somewhat analogous observation was made by Grube, who described more in detail the young of *Anochanus* (*Echinobrissus*), which he found living under very similar circumstances, in a cavity opening in the abactinal pole of the specimens. No details of the nature of this cavity having been as yet published, it is not possible to compare these two modes of carrying the young in these two genera more closely.

In Spatangoids, with deeply sunken ambulacra, we find, nearly in all cases, that from the sharp edge of the ambulacral groove long spines extend, so as nearly to close the opening of the cavity, entirely bridging it over, and completely concealing from view the ambulacral pores. This arrangement has usually been considered in Spatangoids as a sort of filter to keep foreign particles from affecting the delicate water tubes, which in the Spatangoids perform more or less the function of gills. This is undoubtedly the case in several genera; but in the case of *Hemiaster*, and perhaps in other allied genera, the sunken ambulacral area is used for an entirely different purpose, as was correctly observed by Philippi, that of sheltering the young.

That the many specimens (eight) found in the two posterior sunken ambulacral areas are really the young of *Hemiaster*, is of course only

probable, from the fact that the genital openings, which are unusually large, open directly into the upper part of their sunken area; so that the eggs (or more probably an imperfectly developed Pluteus, like that of *Echinaster*) on escaping from the genital openings would readily find their way into the artificial cavity formed by the spines which conceal the presence of the sunken areas.

Unlike many *Echini*, the ovaries of this genus are small, consisting of compact grape-like clusters of eggs, in very different stages of development, a few of the eggs only attaining a considerable size (nearly 1 mm.) and apparently ready to escape into the sunken area, as soon as the place should be left unoccupied by the preceding brood. No two of the small *Echini* were in the same stage of development: they varied in size from 2 mm. to 3 mm., the smaller specimens having a somewhat pentagonal outline, with rounded angles; the larger ones were more nearly elliptical and cylindrical in shape. In the smaller

Fig. 1.

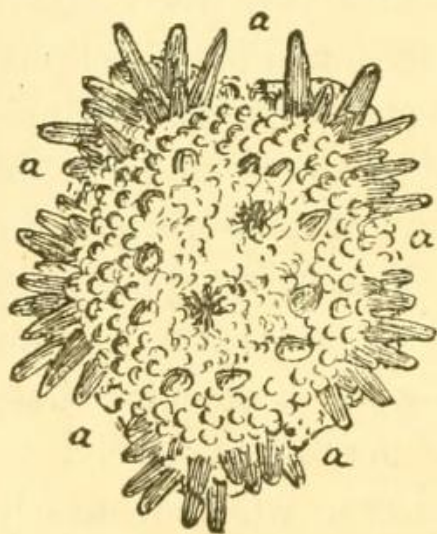
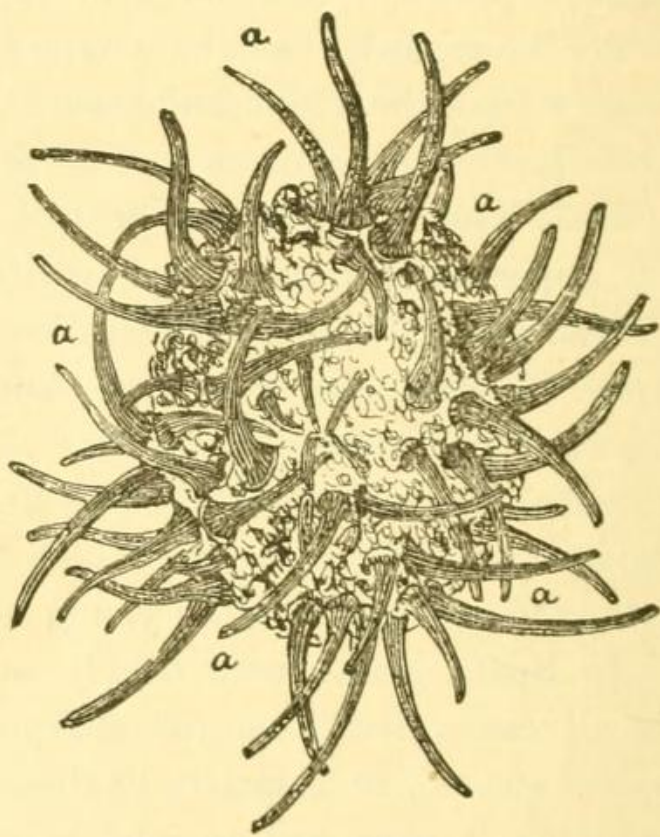


Fig. 2.



specimens (Fig. 1), the spines were short, straight; the longest, and only a few in each interambulacral area, about one-fifth the length of the axis, while the greater number were mere tubercles, scarcely rising above the level of the test. In the largest specimens (Fig. 2),

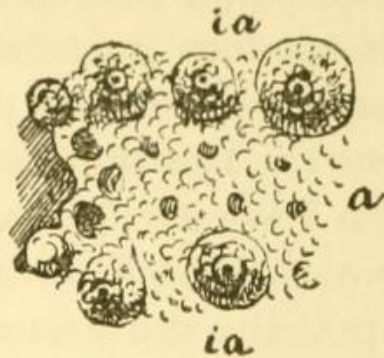
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- FIG. 1. Young *Hemiaster*, measuring 2 mm., seen from the abactinal pole. *a, a*, ambulacral spaces. The peripetalous fasciole is already developed.
 „ 2. Somewhat older *Hemiaster*, measuring 3 mm., seen from the actinal side. *a, a*, ambulacral areas.

many of the spines, nearly equalling the radius of the test, had become curved and assumed the characteristic appearance of Spatangoid spines. Seen from below (Fig. 3), the large angular mouth, covered by a thick membrane, was nearly central, somewhat anterior, the edge of the mouth on the level of the test, and a few small indistinct pores (Fig. 4)

Fig. 3.



Fig. 4.



arranged in parallel lines, showing the position of the future actinal petal; the ambulacral areas were occupied by coarse granulation, while the tubercles of the interambulacral spaces were large with well-developed crenulation, and already perforated. The interambulacral areas were already broad, leaving but narrow ambulacral spaces, in which the short, club-shaped ambulacral tubes could with difficulty be traced; they were largest near the apex, and near the actinostome (Figs. 4, 5).

Seen from above (Fig. 5), the most marked feature of all these young Echini was the broad fasciole, occupying so large a part of the abactinal surface, the position of the interambulacral area being clearly marked by the two large tubercles at the extremity of these areas on the abactinal edge of the fasciole. The whole fasciole was covered by a coarse granulation.

Fig. 5.

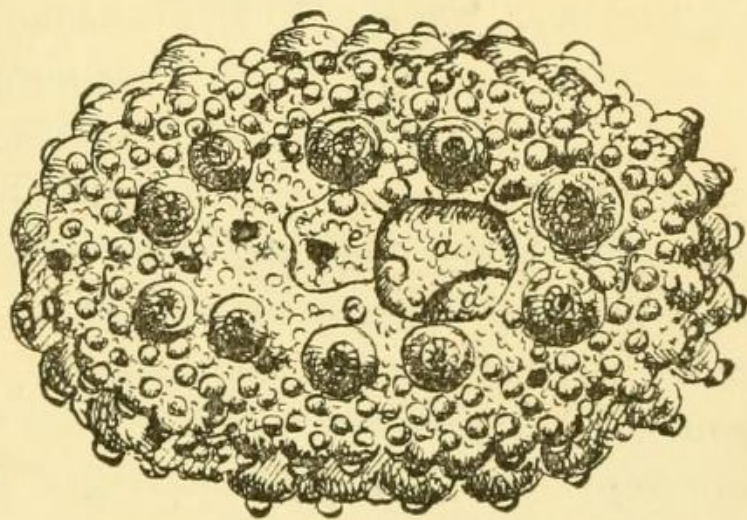


FIG. 3. Young Hemiaster denuded of spines, seen from the actinal side.

„ 4. Portion of actinal surface of Fig. 3, adjoining actinostome to show structure of tubercles. *a*, ambulacral area with pores; *ia, ia*, adjoining interambulacral spaces.

„ 5. Fig. 3, seen from the abactinal side, somewhat more enlarged to show the position of anal system (*a*), entirely enclosed by the peripetalous fasciole (*f*), the few ambulacral pores of the lateral ambulacra, and the more numerous pores of the odd ambulacrum.

The most striking feature in the structure of these small Echini is the position of the anal opening (Fig. 5, *a*). This is nearly in the central part of the abactinal surface towards the posterior edge, and entirely surrounded by the fasciole. This fasciole, from its position, must undoubtedly be the peripetalous fasciole, as it agrees in position with the same fasciole in *Brissopsis*, though in the latter genus it does not enclose the anal opening. In the adult *Hemiaster* the anal opening is not thus surrounded, an additional example of the little value we can place upon the position of the anal opening as a systematic character. The transfer of the anal opening to the exterior of the fasciole I was not able to trace, all the specimens being too young to show when it took place. There is no trace in these young stages of any genital openings, or of genital plates; the ocular plates are

somewhat more prominent than the other ambulacral plates, one specially, that of the odd ambulacrum (see Fig. 5). On opening one of these young Echini (Fig. 6), we find that, notwithstanding the position of the anal opening, the intestine already makes a half circuit round the edge of the test, and is attached to the sides by the usual mesenteries, the actinal extremity of the alimentary canal towards the an-

terior end being free; the stone canal also leads nearly vertically from the anal opening to a terminal interambulacral plate situated to the right of the odd ambulacrum. The anal opening is large, pentagonal, separating completely the trivium from the bivium, and is covered by a large plate having a small opening opposite the left posterior ambulacrum.

The only other young Spatangoid known, resembling so closely a regular *Echinus*, is a young Spatangoid figured by Müller, while still in the *Pluteus* stage, with straight spines similar to these figured here in the youngest specimen. This was the first indication we had of the great similarity of the spines of the young stages in the regular and irregular Echini. The presence of an anal opening in the young

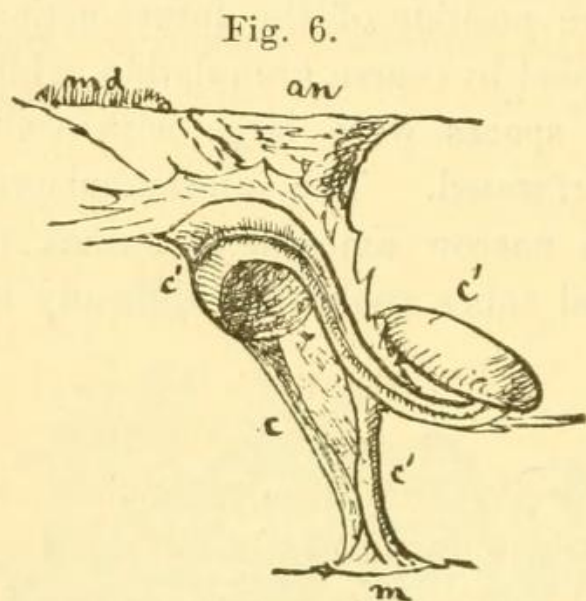


FIG. 6. Section of *Hemiaster*, showing the course of the alimentary canal *c'*, from the mouth *m*, to the anal system *an*; *c*, the stone canal, extending from the circular ring to madreporic body *md*.

Hemiaster connected, so to speak, with the abactinal system is a most interesting feature, as well as the complete separation of the bivium and trivium, the origin of which among Echini had not been understood. The whole family of Collyritidæ, in which this is the normal state, appear in geological times as an abnormal group, disconnected entirely, and isolated from all the other Spatangoids, which it precedes in time, and seeming thus far to have no connection with the Spatangoids of later geological periods. Their connection as an embryonic stage is now clearly shown by the young of Hemiaster here figured, as well as the close relationship existing between the regular Echini and such Spatangoids as Collyrites, appearing as the earliest geological representatives of the Spatangoids. The Collyritidæ are, therefore, not structurally so far removed as has been generally supposed from the regular Echini.

The earlier development, that preceding the stage when the embryo escapes in to the ambulacral area, could of course not be traced satisfactorily. But enough could be seen of the shape of the embryo mass to render it highly probable that the development was very similar to that of other viviparous Echinoderms (Star-fish and Ophiurans), in which the young are carried about by the parents till they are well advanced star-fishes (Sars, Müller, Agassiz), or hatched from the main cavity as well-developed Ophiuridæ (Quatrefages, Schultze, Lyman, Agassiz), and where the plutean development is passed through in a very imperfect manner, owing to the rudimentary development of the arms, which take such an extreme degree of growth in the pelagic Pluteus of Echini and Ophiurans, traces only of these arms being found in the younger stages of growth of these viviparous Echinoderms.

The specimens I have had the opportunity of examining were collected at the Kerguelen Islands by Dr. J. H. Kidder, the Naturalist attached to the Transit of Venus Expedition, and were sent to me for examination by Professor Verrill. He has described the species as new, under the name of *H. cordatus*; but I cannot distinguish it from *Hemiaster cavernosus* and *H. Australis*, which I was led to consider (from analogy with *H. Philippii*) to be identical species. It is remarkable that, in the young stages of both these species, all the ambulacra are but little sunken, and it is only when they have attained a considerable size that the posterior ones begin to deepen. *Philippii* considered this might be a sexual feature. We have not sufficient data to decide the question, but can only say that up to a certain size, at any rate, there is no difference in the depth of the ambulacra of males and

females. See Pl. IV., Figs. 4-8, Echini of Hassler Expedition. Ill. Cat. Mus. Comp. Zoöl. No. VIII. I have examined a large number of a common Spatangoid from our southern coasts (*Moiria atropos*), with ambulacra still more deeply sunken than in *Hemiaster*, in hopes of finding the young, but thus far without success; from the eggs of *Schizaster canaliferus* from the Mediterranean, in which some of the ambulacra are also deeply sunken, a pelagic *Pluteus* is known to be developed; so that in many of the genera with sunken ambulacral petals the sunken area does not shelter the young in their earliest stages of development.