35. *Male-female Superposition of the Sea-star* *Archaster typicus* Müll. et Trosch.¹⁾

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During our stay at Ishigaki Island of the island group Yaéyama, Southern Riukiu, in July, 1933, some ecological observations were made on the tropical sea-star, *Archaster typicus* Müller et Troschel, which inhabits the shores of Nagura of that island. The shores, covered with broken shells and coarse coral sand, are thronged with hundreds of specimens of this sea-star, whose abactinal surface could be distinguished from the sandy surface only with some difficulty, as is aptly described by Sluiter (1889) and Boschma (1924). The peculiar habit of superposing of the male on top of the female, first noticed by Boschma, and further verified by Mortensen (1931), was also found by us taking place there very often. That this striking feature of a species, first described as early as 1840 by Müller and Troschel, and known to be one of the very common forms in shallow water of the tropical Pacific and Indian Oceans, should have escaped the attention of many later observers, is very strange, as Mortensen has noted.

When the tide was sufficiently high, hardly any superposing couples were found on the bottom deeper than 30–40 cm. With the preceding of the tide, the sea-star crept about in search of its mate, and when the sandy bottom became exposed we saw a number of couples quietly lying on the sand. At the ebb-tide, when the sand was nearly dry, the mating couples hid themselves under the sand. When the tide came up and the bottom was again flooded with water, the upper one slowly detached itself from the one beneath, and crept away. Microscopical examinations of the gonads revealed that, in more than 180 couples, it was the rule that the underlying individual was a female while the one lying on top was a male. Boschma assures us that there was no exception to this rule. We however observed some few exceptions, such as 8 cases of male-male superposition and 3 reversed cases, namely

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female-male superposition. Not a single instance was found where a female lay on a female. Other unusual cases were 12 sets of 3 individuals, and 4 sets of 4 individuals superposed one upon another, and here without exception only the lowermost individual of each set was female, while the remaining ones were all males.

When a male lies on a female, their arm generally assume such a position that the radius of the one comes upon the interradius of the other, the centre of the rays being exactly upon the centre of the other individual (fig. 1). No definite relation in the orientation of the body, as judged by the position of the madreporic plate, was observed between the superposing

Fig. 1. Two individuals of *Archaster typicus* in situ, seen from above; the male superposed on the female. H. Ohshima photo.

individuals. A few specimens of 4- and 6-armed individuals were found, and even a 7-armed one was collected, though this was clearly an exception. The above mentioned regular alternation of the arms could not of course be maintained in the cases of the individuals with abnormal ray-numbers.

Our observations were carried out several times at Nagura beach between the 14 and 23 of July, and the gonads of both sexes were found generally well matured. Boschma saw the gonads quite ripe in February and May in Java. It is to be hoped that further study will show whether in our Ishigaki Island the same habit is displayed in early seasons of the year.

In the animals like Echinoderms where copulation does not take place, it is quite common that the spermatic fluid emitted into the water induces the female that happens to lie near to spawn (Fox 1924, Lindahl and Runnström 1929). Here, close approximation of male and female must make the fertilization of the eggs easy. Semon (1896),

referring the multitude of the sea-stars which he saw on the sandy beach of Amboina to *Astropecten* (but which we believe to be *Archaster typicus*¹⁾) suspects that the association is connected with reproduction in one way or another, at least indirectly. Boschma, on the other hand, unhesitatingly calls the phenomenon he observed in *Archaster typicus* copulation. It is most probable that the act is repeated at each high tide, and eventually the spawning takes place upon some stimulus.

Cases of the act that recalls the copulation are on record but few among Echinoderms. The best known case is the interlocking of the arms while spawning in *Asterina gibbosa*, as observed by Ludwig (1882). A phenomenon similar to that seen in *Archaster typicus* was also observed in its ally *A. angulatus* by Mortensen at Mauritius. In *Ophiosphaera insignis*, *Ophiodaphne materna* and *Amphilycus androphorus* the very small male is seen attached to the oral surface of the very much larger female, according to Mortensen (1933; compare also Koehler 1930). Cases of alleged copulation in *Comatula mediterranea* reported by Jickeli (1884), in *Antedon hirsuta* by Anderson (1904), and in *Astrophyton clavatum* by Bell (1901), are all not quite without some doubt. The congress of sea-urchins in breeding season, such as in *Toxopneustes variegatus* noticed by Tennent (1910) and in *Psammechinus miliaris* by Orton (1914) must doubtless bear a significant relation to fertilization.

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1) According to Döderlein (1896), who examined Semon's collection, there were only 2 specimens of *Astropecten* from Amboina (*A. velitaris*), while many others were identified to *Archaster typicus*.

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