

THE GENUS MITHRODIA GRAY, 1840

by

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The following paper was written in the first place by one of us (H.E.) on the basis of specimens in the Amsterdam and Leiden Museums and on others lent by the Bernice P. Bishop Museum and Dr. W. K. Fisher. The MS was then submitted to the other two authors. One of them (D.D.J.) compared it closely with specimens in the British Museum (Natural History)—fifteen of *M. clavigera*, the two types of *M. victoriae*, one specimen each of *M. Bradleyi* and *M. Fisheri*—and suggested such alterations and additions as he thought necessary. After a careful study of the types of *M. victoriae* he concluded that it is safer to regard it as a separate species and added the description given below. In the same way the third author (G. C.) contributed his remarks after the study of thirteen specimens of *M. clavigera*, one specimen of *M. Bradleyi* and seven specimens of *M. Fisheri* from the collection of the Muséum National d'Histoire Naturelle in Paris.

The genus *Mithrodia*, as such easily recognised by the series of large cylindrical spines along the arms, is one of the puzzling genera of Asterids when one tries to identify the species. For many years it was the custom of authors to use the name *M. clavigera* for all *Mithrodias* and to abstain from any description. After de Loriol's clear description of 1885, Fisher (1906) was the first again to call attention to the species problem in the genus.

The present authors, after a careful examination of the material under their charge, as well as of many specimens put at their disposal by other Museums, give their opinion on the species that may be distinguished. They have to thank the Directors of the Leiden and of the Bernice P. Bishop Museums, as well as Dr. W. K. Fisher for sending on loan specimens of the genus. Dr. Fisher moreover gave his experienced advice in this question.

THE CHARACTERS OF THE GENUS

Five-, exceptionally six- or four-, armed seastars, often with unequal arms because of regeneration after injury. Skeleton a meshwork of rods and other smaller, oval, rounded, triangular or irregularly shaped pieces, mostly arranged in a starlike way around larger more or less rounded ossicles. About 13 longitudinal rows of these round ossicles may be present, of which, however, only the ventral, lateral and middorsal rows are fairly regular. Some of them bear the large movable cylindrical or conical spines which give the genus its characteristic appearance. They have excavations with slight rims for the muscular attachment of the spines.

The different pieces of skeleton often slightly overlap each other and form an irregular meshwork, the polyedric (sometimes triangular) meshes of which are the papular fields. Many of the rods are provided with a much smaller movable spiniform to knoblike tubercle articulated to a slight excavation near the middle.

Each adambulacral plate bears a movable spine, much larger than the tubercles, but smaller than the larger spines, fastened on a low (sometimes slightly excavated) knob. In addition each adambulacral bears a fan of slender spines on its ambulacral side.

The larger spines form rather regular longitudinal rows, a ventral, an inferomarginal, a superomarginal and a middorsal row.

The whole skeleton is covered with skin, which is provided, in the papular fields as well as on the rods and the spines, with small calcareous pieces of different sizes, often enlarged on the rods and especially on the tops of the spines.

Pedicellariae may be present throughout the papular fields near their borders. Sometimes a fairly regular series may be found external to the adambulacral spines. They consist of a circle of 4-7 pincerlike slightly arched spinelets, inserted on a very small, relatively high ring-shaped ossicle. Sometimes the skin granules around the pedicellariae are enlarged.

THE SPECIES

A grouping of the specimens available according to their general facies gives the following results:

I. A group of small to medium-sized specimens (cf. pl. I and II) characterised by rather small granules in the skin, which do not conceal the underlying meshwork of tubercles. The conical to cylindrical spines are large and conspicuous, and include a greater or smaller number which form a middorsal series. This is the typical *M. clavigera*.

II. A group of very large specimens (cf. pl. III) in which the granulation is much heavier, concealing the trabecular meshwork. The spines are heavy and conspicuous, except for those of the middorsal series, of which some are most often present, and are smaller and hence less obvious. This group must be considered as the adults of *M. clavigera*.

III. A group of medium-sized specimens (cf. pl. V and VI) in which the tuberculation is more spiniform, concealing the meshwork, and causing the relatively small middorsal spines to appear sometimes less conspicuous. The arms taper more regularly from base to tip (they are much more cylindrical in the other groups). This is *M. Bradleyi* from California.

IV. A group of smaller and larger specimens (cf. pl. VII) with an even covering of thimble-shaped large tubercles, "bristling" with spines, concealing the meshwork, among which the middorsal spines are often missing or at least of the same form and size as the tubercles (Dr. Fisher found carinal spines in young specimens, which may be present in the adult in the proximal part of the arm). The other large spines are shorter than in the other groups, though they remain conspicuous. To this group we may assign Fisher's specimens of *M. Bradleyi* from the Pacific and it may be called *M. Fisheri* Holly, as Holly's rather misshapen specimen clearly also belongs to this group.

V. The two specimens of *M. victoriae* (cf. pl. IV) are regarded, after long hesitation, as belonging to a separate species by the second author (see below).

VI. There is no doubt that *M. gigas* Mortensen (1935, p. 1) is a separate species. It has not been examined by the present authors.

Mithrodia clavigera (Lamarck, 1816)

(Fig. 1-4, Pl. I-III)

- Asterias clavigera* Lamarck, 1816, p. 562.
Mithrodia spinulosa Gray, 1840, p. 288; 1866, p. 2.
Ophidiaster echinulatus Müller & Troschel, 1842, p. 32; Dujardin & Hupé, 1862, p. 363; Perrier, 1869, p. 251.
Heresaster papillosus Michelin, 1844, p. 173; 1849, p. 19, pl. 9.
Echinaster echinulatus von Martens, 1866, p. 59.
Mithrodia echinulatus Lütken, 1871, p. 266.
Mithrodia clavigera Perrier, 1875, p. 378 (pars); Möbius, 1880, p. 50; Studer, 1885, p. 26; Loriol, 1885, p. 13, pl. XI fig. 1 a-d; Sladen, 1889, p. 539; Sluiter, 1889, p. 298; 1895, p. 63; Döderlein 1896, p. 322 (46); Bell, 1902, p. 227; Ludwig, 1905, p. 215; Fisher, 1906, p. 1095; Tortonese, 1937, p. 96; Hayashi, 1938 a, p. 216, pl. 2 figs. 8-10; 1938 b, p. 287, pl. 6 fig. 1, pl. 7 figs. 1-3.
 non *M. clavigera* Ives, 1890, p. 171 (probably *M. Fisheri*); Bell, 1899, p. 138; 1903, p. 246 (are found on re-examination to be *Echinaster callosus* Marenzeller).

Specimens in Zoölogisch Museum Amsterdam.

2 specimens Siboga Expedition, Station 240, 22 XI - 1 XII 1899, Banda anchorage, reef (R 88, 60, 85, 39, 70, r 9, breadth of arm at base 10 mm, R = $7\frac{1}{2}$ - $9\frac{1}{2}$ r; R 80, 68, 76, 55, 77, r 10, br 10 mm, R = 7-8 r).

1 specimen Siboga Expedition, Station 301, 30 I - 1 II 1900, Pepela Bay, East coast of Rotti Island, reef (R 58, 17, 58, 58, 57, r 7, br 8 mm, R = 8 r).

1 specimen Siboga Expedition, Station ?, Eastern part of the East Indian Archipelago (R 71, 70, 60, 34, 32, r 10, br 11 mm, R = 6-7 r).

1 specimen Siboga Expedition, Station Haingsisi, Samau Island (Timor), reef (R 169, 132, 80, 86, 88, r 11-15, br 13-17 mm, R = 11 r).

3 specimens Moluccas, coll. van der Hucht (described by Martens, 1866, p. 59 and by Sluiter, 1895, p. 63) (R 69, 48, 57, 28, 61, r 7, br 8 mm, R = 10 r; R 72, 40, ?, 19, 38, r 9, br 9 mm, R = 8 r; R 68, 29, 9, 22, 35, r 7, br 9 mm, R = 10 r).

1 specimen Mauritius, leg. C. Ph. Sluiter, no. 574, described by Sluiter (1889, p. 298) (R 115, 113, 15, 13, 97, r 13, br 14 mm, R = $7\frac{1}{2}$ -9 r).

Specimens in Rijksmuseum van Natuurlijke Historie Leiden.

1 specimen Java, coll. C. G. C. Reinwardt, no. 724 (R 298, 252, 172, 285, 261, r 20, br 20 mm, R = $12\frac{1}{2}$ -15 r).

4 specimens Larantuka, Flores, leg. J. Semmelinck, nos. 725 and 727, described by Martens (1866, p. 59) (R 138, 131, 128, 103, 130, r 14, br 14 mm, R = 9-10 r; R 88, 77, 70, 77, 87, r 10, br 10 mm, R = 7-9 r; R 110, 107, 27, 77, 108, r 12, br 10 mm, R = 9 r; R 227, 209, 188, 217 (4 arms), r 15, br 15 mm, R = 12-15 r).

1 specimen Timor, leg. G. F. Wienecke, no. 729 (R 69, 14, 60, 66, 37, r 8, br 9 mm, R = $7\frac{1}{2}$ - $8\frac{1}{2}$ r).

2 specimens Australian Sea, no. 726, type and cotype of *Ophidiaster echinulatus* Müller & Troschel (1842, p. 32) (R 112, 102, 104, 53, 81, r 12, br 11, R = $8\frac{1}{2}$ - $9\frac{1}{2}$ r; R 168, 122, 123, 165, 56, r 17, br 17 mm, R = 10 r).

1 specimen Mauritius, purchased Frank, no. 728 (R 204, 180, 13, 197, 203, r 17, br 18 mm, R $10\frac{1}{2}$ -12 r).

Specimens in the British Museum (Natural History).

1 specimen Philippine Islands, purchased Cuming; reg. no. 43.3.29.14 (R 57, 54, 55, 45, 55, r 9, br 10 mm, R = 5-6 r).

1 specimen Red Sea, purchased Cuming; reg. no. 61.4.5.2 (R 165, 144, 130, 115, 140, r 14, br 14 mm, R = 8-12 r).

1 specimen Mauritius, purchased Cutler; reg. no. 75.4.21.2 (R 245, 215, 210, 235, 215, r 17, br 18 mm, R = 12-14 r).

1 specimen Mauritius, purchased Robillard; reg. no. 84.9.23.1 (R 275, 240, 230, 250, 260, r 20, br 20 mm, R = 11-13 r).

1 specimen Mauritius, purchased Robillard; reg. no. 89.3.11.14 (R 285, 240, 280, 245, 210, r 20, br 23 mm, R $10\frac{1}{2}$ -14 r).

1 specimen, Kandavu, Fiji Islands, Challenger coll.; reg. no. 90.5.7.778 a (R 157, 150, 128, 140, 155, r 13, br 15 R = 10-12 r). See pl. III.

1 specimen Macclesfield Bank, 12-23 fms., Admiralty; reg. no. 92.8.22.38 (R 36, 27, 32, 36, 23, r 5, br 5 mm, R = 5-7 r). See pl. I.

1 specimen Macclesfield Bank, 41-44 fms., Admiralty; reg. no. 93.8.25.72. With one arm missing (R approx. 66-60, r 9, br 9 mm, R = about $6\frac{1}{2}$ -7 r).

1 specimen Minikoi, Maldives, Gardiner coll.; reg. no. 1902.3.13.7 (R 113, 104, 88, 98, 100, r 11, br 12 mm, R = 8-10 r). See pl. II.

1 specimen unknown locality, purchased Valenciennes; reg. no. 44.12.9.39 (R 117, 94, 80, 93, 83, r 11, br 12 mm, R = 7- $10\frac{1}{2}$ r).

1 specimen unknown locality, purchased Warwick; reg. no. 62.7.9.48. All arm tips broken off (R was about 100; r 10, br 10 mm, R = 10 r).

1 specimen unknown locality, marked "history unknown"; reg. no. 72.6.21.34 (R 144, 142, 143, 135, 130, r 15, br 15 mm, R = $8\frac{1}{2}$ - $9\frac{1}{2}$ r).

1 specimen unknown locality; reg. no. 1946.8.13.1 (R 84, 58, 82, 28, 41, r 11, br 11 mm, R = nearly 8 r).

1 specimen unknown locality; reg. no. 1947.3.7.1 (R 183, 180, 134, 180, 174, r 15, br 16 mm, R = 9-12 r).

1 specimen unknown locality, no data; reg. no. 42.12.25.53 (R 160, 145, 145, 109, 115, r 13, br 14 mm, R = 8-12 r).

Specimens in Muséum National d'Histoire Naturelle in Paris.

2 specimens New Caledonia, coll. Cotteau, 1894 (R 104, 102, 103, 95, 54, r 9, br 10.5 mm, R = 10-11½ r; R 107, 72, 105, 97, 97, r 12, br 12 mm, R = $8\frac{1}{2}$ -9 r).

1 specimen Moluccas, coll. Cotteau, 1894 (R 98, 96, 97, 96, 63, r 11, br 12 mm, R = 9 r).

1 specimen Marquesas Islands, coll. Siméon Delmas (R 186, 106, 181, 160, 102, r 14, br 15 mm, R = 11-13 r).

1 specimen Society Islands, from Mus. Cambridge (U.S.A.), 1876 (R 66, 64, 62, 63, 42, r 7, br 7.5 mm, R = 9 r).

1 specimen New Britain, coll. Lix, 1889 (R 99, 51, 82, 56, 82, r 10, br 11 mm, R = 8-10 r).

1 specimen Mauritius, coll. Cotteau, 1894 (R 175, 158, 165, 152, 160, r 16, br 16 mm, R = 10-11 r).

1 specimen Mauritius, coll. Carié, so crooked that it was impossible to measure it.

2 specimens Mauritius, coll. Péron and Lesueur, 1803 (labelled *Scytaster subulatus* M. & Tr.) (R 127, 120, 123, 124, 45, r 15, br 16 mm, R = 8-8½ r; R 144, 128, 142, 134, 136, 124, r 15, br 16 mm, R = 8-9½ r).

1 specimen locality unknown (comet, mentioned by Ed. Perrier) (R 53, 33, 40, 34, 36, r 12, br 16 and 11 mm, R: r seems of no value here, because the arms are regenerating).

1 specimen Island Saint Lucia (Borneo?), coll. A. Fleury, 1852 (R 215, 210, 215, 165, 196, r 20, br 21 mm, R = $9\frac{1}{2}$ -10½ r).

1 specimen Madagascar, coll. Grandier, 1905 (two large arms, one of about 40 mm, a fourth of 10 mm).

1 specimen Mauritius (type of *Heresaster papillosus* Michelin) (R 219, 202, 207, 210, 152, r 21, br 24 mm, R = $9\frac{1}{2}$ -10 r).

As stated above there is a distinct difference in facies between the smaller and the larger specimens (cf. pl. I-III). This is partly due to the fact that the larger specimens are usually dried at once, while the smaller first travel in alcohol and hence are better preserved. Moreover, in larger specimens the tubercles are much heavier, while the spines, though they are larger than in the smaller specimens, are relatively less conspicuous, those of the middorsal row showing a tendency to decrease in size and in number, a tendency also to be seen in some younger specimens. The larger specimens remind one of *M. Fisheri*, but they differ from it in that the papular fields are larger and the tubercles smaller and less densely set, while the dorsal spines are most often present. The tubercles appear much less frequent and

smaller than in *M. Fisheri*. This is especially so when the arms are treated with Eau de Javel, so that the adhering dust is cleared away. The figure of Lorient (1885, pl. XI fig. 1 a) shows an intermediate state between smaller and larger specimens.

As may be seen from the measurements given above, R varies from 5-15 r ; the rate usually being lower in the smaller specimens. The measuring of crooked arms is very difficult. It may be done with a thread along the ambulacrum or along the abactinal side. The latter most often proves to be much shorter, and it makes a great difference whether the thread lies in the ambulacral slit or passes over the tops of its spines. Thus two investigators measuring the same animal may get widely different results and even one investigator measuring the same arm more than once may find large differences, e.g., measuring the largest arm of the Haingsisi specimen, given above as 169 mm, several times with a thread, first along the abactinal, then along the actinal side, we get 135, 140, 145, and 173, 180 mm respectively. The radius of the disk (r) on either side of this arm is 12 and 13 mm. The result for this one arm is $R = 10^{1/2}$ -15 r . Hence it follows that these figures give approximate data only. Moreover it must be remarked that many arms are in regeneration. Though their length is given above, they have not been included when giving the ratio $R : r$.

A slight constriction at the arm base is often observable; it is more obvious in specimens which were dried at once, because here the arms usually flatten out. The constriction may occur in all species and hence has no specific value. The angle between the arms is usually rather sharp but is sometimes rounded when two arms stand wide apart (Möbius: "Die Arme können sich nach allen Richtungen krümmen"). Often the arm angles in one specimen differ in this character and it certainly has no specific value.

The length, form and thickness of the spines are very variable, as is their number (fig. 1 a-f, g-l). In the younger specimens they are more slender, becoming usually more club-shaped in the larger specimens, though they are, e.g., typically spiniform in the largest specimens. The specimen from Haingsisi, of medium size, shows the typical facies of the younger specimens but the spines are already thick and cylindrical. In some specimens, especially in some from Mauritius and in that from the Marquesas Islands, the infero- and supero-marginal spines are often flattened, spatulate or even bifid (fig. 1 j) or provided with lateral apophyses (fig. 1 k). In these specimens the small mid-dorsal spines (fig. 1 l) have terminal protuberances and look like molars. It is not possible to find any specific character in the form of the spines.

The number of the adambulacrals and hence the number of the adambulacrals spines (fig. 1 *b* and *h*) and fans (fig. 1 *a* and *g*) (occurring regularly on every adambulacrals plate) increase with size from 67 in the smallest specimen to 178 in the largest.

The second (ventral) row of spines (fig. 1 *c* and *i*) is not regular;

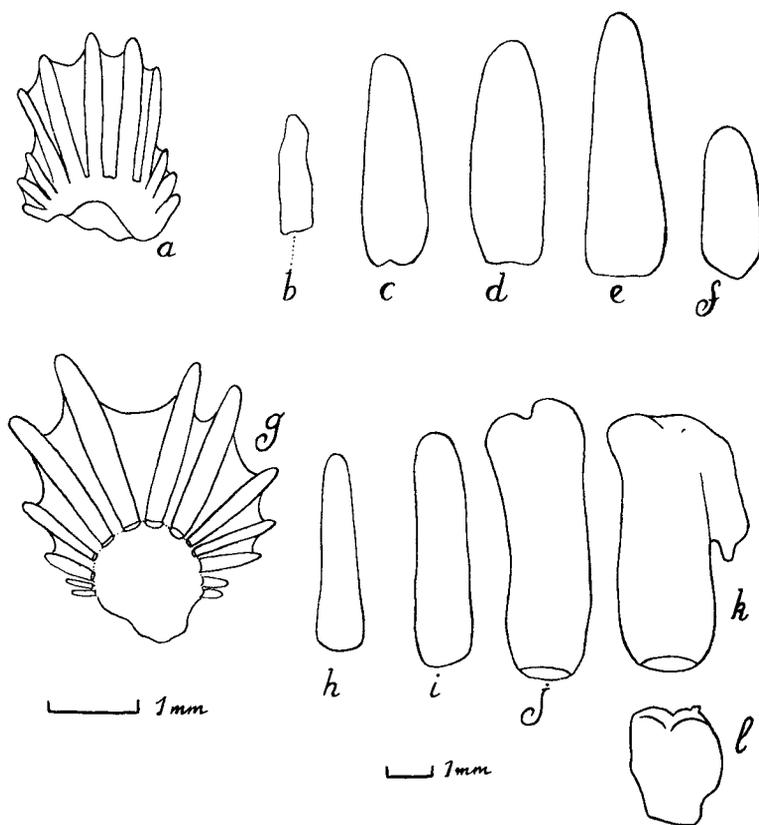


Fig. 1. *Mithrodia clavigera* (Lamarck), Madagascar, coll. Grandidier, Mus. Paris. *a*, fan; *b*, adambulacrals spine; *c*, ventral spine; *d*, infero-marginal spine; *e*, supero-marginal spine; *f*, mid-dorsal spine.

Idem, Mauritius, coll. Carié, Mus. Paris. *g*, fan; *h-l*, as above.

For scales see lines of 1 mm; fans twice as large as other spines.

sometimes there is one to every 3rd adambulacrals spine, but mostly there is one at about every 5th to 7th adambulacrals; they are often more crowded at the arm base. They are not symmetrically arranged either on the two sides of one arm, or on the different arms of one specimen; sometimes the spines succeed each other rapidly, sometimes there is a gap. The total number

on one side of an arm increases from about 13 (11) to 66 according to the size of the animal.

The third (inferomarginal) row of spines (fig. 1 *d* and *j*) alternates in general with the second, but as a consequence of irregularities the total number is somewhat less, increasing from about 11 to 34 with size.

The fourth (superomarginal) row (fig. 1 *e* and *k*) is very irregular and contains a very variable number of spines, from 6 in the smallest specimen to 20 in the largest, though sometimes it is 3-10 in one medium-sized specimen.

The number of the mid-dorsal spines (fig. 1 *f* and *l*) is very inconstant. Sometimes, in the largest specimens, they are missing from some or all of the arms; the largest number on one arm is 10 and that number may occur on small, medium or large specimens; but in one specimen we may find none on one arm and 7 on another, and exceptionally a rather regular row of 6 was counted. Usually they are found in the proximal part of the arm, and sometimes, after a long interval, they occur again in the distal part. In four large specimens the following numbers of mid-dorsal spines were counted: 5,6,2,4 (Larantuka), 0,0,1,6,0 (Australian Sea), 0,0,0,0,0 (Mauritius), 5,6,8,8,5 (Java). The spines are sometimes irregular, not in line. In a specimen from the Society Islands (Paris Museum) they are placed in quincunx.

Sometimes smaller spines occur among the others and solitary spines are often found outside the rows. On the disk there is mostly one spine near the anal opening; in several larger specimens, however, there is none. In the Larantuka specimen there are 9 on the disk, of which 5 surround the anal opening.

The madreporite may be surrounded by some larger tubercles, 4-6 in number, which may attain the size of the median dorsal spines. The madreporite is not always easy to detect, especially when the tuberculation is rather heavy. As a consequence of regeneration it may even be missing or may lie in an arm angle.

The tubercles on the trabeculae are few and small in the smallest specimens, increasing in number and in size in the medium-sized specimens. In the four larger specimens they are larger and much more numerous, more or less concealing the trabeculae which in the smaller specimens are clearly and definitely seen. This character suggests identity with *M. Fisheri* where, however, the skeleton is heavier and more dense, while the tubercles are more regularly set, more thimble-shaped and bristling with spines. In the smaller specimens the tubercles are often enlarged on the disk, especially some near the anus and around the madreporite.

The furrow-armature consists on each adambulacral plate of a spine, smaller than the larger spines, with on its furrow-side a fan of fine spinelets, evenly diminishing in size, the three or five central ones much larger than the others (fig. 1 *a, g*). Both fan and spine can be moved separately to cover and protect the furrow. In the larger specimens there are 8-12 spinelets. In the smaller specimens the fan spinelets vary in number from 6 to 12; they are usually 10-11. They are covered by skin, which may cause their tips to look broader than they really are. When the fan is bent over the furrow, it becomes more expanded and the difference in length between the spinelets is more obvious.

The skin covers the whole skeleton, meshwork, tubercles and spines. It is itself provided with granules, which are rather small on the trabeculae. Some are found in the papular fields as little spines. On the tubercles and the spines their size is very unequal, as, especially near their tips, many are enlarged to squamiform spinelets. In the larger specimens the granules on the tubercles are more coarse, more cone-like, real little spines that bristle from the tubercles. Only on the inner side of the large adambulacral spines, where the fan-spines touch them when the furrow is opened, a larger or smaller area is naked. The size of this area differs from individual to individual, being relatively smaller in the larger, more granulose, specimens. The skin covering the fan and forming a web between the spinelets is destitute of calcareous pieces. In one specimen only small spinous granules were found on the tip of the larger fan-spines. Probably as a consequence of the shrinking of the skin when drying, the tip of the tubercles may break through the skin and appear among the granules as one of them.

When the skin is dissolved in Eau de Javel, it is found to contain spicules (fig. 2) which comprise (1) minute tables, like those of Holothurians, with perforated plate-like bases and richly spiny turrets, (2) large dense conical masses with flattened bases, and (3) stages intermediate in size and nature between the two. It appears then that the cones develop out of the tables; and it is interesting to observe that in some small specimens tables predominate over cones, and that in large specimens cones are numerous and tables very scarce. The surfaces of the narrower ends of the conical masses—away from the flattened bases—are produced into minute thorny spines. The cones when developed to the full become the granules which give the skin its prickly appearance and feel.

There is in the British Museum collection one specimen (reg. no. 1946.8.13.1) accompanied by no data in which the skin is soft: it contains no spicules or granules. But pieces of it after immersion in Eau de

Javel show, as it were, the shadowy shapes of spicules. It is presumed that they were present but have disintegrated.

The skeleton consists of more or less rounded pieces (some of which

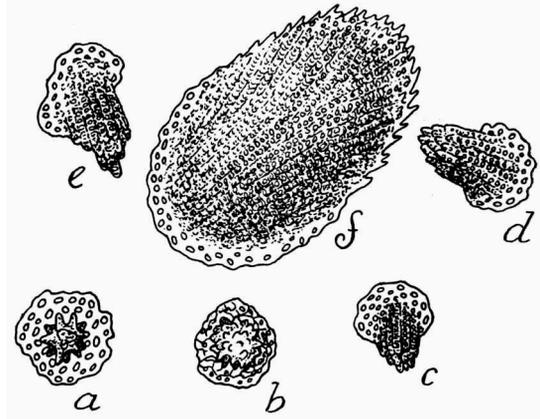


Fig. 2. *Mithrodia clavigera* (Lamarck). Skin deposits. a, a table; b-e, older stages of tables; f, conical mass with flattened base. All \times ca. 69.

carry the large spines) connected by small rod- or shuttle-like pieces each of which usually bears a small tubercle (fig. 3). These rods radiate in a starlike way from the round pieces and form the trabeculae of the irregular

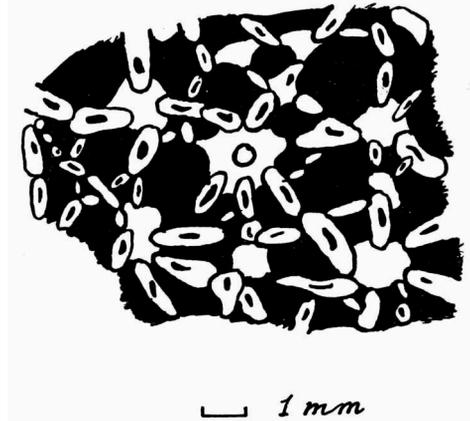


Fig. 3. *Mithrodia clavigera* (Lamarck), Banda-reef, R 80 mm, Mus. Amsterdam. Skeleton as it is revealed after treatment with Eau de Javel.

polygonous meshwork, the meshes being the papular fields. The trabeculae are each formed not by one but by a number of rods, the rods partly covering each other with their flattened keeled ends. Not every corner of the mesh-

work has a rounded central piece, for the meshes are often formed by the small rods only. The rounded pieces form regular rows on the actinal side, but dorsally, especially in the larger specimens, the rows become irregular.

The row next to the adambulacrals is formed of more or less triangular skeletal pieces, each fitting with its base against about two adambulacrals, without intervening rods between it and them. These rods, however, are present, though small, between the pieces themselves and between them and the next row. About every 3rd or 4th ossicle of this first row bears a spine (belonging to the second or ventral row of spines). If spine-bearing the ossicle shows a round rimmed excavation to which the spine articulates.

The second ventral, the infero-marginal, row of rounded ossicles has a spine on about every 2nd or 3rd ossicle, often alternating with those of the preceding row.

In the third row of ossicles no spines are as a rule found, so that this row is less obvious and distinct. Exceptionally a spine may occur.

In the fourth, the superomarginal, row only every 3rd or 4th ossicle may bear a spine.

It is not easy to decide how many rows are present between the superomarginal and the mid-dorsal rows. There are probably two. It is not always appropriate to speak of rows, for the arrangement may be irregular. Spines may occasionally occur here.

In the mid-dorsal row a spine may be found on every 2nd to 4th ossicle; they may be missing over a long stretch, or even (in larger specimens) be totally absent. In that case the mid-dorsal row itself becomes rather irregular and one can speak only of a dorsal field.

The non-spine bearing ossicles are seen rather as a depression of the skin in the centre of the rod-stars.

The spines, when seen without the skin-covering, are spiniform, often more cylindrical or even club-shaped in the larger specimens, though in the largest specimen they are conical and spiniform. They may be flattened, spatulate or bifid (see above, cf. fig. 1). The spines of the first and of the mid-dorsal row are usually smaller than the others.

The tubercles, small knobs, are inserted on nearly every rod of the skeleton; they are seated in small pits. They are very small in the younger specimens, increasing considerably in size in the adults, sometimes nearly equalling the smaller spines. In dried specimens, as has been said, the spines and tubercles often pierce the skin at their tips because of the shrinking of the skin.

Pedicellariae (fig. 4) are not always present and not always easily detected. They are found in the papular fields near their borders. Sometimes a rather regular series may be found external to the adambulacral spines. They may occur in virtually every papular field, even though very sparsely, on the dorsal side. They are inserted on a separate, relatively high small ring-shaped piece of skeleton and they consist of a circle of from 4 to 7 pincerlike slightly arched spinelets, the tips of which meet in the centre. Sometimes the skin granules around the pedicellariae are enlarged.

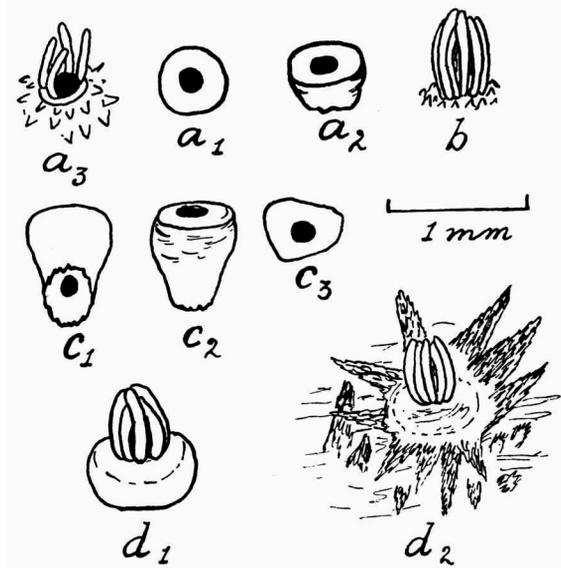


Fig. 4. *Mithrodia clavigera* (Lamarck). Pedicellariae. *a*, Moluccas, Mus. Amsterdam; *a*₁, ossicle seen from above; *a*₂, from the side; *a*₃, in situ; *b*, in situ from Haingsisi specimen, Mus. Amsterdam; *c*₁₋₃, different aspects of one ossicle from Flores specimen, no. 725 Mus. Leiden; *d*, Java, coll. Reinwardt, Mus. Leiden; *d*₁, ossicle, denuded, in situ; *d*₂, in situ with neighbouring spines.

In the larger specimens the pedicellariae are present, though it is not easy to detect them among the rough granulation of badly preserved dried specimens.

Hayashi (1938 a) has given a figure of a pedicellaria. He was in error in saying that in the genus *Mithrodia* no pedicellariae had previously been reported, for Fisher (1925) described them in specimens which he assigned to *M. Bradleyi*.

Many specimens show traces of the dark irregular (red or brown) bands which Michelin gives in his coloured figure and which de Loriol describes as: "brun clair taché et vaguement annelé de brun foncé sur les bras. Le

disque est foncé, la face inférieure bien plus claire". Von Martens, however, has: "Farbe während des Lebens braun".

A critical study of the literature is difficult, since it contains so many inadequate descriptions and records with none at all.

The fact that Lamarck (l.c.) describes large specimens with clavate spines makes it quite certain that his specimen from an unknown locality was the type of the species here described. It is remarkable that he describes the small knobs as "laevis", since especially in large specimens they are granular, like the spines. His type was not preserved in the Paris Museum. As early as 1875 Perrier does not mention the type, so probably it was not there then. The Paris collections contain under the name *Scytaster subulatus* Müller & Troschel (1842, p. 36) two specimens from Mauritius collected by Péron and Lesueur in 1803, which proved to belong to *Mithrodia clavigera*. They have been described above. The spines are in one specimen claviform, resembling those of *M. Fisheri*, but less heavy, longer and very granular, and in the other typically "*clavigera*", longer yet than in the first. The animals are of a very dark chestnut brown.

Gray's type of *Mithrodia spinulosa* could not be found in the collections of the British Museum. It also was from an unknown locality. From Gray's description we can infer that he really studied the species, as he gives more details than Lamarck. As he says: "skeleton netted with scattered small rugose spines, and series of large clavate spinulose spines", it may be taken for granted that his species is identical with *M. clavigera*.

Lamarck compared his *A. clavigera* only with *Pentadactylosaster reticulatus* Linck, p. 34, tab. 9 and 10, no. 16, which was an Italian seastar and certainly no *Mithrodia*, as Linck's figure shows. It was copied in the *Encyclop. Méth.*, pl. 112 fig. 1-2. In the *Supplément to the Enc. Méth.* (1824, p. 121, no. 29) Linck's species is quoted as a doubtful synonym. Gray gives *A. clavigera* as well as *P. reticulatus* Linck as doubtful synonyms of his *M. spinulosa*. When Müller & Troschel (1842, p. 18) named the species of Linck *Asteracanthion linckii*, they included *M. spinulosa* Gray as a synonym, which was a reason for Gray (1866, p. 2) to quote *A. linckii* as the only non-doubtful synonym of his *M. spinulosa*. This is an accumulation of errors, which, however, has no further importance.

Ophidiaster echinulatus Müller & Troschel (1842, p. 32) appears according to the description to be the common *M. clavigera*, and is proved to be so by the animals from the Leiden Museum referred to by them. They are mentioned above in the list of species at hand from the Australian Sea. One may be designated as the type, the other as the cotype of *O. echinu-*

latus. The type is a younger specimen with visible meshwork and small tubercles, the cotype an older well-preserved one with heavy tuberculation. The description of Müller & Troschel was translated by Dujardin and Hupé (1862, p. 363), who obviously amplified it with the Paris specimens of Müller and Troschel at hand. These Paris specimens have disappeared from the collections of the Muséum National.

The type of *Heresaster papillosus* Michelin (1844, p. 173 and 1849, p. 19, pl. 9), from Mauritius, is preserved in the Paris Museum. His was a beautiful medium-sized specimen. His figure indicates the reddish colour of the back, with darker bands across the arms. It was described above. It is dry and of a light chestnut brown colour.

The animals which Martens (1866, p. 59) described as *Echinaster echinulatus* from the Leiden Museum, were also examined by us: the four specimens from Larantuka on the island of Flores. They all belong to *M. clavigera*, as do the specimens from the Moluccas, which he mentions as seen in the Amsterdam Museum (see above in our list); they were mentioned again by Sluiter (1895, p. 63). His observation "Scheibe ohne Stacheln" is wrong, as only one specimen from the Moluccas shows no clear spines on the disk and this is a badly preserved specimen, from which the spines may have been broken off. The number of fan spines is not 5-6, but as usual 6-12, mostly 10-11. Perhaps the letter "M" indicates that Martens possessed a specimen from Larantuka himself, to which R 85 mm and other characters might refer.

Ed. Perrier (1869, p. 251, under *Ophidiaster echinulatus*) searched in vain for the pedicellariae. In 1875 (p. 378, under *Mithrodia clavigera*) he gave as his opinion that all the above mentioned animals belong to one species, and he repeated this in the second part of his work (1876, p. 257), including even *M. Bradleyi*. He refers to animals from Mauritius collected by Péron and Lesueur, which are the animals mentioned above as preserved in Paris under the name *Scytaster subulatus*. Ed. Perrier mentions the fact that the Sandwich specimens have no mid-dorsal spines and were considered by Horace Mann as of another species than those from Mauritius (Mann named the Sandwich specimens *M. clavigera* and the Mauritius specimens *M. spinulosa*). Later on Perrier seems to have changed his mind, for the Paris collections contain the animals which he mentions as being collected by Bailleu at the Sandwich Islands and they are labelled *M. Bailleui*, a name which has not been published. They proved to belong to *M. Fisheri* (see below).

Möbius (1880, p. 50) observed the living *M. clavigera* in Mauritius and makes the interesting remarks: "Übertrifft alle anderen Asterien des

Riffes durch seine Grösse.... Da die Arme sich nach alle Richtungen krümmen können, so ist dieser Seestern fähig sich an allen Stellen des Riffbodens festzuklammern”.

The specimens of Studer (1885, p. 26) were from Mauritius and hence probably belong to *M. clavigera*, like those of Loriol (1885, p. 13) from the same habitat. Loriol was the first to give a really adequate description of the species and he compared his specimens with animals from Samoa (Iles des Navigateurs) which he found to be identical, though they had less apparent, smaller tubercles and more widely spaced ventral spines. He also compared *M. Bradleyi* from Lower California.

Hayashi (1938 a, p. 216) gives an excellent account of 2 specimens from the Ryukyu Islands, one from Yaeyama Is. and one from Inanza Reef, Okinawa Is. In the same year (1938 b, p. 287) he describes 4 large specimens from the vicinity of the Seto Marine Biological Laboratory. He points out the fact that 2 of the latter have reduced spines, while the knobs on the abactinal ridges are more numerous, the papular areas smaller, while the granulation of the spines is less coarse. The colour in life is grey with darker, large irregular transverse patterns, or grey with irregular transverse blackish and pale pinkish red patterns. His figures show animals that fall within the variation of our specimens.

It is most probable that the following authors refrained from a description because Perrier and Loriol had emphasized the great variability of *M. clavigera*: Sladen (1889, p. 539) (Hab. Kandavu, Fiji Islands, on the reefs, specimen in the British Museum); Sluiter (1889, p. 298) (Hab. Mauritius, his specimen is in the Amsterdam Museum and described here, and is a typical medium-sized *M. clavigera*); Sluiter (1895, p. 63) (Hab. Moluccas, see above; New Ireland, a specimen described here); Döderlein (1896, p. 322 (46)) (Hab. Ambon); Bell (1902, p. 277) (Hab. Suvadiva, Maldive Islands, 30 fathoms, on hard bottom); Ludwig (1905, p. 215) (Hab. Reef of Fakarava, Paumotu Islands, R 115 mm, R : r 12.78, anatomical remarks!). The specimens recorded by Bell from the Loyalty Islands (1889 p. 138) and from Wasin, Zanzibar (1903, p. 246), are found upon re-examination to be of *Echinaster callosus* Marenzeller. Ives' specimen (1890, p. 171) is from Oahu and hence probably a *M. Fisheri*. The specimen of Tortonese (1937, p. 96) is from an unknown locality.

Fisher (1906, p. 1095) re-opened the species problem in this genus by pointing to the fact that the Hawaiian *Mithrodias* are different from *M. clavigera*. He had only one *M. clavigera* from the Fiji Islands for comparison and considered the Hawaiian animals identical with *M. Bradleyi*.

As stated below, they are rather to be considered as a separate species, *M. Fisheri*, an opinion which Dr. Fisher now also shares, as he wrote to one of us (H. E.) October 14, 1946: "I agree with you that the Hawaiian species is not *Bradleyi*. My identification of the Hawaiian specimens as *M. Bradleyi* in my Hawaiian report was due to insufficient material for comparison, that of *M. Bradleyi* being little and poorly preserved, and to Ed. Perrier's opinion as quoted on p. 1096. I now have examined in the U. S. Nat. Mus. two *M. clavigera* (Takarava, Paumotu Is., coll. Albatross; Mauritius, coll. Möbius). The large specimen of Mauritius (R 184 mm) is devoid of large abactinal spines but has a great number of small spines or tubercles (covered with conical granules). There are very many more in the Takarava specimen, which has in addition to these secondary spinelets (seated on secondary connecting plates) from 10 to 15 additional primary spines arising from primary nodal plates. Of pedicellariae I can not find any in *M. clavigera* from Takarava (a favorable specimen). The Mauritius specimen is not so well preserved". Dr. Fisher suggests that a "forma" having the small dorsal spines of Holly's type of *M. Fisheri* and of his "peculiar specimen" (see below) occurs also in *M. clavigera* as an equivalent forma.

Geographical Distribution (fig. 12). Madagascar, Mauritius, Zanzibar, Maldive Islands, Red Sea, Java, Flores, Timor, Moluccas, Banda, Ambon, Borneo?, Philippine Islands, Macclesfield Bank, Japan, New Britain, New Caledonia, Loyalty Islands, Fiji Islands, Society Islands, Paumotu Islands, Marquesas Islands¹⁾.

***Mithrodia victoriae* Bell, 1882**

(Fig. 5; Pl. IV)

Mithrodia victoriae Bell, 1882, p. 123, pl. 6 fig. 2 (not 3).

2 incomplete specimens Victoria Bank, off Brazil, 39 fms., bottom dead coral, British Museum, "Alert" collection, reg. no. 79.8.19.97 (R ca. 32, 25 and 21, r 5, breadth of arm at base 4 mm, R = 4-6 r; R ca. 29, r 4, br 4, R = 7 r). See Pl. IV.

? 1 specimen Brazil, purchased Frank, Mus. Leiden no. 730 (R 85, 65, r 10, br 11 mm, R = 6½-8½ r).

Were it not that the two small and incomplete "Alert" specimens (pl. IV)

1) If the following species, *M. victoriae*, really proves to be a synonym of *M. clavigera*, this species shows a most curious distribution: Indo-West Pacific and coast of Brazil. The genus is unknown from the West Indies and on the Pacific Coast of tropical America we find a separate species, *M. Bradleyi* (see fig. 12).

are the only ones known from the Atlantic (except perhaps for one from the Leiden Museum) they might well be included in *M. clavigera*, for there appear to be no essential differences except that the skin of these specimens is soft. Despite its softness it is raised into rugosities, small on the trabeculae, large on the spines, such as the granules cause in *M. clavigera*; embedded in the skin are numerous spicules which with age might have developed into granules and tubercles (see below). The specimens are preserved in spirit and are faintly green in colour with numerous light speckles caused by the rugosities of the skin. Each has three arms remaining. Some of the papulae are darkly pigmented. The arms are slightly constricted at the base, rounded in section, and tapering. The spines are elongated cones.

Bell gave as the distinguishing features from *M. clavigera* (1) the rarity of the papular spaces on the abactinal surface, (2) the proportionally smaller spines, and (3) the absence of a row of spines between the ventro-marginal series and the abactinal rows. As for the papular spaces, one wonders if Bell had intended to write "actinal" and not "abactinal" for, earlier in his account, he had described the papulae on the actinal surface as rare. However this may be, the incidence of occurrence is not markedly different in these specimens and in specimens of *M. clavigera* of similar size. The spines do not as a whole appear to be proportionally smaller; and they bear in size much the same relationship to one another as those of *M. clavigera*. Bell was in error in denying the presence of an actinal row of spines: it is present though the spines comprising it are of very irregular occurrence and number and are few compared with those of *M. clavigera*. There are from three to eleven on one side of one arm. Where the number is low there are, of course, long gaps without them and these are usually in the proximal part of the arm. When the number is higher they tend to stand opposite gaps in the next row. They are of unequal size, the smallest only half as long as the largest; and the largest are only about half as long as those of the next, the infero-marginal, row. Occasionally two stand side by side. There are nine to eleven spines in the infero-marginal row, each about 2 mm long; four or five in the supero-marginal row which are slightly longer; and five or six in the mid-dorsal row, a little smaller than those of the supero-marginal row.

There are six or seven furrow spines forming a rounded fan.

The skeleton appears similar to that of typical *clavigera*. Tubercles are not developed on the trabeculae. Although the skin is soft it is, as stated above, rich in spicules. They are of two kinds (fig. 5). There are Holothurian-like tables, with broad perforated bases and richly spiny turrets,

placed in one layer, and so thickly so that the base of one is nearly touching those of the tables surrounding it. (They are similar to the tables found in *M. clavigera*). In addition there are a very few large dense cone-shaped masses. They differ from those of *M. clavigera* in that their bases are not in

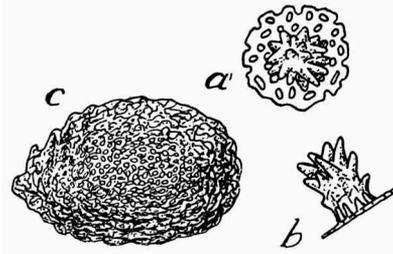


Fig. 5. *Mithrodia victoriae* Bell. Skin deposits. *a*, a table from above; *b*, a table from the side; *c*, conical mass. All \times ca. 69.

any way flattened: they are on the contrary strongly rounded; and in that they are not spiny on the outer side of the thinner end, their denseness is even throughout.

There are two or three papulae in each area on the disk, up to seven or eight in the larger areas on the dorsal side of the arms.

No pedicellariae have been detected.

A specimen of *Mithrodia* in the Leiden Museum (no. 730) purchased from Frank is labelled as of this species and as coming from Brazil. It is said that the locality cannot be relied upon as accurate. Its measurements are given above. It is dried and very brittle and three of its arm tips are broken off. It appears to be a typical *M. clavigera* of its size except perhaps that the actinal row of spines is more regular in the proximal part of the arm than is usual. It is richly supplied with pedicellariae especially on the actinal side. The skin deposits include cone-shaped masses such as are described above from the types of *victoriae* as well as cones with flattened bases such as are described for *M. clavigera*; and tables with their perforated bases in close juxtaposition.

This specimen, which may or may not come from Brazilian waters, adds to the difficulty of deciding the true status of *M. victoriae*; only more material can do that. In the meantime it is certainly safer to regard it as a distinct species. Compare footnote p. 18.

***Mithrodia Bradleyi* Verrill, 1867**
(Fig. 6-8; Pl. V, VI)

Mithrodia Bradleyi Verrill, 1867, p. 288; 1871, p. 575; Loriol, 1885, p. 14; Fisher,

1906, p. 1095 (the two specimens from the Gulf of California only); Verrill, 1914, pl. 107 fig. 1 (type); Steinbeck & Ricketts, 1941, p. 380, pl. XXIII fig. 3 (fide Caso); Caso, 1944, p. 253, pl. VI figs. 1, 2, pl. VII figs. 1, 2.

? *Mithrodia Bradleyi* Fisher, 1928, p. 491; Clark, 1910, p. 336.

non *Mithrodia Bradleyi* Fisher, 1906, p. 1094, 1096; 1925, p. 82; Ely, 1942, p. 27.

1 specimen Gulf of California, leg. H. ten Kate (Museum Leiden no. 723) (R 128, 128, 128, 124, 115, r 10-12, breadth of arm at base 13 mm; R = $9\frac{1}{2}$ -13 r).

1 specimen La Paz, Lower California, shallow water (Hopkins Marine Station) (R 183, ..., 179, 179, 167, r 15, br 15 mm, R = $10\frac{1}{2}$ -12 r). See pl. V and VI.

1 specimen La Paz, Gulf of California, British Museum (Natural History), reg. no. 70.8.22.40 (from A. E. Verrill, collected by J. Pedersen) (R 118, 116, 110, 110, 108, r 14, br. 17 mm, R = $8-8\frac{1}{2}$ r).

1 specimen Gulf of California, collection Cotteau, 1894, Muséum Paris (R 154, 142, 148, 136, 151, r 15, br. 16 mm, R = 9-10 r).

Authors agree that *M. Bradleyi* is a distinct species. At first sight it shows a different facies (pl. V and VI); as Lorient puts it: "Ses bras sont plus effilés vers l'extrémité", they taper more evenly and regularly from beginning to end than in the other species where they are more cylindrical. The colour of the dried specimens is a lighter brown and the large spines seem to be less prominent; the tubercles, however, are more conspicuous. An examination of the skeleton shows that in *M. Bradleyi* many rods are destitute of tubercles. While in the other species the rounded ossicles are most often spineless, they can nearly all bear spines or tubercles (the difference in size and form between spines and tubercles being less, especially in large specimens) in *M. Bradleyi*. The abactinal spines are present on the disk; and on the rays, either as a middorsal row or irregularly distributed. They are more obvious in the young specimens. As has been said, *M. Bradleyi* Fisher of the Hawaiian Islands must be distinguished as a separate species: *M. Fisheri* Holly.

The type has been figured by Verrill (1914, pl. 107 fig. 1).

Description of the first two specimens in the list above. Both have the flat arms of dried specimens (pl. V and VI) and are rather badly preserved. The Leiden specimen has lost nearly all its abactinal spines. R : r is $9\frac{1}{2}$ -13, and $10\frac{1}{2}$ -12 respectively in the two specimens. The arms are slightly constricted at the base, a character usually more prominent in dried specimens. The arm angles are rather sharp, except when two arms stand wide apart. The spines are clearly spiniform (fig. 6), sometimes more cylindrical. The number of adambulacrals is about the same as in *M. clavigera* and *M. Fisheri* of the same size, 123 and 130 respectively in the two specimens. In the adambulacral armature there is no difference between this and the other species that can be used to distinguish them from one another,

though the median 2-3 fan spines are relatively longer (fig. 6 *g'*, *m'*) and all the fan spines seem to have a slightly broader base. The size diminishes more abruptly and hence the number of fan spines tends to be less, about 8 (7-10), the outer ones being very small indeed and they are often missing.

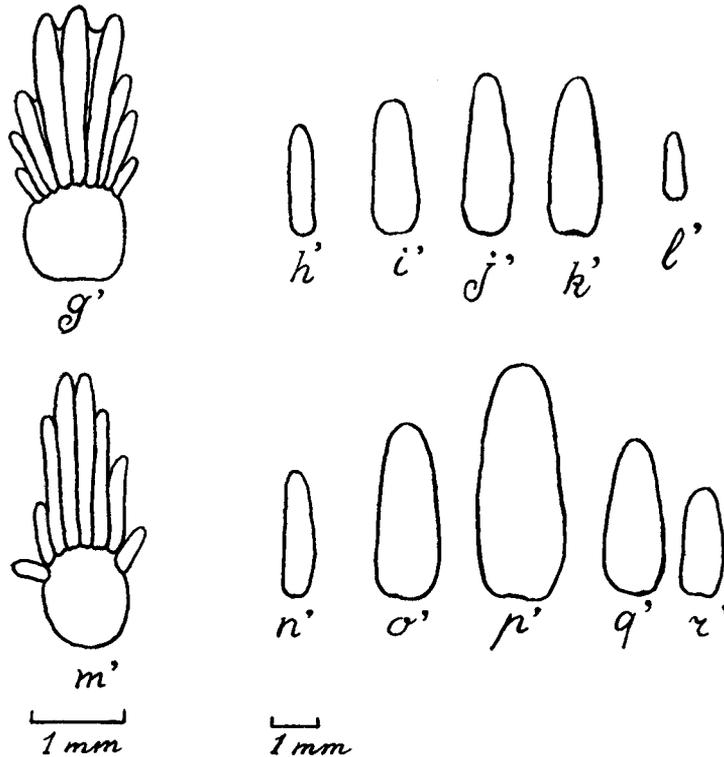


Fig. 6. *Mithrodia Bradleyi* Verrill, La Paz, Hopkins Marine Station. *g'*, fan; *h'*, adambulacral spine; *i'*, ventral spine; *j'*, infero-marginal spine; *k'*, supero-marginal spine; *l'*, mid-dorsal spine.

Idem, Gulf of California, coll. Ten Kate, Mus. Leiden. *m'*, fan; *n'*, adambulacral spine; *o'*, ventral spine; *p'*, infero-marginal spine; *q'*, supero-marginal spine; *r'*, mid-dorsal-spine.

For scales see lines of 1 mm; fans twice as large as other spines.

The fan varies greatly and its appearance depends on its position along the arm.

The second or ventral row of spines (fig. 6 *i'* and *o'*) (the adambulacral spines (fig. 6 *h'* and *n'*) forming the first row) is irregular, containing in our two specimens 20-30 spines, about one at every fifth adambulacral spine, but with many gaps and irregularities. They are usually more numerous at the arm base. The third or infero-marginal row (fig. 6 *j'* and *p'*) alternates

in general with the second. There is no row of spineless rounded ossicles between the ventral and infero-marginal row. It must be remarked that there is less difference in size than in *M. clavigera* between the spines of the ventral and the infero-marginal row; those of the ventral row are slightly longer and those of the infero-marginal row slightly shorter, compared with *M. clavigera*. Yet here also the spines of the infero-marginal row are the largest.

The fourth or supero-marginal row of spines (fig. 6 *k'* and *q'*) is, again just as in *M. clavigera*, very irregular in size, number and frequency. While, however, in *M. clavigera* large spines are present only on a few of the rounded pieces of the dorsal side and mostly on mid-dorsal ones, we find in *M. Bradleyi* from La Paz a spine on nearly every rounded ossicle of the dorsal side, usually of the size of the tubercles, among which they accordingly are not conspicuous. Exceptionally and irregularly some are enlarged to form a small, often cylindrical spine. On the disk the same holds good. In the other specimen, of the Leiden Museum, which has lost nearly all its abactinal spines, the rounded ossicles with strong bosses indicate that the spines were present on the disk and in a carinal series. Also a few are seen between this and the supero-marginal series. The few mid-dorsal spines that have been preserved are only slightly larger than the spiniform tubercles (fig. 6 *l'* and *r'*); there is less difference here than in Verrill's type specimen. While in *M. clavigera* nearly every rod bears a tubercle it is curious to note that in *M. Bradleyi* many rods are spineless, and yet, because the tubercles are longer and more spinelike, the whole gives a more prickly impression (but not so regularly tuberculated as in *M. Fisheri*).

The madreporite could not be detected in the larger specimen until after a long search; it is not surrounded by special tubercles in either specimen.

The skeleton (fig. 7) is more compact than in *M. clavigera*, but less so than in *M. Fisheri*. It is much more irregular than in *M. clavigera*. The first row of rounded ossicles, bearing the ventral row of spines, next to the adambulacrals, are of very unequal size, while the connecting rods are often missing. The distance between the rounded ossicles is much less and there is no row of spineless ossicles between the ventral and the infero-marginal row of spines (i.e., the first and second row of ossicles). The third row of ossicles bears the fourth or supero-marginal row of spines. In our specimens regularity fails on the dorsal side. In the smaller specimens a mid-dorsal row may be distinguished, while between it and the supero-marginal row only one row of ossicles seems to be present. In the larger specimen no distinct mid-dorsal row is distinguishable; 5 or 6 irregular

“rows” of ossicles seem to be present between the two supero-marginal rows. (Compare Verrill's pl. 107 fig. 1 of the type, where mid-dorsal spines are distinct and probably one row of ossicles present between it and the supero-marginal row). On the dorsal side most rounded ossicles have a pit for a larger or smaller spine. Often the rounded ossicles have, beside a

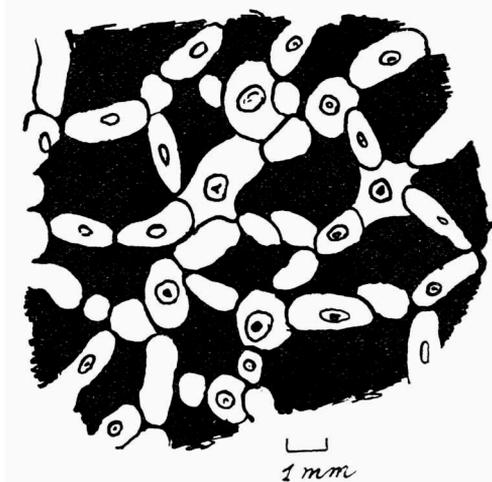


Fig. 7. *Mithrodia Bradleyi* Verrill, La Paz, Hopkins Marine Station. Skeleton as it is revealed after treatment with Eau de Javel.

rimmed pit for a spine, two or more smaller pits for the tubercles. It is curious to note that, perhaps as a consequence of the density of the ossicles and the large size of the tubercles, so many rods are spineless, and have no pit for a tubercle. It is obvious that the skeleton of *M. Bradleyi* is different from *M. clavigera* of the same size. It differs also from that of *M. Fisheri*, in which it is more compact, the ossicles are more rounded, less flat, while most rounded ossicles on the dorsal side are spineless.

The pedicellariae (fig. 8) vary in place and in number as usual, but they seem to be more numerous. In the smaller specimen they occur in great numbers along the outer side of the adambulacrals, as also very frequently in the dorsal papular fields. In the large specimen they were only found along the adambulacrals. They have about 6 teeth. As in *M. clavigera* they stand on loose ring-shaped, rather high, small ossicles.

The skin-covering is essentially the same as in *M. clavigera*, but the calcareous bodies are much larger on the trabeculae and less flat on the spines, being on the whole much more homogeneously spiniform. The naked innerside of the adambulacral spines is as in *M. clavigera*. Under the microscope no difference with *M. clavigera* was found.

Notes on the British Museum specimen. The label is inscribed "type" but bears the printed words "coll. — J. Pedersen, From A. E. Verrill". It is therefore taken to be not the type but one of the two specimens from La Paz mentioned in the footnote on p. 209 of Verrill (1869). It is dry and in very poor condition, the dorsal surface being entirely denuded of spines and tubercles. Nevertheless it has quite a different facies to *M. clavigera*.

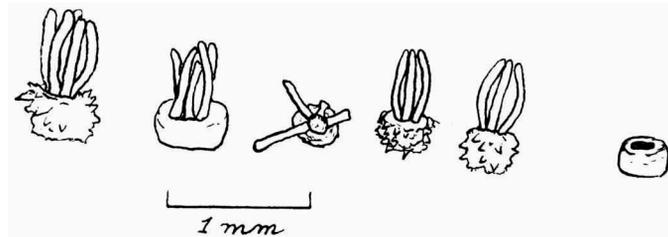


Fig. 8. *Mithrodia Bradleyi* Verrill. Pedicellariae from the side and from above, one with denuded ossicle, all from Gulf of California specimen, Mus. Leiden; an isolated ossicle of the La Paz specimen, Hopkins Marine Station.

It is smaller than those described above. The number of adambulacrals is about 114; of fan spines there are 7 proximally, 5 distally. So far as other characters go, and in so far as they can be seen, the specimen agrees on the whole with those described above. The abactinal skeleton is exposed and seen to be compact and irregular. One arm, better preserved than the others, shows in the proximal half six rounded ossicles raised into strong bosses running down the mid-line. They make it clear that this arm bore a distinct row of spines down the centre (as in the type figured by Verrill, 1914, pl. 107 fig. 1). There appears to be only one row of rounded ossicles present between this mid-dorsal and the supero-marginal rows, but it is difficult to be certain of it. Most of the rods of the abactinal skeleton show, by their scars, that they bore only one or two tubercles each; many bore none.

Pedicellariae are very numerous around the dorsal papular areas; although the teeth have gone, the basal pieces remain. They are present in smaller numbers in papular areas elsewhere and outside the adambulacrals.

Notes on the Paris specimen. The specimen is dry, completely flattened and in a very bad state. It does not permit of an exact examination, particularly of the number and arrangement of the spines. The fans so strongly resemble those of *M. clavigera* that it appears possible that it is of that species, and that the label gives the wrong locality.

Comparing this with the literature we find that Verrill (1867, p. 288 and

1871, p. 575) (the type being photographed later on, Verrill, 1914, pl. 107 fig. 1) gives $R:r = 7$ and 5-7 fan-spines in his specimen with R 109 mm from Panama, $R:r = 7$ and 6 fan-spines in the smaller of the two from La Paz. Loriol (l.c.) tries to enumerate the differences with *M. clavigera*. Of these we can confirm only the following: arms more evenly tapering; less difference between tubercles and spines on the dorsal side; granulation more rough; granules more spinelike. We can certainly not confirm his remark that in *M. Bradleyi* the number of fan-spines is greater than in *M. clavigera*, nor that the arms are broader and relatively shorter, while the naked field on the inner side of the large adambulacral spines is of varying extension in all three species.

The description Fisher (1906, p. 1095) gives of 2 specimens from the Gulf of California supports our opinion. As we have remarked, and as substantiated below, it is our opinion that Fisher's *M. Bradleyi* from the Hawaiian Islands (1906, p. 1094) is not identical with *M. Bradleyi* from California. Dr. Fisher agrees with us in this point and writes in his letter of October, 14, 1946: "I have examined in the U.S. Nat. Mus. a perfect specimen of *M. Bradleyi* collected in 1940 at Marcial Point, Lower California. There are several old *M. Bradleyi* from Lower California, dried before being preserved, that are of little value. There are also four *M. Bradleyi* from the coast of Colombia (R 70-80 mm). I agree with you that the Hawaiian species is not *Bradleyi* in which the skeletal ossicles are slenderer and the skeletal intervals are larger than in the Hawaiian species. Also *M. Bradleyi* has true major abactinal spines on disk; and on rays, either as a carinal (radial) series of upward of 8 (Colombia) or irregularly distributed between the 2 series of regular, spaced supero-marginal spines (Marcial Point, Lower California). The carinal spines in *M. Bradleyi* occur throughout all of R or are accentuated on the distal half, they are a juvenile character in *M. Fisheri* and an adult character in *M. Bradleyi*. On the adambulacral plates of *M. Bradleyi* (Marcial Point, Lower California) are rather numerous pedicellariae with 4 (sometimes 3 or 5) slender upright (perpendicular) spiniform jaws about 0.5 mm long. Also a few on actinal plates. Present also on Columbia specimens".

Caso's description (1944, p. 237) supports our views. She includes under "the ambulacral spines" the fan spines only; and describes what are obviously the pedicellariae as small spines ("espinas papulares"). For the number of fan spines she gives 6-7 in her small, 7-10 in her large specimen. Her (two) specimens had 12-18 spines in the ventral (second) row, 10-12 in the ventro-marginal (third) row. The supero-marginal (fourth) row is not mentioned, but shown in pl. VII fig. 1. She adds some new localities

in the Gulf of California: Puerto Refugio, Puerto Escondido, Punto Lobos. Her own specimens are from Mazatlan. R 108 and 55 mm, R = 6.7 r. The dorsal side in her figures is like in our larger specimen, but the spines are more cylindrical.

Geographical Distribution (fig. 12). Gulf of California and Lower California (La Paz, Marcial Point, Puerto Refugio, Puerto Escondido, Punto Lobos, Mazatlan), Panama, Coast of Columbia and probably Galapagos Islands.

It is an important point for the geographical distribution to know whether the specimens of Fisher (1928 p. 491, Galapagos Islands) and of Clark (1910, p. 336, Arica, Peru) belong here or to *M. Fisheri*. The beautiful photograph of the latter looks like *M. Fisheri*, but one would be induced from the geographical distribution to expect *M. Bradleyi* in Peru. Dr. Fisher wrote us: "I cannot find the specimen of *Mithrodia* from the Galapagos Islands. I have no doubt it is *M. Bradleyi*, as I found four specimens of that species from Colombia".

***Mithrodia Fisheri* Holly, 1932**

(Fig. 9-11; Pl. VII, VIII)

- Mithrodia* spec. Verrill 1867, p. 289 footnote.
Mithrodia clavigera Perrier, 1875, p. 381 (Kanaï, Iles Sandwich, par M. Rémy; des mêmes îles par M. Bailleu).
Mithrodia clavigera Ives, 1889, p. 171.
Mithrodia clavigera Sluiter, 1895, p. 63 (1 specimen New Ireland).
Mithrodia Bradleyi Fisher, 1906, p. 1094, pl. 36 fig. 1-2, pl. 37 fig. 1.
Mithrodia Bradleyi ("peculiar specimen") Fisher, 1906, p. 1096, pl. 37 figs. 2-3.
? *Mithrodia Bradleyi* Clark, 1910, p. 336, Pl. VI fig. 1.
Mithrodia Bradleyi Fisher, 1925, p. 82.
? *Mithrodia Bradleyi* Fisher, 1928, p. 491.
Mithrodia Fisheri Holly, 1932, p. 6, fig. 2.
Mithrodia Bradleyi Ely, 1942, p. 27, pl. 8.
Mithrodia Fisheri Ely, 1942, p. 28.
Mithrodia Bailleui Ed. Perrier, nomen nudum in coll. Mus. Paris.

1 specimen New Ireland (described by Sluiter, 1895, p. 63), Museum Amsterdam (R 124, 123, 124, 98, 104, r 12, breadth of arm at base 14 mm, R = 8-10½ r).

1 specimen Hawaiian Islands, French Frigate shoals, Tanager Expedition (described by Fisher, 1925, p. 82), Bernice P. Bishop Museum no. 716 (R 109, 97, 92, 101, 104, r 9-11, br 11 mm, R = 8½-12 r).

1 specimen Hawaiian Islands, Pearl and Hermes Reef, coll. T. Dranga, April 1927, Bernice P. Bishop Museum no. 674 (acc. no. 938) (R 80, 77, 72, 34, 56, r 9-10, br 10 mm, R = 7-9 r).

1 specimen Hawaiian Islands, purchased Cuming, British Museum, reg. no. 57.4.23.1 (R 248, 230, 233, 237, 223, r 25, br 30 mm, R = 9-10 r).

1 specimen Hawaiian Islands, coll. Cotteau 1894, Muséum Paris (Type of *M. Bailleui*

Ed. Perrier, nom. nud. in coll. Muséum Paris) (R 108, 101, 106, 105, 99, r 12, br 13 mm, R = 8-9 r).

1 specimen Hawaiian Islands, don. Agassiz, 1876, Muséum Paris (R 94, 91, 91, 92, 87, r 12, br 14 mm, R = 7-8 r). See Pl. VII.

3 specimens Hawaiian Islands, coll. Bailleu, 1874, Muséum Paris (R 242, 168, 228, 222, 224, r 22, br 25 mm, R = 10-11 r; R 166, 128, 152, 162, 81, r 17, br 19 mm, R = 9-10 r; R 207, 196, 195, 198, 204, r 21, br 25 mm, R = 9-10 r). See Pl. VIII.

1 specimen Philippine Islands, coll. Marche, 1882 (R 96, 49, 66, 94, 84, r 11, br 11 mm, R = 8-9 r).

1 specimen Hawaiian Islands, coll. Rémy, 1857. Two loose arms only, badly preserved.

Specimens of this species were described by Fisher (1906) as *M. Bradleyi*, but in our opinion his specimens are not identical with *M. Bradleyi* from California (see above). Holly (1932) described a sea-star as *M. Fisheri* which was obviously a poor specimen, regenerating the tips of all its arms. He identified it with Fisher's "peculiar specimen" (1906, p. 1096). It is our opinion that all these Hawaiian animals belong to one species, an opinion with which Dr. Fisher now agrees. His description of 1906 gives important particulars about the series of 36 specimens he could examine; we can only give some additions from the specimens at hand.

The Director of the Bernice P. Bishop Museum at Honolulu was so kind as to send us two specimens on loan. There was one in the British Museum and six in the Muséum National d'Histoire Naturelle in Paris (Pl. VII-VIII), all from the Hawaiian Islands. Moreover, the Paris Museum contained a specimen from the Philippine Islands, and the Amsterdam Museum one from New Ireland, which showed the characters of this particular species. Dr. Fisher gave us his recent opinion on the subject. One of our Hawaiian specimens was mentioned by him (1928, p. 82), the other is not the specimen photographed and described by Holly, though it is from the same locality.

Description of the first three specimens in the above list.

These animals are at first sight distinctive because their tuberculation is very regular and dense, while the dorsal spines are missing. They are sometimes present in young specimens (see below). The two Hawaiian specimens are of a light brown colour, the one from New Ireland is of a dirty grey. The smaller specimen has one arm in regeneration and one arm with a regenerating tip. The relation R:r ranges from 7 to 12. Most arms are slightly constricted at the base, the arm-angles somewhat less sharp than in *M. clavigera* and *M. Bradleyi*, even in specimens so fixed that a pair of contiguous arms lie close together and parallel to one another. Obviously the capacity to bend the arms in all directions is as well developed as in the other two species. The spines, which are well developed on the

ventral side only, are relatively thicker, shorter and more frequent (cf. Fisher, 1906, pl. XXXVII fig. 1 and Holly, l.c.). The number of adambulacrals is about the same as in individuals of the same size of the other species.

Every adambulacral plate has a spine and a fan. The second, ventral, row of spines is, though also irregular, much more developed than in the other species. Especially at the arm base there may be one at every second adambulacral or even less; an interval of 5 adambulacrals may be called an exception, though here also is found a great variability in the individuals and even in the individual arms of one specimen. There are 20-30 in the smallest specimens, about 32 in the middle-sized and 25-40 in the larger.

The third, infero-marginal, row of spines may alternate here and there with the second, but most often, especially at the arm base, there are many more second-row spines. In the smallest specimen 6-12 were counted on two sides of one arm and up to 20 on the other arms, 15-20 in the middle-sized specimen and an equal number in the larger.

The fourth or supero-marginal row consists of low spines, not much larger than the tubercles, which may account for their being not conspicuous in Fisher's "peculiar specimen" and in Holly's; from 5-12 in number according to the size of the animal.

Mid-dorsal spines are absent, at least they are not larger than the tubercles. The same is the case on the disk.

The madreporite is closely hemmed in by crowded tubercles and hence not easily detected.

The trabeculae show a dense covering of short thick thimble-shaped tubercles; without skin they look globular, never spinelike. This covering is very even and conceals the meshwork, thus giving the animals their typical facies. The fan-spines are from 10 — 11 in number in these three specimens. While in *M. Bradleyi* 2 or 3 spines are by far the largest, while the rest decreases in size rather abruptly, there are here 4 or 5 larger spines, diminishing more evenly in size, even more so than in *M. clavigera*.

As in the other species the skin covers the whole skeleton. It is armed with granules which are more coarse than in the other species, being in reality small spinelets; they are small on the papular fields, slightly enlarged on the trabeculae and strong and bristling on the tubercles and the spines. The skin is naked only on the fans and on the inner side of the adambulacral spines. While on the tips of the spines the granules are slightly flattened (though less than in *M. clavigera*), they tend to be more of one size here. After treatment with Eau de Javel cones and tables were found; they seem to afford no distinguishing characters between the species.

Fisher (1925) described pedicellariae as being found on middle-sized specimens, especially between the adambulacrals and the first row of spines, and as being provided with 4 pincers. We also find them (fig. 9) in a similar position in our specimen of medium size as well as on the dorsal surface of its disk and of the proximal parts of its rays. They appear to be missing from the small specimen. In the larger specimen they are as Fisher described them and are very difficult to detect (see Fisher's remarks below). Only one was found on the dorsal surface, it was of the usual size. The small ossicles bearing the pedicellariae are as described for *M. clavigera*.

The skeleton is built on the same principle as in *M. clavigera*, but there are no dorsal spines or they are of the same size as the tubercles (as may be deduced from the fact that many of the rounded ossicles of the dorsal

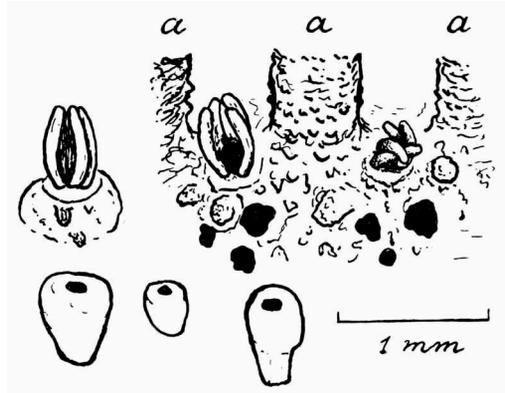


Fig. 9. *Mithrodia Fisheri* Holly. Pedicellariae in situ from the middle-sized specimen, Hawaiian Islands, Bernice P. Bishop Museum no. 716, and isolated ossicles from the New Ireland specimen, Mus. Amsterdam. *a*, bases of adambulacrals.

side have an impression, pointing to the adherence of a tubercle). The meshwork (fig. 10) is much narrower than in the other species, as the rods and rounded ossicles are larger; the rods thicker, more rounded, again nearly all bearing a tubercle. The whole is much more irregular and crowded. The papular fields are small, of irregular form and size. Here and there a spineless ossicle is present between the infero- and supero-marginal row. The distribution of the ossicles on the dorsal side is irregular, perhaps 4-5 "rows" may be present, but it is impossible to recognize them as such.

Note on British Museum specimen. It has arms twice as long as those of the largest described above and is considerably bigger than the largest

of Fisher's specimens. It is dried and was badly distorted in the process. The underside—spines and tubercles included—has been pressed into a quite flat surface. The upper side is well preserved and appears exactly similar to that of Fisher's "peculiar specimen".

It is difficult to make out the characters of the under surface but some of them can be seen. There are only 8 furrow spines as in Fisher's "peculiar specimen", not 10-11 as in the smaller specimens described above. The second row of spines is better developed, more numerous, than in the other species; the third row can in places be distinguished and fits in with the account given above. A fourth row cannot be traced and in this, as in other points, the specimen agrees with Fisher's "peculiar specimen".

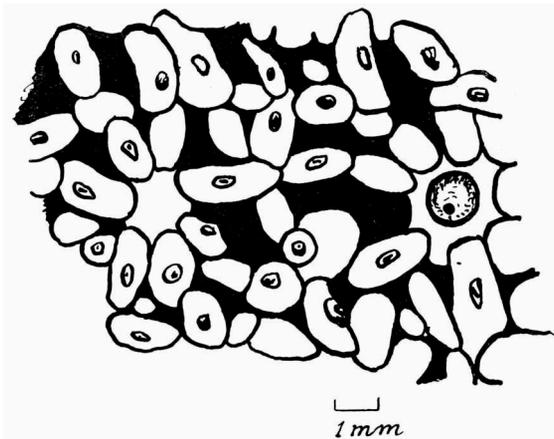


Fig. 10. *Mithrodia Fisheri* Holly, New Ireland, Mus. Amsterdam. Skeleton as it is revealed after treatment with Eau de Javel.

Pedicellariae are numerous on the actinal surface; three were found on the abactinal surface after long search.

Notes on the specimens of the Muséum Paris.

The arms are flattened or rounded, often constricted at base (pl. VII and VIII). The colour is blackish in the (alcohol) specimen with R 94, dark brown in that with R 108 (dry), dark red in that with 2 arms (coll. Rémy, alcohol), marbled in dark red dorsally and lighter red ventrally in that with R 96 (alcohol), brick red in one with R 207 (alcohol). The others are yellowish white.

The fan (fig. 11 *a'* and *m*) contains 9 spines of which 3-4 are large, the others evenly diminishing in size.

The number of adambulacrals varies from 82-170, according to the size

of the animal. For the relative size of the different rows of spines see fig. 11 *b'-f', n-q*.

The ventral or second row of spines contains from 20-30 in the smallest specimens, up to 50 in the middle-sized, and 28-70 in the larger ones. In the proximal part of the arms there is one to every adambulacral spine, farther on the relation is one to every 2 to 4 adambulacrals, and distally it becomes one to every 3 to 7. In the specimen from the Philippine Islands the relation along the whole arm is one ventral spine to 4 to 6 adambulacrals.

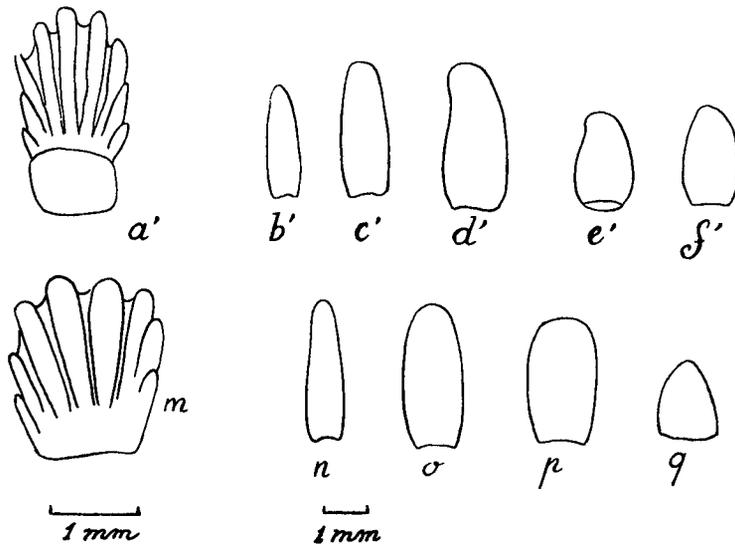


Fig. 11. *Mithrodia Fisheri* Holly, Hawaiian Islands, coll. Agassiz, Mus. Paris. *a'*, fan; *b'*, adambulacral spine; *c'*, ventral spine; *d'*, infero-marginal spine; *e'*, supero-marginal spine; *f'*, mid-dorsal spine.

Idem, Hawaiian Islands, large specimen, coll. Bailleu, Mus. Paris. *m*, fan; *n*, adambulacral spine; *o*, ventral spine; *p*, infero-marginal spine; *q*, supero-marginal spine (no mid-dorsal spine!).

For scales see lines of 1 mm; fans twice as large as other spines.

The infero-marginal row has 12-15 spines in the smaller specimens, 18-20 in the middle-sized and 20-30 in the largest specimens. In the largest and smallest specimens of Bailleu it is impossible to distinguish the infero- and supero-marginal spines from the tubercles, except in one arm of the largest specimen.

Seven to fourteen supero-marginal spines were counted. They are often inconspicuous among the large tubercles, especially in the larger specimens.

Mid-dorsal spines are present only in the specimens with R 108 (5-6 small spines in the proximal part of arm), and with R 94 (3-4 proximally);

in the rest they are totally absent. In the first, the granulation on the dorsal side is strong, the largest granules about the size of the mid-dorsal spines. There is a rather large spine in the middle of the disk. In the second, the dorsal granulation is stronger, but less dense, and the meshwork is more apparent. This specimen also has one spine in the centre of the disk, which is surrounded by 6 large tubercles (see fig. 11 *f'*). In the specimen with R 207 the skin on the dorsal side seems to be thicker than in the others. In the small specimen from the Philippine Islands the round arms taper more than in the others and the spines are more conical.

The spicules in the skin were not found to be different from those of *M. clavigera*.

Dr. Fisher wrote to us concerning this species in his letter of October 14, 1946: "I have examined numerous Hawaiian *Mithrodia* in the U.S. Nat. Mus. I agree with you that the Hawaiian species is not *M. Bradleyi* in which the skeletal ossicles are slenderer and the skeletal intervals are larger than in the Hawaiian species. Also *M. Bradleyi* has true major abactinal spines on disk; and on rays. Small specimens of *M. Fisheri* (that is the normal Hawaiian form, not Holly's "freak") with R up to 30 mm have a regular series of 4 or 5 prominent carinal spines and a spine on the primary central plate of disk. These 4 or 5 spines persist on the proximal half of ray of a specimen (stat. 3960) having R 65 mm. In other words, the distal-most spine is about 30 mm from center of ray and the distal half of ray is already assuming the adult state of spineless carinals. These carinal spines occasionally persist in large specimens, but are on proximal part of ray, whereas in *M. Bradleyi* they occur throughout all of R or are accumulated on the distal half. The carinal spines are therefore a juvenile character in *M. Fisheri* and an adult character in *M. Bradleyi*. I think this amounts to the same as you have said, with the exception of the few major carinal spines that sometimes occur proximally and are borne on primary lobed carinal plates, as I have determined by removing all the skin and granules. I do not think there are two species in the Hawaiian Islands, but one species having several formae. My idea is that a forma having the small spines of Holly's type and my "peculiar specimen" occurs also in *M. clavigera* (equivalent formae in the 2 species). For instance, the large specimen of *M. clavigera* (Mauritius, R 184 mm) is devoid of large abactinal spines but has a great number of small spines or tubercles (covered with conical granules). (There are very many more than in the Takarava specimen, which has in addition to these secondary spinelets, seated on secondary connecting plates, from 10 to 15 additional primary spines arising from

primary nodal plates). *Pedicellariae* I can not find in all specimens of *M. Fisheri*; they are present in the specimens from Stat. 4163 (R about 150 mm); Station 4169 (R 68 mm); Station 3960 (R 65 mm); much less numerous than in *M. Bradleyi*—at least much less visible. In a cleaned specimen of *M. Fisheri* (R 50 mm)—that is spines and granules removed—the pedicellaria-ossicles are seen to be small circular convex platelets with a hole in center. They occur on the sutures between adambulacrals and actinals; on border of actinal plates and papular areas; on border of intermarginal papular areas; and on border of some of the abactinal papular areas. I think the abactinal pedicellariae must have very short jaws or valves as I am unable to distinguish them among granules of uncleaned specimens". As has been said, we found them to be of the normal size on the dorsal side of our middle-sized specimen.

As has been mentioned above, Ed. Perrier (1875, p. 381) already pointed to the fact that according to Horace Mann the Sandwich specimens may be considered as a separate species (plus robuste que ceux de l'Île de France et manquant de la rangée dorsale de piquants), which in the Paris Museum were labelled *M. Bailleui*, a name which has not been published and hence is unavailable.

Verrill (1867, p. 289) mentions a specimen with remarkably long arms, nearly allied to *M. clavigera*, collected at the Sandwich Islands by Mr. Horace Mann.

About the Galapagos specimen (Fisher, 1928, p. 491) Dr. Fisher writes us "I cannot find the specimen of *Mithrodia* from the Galapagos-Islands. I have no doubt it is *Bradleyi*, as I found 4 specimens of that species from Colombia". We mention it here, and Clark's animal from Peru, to draw the attention to these important habitats.

Ely (1942, p. 27-28), revising the Hawaiian Asteroidea and Ophiuroidea, uses Fisher's and Holly's descriptions, distinguishing *M. Bradleyi* and *M. Fisheri* on characters which we consider to be of no specific value. He gives a beautiful photograph of a complete specimen ($\times 0.3$, so R about 144 mm), where the meshwork seems more apparent than usual, though the thimble-shaped tubercles and the small meshes prove it to be a typical *M. Fisheri*. In the proximal part of the rays the carinal tubercles are conspicuous, though of the same size as the surrounding ones. Moreover a detail of the ambulacral armament is given.

Geographical Distribution (fig. 12). Hawaiian Islands, New Ireland, Philippine Islands. As remarked under *M. Bradleyi* it is important to know

whether the specimens of Fisher (1928, p. 491, Galapagos Islands) and of Clark (1910, p. 336, Arica, Peru) belong here or to *M. Bradleyi*. Clark's photograph looks very much like *M. Fisheri*; yet he quotes the habitat with a mark of interrogation and the occurrence of *M. Bradleyi* on the coast of Columbia suggests the possibility that it may occur in Peru also.



Fig. 12. Geographical distribution of *Mithrodia Gray*.

● *Mithrodia clavigera* (Lamarck), ○ *Mithrodia victoriae* Bell (probably synonym of *M. clavigera*), × *Mithrodia Bradleyi* Verrill, + *Mithrodia Fisheri* Holly, ? see text (*Mithrodia Bradleyi* or *Fisheri*), Δ *Mithrodia gigas* Mortensen.

SYNOPSIS

Spines large, spiniform or cylindrical, sometimes bifid; middorsal spines present except in some large specimens. Tubercles small in young specimens, larger in the adult. Fan with 6-12 spinelets; the 3-4 central ones largest; the others evenly diminishing in size. Meshwork of skeleton with rather wide meshes; papular fields always clearly visible in young specimens, in larger ones the tuberculation may more or less conceal the meshwork. Rods of skeleton shuttle-like; skeleton rather regular; most rounded ossicles without a spine; most rods with tubercles. Granulation of skin rather fine, enlarged on tip of spines and tubercles, more coarse and spinous in the larger specimens. Pedicellariae of varying occurrence, with 4-7 pincers, often many along the external side of the adambulacral spines; but frequently missing. Arms cylindrical, tapering at tip. Colour brown-red, sometimes with darker rings round the arms. *Mithrodia clavigera* (Lamarck, 1816).

Strongly resembling *M. clavigera* of small size; differing from it in that the actinal row of spines is of smaller number, more irregularly arranged; and in that the skin is soft. (Known only from two small specimens from Victoria Bank, Brazil). *Mithrodia victoriae* Bell, 1882.

Spines spiniform, sometimes cylindrical, somewhat less conspicuous among the equally spiniform larger tubercles. The mid-dorsal spines are not much larger than the surrounding tubercles, often inconspicuous, though they are always present. Fan spines 7-10, the 2-3 central ones largest, the others more abruptly diminishing in size, the outer ones very small or missing. Meshwork with smaller meshes than in *M. clavigera*, though not so small as in *M. Fisheri*; papular fields rather concealed by the larger more spiniform tubercles. Dorsal rounded ossicles nearly all with a spine or spinous tubercle. Many rods without tubercles. Skin with larger granules on the trabeculae, less flat on the spines and tubercles, more homogeneously spiniform. Pedicellariae numerous, especially along the external side of the adambulacrals, and present also in dorsal papular fields; with about 6 pincers. Arms more evenly tapering from base to tip than in *M. clavigera* and *M. Fisheri*. *Mithrodia Bradleyi* Verrill, 1867.

Spines more cylindrical, thicker and shorter than in the other species; much more frequent ventrally. Middorsal spines only present in younger specimens, sometimes preserved in proximal part of arm in the adult, but always less conspicuous among the dense regular covering of thimble-shaped tubercles, which bristle with spinous granules. Fan with 6-11 spines, the 4-5 central ones larger, the others evenly diminishing in size. Meshwork very dense, papular fields usually concealed by the regular dense tuberculation. Rounded ossicles thicker, larger. Rods thicker, more rounded, much more heavily crowded. Most dorsal rounded ossicles without spines, nearly all rods with a tubercle. Granulation more spinous than in the other species. Pedicellariae variable; may be numerous, or not easily detected, sometimes missing; if present are found especially along external side of adambulacrals, but some also on the lateral and dorsal sides, usually with only 4 pincers. Arms cylindrical, tapering at tip. Colour uniformly vermilion or more brownish, sometimes with darker crossbars on the arms

Mithrodia Fisheri Holly, 1932.

No conspicuous spines as in the other species except for adambulacral row, which is similar. Disk beset with low, almost spherical, knobs with low, rounded, scaly prominences; they are present on other parts of the body

also; on the ventral side of arms they grow larger as they approach ambulacral furrow and pass evenly into outer adambulacral spines; fewer on dorsal side of arms, becoming scarce on distal half, replaced at tips of arms by large and conspicuous knobs 5 mm in diameter. Fan consisting of 4 spines only. Colour purplish pink, tips of rays more cinnamon red, below pale yellowish. Known from one specimen only; from 25-30 fathoms off Point Morgan, East London, South Africa (cf. Mortensen, 1935, p. 1).
..... *Mithrodia gigas* Mortensen, 1935.

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EXPLANATION OF THE PLATES

Plate I

- Fig. 1. *Mithrodia clavigera* (Lamarck), Macclesfield Bank, Admiralty, Brit. Mus., reg. no. 92.8.22.38, R 36 mm, abactinal view. Enlarged.
Fig. 2. The same, actinal view. Enlarged.

Plate II

- Fig. 1. *Mithrodia clavigera* (Lamarck), Minikoi, Maldives, Gardiner coll., Brit. Mus., reg. no. 1902.3.13.7, R 113 mm, abactinal view. Reduced.
Fig. 2. The same, actinal view. Reduced.

Plate III

- Fig. 1. *Mithrodia clavigera* (Lamarck), Kandavu, Fiji Islands, Challenger Exp., Brit. Mus., reg. no. 90.5.7.778 a, R 157 mm, abactinal view. Reduced.
Fig. 2. The same, actinal view. Reduced.

Plate IV

- Fig. 1. *Mithrodia victoriae* Bell, Victoria Bank, off Brazil, Alert Exp., Brit. Mus., reg. no. 79.8.19.97, type, R ca. 32 mm, abactinal view. Enlarged.
Fig. 2. The same, actinal view. Enlarged.

Plate V

- Mithrodia Bradleyi* Verrill, La Paz, Lower California, Hopkins Marine Station, R 183 mm, abactinal view. One arm treated with Eau de Javel to show the skeleton. Reduced.

Plate VI

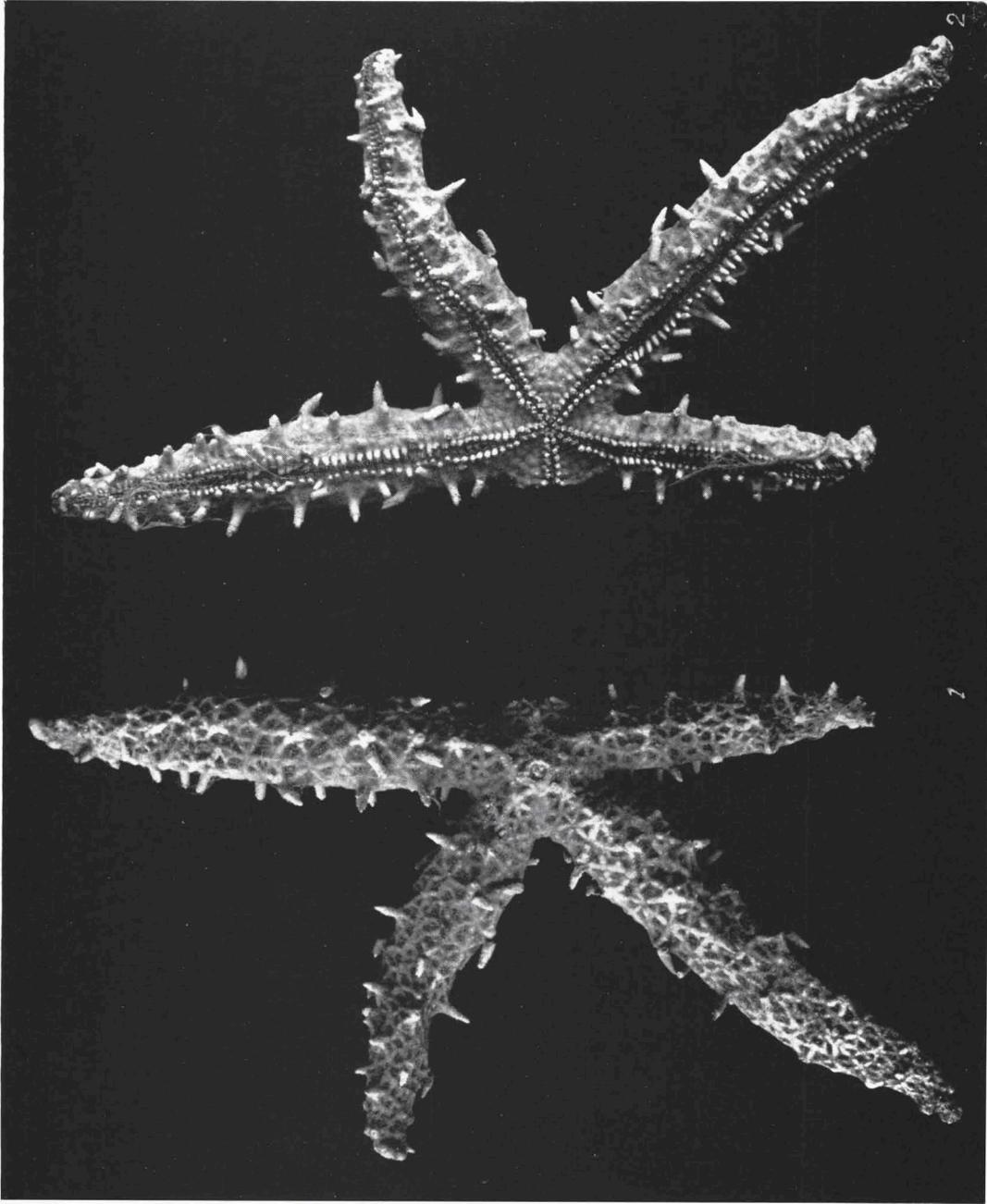
- Mithrodia Bradleyi* Verrill, La Paz, Lower California, Hopkins Marine Station, R 183 mm, actinal view. One arm treated with Eau de Javel to show the skeleton. Reduced.

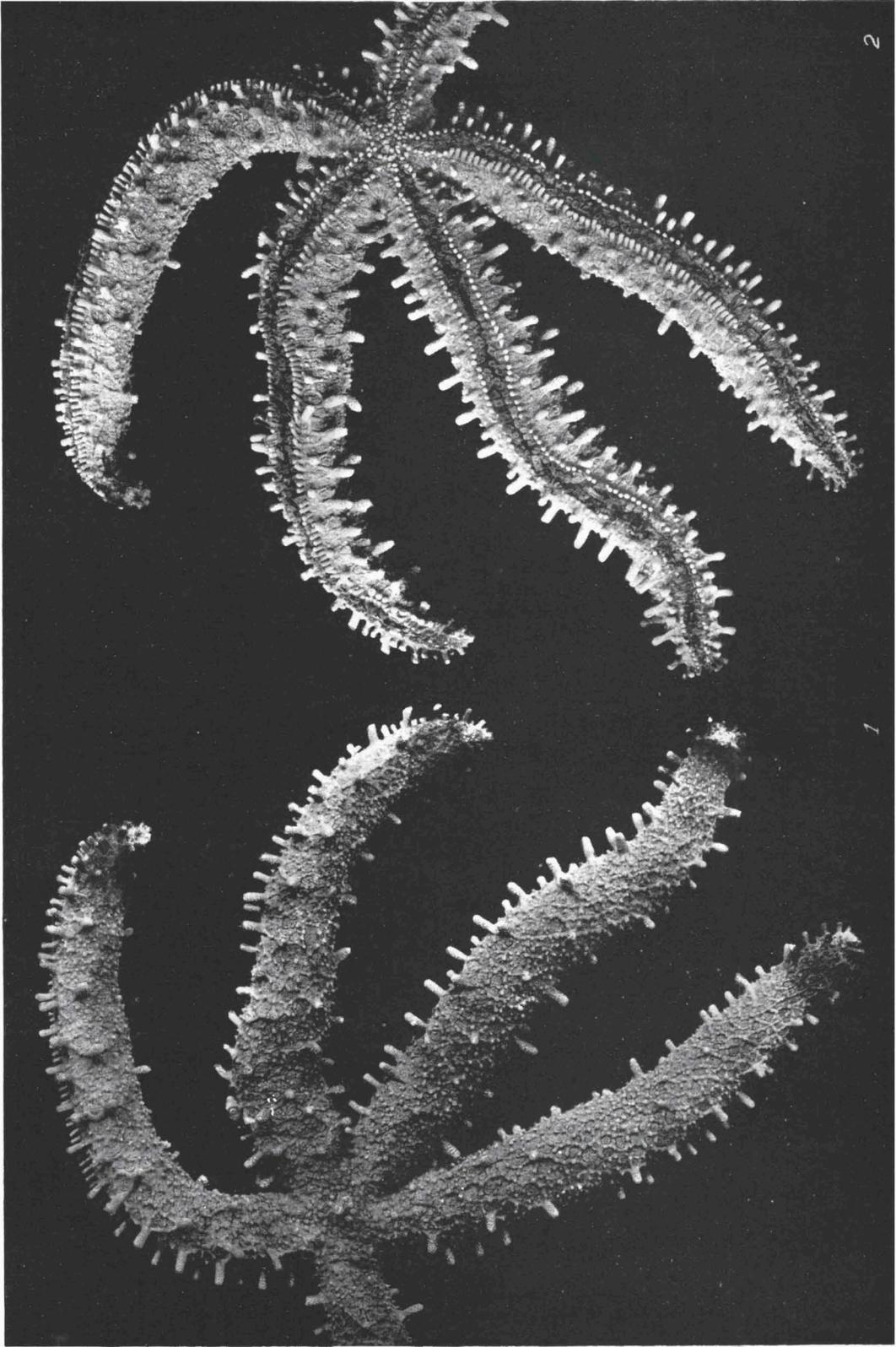
Plate VII

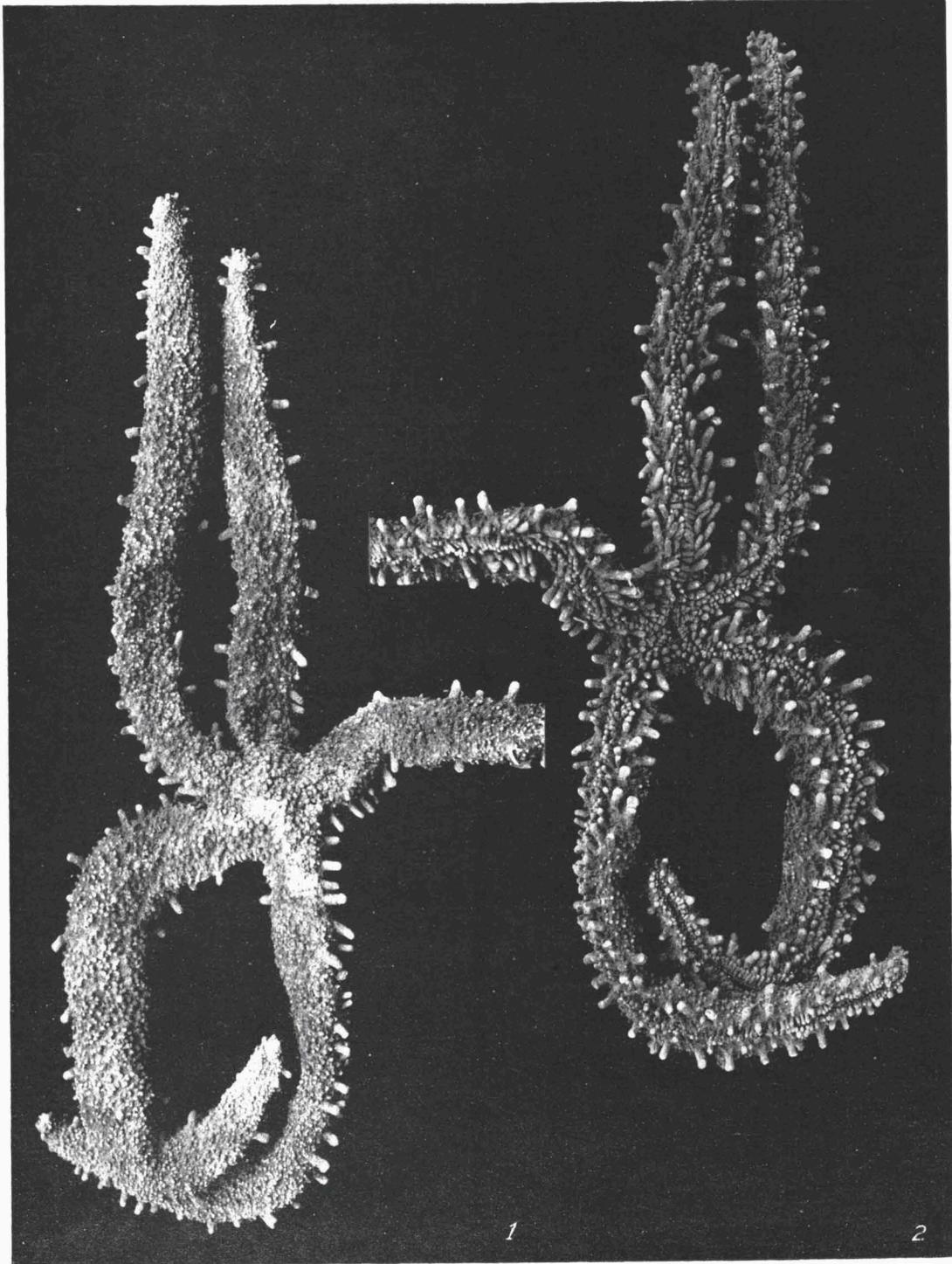
- Fig. 1. *Mithrodia Fisheri* Holly, Hawaiian Islands, coll. Agassiz, Mus. Paris, R 94 mm, abactinal view. One arm treated with Eau de Javel to show the skeleton. Reduced.
Fig. 2. The same, actinal view. Reduced.

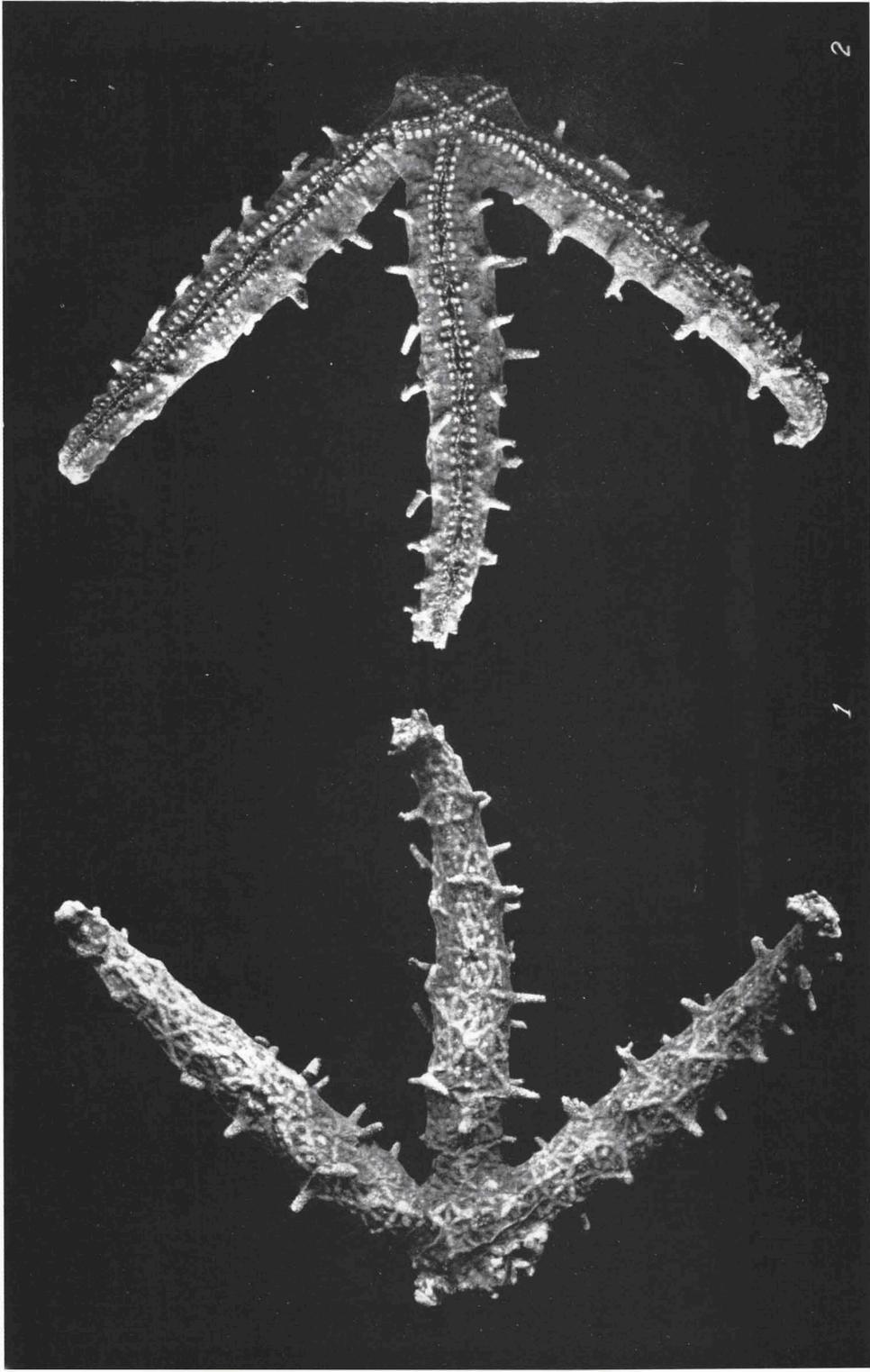
Plate VIII

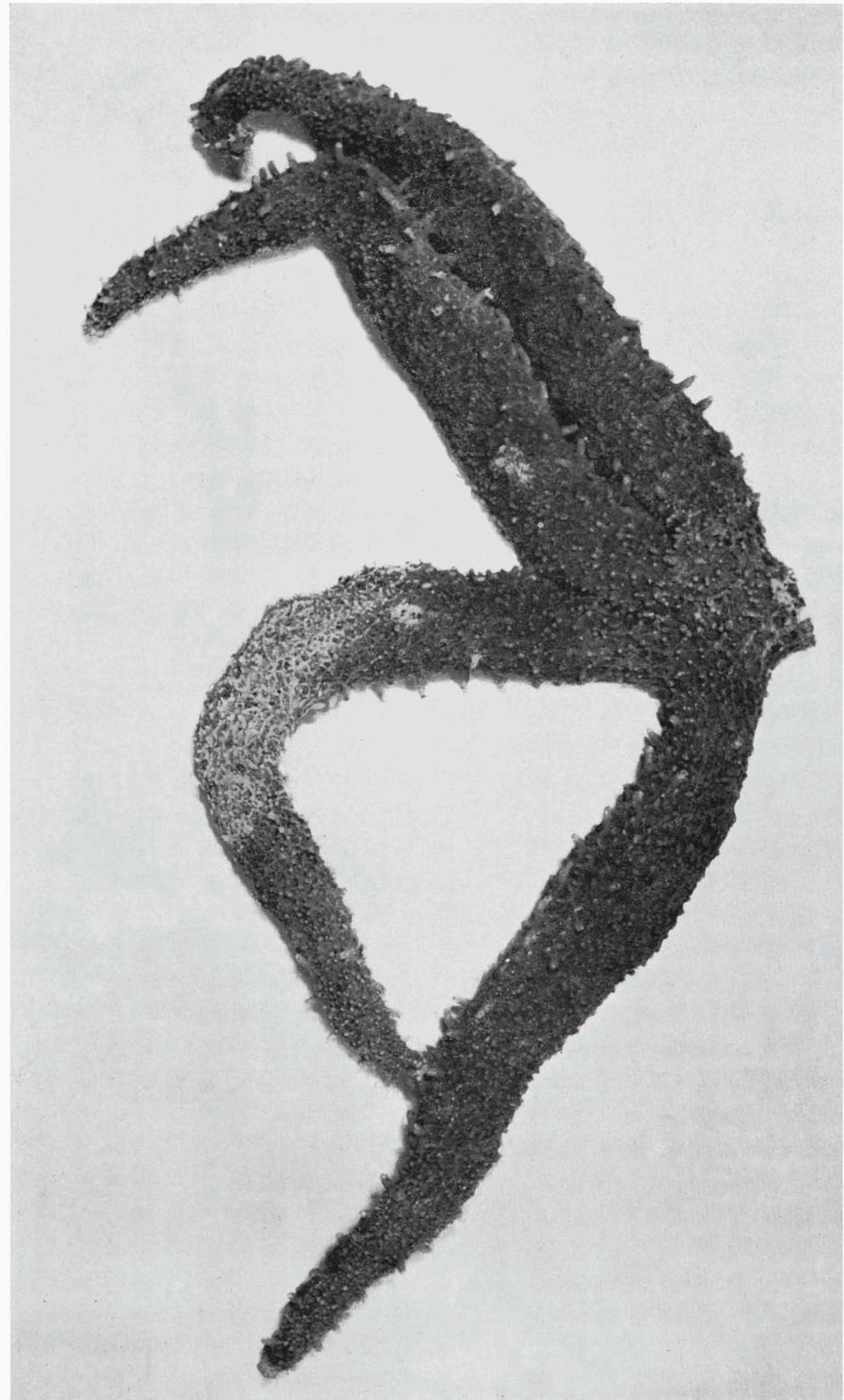
- Mithrodia Fisheri* Holly, Hawaiian Islands, coll. Bailleu, Mus. Paris, R 207 mm, abactinal view, one arm showing the actinal side. Reduced.

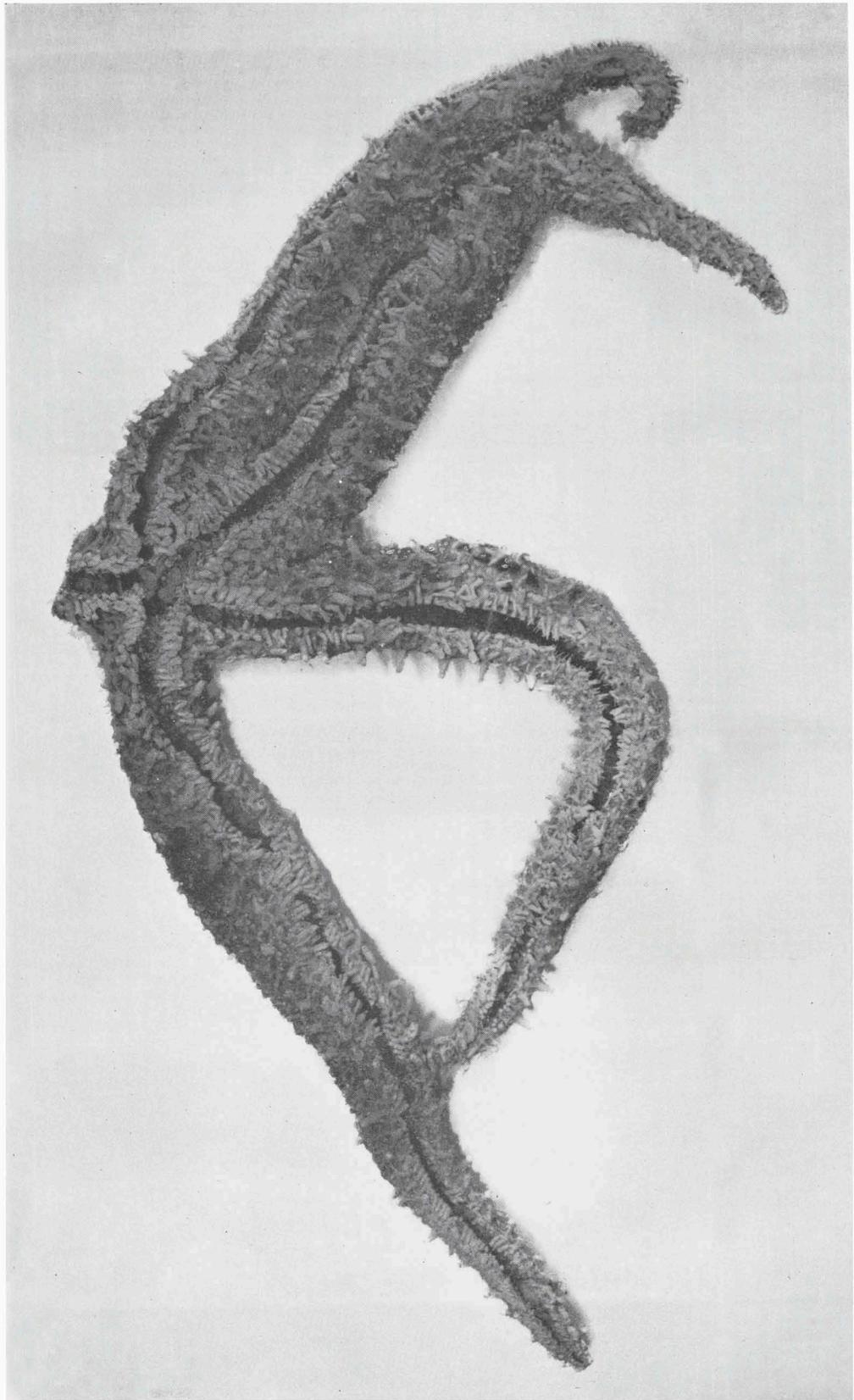


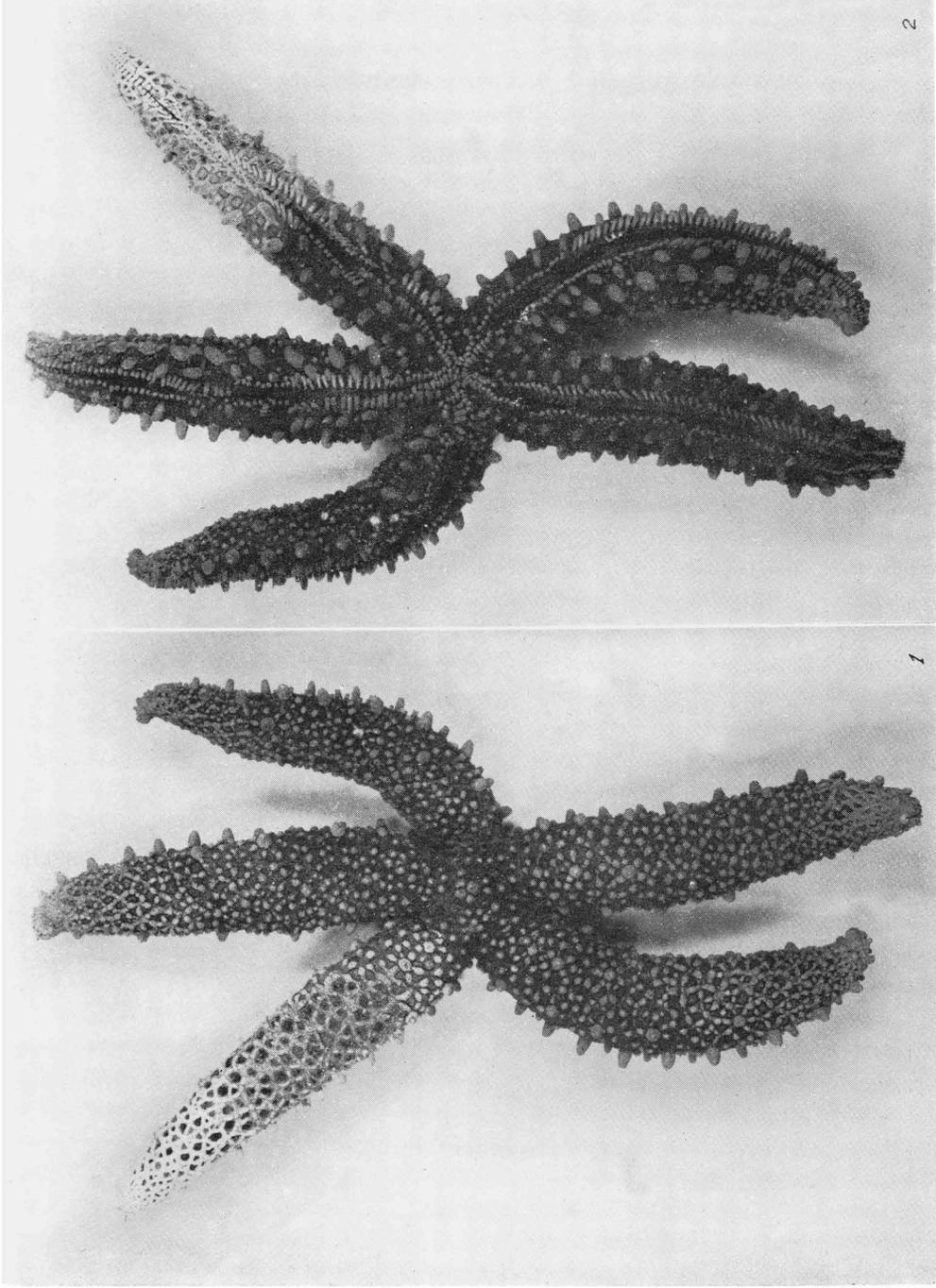












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