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INDO-PACIFIC OPHIOTRICHIDS AND
OPHIODERMATIDS (OPHIUROIDEA)

AILSA M. CLARK

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Pp. 275-322; 1 *Plate*, 10 *Text-figures*.

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NOTES ON SOME TROPICAL INDO-PACIFIC OPHIOTRICHIDS AND OPHIODERMATIDS (OPHIUROIDEA)

By AILSA M. CLARK

IN the course of studies on the shallow-water species of ophiuroids of the tropical Indo-West Pacific, I have sought to clarify the systematic positions of some of the less well-known species, especially of the family Ophiotrichidae. Valuable type-material has been borrowed from Dr. K. K. Günther of the Institut für Spezielle Zoologie und Zoologisches Museum, Berlin, Dr. H. B. Fell of the Museum of Comparative Zoology, Harvard and Dr. F. Jensenius Madsen of the Universitetet Zoologiske Museum, Copenhagen, to all of whom I am much indebted. This material forms the basis for the major part of this paper but in addition a new Ophiotrichid species from the collections of the Zoologisk Museum, Oslo, is included, for the opportunity of studying which my thanks go to Dr. T. Soot-Ryen and Mr. K. Knaben. Two new species of *Macrophiothrix* are also described from the British Museum collections. As for the Ophiodermatidae, the holotype of one new species is from the collections of the Smithsonian Institution, where I was able to examine it some years ago; that of the other is in the British Museum. In addition the genus *Ophiopsammus* is revived here from the synonymy of *Pectinura*.

Under the distribution headings for each species the first locality mentioned is the type-locality. The species themselves are dealt with in alphabetical order.

Ophiotrix (Acanthophiotrix) vigelandi sp. nov.

fig. 1

Ophiotrix koreana: Koehler, 1922 : 242-246, pl. 45, figs. 1-6, pl. 99, fig. 4; 1930 : 142-143. [Non *O. koreana* Duncan, 1879.]

MATERIAL. Oslo Museum, New Caledonia, Johnson and Seeberg, 18/10/1887, one specimen. Oslo Museum, Noumea Harbour, New Caledonia, Vigeland, 13/8/1959, four paratypes. B.M. No. 1967.10.23.36-38, same locality and source, the holotype and three paratypes.

DESCRIPTION OF HOLOTYPE. D.d. (disc diameter) 4.75 mm. All the arms have the tips broken; their length was probably c. 30 mm.

The disc is sparsely covered with predominantly trifid stumps, though the number of points ranges from one to four. In addition there are about twenty thorny spines, up to 0.8 mm. long. The radial shields are about 1.3 mm. long, or just over half the disc radius; they are almost completely naked but for three to nine, usually about six stumps similar to those on the disc scales, placed mostly towards the proximal end.

On the ventral side the stumps are a little more sparse proximally though fairly numerous near the periphery. The adoral shields meet broadly interradially proximal to the broad pentagonal oral shields.

The arms are fairly narrow; at the fifth free segment the minimum breadth is 1.1 mm. The dorsal arm plates are rhombic, about as long as broad near the arm bases but becoming relatively longer distally by attenuation of the proximal end. The distal angle is slightly truncated but for a faint median "beak" emphasized by the median carination which it continues. The consecutive plates are only narrowly contiguous. The first two ventral arm plates have the distal edge convex but on all the rest it is distinctly concave. On the proximal half of the arm the breadth of the plates just exceeds their length but the distal ones become narrower.

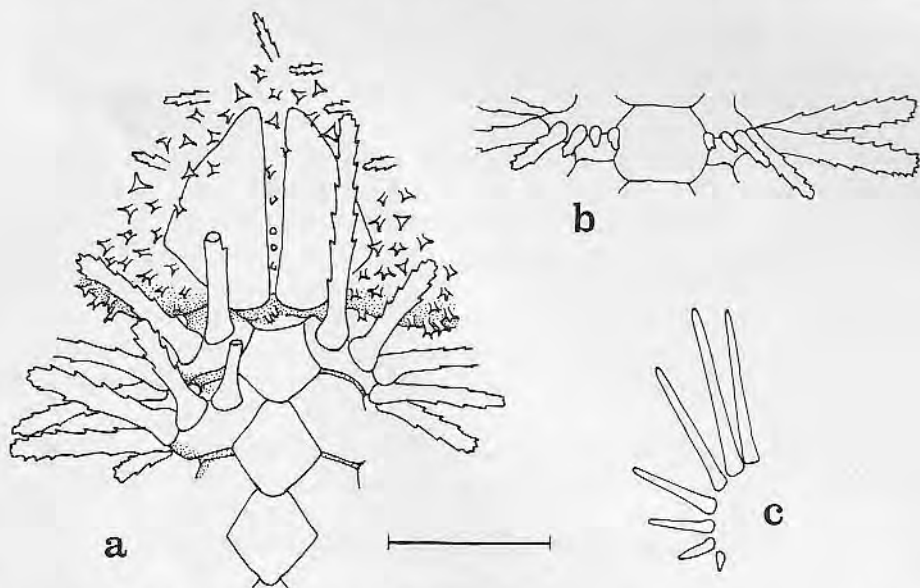


FIG. 1. *Ophiothrix (Acanthophiothrix) vigelandi* sp. nov. Holotype. a. Dorsal view of part of disc and arm base; b. ventral view of fourth free segment; c. arm spines of second free segment. The scale equals 1 mm. for a and b and 2 mm. for c.

The arm spines number seven for one or two basal segments, the two uppermost being the longest and measuring up to 2.1 mm. compared with a segment length of 0.65 mm., a ratio of 3.2 : 1. The third spine from the top measures *c.* 1.75 mm. and the lower ones are progressively shorter. The number of spines soon falls to five and their length, especially that of the uppermost ones, tends to increase so that the distal upper spines are up to 2.6 mm. long. The spines are markedly flattened dorsoventrally and so appear smooth and fairly slender when viewed along the plane of the arm. Conversely, seen from above or below, they appear strongly thorny and moderately stout, the uppermost one or two slightly tapering but the lower ones bushy at the tip or even somewhat clavate (Text-fig. 1a, b). Distally the lowest spine becomes hooked with three or four sharp teeth.

There is no tentacle scale on the first segment; on the remaining pores the scale is somewhat rugose.

The colour of the disc in spirit is pinkish and the arms are almost white except for some reddish-brown spots on some of the dorsal arm plates but more particularly on the upper side of the lateral plates.

VARIATIONS. Of the eight paratypes in the British Museum and Oslo collections, four have a conspicuous double dark line along the arms while two others show the same pattern more faintly, the lines tending to resolve into spots. The largest specimen, d.d. 5.5 mm., has the dorsal arm plates more obviously beaked at the distal end than the holotype but its disc armament is equally sparse, whereas the other specimens may have more numerous stumps than the holotype, often with very long points, as shown by Koehler (1922, pl. 99, fig. 4), presumably from one of his Philippine specimens. One specimen lacks disc spines.

REMARKS. As I pointed out in 1965 (p. 61), *Ophiothrix koreana*: H. L. Clark, 1911, is not the same as *koreana* Duncan, 1879, which belongs to *Ophiothrix* sensu stricto. It is therefore necessary to find a new name for the tropical Pacific specimens which Koehler (1922 and 1930) referred to *O. koreana* following Clark's misinterpretation.

AFFINITIES. *Ophiothrix vigelandi* is referable to the subgenus *Acanthophiothrix* on account of the relatively elongated dorsal arm plates and the position of the largest arm spines on the upper end of the series, as well as by the almost bare radial shields. More precisely it can be related to *Ophiothrix (Acanthophiothrix) scotiosa* Murakami, 1943, *armata* Koehler, 1905, *exhibita* Koehler, 1905, *diligens* Koehler, 1898 and *eusteira* H. L. Clark, 1911. All these belong to the group of species intermediate between *Acanthophiothrix purpurea* and its relatives and *Ophiothrix* sensu stricto, since they have the radial shields less conspicuously naked, the arm spines relatively shorter and not needle-like and the arms not so attenuated, though the dorsal arm plates are at least as long as broad.

Of these nominal species, *O. (A.) scotiosa* from the Caroline Islands differs from *vigelandi* in having short points on the disc stumps (judging from the figure), the disc completely naked on the under side, the radial shields completely naked and as much as two-thirds as long as the disc radius, though this may not be significant, while the figure shows as many as nine arm spines, though the lowest might be the tentacle scale and only six or seven are mentioned in the description; finally the colour is black above.

O. (A.) armata again differs in having the disc naked below although on the radial shields some disc stumps do occur proximally. According to Koehler's description the ventral arm plates differ in being longer than broad but in the figure the reverse proportions are shown. There are only five arm spines at d.d. 5 mm., rather than seven. However, like *vigelandi* there may be a light midline to the arms bordered by two dark lines.

O. (A.) exhibita only appears to differ in having the ventral arm plates with the distal side "rounded" (though they appear straight in Koehler's diagrammatic drawing), besides lacking any disc spines, though this last is true in one of the paratypes of *vigelandi*. However, *O. exhibita* has only been taken at a depth of 180 or more metres.

O. (A.) diligens also has trifid disc stumps with very long points, as well as a few

disc spines, six or seven very thorny arm spines and a colour pattern very like that of *vigelandi* with pink or grey disc and a light midline along the arms defined by dark markings, though these are evidently discontinuous. It differs in having the arm spines all pointed and the ventral arm plates, as well as the dorsal ones, longer than broad, though this could be correlated with the small size, d.d. only 3 mm. The type locality is the Andaman Islands at a depth of 75 metres.

None of these species are described as having the dorsal arm plates carinate, unlike *vigelandi* but keeled arms are found in *O. (A.) eusteira* from Japan. However, the arm spines in *eusteira* are described and figured as acute and the radial shields are completely naked.

Were it not for the fact that Koehler in 1922 recorded *O. (A.) armata* from the East Indies simultaneously with *koreana* and in 1930 likewise *O. (A.) diligens* and *exhibita*, I would have been inclined to refer these specimens from New Caledonia to one of the three, most likely *diligens*. As it is, it seems best to propose a new name for *koreana*: Koehler though I am reluctant to overburden *Ophiothrix* with yet another specific name.

DISTRIBUTION. Known from New Caledonia, probably between tidemarks; also from the Philippine Islands, Amboina and the Kei Islands in 7-618 metres; doubtfully from Port Hacking, N.S.W. in 3-5 metres (Koehler, 1930).

Ophiothrix (Acanthophiothrix) viridialba von Martens

Text-fig. 2a-d

Ophiothrix viridialba von Martens, 1867 : 347, 1870 : 256-257; Lyman, 1882 : 218; Koehler, 1922 : 265-266; 1930 : 159-160.

MATERIAL. Zoologisches Museum, Berlin, no. 1499; China Sea; 73 metres; one syntype.

DESCRIPTION. D.d. 10 mm. Those arms which are not broken appear to have regenerated and this has exaggerated the degree to which they taper. The longest remaining is less than 40 mm. long.

The disc is almost completely covered by the huge radial shields, up to 4.0 mm. long, or three-quarters to four-fifths of the disc radius, leaving only narrow areas of scales between them. The scales mostly bear very short rugose stumps but a few of them are markedly enlarged and carry single, slightly tapering, but blunt-tipped thorny spines *c.* 1.5-2.0 mm. long. There are about seven of these spines in each interradiar area. The ventral side of the disc bears short rugose stumps all over. The adoral shields are broadly contiguous interradially.

The arms are constricted basally and the lateral arm plates of the first free segment are reduced in comparison with the much enlarged ones of the second segment, which almost meet mid-radially above. The proximal dorsal arm plates are rhombic, with marked distal median angles, as long as or slightly longer than broad and only narrowly contiguous but becoming somewhat truncated medially on the following segments and more widely in contact. They are raised into a marked median keel.

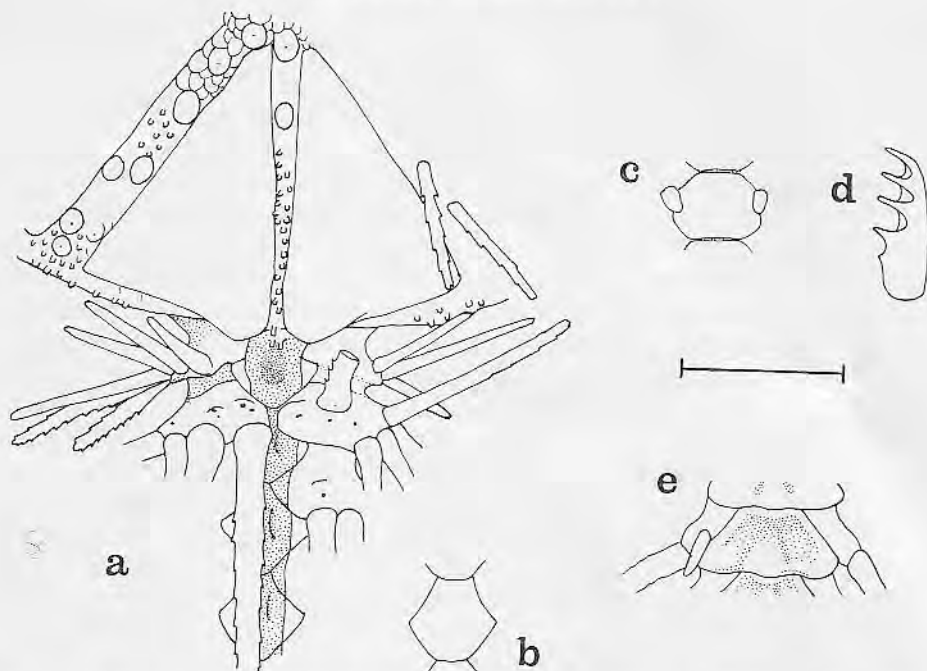


FIG. 2. *Ophiothrix* (*Acanthophiothrix*) *viridialba* von Martens. Holotype. a. Dorsal view of part of disc and arm base; b. the sixth dorsal arm plate; c. ventral view of fourth free segment; d. lowest arm spine from distal segment. e. *Ophiothrix* (*Keystonea*) *propinqua* Lyman (syntype of *O. triloba* von Martens), dorsal view of ninth free segment. The scale equals 2 mm. for a, b, c and e and 0.5 mm. for d. In (a) the upper arm spines are displaced.

Contrary to von Martens' description, only the first three ventral arm plates have strongly convex distal edges, the following ones (on the broadest part of the arm) having a distinct distal concavity, while their shape is octagonal and broader than long, the plate of the fourth free segment (the eighth actual plate) having length : breadth = 0.85 : 1.05 mm.

There are eight glassy arm spines on the second free segment but the number soon falls to the four or five counted by von Martens. The uppermost one or two spines of the proximal segments are extremely long, 7 or 8 mm., or seven or eight times the segment length, with fine rugosities along their length and ending in a blunt tip. The lowest spine on the more distal segments is hook-like with three to five strong curved teeth, usually four.

The tentacle scale is elongated, blunt-tipped and, in the specimen as preserved, inclined obliquely over the ventral arm plate rather than projecting across the pore.

The colour after a hundred years or more in spirit is mainly white but the arms have a broad coloured mid-line which is now khaki but was vivid green in von Martens' day. This band has very well-defined lateral edges and tends to intensify in colour

mid-radially, so that the central keel is certainly no lighter than the rest, in contrast to that of *O. (A.) proteus* Koehler, 1905 and *accedens* Koehler, 1930. The sides of the arms are dappled with small brown spots.

AFFINITIES. I had anticipated that this species might be synonymous with *Ophiothrix proteus* Koehler, of which there are numerous specimens in the British Museum collections from Macclesfield Bank in the South China Sea. However, although there is considerable resemblance between them in many characters, *O. proteus* rarely has the radial shields completely naked, while its ventral arm plates—a valuable source of differential characters in this family—are quite a different shape, all of them longer than broad at d.d. 10 mm. and with the distal edge slightly *convex*. Also *O. proteus* invariably has the midline of the arms pale. *O. accedens* Koehler does have relatively broad and distally concave ventral arm plates, even more markedly than in *viridialba*, but differs again in having the midline of the arms pale; also its arm spines are not so over-developed and the arms are relatively broader.

The species closest to *O. (A.) viridialba* are *O. (A.) signata* Koehler, 1922, *vetusta* Koehler, 1930, *vexator* Koehler, 1930 and *purpurea* von Martens, 1867. Not only do these have a median dark more or less broad band along the arms but also the radial shields are completely naked.

O. (A.) vetusta has the ventral arm plates concave distally but they are not broader than long, though the holotype has d.d. only 6 mm., which could account for this difference. Also the lowest spine modifies into a hook with only two teeth. *O. vetusta* has a conspicuous light ventral midline bordered by two dark lines, of which there is no trace in *viridialba*.

As for *O. (A.) vexator*, I doubt whether it can be maintained distinct from *O. purpurea*, which is rather variable. Koehler distinguished it by the greater number of arm spines basally, eight or nine in the holotype with d.d. 10 mm., compared with up to seven in larger specimens of *purpurea*, and by the more uniform red colour of the disc, which seems to me to be of very doubtful importance, judging from the colour variation of so many Ophiotrichids.

The holotype of *O. (A.) signata* from nearly 140 metres in the Philippines appears very similar to that of *viridialba* in the proportions of the arm spines. The disc armament differs in having intermediates between the stumps and the spines, though I doubt if this is significant, also the radial shields have a row of small stumps near the radial border, but this again may not be significant since the occurrence of such stumps is variable in *O. (A.) proteus*. The dorsal arm plates are "strongly carinate" in *signata* but slightly broader than long (at d.d. 11 mm.). The ventral arm plates have the distal edge slightly convex, though on the proximal part of the arm they are broader than long. Basally there are ten arm spines. The colour of the disc of *O. signata* is pinkish grey with some brownish-purple spots but the arms have a broad dark green band along the upper side covering the entire dorsal arm plates and the uppermost ends of the lateral arm plates. A narrow median part of the keel, however, is lighter in colour. This being the case, it is possible that the affinities of *signata* are with *proteus*. Koehler noted that *signata* appears to be very close to *viridialba* but he was hampered by von Martens' very brief description. Both have strongly keeled arms and distinctive green colouration on the arms but differ

again in the shape of the ventral arm plates and possibly in the breadth of the dorsal arm plates and number of arm spines.

Since green-patterned specimens have been recognized by Koehler (1922) as conspecific with examples of *O. proteus* of the more usual red or purple colour, the green tint may not be a barrier to synonymy of *viridialba* with *purpurea*. However, here again there appears to be a difference in the ventral arm plates which are relatively longer in *purpurea* and with the distal edge usually straight or only slightly notched, while their whole surface is slightly convex in contrast to the very slightly keeled contours of the ventral arm plates of the type of *viridialba*. Also *O. purpurea* usually has the radial shields with their broadest part near the middle of their length or even proximal to this, though they are rather variable in shape.

DISTRIBUTION. Known only from the China Sea in 73 metres.

Ophiothrix (Keystonea) propinqua Lyman

fig. 2e

- Ophiothrix propinqua* Lyman, 1861 : 83; 1865 : 174-175; Koehler, 1898 : 98-100, pl. 3, figs. 20-22; 1922 : 256-257, pl. 38, figs. 1, 2, pl. 101, fig. 4.
Ophiothrix triloba von Martens, 1870 : 260-261; Brock, 1888 : 509; de Loriol, 1893 : 41-43, pl. 24, fig. 4; Döderlein, 1896 : 293, pl. 16, fig. 15; Koehler, 1898 : 97.
Ophiotrichoides propinqua: H. L. Clark, 1939 : 90-91; Balinsky, 1957 : 21-22.

MATERIAL. Zoologisches Museum Berlin No. 1750, Red Sea, one syntype of *Ophiothrix triloba*. Also about fifty specimens in the British Museum collections ranging from the Gulf of Suez south to Mauritius and east to Tonga.

SYNONYMY. After studying the syntype of *O. triloba* von Martens, I believe that it is not specifically distinct from *O. propinqua*. Comparison with the "Challenger" specimens from Tongatabu, identified as *O. propinqua* by Lyman, shows no significant difference. The shape of the dorsal arm plates, supposedly characteristically trilobed in *triloba*, is very variable in *propinqua*, being most often more or less flattened fan-shaped but sometimes the median part of the distal side instead of being straight (rarely even slightly concave) has a small lobe. (See Text-fig. 2e.) Koehler (1898 and 1922) has commented on the occurrence of trilobed plates in *propinqua* and his earlier figure shows a form very similar to that of the syntype of *triloba*. Contrary to von Martens' description, the syntype has the longest arm spines little more than twice the segment length; in shape these spines are slightly expanded and rounded at the tips, as usual in *O. propinqua*. Proximally there are up to nine spines in the syntype. This specimen also has single tentacle scales (von Martens thought these were absent), which distally at least have a single point, as Koehler (1922) showed is the case in *propinqua*. The comblike form of the lowest arm spine distally is also as Koehler showed it (pl. 101, fig. 4.) There is just one character shown by the syntype of *O. triloba* which is worthy of comment; this is the relatively elongated form of the stumps on the ventral side of the disc. These are up to 0.45 mm. long, or more than four times as long as broad. The shape of the stumps is, however, very variable in *O. propinqua*.

AFFINITIES. *Ophiothrix propinqua* occupies an intermediate position between *Ophiothrix* subgenus *Keystonea* as defined by me in 1967 (a) and *Macrophiothrix*, since the disc scales of the upper side in many specimens have a sparse armament of almost granuliform stumps. However, large specimens of *O. (Keystonea) nereidina* may also have some stumps centrally.

DISTRIBUTION. Known from the Gilbert and other south Pacific islands (but not from the Hawaiian Islands) westwards to the Red Sea, Mauritius and Mozambique.

MACROPHIOTHRIX

This genus was established by H. L. Clark in 1938 with type-species *Ophiura longipeda* Lamarck, 1816 and with twenty-one further species included, of which ten were new to science. In 1957 Balinsky referred another new species to *Macrophiothrix* and in 1967(a) I included six further previously-described species removed from *Ophiothrix* as well as five more provisionally. As a result of the present study I would also include now:

Macrophiothrix demessa (Lyman), 1861—now regarded as distinct from *M. hirsuta*.
M. coronata (Koehler), 1905—though this is possibly a synonym of *demessa* also
M. picturata (de Loriol), 1893—though this is possibly a synonym of *M. hirsuta cheneyi*.

Thanks to Drs. Günther, Fell and Madsen I have been able to examine type-material of the following:

Ophiothrix galataeae Lütken, 1872. Copenhagen Museum.
Ophiothrix aspidota Müller & Troschel, 1842. Berlin Museum.
Ophiothrix hirsuta Müller & Troschel, 1842. Berlin Museum.
Ophiothrix punctolimbata von Martens, 1870. Berlin Museum.
Ophiothrix cheneyi Lyman, 1861. Harvard Museum.
Ophiothrix demessa Lyman, 1861 (a "topotype" only) Harvard Museum.
Ophiothrix rhabdota H. L. Clark, 1951. Harvard Museum.
Macrophiothrix callizona H. L. Clark, 1938. Harvard Museum.
Macrophiothrix calyptaspis H. L. Clark, 1938. Harvard Museum.
Macrophiothrix rugosa H. L. Clark, 1938. Harvard Museum.
Macrophiothrix scotia H. L. Clark, 1938. Harvard Museum.
Macrophiothrix spinifera H. L. Clark, 1938. Harvard Museum.
Macrophiothrix sticta H. L. Clark, 1938. Harvard Museum.

Supplementary descriptions of these are given in the following pages.

Apart from that of H. L. Clark himself, the greatest contribution to our knowledge of the species currently included in *Macrophiothrix* is that of Koehler. However, my examination of type-material convinces me that he was mistaken in his identifications of *M. galataeae* and *punctolimbata* as well as of the Pacific specimens which he referred to *hirsuta*. This results in the establishment here of two new nominal species and the restoration of *Ophiothrix variabilis* Duncan as distinct from *M. hirsuta*. In addition I believe that *O. cheneyi* Lyman can be subspecifically

distinguished from *M. hirsuta*. I also find now that my identification in 1952 of specimens from the Gulf of Aqaba as *M. hirsuta* coupled with reference to *hirsuta* of the Murray Expedition's specimens named *demessa* by H. L. Clark, were incorrect, further comparison between *hirsuta* and a specimen of *demessa* from the type-locality having revealed several differences. Recognition of *demessa* brings *Amphiothrix* H. L. Clark, 1946, of which it is the type and only species, within the synonymy of *Macrophiothrix*.

The characters which I have found most useful in distinguishing between the species of *Macrophiothrix* include the shape of the dorsal and ventral arm plates, the shape and distribution of the disc stumps, the modification of the lowest arm spine distally, the shape of the longest arm spines, the relative arm length, the occurrence of stumps or spinelets on the distal edge of the oral shields and the colour pattern. I do not think that other differences in the oral structure are significant in this genus, nor do differences in the shape and size of the radial shields provide reliable distinctions.

Macrophiothrix aspidota (Müller & Troschel)

Text-figs. 3a, 4a, 5a, b, c, 7a

Ophiothrix aspidota Müller & Troschel, 1842 : 115; Lyman, 1874 : 234; Bell, 1889 : 7; Koehler, 1904 : 87-90, figs. 50-54; 1922 (pt.) : 209-211, pl. 32, figs. 1, 2, pl. 33, fig. 8 [non pl. 32, figs. 3-5, nec pl. 33, fig. 7, nec pl. 97, fig. 3]; 1930 : 134.

Macrophiothrix aspidota: H. L. Clark, 1938 : 284; Balinsky, 1957 : 18 [? = *M. robillardii*].

MATERIAL. Berlin Museum no. 1008; "Ostindien"; Schöenlein; holotype. British Museum No. 88.11.15.1-2; Ramesvaram, Gulf of Manaar; Thurston collection; three specimens. 1958.11.5.3 and 1961.8.23.11-14; Bombay; Sane collection; seven specimens. 81.4.1.21 and 82.1.5.11-12; Karachi; from Karachi Museum; four specimens.

DESCRIPTION OF HOLOTYPE. Disc diameter (d.d.) 11.5 mm.; the arms are all broken within 50 mm. of the disc. [It may be noted here that Koehler (1904) estimates the disc diameter as only 10.5 mm.]

The radial shields are conspicuous, c. 3.8 mm. long and abruptly naked in contrast to the superficially granuliform armament of stumps on the disc scales. No special preparation of these stumps was made because of the relatively small size and imperfect condition of the specimen but the peripheral stumps appear to be cylindrical or slightly tapering and the dorsal ones are multifid with usually five or six points and relatively short.

The dorsal arm plates (Text-fig. 5a) are fan-shaped, widest just distal to the middle, the lateral angles being about 90° since the distal edge curves back a little more abruptly at its extremities. However, some of the plates have the distal edge divided into three parts by a pair of angles, although these are very obtuse, so that the shape of the plate may be somewhat hexagonal. The arms are slightly carinate and some of the dorsal arm plates are divided into two longitudinally, as sometimes occurs in other species of the genus. The fifteenth dorsal arm plate has length : breadth = 0.68 : 1.58 mm., a ratio of 1 : 2.3.

The ventral arm plates (Text-fig. 7a) are broad hexagonal with the widest part at about the middle; the consecutive ones are slightly separated. The plate of the fifteenth free segment has length : breadth = 0.60 : 1.00 mm. or 1 : 1.7. The distal edge of each plate is straight or slightly concave.

Basally there are eight arm spines on one or two segments only but the number soon falls to six. [Müller & Troschel give the number as eight or nine but I cannot find the larger number.] The flattened spines when viewed from above or below are moderately rugose for most of their length with the sides almost parallel but some of the longest are slightly clavate. These long spines measure about 2.6 mm. Many of the lowest spines are damaged but some are clearly modified into a hook with about four teeth but the very tips may be rugose (Text-fig. 4a).

No colour remains.

VARIATIONS. Of the British Museum specimens, five from Bombay have most of the arms complete. There appears to be some variation in length even within a single individual, one having d.d. : a.l = 1 : 5.3-7.8, while in the four others the ratio is 1 : 5.3-6.2, 1 : 6.3-7.4, 1 : 7.2-7.5 and 1 : 8.0. A specimen from Ramesvaram has an almost complete arm *c.* 120 mm. long, d.d. being 14 mm., giving a ratio of 1 : 8.6, while two larger specimens from Karachi with d.d. 19 and 22 mm. have ratios of 1 : 8.2 and 1 : 8.0. Koehler (1904) estimated the holotype to have arms *c.* 90 mm. long giving a ratio of 1 : 7.8 using my measurement of 11.5 mm. for the disc diameter. Koehler also had a specimen from Trincomalee, Ceylon, for which he gave a ratio of 1 : 9. It therefore appears that *M. aspidota* habitually has relatively short arms, less than ten times the disc diameter, unlike most species of the genus.

The radial shields of the British Museum specimens appear to be a little smaller relatively than those of the holotype, with ratios to the disc radius of 1 : 1.7-2.0, compared with 1 : 1.5, but this may be due to an underestimate of their length in these better-preserved specimens, all of which have some tapering stumps or grains along the abradial margins which tend to conceal the proximal end of the shields. There are also a few scattered grains over the rest of the surface of the shields, more in some specimens than others but the general impression is that the shields are naked in comparison with the rest of the disc.

The shape of the dorsal arm plates is rather variable. In the two large specimens from Karachi they are broad fan-shaped with the broadest part hardly at all distal to the middle and the lateral angles acute; in the Bombay specimens (Text-fig. 5c) they are more often distinctly hexagonal, while the Ramesvaram material (Text-fig. 5b) shows both shapes or intermediates between them, even on different parts of the same arm. The fifteenth plate in one of the last specimens has a length : breadth ratio of 1 : 2.4.

The arms may be distinctly carinate, at least basally.

The ventral arm plates have the distal edge more or less distinctly concave.

The longest arm spines measure four to five times the corresponding segment length and are slightly expanded and bushy at the tip, sometimes sufficiently so to be termed clavate, this being particularly true of some of the Bombay specimens.

The lowest arm spines are modified into a well-developed transparent hook, though

the number of teeth varies, even in a single specimen; most often there are two subterminal teeth within the enlarged end tooth but there may be up to five teeth altogether. The outside of the end of the hook may be smooth or slightly rugose.

The disc stumps studied in one of the Karachi specimens are cylindrical and multifid (Text-fig. 3a).

The colour is purple, often with very dark spots on the abradial sides of the radial shields and with the arms predominantly purple above, usually deeper on every fourth segment to give a banded effect. The edges of the dorsal arm plates are rimmed with white and on some specimens the distal white rim is broad, especially on the distal plates. Often there is also a median white mark, which occasionally is large enough to give the impression of a discontinuous longitudinal light line. The purple colour over most of the dorsal plates may be even or mottled. The ventral arm plates have a more or less broad light area extending on both sides of the suture between consecutive plates.

REMARKS. The specimen from Ibugos Island, north of the Philippines, which Koehler (1922) referred to *aspidota* is clearly not conspecific with the holotype and the present material, or with Koehler's earlier examined specimen from Trincomalee. Not only does it have the dorsal arm plates trapezoidal with the distal edges almost straight (as in *M. galateae* and *longipeda*) but the arms were evidently more than ten times the d.d., the disc stumps are mainly trifid and the lowest arm spines are comblike with numerous closely-placed teeth. I think the specimen should be referred to true *M. galateae* Lütken, which Koehler confused with another species, (see below).

DISTRIBUTION. Known to the east and west of India and Pakistan.

Macrophiothrix belli (Döderlein)

Text-figs. 3b, 4b-e, 5d, 7b

Ophiothrix belli Döderlein, 1896 : 292-293, pl. 14, fig. 5, pl. 16, fig. 14.

Macrophiothrix belli: H. L. Clark, 1938 : 287-288; 1946 : 221.

MATERIAL. Fourteen specimens in the British Museum collections, from Thursday Island (the type-locality), Great Barrier Reef Expedition station XIX, Port Essington, Northern Territory, the N. side of Holothuria Bank, N.W. Australia, Cape Boileau, N.W. Australia and the Monte Bello Islands.

DISTRIBUTION. Known from the northern coasts of Australia.

Macrophiothrix callizona H. L. Clark

Text-figs. 3c, 4f, 5e, f, 7c

Macrophiothrix callizona H. L. Clark, 1938 : 293-294, pl. 24, fig. 1; 1946 : 221.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 5113; Broome, N.W. Australia, one paratype.

DESCRIPTION. The d.d. is 10.0-10.5 mm. All the arms appear to have regenerated from close to the base.

The disc stumps (Text-fig. 3c) are probably mostly trifold, as described by H. L. Clark but many of those in the preparation made have been badly rubbed and blunted at the tips. The armament of the radial shields also consists of stumps, not rugose granules; these are slightly spaced in comparison with the stumps on the scales.

The original basal dorsal arm plates (Text-fig. 5e) are slightly carinate, overlapping, rounded fan-shaped and with a few small peripheral rugosities. The regenerated dorsal arm plates (Text-fig. 5f) in contrast are elliptical, almost flat and fairly smooth, the consecutive ones slightly spaced. The plates of the widest part of the arm have length : breadth = $c. 0.7 : 1.6$ mm. = $1 : 2.3$ and the longest spines of these segments are $c. 2.4$ mm. long, or 3.4 times the segment length. The spines are moderately thorny for at least the outer two-thirds of their length, the longer ones with parallel sides and truncated tips. Basally there are eleven spines. The lowest one on the more distal segments becomes hook-like with usually three teeth, the outermost the largest (Text-fig. 4f).

The ventral arm plates (Text-fig. 7c) are relatively broad rectangular, the proximal ones $c. 0.4 : 0.75$ mm. with the distal edge concave and the consecutive plates widely separate. The tentacle scales have one to three sharp points.

REMARKS. See under *M. calyptaspis*.

DISTRIBUTION. Known only from Broome, N.W. Australia.

Macrophiothrix calyptaspis H. L. Clark

Text-figs. 3d, 4g, 5g, 7d

Macrophiothrix calyptaspis H. L. Clark, 1938 : 294-295, pl. 25, fig. 3; 1946 : 222.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 5115; Broome, N.W. Australia; one paratype.

DESCRIPTION. The d.d. is 11 mm.

The disc stumps (Text-fig. 3d) are of moderate length with three to six points, most often three. The radial shields are more sparsely covered with stumps than the disc scales.

The arms appear faintly carinate but this may be illusory since the suture between consecutive dorsal arm plates is abruptly finer midradially. The dorsal arm plates (Text-fig. 5g) are hexagonal and widest just distal to the middle of their length; the distal edge is slightly concave in the middle. The twelfth plate has length : breadth = $0.7 : 1.7$ mm. = $1 : 2.4$. The corresponding longest arm spines are $c. 2.6$ mm. long, or 3.7 times the segment length. Basally there are eleven arm spines. The longer ones are moderately thorny except for the basal quarter of their length and are slightly broadened at the tip. The lowest spine distally is hook-like with three or four teeth (Text-fig. 4g).

The ventral arm plates (Text-fig. 7d) are widely separated, concave both proximally and distally and relatively broad, that on the twelfth free segment having length : breadth = $0.55 : 0.8$ mm.

AFFINITIES. *M. calyptaspis* seems to me to be very closely related to the sympatric *M. callizona*, the main difference being in the relative length of the arms, which are ten to twelve times the d.d. in *callizona* but only seven to eight times in *calyptaspis*. However, the paratype of *M. calyptaspis* which I have seen has clearly regenerated all its arms and, judging from the elliptical shape of the dorsal arm plates described for the holotype, the same may be true of that specimen. It is possible that regeneration has resulted in abnormal arm lengths. Only two specimens of each nominal species have been recorded. Both species have stumps rather than granules on the radial shields, broad rectangular widely spaced ventral arm plates with proximal and distal sides concave, similar arm spines, the longer ones slightly expanded at the tips and similar hook-like lowest arm spines. There are small differences in the shape of the disc stumps and possibly in the dorsal arm plates but I suspect that further material from Broome will prove that only a single species can be recognized.

Otherwise the affinities of the two are with *M. hirsuta* and *variabilis*, the differences lying in the elongated armament of the radial shields and the smaller disc stumps with fewer points.

DISTRIBUTION. Known only from Broome, N.W. Australia.

Macrophiothrix demessa (Lyman)

Text-figs. 3e, f, 4h, 5h, 7e

- Ophiothrix demessa* Lyman, 1861 : 82; 1865 : 172-173; Marktanner-Turneretscher, 1887 : 310; Brock, 1888 : 513; Koehler, 1905 : 91-92, pl. 9, figs. 5, 6; H. L. Clark, 1921 : 109; 1939 : 83; Ely, 1942 : 44-45, fig. 11; A. H. Clark, 1949 : 39-40.
Ophiothrix mauritiensis de Loriol, 1893 : 38-39, pl. 24, fig. 5.
Macrophiothrix hirsuta: A. M. Clark, 1952 : 209-210; Tortonese, 1953 : 33-34 (?). [Non *M. hirsuta* (Müller & Troschel, 1842) nec A. M. Clark, 1967.]
Macrophiothrix mossambica Balinsky, 1957 : 18-20, fig. 7, pl. 3, figs. 11, 12.
Amphiothrix demessa: H. L. Clark, 1946 : 217.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 4491; off Lahaina, Maui, Hawaiian Islands. Also twenty-three specimens in the British Museum collections, from the Gulf of Aqaba, the Sudanese Red Sea, the Gulf of Aden, Zanzibar, the Seychelles, Amirante, Maldive and Ellice Islands.

DESCRIPTION. The Hawaiian specimen approximates to Lyman's type-locality. It has the d.d. only 8.5 mm.; the arms are all broken. [Lyman gives the ratio of d.d. : a.l. as c. 1 : 9, H. L. Clark (1946) as 1 : 9-12, de Loriol (for *mauritiensis*) as c. 1 : 10, Balinsky (for *mossambica*) as "a little under" 1 : 10 and Ely as 1 : 4, which last must surely be a mistake.]

The superficial appearance is very like that of *M. hirsuta*.

The disc is covered with slightly waisted stumps with three to six terminal points (Text-fig. 3e). [Lyman gives the number of points as commonly four to six but certainly in this specimen three is the usual number.] There are similar but slightly smaller stumps on the radial shields; on the under side of the disc the stumps do

not extend far below the ambitus but as the disc is dry and shrunken some could have been lost.

The dorsal arm plates (Text-fig. 5h) are fan-shaped with the distal edge evenly convex except at the lateral extremes where it sweeps back abruptly so as slightly to round off the lateral angles. The plates bear scattered stumps but these are much shorter than those on the disc and usually have only two or three points. The plate of the tenth free segment has length : breadth = 0.55 : 0.85 mm., a ratio of 1 : 1.6.

The ventral arm plates after the first few are relatively narrow with length and breadth approximately equal but soon become distinctly longer than broad (Text-fig. 7e). They are octagonal with the proximal and distal sides longer than the rest. The distal edge is straight or, more often, slightly concave and on the more distal parts of the arms the concavity is more marked. The plate of the tenth free segment has length : breadth = 0.55 : 0.50 mm.

Basally there are eleven arm spines, all of which are slightly tapering and bear strong thorns, much more prominent than those of *M. hirsuta*, for their whole length. The longest spine of the tenth free segment is *c.* 1.15 mm. long, or just over twice the segment length. The lowest spine beyond the basal segments is modified into a comb with five to nine teeth (Text-fig. 4h).

VARIATIONS. A specimen from Sherm Sheik, Gulf of Aqaba, has d.d. : a.l. = 21 : *c.* 240 mm., a ratio of 1 : 11.5, while in another from the Sudanese Red Sea it is 19 : *c.* 280 = 1 : 15, an unusually high value, though possibly correlated with the much larger size in comparison with the Hawaiian specimen. The largest of nine specimens from the Seychelles (the closest to the type-locality of *mauritiensis*) has d.d. : a.l. = 18 : 170-*c.* 200 mm., a ratio of probably just over 1 : 10, as in de Loriol's holotype. It also has thirteen or rarely even fourteen arm spines on the basal segments. The disc stumps in these Seychelles specimens are variable in length, sometimes as long as in specimens from the Red Sea or somewhat shorter but the stumps on the dorsal arm plates are granuliform and more or less densely crowded so as to obscure the limits of the plates. When denuded the plates are seen to have approximately 90° latero-distal angles; the tenth has length : breadth = 0.90 : 1.85 mm., a ratio of *c.* 1 : 2; a number of the plates are split longitudinally. The armament of the radial shields in the Seychelles specimens is also unusually granuliform. Ventrally the disc stumps extend almost to the oral shields, while in the large specimen from the Gulf of Aqaba all the scales of the ventral side bear stumps.

The Aqaba specimen has a median white area across the distal end of each dorsal arm plate extending on to the next plate, this area being generally devoid of stumps, which are restricted to the sides of the plates. A similar colour pattern and restriction of the armament are evident in de Loriol's figure of these plates in the type of *mauritiensis*, while the colour pattern of the ventral plates with a curved dark mark on each side is also found in the Seychelles specimens, though the one from Aqaba has instead a coloured rim along both sides and across the distal edge of each ventral arm plate.

REMARKS. My confusion of *M. demessa* with *hirsuta* in 1952, owing to inadequate knowledge of the latter has probably misled Tortonese (1953). Judging from his

description of the dorsal arm plates as armed with grains or short stumps, his specimen from Nocra, Eritrea, was more likely to have been *demessa* than *hirsuta*. Apart from the superficial nature of this armament, the two species can most easily be distinguished by the shape of the ventral arm plates, those of *demessa* being longer than broad.

AFFINITIES. Except for the unusually high number of arm spines and the relatively inconspicuous radial shields—neither of which do I consider are characters of more than specific weight—*Ophiothrix demessa* Lyman seems to me to agree very well with H. L. Clark's diagnosis of *Macrophiothrix* (1938), notably in the puffy disc with uniform covering of stumps, the relatively long arms and the broadly contiguous dorsal arm plates. Balinsky did not hesitate to refer his new nominal species, *mossambica*, to *Macrophiothrix*, evidently regarding the presence of thorny granules on the dorsal arm plates as less than a generic character—as I also do. Accordingly *Amphiophiothrix*, which H. L. Clark subsequently established (1946) to accommodate *demessa*, is here referred to the synonymy of *Macrophiothrix*.

As for the specific limits of *M. demessa*, I do not think that either *mauritiensis* or *mossambica* can be maintained as separate species. De Loriol noted that *mauritiensis* is very close to *demessa* but he distinguished it on several characters to do with the oral structure, such as the number of tooth papillae, which I do not consider are of taxonomic importance, as well as on the shape of the ventral arm plates, which look to me to be very similar, while the lateral angularity and the density of armament of the dorsal arm plates are somewhat variable in the specimens now studied; nor can I see a significant difference in the arm spines. *M. mossambica* was based on a single specimen with d.d. only 8 mm. Balinsky compared it with *M. obtusa* and *callizona*, neither *demessa* nor *mauritiensis* having been mentioned in connection with the genus up to that time. The only difference which might be of some significance is that the arm spines are said to number only eight. Even at this small size, one would expect to find ten or more spines basally in *M. demessa*. If I am correct in synonymizing these two with *M. demessa*, then we have a single species of wide range, from Mauritius and S.E. Africa to the Hawaiian Islands.

In relation to the other species of *Macrophiothrix*, *M. demessa* occupies a fairly isolated position. *M. callizona*, *hirsuta*, *cheneyi* and *rugosa* approximate to it though they have a rugose texture to the fan-shaped dorsal arm plates, as opposed to having separate superimposed stumps or grains, but they differ in having broad ventral arm plates and hook-like rather than comb-like lowest arm spines with only about four teeth.

DISTRIBUTION. Known from the Hawaiian Islands to northern Australia and westwards to the Red Sea and S.E. Africa.

***Macrophiothrix elongata* H. L. Clark**

Text-figs. 3g, 4i, 5i, 7f

Macrophiothrix elongata H. L. Clark, 1938 : 292-293, pl. 24, fig. 4.

MATERIAL. Two specimens in the British Museum collection from Hor Kawi and Tarub Island, Persian Gulf and one from Muscat, Gulf of Oman.

REMARKS. Although close to *M. hirsuta* both geographically and morphologically, *M. elongata* is easily distinguished by the relatively much longer arms, about twenty times the d.d. rather than ten times or less, also by the relatively narrow ventral arm plates and the smaller disc stumps with fewer points. Both have the distal lowest spines hooked and *M. hirsuta cheneyi* also has median light stripes on the arms like *elongata*.

DISTRIBUTION. Known only from the Persian Gulf and Gulf of Oman.

Macrophiothrix expedita (Koehler)

Text-figs. 3h, 4j, 5j, 7g

Ophiothrix expedita Koehler, 1905 : 96-98, pl. 9, figs. 10-14, pl. 15, fig. 5; 1922 : 229-230, pl. 31, fig. 6, pl. 33, fig. 5, pl. 98, fig. 5; 1930 : 140.

Macrophiothrix expedita: H. L. Clark, 1938 : 284-285.

MATERIAL. One specimen in the British Museum collections from Zamboanga, Philippines, "Challenger" Expedition; named *O. longipeda* by Lyman (1882).

REMARKS. See under *M. rhabdota*.

DISTRIBUTION. Known from the East Indies, Philippines and the Palao (Pelew) Islands.

Macrophiothrix galathea (Lütken)

Text-figs. 3i, 4k, l, 5k, 7h, pl. 1, fig. 1

Ophiothrix galathea Lütken, 1872 : 90-92, 108. [Non *O. galathea*: Marktanner-Turneretscher, 1887 : 309; Brock, 1888 : 517; de Loriol, 1893a(?) : 420; H. L. Clark, 1915 : 272; nec *O. galathea*: Koehler, 1905 : 84-85; 1922 : 233-234; 1930 : 141; Tortonese, 1936 : 219; nec *Macrophiothrix galathea*: H. L. Clark, 1938 : 285; nec *M. galathea*: Tortonese, 1953 : 34; see *M. koehleri*.]

MATERIAL. Universitetets Zoologiske Museum, Copenhagen, Nicobar Islands, the holotype. Also one specimen in the British Museum collections from Tongatabu, "Challenger" Expedition; named *O. longipeda* by Lyman (1882).

The identity of this species has generally been mistaken since Brock stated that it is characterized by the opacity of the arm spines; consequently the name has been used for quite another species, possibly more than one, in which this character holds good in combination with the development of naked radial shields. Re-examination of the holotype reveals the fact that *M. galathea* is a species of the *longipeda*-group with dorsal arm plates of trapezoidal form, having very sharp latero-distal angles.

DESCRIPTION. The holotype has the disc somewhat shrunken; it now measures 14 × 15 mm. The arms are broken and their length is difficult to estimate; Lütken puts it at 250 mm., which is about eighteen times the disc diameter.

Superficially the disc appears smooth due to the bare radial shields and the very fine armament on the scales, which looks granuliform in spirit, the skin covering the stumps not being shrunken. The radial shields are completely naked except for a

very few granuliform stumps on the distal projection. The ratio of length : breadth of a shield is 4.0 : 1.75 mm., the broadest part being near the middle. The form of the disc stumps is shown in Text-fig. 3i. On the ventral side the stumps are reduced to fine thorns, often with single points; these extend up to the genital slits but stop short of the oral shields. The oral shields are as usual broad rhombic and the rather transparent adoral shields do not meet proximal to them.

The dorsal arm plates are of the *longipeda*-type, trapezoidal in shape, with very sharp latero-distal corners (fig. 5k). The plate of the twelfth free arm segment has length : breadth = 0.8 : 1.9 mm.; the arm breadth at this point is 2.0 mm. and the longest spine of the corresponding segment measures 1.9 mm. Further out on the arm the spines become longer, up to *c.* 2.25 mm.

The ventral arm plates (Text-fig. 7h) after the first few are slightly broader than long; length : breadth of the twentieth (i.e. the plate of the twelfth free segment) = 0.8 : 0.9 mm. The distal edge of each plate is straight or very slightly concave.

There are ten arm spines on about two basal segments, then the number falls to nine; the longer ones have parallel or slightly divergent sides and are blunt at the tip, so that they appear spatulate rather than clavate. The longest spines of the twelfth free segment are *c.* 1.9 mm. They are light brown in colour and translucent, without the opaque distal core described by Koehler. The proximal halves of the longer spines are almost completely smooth but the distal halves are finely thorny. On the distal part of the arm some of the lowest spines become rather comb-shaped (Text-fig. 4k), but many are somewhat irregular.

The colour is very distinctive and most unusual for a member of this genus. The radial shields are marked with three, sometimes four, discontinuous undulating dark-brown to black lines running parallel close to the proximal interradial side, with a single brownish line just inside the edge of the radial and distal sides, together making an inset replica of the shape of the shield. Similarly the dorsal arm plates are emphasized by a dark blue or purple band close to the lateral and distal edges. The ventral arm plates also have light edges but are centrally darker. On about two consecutive plates out of every four or five the darker colour is deeper, giving a banded effect.

VARIATIONS. The "Challenger" specimen from Tongatabu has d.d. 20 mm. and arm length over 300 mm., giving a ratio of more than 1 : 15. The disc armament is like that of the holotype, the stumps being very short, not more than twice as long as wide and superficially appearing granuliform. Some extremely short stumps or granules extend on to the radial shields both at their proximal and distal ends but the main part of the shield is again naked. Length : breadth of one pair of shields measured is 5.5 : 2.0-2.3 mm., the widest part being at about the middle of the length.

The dorsal arm plates are as in the holotype, trapezoidal with acute latero-distal angles. The twelfth plate has length : breadth = 0.9 : 1.7 mm. = 1 : 1.9. The spines are again light brownish but a little more opaque than in the holotype; the distal half of the longer spines is somewhat expanded but again they can hardly be called clavate; the texture of the spines is more extensively rugose, even on the basal parts, which are only smooth on the side facing the disc.

The distal lowest arm spines are hardly at all modified and none were seen to be comb-like (Text-fig. 41).

The colour pattern is somewhat similar to that of the holotype, with the radial shields outlined in darker colour and the dorsal arm plates with pale edges all round but darker markings within. However, in this case all the coloured markings are reddish-brown. Also the dark patches on the dorsal arm plates are mainly lateral, there being no strong transverse band near the distal border.

REMARKS. *Macrophiothrix galataeae* is most easily distinguished from the species which Koehler confused with it by the trapeziform dorsal arm plates and the absence of stumps from the distal edge of the oral shields. In addition the disc stumps are much shorter and the arm spines less opaque and less clavate.

DISTRIBUTION. Owing to the uncertainty hitherto about the identity of this species, the only two positive records are from the Nicobar and Tonga Islands.

Macrophiothrix hirsuta hirsuta (Müller & Troschel)

Text-figs. 3j, 4m, 5l, m, 7i

Ophiothrix hirsuta Müller & Troschel, 1842 : 111; Lyman, 1865 : 176; 1882 : 226; Marktanner-Turneretscher, 1887 : 311-312 (part); Tortonese, 1936 : 218; 1949 : 37-38 (?). [Non *O. hirsuta*: Kochler, 1898 : 96; Ludwig, 1899 : 549; Koehler, 1905 : 93; M'Intosh, 1910 : 164; Matsumoto, 1917 : 225-226, fig. 63; Koehler, 1922 : 234-235; Gravely, 1927 : 8; Koehler, 1930 : 141; Mortensen, 1942 : 67-68(?); A. H. Clark, 1948 : 4(?).]

Macrophiothrix hirsuta: H. L. Clark, 1938 : 285 (part); Tortonese, 1953 : 33-34(?); 1954 : 70; A. M. Clark, 1967 : 47. [Non *M. hirsuta*: Murakami, 1943 : 209; A. M. Clark, 1952 : 209-210; Balinsky, 1957 : 17-18.]

MATERIAL. Zoologisches Museum, Berlin, No. 1000, Red Sea, the holotype. Also ten specimens in the British Museum collections from the "Red Sea" (no details), the Dahlak Archipelago, Eritrea and from Aden.

REMARKS. Contrary to widespread opinion, I believe that *M. hirsuta* has a restricted geographical range, confined to the Red Sea and the immediate vicinity. I consider that Lyman's second thoughts (1882) about the separate identity of his *Ophiothrix cheneyi* with *hirsuta* and Koehler's (1905) similar synonymizing of *O. variabilis* Duncan are incorrect, though the former does merit a subspecific distinction. Koehler's concept of *hirsuta* is, I think, based on a misidentified specimen of *cheneyi*, as his description of the dorsal arm plates as laterally rounded is at variance with that of Müller and Troschel. Fortunately it is now possible to give a full description and figures of the holotype of *hirsuta*.

DESCRIPTION. The holotype has d.d. 22 mm. and arm length 170 + mm., probably when complete more than 200 mm., since Müller & Troschel estimate the ratio as 1 : 10. The disc is covered with fairly short multifid stumps (Text-fig 3j), markedly flared from the base or from the middle, up to c. 0.4 mm. long and usually with five or six points. The radial shields are covered with coarse granules. They are c. 6 mm. long.

The fan-shaped dorsal arm plates (Text-fig 5l) have a fine rugose texture proximally and laterally; they are slightly carinate and the proximal ones have a more or

less well developed median distal angle, though the following plates become more flattened medially. The latero-distal corners on most plates are distinctly acute, or else right-angled. The widest part of each plate is just distal to the middle of its length. The plate of the twelfth free arm segment has length : breadth = 0.9 : 2.1 mm. The longest spines of this segment are *c.* 4.0 mm. Except for the basal few, the ventral arm plates (Text-fig. 7i) are markedly broader than long, that of the twelfth free segment having length : breadth = 0.9 : 1.5 mm.; they are broadest in the middle of the length and distinctly concave distally. I cannot count more than nine arm spines proximally, though Müller & Troschel give the number as ten. The spines have their sides parallel or else are slightly tapering, the ends blunt but not very thorny and the sides moderately thorny for most of the length; they are somewhat opaque at the tip. Distally the lowest spine becomes a well-developed hook with three or four teeth, the outermost the largest (Text-fig. 4m). The single tentacle scale is small and rounded.

The colour is lost.

VARIATIONS. The specimens from the "Red Sea" have d.d. 12–20 mm. The three larger ones have the dorsal arm plates (Text-fig. 5m) laterally angular like the holotype but in the smallest there is some rounding of the angles. The ventral arm plates are not so broad, especially in the smallest one where the plates proximally are about as broad as long. This specimen has up to only eight spines, whereas the larger ones have nine or ten basally. The colour pattern is dappled or spotted dark greyish-blue but the middle of the distal edge of most of the dorsal plates is paler, though this is not sufficiently extensive as to give the effect of a light longitudinal line. Similar light markings are shown on the specimens from the Dahlak Archipelago, the colour being otherwise dappled. Three of these have some arms more or less complete so that an estimate can be made; the ratios of d.d. : a.l. are: 13/120 mm. = 1/9.2; 20/200 mm. = 1/10; 17/155 or 195 + mm. (the arms being obviously very variable in length since the shorter one is complete and does not show any sign of having regenerated) = 1/9 or 1/c. 12. Finally the specimen from Aden has d.d. : a.l. = 15/190 mm. = 1/12.5. Its dorsal arm plates are rather variable in shape, some laterally angular, others somewhat rounded; they are finely rugose all over. The ventral arm plates are broad and the longest arm spines are slightly clavate. The disc stumps are a little smaller than those of the specimens previously mentioned, some of them having only three points. There is no sign of median light markings on the upper side of the arms, which are dappled all over.

The specimen from Mogadishu, Somalia, described as *M. hirsuta* by Tortonese (1949) had d.d. only 6 mm. and the arms but seven to eight times as long. The radial shields are almost naked. The dorsal arm plates are fan-shaped with well-marked lateral angles. The colour is grey-blue with darker markings on the radial shields and dorsal arm plates but no sign of median light areas. In spite of the relatively short arms, these last two characters suggest that the specimen could be a true *hirsuta*, the arm length being attributable to the small size; smaller specimens of subspecies *cheneyi* from Zanzibar often having the ratio only *c.* 1 : 5.

Clearly there is some variation in the relative arm length, the shape of the dorsal arm plates and the development of median light markings on the arms in specimens

of *hirsuta* from the vicinity of the southern end of the Red Sea. Although the material available is small, the difference in all three characters taken together justifies, in my opinion, at least a subspecific difference from *cheneyi* Lyman, the large sample of which from Zanzibar mentioned below shows consistent and correlated differences in these same characters.

DISTRIBUTION. Known only from the Red Sea and the immediately adjacent Indian Ocean.

Macrophiothrix hirsuta cheneyi (Lyman)

Text-figs. 3k, 4n, 5n, 7j

Ophiothrix cheneyi Lyman, 1861 : 84; 1865 : 175-176.

Ophiothrix hirsuta: Ludwig, 1899 : 549; Koehler, 1905 : 95 (part); 1922 : 234-235, pl. 31, fig. 1 [non fig. 2], ?pl. 99, fig. 2. [Non *O. hirsuta* Müller & Troschel, 1842.]

Macrophiothrix brevipeda H. L. Clark, 1938 : 290-292, fig. 20; 1939 : 91.

Macrophiothrix hirsuta: Balinsky, 1957 : 17-18.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 4097; Zanzibar; one paratype. Also c. 170 specimens in the British Museum collections from Zanzibar (c. 120), Mossel Bay, S. Africa and several stations of the John Murray Expedition off S. Arabia.

HISTORY. In 1865 Lyman redescribed *Ophiothrix cheneyi* and noted that it is closely related to *O. hirsuta* Müller & Troschel, of which he had studied the holotype in the Berlin Museum. However, he said then that two other specimens from the Red Sea "agree well with *O. cheneyi*; but are not clearly the same species as the original" (i.e. of *hirsuta*). Nevertheless, in 1882 (p. 226) Lyman included *cheneyi* in the synonymy of *hirsuta*, a disposition which has been followed by subsequent authors.

Notwithstanding Müller & Troschel's description of the dorsal arm plates of *O. hirsuta* as angular laterally (see Text-fig. 5l) Koehler described them as rounded, never keen and the specimen from the Red Sea of which he published photographs in 1922 appears to be an example of *cheneyi*, having not only laterally rounded dorsal arm plates but also a median light line along the proximal part of the arms, though this is not very strongly defined.

When he established *Macrophiothrix* in 1938, H. L. Clark seems to have had a rather confused impression of the identity of *hirsuta*, based largely on the type-material of *cheneyi* from Zanzibar, which he says is "typical". It is remarkable that at the same time he described some specimens from Natal as a new species, *M. brevipeda*, which is clearly indistinguishable from *cheneyi*, having the same obtuse lateral angles to the dorsal arm plates, median light lines and relatively short arms, less than ten times the d.d. (Lyman gives nine times under the heading "special marks" but in his description the ratio of 21 : 170 mm. works out at eight times; the paratype lent to me has all the arms broken in the middle.) The John Murray Expedition specimens determined as *M. brevipeda* by H. L. Clark are in the British Museum and show no significant differences from the Zanzibar material.

DESCRIPTION. The following remarks may be added to Lyman's description. D.d. of the paratype studied is 18 mm.; the arms are all broken. The disc is densely covered with multifid stumps (Text-fig. 3k) but the radial shields with much lower rugose grains. The ventral armament is more nearly spiniform with fewer points on the individual stumps.

The dorsal arm plates (Text-fig. 5n) are hexagonal with the distal edge often slightly concave in the middle and with the widest part at about the middle of the length or just distal to this and the lateral angles 90° or more, often more or less continuously curving. Laterally the plates are somewhat rugose in surface texture. Some of them are also split longitudinally. The twelfth free segment has the dorsal arm plate with length : breadth = 0.95 : 2.1 mm., the corresponding longest arm spines measuring 3.4 mm. The spines are relatively long, moderately thorny especially in the distal half and more or less clavate at the tip, especially the longer ones. Basally they number ten.

The ventral arm plates (Text-fig. 7j) have the distal edge distinctly concave; the consecutive ones are separated and they are relatively broad, that of the twelfth free segment measuring 0.7 : 1.3 mm.

The longest remaining arm stump extends only to the forty-fifth segment and the lowest arm spine is only partially modified into a hook.

The arms are marked with a double dark blue line defining a median light line on the upper side.

VARIATIONS. Eighty-seven specimens from Zanzibar have the d.d. ranging from 4 to 20 mm.; in twenty-eight with one or more arms near enough to being complete, the ratio of d.d. : a.l. is 1 : 5.0-10.0, with a mean of 1 : 7.35. Only a single individual has the top value of 10.0 and but two others have it over 9.0.

The specimens consistently have the dorsal arm plates without sharp lateral angles, though their shape is somewhat variable; the widest part is usually at or just distal to the middle; they are more or less distinctly carinate, at least proximally and those of the distal part of the arm, if not of the entire arm, show the pair of dark longitudinal lines bordering the light line. The ventral arm plates always have the distal edge distinctly concave and, except for the smallest specimen, are broader than long. The lowest arm spine distally is hooked with three or four teeth (Text-fig. 4n). The longitudinal ventral stripe is not always distinct. The general colour is variable, being most often greyish-purple but occasional specimens are khaki-coloured, greenish or brownish.

AFFINITIES. Certainly *M. cheneyi* is very closely related to *M. hirsuta*, agreeing in the armament of the disc, the disc stumps being almost identical, in the shape of the ventral arm plates, the proportions of the arm spines (though the longer ones tend to be more clavate than those of *hirsuta*) and the hooked shape of the distal lowest arm spines (though this last is shared by several other species). However, the consistently more rounded dorsal arm plates, arms nearly always shorter than ten times the disc diameter and the longitudinal lines on the arms convince me that it is worthwhile distinguishing *cheneyi*, at least at an infra-specific level. Judging from the present evidence, *M. hirsuta* is restricted to the Red Sea with *cheneyi*

coming in at the southern end. It is unfortunate that Koehler did not give a more precise locality for the specimen figured in 1922 which I believe is referable to *cheneyi*. As noted under the heading of *M. hirsuta hirsuta*, specimens from the islands off Eritrea and from Aden show some intermediate characters.

DISTRIBUTION. Known from Zanzibar south to Mossel Bay, S. Africa and north to southern Arabia and the southern part (at least) of the Red Sea.

***Macrophiothrix koehleri* sp. nov.**

Text-figs. 3l, 40, 50, 7k, pl. 1 fig. 2

?*Ophiothrix longipeda*: Müller and Troschel, 1842 : 113. *O. longipeda* (part): H. L. Clark, 1932 : 204. [Non *O. longipeda* (Lamarck), 1816.]

?*Ophiothrix galatæae*: Marktanner-Turneretscher, 1887 : 309; Brock, 1888 : 517; de Loriol, 1893a : 420; H. L. Clark, 1915 : 272. [Non *O. galatæae* Lütken, 1872.]

Ophiothrix galatæae: Koehler, 1905 : 84-85; 1922 : 233-234 (part), pl. 33, fig. 11, pl. 34, figs. 1, 3 (non ?2, 4), pl. 99, fig. 1 (part); 1930 : 141.

MATERIAL. British Museum No. 1967.12.13.3, Matui Island, Marovo Lagoon, New Georgia Islands, Solomon Islands, Dr. H. G. Ververs, Royal Society Expedition, 1965, the holotype; reef platform, Graham Point, Maran Sound, E. Guadalcanal, Solomon Islands, Dr. P. E. Gibbs, same expedition, six specimens. No. 82.12.23.191, Ternate, Mollucca Islands, "Challenger" Expedition, one specimen. No. 40.11.30.-, Mindoro, Philippines, Hugh Cuming, two specimens. No. 1932.4.28.46-47, Low Islands, Queensland, Great Barrier Reef Expedition, two specimens.

DESCRIPTION. D.d. is 20 mm. and the arm length $280+$ at least another 50 mm., the ratio being well over 1 : 15.

The disc is densely covered with small multifid stumps (Text-fig. 3l) about 0.3 mm. long, flared from just below the middle of their length, with transparent flanges ending in usually four to six points. The radial shields are about 6 mm. long and bear a few scattered very low granules, mainly around the edge, though there are some widely-spaced ones centrally. On the lower side of the disc the stumps extend on to the distal side of the oral shields, which are very broad rhombic in shape.

The dorsal arm plates (Text-fig. 50) are trapezoidal with sharp and often slightly prolonged lateral angles. Their distal edge is usually divided into three sectors by two extremely obtuse angles but sometimes the entire distal edge is slightly convex. The twelfth plate has length : breadth = 0.9 : 1.9 mm. = 1 : 2.1.

The ventral arm plates (Text-fig. 7k) are hexagonal but distinctly broader than long on the widest part of the arm, though the distal ones become as broad as long. The plate of the twelfth free segment has length : breadth = 0.9 : 1.05 mm. The median part of the distal edge is usually quite straight, occasionally slightly concave.

There are up to ten arm spines basally. The longest ones of the twelfth free segment are up to 2.35 mm. long, or 2.6 times the segment length. The longer spines are flared from just beyond the base to a broad tip and can be described as clavate, though they are neither so bushy nor so thick distally as those of *M. belli*.

Their shafts are smooth until just short of the tip. Beyond the arm base the lowest spine (Text-fig. 40) transforms into a comb with about eight teeth but with a slightly irregular tip as a rule.

The tentacle scale is small and rounded or may have an indented free edge.

The colour consists of very dark bluish-purple spots or blotches on a lighter ground with the arm spines evenly light purple except for their tips which are abruptly white.

VARIATIONS. A paratype from the Solomon Islands has d.d. 23–24 mm. and arm length $580 + c. 10$ mm., a ratio of $c. 1 : 25$ and in a third specimen from the same locality the proportions appear to about the same. The Ternate specimen has d.d. : a.l. = $16/260 + c. 20$ mm. = $1 : 17.5$. The Philippine and Low Islands specimens are dried and their arms are broken or coiled up and difficult to estimate but again appear to be extremely long. Most of these have the granulation of the radial shields restricted to the periphery. In the largest specimens the armament of the oral shields is reduced to a few spaced pointed thorns or even lost altogether on some shields and the shields themselves become extremely short and broad. On at least one specimen many of the dorsal arm plates are split longitudinally. There may also be a white midline along the arms.

As for Koehler's specimens, one from Dumurug Point, Philippines shown in pl. 33, fig. 11 and pl. 34, fig. 1 and the one from Billiton shown in pl. 34, fig. 3, agree well with the present material of *M. koehleri* in the appearance of the disc including the nearly naked radial shields, the shape of the dorsal arm plates and spines. The one in pl. 34, fig. 3, may possibly also be conspecific with *koehleri* but the other Billiton specimen in fig. 4 is very doubtful. Unfortunately, except for part *b*, which is definitely of this last specimen, Koehler does not make it clear from which specimens the various parts of pl. 99, fig. 1 are taken. The disc stumps, *a*, certainly agree with those of *koehleri*, unlike those in *b*, while the clavate, thorny-tipped longer arm spines are also similar. However, fig. 1*f* of the distal lowest arm spines show only four teeth and Koehler rightly says that they contrast with the comparable spines of *longipeda*, whereas the comblike form in *koehleri* does agree with *longipeda*. I suspect that the spines shown by Koehler are from this same specimen of pl. 34, fig. 4.

The specimen described under the name of *O. longipeda* by Müller & Troschel (1842) has stumps on the distal part of the oral shields and so could well belong to this species rather than to *longipeda*. Although they also describe the oral shields as being as long as wide—an unusual condition for *Macrophiothrix*—it is possible that the shields were obscured by opaque skin and they were misled by the contours of the adoral shields.

AFFINITIES. *M. koehleri* is certainly related to *M. longipeda* in its trapezoidal dorsal arm plates and comblike lowest arm spines but the species to which it comes the closest is *M. expedita* Koehler, 1905. They agree especially in the arm structure, the arms of both being immensely long, more than fifteen times the d.d., while the dorsal and ventral arm plates are almost identical in shape and the clavate, thorny-tipped but smooth-shafted longer arm spines are indistinguishable. Also the disc

Their shafts are smooth until just short of the tip. Beyond the arm base the lowest spine (Text-fig. 40) transforms into a comb with about eight teeth but with a slightly irregular tip as a rule.

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stumps are very similar, although in none of the specimens of *koehleri* which I have seen are any of the stumps elongated into spinelets, as often happens in *expedita*. However, there are notable differences, particularly the reduction of the armament of the radial shields to scattered low granules in *koehleri*, in contrast to the covering of elongated stumps in *expedita*, besides the development of spinelets or stumps along the distal edge of the oral shields in *koehleri*, which are evidently lacking in *expedita* (at least in the two specimens seen by me, while they are not mentioned in Koehler's descriptions not shown in his figures). In addition the colour pattern is different, there being no more than a single light line along the arms, if any, compared with the triple line said by Koehler to be a constant feature of *M. expedita*.

Another close relative is *M. belli* Döderlein, 1896, so far recorded only from the northern coasts of Australia. Like *M. koehleri* this has the radial shields superficially appearing almost naked, the dorsal arm plates trapezoidal and the arm spines clavate. However, the clavate form is carried to a much greater degree, especially on the distal halves of the arms in *M. belli*, which also differs in having more slender disc stumps not flared distally and with fewer points, the lowest arm spines not becoming comblike, but irregular, though variable in form judging from the present material and in addition the oral shields completely naked. The arms appear to be a little shorter in *M. belli*, Döderlein gives a measurement of fourteen times the d.d., but this may not be a significant difference. H. L. Clark (1938) stresses the development of stumps on the oral shields as a specific character of importance but it is possible that it may prove to be variable; some of the present specimens, especially the largest ones, lack stumps on one or more of the shields. If this does prove to be unreliable, then there may be insufficient grounds for maintaining *koehleri* and *belli* as distinct species.

DISTRIBUTION. Known from the Solomon Islands, the Low Islands in the Great Barrier Reef, the Philippines and Moluccas.

Macrophiothrix longipeda (Lamarck)

Text-figs. 3m-o, 4p-r, 5p-r, 7l, m

Ophiura longipeda Lamarck, 1816 : 544.

Ophiothrix longipeda: Lyman, 1865 : 176-177; de Loriol, 1893 : 36-37; Döderlein, 1896 : 293, pl. 14, fig. 6, pl. 16, fig. 17; Koehler, 1922 : 235-238, pl. 31, figs. 3, 4, pl. 33, figs. 9, 10, pl. 100, fig. 2. [?Non *O. longipeda*: Müller & Troschel, 1842; see *M. koehleri*.]

Ophiothrix punctolimbata von Martens, 1870 : 257. [Non *O. punctolimbata*: de Loriol, 1893a : 416-419, pl. 15, fig. 2; nec Döderlein, 1896 : 294, pl. 14, fig. 7, pl. 16, fig. 18; nec Koehler; 1905 : 93-95; nec Matsumoto, 1917 : 226; see *M. lorioli*.]

Macrophiothrix longipeda: H. L. Clark, 1938 : 288-290; 1946 : 221.

MATERIAL. Zoologisches Museum, Berlin, No. 1749, Java, Jagor, the holotype of *Ophiothrix punctolimbata* von Martens. Also thirty-five specimens in the British Museum collections from Mauritius (one), S.E. Africa (one), Zanzibar (nine), the Seychelles (ten), Maldive Islands (three), Christmas Island, Indian Ocean (two), Timorlaut (one), Loyalty Islands (one), Tahiti (one), Fiji Islands (one), northern Australia (five).

REMARKS. Although von Martens ranged *O. punctolimbata* among the species of *Ophiothrix* with granuliform disc armament, Brock (1888) described it as having multifid granulation on the radial shields and disc scales alike, which was interpreted by de Loriol and others as meaning that the armament consists of similar and somewhat elongated stumps all over. This is not the case in the holotype of *punctolimbata*, described below and consequently I cannot find any way of distinguishing this from *M. longipeda*.

DESCRIPTION. The holotype of *O. punctolimbata* has d.d. 13 mm. and arm length $180 + c. 20$ mm., giving a ratio of $c. 1 : 15$.

The disc has a dense covering of short stumps (Text-fig. 30), some of which are almost granuliform, though others are more than twice as long as wide; the longer ones are less than 0.2 mm. long. The radial shields have a dense covering of granules no higher than broad. The oral shields are broad rhombic and completely bare.

The dorsal arm plates are trapezoidal (Text-fig. 5r) with sharp latero-distal angles; that of the tenth free arm segment has length : breadth 0.95 : 2.0 mm. = 1 : 2.1. Occasional plates are split longitudinally.

The ventral arm plates on the basal half of the arm (Text-fig. 7m) are very little broader than long, that of the tenth free segment having length : breadth = 0.95 : 1.05 mm. Their shape is octagonal and the distal edge straight.

Basally there are ten arm spines on one or two segments. The longest ones measure $c. 2.3$ mm. They are finely thorny for the distal half of their length at least, sometimes also on the basal half to some extent. The lowest spine distally (Text-fig. 4r) becomes comb-like with multiple teeth.

The colour is now white with greenish-black spots along the distal and often also the proximal edges of the dorsal arm plates, while about every fourth plate is more extensively coloured so as to give a banded appearance. There are also spots on the disc.

VARIATIONS. Unfortunately the only available specimen from Mauritius, the type-locality of *M. longipeda*, is dried and not in very good condition. It is unusual in having many of the dorsal arm plates with the distal edge convex (Text-fig. 5q), although the lateral angles are still acute. In the other specimens the distal edge is usually divided into three straight sectors by two very obtuse angles, though occasional plates are somewhat convex. The length : breadth ratio of the plates is usually 1 : just over 2.

The armament of the disc scales (Text-fig. 3m) in the Mascarene specimen is fairly elongated, the stumps being mostly 2.5–3.5 times as long as broad; also the more peripheral granules of the radial shields are often slightly longer than broad. The same is true of the specimen from the Loyalty Islands, near the opposite end of the range of *M. longipeda*, but usually the armament of the radial shields is simply granuliform. In most of the other specimens where the disc armament was examined microscopically, the stumps on the scales were usually 2.5–3.0 times as long as broad but in one of the specimens from the Seychelles they are particularly short, many of them almost granuliform (Text-fig. 3n). Kochler notes (1922) that in specimens from the Philippines the disc stumps are "three to four times as long as broad",

but it is clear that throughout the range there is some variation in the relative length. However, the shape is otherwise fairly constant in being cylindrical, very few stumps being at all flaring, and there are usually three to five points at the tip.

The arm spines do not normally exceed the arm breadth in length, as Lamarck commented, and indeed are often somewhat shorter, the longer ones usually just exceeding twice the segment length. Most of them are finely rugose for almost their entire length but the second and third spines from above may be smooth on the basal half, at least on the side facing the disc. These longer spines have their sides parallel or slightly tapering and the ends truncated so they cannot be described as at all clavate. The lowest spine distally (Text-fig. 4p) is always more or less comb-like with multiple teeth but in the specimen from the Seychelles the terminal tooth may be unusually enlarged (Text-fig. 4q).

The colour pattern normally consists of the well-defined dark intersegmental spots on the arms said to be characteristic of *punctolimbata*.

DISTRIBUTION. Known from Mauritius, E. Africa, the islands of the western Indian Ocean, the Maldivé Islands, Ceylon, the East Indies, Philippines, southern Japan, the S. Pacific islands (but not the Hawaiian Islands) and northern Australia. Records from the Red Sea and Persian Gulf need confirmation, being possibly based on material of *M. hirsuta*, *demessa* or *elongata*.

Macrophiothrix lorioli sp. nov.

Text-figs. 3p, 4s, 5s, 7n, pl. 1, fig. 4

Ophiothrix punctolimbata: de Loriol, 1893a: 416-419, pl. 15, fig. 2; Koehler, 1905: 93-95; 1922: 237, pl. 32, fig. 6, pl. 101, fig. 7. [Non *O. punctolimbata* von Martens, 1870.]

MATERIAL. British Museum No. 1967.12.13.1, north side, Gaskell Island, (Florida Islands), Solomon Islands, Dr. H. G. Ververs, Royal Society Expedition, 1965, the holotype; No. 1967.12.13.2, north-west side, Gaskell Island, same source, one paratype; reef platform, Graham Point, Maran Sound, Guadalcanal, Solomon Islands, Dr. P. E. Gibbs, same expedition, one specimen. No. 92.8.22.49, Macclesfield Bank, S. China Sea, 24 metres, Admiralty, one specimen. No. 82.12.23.200 (part), Tongatabu, "Challenger", one specimen. No. 94.5.18.1, coral reef, Tongatabu, R. B. Leafe, one specimen.

DESCRIPTION. The holotype has d.d. 16 mm. and arm length *c.* 300 mm. and *c.* 225 mm. on two arms measured, giving ratios of 1 : 19 and 1 : 14.

The disc is closely covered with elongated stumps (Text-fig. 3p) having two to five points, most often three; most of them are flared from close to the base with transparent flanges ending in the points. The longer stumps are *c.* 0.4 mm. long. The radial shields are about 6 mm. in length and closely covered with stumps similar to but smaller than those on the disc scales; again these are mostly trifid. On the ventral side of the disc the stumps tend to have fewer points, especially the proximal ones, which may consist of a single tapering thorn. These stop short of the genital slits and the oral shields, which are broad rhombic, with length : breadth 1.25 : 1.9 mm.

The dorsal arm plates (Text-fig. 5s) are approximately fan-shaped, though the median part of the distal edge tends to be flattened. Some are angular laterally, the angle usually measuring just over 90° , but others are somewhat rounded. The widest part is distal to the middle of the length of the plate. The twelfth plate has length : breadth = $0.8 : 1.75$ mm. = $1 : 2.2$. The corresponding longest spines measure 2.35 mm. Further out the arms are slightly broader, the thirty-fifth plate measuring $0.9 : 2.05$ mm. and the longest spines are *c.* 2.9 mm. long. Some of the basal dorsal arm plates are slightly arched but for most of the arm they are flattened.

The ventral arm plates (Text-fig. 7n) are approximately hexagonal with the three distal sides curving into one another, the distal edge being slightly convex. The plate of the twelfth free segment has length : breadth = $0.8 : 1.1$ mm.

The arm spines number up to eight proximally. The longer ones have parallel sides and truncated tips and are finely rugose for most of their lengths. Distally the lowest spines become comb-like but with rugose tips (Text-fig. 4s).

The colour in spirit is purple on white. There are dark spots on the radial shields and on the dorsal arm plates leaving a light transverse bar towards the distal edge of each plate. The colour is intensified at regular intervals giving a banded effect. The ventral side of the arms is marked only with about four dark spots between each segment; there is no trace of a median ventral light line.

VARIATIONS. A second specimen from the Solomon Islands has numerous bifid as well as trifid disc stumps. Its disc appears to have regenerated as well as the distal parts of the arms. It has many of the proximal dorsal arm plates split longitudinally and also differs from the holotype in having opaque cores in the distal parts of the arm spines. The white markings on the arm plates are more T-shaped and suggest a median white line, though this is discontinuous. A more definite white midline is shown in the specimen from Macclesfield Bank and the same is true in one of the specimens from Tongatabu.

REMARKS. The discovery that the holotype of *Ophiothrix punctolimbata* has trapeziform dorsal arm plates and granular armament on the radial shields and is a synonym of *M. longipeda* leaves nameless the specimens which de Loriol and Koehler referred to von Martens' species, necessitating the introduction of the name *lorioli*.

I am uncertain as to the identity of the specimen from Thursday Island, Torres Strait, which Döderlein (1896) referred to *O. punctolimbata*. Superficially it resembles the present species but its disc stumps are evidently multifid.

AFFINITIES. The species most closely related to *M. lorioli* is *M. rhabdota* H. L. Clark, which shares the combination of fan-shaped dorsal arm plates (though in the paratype of *rhabdota* seen by me these are more consistently angular laterally), predominantly trifid elongated stumps on the radial shields as well as the disc scales, naked oral shields and distal lowest arm spines which are irregularly comb-like in form. The main difference is the presence of triple light lines along the upper side of the arms and a single light line on the lower side in *M. rhabdota*. Koehler (1915) finds that such lines are a consistent feature of *M. expedita*, though in that case the dark intervening lines are reddish and not blue. Accordingly there seems to be

some justification for ranking *lorioli* as specifically distinct on the basis of the present material at least.

DISTRIBUTION. Known from the Solomon Islands, the East Indies and the Philippines.

***Macrophiothrix megapoma* H. L. Clark**

Text-figs. 3q, 4t-v, 6a, 7o

Ophiothrix longipeda (part): H. L. Clark, 1932 : 204.

Macrophiothrix megapoma H. L. Clark, 1938 : 297-299, fig. 22; 1946 : 219-220; Endean, 1957 : 243.

MATERIAL. British Museum No. 1936.6.2.1, station IX, 22-27 metres, Great Barrier Reef Expedition, the holotype. Also twenty other specimens in the British Museum collections ranging from the Dampier Archipelago near the north-west corner of Australia to Port Curtis, Queensland in depths down to 68 metres.

REMARKS. As shown in Text-fig. 6a, the shape of the dorsal arm plates in the holotype is rather different from the trilobed form drawn by H. L. Clark, presumably from the paratype in the Harvard Museum's collection from near Cape York. The contours of the plates are also less markedly carinate. There is some variation in the shape of the plates in the other specimens; in one with d.d. only 10 mm. from Torres Strait they are almost flat but usually there is some degree of carination.

The longest arm spines on the broadest part of the arm are long and slender; on the twenty-fifth free segment in the holotype they are up to 3.6 mm. long or four times the segment length. The arms are broken within 60 mm. of the base in the holotype and the more distal lowest arm spines are little modified; however, the tip of one arm has regenerated and the lowest spines on that have teeth on one side only (Text-fig. 4t); in one there are as many as seven teeth but more often the shape is hook-like with only about four teeth. In some of the other specimens from which preparations of lowest distal spines were made there are similarly about four teeth and the tip is slightly irregular (Text-fig. 4u, v).

The arms may be spotted above, as in *M. sticta*.

DISTRIBUTION. See under material.

***Macrophiothrix rhabdota* (H. L. Clark)**

Text-figs. 3r, 4w, 6b, 7p

Ophiothrix rhabdota H. L. Clark, 1915 : 278, pl. 13, fig. 4; 1921 : 113, pl. 15, figs. 6, 7.

?*Ophiothrix expedita* var. *rhabdota*: Koehler, 1922 : 230-233, pl. 31, fig. 5, pl. 33, fig. 6.

Macrophiothrix rhabdota: H. L. Clark, 1938 : 286-287; 1946 : 220-221; Endean, 1957 : 243.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 3817, Mer, Torres Strait, one paratype.

REMARKS. The paratype has d.d. 9.5 mm.; the arms are all incomplete. The dorsal arm plates (Text-fig. 6b) have the distal edge curved back at the sides to form an angle of usually about 90° with the divergent sides. This contrasts with the

more acute angles in the specimen of *M. expedita* in the British Museum collections, which give the plates a trapeziform-shape rather than a fan-shape. In this respect *M. rhabdota* is intermediate between the *longipeda*-group of species with trapeziform plates and the *hirsuta*-group with fan-shaped plates. Although there is some variation in the shape of the plates in any one species of *Macrophiothrix*, and indeed of different plates of any one specimen, the shape normally provides a useful character for distinguishing the groups of species. Accordingly I am inclined to support H. L. Clark in retaining *rhabdota* as a species distinct from *expedita*, though better samples may show that Koehler was correct in ranking *rhabdota* infraspecifically. He did this on the basis of three specimens from the Philippines which agree with the type-material of *M. expedita* (but not with that of *rhabdota*) in having spinelets among the disc stumps. Koehler's reason for referring these specimens to *rhabdota* is that the colour pattern is greyish-blue rather than the red usual in *expedita*. Having seen reddish specimens of both *M. demessa* and *M. galateae* which are morphologically indistinguishable from type-material of the more usual colour, I doubt whether this provides a valid distinction, although I think that the colour *pattern* is more important.

As mentioned under the heading of *M. lorioli*, that species is closely related to *M. rhabdota*, the main difference being the absence in *lorioli* of triple light lines on the arms, besides rather rounded lateral angles on many of the dorsal arm plates.

DISTRIBUTION. Known with certainty only from Torres Strait, the records of H. L. Clark and Koehler from the Philippines needing a critical comparison.

Macrophiothrix robillardi (de Loriol)

Text-figs. 3s, 4x, 6c, 7q

Ophiiothrix Robillardi de Loriol, 1893 : 39-41, pl. 24, fig. 3.

Macrophiothrix robillardi: A. M. Clark, 1967 : 649.

MATERIAL. British Museum No. 1949.10.21.1, Mauritius, one specimen. [This is an old specimen of which the original registration number (if any) has been lost; it is quite possible that it came from de Robillard like the holotype, since much of our old mascarene material was purchased from him.]

REMARKS. There is a faint suggestion of a median longitudinal light line, what little colour remains elsewhere being blue.

DISTRIBUTION. Known only from Mauritius.

Macrophiothrix rugosa H. L. Clark

Text-figs. 4y, 6d, 7r

Macrophiothrix rugosa H. L. Clark, 1938 : 229-230, fig. 23; Eudean, 1957 : 243.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 3799A, Mer, Thursday Island, Torres Strait, one arm of the holotype.

DESCRIPTION. The dorsal arm plates (Text-fig. 6d) are broad fan-shaped except that the median part of the distal edge is slightly concave; there appears to be an additional suture at the proximal end of each plate so that the successive plates do not overlap. Many of the plates are split longitudinally, a feature not mentioned by H. L. Clark. He also describes the surface of the plates as uniformly covered with prickly granules, implying that these are superimposed, whereas in fact the surface of the plate itself has a markedly rugose texture. One of the proximal dorsal arm plates on the detached arm has length : breadth = 0.75 : 1.9 mm. = 1 : 2.6. The longest corresponding spine is 2.75 mm. The longer spines are slightly tapering and finely thorny. The lowest spines distally (Text-fig. 4y) become very short, with a few short transparent points on the outer part or a slightly curved tooth but they cannot really be described as hook-like. There are only seven spines on the proximal-most segment remaining.

The ventral arm plates (Text-fig. 7r) are broad rectangular and widely separated, though the proximal edge is very indistinct; the distal edge is slightly convex in contrast to that of *M. callizona* and *calyptaspis*. A proximal plate measured has length : breadth = 0.55 : 1.0 mm.

DISTRIBUTION. Known only from Torres Strait.

Macrophiothrix scotia H. L. Clark

Text-figs. 3t, 4z, 6c, 7s

Macrophiothrix scotia H. L. Clark, 1938 : 300-302, pl. 24, fig. 2; 1946 : 220.

MATERIAL. British Museum No. 1967.11.14.7, Broome, N.W. Australia, one paratype.

AFFINITIES. The differences detailed by H. L. Clark in his key between *M. megapoma* and *scotia* appear to me very slight. The disc armament of multifid stumps (Text-fig. 3t) and the shapes of the arm plates and spines, with the lowest one distally (Text-fig. 4z) only half-way modified into a hook, are very similar, allowing for the difference in size of the specimens illustrated (d.d. 19 mm. in the holotype of *megapoma* or 18 mm. according to H. L. Clark and 13 mm. in the paratype of *scotia*). The tentacle scales of *scotia* are not significantly smaller and although the colour is particularly dull, this may also be true in *megapoma*; both have a broad light longitudinal band along the under side of the arms.

DISTRIBUTION. Known from Lagrange Bay (west of Broome), N.W. Australia, eastwards only to Darwin.

Macrophiothrix spinifera H. L. Clark

Text-figs. 3u, 6f, 7t

Macrophiothrix spinifera H. L. Clark, 1938 : 302-304, pl. 24, fig. 3; 1946 : 220.

MATERIAL. British Museum No. 1967.11.14.8, Broome, N.W. Australia, one paratype.

AFFINITIES. Judging again from only single preserved specimens I cannot see any significant difference in the flatness or shape of the arms and arm spines between *M. spinifera* and *scotia*, as postulated by H. L. Clark in his key. The disc stumps of *spinifera* are rather smaller as Dr. Clark notes but this alone does not provide a specific distinction. He comments that the young of *spinifera* and *scotia* are indistinguishable but the adults are very different.

DISTRIBUTION. Known only from the Broome area of N.W. Australia, from Lagrange Bay to Cape Leveque.

Macrophiothrix sticta H. L. Clark

figs. 4a', 6g, 7u

Macrophiothrix sticta H. L. Clark, 1938 : 304-305, fig. 24; 1946 : 219.

MATERIAL. Museum of Comparative Zoology, Harvard, No. 2345A, Shark Bay, W. Australia, part of one arm of the holotype.

DESCRIPTION. The piece of arm measures 95 mm. and is probably about half or less of the whole arm, judging from the very slight degree of tapering distally; H. L. Clark's estimate of their probable total length is *c.* 200 mm.; he also gives the d.d. as 15 mm.

The dorsal arm plates (Text-fig. 6g) are flat broad and hexagonal or elliptical, widest at about the middle of their length. A proximal one has length : breadth = 0.85 : 2.2 mm. = 1 : 2.6. The longest corresponding spine is 3.8 mm. long or 4.5 times the segment length but the spines on the more distal remaining segments are even longer, up to *c.* 5.25 mm. The longer spines have almost parallel finely thorny sides and some of them are slightly expanded at their truncated tips. The lowest spine on the more distal remaining segments (Text-fig. 4a') is not very much modified; possibly those on the lost distal part of the arm were more hook-like.

The ventral arm plates (Text-fig. 7u) are contiguous and rounded pentagonal in shape with the proximal angle slightly truncated. The distal side is straight or very slightly concave.

The dorsal arm plates are marked with large spots, as described by H. L. Clark, or with poorly defined transverse lines.

AFFINITIES. Of the three other Australian nominal species besides *M. megapoma* with the oral shields armed with stumps and included by H. L. Clark, *M. sticta* seems to me to be the only one significantly different from *megapoma*, judging from the arm structure. The dorsal arm plates are broad hexagonal, as opposed to fan-shaped and the arm spines are relatively longer, 4.5 times the segment length compared with 3.3 to 3.7 times the segment length in the material of *megapoma*, *scotia* and *spinifera* measured. In these three also the longer spines are not at all broadened at the tip.

DISTRIBUTION. Known only from Shark Bay, W. Australia.

Macrophiothrix variabilis (Duncan)

Text-figs. 3v, w, 4b', c', 6h, i, 7v, pl. fig. 3

Ophiiothrix variabilis Duncan, 1887: 99-101, pl. 9, figs. 18, 19, pl. 11, figs. 32-36.*Ophiiothrix hirsuta*: Koehler, 1905: 93; 1922: 234-235 (part), pl. 31, fig. 2 (non fig. 1), pl. 33, fig. 13 (?non pl. 99, fig. 2). [Non *O. hirsuta* Müller and Troschel, 1842.]

MATERIAL. Oslo Museum, off Pasir Panjang Power Station, Singapore, and specimen. Also six specimens in the British Museum collections from Tuticorin one Ramesvaram, Gulf of Manaar.

REMARKS. I disagree with Koehler (1905) that *O. variabilis* is conspecific with *O. hirsuta* although the two are certainly closely related. In all the specimens of

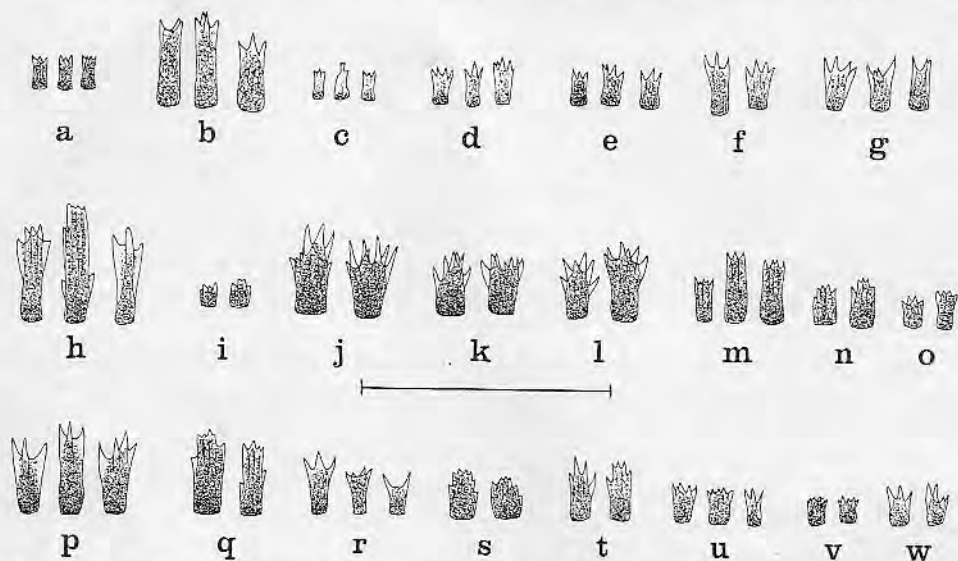


FIG. 3. *Macrophiothrix* spp. Disc stumps. a. *M. aspidota*, 82.1.5.11, Karachi, d.d. 22 mm.; b. *M. belli*, 42.2.24.1, Port Essington, N. Australia, d.d. 25 mm.; c. *M. callizona*, paratype, M.C.Z. 5113, Broome, d.d. 10.5 mm.; d. *M. calyptaspis*, paratype, M.C.Z. 5115, d.d. 11 mm.; e. *M. demessa*, M.C.Z. 4491, Hawaiian Islands, d.d. 8.5 mm.; f. *M. demessa*, 1949.10.20.1, Gulf of Aqaba, d.d. 19 mm.; g. *M. elongata*, 1922.3.1.11, Persian Gulf, d.d. 16 mm.; h. *M. expedita*, 82.12.23.62, Philippines, d.d. 15 mm.; i. *M. galateae*, holotype, Copenhagen Museum, Nicobar Islands, d.d. 14.5 mm.; j. *M. hirsuta hirsuta*, holotype, Berlin Museum 1000, Red Sea, d.d. c. 22 mm.; k. *M. hirsuta cheneyi*, paratype, M.C.Z. 4097, Zanzibar, d.d. 17 mm.; l. *M. koehleri*, holotype, 1967.12.13.3, Solomon Islands, d.d. 20 mm.; m. *M. longipeda*, 42.12.26.60, Mauritius, d.d. 25 mm.; n. *M. longipeda*, 82.10.16.85, Seychelles, d.d. 20 mm.; o. *M. longipeda* (holotype of *Ophiiothrix punctolimbata*), Berlin Museum 1749, Java, d.d. 13 mm.; p. *M. lorioli*, holotype, 1967.12.13.1, Solomon Islands, d.d. 16 mm.; q. *M. megapoma*, holotype, 1936.6.2.1, Great Barrier Reef, d.d. 18 mm.; r. *M. rhabdota*, paratype, M.C.Z. 3817, Torres Strait, d.d. 9.5 mm.; s. *M. robillardi*, 1949.10.21.1, Mauritius, d.d. 15 mm.; t. *M. scotia*, paratype, 1967.11.14.7, Broome, d.d. 13 mm.; u. *M. spinifera*, paratype, M.C.Z. 5126, Broome, d.d. 11 mm.; v. *M. variabilis*, Oslo Museum, Singapore, d.d. 22 mm.; w. *M. variabilis*, 88.11.15.1, Ramesvaram, d.d. 25 mm.

variabilis I have seen many of the dorsal arm plates (Text-fig. 6h, i) are distinctly trilobed, a form not found in *hirsuta* and in addition the lateral angles are much more rounded, as in *hirsula cheneyi* but not in *hirsula hirsuta*. The arms are very smooth dorsally and covered with thick skin which tends to obscure the limits of the plates in spirit specimens. There is no sign of the rugosities on the surface of the plate which are regularly found in *M. hirsuta*. The disc stumps (Text-fig. 3v, w) are consistently only half as long as those of *M. hirsuta* and usually have only three or four points instead of about six, although in the specimen from Singapore they are

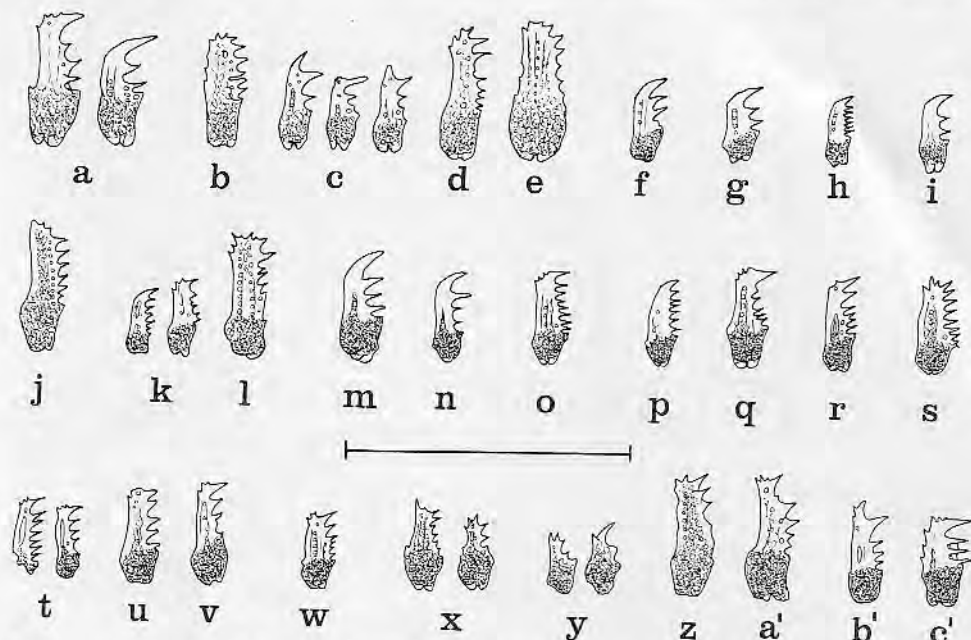


FIG. 4. *Macrophiiothrix* spp. Lowest arm spines, from distal part of arm unless otherwise stated. a. *M. aspidota*, 88.11.15.2, Ramesvaram; b. *M. belli*, 83.12.9.55, Torres Strait; c. *M. belli*, 82.2.22.133, Torres Strait; d. *M. belli*, 42.2.24.1, Port Essington; e. *M. belli*, 1953.1.24.13, Monte Bello Islands (? middle segment); f. *M. callizona*, paratype, M.C.Z. 5113, Broome; g. *M. calyptaspis*, paratype, M.C.Z. 5115, Broome; h. *M. demessa*, M.C.Z. 4491, Hawaiian Islands; i. *M. elongata*, 1922.3.1.11, Persian Gulf; j. *M. expedita*, 82.12.23.62, Philippines (? middle segment); k. *M. galateae*, holotype, Copenhagen Museum, Nicobar Islands; l. *M. galateae*, 82.12.23.200(pt.), Tonga Islands. (? middle segment); m. *M. hirsuta hirsuta*, holotype, Berlin Museum 1000, Red Sea; n. *M. hirsuta cheneyi*, paratype, M.C.Z. 4097, Zanzibar; o. *M. koehleri*, holotype, 1967.12.13.3, Solomon Islands; p. *M. longipeda*, 42.12.26.60, Mauritius; q. *M. longipeda*, 82.10.16.85, Seychelles; r. *M. longipeda* (holotype of *Ophiiothrix punctolimbata*), Berlin Museum 1749, Java; s. *M. lorioli*, holotype, 1967.12.13.1, Solomon Islands; t. *M. megapoma*, holotype, 1936.6.2.1, Great Barrier Reef (from regenerated arm tip); u. *M. megapoma*, 82.12.23.179, Torres Strait; v. *M. megapoma*, 81.10.26.95, Port Curtis; w. *M. rhabdota*, paratype, M.C.Z. 3817, Torres Strait; x. *M. robillardi*, 1949.10.21.1, Mauritius; y. *M. rugosa*, holotype, M.C.Z. 3799A, Torres Strait; z. *M. scotia*, paratype, 1967.11.14.7, Broome; a'. *M. sticta*, holotype, M.C.Z. 2345A, Sharks Bay (middle segment); b'. *M. variabilis*, Oslo Museum, Singapore; c'. *M. variabilis*, 88.1.2.60, Tuticorin.

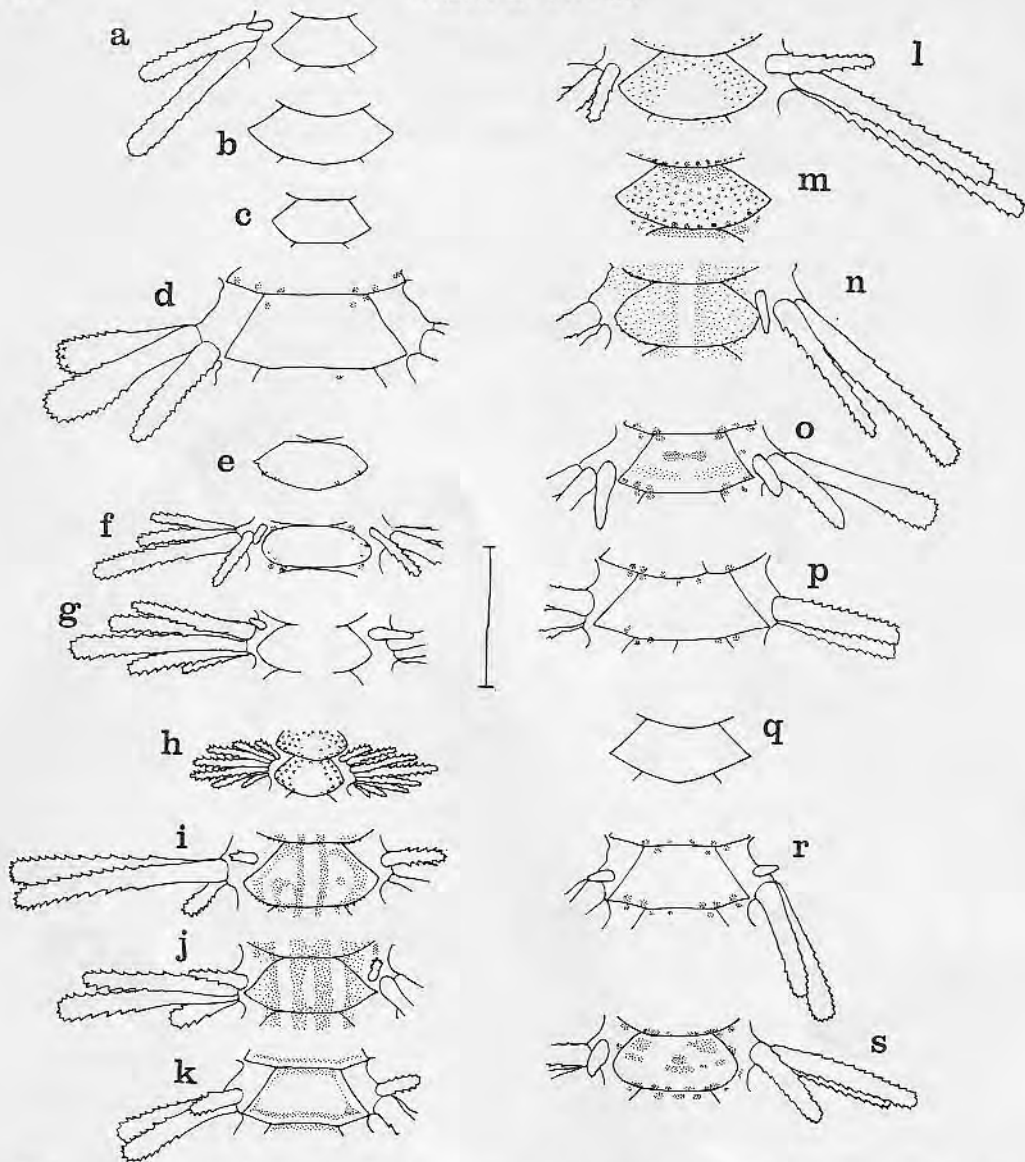


FIG. 5. *Macrophiothrix* spp. Proximal arm segments from about twelfth to twentieth free ones), in dorsal view. a. *M. aspidota*, holotype, Berlin Museum 1008, E. India; b. *M. aspidota*, 88.11.15.2, Ramesvaram, d.d. 14 mm.; c. *M. aspidota*, 1961.8.23.11, Bombay, d.d. 15 mm.; d. *M. belli*, 1953.1.24.13, Monte Bello Islands, d.d. 22 mm.; e. & f. fourth dorsal arm plate and twentieth free segment of *M. callizona*, paratype, M.C.Z. 5113, Broome, d.d. 10.5 mm.; g. *M. calyptaspis*, paratype, M.C.Z. 5115, Broome, d.d. 11 mm.; h. *M. demessa*, M.C.Z. 4491, Hawaiian Islands, d.d. 8.5 mm.; i. *M. elongata*, 1922.3.1.11, Persian Gulf, d.d. 16 mm.; j. *M. expedita*, 82.12.23.62, Philippines, d.d. 15 mm.; k. *M. galateae*, holotype, Copenhagen Museum, Nicobar Islands, d.d. 14.5 mm.; l. *M. hirsuta hirsuta*, holotype, Berlin Museum 1000, Red Sea, d.d. c. 22 mm.; m. *M. hirsuta hirsuta*, 49.8.24.118, Red Sea, d.d. 18 mm.; n. *M. hirsuta cheneyi*, paratype, M.C.Z. 4097, Zanzibar, d.d. 17 mm.; o. *M. koehleri*, holotype, 1967.12.13.3, Solomon Islands, d.d. 20 mm.; p. *M. longipeda*, 82.10.16.85, Seychelles, d.d. 20 mm.; q. *M. longipeda*, 42.12.26.60, Mauritius, d.d. c. 25 mm.; r. *M. longipeda* (holotype of *Ophiothrix punctolimbata*), Berlin Museum 1749, Java, d.d. 13 mm.; s. *M. lorioli*, holotype, 1967.12.13.1, Solomon Islands, d.d. 16 mm. The colour pattern is shown in d, f, i, j, k, m-p, r and s only.

multifid, though extremely small (Text-fig. 3v). The arm spines are relatively much longer in *hirsuta*, the longest ones over four times the corresponding segment length in the holotype of *hirsuta* compared with less than 3.5 times the segment length in *variabilis*. This is also shown up in a comparison of figs. 1 and 2 in Koehler's pl. 31, 1922, fig. 1 being of a specimen from the Red Sea, probably of *M. hirsuta cheneyi*, while I believe that fig. 2 is of *variabilis*. The lowest arm spine distally is somewhat different; in *M. hirsuta* it usually forms a perfect hook (Text-fig. 4m) but in *variabilis* (Text-fig. 4b', c') the tip of the hook is more or less irregular. Finally, Duncan gives the arm length of *variabilis* as twelve to fourteen times the d.d., whereas in *M. hirsuta hirsuta* although in one specimen from Aden the arms are about 12.5 times the d.d. the usual proportion is probably about ten times and in *hirsuta cheneyi* even less.

DISTRIBUTION. Known from the Mergui Archipelago, Singapore and the southern tip of India. It remains to be seen whether the specimens from the East Indies which have been referred to *hirsuta* are in fact *variabilis*; I suspect that many of them are.

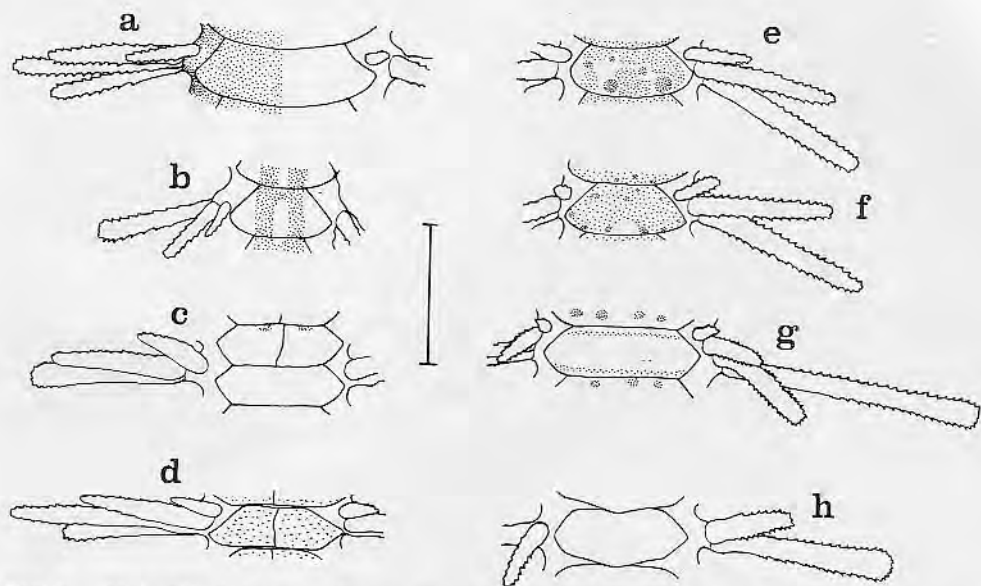


FIG. 6. *Macrophiothrix* spp. Proximal arm segments in dorsal view (cont.). a. *M. megapoma*, holotype, 1936.6.2.1, Great Barrier Reef, d.d. 18 mm.; b. *M. rhabdota*, paratype, M.C.Z. 3817, Torres Strait, d.d. 9.5 mm.; c. *M. robillardi*, 1949.10.21.1, Mauritius, d.d. 15 mm.; d. *M. rugosa*, holotype, M.C.Z. 3799A, Torres Strait, d.d. 16 mm.; e. *M. scotia*, paratype, 1967.11.14.7, Broome, d.d. 13 mm.; f. *M. spinifera* paratype, 1967.11.14.8, Broome, d.d. 11 mm.; g. *M. sticta*, holotype, M.C.Z. 2345A, Shark's Bay, d.d. 15 mm.; h. *M. variabilis*, Oslo Museum, Singapore, d.d. c. 22 mm. The carination is shown by shading in (a) and the colour pattern in b, c, e, f & g only.

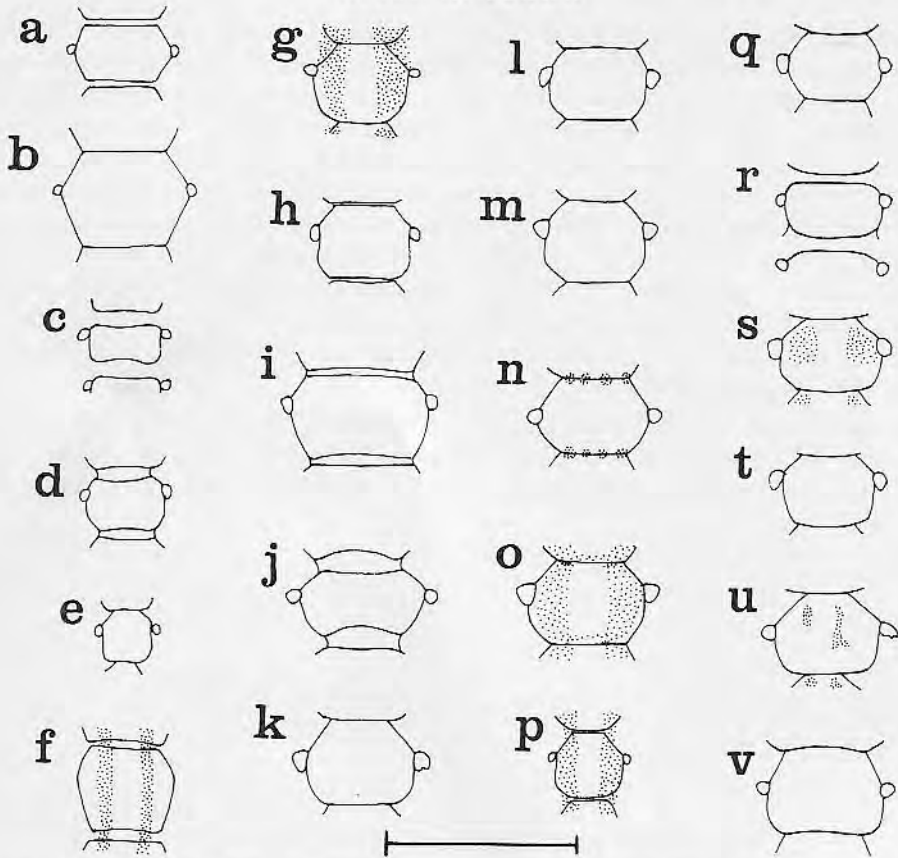


FIG. 7. *Macrophiothrix* spp. Proximal arm segments in ventral view. Details as for figs. 5 and 6, unless otherwise stated. a. *M. aspidota*, holotype; b. *M. belli*, 1953.1.24.13; c. *M. callizona*, paratype; d. *M. calyptaspis*, paratype; e. *M. demessa*, M.C.Z. 4491; f. *M. elongata*, 1922.3.1.11; g. *M. expedita*, 82.12.23.62; h. *M. galateae*, holotype; i. *M. hirsuta hirsuta*, holotype; j. *M. hirsuta cheneyi*, paratype; k. *M. koehleri*, holotype; l. *M. longipeda*, 42.12.26.60; m. *M. longipeda* (holotype of *Ophiothrix punctolimbata*); n. *M. lorioli*, holotype; o. *M. megapoma*, holotype; p. *M. rhabdoia*, paratype; q. *M. robilardi*, 1949.10.21.1; r. *M. rugosa*, holotype; s. *M. scotia*, paratype; t. *M. spinifera*, paratype; u. *M. sticta*, holotype; v. *M. variabilis*, 88.1.2.1, Tuticorin, d.d. 20 mm. The colour pattern is shown in f, g, n, o, p, s and u only.

Family *OPHIODERMATIDAE*

Ophiopeza fallax fallax Peters

Text-fig. 9c

Ophiopeza fallax Peters, 1851 : 465; Lyman, 1874 : 221.

Pectimura fallax: H. L. Clark, 1909 : 119; 1915 : 303, pl. 18, figs. 9, 10.

MATERIAL. About forty specimens in the British Museum collections from Zanzibar.

NOMENCLATURE. The use of the combination *Ophiopeza fallax* by Mortensen (1940), when dealing with what I am now calling *O. fallax arabica*, is preferable to that used by H. L. Clark. As Mortensen commented, the synonymizing of *Ophiopeza* Peters, 1851 with *Pectinura* Forbes, 1843 was premature in view of the very little which is known about the type-species of *Pectinura*, *P. vestita* Forbes, the genus being originally monotypic. The holotype is the only recorded specimen and its whereabouts are unknown. It had d.d. only 2 or 3 mm. (one-tenth of an inch). Judging from the description and figures each oral shield (ovarian plate of Forbes) is accompanied by a broad supplementary shield. No such supplementary shields are exposed as a rule in *Ophiopeza fallax* (although they may be present concealed under the granulation) but H. L. Clark discarded their occurrence as a character of generic weight, a conclusion with which I concur in view of the variable occurrence of such shields in several species of Ophiidermatidae. I think it quite possible that the holotype of *P. vestita* could have been a specimen of *Ophioconis forbesi* (Heller) with the granule-covering rubbed off the oral shields. *O. forbesi* has been recorded from the Adriatic and further west in the Mediterranean. The type-locality of *P. vestita* is off southern Turkey, from which part little collecting has been done; until this omission is rectified and more Ophiidermatids are taken from that area of the Mediterranean, no further assumptions about the nature of *Pectinura* should be made.

In 1949 A. H. Clark referred *fallax* to *Ophiopezella*, again dealing with the sub-species described below, on account of the prominence of the series of plates just above the margin of the disc interradially. This same character was used by H. L. Clark as diagnostic of *Ophiopezella* Ljungman, 1872, type-species *Ophiarachna spinosa* Ljungman, 1867, regardless of its occurrence, though less conspicuously, in *Ophiopeza fallax* (Text-fig. 9a, p. 318). Since *Ophiopeza* antedates *Ophiopezella* the latter becomes a synonym and the two species included, *O. spinosa* and *O. dubiosa* de Loriol, are referable to *Ophiopeza*. A third nominal species, *Ophiopezella decorata* Mortensen (1933, Vidensk. Meddr dansk naturh. Foren. **93** : 379) from Durban, South Africa, I think is probably a synonym of *Ophiopeza fallax*; it has no exposed supplementary oral shields and the relatively broad oral shields provide a dubious distinction since the shape of these is somewhat variable in most Ophiidermatids. The remaining species which have been referred to *Pectinura* (namely *aequalis* Lyman, *anchista* H. L. Clark, *arenosa* Lyman, *assimilis* (Bell), *cylindrica* (Hutton), *dyscrita* H. L. Clark, *exilis* (Koehler), *gracilis* Mortensen, *maculata* (Verrill) and *nigra* H. L. Clark) with the exception of *P. yoldii* dealt with below, are all congeneric with *Ophiopeza fallax* in my view.

DISTRIBUTION. Known from Mozambique (? south to Natal) to Zanzibar; Brock's record from Amboina (1888) and Koehler's from the Sulu Archipelago, Philippines, need re-investigation in view of the subspecies described below.

***Ophiopeza fallax arabica* subsp. nov.**

fig. 8, pl. 1, figs. 5, 6

Ophiopeza fallax: Mortensen, 1940 : 100 [Non *O. fallax* Peters, 1851.]
Ophiopezella fallax: A. H. Clark in Clark & Bowen, 1949 : 5.

MATERIAL. U.S.N.M. No. E.7734, Tarut Bay, Persian Gulf, under stones, the holotype. B.M. No. 1962.8.16.5, north of Jazirat al Yas Island, Trucial Oman, Persian Gulf, one specimen. Pakistan Marine Biological Laboratory No. 836 and B.M. No. 1967.11.1.14, Bulejee Village, Karachi, two specimens.

DESCRIPTION. The holotype has the d.d. 14 mm. and arm length *c.* 45 mm.

The disc is covered with fine granules which under high magnification can be seen to be polygonal and often centrally indented. There are *c.* 28 granules to the linear mm. near the centre. The peripheral interradial plates on the upper side are distinctly convex and their contours are emphasized by a slight increase in the size of the granules covering them. The major parts of the radial shields, a broad plate in the middle of each interradius and a triad of plates opposite the base of each arm are abruptly bare of granules. The bare areas stand out slightly from the surface of the plates bringing them level with the top of the granules to give a smooth finish. A few other smaller bare areas also occur on the peripheral plates. On the ventral side of the disc the granulation is continuous up to the oral shields.

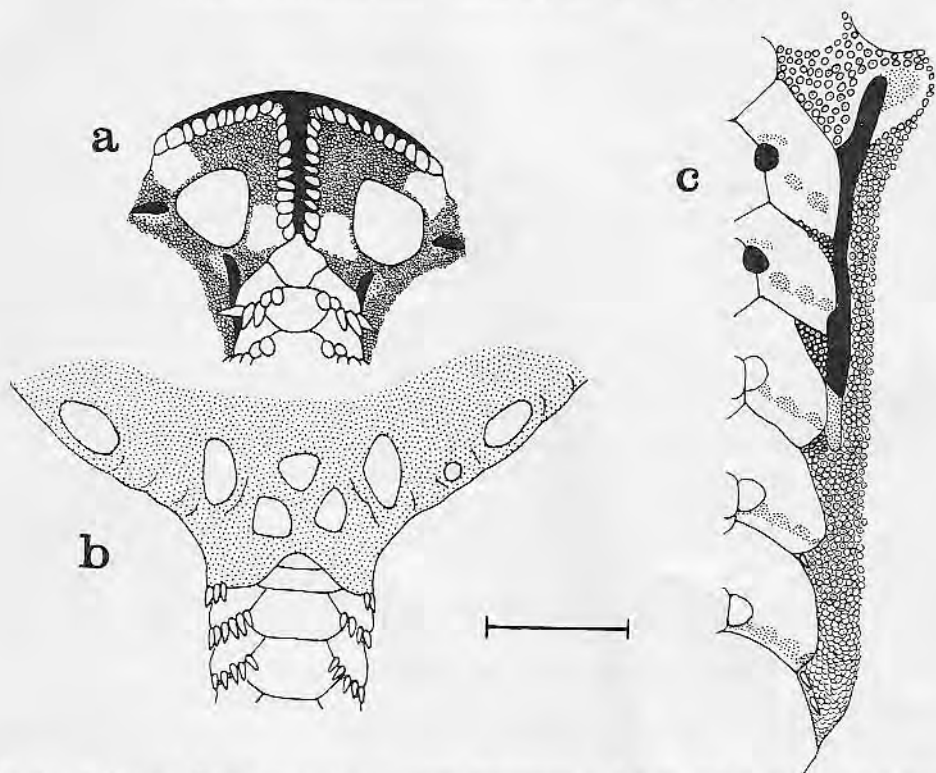


FIG. 8. *Ophiopeza fallax arabica* subsp. nov. Holotype, U.S.N.M. No. E.7734, Tarut Bay, Saudi Arabia (Persian Gulf). a. Two jaws; b. part of disc and arm base in dorsal view, the very fine granulation is indicated by stippling; c. detail of the side of an arm base in ventral view showing a few fine spinelets on the adjacent disc scales; the arm spines and the tentacle scales of the first two pores lacking. The scale measures 2 mm. for a and b and 0.67 mm. for c.

The oral shields are pentagonal or could be described as triangular with the latero-distal angles truncated; their length is about equal to or just exceeds the breadth. The proximal granules were removed from two interradia (pl. 1, fig. 5); one of these shows a well-developed supplementary oral shield previously concealed but otherwise resembling the corresponding shield of species such as *Ophiarachmella infernalis*. In the second area, however, there are two enlarged scales in this position adjacent to the oral shield. The distal parts of the adoral shields are naked but the rest of the jaw angle is covered with granules which are coarser than those on the disc. There are about ten oral papillae each side, including the second oral tentacle scale at the distal end of the series.

The arms become squarish in cross section distally with the dorsal side slightly concave; proximally they are somewhat more rounded. The dorsal arm plates are proximally hexagonal with the middle of the distal side straight or slightly concave. The plates are thickened and bevelled at the edges but flat above. The ventral arm plates are mostly octagonal, the proximal ones slightly broader than long. Basically there are eleven arm spines, each tapering to a blunt point, the lowest one no longer than the rest and none of them exceeding half the segment length. There are two tentacle scales, the smaller outer one overlapping the base of the lowest spine, as usual in the family.

The arms are marked with sharply defined dark brown bands.

[I am much indebted to Miss M. Downey of the U.S. National Museum for estimating the density of the disc granulation and the occurrence of the supplementary oral shields for me, these being features which I omitted to examine when visiting the U.S. National Museum in 1953. Miss Downey also tells me that the two other specimens from the same locality as the holotype mentioned by A. H. Clark must be in the American Museum in New York.]

VARIATIONS. The three other specimens studied have d.d. : a.l. respectively 11.5 : 40 mm. = 1 : 3.5; 14 : 45 mm. = 1 : 3.2 and 11 : 40 mm. = 1 : 3.6. They also appear to have rather coarser disc granulation than the holotype, the larger Karachi specimen having about nineteen granules per linear mm. in the centre of the disc while the one from Trucial Oman has only about seventeen. None of the specimens has so many bare disc plates as the holotype and only the Oman specimen has any of the radial shields bare; in this case three and a half pairs of the shields are partially naked. In all three specimens a rounded bare patch occurs in most of the interradia just above the margin and there are one to three bare areas opposite the base of each arm on the triad of slightly swollen plates. The Oman specimen has unusually elongated oral shields with length : breadth = 1.35 : 1.0 mm. Only in the larger Karachi specimen is even one supplementary oral shield partly naked but wherever the granulation was removed in all the specimens one or sometimes two distinctly enlarged scales, more or less semicircular in shape, were revealed. The specimens have up to eleven (rarely twelve), thirteen and twelve arm spines basally respectively, the corresponding disc diameters being 11.5 mm., 14 mm. and 11 mm. The extent of the dark bands on the arms is variable; in the Oman specimens they extend for only one and a half to two segments, in the larger Karachi

specimen for three to six segments and in the smaller one for about three segments. The discs are mid-brown, dappled with small darker spots.

AFFINITIES. These specimens from the Persian Gulf and Arabian Sea are very similar to *Ophiopeza fallax* from E. Africa, differing mainly in the consistent occurrence of some bare plates on the disc. I had thought that the disc granulation was also coarser in the northern specimens, since examples of *fallax* from Zanzibar examined have twenty-five to thirty granules per mm. and those from Oman and Karachi less than twenty. However, the number in the holotype of *arabica* comes within the range for *fallax fallax*. Accordingly I do not believe that the difference between them can be rated as a specific one, the distribution of the disc granulation being somewhat variable.

Ophiopeza fallax arabica serves to bridge the gap not only between *Ophiopeza* without exposed supplementary oral shields and *Ophiopezella* in which such plates are present (and incidentally serves to confirm the doubtful worth of this character as already expressed, notably by H. L. Clark in 1909), but also between *Ophiopeza* with granule-covered radial shields and *Ophiarachnella* with naked ones (as well as with naked supplementary oral shields). Thus it tends to minimize the extent of the granulation as a character of generic weight in this family.

OPHIOPSAMMUS Lütken, 1869

Ophiopsammus Lütken, 1869 : 37(19), 88(70), 98(80). Type-species *Ophiopeza Yoldii* Lütken, 1856.

Ophiopeza (part): Lyman, 1874 : 221; Bell, 1884 : 137; Koehler, 1905 : 12.

Pectinura (part): H. L. Clark, 1909 : 119; Koehler, 1922 : 338.

DIAGNOSIS. A genus of Ophiidermatidae in which the disc is wholly covered with granules, concealing the radial shields; there is a horizontal series of enlarged scales interradially between the radial shields just above the periphery but these are not in the least convex, their existence and positions being revealed only by removal of the granules; the oral shields are naked and are normally unaccompanied by supplementary shields; the arms are markedly carinate above with relatively broad dorsal arm plates, the proximal ones more than twice as broad as long and with straight distal edges; the arm spines are relatively few, up to only nine in large specimens (very rarely ten) with d.d. c. 15 mm. or seven or eight when d.d. is 10-12 mm., they are not closely appressed to the side of the arm and the longer ones are about equal in length to the segment; the tentacle scales number two basally, the outer one overlying the base of the lowest arm spine, but give way to one further out on the arm; there are only two genital slits in each interradiar area.

REMARKS. I have been unable to trace any justification by Lyman for his inclusion in 1874 of *Ophiopsammus* in the synonymy of *Ophiopeza*, a move which was followed by other specialists until 1909 when H. L. Clark revised the generic limits within this part of the family and referred *Ophiopeza* to the synonymy of *Pectinura*, from which he simultaneously removed *Ophiarachnella* Ljungman, 1872, *Ophiochasma* Grube, 1868, *Ophiopezella* Ljungman, 1872, *Bathypectinura* and *Cryptopella*, the last two being new genera. As mentioned above, I agree with Mortensen (1940)

that the synonymizing of *Ophiopeza* is premature and it should be retained as a genus separate from *Pectinura* until more is known about the type-species of the latter. Nor do I consider that *Ophiopeza yoldii* is congeneric with *O. fallax*. One of the main characters which has been used for distinction of the genera of Ophiordermatidae is the extent of the granulation, whether or not it covers the adoral, oral, supplementary oral (if present) and radial shields and arm bases. In view of the variation in granulation shown by some Ophiordermatidae including *Ophiarachmella infernalis* and *Ophiopeza fallax fallax* as opposed to *fallax arabica* I do not regard this character as having any great weight. A number of species such as *Ophiopeza fallax*, *Ophiarachmella infernalis*, *Ophiostegastus instratus* and *Cryptopelta granulifera* among others show considerable morphological resemblance, notably in the structure of the arms which are flattened above while the dorsal arm plates are not particularly broad and have continuously rounded distal edges. However, these are placed in different genera on account of differences in the distribution of the granules. The markedly carinate arms with very broad rectangular dorsal arm plates in *Ophiopeza yoldii* are such a conspicuous departure from this form that I am convinced it should be kept in a distinct genus as treated by Lütken.

Apart from the difference in arm structure, the smooth periphery of the disc also serves to differentiate it from the species of *Ophiopeza*, mature specimens of which have the interradial plates above the margin markedly convex. A comparable series of enlarged plates is developed in *Ophiopsammus yoldii* but they are not at all convex (Text-fig. 9b).

***Ophiopsammus yoldii* (Lütken)**

fig. 9a, b

Ophiopeza Yoldii Lütken, 1856 : 9; Lyman, 1874 : 221.

Ophiopsammus Yoldii: Lütken, 1869 : 37.

Ophiopeza conjugens Bell: 1884 : 137-138; Döderlein, 1896 : 281-282, pl. 15, fig. 1.

Pectinura yoldii: H. L. Clark, 1909 : 119; Koehler, 1922 : 338; 1930 : 270.

MATERIAL. About thirty-five specimens in the British Museum collections of which twelve are from the Indian Ocean, the rest from northern Australia.

NOMENCLATURE. The revival of the generic name *Ophiopsammus* for this species is dealt with above.

DISTRIBUTION. The type-locality is unknown, "possibly the West Indies" according to Lütken but probably rather the East Indies. The species is very common in northern Australia and extends westwards to the Bay of Bengal.

***Ophiostegastus compsus** sp. nov.**

Text-fig. 10

MATERIAL. B.M. No. 1967.II.9.1-3, Qudhaibiya Bay, Bahrein, Persian Gulf, on stones on mud flats, intertidal, Capt. England, the holotype and three paratypes.

DESCRIPTION OF THE HOLOTYPE. D.d. 10.5 mm. All the arms are broken within 27 mm. of the disc, the complete length may have been about 35 mm.

*From the greek *compos*—elegant.

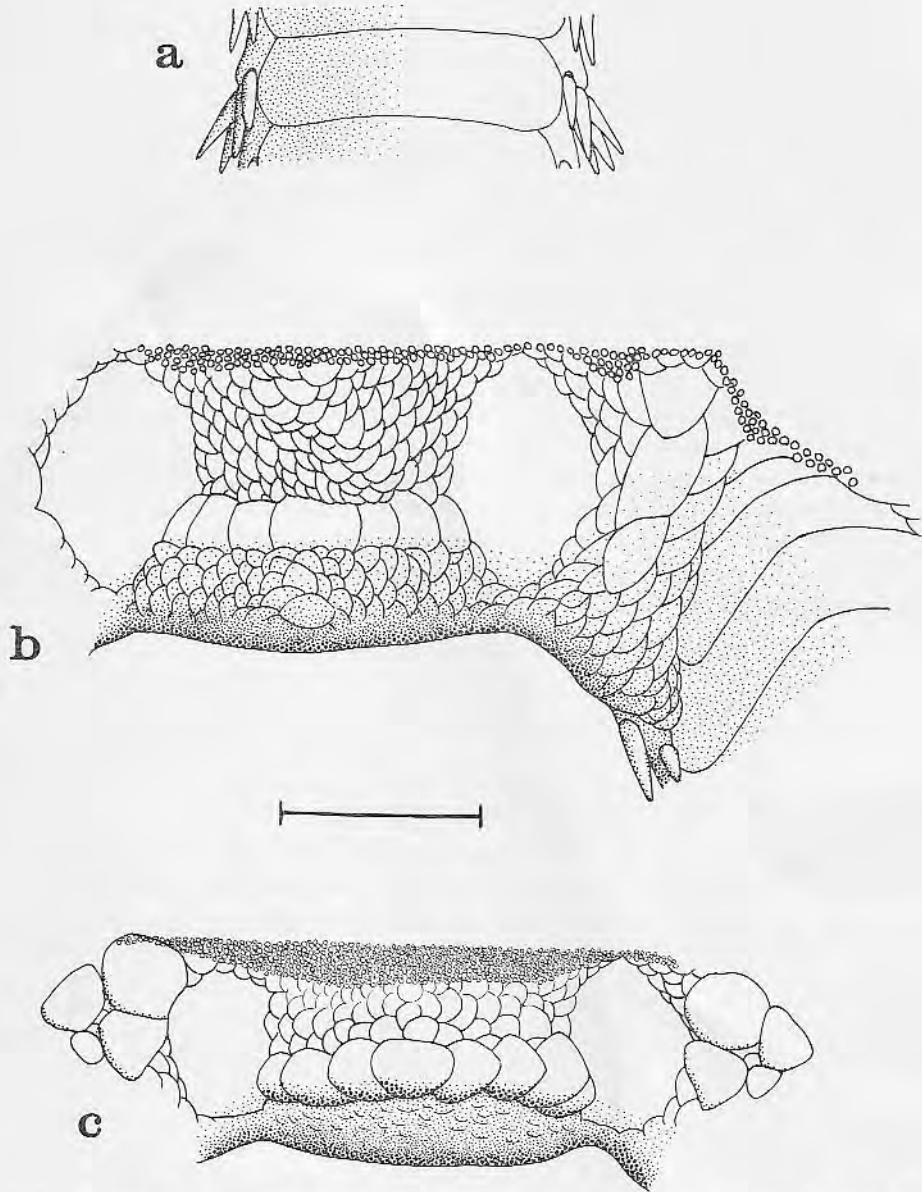


FIG. 9. *Ophiopsammus yoldii* (Lütken). B.M. No. 1949.1.14.19, "Indian Ocean", d.d. 15 mm. a. Fifth free arm segment in dorsal view; b. a denuded interradius and one adjacent arm base in side view. c. *Ophiopeza fallax fallax* Peters, 1965.6.1.501, Zanzibar, d.d. 11 mm., a denuded interradius in side view. The scale measures 2 mm.

The disc is covered uniformly with fine granules, which also conceal the radial shields; there are about 20 in a linear mm. near the centre of the disc. Most of the granules are rounded but some are slightly polygonal. The marginal plates are slightly convex, their contours visible through the granulation and the enlarged mid-interradial plate has been partially rubbed clean of granules in three interradii. On the ventral side the granulation continues up to and around the oral shields, separating them more or less completely from the adoral shields.

The oral shields are bare and approximately triangular in shape though the latero-distal angles are slightly truncated. Their length and breadth are approximately equal. Proximal to the oral shields the jaws are covered with granules which are coarser than those on the disc. There are about ten oral papillae in each series, counting the superficial second oral tentacle scale at the distal end of the series. The second to fifth papillae are conical but the distal ones more nearly rectangular.

The arms are square in cross-section, especially distally where the dorsal surface becomes slightly concave. The disc granulation continues on to the arm bases dorsally, completely encircling the first four to six dorsal arm plates but it becomes reduced at the proximal median part of the segment so that there is only a single row of granules between the lateral plate each side and the dorsal plate from about the twelfth free segment. The naked parts of the proximal dorsal arm plates are broad heart-shaped, the fourth plate with length : breadth = 0.8 : 1.25 mm. with a slightly concave median sector to the distal edge. The following plates become more nearly triangular, widest near the distal end and the median part becomes first straight and then shortens until it is lost and the whole distal edge is slightly convex. When the granulation is removed from the proximal plates the cleared areas are seen to be slightly sunken. The ventral arm plates have the common octagonal form found in many species of this family, with the three distal edges tending to form a continuous curve and the lateral edges notched for the tentacle pore and partially overlain by the inner of the two tentacle scales. The ninth ventral arm plate, corresponding to the fourth free segment, has length : breadth = 0.8 : 1.05 mm. The arm spines number up to nine basally; all are short, less than half the segment length and taper to blunt tips; the lowest is no longer than the rest.

The disc in alcohol is now light brown in colour, dappled with small lighter areas and finely dotted with individual dark brown granules. The oral shields have a median brown spot. The arms are each marked with about five dark brown bands, extending for from one to four segments and separated by longer lighter areas.

PARATYPES. None of these have the arms complete. The largest has d.d. 10.5 mm. like the type but it differs in having less granulation on the arms and the median distal edges of the dorsal arm plates are mostly straight rather than concave; also opposite the base of four of the arms there is a small bare patch on the disc with a brown spot in the middle of it. Both these features add to the resemblance to *Ophiopora fallax arabica*. The two smaller specimens have d.d. 8 mm. and show no sign of bare areas on the disc. Conversely their arm granulation is more extensive than in either of the larger specimens, the granules running right across the proximal end of each segment as far out as about the twentieth free segment. They also have some dorsal arm plates with a median concavity in the distal edge. Their

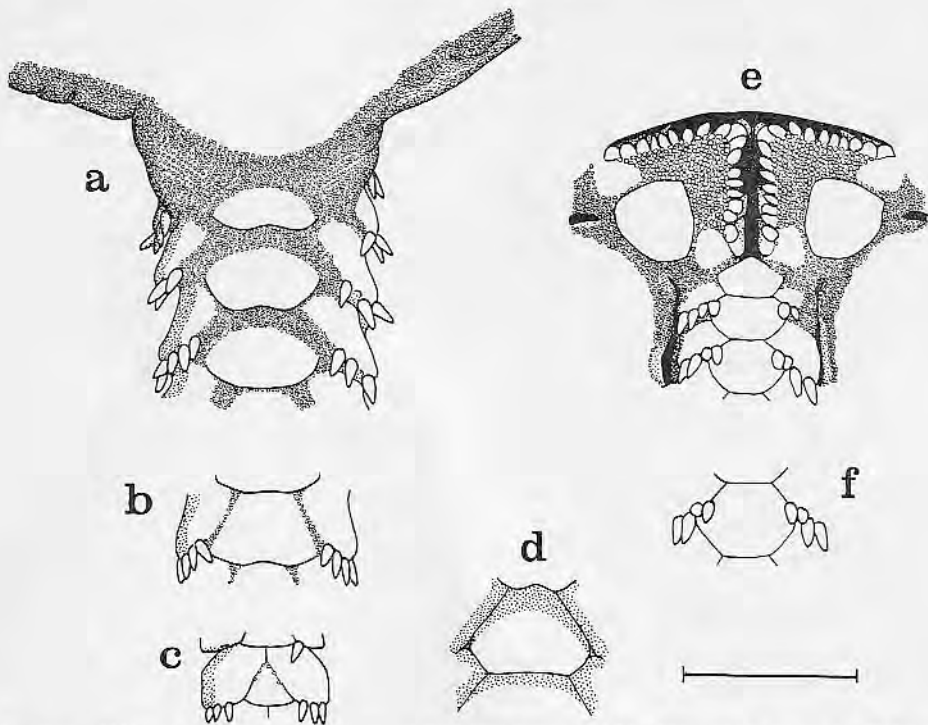


FIG. 10. *Ophiostegastus compsus* sp. nov. Holotype, B.M. No. 1967.11.9.1, Bahrein, Persian Gulf. a. Part of disc and arm base in dorsal view; b. the tenth free segment and c. the thirtieth free segment, also in dorsal view; d. the second dorsal arm plate denuded showing the recesses to house the granules; e. two jaws and the adjacent arm base; f. the eighth ventral arm plate. The scale measures 2 mm.

arm spines number up to eight. None of the three have any bare supplementary oral shields present and cleaning the proximal parts of two interradii of one of the smaller specimens did not reveal any such plates under the granulation, though in one case the two scales bordering the oral shields were somewhat enlarged.

AFFINITIES. At first I thought that these specimens were referable to *Ophiopeza* since they have squared arms, slightly convex marginal disc plates and disc granulation of much the same extent as *Ophiopeza fallax*. However, since other Ophiodermatids with the granulation extending on to the arms have been generically distinguished, it seems best to ally the present species with *Ophiostegastus* Murakami, 1944, type-species *O. instratus* Murakami from Japan, from which it differs in having the supplementary oral shields undeveloped and the dorsal arm plates with a tendency to become concave at the distal edge. *Ophiostegastus* has similar granulation around the proximal dorsal arm plates and leaving bare the oral and adoral shields, unlike *Ophiodyscrita* H. L. Clark, 1938, although the latter too has granulation on the arms. I must admit to considerable doubt about the distinctness of these two nominal genera, especially in view of the progressive reduction in the

extent of the granulation with size shown by the present material, even though their size range is only 2.5 mm. The types of *Ophiodyscrita acosmela* and *pacifica* have d.d. only 5 and 4 mm. respectively, which could well explain the extension of the granulation over the oral and adoral shields. A good series of specimens should give a better appreciation of the interrelationships of these species.

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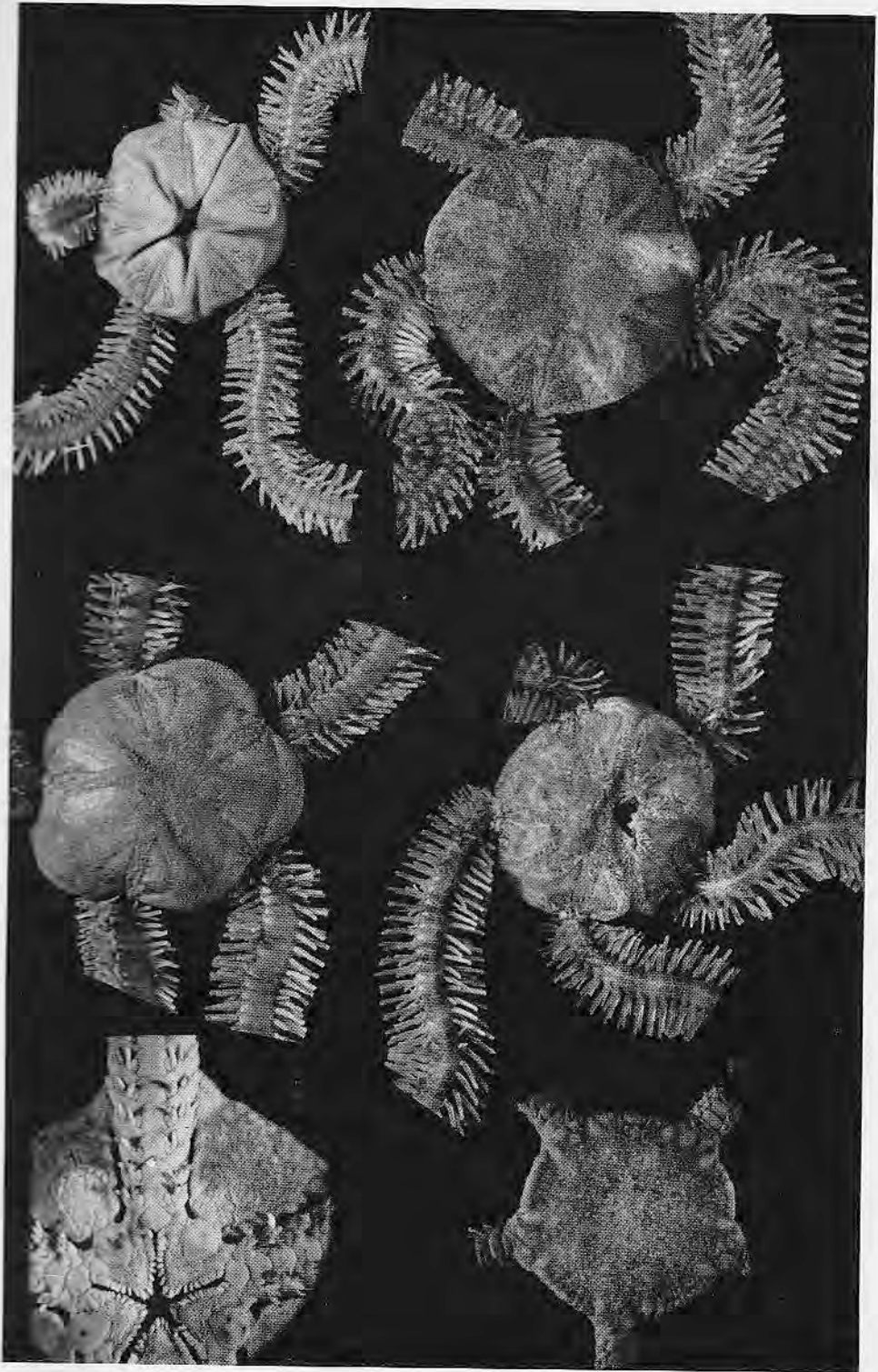
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PLATE I

- FIG. 1. *Macrophiothrix galatae* (Lütken), holotype, Nicobar Islands.
FIG. 2. *Macrophiothrix koehleri* sp. nov., holotype, Solomon Islands.
FIG. 3. *Macrophiothrix variabilis* (Duncan), 88.1.2.1, Tuticorin.
FIG. 4. *Macrophiothrix lorioli* sp. nov., holotype, Solomon Islands.
FIG. 5. *Ophiopeza fallax arabica* subsp. nov., holotype, Persian Gulf, part of disc in ventral view, $\times 4$.
FIG. 6. The same in dorsal view. [Both by courtesy of Miss M. Downey, Smithsonian Institution.]

(all $\times 2$, except for fig. 5)



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