

A revision of the genus *Ophionereis* (Echinodermata, Ophiuroidea).*

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(With Plates 1-3 and 12 figures in the text.)

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INTRODUCTION.

The type of the genus *Ophionereis* is *Ophiura reticulata* Say, from the West Indies.

The chief trouble in differentiating the species of *Ophionereis*, as with other genera, is to distinguish between the really characteristic features and those which are contingent upon the particular ontogenetic stage reached. For example, a species described from a single large specimen with disc diameter say 15 mm. and having four arm-spines on the basal joints, very probably passes through a young stage in which there are but three arm-spines throughout. The occurrence of such changes during the life history should always be borne in mind and wherever possible comparison made between specimens of similar size.

Features typical of most juvenile Ophionereids with disc diameter only about 2 mm., include the relatively large size and small numbers of the disc plates; the fewer oral papillae; the relatively short arms and stumpy arm-spines; the small supplementary dorsal arm-plates extending for little more than half the length of the joint so that the upper side of the arms is covered almost entirely by the large dorsal arm-plates; the much longer than wide ventral arm-plates with their proximal angles not yet overlapped by the preceding plate; and lastly the small size of the genital slits and the absence or rudimentary condition of the genital papillae.

On the other hand, very large specimens tend to have relatively long arms and the spines on their widest part are much longer than the corresponding segments, particularly the middle spines; the disc scales are nearly uniform in size and relatively very small; the dorsal arm-plates tend to widen out with a straight distal edge rather than a curved one and the ventral plates are roughly square or even wider than long, with the proximal angle truncated.

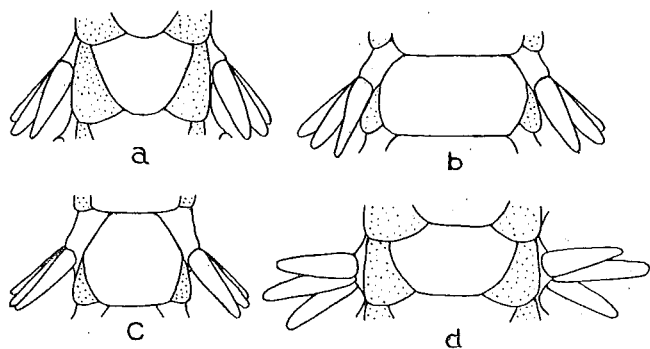
In some species, however, by a process of positive or negative allometric growth, some of the juvenile characters may be prolonged into later stages in the ontogeny. For instance, in the species *Ophionereis searadia* Mortensen

*Note.—Since this was written, three papers on Ophiuroids of the Japanese area by Dr. S. Murakami have been received, describing one new *Ophionereis*, *O. aplacophora* and two species of *Ophiocrasis*, namely *O. thryptica* and *O. latens*. The latter at least is a synonym of *Ophionereis dubia* in my opinion.

(1936), the supplementary dorsal arm-plates are still very small and only half the length of the joint at a size of 6 mm. disc diameter (see fig. 1 c). This condition is shared by several other species, namely *O. vivipara* Mortensen (1933 a) (a species exhibiting paedogenesis with the disc diameter of the type only 3 mm. but sexually mature), *O. olivacea* H. L. Clark (1902), *O. novae-zelandiae* Mortensen (1936), *O. dolabriformis* D. D. John & A. M. Clark (in the press), and *O. amphilogus* (Zeisenhenne) (the types of these four species having the disc diameter [d.d.] 6 mm., 4 mm., 8 mm. and 4.5 mm. respectively); also to a lesser extent it is found in *O. variegata* Duncan (1879), and even in *O. porrecta* Lyman (1860) and *O. reticulata* (Say) there is a tendency towards it.

The six first-named species mentioned above might be separated off as a subgenus which could be called *Ophiodesmus*, as Zeisenhenne has already used that name for his species *amphilogus*. However, he characterizes it not so much on the state of the dorsal arm-plates as on the condition of the disc scales, which appear to be large and small intermingled, some being overlapped by others so that only a part of them is visible externally. I do not think this in itself warrants a generic distinction and anyway it is shared by several species of *Ophioreis* including *O. variegata* Duncan, *O. australis* (H. L. Clark), *O. novae-zelandiae* Mortensen and *O. squamulosa* Koehler. The last named exhibits the character of the small supplementary plates in the type (d.d. equals only 2 mm.) but (if H. L. Clark's identification was correct) not in larger specimens with d.d. 4.5 mm. or more, which show the more typical condition with these plates running the full length of the joint, one on each side of each dorsal arm-plate (see fig. 1 a).

Figure 1.



Diagrams to show the main forms of the dorsal and supplementary dorsal arm-plates (the latter stippled) found in the genus *Ophioreis*. (a) The *O. dubia*-type for moderate-sized specimens (d.d. about 6 mm.). (b) The *O. fusca*-type with wide dorsal and very small supplementary plates. (c) The *O. searadia*-type with dorsal plates as wide as long and supplementaries again small. (d) The *O. annulata*-type found also in specimens of type (a) of large size.

Besides appearing on the whole length of the arm in young specimens, small supplementary plates are found (see fig. 1 c) towards the arm-tips of all the species which have them better developed (as in fig. 1 a or d) in the proximal half of the arm.

Of the other genera in the family Ophiochitonidae, Matsumoto (1917) has separated off *Ophiochiton* and *Ophioplax* as a distinct subfamily differentiated from the Ophioreidinae (which includes *Ophioreis*) mainly by such internal characters as the shape of the vertebrae and oral frames but differing visibly in the more acute form of the teeth. The other genera included in the latter group are *Ophiodoris* Koehler (1904) and *Ophiocrasis* H. L. Clark (1911). The only

CHRONOLOGICAL LIST OF SPECIES ATTRIBUTED TO *OPHIOREIS*.

Name and Author	Whether valid or synonym	On the authority of	Reference with detailed figures	General locality
<i>reticulata</i> (Ophiura) (Say), 1825	Valid		Lütken, 1859	West Indies south to Rio
<i>dubia</i> (Ophiolepis) (Müller & Troschel), 1842	Valid		Savigny, 1809; this paper	Indo-West Pacific
<i>schayeri</i> (Ophiolepis) (M. & Tr.), 1842	Valid		Mortensen, 1925	South Australia
<i>annulata</i> (Ophiolepis) (Le Conte), 1851	Valid	Lütken, 1859	McClendon, 1909; Nielsen, 1932	California to Ecuador
[<i>neresi</i>] (Ophiolepis) (Lütken), 1856	= <i>annulata</i>	Lyman, 1865		
[<i>triloba</i>] (Ophiolepis) (Lütken), 1856	= <i>annulata</i>	Lyman, 1882		
[<i>acantusii</i>] Lyman, 1860	Valid	Lyman, 1882; ? A. M. C.	Lyman, 1865; Ely, 1942	Hawaii to Mauritius
<i>porrecta</i> Lyman, 1860	= <i>porrecta</i>	Verrill, 1869		
[<i>squamata</i>] Ljungman, 1867	= <i>porrecta</i>			
[<i>crassispina</i>] Ljungman, 1867	Valid		Mortensen, 1925	New Zealand
<i>fasciata</i> Hutton, 1872	Valid		Smith, 1877	Galapagos Islands
<i>albomaculata</i> E. A. Smith, 1877	Valid		Duncan, 1879; Matsumoto, 1917	Japan
<i>variegata</i> Duncan, 1879	Valid		This paper	China, Japan
<i>dubia</i> subsp. <i>sinensis</i> Duncan, 1879 (as variety)	Valid			
[<i>sophiae</i>] Brock, 1888	{ = <i>squamata</i> Lj. } { = <i>porrecta</i> } Valid	Engel, 1938		
<i>fusca</i> Brock, 1888	Valid	A. M. C.		
<i>semonii</i> (Ophiotriton) (Döderlein), 1896	Valid		Koehler, 1904; this paper	Polynesia
<i>nuda</i> Lütken & Mortensen, 1899	Valid		This paper	East Indies, North Australia
	Valid ? (see <i>albomaculata</i>)		Lütken & Mortensen, 1899	Galapagos Islands
<i>olivacea</i> H. L. Clark, 1902	Valid	A. M. C.	H. L. Clark, 1902	West Indies
[<i>dactylosa</i>] (Ophiocrasis) (H. L. C.), 1911	Valid		H. L. C., 1911	California, (?) Japan
<i>eurybrachioplax</i> H. L. C., 1911	Valid			
[<i>squamata</i>] Koehler, 1913	= <i>squamulosa</i>	Koehler, 1914		
<i>squamulosa</i> Koehler, 1914 (nom. nov.)	Valid	A. M. C.	Koehler, 1913; this paper	West Indies
[<i>maritanneri</i>] (Ophiocrasis) (Matsumoto), 1915	= <i>sinensis</i>			
<i>australis</i> (Ophiotriton) (H. L. C.), 1923	Valid		H. L. C., 1923; Mortensen, 1933	South-west Indian Ocean
<i>vivipara</i> Mortensen, 1933 a	Valid		Mortensen, 1933 a	Mauritius
<i>novae-zelandiae</i> Mortensen, 1936	Valid		Mortensen, 1936	New Zealand
<i>searadia</i> Mortensen, 1936	Valid		Mortensen, 1936	West Africa
<i>heavacis</i> H. L. C., 1938	Valid			Darwin & Lord Howe Island
<i>tigris</i> H. L. C., 1938	Valid			Queensland
[<i>stigma</i>] H. L. C., 1938	= <i>dubia</i>			
[<i>roosevelti</i>] A. H. Clark, 1939	= <i>albomaculata</i>			
[<i>dactyota</i>] Zeisenhenne, 1940	= <i>annulata</i>			
<i>perpleca</i> Zeisenhenne, 1940	Valid		Zeisenhenne, 1940	Galapagos Is., West Central America
<i>amphilogus</i> (Ophiodesmus) (Zeisenhenne), 1940	Valid		Zeisenhenne, 1940	Lower California
<i>lineata</i> H. L. C., 1946	Valid			Queensland
<i>dolabriformis</i> D. D. John & A. M. Clark (in the press)	Valid		D. D. John & A. M. C.	West Indies
<i>sasakii</i> sp. n.	Valid		This paper	Northern Japan
<i>intermedia</i> sp. n.	Valid		This paper	Northern Japan
<i>amoyensis</i> sp. n.	Valid		This paper	Southern China

further genus added to the family since 1917 is *Ophiodesmus* Zeisenhenne (1940) which I consider should be merged with *Ophionereis* together with *Ophiocrasis* as explained later, so that the only closely related genus left is *Ophiodoris*. The characters by which that genus is distinguished from *Ophionereis* include the presence of spines on the disc, at least at the bases of the arms dorsally, the absence of supplementary dorsal arm-plates and the presence of one or two additional tentacle-scales besides the usual large oval one common to the whole family. However, the presence or absence of supplementary dorsal arm-plates is taken as the absolute criterion, for several species of *Ophionereis* such as *O. fusca* and *O. sasakii* (described here) have papillae on the disc at the bases of the arms and a second scale on the inner side of the tentacle-pores, but both possess supplementary dorsal arm-plates (though relatively small ones) and are therefore included in *Ophionereis*. The dividing line between these two genera is therefore not very marked. *Ophionereis australis* (H. L. Clark) also approaches the borderline, for it only has supplementary plates on a few of the proximal joints, but although the genital papillae continue to the edge of the disc lateral to the arm-bases, they are very short and inconspicuous and not visible in dorsal view. Displacement of the large tentacle-scale reveals a rudimentary second one along the inner edge of the pore.

As for *Ophiocrasis*, the only character given to distinguish it from *Ophionereis* is the presence of accessory scales at the distal ends of the supplementary arm-plates. I have found these in many specimens of *Ophionereis dubia* from different parts of the Indo-W. Pacific but particularly in the subspecies *sinensis* Duncan, with which I think both the species of "*Ophiocrasis*" are synonymous. Accessory scales are also found irregularly in *O. squamulosa*, which like *dubia* has rather thin delicate arm-plates.

The main characters used for distinguishing the species of *Ophionereis* include the form of the dorsal arm-plates and supplementary plates, the proportions of the disc scales and presence or absence of a skin covering, the occurrence and extent of the genital papillae and finally the relative lengths of the arm-spines and whether their number exceeds three.

The shape of the oral shields may be subject to considerable variation, as has been shown in *Ophionereis annulata* by Nielsen and the only species in which they are sufficiently remarkable and constant in form to be of use as a specific character, is *O. schayeri* from Australia, where they have a long straight distal side unlike the other species which have a distal lobe with a more or less blunt angle.

Although reducing several species to the synonymy of others, I have been obliged to set up three more (all from China or Japan) which I cannot reconcile with any previously described.

Besides a chronological list of the species which have been attributed to this genus, I give a key for the identification of the species. It may be subject to some confusion where the naming of young specimens is concerned but then the same is true of most juvenile Ophiuroids.

(There is a little doubt as to the position in the key of some species, particularly those described by H. L. Clark in 1938 and 1946, which have never been figured in detail, if at all).

KEY TO THE SPECIES OF *OPHIONEREIS*.

- 1. Genital papillae present 2.
- 1'. Genital papillae absent 15.
- 2. Four arm-spines on basal arm-joints (at least in specimens with d.d. 10 mm. or more) 3.
- 2'. Only three arm-spines throughout 7.
- 3. Disc scaling obscured by skin, except around the radial shields. Galapagos Islands *albomaculata* Smith.
- 3'. Disc scaling distinct. Not from the Galapagos 4.

- 4. Supplementary dorsal arm-plates not running the full length of the joint even on the proximal segments, so that the dorsal arm-plates are partly in contact with the lateral plates (text-fig. 1 b). North Pacific 5.
- 4'. Supplementary dorsal arm-plates long, completely bordering the dorsal plates on each side, in the proximal part of the arm at least (text-fig. 1 a or d). Australasia 6.
- 5. Genital papillae carried up on to the dorsal side of the disc around the arm-bases to outside the radial shields (see text-fig. 4 a). Northern Japan *sasakii* sp. n.
- 5'. No papillae visible dorsally at the arm bases. California, (?) Japan *eurybrachiplatea* H. L. Clark.
- 6. The two series of genital papillae in each interradius all but meeting outside the diamond-shaped oral shield. New Zealand *fasciata* Hutton.
- 6'. The two series of genital papillae widely separated proximally, the oral shield with a straight distal edge and a very obtuse rounded inner end. South Australia *schayeri* (Müller & Troschel).
- 7. Supplementary dorsal arm-plates only occurring on a very few basal arm-joints. Indian Ocean *australis* (H. L. Clark).
- 7'. Supplementary dorsal arm-plates present for most of the length of the arm 8.
- 8. Genital papillae well developed, forming a close series, not spaced out (see text-fig. 5 b) 9.
- 8'. Genital papillae isolated, not in a serried row (see text-fig. 12 b) 12.
- 9. Genital papillae continuing up around the arm-bases to the dorsal side outside the radial shields (see text-fig. 5 a). Polynesia *fusca* Brock.
- 9'. No papillae visible at the arm-bases dorsally 10.
- 10. Supplementary dorsal arm-plates very inconspicuous; a longitudinal dark line on each arm. Queensland, 10'. Supplementary plates quite distinct; no longitudinal dark line on arms. Not from Queensland. 11. Arms only about five times the d.d. in length; ventral arm-plates wider at their distal ends, almost fan-shaped (see text-fig. 7). Japan *lineata* H. L. Clark.
- 11'. Arms about seven or eight times the d.d. in length; ventral arm-plates as wide or almost as wide at the proximal end of the tentacle-pores as at the distal end. Indo-W. Pacific except Red Sea *variegata* Duncan.
- 12. Disc scales obscured by skin except around the radial shields. Galapagos Islands *porrecta* Lyman.
- 12'. Disc scales distinct all over *nuda* Lütken & Mortensen.
- 13. Outlines of dorsal arm-plates indistinct, accessory scales present. Japan 13.
- 13'. Outlines of dorsal arm-plates distinct, no accessory scales. E. or W. America *intermedia* sp. n.
- 14. Longest middle arm-spines more than twice the length of the corresponding joints. E. Pacific .. *annulata* (Le Conte).
- 14'. Longest middle arm-spines less than twice the length of the corresponding joints. West Indies and south to Rio de Janeiro *reticulata* (Say).
- 15. Six arms normally 16.
- 15'. Only five arms (rarely the young may reproduce by schizogony, the regenerated form being usually irregularly six-armed) 17.
- 16. Disc scaling not distinct when wet. Australasia. (The absence of genital papillae in this species is presumed, since they are not mentioned in the description) *hexactis* H. L. C.
- 16'. Disc scaling quite distinct. West Africa *sexradia* Mortenson.
- 17. Supplementary dorsal arm-plates well developed, running the full length of the proximal arm-joints at least (fig. 1 a or d) 18.
- 17'. Supplementary plates relatively small, only occupying the distal half of the joint, even on the proximal segments (fig. 1 c) 22.

18. Disc scaling and outlines of plates around the mouth concealed by skin, even when dry 19.
- 18'. Disc scaling very fine but visible when dried off; outlines of mouth plates quite distinct 20.
19. Oral shields not outlined by contrasting colour; arms banded with alternate areas of light and dark of almost equal extent. Queensland *tigris* H. L. C.
- 19'. Oral shields covered with white skin in contrast to the dark skin ringing them round; arms with narrow dark bands separated by wider intervals (see Pl. 2, figs. 3 and 4). N. and S. Australia, E. Indies *semoni* (Döderlein).
20. Distal margins of supplementary dorsal arm-plates bearing a series of "parallel minute ridges conspicuous under high magnification" but apparently no accessory scales. Galapagos Islands *perplexa* Zeisenhenne.
- 20'. No ridges on distal ends of supplementary plates, which are very thin, often with small accessory scales (see text-fig. 10 a). Indo-West Pacific 21.
21. Colour of arms predominantly pale with narrow dark bands at intervals; dorsal arm-plates usually little wider than long, even in the widest part of the arm. Indo-West Pacific *dubia* (M. & Tr.).
- 21'. Colour of arms mainly dark grey; widest dorsal arm-plates more than twice as wide as long. China. *amoyensis* sp. n.
22. Disc scales extremely minute, hardly, if at all, revealing the radial shields; viviparous. Mauritius. *vivipara* Mortensen.
- 22'. Radial shields distinct; not viviparous (as far as is known). Not from the Indian Ocean 23.
23. Disc scales uniformly small, only a little larger round the radial shields (and the central plate may be distinct); middle arm-spines very long. West Indies 24.
- 23'. Disc scales both large and small intermingled; middle arm-spines not longer than two joints. E. Pacific or New Zealand 25.
24. Middle arm-spine nearly twice as long as the other two and with a broad rounded tip *olivacea* H. L. Clark.
- 24'. All three arm-spines long and tapering, the middle one little, if at all, longer than the others [& A. M. Clark
dolabriformis D. D. John
25. Scaling progressively finer on the ventral side towards the genital slits. Lower California *amphilogus* (Zeisenhenne).
- 25'. Scaling on the ventral side fairly uniform. New Zealand *novae-zelandiae* Mortensen.

DESCRIPTIONS OF THE SPECIES OF *OPHIONEREIS*.*

Ophionereis dolabriformis D. Dilwyn John & A. M. Clark.

Ophionereis dolabriformis D. Dilwyn John & A. M. Clark, 195- (in the press). (Since this paper may come out before the "Rosaura" report in which the species is fully described, I give here a condensed description of the type and only specimen.)

Description. Disc diameter 8 mm.; the arms are all broken but were probably about 70 mm. long. In drying, the disc has contracted somewhat interradially.

The scaling of the disc is fine and fairly uniform, only a few mid-radial scales being enlarged. The radial shields are small and are separated by more than their length. There are no genital papillae. The dorsal arm-plates are hexagonal, the small supplementary plates only bordering their distal half. The lateral arm-plates bear three long, slender, tapering, needle-like spines of varying length, either the uppermost or the middle one may be shorter than the other two, or all may be the same length, the maximum length being nearly twice that of the corresponding joint. The ventral arm-plates are axe-head shaped (hence the name) with a convex distal edge and the widest part at the distal end of the tentacle-pores. The oral shields are large and spear-head shaped with the proximal angle more nearly acute than the distal

* Only the more important references are given under the specific headings.

one, although the two outer sides are slightly concave. At their widest point the shields completely overlap the narrow adoral shields to reach the first lateral arm-plates. Interradially the pairs of adoral shields just meet. There are four or five oral papillae on each side and sometimes a small apical one below the lowest tooth; also an oral tentacle-scale beyond the outermost papilla. The colour is pale with very compact dark reticulations on the disc and dark bands one and a half segments long at intervals of about four segments on the arms.

Remarks. *Ophionereis dolabriformis* differs from the other three West Indian species of the genus—*O. reticulata* (Say), *O. olivacea* H. L. Clark and *O. squamulosa* (Koehler)—in the needle-like arm-spines, reduced supplementary arm-plates (shared only by *olivacea* which differs in its spines) and distinct coloration.

Range. Known only from off the mouth of the River Orinoco, Venezuela, in 86 metres depth.

Ophionereis sevradia Mortensen.

Ophionereis sevradia Mortensen, 1936, p. 298, fig. 28.

Remarks. The type locality of this species is off Annobon in the Gulf of Guinea, West Africa, in 18-30 metres. It is the only species of *Ophionereis* yet known from the eastern side of the Atlantic.

Re-examination of the six-armed "Challenger" specimen from Gomera, Canary Islands, in 70 fathoms (128 metres), shows that it too has the hexagonal dorsal arm-plates with very small supplementaries and rather long arm-spines found in the types of *O. sevradia*. Lyman double-queried his identification of it as *Ophionereis dubia* (Müller & Troschel) but his note in the jar only says "scaling coarser than in *O. reticulata*".

The range of this species is thus very considerably extended both vertically and horizontally. More intensive collecting may show that it occurs all round the great bulge of North-west Africa.

Ophionereis squamulosa Koehler.

(Pl. 3, figs. 3 and 4 and text-fig. 2.)

Ophionereis squamata Koehler, 1913, p. 360, pl. 21, figs. 4-6 (non *O. squamata* Ljungman, 1867, p. 310).

Ophionereis squamulosa Koehler, 1914, p. 44; H. L. Clark, 1918, p. 326; 1933, p. 65.

Remarks. The type of this species is a small specimen with disc diameter only 2 mm., from St. Thomas in the West Indies. Being so small, many of the characters described for it are inevitably juvenile features common to young specimens of most species of *Ophionereis*. Such characters include the relatively large size of the disc scales and radial shields, the fact that the dorsal arm-plates occupy most of the upper surface of the arms, the supplementary plates being small, also the much greater length than width of the ventral arm-plates with the proximal angle hardly, if at all, overlapped by the preceding plate. Probably the junction interradially of the adoral shields inside the oral ones and the absence of genital papillae are also juvenile features because the larger specimens which H. L. Clark attributes to this species do not show them, the adorals being entirely lateral to the oral shields and small genital papillae being present at the proximal ends of the slits.

There are four specimens from Buccoo Bay, Tobago, in the British Museum received from the Museum of Comparative Zoology, Harvard, and identified as *Ophionereis squamulosa* by Dr. Clark, as well as two similar ones from the Dry Tortugas. I give here a description of one from Buccoo Bay for comparison with Koehler's description. Not having any specimens of only 2 mm. disc diameter I cannot be absolutely certain that they are the same species and can only follow Dr. Clark in assuming this.

Description. Disc diameter 4.5 mm., arm length c. 30 mm.

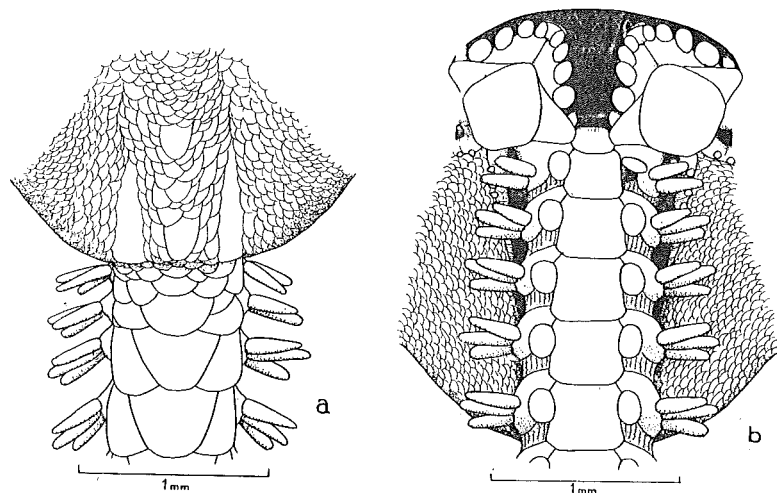
The outlines of the scales are not very clear in the centre of the disc but are quite distinct around the radial shields where they are somewhat larger, particularly between the two shields of each pair. The central plate and some others more irregularly placed are distinctly larger than most of the scales but interradially the scaling is finer. The radial shields are about 0.6 mm. in length and are separated at their outer ends by about five scales, the middle one being the largest. On the ventral side of the disc the scaling is almost uniformly fine. The genital slits are long and at the proximal end the scales along their edges bear a few blunt papillae.

The disc scaling is carried out on to the bases of the arms on the dorsal side and the first few dorsal arm-plates are small. The third or fourth plate and those beyond have the typical almost triangular form with blunt distally directed apex and the supplementary plates large and running the full length of the joint on each side.

The ventral arm-plates are almost square with rounded corners, a little wider than long in the proximal part of the arm.

The lateral arm-plates bear three spines which are rather short proximally but which reach their maximum length at the widest part of the arms, that is about a quarter of their length out from the disc. Here the blunt-tipped upper spine is 0.45 mm. long, the more tapering middle and lower ones both 0.6 mm. as compared with 0.45 mm. for the length of the corresponding dorsal arm-plate.

Figure 2.



Ophionereis squamulosa Koehler, registered number 1939.6.15.105, from Buccoo Bay, Tobago, West Indies. (a) Dorsal view of the base of an arm and part of the disc (b) The same in ventral view.

The tentacle-scales are single, large and oval.

The oral shields are about as wide as long, with the widest part a little nearer the distal than the proximal end. The distal angle is very blunt but the proximal one is rather more marked. The adoral shields are small and entirely lateral in position, not meeting interradially. There are four oral papillae on each side of each jaw angle and an oral tentacle-scale distal to the outermost and broadest one.

The colour of this specimen, formerly in spirit, then dried, is now pale grey with darker grey on the disc between the radial shields and darker bands on the arms. Each band extends for two or three segments and becomes paler

towards its distal end, the proximal end being sharply differentiated from the pale joints between the bands (see Pl. 3, fig. 4).

Remarks. Koehler states that the primary disc plates are much more markedly enlarged in his type than in specimens of *O. reticulata* of the same size, but H. L. Clark says that this is only true of occasional specimens and is not by any means the rule. In the specimen examined here, which is about twice the size of the type, the disc scaling is as fine, and interradially even finer than in similar sized specimens of *O. reticulata*, as Dr. Clark found. A real difference between the two with regard to the disc scaling is the fact that the outlines of the scales are much more obscure in the centre of the disc in *O. squamulosa* than in *O. reticulata*, where they are distinct everywhere. Also in the latter there are fewer enlarged plates and even the primary ones may not be conspicuous, at least in fully grown specimens. The presence of genital papillae proximally and the squaring-up of the ventral arm-plates by the occlusion of the proximal angle, are features shared by the two species, but a point which may be significant in distinguishing them is provided by the extent of the supplementary dorsal arm-plates. In *Ophionereis reticulata* these do not usually reach quite to the proximal end of the joint, so that for a short distance the dorsal arm-plate is visibly in contact with the lateral arm-plate. However, in *O. squamulosa* of d.d. 4 mm. or more, the supplementary plates run the full length of the joints, at least in the proximal part of the arm and their inner ends are overlapped by the preceding plates.

The only other obvious difference is in the coloration. In *O. squamulosa* the wide dark bands on the arms with their indistinct distal limits are quite different from the short, well-defined bands of *O. reticulata* whose characteristic pattern is also much more conspicuous.

Range. Reported from St. Thomas, Tobago, the Dry Tortugas and Parahiba in Brazil, in shallow water down to about 40 metres depth.

Ophionereis reticulata (Say).

(Pl. 1, figs. 1 and 2 and text-fig. 3 a.)

Ophiura reticulata Say, 1825, p. 148.

Ophionereis reticulata, Lütken, 1859, p. 110, pl. 3, figs. 6 a-c; H. L. Clark, 1933, p. 64.

Remarks. The material of this species in the British Museum comes from Cape Florida, St. Thomas, Bermuda, Jamaica, Bahia and Rio de Janeiro. The largest specimen was collected at Bahia by Charles Darwin and measures 14.5 mm. across the disc.

The species is most closely related to *Ophionereis annulata* (Le Conte) from the west coast of Central America. The three main points of difference between the two can best be expressed by means of a comparative table.

Ophionereis reticulata.

1. The longest middle arm-spine in specimens with disc diameter only 7 mm. is c. 1.7 times the length of the corresponding ventral arm-plate.
2. The supplementary dorsal arm-plates do not usually quite equal the joint in length but fall short of the proximal end.
3. The colour is predominantly pale, usually with rather delicate reticulations on the disc.

Ophionereis annulata.

1. The longest middle arm-spine in specimens with disc diameter 7 mm. is c. 2.2 times the length of the corresponding joint.
2. The consecutive supplementary arm-plates, at least in the proximal half of the arm, overlap one another, since they run the full length of each joint.
3. The dark reticulations on the disc are heavy, so that in extreme cases the dark colour predominates, leaving only light spots. Rarely pale all over (at least in spirit).

Range. Known throughout the West Indian region and south to Rio de Janeiro on the east coast of South America in depths down to about 200 metres.

Ophionereis annulata (Le Conte).
(Pl. 1, figs. 3 and 4 and text-fig. 3 b.)

Ophiolepis annulata Le Conte, 1851, p. 317.

Ophiolepis triloba Lütken, 1856, p. 23.

Ophionereis cantusii Lyman, 1860, p. 258; 1865, p. 145.

Ophionereis annulata, Lyman, 1860, p. 203; 1865, p. 143; 1882, p. 162; McClendon, 1909, p. 47, figs. 36, 37; Nielsen, 1932, p. 309, fig. 24 a-h.

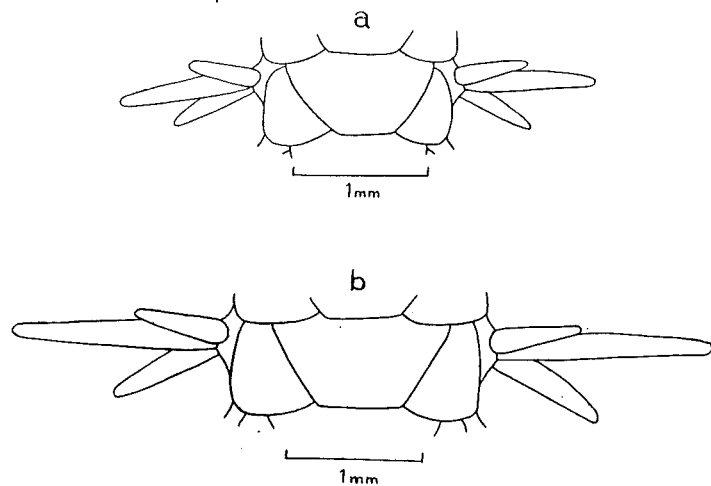
Ophionereis dictyota Zeisenhenne, 1940, p. 29, pl. 6, figs. 1-5.

Remarks. There are two jars of this species in the British Museum, one from Esmeraldas in Ecuador and the other labelled as from Vancouver Island, collected about 1850. The latter must be a mistake for the species is not otherwise known farther north than San Pedro in southern California.

The many specimens from Esmeraldas illustrate very well the great variation in the form of the oral shields noticed by Nielsen, as well as in the extent of the dark purplish colour (shown in spirit at least).

Even in young specimens the middle arm-spines at the widest part of the arm are needle-like and conspicuously longer than the other two spines.

Figure 3.



Dorsal views of the tenth arm-joints of specimens of (a) *Ophionereis reticulata* (Say) and (b) *Ophionereis annulata* (Le Conte).

McClendon's figure of the ventral side shows the adoral shields meeting interradially and not separating the first lateral arm-plate from the oral shield. I do not think this has been properly represented, at any rate it is not usual, for in all the specimens I have studied the adoral shields narrow interradially and do not quite meet, while there is nearly always a distinct outer lobe running down to the genital slit. This is shown in Zeisenhenne's figure of his species *Ophionereis dictyota*, which I think is a synonym of this species. In his remarks about it he makes no mention of *O. annulata*, only comparing that with his other new species *O. perplexa*.

Range. The west coast of Central America from Ecuador in the south northwards to San Pedro in California, in shallow water down to about 35 metres depth.

Ophionereis albomaculata E. A. Smith.

Ophionereis albomaculata E. A. Smith, 1877, p. 92, pl. 11, figs. 1-5.

? *Ophionereis nuda* Lütken & Mortensen, 1899, p. 163, pl. 14, figs. 7-9.

Ophionereis roosevelti A. H. Clark, 1939, p. 9, pl. 2, figs. 7, 8.

In the original description of the type there is no mention of the presence or absence of genital papillae; I have found that these do occur but are small

and irregular, only appearing at the proximal ends of the genital slits, as in Lütken and Mortensen's figure of *Ophionereis nuda*.

Re-examination of the type of *O. albomaculata* also shows that it has most of the disc scales obscured by skin except near the radial shields. This was not mentioned by Smith, who may have dried off the specimen to examine and figure it, in which condition the central disc scaling can just be made out. With this amendment to the original description, there is absolutely no character differentiating *Ophionereis roosevelti* A. H. Clark from *O. albomaculata*; the colour, shape of the dorsal and ventral arm-plates (judging from the photographs of *roosevelti*) and the arm-spines are almost identical. The details of the mouth parts were not described by Mr. Clark and do not show up well in the photographs, but with the similarities mentioned above and the fact that both come from the Galapagos Islands, I think there is no doubt that they are synonymous.

As for *Ophionereis nuda* Lütken & Mortensen, the type specimen was only 8 mm. in disc diameter as opposed to 13 mm. in the type of *albomaculata* and 19 mm. in that of *roosevelti*. This considerably smaller size may account for the fact that there are only three arm-spines throughout the length of the arm and the oral shields are relatively much shorter. A good range of various-sized specimens should clear up this point.

Also from the Galapagos comes *Ophionereis perplexa* Zeisenhenne which the Velero III collected at many stations including some in the Gulf of California and in Ecuador. This species is distinguished by the absence of genital papillae and the long, narrow radial shields surrounded by very fine scales no coarser than the rest. The disc is also covered by a thin membrane which conceals the outlines of the scales when wet.

Range. Known only from the Galapagos Islands, depth not recorded.

Ophionereis sasaki sp. n.

(Pl. 3, figs. 1 and 2 and text-fig. 4.)

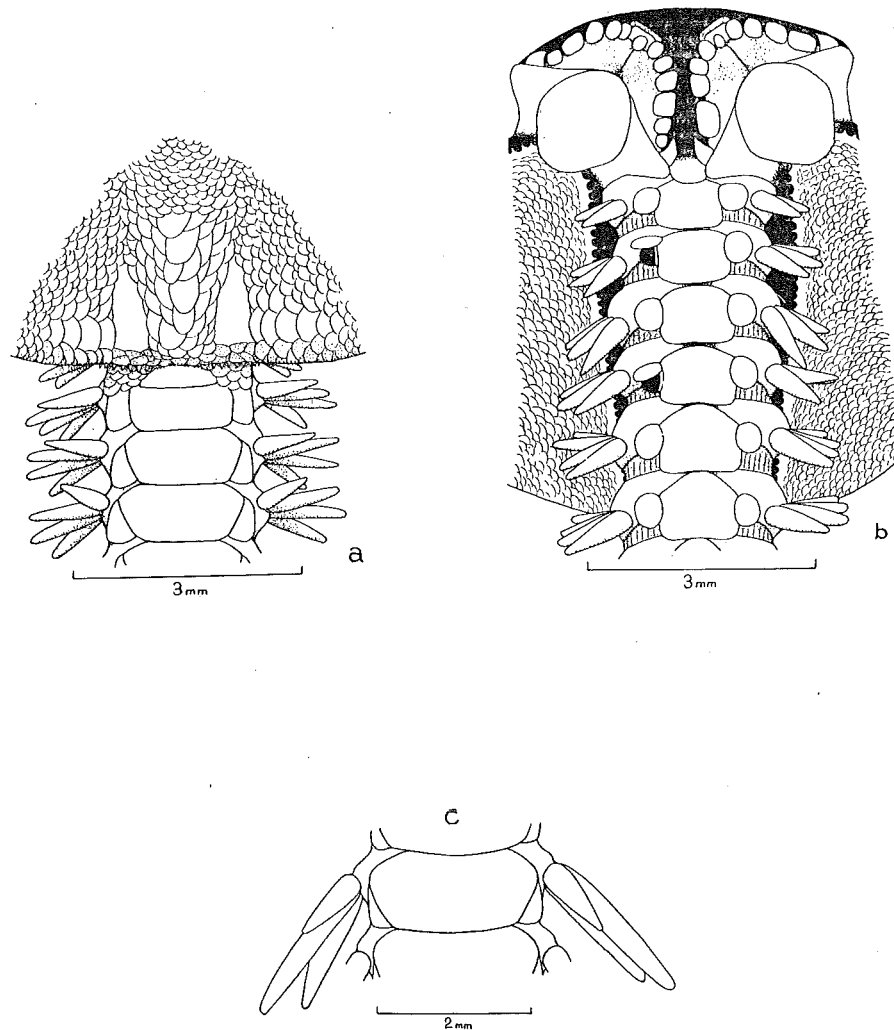
Hakodate, Northern Japan, depth not recorded. From the family of the late Dr. Sasaki; one dry specimen. B.M. Reg. No. 1930.12.23.60. Disc diameter = 12.5 mm.; the arms are all broken within 50 mm. of the disc.

Description. The disc scales are very fine but the primary radial and inter-radial plates are a little larger than the rest and although widely spaced out can be distinguished. The scaling is a little coarser around the radial shields, which are barely 1 mm. long. On the ventral side the fine scaling goes right up to the edges of the genital slits which are bordered by a continuous row of very fine, pointed papillae. These are carried up on to the dorsal side of the disc around the bases of the arms but those of each side are separated by a gap equal to the space between the two radial shields of each pair. The papillae being small, these "arm combs" are rather insignificant and easily missed. The individual papillae are very much smaller and more acute than those of *Ophionereis fusca* Brock.

The first dorsal arm-plate is very short, just projecting a little beyond the disc scales. The second is about two-thirds the size of the following ones and is about two and a half times wider than long. The third plate is similar in shape to the rest with the widest part near the almost straight proximal edge, narrowing in a little distally from the level of the arm-spines to the slightly convex distal edge. The following plates gradually increase in size up to the widest part of the arm, about one-third of the length out from the disc. Here they measure about 1 mm. in length by 2 mm. in width. Correlated with the unusually wide dorsal arm-plates, the supplementary plates are relatively small and even the proximal ones are not equal to the joint in length as they only occupy the dorso-lateral part of the joint distal to the point of insertion

of the uppermost arm-spine and so do not completely separate the lateral arm-plates from the dorsal plates. Distally they become progressively smaller, finally disappearing altogether in the outermost part of the arm (judging from a detached piece).

Figure 4.



Ophionereis sasakii sp. n. Type. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view. (c) Dorsal view of the twelfth arm-joint.

The lateral arm-plates bear four tapering spines for a few segments at the base of each arm but beyond this they carry only three. The lowermost of these spines on the proximal joints is, if anything, the longest, measuring at first just over 1 mm. in length (a little longer than a joint), but at the widest part of the arm all three spines are considerably longer, especially the middle one which measures up to 2.5 mm. in length.

The ventral arm-plates are at first wider than long but in the outer half of the arm are about as long as wide. The first one as usual is considerably smaller than the rest, its convex distal edge slightly overlaps the proximal

edge of the second plate but the distal edges of all the other plates are straight or very slightly concave. The sides are a little hollowed out for the tentacle-pores but the width proximal to the pores is little, if any, less than that at the distal end of the plate. The proximal edge is convex and only narrowly contiguous with the previous plate in the middle. The second to fifth plates are completely separated from one another, their proximal angles being flattened out.

The usual large oval tentacle-scale is present, but where this is displaced laterally, a second but very narrow scale is visible along the lateral edge of the ventral arm-plate.

The oral shields are oval and longer than wide, measuring *c.* 1.5 mm. \times 1.25 mm.; the widest part being about the middle. The inner half is evenly rounded but the outer part forms a blunt angle. On each side the shield is separated from the first lateral arm-plate by an adoral shield, which has an inner prolongation so narrow as to be completely overlapped interradially by the oral shield in all but two of the five angles. Even there the two adorals of each pair do not quite meet.

The number of oral papillae varies from four to six and sometimes there is an odd apical one as well. The outermost is the widest when there are four and is followed distally by the oral tentacle-scale with its usual vertical prolongation up into the mouth slit.

The colour of the disc now is very faint purple with a few small light spots. The arms are very broadly banded with purple on the dorsal side, the bands consisting of and being separated by about six consecutive segments. Even the lighter segments are mottled with purple at the sides.

Remarks. This specimen agrees quite well with the description and figures of *Ophionereis eurybrachioplax* H. L. Clark (1911, p. 174), apart from a difference in the shape of the oral shields, the continuation of the genital papillae up on to the dorsal side around the arm-bases and the presence of a second tentacle-scale normally concealed under the large one. In view of the fact that Dr. Clark has noticed such an extension of the genital papillae in other specimens which he distinguished as *Ophiodoris pericalles* (1911, p. 177), it is unlikely that he would have missed it in those he called *eurybrachioplax* of whose origin in Japan he was doubtful. It is necessary then to give a new name to this specimen from Hakodate, which I therefore call *Ophionereis sasakii* after its collector.

Ophiodoris pericalles has fine papillae outside the radial shields which are continuous with the genital papillae, but the latter are very insignificant, unlike those of *Ophionereis sasakii*. The scaling of the disc is also much coarser in *O. pericalles* and the row of large scales along the upper side of the edge of the disc is continuous across each interradius, not interrupted as in *O. sasakii* by the ordinary scales midway between the outer edge of the radial shield and the interradiial midline. Also there are no supplementary dorsal arm-plates, the oral shields have a very decided inner angle, there are two small tentacle-scales besides the large oval one and there are only three arm-spines from the base of the arm.

The two genera *Ophionereis* and *Ophiodoris* are very near each other as explained in the introduction, the differences being that *Ophiodoris* has no supplementary dorsal arm-plates, but has spinelets at the bases of the arms, sometimes also on parts of the disc, and one or two additional tentacle-scales besides the large oval one typical of the family Ophiochitonidae. *Ophionereis sasakii* and *O. fusca* Brock both have papillae at the bases of the arms but their supplementary dorsal arm-plates, though small, ally them with *Ophionereis*, whereas *Ophiodoris pericalles* lacks the supplementary arm-plates like the other species of *Ophiodoris* described by Koehler (1904).

Range. Known only from Hakodate in the Tsugaru Strait, Japan.

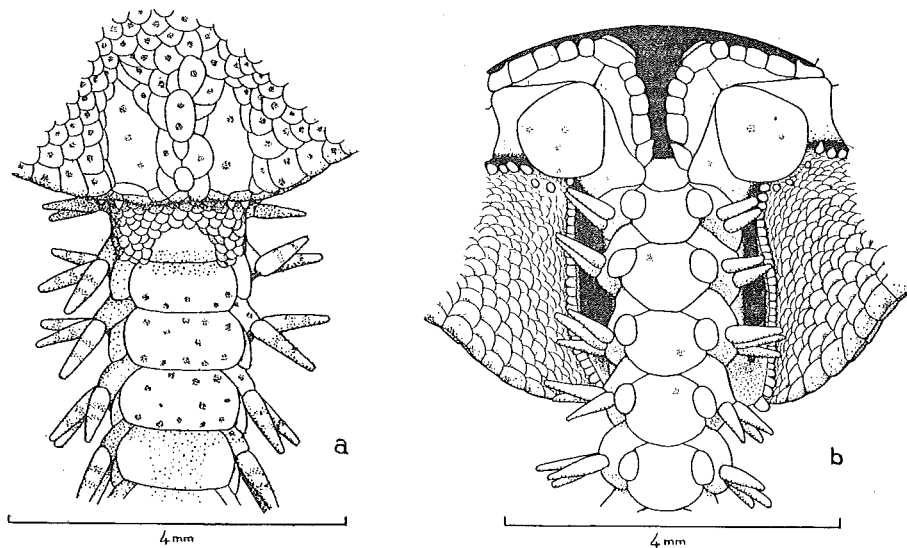
Ophionereis fusca Brock.
(Text-figs. 5 and 6.)

Ophionereis fusca Brock, 1888, p. 492; Koehler, 1904 a, p. 72, fig. 27; 1930, p. 201.

There is one adult specimen of this species in the British Museum from Vao in the New Hebrides. The disc diameter is 10 mm. and the longest arm remaining about 95 mm. long (probably when complete it was at least 110 mm.). A young specimen from the Flinders Bank off Queensland was formerly confused with *Ophionereis porrecta*.

Description. The disc is covered with rather coarse overlapping scales, of which there are about twenty-five in a line from the centre to the edge of the disc interradially. The central plate and three or four others in a row in each

Figure 5.



Ophionereis fusca Brock, registered number 1948.12.6.3, from Vao in the New Hebrides. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view. (An attempt has been made to show the colour pattern.)

radius and interradius are distinctly larger than the rest, besides some plates lateral to the radial shields extending along the edge of the disc. The radial shields are each just under 1.5 mm. long and 0.5 mm. in maximum width. They have a straight distal edge but towards the inner end the overlapping scales gradually approximate from each side, resulting in a blunt proximal angle. There are three to five rows of scales down the space between the two shields of each pair. The scaling is continued on to the ventral side of the disc right up to the genital slits. At the apex of the angle formed by each pair of slits just outside the oral shields there may be a few stout papillae similar to the innermost genital ones. The genital slits themselves are continued as a deep groove for the last third of the distance to the limit of the disc, along the edge of which the short, spatular papillae are continued up towards the dorsal side around the base of each arm. The last few papillae are stout and more isolated than the rest, which are uniform in shape and placed close together to produce a palisade effect.

The disc scaling is continued on to the base of the arm on the dorsal side, partly concealing the innermost arm-plates.

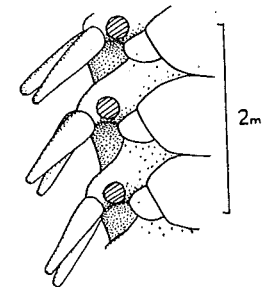
The dorsal arm-plates are about twice as wide as long, with straight proximal and distal edges. As the arm gradually widens to its maximum width (nearly half-way along its length), the plates become proportionally larger, being about 1 mm. in length and nearly 2 mm. wide. The supplementary dorsal plates are rather small and only visible from the dorsal side for about the first ten joints. Beyond this they can be seen from the side by removing or displacing the uppermost arm-spine, but they are gradually reduced and lost altogether in the outer half of the arm. Only the first one is as long as the corresponding dorsal arm-plate.

The lateral arm-plates bear three spines, each tapering to a bluntly rounded tip. The middle one is the stoutest and measures about 1 mm. in length; the lowermost is nearly as long but the upper spine measures only about 0.75 mm.

The ventral arm-plates are about as long as wide, the distal edge being convex while the proximal edge is almost straight and the sides are excavated for the tentacle-pores.

The single, large tentacle-scale typical of the genus, completely covers each pore, but when displaced laterally reveals a second but narrow and rudimentary scale along the edge of the ventral arm-plate.

Figure 6.



Ophionereis fusca Brock. Dorso-lateral view of part of the eighth to tenth arm-joints, the uppermost arm-spines having been removed.

The oral shields are oval and longer than wide (c. 1.6 mm. \times 1.3 mm.), with the widest part nearer the distal edge. The adoral shields do not meet interradially but have an outer lobe separating the oral shield from the first lateral arm-plate on each side.

There are four oral papillae on each side of each mouth angle and beyond the outermost an oral tentacle-scale having a vertical prolongation up into the mouth slit. This scale is based on the adoral shield, unlike the four true oral papillae, which are rather square in outline, the outermost being the largest. There is a gap in the series at the apex of the jaw below the lowest tooth.

The ground colour after some time in spirit is greyish with dark brown spots, one on nearly every disc scale (sometimes two on the larger scales), becoming paler on the ventral side. The radial shields have two or three spots and there are many on the dorsal arm-plates. On the dorsal side of the disc there is an eccentric dark brown patch and along the arms there are brown bands at intervals of about five or six segments each occupying two joints. The arm-spines are also banded with brown.

Remarks. Koehler (1904 a) has already noted the close relationship of this species to *Ophiodoris* upon which I commented in the introduction to this paper. I have not however observed the papillae at the arm-bases forming a continuous comb across each arm as he shows in his rather diagrammatic figure; in this specimen the two series from each side do not meet dorsally.

The species is easily recognizable by the coarse disc scales and papillae and the very distinct spotted coloration.

Range. Known from Amboina, the New Hebrides, the Flinders Bank off Queensland and Jolo in the Philippines, the only recorded depth being 45 metres for the last locality.

Ophionereis porrecta Lyman.

Ophionereis porrecta Lyman, 1860, p. 260; 1865, p. 147; text-figs. 14, 15; Verrill, 1869, p. 390; Ely, 1942, p. 49, text-fig. 50.

? *Ophionereis squamata* Ljungman, 1866, p. 310; Engel, 1938, p. 24, pl. 4, fig. 3.

Ophionereis crassispina Ljungman, 1866, p. 310.

? *Ophionereis sophiae* Brock, 1888, p. 490; Koehler, 1905, p. 54, pl. 6, figs. 5, 6; 1930, p. 202.

Remarks. The type locality of this species is unfortunately not known. Verrill surmised it to be Honolulu because he said material from there was identical with the type, but that was no more than guesswork. In 1866 Ljungman described *Ophionereis crassispina* and *O. squamata* both from Honolulu, the former resembling the type of *porrecta* in having the middle arm-spine the longest, the oral shields oval, the adorals very small and the radial shields ornamented with a white spot as Lyman described in his young specimens of *porrecta*. The description of *O. squamata* only differs significantly from that of *porrecta* in the length of the arm-spines, which are said to be equal in *squamata*, whereas in the type of *porrecta* the middle spine is 1.7 times the length of the upper one and the lowest is 1.3 times that length.

In 1888 Brock described *Ophionereis sophiae* from Amboina, which, he said, differed from all the other known species in having the middle spine of the three not distinctly longer than the others. By that time Lyman (1882, p. 162) had reduced *O. squamata* Ljungman to the synonymy of *O. porrecta*. This move was followed by other authors until 1938, when Engel revived *O. squamata* and amalgamated *O. sophiae* with it, the latter species having been maintained as valid by Koehler in the meantime. Unfortunately Engel based his distinction of *squamata* and *porrecta* not so much on Lyman's description of the latter as on Matsumoto's figures of Japanese specimens, which were not *O. porrecta* at all but should have been named *O. variegata* Duncan. So at least two of the characters (the quadrangular shape of the ventral arm-plates and the absence of secondary lateral arm-plates) used by Engel to distinguish *squamata* are also true of *porrecta*, leaving only the length of the middle arm-spine to distinguish the two forms. The question remains whether *O. squamata* can be maintained as distinct from *porrecta* on the basis of this one character. The material in the British Museum does nothing to solve this problem as, without exception, all the six specimens exhibit a compromise condition with the middle arm-spine from 1.2 to 1.4 times the length of the upper spine, the lowermost one being as long, or very little longer than the upper one. The proportions for the four larger specimens are as follows:—

	Honolulu	Maldive Is.	Amirante Is.	Mauritius
Upper spine	1.0	1.0	1.0	1.0
Middle spine	1.4	1.3	1.3	1.2
Lower spine	1.0	1.06	1.1	1.0

(Taking in each case the length of the upper spine as 1.0.)

In all these the upper spine is flatter than the other two, the lowermost is the most slender but tapers like the middle one. Without further material,

particularly from Honolulu, I am unable to say whether there are two distinct forms *porrecta* (+*crassispina*) and *squamata* (+*sophiae*) and so leave my own material under the former name.

The amalgamation of *Ophionereis variegata* Duncan (1879, p. 462) with *O. porrecta*, although only put forward tentatively by Lyman (1882, p. 162), was followed by other authors including Matsumoto (1917, p. 335), but re-examination of the type of *variegata* has convinced me that this move was a mistaken one, for reasons given under the heading of that name.

Some remark should perhaps be made regarding the extension of the range of this species to the Amirante and Seychelles Islands and Mauritius. De Loriol (1893) only mentions *Ophionereis dubia* from Mauritius and does not describe the genital slits. The specimen from there in the British Museum, also originating from de Robillard, has well-developed, closely placed genital papillae and is clearly *Ophionereis porrecta* rather than *O. dubia*. In other respects it agrees fairly well with de Loriol's description which might cover either species.

Ophionereis fusca Brock may be confused with *O. porrecta* when young before the papillae around the arm-bases are well developed. However, it can be distinguished by the colour, which in *fusca* consists of dark brown or purplish spots, usually one on each disc scale, with a dark blotch or coarse reticular pattern over part of the disc, the arms where not banded with darker colour being also spotted. In *O. porrecta* the disc is usually variegated with a close reticular pattern, or rarely it is almost uniform in colour and is not spotted all over, nor are there dark spots on the arms. A young specimen of *O. fusca* in the British Museum from the Flinders Bank off Queensland was at first thought to be *O. porrecta* but the mainly spotted disc, the distally extended, though not conspicuous series of genital papillae and the relatively larger dorsal arm-plates differentiated it from the material of *O. porrecta* to hand.

Range. Known from Hawaii south and west to Polynesia, Malaya, the Indian Ocean and (?) South-east Africa, from the shore down to about 60 metres.

Ophionereis variegata Duncan.

(Text-fig. 7.)

Ophionereis variegata Duncan, 1879, p. 462, pl. 10, figs. 15, 16.

Ophionereis porrecta, Matsumoto, 1917, p. 334, text-fig. 93 (non *O. porrecta* Lyman).

Remarks. Comparison of the type of *Ophionereis variegata* with specimens of *O. porrecta* from Honolulu, the Amirante Islands, Maldives and Mauritius showed that only the first possesses the secondary lateral arm-plates figured by Matsumoto (fig. 93 d) and ventral arm-plates which could be described as "fan-shaped". All the others have only uncalcified tissue between the lateral arm-plates of successive joints and the ventral arm-plates are quadrangular, although the distal edge may be a very little wider than the proximal. Also in *O. variegata* the arms are distinctly shorter than in specimens of *porrecta* of comparable size.

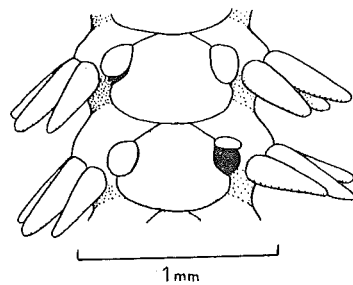
Duncan's type specimen, with a disc diameter of 4.5 mm., is the only representative of the species in the British Museum. It corresponds closely to Matsumoto's figures of his specimen with disc diameter 5 mm. There is at least one accessory lateral scale between the main lateral arm-plates on each side of each joint.

The fact that the ventral arm-plates reach their widest point at the distal edge of the tentacle-pores does not show very clearly in Matsumoto's illustration, so I think it is worth while to give another figure of this. Being smaller, the proximal ends of the ventral arm-plates in the type are not overlapped by the previous plates to quite the same extent as Matsumoto shows, so that the fan shape is emphasized.

The disc scales are large and small intermingled and the arms are relatively short, being only four or five times the disc diameter in length, whereas two

young specimens of *Ophionereis porrecta* from the Seychelles and Amirante Islands have the disc diameter 3 mm. and the arms seven to eight times that length. This difference, together with the presence of accessory lateral scales

Figure 7.



Ophionereis variegata Duncan. Type. Ventral view of two arm-joints to show the shape of the ventral arm-plates.

on the arms and the more fan-shaped ventral arm-plates, is sufficient to distinguish *variegata* from *porrecta*.

Range. Known only from Japanese waters, the single recorded depth being 50 metres.

Ophionereis semoni (Döderlein).

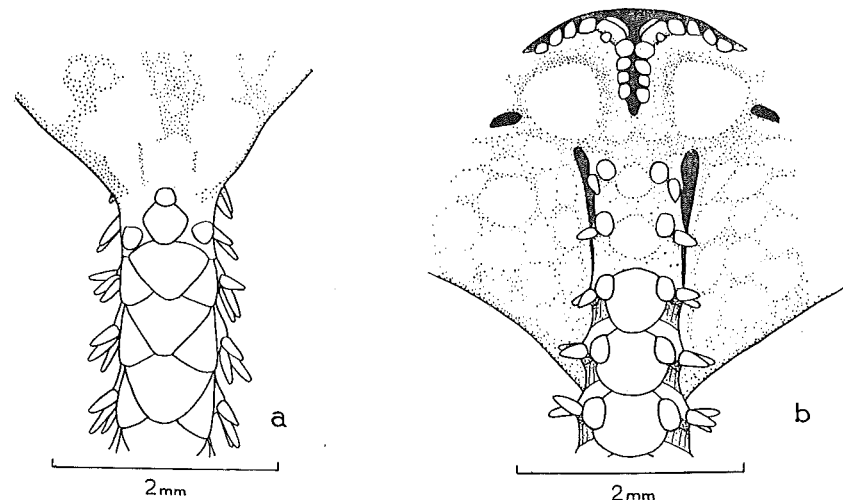
(Pl. 2, figs. 3 and 4 and text-fig. 8.)

Ophiotriton semoni Döderlein, 1896, p. 288, pl. 15, fig. 8.

Ophionereis semoni, H. L. Clark, 1921, p. 118; 1938, p. 322; 1946, p. 240.

Remarks. Dr. Clark (1921) found that all his specimens formerly named *O. dubia* from Torres Strait were in fact *O. semoni*, which led me to re-examine

Figure 8.



Ophionereis semoni (Döderlein), registered number 82.2.22.44, from Torres Strait. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view. (The colour pattern is indicated by stippling.)

the material from northern Australia named *Ophionereis dubia* by Bell. I found that some but not all of these specimens were actually *O. semoni*

although others from Torres Strait and Holothuria Bank (off N.W. Australia) had been correctly named.

In spirit the two species are hardly distinguishable in dorsal view, for the very fine scaling and accessory scales (if present) at the distal ends of the dorsal arm-plates in *dubia* are not usually distinct when wet. In the semi-dry state the outlines of the radial shields of *dubia* do become visible, whereas they are still completely concealed by skin in *semoni* even when absolutely dry.

From the ventral side however the difference between the two is much more conspicuous either in the wet or dry state, consisting as it does of the presence of pigmented skin covering the oral and adoral shields and usually the first few ventral arm-plates also, completely concealing their outlines. The pigmentation is absent over the oral shields so that they appear as white patches surrounded by dark brown, making a striking contrast. In *O. dubia*, of course, there is no pigmented skin and the outlines of the oral shields are quite distinct.

As Dr. Clark has also pointed out, there is a difference in the shape of the ventral arm-plates, which in *O. semoni* are noticeably wider distal to the tentacle-pores than at the proximal end. I also observe that the dorsal and supplementary dorsal arm-plates of *O. semoni* appear to be thicker at their distal ends than those of *dubia*, so that their limits are sharper, there being no accessory scales. The arm-spines of *dubia* are relatively longer also, as can be seen from the photographs (Pl. 2, figs. 2 & 3).

Range. Known from the East Indies and all round Australia except in the south-eastern part (Peronian Province—see H. L. Clark, 1946), from the shore down to about 100 metres.

Ophionereis dubia (Müller & Troschel).

(Pl. 2, figs. 1 and 2 and text-figs. 9 and 10.)

Ophiura sp. Savigny, 1809, pl. 1, fig. 3.

Ophiotelepis dubia Müller & Troschel, 1842, p. 94.

Ophionereis dubia, von Martens, 1870, p. 246; de Loriol (?), 1893, p. 19.

Ophionereis dubia var. *sinensis* Duncan, 1879, p. 464.

Ophionereis porrecta Marktanner-Turneretscher, 1887, p. 302, pl. 12, fig. 18 (non *O. porrecta*, Lyman, 1860, p. 260).

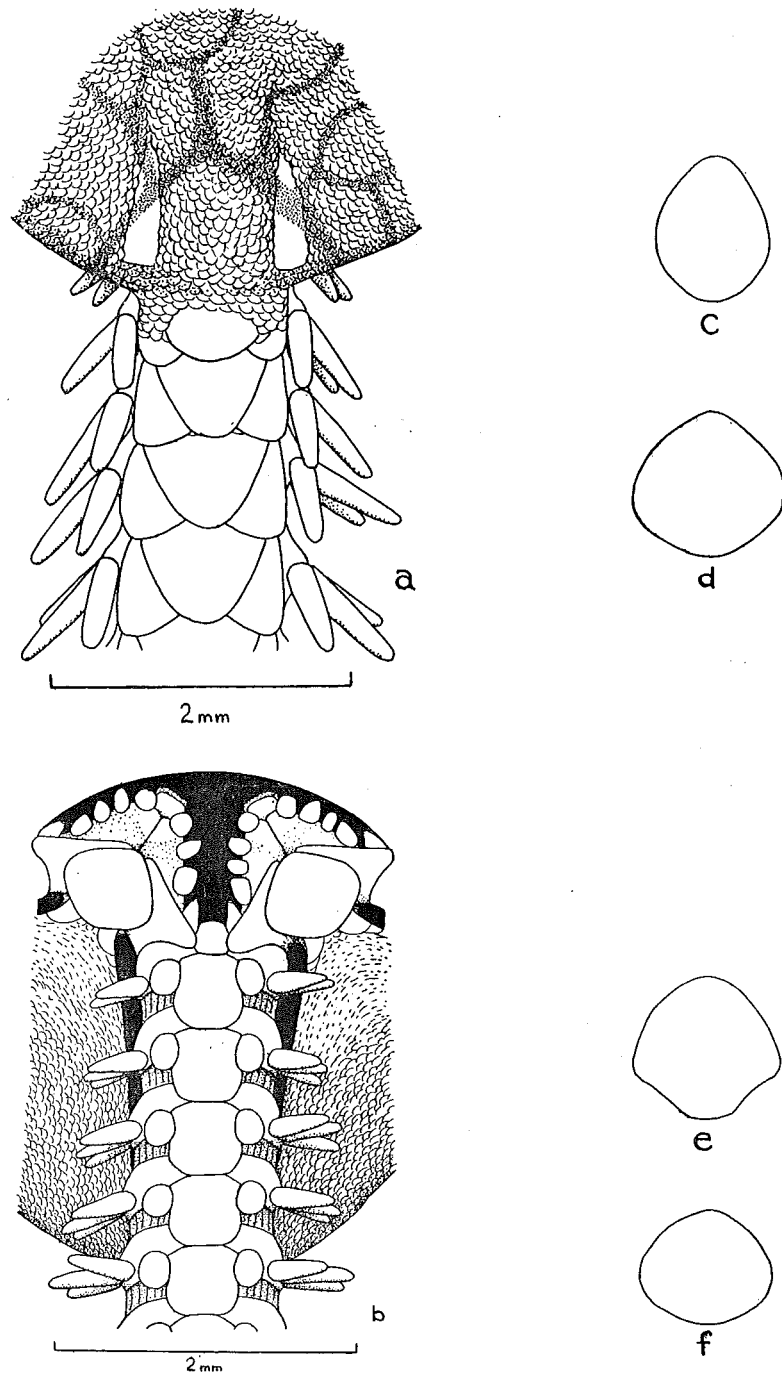
Ophiocrasis dictydisca H. L. Clark, 1911, p. 175, fig. 79.

Ophiocrasis marktanneri Matsumoto, 1915, p. 90; 1917, p. 338.

Ophionereis stigma H. L. Clark, 1938, p. 325; 1946, p. 239.

Remarks. Some explanation is certainly needed for this very formidable synonymy list. The type locality of the species is "Egypt" and presumably the Red Sea coast, since it is not found in the Mediterranean. There are numerous specimens in the British Museum from the Gulf of Suez, collected by McAndrew and by the Cambridge University Expedition of 1923, as well as other material from the Persian Gulf, Madras, Ceylon, Macclesfield Bank, China, Japan, Amboina and several localities along the northern coast of Australia. These last would have been called *Ophionereis stigma* by H. L. Clark, who distinguishes that species from *O. dubia* in his key (1946, p. 237) only by the dark, Y-shaped marks at the bases of the arms on the dorsal side of the disc. He says that the form of this "stigma" varies somewhat in detail but it is quite distinct. I have found it clearly marked in many specimens of *O. dubia* from all other parts of the range as well as in those from northern Australia and Holothuria Bank (off N.W. Australia) and cannot see any reason for the erection of a new species on this account, although it may be worth retaining as a local form with heavier markings than usual. It is strange that Dr. Clark should have compared *O. stigma* with *O. semoni* (Döderlein) rather than with *O. dubia*. *O. semoni* is easily recognised by the skin covering the disc and oral and adoral shields, so that the outlines of the scales and mouth plates cannot be discerned.

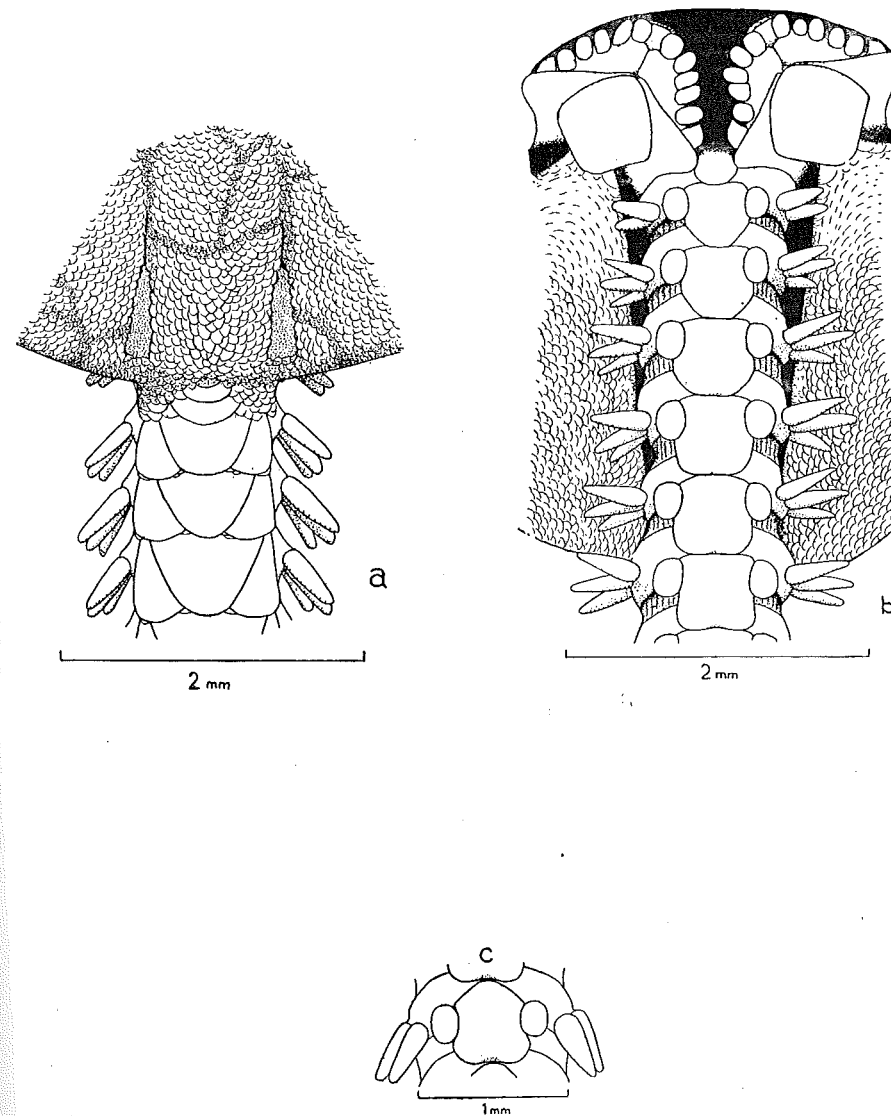
Figure 9.



Ophionereis dubia (Müller & Troschel), registered number 69.7.8.19, from the Gulf of Suez. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view. (c)-(f) Different types of oral shields from various other specimens. (The colour pattern is indicated by stippling in (a).)

I have noticed in most specimens of *O. dubia* from all parts of the range, that there are accessory scales at the distal ends of at least a few of the dorsal and supplementary dorsal arm-plates. In some specimens these occur regularly on every joint at least in the proximal part of the arm, while in others

Figure 10.



Ophionereis dubia subsp. *sinensis* Duncan. Type. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view. (c) Ventral view of the twelfth arm-joint to show the slight concavity of the distal edge. (The colour pattern is indicated by stippling in (a).)

their appearance is more spasmodic and much less conspicuous. In any case the material needs to be at least partially dried for this feature to show up distinctly. These scales are well developed in certain specimens from the

Persian Gulf, Macclesfield Bank, China, Japan and north-west Australia. These last, from Cape Boileau near Broome had been named *Ophiocrasis marktanneri* (probably by G. A. Smith).

The genus *Ophiocrasis* was erected in 1911 by H. L. Clark for Japanese material and it is odd that he did not notice the resemblance between his type species *O. dictydisca* and *Ophiocereis stigma* when he came to name the latter, although of course it was many years later. Some of his sixty-seven specimens of *O. stigma* surely possessed these accessory scales even if only irregularly. In 1928 (p. 437), under the heading of *Ophiocereis semoni*, Dr. Clark remarked that "the genus *Ophiocrasis* is not worth maintaining, as *O. semoni* is such a complete connecting link between it and *Ophiocereis*". In *O. semoni* however I have not observed any such accessory scales on the arms and the outlines of the dorsal arm-plates are very clear-cut, the plates themselves appearing to be thicker than those of *Ophiocereis dubia*.

From Japan, the type locality of both the species of *Ophiocrasis* (*O. dictydisca* H. L. C. and *O. marktanneri* Matsumoto), there are three specimens in the British Museum collected by Captain St. John, two of which can certainly be named *Ophiocereis dubia*. The one dry specimen is presumed to be the type of the variety *sinensis* as Duncan's other types in this collection were also dried. However, it is only labelled "*Ophiocereis dubia* Aud. var." and there is no further detail of locality than "Korean Seas". An earlier registration in 1873 of material from the same source does provide detailed localities, showing that "Korean Seas" covered what would now be called Japanese waters, for the stations include places in the south-east of the main Japanese island of Honshu, in the Tsugaru Strait between Honshu and Hokkaido to the north and also north-east of Hokkaido. There are two spirit specimens from Tsugaru Strait under this earlier registration, of which one at least belongs to this species. They were registered just as *Ophiura*, sharing a number with some specimens which turned out to be *Ophiopholis mirabilis* (Duncan) and it is not known what Duncan himself considered them to be, for they have since been relabelled "*Ophiocereis porrecta*" without preservation of the earlier labels.

I give here detailed figures of the dry specimen which is presumably Duncan's type of the variety *sinensis*. It is almost identical with other specimens of *Ophiocereis dubia* from various parts of the Indo-West Pacific and the only character I can find to distinguish it is the fact that there are more often five than four oral papillae on each side of each jaw. I have only seen more than four papillae on single jaws of a very few other specimens of *O. dubia* from the rest of the range. H. L. Clark gives the number as four to six for *Ophiocrasis dictydisca* and Matsumoto as four or five for *O. marktanneri*. The larger of my two specimens from Tsugaru Strait however has five only on one side and four elsewhere, so this distinction cannot be relied on, and it can only be said that the tendency for multiplicity of these papillae is there.

Duncan distinguished the variety *sinensis* by the form of the ventral arm-plates which he said were notched distally and with an eminence proximally. This is true of the plates beyond the disc but the distal "notch" is produced not so much by actual concavity of the edge of the plate as by a bevelling or thinning of the plate extending inwards from the distal edge, so that it is more transparent at this point, and the slight gap between the lateral arm-plates underneath shows through as a dark patch, giving the illusion of greater concavity. This is also the case however in many Indo-Pacific specimens of *O. dubia*, not just those from Japan. Actually I have found that the shape of the distal edge of the ventral arm-plates varies from convex (the straight part in the middle being very short) to distinctly concave, but even in the former case the transparency may produce a concave effect. As for the proximal "eminence" or angle, this is somewhat truncated by the overlap

of the preceding plates on the first few arm-joints, but beyond the disc, particularly since this specimen is not very large (d.d.=6.5 mm.), it becomes increasingly prominent as in other specimens of *O. dubia*.

The figure of the dorsal side of Duncan's type of *sinensis* shows that, like *Ophiocrasis*, it has accessory scales on all the proximal joints. Like those of *O. marktanneri* Matsumoto, these scales occur in the angles formed between the dorsal and supplementary dorsal arm-plates at the distal ends of the joints, although in other specimens of *O. dubia* they appear more towards the side along the curving distal edge of the supplementary plates. In some cases these scales may occur in both positions simultaneously, particularly at the bases of the arms.

As for the differences between the two species of *Ophiocrasis*, Matsumoto did not apparently have any material of *O. dictydisca* for comparison and describes his species *O. marktanneri* as distinct "in the shape of the dorsal arm-plates, in the less well-developed secondary supplementary pieces (i.e. accessory scales), in the smaller and less distinct radial shields, and in the smaller arm spines of the basal joints". In his key he also distinguishes them by the shape of the ventral arm-plates, which he says are wider than long in *marktanneri* instead of longer than wide as in *dictydisca*. Judging from the drawings of both species (H. L. Clark, 1911, fig. 79 b; Matsumoto, 1917, fig. 94 b), this difference is slight and may be correlated with the 2 mm. greater disc diameter of Matsumoto's type. As for the "less well-developed secondary supplementary pieces" in *marktanneri*, H. L. Clark says himself, under the generic description of *Ophiocrasis*, that their size has been exaggerated in his drawings for the sake of clarity. I do not think this difference is significant, for the development of these scales varies considerably in different specimens of *Ophiocereis dubia* from other parts of the Indo-Pacific. Although Matsumoto has figured the dorsal arm-plates as almost pointed distally, he describes them as "triangular with obtuse outwardly directed apex" and I do not think there can be very much difference in the shape. The relative size of the radial shields and length of the basal arm-spines are characters rather difficult to compare from drawings and the differences postulated may not be significant. Matsumoto does not comment on the apparently larger adoral shields of *O. dictydisca* compared to his species, but this discrepancy again may be due to the greater size of his type. The one thing which may really be important in distinguishing the two is the reproduction of the young of *dictydisca* by autotomy, which Matsumoto did not observe in his abundant material from Sagami Bay. (However, it should be noted that Dr. Clark himself was not absolutely certain that the young six-armed specimens were the same species as his larger pentagonal ones.) One of the specimens of *dictydisca* came from Suno Saki in the Sagami Sea, the type locality of *O. marktanneri*.

The material in the British Museum does little to support the existence of two distinct Japanese forms. The type of *sinensis* seems to compromise between the two descriptions in the form and proportions of the dorsal and ventral arm-plates and the radial shields. The larger of the two specimens from Tsugaru Strait to the north of Honshu, also with the disc diameter 6.5 mm., has the ventral arm-plates after the first few distinctly longer than wide, as in the type of *dictydisca* (H. L. Clark, fig. 79 b). By way of contrast, however, the proximal dorsal arm-plates are much more acute than in Dr. Clark's fig. 79 a and are more like those of *marktanneri* in Matsumoto's figure.

The second specimen from this station is very puzzling in that it is similar to the other in most features but it has small, acute, spaced-out but perfectly distinct genital papillae on the proximal parts of the genital slits. This is so peculiar that I am forced to describe the specimen under a separate name, calling it *Ophiocereis intermedia*, since it is in many ways intermediate between *O. dubia* and *O. sasakii*, also known from Tsugaru Strait.

A specimen from Pintang in Fukein Province, China, considerably farther south than Honshu, is similar to the larger one from Tsugaru Strait; the oral papillae are unfortunately damaged but there seem to be not more than four on each side.

To sum up, I think *sinensis* may be worth retaining as a subspecies of *O. dubia* from China and Japan.

I have tried to find out whether any of the other variations shown by this species are correlated with the geographical locations constantly enough to be designated a subspecies. However, the only other such variation I can find is in the shape of the oral shields in Red Sea material of *O. dubia*. All the specimens I have seen (about ten) from the Gulf of Suez have the oral shields wider than long, just as Savigny shows in his detailed figure of the mouth parts. However, this form of the shields is not limited to the Red Sea, as it occurs in certain specimens from the Persian Gulf, Torres Strait and Macclesfield Bank, although the usual condition outside the Red Sea, is for the shields to be as long or even longer, than wide. In the Red Sea, though, the wide form seems to be the common, or perhaps the only, one found.

Of the "Challenger" specimens which Lyman named *Ophionereis dubia* with a query (1882, p. 161), the one from the Fiji Islands is *O. semoni* and that from the Canary Islands is *O. sevradia* Mortensen. The unqueried one from Amboina was rightly identified.

Range. From the Red Sea to the Persian Gulf, (?) Mauritius, S.E. Africa, Ceylon, India, the East Indies, northern Australia, China and Japan. The greatest depth record I have seen is from Amboina between 180 and 230 metres (Koehler, 1930) but the species is most often taken in about 30 metres or less.

Ophionereis amoyensis sp. n.
(Text-fig. 11.)

Amoy, China; Dr. Chen; one specimen (no depth recorded).

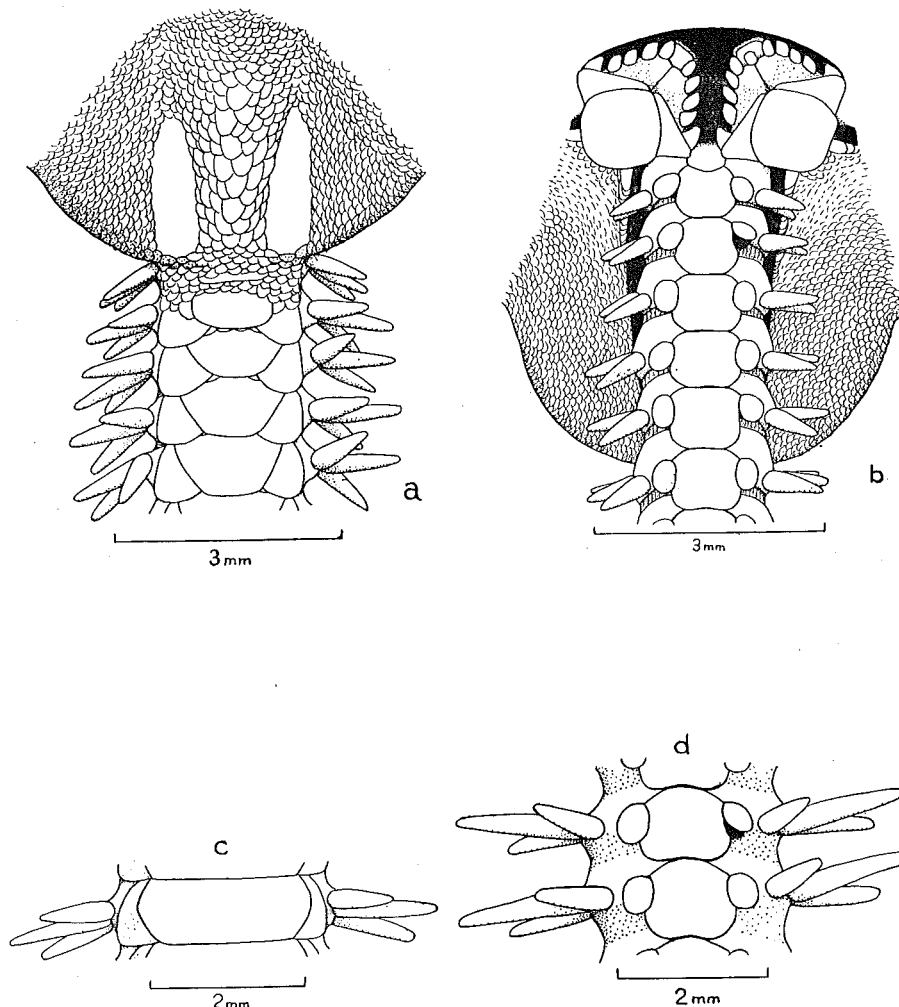
Description. The disc diameter is 10 mm. and the longest remaining arm attached to it measures 60 mm., but this is also broken; it was probably about 100 mm. in total length. The specimen has been dried and the disc has become deeply indented interradially.

The dorsal side is covered with fine overlapping scales, the primary ones indistinguishable from the rest. There are about thirty scales in 3 mm. length across the centre of the disc but around the radial shields they become a little larger. Between the two shields of each pair there are about seven rows of scales. The fine scaling continues on the ventral side up to the genital slits which have no bordering papillae. The radial shields themselves are about 1.4 mm. long and 0.5 mm. at the widest part (near the distal end), proximally they taper to a blunt angle.

The disc scaling extends on to the base of the arm around the first one or two dorsal arm-plates. The third plate measures 0.75 mm. in length and 1.25 mm. at its greatest width, that is near the proximal end, the shape being in general hexagonal with the three proximal sides bounded by the previous dorsal plate and two supplementary plates, while the three distal sides are delimited by the corresponding supplementary plates and the succeeding dorsal plate. On some joints the three distal sides are merged into a continuous curve. As the arm widens a little along its length (the maximum width being about one-third of the distance out from the disc), the dorsal arm-plates become relatively wider, up to 2.25 mm. across, but the length is rarely more than 0.8 mm. The supplementary dorsal arm-plates are well developed and clearly visible for the whole length of the arm remaining, each one equalling in length the corresponding dorsal plate. Proximally on some joints there are small accessory scales at the distal angles of the supplementary plates, occurring irregularly.

The first ventral arm-plate is about half the size of the second and following ones, which are almost square or only a little wider than long, with straight proximal and distal edges and the sides narrowing slightly from just beyond the distal end of the tentacle-pore. After about the fourth plate, the distal

Figure 11.



Ophionereis amoyensis sp. n. Type. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view. (c) A middle arm-joint in dorsal, and (d) in ventral view.

edges gradually come to show a distinct concavity, so that a corresponding convexity appears in the proximal edges of the following plates. On either side of this distal "notch" the edge of the plate curves round gradually to the distal end of the tentacle-pore, where it becomes concave for the accommodation of the pore. The plates in the middle of the arm are not markedly wider than the proximal ones and measure about 0.8 mm. in length by 1.0 mm. wide.

The single tentacle-scale is large and oval and can completely cover the corresponding pore. The lateral arm-plates bear three tapering spines for the whole length of the arm. Proximally the two lower ones measure nearly 1.5 mm. in length, while the upper one is a little shorter and only about 1 mm. long.

The oral shields are about 1.1 mm. in length and the same width, narrowing from the widest part, which is slightly more than half-way out, to rounded proximal and distal angles. The madreporite is larger and is longer than wide. The adoral shields have no distal lobe lateral to the oral shield but are prolonged inwardly and may just meet proximally to the oral shield. There are four oral papillae on each side of each jaw angle and on some angles there is also an apical papilla. Distal to the outermost oral papilla is an oral tentacle-scale based on the outer edge of the adoral shield and having a vertical process up into the oral slit.

The colour on the disc now is pale grey with rather dense dark brown reticulations and the dorsal side of the arms is blue-grey in colour with one or two lighter joints at irregular intervals.

Remarks. This specimen was formerly labelled *Ophionereis eurybrachiola* H. L. Clark (probably by G. A. Smith). It is certainly not that species for it has no genital papillae, no second tentacle-scale, no fourth arm-spine on the basal joints, and the supplementary dorsal arm-plates are larger, running the full length of the joint (at least on the inner half of the arm). At first I believed it to be a large specimen of *Ophionereis dubia* but comparison with such a one from the Red Sea showed that in this Chinese specimen the dorsal arm-plates are much wider (particularly at the broadest part of the arm) and more angular in shape. Also the blue-grey coloration of the arms with irregular lighter patches is quite different from the pale arms with narrow dark bands at fairly constant intervals down their length typical of *O. dubia*. It is therefore necessary to make this the type of a new species.

Range. Known only from Amoy in Southern China.

Ophionereis intermedia sp. n.
(Text-fig. 12.)

41° 12' N. : 140° 45' E. (in the Tsugaru Strait, N. Japan); 80 metres; sand and mud bottom; collected by Captain St. John; one specimen.

Description. The disc is 5.5 mm. in diameter; all the arms have been broken at some distance from the disc and are in process of regeneration, so no accurate idea of their length can be obtained.

The scaling of the disc is very fine and even, not being notably coarser around the radial shields, which are short, about 0.5 mm. in length and widely spaced, with about ten to fifteen scales on a line drawn between the two shields of each pair. Near the centre of the disc two somewhat larger, circular plates can be made out; one of these is probably the central plate and the other one of the five primaries. Apart from these all the scales are about the same size, there being about twelve in a length of 1 mm. and they are a little easier to distinguish when wet than the scales of *Ophionereis dubia*. On the ventral side the scaling runs up to the genital slits which are bordered proximally by a series of small, spaced, very acute genital papillae. In a small triangular area just outside the oral shield the scaling is slightly obscured by skin when wet, as in most other finely scaled species of *Ophionereis* such as *O. dubia*.

On the dorsal side of the arm-bases the disc scaling extends around the first one or two dorsal arm-plates, partially concealing them. The following plates are roughly triangular in shape with a rounded, distally directed apex. They are rather thin and their limits, like those of the supplementary plates which border them, are not very clear, particularly when wet. When partially dried the accessory scales at their distal edges become distinct. The supplementary plates as in *O. dubia* run the full length of the joints, at least on the proximal half of the arm.

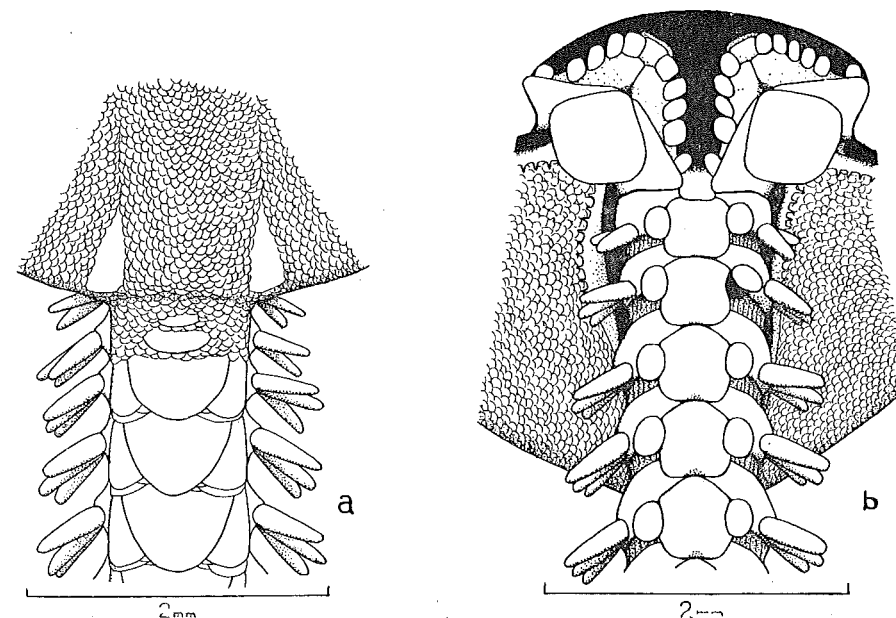
The lateral arm-plates bear three somewhat flattened, blunt-tipped arm-spines, of which the middle one on the widest part of the arm (a little way out from the disc) is the longest and stoutest, just exceeding a joint in length. The lower is almost as long but more slender and the upper one is a little shorter still—about equal to the corresponding joint.

The ventral arm-plates after the first two or three are distinctly pentagonal with the proximal angle just touching the distal edge of the preceding plate. The distal edge is straight or very slightly concave, although, like *O. dubia*, it appears at first sight to be very concave; however, this is due to transparency perhaps aided by actual thinning of the plate towards the distal end.

The tentacle-scale is large, oval and single.

The oral shields are four-sided, about as wide as long, with the widest part a little nearer the distal edge than the proximal; the distal angle is consequently more obtuse than the proximal one. The adoral shields do not meet interradially but their outer part extends down to the genital slit lateral to the oral shield.

Figure 12.



Ophionereis intermedia sp. n. Type. (a) Dorsal view of the base of an arm and part of the disc. (b) The same in ventral view.

There are four, sometimes five oral papillae on each side, the outermost a little larger, when there are four, and followed after a space by the oral tentacle-scale, which is rounded and for once does not appear to have a vertical prolongation up into the mouth slit. It is based on the adoral shield rather than on the oral plates unlike the other papillae.

The colour after seventy years in spirit is brownish with darker brown reticulations on the disc and some traces of darker bands on the arms.

Remarks. This species seems to be intermediate between *Ophionereis dubia* and *O. sasakii* although it has some features in common with *O. annulata* from the other side of the Pacific.

The presence of small, though distinct, genital papillae precludes its identification as *O. dubia*, from which it also differs in the very short radial shields and slightly more distinct disc scaling. From *O. sasakii* it differs in the thin, poorly defined dorsal arm-plates and relatively large supplementary plates as well as in lacking the second tentacle-scale on the ventral arm-plate and having only three arm-spines throughout (though the smaller size might account for that). From *O. annulata* also it is distinguished by the badly defined dorsal arm-plates and the less markedly enlarged middle spine.

The two other species of *Ophionereis* from China and Japan are *O. amoyensis* and *O. variegata*. The former has no genital papillae and much smaller adoral shields than this specimen, while the latter has much coarser disc scales and the genital papillae closely placed.

Range. Known only from the Tsugaru Strait, northern Japan, in about 80 metres depth.

SUMMARY.

The relationship between *Ophionereis* and the other genera of the family Ophiochitonidae is discussed briefly.

The species attributed to *Ophionereis* are listed and a key to those which are valid is given. Some of these, including three new species from China and Japan are described and figured.

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EXPLANATION OF THE PLATES.

PLATE 1.

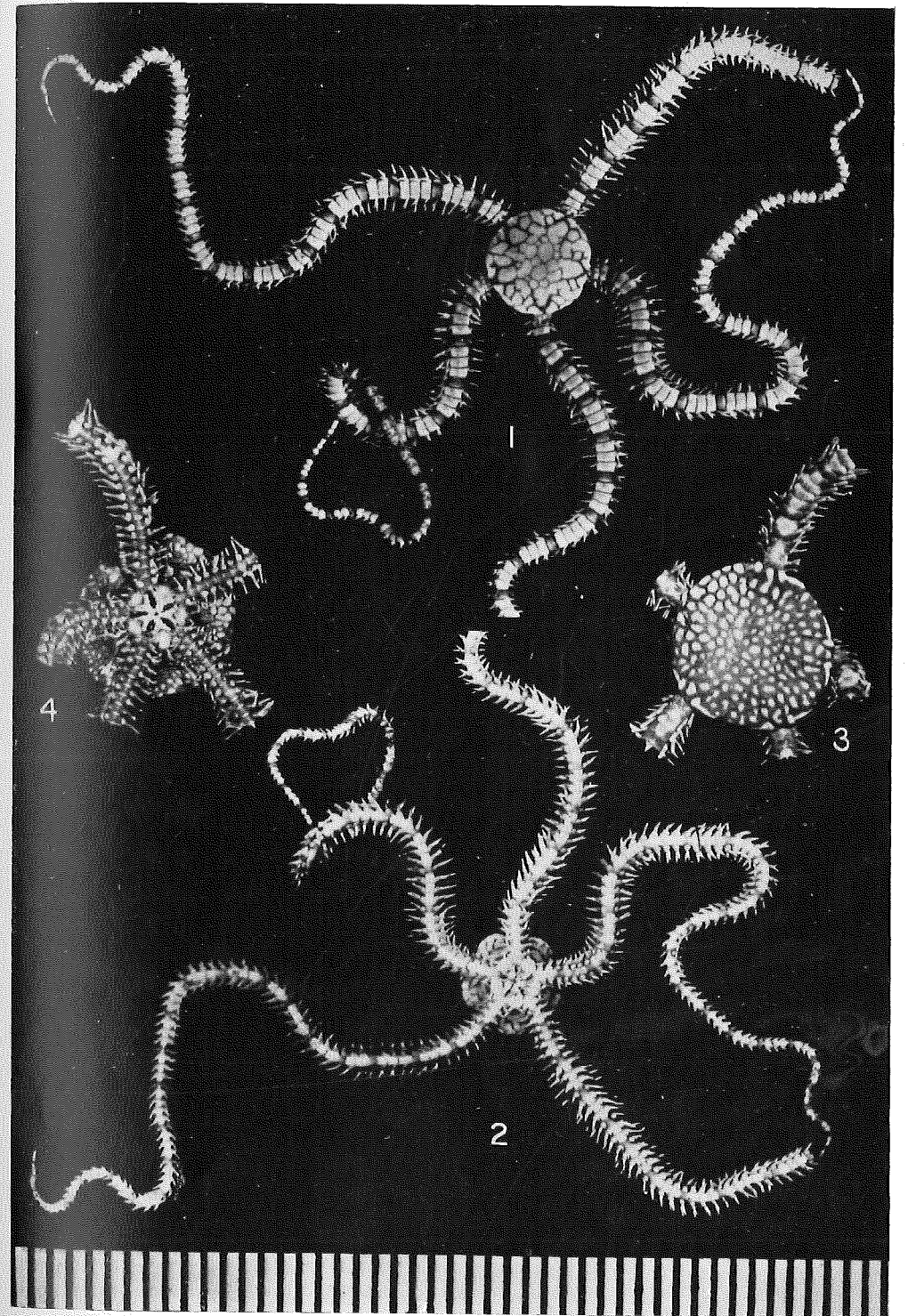
- Fig. 1. *Ophionereis reticulata* (Say), registration number 60.4.25.35; from St. Thomas, West Indies. Dorsal view.
 2. The same in ventral view.
 3. *Ophionereis annulata* (Le Conte), number 1925.10.19.5; from Esmeraldas, Ecuador. Dorsal view of disc, the arms all being broken.
 4. The same in ventral view.
 (The scale is in millimetres.)

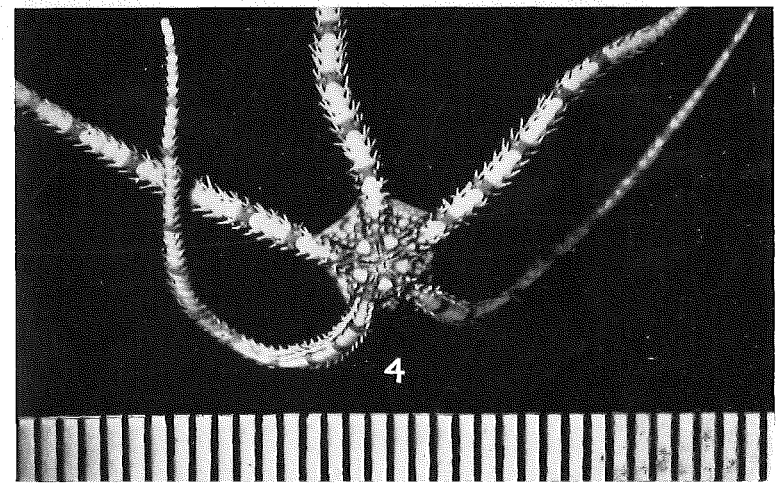
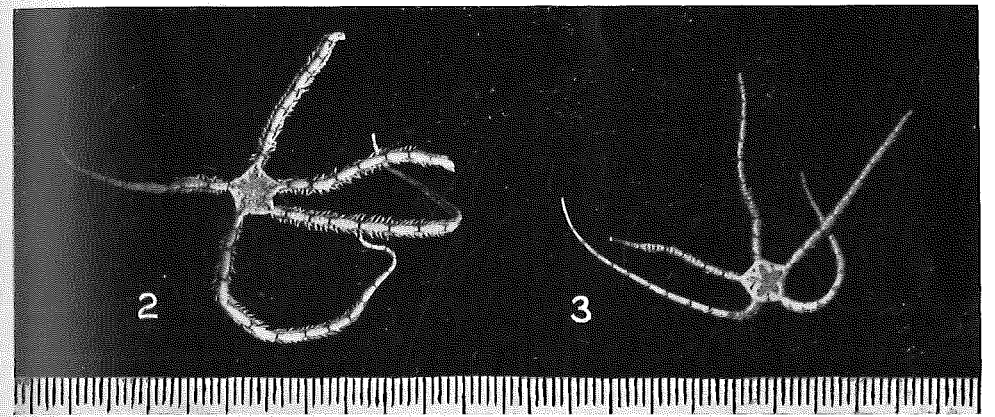
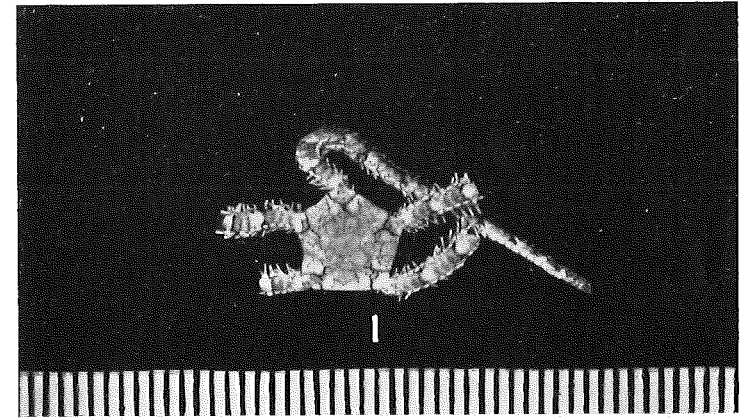
PLATE 2.

- Fig. 1. *Ophionereis dubia* (Müller & Troschel), number 69.7.8.19; from the Gulf of Suez. Dorsal view, showing the disc markings.
 2. *Ophionereis dubia* (Müller & Troschel), number 82.2.22.45; from Torres Strait. Dorsal view, natural size for comparison with fig. 3.
 3. *Ophionereis semoni* (Döderlein), number 82.2.22.44; also from Torres Strait. Dorsal view.
 4. The same in ventral view but enlarged to show up the characteristic coloration.
 (The scales are in millimetres.)

PLATE 3.

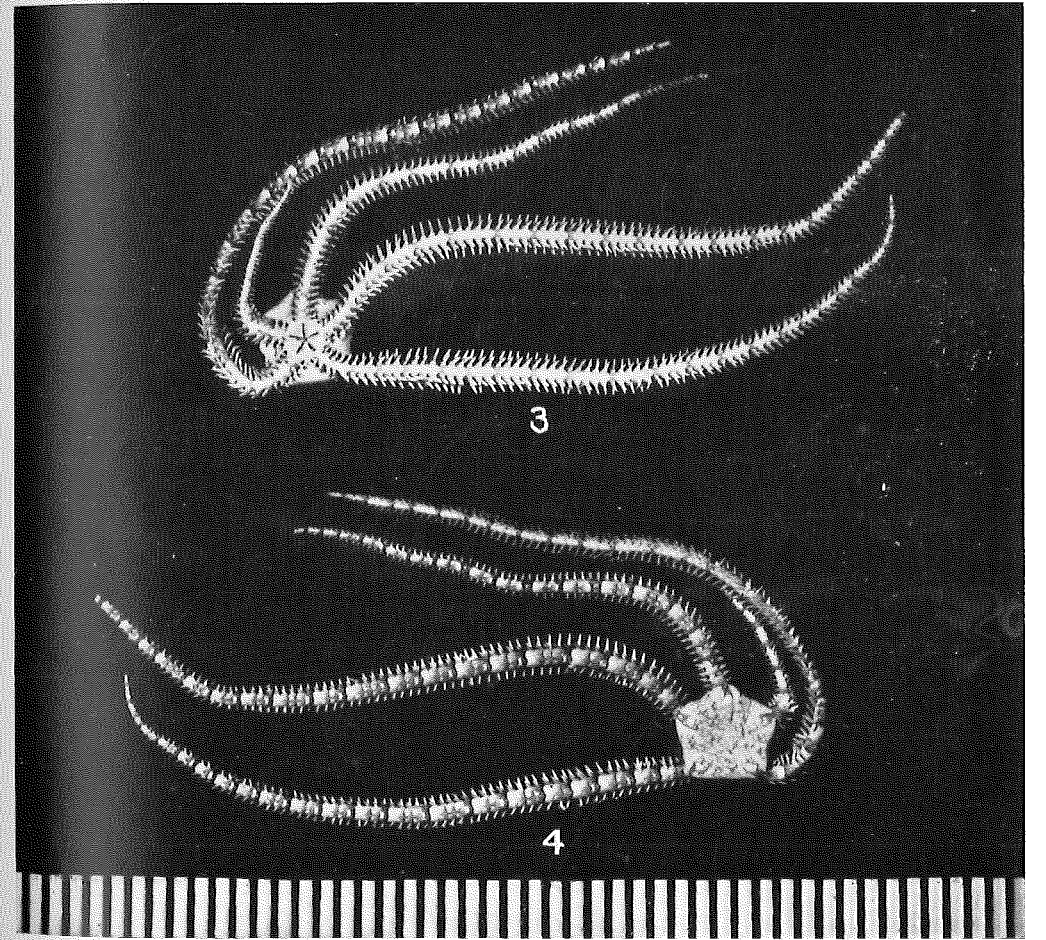
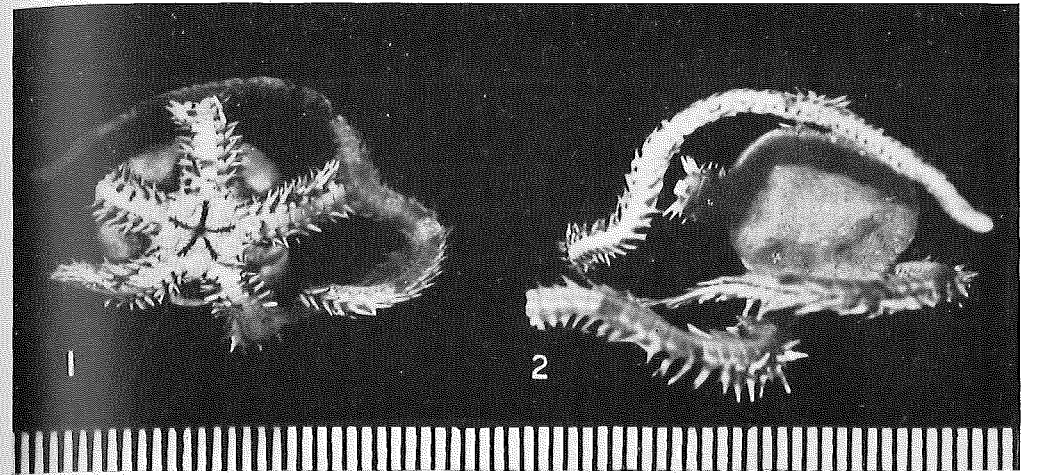
- Fig. 1. *Ophionereis sasakii* sp. n., number 1930.12.23.60; Hakodate, N. Japan. Ventral view.
 2. The same in dorsal view.
 3. *Ophionereis squamulosa* Koehler, number 1939.6.15.105; Buccoo Bay, Tobago, West Indies. Ventral view.
 4. The same in dorsal view.
 (The scales are in millimetres.)





Revision of the genus *Ophioneis*.





Revision of the genus *Ophioneis*.

