

**A Monograph of Japanese Ophiuroidea, arranged
according to a New Classification.**

By

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With 7 Plates and 100 Figures and 1 Chart in Text.

Introductory.

The marine fauna of Japan is interesting by reason of its peculiar facies due to the mingling of tropical and arctic elements. This peculiarity is also apparent in the ophiuran fauna, which is by no means poor in species. The Japanese ophiurans in the collection of the Zoological Institute of the Imperial University of Tokyo number more than one hundred species, but they have not been thoroughly studied. Dr. IZUKA was the first Japanese zoologist who undertook a study of this group, and he was followed by Mr. KAWAMURA, who has kindly handed over to me his drawings and separates of several valuable papers in his possession. To Dr. IZUKA also I am indebted for the use of some publications, and to both gentlemen for helpful advices.

My own study of this group was undertaken at the suggestion of Prof. GOTO, to whom my thanks are due for supervision and the revision of the manuscript. Dr. TAKAHASHI of the First High School and Mr. IKEDA of the Seventh High School have kindly permitted me to study the specimens in their charge. I owe specimens to many other friends, to all of whom my hearty thanks are due. Especially, I have received a great help from Dr. HURBERT L. CLARK of the Museum of Comparative Zoology at Harvard College, in the form of many precisely determined specimens in his charge and of some very helpful advices, and my best thanks are due to him; and it was due to his kind suggestion that a preliminary paper of the present study was published in America. Finally, I ever recall in mind my friend, HIDEKI CHIBA, who met with an untimely death a few days after assisting me in dredging for my materials in the Sagami Sea, and to his memory I dedicate the present paper.

My original purpose in undertaking the present study was merely to identify and name species. But I soon found that, the classifications of *Ophiuroidea* hitherto proposed were very unsatisfactory. Indeed, their imperfections became a haunt to me; so I determined to adopt a new classification of my own.

For this purpose, I have dissected representatives of as many genera as are accessible to me; and the following are some of the more important results obtained.

A. Morphological.

1. Those forms that have arms, which are capable of being coiled vertically, have very compact oral skeleton: the adoral shields are entirely proximal to the oral shield, being firmly united to it; the oral frames are very stout, those of the same radius

being firmly united together; the peristomial plates are entire and more or less soldered to the oral frames; &c. The vertebræ are very short and stout and have streptospondyline articulation; and all or some arm spines are converted into compound hooks. E. g. *Ophiobyrssine* mihi; *Trichasteridæ* mihi; *Gorgonocephalidæ*, *Ophiacanthidæ* pars; *Hemiëuryalidæ* mihi; *Ophiopholis*; and *Ophiotrichidæ* pars (certain forms, as *Ophiopholis* and *Ophiotrichidæ* pars, in which the tendency of coiling of the arms is not very strong, have, however, rather zygospondyline articulation of the vertebræ).

2. The more or less divided vertebræ are found only in certain genera with horizontally flexible arms, but never in those forms in which the arms are capable of being coiled vertically. These two results are evidently serious objections to BELL's classification, because the greater part of BELL's *Streptophiuræ* have, according to my own observations, horizontally flexible arms and more or less divided vertebræ, of which the articulation is typically zygospondyline, instead of being "primitive streptospondyline."¹⁾ For the same reason, I am unable to believe that, GREGORY's Palæozoic *Streptophiuræ*, or STÜRTZ's *Protophiuræ* have streptospondyline articulation of the vertebræ.

3. The more or less divided vertebræ are of two kinds.

a. Those which are divided into halves by a single fusiform pore, are found in those forms in which the dorsal side of the arms is more or less unprotected. E. g. *Ophiohelus*; *Ophiogeron*; *Ophioscisma*; *Ophiostiba*; *Ophiohyalus*; *Ophiomyxa*; &c.

1) As to the imperfection of BELL's classification, see the following papers:—IGERNA B. J. SOLLAS, On *Omychaster*, a Carboniferous Brittle-Star; Philos. Transact, Ser. B, Vol. 204, 1913;—TH. MORTENSEN, On the Alleged Primitive Ophiuroid, *Ophioteropsis elegans* BELL, &c.; Mindeskr. for JAPETUS STEENSTRUP, 1913.

b. Those which are divided into halves by a series of small pores or by a moniliform pore, are found in those forms in which the dorsal side of the arms is entirely protected. E. g. *Microphiura*; *Ophiologimus*; *Ophiothamnus* emend.; “*Ophiactis*” pars, i.e. my *Amphiactis*; “*Ophioconis*” pars, i.e. my *Ophiuroconis* and *Ophiurodon*; *Astrophiura*; &c.

4. Those forms with quadrangular and stout teeth have oral frames with well developed lateral wings for the attachment of voluminous masticatory muscles. E. g. *Amphiuridæ* mihi; *Ophiotrichidæ*; *Ophioceramis*; *Ophionereidince* mihi; and *Ophiocomidæ*.

B. Systematic.

1. *Astroceras*, *Trichaster* and *Euryale* have a certain common structure, by which they may be distinguished from either *Asteronyx* or *Asteroschema*.

2. *Astrotoma* and its allies have a certain distinctive character in contrast to *Asteroporpa*, *Astrochele*, *Gorgonocephalus*, *Astrodrum*, *Astrocladus* and their allies.

3. The *Amphiuridæ* mihi and *Ophiotrichidæ* stand in a very intimate relation in their internal structures.

4. “*Ophiactis*” pars, i.e. my *Amphiactis* is a connecting link between the *Ophiacanthidæ* and *Amphiuridæ*.

5. The *Ophiolepididæ*, *Ophiodermatidæ* and *Ophiocomidæ* form together another compact group.

6. The “*Amphiuridæ*” pars, i.e. my *Ophiochitonidæ* are by no means allied to the genuine *Amphiuridæ*, but are very near to the *Ophiodermatidæ* and *Ophiocomidæ*.

7. *Ophiopsila* is, as a matter of fact, nothing else than an ally of the *Ophiocomidæ*.

8. “*Ophioconis*” pars, i.e. my *Ophiuroconis* and *Ophiurodon*,

and "*Ophiochæta*" pars, i.e. my *Ophiurochæta*, may be clearly distinguished from *Ophiolimna* emend. by certain internal structures.

Prefixing so much, I now proceed to the exposition of my own views, leaving them to be judged by their own merits.

I have several representatives of Palæozoic ophiurans in hand, and I purpose to publish a revision and classification of them in the near future.

The greater part of the present study was done in the Zoological Institute of the Imperial University of Tokyo, to which the type specimens of all the new species described in this paper belong. Such new genera as *Astrothamnus*, *Ophiosemmotes*, *Haplophiura*, *Amphiophiura*, *Ophiozonella*, *Ophiuroconis*, *Ophiurochæta*, &c., are directly or indirectly based upon the specimens in Dr. H. L. CLARK'S charge. All the text and plate figures in this paper were drawn by me.

Subclass I. CEGOPHIUROIDA MATSUMOTO.

Ophiuroidea with external ambulacral grooves and without ventral arm plates. Radial shields, genital plates and scales, oral shields, peristomial plates and dorsal arm plates also absent. Ambulacral plates alternate or opposite; in the latter case, they may often be soldered in pairs to form the vertebræ. Adambulacral plates, i.e. lateral arm plates, subventral in position. Madreporite either dorsal or ventral, often large and similar in shape to that of an asteroid.

This subclass mostly consists of Palæozoic forms, and lacks all the fundamental characters by which the recent ophiurans are clearly distinguished from the asteroids. Indeed, the distinction of

the present subclass from the asteroids depends merely upon the different development of certain common structures.

Subclass II. **MYOPHIUROIDA** MATSUMOTO.

Ophiuroidea without external ambulacral grooves, and with ventral arm plates. Radial shields, genital plates and scales, oral shields, peristomial plates and dorsal arm plates usually present; but sometimes, some or all of them may be rudimentary or absent. Ambulacral plates opposite, usually completely soldered in pairs to form the vertebræ. Madreporite represented by one, or sometimes all, of the oral shields.

This subclass includes certain Palæozoic forms and all the ophiurans from the Mesozoic downwards.

The Palæozoic *Myophiuroidea* appear to me to represent a distinct order by themselves; but I defer the question to a future paper.

Order i. **PHRYNOPHIURIDA** MATSUMOTO.

Disk and arms covered by skin. Radial shields either very rudimentary or long and bar-like. The radial shield and genital plate of either side of each radius articulate with each other by means of a simple articular face or a transverse ridge of either plate. Peristomial plates large, entire, double or triple. Oral frames entire, without well developed lateral wings. Lateral arm plates subventral or ventral in position, while the dorsal arm plates are either entirely absent or rudimentary, so that the dorsal side of the arms is mostly unprotected. Vertebral articulation zygospondyline or streptospondyline.

Key to families of *Phrynophiurida*.

- A*—Radial shields very rudimentary or more or less long and bar-like; arms not exceedingly long, always simple; lateral arm plates sub-ventral in position; arm spines not confined to the ventral side of the arm; vertebræ rather slender, not exceedingly short and discoidal; vertebral articulation either zygospondyline or streptospondyline; both upper and lower muscular fossæ of the vertebræ large. *Ophiomyxidæ*.
- AA*—Radial shields very long and bar-like; arms exceedingly long, either simple or branched; lateral arm plates ventral in position; arm spines confined to the ventral side, all serving as tentacle scales; vertebræ very stout, exceedingly short and discoidal; vertebral articulation typically streptospondyline; upper muscular fossæ of the vertebræ extremely large, the lower very small.
- a*—Teeth very stout, arranged in a single vertical row; oral and dental papillæ not very well developed; adoral shields very stout; arms not annulated by rows of hook-bearing granules; arm spines covered by thick skin. *Trichasteridæ*.
- aa*—Teeth and dental papillæ, often also oral papillæ, all similar, spiniform; adoral shields not very stout; arms annulated by double rows of hook-bearing granules; arm spines naked or covered by very thin skin. *Gorgonocephalidæ*.

Family 1. *Ophiomyxidæ* (LJUNGMAN, 1866) mihi, 1915.

Disk and arms covered by a soft skin. Radial shields very rudimentary or more or less long and bar-like. The radial shield and genital plate articulate with each other by a simple face. Genital scales slender, bar-like, articulated with the genital plate at a distance inwards from the outer end of the latter. Peristomial plates very large, either double or triple, and thin or entire and

very thick. Oral frames either long and slender or short and very stout, without well developed lateral wings. Arms slender, not exceedingly long, always simple. Dorsal arm plates absent or rudimentary, lateral arm plates subventral in position, so that the dorsal side of the arms is mostly unprotected. Arm spines not confined to the ventral side, skin-covered. Vertebrae rather slender, not very short and discoidal, often incompletely calcified and more or less divided into halves by a longitudinal, fusiform pore. Vertebral articulation zygospondyline, the articular peg being well developed, or streptospondyline, the peg being very rudimentary or entirely absent. Both upper and lower muscular fossæ large.

This family includes twenty-two genera, which may be grouped into two subfamilies as follows :

Subfamily 1. *Ophiomyxinae* mihi, 1915.—Oral shields small, separated from the first lateral arm plates by the outer lobes of the long and slender adoral shields; vertebrae long and very slender, often divided into halves; wings of the vertebrae very much thinner laterally than dorsally, so that the vertebrae are fairly rhomboidal in dorsal view; vertebral articulation zygospondyline, the articular peg being well developed.

I. Second oral tentacle pores opening outside the oral slits.

a. Teeth present, arranged in a single vertical row.

Ophiohelus LYMAN, 1880.

Ophioscisma LYMAN, 1878.

Ophiogeron LYMAN, 1878.

Astrogeron VERRILL, 1899.

Ophiostyracium CLARK, 1911.

Ophiocynodus CLARK, 1911.

b. Teeth almost absent.

Ophiosyzygus CLARK, 1911.

Ophioleptoplax CLARK, 1911.

II. Second oral tentacle pores opening entirely within the oral slits.

a. Teeth and oral papillæ acute, not widened and serrate.

Ophioscolex MÜLLER & TROSCHEL, 1842.*Neoplax* BELL, 1884.*Ophiostiba* MATSUMOTO, 1915.*Ophiomora* KOEHLER, 1907.

b. Teeth and oral papillæ widened and serrate along the free end:

Ophiohyalus MATSUMOTO, 1915.*Ophiomyxa* MÜLLER & TROSCHEL, 1842.*Ophiodera* VERRILL, 1899.*Ophiohymen* CLARK, 1911.

Subfamily 2. *Ophiobyrsinæ* MATSUMOTO, 1915.—Oral and adoral shields very thick, intimately joined to each other, the latter being entirely proximal to the former; vertebræ short and stout, always entire; wings of the vertebræ very thick laterally as well as dorsally; vertebral articulation streptospondyline, the articular peg being very rudimentary or entirely absent.

I. Oral shields absent, except in one interradius; a single genital slit to each interradius.

Ophioschiza CLARK, 1911.

II. Oral shields well developed; two genital slits to each interradius.

Ophiophrixus CLARK, 1911.*Ophiobyrsa* LYMAN, 1878.*OphiobyrSELLA* VERRILL, 1899.*Ophiosmilax* MATSUMOTO, 1915.*Ophiobrachion* LYMAN, 1883.

The difference between the *Ophiomyxinae* and *Ophiobyrinae* appears to me to be very sharp, especially in the internal structures. In *Ophiodera anisacantha*, the peristomial plates are triple, the unpaired one filling up, like a wedge, the outer open angle formed by the paired ones, which are very long and boot-shaped. The oral frames are stout, with a distinct groove for the ambulacral ring canal. The first few vertebræ are very short, with very thin wings. The genital plates are very slender, articulating with the genital scale at a distance inwards from the outer end. The articulation of the genital plate and radial shield is very simple, without any articular condyle or pit. Each vertebra outside of the base is composed of a slender body and very thin wings. The vertebral articulation is zygospondyline. The articular peg is well developed, connected with the halves of the articular shoulder by a short, narrow ridge, so that the whole trio is shaped like an **M**, of which the upper open angle corresponds to the pit for the articular umbo and the lower open angles to the pits for the articular knobs of the next vertebra. The articular umbo is very stout, elongated rhomboidal, while the articular knobs are rather feeble, separated from each other by the pit for the articular peg. In *Ophiomyxa flaccida* MÜLLER & TROSCHER and *O. australis* LÜTKEN, the peristomial plates are double, nearly soldered together; especially in very small specimens of the last species, the double plates are very firmly soldered together, so as to appear almost entire. The vertebral articulation of the last species is rather peculiar: the trio of the articular peg and halves of the articular shoulder are closely set side by side, so as to appear like a united mass leaving a furrow-like pit for the articular umbo of the next vertebra above them; the articular umbo is very prominent, while the articular knobs are scarcely developed, being represented only

by two insignificant ridges between the pits for the articular peg and the halves of the articular shoulder. In *Ophiohyalus gotoi* the peristomial plates are usually double, with oblong halves, but are triple in some interradii, the unpaired one being quadrangular and overlapping the paired ones. In *Ophiostiba hidekii* the peristomial plates are double, often with unequal halves, one of which overlaps the other. According to LYMAN, *Ophioscolea glacialis* MÜLLER & TROSCHEL has triple peristomial plates and slender, cylindrical oral frames, without distal wings.¹⁾

In *Ophiobyrsa rudis* LYMAN, the internal structures of which were studied by LYMAN, the characteristics of the *Ophiobyrsinæ* appear to be well realised. The whole oral skeleton is very compact. The peristomial plates are entire, stout, intimately soldered to the oral frames, which are also stout. The radial shields, as well as the genital plates and scales, are comparatively small, the plates and scales bounding only the outer part of the long genital slits. The vertebræ are stout, short, more or less discoidal, the wings being very thick laterally as well as dorsally; a number of basal vertebræ are especially discoidal, like those of the next two families. The vertebral articulation is perfectly streptospondyline, the articular peg being entirely absent. The articular shoulder is divided into two long, stout, parallel condyles by a median groove. The articular umbo is very stout, the downward prolongation connected without any boundary with the upward prolongation of the soldered mass of the articular knobs, so that the whole of the umbo and knobs taken together is long dumb-bell shaped. In *Ophiosmilax mirabilis* the vertebral articulation is essentially similar, but there persists a well marked line of contact between the articular umbo and the soldered mass of the articular knobs.

1) This peculiarity will be discussed in a future paper.

In both species, the upper and lower muscular fossæ are both large, a characteristic of the "common ophiurans" in contrast to the next two families, to which the *Ophiobyrsinæ* rather approach in almost all characters.

Key to Japanese genera of *Ophiomyxinae*.

- A*—Second oral tentacle pores opening outside the oral slits.
- a*—Disk free of spines; radial shields absent; arm spines not very conspicuously thorny; a few oral and dental papillæ present; no teeth.
- b*—Dorsal arm plates entirely absent; arm spines connected together by a web-like membrane..... *Ophiosyzygus*.
- bb*—Rudimentary dorsal arm plates present, entire and hyaline; arm spines free from each other. *Ophioleptoplax*.
- aa*—Disk beset with a number of long, acute, conspicuous spines; radial shields conspicuous, each bearing one long, acute, conspicuous spine; arm spines very conspicuously thorny; a few spiniform oral papillæ, besides one short and rounded outermost one, which arises from the first ventral arm plate *Ophiostyracium*.
- AA*—Second oral tentacle pores opening within the oral slits.
- c*—Teeth and oral papillæ triangular, acute, not hyaline; radial shields very rudimentary; marginal disk scales present; dorsal arm plates entirely absent; arm spines converted into compound hooks.
..... *Ophiostiba*.
- cc*—Teeth and oral papillæ flattened, with widened and serrate end more or less hyaline.
- d*—Marginal disk scales present.
- e*—Rudimentary dorsal arm plates always *entire*; radial shields very rudimentary; vertebræ divided into halves, except in several basal arm joints; arm spines converted into compound hooks.. *Ophiohyalus*.
- ee*—Rudimentary dorsal arm plates divided into several secondary plates, except in the distal arm joints; radial shields not very rudimentary;

vertebræ entire, except in very distal arm joints; arm spines not converted into compound hooks, except in the very distal arm joints. *Ophiomyxa*.

dd—Marginal disk scales absent.

f—Radial shields present; dorsal arm plates usually absent (or sometimes present, being divided into several secondary plates, as in the Japanese species); arm spines free from each other. . . *Ophiodera*.

ff—Radial shields absent; dorsal arm plates entirely wanting; arm spines connected together by a web-like membrane. . . . *Ophiohymen*.

***Ophiosyzygus disacanthus* CLARK.**

Ophiosyzygus disacanthus: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 276, fig. 139.

Off Kagoshima Gulf; 103–152 fathoms (CLARK). Uruga Channel; 88 fathoms (CLARK).

***Ophioleptoplax megapora* CLARK.**

Ophioleptoplax megapora: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 279, fig. 141.

Eastern Sea; 71 fathoms (CLARK).

***Ophiostyracium trachyacanthum* CLARK.**

Ophiostyracium trachyacanthum: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 253, fig. 124.

Eastern Sea; 440 fathoms (CLARK).

***Ophiostiba* MATSUMOTO, 1915.**

Disk and arms covered by a soft, thin skin, which contains some granules in the former. Marginal disk scales present. Radial shields very rudimentary, forming a continuous row with the marginal disk scales. Teeth and oral papillæ present, triangular,

with acute tips. Dental papillæ absent. Second oral tentacle pores opening entirely within the oral slits. Vertebrae more or less divided into halves by a longitudinal fusiform pore in the outer half of the arm. Dorsal arm plates entirely absent, lateral arm plates more or less subventral in position, so that the dorsal side of the arm is mostly unprotected. Two or three arm spines, all converted into compound hooks. Tentacle scales absent.

This genus differs from *Ophioscolex* chiefly in the presence of the marginal disk scales and in the conversion of the arm spines into compound hooks; and from *Neoplax* in the fewer arm spines, which are all converted into compound hooks, and in the absence of the tentacle scales.

Ophiostiba hidekii MATSUMOTO.

Ophiostiba hidekii: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, LXVII, 1915, p. 47.

Two specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Diameter of disk 3.5 mm. Length of the longest arm 16 mm. Width of the same at base 0.8 mm.

Disk hexagonal, with concave interbrachial borders, rather convex dorsally, covered by a soft skin, which contains fine, scattered, calcareous granules. Marginal disk scales present, but rudimentary, liable to be overlooked. Radial shields very rudimentary, insignificant, forming a continuous row with the marginal disk scales. Genital slits very small and short.

Oral shields rhomboidal, with perfectly rounded outer and lateral angles; convex, slightly longer than wide; all serving as madreporites. Adoral shields narrow, but with widened outer end, which entirely separates the oral shield from the first lateral arm plate; adradially concave, meeting each other within. Four or

five oral papillæ on either side of each jaw, triangular, with acute apices, the proximal parts being covered by a common skin. Teeth stout, triangular, acute.

Six arms, of which three are longer than the other three, as a result of schizogony and regeneration; very slender, only horizontally flexible. Outer vertebræ divided into bar-

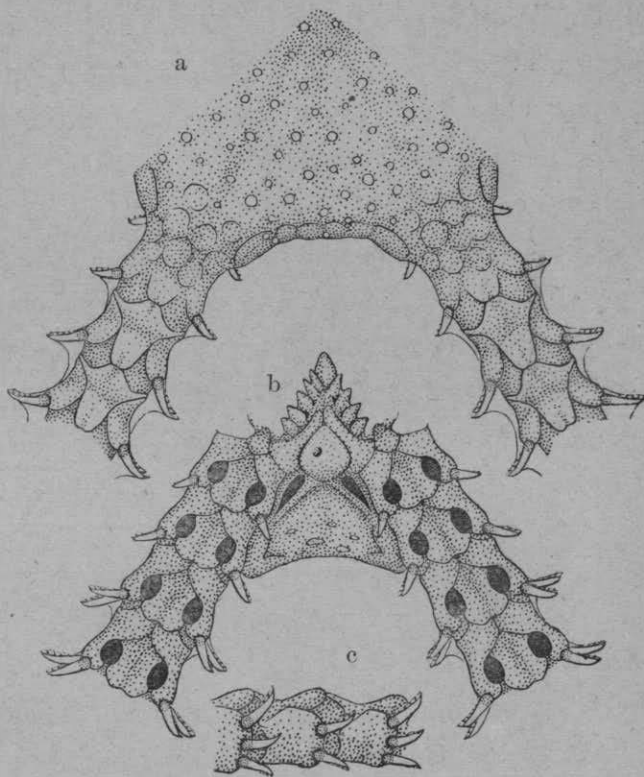


Fig. 1. *Ophiostiba lidekii*. $\times 20$. a. From above. b. From below. c. Side view of three arm joints near disk.

like halves by a longitudinal fusiform pore. Dorsal arm plates entirely absent; and the dorsal side of the vertebræ are seen through the skin to be rhomboidal, long and narrow. Lateral arm plates low, subventral in position; those of both sides meeting each other below, but widely separated above. First ventral arm plate very small, rhomboidal, with the inner sides longer than the outer, longer than wide. Those beyond heptagonal, with strongly concave inner lateral and outer sides, the former corresponding to the tentacle pores; much longer than wide, widest at the outer

ends of the tentacle pores; the calcification is very feeble along the median line, so that the plates appear as if grooved. Two or three arm spines, transparent, except the ball-like base, which is opaque; all converted into compound hooks, with four or five denticles along the abradial side; the lowest spine is slightly shorter than the upper ones, which are about two-thirds as long as the corresponding arm joint, except in the very basal arm joints, where they are shorter. The uppermost spines of either side of successive arm joints are connected together by a hyaline membrane, except in the very basal and very distal parts of the arm. Tentacle pores large, without any scales.

Colour in alcohol: disk deep chocolate brown, except the calcareous granules, which are white; arms brownish yellow.

This species evidently reproduce by schizogony, as indicated by the heteractiny and by the occurrence of six madreporites.

Ophiohyalus MATSUMOTO, 1915.

Disk covered by a soft skin, with a row of marginal scales. Radial shields very rudimentary, insignificant, forming a continuous row with the marginal scales. Oral papillæ and teeth present, flattened and serrate along the free edge. Dental papillæ absent. Arms very slender, only horizontally flexible. Vertebrae more or less, or entirely, divided into halves by a longitudinal fusiform pore. Dorsal arm plates present, entire, but very rudimentary, transparent, separated from each other by a naked space. Two or three arm spines, all converted into compound hooks. Tentacle scales absent.

This genus is very near to *Ophiomyxa*, but differs from it in the very rudimentary radial shields, in the more markedly

divided vertebræ, in the entire rudimentary dorsal arm plates and in the conversion of all the arm spines into compound hooks; and in almost all characters, this genus retains more embryonal features.

Ophiohyalus gotoi MATSUMOTO.

Ophiohyalus gotoi: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, LXVII, 1915, p. 48.

Two specimens; probably off Misaki.

Diameter of disk 9 mm. Length of arms 28 mm. Width of arms at base 1 mm.

Disk pentagonal, with concave interbrachial borders, very flat, covered by a very thin, naked skin. Marginal disk scales present but very feeble. Radial shields very rudimentary, insignificant, forming a continuous row with the marginal scales. Genital slits very small, short, extending from the outer end of the adoral shield to that of the second lateral arm plate.

Oral shields large, triangular, with perfectly rounded lateral angles, inner sides forming together a brace-shape, outer side slightly concave; two and a half times as wide as long. Adoral shields large, triangular, very long, acutely tapered inwards, not meeting with each other. Oral plates long and narrow. The space encircled by the oral and adoral shields and oral plates is strongly depressed. Three or four oral papillæ on either side, thin, transparent and finely serrate along the free edge. Two or three short, wide, flattened teeth, with rounded and finely serrate ends. Deep in the oral slits, on either side, occurs one conical, rough papilla.

Arms slender, covered by a very thin, transparent skin. The halves of the vertebræ are incompletely soldered together, except

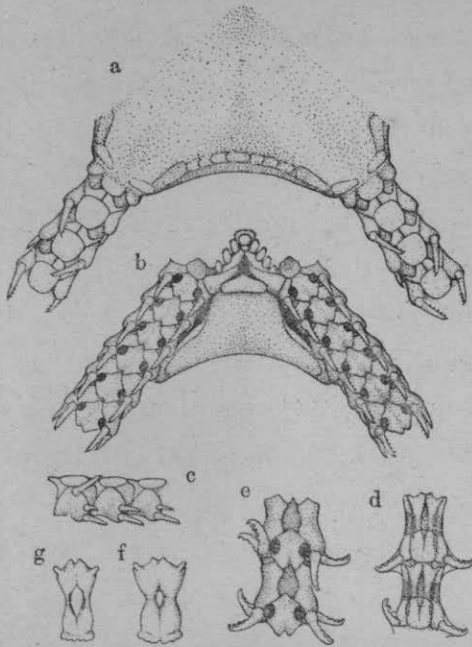


Fig. 2. *Ophiichthys gotoi*. a. From above. $\times 7$. b. From below. $\times 7$. c. Side view of three arm joints near disk. $\times 7$. d. Dorsal view of two arm joints near the extremity. $\times 14$. e. Ventral view of two arm joints somewhat near the extremity. $\times 16$. f. Dorsal view of the vertebra of the fourth free arm joint. $\times 14$. g. Dorsal view of the vertebra of the tenth free arm joint. $\times 14$.

within the disk and at the base of the arms, where the fusion is complete. Each vertebra has at its middle part a longitudinally fusiform pore, which becomes larger and longer in the more distal part of the arm and finally divides the vertebra into halves. Dorsal arm plates small, oval, thin, transparent, longer than wide, wider within than without, separated from each other; they lie over the distal parts of the vertebrae of the corresponding arm joints, and become very small and delicate towards the extremity of the arm. Lateral arm plates slightly flared, successive plates not in contact with each

other, but separated by a naked space, which is widened upwards and continued into a large naked space bounded by the dorsal and lateral arm plates and the vertebra. First ventral arm plate not very small, quadrangular, with strongly curved outer edge, much wider without than within. Those beyond nearly rhomboidal in outline, with a conspicuous notch at the outer end and a half pore for the tentacle at each lateral angle; much longer than wide, being widest at the outer ends of the tentacle pores; successive plates not in contact with each other,

except in the disk. The lateral arm plates do not however meet each other in the ventral median line, so that there is left here a naked, depressed space, which is especially well marked near the extremity of the arm. Two arm spines, subventral, unequal, glassy, all converted into compound hooks, with a series of hooklets along their ventral side, covered by a thin, transparent membrane; the lower one is much larger than the other. In some basal joints, there occurs on the lateral arm plates one more spine, which is placed on the dorsal margin of the plate and also bears a series of hooklets on one side; it is larger than the other two, and nearly as long as the corresponding arm joint. No tentacle scale.

Colour in alcohol yellowish white.

Ophiomyxa australis LÜTKEN.

Ophiomyxa australis: LÜTKEN, Addit. ad Hist. Oph., III, 1869, p. 45 & 99; LYMAN, Rep. Challenger, V, 1882, p. 246; LYMAN, Bull. Mus. Comp. Zool., X, 1883, p. 274; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 532; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 123; KÖHLER, Ibid., XLI, 1907, p. 341; CLARK, Mem. Austral. Mus., IV, 1909, p. 547; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 271.

Four specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Off Suno Saki, Sagami Sea; 41-50 fathoms (CLARK). Korea Strait; 59 fathoms (CLARK). Eastern Sea; 95 fathoms (CLARK).

Amboina; 100 fathoms (LYMAN). Sulu Sea; 82-102 fathoms (LYMAN). Tongatabu Is.; 18-240 fathoms (LYMAN). Near Fiji Is.; 310-315 fathoms (LYMAN). Southern Australia and Bass Strait; 38-120 fathoms (LÜTKEN, LYMAN, CLARK). New Zealand (KÖHLER).

My specimens are all small, the largest being 7 mm. across

the disk. The colour is purplish brown in alcohol, the disk being beautifully spotted with darker shades.

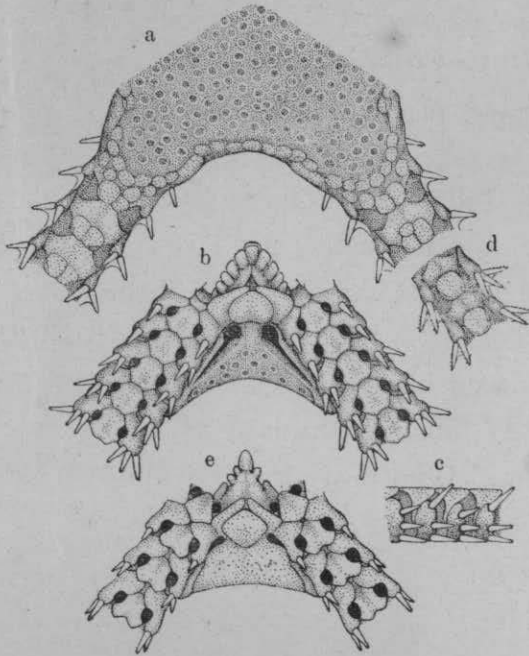


Fig. 3. *Ophiomyxa australis*. a. From above. $\times 7$. b. From below. $\times 7$. c. Side view of four arm joints near disk. $\times 7$. d. Dorsal view of two arm joints at the middle part. $\times 7$. e. Young specimen; from below. $\times 14$.

The rudimentary dorsal arm plates are entire and transparent at the outer parts of the arms, but are divided into two or three opaque, secondary plates in the basal arm joints. The smallest specimen, with the disk diameter of 3.5 mm., has entire dorsal arm plates throughout, and has only one or two granule-like oral papillæ on either side and less flattened and not serrate teeth, besides a very short and wide distal papilla, situated deep within the oral slit. The

second oral tentacle pores of the same specimen open outside the oral slits, and the first ventral arm plates are comparatively large. A specimen with the disk diameter of 4 mm. has three of the jaws with typical papillation, and two papillated as in the smallest specimen mentioned. Probably, the oral papillæ next the apex of the jaws are the first to appear, and the more distal ones are formed later. The distal papilla of the smallest specimen is not a true oral papilla, lying at a higher level than the ordinary ones. It may be distinguished as the primary oral papilla in contrast to

the genuine or secondary oral papillæ. The primary oral papillæ are usually predominant in many genera, which have exposed second oral tentacle pores.

Ophiodera anisacantha (CLARK).

Ophiomyxa anisacantha: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 277, fig. 136.

One specimen; Suruga Gulf; 115 fathoms. One specimen Mera-out-Oisegaké, Sagami Sea; 300 fathoms. Five specimens; Sagami Sea. One specimen; Uraga Channel; 125 fathoms.

Uraga Channel; 197 fathoms (CLARK). Suruga Gulf; 108-131 fathoms (CLARK). Off Suno Saki, Sagami Sea; 83-158 fathoms (CLARK). Eastern Sea; 95-181 fathoms (CLARK).

Diameter of disk 28 mm. Length of arms 140 mm. Width of arms at base 4 mm.

Disk pentagonal or five-lobed, with concave or slightly notched interbrachial borders, covered by a thick skin, which is finely and almost concentrically wrinkled in alcohol.

The radial shields can be observed by drying the specimens; they are exceedingly small and club-shaped. Genital slits long, not quite reaching the disk margin, narrow in the outer part, bordered adradially by the stout genital plates, much widened in the inner part

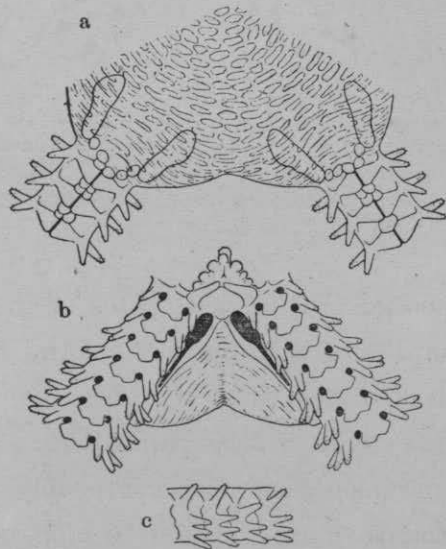


Fig. 4. *Ophiodera anisacantha*. $\times 3$. a. From above. b. From below. c. Side view of four arm joints near disk.

lying within the genital plates, where they present elongated oval outlines. The genital plates and scales are distinguishable, though they are covered by the skin.

The oral skeleton can be observed by drying the specimens. The oral shields are transversely oval, or rather rhomboidal, with an obtuse inner angle, and widely rounded outer and lateral angles. Adoral shields small, curved abradially as a whole, tapering inwards, where they do not meet each other. Four oral papillæ on either side, flat, thin, translucent, and finely serrate along the free edge. Five to seven teeth, short, flat, with rounded, finely serrate or nearly entire end; the uppermost one is longer and more or less conical. Below the first oral tentacle pore in the oral slit, occur one to three spiniform papillæ.

Arms slender, covered by a thick skin. The arm plates and vertebræ can be observed by drying the specimens or by boiling an arm piece in potash. The vertebræ are rhomboidal when viewed from above, much wider than long, with a conspicuous median groove. Between them, there are, in the proximal parts of the arms, a few irregular scales, perhaps representing the dorsal arm plates. Lateral arm plates subventral, meeting below, where they are soldered together and with the ventral arm plates of the corresponding joints. The ventral arm plates are eight-sided; two sides embracing a conspicuous notch at the outer end of the plate; inner sides the longest, straight, meeting each other in a wide angle; inner lateral sides concave, corresponding to the tentacle pores; wider than long, widest at the outer ends of the tentacle pores. Three or four arm spines, short, stout, conical, blunt, enclosed in skin, rough at the end; the uppermost one is the longest, nearly as long as the corresponding arm joint, somewhat isolated from the rest which are near together. The arm spines

are smaller in the basal joints, and only one is present in the first and second, but two in the third and fourth. No tentacle scale.

Colour in alcohol: disk bluish gray; arms light yellow; disk and arms of younger specimens light grayish pink.

In the smaller specimens, the disk skin is seen to contain, when examined under a microscope, very fine scales scattered in it, much resembling the perforated spicules of a holothurian; but in the larger ones they are entirely absent. The oral papillæ, the papillæ just below the first oral tentacle pores, the teeth and the arm spines appear to increase in number with the growth of the animal. In the specimens before me, the arm spines are not so long and so slender as are shown in CLARK'S figure. Further, his figure appears to me to be inaccurate in so far as it represents the arm spines as being two in number and equally long already in the first arm joint.

Ophiohymen gymnodiscus CLARK.

Ophiohymen gymnodiscus: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 277, fig. 140.

Eastern Sea; 107-139 fathoms (CLARK).

Key to Japanese genera of *Ophiobyrinae*.

A—Radial shields more or less long and bar-like; disk or, at least, radial shields spinulate; arm spines spiniform, not all converted into compound hooks.

a—Dorsal arm plates entirely absent; arm spines very long and serrate..... *Ophiophriscus*.

aa—Rudimentary dorsal arm plates present, being divided into a number of secondary plates; arm spines rather short and not serrate...

..... *Ophiobyrsa*.

AA—Radial shields very rudimentary, disk entirely free of spines; arm spines all converted into compound hooks.....*Ophiosmilax*.

***Ophiophrixus acanthinus* CLARK.**

Ophiophrixus acanthinus: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 273, fig. 137.

Off Seno Umi, Suruga Gulf; 94–150 fathoms (CLARK).

Key to Japanese species of *Ophiobyrsa*.

A—Each dorsal arm plate represented by a zone of a mosaic of small, irregular, secondary plates, each of which carries a spinule; six or seven arm spines not webbed together, the lowest one is converted into a compound hook and serves as a tentacle scale.
..... *acanthinobrachia*.

AA—Each dorsal arm plate represented by a row of secondary plates, of which the median two are the largest, none of them spinulate; four arm spines connected together by a web-like membrane
..... *synaptacantha*.

***Ophiobyrsa acanthinobrachia* CLARK.**

Ophiobyrsa acanthinobrachia: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 269, fig. 134.

Suruga Gulf; 108 fathoms (CLARK). Eastern Sea; 95 fathoms (CLARK).

***Ophiobyrsa synaptacantha* CLARK.**

Ophiobyrsa synaptacantha: CLARK, loc. cit., p. 270, fig. 135.

Eastern Sea; 152 fathoms (CLARK).

***Ophiosmilax* MATSUMOTO, 1915.**

Disk and arms covered by a thick skin, which may contain

some fine scales in the former. Radial shields very rudimentary (apparently "absent"), lying marginally. Oral slits small. Single oral papilla on either side, and two or three dental papillæ at the apex of each jaw. Teeth in a single vertical row. Teeth and papillæ all alike, stout, stumpy, conspicuously thorny at tip. Second oral tentacle pores opening outside the oral slits, each provided with a thorny, stumpy papilla, which arises from the adoral shield. Arms vertically coiled. Vertebrae very stout, with saddle-shaped articulation. Dorsal arm plates entirely absent, while the lateral arm plates are subventral, so that the dorsal side of the arms is covered merely by a naked skin. Two or three arm spines, all converted into compound hooks. Tentacle scales absent.

This genus rather resembles *Ophiophrixus* in the total absence of the dorsal arm plates, but differs from it in the very rudimentary radial shields, in the peculiarities of the teeth and papillæ, and in the conversion of all the arm spines into compound hooks. This last character is also found in *Ophiobrachion*, but the present genus differs from it in the total absence of the disk spines, in the peculiarities of the teeth and papillæ, and in the fewer arm spines.

Ophiosmilax mirabilis MATSUMOTO.

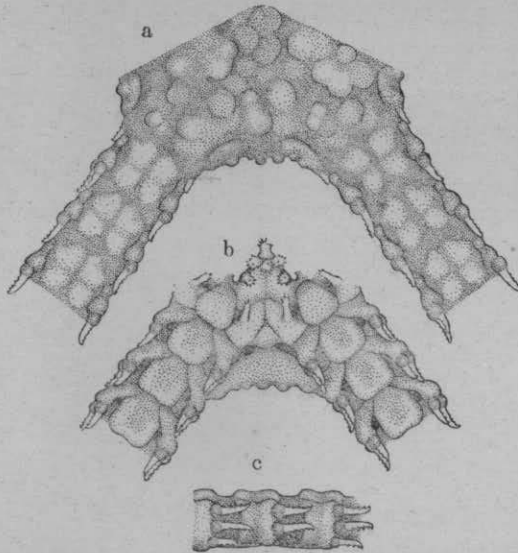
Ophiosmilax mirabilis: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, LXVII, 1915, p. 50.

One specimen; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Diameter of disk 2 mm. Length of arms 12 mm. Width of arms at base 0.8 mm.

Disk flat, pentagonal, with concave interbrachial borders, covered by a thick skin, which contains very fine, thin, trans-

parent scales. Radial shields very rudimentary, insignificant, lying on the disk margin. Genital slit short and very small.



Eig. 5. *Ophiosmilax mirabilis*. $\times 20$. a. From above. b. From below. c. Side view of three arm joints near disk.

Oral shields triangular, with convex outer border. Adoral shields large, quadrangular, longer than wide, wider outwards than inwards, fully meeting with each other within. Oral slits short, fairly closed up. Single oral papilla on either side, stout, stumpy, conspicuously thorny at tip, turned up ventrally, instead of projecting towards the oral slit. Two or three dental papillæ at the apex

of each jaw, similar in shape and size to the oral papilla, also turned up ventrally. Teeth in a single vertical row, also stout, stumpy and thorny at tip. Second oral tentacle pores opening entirely outside the oral slits, each provided with a stumpy and thorny papilla, which arises from the adoral shield.

Arms more or less vertically coiled, covered by a thick skin. Dorsal arm plates entirely absent. Lateral arm plates subventral, strongly flared laterally. First ventral arm plate large, quadrangular, with rounded angles, slightly longer than wide, much wider without than within. Those beyond larger, hexagonal, the inner and inner lateral sides being very short; outer angles perfectly rounded; as long as, or slightly longer than wide, feebly

calcified and transparent, except the outer and lateral peripheries, where the calcification is complete and the plate is opaque. Two or three arm spines lying flat on the arm, all converted into compound hooks, transparent, except the ball-like basal portions, which are opaque. The uppermost two are subequal, about two-thirds as long as the corresponding arm joint, while the third, the lowest, is very small and about half as long as the same. The smaller compound hooks have two or three denticles in one plane, while the larger ones have six or seven denticles in two planes, making certain acute angles with the axis of the spine. Tentacle pores small, free of tentacle scales.

Colour in alcohol brownish yellow.

Family 2. *Trichasteridæ* (DÖDERLEIN, 1911) mihi, 1915.

Disk and arms covered by a thick skin, which may contain fine scales or granules. Radial shields long, bar-like, forming a system of radiate ribs. The radial shield and genital plate articulate with each other by means of a transverse ridge on both the plates. Genital plates long and stout, while the genital scales are rather very small. Oral shields small, adoral shields very stout. Teeth very stout, arranged in a single vertical row; oral and dental papillæ rudimentary as a rule, sometimes absent. Peristomial plates entire, stout, soldered with the also very stout oral frames. Arms exceedingly long, simple or dichotomously branched, vertically coiled. Dorsal arm plates either entirely absent or represented by very insignificant double rows of fine subcutaneous scales, which are soldered together to form two, right and left, secondary plates in the free arm bases of the adult in certain genera; entirely free of rows of minute hooks. Lateral

and ventral arm plates, as well as the skin-covered arm spines, confined to the ventral side of the arm. Vertebrae very short and exceedingly stout, discoidal, with typically streptospondyline articulation. Upper muscular fossæ of the vertebrae extremely large, the lower very small.

This family includes ten genera, which may be grouped into three subfamilies as follows :

Subfamily 1. *Asteronychinae* mihi, 1915.—Disk large and arms slender; only a single madreporite is present; perihæmal canal entirely closed; peritoneal cavity divided into five separate compartments by the interradial attachments of the gastral pouches to the body wall; genital bursæ free from the perihæmal canal, but communicating with each other in radial pairs; lateral arm plates of either side separated from each other by the comparatively large ventral arm plates; more than three arm spines on each plate.

Astrodia VERRILL, 1899.

Asteronyx MÜLLER & TROSCHEL, 1842.

Subfamily 2. *Trichasterinae* mihi, 1915.—Disk moderately large and arms moderately stout; one madreporite to each inter-radius; perihæmal canal and genital bursæ with open communications; lateral arm plates of either side separated from each other by the ventral arm plates, distal ones projecting ventrally in the form of hanging rods; two subequal arm spines on each plate.

I. Arms simple.

Ophiuroopsis STUDER, 1884.

Astroceras LYMAN, 1879.

II. Arms divided.

Trichaster AGASSIZ, 1835.

Sthenocephalus KÖHLER, 1898.

Euryale LAMARCK, 1816.

Subfamily 3. *Asteroschematinæ* mihi, 1915.—Disk very small and arms very stout; one madreporite to each interradius; perihæmal canal closed; genital bursæ free from the perihæmal canal or from each other; lateral arm plates of either side meeting each other in the ventral median line, distal ones not projecting ventrally in the form of hanging rods; two unequal arm spines on each plate.

Asteroschema CERSTED & LÜTKEN, 1856.¹⁾

Astrocharis KÖHLER, 1904.

Astrogymnotes CLARK, 1914.

A very characteristic feature of the *Asteronychinae* is the position of the genital scales, which articulate with the genital plates near the inner ends of the latter, while in the other subfamilies, the scales articulate with the plates near the outer ends of the latter. In *Asteronyx loveni* MÜLLER & TROSCHEL, the radial shields are composed of several lamellar secondary plates, which overlap and fuse together. The wall of the gastral cavity is attached to the body wall at the central part on the dorsal side of the disk and along the interradiial lines above and below, so that the peritoneal cavity is perfectly divided into five radial compartments, which are filled up by the folded generative glands. The perihæmal canal is entirely closed. The genital bursæ are very spacious, but do not communicate with the perihæmal canal, and are separated from the peritoneal cavity by a thin, folded membrane. Each radial pair of the bursæ however communicate with each other just above the outer end of the oral frames and the first

1) Including *Ophiocreas* LYMAN, 1869.

As far as the external characters are concerned, *Ophiocreas adherens* STUDER, 1884, and *Asteroschema köhleri* DÖDERLEIN, 1898, appear to be referable to the *Trichasterinae*; they may possibly be young forms of *Astroceras*.

vertebra. In very young specimens, the genital plates are very high in position, lying nearly dorso-laterally to the first two vertebræ, and the lower muscular fossæ of the vertebræ are not notably smaller than the upper, so that the genital plates and vertebræ rather remind one of those of the *Ophiobryance*.

A most important internal character of the *Trichasterina* is that the genital bursæ communicate with the perihæmal canal. In *Astroceras*, *Trichaster* and *Euryale*, I was able to observe this communication; and I believe that this character is a decisive proof for the close relationship of these genera, as stated by LYMAN and KÖHLER. In *Astroceras pergamena* LYMAN, the genital bursæ communicate merely with the perihæmal canal, while in *Trichaster elegans* LUDWIG, they communicate also with each other in radial pairs, the communications taking place above the vertebræ just inside the disk margin; in both the genera, the peritoneal cavity, as well as the generative glands, is confined to the arm bases. The skin of the arm consists of two layers, which are easily separated by boiling in potash. The inner layer, which is thicker than the outer, contains the rudiments of the dorsal arm plates, which are in smaller specimens very insignificant, being represented by double rows of very feeble calcareous scales, continued above from the lateral arm plates, as stated by LYMAN in *Euryale aspera* LAMARCK. But in larger specimens, with the generative glands extending into the arm bases, the dorsal arm plates become conspicuous in the proximal arm joints containing the generative glands, so that the arm bases are strongly ribbed. At this stage, each dorsal plate is represented by a pair of bar-like plates in *Astroceras*, and by a pair of about triple rows of nodule-like secondary plates in *Trichaster*. In *Trichaster elegans*, the genital plates and scales are very stout, lying very closely side by side

to form very solid interbrachial borders. The peristomial plates are stout, without median groove, soldered with the oral frames and oral plates. A single, very long dental plate is present at the apex of each jaw. The adoral shields are very stout, divided into inner and outer halves, so that there are four in each interradius, closely set together. The radial shields are stout, composed of several secondary plates, which are soldered together. The ventral arm plates are large, often divided into two or three secondary plates. The lateral arm plates are very small, those of the two sides not meeting each other; in the distal arm joints outside the second bifurcation, they are projected ventrally in the form of hanging rods, bearing two hook-shaped arm spines. The dorsal arm plates are represented by three or four rows of nodule-like secondary plates on either side of each proximal arm joint, two rows being internal and the other one or two external. According to LYMAN, the genital slits in *Euryale aspera* penetrate directly into the "peritoneal cavity," which communicates with the perihæmal canal, and the generative glands lie in the "peritoneal cavity," the "genital bursæ" being entirely absent. As far as I can judge, LYMAN seems to be mistaken in his interpretation of the parts. In my opinion, his "peritoneal cavity" is not the genuine peritoneal cavity but merely the genital bursæ, which are in direct communication with the perihæmal canal and are very spacious and provided with a very thin membrane; and the genuine peritoneal cavity is perfectly divided into five radial compartments, which are entirely filled up by the folded generative glands. The correctness of this interpretation of mine is proved by the fact that, the generative glands do not lie in the "peritoneal cavity," as LYMAN thinks, but are separated from it by a thin but distinct membrane and the brachial body cavity, which is the direct con-

tinuation of the true peritoneal cavity is entirely free from LYMAN'S "peritoneal cavity." Thus, it may clearly be seen that, *Euryale* is similar to *Astroceras* and *Trichaster* in having direct communication between the genital bursæ and the perihæmal canal, and to the *Asteronychinæ* in having the generative glands and the peritoneal cavity lying in the disk instead of being confined to the arm bases.

The *Asteroschematinæ* are similar to the *Asteronychinæ* in the perihæmal canal being entirely free from the genital bursæ, but differ from them in the genital bursæ being free from each other. In *Asteroschema japonicum* (KÖHLER), the genital plates are long, stout, lie oblique to the arm axis; and curve abradially in the outer half of their entire length, so as to narrow the ventral interbrachial spaces. The genital scales are very small, directed laterally to support the disk borders, instead of supporting the abradial border of the genital slits. The genital bursæ are very spacious, but do not communicate with the perihæmal cavity or with each other. The radial shields are very long, bar-like, composed of several secondary plates, so that they are capable of bending like elastic bars. The peristomial plates are very stout, with notched outer borders, distinctly grooved in the radial line on the dorsal surface. The oral frames are stout, more or less cylindrical, without distinct distal wings. LUDWIG'S 'first ventral arm plate' is present at the dorsal outer corner of each oral slit. Oral plates strongly projecting ventrally as well as dorsally, and provided on the adradial sides with low, smooth, pavement-like grains, corresponding to the oral papillæ. The dental plates are in a single piece for each jaw, with a canal between plate and jaw. Teeth very stout, arranged in a single vertical row. Adoral shields entire, very large; the outer open angle between each

interradial pair is filled by the oral shield, the madreporite, which is rather large and pear-shaped. The ventral arm plates are very small and granule-like, except the first and second, which are comparatively large, the first being triangular, with the apex directed inwards, and the second being fan-shaped with a convex, longest outer side. The lateral arm plates are transversely bar-like, meeting each other in the ventral median line. Their outer ends are forked, the arm spines arising from the ventral process, while the row of plates which correspond to the dorsal arm plates proceed dorsally from the dorsal process. In the proximal joints of large, sexually mature specimens, each dorsal arm plate is represented by a pair of simple, bar-like rows of secondary plates, while in the distal joints, as throughout in smaller specimens, each dorsal plate is represented by a double row of very fine, insignificant scales. In *Asteroschema caudatum* (LYMAN), the structure is essentially similar, but the lateral arm plates are stouter than in the foregoing species, and the ventral arm plates are often divided into two secondary plates.

Asteronyx loveni MÜLLER & TROSCHEL.

Asteronyx loveni: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 119, Pl. X, figs. 3-5; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 285; DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 115; MORTENSEN, Zeitschr. wiss. Zool., CL, 1912, pp. 264-289, Pls. XIV-XVIII.

Asteronyx loveni: LYMAN, Rep. Challenger, V, 1882, p. 285; KOEHLER, Ech. Ind. Mus. Deep-sea. Oph., p. 74; KOEHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 167.

One specimen; Hokkaidô, more precise locality unknown. Several specimens, clinging to *Isis* and other gorgonaceans; off Misaki.

Japan; 350 fathoms (LYMAN). Hiuga Sea; 405–578 fathoms (CLARK). Off Omai Zaki; 475–918 fathoms (CLARK). Off Suno Zaki, Sagami Sea; 83–158 fathoms (CLARK). Off Kinkwa San; 129 fathoms (CLARK). Off Kii, Kumano Sea; 440–649 fathoms (CLARK). Okhotsk Sea; 100–510 fathoms (CLARK).

Indian Ocean (KOEHLER). Malaysian waters (KOEHLER). Bering Sea (CLARK). Alaska (CLARK). Washington (CLARK). California (CLARK). Eastern coasts of North America. West Indies. Norwegian coasts. Finmark. Scotland.

The specimen from Hokkaido is very large, and is 42 mm. in the disk diameter, 500 to 590 mm. in the arm length and 5.5 to

6.5 mm. in the arm width at the base; the largest arm having about six hundred and twenty joints. The other specimens are all young, with the disk diameter of 6 to 7 mm., and hardly showing the specific characters of the oral apparatus and arm spines. The oral papillae and teeth are flat, serrate along the free margin, covered over by skin, except at the free margin; so that, they are quite similar to those of *Astrodia*. On the disk, there are several scattered, delicate scales embedded in the skin, which remind us of the disk scales of *Astrodia*, and are destined to be absorbed in older examples.

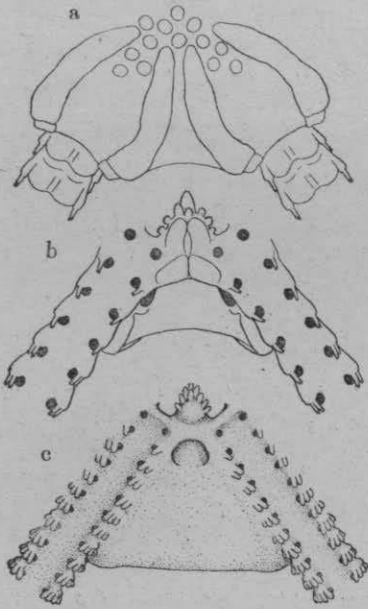


Fig. 6. *Asteronyx loveni*. a. From above, $\times 10$. b. From below, $\times 10$. c. From below, $\times 1\frac{1}{2}$. a and b. Young.

Key to Japanese genera of *Trichasterinae*.

- A*—Arms simple; generative glands extending into the arm bases as two pairs of ribbon-like bodies; in basal arm joints of adult specimens, each dorsal arm plate is represented by a pair of transversely bar-like plates, which bear a stumpy tubercle at the upper end ..
..... *Astroceras*.
- AA*—Arms dichotomously divided.
- a*—Arms divided only near the tip; generative glands extending into the arm bases as four pairs of ribbon-like bodies; in basal arm joints of adult specimens, each dorsal arm plate is represented by a pair of about triple rows of nodule-like plates..... *Trichaster*.
- aa*—Arms divided nearly from the base; generative glands confined to the disk; dorsal arm plates always very insignificant..... *Euryale*.

***Astroceras pergamena* LYMAN.**

Astroceras pergamena: LYMAN, Bull. Mus. Comp. Zool., VI, 1879, p. 62, Pl. XVIII, figs. 478-480; LYMAN, Rep. Challenger, V, 1882, p. 284, Pl. XXXIV, figs. 1-5; CLARK, Zool. Anz., XXV, 1902, p. 671; KÖHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 159; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 284; DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 61, Pl. VI, figs. 4-4 b, Pl. VIII, fig. 13.

Astroschema sp.; DÖDERLEIN, *ibid.*, p. 57, Pl. VII, fig. 3.

Numerous specimens; Sagami Sea; 100 fathoms. Numerous specimens; off Ukishima, Uraga Channel; 300 fathoms.

Eastern Sea; 95-106 fathoms (CLARK). Yenshû Sea; 565 fathoms (LYMAN). Off Omai Zaki; 34-37 fathoms (CLARK). Suruga Gulf; 52-180 fathoms (CLARK, DÖDERLEIN).

Timor; 216 m. (KÖHLER).

The largest one of my specimens is 7 mm. across the disk. The first ten basal free joints of the arms are wide and provided with transverse plates, which form ridges on either side and are

well developed in every second or third joint, in which they bear each a conspicuous, movably articulated tubercle at the upper end.

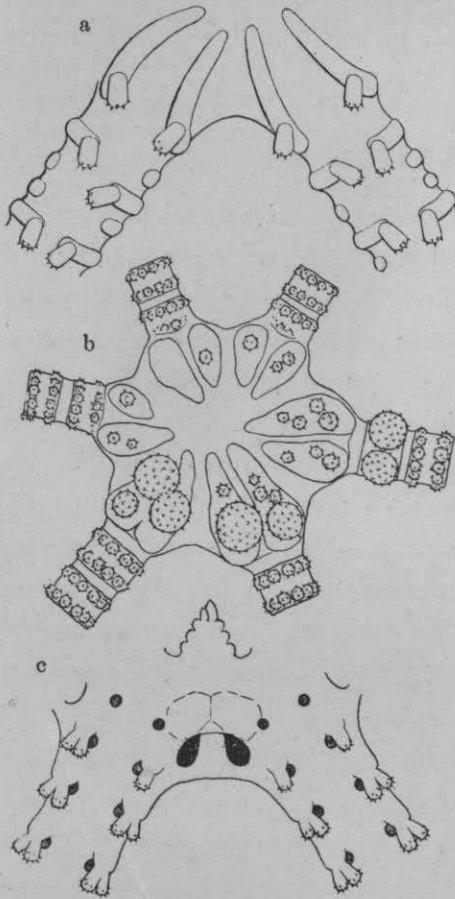


Fig. 7. *Astroceras pergamena*. a. From above. $\times 7$. b. From above. $\times 8$. c. From below. $\times 14$. b and c. Young.

Most specimens are quite young and smaller than 4 mm. in the disk diameter. They are mostly six-armed, rarely five or seven-armed. On the upper side of each arm joint, there are two transverse rows of rough, skin-covered nodules, six to eight in each row. Similar nodules occur on the radial ribs; and in the larger specimens they are also found on the joints of the slender parts of the arms.

I have also some six-armed specimens, in which the middle one of the three regenerating arms is distinctly smaller than the other two; but I do not agree with CLARK in looking upon the smaller arm as being destined for resorption, so that the

animal would become five-armed. The smaller size of the arm in question is perhaps due to its unfavourable position with regard to the supply of nutrition. In fact, we see in many ophiurans which reproduce by schizogony, that the regenerating arms do not often keep to the original number, and the same occurs also in

this species. I have five-armed specimens, in which two of the arms are smaller and are undoubtedly regenerated ones; so that, the five-armed condition may be attained by the final regeneration of only two arms in place of three, in the equally divided halves of six-armed individuals.

Key to species of *Trichaster*.

- A*—Interbrachial ventral surfaces extremely narrow, so that the two genital slits are so close together as to form a single aperture; arms almost triangular in section; about sixty-two arm joints within the first bifurcation; each proximal arm joint bearing a pair of stumpy tubercles on the dorsal side; arm width at the first bifurcation being about one-third of that at the base. *palmiferus*.
- AA*—Interbrachial ventral surfaces not extremely narrow, so that the two genital slits are rather well separated from each other; arms quadrangular in section; thirty-nine to fifty-three, usually forty-five, arm joints within the first bifurcation; arms entirely free of stumpy tubercles; arm width at the first bifurcation being less than one-fourth of that at the base. *elegans*.

Trichaster palmiferus (LAMARCK).

Euryale palmiferum: LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 539.

Trichaster palmiferus: AGASSIZ, Mem. Soc. Sci. Nat. Neuchâtel, I, 1835, p. 139¹⁾; MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 120; LYMAN, Rep. Challenger, V, 1882, p. 267; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 287; DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 62; BOMFORD, Rec. Ind. Mus., IX, Pt. 4, 1913, p. 220, Pl. XIII, fig. 2.

Trichaster fragellifer: V. MARTENS, Wieg. Arch. Nat., XXXII, 1877, p. 87.¹⁾

1) These papers were not seen by me.

Colnett Strait; 83–84 fathoms (CLARK).

Bay of Bengal. Ceylon. Malaysian waters. Hong-kong.

Trichaster elegans LUDWIG.

Trichaster elegans: LUDWIG, Zeitschr. wiss. Zool., XXXI, 1878, pp. 59–67, Pl. V, figs. 1–9; LYMAN, Rep. Challenger, V, 1882, p. 267; BOMFORD, Rec. Ind. Mus., IX, Pt. 4, 1913, p. 220, Pl. XIII, figs. 3 & 4.

Two specimens; Tanabé Bay, Kii.

Pacific Ocean (LUDWIG). India (BOMFORD).

DÖDERLEIN thinks that the present species is a young form of *T. palmiferus*; but like BOMFORD I can not agree with this opinion. My two specimens are quite large, and are of course adult and sexually mature. The large arm tubercles, which are characteristic of *T.*

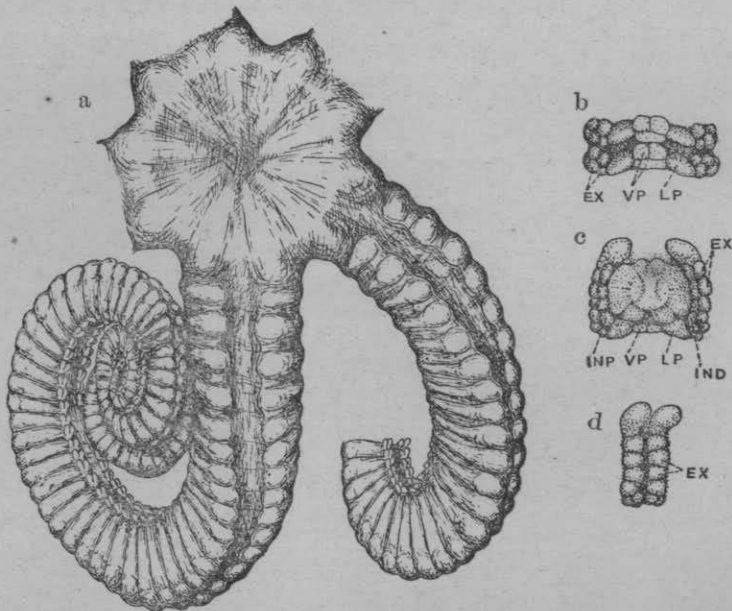


Fig. 8. *Trichaster elegans*. $\times 1$. a. From above. b. Ventral view of skeleton of two arm joints. c. Frontal view of skeleton of an arm joint. d. Lateral view of skeleton of two arm joints.

EX. External row of nodules. IND. Internal distal row of nodules. INP. Internal proximal row of nodules. LP. Lateral arm plate. VP. Ventral arm plate.

palmiferus, at least in the adult, are entirely absent in my specimens. DÖDERLEIN states that, the part of the arm within the first bifurcation is composed of about sixty-two joints in *T. palmiferus*, while in my specimens, that part is composed of from forty-three to forty-five joints, except in an arm of one of the specimens, in which that part is composed of fifty-three joints. LUDWIG makes no statement on this point, but in his fig. 1, about forty-six joints are indicated in the part in question. This number almost agrees with what obtains in my specimens, but is very far from that given by DÖDERLEIN. BOMFORD records thirty-nine to fifty-two joints in the part in question. So I must agree with BOMFORD in recognising the present species as distinct from *T. palmiferus*.

In one of my two specimens, the disk is 33 mm. in diameter, and the arms are divided six times and about 310 mm. in total length. In the other specimen, the disk is 32 mm. in diameter, and the arms are divided five or six times and about 290 mm. in total length. As to the ratio of the width to height of the arms the two specimens stand in striking contrast, as shown in the following table.

Disk diameter of specimen.	Width and height of arm at base.	Ditto at the 20th. free joint.	Ditto at the 40th. free joint.
33 mm.	W. 17 mm. H. 15 mm.	W. 12 mm. H. 13 mm.	W. 7.5 mm. H. 8 mm.
32 mm.	W. 17 mm. H. 13 mm.	W. 13 mm. H. 12 mm.	W. 8 mm. H. 7.5 mm.

The generative glands extend into the arms as four pairs of ribbon-shaped bodies for each arm. Microscopical examinations of the generative glands showed that, the larger one of the two specimens was male and the smaller one female. The testicular

ribbons are much more slender than the ovarial; so that, the dorsal median groove of the arms is much deeper and narrower in the male than in the female. I am inclined to think that, the striking contrast of the ratio of the width to height of the arms in the two specimens is a sexual difference.

I have one more statement to make about the smaller specimen, viz. that it is four-armed. Not only the arms but the body generally is quadrimerous throughout, and there are no indications of external injury. The great width of the arms in this specimen might be looked upon as a result of the quadrimerism; but I think it only explains the great width of the arm bases, and not that of the distal part of the arms within the first bifurcation.

Key to species of *Euryale*.

- A*—Proximal parts of arms beset with two rows of large stumpy tubercles; some similar tubercles are found also on the radial ribs.
 *aspera*.
- AA*—Arms entirely free of stumpy tubercles, but some very small tubercles present on the radial ribs. *anopla*.

Euryale aspera LAMARCK.

Euryale asperum: LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 535.

Astrophyton asperum: MÜLLER & TROSCHER, Sys. Ast., 1842, p. 124; LUDWIG, Zeitschr. wiss. Zool., XXXI, 1878, p. 66.

Euryale aspera: LYMAN, Rep. Challenger, V, 1882, p. 266; STUDER, Abh. K. Akad. Wiss. Berlin, 1882, p. 53, Pl. V, fig. 10; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 114.

Euryale studeri: LORIO, Rev. Suisse Zool., VIII, 1900, p. 8, Pl. VIII, fig. 4, Pl. IX, fig. 1; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 132; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 350.

Euryala aspera: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 65 & 98, fig. 16, Pl. V, figs. 7 & 7a.

One specimen; Okinawa.

Eastern and western Australia. Malaysian waters. Philippines. Gulf of Siam. Southern China.

This specimen is very small, being only 4 mm. in the disk diameter. The arms are branched about eight times, and are about 27 mm. in total length. At the central region of the disk, six very small, rather inconspicuous primary plates are present. Each radial rib bears near its outer end one large, cylindrical, blunt

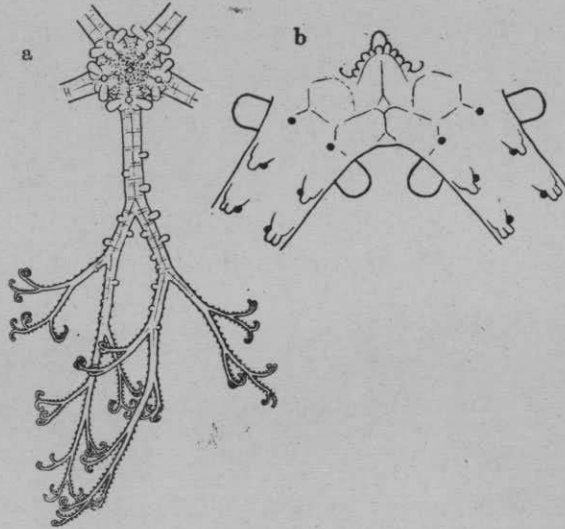


Fig. 9. *Euryala aspera*. a. From above. $\times 2$.
b. From below. $\times 10$.

tubercle joined by a movable articulation. A grain is present in the radial line somewhere between each pair of the tubercles. Further, some of the arm joints bear each one short, cylindrical, blunt tubercle joined by a movable articulation. Such a tubercle never lies in the median line, but in such a position as to suggest that it is one of a pair, of which the fellow is absent.

Euryala anopla CLARK.

Euryala anopla: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 294, fig. 144.

Euryala anopla: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 98.

Eastern Sea; 103-152 fathoms (CLARK).

Key to Japanese genera of *Asteroschematinae*.

- A*—Radial shields entirely covered over; interbrachial ventral surfaces not so narrowed as to be slit-like; arm bases strongly ribbed in adult specimens; arm spines not very small. *Asteroschema*.
- AA*—Radial shields partially naked; interbrachial ventral surfaces very narrow and slit-like; arm bases much widened, not strongly ribbed, but almost smooth; arm spines exceedingly small *Astrocharis*.

Key to Japanese species of *Asteroschema*.

- A*—Disk and arms closely covered with granules. . . typical *Asteroschema*.
- a*—Radial ribs narrow, not occupying the entire dorsal side of disk; arms about fourteen times as long as the disk diameter; three or four granules in 1 mm. on the dorsal side of the arm bases; oral tentacle pores and some ten first tentacle pores opening by means of tubes. *tubiferum*.
- aa*—Radial ribs stout, almost occupying the entire dorsal side of the disk; five or six granules in 1 mm. on the dorsal side of the arm bases; oral tentacle pores and only a few first tentacle pores opening by means of tubes.
- b*—Ventral side of arms closely covered with granules, like the other parts; arms about nine times as long as the disk diameter.
 *glaucum*.
- bb*—Ventral side of the arms covered by a skin, which is almost free of granules; arms about twelve times as long as the disk diameter
 *hemigymnum*.
- AA*—Disk and arms covered by a thick, naked skin, which may, how-

- ever, contain fine granules in younger stages....section *Ophiocreas*.
- c*—Arms one-third to one-fourth as wide as the disk diameter.
- d*—Arms thirteen to seventeen times as long as the disk diameter.
- e*—Skin of the disk and arms very thick; arm spines not very slender; no large depressions just outside the tentacle pores.....*caudatum*.
- ee*—Skin of the disk and arms very thin; arm spines long and very slender; a large depression present just outside each tentacle pore.
.....*japonicum*.
- dd*—Arms about eight times as long as the disk diameter; skin of the disk and arms moderately thick; arm spines short; genital slits very short, situated near the interbrachial angle.....*abyssicola*.
- cc*—Arms about one-half as wide as the disk diameter, and nine to twelve times as long as the same; skin of the disk and arms thick, covering the underlying parts very loosely.....*glutinosum*.

It is by no means easy to distinguish clearly the species of *Asteroschema*, especially those of the section *Ophiocreas*, owing to the fact that, this genus assumes different appearances according to its developmental stages. The oral papillæ are papilliform and arranged in a single horizontal row in younger stages, but are converted into flattened and pavement-like grains in larger specimens. The generative glands extend into the arm bases as two pairs of ribbon-shaped bodies only in the adult, the extent of the lobes increasing with growth. The parts of the arms containing the generative glands are much widened and knotted, owing to the appearance of a transverse row of secondary plates on either side of each arm joint. In the section *Ophiocreas*, the younger specimens are more granular, and the full-grown ones are almost entirely naked. The ratio of the arm length to the disk diameter increases with growth. In exceedingly young specimens of a certain species, only a single arm spine (the adradial one in the larger specimens) is present for each tentacle pore. On the basis

of these considerations, I am convinced that, the identification and naming of *Asteroschema* merely on the ground of the oral papillæ, widened or not widened arm bases, degree of granulation, arm length, &c., without reference to the size of the specimens, would inevitably lead to a great confusion. Thus, I am obliged to transfer several species set up by eminent authors to the list of synonyms.

Asteroschema tubiferum MATSUMOTO.

Asteroschema tubiferum : MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 52.

Two specimens ; Okino-sé, Sagami Sea. One specimen ; off Misaki, Sagami Sea.

Diameter of disk 16 mm. Length of arms 230 mm. Width of arms at base 4.5 mm.

Disk rather arched, a little higher than the arms, closely covered with very fine smooth granules. Radial ribs long and narrow, narrower within, nearly reaching the centre. The disk granules are finer and rather well spaced towards the centre, but coarser and very close-set on the radial ribs. Interbrachial ventral surfaces rather vertical, forming a notch, in which lie

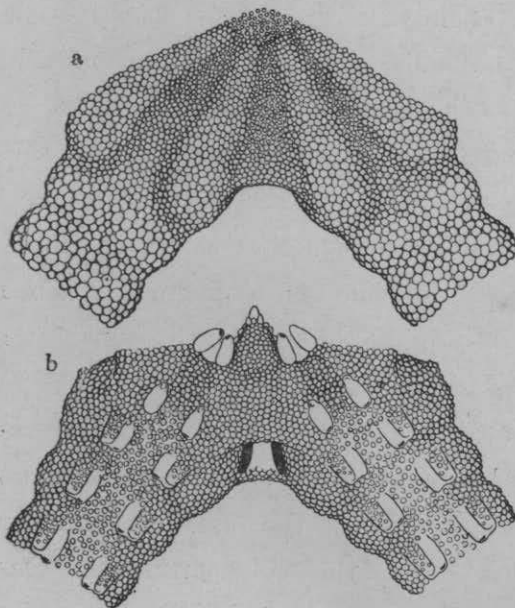


Fig. 10. *Asteroschema tubiferum*. $\times 4$. a. From above. b. From below.

the two rather large, nearly parallel genital slits. On the floor of each notch, opens one madreporic pore. Oral angles convex laterally and downwards, almost filling up the oral slits. Eleven or twelve teeth in a single vertical row, triangular and stout. On either side of the oral angle, there are several flat, smooth, pavement-like grains corresponding to the oral papillæ.

Arms long and slender, as high as wide near the base, not smoothly rounded, but inclined to be quadrangular in transverse section, wider above than below; more distally arched above and plane below, higher than wide; closely covered with fine, smooth granules, of which three or four lie in 1 mm. on the dorsal side near the arm base. Arm joints rather distinct. First tentacle pore without arm spines, next three or four pores with one, and the rest with two spines. The abradial spine is very small, conical, enclosed in skin, with rough end. The adradial one is short and conical in the basal joints; more distally they become longer, stouter and club-shaped, finally about as long as two arm joints; enclosed in skin, rough; the minute thorns at the end of the spines become distally rather concentrated on the inner side of the spines. Oral tentacle pores and some ten basal tentacle pores opening by means of tubes, in which they are enclosed; each tube, except that of the oral and the first tentacle, is attached to the adradial arm spine on its adradial side.

Colour in alcohol light pinkish brown or flesh-coloured.

This species is quite near to *A. rubrum* LYMAN, but differs from it chiefly in the much coarser granules on the basal parts of the arms, in having tentacle tubes not only for the oral tentacles but also for some ten first tentacles, and in the club-shaped and relatively longer and stouter arm spines.

Asteroschema glaucum MATSUMOTO.

Asteroschema glaucum: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 53.

Three specimens; Dôketsuba, Sagami Sea; 110 fathoms.

Diameter of disk 11 mm. Length of arms 100 mm. Width of arms at base 4 mm.

Disk five-lobed, the lobes being continued without any distinct demarcation into the arms; flat, about as high as the arms, closely covered with very fine, smooth granules. Radial ribs rather indistinct. Interbrachial ventral surfaces rather vertical, very narrow, forming a deep notch, in which lie the two rather large, parallel genital slits. Oral angles convex laterally and downwards, almost filling up the oral

slits. Six or seven teeth in a single vertical row, triangular and stout. On either side of the oral angle, there are several flat, smooth, pavement-like grains corresponding to the oral papillæ. Sometimes a few round smooth grains occur below the teeth.

Arms as high as wide, very stout at the base, so that the interbrachial spaces are very narrow below; distally rather slender and higher than wide; covered

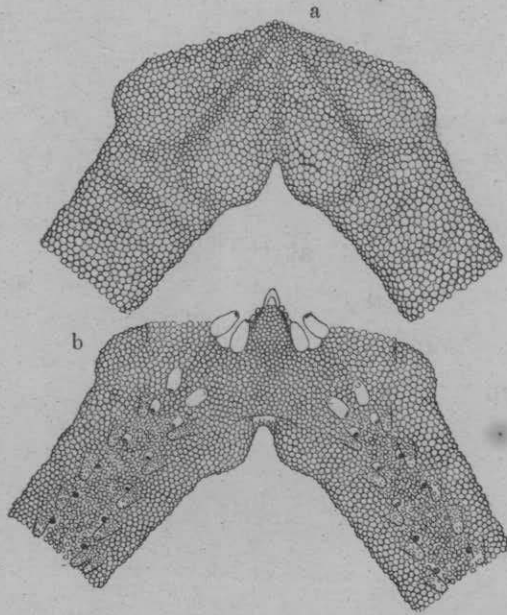


Fig. 11. *Asteroschema glaucum*. $\times 4$. a. From above.
b. From below.

with fine, smooth, close-set granules, of which there are about six in 1 mm. on the radial ribs and the arm bases. Arm joints indistinct in the basal parts. First tentacle pore without arm

spines; next four or five with one, and the rest with two spines. The abradial spine is very small, conical, enclosed in skin, with rough end. The adradial one is small and conical in the basal joints, distally longer and somewhat club-shaped, and slightly longer than the arm joint itself; enclosed in skin, rough; the minute thorns at the end of the spine become distally rather concentrated on the inner side of the spine, and finally, towards the very extremity of the arms, the arm spines are transformed into compound hooks, each with three or four hooklets. Oral tentacles enclosed in tubes. The first two or three tentacle pores are also provided with tubes, though rudimentary.

Colour in alcohol pale gray.

This species is very near to *A. salyx* LYMAN, but differs from it chiefly in the coarser granules of the disk and arm bases, in the stout arm bases being as wide as high, in the much shorter arm spines, and in the oral tentacles being enclosed in tubes.

Asteroschema hemigymnum MATSUMOTO.

Asteroschema hemigymnum: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 53.

One specimen; off Misaki, Sagami Sea.

Diameter of disk 10 mm. Length of arms 120 mm. Width of arms at base 3 mm.

Disk rather flat, divided into ten lobes corresponding to the radial ribs by ten radiating furrows, covered by a skin, which contains very fine, smooth, close-set granules. Interbrachial ventral surfaces rather vertical, narrow, forming a deep notch, on the floor of which opens one madreporic pore. Genital slits rather short, a little diverging dorsally. The ventral surface of the disk is covered by a finely and rather sparsely granulated skin. Oral

angles not markedly set off from the outer parts. Six or seven teeth

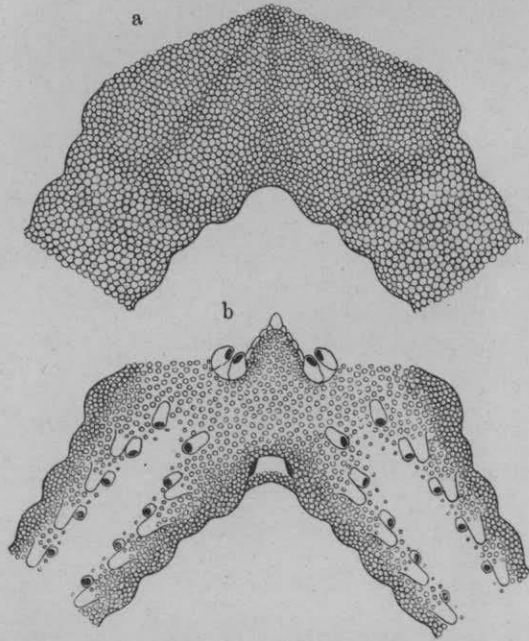


Fig. 12. *Asteroschema hemigymmum*. $\times 6$. a. From above. b. From below.

arranged in a single vertical row, very stout. On either side of the oral angles, there occur several coarse, flat, smooth, pavement-like grains corresponding to the oral papillæ.

Arms very stout for the first three or four free joints, but becoming rather slender further out; their width just outside the fourth free joint is 2.5 mm. They constantly taper outwards, so that they are exceedingly slender to-

wards the extremities, and acute at the tips. Dorsal and lateral surface of the arms covered by a skin, which is similar to that of the disk and contains very fine, smooth, close-set granules, of which there are about five in 1 mm. on the dorsal surface of the arm bases. The granules become much finer outwards, and almost disappear nearer the extremity of the arm. The vertebræ are visible through the skin, but the surface of the arms is practically smooth and without distinct demarcations of the joints, except in the first three or four free joints, which are marked off by shallow constrictions. The ventral surface of the arms is entirely naked, and the lateral and ventral arm plates are clearly visible through the skin. First tentacle pore without arm spines; next four or five with one, and the rest with two spines. The abradial spine

is very small, cylindrical, enclosed in skin, more or less rough at the free end. The adradial one is club-shaped, enclosed in skin, very rough at the free end. The arm spines are largest at the middle of the arms, the adradial one being one and a half times as long as, and the abradial one a little shorter than, the corresponding arm joint. They are transformed into compound hooks with three to six hooklets towards the very extremity of the arm. The oral tentacle pore and the first three or four tentacle pores are provided with tubes.

Colour in alcohol grayish brown.

Like *A. intectum* LYMAN and *A. migrator* KOEHLER, this species appears to be an intermediate form between the sections *Asteroschema* s. str. and *Ophiocreas*.

Asteroschema (Ophiocreas) caudatum (LYMAN).

Ophiocreas caudatus: LYMAN, Bull. Mus. Comp. Zool., VI, 1879, p. 64, Pl. XVI, figs. 439-442; LYMAN, Rep. Challenger, V, 1882, p. 281, Pl. XXXII, figs. 5-8.

Ophiocreas cedipus: CLARK Bull. U. S. Nat. Mus., LXXV, 1911, p. 283. (Non LYMAN, 1879.)

Asteroschema (Ophiocreas) sagaminum: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 60, Pl. VI, figs. 6 & 6 a, Pl. VII, fig. 10.

Asteroschema (Ophiocreas) caudatum: DÖDERLEIN, *ibid.*, p. 113.

One specimen; Ôtaba, Sagami Sea; 420 fathoms. Numerous specimens; outside Okinosé, Sagami Sea; 330 fathoms. Numerous specimens; Sagami Sea.

These specimens range from very small to very large ones. In the largest one, the disk is 25 mm. in diameter, and the arms are 420 mm. in length and 7.5 mm. in width. The oral tentacle

pores and some ten basal tentacle pores open by means of tubes,

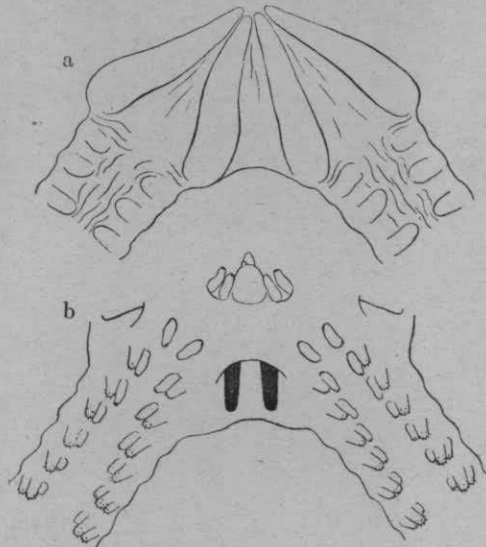


Fig. 13. *Asteroschema (Ophiocreas) caudatum*.
 ×4. a. From above. b. From below.

a character which was overlooked by LYMAN. Colour in alcohol, light pinkish brown, or dark brownish purple, if the specimens have not lain in alcohol for a long time. The dermal granules, which are present in the arm bases and the disk, are more conspicuous in smaller specimens. I have failed to find any important distinguishing characters between *A. sagaminum* DÖDERLEIN and the young specimens of corresponding size of the

present species, so that I consider the former as a synonym of *A. caudatum*.

In this species, the ribbon-shaped generative glands reach out to an enormous extent. In a specimen with the disk diameter of 25 mm., they extend outwards about 180 mm. and as far as the seventieth free arm joint. The parts of the arms containing the generative glands are quadrangular in transverse section, covered dorsally by a much wrinkled skin, and have, on the dorsal and lateral sides of each joint, a row of plates supporting and protecting the cavity in which the generative glands lie. These plates are replaced by double rows of minute scales in the sterile parts of the arms. In smaller specimens, the generative lobes are confined to the short basal portion of the arms, which is much widened. Thus, specimens of about 12 mm. in the disk diameter

much resemble the type of *A. ædipus* (LYMAN), but are distinguished from it chiefly by the presence of abundant dermal granules, by the much shorter and stouter arms, and by the tentacle pores with a single spine extending further into the arms.

Through Dr. H. L. CLARK'S kindness, I was able to examine a specimen of his "*Ophiocreas ædipus*" from Japan. It is, in my opinion, undoubtedly referable to the present species, so I have no hesitation to drop *Asteroschema* (*Ophiocreas*) *ædipus* from the list of Japanese ophiurans.

Asteroschema (*Ophiocreas*) *japonicum* (KOEHLER).

Ophiocreas japonicus: KOEHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 346, Pl. XIV, fig. 54.

Ophiocreas papillatus: CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 298.

Asteroschema (*Ophiocreas*) *japonicum*: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 59, Pl. VI, figs. 5 & 5 a, Pl. VII, fig. 9.

Asteroschema (*Ophiocreas*) *monacanthum*: ibid., p. 58, Pl. VI, figs. 9-9 b.

Asteroschema (*Ophiocreas*) *enoshimanum*: ibid., p. 60, Pl. VI, figs. 8 & 8 a.

One specimen; Suruga Gulf. Three specimens; Okinosé, Sagami Sea; 290 fathoms. Numerous specimens; outside Okinosé; 330 fathoms. Numerous specimens; Sagami Sea.

These specimens range from very small to very large ones representing all growth stages. In the larger ones, the skin is entirely free of granules. In somewhat smaller specimens, the skin contains some granules in the disk and arm bases, while in still smaller ones, the skin is strongly granulated on the dorsal, as well as on the ventral, surface of the disk and arms. The oral

papillæ appear to have been overlooked by K EHLER and D ODERLEIN, but they are present in the form of several flat, smooth, pavement-like grains, which are however not very distinct in larger

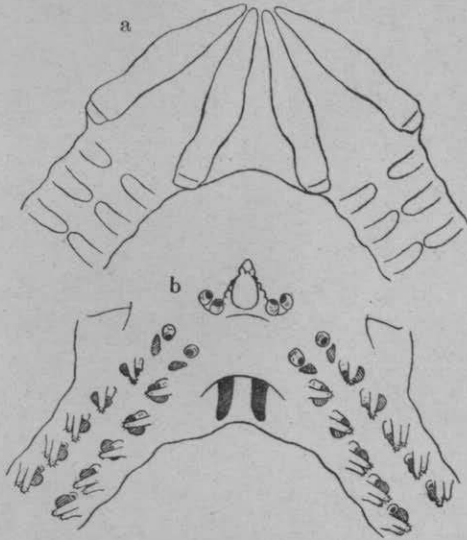


Fig. 14. *Asteroschema (Ophiocreas) japonicum*. $\times 4$.
a. From above. b. From below.

specimens, but are more prominent and papilliform in smaller ones. K EHLER, CLARK and D ODERLEIN erroneously call the depression just outside the tentacle pore large tentacle pore, but this large depression is distinct from the pore itself. D ODERLEIN doubts the taxonomic value of this depression, but it is present in all my specimens and in no other species in my knowledge. I have examined pieces of arms of

the foregoing and the present species after boiling them in potash. In *A. caudatum*, the bar-like lateral arm plates are stout, with much widened adradial ends, and the ventral arm plates are divided into right and left halves, so that the spaces for the tentacles are very small. In *A. japonicum*, the bar-like lateral arm plates are very slender, with feebly widened adradial ends, and the ventral arm plates are very small and granuliform, so that the spaces for the tentacles are very large. Thus, I have no doubt that, the depression in question of the present species is a specific character.

I have compared *Ophiocreas papillatus* CLARK, *A. enoshimanum* D ODERLEIN and *A. monacanthum* D ODERLEIN with the corresponding

specimens of the present species, and I am quite satisfied as to their specific identity. The three forms just mentioned are, in my opinion, merely younger stages of the present species before the disappearance of the dermal granules and the occlusion of the oral papillæ; *A. monacanthum*, being the youngest, is only 4 mm. across the disk and has only the adradial arm spine. In slightly larger specimens, the abradial spine begins to appear as a very small rudiment.

The specimens are light pinkish brown or flesh-coloured in alcohol, or dark brownish purple, if they have not lain in alcohol for a long time, or sometimes yellowish brown, when badly preserved in weak alcohol.

Asteroschema (Ophiocreas) abyssicola (LYMAN).

Ophiocreas abyssicola: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 64, Pl. XVII, figs. 470-473; LYMAN, Rep. Challenger, V, 1882, p. 282, Pl. XXXII, figs. 1-4.

Asteroschema (Ophiocreas) abyssicola: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 113.

Eastwards from Honshû; 2,300 fathoms (LYMAN).

Asteroschema (Ophiocreas) glutinosum DÖDERLEIN.

Asteroschema (Ophiocreas) glutinosum: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 59, Pl. VI, figs. 5 & 5 a, Pl. VII, fig. 9.

One specimen (belonging to the First High School); Sagami Sea. Numerous specimens, clinging to a gorgonacean, together with some specimens of *A. caudatum* and *A. japonicum*; outside Okinose, Sagami Sea; 330 fathoms.

The ratio of the arm length to the disk diameter is much

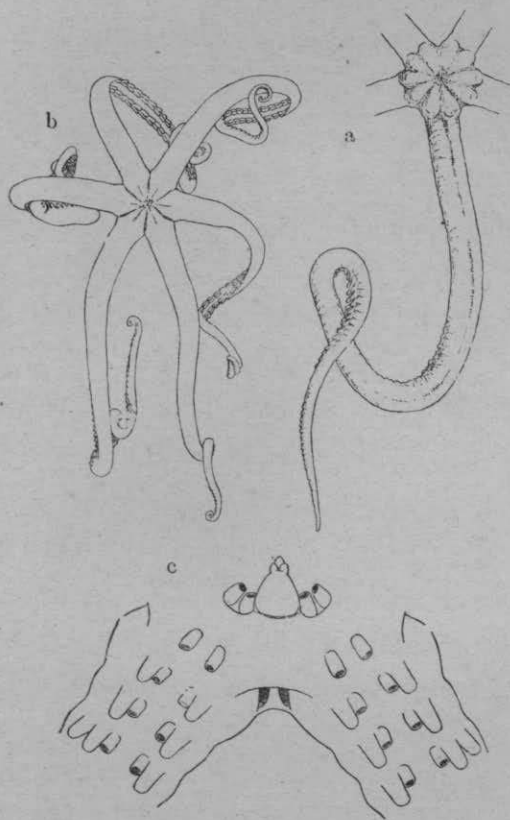


Fig. 15. *Asteroschema (Ophiocreas) glutinosum*. a. From above. $\times \frac{2}{5}$. b. From above. $\times \frac{2}{5}$. c. From below. $\times 3$.

smaller in smaller specimens. Three of the above specimens are six-armed, but there is no trace of schizogony. On either side of the oral angles, there are several flat, smooth pavement-like granules, which are however not very distinct. Sometimes, there occur one or two papilliform grains below the teeth. The colour is white in alcohol, or brown, if the specimens have not lain in alcohol for a long time.

In *Astroceras*, *Asteroschema* and *Trichaster*, the generative glands extend into the arms as ribbon-shaped bodies, and as a consequence, the arms present certain peculiar features. The parts of the arms containing the generative lobes are more or less widened, quadrangular in transverse section, strongly knotted, and has a conspicuous dorsal median groove. In *Astroceras* and *Asteroschema*, there are two pairs of generative glands in each arm, and the parts containing them present a knotted appearance, owing to the presence of transverse ridges on either side. In the first named genus, these ridges are formed by bar-like plates, but in the latter

by a row of plates, supporting and protecting the cavity in which the generative glands lie. In the sterile parts of the arms, these plates are replaced by two rows of nodules in each joint in *Astroceras*, and by two rows of minute scales in *Asteroschema*. In *Trichaster*, there are four pairs of generative glands in each arm, which bears masses of irregular nodules. These nodules are arranged in two layers and form three or four rows on either side of each joint in the proximal parts of the arms: two of the rows belonging to the internal layer, two to the external layer on the ventral side and one on the lateral side. Besides, there is a large nodule on the upper end of the ridge formed by the rows of nodules on either side of each joint. These nodules form two longitudinal rows of humps on each arm. In the sterile part of the arms, the nodules are replaced by two rows of scales in each joint. The species in which the extension of the generative glands into the arms has been observed are shown below, together with some additional facts.

Species.	Disk diameter of specimen.	Free basal arm joints containing the generative glands.	Length of the foregoing part.
<i>Astroceras pergamena</i>	7 mm.	10	9 mm.
<i>Asteroschema tubiferum</i> .	16 mm.	8	15 mm.
" <i>glaucum</i>	11 mm.	0	0
" <i>hemigymnum</i>	10 mm.	4	5 mm.
" <i>caudatum</i>	25 mm.	70	180 mm.
" "	12 mm.	6	10 mm.
" <i>japonicum</i>	31 mm.	46	120 mm.
" "	22 mm.	10	20 mm.
" <i>glutinosum</i>	25 mm.	12	25 mm.
" "	15 mm.	9	15 mm.
<i>Trichaster elegans</i>	33 mm.	56 ^(2. bifur- cation.)	165 mm.
" "	32 mm.	36	120 mm.

Astrocharis ijimai MATSUMOTO.

Astrocharis ijimai: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia 1915, p. 54.

Numerous specimens, clinging to a coral; Misaki, Sagami Sea.

Diameter of disk 4.5 mm. Length of arms 50 mm. Width of arms at base 2.5 mm.

Disk five-lobed, with deeply indented interbrachial borders, with the lobes emarginate towards the arms, flat, sunken at the central region, raised at the lobes, covered with very fine, smooth, irregular scales, which are very closely set and partly imbricated.

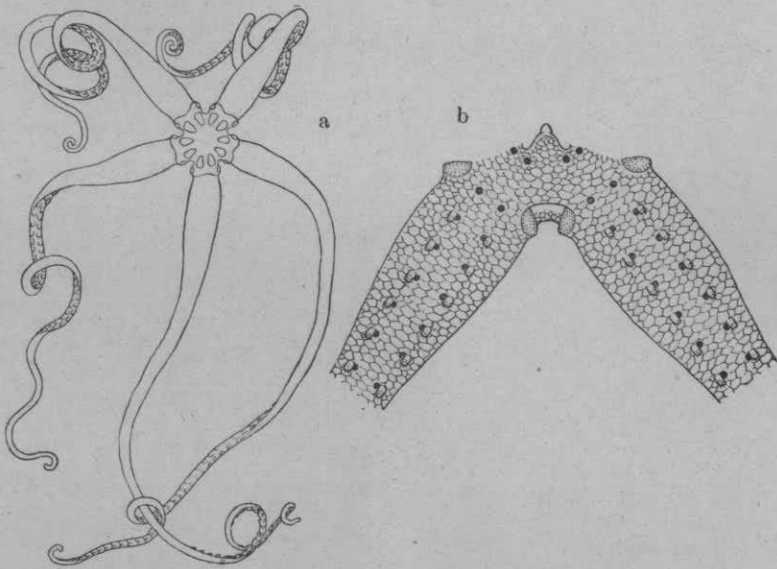


Fig. 16. *Astrocharis ijimai*. a. From above. $\times 2$. b. From below. $\times 10$.

Radial shields naked, very small, triangular, with the apex turned within, tuberculous when examined under the microscope. Interbrachial ventral surfaces forming very deep notches, exceedingly narrowed by the very wide arm bases. Two genital slits, small, parallel, nearly vertical. On either side of each lobe of the disk,

lies the naked genital plate, which is large, oval, and tuberculous under the microscope like the radial shields. Thus, each inter-brachial ventral surface is bounded on either side by the genital plate. Oral angles puffed laterally, almost filling up the oral slits. Teeth small, triangular, arranged in a single vertical row. No oral or dental papillæ.

Arms very wide at the base, keeping the same width to the distance of about 4 or 5 mm., then rather rapidly narrowed, becoming slender and cylindrical, with the width of about 1 mm.; covered with scales similar to those of the disk. Arm joints invisible in the proximal part, but more or less distinct distally. First tentacle pore without arm spine, the following ones with one spine, which is very small, short, peg-like, somewhat flattened, rough at the end under the microscope, lying flat on the ventral surface of the arm. Half way out in the arms, the tentacle pores are each provided with two spines, of which the second or the abradial one is exceedingly small and rather inconspicuous; while the adradial one is a little longer and erect.

Colour in alcohol white or light pale yellow.

In smaller specimens, the arms are scarcely widened at the base, which is also the case in regenerating ones; for, schizogony takes place in this species, as in the genotype, *A. virgo* KÖHLER. Most specimens are five-armed, but the arms are often unequal, two or three being larger than the others. I have, however, one specimen with six arms, three larger and three smaller. In the four-armed specimens, two or three of the arms may be larger and the other two or one smaller. Still another specimen has only three arms and three pairs of radial shields, doubtless indicating that it has lately undergone division, and that the lost parts have not been regenerated. It can be easily observed in

this species that, only two arms may sometimes be regenerated in place of three, or one in place of two.

This species can be distinguished very easily from the genotype, *A. virgo*. The arms are slightly less widened at the base and keep their width for a less extent. The arm spines are only one to each tentacle pore for over half the length of the arms, while in the genotype, two are present even in the basal region. Finally, the disk and arms are covered with fine scales instead of granules.

In this species, the widening of the arm bases is caused by the widening of the vertebræ, and is not accompanied by the extension of the generative glands, so that even in the widened part, the arm covering of the dorsal side is in direct contact with the vertebræ. I suppose that this condition is a generic character, though there is no observation on this point in the genotype.

Family 3. **Gorgonocephalidæ** (DÖDERLEIN, 1911) mihi, 1915.

Disk and arms covered by a thick skin, which contains granules, very often beset with stumpy tubercles. Radial shields long, bar-like, forming a system of radiate ribs. The radial shields and genital plates articulate with each other by means of a transverse ridge on both the plates. Genital plates long and stout, genital scales small. Oral and adoral shields very small, the former being often separated from the latter by a mosaic of supplementary plates. Teeth and dental papillæ, often as well as oral papillæ, similar, spiniform, acute, forming a clump or cluster at the apex of each jaw. Peristomial plates entire, stout, soldered with the also very stout oral frames. Arms exceedingly long, simple or branched, vertically coiled. Dorsal arm plates represent-

ed by double rows of hook-bearing granules, so that the arm is annulated by the minute hooks. Lateral and ventral arm plates confined to the ventral side of the arm. More than three arm spines, all ventral in position, serving as tentacle scales. Vertebrae very short and exceedingly stout, discoidal, with typically streptospondyline articulation. Upper muscular fossae of the vertebrae extremely large, the lower very small. This family includes twenty-four genera, which may be grouped into two subfamilies.

Subfamily 1. *Gorgonocephalinae* mihi, 1915:—Teeth, dental papillae and oral papillae all similar, spiniform; oral angles not strongly projected ventrally; genital slits small, often pore-like, lying near the disk border; basal vertebrae not very small, not covered over by the muscles lying between the basal vertebrae and genital plates; arms simple or divided; those forms with arms simple or divided a few times have no supplementary plates in the spaces between the oral angles and the interbrachial ventral surfaces, while those with arms divided many times have well developed supplementary plates in the spaces mentioned.

I. Arms simple or divided a few times; no supplementary plates in the spaces between the oral angles and the interbrachial ventral surfaces.

a. Arms simple.

Astrogomphus LYMAN, 1869.

Astrochlamys KOEHLER, 1912.

Astrochele VERRILL, 1878.

Asteroporpa ERSTED & LÜTKEN, 1856.

b. Arms divided a few times.

Astrocnida LYMAN, 1872.

Conocladus CLARK, 1909.

II. Arms divided many times; supplementary plates well

developed between the oral angles and the interbrachial ventral surfaces.

a. Madreporite single.

Astroconus DÖDERLEIN, 1911.

Gorgonocephalus LEACH, 1815.

Astrodendrum DÖDERLEIN, 1911.

Astrocladus VERRILL, 1899.

Astrospartus DÖDERLEIN, 1911.

Astroboa DÖDERLEIN, 1911.

Astrophyton MÜLLER & TROSCHEL, 1842.

Astrochalcis KÖHLER, 1905.

Ophiocrene BELL, 1894.

b. Madreporites five.

Astrogordius DÖDERLEIN, 1911.

Astrocyclus DÖDERLEIN, 1911.

Astrocaneum DÖDERLEIN, 1911.

Astrodactylus DÖDERLEIN, 1911.

Subfamily 2. *Astrotominae* MATSUMOTO, 1915:—Teeth and dental papillæ similar, spiniform; oral papillæ very rudimentary or entirely absent; oral angles strongly projected ventrally; genital slits rather large, long, extending nearly from the inner corners of the interbrachial ventral surfaces to the disk border; basal vertebræ very small, distinctly narrower than those just beyond, covered over by the muscles lying between the basal vertebræ and genital plates; arms simple or divided a few times; well-developed supplementary plates present in the spaces between the oral angles and the interbrachial ventral surfaces.

a. Arms simple.

Astrothamnus MATSUMOTO, 1915.

Astrothrombus CLARK, 1909.

Astrothorax DÖDERLEIN, 1911.

Astrotoma LYMAN, 1878.

b. Arms divided a few times.

Astrocolon LYMAN, 1879.

LYMAN, whose erroneous interpretation of certain parts in *Euryale aspera* was pointed out before, has made a similar mistake in the present family, inasmuch as he states that, in *Astrocnida isidis* (DÜCHASSAING), *Gorgonocephalus arcticus* LEACH [= *G. agassizi* (LYMAN)] and *G. chilensis* (PHILIPPI), the genital slits are not surrounded by any "bursa" but directly penetrate into the "peritoneal cavity," in which the generative glands lie. I have studied the internal structure of *Astrochèle lymani* VERRILL, *Asteroporpa hadracantha* CLARK, *Gorgonocephalus tuberosus* DÖDERLEIN, *G. arcticus*, *G. caryi* (LYMAN), *G. dolichodactylus* DÖDERLEIN, *Astrodrum sageminum* (DÖDERLEIN), *Astrocladus annulatus* MATSUMOTO, *A. coniferus* (DÖDERLEIN), *Astroboa arctos* MATSUMOTO, *Astrothammus echinaceus* MATSUMOTO and *Astrotoma sobrina* MATSUMOTO, and am convinced that, LYMAN'S "peritoneal cavity" is not the genuine peritoneal cavity but merely the genital bursæ, which are very spacious and communicate with each other, and usually also with the perihæmal canal, so as to form a single compound cavity; the genuine peritoneal cavity is perfectly divided into five radial compartments, which are entirely filled up by the very voluminous, folded generative glands, and no longer appear as cavities; the generative glands do not lie in LYMAN'S "peritoneal cavity," i.e. genital bursæ, but are separated from them by a thin but distinct membrane and lie morphologically outside them. As I have already pointed out in *Euryale aspera*, the fact that the brachial body cavity, which is the direct continuation of the true peritoneal cavity, has no direct communication with LYMAN'S "peritoneal cavity,"

i.e. genital bursæ, also in these genera, is a decisive proof against LYMAN'S interpretation.

According to LYMAN, *Astrogomphus vallatus* LYMAN has a very simple oral skeleton, which "somewhat recalls the shape in *Ophioscolex*, though the peristomial plates are entire and transversely oval." LUDWIG'S 'first ventral arm plate' is present at the upper outer corner of the oral slit. The radial shields are long, bar-like, narrow, composed of several overlapping secondary plates soldered together. Again, according to LYMAN, in *Astrocnida isidis* the digestive cavity has its roof firmly attached to the body wall, but the floor is entirely and the sides partially free. The perihæmal canal is entirely closed, and judging from LYMAN'S statements, the genital bursæ appear to communicate with one another so as to form a single compound cavity, regarded by LYMAN as the "peritoneal cavity." I do not know any other genus of the present family with entirely closed perihæmal canal.

My own observations have been made upon *Astrochele lymani* and *Asteroporpa hadracantha*, as representatives of the simple-armed genera of the *Gorgonocephalinæ*. In the first named species, the radial shields are long, narrow, bar-like, almost reaching the centre of the disk, composed of several overlapping secondary plates soldered together. The genital plates are stout, lying close to the sides of the basal vertebræ. The genital scales are very small, flat, lamella-like, articulated to the genital plates at a short distance from the outer ends of the latter. The basal vertebræ within the disk are not covered over by the muscles lying between them and the genital plates. The peristomial plates are entire, very large, roughly pentagonal, with the longest side inwards and the most obtuse angle outwards, much wider than long, closely soldered with the oral frames, which are rather

simple and not very stout. LUDWIG'S 'first ventral arm plate' is present at the upper outer corner of the oral slit. The oral plates are very slender and rather long. The interradial attachments of the floor of the gastral cavity extend from the middle of the peristomial plates outwards, and the radial attachments from the outer end of the first vertebræ outwards. The perihæmal canal and genital bursæ communicate with each other, so as to form a single cavity, which is however divided into ten radiating compartments by the radial and interradial attachments of the floor of the gastral cavity. The peritoneal cavity is perfectly divided into five radial compartments, which is entirely filled up by the generative glands. The ventral arm plates are present, being represented by two or three secondary plates. The minute hooks of the arm annulations are comparatively coarse, being composed of from one to three supplementary hooklets, besides the main terminal one. In *Asteroporpa hadracantha*, the radial shields are entire instead of being composed of several secondary plates, stout and very thick. The interradial attachments of the floor of the gastral cavity extend from the outer end of the peristomial plates outwards. The ventral arm plates are entire, quadrangular, slightly separated by the adradial parts of the bar-like lateral plates. The minute hooks are much finer than those of the foregoing species, having only a single supplementary hooklet besides the main one, as in many higher genera. The other structures are almost similar to those of the preceding species. In higher genera with the arms branched many times, the genital plates lie at the lower lateral sides of the basal vertebræ, and do not extend inwards to the first vertebræ, as they do in the simple-armed genera.

The species of *Gorgonocephalus* may be divided into three groups on the basis of the attachments of the gastral pouches to

the basal vertebræ, *G. tuberosus* representing the first, *G. arcticus* the second, and *G. dolichodactylus* the third. In *G. tuberosus*, the floor of the gastral cavity is almost free from the basal vertebræ, except in the very peripheral parts, where it is attached to the one or two vertebræ just inside the disk border. In *G. arcticus*, the floor of the gastral cavity is firmly attached to the basal vertebræ within the disk, save one or two first vertebræ which are free from the gastral wall. *G. caryi* and, according to LYMAN, also *G. chilensis* belong to this type. In *G. dolichodactylus*, the attachments of the floor of the gastral cavity to the basal vertebræ extend from the second to the sixth vertebræ, so that the two compartments of the perihæmal canal plus genital bursæ on either side of a radius communicate together in two places, one lying inwards just above the second vertebra and the other outwards just above the sixth vertebra. In all the three types, the gastral cavity is divided into ten radiating compartments, the radial and interradiating gastral pouches, of which the walls again present radiating folds and are thickened by the presence of the inner layer of yellowish or brownish glandular cells, the foldings and thickenings being however more prominent in the second and third types than in the first; and the peritoneal cavity is perfectly divided into five radial compartments, which are entirely filled up and obliterated by the very voluminous, strongly folded generative glands. The internal differences appear to me to be correlated with certain external features; the first type being characterised by the high disk and strongly concave interbrachial ventral surfaces, the second by the low disk and flat interbrachial ventral surfaces, and the third by the very high outer ends of the genital slits. *Astrodendrum sagaminum* is almost similar to the second type of *Gorgonocephalus* in its internal structure. In *Astrocladus annulatus*,

the general plan of the internal structure is similar to that of the second type of *Gorgonocephalus*; while in *Astrocladus coniferus*, the plan is that of the third type, though the foldings of the gastral pouches, as well as of the generative glands, are more complex and the layer of the glandular cells of the wall of the gastral cavity is extraordinarily thick, so that the cavity itself is much less spacious. In *Astroboa arctos*, the internal structure is essentially similar to that of the preceding, but there is often a fenestra in each interradial septum between the two compartments of the perihæmal canal plus genital bursæ on either side of an interradial line, placing the two in communication with each other. In this species, the inner side of the dorsal surface of the vertebræ is strongly convex, and the outer side correspondingly concave.

DÖDERLEIN has divided the *Gorgonocephalidæ* into two sub-families according to the presence or absence of supplementary plates in the spaces between the oral angles and the interbrachial ventral surfaces. But his statement is in my opinion based on an error, because my *Astrotochinæ* evidently have the supplementary plates in question. In *Astrothamnus echinaceus*, the supplementary plates in question are well developed, and the adoral shields are separated by them from the interbrachial ventral surfaces. Besides, there occurs a not very large supplementary plate among the adoral shields and oral plates. The greater inner parts of the oral plates markedly project ventrally. The oral skeleton is firmly soldered together. The peristomial plates are entire, irregular in shape, with convex dorsal surface. The oral frames are humped dorsally near the outer ends, being much higher than the basal vertebræ. LUDWIG'S 'first ventral arm plate' is present at the dorsal side of the distal end of each oral slit, being firmly soldered with the oral frames. The second to sixth vertebræ are markedly

small and narrow, being narrower than the first vertebra and the basal free vertebræ of the arms, and are covered over by the muscles lying between them and the genital plates. The genital plates are very stout, lying close on the sides of the adjacent vertebræ. The genital scales are very small, articulated to the outer parts of the genital plates. The radial shields are long, narrow, thick, with humped interior surfaces, nearly reaching the disk centre. The gastral cavity is divided into ten radiating pouches, the roof being firmly attached to the body wall. The floor of the gastral cavity has ten attachments, the radial ones extending from the second vertebra to the disk margin and the interradianal ones from the peristomial plate to the same. The perihæmal canal communicates with the genital bursæ, which are very spacious. The peritoneal cavity is perfectly divided into five radial compartments, which are entirely filled up by the generative glands. The ventral arm plates are rhomboidal, much wider than long, separated from one another by the lateral arm plates, which meet each other in the ventral median line. The abradial parts of the lateral plates strongly project ventrally to form a very prominent spine ridge. The minute hooks of the annuli of the arms are compound, being composed of a terminal main hooklet and of three to five comb-like supplementary ones. In *Astrotoma sobrina*, the essential structure is almost similar, but the supplementary plates in the spaces between the oral angles and the interbrachial ventral surfaces are better developed; the muscles lying between the basal vertebræ and the genital plates are more massive; the radial shields are distinctly keeled ventrally; the radial attachments of the floor of the gastral cavity extend from the first vertebræ to the disk border; and the minute hooks of the annuli of the arms are composed of from one to three supplementary hooklets, besides

the terminal main one. According to DÖDERLEIN, the minute hooks of the annuli of the arms of *Astrothorax misakiensis* DÖDERLEIN have a single supplementary hooklet, besides the terminal main one. The position of the madreporic shield of *Astrotoma agassizi* LYMAN is almost the same as in *Astrospartus*, and such a position of the shield is hardly possible unless the supplementary plates are present in the space inside the interbrachial ventral surface.

Key to Japanese genera of *Gorgonocephalinae*.

- A*—Arms simple; no supplementary plates in the spaces between the oral angles and the interbrachial ventral surfaces; annulations of the arms continued onto the dorsal side of the disk, so that the latter is concentrically annulated as a whole *Asteroporpa*.
- AA*—Arms divided from the base; supplementary plates present in the spaces between the oral angles and the interbrachial ventral surfaces; disk not concentrically annulated.
- a*—Arm spines present from the very base.
- b*—Interbrachial margins of the disk with a row of marginal scales ..
..... *Gorgonocephalus*.
- bb*—Marginal disk scales absent *Astrodendrum*.
- aa*—Arm spines absent at least within the first bifurcation; marginal disk scales absent.
- c*—Arm spines present within the second or third bifurcation
..... *Astrocladus*.
- cc*—Arm spines absent at least within the fourth bifurcation.. *Astroboa*.

Asteroporpa hadracantha CLARK.

Asteroporpa hadracantha: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 280, fig. 142.

One specimen; Uji-shima, Ōsumi; 80–90 fathoms. One speci-

men; Oniga-sé, Sagami Sea; 150-200 fathoms. One specimen; locality unknown, probably Sagami Sea.

Eastern Sea; 103 fathoms (CLARK). Off Omai Zaki, Yenshû Sea; 34-37 fathoms (CLARK). Off Suno Saki, Sagami Sea; 44-50 fathoms (CLARK).

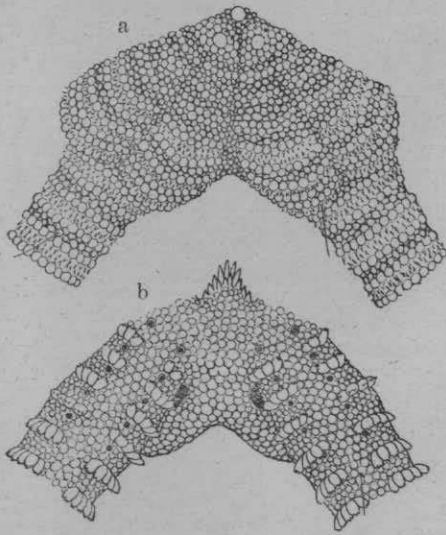


Fig. 17. *Asteroporpa hadracantha*. $\times 8$. a. From above. b. From below.

The largest one of my specimens measure 7 mm. across the disk and 35 mm. in the length of the arms. In one specimen, some of the superficial granules of the disk and arms, both above and below, bear here and there a very long glassy hair.

Ophiocrene BELL and the *Ophiocrenoid* stage.

The curious genus, *Ophiocrene* BELL, is characterised by the disk being covered mostly by the naked primary plates and by the radial shields being not long and bar-like but short and rounded. I have two very small, generically and specifically indeterminable specimens, which are almost similar to *Ophiocrene* in dorsal view, but differ from it in the occurrence of arm spines even in the very base of the arms. According to LYMAN and GRIEG, very young specimens of *Gorgonocephalus arcticus* LEACH (= *G. agassizi*) also have the disk essentially similar to that of *Ophiocrene*. I therefore imagine that, the disk characters of *Ophiocrene* occur in a certain young stage of many—presumably all—genera of the *Gorgonocephalidæ*, and

propose the name *ophiocrenoid* for it. Judging from the presence of a single madreporite and the absence of the arm spines in the basal parts of the arms, *Ophiocrene* may probably be the *ophiocrenoid* stage either of *Astroboa* or of *Astrochalcis*; and if this connection should be proved, *Ophiocrene* has priority as a generic name.

An *Ophiocrenoid* stage of one of the *Gorgonocephalinae*.

Two specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Diameter of disk 2.5 mm. Arms twice divided; length of the primary shafts 3 mm., of the secondary shafts 2.5 mm., and of the last shafts 1.5 mm. Width of arms at base 0.7 mm.

Disk five-lobed, rather high, with strongly concave interbrachial borders, covered by a pavement of naked plates, among which the central, five radials, five interradials, as well as the radial shields are most conspicuous, with convex surfaces. The secondary plates are very small and inconspicuous, and form a system of zones surrounding the primaries. Ventral side of disk covered by a granulated skin, through which the oral and adoral shields can be seen as being entire and without sup-

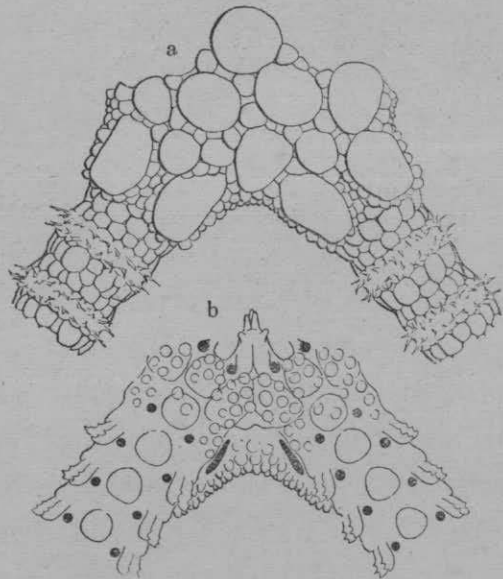


Fig. 18. An *Ophiocrenoid* (? *Gorgonocephalus* or *Astrodendrum*). $\times 20$. a. From above. b. From below.

and adoral shields can be seen as being entire and without sup-

plementary plates. Teeth, dental papillæ and oral papillæ very few in number.

Arms covered by a pavement of flattened, polygonal granules, and distinctly annulated by double rows of compound hooks, of which the terminal hooklet is smaller than the accessory one. Ventral side of arms covered by a naked skin, through which the ventral and lateral arm plates are visible. Two small, peg-like arm spines occur on the second and outer lateral arm plates.

Colour in alcohol white.

The smaller one of the two specimens is only 1 mm. across the disk and has the arms divided only once. The disk is entirely covered with the primaries and the radial shields, secondary plates being absent. The arms are not yet annulated by the double rows of compound hooks, but there are from three to five secondary plates in place of each dorsal arm plates, so that the dorsal view of the arms reminds us of that of *Hemieuryale*.

Key to Japanese species of *Gorgonocephalus*.

- A*—Arms composed of short shafts; arm spines almost as long as the corresponding arm joint.
- a*—Teeth and papillæ, as well as arm spines, very acute; internal structure of the first type. *tuberosus*.
- aa*—Teeth and papillæ, as well as arm spines, blunt; internal structure of the second type..... *caryi*.
- AA*—Arms composed of long shafts; arm spines shorter than half the corresponding arm joint; internal structure of the third type.....
..... *dolichodactylus*.

Gorgonocephalus tuberosus DÖDERLEIN.

Gorgonocephalus tuberosus: DÖDERLEIN, Zool. Anz., XXV, 1902, p.

322; DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 33, Pl. II, figs. 1 & 2.

Four specimens; off Misaki, Sagami Sea.

Sagami Sea; 240 m. (DÖDERLEIN).

The largest one of my specimens is 56 mm. across the disk, which is beset with very numerous rough tubercles. One specimen (fig. c), measuring 27 mm. across the disk, closely resembles the next species, almost agreeing with LYMAN'S description of the same, except that the apparent granules, which are scattered on the disk, are in reality very fine, rough spinules as ascertained by an examination under the microscope. A vertical section of this specimen showed that it had the internal structure of the first type. I am inclined to regard this specimen as possibly a natural hybrid between the typical *G. tuberosus* and the next species, as the two occur almost in the same place.

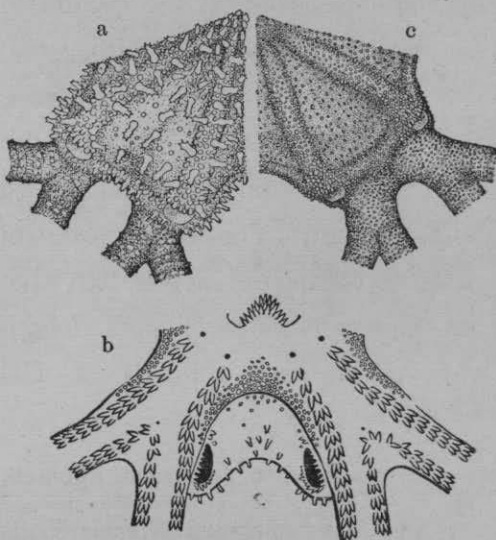


Fig. 19. *Gorgonocephalus tuberosus*. a. From above. $\times 1\frac{1}{2}$. b. From below. $\times 1\frac{1}{2}$. c. From above. $\times 2$.

Gorgonocephalus caryi (LYMAN).

Astrophyton caryi: LYMAN, Proc. Boston Soc. Nat. Hist., VII, 1860, p. 424¹⁾; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 184.

1) This paper was not seen by me.

Astrophyton stimpsonii: VERRILL, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 388.¹⁾

Gorgonocephalus caryi: LYMAN, Rep. Challenger, V, 1882, p. 264; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 287.

Gorgonocephalus stimpsoni: LYMAN, loc. cit., 1882, p. 264.

Gorgonocephalus japonicus: DÖDERLEIN, Zool. Anz., XXV, 1902, p. 322; DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 31, Pl. I, figs. 1-3, Pl. VII, figs. 1-2c.

Gorgonocephalus sagaminus: DOFLEIN, Ostasienfahrt, 1906, p. 204, fig. (Non DÖDERLEIN, 1902.)

Four specimens; off Misaki, Sagami Sea.

Sagami Sea; 150-800 m. (DÖDERLEIN). Off Ôsé Zaki, Suruga Gulf; 63-75 fathoms (CLARK). Eastern Sea; 181-391 fathoms (CLARK). Korea Strait; 66 fathoms (CLARK). Korea (DÖDERLEIN). Sea of Japan; 59-428 fathoms (CLARK). Saghalin; 40-43 fathoms (CLARK). Saghalin (DÖDERLEIN). Ochotsk Sea; 73 fathoms (CLARK). Ochotsk Sea (VERRILL).

Arctic Sea. Bering Sea. Alaska to California.

One of my specimens is evidently the *japonicus* type, the surfaces just inside the interbrachial ventral surfaces, as well as the ventral side of the arms being entirely free of granules. The lower margins of both sides of the arms are covered with irregularly polygonal plates, without granules, as shown in DÖDERLEIN'S fig. 2a, Pl. VII. DÖDERLEIN has not found the *caryi* type in Japanese waters. But my two specimens agree well with LYMAN'S description, the granulations of the interbrachial ventral surfaces distinctly extending as far as the base of the oral angles and the outer end of the oral slits. The ventral side of the arms is rather sparsely granulated, the granules being however finer

¹⁾ This paper was not seen by me.

than those of the outer parts. The lateral sides of the arms are entirely covered with fine granules, as shown in DÖDERLEIN'S fig. 1a, Pl. VII. In the arm coverings, these two specimens are therefore quite similar to DÖDERLEIN'S "*japonicus* var." The disk is rather sparsely and uniformly granulated. The internal structure is of the second type in all the four specimens.

Gorgonocephalus dolichodactylus DÖDERLEIN.

Gorgonocephalus dolichodactylus: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 34, Pl. I, figs. 4 & 5, Pl. VII, figs. 3-4b.

Two specimens;
off Misaki, Sagami
Sea.

Sagami Sea; 150-
200 m. (DÖDERLEIN).

One of these specimens is very abnormal, all the pairs of the radial shields being fused into one almost along the entire adradial border, though remaining separate towards the centre, so that there is here a bifurcation.

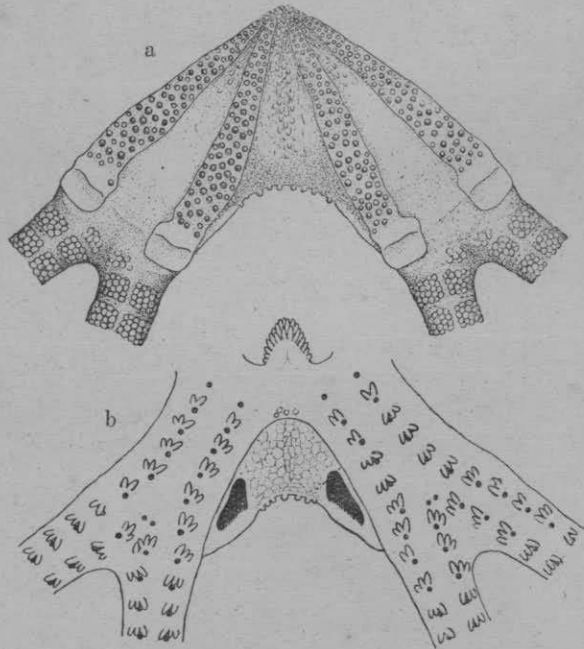


FIG. 20. *Gorgonocephalus dolichodactylus*. $\times 1\frac{1}{3}$. a. From above. b. From below.

Astrodendrum sagaminum (DÖDERLEIN).

Gorgonocephalus sagaminus: DÖDERLEIN, Zool. Anz., XXV, 1902, p. 321; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 292.

Astrodendrum sagaminum: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd., I, 1911, p. 38, Pl. II, figs. 3-5, Pl. VII, fig. 8; BOMFORD, Rec. Ind. Mus., IX, Pt. 4, 1913, p. 220.

Numerous specimens; off Misaki, Sagami Sea; 100-200 fathoms.

Ôse Zaki, Suruga Gulf; 63-75 fathoms (CLARK). Eastern Sea; 95 fathoms (CLARK). Sea of Japan; 59-172 fathoms (CLARK). Sagami Sea (DÖDERLEIN).

Indian Ocean (BOMFORD).

Key to Japanese species and varieties of *Astrocladus*.

- A*—Disk covered by an apparently smooth skin, in which however very fine, insignificant, close-set granules are contained; internal structure as in the second type of *Gorgonocephalus* *annulatus*.
- AA*—Disk covered by a pavement of granules, which have acute, spiny tips; internal structure as in the third type of *Gorgonocephalus* *coniferus*.
- a*—Disk and arms free of tubercles, or a conical, blunt tubercle may occur on each radial rib near the outer end.
- b*—Colour variegated, with whitish ground colour and purplish brown patches of various shape and size var. *pardalis*.
- bb*—Colour simple, deep purplish brown or purplish black typical *coniferus*.
- aa*—Disk and arms beset with numerous hemispherical, or more or less conical, tubercles; colour variegated, or simply deep purplish brown or purplish black var. *dofteini*.

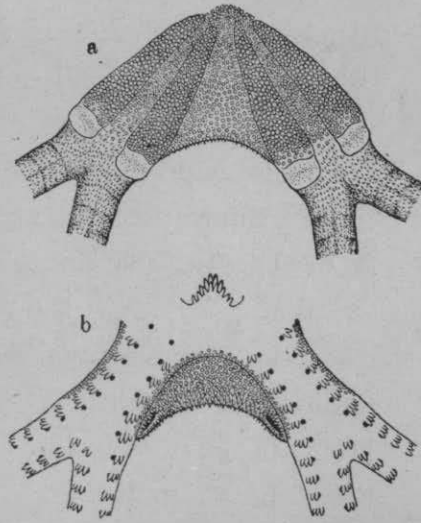


Fig. 21. *Astrodendrum sagaminum*. $\times 3$.
a. From above. b. From below.

Astrocladus annulatus MATSUMOTO.*Astrocladus annulatus*: MATSUMOTO, Proc. Acad. Nat. Sci., 1915, p. 56.

One specimen; off Misaki, Sagami Sea.

Diameter of disk	22 mm.
Distance from the centre of the disk to the interbrachial margin	8.5 mm.
From the outer end of the oral slit to the 1 st . bifurcation	11 mm.
From the disk margin to the 1 st . bifurca- tion	1.5 mm.
From the 1 st . bifurcation to the 2 nd	7 mm.
From the 2 nd . to the 3 rd	8.5 mm.—6.5 mm.
From the 3 rd . to the 4 th	5.5 mm.—9 mm.
From the 4 th . to the 5 th	9 mm.—4 mm.
From the 5 th . to the 6 th	4 mm.—9 mm.
From the 6 th . to the 7 th	10 mm.—4 mm.
From the 7 th . to the 8 th	4 mm.—7.5 mm.
From the 8 th . to the 9 th	7 mm.—3.5 mm.
From the 9 th . to the 10 th	3.5 mm.—8 mm.
From the 10 th . to the 11 th	8 mm.—3.5 mm.
From the 11 th . to the 12 th	3 mm.—7 mm.
From the 12 th . to the 13 th	9 mm.—3 mm.
From the 13 th . to the 14 th	2.5 mm.—5 mm.
From the 14 th . to the 15 ^t	5 mm.—2.5 mm.
From the 15 th . to the 16 th	2 mm.—3.5 mm.
From the 16 th . to the 17 th	3.5 mm.—2 mm.
From the 17 th . to the 18 th	1.5 mm.—3.5 mm.
From the 18 th . to the 19 th	3 mm.—1.5 mm.
From the 19 th . to the end	1 mm.—2 mm.

Total length of the arm	126 mm.
Width of the ventral side of the arm base within the disk	4.5 mm.

Disk five-lobed, with concave interbrachial borders, covered by a thick skin, which is apparently smooth, but contains very fine and close-set granules of microscopic size. On the radial ribs, these granules are very flattened and smooth, and coarser, being visible even to the naked eye. Several smooth, hemispherical

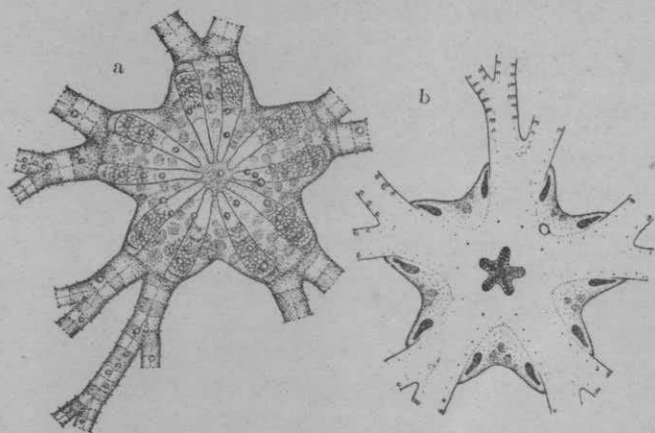


Fig. 22. *Astrocladus annulatus*. $\times 1\frac{1}{2}$. a. From above.
b. From below.

tubercles are scattered on the disk. Radial ribs gently raised and forming rounded ridges, with rather indistinct outlines, not quite reaching the centre; their back is marked with concentrically arranged swellings, corresponding to

the imbricating, soldered plates, of which the radial shields are composed. The ventral surface of the disk appears very smooth to the naked eye. Genital slits not very large. Madreporic shield single, at the inner corner of one of the interbrachial ventral surfaces, small, transversely oval. The teeth and dental papillæ are conical and rather stout. The oral papillæ and lower dental papillæ are smaller and very short; their number for each oral angle is not very great.

Arms slender and branched, with distinction of trunk and

lateral branch even at the basal region, covered on the upper side by a finely and closely granulated skin, with several scattered, smooth, hemispherical tubercles on the more proximal shafts, distinctly annulated with hook-bearing segments throughout. Ventral surface of the arm entirely smooth to the naked eye. The arm spines which are present beyond the first bifurcation, are very fine, and three or four in number for each tentacle pore.

Colour in alcohol: disk mottled, arms annulated with yellowish and grayish brown.

This species can be easily distinguished from the other species of *Astrocladus* by the entirely smooth disk covering and by the arms being distinctly annulated with hook-bearing segments even at the very basal region.

Astrocladus coniferus (DÖDERLEIN).

Astrocladus coniferus var. *pardalis* (DÖDERLEIN).

Astrocladus coniferus var. *dofteini* (DÖDERLEIN).

Astrophyton pardalis: DÖDERLEIN, Zool. Anz., XXV, 1902, p. 323; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 293.

Astrophyton coniferum: DÖDERLEIN, loc. cit., p. 325.

Astrocladus dofteini: DÖDERLEIN, SCHULTZE—Zool. Ergebn., IV, 1910, p. 256¹⁾; DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss, Suppl.-Bd. I, 1911, p. 41, fig. 9, Pl. II, fig. 6, Pl. III, figs. 1-4, Pl. IV, figs. 15-15b; BOMFORD, Rec. Ind. Mus., IX, Pt. 4, 1913, p. 200, Pl. XIII, fig. 1.

Astrophyton cornutum: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 292. (Non KOEHLER, 1909.)

Astrocladus coniferus: DÖDERLEIN, loc. cit., 1911, p. 46 & 76, Pl. II, figs. 7 & 7a, Pl. IV, figs. 1-3a, Pl. VI, figs. 5-6a & 16.

Numerous specimens; Misaki. Several specimens; off Moroiso, Misaki; 10 fathoms.

1) This paper was not seen by me.

Sagami Sea. Suruga Gulf; 108 fathoms (CLARK). Off Omai Zaki, Yenshû Sea, 34–36 fathoms (CLARK). Kagoshima (DÖDERLEIN). Colnett Strait; 83–84 fathoms (CLARK). Eastern Sea; 103–152 fathoms (CLARK). Fusan, Korea (CLARK).

Wladiwostok (DÖDERLEIN). ? Off Agattu Is.; 482 fathoms (CLARK). Indian Ocean.

I fail to find any marked distinction between the *coniferus* and the *dofleini* type. There are many specimens which must be

referred to the *coniferus* type in most characters, but are beset with a few or many large hemispherical tubercles on the dorsal side of the arms, as observed by DÖDERLEIN himself, but there are others which gradually pass over into the *dofleini* type. The large tubercle on the back of each radial shield near its outer end, present in most specimens of the *coniferus* and in some of the *pardalis* type, is also often present in smaller and moderately large specimens of the *dofleini* type. Such a tubercle is indicated on some of the radial shields

in DÖDERLEIN'S fig. 5, Pl. IV.

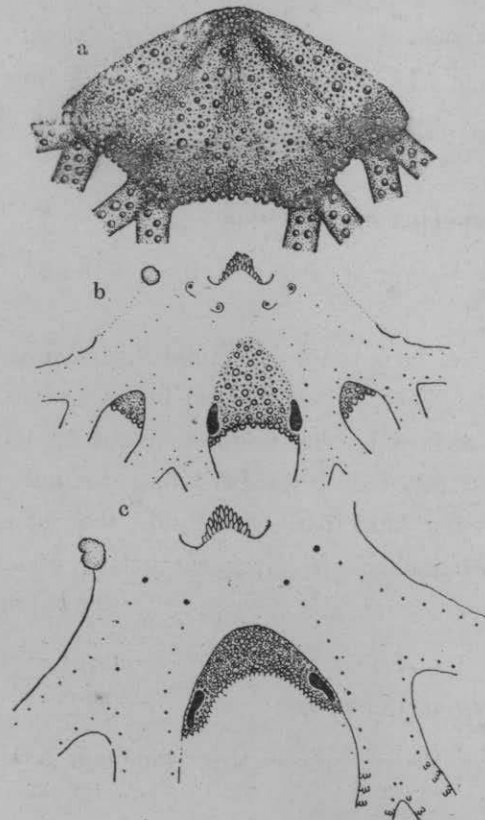


Fig. 23. *Astrocladus coniferus*. a. From above. $\times \frac{3}{2}$. b. From below. $\times \frac{3}{2}$. c. From below. $\times 2$.

quite indistinguishable, owing to the increase in number of similar

tubercles on the entire dorsal surface of the disk. In distinguishing *A. dofleini* from the *coniferus* and *pardalis* type, DÖDERLEIN seems to lay weight upon the fact that, the granules of the arm bases of the former have no acute tips, but are smooth. But, one of my specimens, measuring 55 mm. across the disk, has very abundant hemispherical tubercles on the arms and easily recognizable acute granules on the arm bases, the latter being distributed as far out as the fifth bifurcation. The colour of the same specimen is simply deep purplish black, and the disk coverings are almost similar to those of the *coniferus* type, though the conical tubercles on the radial ribs near the outer ends are not present.

Key to Japanese species of *Astroboa*.

- A*—Madreporic shield lying at the inner angle of the interbrachial ventral surface.
- a*—Annulations of double rows of hook-bearing granules distinct even in the stout proximal parts of arms; colour purplish black .. *nigra*.
- aa*—Annulations of double rows of hook-bearing granules absent in the stout proximal parts of arms; colour dark grayish brown. .. *arctos*.
- AA*—Madreporic shield lying on the hard part just inside the interbrachial ventral surface, being almost free from the latter; colour light pinkish brown *globifera*.

Astroboa nigra DÖDERLEIN.

Astrophyton clavatum: PFEFFER, Mitteil. Naturh. Mus. Hamburg, XIII, 1896, p. 48.¹⁾ (Non LYMAN.)

Astroboa nigra: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 83, Pl. IX, figs. 9 & 9a.

1) This paper was not seen by me.

Hirado Strait; 72 m. (DÖDERLEIN).

Zanzibar (DÖDERLEIN).

Astroboa arctos MATSUMOTO.

Astroboa arctos: MATSUMOTO, Proc. Acad. Nat. Sci., 1915, p. 57.

Two specimens; off Moroiso, Misaki; 5–10 fathoms. Four specimens; off Misaki.

Diameter of disk	65 mm.
Distance from the centre of the disk to the interbrachial margin. . .	25 mm.
From the outer end of the oral slit to the 1 st bifurcation	32 mm.
From the 1 st bifurcation to the 2 nd	10 mm.
From the disk margin to the 2 nd bifurcation	4 mm.
From the 2 nd . to the 3 rd 12 mm.—16 mm.	14 mm.—13 mm.
From the 3 rd . to the 4 th 18 mm.—8 mm...11 mm.—15 mm.	
From the 4 th . to the 5 th 10 mm.—18 mm.	16 mm.—11 mm.
From the 5 th . to the 6 th 17 mm.—9 mm...10 mm.—18 mm.	
From the 6 th . to the 7 th 9 mm.—16 mm.	14 mm.—11 mm.
From the 7 th . to the 8 th 15 mm.—8 mm...9 mm.—17 mm.	
From the 8 th . to the 9 th 8 mm.—16 mm.	14 mm.—11 mm.
From the 9 th . to the 10 th 16 mm.—8 mm...8 mm.—14 mm.	
From the 10 th . to the 11 th . .. 8 mm.—16 mm.	13 mm.—8 mm.
From the 11 th . to the 12 th 15 mm.—6 mm...7 mm.—20 mm.	
From the 12 th . to the 13 th . .. 6 mm.—17 mm.	11 mm.—7 mm.
From the 13 th . to the 14 th 15 mm.—6 mm...7 mm.—11 mm.	
From the 14 th . to the 15 th . .. 6 mm.—10 mm.	10 mm.—5 mm.
From the 15 th . to the 16 ^t 14 mm.—6 mm...5 mm.—9 mm.	
From the 16 th . to the 17 th . .. 6 mm.—11 mm.	11 mm.—5 mm.
From the 17 th . to the 18 th 14 mm.—5 mm...6 mm.—9 mm.	
From the 18 th . to the 19 th . .. 4 mm.—12 mm.	14 mm.—5 mm.
From the 19 th . to the 20 th 16 mm.—5 mm...6 mm.—10 mm.	

From the 20 th . to the 21 st .	5 mm.-12 mm.	9 mm.-4 mm.
From the 21 st . to the 22 nd .	11 mm.-5 mm.	4 mm.-9 mm.
From the 22 nd . to the 23 rd .	4 mm.-10 mm.	9 mm.-4 mm.
From the 23 rd . to the 24 th .	8 mm.-4 mm.	4 mm.-9 mm.
From the 24 th . to the 25 th .	4 mm.-10 mm.	9 mm.-4 mm.
From the 25 th . to the 26 th .	11 mm.-4 mm.	3 mm.-6 mm.
From the 26 th . to the 27 th .	4 mm.-11 mm.	7 mm.-3 mm.
From the 27 th . to the 28 th .	9 mm.-3 mm.	3 mm.-6 mm.
From the 28 th . to the 29 th .	5 mm.-9 mm.	4 mm.-3 mm.
From the 29 th . to the 30 th .	7 mm.-4 mm.	2 mm.-4 mm.
From the 30 th . to the 31 st .	3 mm.-8 mm.	3 mm.-2 mm.
From the 31 st . to the 32 nd .	6 mm.-4 mm.	2 mm.-3 mm.
From the 32 nd . to the 33 rd . (or to the end)	3 mm.-6 mm.	2 mm.-1 mm.
From the 33 rd . to the 34 th .	6 mm.-4 mm.	
From the 34 th . to the 35 th .	4 mm.-5 mm.	
From the 35 th . to the 36 th .	3 mm.-2 mm.	
From the 36 th . to the 37 th .	2 mm.-3 mm.	
From the 37 th . to the end	2 mm.-1 mm.	
Total length of the arm	421 mm.	324 mm.
Width of the ventral surface of the arm within the disk		17 mm.
Width of the shaft between the 1 st and 2 nd bifurcations		10 mm.
Width of the main (adradial) shaft between the 2 nd and 3 rd bifurcations		7 mm.

Disk decagonal, with concave interbrachial and brachial borders, the former being longer and more concave than the latter; very convex, but with more or less depressed central region, covered by a thick skin, which is chagreened by the presence of very fine, close-set granules. The granules are smooth, not acute, irregular in size when viewed under the microscope, the coarser ones being more numerous on the radial ribs than in the intercostal spaces.

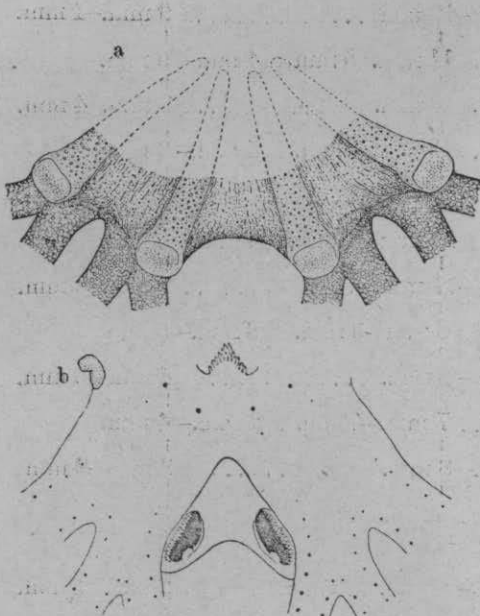


Fig. 24. *Astroboa arctos*. $\times 1\frac{1}{2}$. a. From above.
b. From below.

The radial ribs are bar-like, narrow, widest at the outer end, suddenly narrowed for a very short distance, then uniformly tapered inwards, nearly reaching to the centre. Interbrachial ventral surfaces covered by a thick, apparently smooth skin, which contains very fine granules. Adradial border of the genital slits closely spinulated. The madreporic shield, situated at the inner angle of the interbrachial ventral surface, is more or

less semilunar, with a semicircular inner side and a distinctly notched outer side, the lateral angles being rounded. The spaces inside the interbrachial ventral surfaces are apparently smooth, but in reality closely covered with very fine granules of microscopic size, the granules being rather coarse and distinct at the oral angles. Teeth and papillæ very numerous. The oral and dental papillæ are rather small, spiniform, not very acute, while the teeth are much larger and longer than the papillæ, and are distinctly spatulate and flattened at the tip, the upper teeth being larger and more pronouncedly spatulate than the lower.

The two main stems of each arm are not equally developed, but one is longer, stouter, and richer in bifurcations than the other, as shown in the preceding table of dimensions. Dorsal and lateral sides of arms covered by a thick skin, which is very

finely and closely granulated, the granules being very irregular in size and roughly distinguishable into two kinds. The finer granules are entirely covered over by the skin, and are flat and irregularly polygonal, forming together a sort of mosaic; while the coarser granules, which are coarser than any granules of the disk, are hemispherical and tubercle-like, and are uniformly scattered. Ventral surface of arms apparently smooth, but really covered by a mosaic of flat and irregularly polygonal granules of microscopic size. The first pair of tentacle pores are distinct and open in slight depressions. The second are often visible. The following three or four pairs are entirely absent, those beyond being again distinct. The arm spines are entirely absent in the proximal joints, but are present from the fourth or fifth bifurcation outwards. They are exceedingly minute and granule-like, two to four of them occurring for each tentacle pore. The double rows of hook-bearing granules are present only in very fine twigs, the main stems within the fourteenth or fifteenth bifurcation being free of them. The shaft between the first and second bifurcations usually contains four arm joints. The outer shafts are composed of from six to eight, usually seven, joints.

Colour in alcohol, as well as in a dry state; dark grayish brown above, and dark yellowish brown below.

Of the five known species of *Astroboa*, *A. clavata* (LYMAN) is distinguished from the others by the spiny granules of the disk and arms, and *A. globifera* (DÖDERLEIN) by the position of the madreporic shield. *A. nuda* (LYMAN) and *A. nigra* DÖDERLEIN have distinct annulations of hook-bearing granules on the arms, while *A. ernæ* DÖDERLEIN has no such annulation on the greater proximal parts of the arms. This species is therefore very near to the last named but differs from it in the less distinct and much finer

granules of the disk, and in the less number of arm joints contained in a shaft. In the last characters, *A. arctos* rather resembles *A. nigra* from Zanzibar and Hirado Strait, Japan.

This species is common in the shallow waters around Misaki, and occurs in the same localities with the foregoing species.

***Astroboa globifera* (DÖDERLEIN).**

Astrophyton globiferum: DÖDERLEIN, Zool. Anz., XXV, 1902, p. 324.

Astroboa globifera: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 51, Pl. II, figs. 8-9; Pl. VII, figs. 7 & 7a.

One specimen; off Kôtsu-jima, Izu.

Sagami Sea; 150-200 m. (DÖDERLEIN).

Key to genera of *Astrotominae*.

- A*—Interannuli of the arm covered with two rows of coarse granules; arms simple.
- a*—Disk more or less closely beset with thorny tubercles or spiny granules *Astrothamnus*.
- aa*—Disk covered with rounded plates, which are surrounded by belts of granules.
- b*—Disk plates irregular in size; two or three arm spines *Astrothrombus*.
- bb*—Disk plates regular in size; three to seven arm spines. *Astrothorax*.
- AA*—Interannuli of the arm covered with many rows of fine granules; disk also covered with fine granules.
- c*—Arms simple. *Astrotoma*.
- cc*—Arms divided a few times near the tip *Astroclon*.

***Astrothamnus* MATSUMOTO, 1915.**

Disk divided into ten radiating lobes by radial and interradiial furrows, closely covered with coarse, thick granules, which are

more or less stumpy and usually have spiny tips. Interradial ventral surfaces strongly concave, each with two large, nearly parallel genital slits. A single madreporic shield is present at the inner border of an interbrachial ventral surface. Teeth and dental papillæ similar, spiniform, forming clusters at the apices of jaws. Oral papillæ absent, so that the sides of the oral slits are naked. Arms simple, covered by a pavement of granules, distinctly annulated by zones of densely set, minute, compound hooks, each of which consists of one main and several supplementary hooklets. Three to five arm spines, peg-like, usually with rough tips, serving as tentacle scales.

This genus includes *Astrotoma bellator* KÖHLER, 1904, *vecors* KÖHLER, 1904, and *rigens* KÖHLER, 1910, besides the genotype, *Astrothamnus echinaceus*. They may be distinguished as follows.

Key to species of *Astrothamnus*.

- A—Brachial ventral surfaces smooth; spaces just inside the interbrachial ventral surfaces, as well as oral angles, beset with slender spines; three arm spines.
 - a—Basal arm spines unusually long and stout, longer than the corresponding arm joints *rigens*.
 - aa—Basal arm spines not unusually long and stout, nearly as long as the corresponding arm joints *vecors*.
- AA—Brachial ventral surfaces, spaces just inside the interbrachial ventral surfaces, as well as oral angles, beset with coarse, stumpy granules.
 - b—Three arm spines not very small, nearly as long as the corresponding arm joints *echinaceus*.
 - bb—Five arm spines very small, hardly half as long as the corresponding arm joints *bellator*.

The distribution of *Astrothamnus* is very interesting, for, as

shown in the foregoing key, there are two specific groups in this genus, each represented by a Malaysian species. The Arabian species, *A. rigens*, is nearly allied to the Malaysian *A. vecors*, and the Japanese type, *A. echinaceus*, to the Malaysian *A. bellator*.

***Astrothamnus echinaceus* MATSUMOTO.**

Astrothamnus echinaceus: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 55.

Diameter of disk 22 mm. Length of arms 140 mm. Width of arms at base 4 mm.

Disk distinctly five-lobed, with five interradiial furrows, each lobe being again divided into two secondary lobes by the radial furrow. Radial ribs very prominent, large, occupying almost the whole dorsal surface of disk, leaving between them only ten narrow

furrows radiating from the centre; closely covered with rather large stumpy tubercles with thorny crowns, between which lie thick, irregularly polygonal plates. Interbrachial ventral surfaces strongly concave, closely covered with stumpy tubercles terminating with one or a few thorny points. Genital slits rather large, more or less parallel. Madreporic shield distinct, small, irregular in outline. The area inside the interbrachial

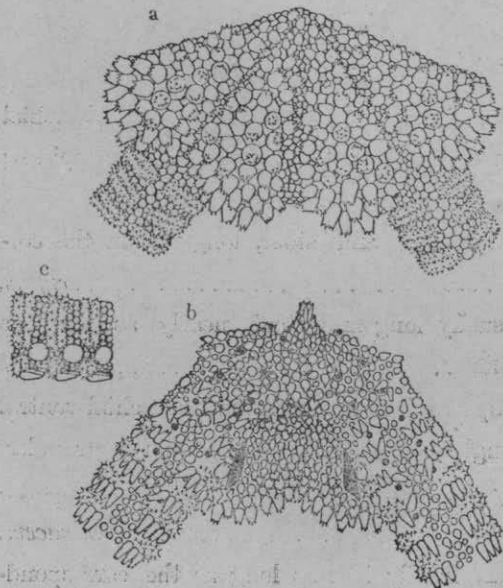


Fig. 25. *Astrothamnus echinaceus*. $\times 2\frac{1}{2}$. a. From above. b. From below. c. Side view of three arm joints near disk.

ventral surfaces, as well as the brachial spaces, are also closely covered with tubercles similar in form to those of the interbrachial ventral surfaces. Oral angles covered with close-set, sharp, conical tubercles, which become, towards the mouth, somewhat indistinguishable from the dental papillæ. Dental papillæ and teeth similar, conical and very acute. No oral papillæ.

Arms rather slender, uniformly tapered, with alternating annuli of two forms, one with two rows of granules entirely covered over with very densely set minute hooks, the other with two irregular rows of smooth, naked granules. Ventro-laterally on either side of the arms, in line with the annuli formed by the smooth granules, there is a series of large, round, naked plates. In the arm bases, the hook-covered annuli are usually broken at the dorsal median line by conical granules terminating with one or a few thorny points. Ventral surface of the arms with rather well spaced tubercles, which are conical or terminate with one or a few thorny points; these tubercles become rounded and smooth distally. The first and second tentacle pores without arm spines, the third with one or two spines, the fourth with two or three, and the rest with three. The arm spines of the basal pores are somewhat indistinguishable from the conical or thorned tubercles, but the rest are peg-like, nearly as long as the corresponding arm joints, and bear two or three denticles at the end. The oral tentacle pores and the first and second tentacle pores open by means of short tubes bearing a few spinules.

Colour in alcohol dull grayish purple.

Astrothorax misakiensis DÖDERLEIN.

Astrothorax misakiensis: DÖDERLEIN, Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 24, Pl. VI, figs. 2-2b, Pl. VII, figs. 12 & 14b.

Sagami Sea (DÖDERLEIN).

Astrotoma sobrina MATSUMOTO.

Astrotoma murrayi: DÖDERLEIN (non LYMAN, 1879), Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 23, fig. 1, Pl. VI, figs. 1 & 1a, Pl. VII, figs. 14-14b.

Five specimens; off Misaki, Sagami Sea.

Diameter of disk 34 mm. Length of arms 200 mm. Width of arms at base 7 mm.

Disk five-lobed, flat, rather sunken towards the centre, covered with very fine, smooth, closely soldered granules and many small, oval plates, which are sunken below the level of the granules; there are also on the disk numerous, large, smooth, spherical or slightly cylindrical tubercles with rounded ends. Radial ribs

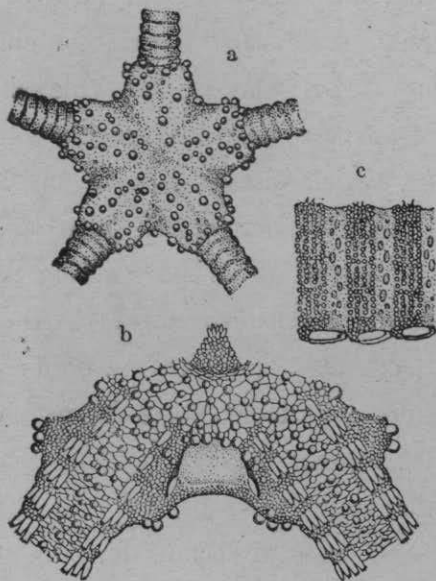


Fig. 26. *Astrotoma sobrina*. a. From above. $\times \frac{2}{3}$. b. From below. $\times 1\frac{1}{3}$. c. Side view of three arm joints near disk. $\times 3$.

almost indistinguishable. Interbrachial ventral surface covered by a thick, leather-like skin, which becomes granulated on drying. Genital slits rather large and divergent. The madreporic shield is small, but very distinct, more or less oval, vertical, lying at the inner corner of one of the interbrachial ventral surfaces. The area inside the ventral interbrachial surfaces, as well as the brachial spaces, are covered with thick, irregular, pavement-like plates and smooth, scattered tubercles, which are

smaller and more numerous than on the dorsal surface of the disk. Oral region surrounded by a circular groove, and distinctly set off from the outer parts. Oral angles strongly puffed downwards, covered with close-set granules of various sizes. Teeth and dental papillæ similar, spiniform, short and slender, acute, forming vertical clumps at the apices of the jaws. No oral papillæ.

Arms rather stout, uniformly tapered towards the extremity, dorsally and laterally with raised and depressed annuli; on the raised annuli, the granules are coarser, rather distinct and well spaced, arranged in four irregular rows, of which the middle two bear hooks, the series of hooked granules being interrupted by smooth ones; on the depressed annuli, the granules are very fine and form a smooth covering, with many small, oval plates, which are sunken below the plane of the granules. Ventral surface of the arms covered by the continuation of the ventral brachial space of the disk, with a pavement of irregular plates, which are so arranged as to bring about transverse wrinkles in the skin, and bear smooth, scattered tubercles, which distally become smaller and indistinguishable from the smooth granules. No arm spine to the first tentacle pore; one or two spines to the second; two or three spines to the third; and three or four spines to those beyond; but only two spines to each pore near the extremity of the arm. The arm spines are peg-like and flattened, and terminate with three or four thorny points; those situated adradially are somewhat longer than the abradial ones, and beyond the basal arm joints the most adradial spine becomes almost as long as the corresponding arm joint.

Colour in alcohol reddish or yellowish brown.

In younger specimens, the disk tubercles are much less

numerous, and the disk is less distinctly set off from the arms. In larger specimens, the disk tubercles are more numerous and show a tendency to arrange themselves, though very irregularly, in ten radiating rows, one on each radial rib.

The present species is very near to *A. murrayi* LYMAN, but differs from it in the much narrower brachial lobes of the disk, in the narrower interbrachial ventral surfaces, in the longer genital slits, in the fewer and larger tubercles in the spaces just inside the interbrachial ventral surfaces, in the much shorter arms, and in the slightly fewer arm spines.

Astroclon suenisoni MORTENSEN.

Astroclon suenisoni: MORTENSEN, Vidensk. Medd. Naturhist. Foren. Kjobenhavn, LXIII, 1911, p. 209.

Off Amakusa, Eastern Sea (MORTENSEN).

Order ii. LÆMOPHIURIDA MATSUMOTO.

Disk covered by a soft skin, or with fine scales or plates; very often beset with granules, spines or stumpy tubercles. Radial shields sometimes rudimentary. The radial shield and genital plate articulate with each other by means of a simple face or a transverse ridge on both the plates. Peristomial plates very large, usually entire. Oral frames without well developed lateral wings. Arms entirely covered by the three kinds of arm plates, of which the dorsal and ventral ones are usually very small, while the lateral ones are very well developed, very often approximating dorsally as well as ventrally. Vertebral articulation either zygospondyline or streptospondyline.

This order is very near to the *Phrynophiurida*, especially the *Ophiomyxidae*, but differs from them essentially in the entirely

protected dorsal side of the arms. Further, there are two types of primitive ophiurans differing in the embryonal condition of the vertebræ, one being the Phrynophiuridan type and the other the Læmophiuridan. In the Phrynophiuridan type, the distal vertebræ are divided into halves by a single fusiform pore, the middle parts of the halves being widely separated from each other. These vertebræ are proved to be present in *Ophiohelus*, *Ophiogeron*, *Astrogeron*, *Ophiosciadma*, *Ophiohyalus*, *Ophiomyca*, *Ophiostiba*, &c. In the Læmophiuridan type, the distal vertebræ are divided into halves by a series of small pores, the halves being connected with each other by a series of bridges between every two pores. These vertebræ are present in *Microphiura*, *Ophiothamnus*, *Ophiologimus*, *Amphiactis*, &c. In *Astrophiura*, the vertebræ of the free arm joints are divided into halves by a moniliform pore, the halves being closely set against each other, so that the condition, though rather near to the Læmophiuridan type, is intermediate between the two types.

Key to the families of *Læmophiurida*.

A—Disk and arms of slender build, the disk scales or plates, as well as arm plates, being not very stout; the genital plate and scale on either side of a radius articulate with each other, instead of being soldered together; vertebræ not very stout, often divided into halves. *Ophiacanthidæ*.

AA—Disk and arms of very heavy build, the disk and arm plates being very stout; the genital plate and scale on either side of a radius are firmly soldered together; vertebræ very stout, always entire, though the ventral median groove is very prominent. *Hemieuryalidæ*.

Family 1. **Ophiacanthidæ** (PERRIER, 1891) mihi, 1915.

Disk covered by a soft skin or with fine scales, and usually beset with granules, spines or stumpy tubercles. The radial shield and genital plate articulate with each other by means of a transverse ridge, or a simple face on both the plates. The genital plate and scale on either side of each radius articulate with each other, and are not soldered together. Peristomial plates entire, or rarely triple, very large. Oral frames entire, without well developed lateral wings. Teeth and oral papillæ always present, spiniform as a rule. Dental papillæ rarely present, similar to the oral papillæ. Arms usually knotted, the spine ridges of the lateral arm plates being very prominent; inserted very often laterally, but sometimes ventrally, to the disk. Dorsal and ventral arm plates very small, while the lateral arm plates are very well developed, covering most parts of the arms. Numerous arm spines, variable in number in successive arm joints, long, flagellate, often hyaline and serrate. Vertebrae slender, often incompletely divided into halves by a series of pores. Vertebral articulation zygospondyline or streptospondyline. Upper and lower muscular fossæ equally large.

This family includes thirty-three genera, which may be artificially grouped as follows:

A. Tentacle pores very large and open.

I. Disk extraordinarily bulged up, covered by a naked skin or with fine scales; radial shields absent.

Ophiothobia LYMAN, 1880.

Ophiomyces LYMAN, 1869.

II. Disk not very high, covered by a naked skin or merely with fine scales; radial shields small or rudimentary.

Ophiocimbium LYMAN, 1880.

Ophiologimus CLARK, 1911.

Amphipsila VERRILL, 1899.

Ophiophrura CLARK, 1911.

Ophiotoma LYMAN, 1883.

Ophioblenna LÜTKEN, 1859.

III. Disk beset with granules or spines; radial shields small or rudimentary.

Ophiopora VERRILL, 1899.¹⁾

Ophiotrema KÖHLER, 1907.¹⁾

Ophiambix LYMAN, 1880.²⁾

Ophiomedeia KÖHLER, 1906,

Ophiopristis VERRILL, 1899.

Ophioprium CLARK, 1915.

B. Tentacle pores small and inconspicuous.

IV. Radial shields small, short.

Microphiura MORTENSEN, 1910.

Ophiolinna VERRILL, 1899.

Ophiomitrella VERRILL, 1899.

Ophiophthalmus, nov.

Ophientrema VERRILL, 1899.

Ophioscalus VERRILL, 1899.

Ophiocopa LYMAN, 1893.

Ophiochondrella VERRILL, 1899.

Ophiosemmotes, nov.

1) These genera have been stated by CLARK, 1915, to be congeneric with *Ophiotoma*, notwithstanding that they differ from it in the covering of the disk. It is of course true that these three genera resemble one another in the large tentacle pores. But this character is also common to all the genera belonging to the group A. So that I am obliged to disagree with him.

2) This genus is very doubtful in position. I provisionally refer it here, merely because the tentacle pores and scales remind us of those of *Ophiophrura* and *Ophiotrema*.

V. Radial shields long, narrow, bar-like.

Ophiacantha MÜLLER & TROSCHEL, 1842.*Ophialcea* VERRILL, 1899.*Ophiacanthella* VERRILL, 1899.*Ophiolebes* LYMAN, 1878.

VI. Radial shields large, long, wide.

Ophiothamnus LYMAN, 1869. (= *Ophioleda* KÄHLER, 1906).*Ophiurothamnus*, nov.*Ophiomytis* KÄHLER, 1904.*Ophioplinthaca* VERRILL, 1899.*Ophiomitra* LYMAN, 1869.*Ophiocamax* LYMAN, 1878.

As the present family includes both those forms with only horizontally flexible arms and those with more or less coiled arms, two types of internal structures are also distinguishable roughly. The first type, found in those forms with only horizontally flexible arms, is characterised by the very thin, delicate, sometimes divided peristomial plates, the slender oral plates and frames, the very slender vertebræ, the very thin wings of the basal vertebræ, the more or less divided distal vertebræ and the zygospondyline vertebral articulation. The second type, found in those with more or less coiled arms, is characterised by the very thick, always entire peristomial plates, the more or less stout oral plates and frames, the more or less short, stout, always entire vertebræ, the more or less thick wings of the basal vertebræ and the usually streptospondyline vertebral articulation. The internal structures of *Ophiothamnus venustus* MATSUMOTO is almost perfectly similar to those of *O. vicarius* LYMAN. The peristomial plates are very large, thin and triple, the two paired secondary plates forming an out-

wardly open angle, which is occupied by the unpaired median one. The oral plates and frames are short and slender. The genital plates are long, more or less club-shaped, lying closely parallel in pairs, just above the arm base. The genital scales are absent. The genital bursæ are very rudimentary, being represented merely by the creases between the interbrachial ventral surfaces and the arm bases. The generative glands are enclosed in a membranous sac, the wall of which contains fine, thin, transparent scales, when viewed under the microscope, just as is stated by MORTENSEN to be the case in *Ophiopus arcticus*. The vertebræ are very slender, and those of the distal arm joints are imperfectly divided into halves by a series of pores, just as in *Microphiura* according to MORTENSEN. The last named genus is stated to lack the genital plates and scales and to have entire or divided peristomial plates, besides an additional plate, which is perforated by a pore just between the peristomial plates and the oral shield. I imagine that the perforated plate just referred to may correspond to the unpaired secondary plate of the peristomial system, because I know that in certain genera the unpaired secondary plate has a half pore on its outer border. In *Ophiolimna antarctica* (LYMAN) and *O. papillata* (CLARK), the peristomial plates are large, wide, short, thin, imperfectly divided, with soldered halves, the oral plates and frames are short and slender, and the genital plates and scales and genital bursæ are normal. In *Ophiologimus hexactis* CLARK, the internal structures are essentially similar to those of *Ophiolimna*, which has also imperfectly divided peristomial plates. The radial shields though externally invisible, are present and short and rounded. Also in this species I was able to prove that the distal vertebræ are imperfectly divided by a series of pores. According to LYMAN, *Ophiomyces*

frutectosus LYMAN has no peristomial plates, but the oral plates and frames are of an elegant shape and curiously twisted; the genital plates are thin, wide, long, and curved over the dorsal side of the arm base; no genital scales; the basal vertebræ, have large and thin wings without marginal grooves, and the vertebral articulation is very peculiar with a large articular umbo and no articular peg.

Certain species of *Ophiacantha* appear to stand at the very base of the second type, which is found in those forms with the arms more or less capable of coiling vertically. In *Ophiacantha bidentata* (LINNÉ), the peristomial plates are very large, simple, rather thick, the oral plates and frames are more or less stout, the vertebræ are comparatively stout, and the vertebral articulation is perfectly streptospondyline, the articular peg being absent. On the contrary, *Ophiacantha cuspidata* LYMAN is stated by the author to have the zygospondyline vertebral articulation, with a well formed articular peg. In *Ophiolebes tuberosa* MATSUMOTO, the peristomial plates are very large, wide, thick, firmly fixed to the oral frames, which are also very stout, and bear each two small supplementary plates on the outer border. The vertebræ are short and stout, with decidedly thick wings. The vertebral articulation is of course streptospondyline. The genital plates and scales are peculiarly undulated. The radial shields are narrow and bar-like. The internal structures of *Ophiosemmotes adidisca* (CLARK) much resemble those of the preceding, save that the radial shields are wide, rounded and joined in pairs in internal view. According to LYMAN, *Ophiocamax hystrix* LYMAN has very stout oral plates and frames, to which the peristomial plates are perfectly soldered, very stout and short vertebræ with very thick wings and a perfectly streptospondyline vertebral articulation. The vertebræ of *Ophio-*

chondrella squamosa (LYMAN) are quite like those of *Ophiolebes*. Taking all the characters into consideration, *Ophiolebes*, *Ophiosemmotes*, *Ophiochondrella*, *Ophiocamax*, &c. appear to me to represent one of the two types of the *Ophiacanthidae*.

Key to Japanese genera of *Ophiacanthidae*.

- A*—Tentacle pores very large and open; oral shields entirely separated from the first lateral arm plates by the adoral shields.
- a*—Disk extraordinarily bulged up, covered with fine scales; radial shields absent; numerous large, flat, spatulate oral papillæ; numerous flattened arm spines; tentacle scales spatulate *Ophiomyces*.
- aa*—Disk not very high.
- b*—Disk finely imbricated, entirely free of granules or spines; tentacle scales present.
- c*—Outer oral papillæ not especially long; ventral arm plates longer than wide; three arm spines; two very small, leaf-like tentacle scales *Ophiologimus*.
- cc*—Outermost three oral papillæ very long, slender, spiniform, arising from the adoral shields; ventral arm plates wider than long; four arm spines; three or four spiniform tentacle scales *Ophiophrura*.
- bb*—Disk closely beset with granules or spines.
- d*—Dorsal arm plates entire; no tentacle scales *Ophiopora*.
- dd*—Dorsal arm plates absent, dorsal side of arms, as well as disk, being closely beset with spines; three or four spiniform tentacle scales *Ophiambix*.
- AA*—Tentacle pores small and inconspicuous.
- e*—Arm plates and arm spines not covered over by a cereous skin.
- f*—Radial shields small or moderate.
- g*—Radial shields short, rounded or triangular.
- h*—Disk closely covered with granules; oral shields separated from the first lateral arm plates by the adoral shields; oral angles beset with granules; outermost oral papilla large and operculiform . . *Ophiolimna*.

- lh*—Disk scales visible, sparsely beset with granules, spines or stumpy tubercles; oral shields usually joined with the first lateral arm plates; oral angles free of granules.
- i*—Arms strongly knotted, with very prominent spine ridges; arm spines of both sides of free basal joints approximating dorsally; dorsal arm plates very small, widely separated from each other by the lateral arm plates *Ophiomitrella*.
- ii*—Arms not very knotted; arm spines of both sides not approximating dorsally; dorsal arm plates not very small, in contact with each other at least in proximal arm joints.
- j*—Basal tentacle pores not especially large; single flat tentacle scale to each pore; radial shields oval *Ophiophthalmus*.
- jj*—Several first tentacle pores especially large, while the outer ones are very small; no true tentacle scales, which are represented by a number of lowest arm spines much smaller than the upper ones...
..... *Ophientrema*.
- gg*—Radial shields long, narrow, bar-like.
- k*—Radial shields separated from each other; disk, as well as radial shields, more or less closely covered with granules, spines or stumpy tubercles *Ophiacantha*.
- kk*—Radial shields perfectly joined in pairs, naked; disk sparsely beset with spines or granules, the disk scales being quite distinct.....
..... *Ophiacanthella*.
- ff*—Radial shields large, long and wide; disk scales quite distinct.
- l*—Oral papillæ arranged in a regular series.
- m*—Outermost oral papillæ large and operculiform; arms strongly knotted, with very prominent spine ridges; arm spines of both sides of free basal joints approximating dorsally; dorsal arm plates very small, widely separated from each other by the lateral arm plates.
- n*—Disk distinctly five-lobed; radial shields divergent, those of a pair slightly in contact in the outer parts; oral shields small, separated from the first lateral arm plates by the adoral shields; interbrachial ventral surfaces covered with numerous fine scales; genital bursæ

- rudimentary, being represented merely by the creases between the interbrachial ventral surfaces and arm bases..... *Ophiothamnus*.
- nn*—Disk not distinctly five-lobed; radial shields joined in pairs nearly along the entire length; oral shields large, joined with the first lateral arm plates; each interbrachial ventral surface covered chiefly with two or three very large scales; genital bursæ well developed. . . *Ophiurothamnus*.
- mm*—Outermost oral papilla not especially large; arms not very knotted; arm spines of both sides never approximating dorsally; dorsal arm plates rather large, in contact with each other at least in proximal arm joints; disk distinctly five-lobed; special marginal disk scales well developed..... *Ophioplinthaca*.
- ll*—Numerous oral papillæ not in a single series, but clustered along the sides and at the top of each jaw, or at least on both sides of the outer end of each oral slit.
- oo*—Disk distinctly five-lobed; special marginal disk scales well developed; radial shields separated from each other; single tentacle scale to each pore..... *Ophiomitra*.
- oo*—Disk not distinctly five-lobed; special marginal disk scales absent; radial shields joined in pairs along the entire length; usually three tentacle scales forming a tube for the ventrally turned up tentacle..... *Ophiocamax*.
- ee*—Arm plates and arm spines covered over by a cereous skin.
- p*—Radial shields long, narrow, bar-like..... *Ophiobebes*.
- pp*—Radial shields short, rounded or triangular..... *Ophiosemnotes*.

***Ophiomyces spathifer* LYMAN.**

Ophiomyces spathifer: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 47, Pl. XIV, figs. 386–388; LYMAN, Rep. Challenger, V, p. 240, Pl. XIX, figs. 10–12.

Yenshû Sea; 565 fathoms (LYMAN).

***Ophiologimus hexactis* CLARK**

Ophiologimus hexactis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 252, fig. 123.

One specimen ; Mera-out-Oisegaké, Sagami Sea ; 350 fathoms.

One specimen ; off Ôshima ; 90–100 fathoms.

Off Suno Saki, Sagami Sea ; 83–158 fathoms (CLARK).

Though the radial shields are externally invisible, they have been proved to be present by dissection, and are very small, short, bar-like, widely separated from each other. My specimens also invariably show an indication of schizogony, for they are six-armed, three arms being distinctly smaller than the other three.

Ophiophrura liodisca (CLARK).

Ophiophrura liodisca : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 249, fig. 121.

Off Omai Saki, Yenshû Sea ; 475–505 fathoms (CLARK).

Ophiopora megatrema (CLARK).

Ophiacantha megatrema : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911 p. 237, fig. 113.

Off eastern Japan ; 587–943 fathoms (CLARK):

As stated by Kœhler, *Ophiopora* and *Ophiotrema* are closely related to each other. All the members of these genera, i.e. *Ophiopora bartletti* (LYMAN, 1883), *O. paucispina* (LÛTKEN & MORTENSEN, 1899), the present species and *Ophiotrema alberti* Kœhler, 1894, have visible disk scales, large adoral shields, which separate the oral shields from the first lateral arm plates, narrow oral angles, gaping oral slits, very large tentacle pores and distally notched ventral arm plates. I look upon the present species to be an *Ophiopora* standing next to *Ophiotrema*, because the distal oral papillæ are differentiated in size from the inner ones, quite like those of *Ophiotrema*, while the total absence of tentacle scales is a character of *Ophiopora*.

Ophiambix aculeatus LYMAN.

Ophiambix aculeatus: LYMAN, Anniv. Mem. Boston Soc. Nat. Hist., 1880, p. 11, Pl. II, figs. 29-31; LYMAN, Rep. Challenger, V, 1882, p. 235, Pl. XXVII, figs. 10-12; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 114.

Colnett Strait; 1,008 fathoms (CLARK).

Near Fiji Is.; 1,350 fathoms (LYMAN).

Ophiolimna VERRILL, 1899, emend.

Disk covered with fine granules, the radial shields being usually concealed. Oral shields large, wide, separated from the first lateral arm plates by the adoral shields. Oral angles more or less granulated. Four to six oral papillæ, of which the outermost one is very large and operculiform. Arms slender, horizontally flexible. Ventral arm plates wider than long, not in contact with each other. Four to seven arm spines, long, glassy. Single large, leaf-like tentacle scale to each pore.

This genus includes *Ophiacantha bairdi* LYMAN, 1883 (referred to *Ophiolimna* by VERRILL, 1899), *Ophioconis antarctica* LYMAN, 1879, *Ophiacantha perfida* KÆHLER, 1904, *Ophiolimna operculata* KÆHLER, 1907, *Ophioconis diastata* CLARK, 1911, *O papillata* CLARK, 1911 and *Ophiacantha lambda* CLARK, 1911.

Ophiochaeta(?) *mixta* LYMAN, 1878 (referred to *Ophiolimna* by VERRILL, 1899) and *Ophiolimna littoralis* KÆHLER, 1912, are in my opinion not genuine *Ophiolimna*, being different from it in the more numerous oral papillæ, of which the outermost one is small and stretches inwards above the next papilla; in the well developed ventral arm plates, which are fully in contact with each other; and in the presence of two tentacle scales, of which the abradial

one overlaps the base of the lowest arm spine. (See under *Ophiodermatidæ*.)

Key to Japanese species of *Ophiolimna*.

- A*—Radial shields entirely covered over.
- a*—Disk granules very fine; four to five arm spines rather blunt, somewhat longer than the corresponding arm joint *diastata*.
- aa*—Disk granules coarse, mingled with some scattered spines; seven acute arm spines, longer ones about thrice as long as the corresponding arm joint *bairdi*.
- AA*—Radial shields partially naked; disk granules coarse and elongated; five acute arm spines, of which the uppermost is the longest and about thrice as long as the corresponding arm joint..... *lambda*.

Ophiolimna diastata (CLARK).

Ophiocoris diastata: CLARK, Bull. U. S. Nat. Mus., LXXV, p. 27, fig. 3.
Off Shio Misaki; 244–253 fathoms (CLARK).

Ophiolimna bairdi (LYMAN).

Ophiacantha bairdi: LYMAN, Bull. Mus. Comp. Zool., X, 1883, p. 256, Pl. V, figs. 70–72; LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 177, Pl. VIII, figs. 9–13; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 230.

Ophiolimna bairdi: VERRILL, Bull. Labor. Nat. Hist. State Univ. Iowa, V, No. 7, 1899, p. 44¹⁾; VERRILL, Transact. Connecticut Acad., X, 1899, p. 345.

Off Mikawa, Yenshû Sea; 943 fathoms (CLARK).

Bering Sea. Alaska. Washington. Gulf of Panama. Caribbean Sea. Eastern Atlantic.

1) This paper was not seen by me.

Ophiolimna lambda (CLARK).

Ophiacantha lambda: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 231, fig. 108.

Off Hiuga, southern Japan; 437 fathoms (CLARK).

Key to Japanese species of *Ophiomitrella*.

- A—Radial shields wider than long; four oral papillæ, of which the outermost one, arising from the first ventral arm plate, stretches above the next papilla; ventral arm plates not in contact with each other; seven or eight arm spines, of which the uppermost is the longest *stellifera*.
- AA—Radial shields about as wide as long; six oral papillæ on either side; ventral arm plates slightly in contact with each other; nine or ten arm spines, of which the uppermost and lowest are the shortest *polyacantha*.

Ophiomitrella stellifera, sp. nov.

Two specimens; off Inatori, Izu. One specimen; Locality unknown.

Diameter of disk 4 mm. Length of arms 20 mm. Width of arms at base 0.8 mm.

Disk almost circular but with a small indentation in each interbrachial border, flat, covered with coarse, stout, partly imbricated scales, which almost invariably bear each a large stumpy tubercle with a six-rayed stelliform crown. Radial shields very small, irregularly triangular, with much rounded inner angle, a little larger than the disk scales, wider than long, separated from each other. Interbrachial spaces below covered with a few coarse, irregular, imbricated scales, without any stumpy tubercles. Genital slits short.

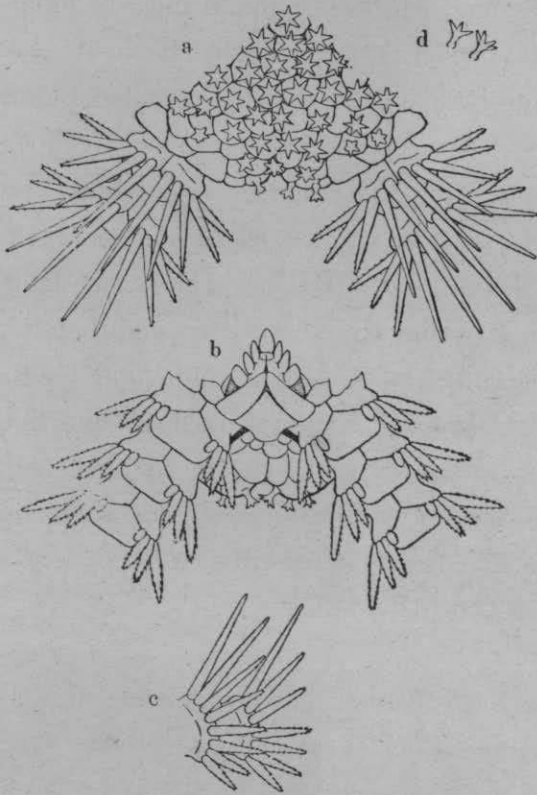


Fig. 27. *Ophiomitrella stellifera*. $\times 12$. a. From above.
 b. From below. c. Side view of two arm joints near disk.
 d. Side view of two disk tubercles.

Oral shields large and stout, pentagonal, with acute inner and lateral angles, rounded outer angles, concave outer lateral sides and curved outer side. Adoral shields large, long, stout, three-sided, with rounded angles and nearly straight adradial and convex abradial sides, meeting each other. Three oral papillæ on either side; the outermost one is very large, flattened and blunt; the rest are conical, somewhat flattened, obtusely pointed. There is an additional pointed papilla,

which arises from the first ventral arm plate and is directed inwards. Teeth stout, triangular, obtuse.

Arms strongly knotted. Dorsal arm plates in the proximal part very small, three-sided, with strongly convex outer side and very wide inner angle, much wider than long, with convex surface; more distally, they become more or less regularly triangular and as long as, or longer than, wide. Lateral arm plates very well developed, strongly constricted at the middle of each joint, those of the two sides meeting each other both above and below. First

ventral arm plate small, pentagonal, with wide and truncated inner angle and curved outer side, wider than long. The rest are large, pentagonal, with wide inner angle and perfectly rounded outer angles, much wider than long. Arm spines long, slender, hyaline, flattened and thorny, except the uppermost one or two which are nearly terete; upper ones longer; the uppermost spine is about two to three times, and the lowest one about two-thirds, as long as the corresponding arm joint. From the seventh or eighth joint outwards the lowest spine is transformed into a compound hook, being slightly bent inwards and bearing series of hooklets on the inner side. The arm spines are seven or eight in number and approximated dorsally in the basal joints, but rapidly decrease in number outwards, so that they are four or five in the tenth joint. One tentacle scale, small, oval and flat.

Colour in alcohol white.

In one of the specimens, the tubercles of the disk are fewer, but in the second, they are larger, and the stelliform crowns are more complex, some of the rays bearing two or three denticles each. In the third specimen, the disk scales are coarser than in the other two, and the radial shields are slightly longer than wide.

This new species is near to *Ophiomitrella partita* (LÜTKEN & MORTENSEN, 1899), but differs from it chiefly in the smaller radial shields, in the disk tubercles having more slender stem and larger crown, in the arm spines being approximated dorsally in the first basal joints, and in the lowest arm spine being transformed into a compound hook. The six rays of the crown of the disk tubercles are formed by the bifurcation of the three primary rays, so that the disk tubercles are fundamentally of the same plan in both species.

Ophiomitrella polyacantha (CLARK).

Ophiomitra polyacantha: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 187, fig. 86.

Eastern Sea; 103 fathoms (CLARK).

Ophiophthalmus, g. nov.

Disk covered with more or less imbricating, irregular scales, and may be beset with coarse granules. Radial shields naked, rounded or oval. Three to six oral papillæ on either side. Teeth arranged in a single vertical row. Dental papillæ absent. Dorsal arm plates in contact with each other in the basal arm joints. Numerous arm spines, long, conical, opaque, hardly serrate, never approximating dorsally. Usually a single large, flat, leaf-like tentacle scale to each pore.

This new genus includes *Ophiacantha normani* LYMAN, 1879 (referred to *Ophiomitra* by LYMAN, 1882), *Ophiomitra granifera* LÜTKEN & MORTENSEN, 1899, *Ophiacantha relictæ* KÖHLER, 1904, *Ophiomitrella mutata* KÖHLER, 1904, *O. languida* KÖHLER, 1904, *O. placida* KÖHLER, 1904, *Ophiomitra microphylax* CLARK, 1911, *O. codonomorpha* CLARK, 1911, *Ophiacantha leucorhabdota* CLARK, 1911, *O. euryppoma* CLARK, 1911, *O. hylacantha* CLARK, 1911, *Ophiomitrella americana* KÖHLER, 1914, &c., besides the genotype, *Ophiacantha cataleimmoida* CLARK, 1911.

The present genus is very nearly allied to *Ophiomitrella*, but differs from it in the comparatively well developed dorsal arm plates, the basal ones being in contact with each other, and in the arm spines not approximating dorsally in the basal arm joints. Further, this genus differs from the genuine *Ophiacantha* in the short and rounded radial shields and in the coarser disk scales.

In my opinion, the shape of the radial shields is an important character in the systematic of the present family. The radial shields of the genuine *Ophiacantha* are long, narrow and bar-like. In VERRILL'S key, the species of *Ophiophthalmus* would appear as belonging to *Ophialcea*, but the latter is a close ally of *Ophiacantha*, with long and bar-like radial shields.

Key to Japanese species of *Ophiophthalmus*.

- A*—Disk beset with some granules, or sometimes with spines; a single large tentacle scale to each pore.
- a*—Disk with granules only, without spines.
- b*—Disk granules abundant, uniformly distributed on both the dorsal and ventral sides.
- c*—Radial shields small, widely separated from each other; several granules occur at the outer border of the dorsal arm plates of basal free arm joints; four or five oral papillæ, of which the outermost one arises from the first ventral arm plate.
- d*—Disk scales coarse; outer second oral papilla very large, wide; six or seven arm spines *cataleimmoidus*.
- dd*—Disk scales fine; innermost oral papilla largest; four arm spines ..
..... *normani*.
- cc*—Radial shields large, lying closely side by side in pairs, but not in contact with each other; six oral papillæ on either side; eight or nine arm spines *leucorhabdotus*.
- bb*—Disk granules few, being present only in the central parts of the dorsal surface, radial shields large, widely separated from each other; three oral papillæ on either side; eight arm spines.....
..... *codonomorpha*.
- aa*—Disk beset with stout rough spines, besides granules; radial shields moderately large; four oral papillæ on either side; eight arm spines *hylacantha*.
- AA*—Disk beset with many stumpy tubercles with stelliform crowns; radial

shields very small, widely separated from each other; six or seven oral papillæ on either side, the outermost two arising from the adoral shield; oral shields separated from the first lateral arm plates; six arm spines; a single very small tentacle scale. *microphylax*.

Ophiophthalmus cataleimmoidus (CLARK).

Ophiacantha cataleimmoida: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 217, fig. 100.

Three specimens; off Misaki, Sagami Sea. Numerous specimens, probably the young of the present species; off Misaki, Sagami Sea.

Off Omai Zaki; 475–624 fathoms (CLARK). Uraga Channel; 302 fathoms (CLARK). Yenshû Sea, 507 fathoms (CLARK). Off Kurile Is.; 229 fathoms (CLARK).

Bering Sea. Alaska.

The disk scales are very coarse, stout, partially imbricated, or rather tessellated and with distinct sutures, each scale bearing several granules, which are never situated on the sutures, except in the peripheral zones of the

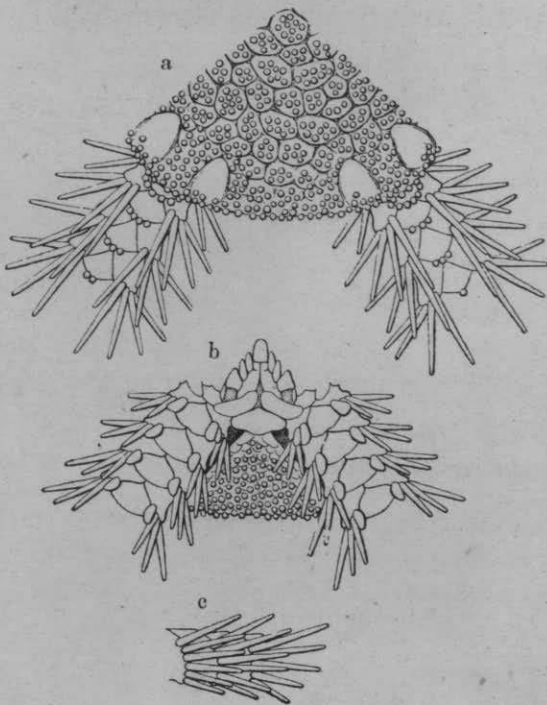


Fig. 28. *Ophiophthalmus cataleimmoidus*. $\times 5\frac{1}{2}$. a. From above. b. From below. c. Side view of three arm joints near disk.

disk, where the sutures are more or less obscured.

Ophiophthalmus normani (LYMAN).

Ophiacantha normani: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 58, Pl. XVI, figs. 414-416; LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 170, Pl. XVI, figs. 1-4; VERRILL, Trans. Connecticut Acad., X, 1899, p. 349 & 353; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 215.

Ophiomitra normani: LYMAN, Rep. Challenger, V, 1882, p. 208, Pl. XXVI, figs. 9-11.

Eastern Sea; 95-106 fathoms (CLARK). Yenshû Sea; 565-662 fathoms (LYMAN, CLARK). Sagami Sea; 345-775 fathoms (LYMAN, CLARK). Off eastern Japan; 440-629 fathoms (CLARK). South of Hokkaido; 464 fathoms (CLARK). Yezo Strait; 533 fathoms (CLARK). Okhotsk Sea; 75-510 fathoms (CLARK).

Bering Sea. Alaska. Off Washington. West coast of Mexico.

Ophiophthalmus leucorhabdotus (CLARK).

Ophiacantha leucorhabdota: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 222, fig. 102.

Eastern Sea; 103-152 fathoms (CLARK).

Ophiophthalmus codonomorpha (CLARK).

Ophiomitra codonomorpha: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 189, fig. 87.

Off Mikawa, Yenshû Sea; 943 fathoms (CLARK).

Ophiophthalmus hylacantha (CLARK).

Ophiacantha hylacantha: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 227, fig. 106.

Off Omai Zaki; 918 fathoms (CLARK).

Ophiophthalmus microhylax (CLARK).

Ophiomitra microhylax: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 184, fig. 84.

Eastern Sea; 103–152 fathoms (CLARK).

Ophientrema VERRILL, 1899.

CLARK¹⁾ says that his *Ophiacantha leucosticta* “is almost certainly entitled to be the type of a new genus, the large amount of uncalcified skin and the peculiar condition of arm spines and tentacle scales furnishing good generic characters.” As far as I can judge, the species in question belongs to VERRILL’S subgenus *Ophientrema*, being identical with *Ophiacantha (Ophientrema) scolopendrica* LYMAN, 1883.

Though *Ophientrema* was established as a subgenus of *Ophiacantha*, I am inclined to rank it as a distinct genus, because the shape of the radial shields, the large basal tentacle pores, the peculiar lower arm spines and tentacle scales, &c. are different from those of the genuine *Ophiacantha*. This procedure would naturally satisfy the need felt by CLARK.

Key to species of *Ophientrema*.

- A—Disk covered with fine imbricating scales, and with minute, thorny, scattered tubercles *euphylacteum*.
 AA—Disk covered by a soft skin, scales being distinct only near the radial shields, and with minute, scattered granules.. *scolopendricum*.

Ophientrema euphylacteum.

Ophiacantha euphylactea: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 225, fig. 105.

1) Bull. U. S. Nat. Mus., LXXV, 1911, p. 236.

Off Manazuru Zaki, Sagami Sea; 120-265 fathoms (CLARK).

Ophientrema scolopendricum (LYMAN).

Ophiacantha scolopendrica: LYMAN, Bull. Mus. Comp. Zool., X, 1883, p. 259, Pl. VI, figs. 85-87.

Ophiacantha (Ophientrema) scolopendrica: VERRILL, Transact. Connecticut Acad., X, 1899. p. 332.

Ophiacantha leucosticta: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 235, fig. 111.

Yenshû Sea; 565 fathoms (LYMAN), 507 fathoms (CLARK).

Key to Japanese species of *Ophiacantha*.

- A*—Oral papillæ arranged in a single series.
- a*—Single tentacle scale to each pore.
- b*—Arm spines smooth.
- c*—Disk covered with spines or stumpy tubercles.
- d*—Disk tubercles ending with a thorny crown.
- e*—Four to seven arm spines.
- f*—Four arm spines, which are shorter than the corresponding arm joint *dallasii*.
- ff*—Five or more arm spines, of which the upper ones are distinctly longer than the corresponding arm joint.
- g*—Five or six arm spines; outer end of the radial shields naked.. *enigmatica*.
- gg*—Seven arm spines; radial shields entirely covered over.
- h*—Outermost oral papilla very large and wide.
- i*—Outermost oral papilla much wider than long; tentacle scales acute..
..... *levispina*.
- ii*—Outermost oral papilla longer than wide; tentacle scales large, flat, blunt *omoplata*.
- hh*—Outermost oral papilla not especially large and wide.
- j*—Oral shields wide, with acute lateral angles; tentacle scales very small, spiniform and acute..... *pentagona*.

- jj*—Oral shields not very wide, with rounded lateral angles; tentacle scales oval, flat, bluntly pointed *adiaphora*.
- ee*—Ten or eleven arm spines; stumpy tubercles of the disk very short; oral shields wide; tentacle scales large, long, acute..... *anchilabra*.
- dd*—Disk covered only with spines.
- k*—Three oral papillæ on either side; no spines along the outer border of basal dorsal arm plates.
- l*—Disk spines smooth; outermost oral papilla very long and spiniform; eight or nine arm spines; tentacle scales conical, acute.....
..... *lophobrachia*.
- u*—Disk spines rough; outermost oral papilla flat and clavate; ten or eleven arm spines; tentacle scales long and flat..... *acanthinotata*.
- kk*—Six oral papillæ on either side; a row of spines present along the outer border of basal dorsal arm plates; eight arm spines; tentacle scales acute..... *inutilis*.
- cc*—Disk covered with granules; seven or eight arm spines; tentacle scales large..... *bidentata*.
- bb*—Arm spines serrate.
- m*—Oral papillæ and tentacle scales smooth.
- n*—Disk covered with fine scales and sparsely beset with rough, stout spines; six arm spines *prionota*.
- nn*—Disk covered with thorny, stumpy tubercles, among which several long, thorny spines are mingled; nine arm spines *diploa*.
- mm*—Oral papilla and tentacle scales rough; disk tubercles ending with a thorny crown; six to eight arm spines *rhachophora*.
- aa*—Two tentacle scales to each pore; disk covered with fine granules; six arm spines, flattened, smooth *bisquamata*.
- AA*—Oral papillæ not arranged in a single series, but the outer ones clustered around the second oral tentacle pore; disk covered with short, granule-like spines; twelve serrate arm spines; single tentacle scale to each pore *rosea*.

Ophiacantha dallasii DUNCAN.

Ophiacantha dallasii: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 471, Pl. XI, figs. 25-27; LYMAN, Rep. Challenger, V, 1882, p. 199; DÖDERLEIN, SEMON-Zool. Forschungsr. Australien u. Malayischen Archipel, V, 1896, p. 291, Pl. XIV, figs. 3a-3c, Pl. XVI, figs. 12-12a.

Off Korea, Sea of Japan; 50 fathoms (DUNCAN).

Amboina (DÖDERLEIN).

Ophiacantha enigmatica, sp. nov.

Seven specimens; off Misaki, Sagami Sea.

Diameter of disk 5 mm. Length of arms 25 mm. Width of arms at base 1.2 mm.

Disk pentagonal, with concave interbrachial borders, flat, thin, covered by a thick skin, containing rather fine, rounded, thin, irregular scales, which become distinct when dried; sparsely beset with small stumpy tubercles, which are bifid or crown-

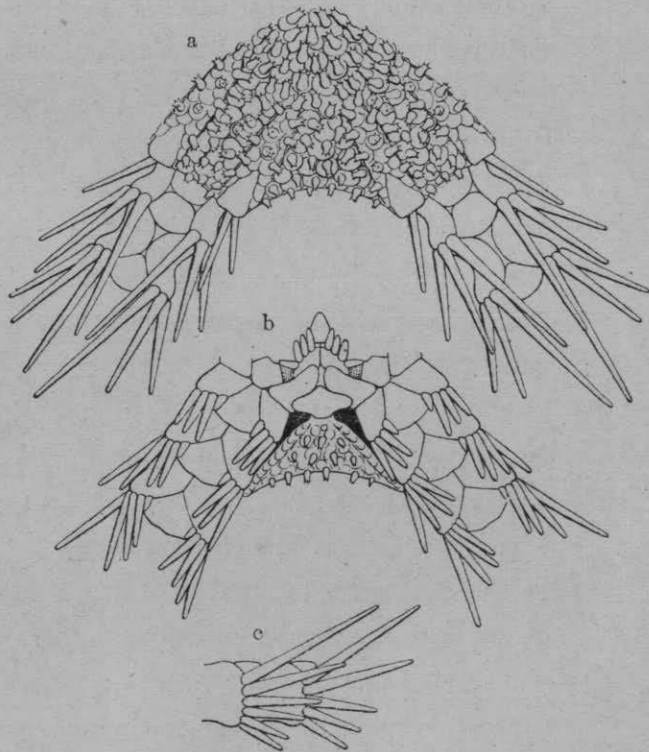


Fig. 29. *Ophiacantha enigmatica*. $\times 12$. a. From above. b. From below. c. Side view of two arm joints near disk.

ed with a few thorns. Radial shields raised, long, narrow, about two-thirds as long as the disk radius, those of the same pair parallel to each other. They are covered by the skin, and usually also by the scales except at the outer ends. In some specimens, they are almost entirely free from the scales. Interbrachial ventral surfaces similar to the dorsal side, but the stumpy tubercles are fewer and finer. Genital slits large, long, almost reaching the disk margin, much widened and rounded at the inner ends.

Oral shields small, rhomboidal, with concave sides and perfectly rounded lateral and outer angles, inner angle like a beak, so that the inner sides form a brace-shape; very short, about twice as wide as long. Adoral shields large, stout, with concave adradial side, more or less separated from each other by a naked, depressed space, or sometimes entirely in contact. Three or four oral papillæ on either side, long, conical, rather obtuse; the outermost one is directed laterally and protects the second oral tentacle pore; the next is the stoutest. Five or six teeth, obtuse or sometimes widened at the free end, with two or three irregular denticles, except the uppermost one, which is acute and is the longest.

Arms rather stout, uniformly tapered, knotted, with very long joints. First two dorsal arm plates quadrangular, with very convex outer side, wider than long, in contact with each other. The second is the largest, and is wider without than within. Those following are small, triangular, with very convex outer side, slightly longer than wide, not in contact with each other. Lateral arm plates well developed, with prominent spine ridges, meeting each other above and below, except between the first and second ventral arm plates and between the first and second dorsal plates; besides, the second and third dorsal plates often do not meet,

leaving a long, narrow, naked space. First ventral arm plate small, hexagonal, with concave inner side, about as wide as long. The second is the largest, and is triangular, with truncated inner angle and curved outer border, a little wider than long, in contact with the first plate. The rest are triangular, with acute inner angle and curved outer border, wider than long, separated from each other by the lateral arm plates. The outer border of the ventral plates consists indistinctly of three portions, of which the median is very slightly concave. Five or six arm spines, long, slender, spiniform, terete, solid, entire, except the lower spines, which are slightly thorny at the tips. The upper spines are longer than the lower. The uppermost one is about twice as long as, and the lowest a little shorter than, the corresponding arm joint. The lower spines are crowded and lie flat on the ventral surface of the arms. One tentacle scale, very minute, acutely pointed.

Colour in alcohol: disk light yellowish gray, arms light yellow.

This species is very near to *O. trachybactra* CLARK, 1911, but differs from it chiefly in the fewer disk tubercles, in the fewer oral papillæ, in the shape of the oral shields and ventral arm plates, and in the fewer arm spines, which are never club-shaped.

Like *O. trachybactra*, this species has some external resemblances to *Ophiolebes*. However, I believe with CLARK, that it is more natural to place it in *Ophiacantha* than in *Ophiolebes*.

Ophiacantha levispina LYMAN.

Ophiacantha levispina: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 147, Pl. X, fig. 277; LYMAN, Rep. Challenger, V, 1882, p. 196, Pl. XXV, figs. 1-3; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 198.

Sea of Japan ; 224–248 fathoms (CLARK). Off Kii, Kumano Sea ; 507–649 fathoms (CLARK). Off Omai Zaki ; 624 fathoms (CLARK). Off Hiuga ; 720 fathoms. Eastern Sea ; 361–440 fathoms (CLARK).

Malaysian waters.

Ophiacantha omoiplata CLARK.

Ophiacantha omoiplata : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 202, fig. 93.

Off Korea ; 136 fathoms (CLARK).

Ophiacantha pentagona KÖHLER.

Ophiacantha pentagona : KÖHLER, Ann. Sci. Nat. Zool., 8° Ser., IV, 1897, p. 342 ; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 53, Pl. IV, figs. 27–29 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 196.

Ophiacantha pentagona var. *armata* : KÖHLER, Rés. Camp. Sci. Monaco, XII. 1198, p. 55.

Numerous specimens ; Uraga Channel. Numerous specimens ; Sengenzuka-Aoyamadashi, Sagami Sea ; 85 fathoms. Numerous specimens ; Mera-out-Oisegaké, Sagami Sea ; 300 fathoms. Numerous specimens ; off Ôshima ; 90–100 fathoms.

Off Kii, Kumano Sea ; 191–253 fathoms (CLARK). Off Mikawa, Yenshû Sea ; 943 fathoms (CLARK). Off Port Heda ; 161–167 fathoms (CLARK). Sagami Sea ; 52–153 fathoms (CLARK). Suruga Gulf ; 45–131 fathoms (CLARK). Off Omai Zaki ; 918 fathoms (CLARK). Eastern Sea ; 95–369 fathoms (CLARK). Korea Strait ; 59 fathoms (CLARK).

Malaysian waters. West of Africa.

Ophiacantha adiaphora CLARK.

Ophiacantha adiaphora: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 199, fig. 91.

Sagami Sea; 622 fathoms (CLARK). Sea of Japan; 90-207 fathoms (CLARK). Okhotsk Sea; 68 fathoms (CLARK).

Bering Sea.

Ophiacantha anchilabra CLARK.

Ophiacantha anchilabra: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 205, fig. 95.

One specimen; locality unknown, probably Sagami Sea.

Off Kii, Kumano Sea; 649 fathoms (CLARK). Off Omai Zaki; 918 fathoms (CLARK).

Ophiacantha lophobrachia CLARK.

Ophiacantha lophobrachia: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 232, fig. 109.

Eastern Sea; 152 fathoms (CLARK).

Ophiacantha acanthinotata CLARK.

Ophiacantha acanthinotata: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 203, fig. 94.

Numerous specimens; Okinosé, Sagami Sea. Two specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Gulf of Tokyo; 169 fathoms (CLARK). Eastern Sea; 181 fathoms (CLARK).

Ophiacantha inutilis KOEHLER.

Ophiacantha inutilis: KOEHLER, Exp. Siboga, XLV, Pl. 1, 1904, p. 111, Pl. XXI, figs. 6-8; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 208.

Off Kii, Kumano Sea; 191 fathoms (CLARK). Uruga Channel;
70–197 fathoms (CLARK). Eastern Sea; 440 fathoms (CLARK).
Malaysian waters.

Ophiacantha bidentata (RETZIUS).

Asterias bidentata : RETZIUS, Diss., 1805, p. 33.¹⁾

Ophiura retzii : NILSSON, Coll. Zool. Scand., 1817, p. 15.¹⁾

Ophiocoma arctica : MÜLLER & TROSCHER, Sys. Ast., 1842, p. 103.

Ophiacantha spinulosa : MÜLLER & TROSCHER, *ibid.*, p. 106; LÜTKEN, Addit. ad Hist., I, 1861, p. 65, Pl. II, fig. 14; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 93, figs. 6 & 7.

Ophiacantha grönlandica : MÜLLER & TROSCHER, Arch. Naturg., 1844, p. 183.¹⁾

Ophiocoma echinulata : FORBES, SUTHERLAND'S Journ. Voy. Baffin's Bay II, App., 1852, p. 205.¹⁾

Ophiacantha bidentata : LJUNGMAN, Öfv. K. Vet. Akad. Forh. XXVIII, 1871, p. 652²⁾; LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 149; KÖHLER, Rés. Camp. Sci. Monaco, XII, 1898, p. 55; GRIEG, Fauna Arctica, I, 1900, p. 267; RANKIN, Proc. Acad. Nat. Sci. Philadelphia, 1901, p. 179; NORMAN, Ann. Mag. Nat. Hist., 7th. Ser., XII, 1903, p. 407; KÖHLER, Mem. Soc. Zool. Fr., XIX, 1906, p. 6; KÖHLER, Exp. Sci. Travailleuse et Talisman, VIII, 1907, p. 289; KÖHLER, Bull. Sci. Fr. Belg., XXXIV, 1907, p. 317; KÖHLER, Bull. Mus. d'Hist. Nat., 1909, p. 123; KÖHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909, p. 184; KÖHLER, Bull. Mus. d'Hist. Nat., 1909, p. 123; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 195; KÖHLER, Bull. Mus. d'Hist. Nat., 1913, p. 14; KÖHLER, Bull. U. S. Nat. Mus., LXXXIV, 1914, p. 80.

One specimen; locality unknown.

Sea of Japan; 130–536 fathoms (CLARK). Gulf of Tartary
318 fathoms (CLARK). Off Kurile Is.; 229 fathoms (CLARK).

1) These papers were not seen by me.

Bering Sea. Arctic Ocean. North Atlantic.

Ophiacantha prionota CLARK.

Ophiacantha prionota: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 213, fig. 99.

Off Tanega-shima ; 1,008 fathoms (CLARK).

Ophiacantha diploa CLARK.

Ophiacantha diploa: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 207.

Off Hiuga ; 437 fathoms (CLARK).

Ophiacantha rhachophora CLARK.

Ophiacantha rhachophora: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 201, fig. 92.

Four specimens ; off Inatori, Izu.

Eastern Sea ; 106-139 fathoms (CLARK). Off Omai Zaki ; 475-505 fathoms (CLARK). Off Ôse Zaki, Suruga Gulf ; 63-100 fathoms (CLARK). Sagami Sea ; 83-153 fathoms (CLARK). Uraga Channel ; 197 fathoms (CLARK). Off Kii ; 191-253 fathoms (CLARK). Sea of Japan ; 90-207 fathoms (CLARK).

Bering Sea.

I hesitated at first to refer these specimens to the present species. The distal end of the radial shields is naked but not conspicuous, and the outermost oral papilla arises from the adoral shield. Besides, there occurs one scale-like papilla on the first ventral arm plate, projecting inwards and vertically. These characters are not apparent in CLARK'S figure ; but it is to be remarked that the insertion of the outermost oral papilla is very liable to be misunderstood when the papilla is not turned up but

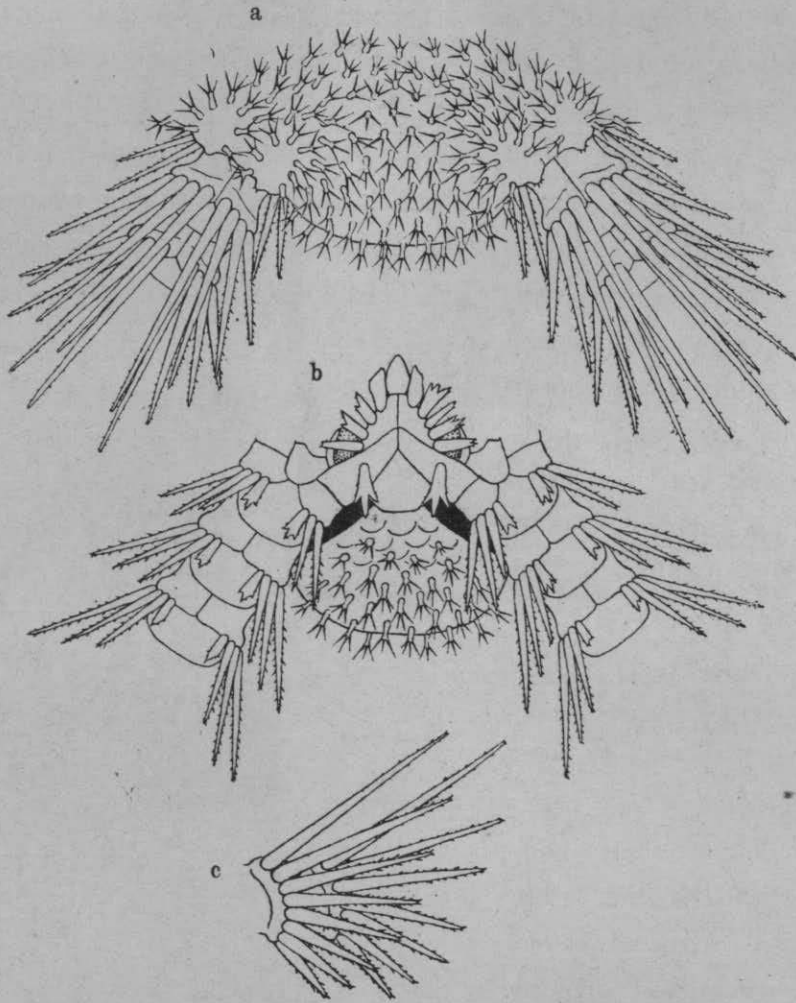


Fig. 30. *Ophiacantha rhachophora*. $\times 18$. a. From above. b. From below.
c. Side view of two arm joints near disk.

directed in the same direction with the others, so that in such a case the oral papillæ appear as shown in CLARK'S figure.

***Ophiacantha bisquamata* MATSUMOTO.**

Ophiacantha bisquamata: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia LXVII, 1915, p. 62.

Two specimens ; off Ôshima, Sagami Sea ; 75-85 fathoms.

Diameter of disk 6 mm. Length of arms 34 mm. Width of arms at base 1.5 mm.

Disk pentagonal, with nearly straight or slightly convex interbrachial borders, flat, soft, closely covered with fine granules, of which eight or nine are contained in 1 mm. Radial shields entirely covered over, very small, bar-like, separated from each other. Interbrachial ventral surfaces similar to the dorsal side, but free of granules and covered with fine scales in the inner parts. Genital slits long, nearly reaching the disk margin.

Oral shields small, rhomboidal, with convex inner sides and rounded outer angle, nearly as long as, or slightly longer than, wide, joined with the first lateral arm plates. Adoral shields small, triangular, pointed inwards, meeting with each other. Five or six oral papillæ on either side of each jaw ; the outermost two are

flat, leaf-like and protect the second oral tentacle pore, while the others are very narrow and acute ; the innermost one, which forms a pair with that of the other side, is infradental. Four or five teeth in a single vertical row, more or less stout, obtuse.

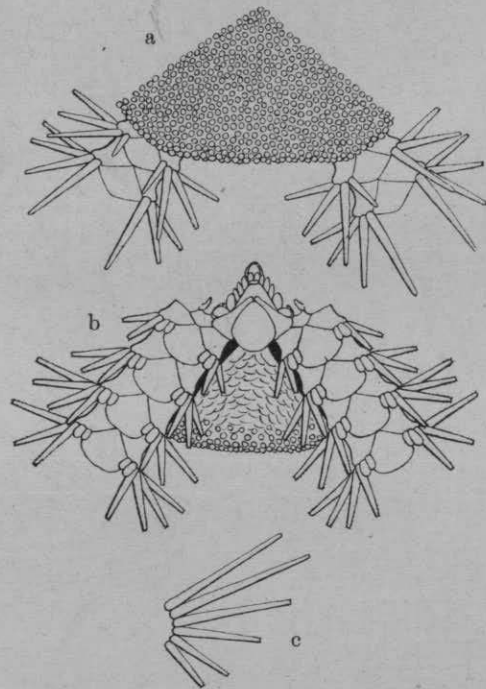


Fig. 31. *Ophiacantha bisquamata*. $\times 8$. a. From above. b. From below. c. Arm spines of one side of an arm joint near disk.

Arms composed of short and wide joints, uniformly tapered. Dorsal arm plates rhomboidal, with very obtuse outer angle, wider than long, slightly in contact with each other, with a more or less distinct median keel, so that the dorsal side of the arm is keeled as a whole. Lateral arm plates with prominent spine ridges, meeting neither above nor below. First ventral arm plate very small, quadrangular, with concave inner side, longer than wide. Those following are moderately large, pentagonal, with convex but slightly notched outer side and rounded outer angles, about as wide as long. Six arm spines, long, flattened, more or less curved, truncate, translucent, but not serrate; the uppermost or the next spine is the longest and is about two and a half times as long as the corresponding arm joint, while the lowest one, the shortest, is slightly longer than the same. Two oval, thin, leaf-like tentacle scales to each pore.

Colour in alcohol: disk grayish brown; one specimen with five white patches, which correspond to the radial shields, the other without any; arms banded with grayish brown and white. The grayish brown parts are dark green and the white parts vivid red in life, according to my own observation on board the "Ikuomaru."

This species more or less resembles *O. bidentata* in the disk coverings, though precise comparison may be dispensed with. The presence of two tentacle scales to each pore, together with the very fine granulation, makes the present species very easy to be recognised.

Ophiacantha rosea LYMAN.

Ophiacantha rosea: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 139, Pl. X, figs. 267 & 268; LYMAN, Rep. Challenger, V, 1882, p. 148, Pl. XXV, figs. 10-12.

Sagami Sea; 420-775 fathoms (LYMAN).

! Lat. $46^{\circ} 40' S.$, long. $37^{\circ} 50' E.$; 310 fathoms (LYMAN). ! Lat. $50^{\circ} 10' S.$, long. $74^{\circ} 42' E.$; 175 fathoms (LYMAN).

Ophiacanthella acantophora (CLARK).

Ophiomitra acantophora: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 190, fig. 88.

Off Kurile Is.; 229 fathoms (CLARK).

Bering Sea. Alaska. Off Aleutian Is.; 1,213 fathoms (!) (CLARK).

This species appears to be distinguished from the genotype, *O. troscheli* (LYMAN, 1878), by the total absence of the disk granules, by the more numerous disk spines, which have a few denticles near the tip, by the fewer oral papillæ and arm spines, and by the smaller dorsal arm plates, which are not in contact with each other. I consider that, it is more natural to refer this species to the present genus than to any other known one.

Revision of *Ophiothamnus*, s. ext.

It is a wonder that, the present genus has been long left in a great confusion. As far as I can judge, those species which have been referred to the present genus by modern systematists correspond to a type, which was not considered to be *Ophiothamnus* by LYMAN, while certain species, which must be congeneric with LYMAN's type of *Ophiothamnus*, have been referred to various other genera. For example, the so-called "*Ophiothamnus*" of modern systematists includes *Ophiomitra exigua* LYMAN, 1879 (referred to *Ophiothamnus* by VERRILL, 1899), *Ophiothamnus laevis* LÜTKEN & MORTENSEN, 1899, *O. stultus* KOEHLER, 1904, &c., while the genuine *Ophiothamnus*, referred to other genera by modern systematists,

includes *Ophioleđa minima* KÖEHLER, 1906 (= *Ophioplınthaca oclusa* KÖEHLER, 1907), *Ophiomitra habrotata* CLARK, 1911, &c. The differences between these two groups may be given as follows :

Genuine *Ophiothamnus* :—Disk marked out into five brachial lobes by deep interr radial notches of the interbrachial borders, and strongly puffed out interbrachially ; disk scales fine ; radial shields not perfectly joined, but in contact with each other only at the outermost parts (except in *O. remotus*) ; oral shields very small, separated from the first lateral arm plates by the adoral shields, which are very large ; interbrachial ventral surfaces large, covered with numerous fine scales ; arms very slender, composed of long and slender joints ; arm spines not serrate, the lowest one being never hook-shaped ; ventral arm plates very small, much narrower than the corresponding arm joint ; genital bursæ very rudimentary, being represented merely by the creases between the interbrachial ventral surfaces and the arm bases ; genital plates very closely set in radial pairs, lying above the basal vertebræ ; genital scales absent ; generative glands covered by a membrane, which contains fine scales ; peristomial plates triple ; distal vertebræ incompletely divided into halves by a longitudinal series of pores.

So-called *Ophiothamnus* :—Disk not distinctly lobed ; disk scales coarse ; radial shields joined in pairs along nearly the entire length ; oral shields large, in contact with the first lateral arm plates ; adoral shields large, lying entirely proximal to the oral shields ; interbrachial ventral surfaces small, covered with rather few coarse scales, of which two or three are large and conspicuous ; arms stout at the base, composed of short and stout joints ; arm spines usually

serrate, the lowest one being hook-shaped in distal arm joints; ventral arm plates large, wide, nearly as wide as the corresponding arm joint; genital bursæ well developed; genital plates, genital scales, generative glands and peristomial plates unknown, but probably normal; distal vertebræ unknown.

In view of these differences, the two groups can hardly be united in a single genus. I therefore propose the name *Ophiurothamnus*, nov., for the so-called *Ophiothamnus*, to distinguish it from the genuine *Ophiothamnus*.

There are two other species, viz. *Ophiothamnus gracilis* STUDER, (1882) 1883, and *Ophiacantha gracilis* VERRILL, 1885 (referred to *Ophiothamnus* by V., 1899), which have been referred to *Ophiothamnus*, but probably belong neither to the genuine *Ophiothamnus* nor to *Ophiurothamnus*. Though I am not able to settle their systematic position owing to their very imperfect descriptions, they may possibly be referable to *Ophiacantha*.

***Ophiothamnus* LYMAN, 1869, emend.**

Syn. *Ophioleda* KÖHLER, 1906.

Disk divided into five brachial lobes, covered with fine, imbricating scales, and beset with scattered spines. Radial shields large, naked, more or less joined in pairs outwards. Genital bursæ very rudimentary, being represented by the creases between the disk and the arm bases. Oral shields small, separated by the large adoral shields from the first lateral arm plates. Three or four oral papillæ on either side of each jaw, the outermost one being very large and operculiform. Peristomial plates very large, triple. Arms inserted ventrally to the disk, composed of long, slender, hour-glass-shaped joints. Arm spines long, slender, spini-

form, acute, glassy, but not serrate, the lowest one being never hook-shaped.

This genus includes *Ophiothamnus vicarius* LYMAN, 1869, *O. affinis* LJUNGMAN, 1871, *O. remotus* LYMAN, 1878, *Ophioleđa minima* KÖHLER, 1906, *Ophiomitra habrotata* CLARK, 1911 and *Ophiothamnus venustus* MATSUMOTO, 1915, the first being the genotype.

I consider *Ophioleđa* KÖHLER as a synonym of *Ophiothamnus* LYMAN, because I am not able to make any essential distinctions of generic character between the two genotypes, judging from the descriptions and figures of LYMAN and KÖHLER.

Key to Japanese species of *Ophiothamnus*.

- A*—Disk spines dimorphic, a few very long, acute spines being present, besides very minute ones; interbrachial ventral surfaces entirely free of spines; dorsal arm plates comparatively large, longer than half the corresponding arm joint in free basal joints; eight or nine arm spines.....*habrotatus*.
- AA*—Disk spines monomorphic, very minute; interbrachial ventral surfaces also beset with several spines; dorsal arm plates very small, much shorter than half the corresponding arm joint; nine or ten arm spines.....*venustus*.

Ophiothamnus habrotatus (CLARK).

Ophiomitra habrotata: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 182, fig. 83.

Eastern Sea; 95–106 fathoms (CLARK).

Ophiothamnus venustus MATSUMOTO, 1915.

Ophiothamnus venustus: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 63.

Numerous specimens; off Inatori, Izu, Sagami Sea.

Diameter of disk 3 mm. Length of arms 23 mm. Width of arms at base 0.5 mm.

Disk five-lobed, i.e. divided by five radiating interradial furrows into five heart-shaped lobes, with large radial shields and

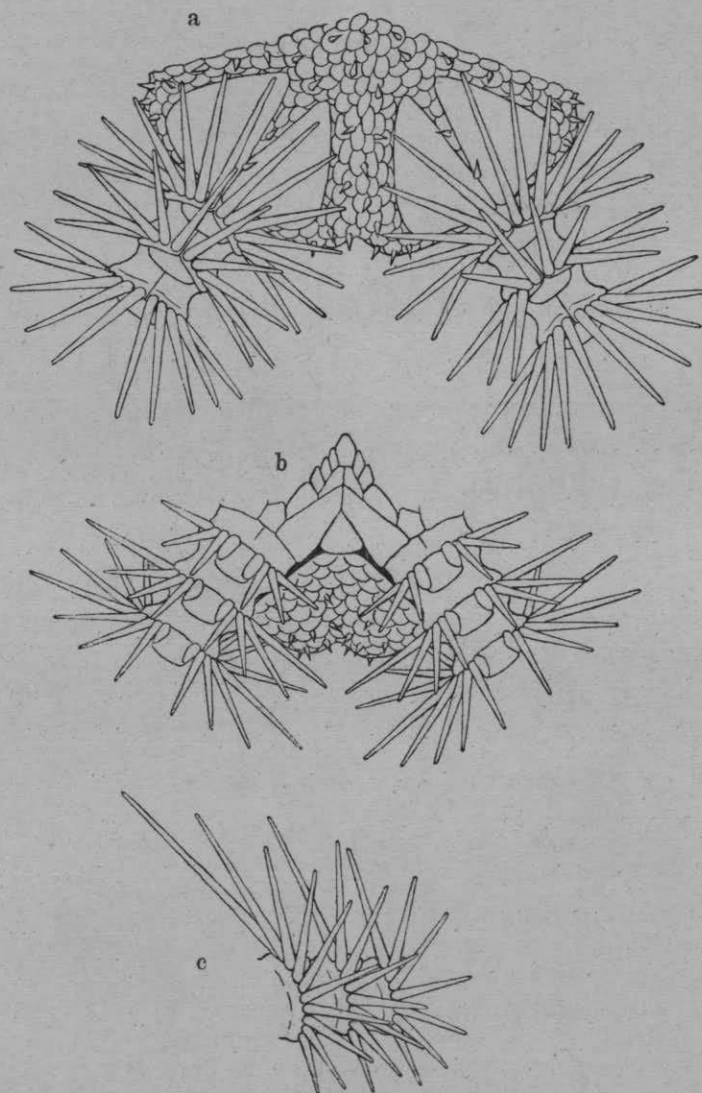


Fig. 32. *Ophiothamnus venustus*. $\times 20$. a. From above. b. From below. c. Side view of three arm joints near disk.

fine, imbricating scales, the latter bearing here and there very short, acute spines. The radial shields are very large, triangular, with rather acute inner and perfectly rounded abradial angles; the adradial side is the longest, three-fourths as long as the disk radius; the shields are about twice as long as wide, and are apposed to each other by the outer one-third to one-fourth of the adradial sides. Interbrachial ventral surfaces covered by fine, imbricating scales and beset with short, acute spines; the latter being less numerous than on the dorsal surface.

Oral shields very small, triangular, with acute inner and rounded outer angles, slightly longer than wide. Adoral shields very large, long, stout, wider outwards, tapered inwards, meeting with each other. Oral plates exceedingly small. Three or rarely four oral papillæ on either side; the outermost one arises from the adoral shield and is very large and unusually wide; the rest are very small; there is often one additional infradental papilla. Teeth four, blunt, with widened free end, except the uppermost one, which is the longest and is acute.

Arms slender and long, strongly knotted. Dorsal arm plates very small, three-sided, with extremely wide inner angle and curved outer border, extremely short, much wider than long. Lateral arm plates extremely well developed, meeting each other above and below, and so well soldered below that the line of suture is hardly visible; with well developed spine ridges; strongly constricted at the middle. First ventral arm plate exceedingly small, pentagonal. The rest are quadrangular, with curved outer side, wider than long, decreasing in size outwards. The arm spines are needle-like, very long, acute. They are nine or ten in number and approximated dorsally in the first two or three free joints. In the first free joint, the uppermost spine is about three

times, and the lowest one about one and a half times, as long as the corresponding arm joint. More distally, the arm spines become rather rapidly fewer and shorter, so that in the tenth free arm joint, they are five in number and about as long as the corresponding arm joint. One tentacle scale, comparatively large, blunt in the basal joints, but pointed more distally.

Colour in alcohol white.

I have observed the internal structures of this species, and ascertained that the internal oral skeleton, genital plates and generative glands are quite similar to those of the genotype (LYMAN, Challenger Rep., Pl. XLII, fig. 1).

Ophiurothamnus, g. nov.

Disk covered with rather coarse scales. Radial shields large joined in pairs nearly along the entire length. Interbrachial ventral surfaces small, with a pair of large, distinct plates joined to each other in the interrarial line. Another large, prominent plate is present at the middle of the interrarial margin, lying just outside the paired plates mentioned. Genital bursæ well developed. Oral and adoral shields stout, the latter being entirely proximal to the former. Three or four oral papillæ on either side, the outermost one being usually very large and wide. Teeth arranged in a single vertical row. Dental papillæ absent. Arms strongly knotted, with hour-glass-shaped joints. Dorsal arm plates very small. Lateral arm plates well developed, those of the two sides meeting above as well as below. Ventral arm plates short, very wide, as wide as the corresponding arm joint. Arm spines long, slender, usually serrate; those of the first one or two free arm joints approximated dorsally. Lowest spine of the outer arm joints hook-shaped. One tentacle scale to each pore.

The present genus includes *Ophiomitra exigua* LYMAN, 1879 (referred to *Ophiothamnus* by VERRILL, 1899), *Ophiothamnus lævis* LÜTKEN & MORTENSEN, 1899, and *Ophiothamnus stultus* KÖHLER, 1904, besides the genotype, *Ophiomitra dicycla* CLARK, 1911.

Ophiurothamnus is very near to *Ophiomytis* and *Ophioplinthaca*, but differs from the former chiefly in the very small dorsal arm plates and in the basal arm spines approximating dorsally; from the latter in the absence of the marginal disk scales, in the smaller interbrachial ventral surfaces, which are covered with fewer, coarser scales; in the smaller dorsal arm plates, and in the basal arm spines approximating dorsally. Further, this genus differs from *Ophiothamnus* in the coarser disk scales, in the radial shields being joined along the whole length, in the fewer and coarser scales of the interbrachial ventral surface, in the well developed genital bursæ, in the stout oral shields, which are in contact with the first lateral arm plates, in the stouter arms, in the very wide ventral arm plates, which are as wide as the corresponding arm joints, in the serrate arm spines, and in the usually hook-shaped lowest spines in the distal arm joints.

Ophiurothamnus dicyclus (CLARK).

Ophiomitra dicycla: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 181, fig. 82.

Eastern Sea; 434 fathoms (CLARK). Bungo Channel; 437 fathoms (CLARK).

Ophioplinthaca cardiomorpha (CLARK).

Ophiomitra cardiomorpha: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 179, fig. 81.

Eastern Sea; 361-440 fathoms (CLARK). Bungo Channel; 720 fathoms (CLARK). Off Shio Misaki; 587 fathoms (CLARK). Off Omai Zaki; 624 fathoms (CLARK).

Key to Japanese species of *Ophiomitra*.

- A—Disk scales coarse; radial shields very narrow, widely separated from each other; oral shields rhomboidal or pentagonal, about as wide as long; five or six arm spines, of which the uppermost or the next one is the longest and about twice as long as the corresponding arm joint *bythiaspis*.
- AA—Disk scales fine; radial shields not very wide, lying rather closely side by side; oral shields much wider than long; six or seven arm spines, of which the uppermost or the next one is the longest and about thrice as long as the corresponding arm joint. *lithosora*.

Ophiomitra bythiaspis CLARK.

Ophiomitra bythiaspis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 185, fig. 58.

Off Yenshû Sea; 943 fathoms (CLARK).

Ophiomitra lithosora (CLARK).

Ophiocamax lithosora: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 191, fig. 89.

Off Kii; 244-253 fathoms (CLARK). Eastern Sea; 361 fathoms (CLARK).

In the genuine *Ophiocamax*, the disk is not very deeply lobed and the radial shields are joined in pairs along the whole length. The present species lacks these characteristics of *Ophiocamax*, but exhibits all the characteristics of *Ophiomitra* as emended by VERRILL, 1899.

Ophiocamax polyploca CLARK.

Ophiocamax polyploca : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 193, fig. 90.

Eastern Sea ; 95–152 fathoms (CLARK). Kagoshima Gulf ; 85 fathoms (CLARK).

Key to Japanese species of *Ophiolebes*.

- A*—Four oral papillæ on either side of each jaw ; ventral arm plates not notched outwards at least within the disk ; seven arm spines ; single tentacle scale to each pore ; disk beset with numerous small, rather well spaced, stumpy tubercles*brachygnatha*.
- AA*—Three oral papillæ on either side ; ventral arm plates distinctly notched outwards even within the disk ; five arm spines ; tentacle scales absent.
- a*—Disk closely beset with very numerous small, rather granule-like, stumpy tubercles*asaphes*.
- aa*—Disk sparsely beset with rather large, conical tubercles, which are more or less numerous on the radial shields, but few in the other parts*tuberosa*.

Ophiolebes brachygnatha CLARK.

Ophiolebes brachygnatha : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 240, fig. 115.

Off Simushir Is. ; 229 fathoms (CLARK).

Ophiolebes asaphes CLARK.

Ophiolebes asaphes : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 239, fig. 114.

Off Kinkwasan ; 182 fathoms (CLARK). Off Hokkaido ; 175–349 fathoms (CLARK). Off Saghalin ; 100 fathoms (CLARK).

Ophiolebes tuberosa MATSUMOTO.

Ophiolebes tuberosa: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 64.

Numerous specimens; Okinosé (a submarine bank), Sagami Sea.

Diameter of disk 10 mm. Length of arms 38 mm. Width of arms at base 1.5 mm.

Disk five-lobed, with strongly concave interbrachial borders, deeply hollowed at the central region, covered by a thick, cereous skin, which contains well spaced, coarse granules or thick, rounded scales of various size; beset with several short, conical,

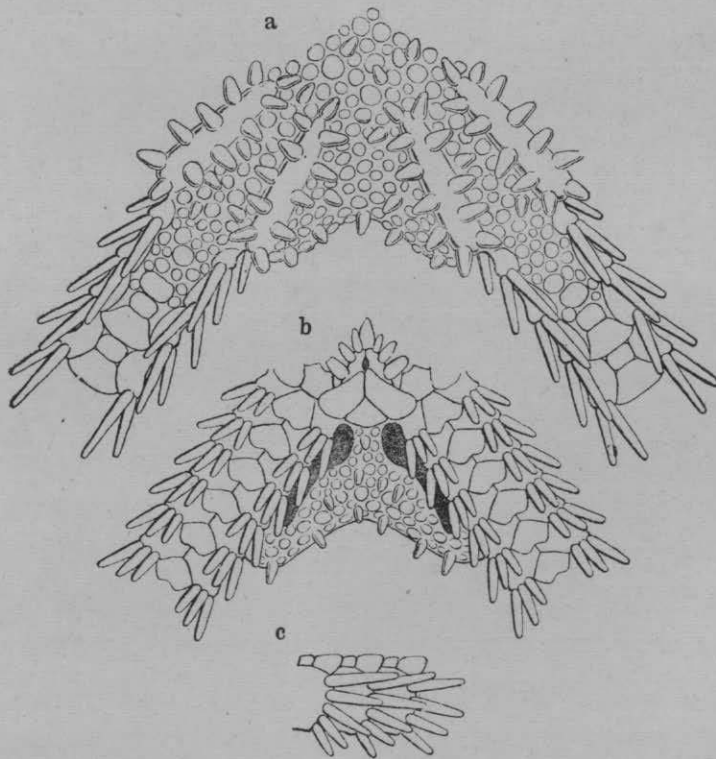


Fig. 33. *Ophiolebes tuberosa*. $\times 8$. a. From above. b. From below. c. Side view of three arm joints near disk.

stout, obtuse tubercles, which are larger and more numerous on the radial shields. Radial shields also covered by the skin, long, narrow, strongly raised, about two-thirds as long as the disk radius. Interbrachial ventral surfaces covered by a skin similar to that of the dorsal surface, the granules and tubercles being however smaller. Genital slits large, long, but not reaching the disk margin.

Oral skeleton also covered by the cereous skin. Oral shields rather small, thick, rhomboidal, wider than long, with wide, rounded outer angle and convex surface. Adoral shields large, quadrangular, with perfectly rounded outer angles and strongly convex surface, wider without than within, meeting with each other inwards. Between each pair of oral plates, occurs a more or less distinct buccal pore. Three or sometimes four oral papillæ on either side, conical and blunt; inner ones smaller; the outermost papilla is very large and stout. There occurs often one additional papilla just below the teeth. The oral papillæ project laterally so as to reach beyond the radial axis, and those of the two sides of each oral slit are placed alternately. Teeth conical, stout, obtuse.

Arms slender, covered by a thin, cereous skin. Dorsal arm plates two to each joint; the inner one has convex surface, and is small, quadrangular, wider than long, but in the more distal part of the arm is often longer than wide; the outer one is large, fan-shaped, much wider without than within, and has convex surface. The dorsal side of the basal region of the arms is covered by the continuation of the disk covering, so that it bears coarse, rounded, smooth, convex, well spaced granules or scales of various size in place of the dorsal arm plates. Lateral arm plates somewhat flared outwards, meeting below for a short

extent. First ventral arm plate comparatively large, hexagonal, with concave inner side and convex surface, widest at the lateral angles, as long as or slightly longer than wide, in contact with the next plate, which is the largest of all, pentagonal, widest at the lateral angles, as long as or slightly longer than wide, and has convex surface and a conspicuous notch at the outer angle. The rest separated from one another, rhomboidal, with a conspicuous notch at the outer angle, with strongly convex surface; more distally they become smaller, oval or round, and the surface is so convex as to appear like hemispherical tubercles. The arm spines are five in number in the proximal joints, but four in the more distal ones. They are conical, blunt, solid, terete; dorsal ones longer and stouter; in the basal joints of the arms, the uppermost spine is about one and a half times, and the lowest one about two-thirds, as long as the corresponding arm joint.

Colour in alcohol yellowish brown.

In younger specimens, the skin of the disk and arms is very thick, and the buccal pores are often indistinct.

This species is apparently near to *O. brachygnatha*, especially in the disk coverings. But a careful comparison will show that, the present species is more closely allied to *O. asaphes* than to *O. brachygnatha*, as shown in the foregoing key.

Ophiosemnates, g. nov.

Disk high and convex, covered by a cereous skin, which obscures the underlying stout scales; beset with granules or stumpy tubercles. Radial shields exposed, rounded or triangular, more or less separated from each other. Three or four oral papillæ on either side of each jaw. Teeth in a single vertical series. Dental

papillæ absent. Arms also covered by a cereous skin. Dorsal arm plates entire. Arm spines conical, blunt, stout, opaque. A single conical, blunt tentacle scale to each pore.

This new genus includes *Ophiolebes tylota* CLARK, 1911, *O. pachyactra* CLARK, 1911, *Ophiactis clavigera* LJUNGMAN, 1866 (referred to *Ophiolebes* by LYMAN, 1882), *Ophiacantha ædidisca* CLARK, 1911, *Ophiolebes diaphora* CLARK, 1911, *O. paucispina* CLARK, 1911, and *O. brevispina* CLARK, 1911, the first being the genotype.

Ophiosemmotes differs from the genuine *Ophiolebes* chiefly in the short, rounded or triangular, exposed radial shields and in the entire dorsal arm plates. In *Ophiolebes* as here restricted, the radial shields are long, narrow, bar-like and not exposed, and the dorsal arm plates are divided into two, inner and outer, secondary plates. *Ophiosemmotes* is very near to *Ophiochondrella*, but differs from it in the short ventral arm plates, which are separated from one another, and in the single thick, not leaf-like tentacle scale to each pore. In *Ophiochondrella* the ventral arm plates are quadrangular, as long as the corresponding arm joint and joined to one another, and the tentacle pores are provided with two thin, leaf-like scales.

Key to Japanese species of *Ophiosemmotes*.

- A—Disk closely covered with fine granules; radial shields oval, separated from each other; dorsal arm plates rather large, in contact with each other in the free basal arm joints, bearing a row of granules along the outer border; arm spines rather short, upper ones being nearly as long as the corresponding arm joint; lower arm spines not clavate.....*ædidisca*.
- AA—Disk sparsely beset with clavate tubercles and granules; radial

shields triangular, more or less separated or the pairs slightly in contact at the outermost part; dorsal arm plates small, separated from each other by the lateral arm plates, entirely free of granules; arm spines long, the uppermost one being nearly thrice as long as the corresponding arm joint; lower arm spines clavate*tylota*.

Ophiosemmotes ædidisca (CLARK).

Ophiacantha ædidisca: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 220, fig. 101.

One specimen; Albatross station 4958, off Hiuga; 405 fathoms.

Off Hiuga; 405-578 fathoms (CLARK). Off Omai Zaki; 505 fathoms (CLARK). Off Kii; 544-545 fathoms (CLARK).

Though this species apparently resembles certain species of *Ophiophthalmus*, the high and convex disk, the very

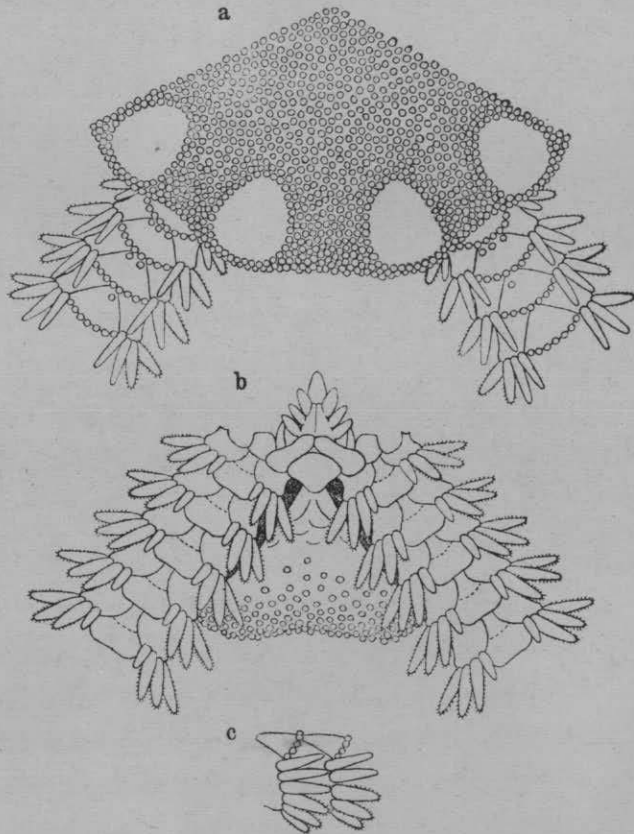


FIG. 34. *Ophiosemmotes ædidisca*. $\times 8$. a. From above. b. From below. c. Side view of two arm joints near disk.

small oral region, the slender, skin-covered arms, the narrow ventral arm plates, of which the outer border is slightly notched, the short, stout, skin-covered arm spines and the conical, not leaf-like tentacle scales show that it is only distantly related to that genus. On the other hand, the present species is very near to *O. diaphora*, which appears to me to find its natural place in this genus.

Ophiosemmotes tylota (CLARK).

Ophiolebes tylota: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911. p. 243, fig. 117.

Sea of Japan; 90–207 fathoms (CLARK).

Bering Sea.

Family 2. **Hemieuryalidæ** (VERRILL, 1899) mihi, 1915.

Disk covered with very heavy plates and stout radial shields, the primaries being usually very conspicuous. Interbrachial ventral surfaces very small, with very short genital slits. Oral and adoral shields very thick. Three or four flat oral papillæ on either side of each jaw. Teeth triangular, arranged in a single vertical series. Dental papillæ absent. Peristomial plates simple, stout, soldered with the oral frames, which are also very stout. Genital plate and scale of the same side of a radius soldered together, very stout. Arms very stout, covered with very heavy arm plates, vertically coiled. Vertebrae stout. Vertebral articulations streptospondyline, articular pegs being very rudimentary or entirely absent.

This family includes seven genera, which may be grouped into two subfamilies as follows.

Subfamily 1. *Ophiochondrinæ* (VERRILL, 1899) mihi, 1915.—

Dorsal arm plates entire, without supplementary plates; five to eight arm spines, moderately long, conical; no tentacle scales proper; but the lowest arm spine may serve as one.

Ophiochondrus LYMAN, 1869.¹⁾

Ophiomæris KÖHLER, 1904 (= *Ophiurases* CLARK, 1911).

Ophiogyptis KÖHLER, 1905.

Subfamily 2. *Hemieuryalinae* MATSUMOTO, 1915.—Dorsal arm plates often accompanied by supplementary plates or replaced by a mosaic of secondary plates; three arm spines and one tentacle scale, both being very short and flat.

Sigsbeia LYMAN, 1878.

Ophiocolcus CLARK, 1915.

Ophioplus VERRILL, 1899.

Hemieuryale VON MARTENS, 1867.

According to LYMAN, *Ophiochondrus convolutus* LYMAN, 1869 has a very heavy armature, which lies under the disk skin. The radial shields are bar-like, long, thick and solid. The genital plates are massive, a full half of the length being occupied by the club-shaped head, while the comparatively small shaft is rounded and tapering. About half way along the length of the genital plate, there is soldered to it the small, rounded genital scale. The peristomial plates are simple, very thick and strong. Within the disk, the vertebræ are short and discoid; but beyond the disk margin, they take on a curious elongate shape. Their outer face has a wide massive articular shoulder to support the large umbo of the next vertebra; the articular peg is very small, and there is no distinct hole for its reception in the next vertebra. The important structures of *Ophiomæris projecta* MATSUMOTO, 1915 are

1) *Ophioplus armatus* KÖHLER, 1907 (referred to *Ophiochondrus* by K., 1914) and *Ophiochondrus granulatus* KÖHLER, 1914, are in my opinion referable to the genuine *Ophiolebes*.

almost similar to those of the preceding, but the radial shields are more massive and the inner parts of the genital plates, as well as the genital scales, are thin and plate-like.

According to LYMAN'S statements, the internal structures of *Hemieuryale pustulata* VON MARTENS, 1867 are essentially similar to those of *Ophiochondrus*, but more specialised. The genital plate and scale of the same side of a radius are also soldered together. The peristomial plates are simple and comparatively small. The articular shoulder of each vertebra is very stout, while the articular peg is entirely absent.

Key to Japanese species of *Ophiomæris*.

- A*—Disk entirely free of large, spherical tubercles; each radial pair of radial shields separated from each other by a row of two or three plates *obstricta*
- AA*—Large, spherical tubercles present along the outer margins of the radials and along the adradial borders of the radial shields; radial shields joined in pairs along the whole length..... *projecta*

Ophiomæris obstricta (LYMAN).

Ophioceramis(?) obstricta: LYMAN, Bull. Mus. Comp. Zool., V. 1878, p. 124, Pl. VI, figs. 164–166; LYMAN, Rep. Challenger, V, 1882, p. 26, Pl. XI, figs. 1–3.

Ophiomæris obstricta: KOEHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 17.

Ophiurases obstrictus: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 250, fig. 122.

Eastern Sea; 95–135 fathoms (CLARK).

Lat. 5° 42' S., long. 132° 25' E.; 129 fathoms (LYMAN).

Ophiomæris projecta MATSUMOTO.

Ophiomæris projecta: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 65.

Two specimens; off Uki-shima; 300 fathoms. One specimen; Uji-shima, Ôsumi.

Diameter of disk 4 mm. Length of arms 13 mm. Width of arms at base 1.5 mm.

Disk five-lobed, with concave interbrachial borders, with a very regular rosette of the central, basal and radial plates, surrounded by the radial shields. Central plate circular, rather large. Radials rhomboidal, considerably larger than the central plate, separated from each other by the small and oblong basals. The radials may be in contact with the central plate, or separated from it by one or two very

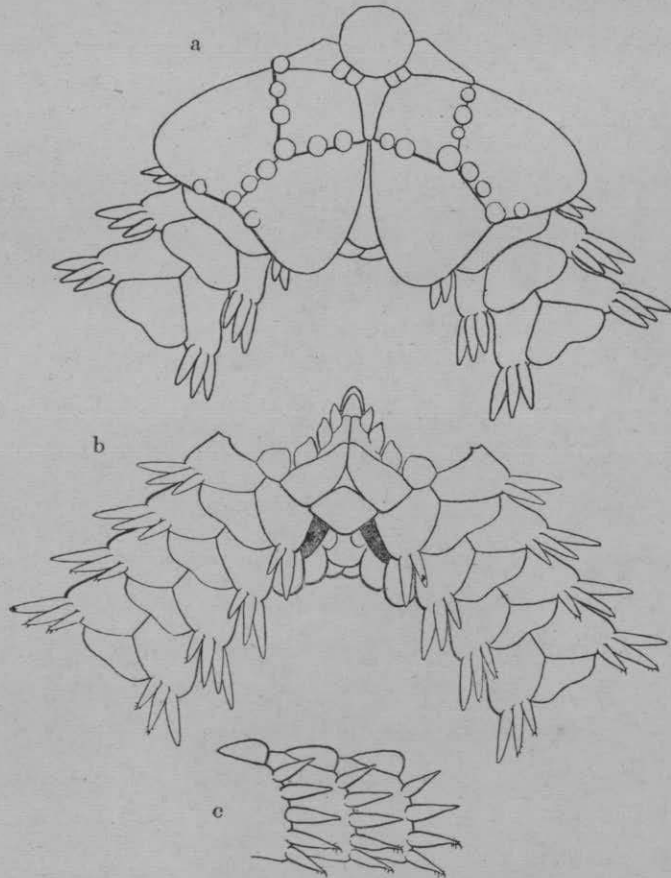


Fig. 35. *Ophiomæris projecta*. $\times 10$. a. From above. b. From below. c. Side view of three arm joints near disk.

small, intervening scales, and bear several very prominent, spherical tubercles along the outer margins. Radial shields very large and stout, triangular, with an acute inner angle, longer than wide, each pair in contact by the outer half of their whole length, and narrowly separated from the next pair by a sunken, oblong plate. The radial shields do not lie in the same plane with the central rosette, but are inclined outwards and interradially, so that the central rosette appears elevated above its surroundings. The radial shields also bear prominent tubercles along or on their adradial borders, as well as often along their outer margins. Just outside and below the outer edge of the radial shields, there is a very stout and nearly vertical plate, on which the radial shields rest elevated above the general surface of the arm. Interbrachial spaces below very small, covered by a few convex plates. Genital slits small, lying just outside the oral shields.

Oral shields large, rhomboidal, wider than long in surface view, but the outer angle is prolonged upwards like a beak. Adoral shields longer than the oral shields, wider without, tapered inwards and meeting each other. Three oral papillæ on either side, rather close-set, outermost one quadrangular, largest of all, wider than long; the next bluntly and the last acutely pointed, both being longer than wide. Four or five teeth, stout, spear-head-shaped, the uppermost one longer and acuter than the rest.

Arms stout and short, uniformly tapered outwards. Dorsal arm plates triangular, with straight inner sides and two-lobed outer, wider than long, strongly convex, separated from one another by the lateral arm plates, which are very stout and strongly flared outwards. First ventral arm plate small, pentagonal, longer than wide, wider within than without, if we except the pointed portion. Second and following triangular, with concave

inner sides, outer side convex as a whole, but slightly concave at the middle, wide and very short. Successive plates separated from one another; distally they become rapidly smaller, and the outer border is then entire. Arm spines conical, acute, short, shorter than the corresponding arm joint; upper ones longer, lower ones somewhat rough at the end, looking like compound hooks towards the extremity of the arms. They are about seven in number in the first basal joints, but rapidly decrease in number as well as in size, so that, on the eighth lateral plate, they are only four and about half as long as the corresponding joint.

The plates of the disk and arms are shagreened.

Colour in alcohol: disk gray, arms banded with grayish brown and white.

The present species is very closely related to *O. obstricta* (LYMAN), but differs from it chiefly in the presence of the prominent tubercles on the disk and in the radial shields joining in pairs in the radial line. In the first mentioned character, this species closely resembles *Ophiogyptis nodosa* KÖHLER, 1905.

Order iii. GNATHOPHIURIDA MATSUMOTO.

Disk covered with fine, imbricating scales, which are very regular in size and arrangement. Radial shields well developed, each having a conspicuous articular pit near the outer end for the reception of a large, ball-like articular condyle of the genital plate. Genital plates usually fixed to the basal vertebræ. Genital scales short, wide, flat, leaf-like, articulating with the genital plates near the outer end of the latter. Besides, an additional scale is present on the abradial border of the innermost part of each genital slit, being also short, wide, flat, leaf-like and firmly fixed to the oral

shield. Peristomial plates entire, or rarely double, usually very small. Oral frames very stout, with strongly developed lateral wings as a rule, for the attachment of voluminous masticatory muscles. Oral and dental plates usually very stout, the two plates usually presenting an **X**-shape in dorsal view. Oral papillæ few, often entirely absent. Dental papillæ well developed only in forms without oral papillæ. Teeth stout, usually quadrangular, with widened, straight or wavy apical edge. Arms slender, inserted ventrally to the disk, horizontally flexible, or sometimes more or less coiled vertically. Vertebral articulation zygospondyline. Dorsal, lateral and ventral arm plates all well developed.

Key to families of *Gnathophiurida*.

- A*—Teeth triangular, not very stout; peristomial plates large; oral frames entire, without well developed lateral wings; genital plates free, not fixed to the basal vertebræ; oral papillæ present; no dental papillæ *Amphilepididæ*.
- AA*—Teeth quadrangular, very stout; peristomial plates small; oral frames with well developed lateral wings; genital plates firmly fixed to the basal vertebræ.
- a*—Oral papillæ present; no vertical clump of dental papillæ.....
..... *Amphiuridæ*.
- aa*—Oral papillæ absent; dental papillæ well developed, forming a vertical clump at the apex of each jaw *Ophiotrichidæ*.

Family 1. *Amphilepididæ* MATSUMOTO, 1915.

Disk covered with fine, imbricating scales. Radial shields sometimes very rudimentary but often well developed, with a

conspicuous articular pit near the outer end for the reception of a large, ball-like articular condyle of the genital plate, which is entirely free from the basal vertebræ. Genital scales short, wide, flat, leaf-like. Peristomial plates entire, very large. Oral frames not very stout, without well developed lateral wings. Oral plates long and slender in interior view. Dental plates very small, or absent. Teeth and oral papillæ present; but no dental papillæ. Arms slender, inserted ventrally to the disk, being only horizontally flexible. Dorsal, lateral and ventral arm plates all well developed. Three to five arm spines, conical or cylindrical, with smooth surface. One or two tentacle scales. Vertebræ slender, with zygospondyline articulation; in the distal part of the arms, they are often incompletely divided into halves by a longitudinal series of pores.

This family includes three genera, which may be grouped as follows.

- I. Second oral tentacle pores opening more or less outside the oral slits, so that the latter are gaping.

Amphilepis LJUNGMAN, 1866.

- II: Second oral tentacle pores opening entirely within the oral slits, so that the latter are closed by the oral papillæ.

Amphiactis MATSUMOTO, 1915.

Ophiochytra LYMAN, 1880.

Though the present family much resembles the next family, *Amphiuridae*, in external features, the internal structures are rather Læmophiuridan, with large peristomial plates and entire oral frames. The articulation of the radial shield and genital plate, as well as the flat, thin genital scales, however, gives ground for placing this family in the present order. In short, the present family is the

least specialised among the Gnathophiurida, and stands next to the Læmophiurida.

In *Amphiactis umbonata* MATSUMOTO, the genital plate and radial shield articulate with each other by means of a hemispherical articular condyle of the former and a large articular socket of the latter, the former being entirely free from the basal vertebræ. The genital scales are flat and thin, articulating with the genital plates near the outer end. The peristomial plates are simple and very large. The oral frames are small and entire, without well developed lateral wings. The oral plates are long and slender in internal view. The dental plates are absent. According to LYMAN, the internal structures of *Amphilepis norvegica* LJUNGMAN, 1866, appear to be essentially similar to those of the above mentioned species, save that the peristomial plates are somewhat smaller and the dental plates are present.

Amphilepis tenuis LYMAN.

Amphilepis tenuis: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 35, Pl. XVI, figs. 432-434; LYMAN, Rep. Challenger, V, 1882, p. 151.

Southwards from Boshû; 1,875 fathoms (LYMAN).

Amphiactis MATSUMOTO, 1915.

Disk covered with imbricating scales, radial shields moderately large. Four or five oral papillæ on either side, unequal in size, arranged almost in a continuous series. Teeth arranged in a single vertical row. Peristomial plates entire, very large; oral frames slender and without lateral wings. Arms long and slender, only horizontally flexible. Distal vertebræ often imperfectly divided into

halves by a series of pores. Three to five arm spines. One or two tentacle scales to each pore.

This genus includes *Amphiura duplicata* LYMAN, 1875, *A. canescens* LYMAN, 1879, *A. patula* LYMAN, 1879, *A. partita* KÖHLER, 1897; *Ophiactis dissidens* KÖHLER, 1904, and *O. parata* KÖHLER, 1904, besides the genotype, *Amphiactis umbonata* MATSUMOTO, 1915.

The representatives of the present genus were formerly referred to *Amphiura* by LYMAN, and then to *Ophiactis* by LÜTKEN & MORTENSEN. *Amphiactis* differs from *Amphioplus* in the absence of the paired infradental papillæ, and from *Ophiactis* in having numerous oral papillæ arranged in a continuous series, so that the oral slits are entirely closed. Further, the internal structures are entirely different from those of the *Amphiuridæ*. Again, the present genus differs from *Ophiochytra* in the well developed radial shields.

Amphiactis umbonata MATSUMOTO.

Amphiactis umbonata: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 67.

Two specimens; off Misaki, Sagami Sea.

Diameter of disk 7 mm. Length of arms 30 mm. Width of arms at base 1.2 mm.

Disk circular, flat, covered with rather coarse and irregular scales. Central plate large, circular, surrounded by ten small scales, corresponding in position to the infrabasals and basals. The five radials large, larger than the central plate, with strongly curved abcentral border, which almost forms a semicircle. The central and radials have each a small but distinct central or subcentral

boss. The second radials and the first to third interradians may also be distinguished, and are large and prominent. Thus, the

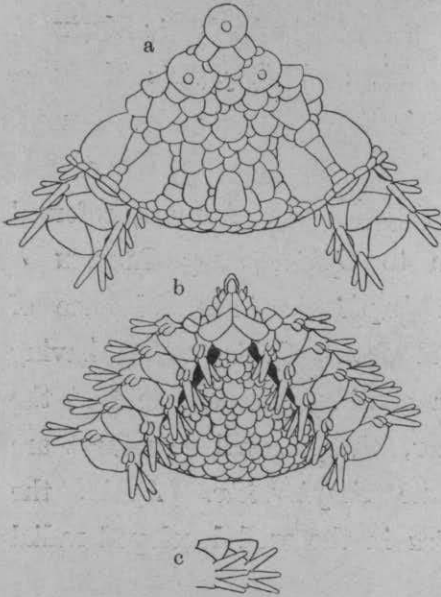


Fig. 36. *Amphictis umbonata*. $\times 8$. a. From above. b. From below. c. Side view of two arm joints near disk.

disk squamation is rather similar to that of *Ophiozona*. Radial shields comparatively small, oblong ovate, about two-fifths as long as the disk radius, twice as long as wide, wider without, more convex abradially than adradially, separated from each other by a row of three or four plates, of which the inner ones are larger. In each interradial space, there are five to seven irregularly radiating rows of scales. Interbrachial ventral surfaces covered with coarse, irregular, imbricating scales. Genital slits long, near-

ly reaching the margin of the disk. Genital scales invisible.

Oral shields small, rhomboidal, with acute inner and rounded lateral and outer angles, and slightly concave inner sides. Adoral shields wider without, nearly or quite meeting within. Four oral papillæ on either side of the oral angle, inner ones smaller and more acute. Deep in the oral slits, on either side of the oral angle, there occurs one long, acute, needle-like papilla. Five teeth, all blunt, except the uppermost one, which is pointed.

Five arms, slender, flattened, uniformly tapered toward the extremity. Dorsal arm plates large, fan-shaped, twice as wide as long; inner sides slightly convex and forming an obtuse angle

within, outer side decidedly convex, outer angles rounded; successive plates separated by the lateral arm plates, except the basal two or three. Lateral arm plates low, not very prominent. First ventral arm plate small, divided into two pieces, of which the inner one is triangular and the other quadrangular. Those beyond large and hexagonal, except the second plate which is pentagonal; much wider than long, widest at the outer lateral angles, with concave lateral sides and slightly convex inner and outer sides, swollen along the outer borders and especially at the outer angle, so that the arms appear keeled along the ventral median line. Three arm spines, subequal, about as long as the corresponding arm joint, but the uppermost one is slightly longer; cylindrical, tapered and blunt. Two flat, oval tentacle scales to each pore, but sometimes three to the first.

Colour in alcohol white.

The present species may be easily distinguished from all the other species of *Amphiactis* by the *Ophiozona*-like squamation, and especially by the presence of the umbonated primary plates.

Family 2. **Amphiuridæ** (LJUNGMAN, 1867) mihi, 1915.

Disk covered with fine, imbricating scales, or rarely by a naked skin, sometimes beset with minute spines. Radial shields well developed, with a conspicuous articular socket on the ventral surface near the outer end, fitting to the large, ball-like articular condyle of the genital plate. Genital plates firmly fixed to the basal vertebrae. Genital scales short, wide, flat, articulating with the genital plates near the outer end of the latter. Besides, there occur a pair of short, flat scales, just outside each oral shield, supporting the proximal abradial border of the genital slits. Peristomial plates very small, usually entire. Oral frames very

stout, with well developed lateral wings for the attachment of voluminous masticatory muscles. The oral and dental plates are very stout in internal view, the two presenting an X-shape. One to six oral papillæ on either side, the innermost one being often infradental. Teeth very stout, widened, squarish, with wavy or notched cutting ends. Arms inserted ventrally to the disk, horizontally flexible, or rarely capable of coiling vertically. Dorsal side of the vertebræ entire, not strongly notched inwards. Vertebral articulation zygospondyline, the articular peg being always present. Arm spines moderately long, conical, stout, opaque. Usually one or two leaf-like tentacle scales, sometimes none.

The present family includes eighteen genera, which may be grouped into two subfamilies as follows.

Subfamily 1. *Ophiactininae* MATSUMOTO, 1915:—No paired infradental papillæ.

Ophiactis LÜTKEN, 1856.

Hemipholis (AGASSIZ) LYMAN, 1865.

Ophiopus LJUNGMAN, 1866.

Ophiopholis MÜLLER & TROSCHER, 1842.

Subfamily 2. *Amphiurinae* mihi, 1915:—Paired infradental papillæ present.

- I. Four or more oral papillæ on either side, the outermost one or two arising from the adoral shield; one additional papilla is present just outside and above the infradental one; oral slits closed by the oral papillæ.

Amphioplus VERRILL, 1899.

Amphichilus, nov.

Amphiacantha, nov.

Amphilimna VERRILL, 1899.

- II. Three, rarely four, oral papillæ on either side, none

arising entirely from the adoral shield; no additional papilla just outside and above the infradental one, which therefore is the highest in position of all; oral slits closed by the oral papillæ.

Amphiodia VERRILL, 1899.

Ophiophragmus LYMAN, 1865.

Ophiocnida LYMAN, 1865.

- III. Three oral papillæ on either side, the outermost one being very large and operculiform; no additional papilla just outside and above the infradental one, which therefore is the highest in position of all; oral slits closed by the oral papillæ.

Amphipholis LJUNGMAN, 1867.

Ophiostigma LÜTKEN, 1856.

- IV. Two, sometimes three, oral papillæ on either side, the outermost one or two arising from the adoral shield; one additional papilla is present just outside and above the infradental one; oral slits gaping.

Amphiura FORBES, 1842 (= *Ophionephthys* LÜTKEN, 1869).

Ophionema LÜTKEN, 1869.

Ctenamphiura VERRILL, 1899.

Paramphiura KÖHLER, 1895.

Ophiocentrus LJUNGMAN, 1866 (= *Amphiocnida* VERRILL, 1899).

I have dissected several specimens of *Ophiactis pteropoma* CLARK, *Hemipholis elongata* (SAY), *Ophiopholis aculeata* (LINNÉ), *Amphioplus ancistrotus* (CLARK), *Amphiacantha acanthina* (CLARK), *A. dividua*, nov., *Ophiophragmus japonicus* MATSUMOTO, *Amphipholis kochii* LÜTKEN, *Amphiura koreæ* DUNCAN, *A. trachydisca* CLARK, *A.*

vadicola MATSUMOTO, *Ophiocentrus verticillatus* (DÖDERLEIN), &c., and am strongly impressed by the uniformity of the internal structures of this family. The oral frames are especially stout, with very well developed lateral wings for the attachment of voluminous masticatory muscles; those of *Ophiactis pteropoma* are less stout than those of the representatives of the other genera. The oral and dental plates are very stout and more or less **X**-shaped in internal view. The peristomial plates are rather or very small and usually entire, save in the representatives of *Amphiura* and *Ophiocentrus*, in which they are double or rarely triple; they are comparatively large in *Ophiopholis aculeata*, *Amphioplus ancistrotus*, *Amphiura koreæ*, *A. trachydisca* and *Ophiocentrus verticillatus*, but exceedingly small in *Hemipholis elongata*, *Ophiophragmus japonicus* and *Amphiura vadicola*. The genital plates are firmly fixed to the basal vertebræ, save in *Amphiacantha dividua*, nov., in which they are free from the basal vertebræ. This peculiarity of the species just mentioned is probably due to the fact that, the single type specimen is very small and young. The genital plates of *Ophiocentrus verticillatus* are somewhat unusual in position, lying entirely dorsal, but not lateral, to the basal vertebræ. As to the genital scales and the articulation of the genital plate and radial shield, the statement in the diagnosis of the present order holds true for all the representatives of the genera thus far studied by myself. The dorsal side of the vertebræ is usually entire, without any conspicuous notch inwards; and only in *Ophiocentrus verticillatus* is it distinctly notched inwards and more or less **Y**-shaped, rather reminding us of that of the next family. According to MORTENSEN, *Ophiopus arcticus* LJUNGMAN. has very rudimentary genital bursæ, which are represented merely by the creases between the arm bases and the interbrachial ventral surfaces, and the genera-

tive glands are covered by a sac-like membrane, which contains very fine and delicate scales when viewed under the microscope.

Key to Japanese genera of *Ophiactininae*.

- A*—Oral angles not exceedingly short; oral papillæ arising from the oral plate; dorsal arm plates entire, without supplementary ones *Ophiactis*.
- AA*—Oral angles exceedingly short; oral papillæ arising from the adoral shield; dorsal arm plates hemmed by a row of supplementary ones along the outer, and often also lateral, sides *Ophiopholis*.

Key to Japanese species of *Ophiactis*.

- A*—Three arm spines; disk nearly or entirely free of spines.
- a*—Five arms; oral shields much wider than long *brachygenys*.
- aa*—Six arms; reproducing by schizogony; oral shields about as wide as long.
- b*—Radial shields separated from each other by a row of three scales; uppermost arm spine the longest *pteropoma*.
- bb*—Radial shields separated from each other by a single wedge-shaped scale, except at the outer ends, where they are in contact; middle arm spine the longest *dyscrita*.
- AA*—Four or more arm spines; disk beset with a number of spines.
- c*—Four arm spines.
- d*—Five arms; disk scales fine; radial shields separated from each other by a row of four scales *affinis*.
- dd*—Six arms; disk scales coarse; radial shields partially joined in pairs *macrolepidota*.
- cc*—Five or more arm spines; six arms; reproducing by schizogony.
- e*—Five arm spines in free basal arm joints; dorsal arm plates exceedingly wide, about thrice as wide as long; single oral papilla on either side *modesta*.

cc—Six arm spines in free basal arm joints; dorsal arm plates less than, or nearly, twice as wide as long; two or three oral papillæ on either side.

f—Adoral shields meeting with each other both in the radial and interradial lines; interbrachial ventral surfaces covered with fine scales *savignyi*.

ff—Adoral shields not meeting with each other either in the radial or interradial lines; interbrachial ventral surfaces covered by a naked skin *gymnochora*.

***Ophiactis brachygenys* CLARK.**

Ophiactis brachygenys: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 135, fig. 51.

Off Manazuru Zaki, Sagami Sea; 120–265 fathoms (CLARK).
Off Hiuga; 437–720 fathoms (CLARK).

***Ophiactis pteropoma* CLARK.**

Ophiactis pteropoma: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 134, fig. 50.

One specimen; Misaki.

Sea of Japan; 195 fathoms (CLARK). Off Kii; 191–253 fathoms (CLARK).

This species appears to me to be very near to *O. profundæ* LÜTKEN & MORTENSEN, 1899, differing from it merely in the arm spines being unequal instead of being subequal.

***Ophiactis dyscrita* CLARK.**

Ophiactis dyscrita: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 137, fig. 52.

Six specimens, clinging to a hexactinellid sponge; off Ôshima, Sagami Sea; 75–85 fathoms.

Kagoshima Gulf; 58 fathoms (CLARK).

The largest one of my specimens measures only 2 mm. across the disk and 10 mm. in the arm length. In some arm joints, the uppermost one of the three arm spines is longer than the middle one, which is usually the longest. The colour in alcohol of these specimens is not gray, but light green.

Ophiactis affinis DUNCAN.

Ophiactis affinis: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 469, Pl. X, fig. 23, Pl. XI, fig. 24; LYMAN, Rep. Challenger, V, 1882, p. 115; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 71; KÖHLER, Res. Exp. Siboga, XLV, Pt. 2, 1905, p. 26.

Korean seas (DUNCAN).

Indian Ocean and Malaysian waters (KÖHLER).

Ophiactis macrolepidota MARKTANNER.

Ophiactis macrolepidota: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturhist. Hofmus. Wien, II, 1887, p. 298, Pl. XII, figs. 12 & 13; DÖDERLEIN, Denkschr. Med. Nat. Ges. Jena, VIII, 1898, p. 484, Pl. XXXVII, figs. 1 & 1a.

One specimen; Uraga Channel. Three specimens; Asami Bay, Tsushima.

Sidney (MARKTANNER-TURNERETSCHER). Amboina (DÖDERLEIN).

The specimens at hand were all found adhering to *Ophiothrix koreana*. The largest one is 1.8 mm. in the disk diameter and 7 mm. in the arm length. Unlike MARKTANNER-TURNERETSCHER'S type, imbricating scales are visible in the interbrachial ventral surfaces in all the specimens. The disk is yellowish and the arms are light greenish above and light yellowish below in alcohol.

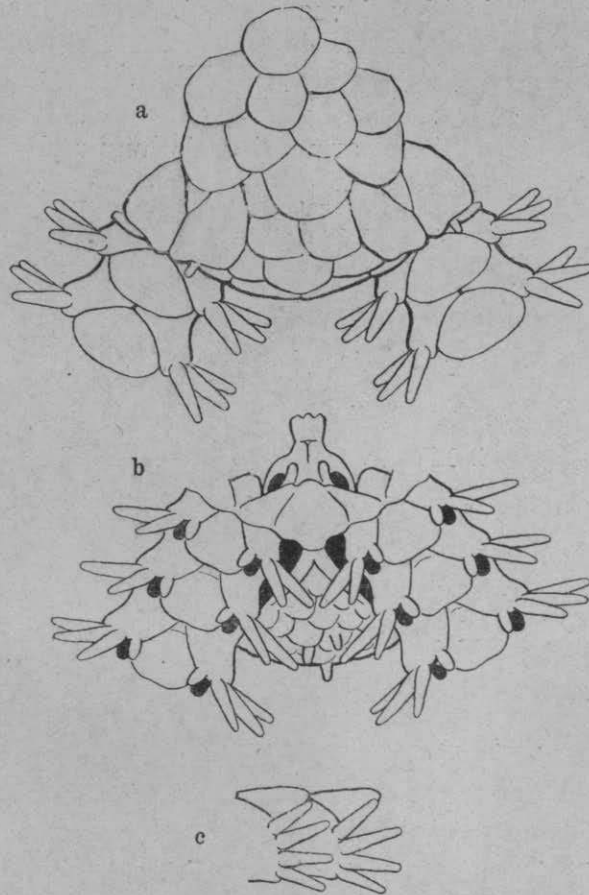


Fig. 37. *Ophiactis macrolepidota*. $\times 40$. a. From above. b. From below. c. Side view of two arm joints near disk.

Ophiactis modesta BROCK.

Ophiactis modesta: BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 482; DÖDERLEIN, SEMON—Zool. Forschungsr. in Austr. u. Malay. Archip., 1896, p. 285, Pl. XIV, fig. 1, Pl. XV, fig. 5; KÖHLER, Mem. Soc. Zool. Fr., XVII, 1904, p. 63, figs. 10 & 11.

Numerous specimens; Misaki.

Amboina.

The largest one of the specimens at hand is 4 mm. in the

disk diameter and 20 mm. in the arm length. With the exception of three which are five-armed, they are all six-armed. One of the five-armed specimens has three larger and two smaller arms, while another has two larger and three smaller ones.

The ventral arm plates have each an hour-glass shaped depression on the surface, which seems to me to be a distinctive character of this species, though apparently unnoticed by previous authors. In DÖDERLEIN'S photograph, this depression is faintly visible.

Colour in alcohol: dull green; disk with two or three patches of very dark green; arms banded, two darker joints alternating

with four or five lighter ones; each dorsal arm plate with three yellowish spots on the outer margin.

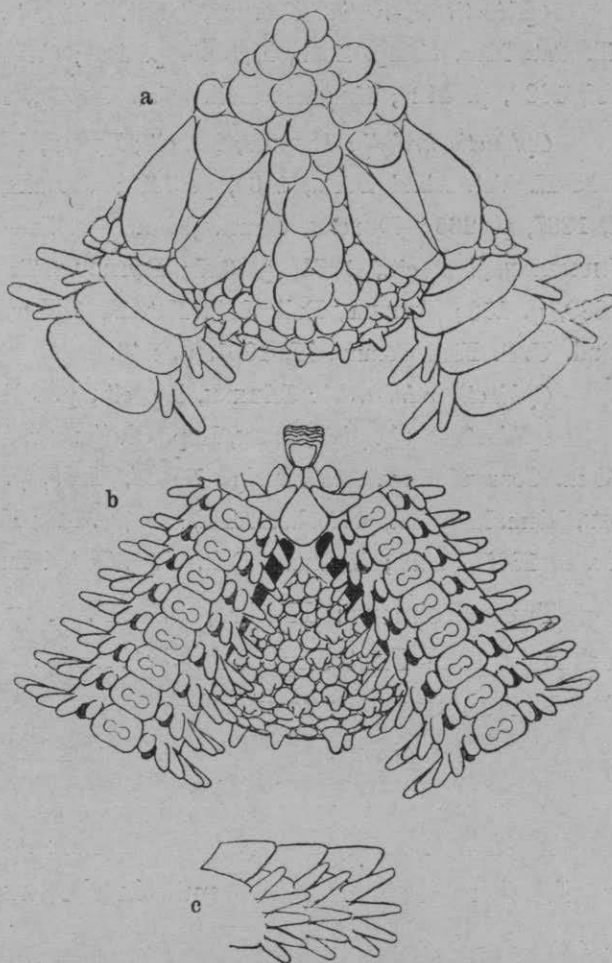


Fig. 38. *Ophiactis modesta*. $\times 20$. a. From above. b. From below. c. Side view of three arm joints near disk.

Ophiactis savignyi (MÜLLER & TROSCHEL).

Ophiolepis savignyi : MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 95.

Ophiolepis sex-radia : GRUBE, WIEG. Arch. Naturg., 1857, p. 343.¹⁾

Ophiactis sex-radia : LÜTKEN, Addit. ad Hist., II, 1853, p. 126; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 115; CLARK, Ann. New York Acad., XI, 1893, p. 412¹⁾; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 72.

Ophiactis krebsii : LÜTKEN, loc. cit.; LYMAN, loc. cit., p. 111; LJUNGMAN, Ofv. K. Vet. Akad. Förh., 1866, p. 323¹⁾; VERRILL, Transact. Connect. Acad., I, 1867, p. 265; DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 465; LJUNGMAN, loc. cit., 1871, p. 627; RATHBUN, Transact. Connect. Acad., V, 1880, p. 153; VERRILL, Bull. Lab. Nat. Hist. Iowa, V, 1899, p. 34¹⁾; CLARK, Bull. U. S. Fish Comm., II, 1901, p. 246.

Ophiactis reinhardti : LÜTKEN, loc. cit., p. 161, Pl. III, fig. 7.

Ophiactis savignyi : LYMAN, Rep. Challenger, V, 1882, p. 115; LUDWIG, Mem. Couronn. Sav. Acad. Belg., XLIV, 1882, p. 14; LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 140; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 26; KÖHLER, Bull. U. S. Nat. Mus., LXXXIV, 1914, p. 41.

Two specimens; Koajiro, Misaki. Numerous specimens (belonging to the First High School); Misaki.

Korean Seas (DUNCAN).

Malaysian waters. Australia. Sandwich Is. Gulf of California. West Indies.

The larger one of the two specimens mentioned first is 3.5 mm. in the disk diameter and 10 mm. in the arm length. The smaller one is 2 mm. across the disk. Both are six-armed, and have no distinct central plate. In the larger specimen, the dorsal arm plates are often divided into two or three pieces, and are scarcely lobed on the outer side; the colour is yellowish brown in alcohol, and faintly banded on the arm near the extremity. In the

¹⁾ These papers were not seen by me.

smaller one, the colour is vivid green in alcohol; the arms have darker and lighter bands of the same colour; and each dorsal arm plate has three white spots on the outer margin, which are especially conspicuous in the dark bands. It seems that, in this species, the colour changes in alcohol from green to brown in the course of time.

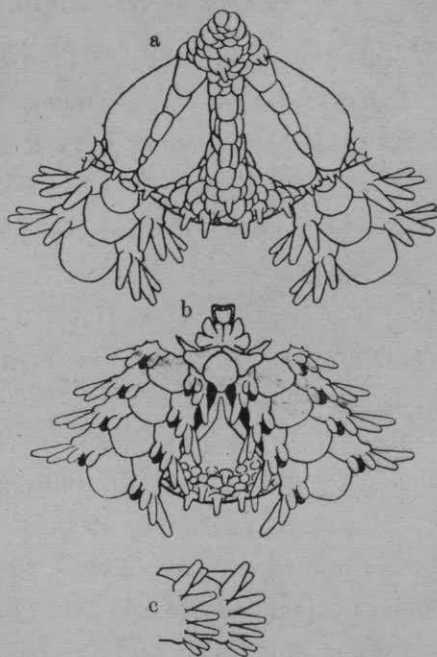


Fig. 39. *Ophiactis savignyi*. $\times 16$. a. From above. b. From below. c. Side view of two arm joints near disk.

Ophiactis gymnochora CLARK.

Ophiactis gymnochora: CLARK,
Bull. U. S. Nat. Mus., LXXV, 1911,
p. 139, fig. 54.

Tanega-shima (CLARK).

Key to Japanese species and varieties of *Ophiopholis*.

- A—One very large supplementary plate present on either side of each dorsal arm plate, besides the smaller supplementary ones. *mirabilis*.
- AA—No especially large supplementary dorsal arm plates, though there is present a row of small supplementary plates along the outer, and often also lateral, borders of each dorsal arm plate.
- a—Supplementary dorsal arm plates occurring along both the outer and lateral borders of the primary ones; oral papillæ short and stout. *aculeata*.
- b—Arm spines short, stout, flattened, blunt; radial shields mostly or entirely covered with granules or spines typical *aculeata*.

- bb*—Arm spines long, slender, conical, rather pointed; radial shields mostly or entirely naked var. *japonica*.
aa—Supplementary dorsal arm plates occurring only along the outer border of the primary ones; oral papillæ long and slender *brachyactis*.

Ophiopholis mirabilis (DUNCAN).

Ophiolepis mirabilis: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 460, Pl. IX, fig. 12, Pl. X, figs. 13 & 14.

Ophiopholis mirabilis: LYMAN, Bull. Mus. Comp. Zool., VI, 1879, p. 43; LYMAN, Rep. Challenger, V, 1882, p. 115; KÖHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909, p. 168; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 117, fig. 43.

Numerous specimens; off Misaki. Numerous specimens (belonging to Mr. R. SAITÔ, Imperial Museum at Uyeno, Tokyo); Aomori Bay. Four specimens; off Hokkaidô, Okhotsk Sea.

Korea (DUNCAN). Uruga Channel; 58 fathoms (CLARK). Off Doumiki Saki; 61 fathoms (CLARK). Off Andô Zaki; 76-79 fathoms (CLARK). Off Kinkwasan; 78 fathoms (CLARK). Hakodate Bay; 11.5-22 fathoms (CLARK).

The largest of these specimens is 10 mm. in the disk diameter and 40 mm. in the arm length. Most specimens are brownish gray in alcohol, variegated or spotted on the disk and banded on the arms with dark gray, and often patched on the disk with white. Some other specimens are yellowish brown, variegated and banded with dark brown, while still others are light brown, not variegated or banded. One specimen is entirely white. The relative size of the dorsal arm plates and the two large supplementary plates is also variable, ranging from 2:1 to 1:1.

Ophiopholis aculeata

(LINNÉ).

Asterias aculeata: LINNÉ,
 Sys. Nat., 1767, p. 1101.

Ophiopholis aculeata:
 GRAY, Rad. Anim. Brit.
 Mus., 1848, p. 25¹⁾; LÜTKEN,
 Addit. ad Hist. Oph., I,
 1861, p. 60, Pl. II, figs. 15
 & 16; LYMAN, Rep. Chal-
 lenger, V, 1882, p. 112, Pl.
 XLVI, fig. 6; LUDWIG, Zool.
 Jahrb., I, 1885, p. 285;
 BELL, Cat. Brit. Mus.
 Echinod., 1892, p. 125;
 GRIEG, Bergens Mus. Aarbog,
 1892 (1893), No. 3, p. 9;
 GRIEG, Fauna Arctica, I,
 1900, p. 264; MICHAILOVSKY,
 Ann. Mus. Pétersbourg,
 1902, p. 494; GRIEG, Ber-
 gens Mus. Aarbog, 1902, p.

13; NICHOLS, Proc. R. Irish Acad., XXIX, 1903, p. 257; NORMAN, Ann. Mag.
 Nat. Hist., Ser. 7, XII, 1903, p. 407; CLARK, Bull. U. S. Fish Comm., 1904,
 p. 559, Pl. V, figs. 24-27, Pl. VII, figs. 41 & 52; KÖHLER, Bull. Sci. Fr.
 Belg., XLI, 1907, p. 298; KÖHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909,
 p. 167; CLARK, Bull. U. S. Nat. Mus., 1911, p. 128, fig. 48; NICHOLS, Proc.
 R. Irish Acad., XXXI, 1911, p. 57; KÖHLER, Bull. U. S. Nat. Mus.,
 LXXXIV, 1914, p. 38.

Eleven specimens (belonging to Mr. H. ASANO, Imperial Bureau
 of Fishery); off Kitami; 60 fathoms.

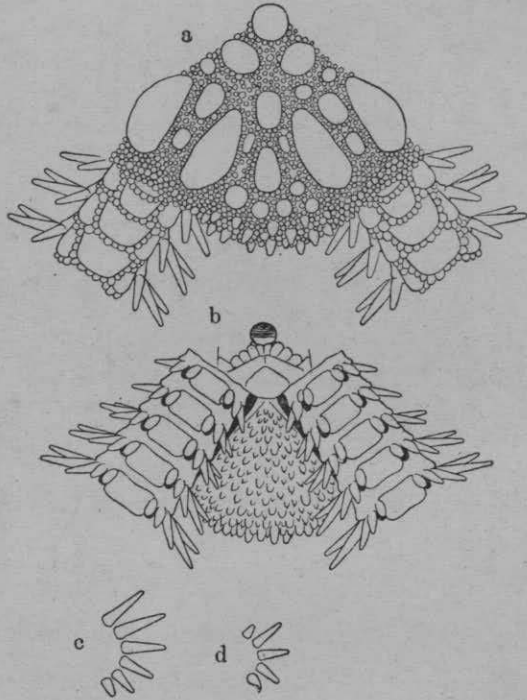


FIG. 40. *Ophiopholis mirabilis*. $\times 6\frac{2}{3}$. a. From above.
 b. From below. c. Arm spines of one side of an arm
 joint near disk. d. Arm spines of one side of an arm
 joint near the extremity.

1) This paper was not seen by me.

Sea of Japan; 59–190 fathoms (CLARK). Gulf of Tartary; 318 fathoms (CLARK). Okhotsk Sea; 64–73 fathoms (CLARK). North Pacific. Arctic Ocean. North Atlantic.

Ophiopholis aculeata var. *japonica* (LYMAN).

Ophiopholis japonica: LYMAN, Bull. Mus. Comp., Zool., VI, Pt. 2, 1879, p. 42, Pl. XIII, figs. 374–376; LYMAN, Rep., Challenger, V, 1882, p. 111, Pl. XXIII, figs. 13–15; KÖEHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909, p. 168.

Ophiopholis aculeata var. *japonica*: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 123, fig. 47.

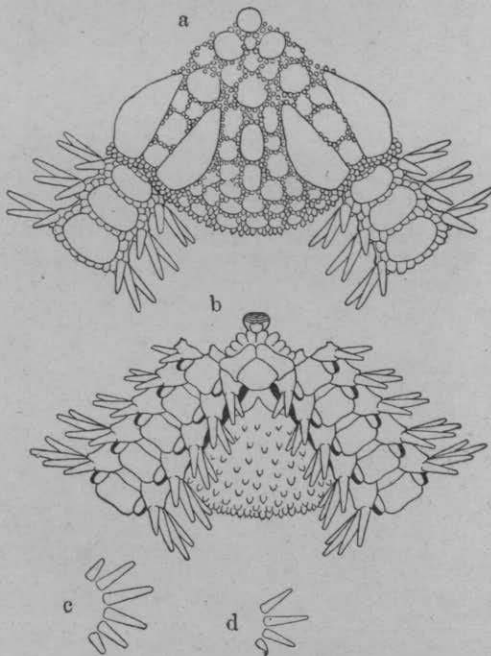


Fig. 41. *Ophiopholis aculeata* var. *japonica*. $\times 6$. *a*. From above. *b*. From below. *c*. Arm spines of one side of an arm joint near disk. *d*. Arm spines of one side of an arm joint near the extremity.

Numerous specimens; off Misaki, Sagami Sea. Three specimens; off Hokkaidô, Okhotsk Sea. One specimen; Albatross station 4784. One specimen; Albatross station 4791.

Off Omai Zaki, Yenshû Sea; 475–565 fathoms (CLARK, LYMAN). Sagami Sea; 369–775 fathoms (CLARK, LYMAN), Uraga channel; 58–302 fathoms (CLARK). Off Kinkwasan; 82 fathoms (CLARK). Off Port Arari; 400–726

fathoms (CLARK). Off Kii; 244-649 fathoms (CLARK). Off southern Hokkaidô; 175-349 fathoms (CLARK). Off Korea, Sea of Japan; 163 fathoms (CLARK). Sea of Japan; 59-428 fathoms (CLARK). Gulf of Tartary; 318 fathoms (CLARK). Off Saghalin; 21-32 fathoms (CLARK). Okhotsk Sea; 64-100 fathoms (CLARK). Yezo Strait; 86 fathoms (CLARK). Off Simushir Is.; 229 fathoms (CLARK).

Bering Sea. Alaska. Kamchatka.

Ophiopholis brachyactis CLARK.

Ophiopholis brachyactis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 117, fig. 44.

Numerous specimens; off Misaki. Numerous specimens; off Uki-shima, Uruga Channel. One specimen, attached to *Synallactes ishikawai* MITSUKURI; Albatross station 5092.

Off Ando Zaki; 79 fathoms (CLARK). Off Kii; 191 fathoms (CLARK). Uruga Channel; 88-197 fathoms (CLARK). Off Manazuru Zaki, Sagami Sea; 153 fathoms (CLARK). Suruga Gulf; 108-131 fathoms (CLARK). Eastern Sea; 103-361 fathoms (CLARK).

The largest of these specimens is 11 mm. in the disk diameter and 66 mm. in the arm length; a medium-sized one is 9 mm. in the disk diameter and 34 mm. in the arm length; and the smallest 4 mm. in the disk diameter and 15 mm. in the arm length. Thus, the arms are in none of my specimens so short as CLARK states, and indeed in the first specimen, they are about six times as long as the disk diameter. It appears to me that this species almost passes on into *O. aculeata* var. *japonica*. Some specimens of the latter, especially of Misaki and vicinity, frequently lack the disk spines and are less granulated on the disk, so that they look

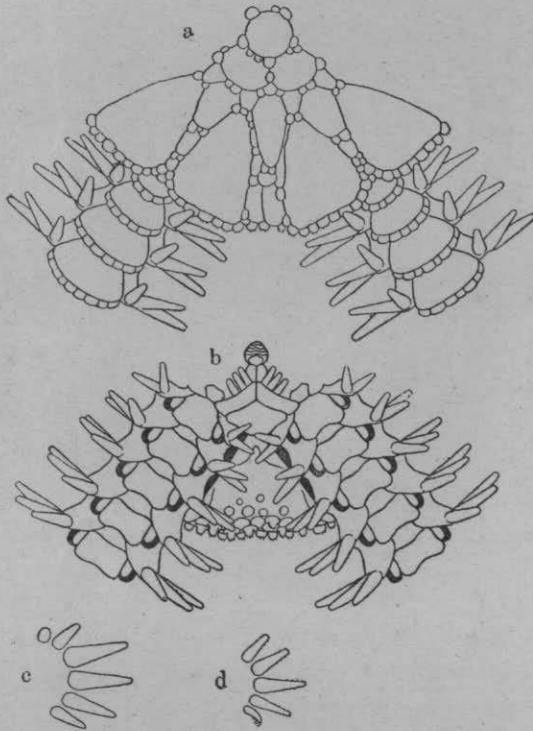


Fig. 42. *Ophiopholis brachyactis*. $\times 8$. *a*. From above. *b*. From below. *c*. Arm spines of one side of an arm joint near disk. *d*. Arm spines of one side of an arm joint near the extremity.

almost exactly like *O. brachyactis*, so far as the disk is concerned; others again have very short and stout arm spines like those of the typical *brachyactis*, while the supplementary plates on the sides of the dorsal arm plates are like those of the typical *japonica*. In the neighbourhood of Misaki, the northern *japonica* and the southern *brachyactis* occur side by side, and it is very possible that natural hybridisation may occur. Both these species are found clinging to gorgo-

naceans and hexactinellids, and are very often found together on the same piece of those animals.

Revision of the genera of *Amphiurinae*.

The forms which I now bring together under the *Amphiurinae*, have hitherto been referred to several genera chiefly on the ground of the character of the disk coverings, such as the presence or absence of scales, complete or localised squamation, the presence or absence of disk spines, &c. But I believe that, such a classi-

fication is very superficial, being based upon characters of merely secondary importance, as may be seen at once on looking over the whole series of this subfamily. The creation of *Hemilepis* and *Ophiopeltis* by LJUNGMAN and of *Ophionephthys* by LÜTKEN; the referring of those species which I now place in *Amphiactis*, to *Amphiura* by LYMAN; the referring of those genera which I now place in the *Ophiochitonidae*, to the *Amphiuridae* by many authors; the referring of a genuine *Amphiura* to *Hemipholis* by DUNCAN, &c. are, in my opinion, some of the more notable errors which have arisen from this superficial classification.

VERRILL has divided *Amphiura* and *Ophiocnida* in a wide sense respectively into five and three distinct genera by the character of the oral papillæ. I am obliged to adopt his subdivisions as a principle, because I believe that, it is scarcely possible otherwise to elucidate the interrelationships of the genera of the *Amphiurinae*. We see that, in almost all the genera of the present subfamily, the oral papillæ are quite similar in form and arrangement to those of any one of VERRILL's subdivisions of *Amphiura* in a wide sense. Thus, *Ophionephthys*, *Ophionema*, *Paramphiura*, *Ophiocentrus*, and VERRILL's *Amphiocnida* correspond in the character mentioned to *Amphiura* in VERRILL's sense; *Ophiophragmus*, as well as *Ophiocnida* in VERRILL's sense, to VERRILL's *Amphiodia*; *Ophiostigma* to *Amphipholis* in VERRILL's sense; and VERRILL's *Amphilimna* to VERRILL's *Amphioplus*. I look upon these relations to be of primary importance, being evidently more fundamental than the characters of the disk coverings.

Granting this, I believe there are two ways open for us; one would be to unite most genera of the present subfamily into a single genus, and the other to subdivide *Amphiura* and *Ophiocnida* in a wide sense into many genera. The first way appears to me

to be less adapted to the purpose of bringing out the interrelationships of the different subdivisions of this subfamily, which is very extensive and very rich in species and species groups. Therefore, I am obliged to adopt the second way.

We may also ask if VERRILL's subdivisions of *Amphiura* s. ext. are sharply distinguishable from one another or not. My answer is affirmative. Unfortunately, *Amphiura* s. str. and *Amphiodia*, or *Amphiodia* and *Amphioplus* are frequently confused by certain authors. My method of distinguishing them from each other is as follows.

I distinguish three groups of oral papillæ in the present subfamily: the first group is infradental, arising from the dental plate¹⁾; the second arises from the oral plate; the third arises from the adoral shield. When a papilla arises partly from the oral plate and partly from the adoral shield, it is referred to the second group. Now, let +I denote the presence of the first group, -I its absence, +II the presence of the second group, &c. Then, the oral papillæ of VERRILL's subdivisions of *Amphiura* s. ext. may be shown by formulæ as follows.

Amphioplus-group: +I +II +III.

Amphiodia-group: +I +II -III.

Amphipholis-group: +I +II -III.²⁾

Amphiura-group: +I -II +III, or rarely +I +II +III.

In both the *Amphioplus*- and *Amphiura*-group, there is present an additional papilla just outside and above the infradental one, so that the latter is not the highest in position of all the papillæ.

1) The infradental papillæ arise from the oral plates, notwithstanding its intimate relation to the dental plate in the adult (H. L. CLARK: Growth-changes in Brittle Stars; Publication No. 182 of the Carnegie Inst., Washington, 1914.).

2) The outermost oral papilla of the *Amphipholis*-group arises from the adoral shield, notwithstanding its partial relation to the oral plate in the adult (CLARK: loc. cit.).

In both the *Amphiodia*- and *Amphipholis*-group, on the contrary, such an additional papilla is entirely absent, and the infradental one is the highest in position. In the *Amphioplus*-group, all the three groups of oral papillæ are well developed and form a continuous row, while in the *Amphiura*-group, the second group of oral papillæ is entirely,—or mostly, as in certain species of *Amphiura*,—absent. In the *Amphiodia*- and *Amphipholis*-group, the third group of oral papillæ is absent, the two subdivisions being distinguished by the different development of the outermost oral papilla.

It must be clear from the above exposition, that the *Amphiodia*-group is not intermediate between the *Amphioplus*- and *Amphiura*-group, but the latter are directly interrelated without the intermediation of the first. In my opinion, those species of *Amphiura* s. str. with two distal oral papillæ on either side are rather intermediate between *Amphiura* with a single distal papilla and *Amphioplus*, instead of being intermediate between the former and *Amphiodia*.

My division of the *Amphiurinae* into four groups almost coincides with VERRILL'S subdivision of *Amphiura* s. ext., but not with KÖHLER'S. Most species of KÖHLER'S *Amphiodia* (e.g. those in Res. Siboga Exp.), as well as *Amphiodia digitula* CLARK, 1911, appear to me not to be genuine *Amphiodia*, but to be *Amphiura* having however two distal oral papillæ, of which at least the outermost one arises from the adoral shield.

Key to genera of *Amphiurinae*.

- I. *Amphioplus*-group :—Oral papillæ +I +II +III, four or five on either side, forming a continuous row, so that the oral slits are more or

- less perfectly closed; an additional papilla present just outside and above the infradental one.
- a*—Disk entirely free of spines.
- b*—Outermost oral papilla small and not operculiform; radial shields divergent *Amphioplus*.
- bb*—Outermost oral papilla very large and operculiform; radial shields more or less perfectly joined..... *Amphichilus*.
- aa*—Disk beset with scattered spines.
- c*—Oral papillæ close-set, the outermost one being not very long and spiniform but short and flat; radial shields divergent; three to five arm spines; tentacle scales short, flat, leaf-like..... *Amphiacantha*.
- cc*—Oral papillæ well spaced and conical, the outermost one being very long and spiniform; radial shields perfectly joined; six to ten arm spines; two spiniform tentacle scales, of which the adradial one is very long and slender..... *Amphilimna*.
- II—*Amphiodia*-group:—Oral papillæ +I +II -III, three or four on either side, subequal, forming a continuous row, so that the oral slits are more or less perfectly closed; no additional papilla just outside and above the infradental one.
- d*—Disk free of spines and granules.
- e*—Disk soft, without special marginal scales or spines; radial shields usually divergent *Amphiodia*.
- ee*—Disk solid, with a row of special marginal scales or spines, so that the boundary between the dorsal and ventral sides of the disk is very sharp; radial shields perfectly joined *Ophiophragmus*.
- dd*—Disk with numerous scattered spines or granules *Ophiocnida*.
- III—*Amphipholis*-group:—Oral papillæ +I +II -III, three on either side, the outermost one being very large and operculiform; oral slits perfectly closed; no additional papilla just outside and above the infradental one.
- f*—Disk entirely free of spines *Amphipholis*.
- ff*—Disk with scattered spines or granules *Ophiostigma*.
- IV—*Amphiura*-group:—Oral papillæ +I -II +III or sometimes +I

+II +III, two or three on either side, discontinuous, the infradental and distal ones being separated from each other by a wide interval; oral slits gaping; an additional papilla present just outside and above the infradental one; radial shields divergent or separated from each other.

- g*—Disk entirely free of spines.
- h*—No supplementary plates between the oral plates and the adoral shields.
- i*—Oral shields not very stout, not in contact with the first lateral arm plates.
- j*—Disk entirely or partially covered with fine scales; radial shields not very narrow and bar-like *Amphiura*.
- jj*—Disk entirely covered by a smooth naked skin; radial shields exceedingly narrow and bar-like *Ophionema*.
- ii*—Oral shields very stout, in contact with the first lateral arm plates; two distal oral papillæ, of which the outer one is small and spiniform, while the inner one is very large and flat; ten arm spines *Ctenamphiura*.
- lh*—Two supplementary plates present between the oral plates and the adoral shields of each interradius *Paramphiura*.
- gg*—Disk beset with numerous spines *Ophiocentrus*.

Key to Japanese species of *Amphioplus*.

- A*—Two tentacle scales to each pore.
- a*—Three arm spines.
- b*—Tentacle scales unusually large, nearly closing the large pores; ventral arm plates much wider than long; disk unknown
..... *megapomus*.
- bb*—Tentacle scales small, not closing the large pores; ventral arm plates longer than wide; radial shields slender, partly joined in pairs *rhadinobrachius*.
- aa*—Four or more arm spines.

- c*—Four or five arm spines, of which the second lowermost is hook-shaped at the tip and microscopically serrate along the concave side; radial shields small, divergent; outer end of each genital plate bearing, just distally to the radial shield, a small projection, which is microscopically thorny at the tip..... *ancistrotus*.
- cc*—Six arm spines, one or more middle ones terminating with a minute, glassy cross-bar; upper arm plates hexagonal, twice as wide as long; disk unknown *hexacanthus*.
- AA*—Single tentacle scale to each pore.
- d*—Three arm spines, of which the uppermost one is the longest and the lowest one the shortest; disk scales rather coarse, with very distinct six primaries; radial shields very large and wide, divergent; oral shields very small, triangular; ventral arm plates hexagonal, in contact with each other for a short extent; tentacle scales large and oval *cernuus*
- dd*—Four or five arm spines.
- e*—Four arm spines, of which the uppermost and the lowest ones are longer than the middle two; disk scales fine; radial shields slender, partly joined in pairs; interbrachial ventral surfaces covered by a naked skin; oral shields small, rhomboidal; ventral arm plates quadrangular, widely in contact with each other; tentacle scales small and crescentic..... *glaucus*.
- ee*—Five arm spines, of which the lowest one is the longest; disk scales fine; radial shields long and rather narrow, divergent; oral shields large, pentagonal, much wider than long; ventral arm plates quadrangular, much wider than long, widely in contact with each other; tentacle scales small and oval..... *macraspis*.

Amphioplus megapomus CLARK.

Amphioplus megapomus: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 170.

Off Kii, Kitan Channel; 37 fathoms (CLARK).

Amphioplus rhadinobrachius CLARK.

Amphiura sp.: LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 158, Pl. XIII, figs. 1-3.

Amphioplus rhadinobrachius: CLARK, Bull. U. S. Nat. Mus., LXXV 1911, p. 169, fig. 74.

Numerous specimens; Okinosé (a submarine bank), Sagami Sea; 85 fathoms.

Sagami Sea; 369-405 fathoms (CLARK). Suruga Gulf; 282-503 fathoms (CLARK).

In the larger specimens, the interbrachial ventral surfaces are almost naked, though in the smaller ones they are distinctly squamated, as shown in CLARK'S figure. LÜTKEN & MORTENSEN'S species, which was not named because the disk was wanting, agrees very well with the present species. Many of my specimens also lack the whole dorsal side of the disk.

Amphioplus ancistrotus (CLARK).

Amphiodia ancistrota: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 161, fig. 69.

Numerous specimens; Okinosé (a submarine bank), Sagami Sea; 85 fathoms. Two specimens; Yahagi-gaké, off Misaki, Sagami Sea; 310 fathoms.

Uraga Channel; 70-197 fathoms (CLARK). Off Manazuru Zaki, Sagami Sea; 153 fathoms (CLARK). Off Ôsé Zaki, Suruga Gulf; 45-65 fathoms (CLARK). Off Kii, Kitan Channel; 191 fathoms (CLARK). Sea of Japan; 61 fathoms (CLARK).

In my specimens, the radial shields are narrower and less divergent than in CLARK'S type. The oral shields are rhomboidal and longer than wide, but variable. On either side of the oral

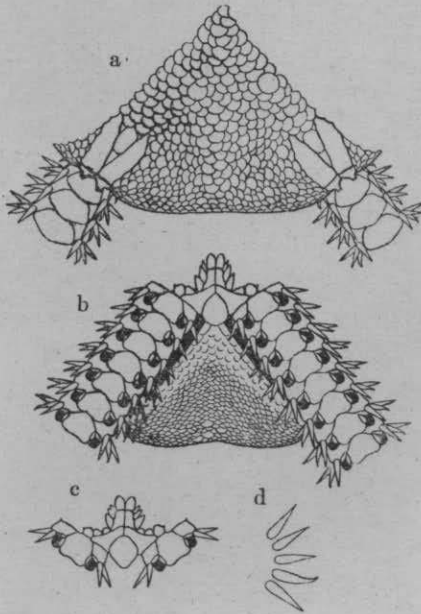


Fig. 43. *Amphioplus ancistrotus*. a. From above. $\times 8$. b. From below. $\times 8$. c. Ventral view of an oral angle. $\times 16$. d. Arm spines of one side of an arm joint near disk. $\times 16$.

angle, there are usually four oral papillæ, of which the outermost one arises from the adoral shield; besides, there occurs an additional papilla, placed above the level of the ordinary papillæ, but visible from below just between the infradental and the next papilla. In some specimens, there are five ordinary and one additional papillæ, of which the outermost two arise from the adoral shield (fig. c). Thus, the mouth parts of the present species present the characters of *Amphioplus*, and not of *Amphiodia*.

Amphioplus hexacanthus CLARK.

Amphioplus hexacanthus: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 70.

Uraga Channel; 88 fathoms (CLARK).

Off California; 50 fathoms (CLARK).

Amphioplus cernuus (LYMAN).

Amphiuura cernua: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 28, Pl. XII, figs. 323-325; LYMAN, Rep. Challenger, V, 1882, P. 138, Pl. XVII, figs. 13-15.

Amphioplus cernua: VERRILL, Transact. Connecticut Acad., X, 1899, p. 315.

Eastwards from Honshû; 2,300 fathoms (LYMAN).

Amphioplus glaucus (LYMAN).

Amphiura glauca: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 29, Pl. XII, figs. 326-328; LYMAN, Rep. Challenger, V, 1882, p. 139, Pl. XVIII, figs. 1-3.

Amphioplus glauca: VERRILL, Transact. Connecticut Acad., X, 1899, p. 315.

Sagami Sea; 345 fathoms (LYMAN). Yenshû Sea; 420 fathoms (LYMAN).

Amphioplus macraspis (CLARK).

Amphiodia macraspis: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 157, fig. 66.

Numerous specimens; Ôtaba, Sagami Sea; 500 fathoms.

Off Honshû; 501-749 fathoms (CLARK). Suruga Gulf; 60-270 fathoms (CLARK). Sagami Sea; 622 fathoms (CLARK). Off Korea; 184 fathoms (CLARK). Gulf of Tartary; 318 fathoms (CLARK).

Off Washington; 115 fathoms (CLARK).

In the larger specimens, the radial shields are rather narrower and the ventral arm plates comparatively wider. As far as I have observed, there is present in all cases a single tentacle scale to each pore. The oral papillæ are very variable. There are present usually four genuine oral papillæ on either side, besides an additional one, which occurs just between the infradental and the distal papillæ. The additional papilla is smaller and

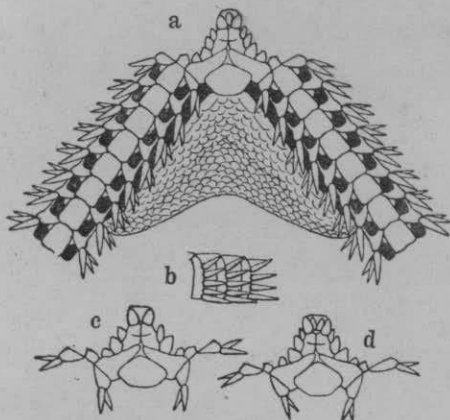


Fig. 44. *Amphioplus macraspis*. $\times 9$. a. From below. b. Side view of three arm joints near disk. c. Ventral view of an oral angle. d. Ditto.

acuter than the ordinary ones, and is sometimes placed at a higher level than the distal oral papillæ (fig. d), but very often forms a continuous series with the latter (fig. a). Sometimes, there occur only two genuine distal papillæ (fig. c), besides the comparatively large additional one. The outermost papilla is very small, often so small as to be almost imperceptible; the next is the largest of all. These two arise

from the adoral shield. Sometimes, a single (fig. a) or paired (fig. d.) very small additional infradental papillæ are present, just above and between the pair of the ordinary ones.

As already mentioned, *Amphiodia* does not stand intermediate between *Amphiura* and *Amphioplus*, but the last two genera are directly related to each other. In my opinion, the species of *Amphiura* with two distal oral papillæ on either side, such as *A. anomala* LYMAN, *A. crassa* KÆHLER, *A. servata* KÆHLER, *A. grata* KÆHLER, *A. reposita* KÆHLER, *A. koreæ* DUNCAN, *A. assimilis* LÜTKEN & MORTENSEN, *A. digitula* (CLARK), &c. are *Amphioplus*-like *Amphiura*, while the present species is a representative of *Amphiura*-like *Amphioplus*. The oral angle shown in fig. c more or less reminds us of that of an *Amphiura*.

Amphichilus, g. nov.

Disk covered with fine, imbricating scales. Radial shields small, narrow, usually joined in pairs. One apical and two distal pairs of oral papillæ to each oral angle; the apical pair are infradental, arising from the dental plate; the inner pair of the distal ones arise from the oral plate; the outermost pair are very large, wide, operculiform, arising from the adoral shield. Besides, an additional papilla occurs just above and between the apical and inner distal papillæ, so that the oral slits are perfectly closed. Arms long, slender, flattened, inserted ventrally to the disk, only horizontally flexible. Three arm spines. One or two tentacle scales to each pore.

This new genus includes *Amphiura dalea* LYMAN, 1874, and *A. intermedia* KÖHLER, 1905, besides the genotype, *Amphichilus trichoides*, nov.

Amphichilus differs from *Amphioplus* in the presence of only three genuine oral papillæ, besides an additional one, on either side of each oral angle; in the very large and operculiform outermost oral papilla; and in the usually joined radial shields. It differs from *Amphipholis* in the discontinuous arrangement of the genuine oral papillæ, and in the presence of the additional oral papilla, which fills up the space between the apical and inner distal papillæ.

Amphichilus trichoides, sp. nov.

One specimen; locality unknown, perhaps Sagami Sea.

Diameter of disk 6 mm. Length of arms 60 mm. Width of arms at base 0.5 mm.

Disk circular, rather convex dorsally, covered with very fine,

imbricating scales, which are finer outwards and along the sides of the radial shields. Primary plates indistinct. Radial shields long and narrow, acutely pointed within, about one-fifth as long as the disk diameter, meeting with each other for nearly their whole

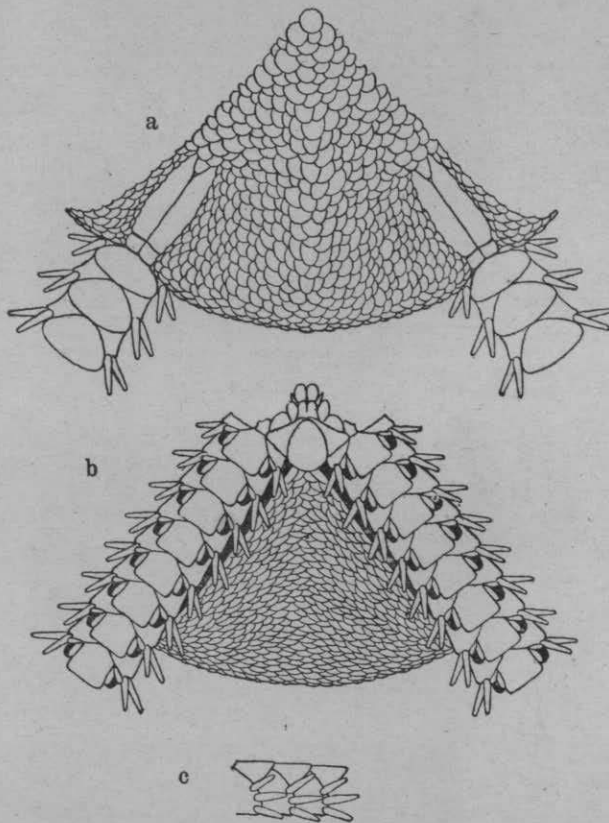


Fig. 45. *Amphichilus trichoides*. $\times 20$. a. From above. b. From below. c. Side view of three arm joints near disk.

length but parted at the proximal end. Interbrachial ventral surfaces covered also with imbricating scales, which are somewhat finer than those of the dorsal surface. Genital slits long.

Oral shields ovate, or rather triangular with perfectly rounded angles, lateral sides quite and outer side strongly convex; much longer than wide. Adoral shields triangular, tapered within to a point,

where they nearly meet. The apical oral papillæ are oval and stout. Two distal oral papillæ on either side; the outer one is the largest of all, much wider than long, flat, thick, has curved free edge, and arises from the adoral shield; the other longer than wide, flat, thick, with obtuse end. Besides, there occur above the

level of the ordinary ones between the apical and the next papilla, an acute additional papilla, which together with the others closes the oral slit.

Arms long and very slender, flattened. Dorsal arm plates triangular, with much rounded angles, inner sides slightly and outer side strongly convex, wider than long, successive plates slightly in contact. Lateral arm plates low, joined on the sides, but not meeting above; below, the plates meet slightly beyond the basal region of the arms. First ventral arm plate very small, pentagonal, longer than wide; those beyond hexagonal, nearly as long as wide, slightly wider without than within, successive plates a little in contact in the basal joints; but more distally, they are separated by the lateral plates, and are pentagonal. Three arm spines, subequal, about as long as the corresponding arm joint, conical and obtuse. Two tentacle scales, a larger adradial and a smaller abradial forming nearly a right angle.

Colour in alcohol light yellowish gray.

This new species differs from *A. daleus* (LYMAN) in the narrower and perfectly joined radial shields, in the smaller adoral shields, in the shape of the ventral arm plates and in the presence of two tentacle scales; and from *A. intermedius* (KÖHLER) in the shape of the radial and oral shields, in the shape of the oral papillæ, especially of the infradental ones, and in the narrower arms. The last species appears to be most nearly allied to the present.

Amphiacantha, g. nov.

Disk covered with fine, imbricating scales, and scattered spines. Radial shields usually divergent, sometimes entirely

separated from each other. Four or five pairs of oral papillæ to each oral angle, short, close-set; the apical infradental pair arise from the dental plate, and the outermost pair from the adoral shield. Arms long, slender, flattened, inserted ventrally to the disk, only horizontally flexible. Three to six arm spines. One or two small, leaf-like tentacle scales.

This new genus includes *Ophiostigma formosa* LÜTKEN, 1872, *Ophiocnida serradia* DUNCAN, 1889, *Amphiura notacantha* LÜTKEN & MORTENSEN, 1899, *A. gastracantha* LÜTKEN & MORTENSEN, 1899, *Ophiocnida libera* KÖHLER, 1907, *O. amphacantha* McCLENDON, 1909, *Amphilimna pentacantha* CLARK, 1911, and *Amphiacantha dividua*, nov., besides the genotype, *Amphioplus acanthinus* CLARK, 1911.

Amphiacantha is practically *Amphioplus* with disk spines, and differs from *Amphilimna* VERRILL (non CLARK, 1911), in the divergent radial shields, in the close-set oral papillæ, in the not very long, but short and flattened outermost oral papilla, in the fewer arm spines, and in the not long and spiniform, but short and leaf-like tentacle scales.

Key to Japanese species of *Amphiacantha*.

- A*—Three arm spines; two tentacle scales; radial shields not very small, joined or closely set in pairs.
- a*—Disk spines very numerous, very short, blunt, present on both the dorsal and ventral sides; radial shields joined in pairs; oral shields much wider than long; ventral arm plates longer than wide.
 *formosa*.
- aa*—Disk spines not very numerous, very long, slender, acute, present only on the dorsal side; radial shields divergent, the pairs being in contact only at the outer ends; oral shields much longer than wide; ventral arm plates wider than long *acanthina*.

AA—Four arm spines; single tentacle scale; radial shields very small, widely separated from each other; disk spines not very numerous, very short, blunt, present only on the dorsal side. *dividua*.

Amphiacantha formosa (LÜTKEN).

Ophiostigma formosa: LÜTKEN, Oph. Nov., 1872, p. 3, Pl. I-II, figs. 5a & 5b; LYMAN, Rep. Challenger, V, 1882, p. 166; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 76; KÖHLER, Res. Exp. Siboga, XLV, Pt. 2, 1905, p. 24, Pl. II, fig. 1.

Strait of Formosa (LÜTKEN).

Indian Ocean and Malaysian waters.

As far as I can judge from LÜTKEN's description and figures, this species is evidently not referable to *Ophiostigma*, having four oral papillæ, of which the outermost one is very small and rudimentary, quite as in the next species.

Amphiacantha acanthina

(CLARK).

Amphioplus acanthinus: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 168, fig. 75.

Two specimens; Uraga Channel; 140 fathoms.

Off Tsurugi Saki; 110–259 fathoms (CLARK). Suruga Gulf; 148 fathoms (CLARK).

The disk scales are fine and regular in one of the

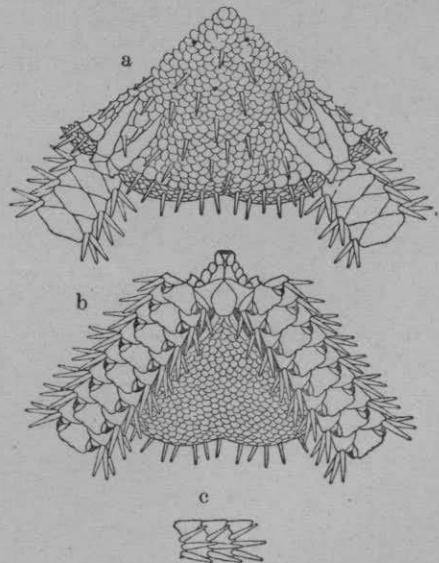


Fig. 46. *Amphiacantha acanthina*. $\times 5$. a. From above. b. From below. c. Side view of three arm joints near disk.

specimens, but coarse and irregular in the other. The oral papillæ are usually five on either side, but four in some of the oral angles. The outermost papilla is very small. The disk spines are rather more numerous than in CLARK'S type.

Amphiacantha dividua, sp. nov.

One specimen; locality unknown, probably Sagami Sea.

Diameter of disk 3 mm. Length of arms 15 mm. Width of arms at base 0.7 mm.

Disk subpentagonal, with slightly convex interradial borders, covered with very fine, imbricating scales and scattered spines, which are very short, conical and obtuse. Radial shields very small, subtriangular, with the adradial side longest, about twice as long as wide. Interbrachial ventral surfaces covered also with imbricating scales, which are somewhat finer than those of the dorsal side; without any spines. Genital slits long.

Oral shields oval, or rather rhomboidal with rounded angles and convex sides, distinctly longer than wide, wider without than within. Adoral shields triangular, long, rather narrow, tapered inwards to an acute point, not

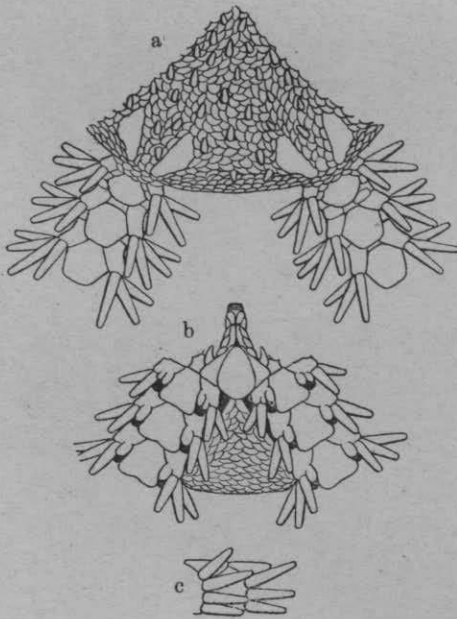


Fig. 47. *Amphiacantha dividua*. $\times 16$. a. From above. b. From below. c. Side view of two arm joints near disk.

in contact with each other. Oral plates long and narrow. Six oral papillæ on either side, flat, obtuse, except the outermost one, which has pointed inner end. Teeth quadrangular, stout, with truncate free end.

Six arms, of which three are longer and stouter than the others. Dorsal arm plates hexagonal, with rounded outer angles, slightly longer than wide, widest at the lateral angles, in contact with each other. Lateral arm plates low, those of the two sides not meeting above or below. First ventral arm plate very small, pentagonal, longer than wide. Those beyond hexagonal, with concave lateral and notched outer borders and rounded outer angles, slightly longer than wide, widest at the outer angles. Four arm spines in the free basal joints, cylindrical, tapered, blunt; the second from above which is the longest, is slightly longer than the corresponding arm joint, while the lowest one, which is the shortest, is slightly shorter than the same. A short distance out from the disk, there are only three arm spines on either side of each arm joint, the uppermost being the longest. A single large, oval, flat tentacle scale to each pore, except the first which has usually two scales.

Colour in alcohol bluish.

This new species very much resembles *A. sexradia* (DUNCAN, 1889), but differs from it in the fewer and more widely spaced disk spines, in the quite distinct disk scales and radial shields, in the more numerous oral papillæ, in the longer and narrower oral shields, in the shape of the dorsal and ventral arm plates and in the longer arm spines.

Key to Japanese species of *Amphiodia*.

- A*—Radial shields fully in contact in pairs; ventral arm plates pentagonal, as wide as, or wider than, long; four arm spines; two tentacle scales *craterodometa*.
- AA*—Radial shields divergent, slightly or not at all in contact in pairs; ventral arm plates quadrangular, longer than wide; outer two oral papillæ pointed; tentacle scales very rudimentary.
- a*—Interbrachial ventral surfaces finely squamated; four or five arm spines; one or two rudimentary tentacle scales..... *euraspis*.
- aa*—Interbrachial ventral surfaces covered by a naked skin; four or five arm spines; single rudimentary tentacle scale to each pore. *psilochora*.

***Amphiodia craterodometa* CLARK.**

Amphiodia craterodometa: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911 p. 155, fig. 65.

Yezo Strait; 533 fathoms (CLARK). Okhotsk Sea; 58–69 fathoms (CLARK). Off Saghalin; 21–32 fathoms (CLARK). Gulf of Tartary; 318 fathoms (CLARK). Off Korea; 116 fathoms (CLARK). Alaska (CLARK). Bering Sea (CLARK). Arctic Ocean (CLARK).

***Amphiodia euraspis* CLARK.**

Amphiodia euraspis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 158, fig. 67.

Suruga Gulf; 211–293 fathoms (CLARK). Off Korea; 184–250 fathoms (CLARK). Gulf of Tartary; 318 fathoms (CLARK). Bering Sea (CLARK). California (CLARK).

***Amphiodia psilochora* CLARK.**

Amphiodia psilochora: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 165, fig. 72.

Sagami Sea ; 292-622 fathoms (CLARK). Off Ôse Zaki, Suruga Gulf ; 55-65 fathoms (CLARK). Off eastern Japan ; 440 fathoms (CLARK).

Ophiophragmus japonicus MATSUMOTO.

Ophiophragmus japonicus : MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 70.

Numerous specimens ; off Namami, Kagoshima Bay ; 8-15 fathoms. Two specimens ; Enoura, Suruga. Numerous specimens ; off Oginohama, Rikuzen ; 10-20 fathoms.

Diameter of disk 7 mm. Length of arms 45 mm. Width of arms at base 1 mm.

Disk five-lobed, with very convex interbrachial borders, covered with very fine, imbricating scales. Six primary plates more or less distinguishable at the central region. Radial shields semilunar, one-third as long as the disk radius, twice as long as wide, separated only at the proximal end, obtusely pointed within. A row of large and squarish marginal scales occurs on the disk. The scales of the interbrachial ventral surfaces just outside the marginal scales are turned up, so as to form a sort of fence. The marginal scales are more elevated than

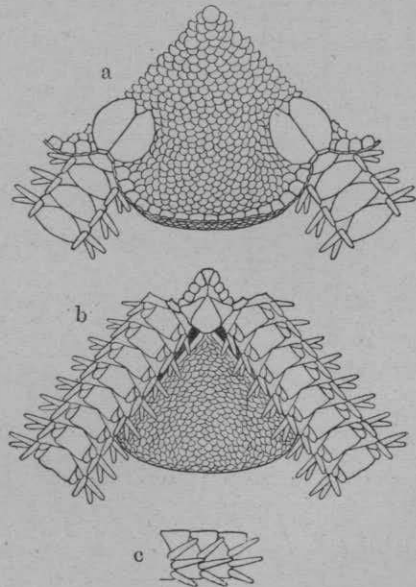


Fig. 48. *Ophiophragmus japonicus*. $\times 8$.
a. From above. b. From below. c. Side view of three arm joints near disk.

the arms, and the interbrachial region of the disk is strongly convex below. Genital slits long.

Oral shields rhomboidal, with the inner sides much longer than the outer, with acute inner and rounded lateral and outer angles, much longer than wide. Adoral shields triangular, tapered within to a point, and not meeting with each other. Four oral papillæ on either side of the oral angle, close-set, continuous, subequal and blunt, the innermost one somewhat stouter.

Dorsal arm plates oval, large, outer border curved, inner border strongly convex, forming part of a circle; as wide as the arms, twice as wide as long, a little in contact with each other. Lateral arm plates inserted like so many wedges between the successive dorsal plates above and ventral plates below; well separated above but closer below. First ventral arm plate very small, quadrangular, much wider than long. Those beyond pentagonal, with very large inner angle and slightly notched outer border, wider than long, only a little in contact with each other. Three arm spines, conical, subequal, blunt, nearly as long as the corresponding arm joint. Two tentacle scales, very flat and thin; abradial one smaller than the adradial, and overlapping its base.

Colour in alcohol light yellow.

This species somewhat resembles *O. affinis* DUNCAN, especially in the number of the oral papillæ, but differs from it in the shape of the radial and oral shields and of the dorsal arm plates. In my opinion, *Amphipholis andreæ* LÜTKEN, 1872, *Amphiura præstans* KÖHLER, 1905, and *Amphiodia periercta* CLARK, 1911, are referable to *Ophiophragmus*, each showing certain affinities to the present species. I have observed also in younger specimens of the present species that, the marginal disk scales are so prominent as to form a hem-like

row of denticles, so that the disk border is serrate, quite as in CLARK's fig. 68d of *O. perierctus*.

Key to Japanese species of *Amphiopholis*.

- A*—Radial shields perfectly joined in pairs.
- a*—Arms three to four times as long as the disk diameter; dorsal arm plates distinctly shorter than the corresponding arm joint, without any streak along the median line.
- b*—Disk scales thin, rather indistinct from one another, so that the surface of the disk is very smooth; radial shields not very wide, about two and a half times as long as wide, the united width of each pair being nearly equal to the width of the corresponding arm base; three arm spines, of which the uppermost one is the longest, the lowest one the shortest, and the middle one the stoutest but not distinctly compressed.....*japonica*.
- bb*—Disk scales thickened along the free margins, concave, very distinct from one another, so that the surface of the disk is not very smooth; radial shields very wide, about twice as long as wide, the united width of each pair much exceeding the width of the corresponding arm base; three, sometimes four, arm spines, of which the uppermost one is the longest, and the middle one the shortest and stoutest and distinctly compressed.....*sobrina*.
- aa*—Arm seven to eight times as long as the disk diameter; dorsal arm plates as long as the corresponding arm joint, with a distinct white streak along the median line.....*pugetana*.
- AA*—Radial shields divergent, being nearly or entirely separated from each other by a row of scales; three arm spines, of which the lowest one is the longest; adradial tentacle scale much larger than the abradial.....*kochii*.

Amphipholis japonica MATSUMOTO.

Amphipholis japonica: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 71.

Numerous specimens; Arai Beach, Misaki Marine Biological Station. One specimen; Tomo, Bingo. One specimen; Asami Bay, Tsushima. One specimen; Akuné, Satsuma. Several specimens; Shimabara, Hizen.

Diameter of disk 3 mm. Length of arms 12 mm. Width of arms at base 0.5 mm.

Disk circular, covered with fine, thin, imbricating scales, which are again covered over by a thin skin, so that the surface

of the disk is very smooth. Radial shields comparatively large, pear-seed shaped, slightly shorter than half the disk radius, about two and a half times as long as wide, completely joined in pairs, except at the very inner ends, where they are separated from each other by a triangular, wedge-shaped scale. Inter-brachial ventral surfaces covered also

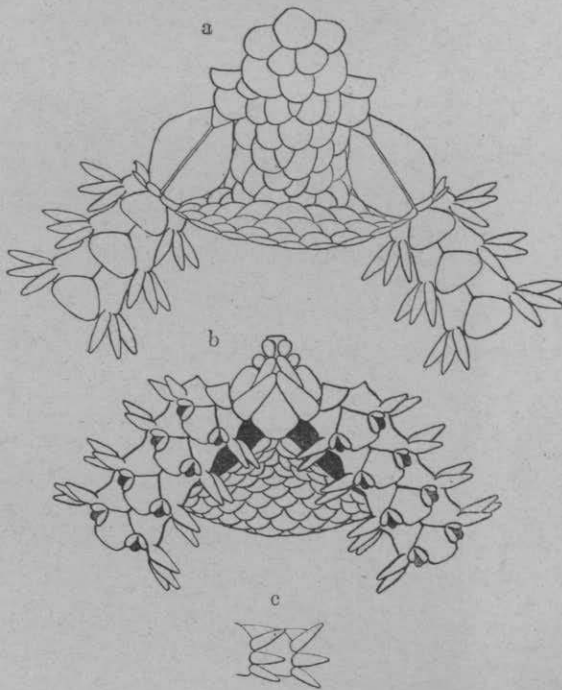


Fig. 49. *Amphipholis japonica*. $\times 27$. a. From above. b. From below. c. Side view of two arm joints near disk.

with fine, imbricating scales, which are only slightly finer than those of the dorsal side. Genital slits long.

Oral shields rhomboidal, with very acute inner and rounded lateral and outer angles, inner sides longer than the outer; longer than wide. Adoral shields triangular, long and narrow, wider outwards than inwards, meeting with each other within. Three oral papillæ on either side; the inner two are rounded, while the outermost one is very large, wide and operculiform. Teeth quadrangular and stout.

Dorsal arm plates triangular, with rounded angles and convex sides, about one and a half times as wide as long, much shorter than the corresponding arm joints, so that the successive plates are separated from one another. Lateral arm plates rather low, distinctly flared outwards, those of the two sides meeting with each other both above and below. First ventral arm plate small, triangular, with convex outer side, wider than long. Those beyond pentagonal, with acute inner angle, outer lateral angles perfectly rounded, inner sides straight, lateral sides concave, outer side convex; about as long as, or slightly longer than, wide, widest at the inner lateral angles. Three arm spines, conical, acute; the uppermost one is the longest, slightly shorter than, or hardly as long as, the corresponding arm joint; the middle one is the stoutest, but not distinctly compressed; the lowest one is the shortest. Two small, oval, flat, leaf-like tentacle scales, of which the adradial one is slightly larger than the abradial.

Colour in alcohol white or light yellow. In life, the disk is light reddish brown.

I have compared these specimens with those of *A. squamata* (DELLE CHIAJE) from Naples, and found only two trifling differences between them. In the Japanese specimens, the arms are three to

four times as long as the disk diameter and the ventral arm plates have a convex outer border and rounded outer lateral angles, while in the Neapolitan specimens, the arms are two and a half to three times as long as the disk diameter and the ventral arm plates have straight outer border and not rounded outer lateral angles. The difference in the arm length may not be very important in the question of the distinctness of the two species, because in *A. squamata* the arms are said to vary from two and a half to four and a half times as long as the disk diameter. I therefore look upon the difference in shape of the ventral arm plates as the only distinctive character of the present species as compared with *A. squamata*. In the shape of the ventral arm plates, the present species much resembles *A. australiana* CLARK, but differs from it in the more numerous disk scales of the dorsal side and coarser disk scales of the ventral side. The radial shields have each a white spot at the outer end, as in *A. squamata*.

The present species is common in the neighbourhood of Misaki and is found living under stones in fine sand. As to its sensitiveness to the coarseness of the sand, I made the following observations at Arai Beach. In the summer of 1910, there were at first among the rocks numerous spots covered with fine sand, and this species was found very abundantly; but after a tempest, it was reduced to small numbers, owing to the fact that the spots with fine sand became very scanty. In the summer of 1911, spots with fine sand were very scanty, and this species was also few. In the summer of 1912, the beach was entirely covered with coarse sand, and the species could not be found any longer. This ophiuran is very quick in motion, and can instantly conceal itself in the sand, when the stone is turned up.

The present species is undoubtedly viviparous like *A. squamata*.

In summer, the larger individuals contain several embryos. I have once dissected out six embryos from a single adult. Animals containing full grown embryos appear to give birth to them the night after they are placed in an aquarium.

Amphipholis sobrina, sp. nov.

Numerous specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms. Five specimens; Sengendzuka-Aoyamadashi, Sagami Sea; 85 fathoms. Three specimens; off Ôshima, Sagami Sea; 75-85 fathoms.

Diameter of disk 3 mm. Length of arms 10 mm. Width of arms at base 0.6 mm.

Disk subpentagonal, covered with imbricating scales, which are rather fine, thickened along the free margins, concave, very distinct from one another and coarser inwards than outwards. Six primaries rather distinct, larger than the other scales, separated from one another. Radial shields large, pear-seed shaped, slightly shorter than half the disk radius, about twice as long as wide, completely joined in pairs, except at the very inner ends, where they are separated from each other by a triangular, wedge-shaped scale; the united width of each

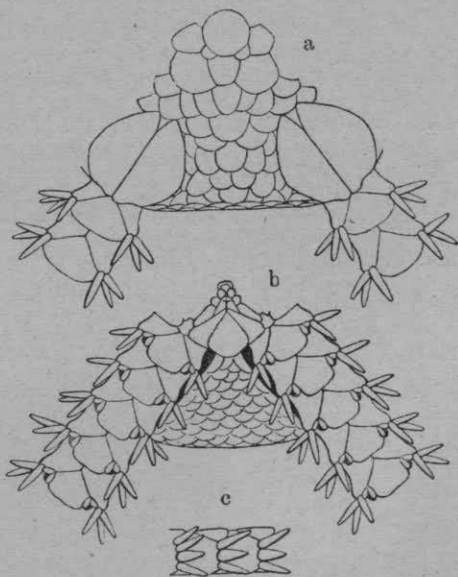


Fig. 30. *Amphipholis sobrina*. $\times 20$. a. From above. b. From below. c. Lateral view of three arm joints near disk.

pair distinctly exceeds the width of the corresponding arm base. Interbrachial ventral surfaces covered also with imbricating scales, which are much finer than those of the dorsal side. Genital slits long.

Oral shields rhomboidal, with acute inner and rounded lateral and outer angles, inner sides longer than the outer; slightly longer than, or nearly as long as, wide. Adoral shields triangular, long, tapered inwards, meeting with each other within. Three oral papillæ on either side, the inner two are rounded, and the outermost one is very large, wide and operculiform. Teeth quadrangular and stout.

Dorsal arm plates triangular, with rounded outer lateral angles and convex outer side, one and a half times as wide as long, shorter than the corresponding arm joint, so that the successive plates are not in contact with each other. Lateral arm plates low, flared outwards, those of the two sides slightly meeting with each other both above and below. First ventral arm plate exceedingly small, pentagonal, longer than wide. Those beyond pentagonal, with rounded outer lateral angles and convex outer side, wider than long, widest at the inner lateral angles, not in contact with each other, except the first two or three plates. Three, or sometimes four, arm spines, of which the uppermost is usually the longest, and the middle one is the shortest and stoutest and is distinctly compressed at the base. Two very small, oval, flat, leaf-like tentacle scales, of which the adradial one is slightly larger than the abradial.

Colour in alcohol: white or yellow, except the dorsal side of the disk, which is light bluish; radial shields with a white spot at the outer end, as in *A. squamata* and *A. japonica*.

The present species is very near to *A. japonica*, but differs

from it in the coarser and more distinct disk scales, in the much larger radial shields, in the wider ventral arm plates and in the middle arm spines being the shortest and distinctly compressed at the base.

The specimens from Mera-out-Oisegaké have stouter arms than those from Sengendzuka-Aoyamadashi and from off Ôshima. This difference may probably be due to bathymetrical factor. I regard the specimens from Mera-out-Oisegaké as the type of the present species.

Amphipholis pugetana (LYMAN).

Amphiura pugetana: LYMAN, Proc. Boston Soc. Nat. Hist., VII, 1860, p. 193¹⁾; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 125; LYMAN, Rep. Challenger, V, 1882, p. 145; KOEHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 305.

Amphipholis pugetana: VERRILL, Trans. Conn. Acad., X, 1899, p. 312; McCLENDON, Univ. California Publ. Zool., VI, 1909, p. 43, Pl. II, figs. 12 & 13; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 166, figs. 73.

One specimen (belonging to Mr. R. SAITÔ, Imperial Museum at Uyeno, Tokyo); Aomori Bay. Four specimens (belonging to Mr. SASAKI, Coll. Agricult., Sapporo); Oshoro, near Otarunai, Hokkaidô. One specimen (belonging to Mr. H. ASANO, Imperial Bureau of Fishery); off Kitami; 60 fathoms.

Puget Sound. California. Washington. Alaska.

The largest one of these specimens measures 4 mm. across the disk and 28 mm. in the arm length. In the larger specimens, the disk scales are very fine and exceedingly numerous, and the primary plates are indistinguishable; while in the smaller speci-

1) This paper was not seen by me.

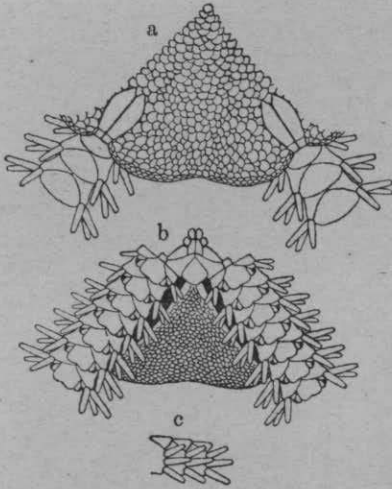


Fig. 51. *Amphipholis pugetana*. $\times 12$. a. From above. b. From below. c. Side view of three arm joints near disk.

mens, the disk scales are comparatively coarse and the primary plates very distinct. The arms are long and very slender, being widest at about one-fourth the entire length from the base. The dorsal arm plates are nearly as wide as the corresponding arm joints, and about one and a half times as wide as long. The ventral arm plates are slightly wider than long and have a notched outer border. The dorsal, as well as the ventral, arm plates

are not in direct contact with one another, being slightly separated by wedge-like prolongations of the lateral arm plates, except the first two ventral arm plates, which are joined to each other. The colour in alcohol well agrees with LYMAN'S description, but the arms are irregularly banded with grayish shade.

I am informed by Mr. SASAKI that the animals are found attached to the rhizomes of *Zostera marina*. It is interesting to find this species occurring in the northern waters of Japan, since it has been known only from the eastern coast of the North Pacific.

Amphipholis kochii LÜTKEN.

Amphipholis kochii: LÜTKEN, Oph. Nov., 1872, p. 10, Pl. I & II, fig. 6.

Amphiuura kochii: LYMAN, Rep. Challenger, V, 1882, p. 146.

Numerous specimens; Arai Beach, Misaki Biological Station.

Numerous specimens; Misaki. One specimen (belonging to Mr. R. SAITÔ, Imperial Museum at Uyeno, Tokyo); Aomori Bay. Uladiwostock (LÜTKEN).

This species is very variable. The disk scales are often coarse and very irregular. The primary plates are sometimes visible. The oral shields are rhomboidal, with the inner sides longer than the outer, and longer than wide; so that in LÜTKEN's fig. 6b, the upper right one is most natural. The ratio of the arm length to the disk diameter is greater in smaller specimens;

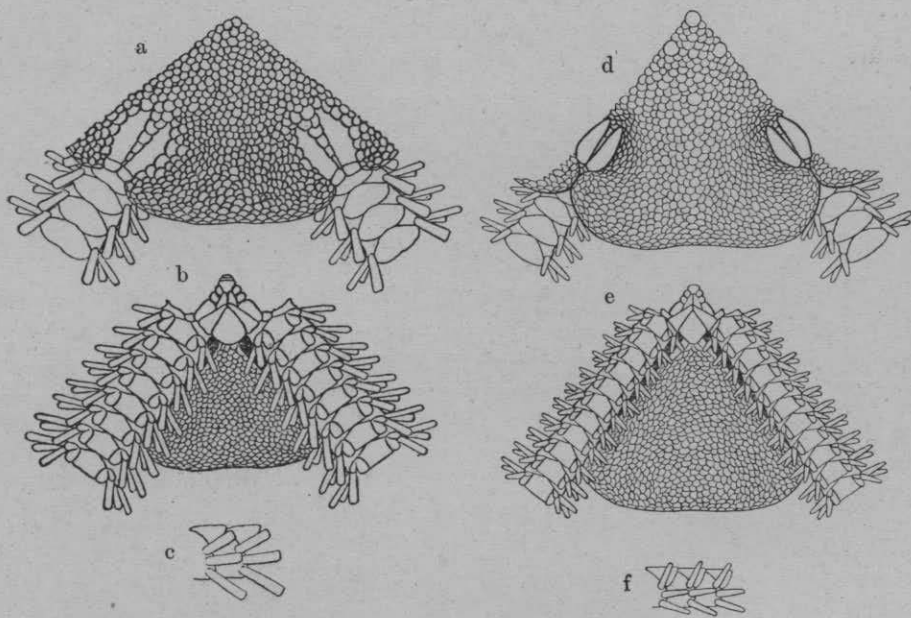


Fig. 52. *Amphipholis kochii*. a. From above. $\times 8$. b. From below. $\times 8$. c. Side view of two arm joints near disk $\times 8$. d. From above. $\times 6$. e. From below. $\times 6$. f. Side view of three arm joints near disk. $\times 6$.

so that the size contrast of the arms is not so striking between two specimens, one of which is 4 mm. and the other is 7 mm. across the disk. In the smaller specimens the disk is flat, sub-

pentagonal, with nearly straight interbrachial borders; while in the larger ones the disk is swollen and the interbrachial regions bulge out more markedly. The radial shields do not take part in this bulging process, and are consequently deeply sunken, while their distance from the centre of the disk is not much greater than in the smaller specimens. The radial shields are distinctly separated in the smaller specimens, but more or less meet with each other in the larger ones. The colour in alcohol, as in life, is also variable. Some specimens are gray or yellowish gray, and spotted on the arms with dark gray; others are dull yellow, with some disk scales gray; the radial shields are usually light yellow, hemmed with dark gray. Specimens with coarse and irregular disk scales are darker in colour.

Amphiura (FORBES, 1842) VERRILL, 1899.

Syn. *Ophionephtys* LÜTKEN, 1869.

I look upon *Ophionephtys* LÜTKEN as a synonym of *Amphiura* s. str. The reduction of the disk scales which is a characteristic of *Ophionephtys* is also observed in *Amphiura acrystata*, as well as in some *Amphiura* formerly referred to *Hemilepis*, while the absence of the tentacle scales is characteristic of certain *Amphiura* formerly referred to *Ophiopeltis*. There is not a single character by which *Ophionephtys* can be satisfactorily distinguished from *Amphiura*.

Key to Japanese species of *Amphiura*.

A—Tentacle scales present.

α—Two tentacle scales to each pore.

- b*—Two, or sometimes three, distal oral papillæ on either side, besides an additional one, which lies deep within the oral slit.
- c*—Three arm spines, subequal, or the middle one slightly longer than the other two; disk distinctly squamated both above and below, with very prominent primaries; radial shields large, rather wide, each pair being separated from each other by a row of usually three large scales; ventral arm plates wider than long *korœa*.
- cc*—Four arm spines, of which the lowest one is the longest and the third from below the shortest; disk distinctly squamated above, but covered with fine granule-like scales below; the primaries are indistinct in larger specimens; radial shields long and very narrow, slightly divergent; outer end of each genital plate, just distal to the radial shield, bearing a projection, which is thorny at the tip; ventral arm plates longer than wide *digitula*.
- bb*—Single distal oral papilla on either side, besides an additional one, which lies more or less deep within the oral slit.
- d*—Four arm spines.
- e*—Disk squamated both above and below.
- f*—Disk scales very fine and thin; radial shields long and narrow, about thrice as long as wide, separated from each other; adoral shields not meeting with each other; arm spines subequal . . . *bellis*.
- ff*—Disk scales rather coarse and thick, some of them projecting like a hemisphere, so that the surface of the disk is very rough; radial shields not very long, about twice as long as wide, separated from each other; adoral shields meeting with each other in the inter-radial line; the uppermost and the lowest arm spines distinctly longer than the middle two *trachydisca*.
- ee*—Disk squamated above, but naked below; radial shields partially joined in pairs; adoral shields meeting with each other in the interradian line; middle two of the four arm spines stouter and blunter than the uppermost and lowest *microdiscus*.
- dd*—Five to seven arm spines; disk naked at least below.

- g*—Disk rather thick, distinctly squamated above; radial shields short; lower arm spines spur-shaped and rough at the tip *euopla*.
- gg*—Disk very thin, mostly naked, the scales persisting only around the radial shields, which are long and rather narrow; arm spines conical, not rough..... *acrystata*.
- aa*—Single tentacle scale to each pore.
- h*—Three arm spines.
- i*—Disk distinctly squamated both above and below.
- j*—Disk scales rather fine; radial shields very wide, widest near the inner end; oral shields rounded, longer than wide; adoral shields widely separated from each other in the interradial line; dorsal arm plates separated from one another by the lateral arm plates; ventral arm plates pentagonal, longer than wide, only slightly in contact with one another; arm spines subequal *acacia*.
- jj*—Disk scales coarse; radial shields not very wide, wider outwards oral shields oval, much wider than long; adoral shields widely meeting with each other in the interradial line; dorsal arm plates widely in contact with one another; ventral arm plates hexagonal or heptagonal, widely in contact with one another; middle arm spine longer than the other two..... *pyncostoma*.
- ii*—Interbrachial ventral surfaces naked; radial shields long and narrow; oral shields rounded pentagonal, wider than long; adoral shields not meeting with each other in the interradial line; distal oral papilla long and spiniform; dorsal, as well as ventral, arm plates slightly in contact with one another; arm spines subequal..... *carchara*.
- hh*—Four to seven arm spines.
- k*—Four or five arm spines, of which the lowest is the longest and the third from below the shortest.
- l*—Four, rarely five, conical arm spines, of which the maximum length does not exceed twice the corresponding arm joint; disk scales ill-defined, not distinctly imbricated, but pavement-like; radial shields very long and narrow, bar-like; oral shields large, much wider than

long; distal oral papilla not much larger than the apical papilla and tentacle scales, rather thick; dorsal arm plates very convex in longitudinal section; ventral arm plates not keeled.....*iris*.

ll—Five flattened arm spines, of which the maximum length is about thrice the corresponding arm joint; disk scales distinctly imbricated; radial shields not very long, pear-seed shaped; oral shields small, nearly as long as wide; distal oral papilla much larger than the apical papilla and tentacle scales, very flat and thin; dorsal arm plates rather straight in longitudinal section; ventral arm plates with a median keel*iridooides*.

kk—Six or seven arm spines.

m—Six arm spines, of which the third or fourth from above is the longest; radial shields long and narrow; oral shields diamond-shaped, about as long as wide; distal oral papilla subspinous, long, compressed*lütkeni*.

mm—Six or seven arm spines, of which the lowest one is the longest; radial shields extremely small, short and narrow; oral shields oval, about as long as wide; distal papilla very large, fan-shaped, flat.....*micraspis*.

AA—Tentacle scales absent; disk mostly naked, the disk scales persisting only around the radial shields; numerous arm spines, of which the lower ones are rough at the tip.

n—Five to seven arm spines; dorsal and ventral arm plates wider than long.

o—Five arm spines near disk, but four more distally; dorsal arm plates very large and wide even at the arm bases; arms twelve or thirteen times as long as the disk diameter.....*cestuarii*.

oo—Six or seven arm spines near disk, but five or six more distally; dorsal arm plates very small and rudimentary at the arm bases; arms exceedingly long, more than thirty times as long as the disk diameter.....*vadicola*.

nn—Ten arm spines; dorsal and ventral arm plates much less wide than

long; arms about fourteen times as long as the disk diameter....

..... *conomiotata*.

Amphiura koreæ DUNCAN.

Amphiura koreæ: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 466. Pl. X, figs. 18 & 19.

Amphiura coreæ: LYMAN, Rep. Challenger, V, 1882, p. 146.

Amphipholis coreæ: VERRILL, Transact. Connecticut Acad., X, 1899, p. 321.

Amphiura diomedææ: LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXII, 1899, p. 151, Pl. XIII, figs. 1-7; KÖHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 86; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 140.

Numerous specimens; Ôtaba, Sagami Sea; 500 fathoms.

Off Manazuru Zaki, Sagami; 120-749 fathoms (CLARK). Off Port Arari; 400-726 fathoms (CLARK). Suruga Gulf; 140-503 fathoms. Off Omai Zaki; 475-662 fathoms (CLARK). Off eastern Japan; 39 fathoms (CLARK). Sea of Japan; 79 fathoms (CLARK). Kagoshima Gulf; 58 fathoms (CLARK).

Pacific side of Central America. Malaysian waters (KÖHLER).

That the specimens at hand are referable to *A. diomedææ* appears to me certain. But an examination of DUNCAN's description and figures of *A. koreæ*, which is considered by several authors to belong to what is now called *Amphipholis*, has convinced me that DUNCAN's species in question is merely an *Amphiura* s. str., and is probably identical with *A. diomedææ*. DUNCAN did not

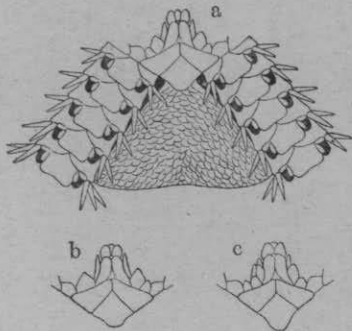


Fig. 53. *Amphiura koreæ*. $\times 7$. a. From below. b. Ventral view of an oral angle. c. Ditto.

mention the size of his type specimen; but judging from the magnification of his figures, his specimen must have been much smaller than LÜTKEN & MORTENSEN's type. The smaller specimens in my hands appear to me to correspond well to DUNCAN's description and figures, the only essential difference being the shape of the oral shield, which is lyre-shaped and very wide outwards in DUNCAN's figure. But the oral shields, adoral shields and oral papillæ, &c. of *A. diomedææ* are subject to great variation, as stated by LÜTKEN & MORTENSEN. Therefore, I am inclined to look upon *A. koreæ* and *A. diomedææ* to be conspecific, the former having the priority.

In the specimens at hand, the arms are mostly four to six times as long as the disk diameter, so that they are usually longer than in DUNCAN's and KÖHLER's specimens, but usually shorter than in LÜTKEN & MORTENSEN's. In some of the oral angles, there may be one to three additional infradental papillæ besides the ordinary pair. The disk is usually light bluish and the arms yellowish or light brownish in colour in alcohol.

Amphiura digitula (CLARK).

Amphiodia digitula: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 162, fig. 70.

Four specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Off Ôse Zaki, Suruga Gulf; 45-48 fathoms (CLARK). Sea of Japan; 70 fathoms (CLARK).

In my opinion, the present species is evidently referable to *Amphiura* s. str., though CLARK refers it to *Amphiodia*. The distal oral papillæ are usually two in number on either side, both arising from the adoral shield. In some cases, there are three

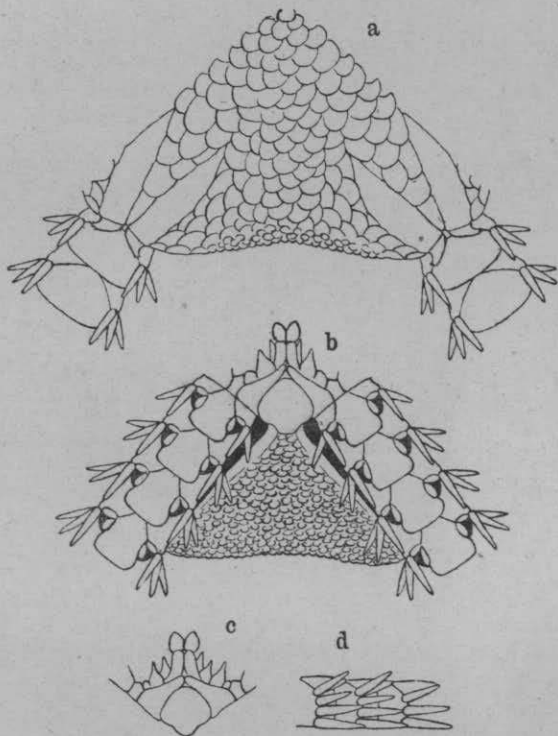


Fig. 34. *Amphiura digitula*. $\times 15$. a. From above. b. From below. c. Ventral view of an oral angle. d. Side view of three arm joints near disk.

distal oral papillæ, of which one arises from the oral plate (fig. c); besides, there is an additional papilla, which evidently corresponds to the scale of the first oral tentacle, just inside and above the innermost one of the distal papillæ, thus almost approaching the type of the oral papillæ of *Amphioplus*. The disk is light bluish and the arms whitish in colour in alcohol.

Amphiura bellis LYMAN.

Amphiura bellis: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 19; LYMAN, Rep. Challenger, V, 1882, p. 127, Pl. XVIII, figs. 4-6, Pl. XL, figs. 16-18; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 140.

Sagami Sea; 345-775 fathoms (LYMAN). Off Manazuru Zaki, Sagami Sea; 120-265 fathoms (CLARK). Off Ôsé Zaki, Suruga Gulf; 63-75 fathoms (CLARK). Off Omai Zaki; 624 fathoms (CLARK). Off Kii; 649 fathoms (CLARK).

Lat. $19^{\circ} 10' S.$, long. $178^{\circ} 10' E.$; 210-610 fathoms (LYMAN).

Amphiura trachydisca CLARK.

Amphiura trachydisca: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 149, fig. 60.

One specimen; Yahagi-gaké, Sagami Sea; 310 fathoms.
Two specimens; Nakano-yodomi, Sagami Sea; 210 fathoms.
Numerous specimens; Okinosé, Sagami Sea; 100 fathoms.
Numerous specimens; Sagami Sea.

Off Heda; 161-167 fathoms (CLARK). Suruga Gulf; 108-148 fathoms (CLARK). Uruga Channel; 88 fathoms (CLARK).

The largest one of these specimens is 15 mm. across the disk. Those from Okinosé are somewhat different from the other specimens, which agree quite well with CLARK's type, and have an almost smooth disk and relatively narrower arms, though there is no doubt that they belong to this species.

Amphiura microdiscus DUNCAN.

Hemipholis microdiscus: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 467, Pl. X, figs. 20-22; LYMAN, Rep. Challenger, V, 1882, p. 158.

Korea Strait; 51 fathoms (DUNCAN).

According to DUNCAN, this species has two pairs of oral papillæ to each oral angle, the apical ones being infradental and the distal ones arising from the adoral shields. There is therefore no doubt that, this species is a genuine *Amphiura* and not a *Hemipholis*.

Amphiura euopla CLARK.

Amphiura candida: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus., II, 1887, p. 299. (Non LJUNGMAN, 1866.)

Amphiura euopla: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 144, fig. 57.

One specimen; Enoshima, Sagami. Numerous specimens; Misaki. Numerous specimens; Izuhara, Tsushima.

Off Ôsé Zaki, Suruga Gulf; 45–60 fathoms (CLARK).

The specimen from Enoshima is the largest of all, being 6 mm. in the disk diameter, and is the only one in which the primaries are invisible. The others are all small, and have conspicuous primaries and distinctly squamated interbrachial ventral surfaces. The distal oral papilla is not so long and spini-form as in CLARK'S type, and the oral shields are not so long, but slightly longer than wide. Further, in the smaller specimens, they are as wide as, or wider than, long. The arm spines are much flattened, except in the basal region of the arms, and are thorny at the end, with the exception of the uppermost one or two. In the smaller specimens, they are less flattened and less thorny.

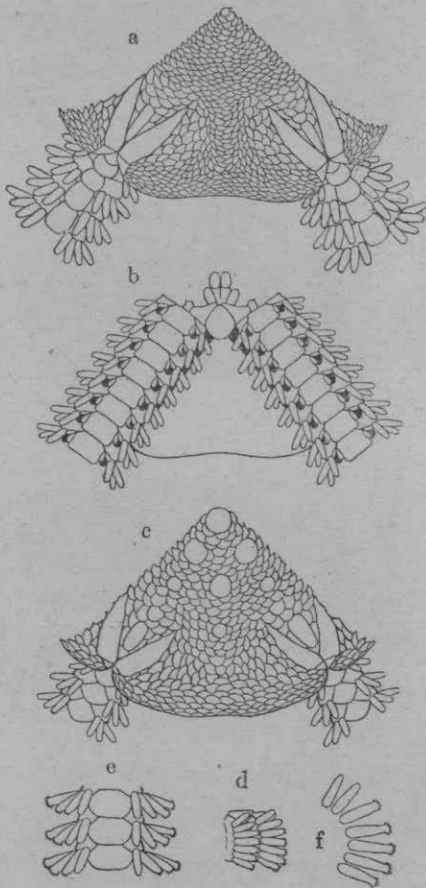


Fig. 55. *Amphiura euopla*. a. From above. $\times 8$. b. From below. $\times 8$. c. Young specimen, from above. $\times 14$. d. Side view of two arm joints near disk. $\times 8$. e. Dorsal view of three arm joints near disk. $\times 8$. f. Arm spines of one side of an arm joint near disk. $\times 14$.

Amphiura acrystata CLARK.

Amphiura acrystata: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 145, fig. 58.

Numerous specimens; Okinosé (a submarine bank), Sagami Sea; 85 fathoms.

Off Tsurugi Zaki; 110–259 fathoms (CLARK). Off Kii; 191 fathoms (CLARK). Sea of Japan; 59 fathoms (CLARK). Southwards from Hokkaidô; 269–464 fathoms (CLARK).

California; 8–33 fathoms (CLARK).

In the larger specimens, the disk coverings remind us of those of the *Ophionephthys*-type, the tentacle scales being however well developed. This species may be brought forward to prove the small taxonomic value of the reduction of the disk scales, which is the character separating *Ophicnephthys* from *Amphiura*.

Amphiura acacia LYMAN.

Amphiura acacia: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 21, Pl. XI, figs. 292–294; LYMAN, Rep. Challenger, V, 1882, p. 130, Pl. XVI, figs. 15–17.

Yenshû Sea; 565 fathoms (LYMAN).

Amphiura pycnostoma CLARK.

Amphiura pycnostoma: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 151, figs. 62.

Off Kii, Kumano Sea; 440 fathoms (CLARK).

Amphiura carchara CLARK.

Amphiura carchara: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 142, fig. 55.

Sagami Sea; 614 fathoms (CLARK).

Bering Sea. Alaska. Washington.

Amphiura iris LYMAN.

Amphiura iris: LYMAN, Bull. Mus. Comp. Zool., VI, Pt. 2, 1879, p. 23, Pl. XI, figs. 302-304; LYMAN, Rep. Challenger, V, 1882, p. 132, Pl. XVI, fig. 4-6; KÖHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 81.

One specimen; Mera-out-Oisegaké; Sagami Sea; 300 fathoms. Seven specimens; Okinosé (a submarine bank), Sagami Sea; 85 fathoms.

Sagami Sea; 420-775 fathoms (LYMAN).

Malaysian waters; 1,595m. (KÖHLER).

The first specimen, which is the largest, measures 5.5 mm. across the disk and 25 mm. in the arm length. The disk scales are fine, ill-defined, convex and pavement-like, so that the dorsal surface of the disk appears rough. The radial shields are long, narrow, bar-like, about half as long as the disk radius, about four times as long as wide, completely separated from each other, those of a pair almost parallel. The distal oral papilla is subquadrangular, with truncated or indented free end. The apical one is also squarish, but slightly smaller than the distal one. The additional papilla, which corresponds to the scale of the first oral tentacle pore, is also squarish, with truncated or indented free end, smaller than the distal, but larger than the apical one. The dorsal arm plates are rather oval and slightly in contact with one another; the surface is convex both transversely and longitudinally, so that the plate is more or less humped. The ventral arm plates are subpentagonal, slightly in contact with one another. The arm spines are variable in length; the ratio of their length to the corresponding arm joint in different parts of an arm may be shown approximately as follows:—

Number of lateral arm plates. Number of arm spines.	1st.	5th.	10th.	15th.	20th.	30th.
Uppermost		1.6				
4th. from below		1.3	1.2	1.2	1.2	
3rd. from below		0.9	0.9	1.0	1.1	1.2
2nd. from below ...	0.5	1.1	1.1	1.2	1.1	1.1
Lowest	1.2	1.4	1.8	1.7	1.6	1.4

The tentacle scale is oval and leaf-like, but relatively smaller than in the next species.

Amphiura iridoides, sp. nov.

Amphiura glabra: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus., II, 1887, p. 300. (Non LYMAN, 1879.)

Twelve specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Diameter of disk 4 mm. Length of arms 20 mm. Width of arms at base 0.9 mm.

Disk subpentagonal, with more or less straight interbrachial borders, covered with rather fine, imbricating scales, which are finer outwards than inwards. Six primaries prominent, distinctly larger than the other scales. Radial shields rather large, pear-seed-shaped, about two-fifths as long as the disk radius, two and a half to three times as long as wide, widest at about one-third of the entire length from the outer end, entirely separated from each other, divergent. Interbrachial ventral surfaces covered also with fine, imbricating scales, which are finer than those of the dorsal side. Genital slits long, extending from the oral shields to the disk border.

Oral shields small, rhomboidal, with obtuse inner and rounded

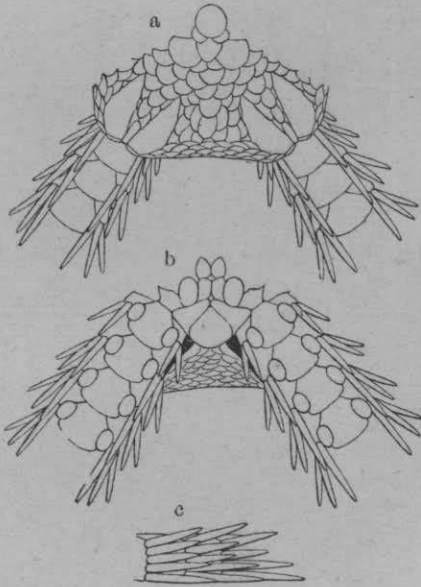


Fig. 56. *Amphiura iridoides*. $\times 14$. a. From above. b. From below. c. Side view of three arm joints near disk.

lateral and outer angles, about as wide as long. Adoral shields also small, triangular, with concave adradial side, longer than wide, tapering inwards, nearly meeting with each other in the interradiial line. Oral plates rather short, very narrow. There is a small, naked, depressed space between the adoral shields and the oral plates of each oral angle. Two oral papillæ on either side; the distal one, arising from the adoral shield, is very large, oval, flat, thin and leaf-like; the apical one is infradental,

small, short, very thick. Teeth quadrangular and thick.

Arms stout in comparison to the disk diameter, more or less cylindrical, wider than high, very gradually tapering outwards. Dorsal arm plates fan-shaped, with convex outer border, wider than long, wider outwards than inwards; the surface is nearly level longitudinally, but decidedly convex transversely. Lateral arm plates rather high, those of the two sides not meeting with each other above or below, except in the very distal arm joints; they are almost covered over by the arm spines. First ventral arm plates not very small, pentagonal, wider than long. Those beyond hexagonal, with the shortest inner lateral sides and longest and convex outer border, lateral sides concave, corresponding to the tentacle pore; about as long as, or longer than, wide, widest at the outer ends of the tentacle pores, faintly

keeled along the longitudinal median line, widely in contact with each other. Five arm spines, long, flattened, acute, unequal in length; the ratio of their length to the corresponding arm joint in different parts of an arm may be shown approximately as follows.

Number of lateral arm plates. Number of arm spines.	1st.	5th.	10th.	15th.	25th.	35th.
Uppermost		1.4	1.4	1.3		
4th. from below		1.2	1.2	1.1	1.1	1.1
3rd. from below		1.0	1.0	1.0	1.0	0.9
2nd. from below	1.0	1.3	1.4	1.3	1.2	1.1
Lowest	1.3	1.5	2.0	3.0	1.8	1.4

Thus, the lowest spine is always the longest and the third from below the shortest; the lowest one is longest at a certain distance from the disk, being there about thrice as long as the corresponding arm joint. Single, very large, oval, flat, leaf-like tentacle scale to each pore.

Colour in alcohol: whitish, except the dorsal side of the disk, which is frequently light blue.

This new species is very near to *A. iris*, which occurs also in the Sagami Sea, but differs from it in the distinctive characters already mentioned. Further, *A. iridoïdes* appears to me to differ from *A. glabra* LYMAN in the very prominent primary plates, in the distinctly squamated interbrachial ventral surfaces, in the much smaller and narrower oral shields, in the not very distinctly separated adoral shields, in the larger, oval, flattened distal oral papillæ, in the longer and flattened arm spines, and in the larger tentacle scales. Judging from MARKTANNER-TURNERETSCHER'S description, the specimen which he refers to *A. glabra* appears to me likely to belong to *A. iridoïdes*.

Amphiura lütkeni DUNCAN

Amphiura lütkeni: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 464, Pl. X, fig. 17. (Non LYMAN, 1882.)

Amphiura duncani: LYMAN, Rep. Challenger, V, 1882, p. 143; LORIOU, Rev. Suiss. Zool., I, 1893, p. 403; KÖHLER, Res. Exp. Siboga, XLV, Pt. 2, 1905, p. 33.

Korean Seas (DUNCAN).

Malaysian waters (KÖHLER).

The specific name of this species was changed by LYMAN, because he thought that, after the union of LJUNGMAN'S *Amphipholis* with *Amphiura*, *Amphiura lütkeni* was preoccupied by *Amphipholis lütkeni* of LJUNGMAN. Now, the latter species has been referred by VERRILL to *Ophiocnida* or possibly to *Amphiodia*, so that the specific name of the present species can be revived.

Amphiura micraspis CLARK.

Amphiura micraspis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 150, fig. 61.

Off Omai Zaki; 36 fathoms (CLARK).

Amphiura aestuarii MATSUMOTO.

Amphiura aestuarii: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 73.

Numerous specimens; Aburatsubo, Misaki Marine Biological Station.

Diameter of disk 6 mm. Length of arms 75 mm. Width of arms at base 0.8 mm.

Disk five-lobed, covered by a soft naked skin, except along

the abradial and inner borders of the radial shields, where it is covered by fine, imbricating scales, arranged in four or five rows

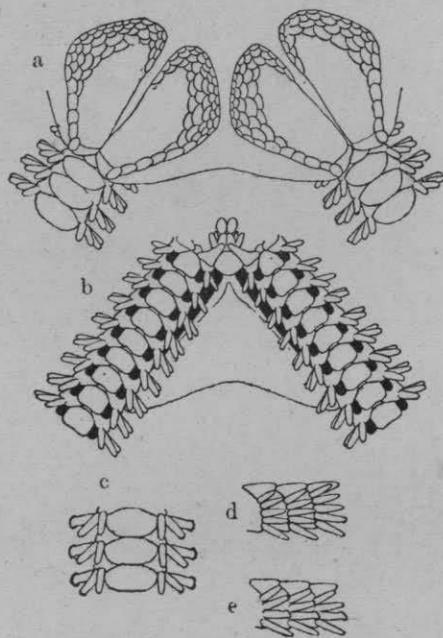


Fig. 57. *Amphiura aestuarii* $\times 10$. a. From above. b. From below. c. Dorsal view of three arm joints at about one-third of the arm length from the base. d. Side view of three arm joints near disk. e. Side view of three arm joints at about one-third of the arm length from the base.

on the inner border but in only one on the outer part of the abradial side, and finer inwards than outwards. Naked part of radial shields large, pear-seed-shaped, more than half as long as the disk radius, more than twice as long as wide, hardly in contact with-out, slightly divergent within. Interbrachial ventral surfaces also covered by a soft naked skin. Genital slits long.

Oral shields rhomboidal, or pentagonal with a very short inner side and a much rounded outer angle; wider than long; madreporic shield much larger and almost circular.

Adoral shields triangular with concave adradial side, tapered within, where they do not meet. Two pairs of oral papillae in each oral angle; apical ones oval and very stout; distal ones spiniform, obtuse, arising from the adoral shields. Besides, there occurs one spiniform papilla on either side just above the distal one.

Dorsal arm plates transversely oval, twice as wide as long, successive plates in contact. Lateral arm plates not very prominent, almost concealed by the arm spines, not meeting above

or below, not in contact on the sides, but separated by a naked space. First ventral arm plate very small, pentagonal or quadrangular, wider within than without. Those beyond quadrangular, with convex inner side, notched outer side and rounded outer angles; wider than long, except the basal one or two; the successive plates are not in contact but separated by narrow spaces, where the ventral ends of the lateral arm plates are wedged in. Arm spines five in the basal joints, but four in the middle part of the arms, subequal, but slightly longer downwards, nearly equal to, or a little longer than, the corresponding arm joint; they are conical and obtuse in the proximal joints, but are flattened more distally; the second spine from below is especially flattened and rather spur-shaped, with numerous thorns on the very much flattened end; the lowest one, as well as the third from above is also somewhat thorny at the end. Tentacle pores large, without scales.

Colour in alcohol: disk gray, radial shields and arms straw-yellow.

A. cestuarii differs from *A. phalerata* (LYMAN, 1874) and the next species, *A. vadicola*, in the shape of the radial shields, in the much shorter arms and in the dorsal arm plates, which are very wide even in the basal arm joints. *A. cestuarii* appears to be closer to *A. phalerata* than to *A. vadicola* in the arm spines, which are four or five in number and less flattened and rather conical in the basal arm joints. Further, *A. cestuarii* differs from *A. ecnomiotata* in the shape of the radial shields, and of the dorsal and ventral arm plates, as well as in the fewer and less thorny arm spines.

A. cestuarii can be easily obtained together with *A. euopla* by dredging in the muddy bottom of Aburatsubo Cove. It probably

lives buried in mud, as *A. vadicola* does in sand, and I believe that, the reduced disk scales and the numerous and thorny arm spines are correlated with its mode of life.

Amphiura vadicola MATSUMOTO.¹⁾

Ophionephthys phalerata: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturhist. Hofmus., II, 1887, p. 301. (Non LYMAN, 1874.)

Amphiura vadicola: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 71.

Numerous specimens; Sakura-jima, Kagoshima Gulf. One specimen; Chintô, Korea.

Diameter of disk 8 mm. Length of arms 260 mm. Width of arms at base 1 mm., at the widest part 1.3 mm.

Disk five-lobed, with indented interbrachial borders, covered by a soft naked skin, except along the abradial and inner borders of the radial shields, where it is covered by several rows of fine, imbricating scales. Radial shields large, long, pear-seed-shaped; naked part two-thirds to one-half as

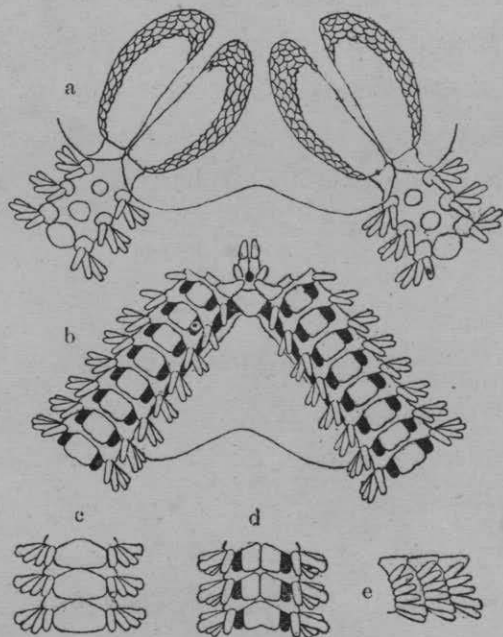


Fig. 38. *Amphiura vadicola*. $\times 7$. a. From above. b. From below. c. Dorsal view of three arm joints at about the widest part. d. Ventral view of three arm joints at about the widest part. e. Side view of three arm joints somewhat near disk.

1) As to the interesting life mode of this ophiuran, see Prof. MITSUKURI & HARA's "The Ophiurian Shoal" in Annot. Zool. Japon., I, 1897, p. 68.

long as the disk radius, and about thrice as long as wide. Interbrachial ventral surfaces covered also by a soft naked skin. Genital slits long. Genital scales not very conspicuous unless the specimen is dried, arranged in a row and overlapping one another.

Oral shields pentagonal, with rounded angles, outer sides longest, inner side a little concave; madreporic shields much larger and almost circular. Adoral shields triangular, with concave adradial side, neither meeting radially nor interradially. There is a more or less conspicuous depression between the oral plates, as in *Ophiothrix*. Two oral papillæ on either side of the oral angle, conical, blunt, very stout; the distal one arises from the adoral shield, and is longer than the apical one.

Arms exceedingly long, more than thirty times as long as the disk diameter; they are widest at about one-third of the entire length of the arms from the base. Dorsal arm plates almost oval, bounded within by two nearly straight lines forming a very large and obtuse angle, and without by a curve, which is nearly flat medially but very convex laterally; about twice as wide as long, successive plates slightly in contact. In the basal joints, they are very small and separated by spaces which are covered by a soft naked skin. Lateral arm plates not very prominent, almost covered over by the arm spines, not meeting above or below, nor in contact on the sides but separated by a naked space. First ventral arm plate very small, quadrangular, wider than long. Those beyond quadrangular, wider than long, except the basal one or two, which are as long as, or longer than, wide. They increase in size, especially in width, outwards, and become pentagonal beyond the disk, with large and obtuse inner angle, rounded outer angles, and notched outer side; the successive plates are separated

by very narrow spaces, where the ventral ends of the lateral arm plates are wedged in. The ventral arm plates are often divided into halves along the median line. Arm spines six or seven near the base, five or six in the middle part of the arms, peg-like, flattened, blunt, longer downwards, nearly equal to, or slightly longer than, the corresponding arm joint; much flattened and thorny at the end, except the uppermost one or two; the second one from below is spur-shaped and very thorny. Large tentacle pores, unprotected.

Colour in alcohol brown; the scales around the radial shields are lighter; arms grayish brown to gray in the outer parts.

This species is very near to *A. phalerata* (LYMAN, 1874) but differs from it in the much larger radial shields, in the not oval but pentagonal oral shields, in the adoral shields being joined neither radially nor interradially, in the more projecting oral angles, in the dorsal arm plates being in contact with one another, in the ventral arm plates being separated from one another and not very wide basally, and in the not cylindrical but much flattened and thorny arm spines. *A. radicola* differs from *A. enomiotata* CLARK in the exceedingly long arms, in the shape of the dorsal and ventral arm plates, and in the fewer arm spines.

Amphiura enomiotata CLARK.

Amphiura enomiotata: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 148, fig. 59.

Off Seno-umi, Suruga Gulf; 31-41 fathoms (CLARK).

Ophiocentrus verticillatus-(DÖDERLEIN).

Ophiocnida verticillata: DÖDERLEIN, SEMON-Zool. Forschungsst. Austr.

u. Malay. Arch., 1896, p. 287, Pl. XIV, figs. 2a & b, Pl. XV, figs 7 & 7a;
 KÖHLER, Exp. Siboga, XLV, Pt. 2, p. 29, Pl. II, fig. 4.

One specimen; Enoshima. One specimen; perhaps Misaki.
 Malaysian waters.

The first specimen is about 5 mm. across the disk, and has eight arm spines in the basal joints. The second is about 12 mm., and has only seven arm spines notwithstanding its larger size.

The arm spines decrease in number rather rapidly outwards, there being only about five in the middle part of the arms. They are not so flattened as in DÖDERLEIN'S type, and are rather thorny at the end as in KÖHLER'S. The disk is covered, between the spines, by a thick skin; but on drying, the scales around the radial shields become visible, so that the disk is like that of an *Ophiopnephthys*, if we leave the spines out of consideration. The colour in alcohol of the larger specimen is dark olive green on the disk and light yellow

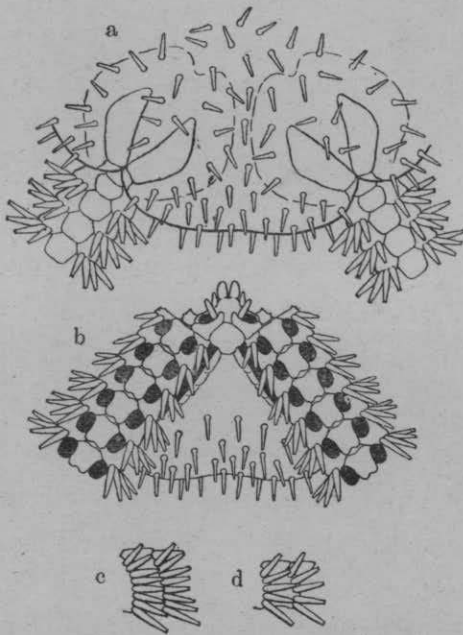


Fig. 59. *Ophiocentrus verticillatus*. $\times 8$. a. From above. b. From below. c. Side view of two arm joints near disk. d. Side view of two arm joints in the middle part of an arm.

on the arms.

Family 3. Ophiotrichidæ LJUNGMAN, 1867.

Disk covered with plates or scales, or by a naked skin, very

often beset with minute spines or stumpy tubercles. Radial shields very large, with a conspicuous articular socket on the ventral surface near the outer end, fitting to the large, ball-like articular condyle of the genital plate. Genital plates firmly fixed to the basal vertebræ. Genital scales short, wide, flat, articulating with the genital plates near the outer end of the latter. Besides, there occur a pair of short, flat scales, just outside each oral shield, supporting the proximal abradial border of the genital slits. Peristomial plates small, entire. Oral frames very stout, with well developed lateral wings for the attachment of voluminous masticatory muscles. In internal view the oral and dental plates are very stout, together forming an **X**-shape. Teeth very stout, widened, squarish. Dental papillæ well developed, forming a vertical clump at the apex of each jaw. Oral papillæ absent. Arms inserted ventrally to the disk, horizontally flexible or capable of coiling vertically. Dorsal side of the vertebræ **Y**-shaped, being conspicuously notched inwards. Vertebral articulation zygospondyline, the articular peg being always present. Arm spines either moderately long, conical and opaque, or very long, flattened, serrate and hyaline. Tentacle pores large, with one or two scales or none.

This family includes fifteen genera, as follows.

Ophiothrix MÜLLER & TROSCHER, 1842.

Ophiopteron LUDWIG, 1888.

Ophiocampsis DUNCAN, 1887.

Ophiotrichoides LUDWIG, 1882.

Ophicmaza LYMAN, 1871.

Ophiophthyreus DÖDERLEIN, 1897.¹⁾

Ophiocnemis MÜLLER & TROSCHER, 1842.

1) It is possible that, *Ophiophthyreus* may be merely a very young stage of *Ophiomaza* or *Ophiotrichoides* or an allied genus.

Ophiothela VERRILL, 1867. (= *Ophioteresis* BELL, 1892).

Ophiopsammium LYMAN, 1874.

Ophiogymna LJUNGMAN, 1866.

Lütkenia BROCK, 1888.

Gymno'ophus BROCK, 1888.

Ophio'ophus MARKTANNER, 1887.

Ophioæthiops BROCK, 1888.

Ophiosphæra BROCK, 1888.

The internal structures of this family are very uniform and essentially similar to those of the *Amphiuridae*. In *Ophiothrix nerzidina* (LAMARCK), the oral frames are very stout, with very well developed lateral wings for the attachment of voluminous masticatory muscles. The peristomial plates are very small, entire, transversely bar-like, with a very slight notch at the middle of the outer border. The oral and dental plates are very stout, together forming an X-shape in internal view. The teeth are also very stout and quadrangular. The genital plates are very long, bar-like, firmly fixed to the third to sixth vertebra, with a very conspicuous, ball-like articular condyle near the outer end to fit into the large articular socket of the radial shield; just anterior to the articular condyle, there occurs a wing with a depression for the attachment of the muscle between the genital plate and radial shield. The genital scales are short, wide, flat, leaf-like, articulating with the genital plate near the outer end of the latter. In internal view the radial shields are extremely large and triangular, has a very large articular socket at the outer adradial corner, and are completely joined in pairs. As seen from the dorsal side the first vertebra is very short and rhomboidal; the second, which is the shortest, almost linear transversely; the third like a cross, with

slender transverse and stout longitudinal bars; those beyond **Y**-shaped. The internal structures of *Ophiothrix koreana* DUNCAN are almost similar to those of the preceding, but the peristomial plates are distinctly larger, the genital plates are shorter and firmly fixed only to the third and fourth vertebræ, and the genital scales are much smaller. In *Ophiothela danca* VERRILL, the oral frames are less stout than in *Ophiothrix nereidina* and *O. koreana*, but have also well developed lateral wings with wavy peripheries. The peristomial plates are small and oval and have a conspicuous notch at the middle of the outer border. The genital plates are firmly fixed to the first to third or fourth vertebræ, and have also a conspicuous ball-like articular condyle near the outer end; the muscle impression just anterior to the articular condyle is not very distinctly differentiated. The genital scales are also short, wide, flat and leaf-like. The dorsal side of the first vertebra is like a cross, with very slender transverse and stout longitudinal bars; and of those beyond **Y**-shaped. Judging from LYMAN'S statements, *Ophiomaza*, *Ophiocnemis*, *Ophiopsammium* and *Ophiogymna* do not appear to differ fundamentally in their internal structures from the forms here described.

Key to Japanese genera of *Ophiotrichidae*.

A—Dorsal arm plates entire.

a—Disk beset with spines or stumpy tubercles; arm spines long, flattened, serrate, hyaline..... *Ophiothrix*.

aa—Disk entirely free of spines or tubercles; arm spines of moderate length, conical, entire, opaque..... *Ophiomaza*.

AA—Dorsal arm plates represented by a number of nodule-like granules or secondary plates; disk beset with granules or tubercles; arm spines of moderate length, conical, serrate, hyaline..... *Ophiothela*.

Key to Japanese species of *Ophiothrix*.

- A*—Dorsal arm plates more or less rhomboidal, not very wide, only slightly wider than long or longer than wide, only slightly in contact with one another.
- a*—Ventral arm plates notched outwards.
- b*—Arms short, less than five times as long as the disk diameter.
- c*—Radial shields entirely or mostly naked.
- d*—First dorsal arm plate with a tubercle, on which a conspicuous spine is borne; disk closely beset with spines, which are cylindrical, blunt and rough at tip..... *panchajendya*.
- dd*—First dorsal arm plate free of tubercles and spines; disk beset with trifid, or rarely bifid, tubercles or thorny spines of various length or with both *koreana*.
- cc*—Radial shields, as well as disk, closely beset with stout, thorny spines of almost uniform length..... *marenzelleri*.
- bb*—Arms long, twelve to fifteen times as long as the disk diameter; radial shields covered by a thick skin, except at the outer adradial border, where they are naked; disk beset on the dorsal side with slender, thorny spines of various length *macrobrachia*.
- aa*—Ventral arm plates with entire and convex outer border; arms four to seven times as long as the disk diameter.
- e*—Radial shields naked; disk beset with bifid or trifid tubercles and thorny spines *eusteira*.
- ee*—Radial shields, as well as disk, closely beset with stellate tubercles and thorny spines..... *stabilis*.
- AA*—Dorsal arm plates more or less fan-shaped, very wide, much wider than long, widely in contact with one another.
- f*—Dorsal side of disk entirely free of spines or tubercles, or beset with a group of thorny tubercles only at the central region, with a beautiful network of white streaks; each dorsal arm plate with a transverse white streak; arms about fifteen times as long as the disk diameter..... *neridina*.

- ff*—Disk, and radial shields usually, closely beset with minute tubercles, without a network of white streaks; dorsal arm plates free of transverse white streaks.
- g*—Arms six to thirteen times as long as the disk diameter; arm spines of free basal arm joints not exceedingly short.
- h*—Arms seven to nine times as long as the disk diameter; outer lateral angles of the dorsal arm plates perfectly rounded.
- i*—Arms about seven times as long as the disk diameter; dorsal arm plates less than twice as wide as long, with well defined inner lateral angles and the lateral borders moderately divergent outwards; middle arm spines clavate *obtusa*.
- ii*—Arms about nine times as long as the disk diameter; dorsal arm plates more than twice as wide as long, with the lateral borders very strongly divergent outwards, so that the inner and lateral borders practically form one continuous curve; arm spines not clavate *hirsuta*.
- hh*—Arms about thirteen times as long as the disk diameter; dorsal arm plates more than twice as wide as long, with the inner and outer lateral angles not rounded but sharp; each plate with three white spots along the outer border; arm spines not clavate..... *punctolimbata*.
- gg*—Arms about eighteen times as long as the disk diameter; spines of free basal and more internal arm joints exceedingly short; dorsal arm plates about twice or more than twice as wide as long, with very well defined angles and borders *longipeda*.

Ophiothrix panchyendyta CLARK.

Ophiothrix panchyendyta: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 264, fig. 131.

Korea Strait; 59 fathoms (CLARK).

Ophiothrix koreana DUNCAN.

Ophiothrix koreana: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 473, Pl. XI, figs. 28-32; LYMAN, Rep. Challenger, V, 1882, p. 226; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 308; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 257, figs. 127 & 128.

Numerous specimens; off Nii-jima, Sagami Sea. Numerous specimens; off Jôga-shima, Sagami Sea. Numerous specimens; Uraga Channel.

Hakodaté Bay; 11.5-15.5 fathoms (CLARK). Gulf of Tokyo; 169 fathoms (CLARK). Uraga Channel, 58-302 fathoms (CLARK). Sagami Sea; 41-153 fathoms (CLARK). Suruga Gulf; 13-150 fathoms (CLARK). Sea of Japan; 44-114 fathoms (CLARK). Korea Strait; 23-59 fathoms (DUNCAN, CLARK). Eastern Sea; 53-181 fathoms (CLARK). Kagoshima Gulf; 58 fathoms (CLARK). Off Satsuma; 39-51 fathoms (CLARK).

Molucca (MARKTANNER-TURNERETSCHER).

The disk covering is very variable, as noted by CLARK. The colour is whitish or partly light pink in alcohol. In some specimens, the arms are annulated with light pink; in others, some of the dorsal arm plates, besides being annulated, bear each a red spot; in still others, the annulation of the arms is very faint, although the red spots are present; in a fourth lot, the red spots are present on all the dorsal arm plates, but the annulations are entirely absent. These red spots may possibly be phosphorescent organs.

Ophiothrix marenzelleri KOEHLER.

Ophiothrix stelligera: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus., Wien, II, 1887, p. 310. (Non LYMAN, 1874.)

Ophiothrix marenzelleri: KÖHLER, Mem. Soc. Zool. Fr., XVIII, 1904, p. 103, figs. 77-78.

Ophiothrix hylodes: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 263, fig. 130.

Littoral form:—Two specimens; Tomo, Bingo. Two specimens; Toba, Shima. Numerous specimens; Arai Beach to Gorgonian Cave, Misaki Marine Biological Station. Numerous specimens; entrance of the Gulf of Tokyo.

Sublittoral form:—Eight specimens; Kagoshima Gulf; 70 fathoms. Five specimens; Asami Bay, Tsushima. Numerous specimens; off Jōga-shima, Sagami Sea. One specimen; Kominato, Bōshū.

In the littoral form, which may be taken as the type of this species, the disk is closely and uniformly covered with thorny spines. The arm spines are much widened toward the end and somewhat clavate at the top. The colour of the body is very variable, and may be green, blue, brown, or purple, or very often variegated with combinations of these colours. The arms are annulated, and there is on the dorsal side usually a longitudinal white or light-coloured striation hemmed by two lines of a darker shade, running along the entire length of the arm.

In the sublittoral form, the disk is closely and uniformly covered with fine tubercles bearing several thorns on the top and sometimes also on the sides. In some specimens there are also a few long, slender, rough spines on the dorsal surface of the disk. The arm spines are slender like those of *O. koreana*, and not so widened towards the ends or clavate at the top as in the littoral form. The colour of the body is very variable, but on the whole lighter than in the littoral form. The arms are annulated, but there is no distinct longitudinal striation on the dorsal surface.

The sublittoral form approaches *O. koreana* more closely than the littoral form. It is also somewhat probable that, the present species may prove to be an extreme variety of *O. koreana*, as suspected by CLARK.

Ophiothrix macrobrachia CLARK.

Ophiothrix macrobrachia: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 267, fig. 133.

Numerous specimens; Off Nii-jima, Sagami Sea. Numerous specimens; Okinosé, a submarine bank, Sagami Sea. One specimen; off Jôga-shima, Sagami Sea; 75 fathoms. Four specimens; Uraga Channel.

Suruga Gulf; 34-131 fathoms (CLARK). Bungo Channel; 65 fathoms (CLARK). Korea Strait; 59 fathoms (CLARK). Eastern Sea; 95-135 fathoms (CLARK).

In my specimens, the arms are somewhat shorter than in CLARK's type. For example, one specimen has the disk diameter of 10 mm. and an arm length of 115 mm. Some specimens bear one or several individuals of a species of parasitic gastropods, *Stylifer* or its allies. The parasites are attached to the host at the genital slits, as figured by K EHLER in *Ophiothrix crassispira* K EHLER, 1904. The shell of the parasites is almost white or light pink in alcohol.

Ophiothrix eusteira CLARK.

Ophiothrix eusteira: CLARK, BULL. U. S. Nat. Mus., LXXX, 1911, p. 265, fig. 132.

Two specimens; Pinnacle Is. Three specimens; off Jôgashima, Sagami Sea; 75 fathoms. Numerous specimens; off Misaki,

Sagami Sea. Numerous specimens; off Uki-shima, Uraga Channel.
One specimen; Kominato, Bôshû.

Ôshima (CLARK).

The disk scales become almost visible on drying, and there

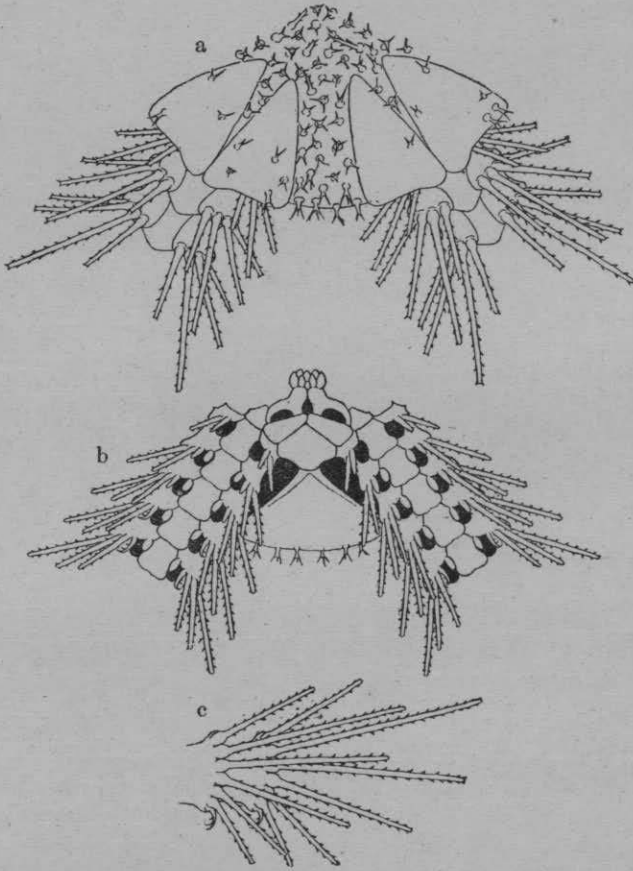


Fig. 60. *Ophiotlrix eusteira*. $\times 13$. a. From above. b. From below. c. Side view of two arm joints near disk.

are four or five rows of them in each interradial space on the dorsal side. In many specimens and especially in younger ones, a small, circular, depressed central plate is visible. The dorsal surface of the disk is usually covered with thorny spines and spiny tubercles, but sometimes with only one of the two forms. The arm spines are

very slender, and often not much flared laterally. The present species appears to resemble *O. galapagensis* LÜTKEN & MORTENSEN in certain points.

Ophiothrix stabilis KÖHLER.

Ophiothrix stabilis: KÖHLER, Mem. Soc. Zool. Fr., XVII, 1904, p. 84, figs. 46-49.

Ophiothrix ciliaris: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 257. (Non MÜLLER & TROSCHEL, 1842.)

One specimen; Gorgonian Cave, Misaki Marine Biological Station.

Japan (KÖHLER). Kobé; 8 fathoms (CLARK).

The specimen at hand is perfectly similar to KÖHLER's type, except in colour. The disk is purplish black, except just inside the dorsal side of the arm base, where there is a white patch, which is continued on to the longitudinal white streak on the dorsal side of the arm. Arm spines nearly white, with purplish black marginal denticles.

Ophiothrix nereidina (LAMARCK).

Ophiura nereidina: LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 544.

Ophiothrix nereidina: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 115; LYMAN, Rep. Challenger, V, 1882, p. 221; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 26; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 309; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 832, Pl. XXXII, figs. 5a-5c; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 97; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 334.

Ophiothrix cataphracta: VON MARTENS, Arch. Naturg., XXXVI, 1870, p. 259; LYMAN, loc. cit., p. 227; PFEFFER, Abh. Senckenberg. Naturf. Gesell., XXV, 1900, p. 85.

One specimen; Yayeyama, Riu-kiu. One specimen; Okinawa. Two specimens; Shimoda, Izu. Numerous specimens; Arai Beach to Gorgonian Cave, Misaki Marine Biological Station.

Indo-Pacific. So far as known, Misaki is about the northern limit of this species.

This species is one of the most common littoral ophiurans in the vicinity of Misaki. The colour in alcohol is blue, with a

beautiful network of white streaks on the disk and fine regular annulations on the arms; the network consists of the white peripheral zones of the disk plates and of the white, more or less meandering lines on the radial shields, and the annulations are due to the presence of a white, transverse streak on each dorsal arm plate. If I remember aright, the specimens were in life shades of vermilion red in colour and perhaps of dark purplish brown.

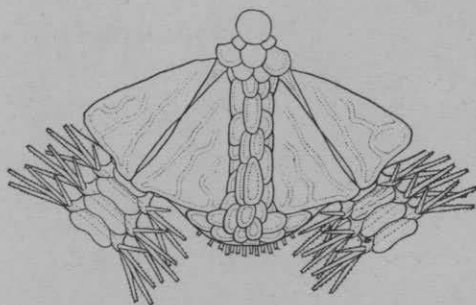


Fig. 61. *Ophiothrix nereidina*. From above. $\times 5\frac{1}{3}$

Ophiothrix obtusa KÖHLER.

Ophiothrix obtusa: KÖHLER, Exp. Siboga, XLV, Pt. 2, 1995, p. 98, Pl. XI, figs. 6-10, Pl. XVI, fig. 5.

One specimen; Okinawa, Riu-kiu.

Malaysian waters (KÖHLER).

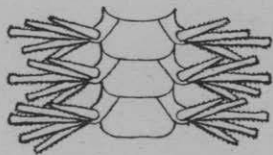


Fig. 62. *Ophiothrix obtusa*. Dorsal view of three arm joints somewhat near disk. $\times 7$.

Ophiothrix hirsuta MÜLLER & TROSCHER.

Ophiothrix hirsuta: MÜLLER & TROSCHER, Sys. Ast., 1842, p. 111; VON MARTENS, Arch. Naturg., XXXVI, 1870, p. 255; LYMAN, Rep. Challenger, V, 1882, p. 226; MARKTANNER-

TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 311, Pl. XIII, figs. 34 & 35; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 96; LUDWIG, Abh. Senckenberg. Naturf. Gesell., XXI, 1889, p. 549; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 93; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 333.

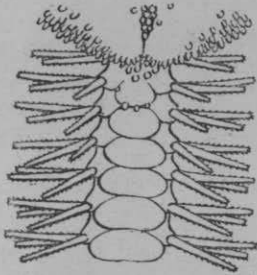


Fig. 63. *Ophiothrix hirsuta*. Dorsal view of an arm base. $\times 6$.

Ophiothrix cheneyi: LYMAN, Proc. Boston Soc. Nat. Hist., VIII, 1861, p. 84¹⁾; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 175.

Ophiothrix variabilis: DUNCAN, Jour. Linn. Soc. London, XXI, 1886, p. 99, Pl. XIII, figs. 44 & 35.

One specimen; Pinnacle, Riu-kiu.

The specimen at hand appears to belong to the *variabilis*-type, having the radial shields almost free of tubercles.

Ophiothrix punctolimbata VON MARTENS.

Ophiothrix punctolimbata: VON MARTENS, Arch. Naturg., XXXVI, 1870, p. 257; LYMAN, Rep. Challenger, V, 1882, p. 227; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 26; BELL, Rep. Zool. Coll. Alert, 1884, p. 143; BELL, Proc. Zool. Soc. London, 1888, p. 388; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 512; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 416, Pl. XV, fig. 2; LORIOL, Rev. Suisse Zool., I, 1893, p. 416, Pl. XV, fig. 2; BELL, Proc. Zool. Soc. London, 1894, p. 397; DÖDERLEIN, SEMON—Zool. Forschungsr. V, 1897, p. 294, Pl. XIV, figs. 7a & 7b, Pl. XVI, figs. 18 & 18a; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 93.

Ophiothrix hirsuta var. *punctolimbata*: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus., II, 1887, p. 312.

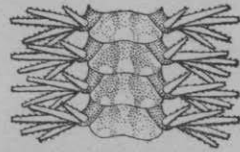


Fig. 64. *Ophiothrix punctolimbata*. Dorsal view of four arm joints somewhat near disk. $\times 8$.

1) This paper was not seen by me.

One specimen; locality unknown, perhaps Misaki.
Indo-Pacific.

Ophiothrix longipeda (LAMARCK).

Ophiura longipeda: LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 544.

Ophiothrix longipeda: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 113; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 176; VON MARTENS, Arch. Naturg., XXXVI, 1870, p. 254; LYMAN, Rep. Challenger, V, 1882, p. 220, Pl. XLVII, fig. 4; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 26; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, Pl. XIII, fig. 27; BELL, Proc. Zool. Soc. London, 1888, p. 388; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 512; LORIOL, Rev. Suisse Zool., I, 1893, p. 415; BELL, Proc. Zool. Soc. London, 1894, p. 395; DÖDERLEIN, SEMON-Zool. Forschungsr., V, 1899, p. 293, Pl. XIV, figs. 6a-6c, Pl. XVI, figs. 17 & 17a; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 97; LUDWIG, Abh. Senckenberg. Naturf. Gesell., XXI, 1899, p. 550; PFEFFER, *ibid.*, XXV, 1900, p. 85; KÖHLER, Exp. Siboga, XIV, Pt. 2, 1905, p. 92; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 334; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 298; CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 263.

One specimen; Kominato, Bôshû.
Two specimens; Tanabé Bay, Kii.

Indo-Pacific. So far as known,
Kominato is the northern limit of this
species.

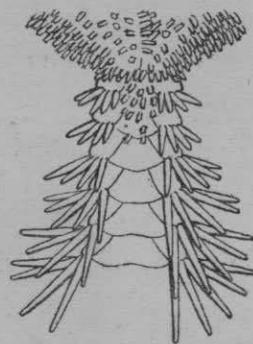


Fig. 65. *Ophiothrix longipeda*.
Dorsal view of an arm base.
×6.

Ophiomaza kanekoi, sp. nov.

One specimen; Shimabara, Hizen.

Diameter of disk 15 mm. Length of arms 35 mm. Width of arms at base 1.8 mm.

Disk rather flat, covered by the large radial shields and rather coarse, partly imbricated and partly tessellated scales. The scales are covered by skin, so that they are very inconspicuous, especially inside and outside the radial shields, where they are finer than between the radial shields. There are two or three rows of them in each interradius, where they are coarse, irregular, polygonal,

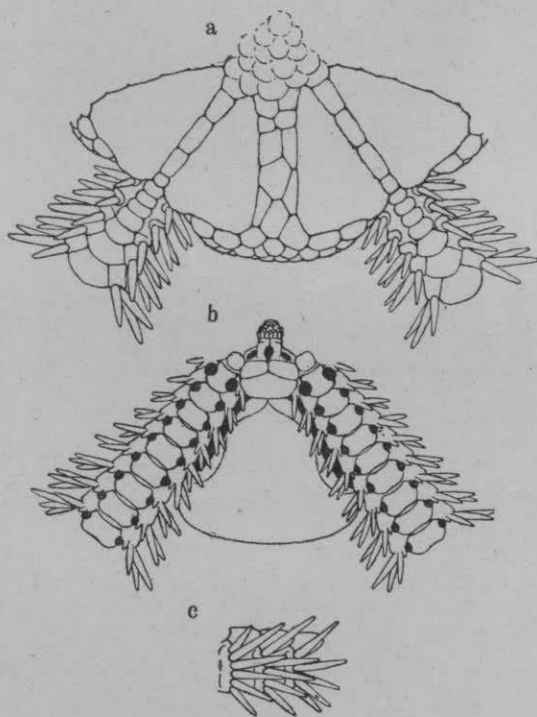


Fig. 66. *Ophiomaza kanekoi*. $\times 4$. a. From above. b. From below. c. Side view of three arm joints near disk.

and tessellated. Radial shields large, triangular, with acute inner angle, longer than two-thirds the disk radius, twice as long as wide, those of a pair separated from each other by a single row of oblong, quadrangular scales, three to five in number. Interbranchial ventral surfaces covered by a soft, naked skin. Genital slits large.

Oral shields small, quadrangular, or rather pentagonal, very wide and short, more than twice as wide as long, with a very large inner angle. Adoral shields very small, quadrangular, joined within. The oral and adoral shields have chagreened external surfaces, which are covered by skin. Buccal

pores very small. Dental papillæ about twenty-five in number, forming a vertical, oval clump; in the lower half they are very small and arranged in four rows; in the upper half they are larger and arranged in two or three rows. Three teeth, quadrangular, with truncated ends; the lowest one is about as long as the upper dental papillæ; the others are much longer than the lowest, the uppermost one being the longest and narrowest.

Arms slender and short, vertically coiled, especially in the distal parts. Dorsal arm plates large, quadrangular, with convex outer border, about twice as wide as long, wider without than within, very convex, so that the dorsal side of the arm is strongly keeled as a whole. Four or five basal dorsal arm plates are smaller and continued on to the radial row of disk scales. Some of the dorsal arm plates are divided into equal or unequal halves. Lateral arm plates not very prominent. First ventral arm plate not very small, quadrangular, with curved inner and outer borders and rounded angles, slightly wider than long, wider within than without. Next one or two plates quadrangular, with curved outer and concave lateral borders and rounded outer angles, slightly longer than wide. Those beyond quadrangular, with concave inner and outer borders and rounded outer angles, wider than long. The surface of the ventral arm plates are chagreened and covered by a skin. The successive ventral arm plates are not in contact, but are separated by a naked, depressed, groove-like space. Arm spines six or seven in proximal free joints, conical, terete, tapered, blunt; the uppermost one is short, slightly longer than the corresponding arm joint; the next is the largest, longer than twice the corresponding joint; the others become shorter downwards, the second lowest being slightly longer than the corresponding joint; the lowest spine is very small and short, serving as a tentacle

scale. The spines rapidly become fewer and shorter outwards, so that in the tenth free arm joint, they are four in number, the uppermost two spines, which are the longest, being about one and a half times as long as the corresponding joint. In the distal parts of the arms, the lowest spine is transformed into a compound hook.

Colour brownish black in alcohol, formerly preserved in formalin.

The present species differs from *O. cacaotica* LYMAN in the more numerous disk scales, in the absence of a distinct central rosette of the primary plates, in the not regularly arranged marginal disk scales, in the narrower arms, in the concave outer border of the ventral arm plates, and in the more numerous arm spines; from *O. mærens* KÖHLER in the larger radial shields, in the shape of the oral shields, in the narrower arms, in the wider ventral arm plates, of which the inner and outer borders are concave, and in the more numerous and longer arm spines; and from *O. obscura* (LJUNGMAN) in the fewer rows of the dorsal inter-radial disk scales, in the larger radial shields, in the narrower arms, in the markedly narrowed basal dorsal arm plates, and in the more numerous arm spines.

Ophiothela danae VERRILL.

Ophiothela danae: VERRILL, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 391¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 230; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 313; DÖDERLEIN, SEMON—Zool. Forschungsr., V, 1897, p. 297, Pl. XVII, figs. 25-25b; KÖHLER, Bull.

1) This paper was not seen by me.

Sci. Fr. Belg., XXXI, 1898, p. 89; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 117; KÖHLER, Bull. Mus. d'Hist. Nat. Paris, 1905, p. 459.

Ophiothela isidicola: LÜTKEN, Bull. Soc. Roy. Copenhagen, 1872, p. 92, Pl. I & II, figs. 4a.-4g; LYMAN, loc. cit., p. 231; BROCK, Zeitschr. wiss. Zool., XLVI, 1888, p. 537; LORIOL, Mem. Soc. Phys. d'Hist. Nat. Genève, XXXII, 1894, p. 52.

Ophiothela verrilli: DUNCAN, Journ. Linn. Soc. London, XIV, 1878, p. 477, Pl. XI, fig. 33.

Ophiothela danæ var. *involuta*: KÖHLER, loc. cit., 1898, p. 89.

Numerous specimens, clinging to *Melitodes*; Moroiso, Misaki; 5-10 fathoms. Numerous specimens; off Misaki.

Strait of Formosa (LÜTKEN). Korea seas (DUNCAN).

Indo-Pacific.

There is no doubt, that *O. danæ*, *O. isidicola* and *O. verrilli* are conspecific, as they are connected by an unbroken series of intergrading forms between *danæ* and *isidicola* on the one hand and between *isidicola* and *verrilli* on the other.

The first of the two lots above mentioned are mostly of the *danæ*-type, while the second is mostly of the *isidicola*- but partly of the *verrilli*-type, both lots containing some intermediate forms. Those of

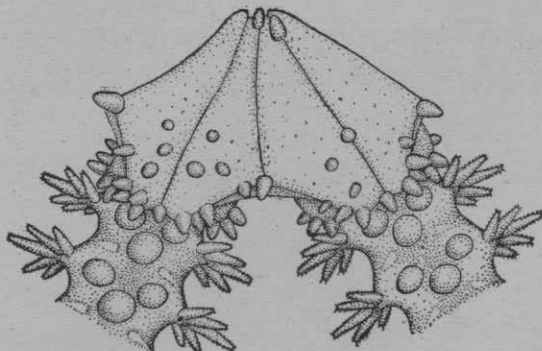


Fig. 67. *Ophiothela danæ*. From above. $\times 20$.

the *danæ*-type are usually dark coloured, being green, blue, purple, or brown, and are annulated on the arms; those of the *isidicola*- and *verrilli*-type are light coloured or white, being light yellow or

very light pink. The *verrilli*-type is closely similar to the *isidicola*-type, so that the two are practically one. I imagine that on an average, the *isidicola*-type (including the *verrilli*-type) has greater bathymetrical range than the *dancæ*-type.

In some specimens, there are as many as seven arms. Again, a few of the disk granules may be conical and pointed. In some of the *dancæ*-type, the dorsal surface of the disk is entirely free of granules or tubercles.

Order iv. **CHILOPHIURIDA** MATSUMOTO.

Disk covered with scales or plates, often with superficial granulations. The radial shield and genital plate on the same side of a radius articulate with each other by means of two articular condyles and one pit on both the plates. Peristomial plates double or triple, not very large. Oral frames with or without well developed lateral wings. Oral papillæ well developed, close-set, very often entirely closing the oral slits; the outermost one being pointed inwards above the next papilla which is the largest, but sometimes modified in certain ways by the displacement of the second oral tentacle pores outside the oral slits. Arms only horizontally flexible, the vertebral articulation being zygospondyline. Arm plates usually all well developed. Arm spines very short or long, lying flat on the arm or erect.

Key to families of *Chilophiurida*.

A—Arm spines short, lying flat on the arm.

a—Disk usually free of granules; second oral tentacle pores opening

- either outside or inside the oral slits; arms short and stout, stoutest at the base..... *Ophiolepididæ*.
- aa*—Disk covered with granules; second oral tentacle pores opening always within the oral slits; arms moderately or very long.
- b*—Arms slender, inserted ventrally to the disk, stoutest at the base or at a distance from it; arm spines few *Ophioteucidæ*.
- bb*—Arms stout, inserted laterally to the disk, stoutest at the base; arm spines numerous *Ophioidermatidæ*, pars.
- AA*—Arm spines long and erect.
- c*—Dental papillæ absent.
- d*—Disk covered with granules; oral angles granulated; arms stout, stoutest at the base; arm spines numerous... *Ophioidermatidæ*, pars.
- dd*—Disk usually free of granules; oral angles not granulated; arms slender, stoutest at a distance from the base; arm spines few....
..... *Ophiochitonidæ*.
- cc*—Dental papillæ well developed, forming a vertical clump at the apex of each jaw; arms stout, stoutest at a distance from the base....
..... *Ophiocomidæ*.

Family 1. *Ophiolepididæ* LJUNGMAN, 1867.

Disk covered with thick scales or plates, among which the primaries are often very prominent. Radial shields usually stout. The radial shield and genital plate on the same side of a radius articulate with each other by means of two articular condyles and one articular pit on both the plates. Genital papillæ very often, and arm combs sometimes, present. Oral papillæ usually few, arranged in a single series; where the second oral tentacle pore opens within the oral slit, the outermost oral papilla is pointed inwards and the next one is the largest. Teeth arranged in a single vertical row. Dental papillæ absent. Peristomial plates small, usually double, rarely simple. Arms inserted laterally to

the disk, short or moderately long, very stout, widest at the base, rapidly tapering outwards, only horizontally flexible. Arm plates either all well developed, or the dorsal and ventral ones may be very rudimentary. Arm spines short, lying flat on the arm. Tentacle scales variable in number, leaf-like, rarely absent.

This family is very extensive and includes thirty-eight genera, which may be grouped into two subfamilies as follows.

Subfamily 1. *Ophiomastinae* MATSUMOTO, 1915:—Second oral tentacle pores opening outside the oral slits.

- I. Several basal lateral arm plates extraordinarily widened; genital slits invisible or very insignificant; disk covered merely with primaries and radial shields.

Astrophiuira SLADEN, 1878.

Ophiophycis KÖHLER, 1901.

Ophiomisidium KÖHLER, 1914.

Ophiotypa KÖHLER, 1897.

Ophiomastus LYMAN, 1878.

- II. Basal lateral arm plates not much widened; genital slits usually large; disk covered usually with both primaries and secondary scales, besides the radial shields.

Haplophiura MATSUMOTO, 1915.

Anthophiura CLARK, 1911.

Aspidophiura MATSUMOTO, 1915.

Ophiopyrgus LYMAN, 1878.

Stegophiura MATSUMOTO, 1915.

Amphiophiura MATSUMOTO, 1915.

Gymnophiura LÜTKEN & MORTENSEN, 1899.

Ophiosteira BELL, 1902.

Ophiochrysis KÖHLER, 1904.

Homalphiura CLARK, 1915.

- Ophiura* LAMARCK, 1816.
Ophioperla KÖHLER, 1912.
Ophionotus BELL, 1902.¹⁾
Ophiotjalfa MORTENSEN, 1913.
Ophiurolepis MATSUMOTO, 1915.
Ophiogona STUDER, 1878.
Ophioplinthus LYMAN, 1878.
Ophiopleura DANIELSSEN, 1877.
Ophiocten LYMAN, 1854.

Subfamily 2. *Ophiolepidinae* mihi, 1915 :—Second oral tentacle pores opening within the oral slits.

I. Tentacle pores limited to a few basal arm joints.

- Ophiomusium* LYMAN, 1869.
Ophiolipus LYMAN, 1878.

II. Tentacle pores present throughout the entire length of the arm.

- Ophiophyllum* LYMAN, 1878.
Ophiopenia CLARK, 1911.
Ophiocraes KÖHLER, 1904.
Ophiomidas KÖHLER, 1904.
Amphipholizona CLARK, 1915.
Ophiozonella MATSUMOTO, 1915.
Ophiozonoida CLARK, 1915.
Ophiozona LYMAN, 1865.
Ophiothyreus LYMAN, 1865.
Ophiolipis MÜLLER & TROSCHEL, 1840.
Ophioplocus LYMAN, 1861.

1) *Ophioglypha hexactis* SMITH, 1876, belongs in my opinion to *Ophionotus*, as distinct from the genuine *Ophiura*.

Ophioceramis LYMAN, 1865.

The internal structures of the *Ophiomastinae* are very divergent, but roughly three types may be distinguished according to the character of the peristomial plates. The first type, represented by *Astrophiura* and *Ophioplinthus*, lacks the peristomial plates; the second, represented by *Ophiomastus* and *Ophiocten*, has simple peristomial plates; and the third, including the majority of the present subfamily, has double peristomial plates.

The internal structures observed in *Astrophiura kawamurae* are most peculiar. The oral frames and plates are very long and slender, while the dental plates are stout. The peristomial plates are entirely absent, though the peritoneal membranes of the oral region, as well as of the other parts, contain very fine, translucent, perforated scales, much resembling the perforated spicules of holothurians, as seen under a compound microscope. The genital plates and scales are entirely internal, both being very slender and narrow; the former are very short, with the outer end forming a simple articular face for the radial shield; the latter are about twice as long as the former, parallel to, and directed above, the adoral shields, not laterally but terminally articulated with the genital plates. The proximal parts of the first lateral arm plate curve inwards and downwards, passing below the radial shield and the genital plate, and articulate with the first vertebra. The dorsal side of each vertebra is not rhomboidal but almost quadrangular, with a rather shallow median groove; that of the first vertebra is much wider than in the others, the abradial peripheries being very thin and translucent. The ventral side of each vertebra has a rather shallow median groove and a well marked median suture. The vertebræ of the free arms are almost entirely divided into halves by a very narrow moniliform slit, the

halves being very slender and lying very closely side by side. The articulation of the vertebræ is primitive and zygospondyline. The articular peg is situated between the halves of the articular shoulder, the three being almost parallel. In the inner articular face, there is present a well developed articular umbo, the articular knobs being, however, very rudimentary, represented merely by the projecting edges of the central ridge, on which the articular umbo and the pit for the articular peg are placed. *Astrophiura* appears to remind us more or less of *Ophioplinthus medusæ* LYMAN, the internal structures of which have been described and figured by LYMAN, by its long oral frames, the absence of distinct peristomial plates and the quadrangular dorsal side of the basal vertebræ.

According to LYMAN, *Ophiomastus secundus* LYMAN has very long oral frames and plates, a small, simple peristomial plate in each interradius and quadrangular, not discoidal, basal vertebræ. I suppose that, the internal structures of *Ophiophycis*, *Ophiomisidium* and *Ophiotypa* are probably similar to those of such genera as *Astrophiura*, *Ophioplinthus* and *Ophiomastus*, though they have not been thoroughly studied. *Haplophiura gymnopora* (CLARK) has also simple, transversely bar-like peristomial plates and short, discoidal basal vertebræ. This genus, as well as *Ophiomisidium*, *Ophiophycis* and *Astrophiura*, lacks the genital bursæ and visible genital slits. *Ophiocten sericeum* LYMAN is described by the author to have also simple peristomial plates and short, discoidal basal vertebræ.

Stegophiura sladeni (DUNCAN), as well as *St. sterea* (CLARK), has double, transversely bar-like peristomial plates and very high outer ends of the oral frames. The internal structures of *Ophiura kinbergi* are almost similar to those of *Stegophiura* except the oral frames, of which the outer ends are not very high. *Ophiura*

lymani (LJUNGMAN) and *Ophiurolepis carinata* (STUDER) (= *Ophioglypha deshayesi* LYMAN) appear to be almost similar to *Ophiura kinbergi* in their internal structures. Those forms with double peristomial plates have always short oral frames and short, discoidal basal vertebræ.

The *Ophiolepidince* are fairly uniform in their internal structures, the two opposite extremes being represented by *Ophiomusium* and *Ophioceramis*. In *Ophiomusium trychnum* CLARK, which is a representative of the species with only two pairs of tentacles to each arm base, the peristomial plates are double and exceedingly small, the oral plates are very long and slender, and the oral frames and basal vertebræ are also extremely long. In *Ophiomusium cancellatum* LYMAN, which is a representative of the species with three pairs of tentacles to each arm base, the internal structures are almost similar to those of the foregoing, but the peristomial plates are larger and the oral plates, oral frames and basal vertebræ shorter. In *Ophiozonella longispina* (CLARK), the peristomial plates are comparatively large, the oral plates short and stout, the oral frames more or less short, and the basal vertebræ short and more or less discoidal. In these three species the first vertebra, and not the second, is the shortest. In *Ophiomusium*, the teeth are very slender, while in *Ophiozonella*, they are more or less squarish and stout. In *Ophiozona impressa* (LÜTKEN), *Ophiolepis cincta* MÜLLER & TROSCHEL and *Ophioplocus japonicus* CLARK, the peristomial plates are comparatively large, the oral plates and frames very short and stout, the basal vertebræ very short and discoidal, the second being the shortest, and the teeth more or less squarish and stout. In *Ophioceramis januarii* (LÜTKEN), the peristomial plates are also double, but very small and transversely bar-like, the oral plates are very short and stout, the oral frames very

stout with well developed lateral wings, the basal vertebrae very short and discoidal, the second being the shortest, and the teeth squarish and very stout. In all these representatives of the *Ophiolepidince*, the genital plate and radial shield articulate with each other by means of two condyles and one pit on both the plates, and the genital plate and scale articulate with each other at some distance inwards from the outer end of the latter.

Astrophiura SLADEN, 1878.

Basal portion of arms very intimately united with the disk proper, so as to form with it a pentagonal "asteroid" body, of which the dorsal surface is entirely covered over by the stout primaries and radial shields of the disk proper and by the dorsal and much widened lateral arm plates of the much modified arm bases. The interradial borders of the "asteroid" body are hemmed by a series of modified arm spines, which are soldered together. The basal lateral arm plates articulate with the vertebrae by means of a bar-like ridge. Arms outside the "asteroid" body very abortive, without dorsal and ventral arm plates, without tentacles. Tentacle pores present only within the "asteroid" body, very large and arranged so as to form a pentamerous petaloid series. Ventral arm plates well developed, forming a continuous series, which extends only as far as the last tentacle pores. Oral shield single or five¹⁾; in the former case, it is the madreporite. Adoral shields long and narrow. Oral plates rather stout. A single dental plate is present at the apex of each jaw. Six or seven oral papillae to each jaw, arranged in a single series,

1) *A. cavellae* KOEHLER, 1915, has five oral shields.

situated deep within the oral slits; apical two or three of them arise from the dental plate. Teeth and dental papillæ proper not present. Interbrachial ventral surfaces covered by a thin skin, which contains fine, hyaline scales. Genital bursæ absent, genital slits invisible. Genital plates and scales entirely internal, very slender, those on the same side of a radius articulating with each other at the end. Peristomial plates absent. Oral frames very long. Vertebrae of the free arms more or less divided into halves by a moniliform longitudinal slit.

I do not agree with SLADEN in the interpretation of certain structures of the body. SLADEN'S "side mouth shields" are, in my opinion, genuine oral plates, and his "genital scales" true adoral shields, i. e. side mouth shields. SLADEN'S "oral papillæ" may be retained, if the meaning of these terms be extended to include the scales of the first oral tentacles. SLADEN'S "apical oral papilla" or the "single tooth" in my preliminary paper is proved not to be a papilla or tooth, but to be the dental plate. The "septa" or "divisional plates of the ambulacral system" of SLADEN are, according to my own observations, not true plates, but merely ridges projecting ventrally from the basal, or adradial, parts of the modified lateral arm plates, and bearing tentacle scales on the margin.

Astrophiiura kawamurai MATSUMOTO.

Astrophiiura kawamurai: MATSUMOTO, Annot. Zool. Japon., VIII, 1913, p. 225, Pl. III, figs. 1 & 2.

One specimen; Okinosé (a submarine bank), Sagami Sea; 330 fathoms.

Diameter of the pentagonal "asteroid" body 12 mm.; that of

the disk proper, or of the circle passing through the outer ends of the radial shields, 7 mm. Length of the free portion of the arms 6 mm. Width of same near the pentagonal body 0.4 mm.

The pentagonal "asteroid" body is very flat, covered entirely by the stout primary plates and radial shields of the disk proper and by the dorsal and lateral arm plates of the modified basal portion of the arms. The primary plates are the central, the five infrabasals, five basals, five radials and five first and five second interradials. The infrabasals, basals and interradials are elevated above the level of the central, radials and radial shields, so as to form a regular symmetrical system of ridges. The central plate is ten-sided, the sides corresponding to the infrabasals being longer than those corresponding to the basals. Infrabasals small, rectangular, wider than long. Basals pentagonal, with truncated inner angle, which abuts on the central plate, lateral edges concave corresponding to the radials, much longer than wide. First interradials rectangular, with concave lateral edges corresponding to the radial shields, much longer than wide. Second interradials large, pentagonal, with short and

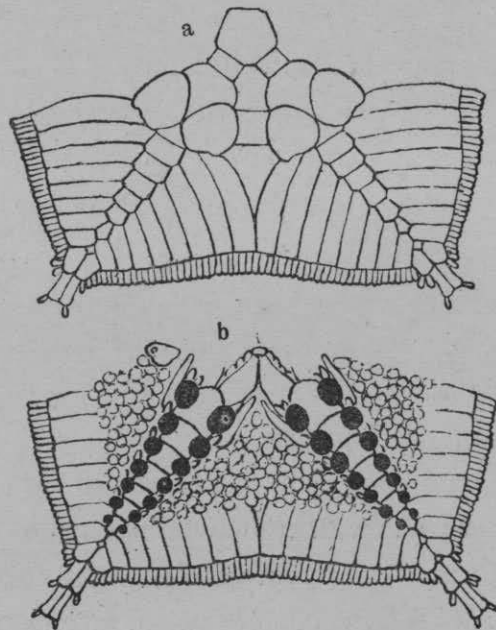


Fig. 68. *Astrophisura kawamurae* x6. a. From above. b. From below.

concave lateral edges corresponding to the radial shields, outer edges very long and concave corresponding to the first lateral arm plates, and terminating with a very acute outer angle. The elevated plates have slightly raised margins, so that the surface is concave. Radials shaped like maiden hair, with a semicircular inner border and concave outer sides corresponding to the radial shields, and with an acute outer angle; longer than wide. Radial shields irregularly triangular, with perfectly rounded angles, convex inner and slightly concave outer borders; about as long as wide, hardly touching each other. Dorsal arm plates seven or eight in number, confined to the pentagonal body. The first one is triangular, wider than long, smaller than but as wide as the next plate. The following plates, which become smaller outwards, are quadrangular, with truncated outer angles, wider without than within; the second to the fourth plates are wider than long. All the plates are in contact with one another, except the last one or two, which are very rudimentary and isolated. Within the pentagonal body, the lateral arm plates are much elongated laterally, with the width almost equal to the length of the corresponding arm joints, lightly bent outwards, striated parallel to the axis of elongation. They meet with the corresponding dorsal arm plates, except the first, which is separated from the first dorsal by the radial shield. The first lateral arm plates of the neighbouring radii are apposed to each other distally, outside the second interradial. The distal edges of the successive lateral plates form a continuous line, the interradial borders of the pentagonal body, which are slightly indented, and hemmed by a series of soldered papillæ, which are evidently the modified arm spines of the modified lateral arm plates. These papillæ are longer towards the middle of the interradial borders, where they are

about as long as the width of the corresponding lateral arm plates. There are three or four of them for each lateral plate.

With the exception of the peripheral zone, the ventral surface of the interradial spaces of the pentagonal body is covered by a thin skin, which contains fine, close-set, polygonal or rounded, delicate, transparent scales. The peritoneal cavity and the genital glands can be seen through the skin, and apparently extend into the arm bases. The genital bursæ are absent and the genital openings are invisible. There is only one oral shield, the mad-reporite, which is irregularly triangular, and so transparent and small as to be almost invisible unless the specimen is dried, and distinguishable only with difficulty from the scales of the inter-brachial ventral surface, and is moreover separated from the adoral shields by a space. The adoral shields are long and very narrow, tapered within to a point, outer end joined to the first ventral arm plate, inner end free, longer than the first ventral plate. Oral plates large and stout, oblong quadrangular, with exceedingly short inner side, convex abradial and concave or nearly straight adradial side, much wider without than within, joined distally to the first ventral arm plate and proximally to each other along the proximal one-third of the abradial side. A single dental plate is present in each jaw, quadrangular in ventral view with curved inner edge. There are six or seven papillæ to each jaw, arranged in a horizontal, continuous row, situated deep within the oral slits, and directed not laterally but upwards. The two or three apical ones arise from the dental plate, so that they may be regarded as dental papillæ, while the outer papillæ lie just below the first oral tentacle pores and protect the latter, so that they may possibly be the tentacle scales of the same.

Ventral arm plates eight or nine in number, limited to within

the pentagonal body. The first one is very large, hastate, but with much rounded apex, lateral edges strongly concave corresponding to the second oral tentacle pore, and with an indentation at the outer edge, longer than wide, very wide without. Following plates, which become smaller outwards, quadrangular, with strongly concave lateral edges corresponding to the tentacle pore, with a saddle-shaped surface. They are closely apposed to one another, except the last one or two, which are very rudimentary, rhomboidal and isolated. The tentacles are very large, uniformly diminishing in size and lying closer together as they proceed outwards, and arranged in a pentamerous petaloid series as a whole. The first pair of tentacles in ventral view are homologous with the second oral tentacles of other ophiurans, because they are situated between the first ventral arm plate and the adoral shields and belong morphologically to the same arm joint with the latter. They are much larger than the other tentacles. The second pair are the true first arm tentacles. They belong to the same joint with the second ventral and the first dorsal and lateral plates. Each tentacle pore is provided with one or two scales, which are rather small, lanceolate, covered by skin, their concave surface facing the tentacle pore, often turned up. The outermost and smallest tentacle pores have no scale. Each two successive tentacle pores are separated by a ridge of the basal or adradial part of the lateral arm plate, which belongs to the same joint with the outer of the two pores.

The free distal portion of the arms outside the pentagonal body is very abortive, exceedingly slender, uniformly tapered outwards, entirely covered by the lateral plates and easy to break. There is a single, exceedingly small and acute arm spine on each lateral plate; but in the first one or two free joints, there are

two or three spines. It may be observed in some radii, that the lateral plates of the first free arm joint are in process of being absorbed into the pentagonal body.

Colour in alcohol: whitish or light yellow; central and radials, radial shields and inner part of the interradial spaces below bluish gray.

This specimen was found attached to a stone by the ventral surface of the pentagonal body, in the same way as *Chiton* or *Patella*.

The present species differs from the genotype, *A. permira* SLADEN from Madagascar, chiefly in the very regular arrangement of the plates on the dorsal surface of the pentagonal body as a whole, in the larger central plate, in the much smaller and quite regular infrabasals, in the much narrower basals and interradials, in the infrabasals, basals and interradials being elevated so as to form a regular symmetrical system of ridges, in the scarcely joined and not overlapping radial shields, in the absence of the central boss on the primary plates, in the very regular and much narrower dorsal arm plates, in the much smaller and rather inconspicuous madreporic shield, in the longer adoral shields, in the oral plates being somewhat narrower and in contact to a less extent, in the perfectly saddle-shaped ventral arm plates and in the much narrower free portion of the arms. Further, this species differs from CHUN's *Astrophiuura* from Agulhas Bank, which is not yet named, chiefly in the smaller and regular infrabasals, in the narrower basals and interradials, in the elevated infrabasals, basals and interradials, in having two, instead of three, sets of interradials¹⁾, in the not overlapping radial shields, in the absence of

1) The presence of two or three sets of interradials may not be of specific value, because KOEHLER has observed both cases in his *A. cavella*.

the central boss on the primary plates, in the much narrower dorsal arm plates and in the much narrower free portion of the arms. Lately, KÖHLER has described *A. cavellæ* from the vicinity of the Cape of Good Hope, from which the present species differs chiefly in the much shorter and smaller infrabasals, in the much narrower basals and interradials, in the radials being not distinctly pentagonal but shaped like maiden hair, in the scarcely joined radial shields, in the absence of the central boss on the primary plates, in the much narrower dorsal arm plates, in the much smaller madreporic shield, in the absence of the ordinary oral shields, in the longer adoral shields, in the oral plates being in contact to a less extent, and in the much narrower free portion of the arms. On the whole, *A. permira*, *A. cavellæ* and CHUN'S *Astrophisura* (there is some possibility that it belongs to one of the two first mentioned species) appear to me to be nearer to one another than any of them is to the present species. This fact may be correlated with the geographical separation of the present species from the others, which occur near together.

Haplophiura MATSUMOTO, 1915.

Disk high, much elevated above the arm bases, covered with rather large plates, among which the primaries are very prominent. Radial shields stout, joined in pairs. Interbrachial ventral surfaces covered with fine granules. Genital slits indistinct. Oral papillæ soldered together. Teeth in a single vertical row. Dental papillæ absent. Arms short, stout. Arm plates convex. First ventral arm plate larger than the following. Few, very small arm spines. Tentacle pores, including the second oral tentacle pore, which opens outside the oral slit, entirely free of scales.

This genus is formed by a single species, *Ophiozona gymnopora* CLARK, 1909.

Revision of *Ophiura* LAMARCK, 1816 (= *Ophioglypha* LYMAN, 1865).

As *Ophiura* s. ext. is a very large and diffuse genus, the necessity for subdivision is admitted by many authors. LUDWIG proposed to divide it into two genera according to the presence or absence of the arm combs. But his type of *Ophioglyphina* is, in my opinion, merely a typical *Ophiura*. KÖHLER tried to divide this genus into two sections according as the second oral tentacle pores opened more or less within the oral slits or entirely outside it. In my opinion, the position of the pores in question is not of such value, though it is of some importance in making subdivisions of *Ophiura* s. ext. I cannot agree with those authors who try to subdivide this genus by only one or two characters; all characters should be taken into account. From this point of view, I have come to the conclusion that LYMAN'S subdivisions may be accepted in principle. I propose here to divide *Ophiura*, as hitherto understood, into a number of genera, which may be distinguished as follows.

- A—Adoral shields not oval but long; no supplementary plates among the oral plates and adoral shields; genital papillæ always, and arm combs usually, present.
- a—Disk high, covered with very stout plates or very thick scales; arms higher than, or as high as, wide, also covered with very thick, heavy arm plates.
- b—Disk covered chiefly or only with very stout primaries and radial shields; interbrachial ventral surfaces almost entirely occupied by a very stout central plate, besides the very heavy genital scales.

- c—Disk flat; oral papillæ soldered together; arms consisting of long, knobby joints; dorsal arm plates rudimentary or absent, ventral arm plates very small, both being widely separated from one another; tentacle pores limited to several basal arm joints, very small; those beyond the second oral pores with a single tentacle scale or without any *Aspidophiura*.
- cc—Disk convex; oral papillæ not soldered together; arms consisting of short, stout joints; dorsal and ventral arm plates not very rudimentary, both being in contact with one another at least in several basal arm joints; tentacle pores present nearly throughout the entire length of the arms, large, with rather numerous scales *Amphiophiura*, pars.
- bb—Disk, as well as interbrachial ventral surfaces, covered with numerous plates or scales;
- d—Arms not very short, not very high but cylindrical, gradually tapered outwards, with blunt extremity; a few, or sometimes numerous, arm spines, arranged in a single row, well spaced.... *Amphiophiura*, pars.
- dd—Arms very short, very high, higher than wide, very stout at the base, rapidly tapered outwards, with very acute extremity; numerous arm spines, very often dimorphic and arranged in two rows..... *Stegophiura*.
- aa—Disk low and flat, covered with rather thin and delicate plates or scales; arms low, being much lower than wide, or cylindrical, being nearly as wide as high, covered with not very thick arm plates; ventral arm plates small, much wider than long, usually separated from one another even in the arm bases; tentacle pores, except the innermost one or two, very small, with only a few scales. *Homalophiura* & *Ophiura* restr.¹⁾

1) CLARK, 1915, has established *Homalophiura*, removing a number of species from *Ophiura* as diagnosed in my preliminary paper. The two genera may be distinguished as follows.

a'—Disk scales rather few and coarse, the primaries being stout and conspicuous; second oral tentacle pores opening entirely outside the oral slits; tentacle pores confined to two or

- AA—Adoral shields oval; one to three supplementary plates present among the oral plates and adoral shields; genital papillæ and arm combs absent *Ophiurolepis*.

Aspidophiura MATSUMOTO, 1915.

Disk rather high, flat, covered chiefly by the very stout primaries and the very large radial shields, which are joined in pairs almost by their entire length. Arm combs present, with conical and acute papillæ. Interbrachial ventral surfaces covered with a very large central plate, besides the very stout genital scales. Oral shields large, peculiar in shape, with a beak-like inner process. Oral papillæ soldered together. Arms strongly knotted, with long arm joints. Dorsal arm plates rudimentary or absent. Lateral arm plates well developed, flared; those of the two sides meeting both above and below. Ventral arm plates small, rhomboidal or triangular. Three arm spines, conical, usually acute. Tentacle pores rather rudimentary, present only in several proximal arm joints. A single tentacle scale to each pore or none beyond the second arm joint.

This genus includes *Ophioglypha minuta* LYMAN, 1878, and *O. forbesi* DUNCAN, 1789 (= *Ophiura glyptodisca* CLARK, 1911), besides the genotype, *Aspidophiura watasei* MATSUMOTO, 1915.

This genus stands rather between the *solida*-group of *Amphiophiura* and *Anthophiura*, but differs from the former in the

-
- three basal arm joints; first ventral arm plate axe-shaped, separated from the next plate *Homalophiura*.
 aa'—Disk scales usually numerous and fine; second oral tentacle pores opening more or less inside the oral slits; tentacle pores not confined to a few basal arm joints; first ventral arm plate usually wider than long, and usually in contact with the next plate....
 *Ophiura*, rest.

In my opinion, *Homalophiura* is close to the *irrorata*-group of *Ophiura*, being however more pedomorphic in certain structures.

flat disk, in the peculiar shape of the oral shields, in the soldered oral papillæ, in the rudimentary dorsal, as well as ventral, arm plates, in the very small tentacle pores, which are limited to the proximal arm joints, and in the very few tentacle scales; and from *Anthophiura* in the entire central plate and in the presence of the genital scales and arm combs.

Key to Japanese species of *Aspidophiura*.

- A*—The six primaries each with a small but conspicuous central boss; radial shields about as large as the radials; ventral arm plates rapidly diminishing in size outwards; arm spines longer than half the corresponding arm joint; no tentacle scale beyond the disk....
 *watasei*.
- AA*—The six primaries without a central boss; radial shields distinctly larger than the radials; ventral arm plates very slowly diminishing in size outwards; arm spines shorter than half the corresponding arm joint; single tentacle scale to each pore beyond the disk....
 *forbesi*.

Aspidophiura watasei MATSUMOTO.

Aspidophiura watasei: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 77.

One specimen; off Misaki, Sagami Sea. One specimen; Uraga Channel.

Diameter of disk 5 mm. Length of arms unknown, but probably about twice the disk diameter. Width of arms at base 1.3 mm.

Disk circular, very flat. The area inside the radial shields is mostly occupied by the six stout primary plates, and the inter-radial spaces of the dorsal surface each by two stout plates. The

pentagonal central, and the hexagonal radials have each a small but conspicuous, mamelon-shaped central boss. Central somewhat smaller than the radials. The first interradials are pentagonal, or quadrangular with irregular inner edge, about as long as wide, wider within than without, a little smaller than the radials, but larger than the second interradials, which are quadrangular, wider than long, and wider without than within. Radial shields about as

large as the radials, as long as wide, irregularly triangular, with convex abradial side, apposed to each other by their entire length. At the meeting points of the radials, first interradials and radial shields, a very small, thick, convex plate is present, and may be duplicated. Radial scales of moderate size, semilunar, with acute, needle-like comb papillæ. Interbrachial ventral surfaces entirely covered over by the large, stout genital scales and a very large, stout plate. Genital slits widened at the inner end, bounded by minute, rather well spaced papillæ.

Oral shields large, stout, triangular as a whole, with widely rounded outer angles and obtuse inner angle, and convex outer and lateral sides, the latter with a blunt notch near the inner end, corresponding to the genital slit; about as wide as long, wider without than within. Adoral shields narrow, of uniform width, meeting with each other. Five oral papillæ on either side,

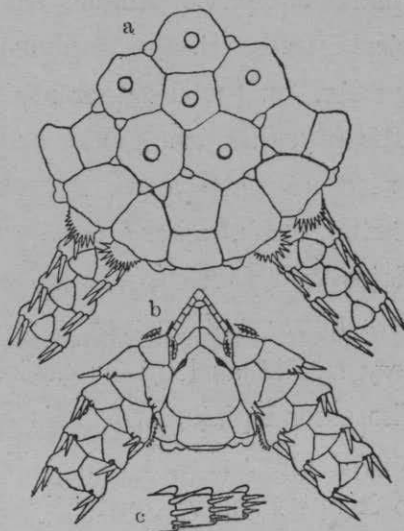


Fig. 69. *Aspidophiura watasei*. $\times 8$. *a* From above. *b*. From below. *c*. Side view of three arm joints near disk.

squarish, wider than long, soldered together. Teeth short, rather triangular, stout.

Arms tapered rather rapidly. Dorsal arm plates triangular, with acute inner angle and very convex outer side, about as wide as long, surface very convex. They extend nearly to the extremity of the arms, where they are very rudimentary. Lateral arm plates well developed, conspicuously flared, very convex, meeting both above and below. First ventral arm plate rhomboidal, not very small, as long as wide, inner sides longer than the outer. The second plate, which is the largest, is triangular, with very convex outer side, much wider than long. Those beyond similar to it but smaller, constantly diminishing in size outwards. Three arm spines, needle-like, acute, well spaced; the middle one longer than the rest, and about two-thirds as long as the corresponding arm joint. Second oral tentacle pore opening entirely outside the oral slit, bounded by about four scales both on the abradial and adradial border. Tentacle pores eight or nine pairs to each arm, very small, destitute of any scales, or a small one may be present on the adoral side in the basal joints.

Colour in alcohol: disk yellowish gray above and white below; arms white.

In the specimen from the Uraga Channel, the disk is covered over only by the primaries and radial shields, without any intervening smaller scales; and the central bosses of the six primaries are not very conspicuous.

This species differs from *A. minuta* (LYMAN) in the presence of a central boss on the central and radials, in the well developed arm combs, in the presence of the dorsal arm plates, and in the strongly flared lateral arm plates; and from *A. forbesi* (DUNCAN) in the presence of a central boss on the six primaries,

in the relatively larger radials, in the fewer and smaller intervening scales, in the shape of the first, as well as second, interradials, in the shape of the first ventral arm plate, in the ventral arm plates diminishing in size more rapidly outwards, and in the larger arm spines.

Aspidophiura forbesi (DUNCAN).

Ophioglypha forbesi: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 449, Pl. IX, figs. 1-3; LYMAN, Rep. Challenger, V, 1882, p. 77; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 63; KÖHLER, Res. Exp. Siboga, XLV, Pt. 2, 1905, p. 22.

Ophiura glyptodisca: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 91, fig. 31.

Korean Sea; 51-59 fathoms (DUNCAN, CLARK).

Indian Ocean and Malaysian waters.

Comparing DUNCAN'S and CLARK'S descriptions and figures, I can not find any tangible characters, by which CLARK'S species is distinguished from DUNCAN'S. I therefore look upon the latter as a synonym of the former. The difference in the number of secondary disk scales, which is the only one I can recognise, appears to me to be due merely to the fact, that CLARK'S type is slightly larger than DUNCAN'S.

Stegophiura MATSUMOTO, 1915.

Disk high and arched, covered with thick plates or scales, among which the primaries are conspicuous. Radial shields stout, more or less joined in pairs. Genital papillæ and arm combs well developed; papillæ of the latter long, usually spiniform. Oral shields large, oval or pyriform. Arms very short, stout, higher

than wide at the base, tapering outwards very rapidly, with very acute extremity. Dorsal arm plates very well developed, widely in contact with one another. Lateral arm plates high. Ventral arm plates quadrangular, widely in contact with one another. Numerous arm spines, short, spiniform or peg-like, often dimorphic and arranged in two rows. Tentacle pores very large, with very numerous scales.

This genus includes *Ophiura nodosa* LÜTKEN, 1854, *O. stuwitzii* LÜTKEN, 1857, *Ophioglypha elevata* LYMAN, 1878, *O. sculpta* DUNCAN, 1879, *O. sladeni* DUNCAN, 1879 (= *Ophiura stiphra* CLARK, 1911 *O. striata* DUNCAN, 1879, *O. sterea* CLARK, 1908, *Ophiura brachyac-tis* CLARK, 1911, &c., besides *Stegophiura vivipara* MATSUMOTO, 1915, the first species being the genotype.

Key to Japanese species of *Stegophiura*.

- A.—Arm spines subequal, arranged in a single series.
 - a.—Oral shields very large, almost entirely covering the inter-brachial ventral surfaces, quite reaching to the disk margin; arm spines minute, flat, fitting into small notches on the inner margin of the succeeding lateral arm plate *striata*.
 - aa.—Oral shields not very large, not reaching to the disk margin; arm spines spiniform, acute, free of notches.
 - b.—Radial shields of the same radius overlapping each other; oral shields pear-shaped; seven or eight arm spines, including the tentacle scales, which are indistinguishable from the spines *vivipara*.
 - bb.—Radial shields not overlapping, but joined in pairs; oral shields pentagonal; eight arm spines *sculpta*.
- AA.—Arm spines dimorphic, arranged in two rows.
 - c.—Arm spines well spaced, not soldered together.
 - d.—Comb papillæ not very numerous, short, flat, blunt; three to six

- arm spines, two of which are larger and longer than the rest, which are very minute.....*nodosa*.
- dd.*—Comb papillæ very numerous, spiniform, acute, but becoming blunter and more flattened as they pass downwards; secondary comb papillæ present, arising from the dorsal and lateral arm plates of the arm base; about five primary arm spines, which are more or less erect, and about ten secondary ones, which lie flat on the arm, are present on each lateral plate of the free basal arm joints.....*sterea*.
- cc.*—Very numerous arm spines, of which the secondary ones, which lie flat on the arm, are soldered together.
- e.*—Three erect primary arm spines, two of which are placed low down and one high up; between the lower two primary spines lies the lowest secondary spine, which is very large and squarish; comb papillæ very numerous, spiniform, acute, but becoming blunter and more flattened as they pass downwards; secondary comb papillæ present, arising from the dorsal and lateral plates of the arm base; oral shields ovate.....*sladeni*.
- ee.*—Two erect primary arm spines, one of which is placed low down and the other high up; comb papillæ flat and blunt; oral shields pear-shaped, much longer than wide.....*brachyactis*.

Stegophiura striata (DUNCAN).

Ophioglypha striata: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 452, Pl. IX, figs. 4-5a; LYMAN, Rep. Challenger, V, 1882, p. 77.

Sondai Bay, Korean Sea (DUNCAN).

Stegophiura vivipara MATSUMOTO.

Stegophiura vivipara: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 79.

Numerous specimens; Sagami Sea. Numerous specimens; Sagami Sea; 75-100 fathoms.

Diameter of disk 6 mm. Length of arms 13 mm. Width of arms at base 1.5 mm.

Disk pentagonal or circular (especially when the animal contains many embryos), convex, covered with fifty to sixty plates on the dorsal side, including the radial shields. Central plate pentagonal. Five radials also pentagonal, directly surrounding the central plate, laterally overlapping each other. In each inter-radial space of the dorsal side, there occurs a large squarish

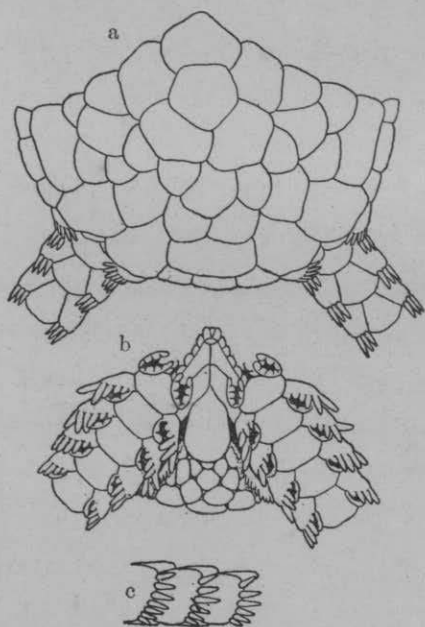


Fig. 70. *Stegophiura vivipara*. $\times 8$. *a*. From above. *b*. From below. *c*. Side view of three arm joints near disk.

plate, wider than long, and in contact with the radial shields. The latter are irregular in outline, about as long as wide, one of a pair overlapping the other, instead of being apposed to each other in the radial line. On the ventral side of the disk, the plates are rounded and knob-like, with furrows between; outer ones larger. Genital papillæ blunt, close-set; longer outwards and upwards, where they form small arm combs.

Oral shields pear-shaped, much longer than wide, wider without than within, with acute inner angle and perfectly rounded outer border. Adoral shields large, meeting within along their whole width. Five oral papillæ on either side, squarish, very short, wide, close-set. A pair of

infradental papillæ at the apex of each jaw, much longer and stouter than the other oral papillæ and rather obtusely pointed. Five teeth, very small, close-set, obtusely pointed.

Arms very short, stout, tapered rapidly outwards. Dorsal arm plates fan-shaped, about as long as wide, convex dorsally. Lateral arm plates convex, those of the two sides separated both above and below in the basal arm joints. First ventral arm plate large, triangular, with obtuse inner angle and convex outer side, wider than long. The following plates are octagonal, with very short inner lateral and outer lateral sides, the former concave at the tentacle pores; wider than long, wider without than within. From the sixth or seventh outwards, the plates are longer than wide, hexagonal, with very short inner and inner lateral, concave lateral and very convex outer sides. Seven or eight arm spines, including the tentacle scales, in the free basal joints, fine, conical, short; middle ones longer than the upper and lower ones, and about half as long as the corresponding arm joint; diminishing in number outwards. The lower spines are much finer and serve as tentacle scales. The second oral tentacle pore is very large, opening outside the oral slit, bounded by three or four scales on both the abradial and adradial sides. The tentacle pores are also large, and bounded in the basal joints by one to three aboral scales, besides the lower arm spines on the adoral side.

Colour pale gray in alcohol.

The arm length varies from one and a half to two and a half times of the disk diameter. The disk plates, including the primaries, are often very irregular in size and arrangement. One monstrous specimen has six arms, of which two arise from a common base, corresponding to a pair of radial shields.

This species is viviparous. I once dissected out twenty-four embryos of various sizes from a single adult.

Stegophiura sculpta (DUNCAN).

Ophioglypha sculpta : DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 455, Pl. IX, figs. 6-8, Pl. XI, fig. 35 ; LYMAN, Rep. Challenger, V, 1882, p. 77.

Ophiura sculpta : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 73.

Korean Straits ; 23 fathoms (DUNCAN). Eastern Sea ; 95-139 fathoms (CLARK). Off Honshû ; 31-41 fathoms (CLARK).

Stegophiura nodosa (LÜTKEN).

Ophiura nodosa : LÜTKEN, Vid. Meddel., 1854, p. 6 ; LÜTKEN, Addit. ad Hist. Oph., I, 1858, p. 48, Pl. II, fig. 9 ; GRIEG, Fauna Arctica, I, 1900, p. 263 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 70, fig. 20.

Ophioglypha nodosa : LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 49 ; LYMAN, Rep. Challenger, V, 1882, p. 78 ; KOEHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909, p. 164, Pl. XXVI, figs. 7 & 8.

Okhotsk Sea ; 40-109 fathoms (CLARK).

Bering Sea. Off Alaska. Arctic Ocean.

Stegophiura sterea (CLARK).

Ophioglypha sterea : CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 243.

Ophiura sterea : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 75, fig. 22.

Numerous specimens ; Okinosé (a submarine bank), Sagami Sea ; 83 fathoms. Numerous specimens ; Uruga Channel ; 35 fathoms. One specimen ; Namerigawa, Etchû.

Uraga Channel, 70–88 fathoms (CLARK). Suruga Gulf; 124 fathoms (CLARK). Off Kii; 191 fathoms (CLARK). Sea of Japan; 70–114 fathoms (CLARK). Off Korea; 82 fathoms (CLARK). Off Honshû; 57–81 fathoms (CLARK).

The primary arm spines stand out more or less at right angles to the arm axis, and are conical and longer and stouter than the secondary ones; they are five in the free basal arm joints. The secondary arm spines are very fine, conical, rather well spaced, nine to eleven in number in the free basal arm joints. Both the primary and secondary arm spines diminish in number outwards, the latter more rapidly, so that there are only three primary and no secondary spines in the distal arm joints.

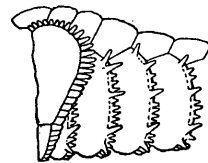


Fig. 71. *Stegophiura sterea*. Side view of an arm base. $\times 8$.

Stegophiura sladeni (DUNCAN).

Ophioglypha sladeni: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 458, Pl. IX, figs. 9–11; LYMAN, Rep. Challenger, V, 1882, p. 77.

Ophiura stiphra: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 82, fig. 25.

Numerous specimens; Okinosé (a submarine bank), Sagami Sea; 83 fathoms. Numerous specimens; Uraga Channel; 35 fathoms.

Off Ôsé Zaki, Suruga Gulf; 65–125 fathoms (CLARK). Off Kagoshima Gulf; 103–152 fathoms (CLARK). Korea Strait; 66 fathoms (CLARK). Sea of Japan; 44–47 fathoms (CLARK). Off Honshû; 45–70 fathoms (CLARK).

The primary arm spines are erect, conical, acute, three in number, one just above the uppermost secondary spine, one just above and the other just below the lowest secondary spine, which

is extremely wide and squarish. The secondary arm spines, which lie flat on the arm, are squarish, flat, close-set, mostly soldered together, smaller upwards, sixteen to eighteen in number in the free basal arm joints; they increase in number with the growth of the animal, so that they are fewer towards the extremity of the arm, as expected from the law of localised stages.

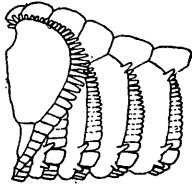


Fig. 72. *Stegophiura sladeni*. Side view of an arm base. $\times 5$.

DUNCAN does not mention the size of the type specimen, but judging from the magnification of his figures, the disk diameter must be about 5 mm. Now, my specimens of corresponding size well agree with DUNCAN'S description and figures. In these young specimens, the lowest secondary arm spine is not very distinctly large, and the secondary arm spines and tentacle scales are apparently similar, forming a continuous series. Again, in DUNCAN'S fig. 11, the primary arm spines are shown to stand apart from the series of the secondary arm spines; but this is probably due to inaccuracy of observation or drawing. As to the specific identity of the full grown specimens at hand with *Ophiura stiphra* CLARK, there is no doubt. Thus, my conclusion is that, *Ophioglypha sladeni* and *Ophiura stiphra* are merely different stages of one and the same species, the former name having priority.

Stegophiura brachyactis (CLARK).

Ophiura brachyactis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 87, fig. 28.

Off southern Saghalin; 75–100 fathoms (CLARK).

Amphiophiura MATSUMOTO, 1915.

Disk high and arched, covered with very thick plates or scales, among which the primaries are very conspicuous. Radial shields stout, joined in pairs. Genital papillæ, as well as papillæ of arm combs, well developed, either spiniform or squarish. Oral shields very large, oval, pyriform or trefoil-shaped. Arms moderately long, stout, cylindrical or higher than wide at the base, very gradually tapered outwards, with blunt extremity. Dorsal arm plates usually well developed, widely in contact with one another in the free basal part of the arms. Lateral arm plates high. Ventral arm plates of the basal arm joints quadrangular or axe-shaped, in contact with one another. One to numerous arm spines, short, peg-like. Tentacle pores large, with numerous scales.

This genus includes (1) species with very large oral shields, which almost entirely cover the interbrachial ventral surfaces, viz. *Ophioglypha bullata* WYVILLE THOMSON, 1873 (the genotype), *O. convexa* LYMAN, 1878, *O. abdita* KÖHLER, 1901, *O. insolita* KÖHLER, 1904, *O. improva* KÖHLER, 1904; (2) species with the interbrachial ventral surfaces covered over by a very large central plate and very stout genital scales, viz. *O. solida* LYMAN, 1883, *O. stellata* STUDER, 1883 (1882), *O. scutata* LYMAN, 1883, *O. paupera* KÖHLER, 1897, *O. sordita* KÖHLER, 1897, *O. liberata* KÖHLER, 1904, *O. urbana* KÖHLER, 1904, *O. remota* KÖHLER, 1904, *O. latro* KÖHLER, 1904, *Ophiura œdiplax* CLARK, 1911, *O. pompophora* CLARK, 1911; (3) species with the interbrachial ventral surfaces covered with many small plates or scales, and with quadrangular ventral arm plates, viz. *Ophioglypha sculptilis* LYMAN, 1878, *O. lacazei* LYMAN, 1878, *O. lapidaria* LYMAN, 1878, *O. undata* LYMAN, 1878, *O. ponderosa* LYMAN, 1878, *O. prisca* KÖHLER, 1904, *O. laudata* KÖHLER, 1904, *O. distincta* KÖHLER,

1904, *Ophiura megapoma* CLARK, 1911, *O. penichra* CLARK, 1911, *O. hadra* CLARK, 1911; (4) species with the interbrachial ventral surfaces covered with many small plates or scales, and with axe-shaped ventral arm plates, viz. *Ophioglypha radiata* LYMAN, 1878, *O. ornata* LYMAN, 1878, *O. abscisa* LÜTKEN & MORTENSEN, 1899, *O. obtecta* LÜTKEN & MORTENSEN, 1899; besides others.

As above indicated, the present genus is divisible roughly into four sections, of which the first rather approaches *Ophiopyrgus*, the second *Aspidophiura*, the third *Stegophiura* and *Gymnophiura*, and the fourth *Ophiura* s. str.

Key to Japanese species of *Amphiophiura*.

- A.*—Interbrachial ventral surfaces entirely covered over by the very large oral shield; central rosette of the central plate, radials and interradials very conspicuous; dorsal, as well as ventral, arm plates widely in contact with one another; three arm spines, short, conical, acute *convexa*.
- AA.*—Interbrachial ventral surfaces not entirely covered over by the oral shields.
- a.*—Each interbrachial ventral surface covered with a very large central plate and very stout genital scales.
- b.*—Disk covered only by the primaries and radial shields; dorsal, as well as ventral, arm plates longer than wide; a single very short arm spine *ædiplax*.
- bb.*—Disk covered by the primaries and radial shields and a number of secondary scales; dorsal, as well as ventral, arm plates wider than long; three peg-like arm spines *pompophora*.
- aa.*—Interbrachial ventral surfaces covered with many small plates or scales.
- c.*—Comb papillæ squarish, flat, close-set.
- d.*—Oral shields not very narrow; arm spines peg-like or spiniform, not very numerous, not close-set.

- e.—Single arm spine; tentacle scales present on both sides of the pore; oral angles free of granules..... *penichra*.
- ee.—Four or five arm spines; tentacle scales present only on the inner abradial border of the pore; oral angles often beset with a few granules *megapoma*.
- dd.—Oral shields very narrow; arm spines very numerous, squarish, flat, close-set; genital papillæ present also on the outer abradial border of the adoral shield; disk plates convex and lumpy..... *ponderosa*.
- cc.—Comb papillæ spiniform, acute, well spaced, though they become shorter, wider, blunter and more close-set downwards.
- f.—Disk covered with numerous small scales besides the primaries, which are separated from one another; oral shields rounded pentagonal, with a very acute inner angle; five well spaced arm spines *sculptilis*.
- ff.—Disk covered with a few secondary plates besides the primaries, which form a central rosette; oral shields trefoil-shaped; thirteen or fourteen arm spines *lapidaria*.

Amphiophiura convexa (LYMAN).

Ophioglypha convexa: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 84, Pl. III, figs. 83 & 84; LYMAN, Rep. Challenger, V, 1882, p. 58, Pl. VI, figs. 13-15; LYMAN, Bull. Mus. Comp. Zool., X, 1883, p. 243, Pl. IV, figs. 40-45; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 293; KÖHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909, p. 149, Pl. XXV, figs. 1 & 2; KÖHLER, Bull. U. S. Nat. Mus., LXXXIV, 1914, p. 12.

Western North Pacific (type locality); 2,050-2,300 fathoms (LYMAN).

Off western Africa. Caribbean Sea.

Amphiophiura œdiplax (CLARK).

Ophiura œdiplax: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 74, fig. 21.

Sea of Japan ; 176–245 fathoms (CLARK).

Amphiophiura pompophora (CLARK).

Ophiura pompophora : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 89, figs. 29 & 30.

Off Suno Saki, Sagami Sea ; 83–158 fathoms (CLARK). Eastern Sea ; 181 fathoms (CLARK).

Amphiophiura penichra (CLARK).

Ophiura penichra : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 84, fig. 26.

Off Kushiro, Hokkaidò ; 175–464 fathoms (CLARK).

Amphiophiura megapoma (CLARK).

Ophiura megapoma : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 79, fig. 23.

Off Noto, Sea of Japan ; 114–163 fathoms (CLARK).

Amphiophiura ponderosa (LYMAN).

Ophioglypha ponderosa : LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 93, Pl. II, figs. 52–54 ; LYMAN, Rep. Challenger, V, 1882, p. 69, Pl. VII, figs. 7–9.

Ophiura ponderosa : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 77.

Sagami Sea ; 345 fathoms (LYMAN). Off Omai Saki ; 475–505 fathoms (CLARK). Okhotsk Sea ; 75–440 fathoms (CLARK).

Alaska. California.

Amphiophiura sculptilis (LYMAN).

Ophioglypha sculptilis: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 84, Pl. IV, figs. 115 & 116; LYMAN, Rep. Challenger, V, 1882, p. 59, Pl. VI, figs. 16-18; KÖHLER, Ann. Sci. Nat. Zool., Sér. 8, IV, 1897, p. 301; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 20; KÖHLER, Bull. U. S. Nat. Mus., LXXXVI, 1914, 1914, p. 24.

Ophioglypha variabilis: LYMAN, loc. cit., 1878, p. 85, Pl. III, figs. 70, 78 & 79; LYMAN, loc. cit., 1882, p. 60, Pl. VI, figs. 10-12.

Ophiura sculptilis: CLARK, Bull. U. S. Nat. Mus., LXXXV, 1911, p. 77. Off Bôshû; 1,875 fathoms (LYMAN). Off Yaku-shima; 1,008 fathoms (CLARK).

Indo-Pacific and Atlantic.

Amphiophiura lapidaria (LYMAN).

Ophioglypha lapidaria: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 90, Pl. III, figs. 67-69; LYMAN, Rep. Challenger, V, 1882, p. 66, Pl. VII, figs. 16-18.

Off Omai Zaki; 565 fathoms (LYMAN).

Gymnophiura (LÜTKEN & MORTENSEN, 1899) mihi, 1915.

Disk high, covered by a soft skin, but partially with fine scales. Radial shields small, narrow, bar-like, widely separated from one another. Genital papillæ, as well as papillæ of arm combs, short, flat, squarish, close-set. Oral shields not very large, hour-glass-shaped. Arms rather long, stout, cylindrical. Dorsal, as well as ventral, arm plates well developed, widely in contact with one another. Lateral arm plates high, bearing seven or eight short, peg-like spines. Tentacle pores very large, with numerous scales.

This genus contains a single species, *G. mollis* LÜTKEN & MORTENSEN, 1899.

LÜTKEN & MORTENSEN have established the present genus to include two species, i.e. *G. mollis* and *G. cælurescens* LÜTKEN & MORTENSEN, 1899. As far as I can judge, the two species are not so closely related to each other as to justify their inclusion in the same genus, unless *Ophiura* in a very wide sense be made to serve for it. Judging from the original description and figures, *G. cælurescens* appears to be conspecific with, or at least very closely related to, *Ophiura flagellata*, which is evidently a typical member of *Ophiura*. The genotype, *G. mollis*, however, rather reminds us of such species as *Amphiophiura ponderosa*, *A. hadra*, *A. penichra*, &c., by its high disk, cylindrical arms and especially by its squarish and flat genital, as well as comb, papillæ. The characters, by which *G. mollis* is distinguished from the above mentioned species of *Amphiophiura*, are the naked disk and the narrow and bar-like radial shields, which are widely separated from one another. I am inclined to look upon the two peculiarities of *G. mollis* as the essential characters of the present genus.

Homalophiura clasta CLARK.

Ophiura clasta: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 64, fig. 16.

Homalophiura clasta: CLARK, Mem. Mus. Comp. Zool., XXV, 1915, p. 326.¹⁾

Off Omai Zaki; 507–918 fathoms.

Ophiura (LAMARCK, 1816) restr.

Disk low and very flat, covered with rather small, imbricating

1) *Homalophiura* CLARK, 1915, is stated by C. to include *Ophioglypha inortata* LYMAN, 1878 (the genotype), *O. confragosa* LYMAN, 1878, *O. intorta* LYMAN, 1878, *O. abyssorum* LYMAN, 1873,

scales, among which the primaries are usually very distinct. Radial shields more or less separated from one another. Genital papillæ well developed; arm combs usually present. Second oral tentacle pores opening more or less inside the oral slits, very large, beset with numerous scales, some of which often form a continuous row with the oral papillæ. Arms not very stout but flat or cylindrical, uniformly tapered outwards. Dorsal arm plates usually well developed, often widely in contact with one another. Lateral arm plates low, bearing three to seven arm spines, which lie flat on the arm. Ventral arm plates small, separated from one another at least outside the disk. Tentacle pores of the first one or two arm joints large and beset with rather numerous scales; those beyond are very small and have only one or two scales.

This genus, as now restricted, includes (1) species with spini-form genital papillæ and comb papillæ, such as *Asterias ophiura* LINNÉ, 1758, *Ophiura albida* FORBES, 1839, *Ophiolepis robusta* AYRES, 1851, *Ophiura sarsii* LÜTKEN, 1854, *O. arctica* LÜTKEN, 1854, *O. carnea* (SARS) LÜTKEN, 1859, *O. affinis* LÜTKEN, 1859, *Ophioglypha lütkeni* LYMAN, 1860, *O. kinbergi* LJUNGMAN, 1866, *O. acervata* LYMAN, 1869, *O. brevispina* SMITH, 1876, *O. inermis* LYMAN, 1878, *O. papillata* LYMAN, 1878, *O. flagellata* LYMAN, 1878, *O. imbecillis*, LYMAN, 1878, *O. lepida* LYMAN, 1878, *O. æqualis* LYMAN, 1878, *O. ljunghmani* LYMAN, 1878, *O. meridionalis* LYMAN, 1879, *O. aurantiaca* VERRILL, 1882, *O. maculata* LUDWIG, 1886, *O. amphitrites* BELL, 1888, *O. indica* BROCK, 1888, *O. thouleti* KOEHLER, 1895, *Ophiozona*

O. tessellata VERRILL, 1894, *O. inflata* KOEHLER, 1898, *O. divisa* LÜTKEN & MORTENSEN, 1899, *O. nana* LÜTKEN & MORTENSEN, 1899, *O. scutellata* LÜTKEN & MORTENSEN, 1899, *O. frigida* KOEHLER, 1900, *O. gelida* KOEHLER, 1900, *Ophiozona inermis* BELL, 1902, *Ophioglypha brucei* KOEHLER, 1907, *O. mimaria* KOEHLER, 1907, *O. partita* KOEHLER, 1907, *O. scissa* KOEHLER, 1970, *O. flexibilis* KOEHLER, 1911, *Ophiura clasta* CLARK, 1911, and *Ophioglypha rouchi* KOEHLER, 1912.

capensis BELL, 1905, *Ophiura leptoctenia* CLARK, 1911, *O. micrantha* CLARK, 1911, *O. quadrispina* CLARK, 1911, *O. bathybia* CLARK, 1911, *Ophiecten oöplax* CLARK, 1911; (2) species with flat and squarish genital papillæ and comb papillæ, such as *Ophioglypha multispina* LJUNGMAN, 1866, *O. lymani* LJUNGMAN, 1870, *O. irrorata* LYMAN, 1878, *O. undulata* LYMAN, 1878, *O. costata* LYMAN, 1878, *O. albata* LYMAN, 1878, *O. jejuna* LYMAN, 1878, *O. loveni* LYMAN, 1878, *O. fraterna* LYMAN, 1878, *O. rugosa* LYMAN, 1878, *O. ambigua* LYMAN, 1878, *O. tenera* LYMAN, 1883, *O. falcifera* LYMAN, 1883, *O. verrucosa* STUDER, 1883, *O. aspera* KÖHLER, 1898, *O. plana* LÜTKEN & MORTENSEN, 1899, *O. clemens* KÖHLER, 1904, *O. concreta* KÖHLER, 1901; *O. mundata* KÖHLER, 1906, *Ophiura monostæcha* CLARK, 1911, *O. atacta* CLARK, 1911, *O. calyptolepis* CLARK, 1911, *O. cryptolepis* CLARK, 1911, *O. paucisquama*, nov. and others.

Ophionotus, *Ophioperla* and *Ophiotjalfa* are very close to the present genus—especially to the *ophiura*-group. *Ophionotus* may be defined as *ophiura*-forms with supplementary dorsal arm plates; *Ophioperla* as the same with superficial granulations on the disk; and *Ophiotjalfa* as the same without genital papillæ or arm combs.

Key to Japanese species of *Ophiura*.

- A.—Genital papillæ, as well as comb papillæ, spiniform, acute, both or at least the latter being well spaced; second oral tentacle pore opening more or less within the oral slit.
- B.—Arms flattened, much wider than high at the free arm base; arm spines rather long and stout.....*ophiura*-group (I).
 - a.—Arm combs well developed, rather large in dorsal view.
 - b.—Three arm spines; oral shields wider within than without.
 - c.—Disk scales naked; arm spines not spatulate.

- d.*—Disk scales coarse; comb papillæ very long and slender, eight to ten of them being visible from above..... *kinbergi*.
- dd.*—Disk scales fine; comb papillæ very short, twelve to fourteen of them being visible from above..... *sarsii*.
- cc.*—Disk scales more or less obscured by a thick, soft skin; lower arm spines of basal arm joints spatulate *flagellata*.
- bb.*—Four arm spines; oral shields wider without than within; comb papillæ short..... *quadrispina*.
- aa.*—Arm combs rudimentary or entirely wanting, genital papillæ present.
- e.*—Three exceedingly long arm spines; dorsal arm plates oval, longer than wide; disk scales fine; oral shields wider without than within *oöplax*.
- ee.*—Four arm spines, not exceedingly long; dorsal arm plates more or less quadrangular, much wider than long; disk scales coarse; oral shields wider within than without..... *maculata*.
- BB.*—Arms cylindrical, about as wide as high at the free base; three arm spines, minute, peg-like, short, well spaced..... *imbecillis*-group (II).
- f.*—Disk scales coarse; radial shields joined in pairs; oral shields trefoil-shaped, about as long as wide; arm bases within the disk especially wide; first ventral arm plate very large and rhomboidal; dorsal arm plates separated from one another..... *imbecillis*.
- ff.*—Disk scales fine; radial shields nearly or entirely separated from one another; oral shields not trefoil-shaped; arm bases within the disk not especially wide; first ventral arm plates small; dorsal arm plates meeting with one another.
- g.*—Radial shields short, only slightly longer than wide; oral shields pentagonal, wider than long; uppermost or lowest arm spine longest, middle one shortest, none of them coming up to the length of the corresponding arm joint *micracantha*.
- gg.*—Radial shields long, about twice as long as wide; oral shields pear-shaped, much longer than wide; uppermost arm spine longest,

- lowest one shortest, the former being as long as, or longer than, the corresponding arm joint *leptoctenia*.
- AA.*—Genital papillæ and comb papillæ squarish, flat, short, blunt, close-set; second oral tentacle pore opening nearly or entirely outside the oral slit; arms cylindrical, about as wide as high at the base; arm spines minute, short *irrorata*-group (III).
- h.*—Disk scales naked; arm spines well spaced.
- i.*—Three arm spines.
- j.*—The two sets of comb papillæ on the sides of an arm base not continuous; oral shields much wider than long.
- k.*—Oral shields wider without than within; arm spines minute, subequal; tentacle scales very numerous, twelve to fifteen to the second oral tentacle pore, eight to eleven to the first tentacle pore, five to eight to the second tentacle pore, &c. *irrorata*.
- kl.*—Oral shields wider within than without; arm spines not very minute, uppermost one longest and lowest one shortest; tentacle scales rather few, eight or nine to the second oral tentacle pore, four or five to the first tentacle pore, three or four to the second tentacle pore, and one or two to those beyond. *paucisquama*.
- jj.*—The two sets of comb papillæ on the sides of an arm base forming a single unbroken series; oral shields about as wide as long, wider within than without; arm spines subequal *monostæcha*.
- ii.*—Six arm spines, minute, peg-like, subequal, evenly spaced; disk scales thin and hard to distinguish; oral shields pentagonal, slightly longer than wide. *albata*.
- hh.*—Disk covered by a thick, soft skin, which obscures the underlying scales; arm spines closely set.
- l.*—Six or seven arm spines; disk scales rather coarse and thick, radial shields present; arm combs rudimentary or entirely absent. *calyptolepis*.
- ll.*—Seven to nine arm spines; disk scales and radial shields almost aborted in adult specimens; arm combs well developed *cryptolepis*.

Ophiura kinbergi (LJUNGMAN).

Ophioglypha kinbergi: LJUNGMAN, Öfv. K. Vet. Akad. Förh., XXVII, 1866, p. 116¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 38, Pl. IV, fig. 70; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 22; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 294.

Ophioglypha sinensis: LYMAN, Ill. Cat. Mus. Comp. Zool., VI, 1871, p. 12, Pl. I, figs. 1 & 2; LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 99; LYMAN, loc. cit., 1882; DÖDERLEIN, SEMON - Zool. Forschungsr., V, 1896, p. 281, Pl. XV, figs. 3 & 3a; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 60, Pl. IV, fig. 39; KÖHLER, Ech. Indian Mus., Shallow-water Oph., 1900, Pl. XV, figs. 6 & 7.

Ophioglypha ferruginea: LYMAN, loc. cit., 1878, p. 68, Pl. III, fig. 76.

Ophiura kinbergi: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 37, fig. 9.

Numerous specimens; Tsushima. One specimen; Tomo, Bingo. Two specimens; mouth of Koajiro Bay, Misaki; 10 fathoms. Numerous specimens; Misaki. Numerous specimens; Uraga Channel.

Off Yokohama; 8-15 fathoms (LYMAN). Inland Sea; 15 fathoms (LYMAN).

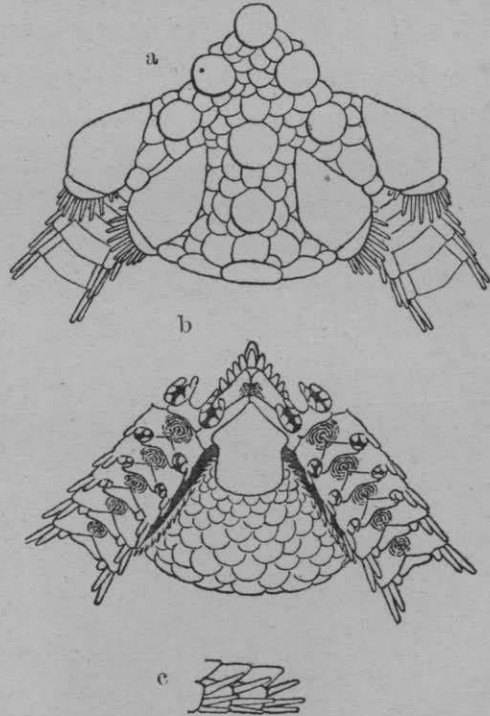


Fig. 73. *Ophiura kinbergi*. $\times 7$. a. From above. b. From below. c. Side view of three arm joints near disk.

1) This paper was not seen by me.

Eastern Sea ; 53 fathoms (CLARK). Off Echigo, Sea of Japan ; 70 fathoms (CLARK).

Indo-Pacific ; ranging southwards as far as Bass Straits.

Ophiura sarsii LÜTKEN.

Ophiura sarsii : LÜTKEN, Vid. Meddel., Nov., 1854, p. 7; LÜTKEN, Addit. ad Hist. Oph., I, 1861, p. 42, Pl. I, figs. 3 & 4; GRIEG, Fauna Arctica, I, 1900, p. 262; NORMAN, Ann. Mag. Nat. Hist., Ser. 7, XII, 1903, p. 467; NICHOLS, Proc. R. Irish Acad., XXIV, Sect. B, 1903, p. 254; CLARK, Bull. U. S. Nat. Mus., LXXV, 1011, p. 37.

Ophioglypha sarsii : LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 41, figs. 2 & 3; LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 99; LYMAN, Rep. Challenger, V, 1882, p. 40; KOEHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 296; KOEHLER, Rés. Camp. Sci. Monaco, XXXIV, 1909, p. 115, Pl. VII, fig. 3; KOEHLER, Bull. U. S. Nat. Mus., LXXXIV, 1914, p. 23, Pl. I, figs. 5-6.

Four specimens ; off Namerikawa, Etchú,

Okhotsk Sea ; 75-109 fathoms (CLARK). Gulf of Tartary ; 318 fathoms. Sea of Japan ; 59-428 fathoms (CLARK). Hakodaté Bay ; 15.5-47 fathoms (CLARK). Off Urakawa, southern coast of Hokkaidó ; 175-349 fathoms (CLARK). Off Kinkwasan ; 57 fathoms (CLARK). Uruga Channel ; 70 fathoms (CLARK). Off Korea ; 163-335 fathoms (CLARK). Eastern Sea ; 181 fathoms (CLARK).

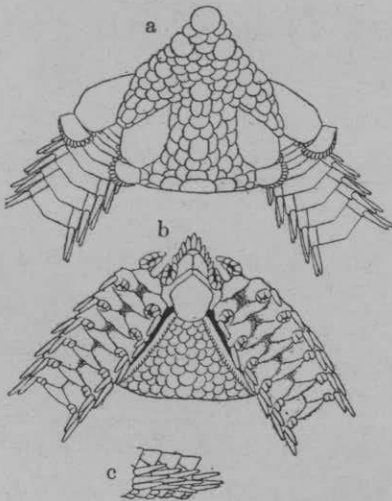


Fig. 74. *Ophiura sarsii*. $\times 2$. a. From above. b. From below. c. Side view of four arm joints near disk.

North Pacific. Arctic Ocean. North Atlantic.

In these Japanese specimens, the primary plates are rather small and have a flat surface, so that the disk is very smooth.

The plates and scales of the disk, as well as the arm plates, are light gray, with whitish peripheries. In one specimen, the primaries are especially dark, so that the disk appears spotted.

Ophiura flagellata (LYMAN).

Ophioglypha flagellata: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 69, Pl. II, figs. 49-51; LYMAN, Rep. Challenger, V, 1882, p. 52, Pl. IV, figs. 16-18; KÖHLER, Ann. Sci. Nat. Zool., Sér. 8, IV, 1896, p. 299; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 18; KÖHLER, Exp. Siboga, XIV, Pt. I, 1904, p. 56; KÖHLER, Mém. Soc. Zool. Fr., XIX, 1906, p. 6; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 294; KÖHLER, Exp. Sci. Travailleur et Talisman, VIII, 1907, p. 261.

Gymnophiura cærulescens: LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 114, Pl. VII, figs. 4-6.

Ophiura flagellata: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 60, fig. 15.

Three specimens; Okinosé, off Misaki; 100 fathoms.

Uraga Channel; 70-302 fathoms (CLARK). Sagami Sea; 292-405 fathoms (CLARK). Off Rikuzen, eastern Japan; 182 fathoms (CLARK). Off Omai Zaki; 475-505 fathoms (CLARK). Eastern Sea; 361 fathoms (CLARK).

Bering Sea and off Alaska (CLARK). Indian Ocean and Malaysian waters (KÖHLER). South-eastern Atlantic (KÖHLER).

The arm spines are much flattened, the lowest one being more or less spatulate. The second oral tentacle pore opens in the oral slit, with four or five abradial and three or four adradial scales, the former showing a tendency to form a continuous series with the oral papillæ. There are three adoral scales to the first

six or seven tentacle pores and two to those beyond; of the aboral scales there are three to the first, two to the second, and one to the third. All the tentacle scales are flat, thin and leaf-like.

I have carefully compared this species with the description and figures of *Gymnophiura cœrulescens* LÜTKEN & MORTENSEN, and have come to the conclusion that the two species agree in almost all characters, e. g. the radial shields, arm combs, interbrachial ventral spaces of the disk, oral shields, adoral shields, oral papillæ, dorsal as well as ventral arm plates, arm spines, tentacle scales, &c. The only difference between my specimens and the type of *G. cœrulescens* is that in the former the scales are present all over the disk, while in the latter there is a star-shaped naked central space on the dorsal side. But LYMAN says that, the disk of the present species is "covered with a thick skin, under which the thin small scales are scarcely, or not at all, distinguishable." Further, CLARK remarks that, his specimens "show a most remarkable difference in the calcification of the disk, for while several of them have the disk covering thick, with the scales hardly distinguishable, as in LYMAN's type, others have it much thinner with the scales evident, while still others have a greater or less part of the disk covered by a naked skin, the calcification being confined to the vicinity of the radial shields and to the interradial margins," and that "the gradation between the two extremes is so complete that there can be no doubt that the amount of calcification is an individual and not a specific or even a local matter." I therefore look upon *G. cœrulescens* as a synonym of the present species.

Ophiura quadrispina CLARK.

Ophiura quadrispina: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 55, fig. 13.

Okhotsk Sea; 109–188 fathoms (CLARK). Yezo Strait; 533 fathoms (CLARK). Sea of Japan; 325–428 fathoms (CLARK).

Bering Sea. Alaska.

Ophiura oöplax (CLARK).

Ophiocten oöplax:
CLARK, Bull. U. S. Nat.
Mus., LXXV, 1911, p.
99, fig. 37.

One specimen;
Albatross station
(number?).

Off Honshû; 94–
507 fathoms (CLARK).
Sagami Sea; 292–
614 fathoms (CLARK).
Eastern Sea; 369–
440 fathoms (CLARK).

In my opinion,
this species is evi-
dently a typical
Ophiura, though
CLARK has referred
it to *Ophiocten*. In
the genuine *Ophioc-*
ten, the tentacle pores

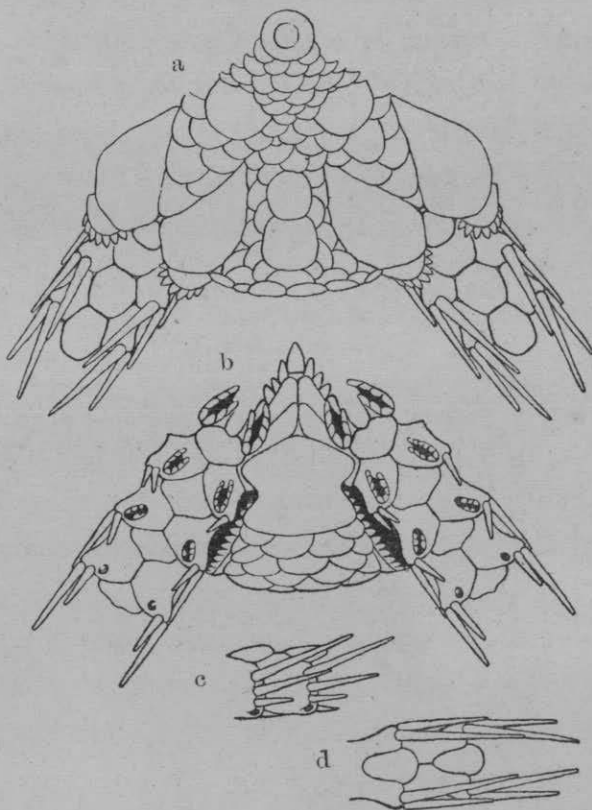


Fig. 75. *Ophiura oöplax*. $\times 15$. a. From above. b. From below. c. Side view of two arm joints near disk. d. Dorsal view of two arm joints somewhat near disk.

are of nearly uniform size and the tentacle scales few or none throughout, while in the present species the tentacle scales are very numerous in the very basal pores and rapidly diminish in number outwards. I am not able to find any character distinguishing this species from the genuine *Ophiura*.

Ophiura maculata (LUDWIG).

Ophioglypha maculata: LUDWIG, Zool. Jahrb. Sys., I, 1886, p. 283, Pl. VI, figs. 11 & 12; CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 49, fig. 11.

Two specimens (belonging to Mr. H. ASANO, Imperial Bureau of Fishery); off Kitami; 60 fathoms.

Bering Sea. Alaska.

Ophiura imbecillis (LYMAN).

Ophioglypha imbecillis: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 78, Pl. III, figs. 63 & 64; LYMAN, Rep. Challenger, V, 1882, p. 46, Pl. IV, figs. 11-13; KÖHLER, Ann. Sci. Nat. Zool., Sér. 8, IV, 1897, p. 303; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 21.

Ophiura imbecillis: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 62.

Uruga Channel; 302 fathoms (CLARK). Sagami Sea; 340-405 fathoms (LYMAN, CLARK). Off Kii; 393 fathoms (CLARK). Off Hiuga; 437 fathoms (CLARK). Eastern Sea; 361 fathoms (CLARK).

Indian Ocean. Malaysian waters.

Ophiura micracantha CLARK.

Ophiura micracantha: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 47, fig. 10.

Two specimens; Okinosé, Sagami Sea; 100 fathoms.

Uraga Channel; 197 fathoms (CLARK). Off Kagoshima Gulf; 152 fathoms (CLARK). Off Gotô Is., Eastern Sea; 139 fathoms (CLARK).

Ophiura leptoctenia (CLARK).

Ophiura leptoctenia: CLARK, Bull. U. S. Nat. Mus., LXX, 1911, p. 51, fig. 12.

Okhotsk Sea; 73-119 fathoms (CLARK). Gulf of Tartary; 318 fathoms (CLARK). Sea of Japan; 92-429 fathoms (CLARK). Southward of Hokkaidô; 175-349 fathoms (CLARK). Off eastern Japan; 191-507 fathoms (CLARK). Off Omai Zaki; 624-662 fathoms (CLARK). Off Korea; 335 fathoms (CLARK).

Bering Sea. Alaska. British Columbia. Oregon. Washington.

Ophiura irrorata (LYMAN).

Ophioglypha irrorata: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 73, Pl. IV, figs. 106-108; LYMAN, Rep. Challenger, V, 1882, p. 47, Pl. V, figs. 7-9.

Ophioglypha orbiculata: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 74, Pl. IV, figs. 103-105; LYMAN, Rep. Challenger, V, 1882, p. 48, Pl. VIII, figs. 10-12.

Ophioglypha grandis: VERRILL, Proc. U. S. Nat. Mus., XLII, 1894, p. 293.

Ophioglypha involuta: KÖHLER, Ann. Sci. Nat. Zool., Sér. 8, IV, 1897, p. 295, Pl. VI, figs. 16-18; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 15, Pl. VIII, figs. 61-63.

Ophioglypha tumulosa: LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 120, Pl. I, figs. 8-13.

Ophiura irrorata: CLARK, Bull. U. S. Nat. Mus., LXXV, p. 62.

Okhotsk Sea; 1,800 fathoms (CLARK). Off Omai Zaki; 624-

918 fathoms (CLARK). Yenshû Sea; 943 fathoms (CLARK). Off Kii; 649 fathoms (CLARK). Off Hiuga; 720 fathoms (CLARK).
Cosmopolitan.

Ophiura paucisquama, sp. nov.

One specimen; off Misaki, Sagami Sea.

Diameter of disk 5.5 mm. Length of arms 20 mm. Width of arms at base 1 mm.

Disk pentagonal, with nearly straight interbrachial borders, very flat, thin, covered with numerous coarse, irregular, imbricated scales. The central plate is indistinguishable, but the radials are distinct, and somewhat larger than the other scales. A large,

squarish plate is present in each interradius, just touching the disk margin. Radial shields irregularly triangular, with acute inner and much rounded outer angles, a little longer than one-third the disk radius, somewhat longer than wide, not in contact with each other. Arm combs very small, with fine, short, blunt, flat, close-set comb papillæ, of which about seven are visible from above. Interbrachial ventral surfaces covered also

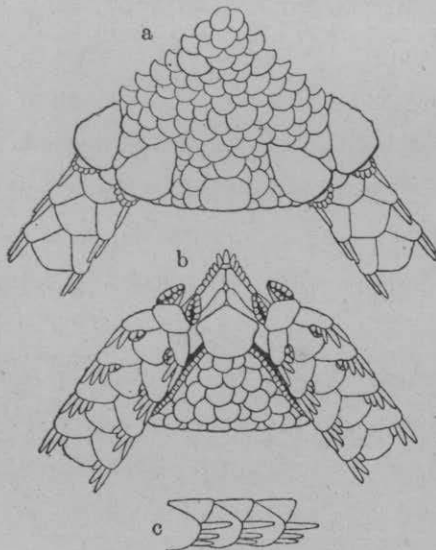


Fig. 76. *Ophiura paucisquama*. $\times 10$. a. From above. b. From below. c. Side view of three arm joints near disk.

with coarse, irregular, imbricated scales. Genital slits long, with fine, short, blunt, close-set genital papillæ on the abradial border.

Oral shields pentagonal, or rather lyre-shaped, with straight inner and notched lateral sides and a slightly convex outer side, wider than long, widest at the inner lateral angles; outer angles perfectly rounded. Adoral shields very long, narrow, meeting with each other within, constricted at about the middle by the second oral tentacle pores and the inner lateral angles of the oral shields; the outer lobe separates the oral shields from the first ventral and lateral arm plates; the inner lobe is wider within than without. Oral plates parallel to the adoral shields, also long and narrow. Four or five oral papillæ on either side, close-set, inner ones longer, narrower and acuter; the outermost one is very wide and short. Besides, there occur two or three long, conical, acute apical papillæ in each jaw. Teeth conical, acute, stout.

Arms slender, uniformly tapered outwards. The first dorsal arm plate is exceedingly small, situated between the pairs of radial shields and of arm combs; the second is also rather small. The third is the largest, pentagonal, with very short inner side and rounded outer angles, about as long as wide. The fourth is similarly pentagonal, but longer than wide, and the inner side much shorter. These plates are in contact with one another, but the rest are separated by the lateral arm plates, rhomboidal, with acute inner and rounded outer angles, longer than wide. They constantly diminish in size outwards, and become exceedingly small near the extremity of the arms. Lateral arm plates flared, meeting both above and below, except in the first joint, in which they do not meet below, and the first three or four free joints, in which they do not meet above. First ventral arm plate not very small, hexagonal, with very short lateral sides and rounded angles, much wider than long, about as wide as, but shorter than, the next plate. The latter is the largest, hexagonal, with very short

inner and very convex outer sides; inner lateral and lateral sides concave, the former being in contact with the lateral arm plates and the latter with the tentacle pores; longer than wide, wider without than within, in contact with the first plate. The third plate is pentagonal, with concave inner and lateral sides and strongly convex outer side, about as wide as long. Those beyond are triangular, with wide inner angle and very convex outer side, wider than long; separated from one another and constantly diminishing in size outwards. Three arm spines, conical, acute, the uppermost is longer and stouter than the others, and are two-thirds as long as the corresponding arm joints; in the free basal joints the lowermost two are half as long as the corresponding joints. The second oral tentacle pore opens hardly within the oral slit, with four or five scales on both the abradial and adradial borders. The first four or five tentacle pores have each two scales on the adoral border, but the rest have only one. Besides, the first and second pores have two very small scales on the aboral border, which are almost covered over by the adoral scales.

Colour in alcohol: disk very light brown, arms white.

The present species differs from *O. irrorata* (LYMAN) in the shape of the oral shields, in the longer arm spines, and in the fewer tentacle scales; from *O. plana* (LÜTKEN & MORTENSEN) in the shape of the radial and oral shields, in the coarser scales of the interbrachial ventral surfaces, and in the fewer tentacle scales; and from *O. mundata* in the shape of the radial and oral shields, in the longer arm spines, and in the fewer tentacle scales.

Ophiura monostæcha CLARK.

Ophiura monostæcha: Bull. U. S. Nat. Mus., LXXV, 1911, p. 65, fig. 17.

Off Honshû; 153 fathoms (CLARK). Suruga Gulf; 270 fathoms (CLARK). Off Hiuga; 405-578 fathoms (CLARK).

Ophiura albata (LYMAN).

Ophioglypha albata: LYMAN, Bull. Mus. Comp. Zool., V, 1873, p. 77, Pl. IV, figs. 95-97; LYMAN, Rep. Challenger, V, 1882, p. 51, Pl. V, figs. 13-15.

Sagami Sea; 775 fathoms (LYMAN).

Ophiura calyptolepis (CLARK).

Ophiura calyptolepis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 67, fig. 18.

Uraga Channel; 70-197 fathoms (CLARK). Sagami Sea; 153-405 fathoms (CLARK).

Ophiura cryptolepis (CLARK).

Ophiura cryptolepis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 1911, fig. 19.

Off Omai Zaki; 475-505 fathoms (CLARK).

Bering Sea. Alaska. Washington.

Ophiurolepis MATSUMOTO, 1915.

Disk covered with two kinds of scales, the larger ones being surrounded by a zone of smaller ones. Radial shields moderately large, rounded, widely separated from one another. Genital

papillæ and arm combs absent. Adoral shields oval, with pointed outer end. One to three supplementary plates present among the oral plates and adoral shields. Oral papillæ close-set, completely closing the oral slits. Teeth in a single vertical row. Dental papillæ absent. Arms long, stout, with very short arm joints. Dorsal arm plates well developed, wide, strongly convex. Ventral arm plates triangular, nearly in contact with, or separated from, one another. Second oral tentacle pore opening entirely outside the oral slit, long, entirely closed by the tentacle scales, which are so modified as to appear like supplementary plates. A single arm spine and three tentacle scales, both being very small and peg-like.

This genus includes a single species, *Ophiolepis carinata* STUDER, 1876 (referred to *Ophioglypha* by STUDER, 1883, after the publication of *Ophioglypha deshayesi* by LYMAN, 1878).

In my opinion *Ophiolepis carinata* STUDER and *Ophioglypha deshayesi* LYMAN are conspecific, the former having priority. Through Dr. HUBERT L. CLARK'S kindness, I was enabled to examine one of LYMAN'S specimens and I am convinced that, it agrees fairly well with STUDER'S description and figures, though the latter are rather imperfect and inaccurate. LYMAN did not take into account *Ophiolepis carinata* when describing *Ophioglypha deshayesi*, probably because he took STUDER'S statement as to genus on trust. It may be remarked that, both STUDER'S and LYMAN'S specimens were taken from the vicinities of Kerguelen Island, the former at the depth of 60-65 fathoms, the latter at 28-150 fathoms.

Ophiurolepis is not very close to any other subdivision of *Ophiura* s. ext., though it more or less resembles the *irrorata*-group of *Ophiura* s. str. *Ophiurolepis* resembles *Ophiolepis* and *Ophiozona* restr., merely in the squamation of the disk.

Key to Japanese genera of *Ophiolepidinae*.

- A*—Tentacle pores limited to a few basal arm joints; disk plates or scales, as well as radial shields, more or less intimately soldered together; oral papillæ more or less soldered together to form a single piece; arm joints long and hour-glass-shaped; dorsal and ventral arm plates more or less rudimentary; arm spines very minute and peg-like. *Ophiomusium*.
- AA*—Tentacle pores well developed throughout the entire length of the arm; disk plates or scales imbricating; oral papillæ not soldered together; arm joints not very long; dorsal and ventral arm plates usually well developed; arm spines not very minute.
- a*—No true tentacle scales, though the lower arm spines may sometimes serve as one; disk covered with fine, granule-like scales; genital slits very minute, placed at the inner corners of the inter-brachial ventral surfaces; dorsal arm plates more or less widely separated from one another by supplementary plates or naked spaces; ventral arm plates separated from one another at least in the basal arm joints. *Ophiopenia*.
- aa*—Tentacle scales always well developed.
- b*—Dorsal arm plates entire, without supplementary plates; ventral arm plates rhomboidal and separated from one another except at the arm base; lateral arm plates of either side meeting both above and below except at the arm base; disk covered with large plates and smaller scales; radial shields very stout; one or two tentacle scales. *Ophiozonella*.
- bb*—Dorsal arm plates not entire, accompanied by supplementary plates; ventral arm plates quadrangular, widely in contact with one another; lateral arm plates of either side not meeting above or below.
- c*—Dorsal arm plates proper not divided, accompanied by small supplementary plates on both sides or also along the outer border; disk covered with two kinds of scales, the larger ones surrounded by a zone of smaller ones; radial shields moderately stout; two tentacle scales, together forming an oval *Ophiolepis*.

- cc—Dorsal arm plates proper divided into halves, which are widely separated from each other by a mosaic of supplementary plates; disk covered with very fine scales; radial shields very small; three or four tentacle scales..... *Ophioplocus*.

Key to Japanese species of *Ophiomusium*.

- A—Two pairs of tentacle pores to each radius; genital slits free of papillæ; genital scales extremely stout; a very conspicuous, large, central plate is present in each interbrachial ventral surface; disk covered with very stout plates and very large radial shields.
- a—Genital slits very short and pore-like, or invisible, free from the oral and adoral shields, which are completely joined; no ventral arm plates beyond the third.
- b—Disk margin free of tubercles; disk with some secondary plates, besides the primaries and radial shields; two or three arm spines.
- c—Disk plates more or less imbricated, or arranged like steps.....
..... *scalare*.
- cc—Disk plates tessellated..... *simplex*.
- bb—Disk margin beset with tubercles; disk with only the primaries, besides the radial shields; five arm spines..... *granosum*.
- aa—Genital slits long, peculiarly situated between the oral and adoral shields, the former being almost axe-shaped.
- d—No ventral arm plates beyond the third.
- e—Disk covered with rather small primaries and smaller secondary plates, besides the radial shields, which are separated from one another; dorsal side of the disk and arms usually very tubercular; interbrachial ventral surfaces covered with a large central and several secondary plates, besides the stout genital scales... *lymani*.
- ee—Disk with only very stout primaries, besides the radial shields, which are joined in pairs; dorsal side of the disk and arms smooth; interbrachial ventral surfaces covered only by a very large central plate, besides the very stout genital scales..... *lunare*.

- dd*—Ventral arm plates present throughout the entire length of the arm.
- f*—Disk covered with stout primaries and smaller secondary plates, besides the radial shields; each primary plate bearing a very large central umbo; five or six peg-lik arm spines..... *trychnum*.
- ff*—Disk covered only by very stout primaries and radial shields; no central umbo on them; three very large, acute, erect arm spines, of which the uppermost and largest is placed on the dorsal surface of the lateral arm plate..... *lütkeni*.
- AA*—Three pairs of tentacle pores to each radius; genital slits provided with papillæ; genital scales not very stout; interbrachial ventral surfaces covered with many small plates or scales, without very prominent central plate; disk covered with many small plates or scales, besides the radial shields.
- g*—Genital slits not reaching to the disk margin; each tentacle pore provided with one scale on the abradial border and often also with an additional one on the adradial border; a group of papillæ present on either side of each arm base, just outside the genital slit and radial shield; three close-set arm spines.
- h*—Oral shields triangular, about as wide as long, wider without than within..... *cancellatum*.
- hh*—Oral shields pear-shaped, much longer than wide, wider within than without..... *jollense*.
- gg*—Genital slits reaching to the disk margin, each tentacle pore provided with two scales on the abradial border; no papillæ on the sides of the arm base; oral shields triangular, about as wide as long; four well spaced arm spines..... *laqueatum*.

Ophiomusium scalare LYMAN.

Ophiomusium scalare: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 117, Pl. I, figs. 1-3; LYMAN, Rep. Challenger, V, 1882, p. 95, Pl. I, figs. 4-6; KÖHLER, Ann. Sci. Nat. Zool., Sér. IV, 1896, p. 308, Pl. VI, figs. 24 &

25; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 26, Pl. II, figs. 12 & 13, Pl. III, fig. 21; KÖHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 65; KÖHLER, Mém. Soc. Zool. Fr., XIX, 1906, p. 6; KÖHLER, Exp. Sci. Travailleur et Talisman, VIII, 1907, p. 266.

Two specimens; off Ukishima, Uraga Channel; 300 fathoms.
Indo-Pacific. Atlantic.

Diameter of disk 9 mm. Length of arms 28 mm. Width of arms at base 2 mm.

Disk pentagonal, rather flat. Dorsal surface covered with about sixty-six stout, somewhat imbricated plates, besides the radial shields; the central plate, basals, first radials, second radials,

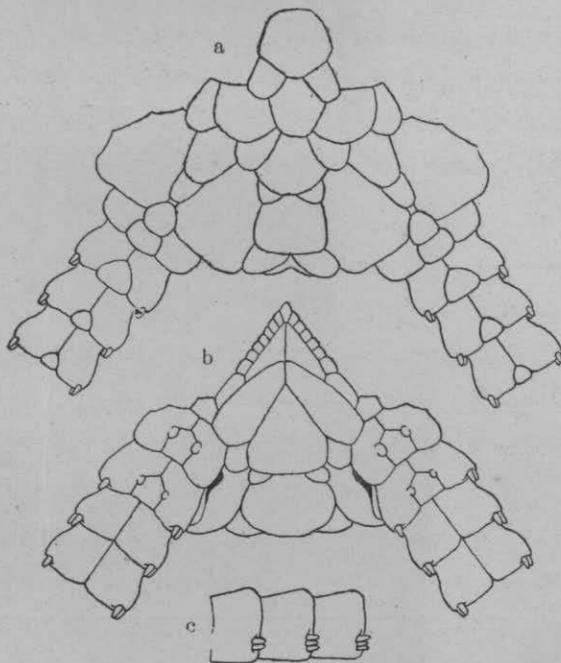


Fig. 77. *Ophiomusium scatara* $\times 10$. a. From above. b. From below. c. Side view of three arm joints near disk.

first interradials and second interradials being the largest. Central plate pentagonal, with the rounded angles placed interradially. First radials semicircular or diamond-shaped, wider than long, separated from the central plate by the small, oblong infrabasals, and from one another by the diamond-shaped basals. First interradials longer than wide, much wider at the outer end than at the inner. Second

interradials quadrangular, wider than long. Radial shields large

and stout, irregularly triangular, longer than wide, longer without than within; those of a pair separated from each other by the large second radial, small third radial and the small first dorsal arm plate. Interbrachial ventral surfaces covered chiefly by the very large, stout genital scales and a very large, stout, convex plate, lying directly outside the oral shield. Genital slits small, very short and narrow.

Oral shields large, pentagonal, with very long inner and very short lateral sides, an acute inner and rounded outer angles, stout, longer than wide, wider without than within. Adoral shields very large, stout, long, wide, tapered inwards, meeting with each other. Seven or eight oral papillæ on either side, squarish, flat, soldered together, and obscuring the original number; the outermost one is exceedingly large and wide, and arises from the adoral shield; the next is much smaller and narrower than the preceding, but distinctly larger and wider than the following. Three teeth, small, triangular, pointed.

Arms cylindrical, gradually tapered. First dorsal arm plate very small, rounded triangular, convex, wedged in between the radial shields. The next is also small, quadrangular, with rounded angles and convex sides, wider than long, with convex surface, in contact with the first. The five or six remaining are small and triangular, with rounded angles and convex sides and surface, and diminish in size outwards. Lateral arm plates well developed, covering almost the entire surface of the arms, convex, flared. Only three ventral arm plates: the first small, pentagonal, wedged in between the adoral shields; the second and third also small, but a little larger than the first, pentagonal, with the tentacle pores at the lateral angles. Only two pairs of tentacle pores and scales; the latter small and oval, the first scales being larger than

the second. Two or three arm spines, very minute, peg-like, situated close together in a notch.

The plates of the disk and arms are minutely tuberculated.

Colour in alcohol white or pale gray.

In the smaller one of these specimens, the tentacle pores and scales are entirely absent, so that the second and third ventral arm plates are triangular instead of being pentagonal.

LYMAN'S type was much smaller and KØEHLER'S specimens much larger than mine. The disk plates are therefore fewest in LYMAN'S and most numerous in KØEHLER'S; they are moreover separated from one another by narrow grooves in the type, but imbricated in both KØEHLER'S specimens and mine. The radial shields are closely in contact in the type, but separated in my specimens, and more so in KØEHLER'S. The oral papillæ are most numerous in mine. The two small plates shown in my figure between the oral shield and the largest interbrachial plate do not occur in the type, and are also absent in KØEHLER'S specimens and the smaller one of mine. Both in the type and in my specimens, the dorsal surface of the disk and arms is not so prominently tuberculated as is indicated in KØEHLER'S figures.

Ophiomusium simplex LYMAN.

Ophiomusium simplex: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 115, Pl. I, figs. 10 & 11; LYMAN, Rep. Challenger, V, 1882, p. 93, Pl. I, figs. 7-9; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 109.

Ophiomusium sanctum: KØEHLER, Exp. Siboga, XLV, Pt. I, 1904, p. 59, Pl. XI, figs. 7-9.

Eastern Sea; 71-139 fathoms (CLARK).

Amboyna. Malaysian waters.

Ophiomusium granosum LYMAN.

Ophiomusium granosum: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 118, Pl. I, figs. 12 & 13; LYMAN, Rep. Challenger, V, 1882, p. 96, Pl. I, figs. 10-12.

Off Boshû; 1,875 fathoms (LYMAN).

Ophiomusium lymani WYVILLE THOMSON.

Ophiomusium lymani: WYVILLE THOMSON, Depth of the Sea, 1873, p. 172, figs. 32 & 33; LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 113; LYMAN, Rep. Challenger, V, 1882, p. 90; LYMAN, Bull. Mus. Comp. Zool., X, 1883, p. 245, Pl. V, figs. 55-57; BELL, Cat. Brit. Ech., 1892, p. 115; KÖHLER, Résult. Camp. Sci. Caudan, 1896, p. 72; KÖHLER, Mém. Soc. Zool. Fr., IX, 1896, p. 204 & 242; KÖHLER, Résult. Camp. Sci. Monaco, XII, 1898, p. 42; LUDWIG, Sitzungsber. Akad. Wiss. Berlin, 1899, p. 220; LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 137, Pl. III, figs. 8-11; KÖHLER, Exp. Siboga, XLV, Pt. I, 1904, p. 58; KÖHLER, Résult. Camp. Sci. Monaco, XXXIV, 1909, p. 161, Pl. III, fig. 1, Pl. IV, fig. 1; McCLENDON, Univ. California Public., Zool., VI, Pt. 3, 1909, p. 36, Pl. I, figs. 4 & 5; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 107; MORTENSEN, Meddel. om Grønland, Kjøbenhavn, XXIII, 1913, p. 354; KÖHLER, Bull. U. S. Nat. Mus., LXXXIV, 1914, p. 26.

Eastern Sea; 152 fathoms (CLARK). Off Omai Zaki; 624-914 fathoms (CLARK). Off eastern Japan; 507-720 fathoms (CLARK). Widely distributed both in the Indo-Pacific and Atlantic.

Ophiomusium lunare LYMAN.

Ophiomusium lunare: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 116, Pl. I, figs. 4-6; LYMAN, Rep. Challenger, V, 1882, p. 84, Pl. I, figs. 13-15; KÖHLER, Exp. Siboga, XLV, 1904, p. 58; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 107.

Eastern Sea ; 103–152 fathoms (CLARK).

Malaysian waters.

Ophiomusium trychnum CLARK.

Ophiomusium trychnum : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 109, fig. 40.

Two specimens ; Iwatogaké, Sagami Sea ; 300 fathoms. Two specimens ; Okinosé, Sagami Sea. Three specimens ; locality unknown.

Suruga Gulf ; 94–150 fathoms (CLARK). Uraga Channel ; 70–302 fathoms (CLARK). Off eastern Japan ; 191–578 fathoms (CLARK).

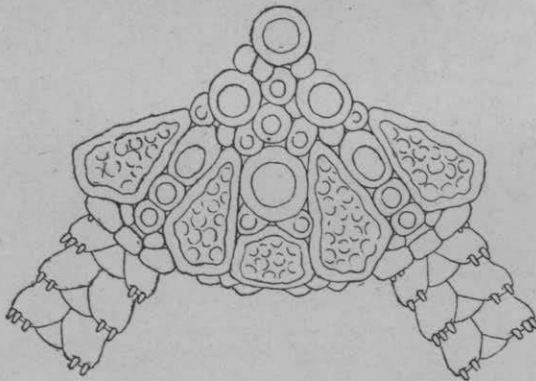


Fig. 78. *Ophiomusium trychnum*. From above. $\times 4$.

In my specimens, there are always two, instead of three, very large plates in each dorsal interbrachial space. The radial shields and the large interrarial marginal plates are often very rough and tubercular. The dorsal side of the arms also shows

a tendency to be rough and uneven.

Ophiomusium lütkeni LYMAN.

Ophiomusium lütkeni : LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 114, Pl. V, figs. 138–140 ; LYMAN, Rep. Challenger, V, 1882, p. 91, Pl. I, figs. 16–18 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 107.

Eastern Sea ; 139–152 fathoms (CLARK).

Arafura Sea ; 129 fathoms (LYMAN).

Ophiomusium cancellatum LYMAN.

Ophiomusium cancellatum : LYMAN, Bull. Mus. Comp. Zool., V, 1878, p. 111, Pl. I, figs. 17 & 18 ; LYMAN, Rep. Challenger, V, 1882, p. 88, Pl. II, figs. 16-18 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 106.

Numerous specimens ; Uruga Channel.

Colnett Strait ; 1,008 fathoms (CLARK). Off Heda ; 168 fathoms (CLARK). Suruga Gulf ; 65-297 fathoms (CLARK). Off Omai Zaki ; 475-505 fathoms (CLARK). Sagami Sea ; 369-775 fathoms (CLARK, LYMAN). Uruga Channel ; 197 fathoms (CLARK). Off eastern Japan ; 191-578 fathoms (CLARK).

Off Bermudas (LYMAN).

Ophiomusium jolliense McCLENDON.

Ophiomusium jolliensis : McCLENDON, Univ. California Public., Zool., VI, Pt. 3, 1909, p. 36, Pl. I, figs. 2 & 3 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 111, fig. 41.

Off Heda ; 167 fathoms (CLARK). Uruga Channel ; 197 fathoms (CLARK). Off eastern Japan ; 191-505 fathoms (CLARK).

California. Washington.

Ophiomusium laqueatum (LYMAN).

Ophiomusium laqueatum : LYMAN, Bull. Mus. Comp. Zool., V, 1878, p., 113, Pl. I, figs. 14-16 ; LYMAN, Rep. Challenger, V, 1882, p. 90, Pl. II figs. 10-12 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 106.

Eastern Sea ; 103-152 fathoms (CLARK).

Lat. 5° 42' S., long. 132° 25' E.; 129 fathoms (LYMAN).

Ophiopenia disacantha CLARK.

Ophiopenia disacantha: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 102, fig. 38.

Sea of Japan; 176–200 fathoms (CLARK).

Bering Sea. Alaska.

Revision of Ophiozona.

I have great doubt about the generic value of *Ophiozona* as now understood. The genotype, *Ophiolepis impressa* LÜTKEN, 1859, has very numerous small disk plates surrounded by a zone of much finer scales, and well developed, quadrangular dorsal, as well as ventral, arm plates, which are perfectly joined to one another. A characteristic feature is the presence of a group of three disk plates between the outer parts of each pair of radial shields. In every character, the genotype is very nearly allied to the genuine *Ophiolepis* and distinguished from it merely by the absence of supplementary dorsal arm plates. But most species of *Ophiozona* as understood at present, differ much from the genotype, having less numerous large disk plates and less well developed, rhomboidal dorsal, as well as ventral, arm plates, which are separated from one another outside the arm base by the lateral arm plates. Moreover, the trio of disk plates above mentioned is entirely absent. Another atypical group of *Ophiozona* is represented by *O. gymnopora* CLARK, 1909, which is characterised by the disk being elevated high above the arm bases, by the completely joined radial shields, by the granulated interbrachial ventral surfaces, by the indistinct genital slits, by the first ventral arm plate being larger than the following, by the second oral tentacle pore opening entirely outside the oral slit, and by the total absence of the

tentacle scales. I propose to distinguish the first atypical group as *Ophiozonella* and the second as *Haplophiura* from the genuine *Ophiozona*, the distinctive characters of the three groups being as follows.

A—Disk low and flat, not much higher than the arm bases; radial shields separated from one another; interbrachial ventral surfaces free of granules; genital slits long; first ventral arm plate smaller than the following; second oral tentacle pore opening within the oral slit; tentacle scales present.

a—Disk covered with very numerous small plates, of which the larger ones are surrounded by a zone of smaller ones; a trio of disk plates distinct between the outer parts of each pair of radial shields; arms very gradually tapering outwards, with rather blunt extremity; dorsal, as well as ventral, arm plates almost quadrangular, widely in contact with one another through almost the entire length of the arm *Ophiozona*, restr.

aa—Disk covered with less numerous large plates mingled with smaller ones; no trio of disk plates between each pair of radial shields; arms rather rapidly tapering outwards, with very acute extremity; dorsal, as well as ventral, arm plates less well developed, separated from one another by the lateral arm plates except at the arm base, where they may be in contact *Ophiozonella*.

AA—Disk elevated high above the arm bases; radial shields joined in pairs; interbrachial ventral surfaces closely covered with granules; genital slits indistinct; first ventral arm plate larger than the following; second oral tentacle pore opening entirely outside the oral slit; tentacle scales absent. *Haplophiura*.

There are two species referred to *Ophiozona*, viz. *O. inermis* BELL, 1902, and *O. capensis*, BELL, 1905, which are left out of account in the above key. The latter is in my opinion referable to *Ophiura* s. str., while the former is referred to *Homalophiura* by CLARK.

Ophiozonella MATSUMOTO, 1915.

Disk covered with stout plates mingled with smaller ones. Radial shields large, usually separated from one another, but sometimes slightly in contact in pairs. Oral and adoral shields rather stout. Four or five oral papillæ on either side of each jaw; the outermost one is pointed inwards above the next papilla, which is the largest. Teeth arranged in a single vertical row. Dental papillæ absent. Genital slits not reaching to the disk margin. Arms short, very stout at base, rather rapidly tapered outwards to very slender extremities. Dorsal, as well as ventral, arm plates more or less rhomboidal, not very widely in contact or mostly separated from one another. Two to four arm spines, short, lying flat on the arm. One or two tentacle scales to each pore.

This genus includes (1) species with two tentacle scales to each pore, viz., *Ophiozona nivea* LYMAN, 1875, *O. tessellata* LYMAN, 1878, *O. marmorea* LYMAN, 1883, *O. clypeata* LYMAN, 1883, *O. bispinosa* KÖHLER, 1897, *O. molesta* KÖHLER, 1904, *O. elevata* CLARK, 1911, *O. platydisca* CLARK, 1911; (2) species with one tentacle scale to each pore, viz., *O. insularia* LYMAN, 1868, *O. stellata* LYMAN, 1878, *O. antillarum* LYMAN, 1878, *O. depressa* LYMAN, 1878, *O. alba* LÜTKEN & MORTENSEN, 1899, *O. contigua* LÜTKEN & MORTENSEN, 1899, *O. casta* KÖHLER, 1904, *O. depressa* var. *media* KÖHLER, 1904, *O. projecta* KÖHLER, 1905, *O. longispina* CLARK, 1908, *O. polyplax* CLARK, 1911, and *O. tjalfiana* MORTENSEN, 1913, the genotype being *O. longispina*.

Key to Japanese species of *Ophiozonella*.

A—Two tentacle scales to each pore.

- a*—Disk convex, covered with one hundred to one hundred and fifty large plates. *elevata*.
- aa*—Disk flat, covered with about two hundred small plates. *platydisca*.
- AA*—One tentacle scale to each pore, often also with one to three small, supplementary ones on the adradial border of the pore in a few basal arm joints.
- b*—Disk convex; arms long and slender, five to eight times as long as the disk diameter; colour reddish or yellowish brown in alcohol. ...
..... *projecta*.
- bb*—Disk flat; arms short, three or four times as long as the disk diameter; colour white in alcohol.
- c*—Disk plates fine; radial shields rather small, about one-third as long as the disk radius; arm spines shorter than the corresponding arm joint..... *polyplax*.
- cc*—Disk plates large; radial shields very stout, about half as long as the disk radius; arm spines of basal arm joints longer than the corresponding joint..... *longispina*.

Ophiozonella elevata (CLARK).

Ophiozona elevata: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 31,
fig. 6.

Off Gotô Is., Eastern Sea; 95–106 fathoms (CLARK).

Ophiozonella platydisca (CLARK).

Ophiozona platydisca: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p.
34, fig. 7.

Off Hiro Misaki; 191 fathoms (CLARK).

Ophiozonella projecta (KOEHLER).

Ophiozona projecta: KOEHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 19,
Pl. I, figs. 16–18; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 36.

Numerous specimens; off Nii-jima, Sagami Sea. Numerous specimens; off Misaki, Sagami Sea.

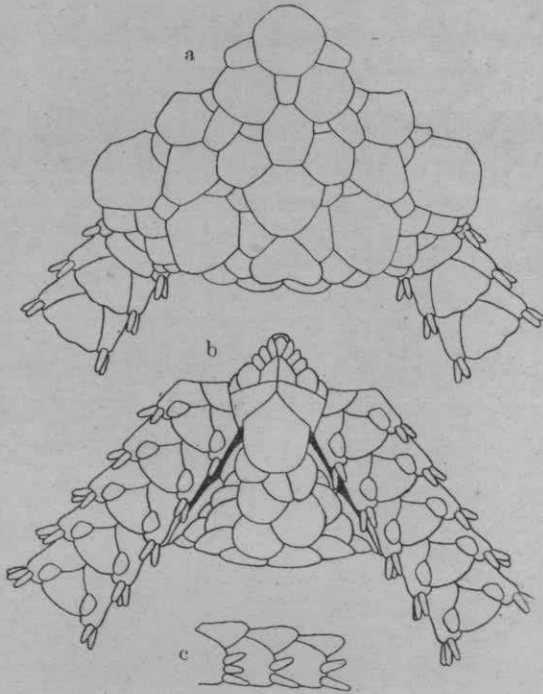


Fig. 79. *Ophiozonella projecta*. $\times 14$. a. From above. b. From below. c. Side view of three arm joints near disk.

The arms are very long and slender, being five to eight times as long as the disk diameter, so that they are longer than in K EHLER'S type. The genital scales are two to each slit, the outer one being much longer than the inner. In some of the basal free arm joints, there are three arm spines instead of two.

Ophiozonella polyplax (CLARK).

Ophiozona polyplax: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 35, fig. 8.

Off southern Japan; 437 fathoms (CLARK). Off Shio Misaki; 440-587 fathoms (CLARK).

Off Got o Is., Eastern Sea; 95-106 fathoms (CLARK).

Malaysian waters.

Sagami Sea is probably the northern limit of this Indo-Pacific species.

The arms are very long and slender, being five to eight times as long as the disk diameter, so that they are longer than in K EHLER'S type. The genital scales are two to each slit, the outer

Ophiozonella longispina (CLARK).

Ophiozona longispina: CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 290; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 33.

Numerous specimens; Suruga Gulf. Numerous specimens; Sagami Sea.

Off Heda; 337 fathoms (CLARK). Suruga Gulf; 45-124 fathoms (CLARK). Uraga Channel; 58 fathoms (CLARK). Off eastern Japan; 191 fathoms (CLARK).

The supplementary tentacle scales are very well developed. In the basal arm joints, there are one or two of them on the adradial border of each pore, beside one large, oval ordinary scale on the abradial border. So that, the tentacle scales of this species, as well as of *Ophiozonella alba* (LÜTKEN & MORTENSEN), remind us of those of *Ophiodoris* and of certain species of *Ophiochiton*. The dorsal and ventral arm plates are relatively wider than in many other species of this genus. The

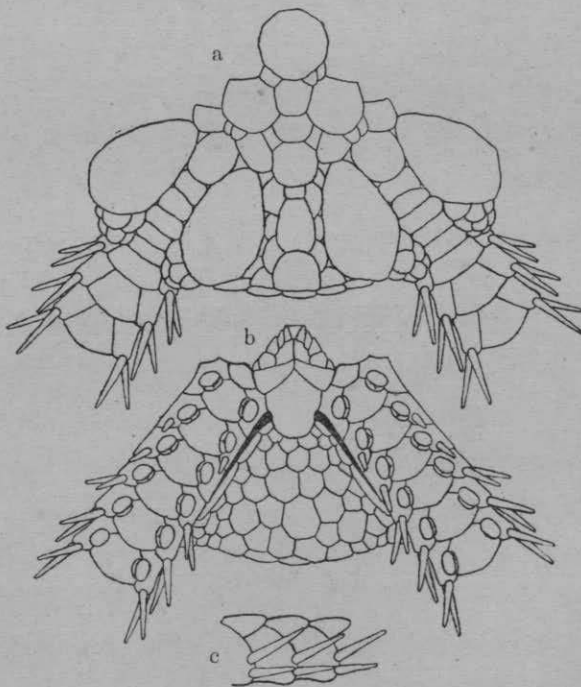


FIG. 80. *Ophiozonella longispina*. $\times 3.3$. a. From above. b. From below. c. Side view of three arm joints near disk.

arm spines are also very long, in contrast to those of other species.

Ophiozona (LYMAN, 1865) restr.

Disk covered with very numerous small plates, the larger ones being surrounded by a zone of smaller ones. Radial shields small, separated from one another. A trio of disk plates distinctly present between the outer parts of each pair of radial shields. Two long genital slits in each interradius. Oral and adoral shields small. Four or five oral papillæ on either side of a jaw; the outermost one is pointed inwards above the next papilla, which is the largest. Teeth arranged in a single vertical row. Dental papillæ absent. Arms rather long and slender, very gradually tapering outwards, with obtuse end. Dorsal as well as ventral arm plates well developed, almost quadrangular, widely in contact with one another through almost the entire length of the arm. Lateral arm plates of either side not meeting above or below. Four or five short arm spines. Two tentacle scales to each pore.

This genus, as here restricted, includes *Ophiolepis impressa* LÜTKEN, 1859, and *O. pacifica* LÜTKEN, 1859, the former being the genotype.

Ophiozona is very near to *Ophiolepis*, being distinguished from it only by the total absence of supplementary dorsal arm plates.

Ophiozona is wholly a littoral form, like *Ophiolepis*, and ranges to the West Indies and the Pacific side of Panama. The faunæ of either side of Panama closely resemble each other, apparently as a result of a former open communication. The distribution of *Ophiozona*, as well as of *Ophioderma*, is interesting in this respect.

Key to Japanese species of *Ophiolepis*.

- A*—Radial shields about as large as the ordinary disk plates; arms slender; supplementary dorsal arm plates present along the outer and lateral borders of the dorsal arm plates proper; three or four arm spines *cincta*.
- AA*—Radial shields much larger than the ordinary disk plates; arms stout; supplementary dorsal arm plates present only on either side of the dorsal arm plates proper; five to seven arm spines *annulosa*.

***Ophiolepis cincta* MÜLLER & TROSCHEL.**

Ophiolepis cincta: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 90; LÜTKEN, Adit. ad Hist. Oph., II, 1859, p. 101, Pl. II, figs. 6a & 6b; VON MARTENS, Arch. Naturg., XXXVI, 1870, p. 245¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 19, Pl. XXXVII, figs. 7-9; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 7; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus., II, 1887, p. 294; DUNCAN, Journ. Linn. Soc. London, XXI, 1887, p. 86; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 475; BELL, Proc. Zool. Soc. London, 1888, p. 388; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 831; LORIOL, Rev. Suisse Zool., I, 1893, p. 398; LORIOL, Mém. Soc. Phys. d'Hist. Nat. Genève, XXXII, 1894, p. 9; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 66; LUDWIG, Abh. Senckenberg. Naturf. Gesell., XXI, 1899, p. 544; PFEFFER, *ibid.*, XXV, 1900, p. 83; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 16; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 287; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 289.

Ophiolepis garrettii: LYMAN, Proc. Boston Soc. Nat. Hist., VIII, 1862, p. 77¹⁾; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 61, Pl. II, fig. 4.

Ophiolepis cincta var. *nigra*: STUDER, loc. cit.

Two specimens; locality unknown.

1) These papers were not seen by me.

Indo-Pacific.

The disk is very convex and nearly hemispherical. In one of the specimens, the disk is 14 mm. in diameter and 6 mm. in height. The arms are of unequal length, and are two and a half times to five times as long as the disk diameter. The colour is mottled on the disk, and annulated on the arms, with greenish and yellowish gray.

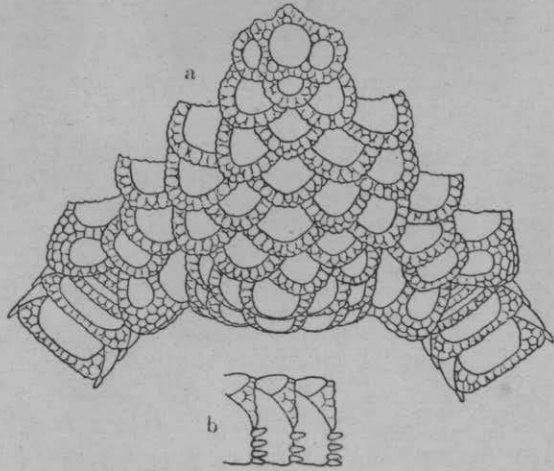


Fig. 81. *Ophiolepis cincta*. $\times 6$. a. From above. b. From below.

Ophiolepis annulosa MÜLLER & TROSCHEL.¹⁾

Ophiura annulosa: BLAINVILLE Manu. Act., 1834, p. 244, Pl. XXIV, figs. 1-4²⁾. (Non LAMARCK, 1816.)

Ophiolepis annulosa: MÜLLER & TROSCHEL, Arch. Naturg., VI, 1840, p. 328²⁾; MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 89, Pl. VIII, fig. 4; LÜTKEN, Addit. ad Hist. Oph., II, 1859, p. 101, Pl. II, figs. 5a & 5b; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 58; VON MARIENS, Arch. Naturg., XXXVI, 1870, p. 246²⁾; LYMAN, Rep. Challenger, V, 1882, p. 19; BELL, Proc. Zool. Soc. London, 1887, p. 140; BELL, *ibid.*, 1888, p. 388; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 831; LORIOL, Mém. Soc. Phys. d'Hist. Nat. Genève XXXII, 1895, p. 10; BELL, Proc. Zool. Soc. London, 1894, p. 395; DÖDERLEIN, SEMON - Zool. Forschungsr., V, 1896, p. 283; LUDWIG, Abh.

1) CLARK has recently proposed a new name *Ophiolepis superba* for this species (*Spolia Zeylanica*, X, 1915, p. 89). Though BLAINVILLE'S *Ophiura annulosa* is preoccupied by LAMARCK'S, MÜLLER & TROSCHEL'S *Ophiolepis annulosa* is entirely free of homonyms.

2) These papers were not seen by me.

Senckenberg. Naturf. Gesell., XXI, 1899, p. 544; PFEFFER, *ibid.*, XXV, 1900, p. 83; KÖHLER, Exp. Siboga, XLI, Pt. 2, 1905, p. 17; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 289.

One specimen; Okinawa.

Indo-Pacific. Okinawa is probably the northern limit of this species.

The radial shields are larger and the space between each radial pair is narrower than in LÜTKEN'S figure. The colour is quite similar to LÜTKEN'S. The arm spines are only five or rarely six in number, so that they are fewer than in MÜLLER & TROSCHEL'S type.

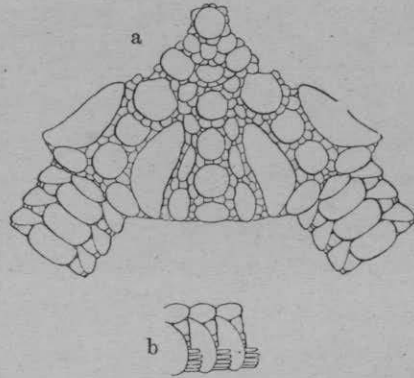


Fig. 82. *Ophioplocis annulosa*. $\times 3$. a. From above. b. Side view of three arm joints near disk.

Key to Japanese species of *Ophioplocus*.

- A—Disk scales more or less convex, so that the surface of the disk is rather rough; genital slits very short, pore-like; the halves of each dorsal arm plate proper separated from each other by six larger and a few smaller supplementary plates.....*imbricatus*.
- AA—Disk scales flat, so that the surface of the disk is very smooth; genital slits rather long, slit-like; the halves of each dorsal arm plate proper separated from each other by eight to ten larger and several smaller supplementary plates.....*japonicus*.

Ophioplocus imbricatus (MÜLLER & TROSCHEL).

Ophioplocis imbricata: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 93; LÜTKEN, Addit. ad Hist. Oph., II, 1859, p. 160.

Ophioplocus tessellatus: LYMAN, Proc. Boston Soc. Nat. Hist., VIII, 1861, p. 76^d.

Ophioplocus imbricatus: LYMAN, III. Cat. Mus. Comp. Zool., I, 1865, p. 69; VON MARTENS, Arch. Naturg., XXXVI, 1870, p. 246¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 20; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 7; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 295; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 477; BELL, Proc. Zool. Soc. London, 1888, p. 388; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 840; LORIOL, Rev. Suisse Zool., I, 1893, p. 298; LORIOL, Mém. Soc. Phys. d'Hist. Nat. Genève, XXXII, 1894, p. 12; PFEFFER, Jahrb. Wiss. Anstalt, Hamburg, XIII, p. 47; DÖDERLEIN, SEMON—Zool. Forschungsgr., V, 1896, p. 283; LUDWIG, Abh. Senckenberg. Naturf. Gesell., XXI, 1899, p. 544; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 333; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 288; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 289; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 30.

One specimen; Okinawa.

Indo-Pacific. Okinawa may be the northern limit of this species.

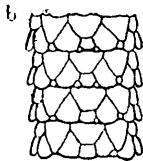


Fig. 83. *Ophioplocus imbricatus*. $\times 5$. a. Side view of three arm joints near disk. b. Dorsal view of four arm joints near disk.

Ophioplocus japonicus CLARK.

Ophioplocus imbricatus: LYMAN, Bull. Mus. Comp. Zool., III, 1874, p. 228 (pars); MARKTANNER-TURNERETSCHER, Ann. K.K. Naturh. Hofmus., II, 1887, p. 295; IVES, Proc. Acad. Nat. Sci. Philadelphia, 1891, p. 4, Pl. V, figs. 6–10.

Ophioplocus japonicus: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 30, fig. 5.

Numerous specimens; Eno-ura, Suruga.

Numerous specimens; Misaki. Numerous specimens; Kominato, Bôshû.

Pacific coast of Honshû, probably eastwards to the limit of the Kuroshiwo Stream.

1) These papers were not seen by me.

This species is distinguished from *O. imbricatus* chiefly by the longer genital slits and by the more numerous supplementary dorsal arm plates. Further, the disk scales and the supplementary plates are coarser, thicker and more convex in *O. imbricatus* than in *O. japonicus*. I suppose that, MARKTANNER-TURNERETSCHER'S specimens from Enoshima are to be referred to the present species, because the occurrence of *O. imbricatus* there is very improbable. *O. japonicus* is undoubtedly the most common ophiuran around Misaki, and perhaps along the entire southern coast of Honshû. It occurs together with *Ophiarachnella gorgonia*, but is far more abundant. In a large specimen in my hands, there are four arm spines in some of the proximal free arm joints.

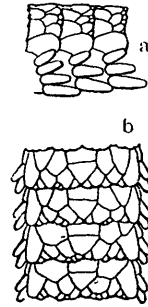


Fig. 84. *Ophioplocus japonicus*. $\times 5$. a. Side view of three arm joints near disk. b. Dorsal view of four arm joints near disk.

Family 2. *Ophioleucidae* MATSUMOTO, 1915.

Disk flat, covered with very thick scales with superficial granulations. Radial shields naked or covered with granules; in internal view, they are very large and joined or very close-set in pairs. The radial shield and genital plate articulate with each other by means of two condyles and one pit. Genital slits very long, extending from the oral plate to the disk border, sometimes onto the dorsal side of the disk. Oral and adoral shields of moderate size or often large; each interradial pair of the latter joined to each other just inside the former. Numerous close-set oral papillæ, arranged in a single row. Dental papillæ absent. Teeth arranged in a single vertical series. Peristomial plates

usually double or triple, of moderate length or sometimes very long. The genital plate and scale of the same side of a radius articulate with each other near the outer end, both being very long and narrow. Arms very long and slender, inserted ventrally to the disk. Arm plates all well developed, or sometimes the dorsal and ventral ones may be very rudimentary. Two, or sometimes more, arm spines, short, conical, lying flat on the arm. One or two tentacle scales to each pore, which is sometimes very large.

This family includes seven genera, which may be grouped as follows.

- I. Single tentacle scale ; dorsal arm plates well developed, widely in contact with one another.

Ophiocepale LJUNGMAN, 1871.

Ophiocirce KOEHLER, 1904.

Ophioleuce KOEHLER, 1904.

Ophiopallas KOEHLER, 1904.

- II. Single tentacle scale ; dorsal arm plates very rudimentary, extremely minute.

Ophiotrochus LYMAN, 1878.

- III. Two tentacle scales ; dorsal arm plates well developed, widely in contact with one another.

Ophiernus LYMAN, 1878.

Ophiopyren LYMAN, 1878.

In *Ophioleuce charischema* (CLARK), the peristomial plates are moderately large, triple, the paired ones being usually separated from each other by a median one. The oral plates are long and very slender. The oral frames are also long and slender, without lateral wings. The basal vertebræ are relatively very long, the first one being the shortest and more or less discoidal. The genital plates are long and bar-like, with two articular condyles

and one articular pit at the outer end to fit to the two condyles and one pit of the radial shield. The genital scales are long, wide, thin, leaf-like, L-shaped in transverse section, articulating with the genital plate near the outer end of the latter. The radial shields in internal view are very large and completely joined in pairs. *Ophiopæpale goësiana* LJUNGMAN and *Ophiernus vallincola* LYMAN, which were dissected by LYMAN, appear to be essentially similar to the preceding in the internal structures, save that the peristomial plates of the first are not triple but double, and those of the second single for each oral angle. Again, according to LYMAN, the peristomial plates of *Ophiopyren longispinus* LYMAN are double and very long, forming together a complete ring around the mouth. As a whole, the internal structures of the present family resemble those of *Ophiura* and its allies.

Key to Japanese genera of *Ophioleucidae*.

- A*—Tentacle pores small, each provided with a single scale.
- a*—Oral papillæ not soldered together, uniform in size, or the outermost one is larger than the others; arm joints short; dorsal arm plates well developed, widely in contact with one another; arm spines uniform in length *Ophioleuce*.
- au*—Oral papillæ soldered together, except the outermost two, which are exceedingly large; dorsal arm plates very rudimentary, exceedingly minute; basal arm spines especially long, the others short.....
..... *Ophiotrochus*.
- AA*—Tentacle pores large, each provided with two scales; dorsal arm plates very well developed; ventral plates entire, in contact with one another; arm spines uniform in length..... *Ophiernus*.

Key to Japanese species of *Ophioleuce*.

- A*—Dorsal side of disk, including the radial shields, closely covered with granules; oral shields longer than wide; outermost oral papilla not especially large; arm spines more than half as long as the corresponding arm joint *charischema*.
- AA*—Radial shields, as well as the larger disk scales, partially free of granules; oral shields wider than long; outermost oral papilla very large and operculiform; arm spines less than half as long as the corresponding arm joint *brevispinum*.

Ophioleuce charischema (CLARK).

Ophiocten charischema: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 97, fig. 35.

Numerous specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Eastern Sea; 95–152 fathoms (CLARK). Off Honshû; 63 fathoms (CLARK).

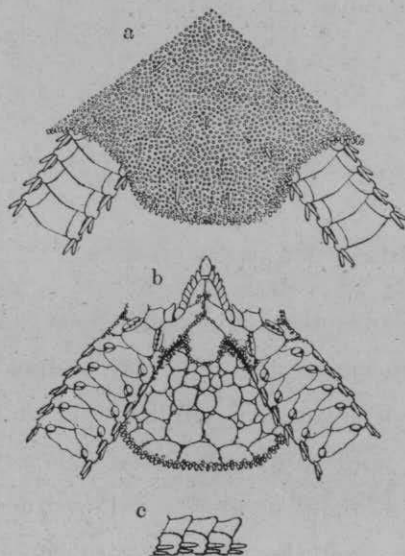


Fig. 85. *Ophioleuce charischema* ×6.
a. From above. b. From below. c. Side view of four arm joints near disk.

In my specimens, several spines are present on the disk, mingled with granules; they fall off easily on rubbing. The smaller specimens have the dorsal disk plates and radial shields partially naked.

Ophioleuce brevispinum

(CLARK).

Ophiocten brevispinum: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 98, fig. 36.

Eastern Sea ; 361 fathoms (CLARK).

Ophiotrochus longispinus CLARK.

Ophiotrochus longispinus : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 94, fig. 33.

Sagami Sea ; 918 fathoms (CLARK).

Ophiernus adpersus LYMAN.

Ophiernus adpersus : LYMAN, Bull. Mus. Comp. Zool., X, 1883, p. 236, Pl. III, figs. 19-21 ; KÖHLER, Ann. Sci. Nat. Zool., Sér. 8, IV, 1896, p. 316 ; KÖHLER, Ech. Indian Mus., Deep-sea Oph., 1899, p. 32 ; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 96, fig. 34.

Ophiernus annectens : LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 107, Pl. V, figs. 4-6.

Eastern Sea ; 440 fathoms (CLARK). Colnett Strait ; 1,008 fathoms (CLARK). Off Hiûga ; 578 fathoms (CLARK). Off Kii ; 244-290 fathoms (CLARK).

West Indies. Eastern Atlantic. Eastern and western Pacific. Indian Ocean.

Family 3. *Ophiodermatidæ* LJUNGMAN, 1867.

Disk closely covered with fine granules, and sometimes with scattered spines. Oral angles, sometimes also the oral shields, covered with granules. Numerous close-set oral papillæ, of which the outermost is pointed inwards and projects above the next papilla, which is the largest. Dental papillæ absent. Peristomial plates triple. Oral frames without well developed lateral wings. Radial shield and genital plate of the same side of a radius articulating with each other by means of two condyles and one pit.

Arms moderately long, stout, cylindrical; stoutest at the base, horizontally flexible. Arm plates all well developed. Numerous arm spines, short or moderately long, lying flat on the arm or erect. One or two tentacle scales to each pore; when there are two, the abradial scale overlaps the base of the lowest arm spine.

This family includes sixteen genera, which may be grouped into two subfamilies as follows.

Subfamily 1. *Ophiarachninae* MATSUMOTO, 1915.—Arm spines not very short, erect.

- I. Oral shields entirely covered with granules; arm plates usually concentrically striated; arm spines hyaline.

Ophiuroconis MATSUMOTO, 1915.

Ophiurodon MATSUMOTO, 1915.

- II. Oral shields naked; arm plates not concentrically striated; arm spines opaque.

Ophiurochaeta MATSUMOTO, 1915.

Ophiarachna MÜLLER & TROSCHEL, 1842.

Subfamily 2. *Ophiodermatinae* MATSUMOTO, 1915.—Arm spines very short, lying flat on the arm.

- A. Single tentacle scale to each pore.

- I. Oral shields entirely covered with granules.

Ophiocornis LÜTKEN, 1869 (= *Ophiocormus* CLARK, 1915).¹⁾

1) I can not find in CLARK's description and figures any tangible character, by which his *Ophiocormus* is distinguished from the genuine *Ophiocornis*. The blunt tip of the arms and the very short and appressed arm spines of his *Ophiocormus* are not at all Ophiocanthine but perfectly Ophiodermatine. CLARK's unique specimen, on which his genus is based, is certainly very young, measuring only 3 mm. across the disk and 6 mm. in the arm length. So that, all the "notable" characters are merely what may be expected in such a young specimen. In my opinion, *Ophiocormus* is a genuine *Ophiocornis*, if indeed it is not a young stage of *Cryptopelta*.

Cryptopelta CLARK, 1909.

II. Oral shields naked.

Bathypectinura CLARK, 1909.

B. Two tentacle scales to each pore.

III. Genital slits entire.

Pectinura FORBES, 1842.

Ophiopezella LJUNGMAN, 1871.

Ophiochaeta LÜTKEN, 1869.

Ophiarachnella LJUNGMAN, 1871.

Ophiochasma LJUNGMAN, 1871.

IV. Genital slits divided into two secondary pores.

Ophioderma MÜLLER & TROSCHER, 1842.

Ophioncus IVES, 1889.

Diopederma CLARK, 1912.

Ophiocryptus CLARK, 1915.

This family is very uniform in its internal structure. The peristomial plates are always triple, one of the three secondary plates filling up the outer open angle formed by the other two, as observed by myself in *Ophiuroconis monolepis* MATSUMOTO, *Ophiurodon grandisquama* (KÖHLER), *Ophiurochæta mixta* (LYMAN), *Ophiarachna incrassata* (LAMARCK), *Pectinura anchista* CLARK, *Bathypectinura gotoi* MATSUMOTO, *Ophiarachnella gorgonia* (MÜLLER & TROSCHER), *Ophioderma januarii* LÜTKEN, *O. brevicauda* LÜTKEN, &c. In *Ophiarachna incrassata* and *Bathypectinura gotoi*, the oral frames are very long and have distinct, V-shaped grooves for the ambulacral ring canal, while in the others they are short and have no distinct grooves for the ring canal. In *Ophioderma*, the genital plate and scales of the same side of a radius are soldered together at the middle, so that the genital slit is divided into two secondary pores, an inner and an outer. An important characteristic of the present

family is that the radial shield and genital plate of the same side of a radius articulate with each other always by means of two articular condyles and one articular pit.

Revision of *Ophioconis*, s. ext.

In my opinion, *Ophioconis* as hitherto understood is a very heterogeneous genus and is divisible into many natural groups, each of which is quite compact and worthy of forming a distinct genus. In treating of *Ophioconis diastata* and *papillata*, CLARK¹⁾ expresses a serious doubt as to the systematic position of *Ophioconis* s. ext., and remarks that, he will "not be surprised if some of the species now placed in *Ophioconis*, really belong in the *Ophiacanthidae*, while others are placed in the *Ophiodermatidae*." KÖHLER²⁾ also says that, "les *O. cupida, permixta, cincta* et *grandisquama* forment, dans le genre *Ophioconis*, un groupe à part et qui offre une physionomie différente de celle des autres *Ophioconis*." Both authors are right in their views. CLARK's species are, in my opinion, referable to *Ophiolimna*, while the species mentioned above by KÖHLER as forming a separate group are to be included in *Ophiurodon* MATSUMOTO. A third atypical group of *Ophioconis* is represented by *O. miliaria* LYMAN, 1878, and *pulverulenta* LYMAN, 1879, which I wish to refer to *Ophiuroconis* MATSUMOTO, while a fourth is represented by *Ophioconis indica* KÖHLER, 1898, for which however I do not dare to propose a new generic name, because I have no specimens of it. Thus the genuine *Ophioconis* includes only two Mediterranean species, viz. *O. forbesii* (HELLER, 1862) and *brevispina* LUDWIG, 1880. The new sub-

1) Bull. U.S. Nat. Mus., LXXV, 1911, p. 28.

2) Exp. Siboga, XLV, Pt. 2, 1905, p. 16.

divisions of *Ophioconis* s. ext., together with certain allied genera, are distinguished as follows.

A—Arm spines long and flagellate, erect.

a—Outermost oral papilla very large and operculiform; peristomial plates simple, very short and wide, the two halves being soldered together fairly well, without median secondary plate
..... *Ophiolimna*, emend.

aa—Outermost oral papilla pointed inwards, projecting above the next papilla, which is the largest; peristomial plates triple, with a median secondary plate, fairly long and wide.

b—Oral shields entirely covered with granules; arm plates usually concentrically striated; arm spines hyaline.

c—Teeth triangular and pointed, ventral arm plates wider than long, usually separated from one another *Ophiuroconis*.

cc—Teeth flat, thin, with much widened and often serrate end; ventral arm plates longer than wide, in contact with one another
..... *Ophiurodon*.

bb—Oral shields naked; arm plates not concentrically striated; arm spines opaque.

d—Disk granulations mingled with a number of spines; accessory oral shields absent *Ophiurochaeta*.

dd—Disk free of spines; accessory oral shields usually present just outside the ordinary ones *Ophiarachna*.

AA—Arm spines very short, lying flat on the arm, hyaline.

e—Oral shields entirely covered with granules *Ophioconis*, restr.

ee—Oral shields naked "*Ophioconis*" *indica*.

Ophiolimna emend. is a typical member of the *Ophiacanthidae*; *Ophiuroconis*, *Ophiurodon*, *Ophiurochaeta* and *Ophiarachna* form the *Ophiarachninae*; and *Ophioconis* restr. and "*Ophioconis*" *indica* are referable to the *Ophiodermatinae*. *Ophioconis* restr. is very near to *Cryptopelta*, but differs from it in the hyaline arm spines, while "*Ophioconis*" *indica* resembles *Pectimira*, differing from it also in

the hyaline arm spines. There is some possibility that, *Ophioconis* and *Cryptopelta* are congeneric and that "*Ophioconis*" *indica* is an extreme form of *Pectinura*.

***Ophiuroconis* MATSUMOTO, 1915.**

Disk and oral angles, including the oral shields, closely covered with fine granules. Six or seven oral papillæ on either side of a jaw; the outermost one is pointed inwards and projects above the next papilla, which is the largest. Teeth triangular and obtusely pointed. Dental papillæ absent. Arms not very long, cylindrical, widest at the base, tapering outwards to a very slender tip, where the vertebræ are imperfectly divided into halves by a series of pores. Ventral arm plates wider than long, not in contact with one another except in the very basal joints. Six or more arm spines, long, flattened, hyaline, laterally flared. One or two tentacle scales to each pore.

This genus includes *Ophioconis pulverulenta* LYMAN, 1879, and *O. miliaria* LYMAN, 1878, besides the genotype, *Ophiuroconis monolepis* MATSUMOTO, 1915.

***Ophiuroconis monolepis* MATSUMOTO.**

Ophiuroconis monolepis: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 85.

Six specimens; Sengendzuka-Aoyamadashi, Sagami Sea; 85 fathoms. Two specimens; Mera-out-Oisegaké, Sagami Sea; 300 fathoms.

Diameter of disk 5 mm. Length of arms 25 mm. Width of arms at base 1 mm.

Disk nearly circular, slightly puffed interbrachially, very soft,

closely covered with very fine granules, of which eleven or twelve lie in 1 mm. Radial shields entirely covered over. Interbrachial ventral surfaces and oral angles, including the oral and adoral shields, also covered with granules, which are similar to those of

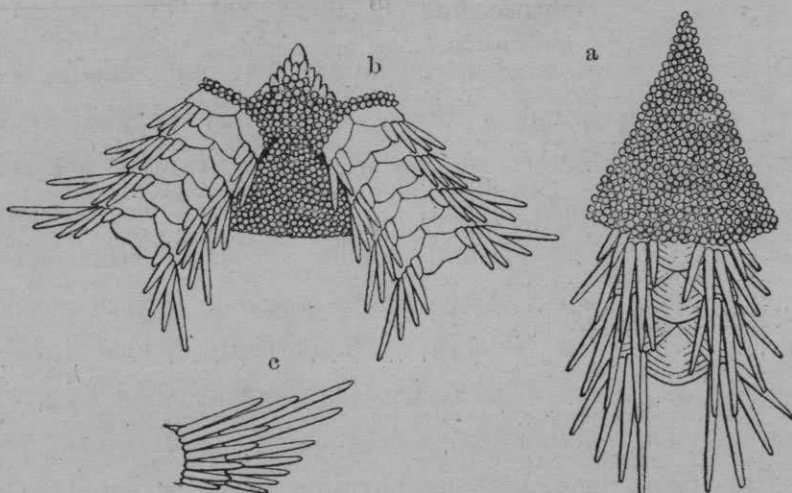


Fig. 8b. *Ophiuroconis monolepis*. a. From above. $\times 15$. b. From below. $\times 12$. c. Side view of two arm joints near disk. $\times 12$.

the dorsal side. Genital slits long, nearly reaching to the disk margin. Six or seven oral papillæ on either side, closely set, acute; the outermost one is pointed inwards, projecting above the next papilla, which is slightly larger than the rest and obtuse. Teeth triangular, not very stout, obtusely pointed.

Arms about five times as long as the disk diameter, more or less cylindrical, widest at the base, uniformly tapered outwards to a very slender tip. Dorsal arm plates rather small, fan-shaped, with convex outer border, slightly shorter than the corresponding arm joint, wider than long, convex along the median line, so that the arm is keeled as a whole. Lateral arm plates of the two sides meeting above as well as below. First ventral arm plate extreme-

ly small and very insignificant. Those following small, triangular, with very large inner angle and very long, convex outer border, shorter than the corresponding arm joints, much wider than long; they become smaller and shorter outwards. All the arm plates are concentrically striated, as seen under the microscope. Six or seven arm spines, spiniform, acute, slightly flattened, hyaline, erect; the uppermost one or two are nearly twice as long as the corresponding arm joint, while the lowest one is slightly shorter than the same. Single small, leaf-like, acute tentacle scale to each pore. Vertebrae of the distal arm joints imperfectly divided into halves by a series of pores.

Colour in alcohol light yellow.

This species is at once distinguished from both *O. miliaria* (LYMAN) and *pulverulenta* (LYMAN) by the fewer oral papillae, by the fewer and shorter arm spines and by the presence of only a single tentacle scale to each pore.

Ophiurodon MATSUMOTO, 1915.

Disk, as well as radial shields, closely covered with fine granules, sometimes bearing scattered spines. Oral angles and oral shields also granulated. Four or five oral papillae on either side, the outermost one projecting inwards above the next papilla. Teeth very flat and widened, with very thin and translucent end, arranged in a single vertical series. Dental papillae absent. Arms not very long, widest at the base, tapering outwards to a very slender tip. Dorsal and lateral arm plates usually concentrically striated. Ventral arm plates very narrow, longer than wide, fully in contact with one another. Vertebrae of the distal arm joints often imperfectly divided into halves by a series of pores. More

than six arm spines, long, flared, longer than the corresponding arm joint. Single tentacle scale to each pore.

This genus includes *Ophioconis cincta* BROCK, 1888, *O. permixta* KÆHLER, 1905, and *O. cupida* KÆHLER, 1905, besides the genotype, *O. grandisquama* KÆHLER, 1904.

Ophiurodon grandisquama (KÆHLER).

Ophioconis grandisquama: KÆHLER, Exp. Siboga, XLV, Pt. 1, 1904, p. 11, Pl. II, figs. 11 & 12.

One specimen; Okinosé, Sagami Sea.

Malaysian waters.

The teeth are very flat, thin, widened, hyaline, but not so sharply serrate as in the three other species of the present genus.

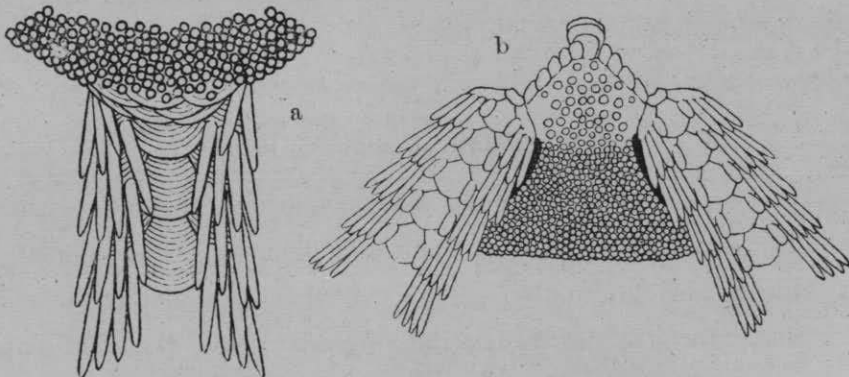


Fig. 87. *Ophiurodon grandisquama*. a. From above. $\times 20$. b. From below. $\times 12$.

The dorsal and lateral arm plates are concentrically striated. The arm spines are longer than in the three other species, and are much flattened, not uniformly tapered, but retain nearly the same width until very near the end, where they abruptly taper. In the first few arm joints, they are more or less spatulate.

Ophiurochæta MATSUMOTO, 1915.

Disk, as well as radial shields, closely covered with fine granules and bearing scattered spines. Oral angles granulated, oral shields naked. Oral papillæ numerous, close-set, the outermost papilla being pointed inwards above the next papilla, which is the largest. Arms not very long, rather stout, widest at the base. Dorsal, as well as ventral, arm plates well developed, fully in contact with one another. Six or more arm spines, long, flared, longer than the corresponding arm joint. Two tentacle scales to each pore, the abradial one overlapping the base of the lowest arm spine.

This genus includes *Ophiochæta mixta* LYMAN, 1878 (referred to *Ophiolimna* by VERRILL, 1899), and *Ophiolimna littoralis* KÖHLER, 1912, the first being the genotype.

This genus apparently resembles *Ophiochæta*, but differs from it in the long and flared arm spines. *Ophiurochæta* differs from *Ophiolimna* VERRILL, 1899, in the more numerous oral papillæ, of which the outermost one is not very large and operculiform, but pointed inwards above the next papilla, which is the largest; in the well developed dorsal and ventral arm plates, and in the presence of two tentacle scales, of which the abradial one overlaps the base of the lowest arm spine. VERRILL thinks that the internal structures of *O. mixta* are much like those of *Ophiacantha*; but my own observations lead to a quite different conclusion.

I have observed the internal structures of *Ophiuroconis monolepis*, *Ophiurodon grandisquama*, *Ophiurochæta mixta*, *Ophiarachna incrassata*, *Ophiochiton fastigatus*, *Ophioplax lamellosa*, &c., and satisfied myself that they all belong to the same type. In these forms, the peristomial plates are always triple, one of the secondary

plates filling up the outer open angle formed by the other two; while in *Ophiacantha*, *Ophiolimma*, &c., the peristomial plates are simple, or double with soldered halves, always lacking the unpaired secondary plate. Further, the peristomial plates are relatively to their width distinctly longer in the former type than in the latter.

When I compared a young specimen of *Ophiarachna incrassata* with a specimen of *Ophiurochaeta mixta*, kindly presented by Dr. H. L. CLARK, and with KÖHLER'S photographs of *O. littoralis*, I was instantly struck by the similarity in their plan of structure. The only differences of *Ophiurochaeta* from *Ophiarachna* are the presence of the scattered disk spines and the absence of the accessory oral shields, besides the smaller size. The systematic value of the accessory oral shields is, however, scarcely recognised by CLARK. And I have also observed the absence of accessory shields in some interradii of a certain specimen of *Ophiarachna incrassata*. One may with good reason regard the relation of *Ophiurochaeta* to *Ophiarachna* to be parallel to that of *Ophiomastix* to *Ophiocoma* or of *Ophiochaeta* to *Pectinura*.¹⁾

1) CLARK, 1915, has provisionally referred my *Ophiurochaeta* to VERRILL'S *Ophiotreta*. The latter genus, which includes six species according to CLARK, is undoubtedly too heterogeneous to be looked upon as a distinct genus; and I can find practically no common characteristic for these six species. I look upon VERRILL'S *Ophiotreta* merely as a section of the genuine *Ophiacantha*. As CLARK'S *Ophiotreta* is very heterogeneous, it is almost useless to compare my *Ophiurochaeta* with the rest of CLARK'S *Ophiotreta*. So that I wish here to compare my *Ophiurochaeta* with the type of *Ophiotreta*. They differ as follows.

Ophiurochaeta.—Disk covered with fine granules, besides scattered spines; oral angles regularly triangular, regularly closing the oral slits, distinctly granulated; oral shields situated far inwards, so that the distance from their inner end to the tip of the oral angles is very short; no cluster of dental papillæ, though a few infradental papillæ may be present; orsal arm plates fairly wide, so that the arm spines do not approximate dorsally; ventral arm plates distinctly in contact with one another; arm spines not extremely long, opaque and not serrate (at least in adult); two tentacle scales to each pore, the abradial one overlapping the base of the lowest arm spine.

Ophiacantha (Ophiotreta) lineolata.—Disk covered with coarse granules, besides scattered spines; oral angles distinctly narrowed at base by the second oral tentacle pores, so that the oral slits are gaping; no granulation on the oral angles; oral shields situated far outwards from

Ophiarachna incrassata (LAMARCK).

Ophiura incrassata: LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 542.

Ophiarachna incrassata: MÜLLER & TROSCHER, Sys. Ast., 1842, p. 104; LÜTKEN, Addit. Hist. Oph., III, 1869, p. 33; LYMAN, Bull. Mus. Comp. Zool., III, 1874, p. 221; LYMAN, Rep. Challenger, V, 1882, p. 173; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 495; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 64; KÖHLER, Bull. Sc. Fr. Belg., XLI, 1907, p. 330; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 298; CLARK, *ibid.*, LII, 1909, p. 128.

Three specimens; Bonin Is. One specimen; Okinawa.

Indo-Pacific. Okinawa and Bonin Is. seem to be the northern limits of this species.

One of the specimens from the Bonin Is. and the one from Okinawa agree perfectly with MÜLLER & TROSCHER'S description. The largest one from the Bonin Is. is 50 mm. in the disk diameter, 170 mm. in the arm length and 8 mm. in the arm width at base. Its colour in alcohol differs from that of the others, and is yellowish brown above, dark brown below, being handsomely dotted with lighter shade on the ventral interbrachial spaces, on the oral shields, on the tentacle scales, and on the lower arm spines. The third specimen from the Bonin Is. is notably different from the others: the oral shields are a little longer than wide, and the

the tip of the oral angles; cluster of dental papillæ present; dorsal arm plates very narrow, so that the arm spines more or less approximate dorsally in a few basal arm joints; ventral arm plates entirely separated from one another; arm spines extremely long, translucent and finely serrate; single tentacle scale to each pore (two scales to the first pore only), not overlapping the base of the lowest arm spine.

All the distinctive characters of *Ophiurochata* are perfectly Ophiodermatine, and those of the type of *Ophiotreta* thoroughly Ophiacanthine. I believe that, *Ophiurochata* cannot be united with *Ophiotreta*, unless the majority of the now recognised genera of the Ophiuroidea should be united to a single genus.

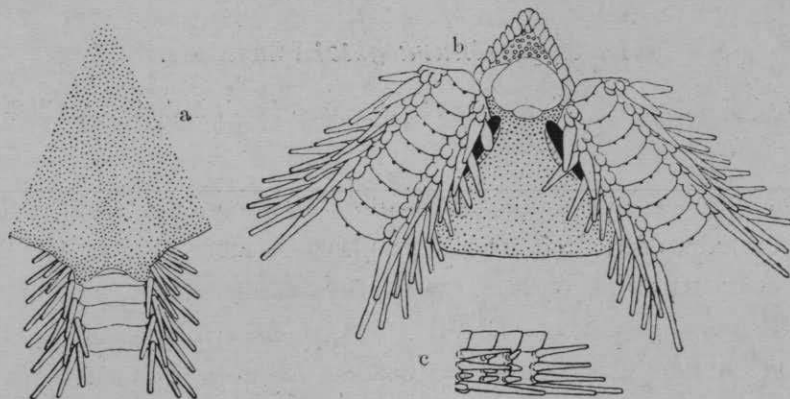


Fig. 88. *Ophiarachna incrassata*. $\times 1\frac{1}{3}$. a. From above. b. From below. c. Side view of four arm joints near disk, showing the regenerated arm spines.

accessory oral shields are very rudimentary or absent.¹⁾ Comparing these four specimens, we find that the arm spines are longer, blunter and more flattened in the larger specimens. The proportion of width to length of the oral shields is not constant. The size ratio of the accessory oral shield to the oral shield proper differs in specimens. The pairs of the adoral shields are sometimes asymmetrical. The arm spines may regenerate.

Key to Japanese genera of *Ophiodermatinae*.

- A—Single oval tentacle scale to each pore; three or four arm spines; radial shields partly naked *Bathypectinura*.
 AA—Two tentacle scales, of which the abradial one overlaps the base of the lowest arm spine; six or more arm spines.
 a—Radial shields covered over *Pectinura*.
 aa—Radial shields naked *Ophiarachnella*.

1) In *Pectinura*, *Ophiarachnella*, *Bathypectinura* and *Ophiarachna*, the accessory oral shields are not constantly present. I therefore consider it more natural to refer *Ophiopeza danbyei* FARQUHAR to *Ophiarachna* than to *Pectinura*, notwithstanding the absence of the accessory oral shields.

Bathypectinura gotoi MATSUMOTO.

Bathypectinura gotoi: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 87.

Two specimens; Nishinoyodomi, Sagami Sea; 170 fathoms.

Diameter of disk 50 mm. Length of arms 195 mm. Width of arms at base 7 mm.

Disk pentagonal, flat, closely covered with fine granules, of which four or five occur in 1 mm. Radial shields only partly naked, but distinguishable through the superficial granulations as large, elongated ovate, slight swellings, nearly half as long as the disk radius, and wider outwards; the naked part is very small, ovate, and wider without than within. Genital slits very long, almost reaching to the margin of the disk. Genital plates distinct, long and very stout.

Oral shields small, triangular, with rounded angles and convex sides, almost as wide as long. Accessory oral shields very rudimentary. In one of the two specimens, they

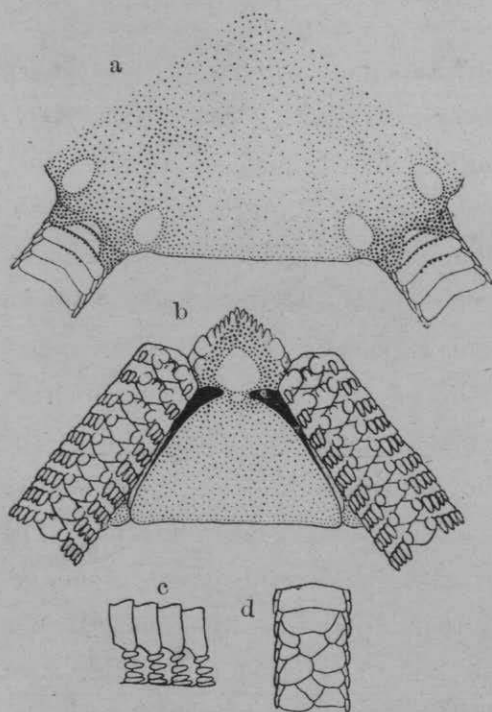


Fig. 89. *Bathypectinura gotoi*. $\times 1\frac{2}{3}$. a. From above. b. From below. c. Side view of four arm joints near disk. d. Dorsal view of five arm joints somewhat near disk, showing the divided dorsal arm plates.

are absent; but in the other they are indistinctly represented by one or two small scales, separated from the oral shield by granules. The adoral shields are almost, and the oral plates entirely, covered with granules, which are coarser and sparser than in the outer parts. Eight or nine oral papillæ on either side; the outermost two or three are large, flat, thin; the second from the outermost is the largest; inner ones very small, somewhat conical, obtuse. At the apex of the jaw, an unpaired infradental papilla is often present. Five to seven teeth, irregular in shape and size, with pointed or rounded ends, arranged in an irregular vertical row.

Arms long, stout, gradually tapered, with a rather sharp dorsal ridge, triangular in transverse section. Dorsal arm plates large, almost occupying the entire dorsal surface of the arm, quadrangular, with rounded outer corners, a little wider without than within, much wider than long, three to four times as wide as long, with a rather sharp ridge in the median line; some of them divided into several irregular pieces. Lateral arm plates very low, less than half the height of the arm, meeting neither above nor below. Ventral arm plates small, rhomboidal, with the shorter diagonal parallel to the arm axis. The first plate is almost as wide as, but much shorter than, the following. The three or four plates beginning with the second have a median keel, which is more prominent proximally both with regard to one plate and to the arm as a whole. Arm spines four for the most part, but three in the distal part, very short, flattened, lanceolate, obtuse; the lowest one is somewhat longer than the others. One tentacle scale, large, oval, thin, flat; adoral ones larger.

Colour in alcohol light yellowish brown.

This species is quite near to *B. lacertosa* (LYMAN), but

differs from it in the coarser disk granules, in the smaller naked part of the radial shields, in the more strongly ridged dorsal arm plates, in the much lower lateral arm plates, in the ventral arm plates being wider than long and angled inwards as well as outwards, and in the arm spines being much shorter than the corresponding arm joints.

Pectinura anchista CLARK.

Pectinura anchista: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 23, fig. 1.

Numerous specimens; off Misaki, Sagami Sea. One specimen; off Uki-shima; 300 fathoms.

Off Suno Saki, Sagami Sea; 49 fathoms (CLARK). Kagoshima Bay; 85 fathoms (CLARK). Eastern Sea; 95–139 fathoms (CLARK).

This species strongly resembles *P. cylindrica* (HUTTON), and it is somewhat doubtful whether the two are really distinct. As to the proportion of the arm length to the disk diameter, the difference pointed out by CLARK has, in my opinion, no significance; for the specimens in my hands have proportionately shorter arms. One specimen is 9 mm. in the disk diameter and 30 mm. in the arm length, while another specimen is 8 mm. in the disk diameter and 33 mm. in the arm length. The colour seems to change in alcohol with time from purple to pink.

Key to Japanese species of *Ophiarachnella*.

- A—No trio of naked disk plates just outside and between each pair of radial shields; oral shields longer than wide*gorgonia*.
 AA—A trio of naked disk plates present just outside and between each pair of radial shields, on the dorsal side of the arm base.

- a*—Radial shields small, not much larger than one of the trio of naked plates; oral shields wider than long *infernalis*.
aa—Radial shields very large, but the trio of naked plates very small; oral shields longer than wide *megalaspis*.

Ophiarachnella gorgonia (MÜLLER & TROSCHEL).

Ophiarachna gorgonia: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 105; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 39.

Pectinura gorgonia: LÜTKEN, Addit. Hist. Oph., III, 1869, p. 15; LYMAN, Rep. Challenger, V, 1882, p. 15; BELL, Rep. Zool. Coll. Alert., 1884, p. 134; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 471; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 830; LORIOU, Rev. Suisse Zool., I, 1893, p. 397; KÖHLER, Ech. Indian Mus., Shallow-wat. Oph., 1900, Pl. I, figs. 1 & 2; PFEFFER, Abh. Senckenberg. Naturf. Gesell., XXV, 1900, p. 83; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 8; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 284; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 289.

Pectinura marmorata: LYMAN, Bull. Mus. Comp. Zool., III, 1874, p. 222, Pl. V, figs. 1-7; LYMAN, loc. cit., 1882, p. 17.

Pectinura ramsayi: BELL, Proc. Zool. Soc. London, 1888, p. 281.

Pectinura intermedia: BELL, loc. cit., 1888, p. 386.

Pectinura stearnsii: IVES, Proc. Acad. Nat. Sci. Philadelphia, 1891, p. 212, Pl. XI, figs. 1-5.

Pectinura venusta: LORIOU, Mém. Soc. Phys. d'Hist. Nat. Genève, XXXII, p. 16, Pl. XXIII, figs. 3-3h.

Ophiarachnella gorgonia: CLARK, Bull. Mus. Comp. Zool., LII, 1909, p. 117.

One specimen (belonging to the Seventh High School, Kagoshima); Kagoshima Bay. One specimen; Eno-ura, Suruga. Numerous specimens; Arai Beach, Misaki.

This Indo-Pacific species is one of the most common ophiurans in the vicinity of the Misaki Marine Biological Station.

The first specimen is very typical, and has a coarse squama-

tion distinguishable through the superficial granulations. The rest are of the *stearnsii*-type, being different from the typical *gorgonia*-type in the disk scales being fine, flat and almost indistinguishable through the superficial granulations. The specimen from Eno-ura, however, rather resembles the *venusta*-type in the shape of the oral shields and accessory oral shields. The largest specimen is 26 mm. in the disk diameter and 95 mm. in the arm length. The number of the arm spines increases with the growth of the animal.

Ophiarachnella infernalis (MÜLLER & TROSCHEL).

Ophiarachna infernalis: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 105.

Pectinura infernalis: LÜTKEN, Addit. Hist. Oph., III, 1869, p. 33; LYMAN, Bull. Mus. Comp. Zool., III, 1874, p. 222, Pl. VII, fig. 1; LYMAN, Rep. Challenger, V, 1882, p. 17; BELL, Rep. Zool. Coll. Alert, 1884, p. 134, Pl. VIII, fig. B; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 471; LORIOL, Rev. Suisse Zool., I, 1893, p. 397; PFEFFER, Abh. Senckenberg. Naturf. Gesell., XXV, 1900, p. 83; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 7, Pl. I, figs. 1-3; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1908, p. 285; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 289.

Pectinura similis: KÖHLER, loc. cit., 1905, p. 6, Pl. I, figs. 4-6.

Ophiarachnella infernalis: CLARK, Bull. Mus. Comp. Zool., LII, 1909, p. 124.

Two specimens;
Okinawa. One specimen;
Eno-shima, Ôsumi.
Two specimens; Eno-
ura, Suruga.

Indo-Pacific.

The radial shields

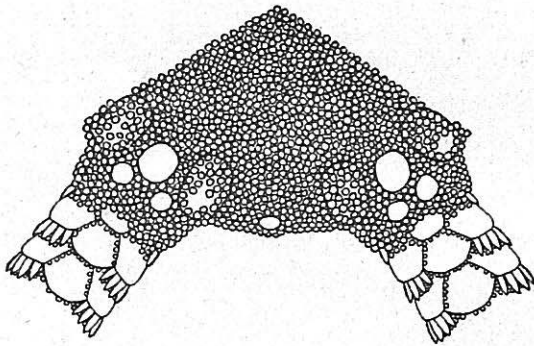


Fig. 90. *Ophiarachnella infernalis*, var. From above.
×10.

are rather small, and often covered with granules on their inner borders. One of the specimens from Okinawa notably departs from the typical ones. It is only 6 mm. across the disk. The radial shields are almost covered with granules. Moreover, in the arm bases, granules which are finer than the disk granules occur on the ventral abradial parts of the lateral arm plates, on the proximal parts of the same under the arm spines, along the dorsal border of the same, and along the distal border of the dorsal arm plates.

Ophiarachnella megalaspis CLARK.

Ophiarachnella megalaspis: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 25, fig. 2.

Off Suno Saki, Sagami Sea; 44-50 fathoms (CLARK). Eastern Sea; 95-106 fathoms (CLARK).

Family 4. **Ophiochitonidæ** MATSUMOTO, 1915.

Disk covered with fine, imbricating scales, or rarely with fine granules; oral angles always free of granules. Five or six oral papillæ on either side of each jaw; the outermost one is pointed inwards, projecting above the next papilla, which is the largest. Teeth arranged in a single vertical row, either triangular and obtusely pointed, or quadrangular, with very stout, truncated end. Dental papillæ absent. Peristomial plates double or triple. Oral frames with or without well developed lateral wings. Radial shield and genital plate of the same side of a radius articulating with each other by means of two articular condyles and one articular pit. Arms long and slender, widest at some distance from the base, horizontally flexible. Dorsal, lateral and ventral arm plates

all well developed, with cereous lustre. Two to four, usually three, arm spines, moderately long, erect. One or two large, leaf-like tentacle scales on the abradial border of each pore; sometimes one to three very small accessory ones may occur on the adradial border.

This family includes five genera, which may be grouped into two subfamilies as follows.

Subfamily 1. *Ophiochitoninae* MATSUMOTO, 1915.—Oral frames without well developed lateral wings; teeth triangular and obtusely pointed; dorsal surface of vertebræ entire, rhomboidal.

Ophiochiton LYMAN, 1878.¹⁾

Ophioplax LYMAN, 1875.

Subfamily 2. *Ophionereidinae* (LJUNGMAN, 1867) mihi, 1915.—Oral frames with well developed lateral wings; teeth very stout, quadrangular, with truncated end; dorsal surface of vertebræ notched at the inner end and **V**-shaped.

Ophiodoris KÖHLER, 1904.

Ophionereis LÜTKEN, 1859.

Ophiocrasis CLARK, 1911.

As shown in the foregoing diagnoses of the subfamilies, there are two types of internal structures in the present family. The internal structures of the *Ophiochitoninae* are very similar to those of the *Ophiodermatidae*. In *Ophiochiton fastigatus* LYMAN, the peristomial plates are triple, one of the secondary plates filling up the outer open angle formed by the other two. The oral frames are very long, with **V**-shaped grooves for the ambulacral ring canal, as in *Ophiarachna incrassata* and *Bathypectinura gotoi*. The genital

1) In my opinion, *Ophiochiton lymani* STUDER, 1883, does not belong here, and is an *Ophiocten*, allied to such species as *Ophiocten hastatum* LYMAN, 1878, and *pacificum* LÜTKEN & MORTENSEN, 1899.

plates and scales are long and slender, being longer and more slender than in the *Ophiodermatidae*. The radial shield and genital plate of the same side of a radius articulate with each other by means of two articular condyles and one articular pit. The dorsal surface of the vertebræ is rhomboidal and slightly notched at the inner end but not so strongly as to be V-shaped. In *Ophioplax lamellosa* MATSUMOTO, the peristomial plates are also triple, being however relatively shorter and wider than in the preceding species; the unpaired secondary plate is very small and is slightly notched on the outside. The oral frames are short and much more flared than in the preceding, while the roof of the first oral tentacle pore is less projected adradially. In other respects it is almost similar to the preceding.

In the *Ophionereidinae*, the internal structures approach those of the next family, *Ophiocomidae*, in certain points. In *Ophionereis annulata* (LE CONTE) and *O. reticulata* LÜTKEN, the peristomial plates are double, without the unpaired secondary plate, and much smaller than in the *Ophiochitoninae*. The oral frames are very long, stout, with well developed lateral wings for the attachment of very voluminous chewing muscles. The teeth are very stout, quadrangular, with widened and truncated end. The dorsal surface of the vertebræ is strongly notched at the inner end corresponding to the elongated outer end of the preceding vertebra, so as to be markedly V-shaped. The radial shields, genital plates and scales are fundamentally similar to those of *Ophiochiton fastigatus*, though the radial shields are much smaller. The internal structures of *Ophiocrasis marktanneri* MATSUMOTO are similar to those of *Ophionereis*, except the peristomial plates, which are triple, with a small unpaired secondary plate. Now we come to a most interesting genus, *Ophiodoris*, which is fairly intermediate in its internal structures between *Ophiochitoninae* and the *Ophionereis-Ophiocrasis*-type. In *Ophiodoris*

pericalles CLARK, the peristomial plates are double, without the unpaired secondary plate. The oral frames are not very stout and have more or less distinct lateral wings, which are less well developed than in *Ophionereis* and *Ophiocrasis*. The dorsal surface of the vertebræ is notched at the inner end so as to be fairly **Y**-shaped, but not so strongly as in *Ophionereis* and *Ophiocrasis*. The radial shields, genital plates and scales are similar to those of *Ophionereis* and *Ophiocrasis*.

As to the biological significance of the characters of the present family, we can recognise two lines along which advance has been made from the *Ophiochitoninae* to the *Ophionereidinae*. In the first place, the *Ophionereidinae* have better developed chewing apparatus than the *Ophiochitoninae*, such as stouter teeth, with widened and truncated end, smaller peristomial plates, stouter oral plates with well developed lateral wings and more voluminous muscles. In the second place, the arms of the *Ophionereidinae* are more flexible than those of the *Ophiochitoninae*, as may be judged from the notched, **V**- or **Y**-shaped dorsal surface of the vertebræ. It may be remarked that the arms of *Ophionereis* and *Ophiocrasis* are strongly flexed in alcohol and very freely mobile in life.

Key to genera of *Ophiochitoninae*.

- A*—Disk entirely free of granules; arms markedly keeled above and below *Ophiochiton*.
AA—Disk or at least the interbrachial ventral surfaces covered with fine granules; arms not keeled, at least below *Ophioplax*.

Ophiochiton fastigatus LYMAN.

Ophiochiton fastigatus: LYMAN, Bull. Mus. Comp. Zool., V, 1878, p.

132, Pl. VII, figs. 182 & 183; LYMAN, Rep. Challenger, V, 1882, p. 176, Pl. XXIV, figs. 13-15; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 133.

Ophiochiton carinatus: LÜTKEN & MORTENSEN, Mem. Mus. Comp. Zool., XXIII, 1899, p. 164, Pl. XIV, figs. 1-3.

Numerous specimens; off Misaki, Sagami Sea.

Sagami Sea; 110-405 fathoms (CLARK). Uraga Channel; 70-197 fathoms (CLARK). Suruga Gulf; 94-270 fathoms (CLARK). Eastern Sea; 406 fathoms (CLARK).

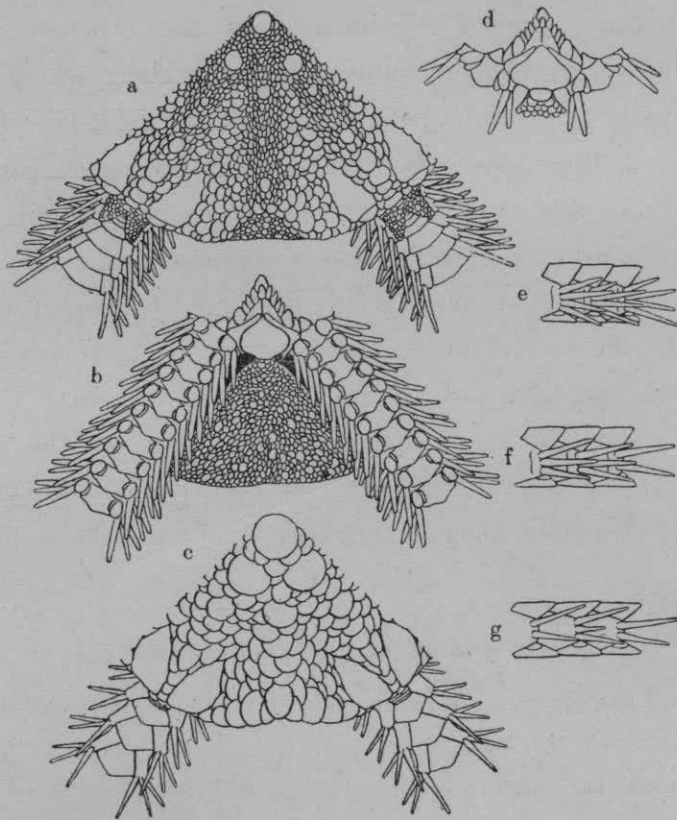


Fig. 91. *Ophiochiton fastigatus*. a. From above. $\times 2$. b. From below. $\times 2$. c. From above. $\times 7$. d. Ventral view of an oral angle, showing the presence of an accessory oral shield. $\times 2$. e. Side view of three arm joints near disk. $\times 2$. f. Side view of three arm joints near disk of a medium-sized specimen. $\times 3$. g. Side view of three arm joints near disk. $\times 7$. c. and g. young.

Lat. $5^{\circ} 41'$ S., long. $134^{\circ} 4'$ E.; 800 fathoms (LYMAN). Gulf of Panama; 322–546 fathoms (LÜTKEN & MORTENSEN).

The largest of my specimens is 31 mm. in the disk diameter, 400 mm. in the arm length, and 4 mm. in the arm width; and the smallest one 8 mm. in the disk diameter, 52 mm. in the arm length, and 0.8 mm. in the arm width. This species is very variable, and has been remarked upon by CLARK. The adoral shields are sometimes very feeble, but often very well developed, especially in the younger specimens, so as to lie between the oral shields and the first lateral arm plates. Therefore, KÖHLER'S subdivision of this genus according as the oral shields are separated or not from the first lateral arm plates, has no meaning at least for the present species. Often, more or less prominent accessory oral shields occur in some of the interradii. This is another fact showing that the present genus is related to *Ophiarachna*.

I consider *O. carinatus* LÜTKEN & MORTENSEN to be a synonym of this species, because specimens of the latter of corresponding size agree almost perfectly with the description and figures of the former. The figures here given, together with those of medium-sized specimens by LÜTKEN & MORTENSEN will give a fair idea of the variability of this species.

Ophioplax lamellosa MATSUMOTO.

Ophioplax lamellosa: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 88.

One specimen; off Kôtsu-jima, Sagami Sea.

Diameter of disk 4.5 mm. Length of arms 35 mm. Width of arms at base 0.8 mm.

Disk flat, thin, pentagonal or rather five-lobed, with indented interbrachial borders, covered with fine, imbricating scales, among

which the six primaries are somewhat distinct. Central plate rather large, circular, conspicuous. Radials smaller and less conspicuous than the central plate, separated from one another and from the central plate. Radial shields triangular, with acute inner

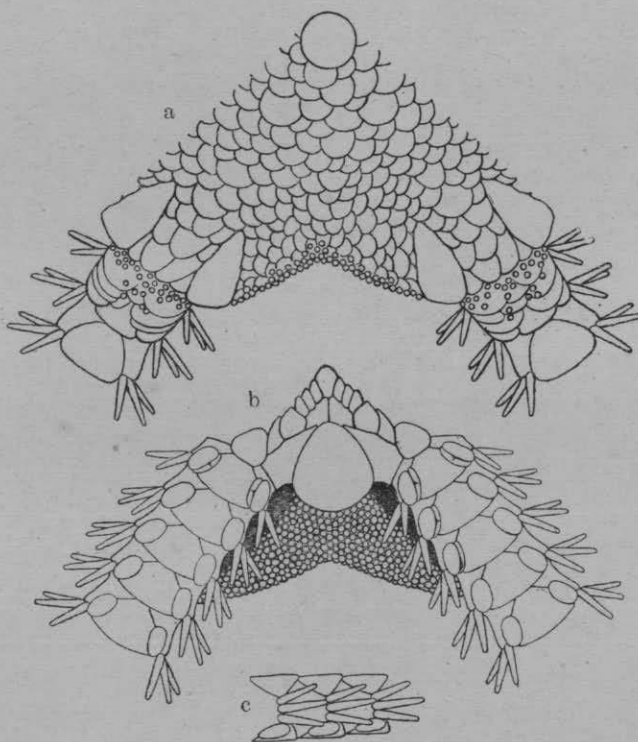


Fig. 92. *Ophioplax lamellosa*. $\times 16$. a. From above. b. From below. c. Side view of three arm joints near disk.

angle, twice as long as wide, those of a pair widely separated from each other. Interbrachial ventral surfaces entirely covered with very fine granules. Genital slits very large, reaching to the margin of the disk.

Oral shields large, triangular, with strongly curved outer border, less curved lateral sides, obtuse inner angle, and perfectly rounded lateral angles; longer than wide. Adoral shields also

large, triangular, long, tapered within to an acute point, where they do not meet. Oral plates naked. Five oral papillæ; outermost one long, acutely pointed within; the second is the largest of all, very wide and flat; the others small, somewhat conical, obtuse. Four or five teeth, very large, with rounded ends, except the uppermost one, which is longer than the others and pointed.

Arms long, slender, thin. Lamellar plates and fine granules occur on the dorsal and lateral surface of the arm bases. First one or two dorsal arm plates small, partly covered over by the lamellar plates. Those beyond triangular at the outset but becoming quadrangular a little further out, with rounded outer corners and curved lateral borders, wider than long, wider without than within. Lateral arm plates not very prominent. First ventral arm plate small, triangular, with rounded angles, nearly as wide as long. Those beyond pentagonal, with an inwardly directed angle, which is covered by the preceding plate; outer border curved, lateral borders concave and bounded by the tentacle pores. Three arm spines, conical, tapering, obtuse, a little longer than the corresponding arm joint, subequal, but the middle one slightly longer than the other two. One tentacle scale on the abradial side of the pore, very large and oval. Besides, on the adradial side of a few basal pores, there occur one or two rudimentary tentacle scales, more or less covered over by the abradial scale.

Colour in alcohol: yellowish gray above and white below; arms banded with dark gray.

It is recorded that the above specimen was taken with a coral net, but the depth is not stated. As the annulation on the arms indicates, this species is not a deep water form, but probably sublittoral.

Ophioplax lamellosa is quite near to both *O. ljungmani* LYMAN, 1875, and *custos* (KOEHLER, 1896), as well as to *Ophiopeza reducta*¹⁾ KOEHLER, 1907. It is distinguished from *O. ljungmani* by the presence of the primary plates, by the coarser disk scales, by the shape of the radial shields, by the disk margin being not so closely granulated, and by the shape of the oral shields; from *O. custos* by the presence of the primary plates, by the coarser disk scales, by the shape of the radial shields, by the adoral shields not meeting within, by the shape of the first and second ventral arm plates, by the presence of the lamellar plates at the arm bases, and by the shape of the dorsal arm plates; and from *O. reducta* by the dorsal surface of the disk being free of granules, by the radial shields not being divergent, and by the shape of the ventral arm plates. KOEHLER states that, in his specimens of *O. custos* the dorsal surface of the disk was also closely covered with fine granules during life, but that they subsequently dropped off. Whether the same holds true for *O. lamellosa* can not be ascertained, as I have not been able to examine living specimens.

Key to genera of *Ophionereidinae*.

- A—Accessory dorsal arm plates absent; a row of spines present along the brachial borders of the disk, just above the arm bases.....
 *Ophiodoris*.
- AA—Accessory dorsal arm plates present.
- a—Only two large accessory plates to each dorsal arm plate.....
 *Ophionereis*.

1) *Ophiopeza reducta*, which CLARK refers to his genus *Bathypectimura*, appears to me to be merely an *Ophioplax*. The presence of only three long, cylindrical arm spines, and of only five papillæ, the annulation on the arms, and the naked oral plates, are all characters of *Ophioplax*, and not of the genuine *Bathypectimura*.

aa—Very small, secondary dorsal accessory plates present besides the two large ones *Ophiocrasis*.

***Ophiodoris pericalles* CLARK.**

Ophiodoris pericalles : CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 177, fig 80.

Off Osé Zaki, Suruga Gulf; 65 fathoms (CLARK). Eastern Sea; 95–106 fathoms (CLARK).

Key to Japanese species of *Ophionereis*.¹⁾

- A*—Genital papillæ present; ventral arm plates without median notch and eminence.
- a*—Disk scales coarse; dorsal arm plates not very wide, slightly wider than long; three arm spines *porrecta*.
- aa*—Disk scales very fine; dorsal arm plates very wide, twice as wide as long or wider; four arm spines in the basal arm joints *eurybrachioplax*.
- AA*—Genital papillæ absent; ventral arm plates with a median notch and eminence. *sinensis*.

***Ophionereis porrecta* LYMAN.**

Ophionereis porrecta : LYMAN, Proc. Boston Soc. Nat. Hist., VII, 1860, p. 260²⁾; LYMAN, Ill. Cat. Mus. Comp. Zool., I, 1865, p. 147, figs. 14 & 15; LYMAN, Rep. Challenger, V, 1882, p. 161; BROCK, Zeitschr. wiss. Zool., XLVIII, 1888, p. 495; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 74; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 53.

1) CLARK, 1915, has recorded *Ophionereis dubia* from "Japan: mouth of the Bay of Yeddo" (=Gulf of Tôkyô). If his record is based upon Prof. MORSE's specimens, it is probably not *O. dubia* but *Ophiocrasis marltanneri*. Some specimens of the last mentioned species in the Zoological Institute, Imperial University of Tôkyô, were also labelled "*Ophionereis dubia* var." by Prof. MORSE. I have yet to find a specimen of *O. dubia* from the vicinity of the mouth of the Gulf of Tôkyô, though *Ophiocrasis marltanneri* is very common there.

2) This paper was not seen by me.

Ophionereis squamata: LJUNGMAN, Oph. viv., Öf. K. Akad. Förh., 1866, p. 310.

Ophionereis variegata: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 462, Pl. X, figs. 15 & 16.

Two specimens; Okinawa. One specimen; locality unknown. Okinawa, Riu-kiu. Korea Strait; 33 fathoms (DUNCAN). Honolulu.

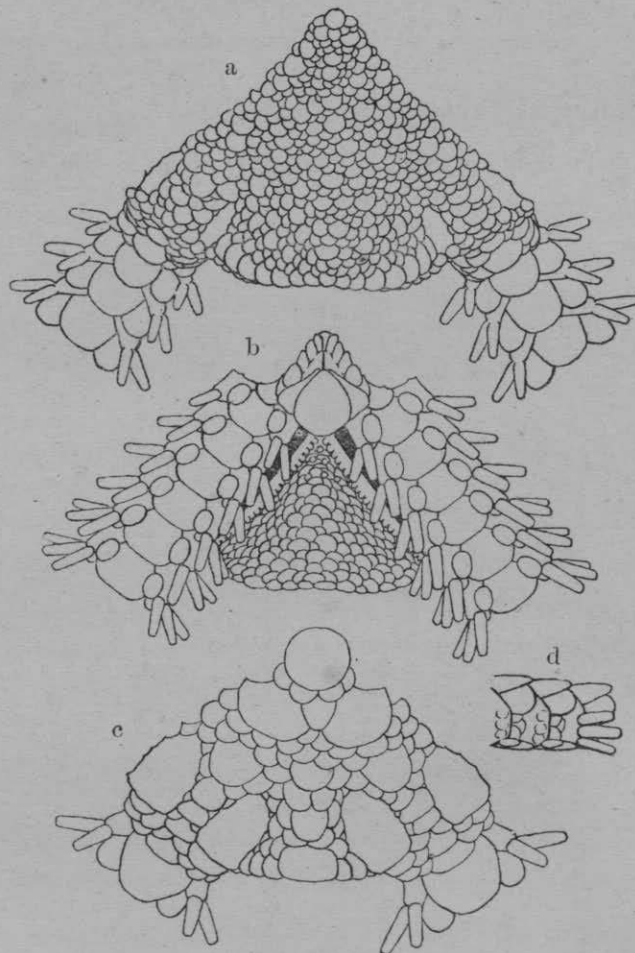


Fig. 93. *Ophionereis porrecta*. a. From above, $\times 15$. b. From below, $\times 15$. c. Young specimen; from above, $\times 30$. d. Side view of three arm joints near disk; two sets of arm spines removed to show the accessory scales. $\times 15$.

The largest one of my specimens is 5 mm. across the disk, with the arms four or five times as long. The apical pair of oral papillæ are infradental, and there is no unpaired papilla. The arms are lightly keeled both above and below, so that they remind us of *Ophiochiton*. There are two or three scale-like supplementary plates between the lateral arm plates; but they are not very conspicuous, being covered over by the arm spines. In smaller specimens, the disk squamation much resembles that of *Ophiozona* and *Ophiozonella*.

Ophionereis eurybrachiplax CLARK.

Ophionereis eurybrachiplax: CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 173, fig. 78.

Off Kinkwa San; 31–41 fathoms (CLARK).

California.

Ophionereis sinensis (DUNCAN).

Ophionereis dubia var. *sinensis*: DUNCAN, Journ. Linn. Soc. London, XIV, 1879, p. 464.

Korea Strait; 33 fathoms (DUNCAN).

This species is very imperfectly described by DUNCAN as a variety of *O. dubia* (MÜLLER & TROSCHER, 1842). His remarks read as follows.

“The form from the Korean Sea is well grown, and differs from the type (*O. dubia*) as follow:—The lower arm-plates have a median notch and eminence; the spines are subequal, and they are rarely banded with colour. It has a marsupium, and doubtless, as was commonly the case in these Korean species, it is viviparous.”

If these differences between the Korean form and the typical *O. dubia* really exist, then it is almost certain that the former is not referable to the same species. Therefore, I am inclined provisionally to look upon the former as a distinct species.

Ophiocrasis CLARK, 1911.

Aside from the presence of the secondary supplementary dorsal arm plates, this genus seems to me to be distinguished from *Ophionereis* principally by negative characters and the different degree of development of certain common structures. The disk scales are even and exceedingly fine; no trace of the marginal row of special disk scales; no genital papillæ; arms much narrower than in *Ophionereis*. Schizogonic reproduction may not be a generic character.

Key to species of *Ophiocrasis*.

- A*—Radial shields not very small; ventral arm plates longer than wide throughout; smaller individuals six-armed, reproducing by schizogony *dictydisca*.
AA—Radial shields exceedingly small and insignificant; ventral arm plates wider than long, at least in the basal parts of the arms; five-armed, not reproducing by schizogony..... *marktanneri*.

***Ophiocrasis dictydisca* CLARK.**

Ophiocrasis dictydisca: CLARK, Bull. U.S. Nat. Mus., LXXV, 1911, p. 175, fig. 79.

Off Suno Saki, Sagami Sea; 52–73 fathoms (CLARK). Korea Strait; 59 fathoms (CLARK).

Ophiocrasis marktanneri MATSUMOTO.

Ophionereis porrecta: MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus., II, 1887, p. 302, Pl. XII, fig. 18. (Non LYMAN, 1860.)

'*Ophionereis porrecta* MARKTANNER': KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 76.

Ophiocrasis marktanneri: MATSUMOTO, Proc. Acad. Nat. Sci. Philadelphia, 1915, p. 90.

Three specimens; Enoshima, Sagami. Numerous specimens; Arai Beach, Misaki Marine Biological Station.

Diameter of disk 9 mm. Length of arms 68 mm. Width of arms at base 1.2 mm.; at the widest part 1.5 mm.

Disk circular, slightly convex, rather soft, covered with

very fine, imbricating scales, which are rather obscured, so that the disk appears as if covered by a thick skin. Radial shields very small, short and exceedingly narrow, tapered within, those of a pair widely separated from each other, also rather obscure. Interbrachial ventral surfaces covered with scales similar to those of the dorsal side, but even more

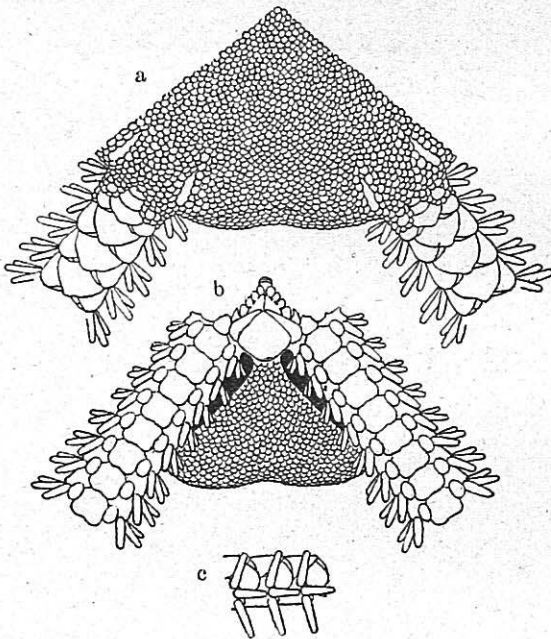


Fig. 94. *Ophiocrasis marktanneri*. $\times 7$. a. From above. b. From below. c. Side view of three arm joints near disk.

obscure. Genital slits large, nearly reaching to the border of the disk. No genital papillæ.

Oral shields rhomboidal, with obtuse inner angle, rounded lateral angles, and widely rounded outer angle; nearly as wide as long, except the madreporic shield, which is decidedly longer than wide. Adoral shields small, acutely tapered within, where they nearly or hardly meet. Four or five oral papillæ on either side, unequal, short, rounded, but the outermost one, which is closely associated with the second oral tentacle pore, has pointed inner end. Four teeth, short, very wide and stout.

Arms long and very slender, narrowed at the base, widest at one-fourth to one-third the arm length from the base. Dorsal arm plates mostly triangular, with obtuse outwardly directed apex, rather small, wider than long, successive plates slightly in contact; quadrangular in the more distal parts. On either side of each dorsal arm plate, occurs a large supplementary plate, which is nearly semicircular, about one-half as large as the dorsal arm plate, and bounded along the distal border by one or two very insignificant secondary pieces, which however are present only for a comparatively short extent. Two or three basal dorsal arm plates and their supplementary plates are smaller than those beyond. The supplementary plates become smaller outwards as the dorsal arm plates become quadrangular, and finally disappear. Lateral arm plates not very prominent, not meeting above or below. First ventral arm plate very small, rather pentagonal, longer than wide. Those beyond quadrangular, with rounded outer lateral angles, truncated inner lateral angles, and slightly notched outer border, about as long as wide, but longer than wide outwards. Three arm spines, short, stout, flattened, slightly tapered, blunt. One large and oval tentacle scale.

Colour in alcohol: grayish yellow; disk reticulated, and arms banded, with dark purplish brown.

The arm length varies from six to eight times the diameter of the disk. In the smaller specimens, the arm spines are less flattened; and in those of less than about 4 mm. across the disk, the secondary supplementary pieces on the arms are almost invisible.

This species differs from the genotype, *O. dictydisca* CLARK, in the shape of the dorsal arm plates, in the less well developed secondary supplementary pieces, in the smaller and less distinct radial shields, and in the smaller arm spines of the basal joints. Further, schizogonic reproduction has not been observed in this species, though I have examined many small specimens. On the other hand, *O. marktanneri*, as well as the genotype, resembles *Ophionereis dubia* (MÜLLER & TROSCHER, 1842) in lacking the genital papillæ, but differs from it chiefly in the presence of secondary supplementary dorsal arm plates, and in the much narrower arms. *O. marktanneri* is by no means near to *Ophionereis porrecta* LYMAN. I could mention some more differences than those enumerated by KÖHLER between these two species, but it will not be necessary to do so here.

This beautiful species is one of the most common ophiurans about Misaki, living under stones and rocks.

Family 5. **Ophiocomidæ** LJUNGMAN, 1867.

Disk covered with fine granules or by a naked skin, sometimes bearing scattered spines. Radial shields very stout, but externally invisible, those of a pair widely separated from each other. Four to six oral papillæ on either side, the outermost one being pointed inwards above the next one. Dental papillæ well developed, forming a vertical clump at the apex of each jaw. Teeth quadrangular and very stout. Peristomial plates double.

Oral frames very stout, with extremely well developed lateral wings. The radial shield and genital plate of the same side of a radius articulate with each other by means of two articular condyles and one pit. Arms moderately long, stout, widest at some distance outside the base. Arm plates all well developed. Arm spines long, stout, perpendicular to the arm axis; the uppermost spines of every second or third lateral arm plates often very large and clavate. One or two tentacle scales to each pore.

This family includes five genera, four of which form a subfamily, while the fifth forms another.

Subfamily 1. *Ophiocominae* MATSUMOTO, 1915:—Radial shields very stout, boot-shaped, those of a pair widely separated from each other; three to five arm spines, the uppermost spines of every second or third lateral arm plates being usually very large and club-shaped; tentacle scales short and leaf-like.

Ophiopteris SMITH, 1877.

Ophiocoma AGASSIZ, 1835.

Ophiomastix MÜLLER & TROSCHEL, 1842.

Ophiarthrum PETERS, 1851.

Subfamily 2. *Ophiopsilinae* MATSUMOTO, 1915:—Radial shields slender, bar-like, each pair being rather close together at the outer ends corresponding to the dorsal approximation of the outer ends of the genital plates; numerous arm spines, none of which is club-shaped; two tentacle scales, of which the adradial one is very long and lanceolate, while the abradial one is very short and acute.

Ophiopsila FORBES, 1842.

The present family is very uniform in its internal structures. I have dissected all the Japanese representatives of this family, viz., *Ophiocoma brevipes* PETERS, *O. scolopendrina* (LAMARCK), *Ophio-*

mastix mixta LÜTKEN, *O. annulosa* (LAMARCK), *O. lütkeni* PFEFFER and *Ophiarthrum elegans* PETERS. In all of them, the radial shields are very stout and boot-shaped, and each consists of a radial bar and a transverse wing projecting laterally from the outer part of the former. Each shield has two articular condyles and one pit, fitting to the two condyles and one pit of the corresponding genital plate. The latter is bar-like, slightly curved laterally, articulating with the genital scale at some distance inwards from the outer end. The genital scales are also bar-like, more or less flattened, but not so wide and leaf-like as those of the *Gnathophiurida*. The peristomial plates are rather small and double, the two being firmly united together. The oral frames are exceedingly stout, with extremely well developed lateral wings for the attachment of very voluminous masticatory muscles. The oral and dental plates taken together are Π -shaped in dorsal view, the former completely overlapping the latter. They are quite different from those of the *Gnathophiurida*. The teeth are quadrangular and very stout.

In *Ophiopsila riisei* LÜTKEN, 1859, the internal structures are almost similar to those of the preceding, save the radial shields, which are slender and bar-like, without transverse wings, and rather closely set in pairs. *Ophiopsila* is by no means near to the *Amphiuridæ* in internal structures, so that I have no hesitation to refer it to the present family, forming however a subfamily for it alone.

Key to Japanese genera of *Ophiocomidæ*.

A—Disk covered with granules or bearing spines.

a—Disk covered only with granules, entirely free of spines. . . *Ophiocoma*.

- aa*—Disk bearing spines, or both granules and spines *Ophiomastix*.
AA—Disk covered by a naked skin, entirely free of granules and
 spines *Ophiarthrum*.

Key to Japanese species and varieties of *Ophiocoma*.

- A*—Interbrachial ventral surfaces entirely covered with granules; oral
 shields usually oval; dorsal arm plates with clearly cut outer
 border; arm spines shorter dorsally than ventrally *brevipes*.
AA—Granulations of the interbrachial ventral surfaces not extending to
 the abradial border of the genital slits, the inner parts being mostly
 naked; oral shields quadrangular; outer border of the dorsal arm
 plates not clearly cut; arm spines longer dorsally than ventrally..
 *scolopendrina*.
a—Disk variegated; arm spines annulated typical *scolopendrina*.
aa—Disk as well as arm spines uniformly black.
b—Arm spines not very short and stout; two tentacle scales to each
 pore var. *erinaceus*.
bb—Arm spines exceedingly short and stout; a single tentacle scale to
 each pore, except in a few basal arm joints var. *schœnleinii*.

Ophiocoma brevipes PETERS.

Ophiocoma brevipes: PETERS, Arch. Naturg., 1852, p. 85¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 172; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 303; BELL, Proc. Zool. Soc. London, 1888, p. 388; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 831; LORIOU, Mém. Soc. Phys. d'Hist. Nat. Genève, XXXII, 1894, p. 25, Pl. XXIII, fig. 4; DÖDERLEIN, SEMON - Zool. Forschungsr., V, 1896, p. 289; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 61; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907,

1) This paper was not seen by me.

p. 325; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 296; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 256.

Three specimens; Natsui, Hiuga. One specimen; Okinawa. One specimen; Yayeyama, Riu-kiu. Three specimens; Kôshun, Formosa. Three specimens; locality unknown.

Indo-Pacific. Natsui appears to be the northern limit of this species for the present.

The colour in alcohol is very variable. In some specimens, the disk is dark grayish brown and sparsely spotted with black. In others, the disk is light bluish green and variegated with white. The oral shields are nearly oval in some specimens, but more or less oblong quadrangular in others. The disk granules are very fine and close-set. The granules occur also on the abradial end

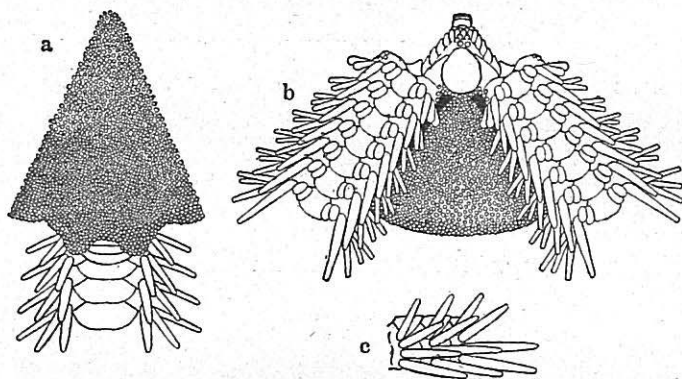


Fig. 95. *Ophiocoma brevipes*. $\times 4$. a. From above. b. From below. c. Side view of three arm joints near disk.

of the adoral shields and of the first lateral arm plates. The oral papillæ are comparatively numerous and number five or six on either side. The dorsal brachial margins of the disk are concave. The dorsal arm plates are wide and have clearly cut outer borders. The arm spines are shorter dorsally than ventrally. A few of the lower dental papillæ are very rudimentary and granule-like, reminding us of the granules of the oral angles of the

Ophiodermatidae. Many of these characters indicate that the present species is a most primitive form of *Ophiocoma*.

***Ophiocoma scolopendrina* (LAMARCK).**

Ophiocoma scolopendrina var. *erinaceus* (MÜLLER & TROSCHEL).

Ophiocoma scolopendrina var. *schænleinii* (MÜLLER & TROSCHEL).

Ophiura scolopendrina: LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 54.

Ophiocoma scolopendrina: AGASSIZ, Mém. Soc. Nat. Neuchâtel, I, 1835, p. 192¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 170; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 20; MARKTANNER-TURNERETSCHER, Ann. K. K. Naturh. Hofmus. Wien, II, 1887, p. 302; BELL, Proc. Zool. Soc. London, 1888, p. 388; BROCK, Zeitschr. wiss. Zool., XLVII, p. 495; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 841; LORIOL, Rev. Suisse Zool., I, 1893, p. 407; LORIOL, Mém. Soc. Phys. d'Hist. Nat. Genève, XXXII, 1894, p. 23; DÖDERLEIN, SEMON - Zool. Forschungsr., V, 1896, p. 288; PFEFFER, Abh. Senckenberg. Naturf. Gesell., XXV, 1900, p. 83; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 60; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 326; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 297.

Ophiocoma erinaceus: MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 98; LYMAN, loc. cit.; STUDER, loc. cit.; MARKTANNER-TURNERETSCHER, loc. cit.; BROCK, loc. cit.; LORIOL, loc. cit., 1893, p. 419; LORIOL, loc. cit., 1894, p. 21; CLARK, loc. cit., p. 296.

*Ophiocoma erinacea*²⁾: DÖDERLEIN, loc. cit., 1888, p. 289; CLARK, Bull. U. S. Nat. Mus., LXXV, p. 257.

Ophiocoma scolopendrina var. *erinaceus*: DÖDERLEIN, loc. cit., 1896, p. 289; KÖHLER, loc. cit., 1905; KÖHLER, loc. cit., 1907.

Ophiocoma schænleinii: MÜLLER & TROSCHEL, loc. cit., p. 99; LYMAN,

1) This paper was not seen by me.

2) I think MÜLLER & TROSCHEL used the specific name as an appositive noun and not as an adjective, *erinaceus* signifying a hedgehog so that, there is no reason to change it to "*erinacea*."

Ill. Cat. Mus. Comp. Zool., I, 1865, p. 70; LYMAN, loc. cit., 1882, p. 171; CLARK, loc. cit., 1908, p. 296.

One specimen; Pinnacle Is. Four specimens; Bonin Is. Numerous specimens; Botel Tobago. Numerous specimens; Kôshun, Formosa. Four specimens; Yayeyama, Riu-kiu. Six specimens; Ôshima, Ôsumi. Numerous specimens (belonging to the Seventh High School, Kagoshima); Kagoshima Gulf.

Indo-Pacific. Kagoshima Gulf seems to be the northern limit of this species.

There is no doubt that *O. scolopendrina*, *erinaceus* and *schaenleinii* are conspecific, as rightly noted by MARKTANNER-TURNERETSCHER. I have closely examined many intermediate specimens, and am fully convinced that there is no line of demarcation. The continuity of the *scolopendrina*- and *erinaceus*-type has already been remarked upon by LUDWIG, MARKTANNER-

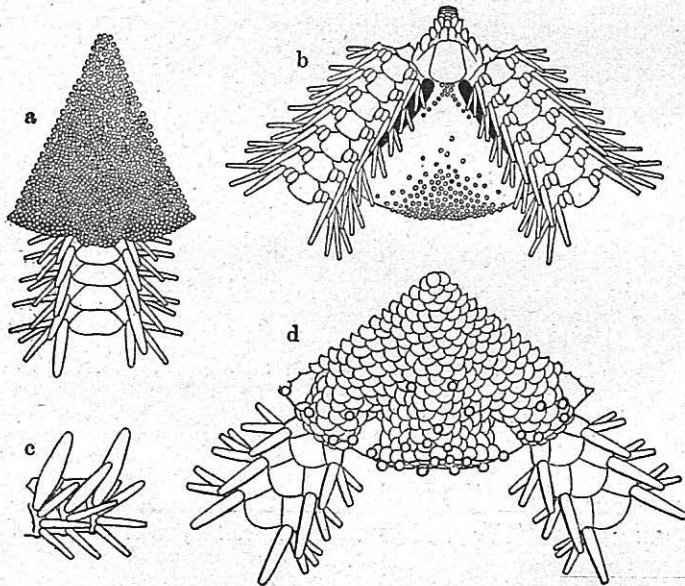


Fig. 96. *Ophiocoma scolopendrina* var. *erinaceus*. a. From above. $\times 3$. b. From below. $\times 3$. c. Side view of three arm joints near disk. $\times 3$. d. Young specimen from above. $\times 14$.

TURNERETSCHER, DÖDERLEIN and KÖHLER. Typical specimens of the *schænleinii*-type have very short and exceedingly stout arm spines and only one tentacle scale to each pore, except in a few basal arm joints within the disk. But there are also many specimens of the *erinaceus*-type with only one tentacle scale, instead of two, to each pore in most of the arm joints. Now, there are two classes of specimens which are intermediate between the *erinaceus*- and *schænleinii*-type. In the first, the arm spines are very short and stout, and there is mostly only one tentacle scale to each pore, though often two are present in some of the free arm joints. In the second, the arm spines are not very short and stout, and there is only one tentacle scale, except in a few basal arm joints within the disk. There are also some specimens which are intermediate between the *scolopendrina*- and *schænleinii*-type, in which the arm spines are very short and stout, and not uniformly blackish, as in the *schænleinii*- and *erinaceus*-type, but annulated or spotted with white as in the *scolopendrina*-type, while of the tentacle scale there is mostly only one, though two may be present in some of the arm joints. The numbers of the specimens of each type and of the intermediate ones, together with the localities, are shown in the following table:

Types:	Localities:	Bonin Is.	Botel Tobago.	Kôshun.	Yayeyama.	Okinawa.
<i>scolopendrina</i>		2	8	7	1	2
intermediate		1	3	6	0	0
<i>erinaceus</i>		1	9	7	1	1
intermediate		0	4	2	0	1
<i>schænleinii</i>		0	7	1	0	2
intermediate		0	1	2	2	0
<i>scolopendrina</i>		—	—	—	—	—

Key to Japanese species of *Ophiomastix*.

- A*—Disk closely covered with granules and bearing a number of very short spines; dorsal arm plates fan-shaped; colour dark red in life and whitish in alcohol *mixta*.
- AA*—Disk sparsely covered with spines, or with spines and granules, neither being very close-set.
- a*—Disk sparsely covered with both spines and granules; dorsal arm plates hexagonal; colour black *lütkeni*.
- aa*—Disk sparsely covered with spines only; dorsal arm plates rhomboidal; colour grayish brown, disk spines and arm spines finely annulated with white *annulosa*.

***Ophiomastix mixta* LÜTKEN.**

Ophiomastix mixta: LÜTKEN, Add. Hist. Oph., Pt. III, 1869, p. 44; LYMAN, Ill. Cat. Mus. Comp. Zool., VI, 1870, p. 15; LYMAN, Rep. Challenger, V, 1882, p. 175; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 497; LORIGL, Rev. Suisse Zool., I, 1893, p. 414; KOEHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 68, Pl. VI, fig. 15, Pl. XV, fig. 1; CLARK, Bull. U. S. Nat. Mus., LXXV, 1911, p. 256, fig. 126.

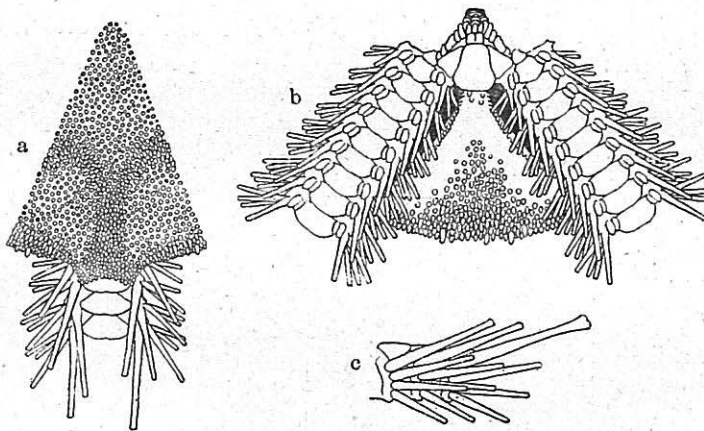


Fig. 97. *Ophiomastix mixta*. $\times 3$. a. From above. b. From below. c. Side view of three arm joints near disk.

One specimen; Enoshima. Numerous specimens; Misaki.

Indo-Pacific. Misaki may be the northern limit of this species.

My specimens have the disk spines not so profusely developed as in the East Indian type, but few, short and inconspicuous; so that they are rather liable to be mistaken for an *Ophiocoma*. The colour is yellowish white in alcohol, but very dark red in life.

Ophiomastix lütkeni PFEFFER.

Ophiomastix
lütkeni: PFEFFER,
Abh. Senckenberg.
Naturf. Gesell.,
1900, XXV, p. 83.

Four speci-
mens; Okinawa.

Philippines
(PFEFFER).

The largest
one of my speci-
mens is 22 mm.
in diameter, 250
mm. in the
arm length, and
4 mm. in the
arm width at
the base. These
specimens agree
exactly with
PFEFFER'S des-

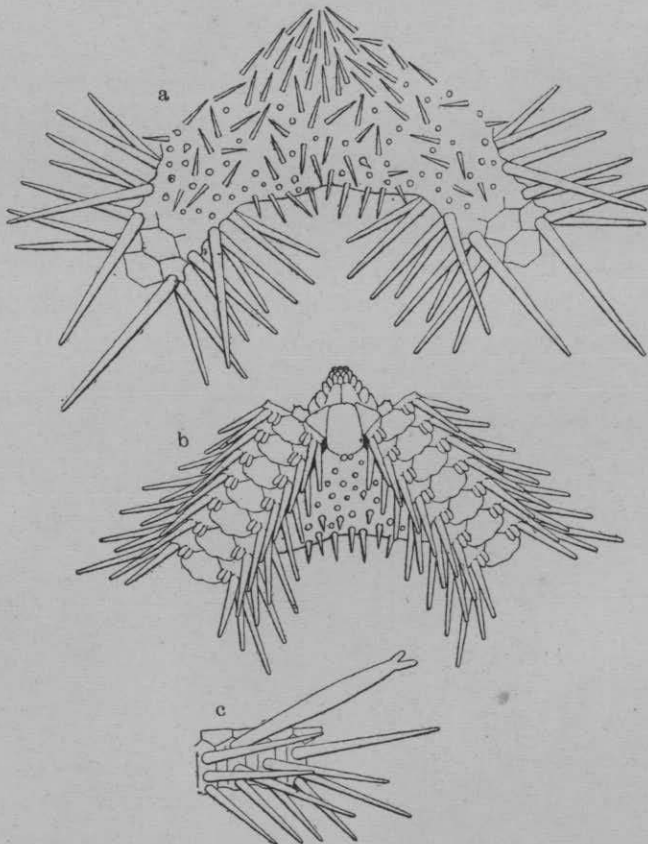


Fig. 98. *Ophiomastix lütkeni*. $\times 3$. a. From above. b. From below. c. Side view of three arm joints near disk.

cription, if we make what I consider to be necessary corrections in his expressions : the three rows of teeth mentioned by him are in reality dental papillæ ; and above them, deep within the mouth, there is a row of about four teeth, which are hardly visible without dissection. In larger specimens, the uppermost stout arm spine is often bifurcated at the free end. The colour is black as in PFEFFER'S type.

Ophiomastix annulosa (LAMARCK).

Ophiura annulosa : LAMARCK, Hist. Nat. Anim. sans Vert., II, 1816, p. 543.

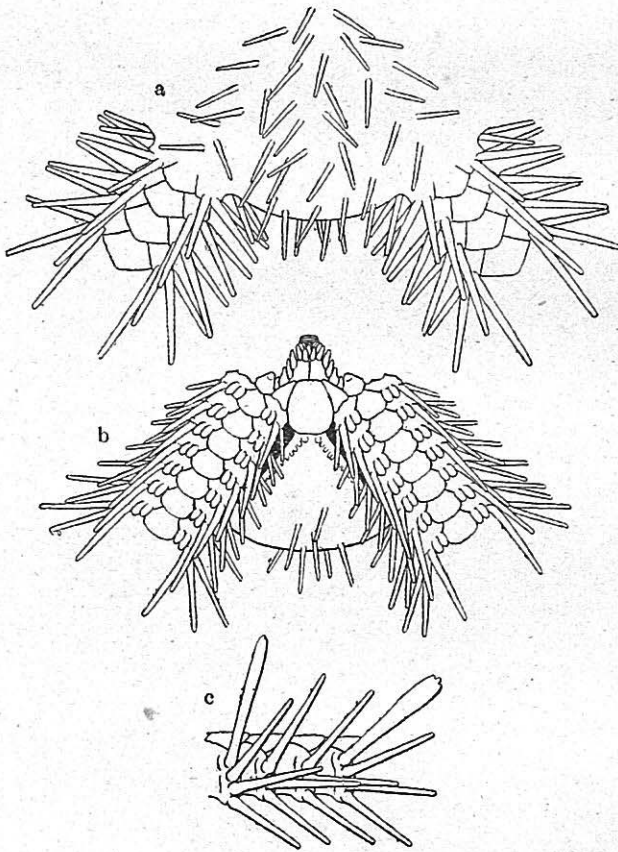


Fig. 99. *Ophiomastix annulosa*. $\times 3$. a. From above. b. From below. c. Side view of four arm joints near disk.

Ophiomastix annulosa : MÜLLER & TROSCHEL, Sys. Ast., 1842, p. 107 ; LÜTKEN, Add. Hist. Oph., III, 1869, p. 44 ; LYMAN, Ill. Cat. Mus. Comp. Zool., VI, 1869, p. 15 ; LYMAN, Rep. Challenger, V, 1882, p. 175 ; STUDER, Abh. K. Preuss. Akad. Wiss. Berlin, 1882, p. 21 ; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 497 ; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 832 ; LORIOU, Rev. Suisse Zool., I, 1893, p. 413 ; KÄHLE, Mém. Soc. Zool.

Fr., VIII, 1895, p. 403; DÖDERLEIN, SEMON—Zool. Forschungsr., V, 1897, p. 289, Pl. XVI, fig. 111; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 84; PFEFFER, Abh. Senckenberg. Naturf. Gesell., XXV, 1900, p. 85; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 65; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 329; CLARK, Bull. Mus. Comp. Zool., LI, 1908, p. 297.

Four specimens; Pinnacle Is., Riu-kiu. One specimen; Kôshun, Formosa. Four specimens; Botel Tobago, Formosa.

Indo-Pacific. Pinnacle Is. may be the northern limit of this species.

Ophiarthrum elegans PETERS.

Ophiarthrum elegans: PETERS, Monatsb. K. Akad. Wiss. Berlin, 1851, p. 463¹⁾; PETERS, Arch. Naturg., XVIII, 2, 1852, p. 82¹⁾; LYMAN, Rep. Challenger, V, 1882, p. 174; STUDER, Abh. K. Akad. Wiss. Berlin, 1882, p. 21; BROCK, Zeitschr. wiss. Zool., XLVII, 1888, p. 497; DÖDERLEIN, Zool. Jahrb. Sys., III, 1888, p. 831; DÖDERLEIN, SEMON—Zool. Forschungsr., V, 1896, p. 289; KÖHLER, Bull. Sci. Fr. Belg., XXXI, 1898, p. 108, Pl. III, figs. 25 & 26; LUDWIG, Abh. Senckenberg. Naturf. Gesell., XXI, 1899, p. 547; PFEFFER, *ibid.*, XXV, 1900, p. 83; KÖHLER, Ech. Indian Mus., Shallow-wat. Oph., 1890, Pl. XIX, figs. 36 & 37; KÖHLER, Exp. Siboga, XLV, Pt. 2, 1905, p. 73; KÖHLER, Bull. Sci. Fr. Belg., XLI, 1907, p. 329; CLARK, Bull. Mus. Comp. Zool., LI, p. 297.

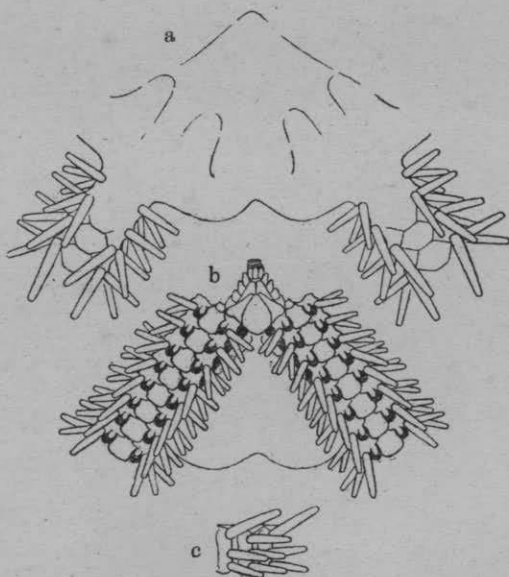


Fig. 100. *Ophiarthrum elegans*. $\times 3$. a. From above. b. From below. c. Side view of three arm joints near disk.

1) These papers were not seen by me.

One specimen; Okinawa, Riu-kiu.

Indo-Pacific. Okinawa may be the northern limit of this species.

The Ophiuran Fauna of Japan.

H. L. CLARK distinguishes four geographical ophiuran faunæ in the North Pacific, namely Honshû, Bering, American and Oceanic. I will discuss the ophiuran fauna of Japan from a somewhat different standpoint from his.

All the known Japanese ophiurans are referable to eighty-eight genera, which may be divided from the distributional standpoint into five groups as follows.

- I. *Cosmopolitan genera*, which are widely distributed in both the Indo-Pacific and Atlantic, as well as in both the Arctic and Antarctic or either one of the latter. The following genera belong here.

Ophiacantha, *Amphiactis*, *Amphiodia*, *Amphipholis*,
Amphiura, *Homalophiura*, *Ophiura*.

7 genera: 8%.

- II. *Arctic genera*, which are essentially circumpolar in distribution or limited to the Bering Sea and very northern Pacific. The following genera belong here.

Gorgonocephalus, *Ophiolebes*, *Ophiosemmotes*, *Ophiopholis*,
Stegophiura, *Ophiopenia*.

6 genera: 7%.

- III. *Intertropical genera*, which are widely distributed in both the Indo-Pacific and Atlantic, but not in the Arctic or Antarctic. The following genera belong here.

Ophioleptoplax, *Ophiomyxa*, *Ophiodera*, *Ophiobyrsa*,

Asteronyx, *Asteroschema*, *Asteroporpa*, *Ophiomyces*,
Ophiologimus, *Ophiopora*, *Ophiolimna*, *Ophiomitrella*,
Ophiacanthella, *Ophiothamnus*, *Ophiurothamnus*, *Ophioplinthaca*,
Ophiomitra, *Ophiocamax*, *Amphilepis*, *Ophiactis*, *Amphioplus*,
Amphichilus, *Ophiophragmus*, *Ophiocentrus*, *Ophiothrix*,
Amphiophiura, *Ophiomusium*, *Ophiozonella*, *Ophiolepis*,
Ophioleuce, *Ophiernus*, *Ophiuroconis*, *Bathypectinura*,
Pectinura, *Ophioplax*, *Ophiocereis*, *Ophiocoma*.

37 genera : 42%.

- IV. *Indo-Pacific genera*, which are distributed in the Indo-Pacific, with the centre of distribution chiefly in the vicinity of Malaysia. The following genera belong here:

Astroceras, *Trichaster*, *Euryale*, *Astrocharis*, *Astrodendrum*,
Astrocladus, *Astroboa*, *Astrothamnus*, *Astrotoma*, *Astroclon*,
Ophiambix, *Ophiophthalmus*, *Ophiomæris*, *Amphiacantha*,
Ophiomaza, *Ophiothela*, *Astrophiuura*, *Aspidophiura*,
Ophioplocus, *Ophiotrochus*, *Ophiurodon*, *Ophiarachma*,
Ophiarachnella, *Ophiochiton*, *Ophiodoris*, *Ophiomastix*,
Ophiarthrum.

27 genera : 30%.

- V. *Honshû genera*, which are known only from the vicinity of Honshû, Shikoku and Kiushû. The following genera belong here.

Ophiostyracium, *Ophiosyzygus*, *Ophiostiba*, *Ophiohyalus*,
Ophiohymen, *Ophiophrixus*, *Ophiosmilax*, *Astrothorax*,
Ophiophrura, *Ophientrema*, *Ophiocrasis*.

11 genera : 13%.

With the exception of *Ophiophthalmus*, which is both tropical and Arctic, the Indo-Pacific and Intertropical genera are represen-

tatives of tropical fauna, and form 72% of the total, in contrast to the Arctic elements, which amount to only 7%. Moreover, almost all of the Honshû genera have tropical, but not Arctic, affinities.

Two hundred and thirty-two species of ophiurans are known from Japanese waters, which may be grouped as follows.

- I. *Circumpolar species*, which occur in the North Atlantic, Arctic and North Pacific. The species belonging here and their known southern limits in the North Pacific are as follows.

Species.	Southern limit.
<i>Ophiacantha bidentata</i> :	off southern Korea, Sea of Japan.
<i>Ophiopholis aculeata</i> , typical :	off southern Korea, Sea of Japan.
Ditto, including var. <i>japonica</i> :	off Kii, Kumano Sea.
<i>Stegophiura nodosa</i> :	off Saghalin, Okhotsk Sea.
<i>Ophiura sarsii</i> :	Eastern Sea ; Uraga Channel (on the Pacific side).

4 species : 2%.

- II. *Bering-American species*, which range from the Bering Sea to Japan and to the western coast of U. S. A. The species belonging here and their known southern limits in Japan are as follows.

Species.	Southern limit.
<i>Gorgonocephalus caryi</i> :	Eastern Sea ; Suruga Gulf (on the Pacific side).
<i>Ophiophthalmus normani</i> :	Eastern Sea ; off Kii, Kumano Sea (on the Pacific side).
<i>Amphiodia euryaspis</i> :	off Korea, Sea of Japan.
<i>Ophiura cryptolepis</i> :	off Omai Zaki, Yenshû Sea.
<i>Ophiura leptoctenia</i> :	off southern Korea, Sea of Japan ; off Omai Zaki, Yenshû Sea (on the Pacific side).

5 species: 2%.

III. *Bering species*, which range from the Bering Sea to Japan, but not to the coast of U. S. A. The species belonging here and their known southern limits are as follows.

Species.	Southern limit.
<i>Ophiophthalmus cataleimmoidus</i> :	off Mikawa, Yenshû Sea.
<i>Ophiacantha adiaphora</i> :	Sagami Sea.
<i>Ophiacantha rhachophora</i> :	Eastern Sea ; off Kii, Kumano Sea (on the Pacific side).
<i>Ophiacanthella acantophora</i> :	off Kurile Is.
<i>Ophiosemmotes tylota</i> :	off Tsugaru, Sea of Japan.
<i>Amphiodia craterodonta</i> :	off Korea, Sea of Japan.
<i>Ophiura quadrispina</i> :	off Shiribeshi, Sea of Japan.
<i>Ophiura maculata</i> :	off Abashiri, Kitami, Okhotsk Sea.
<i>Ophiopenia disacantha</i> :	off Sado, Sea of Japan.

9 species: 4%.

IV. *Intertropical species*, which are widely distributed in both the Indo-Pacific and Atlantic, but not in the Arctic or Antarctic. The intertropical species usually occur in both the East and West Indies. The species to be referred here and their known northern limits in the North Pacific are as follows.

Species.	Northern limit.
<i>Asteronyx loveni</i> ¹⁾ :	Bering Sea.
<i>Ophiolimna bairdi</i> :	Bering Sea.
<i>Ophiacantha pentagona</i> ¹⁾ :	Sagami Sea.
<i>Ophiacantha rosea</i> :	Sagami Sea.
<i>Ophiactis savignyi</i> ¹⁾ :	Misaki districts.

1) These species have been recorded also from East Indian waters.

<i>Amphiophiura convexa</i> :	Eastern Sea.
<i>Amphiophiura sculptilis</i> ¹⁾ :	off Boshû.
<i>Ophiura flagellata</i> ¹⁾ :	off Kinkwasan, Rikuzen.
<i>Ophiura irrorata</i> ¹⁾ :	Bering Sea.
<i>Ophiomusium scalare</i> ¹⁾ :	Uraga Channel.
<i>Ophiomusium lymani</i> ¹⁾ :	British Columbia.
<i>Ophiomusium cancellatum</i> :	Uraga Channel.
<i>Ophiurnus adpersus</i> ¹⁾ :	off Kii, Kumano Sea.

13 species : 6%.

V. *Indo-Pacific American species*, which range from Malaysian waters to the western coast of southern North America or Central America, through Japanese waters. The species belonging here and their known northern limits are as follows.

Species.	Northern limit.
<i>Amphiura koreca</i> :	off Echizen, Sea of Japan ; Sagami Sea (on the Pacific side).
<i>Ophiochiton fastigatus</i> :	Uraga Channel.

2 species : 1%.

VI. *Indo-Pacific species*, which range from the Indian Ocean or Malaysian waters to Japan. The species to be referred here and their known northern limits are as follows.

Species.	Northern limit.
<i>Ophiomyxa australis</i> :	Sagami Sea.
<i>Astroceras pergamena</i> :	Uraga Channel.
<i>Trichaster palmiferus</i> :	Colnett Strait.
<i>Trichaster elegans</i> :	Tanabé Bay, Kii.
<i>Euryale aspera</i> :	Okinawa, Riu-Kiu.

1) These species have been recorded also from East Indian waters.

- Astrodendrum sagaminum* : off Shiribeshi, Sea of Japan ;
Sagami Sea (on the Pacific side).
- Astrocladus coniferus* : Wladiostok ; Sagami Sea (on
the Pacific side).
- Astroboa nigra* : Hirado Strait.
- Ophiambix aculeatus* : Colnett Strait.
- Ophiacantha dallasii* : off Korea, Sea of Japan.
- Ophiacantha levispina* : off Shiribeshi, Sea of Japan ; Yen-
shû Sea (on the Pacific side).
- Ophiacantha inutilis* : Uraga Channel.
- Ophiomæris obstricta* : Eastern Sea.
- Ophiactis affinis* : Korean seas.
- Ophiactis macrolepidota* : Uraga Channel.
- Ophiactis modesta* : Misaki districts.
- Amphiacantha formosa* : Strait of Formosa.
- Amphiura bellis* : Sagami Sea.
- Amphiura iris* : Sagami Sea.
- Amphiura lütkeni* : Korean seas.
- Ophiocentrus verticillatus* : Misaki districts.
- Ophiothrix koreana* : Hakodaté Bay.
- Ophiothrix nereidina* : Misaki districts.
- Ophiothrix obtusa* : Okinawa, Riu-Kiu.
- Ophiothrix hirsuta* : Pinnacle Is., Riu-Kiu.
- Ophiothrix punctolimbata* : precise locality in Japan not
known.
- Ophiothrix longipeda* : Kominato, Boshû.
- Ophiothela dance* : Misaki districts.
- Aspidophiura forbesi* : Korea Strait.
- Ophiura kinbergi* : off Echigo, Sea of Japan ; Uraga
Channel (on the Pacific side).

<i>Ophiura imbecillis</i> :	Sagami Sea.
<i>Ophiomusium simplex</i> :	Eastern Sea.
<i>Ophiomusium lunare</i> :	Eastern Sea.
<i>Ophiomusium lütkeni</i> :	Eastern Sea.
<i>Ophiomusium laqueatum</i> :	Eastern Sea.
<i>Ophiozonella projecta</i> :	Sagami Sea.
<i>Ophiolepis cincta</i> :	precise locality in Japan not known.
<i>Ophiolepis annulosa</i> :	Okinawa, Riu-Kiu.
<i>Ophioplocus imbricatus</i> :	Okinawa, Riu-Kiu.
<i>Ophiurodon grandisquama</i> :	Sagami Sea.
<i>Ophiarachna incrassata</i> :	Okinawa, Riu-Kiu ; Bonin Is.
<i>Ophiarachnella gorgonia</i> :	Misaki districts.
<i>Ophiarachnella infernalis</i> :	Eno-ura, Suruga Gulf.
<i>Ophionereis porrecta</i> :	Korea Strait.
<i>Ophiocoma brevipes</i> :	Natsui, Hiuga.
<i>Ophiocoma scolopendrina</i> :	Kagoshima Gulf.
<i>Ophiomastix mixta</i> :	Misaki districts.
<i>Ophiomastix lütkeni</i> :	Okinawa, Riu-Kiu.
<i>Ophiomastix annulosa</i> :	Pinnacle Is., Riu-Kiu.
<i>Ophiarthrum elegans</i> :	Okinawa, Riu-Kiu.

50 species : 21%.

VII. *Honshû-American species*, which occur on both the western and eastern coasts of the North Pacific. The following species belong here.

Amphioplus rhadinobrachiis.

Amphioplus hexacanthus.

Amphioplus macraspis.

Amphipholis pugetana.

Amphiura carchara.

Amphiura acrystata.

Amphiophiura ponderosa.

Ophiomusium jolliense.

Ophionereis eurybrachiola.

9 species : 4%.

VIII. *Honshû species*, which are known only from the vicinity of Honshû, Shikoku and Kiushû. The following species belong here.

Ophiosyngus disacanthus.

Ophioleptoplax megapora.

Ophiostyracium trachyacanthum.

Ophiostiba hidekii.

Ophiohyalus gotoi.

Ophiodera anisacantha.

Ophiohymen gymnodiscus.

Ophiobyrsa acanthinobrachia.

Ophiobyrsa synaptacantha.

Ophiophriscus acanthinus.

Ophiosmilax mirabilis.

Euryale anopla.

Asteroschema tubiferum.

Asteroschema glaucum.

Asteroschema hemigymnum.

Asteroschema caudatum.

Asteroschema japonicum.

Asteroschema abyssicola.

Asteroschema glutinosum.

Astrocharis ijimai.

Asteroporpa hadracantha.

Gorgonocephalus tuberosus.

Gorgonocephalus dolichodactylus.

- Astrocladus annulatus.*
Astroboa arctos.
Astroboa globifera.
Astrothamnus echinaceus.
Astrothorax misakiensis.
Astrotoma sobrina.
Astroclon suenisoni.
Ophiomyces spathifer.
Ophiologimus hexactis.
Ophiophrura liodisca.
Ophiopora megatrema.
Ophiolimna lambda.
Ophiolimna diastata.
Ophiomitrella stellifera.
Ophiomitrella polyacantha.
Ophiophthalmus leucorhabdotus.
Ophiophthalmus codonomorpha.
Ophiophthalmus hylacantha.
Ophiophthalmus microhylax.
Ophientrema euphylacteum.
Ophientrema scolopendricum.
Ophiacantha enigmatica.
Ophiacantha omoplata.
Ophiacantha anchilabra.
Ophiacantha lophobrachia.
Ophiacantha acanthinotata.
Ophiacantha prionota.
Ophiacantha diploa.
Ophiacantha bisquamata.
Ophiothamnus labrotatus.

- Ophiothamnus venustus*.
Ophiurothamnus dicyclus.
Ophioplinthaca cardiomorpha.
Ophiomitra bythiaspis.
Ophiomitra lithosora.
Ophiocamax polyploca.
Ophiolebes brachygnatha.
Ophiolebes asaphes.
Ophiolebes tuberosa.
Ophiosemmotes ædidisca.
Ophiomæris projecta.
Amphilepis tenuis.
Amphiactis umbonata.
Ophiactis brachygenys.
Ophiactis pteropoma.
Ophiactis dyscrita.
Ophiactis gymnochora.
Ophiopholis mirabilis.
Ophiopholis brachyactis.
Amphioplus megapomus.
Amphioplus ancistrotus.
Amphioplus cernuus.
Amphioplus glaucus.
Amphichilus trichoides.
Amphiacantha acanthina.
Amphiacantha dividua.
Amphiodia psilochora.
Ophiophragmus japonicus.
Amphipholis kochii.
Amphipholis japonica.

- Amphipholis sobrina.*
Amphiura digitula.
Amphiura trachydisca.
Amphiura microdiscus.
Amphiura euopla.
Amphiura pycnostoma.
Amphiura acacia.
Amphiura iridoides.
Amphiura micraspis.
Amphiura aestuarii.
Amphiura vadicola.
Amphiura ecnomiotata.
Ophiothrix panchyendyta.
Ophiothrix marenzelleri.
Ophiothrix macrobrachia.
Ophiothrix eusteira.
Ophiothrix stabilis.
Ophiomaza kanekoi.
Astrophium kawamurai.
Aspidophiura watasei.
Stegophiura striata.
Stegophiura vivipara.
Stegophiura sculpta.
Stegophiura sterea.
Stegophiura brachyactis.
Stegophiura sladeni.
Amphiophiura œdiplax.
Amphiophiura pompophora.
Amphiophiura penichra.
Amphiophiura megapoma.

Amphiophiura lapidaria.
Homalophiura clasta.
Ophiura oöplax.
Ophiura micracantha.
Ophiura paucisquama.
Ophiura monostæcha.
Ophiura albata.
Ophiura calyptolepis.
Ophiomusium granosum.
Ophiomusium trychnum.
Ophiozonella elevata.
Ophiozonella platydisca.
Ophiozonella polyplax.
Ophiozonella longispina.
Ophioplocus japonicus.
Ophioleuce charischema.
Ophioleuce brevispinum.
Ophiotrochus longispinus.
Ophiuroconis monolepis.
Bathypectinura gotoi.
Pectinura anchista.
Ophiarachnella megalaspis.
Ophioplax lamellosa.
Ophiodoris pericalles.
Ophionereis sinensis.
Ophiocrasis dictydisca.
Ophiocrasis marktanneri.

140 species: 60%.

The three groups of Cirumpolar, Bering-American and Bering species are evidently referable to the Arctic fauna, and form all

together 8% of the total number of Japanese species; while the three groups of Intertropical, Indo-Pacific American and Indo-Pacific species unquestionably represent the tropical elements, and form all together 28% of the total number.

Among the Arctic species, three have the southern limit in the Okhotsk Sea, three in the Sea of Japan northward of Sado, five in the Sea of Japan off southern Korea, and four in the Eastern Sea; and along the Pacific coast of Honshû, two in the Sagami Sea and Uruga Channel, four in the Yenshû Sea and Suruga Gulf, and three in the Kumano Sea, off Kii. The Arctic species, which occur in the Eastern Sea, appear to range through the Sea of Japan, but not through the Pacific coast of Honshû.

Among the tropical species, one has the northern limit in the Strait of Formosa, two at Pinnacle Is., seven at Okinawa, one at Bonin Is., three in the Colnett Strait and Kagoshima Gulf, one at Natsui, two in Tanabé Bay and Kumano Sea, one in the Yenshû Sea, one at Eno-ura, twenty-five in the Sagami Sea and Misaki region, one at Kominato, one off Bôshû, one in the Pacific Ocean far off Honshû, one off Kinkwa-san, one in British Columbia and three in the Bering Sea; and by way of the northern part of the Eastern Sea to the Sea of Japan, six in the Eastern Sea, five in Korea Strait and the Sea of Japan off southern Korea, one off Echizen, one off Echigo, one in Hakodaté Bay, two off Shiribeshi and one at Wladiostok.

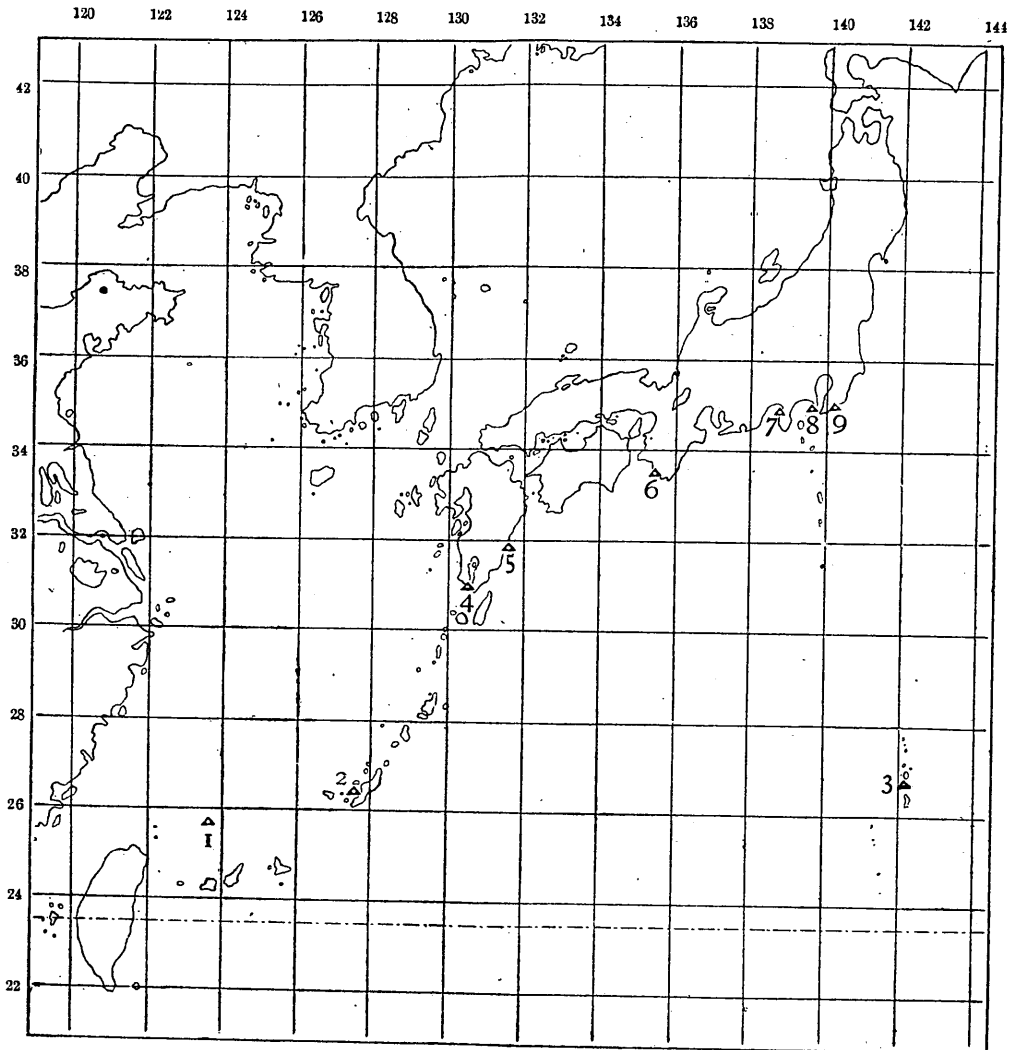
Now, neglecting here the very hardy species, which have their northern limit in British Columbia and in the Bering Sea, the zone of mingling of the Arctic and tropical species extends from off Kinkwasan to the Kumano Sea, on the Pacific side, and from off Shiribeshi and Wladiostok to the northern part of the Eastern Sea, on the side of the Sea of Japan. Thus, the geographical

boundary between the two elements is better marked on the Pacific side than on that of the Sea of Japan. The limits of the zone of contact are approximately $33\frac{1}{2}$. and $38\frac{1}{2}$. parallels on the Pacific side, and 30. and 43. parallels on the side of the Sea of Japan. The axis of the zone of contact is very nearly 36. parallel, which has been stated by CLARK to be the line of contact between his Bering and Honshû faunæ.

The two groups of Honshû-American and Honshû species are evidently heterogeneous. For example, *Amphipholis pugetana*, *Amphiura carchara*, *Gorgonocephalus tuberosus*, *G. dolichodactylus*, *Ophiolebes brachygnatha*, *O. asaphes*, *O. tuberosa*, *Ophiosemmotes ædidisca*, *Ophiopholis mirabilis*, *O. brachyactis*, *Stegophiura striata*, *St. vivipara*, *St. sculpta*, *St. sterea*, *St. brachyactis*, *St. sladeni*, &c. may be derivatives of the Arctic fauna, while the rest are largely derivatives of the tropical, especially Indo-Pacific, fauna.

CLARK has recognised scarcely a dozen species which occur in both the East Indian and Japanese regions. As a result of the present study, I recognise sixty-one species, or more than one-fourth of the total number of Japanese species, that occur also in the East Indian region. On the other hand, the boundary between CLARK'S Bering and Honshû faunæ well coincides with that between my Arctic, chiefly Bering, and tropical, chiefly Indo-Pacific or East Indian, elements. Thus, I am led to look upon the Honshû fauna not as a perfectly distinct one, but to be a terminal section of the Indo-Pacific, or East Indian, fauna.

The known northern limits of several more typical, littoral Indo-Pacific species are shown in the accompanying chart.



1. Pinnacle Is.—*Ophiothrix hirsuta*, *Ophiomastix annulosa*.
2. Okinawa Is.—*Euryale aspera*, *Ophiothrix obtusa*, *Ophiomastix lütkeni*, *Ophiarthrum elegans*,
Ophiolepis annulosa, *Ophioplocus imbricatus*, *Ophiarachna incrassata*.
3. Bonin Is.—*Ophiarachna incrassata*.
4. Kagoshima Bay.—*Ophiocoma scolopendrina*.
5. Natsui.—*Ophiocoma brevipes*.
6. Tanabé.—*Trichaster elegans*.
7. Eno-ura.—*Ophiarachnella infernalis*.
8. Misaki & Sagami Sea.—*Ophiothrix nereidina*, *Ophiactis modesta*, *Ophiocentrus verticillatus*,
Ophiarachnella gorgonia, *Ophiomastix mixta*.
9. Kominato.—*Ophiothrix longipeda*.

Phylogeny of the Ophiuroidea.

It is very evident, that the forms with vertically coiled arms are not archetypal, because they have very solid and always undivided vertebræ, as mentioned in the introduction, while the ophiuran vertebræ are palæontologically, as well as ontogenetically, proved to be primarily divided. Thus, the *Ophiobyrsinæ*, *Trichasteridæ*, *Gorgonocephalidæ*, *Ophiacanthidæ* pars, *Hemieuryalidæ*, *Ophiactinæ* pars, and *Ophiotrichidæ* pars are eliminated from primitive ophiurans. The forms with well developed lateral wings of the oral frames are evidently highly specialised. Thus, the *Amphiuridæ*, *Ophiotrichidæ*, *Ophiolepidinæ* pars, *Ophionereidinæ* and *Ophiocomidæ* are eliminated from primitive ophiurans. The remaining forms are the *Ophiomyxinæ*, *Ophiacanthidæ* pars, *Amphilepididæ*, *Ophiolepididæ* pars, *Ophioleucidæ*, *Ophiodermatidæ* and *Ophiochitoninæ*. Indeed, I have been able to find more or less divided vertebræ in certain representatives of the *Amphilepididæ*, *Ophiolepididæ* and *Ophiodermatidæ*, as well as of the *Ophiomyxinæ* and *Ophiacanthidæ*.

Though it is my purpose to discuss the results of a study of Palæozoic ophiurans in a future paper, I will here enumerate some of the more important structures of Palæozoic *Myophiuroida*, as bearing on the question before us.

1. Disk covered with delicate scales or by a naked skin, without distinct primaries.
2. Radial shields absent.
3. Genital plates and scales absent.
4. Oral shields absent.
5. Adoral shields not very distinctly specialised from the lateral arm plates.

6. Oral plates and frames long and slender.
7. Distinct creases probably present between the interbrachial ventral surfaces and arm bases.
8. Dorsal arm plates entirely absent, or present only in a few basal joints; the dorsal side of the arms therefore largely unprotected.
9. Lateral arm plates with prominent spine ridges, which extend to the ventral side of the arm; those of the two sides not meeting above or below, except in the very distal arm joints.
10. Ventral arm plates higher in position than the lower borders of the lateral arm plates, so that the arm is longitudinally grooved ventrally.

I believe that, the Palæozoic *Myophiuroidea* are the stock from which the recent ophiurans have been directly derived, because they show no trace of peculiar specialisation and are fairly intermediate in their organisation as a whole between the *Ægophiuroidea* and recent ophiurans. If this view be right, then the most archetypal group of recent ophiurans must be looked for among those forms which have the strongest resemblances to the Palæozoic *Myophiuroidea*.

Certain genera of the *Ophiolpididae*, which are frequently said to be primitive, appear to me to be far from being archetypal, though they may evidently be pædomorphic. These genera in the mature stage are in every feature similar to very young stages of other ophiurans, having the disk covered only with the primaries and radial shields, and the arms covered chiefly by the lateral arm plates. But, the existence of such forms in the early ages of the history of the *Ophiuroidea* is entirely unproved. As to the biogenetic law, VON BAER'S view appears to me to be more consonant to facts than F. MÜLLER'S. The term "primitive" may mean

both "archetypal" and "embryonal"; but the two must in my opinion be strictly distinguished. In fact, the genera in question of the *Ophiolepididæ* are, in my opinion, embryonal, but not archetypal.

On the contrary, the *Ophiomyxinæ* and certain genera of the *Ophiacanthidæ* with only horizontally flexible arms, appear to me to be fairly archetypal, being similar to the Palæozoic *Myophiuroida* in many structures, the presence of the genital plates, genital scales and oral shields, and sometimes also of the radial shields being the principal differences. As to the radial shields, I look upon them as a modification of the marginal disk scales, often present in both the Palæozoic and recent ophiurans, which have secondarily become articulated with the genital plates where these have developed; and a very primitive condition of the radial shields may in my opinion be seen in *Ophiostiba*, *Ophiohyalus*, as well as in young specimens of *Ophiomyxa*, &c. This view is in accord with LYMAN'S¹⁾, according to which the radial shields are not special plates but are homologous with the other disk scales, and by no means the first to appear.

The ventral arm plates of many genera of the *Ophiomyxinæ*, as *Ophiosciasma*, *Ophiocynodus*, *Ophiosyzygus*, *Ophioleptoplax*, *Ophiostyracium*, *Ophiohyalus*, *Ophiomyxa*, *Ophiodera*, *Ophiohymen*, &c., and some of the *Ophiacanthidæ*, as *Ophiomyces*, *Ophiologimus*, &c. are long and narrow, being in contact with, or slightly separated by a naked space from, each other, at least in the proximal arm joints. A similar condition may be observed also in certain representatives of Palæozoic *Myophiuroida*. In many genera of the *Ophiacanthidæ*, the ventral arm plates are very small, short and

1) Rep. Challenger, V, 1882, p. 157.

widely separated from one another by the lateral arm plates, which are distinctly in contact with each other in the ventral median line. This condition is also observed in the distal arm joints of the *Ophiomyxinae*; so that, following the law of localised stages, it is evidently more distinctly embryonal than that in which the lateral arm plates are separated by the ventral arm plates. The *Ægophiuroida* had exposed ambulacral grooves; and this groove became covered over by the ventral arm plates for the first time in the Palæozoic *Myophiuroida*; so that, the meeting of the lateral arm plates in the ventral median line can not be a primary condition. Moreover, the assumption that the meeting of the lateral arm plates in the ventral median line is a primary condition, makes it very difficult to assign a probable cause of the acquisition of the ventral arm plates. I therefore think that, the separated condition of the lateral arm plates in the ventral median line is an archetypal but not embryonal feature, while the meeting of those plates is an embryonal but not archetypal feature.

In the *Ophiomyxinae*, the lateral arm plates of the two sides are widely separated from each other on the dorsal side, while in the majority of the *Ophiacanthidae*, they are well in contact. The second condition is what occurs also in the very distal arm joints of the *Ophiomyxinae*, as well as of many Palæozoic ophiurans; so that, following the law of localised stages, it is evidently more distinctly embryonal than the first condition. But, the assumption that the meeting of the lateral arm plates in the dorsal median line is a primary condition makes it very difficult to assign the necessity for the acquisition of the dorsal arm plates. I therefore think that, the meeting of the lateral arm plates in the dorsal median line is an embryonal but not archetypal condition, while the

separation of the same is an archetypal but not embryonal condition. The interpretation put forth in this and the last paragraph is well in accord with the biogenetic law as formulated by VON BAER but not as formulated by F. MÜLLER.

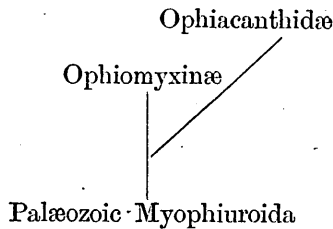
In *Ophioleptoplax* and *Ophiohyalus*, the dorsal arm plates are present but very rudimentary, thin and hyaline. A similar condition may be observed also in the distal arm joints of *Ophiomyxa*, as well as *Ophiodera anisacantha*, though the plates are in these forms divided into several secondary plates in the proximal arm joints. I imagine that, these dorsal arm plates may represent an archetypal condition.

As to the divided vertebræ, those of the *Ophiomyxineæ* appear to me to be more archetypal than those of the *Ophiacanthideæ*, the former reminding us of those of such a Palæozoic form as *Ophiurina*.

Upon the basis of these considerations, I imagine that the *Ophiomyxineæ* are a step more archetypal than the *Ophiacanthideæ*. Those genera of the *Ophiomyxineæ*, in which the second oral tentacle pores open outside the oral slits, have usually very slender adoral shields and very small oral shields, reminding us of the Palæozoic *Myophiuroida*, which are characterised by the second oral tentacle pores opening outside the oral slits, by the adoral shields not being well differentiated from, but almost similar in shape to, the ordinary lateral arm plates, and by the absence of the oral shields. That the second oral tentacle pores open outside the oral slits is a character, which appears to be at once archetypal and embryonal.

The majority of those genera of the *Ophiacanthideæ*, in which the arms are only horizontally flexible, have more or less well developed dorsal and ventral arm plates, which separate the lateral

arm plates of the two sides more or less completely. These genera strongly resemble the *Ophiomyxinae*, especially *Ophioscolex*, save in the presence of well developed dorsal arm plates. I look upon them to be a most archetypal, though not embryonal, group of the *Ophiacanthidæ*. I of course believe that the gap between the *Ophiomyxinae* and *Ophiacanthidæ* is rather not very important. Thus, the phylogenetic origin of the recent ophiurans may be shown somewhat as follows.



Now, I will trace the *Ophiomyxinae*-line further. The *Ophiobysinae* are evidently a step more advanced from the *Ophiomyxinae* toward the *Trichasteridæ* and *Gorgonocephalidæ*, having very compact oral skeleton and more or less short, stout, rather discoidal vertebræ with streptospondyline articulation. The only essential distinction of the *Ophiobysinae* from the *Trichasteridæ* and *Gorgonocephalidæ* arises from the fact, that the vertebræ of the subfamily in question are less discoidal and have less well developed upper and better developed lower muscular fossæ, as compared with those of the two last mentioned families.

Among the *Trichasteridæ*, the *Asteronychinae* appear to me to be most archetypal, because the disk is large, the arms are comparatively slender, the lower muscular fossæ of the vertebræ are relatively little reduced and the arm spines are numerous, instead of being reduced to two in number, thus more or less reminding

us of the *Ophiobyrsinæ*. The *Trichasterinæ* are, in my opinion, nearer to the *Asteronychinæ* than the *Asteroschematinæ* are to the same, because the ventral arm plates of both the *Asteronychinæ* and *Trichasterinæ* are rather well developed and in contact with one another, entirely separating the lateral arm plates, while those of the *Asteroschematinæ* are very much reduced in size and separated from one another by the lateral arm plates, which meet in the ventral median line. This view almost coincides with that of MORTENSEN, who has pointed out the affinity of *Asteronyx* to *Euryale*. The *Asteroschematinæ* are evidently descended from the simple-armed group of the *Trichasterinæ*.

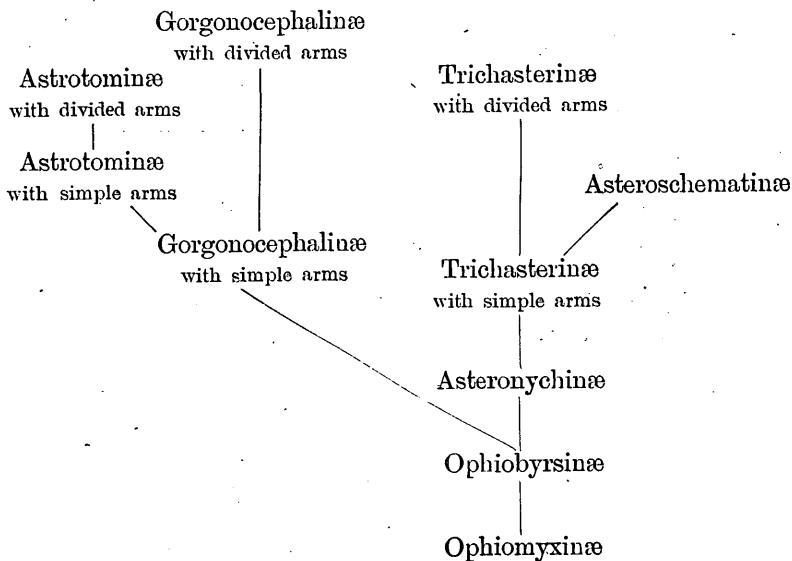
Whether the *Gorgonocephalidæ* are descended from the *Ophiobyrsinæ* or from the *Asteronychinæ* is rather hard to decide, though it is very evident, that the *Gorgonocephalidæ* have no direct relation to the *Trichasterinæ* and *Asteroschematinæ*. The minute hooks of the arm annuli stand in an intimate relation with the arm spines, as may be clearly witnessed in the very distal arm joints, where the arm spines are hook-shaped and the upper ones are smaller and show a tendency to shift their positions alternately so as to form a double row. These upper arm spines are evidently the rudiments of the arm annuli. As already mentioned, the lateral arm plates are approximated dorsally in embryonal stages; and such a dorsal approximation occurs, in the present case, in the arm spines. So I imagine that the arm annuli are due to the persistence of an embryonal feature of the arm spines. If this interpretation be right, then the arm annuli of the *Gorgonocephalidæ* remind us of the arm spines of such genera as *Ophiobrachion* and *Asteronyx*. Though *Ophiobrachion* is referred to the *Ophiobyrsinæ* of the *Ophiomyxidæ* and *Asteronyx* to the *Asteronychinæ* of the *Trichasteridæ*, the difference between

the two subfamilies is by no means very great. So that, it may not be very unreasonable to look upon the *Trichasteridæ* and *Gorgonocephalidæ* as having a blood relation at the very beginning.

Within the limit of the simple-armed genera of the *Gorgonocephalidæ*, the *Gorgonocephalinæ* are evidently more archetypal than the *Astrotominæ*, because the former have less specialised and less localised oral and dental papillæ and less powerful oral angles than the latter, and the latter have well developed supplementary plates in the spaces between the oral angles and the interbrachial ventral surfaces.

Another point to be noted is that the dividing of the arms occurred independently in three groups, viz. the *Trichasterinæ*, *Gorgonocephalinæ* and *Astrotominæ*, an example of parallelism due to certain biological conditions.

The interrelationships between the members of the *Ophiomyxinae*-line, or *Phrynophiurida*, may be shown as follows.



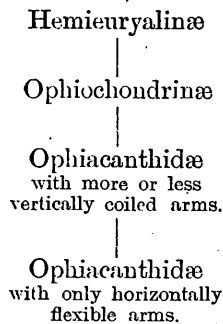
I will now proceed to the consideration of the *Ophiacanthidae*-line. As already mentioned, the genera or species with only horizontally flexible arms are a step more archetypal than those with more or less vertically coiled arms; but the distinction of these two groups can not be very profound, since certain genera include species of both types. As far as the genera examined by myself are concerned, *Ophiologimus* and *Ophiolimna* are typical representatives of the forms with only horizontally flexible arms, and *Ophiolebes*, *Ophiosemmotes* and *Ophiochondrella* of those with more or less vertically coiled arms. *Ophiologimus*, as probably also *Ophiotoma*, *Ophioblenna*, *Ophiomyces*, *Ophiocimbium*, *Amphipsila*, &c. may represent a most archetypal group of the *Ophiacanthidae*, being very close to the *Ophiomyxine* on the one hand and to the *Amphilepididae* on the other. *Microphiura* may be very embryonal, having the oral papillæ completely soldered together and the lateral arm plates extremely well developed. In a very small and young specimen, of which the genus is indeterminable, I have observed that every essential structure is similar to that of *Microphiura*, the oral papillæ being completely soldered together, the genital slits invisible, the second oral tentacle pore opening entirely outside the oral slits, the tentacle pores provided with a crescent-shaped scale, and the lateral arm plates almost completely covering the entire surface of the arm. I therefore consider *Microphiura* to be probably a pædomorphic form, granting that the specimens described by MORTENSEN are sexually mature; it is in my opinion not truly archetypal.

I have already mentioned that the very good development of the lateral arm plates, which separate the dorsal and ventral arm plates from each other, is an embryonal feature. Following this principle, the majority of the *Ophiacanthidae* are embryonal in the

character of the arm plates. The Palæozoic ophiurans are usually very large, one specimen of Palæozoic *Myophiuroida* at hand being about as large as a very large specimen of *Ophiomyxa flaccida*, and another as large as, or larger than, a very large specimen of *Ophiarachna incrassata*; while the *Ophiacanthidæ* are usually very small, and their arms so slender as to equal in thickness only the very distal part of the arms of the Palæozoic *Myophiuroida*. I imagine that the very small size of the recent *Ophiacanthidæ* is intimately correlated to their embryonal characters.

The *Hemieuryalidæ* are, in my opinion, evidently a terminal group of the line of specialisation represented at the base by *Ophiolebes*, *Ophiosemmotes*, *Ophiochondrella*, &c., which are characterised by the pronounced vertical coiling of the arms. Among them, the *Ophiochnodrinæ* are very close to the *Ophiolebes*-group and more archetypal than the *Hemieuryalinæ*.

The interrelationships of the *Læmophiurida* may be shown as follows.



From the *Læmophiurida* upwards, there are, in my opinion, two distinct lines of specialisation: one, forming the *Gnathophiurida*, is characterised essentially by the radial shield and genital plate articulating with each other by means of one large, conspicuous socket of the former and one large, ball-like condyle of the latter;

and the other, forming the *Chilophiurida*, is characterised essentially by the radial shield and genital plate articulating with each other by means of two condyles and one pit of either plate.

Among the *Gnathophiurida*, the *Amphilepididæ* are evidently most archetypal, being closely allied to the *Ophiacanthidæ* with only horizontally flexible arms, in the very large peristomial plates, in the not very stout oral frames without well developed lateral wings, in the very long and slender oral plates, in the genital plates being not fixed to, but free from, the basal vertebræ, and in the often incompletely divided vertebræ.

The *Amphiuridæ* and *Ophiotrichidæ* are characterised by the very small peristomial plates, by the very stout oral frames with well developed lateral wings, by the stout oral and dental plates, by the very stout, quadrangular teeth and by the genital plates being firmly fixed to the basal vertebræ. Among them, the *Ophiactinince* are evidently nearest to the *Amphilepididæ*, because neither have paired infradental papillæ or dental papillæ.

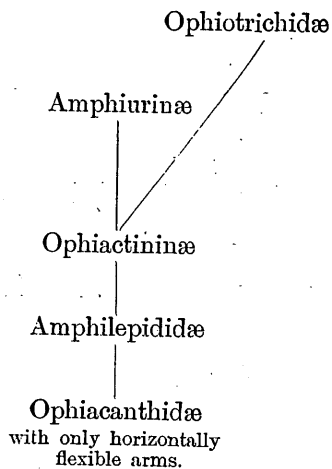
In my opinion, the paired infradental papillæ of the *Amphiurince* and the dental papillæ of the *Ophiotrichidæ* were acquired as supplementary organs for mastication after the teeth had become quadrangular and very stout. The *Amphiurince* might be looked upon as ancestors of the *Ophiotrichidæ*, if the paired infradental papillæ and dental papillæ could be proved to be homologous. But according to CLARK,¹⁾ the paired infradental papillæ are genuine oral papillæ, while the dental papillæ are modifications of the teeth. Hence it appears that the two kinds of papillæ just mentioned are merely analogous organs adapted to a similar function. The *Amphiurince* and *Ophiotrichidæ* are then parallel

1) Growth-Changes in Brittle Stars. Publication No. 182 of the Carnegie Institution, Washington, 1914.

groups and not directly related to each other, not to mention that the *Ophiotrichidæ* are the most highly specialised of the *Gnathophiurida*.

It appears to me to be noticeable that in those forms, in which the masticatory apparatus is well developed, the oral papillæ are liable to reduction. In *Ophiactis*, *Ophiopus*, *Hemipholis*, the *Amphiodia*-group, &c., the papillæ which arise from the adoral shields are absent. In *Ophiopholis* and the *Amphiura*-group, the oral plates are almost free of papillæ. In *Ophiopsila* (*Ophiocomidæ*), the outer oral papillæ are strongly reduced. And finally, the *Ophiotrichidæ* entirely lack the oral papillæ. This fact probably has a certain biological meaning.

The interrelationships of the *Gnathophiurida* may be shown approximately as follows.



The *Chilophiurida* are very extensive and divergent, and it is very difficult to make out their interrelationships clearly. Certain genera of the *Ophiolepididæ*, e.g. *Astrophura*, *Ophiomisidium*, *Ophiomastus*, &c., and *Ophiomusium*, are frequently looked upon by certain authors as very primitive. I can agree with these authors,

if by "primitive" they mean "embryonal" in the strict sense. But if they regard the genera in question as archetypal, I must dissent. My reasons for doing so may be stated as follows.

1. The disk of these forms is entirely or largely covered with the primaries and radial shields, a condition observed in very young and small individuals of other ophiurans. The disk structure of these forms is due to the simple growth of the plates found in a very young stage.

2. In these forms, the genital slits are either entirely invisible or exceedingly small. The genital slits are also entirely invisible in very young and small individuals of other ophiurans.

3. The oral papillæ of these forms are usually fused together to form a single piece. This feature probably represents the stage previous to the division of a common rudiment into individual papillæ.

4. The arms of these forms are extremely short, consisting of only a small number of joints, and are covered chiefly by the lateral arm plates. This condition is also observed in very young and small individuals of other ophiurans.

5. In these forms, the tentacle pores are limited to a few basal arm joints. It appears to me very difficult to look upon this condition as archetypal; it may however be embryonal.

6. The wings of the vertebræ are in these forms exceedingly thick even in the very basal arm joints. This condition may be derived from what is observed in a very young stage by simple growth of the vertebræ without change in the relative size of their constituent parts.

Thus, the genera in question appear to me to be pedomorphic in almost all structures; so I look upon them as neotenic forms. That they can not be truly archetypal, and that embryonal i.e.

pædomorphic characters are not always archetypal, is clear from what I have said already.

In my opinion, the *Ophiarachninae* and *Ophiochitoninae* are the most archetypal of the *Chilophiurida*, some of them being so near to the *Ophiacanthidae* as to be distinguished from the latter only with great difficulty. Indeed *Ophiuroconis* and *Ophiurochæta* have hitherto been confused with *Ophiolimna* of the *Ophiacanthidae* by several authors, and *Ophiochiton* was considered by VERRILL to belong to the *Ophiacanthidae*. Moreover, I have been able to find out incompletely divided vertebræ in certain species of *Ophiuroconis* and *Ophiurodon*.

A next ally of the *Ophiarachninae* is, of course, the *Ophiodermatinae*, which are distinguished from the former by the very short arm spines. Judging from the degree of calcification of the vertebræ, the *Ophiarachninae* are evidently more archetypal than the *Ophiodermatinae*. The *Ophiochitoninae* lead to the *Ophionereidinae*, which are however a step more specialised than the former in having a well developed masticatory apparatus. *Ophiodoris* is evidently intermediate between the *Ophiochitoninae* and the other *Ophionereidinae*. The *Ophionereidinae* are intermediate between the *Ophiochitoninae* and *Ophiocomidae*, so far as the oral skeleton is concerned, and might fairly be looked upon as the direct ancestor of the last mentioned family, if the dorsal surface of the vertebræ were not so strongly notched at the inner end. This last character of the vertebræ of the *Ophionereidinae*, as well as probably of the *Ophiotrichidae*, appears to me to be correlated to the very high flexibility of the arms. The same character is not however equally well developed in all the *Ophionereidinae*, but only very feebly in *Ophiodoris*, which is unique among the *Ophionereidinae* in being destitute of supplementary dorsal arm plates. A parallel character

is found in the *Ophiocomidæ*, in which the dorsal surface of the vertebræ is not distinctly notched at the inner end and the dorsal arm plates are entirely free of supplementary plates. Therefore, it appears to me not very improbable that the *Ophionereidince* and *Ophiocomidæ* may finally merge into a common stock at the very base. I have observed that very young specimens of a certain species of *Ophiocoma* have a squamated disk, which is almost free of granules, and arms which in ventral view remind us of those of *Ophioplax* and *Ophionereidince*. As already pointed out, the oral papillæ are liable to be reduced when the masticatory apparatus is very well developed. This tendency is also observable in the *Ophiopsilince* (*Ophiocomidæ*). Moreover, the *Ophiopsilince* appear to me to be slightly more specialised than the *Ophiocomince*, because the radial shields are fairly bar-like, the outer ends of the genital plates more or less approximated to each other at the dorsal side of the arm base and the tentacle scales very peculiar in shape. I imagine that the *Ophiopsilince* represent a last phase of the *Ophiocomince*.

As suggested by K EHLER, *Ophiochiton* appears to me to resemble much such genera as *Ophiozona* and *Ophiozonella* of the *Ophiolepidince*. This resemblance might be of a superficial nature, if the difference of the arm spines being erect or appressed were of primary importance. But this difference is observable even in the proximal and distal parts of a single arm in many genera. I therefore agree with CLARK, who looks upon the difference of the arm spines in question not to be of primary importance. Then, the relation of *Ophiochiton* to *Ophiozona*, *Ophiozonella*, &c. corresponds to that of the *Ophiarachnince* to the *Ophiodermatince*.

Among the *Ophiolepidince*, *Ophioceramis* has a very well developed masticatory apparatus. Thus, we see that the mastica-

tory apparatus is very well developed more or less independently in three lines, one of which is represented by the *Amphiuridæ* and *Ophiotrichidæ*, the second by the *Ophionereidincæ* and *Ophiocomidæ*, and the third by *Ophioceramis*. As I have already explained, *Ophiomusium* is the most embryonal, i.e. pædomorphic form of the *Ophiolepidincæ*.

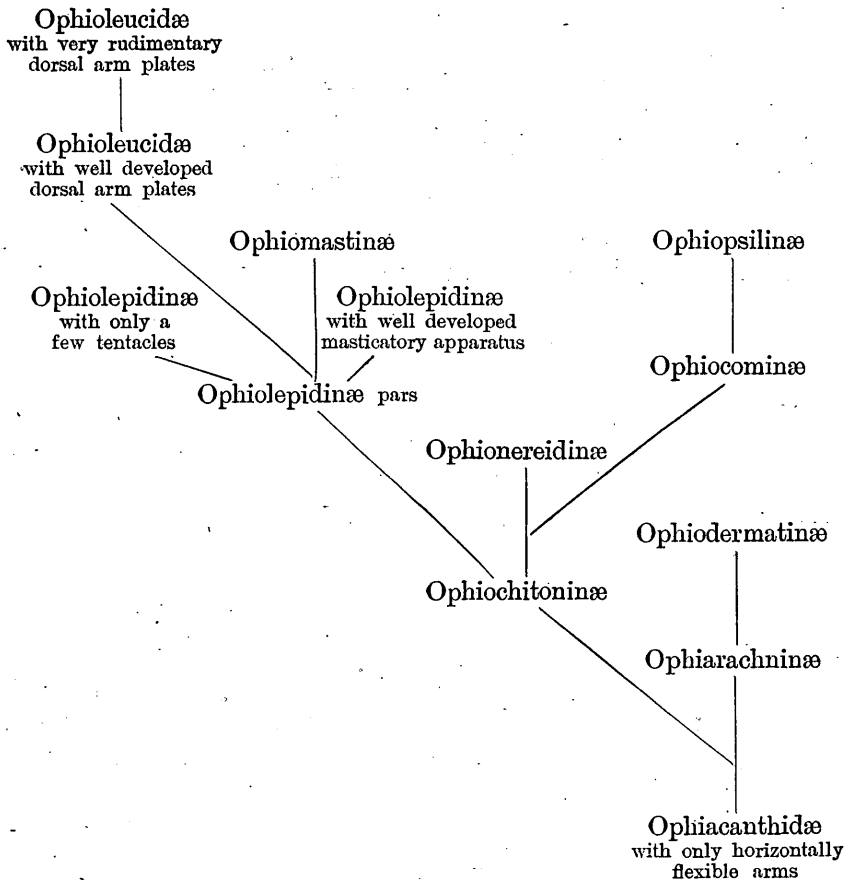
In my opinion, the *Ophiomastincæ* present an almost unbroken series of pædomorphism, of which the terminal members are such genera as *Astrophiura*, *Ophiophycis*, *Ophiomisidium*, *Ophiotypa*, *Ophiomastus*, *Anthophiura*, *Aspidophiura*, *Ophiopyrgus*, &c. The grounds for this opinion have already been stated. If I am right, the *Ophiomastincæ*, as well as *Ophiomusium*, must have been derived from the other *Ophiolepidincæ* by neoteny.

The *Ophioleucidæ* superficially resemble the *Ophiodermatidæ*, but their true allies are, in my opinion, the *Ophiolepidincæ*. The very thick and solid squamation under the superficial granules of the disk, the usually internally joined radial shields, the rhomboidal or lyre-shaped oral shields, the peculiarly long adoral shields, the comparatively long oral plates, the articulation of the genital plate and scale at their outer ends, the flattened arms, the very few—usually only two—arm spines, &c. are characters usually observed also in *Ophiura* and its allies. In certain genera of the *Ophioleucidæ*, the second oral tentacle pores show a tendency to be displaced outside the oral slits. *Ophiotrochus*, which has partially soldered oral papillæ and very rudimentary dorsal and ventral arm plates, may be the most embryonal, i.e. pædomorphic form of the present family.

It is theoretically to be expected that the very embryonal forms of various families, e.g. *Microphiura* of the *Ophiacanthidæ*, *Astrophiura*, *Ophiophycis*, *Ophiomisidium*, *Ophiotypa*, *Ophiomastus*,

Anthophiura, *Aspidophiura*, *Ophiopyrgus*, &c. of the *Ophiomastinæ*, *Ophiomusium* of the *Ophiolepidinæ* and *Ophiotrochus* of the *Ophioleucidæ*, apparently resemble one another in some characters; but these resemblances have in my opinion no significance for the phylogeny.

The interrelationships of the *Chilophiurida* may be shown as follows.



Postscript.

Recently I received CLARK'S "Catalogue of Recent Ophiurans," Mem. Mus. Comp. Zool., Vol. XXV, No. 4. As this paper of mine was then in press, no reference is made to it in the literature of the species. My opinions or notices upon several parts of his monograph have been added as foot-notes.

General Explanation of Plates.

Pl. I, figs. 1-9 illustrate the internal structures of the *Ophiomyxinae*. The peristomial plates are double in *Ophiomyxa australis* (figs. 4 & 7) and *Ophiostiba hidekii* (fig. 9), one overlapping the other in the latter species; triple in *Ophiodera anisacantha* (fig. 1); double or triple in *Ophiomyxalus gotoi* (fig. 8). It is noteworthy, that the peristomial plates show a tendency to be simple in younger stages, as may be seen in fig. 4, illustrating a younger specimen of *Ophiomyxa australis*. The double or triple (at least in adult), thin, delicate peristomial plates, and not very stout oral plates and frames are characteristics of the *Ophiomyxinae* in contrast to the *Ophiobyrsinae*, *Trichasteridae* and *Gorgonocephalidae*. The articulation of the genital plate and radial shield is illustrated in fig. 1 (*Ophiodera anisacantha*) and fig. 4 (*Ophiomyxa australis*); it is very simple, without any particular condyle and socket, a common character of the *Phrynophiurida* and *Lamophiurida*. In the last two illustrations, the genital scales are seen to articulate with the genital plates at some distance away from the outer ends of the latter, a common character of the *Ophiomyxidae* and *Asteronychinae* in contrast to the *Trichasterinae*, *Asteroschematinae* and *Gorgonocephalidae*; and the dorsal surface of the vertebrae (except the very basal ones) is rhomboidal and the wings of the same very thin on the sides, a characteristic of the *Ophiomyxinae* in contrast to the *Ophiobyrsinae*, *Trichasteridae* and *Gorgonocephalidae*. The articular surfaces of the vertebrae are illustrated in figs. 2 & 3 (*Ophiodera anisacantha*) and 5 & 6 (*Ophiomyxa australis*); the articulation is typically zygospondyline, the umbo and knobs on the inner articular surface, and the shoulder and peg on the outer, being all well developed, a character of the *Ophiomyxinae* in contrast to the *Ophiobyrsinae*, *Trichasterinae* and *Gorgonocephalidae*; the great size of both the upper and lower muscular fossae is a character common to the *Ophiomyxidae* and the other "common" ophiurans in contrast to the *Trichasteridae* and *Gorgonocephalidae*.

Pl. I, figs. 10 & 11 and Pl. II, fig. 1 illustrate a vertebra of *Ophiomilax mirabilis*, a representative of the *Ophiobyrsinae*. The articulation is typically streptospondyline or saddle-shaped, a common character of the *Ophiobyrsinae*, *Trichasteridae* and *Gorgonocephalidae* in contrast to the *Ophiomyxinae*. The upper and lower muscular fossae are both large, a character of the *Ophio-*

myxida in contrast to the *Trichasteridæ* and *Gorgonocephalidæ*. The vertebra is moderately short and stout (Pl. II, fig. 1), being shorter and stouter than that of the *Ophiomyxinae* but not so very short and stout as in the *Trichasteridæ* and *Gorgonocephalidæ*, a characteristic of the *Ophiobyrsinae*. The wing of the vertebra is very thick laterally as well as dorsally, a common character of the *Ophiobyrsinae*, *Trichasteridæ* and *Gorgonocephalidæ*. As the specimen, from which the illustration has been made, is very small and young, the characteristic shape of the vertebra is not yet fully developed; the vertebrae near the disk of full-grown specimens of the *Ophiobyrsinae* are much more stout and more distinctly discoidal. Pl. I, figs. 12 & 13 show the two forms of arm spines of *Ophiosmilax mirabilis*, both being converted into compound hooks. It is noteworthy, that the arm spines of the majority—presumably all—of the *Phrynophiurida* are always hook-shaped in their embryonal stages, as observed in the distal arm joints.

Pl. I, figs. 14-16 illustrate the internal structures of *Asteronyx loveni*, a representative of the *Asteronychinae*. The peristomial plates are simple, stout and firmly soldered to the oral frames, which are also very stout, common characters of the *Ophiobyrsinae*, *Trichasteridæ* and *Gorgonocephalidæ* in contrast to the *Ophiomyxinae*. The very basal vertebrae are not notably shorter than the outer; all the vertebrae are short, stout and discoidal; and the vertebral articulation is typically streptospondyline or saddle-shaped; all these characters are common to the *Ophiobyrsinae*, *Trichasteridæ* and *Gorgonocephalidæ*. The upper muscular fossae are fairly large and the lower rather small; this character is rather intermediate between those of the *Ophiomyxidae* and of the other *Trichasteridæ*, for the upper and lower muscular fossae are subequal in size in the former and very unequal in the latter. The relatively small inequality between the upper and lower fossae here illustrated may partially be due to the youngness of the specimen. The genital plates are high in position relatively to the basal vertebrae; this character also approaches to that of the *Ophiomyxidae*. The genital scales articulate with the genital plates near the inner ends of the latter, a characteristic of the *Asteronychinae* in contrast to the *Trichasterinae*, *Asteroschematinae* and *Gorgonocephalidæ*. The articulation of the genital plate and radial shield is very simple, without any particular condyle and socket, a common character of the *Phrynophiurida* and *Lamophiurida*.

Pl. II, figs. 7 & 8 illustrate the skeletal structure of *Trichaster elegans*, a representative of the *Trichasterinae*. The oral plates are very stout, a common character of the *Ophiobyrsinae*, *Trichasteridæ* and *Gorgonocephalidæ*. The adoral shields are also large and stout, a character of the *Ophiomyxidae* and *Trichasteridæ* in contrast to the *Gorgonocephalidæ*; a peculiar feature is that they are divided into inner and outer halves. The lateral arm plates of the two sides are separated from each other by the ventral arm plates, a character of the *Asteronychinae* and *Trichasterinae* in contrast to the *Asteroschematinae*. The ventral arm plates are divided into two or three secondary plates, a peculiar feature. The interbrachial area is very small and the genital plates and scales are very closely set side by side; this is a generic character. That the genital scales do not lie far inward from the outer ends of the genital plates is a common character of the *Trichasterinae*, *Asteroschematinae* and *Gorgonocephalidæ* in contrast to the

Asteronychinae. Text-fig. 8 b-d (p. 38) may also be referred to here. The upper muscular fossæ of the vertebra are much larger than the lower, a common character of the *Trichasteridae* and *Gorgonocephalidae*; each dorsal arm plate being represented by a pair of triple rows of nodule-like secondary plates is a generic character; that each dorsal arm plate is represented by a pair of secondary plates or of groups of secondary plates in the basal arm joints containing the generative glands, is a common character of *Astroceras*, *Trichaster* and *Asteroschema*.

Pl. II, figs. 2-6 illustrate the internal structure of *Asteroschema japonicum*, a representative of the *Asteroschemalinae*. The very stout peristomial plates which are firmly soldered to the also very stout oral frames, the short and stout and markedly discoidal vertebrae, the streptospondyline vertebral articulation, the markedly unequal upper and lower muscular fossæ of the vertebrae, the very simple articulation of the genital plate and radial shield, and the position of the genital scales in relation to the genital plates, are characters which have been already explained. The lateral arm plates are transversely bar-like, and those of the two sides are in contact with each other in the ventral median line, thus separating the very small ventral arm plates from one another, a characteristic of the *Asteroschemalinae*. Each dorsal arm plate is represented by a pair of bar-like rows of secondary plates; this is a generic character, though the fact that each dorsal plate is represented by a pair or group of secondary plates is a common character of *Astroceras*, *Trichaster* and *Asteroschema*, as already explained.

Pl. II, figs. 9 & 10 illustrate the internal structure of *Astrotoma sobrina*, a representative of the *Astrotominae* (*Gorgonocephalidae*). The common characters of the *Trichasteridae* and *Gorgonocephalidae* are sufficiently explained in the text. The basal vertebrae are much narrower and smaller than those beyond, a characteristic of the *Astrotominae* in contrast to the *Gorgonocephalinae*. They are covered over by the muscles between them and the genital plate, also a characteristic of the *Astrotominae*. The adoral shields are very small and insignificant, a characteristic of the *Gorgonocephalidae* in contrast to the *Trichasteridae*. The area just inside the interbranchial ventral surface is occupied by a mosaic of supplementary plates, a characteristic of the *Astrotominae* in contrast to those genera of the *Gorgonocephalinae* with arms simple or divided a few times, and a common character of the *Astrotominae* and those genera of the *Gorgonocephalinae* with arms divided many times. The common character just mentioned may be due to convergence. Pl. II, fig. 11 shows a compound hook of an arm annulus of *Astrothamnus echinaceus*. Such a compound hook with more than two supplementary hooklets besides the terminal one is uncommon among the *Gorgonocephalidae*. The compound hooks of the arm annuli of *Astrotoma sobrina* belong partially to this type with two or three supplementary hooklets and partially to the common type with only a single supplementary hooklet besides the terminal one.

Pl. III, figs. 1-6 illustrate the internal structures of the *Ophiacanthidae*. The peristomial plates of *Ophiacantha bidentata* (fig. 1), *Ophiolebes tuberosa* (fig. 4), *Ophiolimna antarctica* (fig. 5) and *O. papillata* (fig. 6) are almost or perfectly entire and very large, characters common to most of the genera of the *Læmophiurida* and certain groups of the other orders. That the peristomial plates of the two species of *Ophiolimna* just mentioned are almost entire and very wide and short, is a proof of their Ophiacanthine, and not Ophioderminate, affinity; the peristomial plates

of the *Ophiidermatidae* being always triple and rather long relatively to their width. The oral frames of *Ophiolimna* are very slender, a character of those forms of the *Ophiacanthidae* with zygospondyline vertebral articulation; those of *Ophiolebes* and *Ophiacantha bidentata* are rather stout, a character of those forms of the same family with streptospondyline vertebral articulation. The vertebral articulation of the latter type is illustrated here by *Ophiacantha bidentata* (figs. 2 & 3). It is noteworthy that both the types of vertebral articulation are represented in *Ophiacantha*; *Ophiacantha cuspidata* having zygospondyline vertebral articulation according to LYMAN. The streptospondyline articulation is a common character of a part of the *Ophiacanthidae* and all the *Hemieuryalidae* among the *Læmophiurida*, as well as of the *Ophiobyrsinae*, *Trichasteridae* and *Gorgonocephalidae* among the *Phrynophiurida*. *Ophiolebes tuberosa* (fig. 4) has short and stout vertebrae, whose wings are rather thick laterally as well as dorsally, also a common character of those forms with streptospondyline vertebral articulation. The articulation of the genital plate and radial shield is, as shown in the figure, very simple, without any special condyle and socket, a common character of the *Phrynophiurida* and *Læmophiurida*. The genital plate and scale merely articulate with each other, without being soldered together, a character of the *Ophiacanthidae* and some other orders in contrast to the *Hemieuryalidae*.

Pl. III, figs. 7 & 8 illustrate the internal structures of *Amphiactis umbonata*, a representative of the *Amphilepididae*. The peristomial plates are almost simple and very large, a character distinguishing the present family from all the other *Gnathophiurida*. The oral plates and frames are slender and the latter have no lateral wings, also a character distinguishing the present family from the other *Gnathophiurida*. The dental plate is absent; this is a peculiar character. The teeth are not very stout and thick, though appearing wide in the figure, also a character of the present family in contrast to the other *Gnathophiurida*. The genital plates bear a very conspicuous, ball-like articular condyle on the dorsal side near the outer end; this is a characteristic of the *Gnathophiurida* in contrast to all the other orders. The genital scales are wide, thin and leaf-like and articulate with the genital plates near the outer ends of the latter; these characters of the genital scales are notable in the *Gnathophiurida*, though also found in some *Chilophiurida*. The dorsal surface of the vertebra is rhomboidal, instead of being strongly notched at the inner end, a common character of the *Amphilepididae* and *Amphiuridae* in contrast to the *Ophiotrichidae* among the *Gnathophiurida*. The distal vertebrae (fig. 8) are in this species imperfectly divided into halves by a series of pores. Such vertebrae or those in which the halves are divided by a moniliform pore, are found in several of the genera with the arms perfectly protected by the plates (see also Pl. V, fig. 3); while vertebrae with the halves divided by a fusiform pore are found in the *Ophiomyxinae*, in which the dorsal side of the arms is largely unprotected. See text-fig. 2 f & g, p. 18.

Pl. III, figs. 9-13 and Pl. IV, figs. 1-5 illustrate the internal structures of the *Amphiuridae*. The peristomial plates of *Ophiactis pteropoma* (Pl. III, fig. 9), *Ophiopholis aculeata* (Pl. III, fig. 10), *Hemipholis elongata* (Pl. IV, fig. 1), *Amphioplus ancistrotus* (Pl. III, fig. 11), *Amphiacantha dividua* (Pl. III, fig. 12), *Ophiophragmus japonicus* (Pl. IV, fig. 3) and *Amphipholis kochii* (Pl. IV, fig. 2) are simple and very small, a common character of the *Amphiuridae*, with the excep-

tion of the *Amphiura*-group, and the *Ophiotrichidae*; those of *Amphiura vadicola* (Pl. III, fig. 13), *A. trachydisca* (Pl. IV, fig. 4) and *Ophiocentrus verticillatus* (Pl. IV, fig. 5) are double and very small, a character of the *Amphiura*-group. The common outline of the oral and dental plates of all the representatives here illustrated is X-shaped, though that of *Amphiacantha dividua* is slightly atypical owing probably to the fact that the specimen is very small and young. This character is common to the *Amphiuridae* and *Ophiotrichidae* in contrast to those groups of the *Chilophiurida* with well developed masticatory apparatus. The teeth are very stout, squarish, with wide and truncated tips, and the oral frames are very stout and have well developed lateral wings, characters common to the *Amphiuridae*, *Ophiotrichidae*, *Ophioceramis*, *Ophionereidinae* and *Ophiocomidae*. The genital plates in *Ophiopholis aculeata* (fig. 10) and *Ophiocentrus verticillatus* (fig. 5) bear each a very conspicuous, ball-like articular condyle on the dorsal side near the outer end; this is a characteristic of the *Gnathophiurida*, as already explained. They are firmly attached to the basal vertebrae, a common characteristic of the *Amphiuridae* and *Ophiotrichidae* in contrast to all the other ophiurans. The genital scales of *Ophiopholis aculeata* (Pl. III, fig. 10) are wide, thin and leaf-like and articulate with the genital plates near the outer ends of the latter; this is also a character of the *Gnathophiurida* and part of the *Chilophiurida*. The vertebrae are seen in fig. 10, Pl. III (*Ophiopholis aculeata*) and fig. 5, Pl. IV (*Ophiocentrus verticillatus*); their dorsal surface is rhomboidal and not very deeply notched at the inner end, a common character of the *Amphilepididae* and *Amphiuridae*, as well as several groups of the other orders, in contrast to the *Ophiotrichidae*.

Pl. IV, figs. 6-8 illustrate the internal structures of the *Ophiotrichidae*. In all the species here illustrated, viz. *Ophiothrix nereidina* (fig. 6), *O. koreana* (fig. 7) and *Ophiothela danae* (fig. 8), the peristomial plates are simple and small, a common character of part of the *Amphiuridae*, and the *Ophiotrichidae*; the common outline of the oral and dental plates is X-shaped, a common character of the *Amphiuridae* and *Ophiotrichidae*; the teeth are very stout, squarish, with wide and truncated ends, and the oral frames are very stout and have well developed lateral wings, characters common to the *Amphiuridae*, *Ophiotrichidae*, *Ophioceramis*, *Ophionereidinae* and *Ophiocomidae*; the genital plates bear a very conspicuous, ball-like articular condyle on the dorsal side near the outer end, a characteristic of the *Gnathophiurida*; the dorsal surface of the vertebra (except the very basal ones) is Y-shaped, a characteristic of the *Ophiotrichidae* in contrast to the *Amphilepididae* and *Amphiuridae*; the genital scales are wide, thin and leaf-like, a character of the *Gnathophiurida* and part of the *Chilophiurida*. The radial shields are, as seen in fig. 6 (*Ophiothrix nereidina*), very large and triangular, a common character of most of the genera of the *Ophiotrichidae*, and have a very large articular socket to fit to the ball-like articular condyle of the genital plate, a characteristic of the *Gnathophiurida*.

Pl. V, figs. 1-5 show the internal structures of *Astrophium karumurai*. The peristomial plates are absent, though the peritoneal membranes of the oral region and other parts contain very fine scales (fig. 1). It is stated by LYMAN, that *Ophioplinthus medusae* lacks the peristomial plates. The oral frames are very long and slender, also reminding us of those of *Ophioplinthus medusae*. The oral plates are also slender, and the dental plate is stout. The genital

plates and scales are entirely internal and very much reduced in size; the latter are entirely proximal to the former, the two articulating with each other terminally. These features of the genital plates and scales are quite peculiar. The genital plate has no special condyle and socket for articulation with the radial shield, but the outer end itself of the plate serves for an articular facet. It may be thought, that *Astrophiuura* is not Chilophiuridan but Læmophiuridan in the articulation of the genital plate and radial shield; but my view is that, this condition is simply a result of the extreme reduction of the genital plates. The very basal vertebræ are large and long, instead of being very small and short, and are quadrangular in dorsal view, again reminding us of those of *Ophioplithus medusæ*. The ventral side of each vertebra within the pentagonal "asteroid" body has a well marked median suture (fig. 2). The vertebræ of the free arms are divided into halves by a very narrow moniliform slit (fig. 3). The articulation of the same is zygospondyline (figs. 4 & 5), a common character of the *Ophiomyxinae*, *Ophiacanthidae* pars, *Gnathophiurida* and *Chilophiurida*.

Pl. V, figs. 6-12 illustrate the internal structures of the more typical genera of the *Ophiolepidida*. In all the species here illustrated, viz. *Stegophiura sladeni* (fig. 6), *Ophiomusium trychnum* (fig. 7), *O. cancellatum* (fig. 8), *Ophiozonella longispina* (fig. 9), *Ophiozona impressa* (fig. 10), *Ophioplocus japonicus* (fig. 11) and *Ophioceramis januarii* (fig. 12), the peristomial plates are double and small, a character common to the majority of the present family; the double or triple character of the peristomial plates is common to the majority of the *Ophiolepidida* and to all the other families of the *Chilophiurida* (all the members of the *Ophiolepidida* which are atypical on this point are very pædomorphic). The teeth are slender and pointed in *Stegophiura* and *Ophiomusium*, show a tendency to be stout and squarish in *Ophiozonella*, are moderately stout and squarish in *Ophiozona* and *Ophioplocus*, and very strongly so in *Ophioceramis*. The stoutness of the oral frames increases also almost in the same order; the oral frames of *Ophiozona* and *Ophioplocus* show a tendency to have lateral wings, and those of *Ophioceramis* have well developed lateral wings. In *Stegophiura*, *Ophiomusium* and *Ophiozonella*, the first vertebra is the shortest; while in *Ophiozona*, *Ophioplocus* and *Ophioceramis*, the second is the shortest. It is noteworthy, that the very basal vertebræ of *Ophiomusium trychnum* are not much reduced in length; this is a common character of the more pædomorphic forms.

Pl. V, fig. 13 shows the internal structures of *Ophioleuce charischema*, a representative of the *Ophioleucida*. The peristomial plates are rather large and triple; triple peristomial plates are also found in the *Ophiodermatida* but not in the *Ophiolepidida*. The oral plates and frames are long and slender, and the latter do not bear well developed lateral wings; these characters are found also in the typically deep-water forms of the *Ophiolepidida*. The genital plate has two articular condyles and one articular pit to fit to the two condyles and one pit of the radial shield, a characteristic of the *Chilophiurida*. The genital scales are wide, thin and leaf-like; this character is also found in *Ophiura* and its allies, as also in the *Gnathophiurida*, and is correlated with very long genital slits. The first vertebra, not the second, is the shortest; this condition is also observed in the deep-water forms of the *Ophiolepidida*, as well as some other families.

Pl. VI, figs. 1-7 illustrate the internal structures of the *Ophiidermatidae*. In all the species here illustrated, viz. *Ophiurodon grandisquama* (fig. 1), *Ophiurochata mixta* (fig. 2), *Ophiuroconis miliaria* (fig. 3), *Ophiarachna incrassata* (fig. 4), *Bathypectinura gotoi* (fig. 5), *Pectinura anchysta* (fig. 6) and *Ophiarachnella gorgonia* (fig. 7), the peristomial plates are moderately large and triple, a common character of the *Ophiidermatidae* and *Ophiochitoninae* as well as *Ophioleuce* and *Ophiocrasis*; the oral frames do not have well developed lateral wings, a common character of the *Ophiolepididae* pars, *Ophioleucidae*, *Ophiidermatidae* and *Ophiochitoninae*, in contrast to the *Ophionereidinae*, *Ophiocomidae* and *Ophioceramidae*; the teeth are not very stout, though often squarish. That *Ophiurodon*, *Ophiurochata* and *Ophiuroconis* have triple peristomial plates is a proof of their being Ophiidermatine and not Ophiacanthine. The majority of the *Ophiacanthidae* have almost entire peristomial plates, and *Ophiothamnus*, the only known Ophiacanthine member with triple peristomial plates, is very different from the genera in question. The oral frames of *Ophiarachna incrassata* (fig. 4) and *Bathypectinura gotoi* (fig. 5) are especially long and have V-shaped grooves for the ambulacral ring-canal, much reminding us of those of *Ophiochiton fastigatus* (fig. 8).

Pl. VI, figs. 8 & 9 illustrate the internal structures of the *Ophiochitoninae*, which are almost similar to those of the *Ophiidermatidae*. In both the species here illustrated, viz. *Ophiochiton fastigatus* (fig. 8) and *Ophioplax lamellosa* (fig. 9), the peristomial plates are moderately large and triple, quite as in the *Ophiidermatidae*; the oral frames do not have well developed lateral wings, and the teeth are not very stout, again as in the *Ophiidermatidae* and certain other families; and the dorsal surface of the vertebra is rhomboidal, instead of being strongly notched at the inner end, quite as in many other families, but not as in the *Ophionereidinae*. The oral frames of *Ophiochiton fastigatus* are especially long and have V-shaped grooves for the ambulacral ring-canal, like those of *Ophiarachna incrassata* and *Bathypectinura gotoi*, as already mentioned. The genital plate of *Ophiochiton fastigatus* has two articular condyles and one articular pit to fit to the two condyles and one pit of the radial shield, a characteristic of the *Chilophiurida*.

Pl. VI, figs. 10 & 11 and Pl. VII, figs. 1-3 illustrate the internal structures of the *Ophionereidinae*. The peristomial plates of *Ophiodoris periculles* (Pl. VI, fig. 10), *Ophionereis annulata* (Pl. VII, fig. 1) and *O. reticulata* (Pl. VII, fig. 2) are double and very small, quite as in the *Ophiocomidae*, and those of *Ophiocrasis marktanneri* (Pl. VII, fig. 3) are triple and very small. The common outline of the oral and dental plates of all the species here illustrated is T-shaped instead of being X-shaped, a common character of *Ophioceramidae*, the *Ophionereidinae* and *Ophiocomidae* among the *Chilophiurida*, in striking contrast to the *Amphiuridae* and *Ophiotrichidae* among the *Gnathophiurida*. The teeth of all the *Ophionereidinae* are stout and squarish, quite as in *Ophioceramidae*, *Ophiocomidae*, *Amphiuridae* and *Ophiotrichidae*. The oral frames of *Ophiodoris* are moderately stout and have more or less well developed lateral wings, and those of *Ophionereis* and *Ophiocrasis* are very stout and have very well developed lateral wings. The dorsal surface of the vertebra of *Ophiodoris* (Pl. VI, fig. 11) is Y-shaped, except in

the very basal one, being moderately notched at the inner end, and that of *Ophionereis* and *Ophiocrasis* is **V**-shaped, being strongly notched at the inner end. The **Y**- or **V**-shape of the dorsal surface of the vertebra is a common character of the *Ophiotrichidae* among the *Gnathophiurida* and the *Ophionereidinae* among the *Chilophiurida*.

Pl. VII, figs. 4-7 illustrate the internal structures of the *Ophiocominae*. In all the species here illustrated, viz. *Ophiocoma scolopendrina* (figs. 4 & 5), *Ophiomastix annulosa* (fig. 6) and *Ophiarthrum elegans* (fig. 7), the peristomial plates are double and very small, as in *Ophiodoris* and *Ophionereis*; the common outline of the oral and dental plates is **T**-shaped, as in *Ophioceramis* and the *Ophionereidinae*; the teeth are very stout and squarish and the oral frames are very stout and have well developed lateral wings, as in the *Amphiurida*, *Ophiotrichidae*, *Ophioceramis* and the *Ophionereidinae*; the dorsal surface of the vertebra is rhomboidal and not strongly notched at the inner end, a character distinguishing the *Ophiocominae* from the *Ophionereidinae*. The genital plates have, as shown in fig. 7 (*Ophiarthrum elegans*), each two articular condyles and one articular pit to fit to the two condyles and one pit of the radial shield, a characteristic of the *Chilophiurida*. The genital scales are narrow and bar-like and articulate with the genital plates at some distance inwards from the outer ends of the latter, a common character of the majority of the *Chilophiurida*, viz. the *Ophiomastinae* pars, *Ophiolepidinae*, *Ophiodermatida*, *Ophiochilonidae* and *Ophiocomidae*. The radial shields are very large, subtriangular, and consist of the body and a lateral wing, a character distinguishing the *Ophiocominae* from the *Ophiopsilinae*.

Pl. VII, fig. 8 shows the internal structure of *Ophiopsila rüsei*, a representative of the *Ophiopsilinae* with the sole genus *Ophiopsila*. The oral skeleton is throughout similar to that of the *Ophiocominae*. The vertebrae are also similar, though relatively narrower. The genital plates, as well as the radial shields, have each two articular condyles and one pit, and the genital scales are narrow and bar-like and articulate with the genital plates at some distance inwards from the outer ends of the latter, decisive proofs that *Ophiopsila* belongs not to the *Gnathophiurida* but to the *Chilophiurida*, and not to the *Amphiuridae* but to the *Ophiocomidae*. The outer ends of the genital plates of the same radius approach more closely to each other than in the *Ophiocominae*. The radial shields are very narrow and bar-like, the lateral wings being scarcely developed, a character distinguishing *Ophiopsila* from all the *Ophiocominae*.

Abbreviations used in the Explanation of Plates.

- A Adoral shield.
- AP .. Articular peg.
- AS . . . Articular shoulder.
- C Articular condyle of genital plate or radial shield.
- D Dental plate.
- F Oral frame.
- G Genital plate.
- K Articular knob.
- L Lateral arm plate.
- LF .. Lower muscular fossa.
- M Madreporic oral shield.
- O Oral plate.
- OS . . . Oral shield.
- P Peristomial plate.
- R Radial shield.
- S Genital scale.
- U Articular umbo.
- UF .. Upper muscular fossa.
- V Ventral arm plate.

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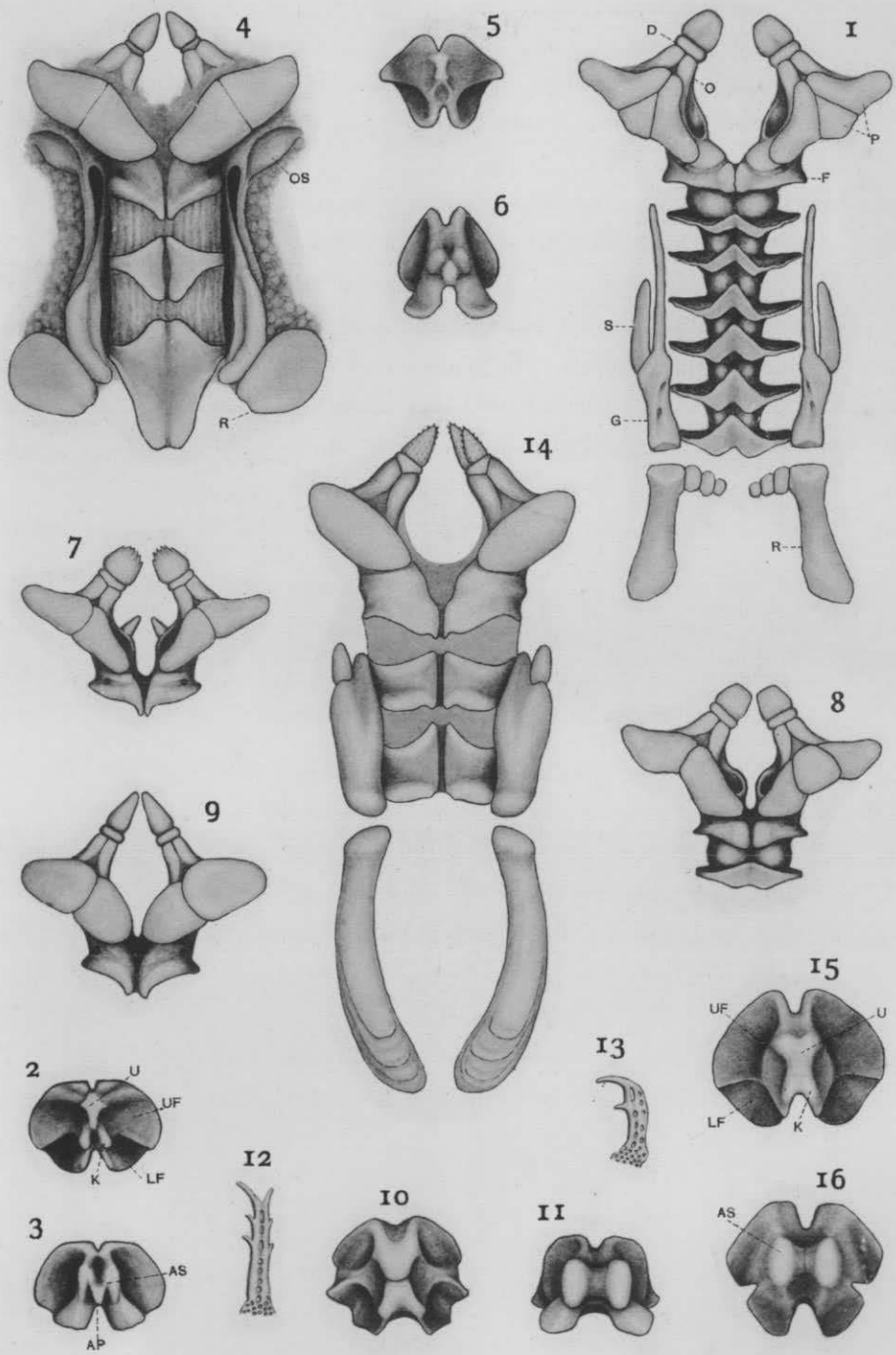
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MONOGRAPH OF JAPANESE OPHIUROIDEA.

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PLATE I.

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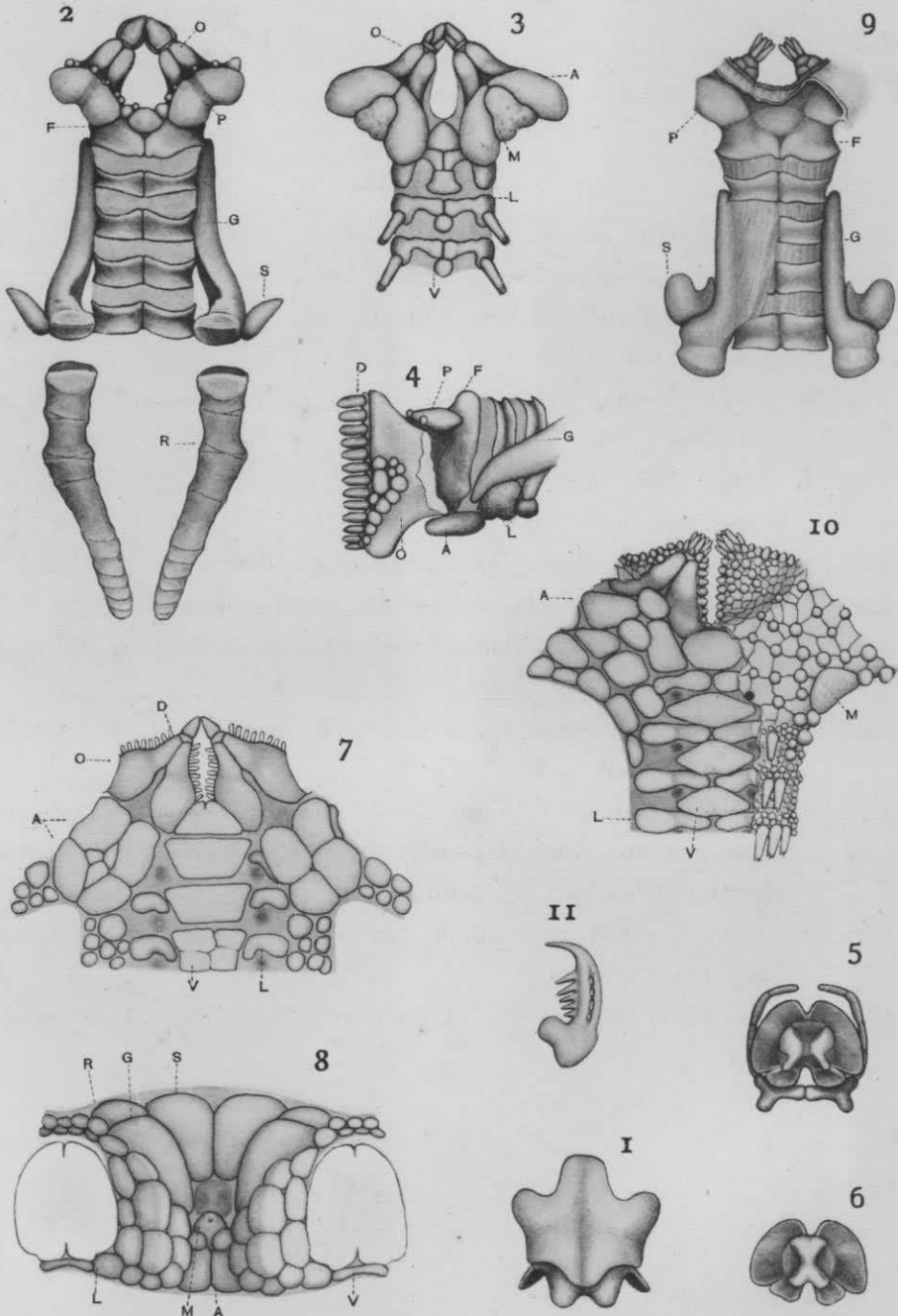
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PLATE II.

PLATE II.

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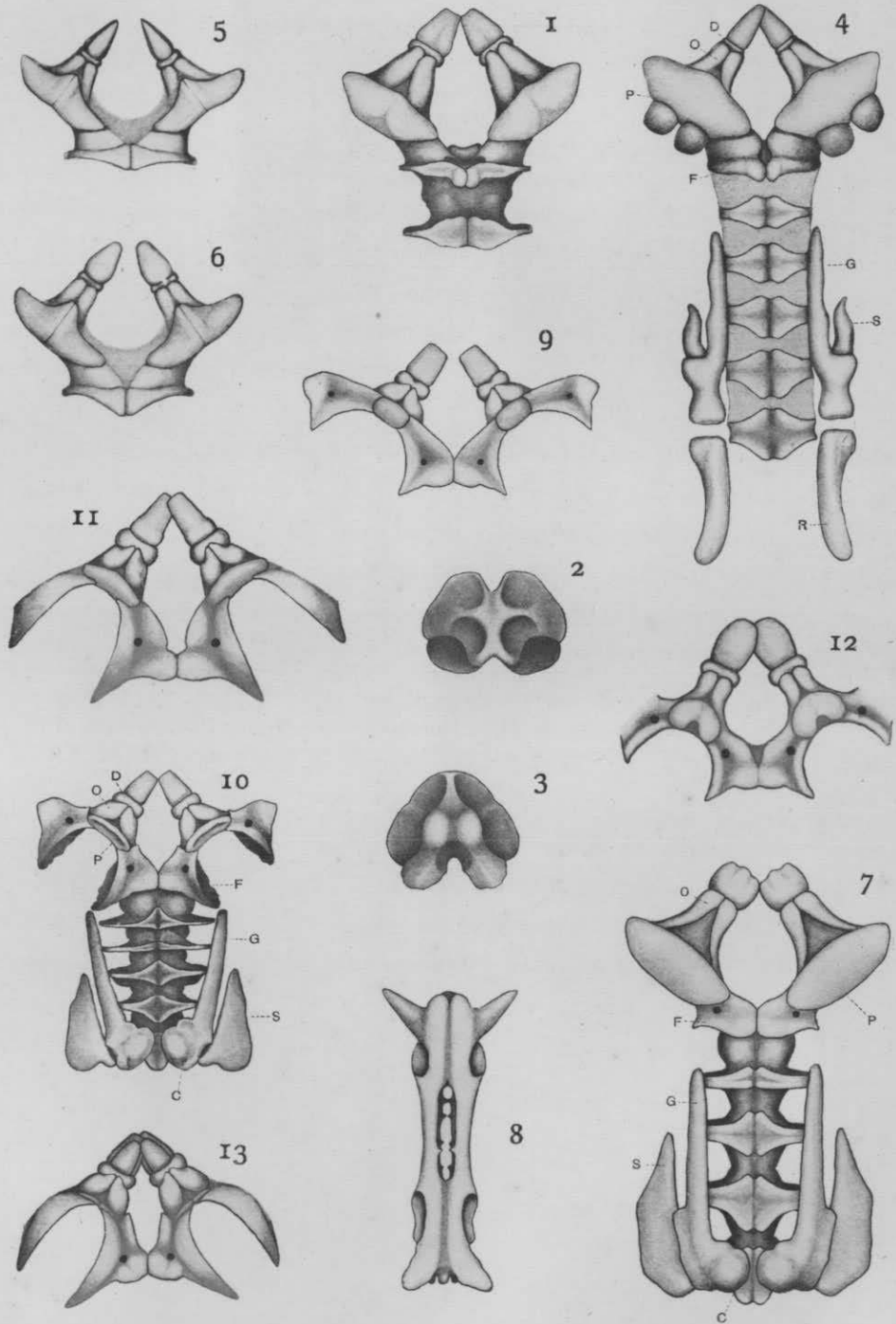
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PLATE III.

PLATE III.

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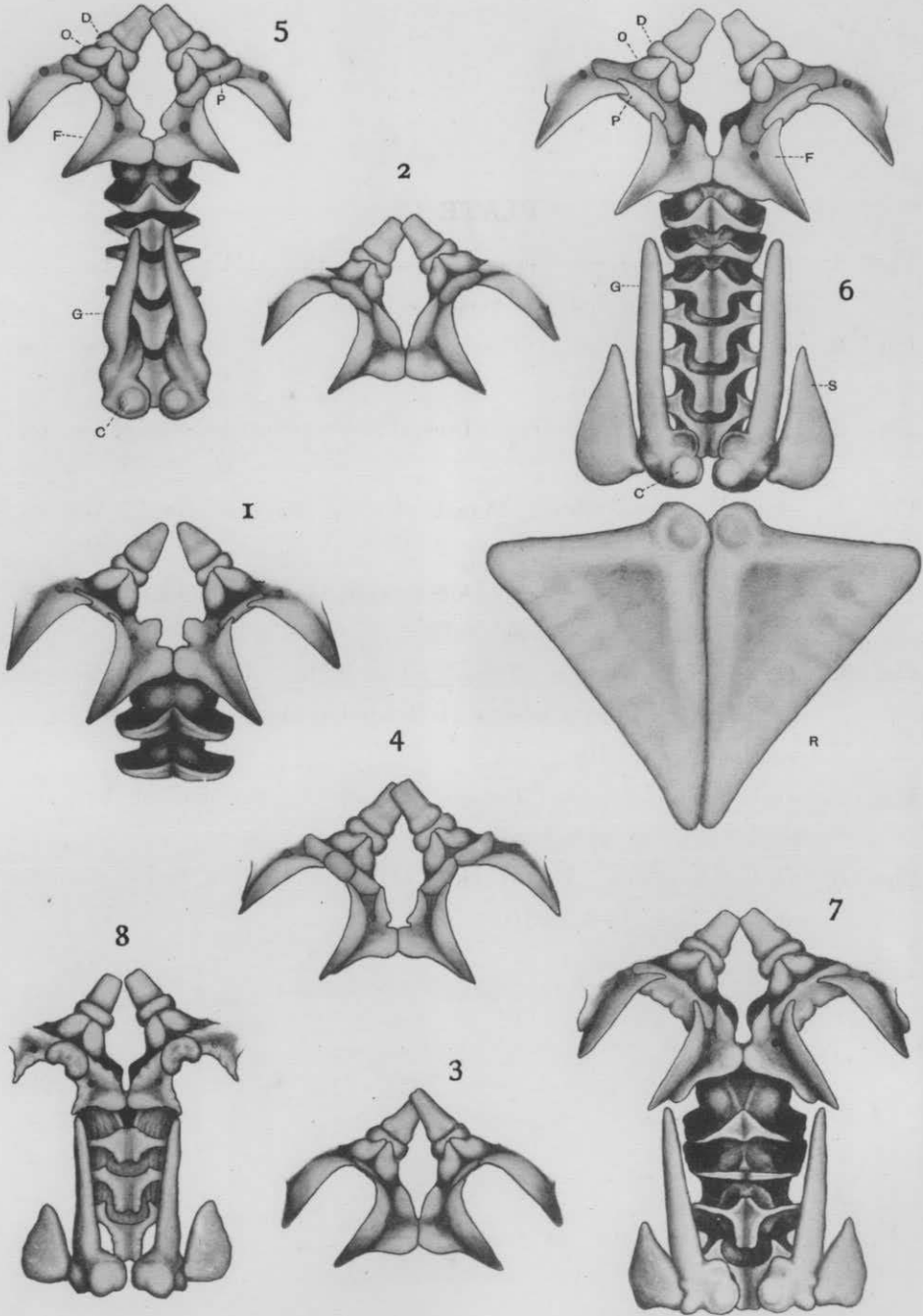
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PLATE IV.

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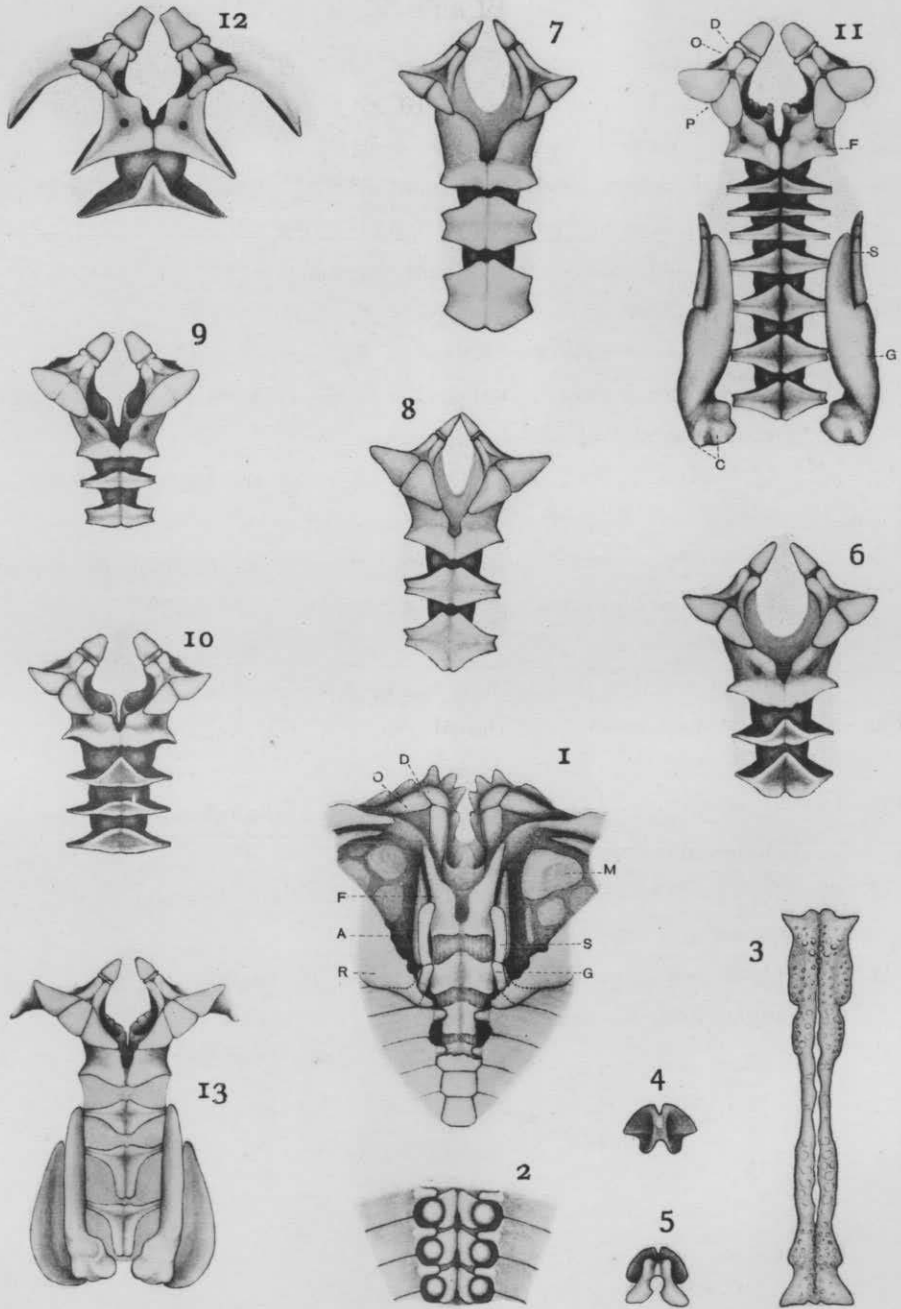
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PLATE V.

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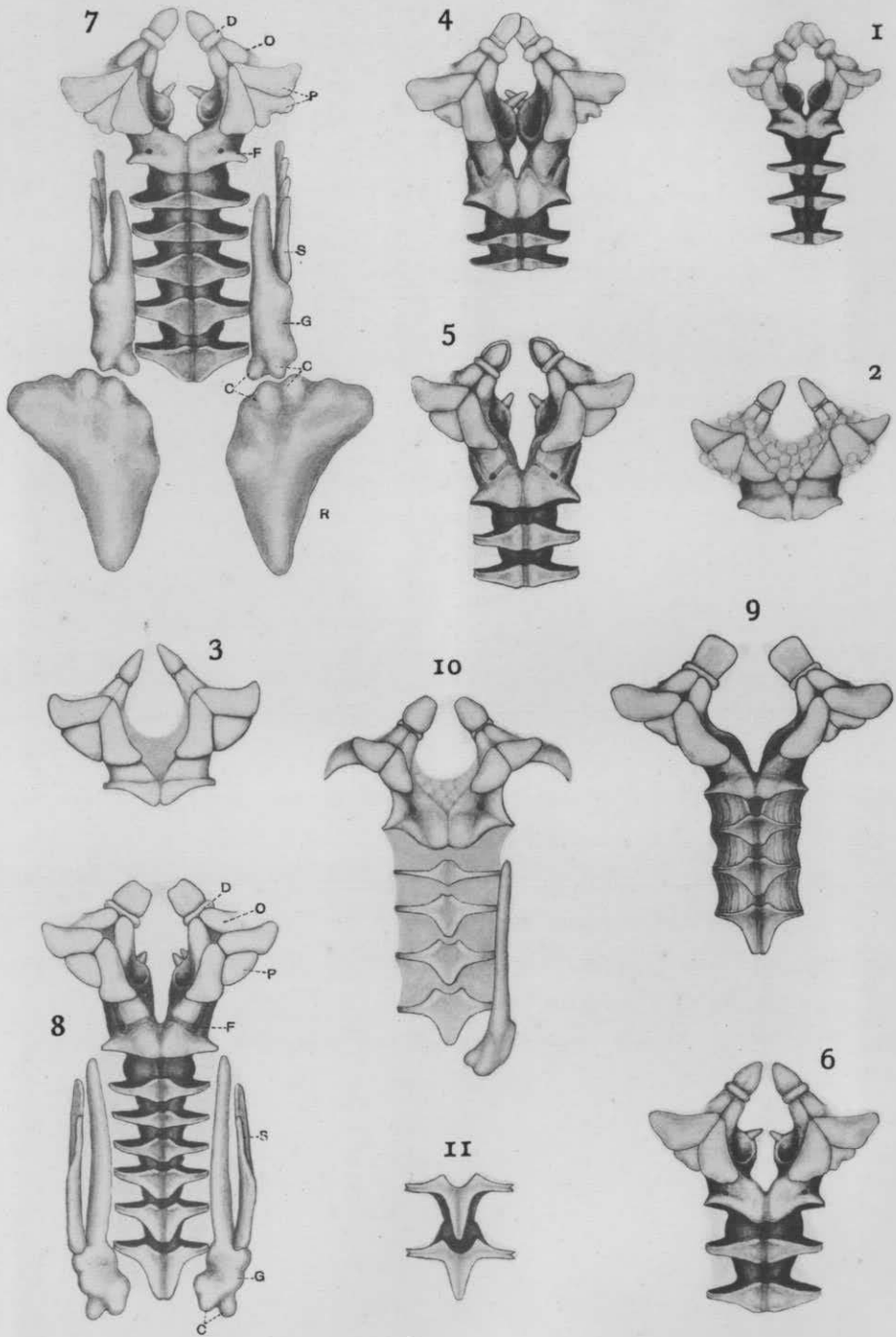
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PLATE VI.

PLATE VI.

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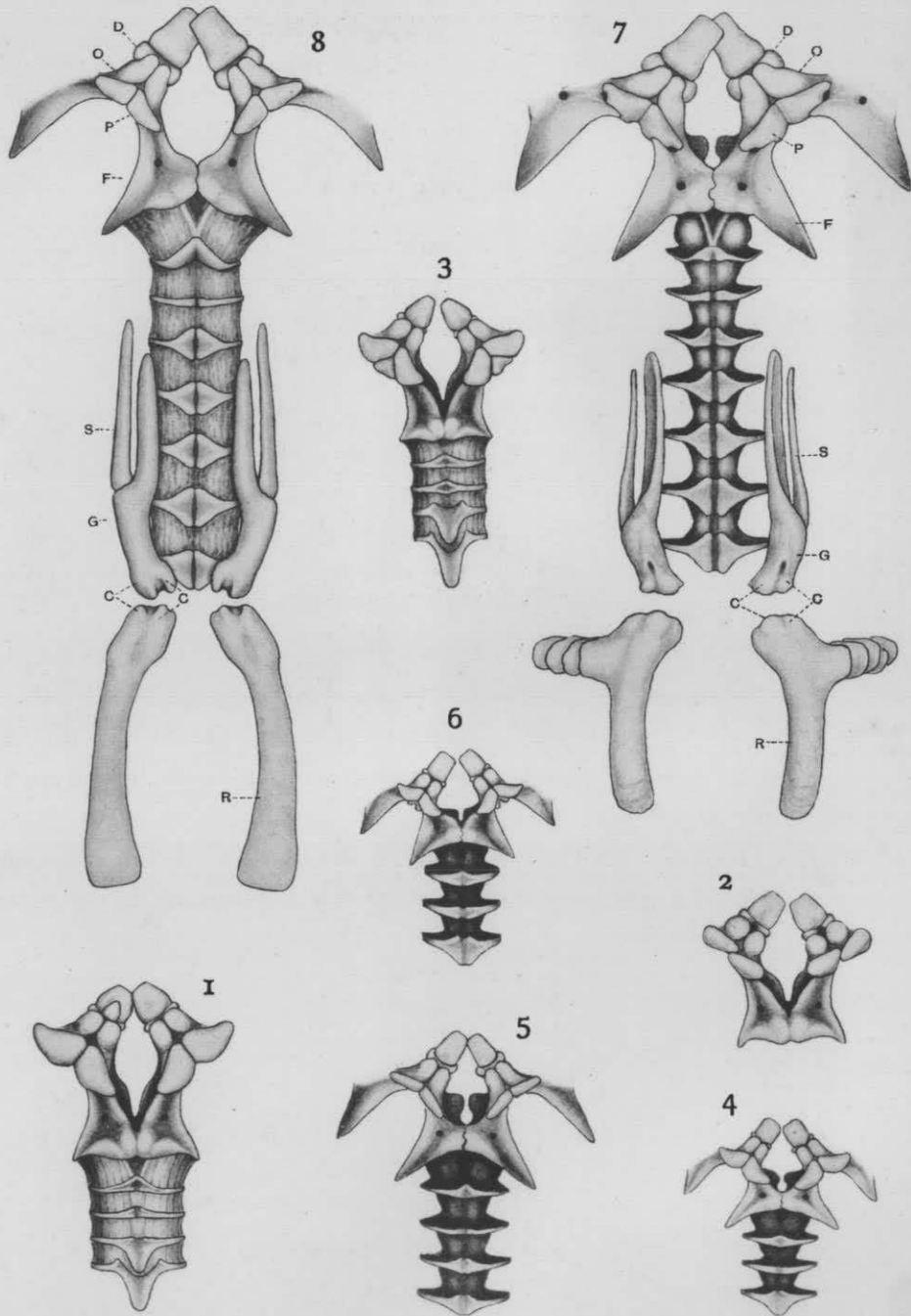
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