

No. 10. — *Ophiuridæ and Astrophytidæ, Old and New.* By  
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### Ophiopeza PETERS.

*Ophiopeza fallax* *Pet.* is well distinguished from *O. Yoldii* Ltk., as I satisfied myself by examination of the originals at Berlin and Copenhagen. Two specimens of the same size differed as follows: *O. fallax*: diameter of disk 9 mm.; grains on disk, 26 in a mm. long; eighteen mouth-papillæ to each angle; eight nearly equal, crowded arm-spines. *O. Yoldii*: diameter of disk, 9 mm.; grains on disk, 13 in a mm. long; five spaced arm-spines, the middle one longest. *Ophiopeza* does not differ from *Pectinura* Fbs., except in having small supplementary mouth-shields, and *O. fallax* even has such pieces as an occasional accident.

### Pectinura FORBES.

Lütken (Addit. ad Hist. Oph., III. pp. 31 and 105) correctly separated from *Ophiarachna* Mull. and Tr. those species which had spines arranged along the outer edge of the side arm-plates, and placed them with *Pectinura* (Forbes, Linn.-Trans., XIX. 143). The original *P. vestita* of Forbes is only known by the figure (Pl. XIII., Figs. 1 - 7), which is apparently that of a young animal. In *Ophiarachna* only two species are left, *O. incrassata*, the largest known Ophiuran, having four arm-spines, and pores between the under arm-plates nearly to the tip of the arm; and *O. affinis*, with six arm-spines and pores only between the first and second under arm-plates. With *Pectinura* should be included *Ophiopezella* Ljn. and *Ophiochasma* Grube, which are only extreme forms of this genus. Its species may then be tabulated as follows:—

|   |  |   |  |
|---|--|---|--|
| Disk covered, under its granulation, with coarse scales, or swollen plates. | No pores between under arm-plates.               | Radial shields, granulated, 13-15 arm-spines                      | } <i>P. spinosa</i> Lym.   |
|   |  | Radial shields naked; also some other disk-plates; 9 arm-spines.  | } <i>P. infernalis</i> Ltk.  |
|   | Pores between first and second under arm-plates. | Arms cylindrical at their insertion in the disk, which is puffed. | } <i>P. gorgonia</i> Ltk.  |
|   |  | Arms widened at their insertion in the disk, which is flat.       | } 10-11 arm-spines. <i>P. marmorata</i> Lym.<br>} 5-6 arm-spines. <i>P. stellata</i> Lkt.* |

\* By comparing the originals I found Grube's *Ophiochasma adpersum* was the *Ophiarachna stellata* of Ljungman.

|   |   |   |   |   |   |                              |
|---|---|---|---|---|---|------------------------------|
| Disk, under its granulation, covered with minute and smooth scales. | { | 10 thin equal arm-spines; under arm-plates encroached on by side arm-plates.  | } | . . . . .   | } | <i>P. vestita</i> Fbs.       |
|   |   | Pores only between first and second under arm-plates.                         | } | . . . . .   | } | <i>P. maculata</i> Vll.      |
|   |   | Pores between the under arm-plates continued for some distance along the arm. | } | 7-8 conical arm-spines, the lowest one a little the longest   | } | <i>P. septemspinosa</i> Ltk. |
|   |   |   | } | 8-9 flat, pointed arm-spines; the lowest one very long and flat, often equal to two joints in length. | } | <i>P. rigida</i> Lym.*       |

**Pectinura** (*Ophiarachna* *M. T.*) **infernalis**. The original at Leyden is lost; but among the unsorted specimens of the Museum Godeffroy at Hamburg I found a specimen from near Sumatra. It was unmistakable, and is figured, Plate VII., Fig 1. I found another specimen from the Philippines, by Semper.

**Pectinura septemspinosa**. The original of Müller and Troschel from the Moluccas is yet at Leyden, and remains unique. Diameter of disk 25 mm. Arms stiff, thick, cylindrical. Disk closely and evenly granulated, with a *smooth* surface not indicating the scales below; six grains in a mm. long. Radial shields small, oval, brown and very distinct. Usually seven arm-spines, but, on the inner joints, eight; they are conical, not so long as a side arm-plate; the lowest one a little the longest, and having its base covered by one of the tentacle-scales. The under arm-plates within the disk have pores between them. Supplementary mouth-shield small. Color, yellow-brown. On Plate VI., Figs. 10-13, are shown the peculiar broken upper arm-plates of this species; an angle of the mouth; and a row of arm-spines.

### **Pectinura marmorata** sp. nov.

Plate V., Figs. 1-7.

*Special Marks*.—Pores only between the first and second under arm-plates. Arms somewhat widened at their insertion in the disk. Eleven arm-spines.

*Description of a Specimen*.—Diameter of disk 20 mm. Length of arm about 105 mm. Width of arm at disk 4.7 mm. Height of the same 4.7 mm. Fourteen small, close-set, tooth-like mouth-papillæ to each mouth-angle, of

\* Mr. F. W. Hutton (Catalogue of the Echinodermata of New Zealand, 1872) has described an *Ophiura* (*Ophiarachna*?) *cylindrica*. It is earnestly to be desired that general zoölogists, who have not large collections for comparison, should abstain from describing species. For such persons, thus situated, to give useful diagnoses is simply *impossible*. They only add to the confusion already existing. Zoölogy, so far as concerns genera and species, has now passed into the hands of specialists; and they alone can treat such subjects.

which the outermost one is widest. Outside this, and continuous in the row, is a long papilla which stretches upward into the mouth-slit, and embraces the second mouth-tentacle; its base rests on the side mouth-shield and on the first under arm-plate. This same piece is seen in other genera, *Ophiocoma*, *Ophiura*, etc., and is usually reckoned among the true mouth-papillæ. In *Ophioglypha* it takes on a great development, and is the piece which carries the scales of the mouth-tentacle, and which gives the forked look to the mouth-slit. In the species under consideration it may carry a sort of lobe or articulated scale. Five short, flat, rounded teeth, the uppermost one a little longer and sharper. Mouth-shields rounded heart-shape; rather wider than long, standing close to the mouth-papillæ; length to breadth 2.5 : 3. Supplementary mouth-shields semicircular and about half the size of the mouth-shields. Side mouth-shields very small and wedged between the first under arm-plate and the mouth-shield. Under arm-plates strongly overlapping, bounded without by a broken curve and by a re-entering curve within; length to breadth, within disk, .6 : .8. The first plate has a broad diamond shape, and, between it and the second, are two large pores. The side arm-plates cover nearly one half the height of the arm at its base, the rest being occupied by the upper arm-plates, which there are considerably arched, have a wavy outer side, and a length to breadth as .6 : 3. A little farther out, the upper arm-plates are lower and less arched. Disk flat and round, but embracing the base of each arm by a forked projection. With the exception of the radial shields and shields of the mouth, it is closely granulated; about eight grains in the length of a mm. This granulation is, however, easily rubbed off, and then the coarse swollen scales of the disk may be seen; among which there are along the edge of the disk, in each interbrachial space, about six imbricated plates, making a close row between outer ends of the radial shields, which are large and conspicuous, oval in shape, and having a length to breadth of 4 : 2. Arm-spines near disk, ten or eleven, small, slightly tapering, somewhat flattened, a little rounded, about two thirds of the length of a side arm-plate; the lowest one scarcely longer than the rest. Two flat, oval tentacle-scales; the one which lies at the base of the lowest arm-spine is smaller, as usual, but has its end rounded and not cut square off.

Color, in alcohol, light yellowish brown above, with lines and patches of darker, and with darker specks on the upper arm-plates; below, the under arm-plates and mouth-region are white.

This species, by its conspicuous radial shields and its arms widened next the disk, stands near *P. stellata*, from which it is easily distinguished by more numerous arm-spines and differently shaped under arm-plates.

C. Semper; Philippines.

**Pectinura rigida** sp. nov.

*Special Marks.*—Very large, with cylindrical arms; disk closely granulated and smooth. Very small sunken radial shields; pores between under arm-plates far out on arm. Nine or ten much flattened arm-spines, the lowest one much the longest and largest.

*Description of a Specimen.*—Diameter of disk 36 mm. Length of arm 175 mm. Width of arm near disk 5.5 mm.; height 6 mm. Ten flat, close-set, rough-edged mouth-papillæ to each mouth-angle, of which the two under the teeth are a little higher than the rest. There is also a small additional papilla, nearly covered by the outermost mouth-papilla, which stretches upward and embraces the second mouth-tentacle. Six short, broad, flat teeth with a curved cutting edge; the lowest one often split in two. Under arm-plates, within the disk broader than long, bounded without by a curve, and within and on the sides by re-entering curves; length to breadth 1.8 : 2.8. Farther out on the arm they are as broad as long, with rounded corners, and they everywhere are thick and even swollen, and have pores between them, nearly to the end of the arm. Side arm-plates flat, and occupying nearly the whole height of arm. Upper arm-plates regular, not broken, and with a wavy outer margin; they occupy most of the upper surface; length to breadth 2 : 4. Mouth-shields large and lying close to the mouth-papillæ, roundish with a small point within, and a re-entering curve without; length to breadth 4 : 4.5. Supplementary mouth-shields small, roundish, about 2 mm. in length and width. Side mouth-shields minute and wedged between the first under arm-plate and the mouth-shield. Disk, except small sunken radial shields about 2 mm. long, and the shields of the mouth, closely and smoothly granulated with about eight grains to 1 mm. long. The underlying scale-coat is of delicate, smooth scales, not more than .4 mm. wide, and difficult to distinguish. Arm-spines nine or ten, much flattened, about three fourths the length of the side arm-plate, except the lowest, which is much stouter, and whose length equals two under arm-plates. The upper spines are somewhat shorter and notably wider than the lower, and all taper to a blunt point. Two tentacle-scales, of a rounded oval shape; the one which covers the base of the lowest arm-spine often larger than the other.

Color, in alcohol, purplish brown, with black radial shields.

*Variations.*—Another specimen, of about the same size, had the lowest arm-spine even longer, and often with a thickened end.

This species stands nearest to *P. septemspinosa*, from which it is distinguished by more numerous and more flattened arm-spines, and by the great length of the lowest one.

Zanzibar; Mr. Cooke.

**Ophiocoma brevipes** PETERS, **insularia** LYM., and **ternispina** v. MART.

I have examined great numbers of these, especially in the Museum Godefroy and the Museum of Comparative Zoölogy, and do confess myself much puzzled. They all agree in being completely and closely granulated, above and below, and in having very regular, cleanly cut arm-plates. The variation in color is from dark brown, through gray, and reticulated in patterns, to pure white. It would seem that *O. brevipes* (originals at Berlin) has five spines on the first eight joints, and then four, and that the upper are the longest. *O. insularia* has four spines at the base of the arm, and the upper are the shortest; the disk granulation is coarser, only six or seven in the length of a mm. *O. ternispina* has but three spines, which are tapering, cylindrical, and often bent. A number of specimens, supposed to be *O. brevipes*, from the Philippines, had only four arm-spines at the base of the arm; there were from nine to twelve grains in the length of a mm. On present evidence it will not do to bring these three under one head. As to *O. squamata* M. T. the original at Paris is lost, and nobody can now tell what it was, though it might have been *O. brevipes*.

**Ophiocoma alternans** (von Martens, Oph. Ind. Oc., p. 251). I found, by the Berlin original, that this is only the young of some species, probably *O. scolopendrina*.

**Ophiarthrum pictum.**

*Ophiocoma picta* Mull. and Trosch., Syst. der Asteriden.

**Plate VII., Figs. 2-4.**

*Special Marks.* — Disk ornamented with meandrine brown lines; a dark line along the upper arm. Three ringed arm-spines, the upper one longest.

*Description of an Individual.* — Diameter of disk 15 mm. Width of arm without spines 3 mm. Distance from outer side of mouth-shield to inner points of mouth-papillæ to that between outer corners of mouth-slits, 3 : 4. Mouth-papillæ four (rarely three) on each side, the outer one tapering and pointed; the next wider than long and rounded; the two innermost as broad as long, and bead-like. Tooth-papillæ (including as such all those under the teeth) fifteen to seventeen, of nearly equal size, bead-like; arranged in two outer vertical rows of four or five each, with a more irregular central row, and two or three odd papillæ below. Teeth four, upper one largest and broadest; all stout and thick, with rounded corners and a straight cutting edge. Mouth-shields nearly round, faintly pointed within; length to breadth 2 : 2. Side mouth-shields thick, nearly joining their neighbor of the next mouth-shield; within, running to a point, but not meeting. Under arm-plates about as broad as long, clearly defined and regular, with outer side slightly curved and lateral sides re-enteringly curved; length to breadth

(4th plate) 1.4 : 1.4. The first plate is minute, being nearly crowded out by the side mouth-shields. Side arm-plates forming only a small ridge for the arm-spines. Upper arm-plates hexagonal, with the outer and inner sides shorter than the others; length to breadth 1.4 : 2. Skin of disk quite smooth, above and below. Arm-spines three, cylindrical, stout, gently tapering, blunt; lengths to that of upper arm-plate (7th joint) 5, 3, 2.7 : 1.4. They are essentially smooth, although, under the microscope, the points look minutely thorny. One large tentacle-scale, longer than broad, and flat. Ground-color of disk and upper arms purplish brown. Disk, above and below, ornamented with patterns in dark brown lines. Above, there are straight lines from arms to centre, and, in interbrachial spaces, above and below, meandrine patterns, which are filled with white, yellowish, or purplish brown. A dark stripe along upper arm; arm-spines with three to five dark rings.

The original specimen of Müller and Troschel at Leyden, brought from Java by Kuhl and Van Hasselt, remained for a long time a unique specimen. Within a few years the Leyden Museum has obtained others from islands near New Guinea, and Professor Semper also got very fine ones from the Philippines and the Pelews. This species, by its well-marked upper arm-plates and regular arm-spines, approaches nearer than *O. elegans* to the genus *Ophiocoma*, from which it differs only by its naked disk.

### **Ophiomastix flaccida** sp. nov.

**Plate VI., Figs. 14, 15.**

*Special Marks.*—No tentacle-scales. Disk smooth, except a few short spines above. Upper and side arm-plates obscured by thick skin.

*Description of an Individual.*—Diameter of disk 15 mm. Length of arm 100 mm. Width of arm 3 mm. Height of arm 2 mm. Distance from outer side of mouth-shield to inner points of tooth-papillæ, compared with that between outer corners of mouth-slits, 3 : 2.5. Mouth-papillæ four on each side, small and bead-like, except the outer one, which is pointed. Tooth-papillæ similar, usually nine, arranged in three regular rows, of which the lowest is on a level with the mouth-papillæ. Teeth five or six, the upper ones longest, with a square cutting edge; the lowermost smaller and rounded, or partly split. Mouth-shields small, of a much rounded heart-shape, length to breadth 2 : 1.8. They are close against the outer mouth-papillæ, leaving little space for the minute side mouth-shields, which do not meet within, and are obscured by thick skin. Under arm-plates squarish, with rounded corners; length to breadth 1.5 : 1.5. Side arm-plates obscured by thick skin, as also are the upper ones, except in dry specimens, where their form is seen to be rounded hexagonal. Disk wholly covered by smooth

skin, sparsely set above with short, slender, rounded spines, about 1.2 mm. long. Arm-spines three; the two lowest slender, rounded, pointed, often bent, and in length about 1.5 mm. On every second or fourth joint, and on alternating sides, the upper spine is much thickened, and has the clove-shape characteristic of the genus; its length is about 2.5 mm. Towards the end of arm there are no such spines, but the upper one is usually the longest and stoutest. No tentacle-scale; the tentacles are rather long and thick and without papillæ. Color, in alcohol, disk dull greenish brown; arms yellowish brown.

Philippines; C. Semper.

### **Ophioplocus Esmarki** sp. nov.

**Plate V., Figs. 12-14; Plate VI., Fig. 6.**

*Special Marks.* — Color, in alcohol, uniform dull purplish above, and light brown below. Arms decidedly flattened, having the width to the height 3.5 : 2. Arm-spines not tapering, and of nearly equal length.

*Description of a Specimen.* — Diameter of disk 16 mm. Length of arm 53 mm. Width of arm 3.5 mm. Distance from outer side of mouth-shield to inner point of teeth, to that between outer corners of mouth-slits, 3 : 3.2. Mouth-papillæ five on each side, or rarely six, stout, irregular, or squarish; the two outer ones rest on the side mouth-shield, the others on the mouth-frames. Teeth five or six, the upper ones short, stout, broader than long, with a curved cutting edge; the lowest one smaller, nearly on a level with mouth-papillæ, and resembling them. Mouth-shields heart-shaped, with a curve without and an angle within; length to breadth 1.2 : 1.2. Side mouth-shields long triangular, somewhat swelled, not quite meeting within; length to breadth 1.3 : 1. Under arm-plates broad pentagonal, with the odd angle inward; length to breadth, close to disk, 1 : 1.5. The upper arm-plate is simple only at the tip joint of the arm; at the next joint a longitudinal crease of division appears; at the next the upper arm-plate is completely divided, and there appear two supplementary pieces on the median line, of which the outer one partly separates the two halves of the plate. Farther down the arm the two halves are wedged apart by the supplementary pieces, whose number has increased to six or seven. Close to the disk most of the upper surface is occupied by thirteen supplementary pieces, of which three, of an irregular hexagonal form, lie on the median line. This development of pieces is quite as in *O. imbricatus*. Side arm-plates small, and crowded mostly to the under side of the arm. Scales of disk, above, irregularly imbricated and thickened; the longest 1 mm. long; below they are thinner, finer, and more regular. Along edge of disk run half a dozen larger rounded, swelled scales. Radial shields small, about 2 mm. long. Genital

slits 3 mm. long and starting close to mouth-shields. Arm-spines three, nearly of equal lengths, stout, rounded, blunt, and not tapering. Lengths to that of under arm-plate, near disk, .8, .9, 1 : 1. Tentacle-scales two, flat, nearly oval, and placed closely side by side. On outer side of tentacle-pore is a semicircular rim or lip. Color, in alcohol, dull uniform purplish above.

This species is of high interest as the first from the Pacific coast of North America, which represents a genus peculiarly characteristic of the great ocean. *Ohioplocus imbricatus*, described thirty years ago by Müller and Troschel, has been brought in plenty from such diverse localities as Zanzibar, Mauritius, New Caledonia, the Philippines, and the Kingsmill Islands. It long remained the sole representative of a genus which was confined to these faunal limits. *O. Esmarki* differs from it in the precise way in which, on the theory of Agassiz, species should differ within their genus, namely, in the proportion of their parts. It will be therefore proper to briefly note these differences. *O. imbricatus* is a thicker animal; not only is the disk thicker, but the arm is higher, having a width to height of 3.5 : 3, from which it follows that the arm-spines are less crowded, having more room; they also taper more, and the undermost is much the longest, having a length of 1.3 : 1 as compared with the under arm-plate. The scaling of the interbrachial space below is coarser and more uneven, having four or five scales in the length of a mm., while in *O. Esmarki* the smallest number is five or six. The genital slit begins at some distance from the mouth-shield, and is very short, while in *O. Esmarki* it begins close to the mouth-shield, and is longer. The minute lip or rim outside the tentacle-pore is barely to be seen, while in the American species it is conspicuous. These differences are all the more instructive from the fact that *O. imbricatus* is a singularly steady species, and shows none of the variations offered by *Ophiocoma scolopendrina* and *O. erinaceus* in the same fauna. In examining great numbers of individuals from many and distant localities, I have found no essential variations in *O. imbricatus*, except three specimens from Japan and one from Java, in the Leyden Museum, in which the genital opening ran as far as the mouth-shield.

Professor Esmark found numerous specimens at San Diego, California, among stones in shallow water.

**Amphiura** (*Amphipholis*) **planispina** v. MARTENS (Monatsber. König. Akad., Berlin, 1867, p. 347). This species is originally described, perhaps by a misprint, as having only *one* mouth-papilla on each side, like *Hemipholis*. The originals, however, show three mouth-papillæ on each side. In color it is just like *Ophiophragmus Wurdemani*, which, however, has a marginal fence of jointed scales round the disk, and its innermost mouth-papillæ are thickened, and run upwards towards the teeth.

**Amphiura lævis** sp. nov.

Plate IV., Figs. 18 - 21.

*Special Marks.* — Disk flat and thin, not lobed, covered with small thin scales. Radial shields narrow and closely joined. Eight mouth-papillæ to each angle. A light line along upper side of arm.

*Description of an Individual.* — Diameter of disk 6.5 mm. The arms (which were broken) were flattened, not very wide (1.2 mm.), gradually tapering, and seemed to have been not less than eight times the diameter of disk. Eight mouth-papillæ to each angle, of which the two outer on either side are scale-like and larger than the others, which are stout and blunt; the outer papilla rests on the side mouth-shield; the others are supported by the mouth-frames. Mouth-shields spear-head shaped; length to breadth .6 : .4. Side mouth-shields long triangular, meeting within, and closely joined to mouth-shields. Under arm-plates wide pentangular, with the odd angle inward; slightly separated by side plates; length to breadth (8th plate) .4 : .6. Side arm-plates meeting below and encroaching above; forming but a slight crest laterally. Upper arm-plates wider than long; bounded by a wide curve within, but nearly straight without; length to breadth (2d plate) .5 : .9. Disk unusually thin and flat, with a fine line of juncture along its rim, between the scaling of upper and lower surfaces. Scales very thin and fine, without central rosette of primary plates; near edge of disk nine or ten scales in 1 mm. long; half-way to centre, four; and in the interbrachial spaces below, seventeen. Radial shields rather long, narrow, closely joined except at the inner tips, which are separated by three little scales; length to breadth of each 1.2 : .3. Arm-spines three, nearly equal, cylindrical, tapering, rather slender; lengths to that of an upper arm-plate .4, .5, .4 : .5. Tentacle-scales two, wide and thin with a curved free edge; they are set at right angles, one on the side arm-plate, the other on the side of the under arm-plate, beyond which it projects. Color, in alcohol, brown-gray, with a light line along upper arm, and obscurer light cross-lines between joints.

This species approaches nearest to *A. gracillima*, *subtilis*, *Januarii*, and *pulchella*, but differs in several respects, especially in having eight mouth-papillæ to each angle.

Philippines; C. Semper.

**Ophionephthys phalerata** sp. nov.

Plate VI., Figs. 7 - 9.

*Special Marks.* — Arm-spine, next the lowest one, much stouter than the rest and with thorns at the end. Disk naked, except a belt of fine scales round each pair of radial shields. No tentacle-scales.

*Description of a Specimen.* — Diameter of disk 9 mm. Arms very long.

One which was broken near the end was 145 mm. Width of arm 1.3 mm. Distance from outer side of mouth-shield to inner point of mouth-papillæ compared with that between outer corners of mouth-slits 1.4 : 1.4. Mouth-papillæ four to each angle; namely, two large wedge-shaped ones, just under the teeth, and one, small and slender, sitting on each side mouth-shield. Mouth-shields small, broader than long, nearly oval; length to breadth .5 : .7. Side mouth-shields curved and united at their ends so as to form a continuous ring. Under arm-plates broader than long, squarish, with a peak within and a re-entering angle without; length to breadth, within the disk, .4 : .5. Side arm-plates nearly meeting above and making only a slight ridge, on which stand the spines. Upper arm-plates irregular oval, rather small, not covering the upper side of arm; length to breadth .4 : .7. The plates next the disk are narrower and more irregular. Radial shields long and narrow; joined for about half their length, which is to their breadth as 2 : .6. Their free sides are edged with two or three parallel rows of minute scales. The rest of the disk is puffed, deeply wrinkled, and quite naked. Arm-spines on the basal and middle portions of the arm five, of which four are short, cylindrical, and tapering; but the one next the lowest is flattened, much thickened, and thorny at its end. Its length is about .4 mm. No tentacle-scales. Color, in alcohol, brownish gray.

The true *Ophionephthys* of Lütken, which includes but one species as yet (*O. limicola*), has lines of fine scales not only round the radial shields, but thence extending towards the centre of the disk and along its edges; also the mouth-papillæ may be either four or six to each angle of the mouth. I prefer, however, to leave the new species in this genus, because the groups which centre about *Amphiura* are not yet very clearly established.

One specimen from Philippines; C. Semper.

### **Ophiocnida echinata?**

*Ophiophragmus echinatus?* Ljungman.

*Ophiocnida longipeda* Lym. M. S.

#### **Plate IV., Figs. 22, 23.**

*Special Marks.*—Upper disk, and a triangular patch in each interbrachial space below, beset with minute sharp spines. Radial shields narrow, wholly separated, naked. Three arm-spines, except close to disk. Four mouth-papillæ on each side. Arms very long.

*Description of an Individual.*—Diameter of disk 10 mm. Length of arm 200 mm. Width of arm 2.2 mm. Four mouth-papillæ on each side, of which the innermost is bead-like, the two next of about the same size but more flattened, and the outer one smallest and tooth-like. Distance from outer side of mouth-shield to inner point of mouth-papillæ to that between outer

corners of mouth-slits 2.2 : 2.2. Mouth-shields oval, with outer end cut off; length to breadth 1.2 : .8. Side mouth-shields broad and thick, widely touching within; they directly join the neighboring side mouth-shields; a continuous ring is thus formed, and the usual rudimentary under arm-plates are not interposed. Under arm-plates squarish with clearly rounded outer corners; length to breadth (2d plate) 1 : .7. Side arm-plates only slightly prominent. Upper arm-plates much broader than long, four-sided, bounded without by a gentle curve, within by a shorter and re-entering curve, and on the sides by straight converging lines; length to breadth (2d plate) .7 : 1.8. Disk flat, but soft and a little wrinkled; pretty evenly beset above with minute, short, tapering spines, the longest about .2 mm. : below, a triangular patch of similar spines. Radial shields long, narrow, pointed within; diverging and completely separated: length to breadth 2.8 : .6. Under the spines, the scaling of the disk is obscurely visible, especially between each pair of radial shields. Arm-spines short, cylindrical, tapering; the lowest usually longest: on the first four or five joints outside disk, usually four; on all beyond, only three: lengths to that of an upper arm-plate .6, .7, .8 : .7. Tentacle-scales two (on first joint only one), small, not over one third as long as an under arm-plate, and disposed at right angles to each other. Color, in alcohol, pale gray. A young one with a disk of 4 mm. had the primary plates in the centre of the disk, naked; and often only three mouth-papillæ on a side.

I deem it best to leave this species under its present name, although it differs from *Ophiophragmus echinatus* Ljn. as follows: *O. longipeda* has no spines on radial shields, which also are wholly separated; mouth-shields oval and not four-sided; four mouth-papillæ on each side: three arm-spines, except on a few first joints. Vide Ljn. Oph. Viven., p. 316.

Philippines; C. Semper.

### **Ophiopsammium**\* gen. nov.

Teeth: tooth-papillæ numerous and arranged in a vertical, oval clump, as in *Ophiothrix*. No mouth-papillæ. Disk and arms naked below, but closely granulated above. Arm-spines stout and thorny, mounted on a crest-like side arm-plate, as in *Ophiothrix*. Tentacles long, covered with papillæ, and issuing, not from the under surface, but from the side of the arm.

This genus is nearest *Ophiothela*, but differs in having the whole upper surface closely granulated, as also in the side arm-plates.

\* ὄφις, a snake; ψαμμίον, a granule.

**Ophiopsammium Semperi** sp. nov.

Plate IV., Figs. 11 - 17.

*Special Marks.* — Six or seven stumpy arm-spines, of which the lowest is flattened and hooked: two or three little spines on the edge of the disk in the interbrachial space: granulation of upper surface fine and even; finer on the disk.

*Description of an Individual.* — Diameter of disk 6.5 mm. Length of arm 23 mm. Width of arm, without spines, 1.7 mm. Mouth-shields small, rounded, broader than long, much obscured by being closely soldered with surrounding parts and covered by thick skin. Tooth-papillæ about twenty-five, of nearly equal size and length, crowded into a short oval clump. Teeth three: the uppermost longest, the lowest touching the mouth-papillæ. Under surface, and part of the sides, of arms, covered by smooth skin, through which may be obscurely seen the outlines of the under arm-plates, which, near base of arm, are wide, short triangles with the apex inward; and, near point of arm, have an angular heart-shape. Side arm-plates covered with thick skin, and forming a well-marked crest, at right angles to the arm, conspicuous from below, but little projecting as seen from above. Upper side of arm densely covered by a granulation, of about fourteen grains in the length of a mm. This granulation descends partly down the side of arm. The terminal joints are naked, with a minute rudimentary upper arm-plate: those which follow have a few scattered grains, and these grow soon into a continuous stratum. Disk, below and on sides, covered with smooth skin; above, with a continuous granulation, finer than that of arms; on edge of disk between the arms, a pair of sharp spines, about .6 mm. long. Genital scales wide, with their outer edge showing on each side of the arm. Arm-spines, near disk, usually seven; short, stout, blunt, minutely thorny, often much swelled at the base; the lowest one flattened and armed on one edge with a double hook, the next one or two also flattened. Length of third and longest spine .8 mm.: length of lowest and shortest .4 mm. At tip of arm, three spines, of which the upper is smallest and pointed; the second pointed or forked; and the third is a sharp double hook. The long tentacles, of an elongated club-shape, issue from the side of the arm just below, and in front of, the middle arm-spine; there is no tentacle-scale. Color, in alcohol, of arms, straw yellow: disk more gray.

A younger specimen had a disk of 4.5 mm., and arms of 16 mm.; there were only six arm-spines.

This singular species has rather flat and little tapering arms, which have a tendency to roll on themselves, as in *Ophiochondrus*.

Philippines; C. Semper.

**Ophiomaza cacaotica** LYM., and **Ophiocnemis obscura** L.JN., which have been considered as perhaps the same, are, on comparing the originals, quite different. The two specimens of *O. obscura* at Stockholm have the interbrachial spaces on the back of the disk, covered by four or five very irregular radiating lines of elongated scales, covered by a thick skin so as to obliterate their outlines; in the centre, a great number of similar but rounded scales. The upper arm-plates are as wide at the base of the arm as beyond, and there is scarcely any notch in the margin above the arm. The specimen at Copenhagen, which Dr. Lütken took to be *O. obscura* (Addit. ad Hist. Oph. 40), is really *O. cacaotica*, which has in each interbrachial space above, only one, or at most two, radiating rows of plates, which are naked, swollen, and clearly defined. Furthermore, however, there is in the Museum Godefroy (No. 6258) a dried specimen of *Ophiomaza*, considerably like *O. cacaotica*, but with a fine scaling imbricated on the interbrachial spaces below. It may be this scaling always exists, but is usually hidden by the extremely thick skin. As to *Ophiomaza* being separated generically from *Ophiocnemis* by the absence of granulation on the disk, I can only say that the same distinction is allowed to separate *Ophiarthrum* from *Ophiocoma*.

**Ophiocnemis marmorata**, see *Ophiothrix clypeata*.

**Ophiothrix comata** MÜLL. & TR. has not been since found and is generally ignored. The originals in the Vienna Museum are dry and nearly ruined by time. It is therefore well to note that the species belongs to the division of the genus which has long needle-like spines, a thin disk, and slender rounded arms. *O. Suensonii* is its type, and *O. comata* resembles it considerably. The sketches (Plate IV., Figs. 27, 28) show that the shapes both of upper and under arm-plates are different; and whereas *O. Suensonii* has a purple arm-stripe above and below, *O. comata* has, along the upper arm, a central white stripe bordered by a purple line on each side, and no stripe at all below.

**Ophiothrix fumaria** MÜLL. & TR. (Plate IV., Figs. 33–36). Originals at the Garden of Plants; dry, and in bad condition. Diameter of disk 9.5 mm. Length of arm 42 mm. Disk-scales conspicuous and bearing thorny cylinders (Fig. 36), which are scattered over the disk, as shown in Fig. 33. Arm-spines seven, rounded, the second and third longest, 2.5 mm, and slightly club-ended. They are opaque and feebly thorny (Fig. 35). Under arm-plates wider than long, of an angular oval shape (Fig. 34). It resembles *O. aspidota*, but has coarser disk-stumps and much shorter arms. I have an Ophiuran from Banka Strait which resembles it closely but has narrower under arm-plates.

**Ophiothrix ciliaris** MÜLL. & TR. (Plate IV., Figs. 29–32). Originals at the Garden of Plants; belonging with *O. fumaria*, and in similar condition. Diameter of disk 5 mm.; length of arm 35 mm. Seven or eight

flattened, delicate, glassy arm-spines with sharp thorns, along their edges only (Fig. 32); the second, third, and fourth are longest, and about equal. Disk closely beset with minute stumps (Fig. 29), which are larger and fluted near the edges of the disk and below (Fig. 30). The radial shields have a less number, and are small. The under arm-plates (Fig. 31) are bounded by a curve without, and have sides which converge. The upper arm-plates are broader than long, overlapping, diamond-shape, and slightly keeled. Color pink. *O. ciliaris* and *O. fumaria* are likewise originals of Lamarck. With them I found *Ophiomaza cacautica*, which marks their locality as the region of the Indian Ocean. No. 128, Museum Godeffroy, seems to be *O. fumaria*.

**Ophiothrix aspidota** MÜLL. & TR. Original at Berlin, No. 1,108, East Indies, by Schoenlein. Diameter of disk 10 mm. Radial shields naked; rest of disk closely beset with minute scarcely thorny conical stumps, which are smaller below. Upper arm-plates have a microscopically granular surface. Arm-spines glassy with very feeble thorns. Dr. von Martens agrees that No. 1,966, from Makassar, is this species. I also have it from the Celibes; and there are young ones — often with a few stumps on the radial shields — in the Museum Godeffroy.

**Ophiothrix propinqua** LYM. The Ophiurans described by Dr. Lütken (Addit. ad Hist. Oph., III. 56) as the young of *O. longipeda* are not that, but the adult *O. propinqua*, and have *naked* radial shields. The tendency of young *Ophiothrices* is to have thorny radial shields, even when these are naked in the full grown.

(**Ophiothrix**) **clypeata** LYN., is the young of an *Ophiocnemis*, almost certainly of *O. marmorata*. In the Garden of Plants are specimens brought in 1842 by Hombron and Jaquinot from Trincomalee, Ceylon.

### **Ophiothrix Martensi** sp. nov.

**Plate IV., Figs. 9, 10.**

*Special Marks.* — Seven stout arm-spines; the upper ones with thorny, club-shaped ends; the lowest having the shape of a triple or quadruple hook. Disk naked above, with short, conical, scattered spines on the edge and in interbrachial spaces below. Color, above, bright indigo, with a darker blue line along the arm, and, along the under side of arm, a white line.

*Description of an Individual.* — Diameter of disk 14 mm. Length of arm 63 mm. Width of arm, without spines, 2 mm. Four thick teeth; below them, two pairs of stout tooth-papillæ; and, below these, the usual oval of small, crowded, tooth-papillæ about thirty-two in number, of which about

seventeen form the margin, and the rest are arranged in two or three irregular lines. Mouth-shields rather broader than long, of a rounded diamond shape. Under arm-plates covered by a thick skin; squarish, with rounded corners. Side arm-plates rather small; although, below, they make a well-marked ridge for the arm-spines. Upper arm-plates much wider than long, six-sided but with much rounded angles; the lateral corners pointed; length to breadth, near disk, .7 : 1.7. Close to tip of arm, the shape is wholly different; longer than broad, wider without than within, the outer side curved; length to breadth .5 : .4. Disk covered by thick skin which obscures the outline of the radial shields, and nearly hides the scaling. Near the edge are a few scattered spines, about .5 mm. long, stout and conical, and which are more numerous on the under side. Radial shields quite smooth; length to breadth 3.5 : 2.5. Arm-spines near the disk, seven; the upper ones short, stout, with a nearly smooth shaft, and a club-shaped end bearing strongly curved thorns; the lowest one keeps the form of a triple or quadruple hook quite to the base of the arm. Lengths, to that of an upper arm-plate, 1.8, 1.9, 1.8, 1, .6, .4, .4, : .7. Close to tip of arm only three spines, of which the uppermost is longest; the lowest is a hook, the other two having a rounded shaft and about six curved thorns at the end. Tentacle-scales small, scale-like, usually serrated. Color, above, bright indigo, with a darker line along the arm, bounded by a lighter one on either side; below, paler indigo, with a white line along the arm.

A smaller specimen with disk of 6.5 mm. had a thinner skin, so that the various plates were better defined, and the ends of the arm-spines seemed more thorny. In the interbrachial spaces between the radial shields could be distinguished four irregular radiating rows of oval scales. Below, the short disk-spines were more numerous than in the full grown, and were a little thorny at their ends. The blue lines along the arms were continued to the centre of the disk, but were not margined by lighter lines. Under arm-plates thick and conspicuous; squarish, with rounded corners; length to breadth (7th plate) .6 : .6. Chewing apparatus the same as in the adult, except that the oval of small tooth-papillæ has only twenty-one, of which eight papillæ form an irregular double or single line.

Philippines; by Semper.

Specimens also in Garden of Plants; at Berlin, and at Stockholm.

### *Ophiothrix pusilla* sp. nov.

Plate III., Figs. 21 - 30.

*Special Marks.* — Upper arm-plates swelled, narrow, covering only part of the arm. Side arm-plates with a projecting point running toward the upper

arm-plate. About nine short arm-spines, of which the lowest continues as a hook quite to base of arm. Disk densely beset, radial shields and all, with very short, even, forked stumps.

*Description of an Individual.* — Diameter of disk 5 mm. Length of arm 16 mm. Width of arm 1 mm. Tooth-papillæ of usual form, arranged in an oval, whose border is made up of about eleven papillæ with a central, single line of three or four papillæ. Mouth-shields small, indistinct; of a rounded diamond shape. Under arm-plates as long as broad, squarish, with a notch in their outer side; they are obscured by thick skin, and are somewhat separate. Side arm-plates stout and pretty strongly projecting; each one has a triangular piece projecting towards and near the upper arm-plate. Upper arm-plates swelled and very distinct, longer than broad, narrow, of an oval diamond shape. Near the base of arm they touch, but near the end they are separated, and, the side-plates being very projecting, there appear considerable naked spaces on the arm. Disk densely and evenly beset, above and below, with minute, forked stumps about .4 mm. high, so that no trace of radial shields is seen. These stumps are very short, and consist of a little trunk with a diverging crown of three, four, or five sharp, slender prongs. Those of the interbrachial spaces below are somewhat longer in the trunk, and a few, towards the mouth, have only short blunt thorns. Genital scales at outer end of openings very broad, and nearly meeting over the arm. Arm-spines short; near base of arm, nine; of which the lowest is a triple hook. Lengths, to that of an upper arm-plate, .7, 1, 1, 1, .8, .6, .5, .4, .3 : .6. The five upper are tapering, rather slender and glassy, with three to six sharp, not very long, thorns on each side. The three lower are blunt, with two to five blunt thorns at their tip. Close to tip of arm there is only a large triple hook, above which is a short and very feeble spine. Tentacle-scale none, or so feeble as to be scarcely visible. Color pale blue, in alcohol.

Philippines; by Semper. Specimens also in Garden of Plants.

### **Ophiothrix exigua** sp. nov.

**Plate IV., Figs. 24 - 26.**

*Special Marks.* — Upper arm-plates thick, distinct; as broad as long; curved without. About seven short arm-spines, of which the lowest continues as a hook to the base of the arm. Disk above densely beset, radial shields and all, with very short, even, forked stumps, but naked *below*.

*Description of an Individual.* — Diameter of disk 5 mm. Length of arm 17 mm. Width of arm 1.1 mm. Tooth papillæ arranged in an oval whose border is composed of about eleven papillæ, with a central line of three. They are more pointed and less crowded than in *O. pusilla*. Mouth-shields much wider than long, and of a diamond shape, with rounded angles. Under

arm-plates about as long as broad, with a strong notch on their outer side and a curve within; they are somewhat separated. Side arm-plates stout, not projecting, and completely covering the space between upper and under plates, so that the arm, without its spines, has a pretty regular, rounded form. Upper arm-plates slightly broader than long; length to breadth, near the disk, .6 : .7 : distinct, rather thick, of a much rounded diamond-shape, with the outer side curved, and the two laterals converging inward nearly to a point. Disk, above, densely beset with very short, minute stumps, each bearing a crown of two, three, or rarely four, sharp, diverging prongs, each stump about .4 mm. high, on the average. Below, the interbrachial spaces are naked. Genital scales, at outer end of openings, very broad, and arching partly over the arm. Seven rather short arm-spines flattened, not much tapering; the longest with seven to nine rather strong thorns on each edge and three blunt thorns at the tip; the lowest has a hooked form even at the base of arm. Lengths to that of an upper plate (7th joint) .8, 1.2, 1.2, .5, .3, .2 : .6. Tentacle-scales minute, pointed. Color, in alcohol, pale blue, with darker markings on upper arm.

It differs from *O. pusilla* in having the disk nearly or quite naked below, in different upper arm-plates, and in wider arm-spines.

Philippines, by Semper. Specimen also in Garden of Plants.

### **Ophiothrix stelligera** sp. nov.

**Plate III., Figs. 15 - 20.**

*Special Marks.* — Disk, above, closely beset with minute, stout stumps, each with a crown of five or six short, not much diverging prongs; there are also a few short spines. Below, interbrachial spaces, near mouth, naked; but near edge of disk, beset with small cylindrical spines. Under arm-plates with a clean curve, without.

*Description of a Specimen.* — Diameter of disk 5.5 mm. Length of arm 28 mm. Width of arm 1.5 mm. About twenty-one tooth-papillæ, of which fifteen form the border of the oval, and six are arranged in an irregular line in the centre. Mouth-shields as broad as long, of a rounded diamond-shape. Under arm-plates a little broader than long; 7th plate, length to breadth, .6 : .8, bounded, without, by a gentle curve, and by laterals which converge moderately, giving the whole plate a nearly oval look. Side arm-plates only moderately projecting, covering completely the space between the upper and under plates. Upper arm-plates thickened and with a slight longitudinal ridge; a little broader than long; length to breadth .6 : .8, near disk; bounded without by a curve; on the sides by re-entering curves, which converge to a blunt point. Disk, above, closely beset with minute, stout stumps, each with a crown of five or six short, not much diverging prongs; the out-

line of the radial shields may be distinguished, because they bear fewer stumps. Under the microscope the disk has a look of being sprinkled with little glass stars, among which appears, very rarely, a short spine. Below, the interbrachial spaces are naked at their inner angle, but towards the margin are beset with cylindrical spines which are about  $\frac{1}{3}$  mm. long, while the stumps are not over  $\frac{1}{7}$  mm. Genital plates wide, at outer end of the openings. Arm-spines about eight, short, glassy, flattened, and rather blunt, about as in *O. exigua*; the longer ones have six to nine well-marked thorns on each edge, and three minute thorns at the tip; lengths to that of an upper arm-plate (7th joint) 1.8, 2, 2, 1.8, 1, .8, .6, .5 : .6. The lowest spine retains the form of a triple hook quite to base of arm. Tentacle-scales blunt, small but distinct. Color, above, disk indigo round margin, paler towards centre; upper arm-plates mottled blue and white, with an ill-marked central line: lower surface paler.

This stands near *O. carinata* v. Mart., but the disk-stumps with their star-like crowns, the disk-spines below, the more numerous arm-spines, and different upper arm-plates, will separate it from this, as well as from *O. exigua* and *O. pusilla*.

Philippines, by Semper; also from Borneo, in the Hamburg Museum.

### **Ophiothrix plana** sp. nov.

#### **Plate IV., Figs. 1 - 8.**

*Special Marks.* — Disk smooth and covered by a thick epidermis, through which the scaling and the outlines of radial shields are seen vaguely. Near edge and on interbrachial spaces below, short thorns covered with so thick an epidermis as often to be bead-like in form. Color of disk pale blue, with minute darker rings. Seven arm-spines, all, usually, with widened ends, except the upper one, and covered with a thick epidermis.

*Description of an Individual.* — Diameter of disk 6.5 mm. Length of arm 32 mm. Width of arm 1.5 mm. Tooth-papillæ eighteen, of which fifteen form the border of the oval, and three much shorter ones a single line in the centre; all the papillæ, except lowest, quite stout. Mouth-shields small, oval, with a peak within, and closely soldered with surrounding parts. Under arm-plates squarish, with rounded corners and a re-entering curve without; length to breadth (8th plate) .6 : .7. Side arm-plates well marked, but small, and lying close to arm. Upper arm-plates small and swelled, bounded without by a wide curve; on the sides by slightly re-entering curves which converge strongly, leaving the inner side very short; length to breadth (8th plate) .6 : 1. At the very tip of arm, the side arm-plates meet above, but not below. Disk nearly smooth, with radial shields rather small and on a level with the rest of the surface; the centre occupied by a rosette of thin

scales, nearly obscured by epidermis; a large, round, primary scale in the centre, surrounded by two and part of a third rather irregular concentric rings of smaller ones; from this central rosette radiate interbrachial bands, each consisting of a line of three or four larger elongated scales, with a line of about five narrower and smaller ones on each side; the whole variable, irregular, and much obscured by a thick epidermis. Along edge of disk, outside radial shields, a cross line of about five large scales. Radial shields smooth and flat; separated by a line of two or three scales; length to breadth 2 : 1. Interbrachial spaces below beset with minute spines, which are encased in such a thick epidermis as sometimes to have a bead-like form: they continue to the edges of the upper surface, but there are none in the centre. Arm-spines seven; a little out on the arm, six; flattened, glassy: the upper one slender, tapering, and with five or six thorns on each edge; the lowest one formed like a stout double hook; the rest with a smooth-shaft much flattened at the end, where it has five to seven long thorns on each edge, giving a wide brush-like shape to the tip, which is increased by the thick epidermis investing the whole; lengths to that of an upper arm-plate (4th joint) 1.8, 1.8, 1, .6, .5, .4 : .6. At the very tip of arm, only three spines, of which two are needle-like and the lowest one is a slender double hook. Tentacle-scale well marked, with a sharp point. Color, above, pale purplish blue with minute spots, or rings, of darker on the disk.

Another specimen with disk of 7 mm. had the arm of 27 mm. The disk-thorns were confined to the interbrachial spaces below.

This species is easily recognized by its smooth, shiny disk, with little dark rings, and its broad-ended arm-spines.

Philippines, by Semper. Specimens also in Garden of Plants; and, from Makassar, at Berlin.

### **Ophiothrix rudis** sp. nov.

**Plate III., Figs. 11 - 14.**

*Special Marks.* — Disk, above, except radial shields, closely set with short, very thick cylinders, jointed at their base, and having rounded ends. Seven stout, rounded, blunt, nearly smooth arm-spines; the two upper ones much the longest.

*Description of a Specimen.* — Diameter of disk 9 mm. Length of arm 62 mm. Width of arm 2.2 mm. About thirty-five crowded tooth-papillæ, whereof twenty-one form the border of the oval, and are much more projecting than the fourteen central ones. Mouth-shields wider than long, of a broad, rounded diamond shape. Under arm-plates closely soldered to each other; near base of arm, broader than long, of an irregular oval shape, with a decided depression or re-entering curve within; length to breadth (8th

plate) 1 : .8. Side arm-plates stout and well marked, but not very prominent. Upper arm-plates, near base of arm, wider than long, with sharp lateral angles, and bounded without by a strong curve, on the sides by re-entering curves converging inwards, and within by a very short line; length to breadth (8th joint) .8 : 1.2. Disk naked below, but the upper surface is closely set with short, even, very stout, nearly smooth cylinders having rounded ends. These cylinders are .5 mm. high, jointed at their base, so that they can lie flat to the disk, and their ends under the microscope are seen to be slightly thorny. Radial shields completely naked, small, separated partially by a single line of little cylinders; length to breadth 3 : 1.5. Seven stout, gently tapering, blunt, rounded, slightly flattened, nearly smooth arm-spines, which are wholly opaque, and only present feeble terminal thorns under the microscope. The two upper ones are much the longest, and usually a little crooked; lengths to that of an upper arm-plate (8th joint) 2.6, 2.8, 1.2, 1, .6, .3 : .8. Tentacle-scales none, or very minute and rounded. Color dull indigo, lighter below, with arm-spines mottled with yellowish.

San Diego, California. Many specimens from shallow water, by Professor Esmark. *O. magnifica* is somewhat near, but has very thorny arm-spines.

*On the Species of Ophiothrix from the Waters of Western Europe and of the Mediterranean.*

The genus *Ophiothrix* is usually the most perplexing in respect of the identification of its species. Those of Europe make no exception, as may be seen by the following list of names taken from the principal writers on echinoderms : —

*Stella scolopendroides*; *Rosula scolopendroides*, Linck de Stel. Mar., p. 52, Pl. XXVI., Fig. 42, 1733.

*Asterias fragilis* ABILDGAARD (O. F. Müller), Zool. Dan., p. 28, Pl. XCVIII., 1789.

*Asterias pentaphyllum*; *varia*; *aculeata*; *hastata*; *fissa*; *nigra* PENNANT, Brit. Zoöl., IV. 54, 55, 1812.

*Ophiura fragilis* LAMK., Hist. des An. sans Verteb., II. 546, 1816.

“ *tricolor* “ “ “ “ “ “

*Asterias tricolor* DELLE CHIAJE, Memorie, III. 78, Pl. XXXIV., Fig. 9, 1823.

“ *echinata* “ “ “ “ “

“ *pentagona* “ “ “ “ “

“ *Cuvieri* “ “ “ “ 79.

“ *Ferussacii* “ “ “ “ “

“ *quinquemaculata* “ “ IV. 197.

- Ophiocoma rosula* FORBES, Brit. Starfishes, 60, 1841.
- Ophiothrix fragilis* MÜLL. & TROSCH., Syst. d. Asterid., 110, 1842.
- |   |                        |   |   |   |   |      |   |
|---|------------------------|---|---|---|---|------|---|
| " | <i>echinata</i>        | " | " | " | " | 111, | " |
| " | <i>alopecurus</i>      | " | " | " | " | "    | " |
| " | <i>tricolor</i>        | " | " | " | " | 112, | " |
| " | <i>Ferussacii</i>      | " | " | " | " | "    | " |
| " | <i>quinquemaculata</i> | " | " | " | " | "    | " |
| " | <i>Rammelsbergii</i>   | " | " | " | " | 113, | " |
- " *fragilis* (var. *tenuispina*) Sars, Middelhavets Littoral Fauna, II. p. 74, 1857.
- " *alba* (?) GRUBE, Wiegmann's Archiv., 1857, 344.
- " *rosula* LYMAN, Illust. Catalogue, 154, 1865.
- " *echinata* LÜTKEN, Addit. ad Hist. Oph., III. 52 and 104, 1869.
- |   |                        |   |   |   |   |   |   |
|---|------------------------|---|---|---|---|---|---|
| " | <i>quinquemaculata</i> | " | " | " | " | " | " |
| " | <i>fragilis</i>        | " | " | " | " | " | " |
- " " LJUNGMAN, Vestindiska och Atlantiska Oph., 623, 1871.
- |   |                     |   |   |   |   |      |   |
|---|---------------------|---|---|---|---|------|---|
| " | <i>lusitanica</i>   | " | " | " | " | 625, | " |
| " | <i>pentaphyllum</i> | " | " | " | " | 622, | " |
| " | <i>rubra</i>        | " | " | " | " | 624, | " |
| " | <i>maculata</i>     | " | " | " | " | 623, | " |
| " | <i>echinata</i>     | " | " | " | " | 653, | " |
- " *Lütkeni*, WYV. THOMSON, Depths of the Sea, 100, 1873.

Do all these names refer to one species or to many? I have tried to throw some light on this question by bringing together for study as many originals and as great a number of specimens as possible.

In this way I had, side by side, in Paris :—

*Ophiothrix echinata*. Original of Müll. & Trosch.; by courtesy of Professor Peters.

*Ophiothrix Rammelsbergii*. Original of Müll. & Trosch.; by courtesy of Professor Peters.

*Ophiothrix alba*. Original of Grube; by courtesy of Professor Grube.

*Ophiothrix fragilis*. Originals, as identified by Ljungman with Abildgaard's *Asterias*; by courtesy of Professor Lovén.

*Ophiothrix Lusitanica*. Original of Ljungman; by courtesy of Professor Lovén.

*Ophiothrix pentaphyllum*. Originals as identified by Ljungman with Penant's *Asterias*; by courtesy of Professor Lovén.

Besides these were great quantities of specimens from the coasts of Denmark and Sweden, the Isle of Wight, the northwest coast of France, coast of Portugal, Madeira (?), Algeria, Spezia, Naples, the northern Adriatic, and the coast of Egypt.

At Stockholm, Professor Lovén permitted me to examine the whole of that great collection, and Mr. Ljungman showed me the originals of his *O. rubra* and *O. maculata*.

At Copenhagen, Dr. Lütken personally set before me the very rich collection of the University, and showed me the original of Wyville Thomson's *O. Lütkeni*. I received like marks of kindness from Mr. Schmeltz of the Museum Godeffroy at Hamburg; from Professor Richiardi at Pisa; Professor Panceri at Naples; Sig. Trois at Venice; Dr. von Martens at Berlin, and from Professor Schlegel at Leyden.\*

All these *Ophiotrices* (with one exception presently to be mentioned) have certain features in common. They have arms rather short, narrow, and rounded, being from four to six times the diameter of the disk; their lower arm-plates have a notch or re-entering curve in their outer side; the upper arm-plates are more or less broad diamond-shaped or rhomboidal, and overlap one another. The arm-spines, eight or nine in number, stout, blunt, but never club-ended, somewhat rounded, feebly translucent, the side thorns not very distinct and from eleven to seventeen on each edge; the disk beset with grains, stumps, or short spines, except the radial shields, which are usually naked, but sometimes have a few stumps which are merely the persistence of a character of the young.

Among these characters the plates of the arms furnish no clew whatsoever; nor yet do the arm-spines, which present a wide range as to length, thickness, and the number of thorns on their edges. A careful microscopic study of the *armature of the disk*, its grains, stumps, or spines, is the best guide to the specific differences; to which may be added a consideration of the *absolute size* attained by these specimens. Some hints, too, may be gained from the *pattern of color*; but this must be taken with great caution. It is true that writers, notably Grube, have successfully distinguished *Ophiotrices* almost wholly by their coloration; but this coloration is that which appears *after immersion in alcohol*, and is not to be confounded with that of the living animal. Thus *Ophiothrix angulata* has the most varied sets of hues,† but in alcohol all these turn to pale blue. The pigment patches are arranged in certain lines or patterns, which are brought out by the alcohol, and which usually are characteristic. In this way, a stripe along the arm (*O. Suensonii*) or regular spots on the disk (*O. plana*) are good guides to species. In the European species this guide is often dubious, because many of the specimens,

\* To Professor Deshayes a special acknowledgment is due. Whenever I have been in Paris he has taken me into his own laboratory at the Jardin des Plantes, given me free access to the collections, and treated me, not as a stranger, but as one who had a claim on his attention.

† Illustrated Catalogue I., Pl. II., Figs. 1, 2, 3.

although brilliant in life, fade to a dull straw-color in alcohol, while others present a mottled and varied look without any special pattern.

Beginning with northern waters, we find, on the shores of Denmark and Sweden, a type which is without question the *Asterias fragilis* of Abildgaard. It is large, and has a fleshy disk swelling into lobes in the interbrachial spaces; a diameter of 15 or 16 mm. is a common size, and specimens with a disk of 9 mm. have still young characters. Here it may be observed that the *upper arm-plates*, at the base of the arm, furnish the best test of the animal having taken on its adult form. For example, in the group under discussion, these plates have a length to breadth about as 2:3; whenever, therefore, the length of these plates, near the disk, is greater than, or equal to, the breadth, it is safe to assume that the creature is still in its young stage. The arm-spines of *O. fragilis* vary more than those of any other European type; they may be found very short, and so thickened that the edge thorns, of which there are only 14, are nearly obliterated; or quite long, flattened, and glassy, with as many as 22 well-marked thorns on each edge. Often, or perhaps generally, the upper arm-plates, instead of being decidedly angular, have the outer side cleanly curved. The radial shields are somewhat sunken in the swelled disk, and are a little bent near their small end. The armature of the disk consists of a great variety of short, stout, stumps, accompanied or not by a few slender cylindrical spines (Plate II., Fig. 42). A very common form of stump is with a crown of four thorns, either cylindrical or else spread like a partly opened fan (Fig. 38); some, too, may have only three thorns, whereof the middle one may be flattened and elongated (Fig. 39). There may be near the centre of the disk a quantity of conical grains covered with minute points (Fig. 43), with which the preceding shapes mingle, especially near the edge. In the young we get the simpler shapes from which are produced the full-grown stumps. Thus, a little one having a disk only 5.5 mm. in diameter exhibited minute, very stout stumps which were simply clavate, or else had a crown of three strong thorns (Fig. 41). When the disk was increased to 7 mm. the same shapes presented themselves, but more elongated (Figs. 37, 40); and there were added a few true spines (Fig. 42), slender, cylindrical, and with very feeble thorns at the tip and along the sides. The same shapes again occurred on a larger disk, 9 mm., with an increased number of spines; and, near the edge, a much elongated modification of the clavate stump (Fig. 44).

*Ophiothrix Rammelsbergii*, Müll. and Trosch., is a half-grown specimen of *O. fragilis*, in which the disk stumps were encased in thick wrappers of skin, giving them the look of smooth papillæ. It is a variety always to be borne in mind while studying this genus, and is illustrated in Figs. 10, 11; in one of which the skin-bag is left on, and in the other partly torn off.

I could not find in *O. alba* Grube any characters to distinguish it from a

half-grown *O. fragilis*, although it is said to have been brought from the Pacific by Escholtz.

It will be best next to speak of the European *Ophiothrix* most unlike that just described. In Naples, Dr. Gasco showed me a large number of living *Ophiothrices*, and called my attention to their great differences. One sort was blue with a swelled body, short arms, and rather stout arm-spines; the other was reddish-brown, with a flat rounded disk and slender spines on it, and long arms, by whose rapid worm-like motion the animal slid briskly over the bottom of a basin filled with sea-water. This latter is the species identified by Lütken as *Asterias quinquemaculata* of Delle Chiaje. Here it is proper to say that the descriptions and plates of that Italian author, so far as concerns Ophiurans, are utterly unrecognizable; the figures, in fact, portray animals that do not exist anywhere. However, to avoid multiplying names, there is no objection to taking the nomenclature of Delle Chiaje and applying it arbitrarily to Mediterranean species. Unlike most Ophiurans, this species is better marked as young than as adult, when it bears some resemblance to *O. pentaphyllum* (to be described further on). With a disk of 3.5 mm. the arm was already 25 mm. long, or in proportion of 7 : 1, which is greater than I have usually found, even in the full grown of other European species. The disk was flat and circular, little lobed, and had its surface regularly sprinkled with minute, equal, slender, trifid stumps, with sometimes none on the radial shields and sometimes as many as four (Pl. II., Fig. 46), also there were long, thin, cylindrical spines, as long nearly as those of the arm, having very small thorns on the sides and tip; these spines were all *articulated* on little mamelons, on which they have a free motion (Fig. 47), a character I have not observed in the other European species. There were but six arm-spines, the two upper ones longest, viz. 2.7, 2.5 mm., with a glassy look and nineteen thorns on each edge. A specimen, whose disk was 7.5 mm. in diameter, had stouter forked and trifid stumps on the centre (Fig. 52); stouter articulated spines; and, on the edge of the disk, much elongated forked stumps (Fig. 53). An individual with a disk of 9 mm. resembled the young one first mentioned, except that the disk spines were of several sizes, and the upper arm-plates, of course, proportionally wider. There were six or seven arm-spines, whereof the longest was 4.5 mm., with as many as twenty-five or even twenty-seven thorns on each edge. A large specimen had the disk 14 mm. in diameter, flat and circular, with large smooth radial shields, resembling in these respects *O. pentaphyllum*; besides the long articulated spines (Fig. 51), there were in the centre numerous short, thick stumps, with crowns of three or four long thorns (Figs. 49, 50), or conical grains with thorns on top (Fig. 48); while near the edge and below were very elongated clavate stumps (Fig. 54). This was the usual armature in a large number of adults, some with the disk as large as 16 mm.; the differences were in the proportion and

closeness of the various stumps and spines mentioned above; there also was sometimes a much elongated form of 49 (Fig. 55). Among the young, the arm is from five to seven times the disk; among the adult, from six and a half to ten times.

The blue species, already mentioned as living beside *O. quinquemaculata*, is that identified by Müller & Troschel with *Asterias echinata* Dell. Ch. One of their originals at Berlin has the disk 11 mm. and the arm about 40 mm. The upper arm-plates are rhomboidal, overlapping, and with a slightly thickened lobe without; length to breadth .9 : 1.2. There are nine short, stout, little, tapering arm-spines, the longest 2.1 mm., and with a dozen blunt, feeble thorns on each edge. The disk is evenly set with larger and smaller trifid stumps (Pl. II., Figs. 2, 3), with very few small cylindrical spines (Fig. 1). This is as large a specimen as I have seen, for the species is small; it has a puffed disk, in which the radial shields' are somewhat sunken, and are therefore not conspicuous. The arms are always short; in five adult specimens the average of the arm to the disk was as 5 : 1. Already, with a disk of 7 mm., the adult characters are taken on; the upper arm-plates are broader than long, as 1 : .6; while a specimen of *O. quinquemaculata*, of the same size, had them of equal dimensions, .9 : .9. The arm-spines vary little; they are even, short, stout, and little tapering, and are from seven to nine in number. The smallest specimen (Naples) had a disk of 2.5 mm., and the arm 13 mm.; the scaling was very distinct, each scale usually bearing a slender, trifid stump (Pl. II., Figs. 12, 13); on the upper surface their character was the same, but some were simply forked; on the radial shields were a few similar but smaller stumps, which, in the adult, wholly or nearly disappear. Another had a disk of 7 mm., which carried on its upper surface, evenly set, two and three forked stumps (Figs. 5, 9) and a few short spines (Fig. 4), there being, on the radial shields, some little trifid ones (Fig. 6). The lower interbrachial spaces were closely set with long stumps and short spines (Figs. 7, 8); between the radial shields of the same pair there was a single line of stumps. Another specimen — disk 10 mm. — was evenly set with little forked stumps, covered with a thick envelope of skin (Figs. 10, 11). An individual from Algeria had a few forked stumps so elongated as more properly to be called spines (Fig. 14), but the greater part of the armature consisted of forms similar to 6, 11, and 12. Four specimens from the Adriatic and one from Egypt presented no new features. It will be noted of this species: first, that it is small; secondly, that the disk-stumps are fine, and never have more than two or three thorns as a crown, while longer spines are wanting, or very rare; thirdly, that the arms are short, being from three and a half to six times the disk.

Helier\* has recalled attention to the Adriatic species *O. alopecurus* Müll.

\* Zooph. und Echinod. des Adriatischen Meeres, 63, 1868.

& Trosch.,\* but without recognizing any specimens, and in his description seems to have included this and *O. echinata* under the name of *O. fragilis*. In the collections of Professors Grube and Richiardi, and at the museum of the Palazzo Ducale in Venice, I found nearly a dozen specimens, collected chiefly near Trieste; and there are others in the museums at Copenhagen and at Stockholm. They present pretty uniform characters, and attract attention by the close-set crop of long, glassy, or silvery spines, by which the disk is almost hidden; closer examination shows that there are no stumps at all on the disk, and that the radial shields are either absolutely naked, or have only a few extremely minute spines. Moreover, the animal is distinguished usually by its dark green color, with which the spines contrast, like spun glass. A specimen with a disk 12 mm. in diameter, and arms 96 mm. long, was dark green, with lighter mottlings on the radial shields, which were naked. The upper arm-plates were rhomboidal, overlapping, and with a well-marked lobe without. The arm-spines were nine, flat and regular; longer, more tapering, and more glassy than in *O. echinata*, and with sixteen or seventeen thorns on an edge. The longest one (usually the second) was to the upper arm-plate as 3.2 : 1. The disk-spines were uniform in shape, being stout at the base, tapering, somewhat flattened, forked at the tip, and with a few very minute thorns on their sides; their length on the back of the disk was 1.2 mm., near the edge longer. Other specimens did not vary essentially from this, except in the comparative length and slenderness of the disk and arm-spines; the former having sometimes a regular fluted form (Pl. III., Fig. 1) and a maximum length of 3 mm. The radial shields are usually wholly naked, but may have a few minute spines, not over .2 mm. long (Pl. III., Figs. 2, 3). One specimen had a light-colored disk, with a black spot on each radial shield, and dark upper arm-plates.

There seems no question as to the distinction of the four species just noticed; there are now to be considered some whose claims are less clear. The *Asterias pentaphyllum* of Pennant is an inhabitant of the English coast; Lütken considers it a variety of *O. fragilis*, while Ljungman regards it as a good species. Those I have seen were from the Isle of Wight and from Madeira (?); they were readily distinguished from *O. fragilis*, but, as there were no young forms, I am unable to speak with a full knowledge. The disk is flat and round, and not puffed; radial shields naked and conspicuous; upper arm-plates with a well-developed peak on the outer side. The disk-stumps and spines seem in their young state to be thorny grains (Pl. II., Fig. 30) and not forked stumps, as is usual; from this form develop larger grains and thick stumps (Figs. 31-33) and even columnar spines (Figs. 34, 35); the more pointed spine (Fig. 36) was found only on two specimens, said to come

\* The original examined by Troschel no longer exists at Leyden, but the present identification of *O. alopecurus* seems a reliable one.

from Madeira. As to arrangement, the thick stumps and thorny grains, of which the most numerous are 32, 33, are concentrated in the centre of the disk, while the coarse spines are sparsely distributed from the centre towards the periphery.

Next comes *O. lusitanica*, the commonest species, or variety, of some parts of the coasts of France and Portugal, and even extending into the Mediterranean. Somewhat larger than *O. echinata*, it is at once distinguished by the greater absolute size and thickness of the disk-stumps, and by the more numerous thorns at their ends; for, whereas *O. echinata* commonly has stumps simply forked, and never with more than three terminal thorns, *O. lusitanica* has them with a crown of four, five, and even six thorns (Pl. II., Figs. 15, 16, 22). A young one whose disk was 5.5 mm. in diameter, had clavate or trifid stumps, and some with four terminal thorns (Figs. 16 - 18); a still smaller one, with a disk of 5 mm., had clavate stumps (Fig. 23) also on the radial shields, where they are scarcely ever seen in the adult. On a specimen from Naples, disk 8 mm., the stumps were chiefly stout cylinders with a crown of five thorns (Fig. 15); but there were, besides, a few stout spines, some columnar with two side thorns and six terminal (Fig. 19), others with a swelled cluster of numerous thorns at the tip (Fig. 20). It should here be added that spines are so rare in this species as almost to be accidents; while the stumps are of so even a height and so closely set as to give to the upper disk the figure of a regular five-rayed star, in which the radial shields are sharply defined. Of many examined, one from St. Va-est la Houge, France, had an occasional spine of a type like that found in *O. echinata* and *O. fragilis*, but much thicker (Fig. 29: compare Figs. 1, 42). To continue among rare forms, an individual from the Iles Chausés had small toothed grains and others more elongated, derived from them (Figs. 25, 26); and 26 may be still further elongated by the shooting up of the three central thorns, and thus take on the character of a small spine; this was found in one specimen from the Iles Chausés (Fig. 27). Among stumps, Figs. 21, 24, are rare eccentric shapes derived from 15. Fig. 28 is an elongated clavate stump, comparable to 9 in *O. echinata*, 44 in *O. fragilis*, and 53 in *O. alopecurus*, and like them found near the edge of the disk. Of eighteen specimens examined with special care, viz. two from Naples, one Portugal, eight St. Va-est la Houge, seven Iles Chausés (France), ranging from 5 to 13 mm. in diameter of the disk, there were five specimens in which the disk-stumps had not developed beyond the two or three forked forms, but, as before mentioned, larger and stouter than in *O. echinata* of the same size. The other thirteen had more or less cylindrical stumps with crowns of four to seven thorns, and two of them had also thorny grains (Figs. 25, 26). Among five adult specimens, the average of the arm to the disk was as 5:1. The upper arm-plates are decidedly angular; the arm-spines about as in *O. echinata*, little variable, and with thirteen to seventeen thorns on an edge.

Of *Ophiothrix rubra* Ljn., there exists only a single specimen, from near Lisbon, at Stockholm. The disk is 7 mm. in diameter, and is crisp, with thorny stumps on it, as well as on the radial shields. Arm-spines stout and thick. Without more material to judge from, I am not satisfied that this differs from *O. lusitanica*. Dr. Ljungman thinks it may be *O. echinata*.

There are at Stockholm two specimens of *Ophiothrix maculata* Ljn., from 120 fathoms on the Josephine bank, near the coast of Portugal. They have disks of 12 mm. diameter and somewhat resemble *O. pentaphyllum*, but have only seven arm-spines, and bear a reddish spot on each upper arm-plate. The fewness of arm-spines is important, though I have seen an *O. quinque-maculata* with a disk of 9 mm. that had no more. The red spots are not of so much consequence, since *O. pentaphyllum* is variously mottled in alcohol, *O. alopecurus* has sometimes banded arms or spots on its radial shields, and *O. echinata* occasionally carries a large five-sided patch on the back of the disk. Dr. Ljungman considers it a well-defined species, and it should at least be provisionally admitted on such excellent authority.

*Ophiothrix Lütkeni* is a deep-sea form, dredged by Wyville Thomson in 374 fathoms S.W. of Ireland. I examined the original at Copenhagen. It differs from others of which *O. fragilis* is the type by having high rounded arms, short, thin arm-spines, and minute spines on the upper arm-plates. The individual was large, and, in its dried state, was light-colored with red mottlings.

This completes the list; and it remains to consider its proper divisions. Dr. Lütken\* admits (1) a northern species, *Asterias fragilis* Abgd., of which he has specimens from Iceland, North Norway, Denmark, North Sea, Spithead, and British Channel. With this he includes, as a variety, *O. pentaphyllum*; and as a variety of the young, *O. echinata* Müll. & Trosch. from Naples. (2) *Ophiothrix quinquemaculata*, also from Naples, the same which has just been noticed. (3) *Ophiothrix alopecurus* (*echinata* Ltk.), from Trieste, also noticed and illustrated above. (4) *Ophiothrix Lütkeni*, dredged by Professor Thomson in 374 fathoms, off Ireland. On *O. lusitanica*, *maculata*, and *rubra* Dr. Lütken has no opinion to offer. In support of his view that all the northern forms are one species, he says pertinently, "That the animals living in the North Sea should afford such differences — that one form should belong to Scandinavia, the other to Britannica — is hardly credible. That would be in opposition to all analogy from all other inhabitants of that sea, which are of course the same on both sides."

I have but one objection to this division: it is not possible to include *O. echinata* as a variety of *O. fragilis*. An examination of the upper arm-plates in two specimens of equal size will satisfy the observer that *O. echinata* is an adult, while an *O. fragilis* of the same diameter is not even half grown.

Dr. Ljungman, who is naturally more inclined to see specific differences,

\* In a letter, December, 1872.

recognizes a greater number, as follows: \* (1) *Ophiothrix fragilis*, the same as understood by Lütken, but in a narrower limit; Denmark, Norway, etc. (2) *Ophiothrix quinquemaculata*, as distinguished by Lütken; Naples. (3) *Ophiothrix alopecurus* Müll. & Trosch. from Trieste, which Mr. Ljungman identifies with *O. fragilis* M. T., *tenuispina* Sars, and *echinata* Ltk. (4) *Ophiothrix maculata* Ljn.; Josephine Bank, 120 fathoms. (5) *Ophiothrix pentaphyllum*, common on south coast of England and west coast of France; identified with *Asterias pentaphyllum* of Pennant, and included by Lütken in his *O. fragilis*. (6) *Ophiothrix lusitanica* Ljn.; as already described above; Portugal. Dr. Ljungman had not seen *O. Lütkeni*, and therefore does not refer to it. It is sufficient to prove the difficulty of the subject, that, of the two European authors best qualified to judge, one recognizes four and the other seven species.

Combining the information from these authorities with personal observation, I am inclined to divide the species as follows: —

1. **Ophiothrix fragilis** DUB. & KOR.

*Asterias fragilis* Ablg.

*Ophiothrix Rammelsbergii* Müll. & Trosch.

*Ophiothrix alba* (?) Grube.

*Ophiothrix fragilis* Sars, Ltk. (pars). Denmark, Norway, Iceland, Faro Isl's.

2. **Ophiothrix quinquemaculata** MÜLL & TROSCH.

*Asterias quinquemaculata* Dell. Ch.

*Ophiothrix quinquemaculata* Ltk.

*Ophiothrix echinata* (?) Ljn. (*non* Müll. & Trosch. *nec* Ltk.). West Coast of Italy.

3. **Ophiothrix echinata** MÜLL. & TROSCH. (*non* Ltk. *nec* Ljn.).

*Asterias echinata* Dell. Ch.

*Ophiothrix fragilis* (*var.* *mediterranea*, *juv.*) Ltk.

*Ophiothrix rubra* (?) Ljn. Algeria, west coast of Italy, Adriatic, Egypt.

4. **Ophiothrix alopecurus** MÜLL. & TROSCH.

*Ophiothrix fragilis* (?) Müll. & Trosch. (*non* *Asterias* Ablg.).

*Ophiothrix fragilis* (*var.* *tenuispina*) Sars.

*Ophiothrix echinata* Ltk. (*non* Müll. & Trosch. *nec* Ljn.). North Adriatic.

5. **Ophiothrix pentaphyllum** Ljn.

*Asterias pentaphyllum*; *varia*; *aculeata*; *hastata*; *fissa*; *nigra*; Pennant (*teste* Ljungman).

*Ophiothrix rosula* Forbes.

*Ophiothrix fragilis* Ltk. (pars). South coast of England, west and north coast of France, Madeira (?).

6. **Ophiothrix lusitanica** Ljn.

*Ophiothrix rubra* (?) Ljn. Northwest coast of France, Portugal, Naples.

\* Letter, March, 1873.

7. *Ophiothrix maculata* Ljn. Josephine Bank, 120 fathoms, off Portugal.  
 8. *Ophiothrix Lütkeni* WYV. THOMS. Southwest of Ireland, 374 fathoms.

Of these species, I consider the first four and the last as well marked; the remaining three, perhaps, need to be illustrated by more specimens and localities.

It may be proper to add, that the foregoing critique is simply intended as a guide to the naturalist who has sufficient specimens of these species for study.

***Astrophyton cacaoticum* sp. nov.**

**Plate VI., Figs. 1 - 3.**

*Special Marks.*—Disk and arms essentially smooth with only a few microscopic grains. Radial ribs high, narrow, and well-marked. Arms unusually slender and forking close to the disk; with hook-bearing ridges feebly raised above the general surface. Five madreporic bodies.

*Description of a Specimen* (dried).—Diameter of disk 30 mm. Arm forked close to disk. Width of arm 6 mm.; of each fork 3 mm. Each then continues as a slender, slowly tapering main trunk, throwing out side branches on alternate sides, and these branches in like manner throw out side twigs.

|                     |                |        |
|---------------------|----------------|--------|
| Distance from first | fork to second | 17 mm. |
| “ “ second          | “ “ third      | 20 “   |
| “ “ third           | “ “ fourth     | 21 “   |
| “ “ fourth          | “ “ fifth      | 20 “   |
| “ “ fifth           | “ “ sixth      | 20 “   |
| “ “ sixth           | “ “ seventh    | 25 “   |
| “ “ seventh         | “ “ eighth     | 25 “   |
| “ “ eighth          | “ “ ninth      | 25 “   |
| “ “ ninth           | “ “ tenth      | 27 “   |
| “ “ tenth           | “ “ eleventh   | 20 “   |
| “ “ eleventh        | “ “ twelfth    | 22 “   |
| “ “ twelfth         | “ “ thirteenth | 12 “   |
| “ “ thirteenth      | “ “ end        | 32 “   |
| Total,              |                | 286 “  |

Along the upper surface of the arm are scattered microscopic granules, which are still fewer and more minute than those of the disk; on an alcoholic specimen these granules would doubtless be invisible. Beginning near the mouth there are two pointed tentacle-spines, 5 mm. long, on each pore, beyond the first fork usually three; and these continue nearly to the tips of the arm, where they are replaced by the hook-bearing ridges, here composed of a double ring of large prominent grains encircling the arm, and with but a short space from one ridge to the next. Each grain bears a minute simple hook. Except at the tip of arm, the hook-bearing ridges are small and low, and separated from each other by a considerable smooth space. The

hooks are found in greater or less number quite to the base of arm. Disk absolutely naked in the interbrachial spaces, except along its edge above, where, as well as on the high narrow radial ribs, there are minute grains, about five in the length of a mm. In the space round the mouth, below, there are a few scattered microscopic granules, which in an alcoholic specimen must be invisible. Five small, narrow madreporic bodies, placed one in the inner angle of each interbrachial space and close against the line of separation between the under and upper surfaces. Mouth and tooth-papillæ sharp and spiniform, arranged in an irregular clump, above which appear three or four teeth, irregularly superimposed, with a striated surface and a rather wide curved cutting edge. Genital openings 2.5 mm. long, situated 1.5 mm. inside the outer end of the radial rib. Color, chocolate-brown.

Guadeloupe; 20 fathoms. A specimen in the Garden of Plants and another, by exchange, in the Museum of Comparative Zoölogy.

***Astrophyton nudum* sp. nov.**

**Plate VI., Figs. 4-5.**

*Special Marks.*—No tentacle-scales on pores. Disk and arms quite smooth; the latter ringed with faint lines, which, magnified, are seen to be rows of minute conical papillæ. One large madreporic body.

*Description of a Specimen.*—Diameter of disk 44 mm. Length of arm about 375 mm., as follows:

|                     |                 |                  |
|---------------------|-----------------|------------------|
| Distance from first | fork to second  | 10 mm.           |
| “ “ second          | “ “ third       | 12 “             |
| “ “ third           | “ “ fourth      | 16 “             |
| “ “ fourth          | “ “ fifth       | 16 “             |
| “ “ fifth           | “ “ sixth       | 17 “             |
| “ “ sixth           | “ “ seventh     | 20 “             |
| “ “ seventh         | “ “ eighth      | 20 “             |
| “ “ eighth          | “ “ ninth       | 19 “             |
| “ “ ninth           | “ “ tenth       | 22 “             |
| “ “ tenth           | “ “ eleventh    | 20 “             |
| “ “ eleventh        | “ “ twelfth     | 20 “             |
| “ “ twelfth         | “ “ thirteenth  | 20 “             |
| “ “ thirteenth      | “ “ fourteenth  | 20 “             |
| “ “ fourteenth      | “ “ fifteenth   | 19 “             |
| “ “ fifteenth       | “ “ sixteenth   | 20 “             |
| “ “ sixteenth       | “ “ seventeenth | 20 “             |
| “ “ seventeenth     | “ “ eighteenth  | 20 “             |
| “ “ eighteenth      | “ “ nineteenth  | 14 “             |
| “ “ nineteenth      | “ “ twentieth   | 17 (tip broken). |
| Total,              |                 | 342              |

Width of arm at disk 16 mm.; width of first fork at its base 6 mm.; at the fifth branch 3.3 mm.; at the fifteenth branch 1.7 mm.; at the twentieth branch 1.2 mm. General surface of arm smooth, without spines or grains; a lens shows a fine network of cross-lines which make an ill-defined mosaic. Each joint is marked by a minute ridge placed in a sunken line and running over the top of the arm and ending on either side near the tentacle-pore. These ridges (about 2 mm. apart at base of arm) consist of minute papillæ not more than .3 mm. long, sometimes in a single row, but more often in zig-zag or alternating order, so as to make an almost double row. Each papilla consists of a hook covered with a thick sheath of skin, and either mounted on a very small base, or else sitting directly on the arm. Approaching the tip of arm, the hook-rows become more and more annular, till, on the fine twigs, they completely encircle the arm in a single row. In this way one or two hooks nearest the tentacle-pores often are prominent, so as to appear like tentacle-scales, though really there are none. Disk essentially naked, although, when partially dry, scattered microscopic grains are seen. Radial ribs regular, rather high, with the outer end cleanly cut off; they are covered with a smooth, close, fine granulation; about eight grains in the length of a mm. Mouth-papillæ, teeth, and tooth-papillæ all flat, spiniform, and similar; about twenty-one in all; those that represent teeth are about three, and are longer than the others. One large madreporic body at the inner angle of interbrachial space, close against the line of separation between upper and lower surfaces. Genital slits 5 mm. long, and lying under outer ends of radial ribs. Color, in alcohol, above, yellowish brown; below and at ends of twigs, much lighter.

A specimen from Philippines, by Semper.

CATALOGUE OF THE OPHIURIDÆ AND ASTROPHYTIDÆ, COLLECTED BY PROF. C. SEMPER, AND NOW BELONGING TO THE MUSEUM OF COMPARATIVE ZOÖLOGY.

|                                       | Number<br>of specimens. |                         |
|---------------------------------------|-------------------------|-------------------------|
| <i>Ophiomastix annulosa</i> Müll. Tr. | 5                       | Philippines.            |
| “ “                                   | 2                       | Pelews.                 |
| “ <i>mixta</i> Ltk.                   | 1                       | Pelews.                 |
| “ <i>flaccida</i> sp. nov.            | 13                      | Philippines.            |
| <i>Ophiocoma scolopendrina</i> Agas.  | 4                       | Pelews.                 |
| “ “                                   | 1                       | Pelews?                 |
| “ “                                   | 14                      | Philippines.            |
| “ <i>erinaceus</i> Müll. Tr.          | 8                       | Philippines and Pelews. |
| “ <i>brevipes</i> ? Peters.           | 4                       | Philippines.            |
| “ “                                   | 5                       | Pelews.                 |
| <i>Ophioplocus imbricatus</i> Lym.    | 9                       | Philippines.            |

|  | Number<br>of specimens. |                         |
|--|-------------------------|-------------------------|
| <i>Ophiarachna incrassata</i> Müll. Tr.                          | 1                       | Pelews.                 |
| “ “  | 2                       | Philippines.            |
| <i>Pectinura marmorata</i> sp. nov.                              | 5                       | Philippines.            |
| “ <i>stellata</i> Ltk.   | 2                       | Philippines.            |
| “ <i>infernalis</i> Ltk.   | 1                       | Philippines.            |
| “ “ “  | 1                       | Pelews.                 |
| “ <i>gorgonia</i> Ltk.   | 2                       | Pelews.                 |
| “ <i>spinosa</i> Lym.  | 1                       | Philippines.            |
| <i>Ophiolepis annulosa</i> Müll. Tr.                             | 1                       | Philippines.            |
| “ <i>cincta</i> Müll. Tr.  | 1                       | Pelews.                 |
| <i>Ophiothrix Galatææ</i> Ltk.                                   | 1                       | Philippines.            |
| “ “ var. ?   | 1                       | Philippines.            |
| “ <i>longipeda</i> Müll. Tr.                                     | 7                       | Philippines.            |
| “ “  | 1                       | Pelews.                 |
| “ “ var. ?   | 3                       | Pelews.                 |
| “ “ var. ?   | 1                       | Philippines.            |
| “ <i>hirsuta</i> Müll. Tr.                                       | 1                       | Philippines.            |
| “ <i>aspidota</i> Müll. Tr.                                      | 1                       | Philippines.            |
| “ “ ?  | 1                       | Philippines.            |
| “ <i>Martensi</i> sp. nov.                                       | 15                      | Philippines.            |
| “ <i>cataphracta</i> v. Martens                                  | 2                       | Philippines.            |
| “ <i>purpurea</i> v. Martens                                     | 1                       | Philippines.            |
| “ <i>exigua</i> sp. nov.   | 12                      | Philippines.            |
| “ <i>striolata</i> Grube   | 9                       | Philippines.            |
| “ <i>plana</i> sp. nov.  | 4                       | Philippines.            |
| “ <i>stelligera</i> sp. nov.                                     | 1                       | Philippines.            |
| “ <i>pusilla</i> sp. nov.  | 2                       | Philippines.            |
| “ <i>elegans</i> ? Ltk.  | 1                       | Pelews.                 |
| “ <i>triloba</i> ? v. Martens                                    | 1                       | Philippines.            |
| <i>Ophiogymna elegans</i> Ljn.                                   | 13                      | Philippines.            |
| <i>Ophiarthrum elegans</i> Peters                                | 4                       | Pelews and Philippines. |
| “ <i>pictum</i> Lym.   | 3                       | Pelews.                 |
| “ “  | 2                       | Philippines.            |
| <i>Ophiocnemis marmorata</i> Müll. Tr.                           | 13                      | Philippines.            |
| <i>Ophiactis sexradia</i> Ltk.                                   | 38                      | Philippines.            |
| “ “  | 1                       | Pelews.                 |
| <i>Ophionephthys phalerata</i> sp. nov.                          | 1                       | Philippines.            |
| <i>Amphiura</i> ( <i>Amphipholis</i> ) <i>depressa</i> Ljn.      | 8                       | Philippines.            |
| “ <i>lævis</i> sp. nov.  | 7                       | Philippines.            |
| <i>Ophiocnida</i> ( <i>Ophiophragmus</i> Ljn.) <i>echinata</i> ? | 4                       | Philippines.            |
| <i>Ophiopeza fallax</i> Peters                                   | 1                       | Philippines.            |

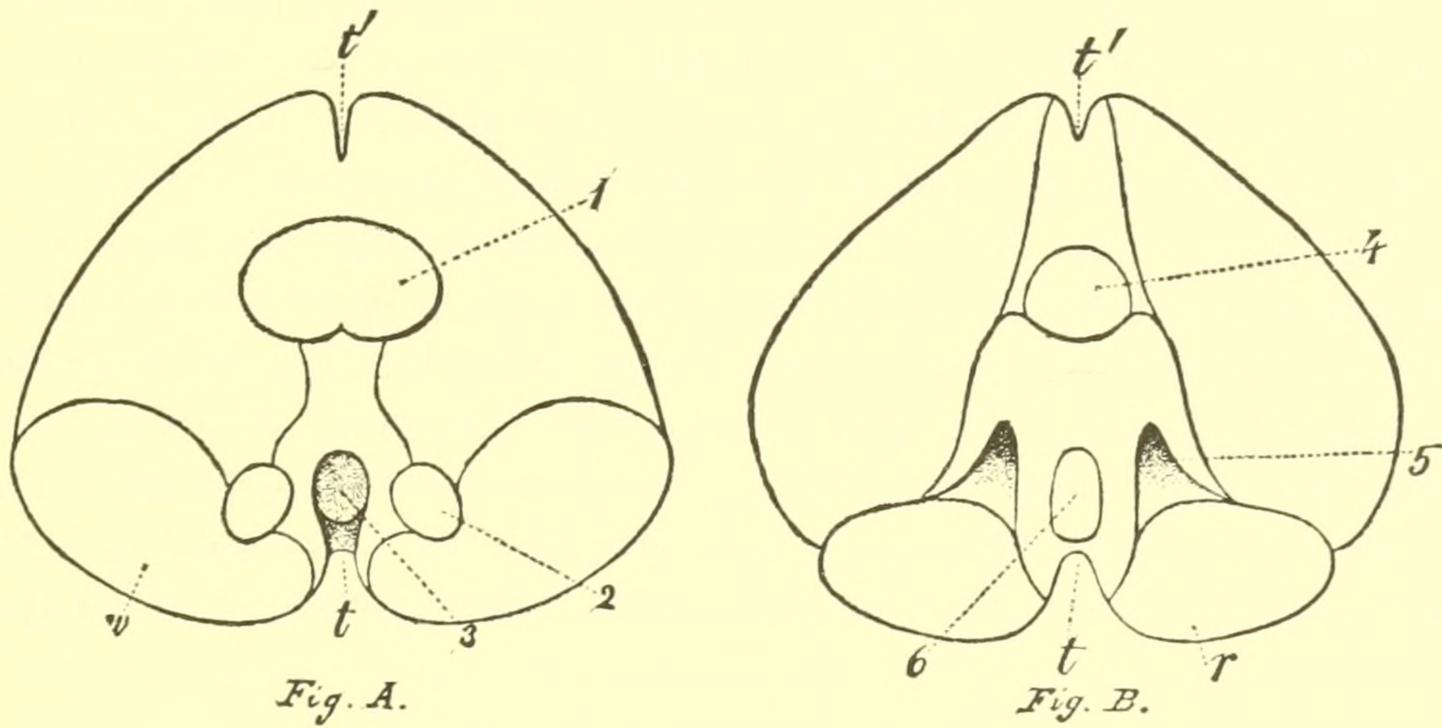
|   | Number<br>of specimens. |              |
|---|-------------------------|--------------|
| <i>Ophioglypha sinensis</i> , Lym. var. ? | 10                      | Philippines. |
| <i>Ophionereis dubia</i> ? Lym.           | 2                       | Philippines. |
| <i>Ophiopsammium Semperi</i> sp. nov.     | 12                      | Philippines. |
| <i>Ophiothela isidicola</i> Ltk. (young)  | 20                      | Philippines. |
| <i>Astrophyton asperum</i> Agas. (young)  | 1                       | Singapore.   |
| “ “                                       | 3                       | Philippines. |
| “ <i>nudum</i> sp. nov.                   | 1                       | Philippines. |

In all, forty-five species, whereof eleven are new. These possess great value as illustrating the fauna of the shallower waters about the Philippine group, because Professor Semper passed several years in that region, and searched diligently for animals of all sorts. On the whole, this collection faithfully represents the fauna of the great ocean, although some rather common species, notably *Ophiocoma Valenciæ* and *O. pica*, are missing. This well may be, because species are often thus lacking in corners of faunal regions, e. g. *Ophiura brevicauda*, abundant at St. Thomas, is almost wanting in Florida. Of *Astrophyton*, besides *A. asperum*, there is a new and beautiful species, *A. nudum*, which, with *A. clavatum* and *A. verrucosum*, make four for the great ocean. To these may perhaps be added *A. exiguum*, in the Garden of Plants, brought by Peron and Lesueur, in 1803, from the South Sea. It is apparently a young one, having a disk of only 8 mm. in diameter, which, with the upper surface of the arm, is granulated finely, and has larger rounded grains among the smaller. Dr. von Martens need have no doubt as to the occurrence of this genus in the limits of the Indian Ocean. We have *A. asperum* not only from China and the Philippines, but also from the Straits of Malacca, brought to the Garden of Plants by Eydoux, in 1832. *A. verrucosum* rests on the authority of a specimen from “Indian seas,” in the Garden of Plants, which may well be good, since such species as *Ophiocnemis marmorata* are found from Port Natal on the south to the Philippines on the north. It seems in every way probable that deep dredging will bring up not only plenty of these species, and of others like *Trichaster palmiferus*, but also additional forms, in the neighborhood of *Astromorpha*.

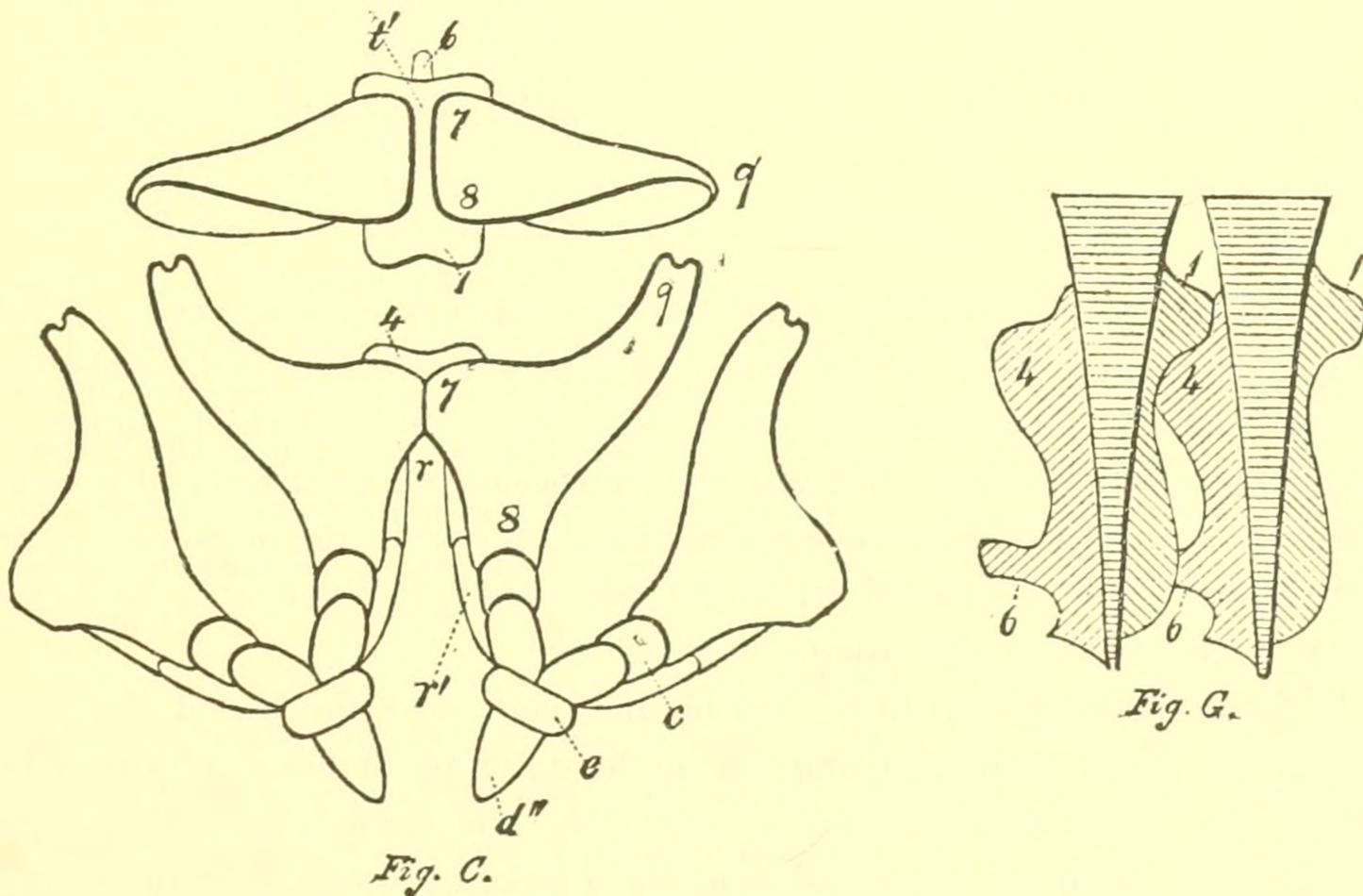
#### HOMOLOGIES OF CHEWING APPARATUS IN OPHIURIDÆ.

The skeleton of an Ophiuran within the circle of the disk (Pl. VII.) consists of the line of arm-bones, jointed one on the other, like vertebræ; the genital plates (Fig. 13, *o*); the radial shields (*l*); of certain irregular pieces arranged along the margin of the disk (Figs. 5 and 18, *s*); and, finally, of the strong forked pieces (Figs. 5, 11, 13, 18, *f*) which form the five angles of the mouth, support the teeth, and thus make up the chewing apparatus. It is

agreed that these forked pieces (*f*) are in some way made from the division of an arm-bone on its median line, and the swinging of each half sideways till it meets and is soldered with the corresponding half of the neighboring



arm-bone. To understand this, an arm-bone must be described in some detail. Each one then is, near the base of the arm, essentially the same as its fellows. Its inner surface (Fig. A) has, above, a broad umbo (1), below



which are two smaller knobs (2) standing on each side of a socket (3); still lower, and quite on the sides, are two large depressions (*w*) for attachment of muscles; above (*t'*) and below (*t*) are notches for the upper and lower

canals, of which the latter has been more studied and is known to carry a nerve and a water-tube. The outer surface of the arm-bone (Fig. B) presents, above, a hollow (4) in which rests the umbo (1) of the next piece beyond it; below are two depressions (5) into which fit the knobs (2), and between which is a peg (6) fitting in the socket (3). On each side of the lower edge is a triangular swelling (*r*), which is the outer wall of the tentacle-socket. Seen from above (Fig. C), the upper longitudinal canal (*t'*) divides the piece in two, leaving on either side an elongated triangular surface on which rest the upper arm-plates. On the outer side may be seen the upper surface of the hollow (4) and the articulating peg below it (6); and within is the upper surface of the articulating umbo (1). A view from below (Fig. D) shows the lower longitudinal canal (*t*); then without is the articulating peg (6) and the two sockets of the tentacles (*r*); within are the great lower muscle-fields (*w*), the two articulating knobs (2), and the socket (3) for the articulating peg. (For detailed views see Pl. VII., Figs. 7-10.) From the way in which the

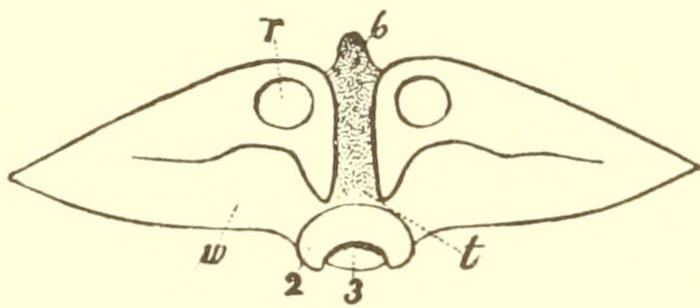


Fig. D.

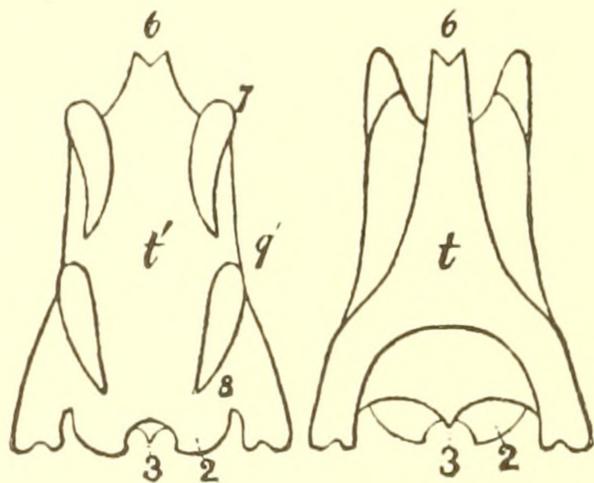


Fig. E.

Fig. F.

joint is held by the umbo above and the peg below, a vertical motion of the arm upward is difficult where these parts are well developed, while the lateral motion is comparatively a free one. As a fact, the chief motion in the living is a lateral one, and only certain species roll their arms in a vertical plane, and this rolling is downward and not upward; the umbo must then slip outward and downward, while the peg must press deeper in its socket (Fig. G, lettered like the others).

A great modification is to be seen in the bones near the tip of the arm, which are much elongated, and are quite different in detail of structure. Along the upper surface runs a very wide and deep longitudinal canal (Fig. E, *t'*); from the outer end projects a forked process, which is the articulating peg (6); at the inner end may be recognized the articulating knobs (2), and the socket (3). On the lower surface may be seen the same parts (Fig. F) and the corresponding canal (*t*), which is slightly marked. (See also Pl. VII., Figs. 16, 17).

To return now to the chewing apparatus, each angle of the mouth has a supporting skeleton (Fig. C) in the form of a V, at whose apex is the jaw-plate (*e*). As has already been said, each side of this V is composed (wholly or in part) of the halves of one or more arm-bones greatly modified, and called collectively mouth-frames (Pl. VII., Fig. 5, *f*). It has generally been assumed that there was only one modified arm-bone in each half of a mouth-frame, but plainly there must be *two*, because there are two tentacle-sockets (*r*, *r'*), in which are lodged the so-called mouth-tentacles; and in no Ophiuran or Astrophyton is there ever more than one tentacle, on each side, to every joint or arm-bone. When the mouth-frames are carefully examined, especially if boiled in potash, there is seen to be a line or suture between the wide outer part (*f*) and the narrow inner point (*c*). The suture runs nearly vertically through, or a little outside, the hollow for the nerve-ring (*u*), and, in some genera, as *Ophioglypha*, this inner point (*c*), called the jaw, is easily detached from the outer portion (*f*), which is more properly the mouth-frame.\* This jaw has no tentacle, and is regarded by Müller as an interambulacral piece, which is soldered with its fellow from the side; and on the angle or point thus made is fixed the jaw-plate (*e*), which belongs to the skin formation, and which in turn supports the teeth (*d''*). It is in *Ophiothrix* that the homology of mouth-frames with the innermost arm-bone may most clearly be seen. In Fig. C, which is a diagram of the innermost arm-bone and of the mouth-frames seen from above, it is evident that the former is split nearly to its outer edge, and that its halves are turned sideways to meet their fellows from the next arm. The angles 7, 8, 9, correspond in the two pieces. This upper portion of the mouth-frame must be considered the first arm-bone having its own tentacle-socket (Pl. VII., Fig. 13, *r'*). The second arm-bone must be placed directly *below* the first, and so intimately soldered with it as to form one; it is provided with its tentacle (*r*), which is the second mouth-tentacle. On this view, each side of a mouth-frame would consist of three pieces, to wit, the first and second arm-bones and an interambulacral piece. All, however, is a theory, based on the position of the tentacles, and needs demonstration from embryology.

The skin formation remains to be considered. It is usual to make two distinct divisions, namely, the skin proper, which includes the arm-plates and the plating or scaling of the disk; and the skin appendages, which are spines, grains, and stumps. Great weight is therefore given, in classification, to these parts; but, morphologically, they are all *the same*, — a fact which may be

\* See J. Müller über den Bau der Echinodermen, 1854, Plate VII., Fig. 6, *f*. This paper, with that of Gaudry, Pièces Solides chez les Stellérides, Annales des Scien. Nat., 1851, p. 339, are the most important for the subject.

illustrated by the arm-plates and spines. If we examine the broken end of an arm which is repairing, and where new joints are rapidly forming, we shall see that the tip is a mere tube (Plate V., Figs. 1, 2, 3, 4. Compare, also, the figures of young Ophiurans given by Müller). This tube is a calcareous network, filled and covered by the secreting tissue, or, as it may be termed, the skin. There seems, then, to be no beginning of an internal arm-bone, — nothing but this open calcareous tube. Immediately, however, there appear annular strictures round the arm, marking the future joints, with a sunken longitudinal line, or even slit, above and below, dividing the tube into two side arm-plates. This embryonic stage is partly persistent in some genera; e. g. species of *Ophiomusium*, which have no under arm-plates on most of the joints. Then appear on the central point of juncture, above, clusters of grains, which, in time, grow into upper arm-plates, and a similar process follows for the lower arm-plates. On the lower surface may be seen (Fig. 1), on the terminal joints, a little flap on each side; this flap grows more acute and rounded, becomes separated from the side arm-plate, and ends as a true arm-spine. So that, in this species of *Pectinura*, beginning with a tube of calcareous network, covered by its secreting skin, we end, at the base of the arm, by the complex assemblage shown in figures 5, 6, 7; and all these parts are merely different growths and divisions of this same network.

The same is true of the various divisions of the upper arm-plates and their supplementary pieces, explained in Plate V. The network may send its branches from its edges or from its upper surface, and these branches may remain connected, and thus enlarge the plate; or they may be separated, and make spines, tentacle-scales, and supplementary plates. It is the same with other Echinodermata, and the process is simply illustrated by the growth of a young spine in *Ophiothrix* (Pl. III., Figs. 4–7). The mouth-parts make no exception. The jaw-plate (Pl. I., Fig. 4, *e*) is a skin-plate, and supports another skin-plate, the tooth (*d'*), which has been separated from it. The peculiar papillæ of *Ophioglyphæ*, which embrace the second mouth-tentacle (*q'*), are, on one side, carried by a peculiar piece attached to the innermost under arm-plate. This piece is only an enlarged outer mouth-papilla (so called), on whose edge have formed these additional papillæ (see the mouth-papillæ described under *Pectinura marmorata*). A similar process gives all the variety in the lamellæ of the stony Polyps. What is true of the arm-plates is true of the skin of the disk, whose scales may be traced from the six primary plates first formed on the back. On these scales may be developed spines, grains, or stumps, just as on the arm-plates. The strict morphological connection of all these parts should warn us not to distinguish them too emphatically, and not to give them too great a value in generic distinctions, especially those minute papillæ which form the armature of the mouth. As to what is provisionally called the skeleton, it is well to remark that Gaudry

is right in considering the arm-bones or disks as parts whose homology is obscure ; certainly they are not properly ambulacral plates, as Joh. Müller thought, because the tentacles, with their water-system, lie *above* the ambulacral plates in starfishes, whereas in Ophiurans they lie *below* the arm-bones and above the under arm-plates, which latter are plainly the true ambulacral plates, not only from their position, but from their early formation, which corresponds to that of the same parts in the starfishes.

## EXPLANATION OF PLATES.

NOTE. — Of these seven plates, all printed by photolithography, the two first are by the Heliotype process of Boston; the five last by the Alberttype, of New York. Although they have the advantage of giving exactly the outlines of the original india-ink drawings, they are very inferior to the drawings themselves; and not only these, but all similar plates I have seen, are faulty in their blurred outlines and their uneven and spotted shading. Their general effect is that of a lithograph from a worn stone. Doubtless the process will, before long, be perfected; but at present it lacks much.

## PLATE I.

## DIAGRAMS.

To make clear the terms commonly used in describing Ophiurans, and to show the varied forms of the parts to which these terms apply, there are given two diagrams, Figs. 1 and 2, representing the under and the upper surface of a disk, with the bases of arms. Each surface is divided into five equal sections, exhibiting the types of as many genera; while the bases of the arms may either correspond, or may belong to others; so that, in the two diagrams, there are nine genera, as follows: A, *Ophiura*; B, *Ophiocoma*; C, *Ophiomyxa*; D, *Ophiothrix*; E, *Ophioglypha*; F, disk of *Amphiura*; G, arm of *Ophiopsammium*; H, arm of *Hemieuryale*; I, arm of *Ophiomusium*.

Fig. 3 is a diagram of one of the five angles of the mouth, seen diagonally from below, to show the relations of the chewing apparatus, mouth-tentacles, mouth-shields, and jaws.

Fig. 4 is a diagram of the mouth parts in *Ophioglypha*, showing half of an angle, with the under arm-plates of two joints.

To these figures the same lettering is applied.

a. *Scutum buccale*; mouth-shield; mündschild; plaque buccale. This plate is always present, though sometimes quite shrouded by a thick skin (*Ophiomyxa*). Sometimes it takes on a great development, running far out into the interbrachial space (some species of *Ophioglypha*); in *Ophiarachna* it has a small supplementary piece lying outside of it. One of the five shields is the madreporic, and is connected with the stone-canal.

b. *Scutella adoralia*; side mouth-shields. These are lettered in Figs. 3, 4, and will be seen inside the point of the mouth-shield in Fig. 1. Often they may be covered either by thick skin (*Ophiomyxa*) or by granulation (*Ophiura*). Their size is considerable in *Ophioglypha* (Fig. 1, E), but in *Ophiothrix* they are small and narrow (Fig. 1, D). Usually their outer end rests against the innermost side arm-plate; but in some species of *Ophiactis* they extend farther, and touch their outer ends at the outer corner of each mouth-slit; thus forming an unbroken ring round the mouth.

c. *Scutella oralia*; jaws; mundeckstück (sometimes included in mouth-frames). These are the only pieces of the skeleton not covered by the tegument or its

plates. They are lettered in Figs. 3, 4, and may be seen in Fig. 1, within the side mouth-shields, against which they usually press, though in *Ophiothrix* they are separated by an indentation. Sometimes they are covered by the skin or by granulation (*Ophiomyxa*, *Ophiura*).

*d. Papillæ orales vel marginales*; saumpapillen; papilles calcaires de la bouche; mouth-papillæ. These run along the lower edge of each mouth-angle, and the greater part, or the whole, rest directly on the mouth-frames; in a whole group or genera they are wanting (*Ophiothrix*, *Ophiocnemis*, etc.). *Ophiomyxa* has them under the form of little comb-like lobes. They are close and numerous in some genera (*Ophiocoma*), and confined to a single papilla on each side in others (*Hemipholis*). They run diagonally upward in some species of *Ophioglypha*. See also under *tentacle-scales*.

*d'. Papillæ dentales*; zahnpapillen; tooth-papillæ. (Fig. 3, *d'*, and the point of the mouth-angle of *Ophiothrix* in Fig. 1.) This group of papillæ, lying just under the teeth, is most developed in *Ophiothrix*, well marked in *Ophiocoma*, but quite wanting in *Ophiura*.

*d''. Dentes*; zähne; teeth. (Figs. 3, and 4 *d''*, and the point of the mouth-angle in *Ophioglypha* and *Ophiura* in Fig. 1.) These, like the tooth-papillæ, are always carried by the jaw-plate, and are never wanting among true Ophiurans. In some genera, they descend to the level of the lower margin of the jaw-frames (*Ophioglypha*, *Ophiura*, *Ophiopeza*), in others they are supplemented by tooth-papillæ (*Ophiocoma*, *Ophiomastix*, *Ophiothrix*); and in *Ophiomyxa* they have the form of comb-like lobes, resembling the rest of the chewing apparatus.

*e. Torus angularis*; maxiller; jaw-plate. (Figs. 3 and 4.) This is a narrow calcareous plate, running vertically along the inner point of the jaws, with little hollows in its surface, to which the teeth are bound by small muscles. It is a part which always exists, and is made up of several pieces, which are often separable.

*h. Scutella ventralia*; bauchschilder; plaques ventrales du bras; under arm-plates. (Figs. 1 and 4, *h*.) They differ extremely in size and form; being always minute and more elongated at the tip of the arm, and in some genera they continue subordinate (*Ophioglypha*, *Ophiomusium*), while in others they widen and make a broad continuous strip (*Ophiura*, *Ophiarachna*, *Ophiocoma*). Some genera have them covered by a thick skin (*Ophiopsammium*, *Ophioscolex*), as also *Ophiomyxa*, where they divided, lengthwise, in two.

*i. Scutella lateralia*; plaques laterales du bras; side arm-plates. These may be considered the fundamental covering of the arm, for they alone surround it at the tip; and in one genus (*Ophiomusium*) they so continue nearly to its base, almost wholly excluding the upper and under plates (Fig. 2, I *i*). Other genera, like *Ophioglypha* (Fig. 1, E *i*), have them persistent on the lower surface of the arm, but replaced above by the upper arm-plates. Coming to forms like *Ophiocoma*, they are widely separated (Fig. 1, B) above and below. Finally, in the extreme case of *Hemicuryale* (Fig. 2, H *i*) the side arm-plates are

reduced to small bead-like projections. Then there are two different forms, — the *ridge*, which stands out free of its neighbors, and bears the spines nearly at right angles to the axis of the arm (Fig. 1, B D), (*Ophiocoma*, *Ophiothrix*, *Ophiacantha*); and the *flat*, which clings close to the surface and overlaps the next plate beyond (Fig. 1, A E; Fig. 2, A I), (*Ophiura*, *Ophioglypha*, *Pectinura*). These bear the spines on their outer edge, and lying close to and parallel with the arm. In consequence of two such modes of structure, Ophiurans are divided into supple-armed and stiff-armed. The ridge-like plates give space for a more or less free lateral motion, while the flat and overlapping ones impart rigidity. If a living *Ophiothrix* be placed side by side with an *Ophiura*, the former will wriggle briskly along the bottom, while the latter may lie quite torpid, or only slightly bend its rigid arms. Dr. Graeffe told me that one of the most singular spectacles he had seen was an *Ophiothrix longipeda* swimming free, and with its five immensely long arms in rapid and perplexing motion. *Ophioglypha* has more mobility than *Ophiura*, but its way of lifting itself along by two of its arms, as described by Professor Mobius,\* is very different from the lively squirming of the arms of an *Ophiothrix*. Even in genera which are clothed by a thick skin, such as *Ophiomyxa*, the side arm-plates will be found well developed underneath.

*j. Scutella dorsalia*; rückenschilder; plaques dorsales du bras; upper arm-plates. Like those of the lower surface, they may either remain very small, as when they first appear at the arm-tip (*Ophiomusium*, Fig. 2, I *j*), or may develop into wide scales, covering the whole upper surface (*Ophiura*, Fig. 2, A *j*; *Ophiarachna*). It is these plates that are specially liable to multiplication, either by breaking up mechanically, or by the addition, in various ways, of supplementary pieces (see p. 267). The extremest case is furnished by *Hemieuryale*, where the original plate becomes lost in a mosaic of additional pieces (Fig. 2, H *j*).

*l. Scutella radialia*; radialschilder; plaques radiales; radial shields. Not properly a part of the general scale covering of the disk, and belonging rather to the interior skeleton through their connection with the genital plate, these shields are an exceptional feature, and one that never is wanting, although sometimes hidden by thick skin (*Ophiomyxa*, Fig. 2, C), or by scales and granules (*Ophiura*, Fig. 2, A); sometimes very large, with their inner portion buried by scales (*Ophiothrix*, Fig. 2, D; *Ophioglypha*, Fig. 2, E), or, again small and narrow (*Amphiura*, Fig. 2, F).

*m.* Radial scales sometimes exist as large scales just next the outer end of the radial shield. In *Ophioglypha* they serve to support an arm-comb of small papillæ (Fig. 2, E *m*).

*n.* Genital scales are largely developed in some genera, where they bound a part of the body wall of the genital opening (*Ophioglypha*, Fig. 1, E *n*), and even pass upwards and arch over the base of the arm (*Ophiothrix*, Fig. 1, D *n*).

*p. Spinæ brachiales*; arm stacheln; piquants; arm-spines. It has already been

\* Schriften des Naturw. Vereins für Schleswig-Holstein, I. 179, 1873.

shown that these spines may stand either on ridges at right angles to the length of the arm (Fig. 1, B C D) or on the outer edges of the side arm-plates, parallel to it (Fig. 1, A E). In the former case the wider diameters of the spines are upward, like the paddles on a wheel (*Ophiothrix*); in the latter, the spine has its edge upward as if it had been revolved 90° on its own axis. The variations in these little organs are almost endless; extremely long, thin, glassy, and thorny (*Ophiothrix Suensonii*), very small, thick, opaque, and smooth (*Ophiomusium burneum*); rounded and tapering (*Ophiocnemis marmorata*); flat and of even width (*Ophiura cinerea*); covered with thick skin (*Ophiomyxa flaccida*); naked (*Ophiocoma echinata*); club-ended (*Ophiomastix annulosa*); armed with hooks (under spine in some species of *Ophiothrix*). The importance of the arm-spines depends partly on their length, thickness, and number, and partly on the extent of the side arm-plates. When these last occupy a large part of the circumference, and the spines also are long and numerous, the arm proper is almost hidden and resembles a round bristle-brush (*Ophiomyces fructosus*).

*q. Papillæ ambulacrales*; tentakel schuppen; papilles tentaculaires; tentacle-scales. Although these small organs are strictly homologous with, and even sometimes similar to, the arm-spines (*Ophioglypha*), they nevertheless have a different function, to wit, that of covering the tentacle drawn in; and usually they differ in form and position from the nearest arm-spine. Thus in *Ophiothrix*, while the lowest spine is often hooked, the tentacle-scale is minute and tooth-like; in *Ophiopsila* it is like a spatula; *Ophionereis* has a single circular one; *Ophiocoma* one, or two, of a shape more or less oval. In *Ophiura* the upper scale laps over the base of the lowest arm-spine, though in most genera the two are separated. One of the tentacle-scales is often carried by the under arm-plate, either on its lateral edge (*Amphiura*) or on its surface, making a continuation of the line of arm-spines (*Ophiomyces*). Although some species of *Amphiura* have two scales, one on the edge of the under arm-plate and the other at right angles on the edge of the side arm-plate, others have no scale at all, — a want shared by many species (*Ophioscolex glacialis*, *Ophiomyxa*, *Ophiopsammium*). The two pairs of mouth-tentacles are not neglected in this respect (Figs. 3, 4, *q' q''*); but, in almost all genera, are furnished with one or more tentacle-scales (*q q*). That of the first, or upper, tentacle sits on a little ridge of the jaw. It is this, when largely developed (as in some species of *Amphiura*), that has been described as a peculiar papilla situated *high up in the mouth*. *Ophiothrix* is one of the few genera that lacks this scale, which exists even in *Ophiomyxa*. While these scales are closely homologous, on the one side, with arm-spines, they also are, on the other, with certain mouth-papillæ. Of this there is an illustration in *Ophioglypha* (Fig. 4), where the tentacle has a row of scales on either side of it, one row carried on the edge of the side arm-plate (*i*), the other on that of the under arm-plate (somewhat displaced in the figure). It is a greater development of what occurs in the *Amphiuræ* with two scales (Pl. IV. Fig. 20). The homologue of the side arm-plate which belongs to the innermost under plate is the side mouth-shield; and

this not only in *Ophioglypha* (*b*), but in most other genera, bears one or more tentacle-scales, under the form of outer mouth-papillæ; while what may exactly be called mouth-papillæ (*d*) are apt to stand on the mouth-frames. This distinction, however, is only one of convenience as applied to parts really homologous. Thus in *Ophioglypha* the two rows of scales belonging to the second pair of mouth-tentacles stand respectively on a plate which is really an overgrown outer mouth-papilla (see under *Pectinura marmorata*), and on the side mouth-shield (partly, also, on the mouth-frames?). The first pair of mouth-tentacles, in the same genus, are duly furnished with their own scales, which stand, as usual, on a ridge of the jaw. All the complex arrangement just described may be most clearly seen in *O. Lymani*.

The integument which encloses the disk is, properly speaking, covered, or beset, with calcareous plates, which, in the young, are six in number, to wit, the largest in the centre and the other five in a close circle round it, one opposite the base of each arm. In some genera the secretion of lime is stopped in the disk integument at an early period; and, in the adult, nothing is to be found but a few minute grains buried in the skin, while the general surface of the disk is smooth and fleshy. Such genera are said to be *naked* (*Ophiomyxa*, *Ophiarthrum*, Figs. 1, 2, C). Others are equally called *naked* where a thick skin covers a regular scaly coat (*Ophiopsila*). In many genera the disk is plainly covered with plates, which may be finely imbricated scales (*Amphiura*, Fig. 2, F) or coarser and thicker ones irregularly arranged (*Ophioglypha*, Figs. 1, 2, E), or thick angular pieces set side by side on the same level, like a mosaic (*Ophiolepis*, *Ophiomusium*). Then there are genera in which the scale coat is beset, or even hidden, by appendages. These may be spines (*Ophiothrix*, Figs. 1, 2, D); or scattered grains (*Ophiocoma*, Fig. 1, B); or grains so closely set as to completely hide the disk, radial shields and all, except the mouth-shields (some species of *Ophiura*, Figs. 1, 2, A). There is one genus (*Ophiopsammium*) in which the disk and upper surface of the arms are covered, first by a smooth integument, and this again by a close granulation. The radial shields are to be seen in all species in which the scale coat is visible, and the mouth-shields are never hidden except in a few species which have a very thick, naked integument.

## PLATE II.

### SPINES AND STUMPS OF THE DISK OF OPHIOTHRIX.

All the figures are enlarged about thirty diameters.

Figs. 1-14 *Ophiothrix echinata*.

“ 15-29 “ *lusitanica*.

“ 30-36 “ *pentaphyllum*.

“ 37-44 “ *fragilis*.

“ 45-55 “ *quinquemaculata*.

1, 2, 3, a spine and two stumps, *O. echinata*, original of Müll. & Trosch. 4-9,

Naples. 10-11, showing a stump covered by skin, and another with the skin partly torn off: Naples. 12-13, stumps from lower interbrachial space of a young, having a disk of 2.5 mm. The scales of the disk are then visible, and Fig. 13 shows how one stump stands on each scale: Naples. 14, a short spine from the interbrachial space below: Algeria.

15-20, *O. lusitanica*, Naples; 16-18 being from the young; 15, 19, 20, from an adult; the last (20) is a very rare spine. 21-29, N. W. coast of France; of these 22 is the common form; the rest are more or less rare; 28 is found near the edge of the disk.

30-35, *O. pentaphyllum*, Isle of Wight; of these 30-33 are the characteristic grains and stumps of the centre of the disk; 34, 35, are its thick columnar spines; 36, a disk spine: Madeira?

*O. fragilis*. 41, stump from a young, with a disk of 5.5 mm. 37, 40, 42, two stumps and a spine from a disk 7 mm. in diameter. 44, an elongated stump from the edge of a disk 9 mm. in diameter. 38, 39, stumps from a large specimen (disk 16 mm.); 39 is rare: Denmark. 43, rough grain from centre of disk; large specimen: Sweden.

*O. quinquemaculata*. 46, 47, stump and articulated spine from a young, with a disk of 3.5 mm.: Naples. 52, 53, short and elongated stumps from a disk 7.5 mm. in diameter; the latter from the edge. 51, articulated spine from a large specimen. 45, irregular, thickened spine from an adult. 48, 49, 50, short stumps from the centre of a large disk. 54, an elongated stump from the edge of the same. 55, a large stump like 49, much elongated: Spezia.

### PLATE III.

#### GROWTH OF SPINES, HOOKS, AND STUMPS.

*Ophiothrix alopecurus* Müll. & Trosch. *Ophiothrix rudis* sp. nov. *Ophiothrix stelligera* sp. nov. *Ophiothrix pusilla* sp. nov.

Fig. 1. The fluted form of the long spines which cover the upper surface of the disk, except the radial shields, in *O. alopecurus*. These usually are more slender, with smaller side thorns and only slight appearance of fluting;  $\frac{3}{1}$ .

Figs. 2, 3. Minute spines, simple and forked, which sometimes are found sparsely on the radial shields;  $\frac{3}{1}$ .

Fig. 4. A young arm-spine from near tip of arm, showing a central shaft with thorns forming on either side, and the holes, along the two lines of juncture, not yet filled up;  $\frac{7}{1}$ .

Fig. 5. A similar spine with the side thorns broken off to show more distinctly the central shaft;  $\frac{7}{1}$ .

Fig. 6. Tip of a similar spine more magnified, to show the holes along the lines of juncture, holes of growth;  $\frac{14}{1}$ .

Fig. 7. Fragment of a very young spine much magnified, to show the soldering of a thorn with the central shaft, and the holes of growth.

Fig. 8. Base of an adult arm-spine, showing the development and close soldering of the side thorns to each other and to the central shaft;  $\frac{2}{1}^0$ .

Fig. 9. Tip of an adult spine magnified, to show the central shaft and side thorns beginning to form.

Fig. 10. Hook from near tip of arm, corresponding to Fig. 4. At its base are seen the holes of growth;  $\frac{7}{1}^0$ . For its position with its three arm-spines, see Pl. VII., Fig. 16.

Fig. 11. *Ophiothrix rudis*. A disk-stump;  $\frac{2}{1}^0$ .

Figs. 12, 13. Under and upper arm-spines from the eighth joint; the latter has a blue belt round the middle;  $\frac{2}{1}^0$ .

Fig. 14. Under arm-plate of the eighth joint;  $\frac{2}{1}^0$ .

Fig. 15. *Ophiothrix stelligera*. Under arm-plates of the seventh, eighth, and ninth joints, with one of the hooks;  $\frac{1}{1}^0$ .

Fig. 16. Upper arm-plate, near the disk;  $\frac{1}{1}^0$ .

Fig. 17. Common form of disk-stump;  $\frac{1}{1}^{\frac{2}{1}0}$ .

Fig. 18. A similar one from above;  $\frac{1}{1}^{\frac{2}{1}0}$ .

Fig. 19. Rare form of disk-stump;  $\frac{1}{1}^{\frac{2}{1}0}$ .

Fig. 20. Spine from the interbrachial space below;  $\frac{1}{1}^{\frac{0}{1}0}$ .

Figs. 21, 23, 25. *Ophiothrix pusilla*. Unusual forms of disk-stumps;  $\frac{6}{1}^0$ .

Fig. 22. The common form of stump on the back of the disk;  $\frac{6}{1}^0$ .

Fig. 24. Stump from interbrachial space below;  $\frac{6}{1}^0$ .

Fig. 26. Stump from interbrachial space near mouth;  $\frac{6}{1}^0$ .

Fig. 27. Side arm-plate of seventh joint with its eight spines and hook;  $\frac{1}{1}^0$ .

Fig. 28. Part of an under and a side arm-plate close to tip of arm, showing the one small arm-spine and the large hook; much magnified.

Fig. 29. Upper arm-plates of sixth, seventh, and eighth joints, with two side arm-plates, to show the triangular projection from the latter;  $\frac{1}{1}^0$ .

Fig. 30. Upper arm-plates, near end of arm, with spines and side arm-plates, showing the triangular projection from the latter.

#### PLATE IV.

*Ophiothrix plana* sp. nov. *Ophiothrix Martensi* sp. nov. *Ophiopsammium Semperi* gen. et sp. nov. *Amphiura laevis* sp. nov. *Ophiocnida* (*Ophiophragmus* Ljn.) *echinata* (?) (*longipeda* Lym. MS.). *Ophiothrix exigua* sp. nov. *Ophiothrix comata* Müll. & Trosch. *Ophiothrix ciliaris* Müll. & Trosch. *Ophiothrix fumaria* Müll. & Trosch.

Fig. 1. *Ophiothrix plana*. Portion of upper surface of disk; at the centre and left the skin is partly dried to exhibit the underlying scales which on the right are covered by the epidermis;  $\frac{5}{1}$ .

Figs. 2, 4. Different forms of the third arm-spine. Fig. 4 has its epidermis;  $\frac{2}{1}^0$ .

Fig. 3. An upper arm-spine;  $\frac{2}{1}^0$ .

Fig. 5. A short disk-stump covered by a thick epidermis ;  $\frac{2}{1}^0$ .

Fig. 6. Three disk-stumps, one with and two without epidermis ;  $\frac{2}{1}^0$ .

Fig. 7. Edge of a side arm-plate near tip, carrying two spines and a double hook ;  $\frac{4}{1}^0$ .

Fig. 8. Under arm-plates ;  $\frac{5}{1}$ .

Fig. 9. *Ophiothrix Martensi*. Hook and arm-spine next above it, with its epidermis ;  $\frac{3}{1}^0$ .

Fig. 10. Upper arm-spine and upper arm-plates close to disk ; showing the central blue line with a white line on each side.

Fig. 11. *Ophiopsammium Semperi*. Twelfth joint, seen diagonally from below, showing, on the further side, an extended tentacle and the lowermost arm-spines ; and, on the nearer portion, a side arm-plate and its spines, foreshortened, and with the tentacle omitted ;  $\frac{2}{1}^0$ .

Fig. 12. Part of upper surface of disk, showing the base of an arm, and the pairs of spines in the interbrachial space ;  $\frac{5}{1}$ .

Fig. 13. Tooth-papillæ and teeth seen from within ;  $\frac{1}{1}^0$ .

Fig. 14. Longest arm-spine (third) near base of arm ;  $\frac{1}{1}^0$ .

Fig. 15. Under arm-plates, as they may be distinguished near tip of arm ;  $\frac{1}{1}^0$ .

Fig. 16. Joints, seen from above, close to end of arm, showing the beginning of the granulation, and the embryonic upper arm-plates ; each side arm-plate is furnished only with two little arm-spines and a strong double hook ;  $\frac{2}{1}^0$ .

Fig. 17. Granulation of the upper arm near its base ;  $\frac{2}{1}^0$ .

Fig. 18. *Amphiura laevis*. A portion of the disk, from above, with the base of an arm ;  $\frac{1}{1}^0$ .

Fig. 19. An angle of the mouth, showing the four mouth-papillæ on each side, with mouth-shield and side mouth-shields ;  $\frac{1}{1}^0$ .

Fig. 20. Two joints of arm, near the disk, seen from below ;  $\frac{1}{1}^0$ .

Fig. 21. *Ophiocnida echinata* ? Part of a side arm-plate with its spines ;  $\frac{5}{1}$ .

Fig. 22. A portion of the disk, from above, with the base of an arm ;  $\frac{5}{1}$ .

Fig. 23. An angle of the mouth, with a mouth-shield and the first two under arm-plates ;  $\frac{5}{1}$ .

Fig. 24. *Ophiothrix exigua*. Upper arm-plates and bases of the arm-spines, near the disk ;  $\frac{1}{1}^0$ .

Fig. 25. The common form of disk-stump ;  $\frac{6}{1}^0$ .

Fig. 26. Hook, standing below the arm-spines ;  $\frac{3}{1}^5$ .

Fig. 27. *Ophiothrix comata* (from the original in the Vienna Museum). An under arm-plate, with its tentacle-scale ;  $\frac{1}{1}^0$ .

Fig. 28. Two upper arm-plates, with the bases of arm-spines ;  $\frac{1}{1}^0$ .

Fig. 29. *Ophiothrix ciliaris* (from the original at the Garden of Plants). A portion of upper surface of disk and two upper arm-plates, showing the distribution of the fine disk-stumps ;  $\frac{8}{1}$ .

Fig. 30. A disk-stump, from near the edge ;  $\frac{1}{1}^8$ .

Fig. 31. Two under arm-plates.

Fig. 32. Second arm-spine ;  $\frac{1}{1}^5$ .

Fig. 33. *Ophiothrix fumaria* (from the original in the Garden of Plants). A portion of upper surface of disk, with some upper arm-plates. On either side of the points of the radial shields appear the upper corners of the genital scales ;  $\frac{4}{1}$ .

Fig. 34. Under arm-plates, with tentacle-scales.

Fig. 35. Arm-spines, near base of arm ;  $\frac{8}{1}$ .

Fig. 36. A disk-stump on its scale, much magnified.

### PLATE V.

#### FORMATION OF ARM-SPINES, ARM-PLATES, AND SUPPLEMENTARY PIECES.

*Pectinura marmorata* sp. nov. ; *Hemieuryale pustulata* v. Mart. ; *Ophioplocus Esmarki* sp. nov. ; *Ophiura squamosissima* Lym. ; *Ophiura cinerea* Lym. ; *Ophiopholis aculeata* Müll. & Trosch. ; *Ophionereis dubia* Lym.

Fig. 1. *Pectinura marmorata*. The tip of an arm undergoing repair. The point is only a tube of calcareous network, covered by the secreting membrane. Farther in, this tube is widened and cut transversely by furrows into joints, which have lobes at their outer edge ; and these lobes grow more sharp and rounded, and finally become the lowermost arm-spine, *p*. There are no under arm-plates at this stage of growth ;  $\frac{4}{1}^0$ .

Fig. 2. The same from above. Almost the entire surface is occupied by the side arm-plates, at whose central point of juncture appear little collections of granules, *j*, which are to be separated later as upper arm-plates ;  $\frac{4}{1}^0$ .

Fig. 3. The same seen from the side. One joint has two partly formed arm-spines, *p*, and the next joints have one each ;  $\frac{4}{1}^0$ .

Fig. 4. The broken arm under repair, showing the old portion, and eighteen new joints ; of which the last five are represented in Figs. 1, 2, 3 ;  $\frac{1}{1}^0$ .

Figs. 5, 6, 7. Two joints, close to the disk, seen from below, from above, and from the side, to compare the perfect plates and spines with the young ;  $\frac{1}{1}^0$ .

Fig. 8. *Hemieuryale pustulata*. Tip of the arm, magnified, showing the tubular point, the side arm-plate, *i*, and the young upper arm-plate, *j*.

Fig. 9. A joint near the tip, seen from above. *p*, arm-spine ; *i*, side arm-plate ; *j*, upper arm-plate ; *k*, supplementary piece.

Fig. 10. Joint farther inward. *i*, side arm-plate ; *j*, upper arm-plate ; *k*, supplementary piece, in addition to which there are now numerous others, smaller.

Fig. 11. Joint about one third out on the arm. *k*, the great supplementary piece, which now is larger than the side arm-plate, *i*, and forms the little cushion characteristic of the genus. The upper arm-plate can no longer be distinguished among the numerous irregular supplementary pieces. This is an instance of great changes in the relative importance of parts in the process of growth.

Fig. 12. *Ophioplocus Esmarki*. Tip of arm showing the very short tubular point, followed by a joint which has a small upper arm-plate. The corresponding plate of the next joint has a longitudinal furrow ; the same is fairly separated in

two parts on the succeeding joint, and has a couple of supplementary pieces within. The two parts are still more diverging on the next joint, *j*; the large side arm-plate, *i*, comes up toward the median line, and the upper arm-spine *p* is prominent;  $\frac{1}{1}^0$ .

Fig. 13. A joint near the middle of the arm. The two parts of the upper arm-plate, *j*, are now completely separated by the intrusion of supplementary pieces, which have increased to seven; *p*, arm-spine; *i*, side arm-plate;  $\frac{1}{1}^0$ .

Fig. 14. A joint at the base of the arm. The two parts of the upper arm-plate *j*, instead of occupying the top, have been wedged apart by supplementary pieces, until they are on each margin. The side arm-plates, *i*, have become small as compared with the supplementary pieces, and the arm-spines, *p*, are no longer conspicuous;  $\frac{1}{1}^0$ .

Fig. 15. *Ophiura squamosissima*. Piece of arm near its tip, enlarged. The outer joint bears a small, simple upper arm-plate; the innermost one has also a simple plate, *j*, outside which are two supplementary pieces, *k*; on either side is a large side arm-plate, *i*, bearing a short spine.

Fig. 16. A joint near the base of the arm. The upper arm-plate still occupies the median line, *j*; but the two supplementary pieces, *k*, have moved from a position beyond, to one on either side of the upper arm-plate, and still another supplementary piece has been formed in a line with the rest and lying on the margin. The side arm-plate has become comparatively small, *i*, and has been crowded down on the side of the arm.

Fig. 17. *Ophiura cinerea*. A joint near base of arm, showing the upper arm-plate broken in several pieces, as is usual;  $\frac{8}{1}$ .

Fig. 18. *Ophiopholis aculeata*. Two joints near end of arm showing the upper arm-plate, *j*, with a row of grains or small supplementary pieces, only along their outer margin;  $\frac{4}{1}$ .

Fig. 19. Two joints near the base, showing the same plates, *j*, completely encircled by a close row of small pieces, which may be double on the sides;  $\frac{4}{1}$ .

Fig. 20. *Ophionereis dubia*. A joint near end of arm showing the simple upper arm-plate, *j*;  $\frac{2}{1}^0$ .

Fig. 21. A joint near base of arm, with a small supplementary piece, *k*, on each side of the upper arm-plate, *j*;  $\frac{2}{1}^0$ .

## PLATE VI.

*Astrophyton cacaoticum* sp. nov.; *Astrophyton nudum* sp. nov.; *Ophioplocus Esmarki* sp. nov.; *Ophionephthys phalerata* sp. nov.; *Pectinura septemspinosa* Müll. & Trosch.; *Ophiomastix flaccida* sp. nov.

Fig. 1. *Astrophyton cacaoticum* (from a dried specimen). A part of the disk, from below, with outline of one fork of the arm, showing the distance of the branches with approximate accuracy;  $\frac{1}{1}$ .

Fig. 2. Part of upper side of disk, showing the slender radial ribs, and the first fork of the arm ;  $\frac{1}{4}$ .

Fig. 3. The head of a radial rib and part of the interbrachial margin, enlarged to show the granulation along the edge ;  $\frac{4}{1}$ .

Fig. 4. *Astrophyton nudum*. Tip of a twig, seen from below, showing the continuous line of hooks covered by a thick skin ; and, in front of them, two short, conical tentacles ;  $\frac{6.0}{1}$ .

Fig. 5. Three hooks, from the double alternating rows of the branches near the base of the arm. From one, the skin has been stripped, showing the naked hook ;  $\frac{4.0}{1}$ .

Fig. 6. *Ophioplocus Esmarki*. Two joints near base of arm, seen from the side ;  $\frac{1.6}{1}$ .

Fig. 7. *Ophionephthys phalerata*. Two angles of the mouth, the base of the arm, and a part of two interbrachial spaces ;  $\frac{7}{1}$ .

Fig. 8. Portion of upper surface of disk, with base of an arm, and radial shields surrounded by their peculiar wreath of scales ;  $\frac{7}{1}$ .

Fig. 9. An upper arm-plate, with a side arm-plate and its spines, showing the peculiar thickened spine ;  $\frac{2.0}{1}$ .

Fig. 10. *Pectinura septemspinosa* (from the original at Leyden). Upper arm-plates and spines, near disk, showing how the former are usually broken ;  $\frac{4}{1}$ .

Fig. 11. An angle of the mouth enlarged, exhibiting the mouth-shield with its small supplementary piece and the surrounding granulation.

Fig. 12. Arm-spines, near disk, with the lowest one somewhat longest, and having its base covered by a tentacle-scale ;  $\frac{4}{1}$ .

Fig. 13. Two under arm-plates within the disk, with the pairs of pores between them ;  $\frac{4}{1}$ .

Fig. 14. *Ophiomastix flaccida*. An angle of the disk and base of an arm, seen from above, where are seen the peculiar upper spines thickened in different degrees ;  $\frac{5}{1}$ .

Fig. 15. Two joints from below, showing two tentacles having no tentacle-scales ;  $\frac{5}{1}$ .

## PLATE VII.

*Pectinura infernalis*. Müll. and Trosch. ; *Ophiarthrum pictum* Lym. ; Homologies of the skeleton of the arm and mouth-parts in *Ophiothrix*, *Ophiura*, *Ophioglypha*, and *Ophiomyxa*.

Fig. 1. *Pectinura infernalis*. Part of upper surface of disk, to show the characteristic arrangement of the naked plates ;  $\frac{4}{1}$ .

Fig. 2. *Ophiarthrum pictum*. A corner of the disk and three upper arm-plates, with the pattern lines and arm-stripe ;  $\frac{5}{1}$ . Specimen from Pelew Islands.

Fig. 3. A tentacle and its scale ;  $\frac{1.6}{1}$ .

Fig. 4. Side arm-plate (third joint from the disk) with its spines, and a corner of the upper arm-plate;  $\frac{5}{1}$ .

Fig. 5. *Ophiura lævis* (Mediterranean). The skeleton of the mouth-parts, and of the arm as far as the edge of the disk, with the genital plates, *o*, *o*, in position, seen from above;  $\frac{5}{1}$ . *c*, jaws; *e*, jaw-plate; *d''*, teeth; *u*, circular canal for the nerve-ring of the mouth; *r*, *r'*, sockets of the second and first pairs of tentacles; *q*, tentacle-scale of the first pair; *f*, mouth-frames; *r*, *r* (on the arm-bones), places for the tentacles; *s*, one of the supplementary pieces lying along the margin of the disk, under the skin; *t'* upper arm-canal. On the left are a few scales of the disk, in position, with their coat of grains. The radial shields are removed.

Fig. 6. Jaws, one mouth-frame, and two arm-bones in profile, the latter are separated and turned so as to show part of the top; lettering as above;  $\frac{5}{1}$ .

Fig. 7. *Inner* side of first arm-bone, showing its points, which articulate with the outer side of the mouth-frames (compare Fig. 6); *t*, lower arm-canal; *h*, under arm-plate; *w*, lower muscle-field;  $\frac{5}{1}$ .

Fig. 8. Fifth arm-bone, *outer* side, with tentacle-sockets, *r*, upper and lower canal, articulating peg, and depression to receive the umbo of the next arm-bone;  $\frac{5}{1}$ .

Fig. 9. *Inner* side of same bone, with the lower muscle-field, *w*, the articulating umbo, and the depression below it to admit the articulating peg;  $\frac{5}{1}$ .

Fig. 10. Same bone from below, with the muscle-field, *w*, on the inner side, and the tentacle-socket, *r*, on the outer, where also is the articulating peg; on the median line runs the lower arm-canal, *t*;  $\frac{5}{1}$ .

Fig. 11. *Ophioglypha cileata* (Mediterranean). Skeleton of arm and mouth-parts, to edge of disk, seen from above, with a genital plate, *o*, in position on one side, and on the other a radial shield, *l*, turned aside to show the underlying parts. On the middle line is the first upper arm-plate, *j*; on one side of it is the lower arm-comb, *m'*; and, on the other, the upper arm-comb or radial scale, *m*. Other letters as above;  $\frac{5}{1}$ .

Fig. 12. Three innermost side arm-plates, *i*, forming one wall of the genital opening. The upper corner of the side mouth-shield, *b*, supports the inner end of the genital plate, *o*, here seen in profile, with the under arm-comb, *m'* (compare Fig. 11), *q*, tentacle-scales;  $\frac{5}{1}$ .

Fig. 13. *Ophiothrix quinquemaculata* (Mediterranean). Skeleton of mouth-parts and arm, as far as edge of disk, with a radial shield and genital plate arranged and lettered as in Fig. 11, except that the mouth-frames are separated from the innermost arm-bone;  $\frac{5}{1}$ .

Fig. 14. Outer articulating surface of mouth-frames (compare Fig. 13);  $\frac{5}{1}$ .

Fig. 15. Inner articulating surface of the arm-bone next the mouth-frames;  $\frac{5}{1}$ .

Fig. 16. *Ophiothrix alopecurus* (Adriatic). An arm-bone close to the tip of the arm, seen from above, with a side arm-plate in position, and bearing a hook and the bases of three young spines;  $\frac{3}{1}$ .

Fig. 17. The same bone from below;  $\frac{3}{1}$ .

Fig. 18. *Ophiomyxa pentagona* (Mediterranean). Skeleton of mouth-parts and arm, as far as edge of disk, seen from above. The radial shields, *l*, are turned upwards and *outwards*, so as to expose the peculiar forked genital plates, *o*. *v*, stout triangular pieces covering the trench of the nerve-ring. These in *Ophioglypha ciliata* appear only as thin plates. *j*, little rudimentary upper arm-plates, split in two. *s*, supplementary pieces lying within the skin, along the disk margin;  $\frac{5}{1}$ .

CAMBRIDGE, February 15, 1874.

