X

ON THE ALLEGED PRIMITIVE OPHIUROID *OPHIOTERESIS ELEGANS* BELL; WITH DESCRIPTION OF A NEW SPECIES OF *OPHIOTHELA*

BY

TH. MORTENSEN

In 1892 F. Jeffr. Bell in his paper on the classification of the Ophiuroids[1]) described under the name of *Ophioteresis elegans* a very remarkable Ophiuroid, differing from all other recent Ophiuroids in the complete absence of ventral plates; further the dorsal plates are stated to be "definitely double", and the side-plates, instead of lying flat against the side of the vertebræ, are wider than long and stand out from the sides of the arm. The vertebræ present an "extremely generalized condition", without knobs and pits, the recesses on the adoral side being excessively shallow and, in correspondance, the articulating elevations on the aboral side very slight and inconspicuous.

"From this simple form differentiation would seem to have preceded along two lines; there has been an increase in complexity of articulation, associated with the fixation of certain ossicles and spines, or there has been vegetative repetition and branching with a more primitive inconstancy and irregularity of anatomical characters" (Op. cit. p. 179). *Ophioteresis* is thus regarded as representing the most primitive type of Ophiuroids, from which have developed along one line the Astrophytids, along another line the rest of the Ophiuroids. These latter are divided into two groups, according to the structure of the vertebræ, viz. the *Streptophiuræ*, with the vertebræ articulating "by means of a more or less simple ball-and-socket joint", and the *Zygophiuræ*, in which "the movement of the ossicles on one another is limited by the development of lateral processes and pits".

These results of Bell's researches have met with great approval. The division of the Ophiuroids into Zygophiuræ and Streptophiuræ has been adopted by J. W. Gregory in Ray Lankester's "Treatise on Zoology" III. Echinoderma, 1900, as also in the same authors paper "On the classification of the Palæozoic Echinoderms of the group Ophiuroidea"[2]); by Meissner in Hamann: Schlangensterne, 1901, in Bronn's "Klassen und Ordnungen"; by Delage & Hérouard in "Traité de Zoologie

[1]) F. Jeffrey Bell. A Contribution to the Classification of Ophiuroids, with Descriptions of some new and little known Forms. Proc. Zool. Soç. 1892. p. 175–183. Pl. XI—XII.

[2]) Proç. Zool. Soc. 1896. p. 1028.

Concrète". III. Les Échinodermes, 1903 (p. 146); by MacBride in "The Cambridge Natural History" I. p. 494, 1906. Likewise B. Stürtz[1]) expresses the opinion that Bell's observations „über die Art der Ausbildung derjenigen Wirbelflächen, die von Wirbel zu Wirbel mit einander artikulieren, bezeichnen einen erheblichen Fortschritt in der Erkenntnis der Ophiuren; selbst gegenüber dem was schon Lyman darüber bekannt machte" (p. 178). Further Koehler in his Monograph of the "Siboga"-Ophiuroidea adopts the classification of Bell, and I have also myself, in my first paper[2]), been of the opinion that Bell here "in der Hauptsache das Richtige getroffen hat" (p. 517). H. Lym. Clark in his work on "the North Pacific Ophiurans in the Collection of the U. S. National Museum"[3]) (p. 2) protests against the classification of Ophiuroids as it stands at present; but it does not appear, this protest is meant to apply to more than the family-arrangement; at least he does not mention the orders Zygophiuræ and Streptophiuræ.

The primitive character of *Ophioteresis* is especially emphasized by Gregory (Treatise on Zoology. III. p. 274—276). He states that in this genus, like *Protaster* "there is a ventral groove", and "it has no ventral plates, but a small ambulacral furrow, and thus agrees with the Palæozoic genera, for which Stürtz in 1885 proposed the family Ophioencrinasteriæ". Nevertheless he does not unite *Ophioteresis* with those fossil forms, but suggests that "when the classification (of the living Streptophiuræ) is attempted, probably *Ophioteresis* will form one family". MacBride (Op. cit. p. 494) says that *Ophioteresis* "appears to possess an open ambulacral groove, though this point has not been tested in sections".

Against the assertion of Gregory that *Ophioteresis* has an open ambulacral furrow, objection has been raised by W. P. Pycraft[4]) and E. A. Minchin[5]) in reviewing the volume on the Echinoderms in the "Treatise on Zoology". I may quote Minchin's remarks on this matter: „The genus *Ophioteresis* is used as an argument for uniting the Asteroids and Ophiuroids on the ground that "the radial ambulacral vessels and nerve trunks lie in shallow grooves on the ventral surface of the arms" (p. 262; also pp. 270 and 274). The author gives no definite authority for this statement, but leaves us to infer that he obtains the fact from Bell's description of the genus. Bell, however, did not describe any such condition as that which Gregory dwells upon so often and makes the basis for such important

[1]) B. Stürtz. Ein weiterer Beitrag zur Kenntniss palæozoischer Asteroiden. Verh. d. naturhist. Vereins d. preuss. Rheinl. u. Westphalen. 56. 1899.

[2]) Th. Mortensen. Über Ophiopus arcticus (Ljungman), eine Ophiure mit rudimentären Bursae. Zeitschr. f. wiss. Zool. Bd. 56. 1893.

[3]) Bulletin U. S. Nat. Museum, 75. 1911.

[4]) Ann. Mag. Nat. Hist. 7. Ser. VI. 1900. p. 342.

[5]) Nature, Vol. 62, 1900, p. 546.

deductions, and it is highly improbable that it occurs at all. It is much more probable the ambulacral vessels and nerve trunks pass in *Ophioteresis* through the aperture in the centre of the vertebral ossicle which Gregory figures plainly enough (Fig. XIV), while maintaining a discreet silence about it". It is true that BELL does not say anything about the existence of an open ambulacral furrow in *Ophioteresis*; but the fact that BELL states that "on the middle line of their (the arms) lower surface there is a distinct groove" (Op. cit, p. 178) combined with his emphasis of the primitive character of *Ophioteresis* and his mentioning *Tæniaster* and *Protaster* in connection with it would seem thus far to justify GREGORY's conclusion[1]) and, moreover, BELL does not say a word either of the aperture in the vertebræ.

Ever since the beginning of my studies on Echinoderms I have been looking for an opportunity of studying more closely this remarkable Ophiurid. I have never felt convinced of the correctness of BELL's observations on its structural features; indeed, I think, it will be agreed that a figure like Pl. XI, 4, reproduced in text figure 1 (p. 8), is anything but convincing; and if there is really no ventral plate, what does then the aperture in the middle of the vertebra mean? For if it represents the ambulacral furrow, closed by thick skin, this must evidently be an important argument against its primitive character; it would simply mean that the absence of the ventral plates was a secondarily acquired feature. On the other hand, if the observations of BELL prove to be correct, it would evidently be of quite unusual interest to study the anatomy of such a remarkable form, since BELL has left us in total ignorance of this side of the question.

On going over recently a collection of zoological material made by Captain E. SUENSON in the San Bernardino Strait, Philippines, I found some specimens of a small Ophiuran, which at once aroused my interest; the fact that no ventral plates could be seen, and that the side arm plates were almost at a right angle to the arm, recalled *Ophioteresis*, so that I thought at first I had another species of that genus before me. On dissolving a piece of an arm in Eau de Javelle, I found however, that it really had ventral plates, but these are completely obscured by the thick skin. As this is also the case in *Ophiothela*, with which genus this species also agrees in the covering of the disk and the dorsal side of the arm, and as also the side plates in *Ophiothela* stand out from the arm, it is plain enough that it belongs to this genus, representing a new species. It is a five-armed form, without the faculty of self-division, all the other species having 6 arms and being self-dividing, except one species, *Ophiothela tigris* Lyman, which differs, however, so much from the new form, that the idea of their identity must at once be abandoned.

[1]) On p. 238 in the "Treatise on Zoology" III. GREGORY says: "in the living *Ophioteresis* there are no ventral plates, and a shallow ambulacral furrow is accordingly present".

On studying Lyman's description and figures of *Ophiothela tigris*[1]) I was very much struck by the resemblance of this species with *Ophioteresis elegans*; in fact I was unable to see how they could be distinguished. This would mean that the famous *Ophioteresis elegans* is simply identical with *Ophiothela tigris*, and that its alleged primitive structure rests only on insufficient examination. I then determined to make all efforts to get material for settling the whole matter. Seeing that *Ophioteresis* has been mentioned by Bell from several localities[2]) and that accordingly a not inconsiderable amount of material must be in the Collection of the British Museum, I asked Professor Bell, if he could spare me a specimen, or only a piece of an arm of a specimen, for study. To my great disappointment this could not be granted. Fortunately, I learned afterwards from Professor Döderlein, that he had two specimens of *Ophioteresis elegans* (one of them four-rayed), and these he most liberally placed at my disposal. Further Professor H. Lym. Clark did me the very great service to send me the cotype af Lyman's *Ophiothela tigris* and an isolated arm of the type specimen, leaving both to my free use. I beg my two colleagues to receive my most sincere thanks for their great liberality, whereby they have enabled me to study the structure of this rather mysterious form, which has played so important a role in the attempts to trace the natural relations of the Ophiuroids.

The comparison of *Ophioteresis elegans* with *Ophiothela tigris* showed at once that they are at least very closely related. I do not venture to maintain their specific identity, because I have found on closer examination one feature (the ventral plates), which would seem to afford a specific difference. But the small amount of material at my disposal renders it uncertain, whether the difference is not due to individual or local variation. The question of the identity of the two forms must be left undecided, and for the present *Ophioteresis elegans* and *Ophiothela tigris* must be regarded as two separate, but so nearly related species[3]), that it is beyond question that they belong to the same genus. The discussion of the question whether they should both be regarded as belonging to the genus *Ophiothela*, or that *Ophioteresis* should be kept

[1]) Th. Lyman. Supplement to the Ophiuridæ and Astrophytidæ. Illustr. Catalogue Mus. Comp. Zool. No. VI. 1871. p. 10. Pl. I. figs. 10—12.

[2]) F. Jeffr. Bell. Report on a collection of Echinoderms from the Neighbourhood of Zanzibar. Ann. Mag. Nat. Hist. 7 Ser. XII. 1903. p. 246. ("Found nestling in the arms of a many-armed Actinometra from Zanzibar").

F. Jeffr. Bell. Report on the Echinoderma (other than Holothurians) collected by Mr. I. Stanley Gardiner in the Western Parts of the Indian Ocean. Trans. Linn. Soc. Ser. 2. Zool. Vol. XIII. p. 19. (No remarks, but it appears to have been found in three or four different localities, in 20—40 fms.).

In the paper quoted, where the species is described, Bell says that there were "some examples" of it (Op. cit. p. 178).

[3]) See Additional Note; p. 16.

as a distinct genus, comprising both the species *elegans* and *tigris*, must be postponed till after the results of my study of the anatomical stucture of the two forms has been set forth.

The first important point to settle is, of course, the presence or absence of the ventral plates. LYMAN says in his description af *O. tigris:* "under armplates covered with thick skin and seen indistinctly, except when dry. They have an irregular triangular form, with a peak within and a lumpy surface. They cover only a part of the arm, and differ in figure one from another". The figure given by LYMAN (Pl. I. 11) shows only the two inner ventral plates and accordingly gives no clear representation of their form. BELL repeatedly emphasises the total absence of the ventral plates in *Ophioteresis*, but his fig. 3 shows a series of plates along the ventral side of the arms. As BELL does not say anything of these plates, he has probably taken them to be the vertebræ. In reality the matter lies thus: the alcoholic specimen of *Ophioteresis* has the ventral surface of the arms covered by a thick, somewhat leathery skin, which completely obscures the plates or the vertebræ. When the specimen is dried, a series of plates are seen (Pl. I, Fig. 10), rather like those seen in the figure quoted in BELL's paper. In order to find out whether these plates are real ventral plates or only the ventral side of the vertebræ, they had to be treated with Eau de Javelle. The result is shown in figs. 6—7, Pl. II; it is seen from them that there is a large, nearly heartshaped ventral plate, which covers most of the ventral side of the vertebra; it is only at the sides that the vertebra itself appears. It must be agreed, however, that the limits of the ventral plate are by no means easy to observe, the plate lying very close to the vertebra and having its very thin edges at a level with the vertebra, as is well seen in the endview, Pl. II, Fig. 6. But the fact that the plate is loosened from the vertebra by the dissolving fluid, leaves no doubt that it is the real ventral plate. It has a slight depression along the middle line — the ventral furrow of BELL — which has given rise to the belief that there is an open ambulacral furrow. The examination of the point of the arm gives a no less definite proof that we have here the real ventral plates; a mere glance at Fig. 2, Pl. I, which represents the underside of the point of an arm of *Ophioteresis*, will leave no doubt that the plates lying there in the middle line are really the ventral plates. On passing farther down (orally) along the arm the ventral plates are seen gradually to assume the same shape as in the fullgrown joints.

With regard to *Ophiothela tigris* I find that the ventral plates are arranged in the same way, only their shape is more elongate, and they cover a somewhat smaller part of the vertebra; further the depression along the median line is hardly so distinct as in *O. elegans* (Pl. I Fig. 9). This difference in the shape of the ventral plates

would seem to show that *O. tigris* is not identical with *O. elegans;* but, as Lyman justly points out, the ventral plates (— which he has evidently seen quite correctly —) vary considerably in shape in the same specimen, so that it is doubtful whether this difference is so constant as to warrant the separation of the two forms into two species.

The alleged absence of the ventral plates in *Ophioteresis* has herewith been proved to rest on insufficient examination. The plates occur in this species as in other Ophiuroids, but are obscured by a thick skin. Hence the open ambulacral furrow is reduced to a myth. As a matter of fact the ambulacral furrow lies rather deeper than usual in the arm, as can be seen in Bell's figure represented in textfigure 1.

As to the dorsal plates they are stated by Lyman to be „represented by a double row of irregular elongated warts, which just at the base of the arm are increased in number so as to form a clump of different-sized pieces," and Bell also says that they are „definitely double". It is a curious fact that while the ventral plates, which are said to be wanting, are really present, the dorsal plates, which are said to be double, are really wanting. In fact, the two elongated lateral warts seen on the dorsal side of each joint (Pl. I Fig. 8) are really parts of the vertebra. (Comp. the figure of the dorsal side of the isolated vertebra, Pl. II Fig 4). On treating the arm with Eau de Javelle no plates can be detached from the dorsal side. The lines represented in Bell's figure (textfigure 1) as separating the „dorsal plates" from the vertebra do not exist. However, traces of dorsal plates may be observed at the point of the arms (Pl. I Fig. 1); in this figure is shown near the middle line at the base of the third joint a small, three-armed plate, which may perhaps represent a dorsal plate. On the following joints there is a small plate on each side (also on the third joint the rudiment of such a plate is found on each side). These lateral plates are evidently absorbed in the course of growth; I have been unable to ascertain from about which joint they have disappeared. It can only be said that they are not found on the fullgrown joints. In the four-armed specimen I find on one arm a small median dorsal plate on the two outer joints, but no lateral plates, while on the following joints neither median nor lateral dorsal plates are to be observed. As Lyman correctly describes, there are at the basis of the arm in *O. tigris* several dorsal plates of different sizes and the same appears to be the case in *O. elegans*, judging from the

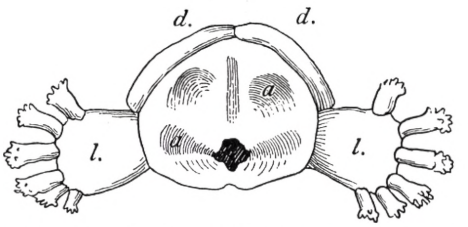


Fig. 1. Armjoint of *Ophioteresis*, seen from the aboral side. (After Bell, from Gregory). a. articular cavities. d. dorsal plates. l. lateral plates.

4-armed specimen, which has been dried; in the other specimen the skin obscures these plates. This means, accordingly, that in the very young specimens dorsal plates are formed, more or less regularly, as in *Ophiothela.*

The side arm-plates, as pointed out by BELL, stand out from the sides of the arm, which feature is apparently considered a primitive one, like the alleged absence of the ventral plates. (Cf. also GREGORY, Op. cit. p. 271). It appears to me very doubtful, whether this position of the side-plates is really a primitive feature; indeed, I think we shall have to regard their form and position in *Ophioteresis* as a very specialized feature. This can, however, scarcely be settled at the present state of our knowledge. In any case it is not peculiar to *Ophioteresis*, as it is also a prominent feature in *Ophiothela* (comp. textfig. 3); but in *Ophioteresis elegans* it is especially developed (Pl. I. Fig. 10). It appears that in *Ophiothela tigris* the side-plates stand less out from the arm (Pl. I. Fig. 9), and at the same time are apparently somewhat different in form from those of *Ophioteresis elegans*, which feature, combined with the difference in the shape of the ventral plates described above, would seem to show that *O. elegans* and *tigris* may perhaps really be different species.

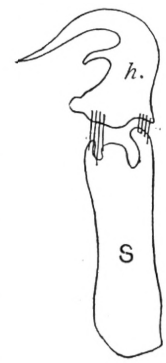


Fig. 2. „Pedicellaria" from *Trichaster elegans.* (After LUDWIG; from GREGORY). h. hook. s. stalk.

LYMAN in his description of *Ophiothela tigris* (p. 11) concludes from the fact that while in one of his specimens the side-plates stand out "independently, as pad-like ridges", they are in the other specimen "folded close on the arm", that "the animal doubtless has the power of moving the side arm-plates". I have paid special attention to this point but have failed to find any such special muscles as would be necessary to move these plates actively. The position of the plates close to the arm in the one specimen I would suppose to be due to the preservation, or perhaps, to individual variation. Observations on living specimens would easily settle the question.

The arm-spines are, in the outer part of the arm, elegantly formed hooks. (Pl. I. Fig. 4). Farther in on the arm they become gradually more complicated, but their original hook-like character is still recognizable (Pl. I. Figs 5—7). The lowermost spine remains the most hook-like; towards the dorsal side of the arm they become gradually more simple spines, the upper one — the last developing — being the simplest.

The figure of a side arm-plate with two spines represented in Pl. I. Fig. 4 recalls very strikingly the so-called pedicellariæ of *Trichaster*, described by LUDWIG[1]).

[1]) H. LUDWIG: Trichaster elegans. Morphologische Studien an Echinodermen. I. p. 218 Zeitschr. f. wiss. Zool. XXXI. 1878).

(textfig. 2). I have examined a specimen of a *Trichaster* in regard to these structures and must state definitely that they have nothing at all to do with pedicellariæ. The part which Ludwig regards as the stalk of the "pedicellaria" is nothing but the side arm-plate. But that an adambulacral plate can never become the homologue of a pedicellaria-stalk, be it ever so elongated and emancipated from the corresponding ambulacral plate, needs no further discussion.

On regarding the outer arm joints it is seen that there is a small rudiment of a tentacular papilla (Pl. I Figs 3—4); this papilla consists of a single rod, rising from a nearly circular, fenestrated base. On the following joints it may be a little more complicated, but it always remains very small. On the fullgrown arm-joints there is no trace of a tentacular papilla to be observed, hence they must be absorbed in the course of growth. I have found the tentacular papilla to begin on the second joint from the terminal plate in the four-armed specimen, while in the regenerating arm from the other specimen they do not appear until the 6—7th joint. — The tubefeet, which are closely set with sensory papillæ, as in *Ophiothrix*, issue from the sides of the arm-joints. The quoted figure 3, Pl. XI, of Bell wrongly shows small tentacular pores at the outer edges of the ventral plates. In that place no pores occur at all, and the real pores are of usual size, not so minute as shown there. The same peculiar position of the tube-feet obtains also in *Ophiothela* (comp. Pl. I Fig. 11), as well as in *Ophiomaza* and *Ophiopsammium*.

As a main argument for the primitive character of *Ophioteresis* Bell emphasizes the very simple structure of the vertebræ, which are stated to be "merely a generalized Ophiurid ossicle, without knobs or pits" (Op. cit. p. 179). The figure Bell gives thereof, reproduced in textfigure 1, certainly gives this impression. In reality, however, the primitive character holds good only for the figure. I have tried to give some more accurate figures of the vertebræ of *Ophioteresis*, represented in Pl. II. figs. 1—7. I suppose that these figures will show convincingly that the typical knobs and pits are really present and well developed. As usual there is on the aboral surface a median knob with a pit at each side of it, and on the adoral side correspondingly a median pit with a knob at each side. (Pl. II. figs. 1—2.). A comparison with e. g. the figures 8—9, Pl. II, representing the oral and aboral surfaces of the vertebra of *Ophiothrix fragilis* shows that there is a complete accordance with regard to the articulation between these two forms. The conspicuous difference otherwise existing between them is due to the different development of the processes for the attachment of the intervertebral muscles; but the processes are the same in both, and the depressions in them are the same; only the grade of their development is somewhat different. — Accordingly *Ophioteresis* cannot on account of its vertebral structure be regarded as in any way more primitive

than a typical Zygophiuran like *Ophiothrix*. This result led me to examine some other of the so-called Streptophiurids, whose vertebræ, according to BELL are of a primitive type, articulating with one another by means of a more or less simple ball-and-socket joint, devoid of the lateral processes and pits, which limit the movement of the vertebræ on one another. I have chosen two of the main genera referred by BELL to the Streptophiuræ, viz. *Ophioscolex* and *Ophiomyxa*. Pl. II. figs. 13—17 represent different views of the vertebræ of *Ophioscolex glacialis* Pl. II. Figs. 18—22 corresponding views of those of *Ophiomyxa australis*. A comparison of these figures with the corresponding views of the vertebræ of typical Zygophiurans like *Ophiothrix fragilis* (Pl. II. Figs. 8—12) and *Ophiomusium Lymani* (Pl. II. Figs. 23—24) makes it quite evident that the alleged difference between them with regard to the development of the articulation does not exist at all. In all of them the articulation is performed by a median knob with a pit at each side of it on the aboral surface of the vertebra, a median pit and a knob at each side of it on the adoral surface; this is the main articulating structure, above which may occur more or less developed knobs and pits; these latter appear to be very diversified and will perhaps be of value for classification. The lateral processes have nothing to do with the articulation; they only serve for the attachment of the intervertebral muscles. The "articular cavities" in the figure of BELL, reproduced in textfigure 1, accordingly have nothing to do with the articulation; they are the grooves for the attachment of the muscles, while the articulating pits and knobs are not at all represented in that figure. The figures given on Pl. II give convincing proof that the subdivisions "*Streptophiuræ*" and "*Zygophiuræ*" lack real foundation, the differences upon which they are established do not exist at all but are due to misunderstanding and superficial examination. The same pits, knobs and processes are found in *Ophioscolex* and *Ophiomyxa* as well as in *Ophiothrix*, *Ophiomusium* and *Ophioteresis*, the former being in no way more primitive than the latter — on the contrary, the articulating pits and knobs may perhaps be said to be more developed than in *Ophiothrix*. — The other genera referred by BELL to the "Streptophiuræ" I have not had the opportunity to examine, but as there has not been given the slightest proof that their vertebral articulations are really more simple than those of the other Ophiurids, I think we can safely depend on their agreement with the other Ophiurids in this respect. The figures of vertebræ of different forms of Ophiurids given by LYMAN in his "Challenger"-Monograph are upon the whole not very good, but it appears that in all of them the structure is essentially the same. Another type of articulation is only found in the Astrophytids — but I shall not enter here into more detail on this matter, contenting myself with having given the

proof that the division of the Ophiurids into Zygophiuræ and Streptophiuræ cannot be maintained.

With regard to the vertebræ of *Ophioteresis* it should still be pointed out that they show the peculiar feature of having on the dorsal side a number of glassy knobs (Pl. I. Fig. 8, Pl. II. Fig. 4), arranged in two longitudinal series. They have been observed by Lyman, as appears from his statement that "at the tapering end of the arm there are still the two warts at the base of each joint (wrongly taken to represent the dorsal plates), and between these a double row of fine grains". Towards the end of the arm they are, indeed, very conspicuous (in dried specimens), but are also found in the grown part of the arm, only they are obscured by the thick skin, which must be removed in order to make them distinct. This transformation of part of the vertebræ into a glassy substance is a feature not known in other Ophiurids (but occurring also in other species of *Ophiothela*), and would seem to indicate a very specialized condition, contrary to Bell's supposition that the vertebræ in this form are very primitive; this supposition obtains no support from their real structure.

Regarding the anatomical structure of the arms I can give no information beyond the conclusions to be deduced from the study of the skeletal parts; but these are sufficient to show that there is full accordance with the typical arm-structure of Ophiurids. Of the anatomy of the disk I can give no information at all. It would, of course, have been very interesting to study the anatomy of this form. But the high importance, which would have attached to the anatomy of *Ophioteresis*, if it had proved to be really so primitive, as it was supposed to be, has gone. It may now be expected that its anatomy will prove to be very like that of its nearest allies. Which are they?

The mouth structure of *Ophioteresis* quite agrees with that of the Ophiotrichidæ, and there is no character, which excludes it from that family. The thick skin covering the ventral plates is found similarly in *Ophiothela* and *Ophiopsammium*, the side arm-plates are as prominent in *Ophiothela* as in *Ophioteresis;* the tentacles issue from the side of the arm, not from the underside, in *Ophiothela* and *Ophiopsammium* as well as in *Ophioteresis;* the naked skin covering the disk is found alike in *Ophiomaza* and *Ophiæthiops*, as also in *Ophiolophus*, *Gymnolophus* and *Ophiohelix*, where, however, the radial shields have a prominent crest. The hook-shaped spines likewise are of general occurrence in the Ophiothrichidæ — in short, no single feature can be pointed out by which *Ophioteresis* might be separated from the Ophiothrichidæ.

The genus of the Ophiothrichidæ to which *Ophioteresis* is nearest related, is beyond doubt *Ophiothela*. Lyman was by no means very wrong in referring his

species *tigris* to *Ophiothela*. Two characters alone distinguish it from this genus, viz. the naked skin covering the disk and the dorsal side of the arm, and the absence of the dorsal arm plates. It may be doubted, whether these two characters are sufficient for a generic distinction; for the present, however, I am inclined to think that they are so, and accordingly the name *Ophioteresis* may be retained. I shall give here an emendated diagnosis of the genus, the diagnosis given by BELL being quite inappropriate, as has ben established by these researches.

Ophioteresis Bell. Disk and arms covered by a thick, naked skin, which obscures the large radial shields and the ventral arm-plates. Dorsal arm-plates wanting, except at the base of the arm and on the growing joints at the point of the arm. Side arm-plates very prominent, carrying the more or less hook-shaped spines. Tube feet issuing from the sides of the arm, without tentacle scales, except on the growing joints near the point of the arm. Mouth structure as usual in the Ophiothrichidæ; the tooth-papillæ arranged in 3 or 4 vertical rows.

To this genus belong the two species *elegans* Bell and *tigris* Lym., which will perhaps prove to be identical[1]).

Upon the classification of the Ophiuroids the results of these researches have mainly a negative bearing. The generally accepted division of the simple-armed Ophiurids into Zygophiuræ and Streptophiuræ has been done away with; we have again only a number of families, which can merely be arranged side by side, without any definite order. In the present state of our knowledge it is impossible to see what their real affinities are. Nobody can say which family represents the more primitive type — not to speak of the fact that the families themselves are partly in a rather chaotic condition (except the Ophiothrichidæ, which on account of their characteristic mouth structure appear to be a very natural group). That *Ophioteresis* is in no way more primitive than the other Ophiothrichids is evident. The same is, in my opinion, the case with another Ophiurid, which has been claimed to be a very primitive form, viz. *Ophiotypa simplex* Koehler. I shall not, however, enter on a detailed discussion of the perplexing Ophiuroid-classification, but only state that it will scarcely be possible to arrive at reliable results until the anatomy and development of a good number of representative types has been thoroughly studied.

I may shortly thus summarize the results of these researches:

Ophioteresis does not lack the ventral plates; they are present as in other Ophiurids, only obscured by the thick skin. Accordingly there is no open ambulacral furrow. — Dorsal plates and tentacle scales

[1]) See Additional Note, pag. 16.

are present on the young, growing arm joints, but gradually become absorbed, and are completely lacking on the grown arm-joints.

The vertebræ of *Ophioteresis* are not more primitive than those of other Ophiurids. The division of the simple-armed Ophiurids into Zygophiuræ and Streptophiuræ cannot be maintained, the difference said to exist between them with regard to the articulating surfaces of the vertebræ not existing in reality.

Ophioteresis belongs to the Ophiothrichidæ, being very nearly related to *Ophiothela*. The species *Ophiothela tigris* Lym. must also be referred to the genus *Ophioteresis*, the two species *tigris* Lym. and *elegans* Bell being probably identical[1]).

The so-called "pedicellariæ" of *Trichaster* and other Astrophytids are only the elongated side arm-plates carrying the hook-shaped arm-spines; they have nothing to do with pedicellariæ, these organs being entirely unknown in Ophiuroids.

I shall here add the description of the new species af *Ophiothela* mentioned above (p. 5), naming it

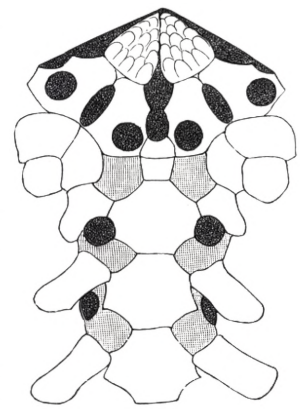
Ophiothela vincula n. sp.

(Pl. I. Figs. 11—13).

Diameter of disk in the largest specimens 5 mm., length of arms ca. 20 mm. Arms five. The disk is covered by more or less rounded grains of different sizes, only the large, triangular radial shields being distinct, though some scattered grains are found on them also. In the middle of the disk the grains are generally larger and somewhat pointed; also those in the narrow interradial line separating each two adjoining pairs of radial shields are larger, and the outer ones are even sometimes developed into rather large, coarse, pointed spines. Interbrachial spaces below covered by naked skin with a few scattered grains; the naked part begins at the outer end of the radial shields and may be observed from the dorsal side, when the interbrachial spaces are somewhat swollen on account of the genital organs. At the sides of the arms there is, just below the outer end of the radial shields a small group of grains. The oral shields are small, rounded, somewhat irregular in shape; the side mouth shields are short, but broad. The exact shape of these plates as well as of the arm-plates cannot be made out by simply drying the specimens, as the thick skin which covers the whole underside obscures their limits. On dissolving the skin (with Eau de Javelle) the shape of the plates is made clear (textfigure 3).

[1]) See Additional Note, p. 16.

In the simply dried specimens a series of somewhat heart-shaped plates, with a slight median furrow, is seen on the ventral side of the arms (Pl. I. Fig. 11). On dissolving the skin one finds them to be polygonal plates, which, however, do not represent the ventral plates alone. The ventral plates are so closely attached to the vertebræ that their limits cannot be distinguished, and it is only when they are loosened by the prolonged action of the dissolving fluid that their real shape can be observed. They are then found to have a rather peculiar shape, (Pl. I. Fig. 13) being elongated, with a pair of wing-like expansions near the distal edge; in the middle line is a slight furrow, bordered by a slight elevation on each side, forming a distinct keel on the inner side. The ventral plate does not cover more than the median part of the ventral side of the vertebra. The first ventral plate has a somewhat different shape (textfig. 3); its inner half is bent inwards, being at an angle with the outer part (the line across the middle of the plate in textfig. 3 is the limit between the outer and inner part of the plate, but the plate is not divided). The dorsal side of the arm is covered by a number of small, irregular plates, among which no primary dorsal plate can be distinguished; they may, however, be much more grain-like than in the specimen figured. On the young joints near the point of the arm there is only one, median, dorsal plate. The side arm-plates are very prominent, as seen especially when the skin has been removed (textfig. 3). They do not widen at their base, so that a conspicuous naked space is left between them. The arm spines are 5—6 on the inner joints. They are rather slender, but on a microscopical examination are easily seen to be transformed hooks. The tube feet, which are closely covered with sensory papillæ, as in *Ophiothrix* a. o., issue from the sides of the arm, but on the inner joint they occupy the position usual in Ophiurids. No tentacle papillæ are found, except on the young joints near the point of the arm, where a rudimentary papilla is observed as in *Ophioteresis*.



Textfigure 3.
Inner part of an arm of *Ophiothela vincula*, treated with Eau de Javelle, whereby the limits of the plates have been made distinct. The arm-spines have been omitted. $^{28}/_{1}$.

The colour is, in the preserved specimens, white or light reddish; on the dorsal side of the arms there is on every 3—4 joints a pair of conspicuous black bands across the arm; also on the radial shields there may be dark spots. Sometimes the dark bands on the arms are represented only by small black spots.

The vertebræ are very nearly of the same shape as those of *Ophioteresis*. Also the glassy grains on their dorsal side are well developed.

Locality. San Bernardino Strait, Philippine Islands (12° 27′ N. 124° 3′ E., 50—100 fathoms; bottom temperature 61° F.). Found among sponges. $^3/_8$ 1911. Captain E. Suenson.

This species differs conspicuously from the other species of *Ophiothela* hitherto described (whether they should all be united into one species, as suggested by Döderlein and Koehler, or not) in having only 5 arms and showing no trace of selfdivision, the other species having 6 arms and being selfdividing.

ADDITIONAL NOTE

After this paper had been sent to print, I had the opportunity, during a short visit to London, of seeing in the British Museum some specimens (8) of *Ophioteresis elegans* from the Seychelles („Alert"). I found them to vary very considerably in the appearance of the ventral side of the vertebræ, so that it is impossible to distinguish between *O. elegans* and *tigris* by means of this character. Also the side arm-plates may be as broad as in the type of *O. tigris*. There is then not a single character by which *O. elegans* may be distinguished from *O. tigris*, and accordingly Bell's *Ophioteresis elegans* is synonymous with Lyman's *Ophiothela tigris*.

Some time afterwards I called on Dr. D. C. McIntosh in Edinburgh, and by a most fortunate coincidence I found him examining some Ophiurids from the Coast of Portuguese East Africa, among which were several specimens af *Ophioteresis*. Dr. McIntosh very kindly allowed me to dissect one of these specimens, so that I can now also give some information of the anatomy of the disk of this Ophiurid. Unfortunately the specimen evidently had been nearly dry, so that it was impossible to trace the shape of such delicate organs as the bursæ and the Polian vesicles. But the structure of the genital organs could be made out. There is a large, compound gonad at each side of the bursa and one at the outer end of the bursal slit. The latter gonad is distinctly fanshaped, overlapping in the median line the corresponding gonad of the other bursa in the same interradial space. This structure and arrangement of the gonads is essentially the same as occurs in *Ophiothrix*, the main difference being that in the latter there are generally two, sometimes three gonads on the adradial side of the bursa.

During the visit to London I was informed by Prof. MAC BRIDE that Miss J. SOLLAS had quite recently published a paper on *Onychaster*[1]), in which she had made some observations on the structure of *Ophioteresis*. On my application Miss SOLLAS kindly sent me a copy of the paper, so that I am able to mention it in this additional note.

Miss SOLLAS, who has had material of *Ophioteresis* from the British Museum, besides a specimen from Cargados Carajas, an island N. E. of Mauritius, for study, has made sections of the arms and found that the radial nerve and water vessel have the position typical in Ophiurids. It is stated that dorsal plates are completely absent, and that the vertebræ, of which photographs are given (Pl. 9, fig. 2) „reveal at once a general similarity to those of typical Zygophiurids and a close examination shows that this resemblance is more than superficial" (p. 57). A detailed and careful description of the articulating surfaces is given, from which the following conclusion is drawn: „It seems then that justification for separating Ophioteresis from the Zygophiuræ is not to be found in the nature of the articulation, and the genus must be removed from the Streptophiuræ as defined by BELL". A suture has been traced „which marks off the median ventral region of the vertebra, suggesting that a separate piece, hexagonal in outline and apposed to the ventral surface of the ossicle, has become fused with it and has formed a floor to the radial canal . . . It can hardly be doubted that this hexagonal piece represents a ventral plate which has sunk inwards and merged its individuality in that of the vertebra". Also the glassy knobs on the dorsal side of the vertebræ have been observed.

After having found that „the vertebral articulation of *Ophioteresis* does not differ in any marked way from the Zygophiurid type", Miss SOLLAS examined some other more typical members of the Streptophiuræ, viz. *Ophiomyxa vivipara* and *O. australis*, and found that they likewise „possess the essential characters of the Zygophiurid ossicle". The conclusion is drawn that „if the group Streptophiuræ is to stand it cannot be defined by the character of its vertebral ossicles" (p. 58).

It is seen that the results of Miss SOLLAS's examination of *Ophioteresis* are fully borne out by my researches, some points being only more definitely settled by me, e. g. that there is really a separate ventral plate, and that the division of the simple-armed Ophiurids into Zygophiuræ and Stroptophiuræ must be definitely dropped, being supported by no facts whatever.

It is rather curious that this form, which was thought to be of so great importance in the study of the morphology and classification of Ophiurids, has now almost at the same time been shown, as a result of two entirely independent researches, to

[1]) Igerna B. J. SOLLAS. On Onychaster, a Carboniferous Brittle-Star. Philos. Transact. Ser. B. Vol. 204. (Publ. separately, May 15, 1913). — My paper was sent to print June 2.

be only quite an ordinary, typical Ophiurid. Unfortunately is has been allowed to remain in its false glory much too long. The inaccurate observations on *Ophioteresis* have resulted in the classification of the Ophiurids given in the four main general zoological text books of recent time, the „Treatise on Zoology", the „Traité de Zoologie concrète", the „Cambridge Zoology" and „Bronn's Klassen u. Ordnungen", being already out of date.

EXPLANATION OF PLATES

Plate I.

Fig. 1. Point of an arm of *Ophioteresis elegans*, seen from the dorsal side. Showing the rudimentary dorsal plates. $^{125}/_{1}$.

— 2. Point of an arm of *Ophioteresis elegans*, seen from the ventral side. In the middle line are seen the ventral plates. The vertebræ have been omitted on the two proximal joints. $^{125}/_{1}$.

— 3. Tentacle scale from one of the distal arm joints of *Ophioteresis elegans*. $^{200}/_{1}$.

— 4. Side arm-plate of *Ophioteresis elegans* (no. 5 from the point), with two hook-shaped spines; the rudimentary tentacle scale (t. s.) is seen on the left (aboral) side. The tube-foot has been omitted. $^{200}/_{1}$.

— 5—7. Arm spines of *Ophioteresis elegans*, from the grown joints; showing distinct traces of the primary hook-shape. $^{140}/_{1}$.

— 8. Piece of an arm of *Ophioteresis tigris* (Lym.) (the type specimen), treated with Eau de Javelle, in order to make the plates (the vertebræ) more distinct.; seen from the dorsal side. The arm spines have been removed. $^{23}/_{1}$.

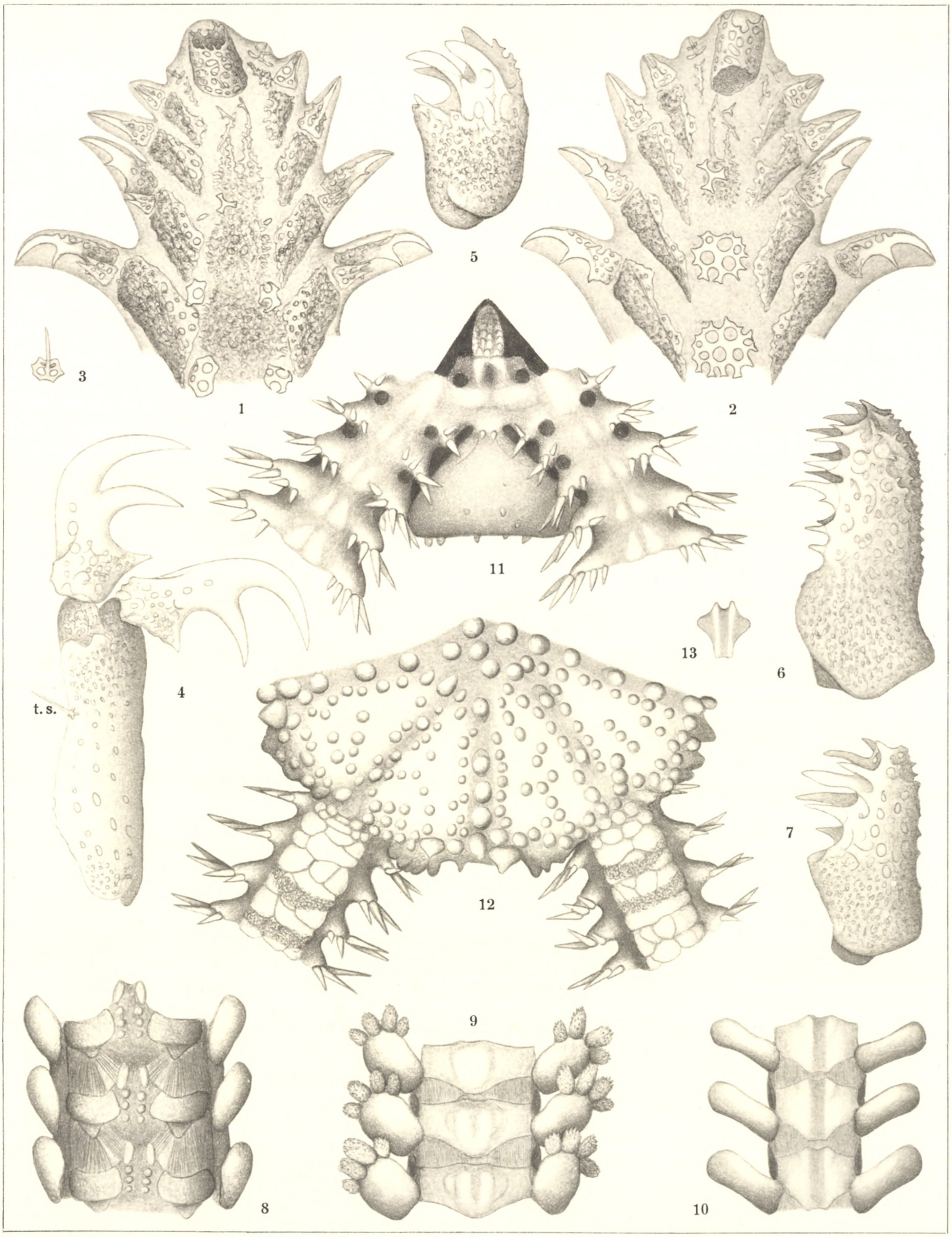
— 9. Piece of arm of *Ophioteresis tigris* (the type specimen), from the ventral side; treated with Eau de Javelle. Showing the ventral plates on the middle of the vertebræ. $^{23}/_{1}$.

— 10. Piece of an arm of *Ophioteresis elegans*, from the ventral side; treated with Eau de Javelle. The arm spines have been omitted. The ventral plates cannot be distinguished from the vertebra. $^{28}/_{1}$.

— 11. *Ophiothela vincula*, ventral side. $^{18}/_{1}$.

— 12. — — dorsal side. $^{18}/_{1}$.

— 13. Ventral plate of *Ophiothela vincula*. $^{30}/_{1}$.

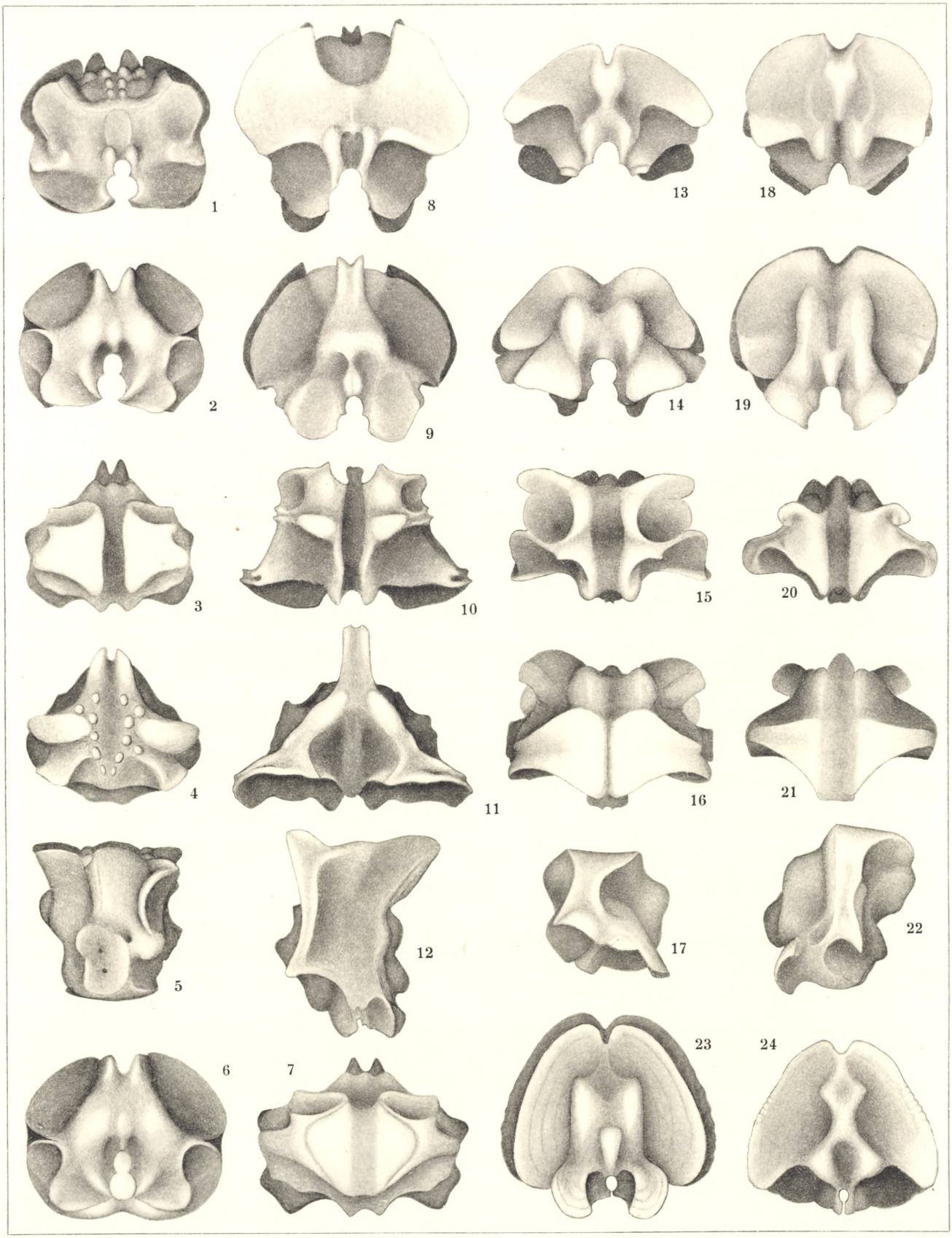


Th. Mortensen del. *Pacht & Crone phototyp.*

1—7, 10. ***Ophioteresis elegans*** Bell. 8—9. ***Ophioteresis tigris*** (Lyman). 11—13. ***Ophiothela vincula*** Mrtsn.

Plate II.

Fig. 1. Vertebra of *Ophioteresis elegans.* Proximal articulating surface. $^{38}/_{1}$.
— 2. — - — — Distal — — $^{38}/_{1}$.
— 3. — - — — Ventral side. $^{38}/_{1}$.
— 4. — - — — Dorsal — $^{38}/_{1}$.
— 5. — - — — Side view. $^{38}/_{1}$.
— 6. — - — — Distal articulating surface. The ventral place is left in place. $^{38}/_{1}$.
— 7. — - — — Ventral side, with the ventral plate in place. $^{38}/_{1}$.
— 8. — - *Ophiothrix fragilis.* Proximal articulating surface. $^{20}/_{1}$.
— 9. — - — — Distal — — $^{20}/_{1}$.
— 10. — - — — Ventral side. $^{20}/_{1}$.
— 11. — - — — Dorsal — $^{20}/_{1}$.
— 12. — - — — Side view. $^{20}/_{1}$.
— 13. — - *Ophioscolex glacialis.* Proximal articulating surface. $^{22}/_{1}$.
— 14. — - — — Distal — — $^{22}/_{1}$.
— 15. — - — — Ventral side. $^{22}/_{1}$.
— 16. — - — — Dorsal — $^{22}/_{1}$.
— 17. — - — — Side view. $^{22}/_{1}$.
— 18. — - *Ophiomyxa australis.* Proximal articulating surface. $^{16}/_{1}$.
— 19. — - — — Distal — — $^{16}/_{1}$.
— 20. — - — — Ventral side. $^{16}/_{1}$.
— 21. — - — — Dorsal — $^{16}/_{1}$.
— 22. — - — — Side view. $^{16}/_{1}$.
— 23. — - *Ophiomusium Lymani.* Distal articulating surface. $^{15}/_{1}$.
— 24. — - — — Proximal — — $^{15}/_{1}$.



Th. Mortensen del. *Pacht & Crone phototyp.*

1—7. *Ophioteresis elegans* Bell. 8—12. *Ophiothrix fragilis* (O. F. Müll.) 13—17. *Ophioscolex glacialis* M. Tr.
18—22. *Ophiomyxa australis* Ltk. 23—24. *Ophiomusium Lymani* W. Th.