IV. *Further Researches on Tomopteris onisciformis, Eschscholtz.* By WILLIAM B. CARPENTER, M.D., F.R.S., F.L.S., F.G.S., and EDOUARD CLAPARÈDE, M.D., Fellow of the Physical Society of Geneva.

Read January 19th, 1860.

HAVING been fortunate enough to capture a considerable number of specimens of this interesting Annelid during our joint sojourn at Lamlash Bay, Arran, during the month of September last, and having been able to add much to the knowledge previously obtained of its organization and reproduction, we have agreed to lay the results of our observations before the Linnean Society, in the form of a continuation of the memoir already communicated to it by one of us, and printed in its Transactions (vol. xxii. p. 353). Although we have much to add, we find nothing to correct in any of the positive statements of fact which that memoir contained; and we have the satisfaction of bearing our joint testimony, based on a renewed comparison of Mr. George West's delineations with the objects from which they were taken, in regard to the truthfulness with which they represent the conformation of this interesting animal*.

In the first place, with respect to the specific diversity affirmed by Drs. Leuckart and Pagenstecher † to exist between *Tomopteris onisciformis* and *T. quadricornis*, chiefly on the ground of the presence in the latter of a pair of cephalic appendages not possessed by the former, we have to state that the conviction already expressed by one of us ‡ as to the insufficiency of this character has been fully borne out by our subsequent observations, which have entirely satisfied us that the presence or absence of the appendages in question depends solely upon the grade of development which the individual has attained. We have been led, however, by certain minute differences between the organization of the *Tomopteris* described by Leuckart and Pagenstecher, and that of the *Tomopteris* which we have studied, to suspect that the forms we have severally described under the designation *T. onisciformis* may not be specifically identical.

The *T. onisciformis* and the *T. quadricornis* of Leuckart and Pagenstecher both possess that remarkable pair of "frontal horns," projecting laterally from the most anterior part of the head, which, as Mr. Huxley has remarked, give to the animal the aspect of a hammer-headed shark; and they both possess that pair of greatly elongated appendages designated in the former memoir as the "styliform," but which we now prefer to term the *second antennæ*. These organs are far longer, relatively as well as absolutely, in the

* In transferring these figures to copper, and in reducing their scale, the engraver has imparted to them a hardness and stiffness which the originals do not possess; and has also, by too deeply shading them, destroyed the effect of *transparency* which the artist had aimed to give.

† Müller's Archiv, 1858, p. 588.

‡ See vol. xxii., supplemental note in p. 362.

advanced stage of the life of *Tomopteris* than in the earlier (compare figs. 1 and 6 of Plate LXII. vol. xxii.); and we have found that this difference results from a gradual increase in their proportional length, which bears a constant relation to the stage of development attained by the body. In an example of this type which we believe to be one of the earliest yet met with (fig. 14, Pl. VII.), these second antennæ (*b, b*) were very short, and presented a much nearer resemblance to the ordinary lateral appendages of the body than they do at a later period. But the distinction between *T. onisciformis* and *T. quadricornis* is mainly rested by Drs. Leuckart and Pagenstecher upon the absence in the former of the pair of cephalic appendages borne by the latter, between the "frontal horns" and the "second antennæ;" these, which were designated in the former memoir as the "second pair of horn-like appendages," will now be spoken of by us as the *first antennæ*, since it is clear that they have more relation to the pair of appendages immediately behind them than to those in advance of them. For, in common with the "second antennæ," they are setigerous, each of them bearing two setæ within its terminal portion (fig. 6); and in the early form just now alluded to, in which the "frontal horns" were entirely wanting, these first antennæ were of such a length as to be the principal appendages of the head (*a, a*, fig. 14). A careful study of the successive stages of the development of *Tomopteris*, in fact, makes it obvious that these *first antennæ* are to be considered as *larval*, and the *second* as characteristic of the *adult*; for the former progressively diminish in relative size, and at last (in most cases) disappear altogether, whilst the latter progressively increase both absolutely and relatively. In the stage represented in fig. 1, Plate LXII. (vol. xxii.), which seems to correspond to the *T. quadricornis* of Leuckart and Pagenstecher, the setigerous portion of the first antennæ is separated from the basal by a constriction which suggests the idea of an articulation (Pl. VII. fig. 6. *a*); about the time when the caudal appendage begins to be developed, the setigerous portion usually detaches itself, while the basal part remains as a mere knob or tubercle; and in the most advanced forms, this tubercle is commonly found to have entirely disappeared. A vestige of it, however, is still to be seen in some specimens; and it would appear, not only from the observation made by one of us last year, but also from the mention of these appendages by Mr. Huxley (p. 359), who described and figured them as "long, curved, spine-like processes arising from the ventral surface of the narrow neck," that these first antennæ are occasionally retained even in the stage of advanced development. It is obvious, therefore, that no distinction between *Tomopteris onisciformis* and *T. quadricornis* can be drawn from the presence or absence of the first antennæ; and if no other constant and important characters of difference can be specified than such as clearly arise out of the respective ages of the specimens, the last-named species must be abolished.

In stating the other additional results of our observations, we shall for the most part enumerate these, for the sake of convenience, in the order in which they occurred to us in proceeding from before backwards along the body of the animal.

In the advanced specimens (by which we mean those in which the caudal prolongation is beginning to show itself), the head bears on its dorsal surface a pair of *ciliated epaulettes* (Pl. VII. fig. 5. *a, a*), which extend over the edges of the bilobed nervous ganglion. These,

at a certain stage of development, are fringed with long cilia both at their margins and at their base; but the cilia are only occasionally to be seen in activity; and we suppose it to have been either from the absence of the cilia, or from their not having been in motion, that they escaped the notice of Mr. Huxley, who describes the epaulettes as rounded elevations on either side of the narrow neck, from which a sort of band or ridge runs back upon the dorsal surface (vol. xxii. p. 359). No trace of these organs is to be seen in the earlier stages of the animal's life.

The lens-like body in each of the pair of *ocelli* (fig. 12. *b, b*) which are seated upon the bilobed ganglion, is not single but double, as has been already stated by Leuckart and Pagenstecher.

We were able clearly to distinguish the spheroidal cells of which the bilobed ganglion is composed; and in its anterior part we noticed (as Leuckart and Pagenstecher had previously done) a pair of vesicles imbedded in its substance (fig. 12. *a, a*). These vesicles are nucleated; but we could not distinguish either otoliths or ciliary movement in their interior. How far they are to be considered as analogous to the auditory vesicles of other Invertebrata, we are therefore unable at present to determine.

After a careful search for *nerve-fibres* in connexion with these ganglia, we feel unable to speak positively either as to their presence or their absence. There is certainly some appearance of a nerve-fibre on either side passing from the ganglion towards the frontal part of the head (as described by Leuckart and Pagenstecher), and also of one passing into the base of the second antennæ (as noticed in the former memoir); but we are not at all sure that these appearances are to be trusted, having now satisfied ourselves that the linear trace which passes on the median line along the dorsal surface is not (as was suggested in the former memoir that it possibly might be) a band of fibrous nerve-substance, but is simply the mark of the attachment of a mesentery by which the intestine is held in its place. We have been unable, notwithstanding our careful and repeated search for it in living specimens, to detect the ventral nervous cord and œsophageal ring described by Grube (see vol. xxii. p. 361); and we cannot but believe that he must have been deceived by appearances produced by the change which the textures of this delicate creature had undergone in the process of conservation to which his specimens of it had been subjected.

The observation of a considerable number of specimens in various stages of development enables us now to state that the *alimentary canal* may present itself at any period either in the state of contraction shown in Plate LXII. fig. 1 (vol. xxii.), or in that of distention shown in Plate VII. fig. 6, or in any intermediate condition. Even when the canal has been most distended, however, it has generally seemed to contain little else than water, very few solid particles being visible in its interior. In one individual, however, we observed in the intestine several fragments of a *Beroë* which had been captured at the same time and had been broken in the tow-net; and these fragments were kept in continual agitation by the persistent movements of their large cilia. This unusual exercise of voracity seemed to have an injurious effect upon the individual; for it was found dead the next morning, whilst several other specimens in the same jar survived. The caudal prolongation of the body is generally in a state of greater or less contraction longitudinally;

and the alimentary canal is thrown by this contraction into convolutions, which are sometimes slight and easily distinguishable, as shown in Plate VII. fig. 2, but which, when the caudal appendage is greatly contracted (as shown in figs. 6 & 7 of Plate LXII. vol. xxii.), may be so close as to render it difficult to follow their course, by reason of the opacity which the part then acquires. The part of the intestine contained in the caudal prolongation has its external surface clothed with cilia; but these are most apparent along particular bands. Cilia are also distinguishable on certain parts of that innermost layer of the general integument which forms the external boundary of the perivisceral space, their action being especially apparent near the ends of those lateral appendages which give support to the pinnulæ. By the agency of these cilia a more special movement is imparted to the corpuscles of the fluid contained within the perivisceral cavity, than that which they receive from the movements of the body generally, and from the peristaltic contractions of the alimentary canal. Although these corpuscles, which are usually of a spheroidal form and of a diameter of about $\frac{1}{5000}$ th of an inch, very commonly float singly, they are often to be seen aggregated in smaller or larger numbers into masses, which sometimes attain a considerable size (fig. 10); and we cannot doubt that the bodies supposed by Mr. Huxley to be young spermatozoa (p. 359, vol. xxii.) were of this nature.

We have given much attention to the ciliated canals, first observed by Leuckart and Pagenstecher, which originate in two orifices near the base of the lateral appendages of each side (figs. 7, 8. *a*, *b*) on their dorsal aspect, and which then rapidly incline towards each other, so as to converge into a single canal, that runs along for some distance in the wall of the body, and then terminates in the perivisceral cavity (fig. 7. *c*). One of these orifices (*a*) is situated in the centre of a sort of rosette*, marked by radiating ridges furnished with large cilia; the other (*b*) has round it a smaller rosette, which does not possess any such ciliated ridges. These ciliated canals are obviously the homologues of those which attain so much greater a complexity in the higher Annelida (the "segmental organs" of Dr. T. Williams). Although they are represented by Drs. Leuckart and Pagenstecher as existing in their specimens on every one of the pinnulated appendages, and even in the bases of the second antennæ, we can state most positively, both from the observation of numerous living individuals, and from the evidence of well-preserved specimens now before us, that, in the form of *Tomopteris* observed by us, they do not exist in the five lateral pairs which immediately follow the second antennæ. And this fact is the more remarkable, since, as will presently appear, there is a stage in the animal's life at which it does not possess more than five pairs of pinnulated members, and in which, therefore, it is entirely destitute of ciliated canals. The direction of the ciliary current always appeared to us to be from without inwards (as affirmed by Leuckart and Pagenstecher, in opposition to what is generally stated on this point); and we repeatedly witnessed the passage through the canals, in this direction, of spermatozoa which had been emitted from the testes into the surrounding water.

Each of the pinnulæ, in our specimens of *Tomopteris*, presented (fig. 7. *d*, *d*) the peculiar

* This rosette was noticed by Busch; but he only imperfectly made out the canal of which it is the entrance.

“rosettenförmiges Organ” which was noticed by Leuckart and Pagenstecher upon the two first pairs of appendages of their *T. quadricornis*, and which is affirmed by them to be entirely wanting in *T. onisciformis*. This is alike remarkable for its form (fig. 9), which somewhat resembles that of a melon, and for its colour, which, being a bright sulphur-yellow, distinguishes it from the coloured spots noticed in the former memoir, these being of a reddish orange. In the very young specimen already adverted to, these organs presented themselves at the bases of the pinnulæ (fig. 14. *c, d*) of the two most developed pairs of members. Of their nature and purpose we have not been able to form even a probable guess.

It is in regard to the *caudal prolongation* of the body, and the organs which it contains, that we have the most novel and important information to offer. We can now state with certainty that the large specimen represented in Plate LXII. figs. 6 & 7 (vol. xxii.) was a *male*,—the eight pairs of ovoidal bodies from which the rudimentary pinnules appeared to spring being really the testes, which occupy the parts of the perivisceral cavity that are prolonged into the short lateral appendages whereon these pinnules are really borne. Each testis (Pl. VII. fig. 2. *a, a*) is an undivided sac, whose cavity, when the organ has attained its maturity, is almost entirely filled with a mass of spermatozoa. The individual parts of this mass are in continual movement upon each other, their motion being kept up chiefly, if not entirely, by the action of the cilia clothing that part of the inner wall of the testis which is near its external orifice. Each testis (fig. 3) can discharge its contents, either externally through an orifice (*a*) in the wall of the lateral appendage within which it is lodged, or internally through another orifice (*b*) into the perivisceral cavity. That the external orifice is distinct from that of the larger, ridged rosette (*c*) of the ciliated canal, we feel ourselves able to affirm with certainty; but we are not equally sure of its distinctness from that of the smaller rosette in its neighbourhood. The internal orifice, by which the spermatozoa escape into the general cavity of the body, can only be seen occasionally; and we are disposed to think that it is formed only when the contents of the testis are fully matured. Whenever we caused these to be discharged by pressure, it was through the external orifice that they escaped.

The *spermatozoa* of *Tomopteris* (fig. 4), which we had abundant opportunities of observing, are peculiar in having *two* flagella—a feature which, although general among the antherozoids of the Algæ, is very rare (if not unique) among the spermatozoa of animals*,—and also in being able to move in either direction with apparently equal facility.

It will presently appear that the testes occupy exactly the same place in the lateral appendages of the caudal prolongation as the ovaria do in those of the body generally,—the chief difference in their apparent positions arising from the smaller size of the lateral appendages in the former region, and from the more complete occupation of the cavity of these appendages by the oval sacs of the testis.

* In his ‘Naturalist’s Rambles on the Devonshire Coast,’ Mr. Gosse mentions (p. 213) that he witnessed the exit from the mouth of *Pedicellina Belgica* of numerous minute pear-shaped bodies, each having “a little tubercle at its larger end, around which are set a few (about four or five) long cilia or setæ, twice or thrice as long as the body. These are not used for vibratile action, but as oars slowly waved through the waters.” Although these are termed “germs” by Mr. Gosse, yet it seems to us probable that they were multiflagellate spermatozoa.

A considerable number of males came under our notice before we met with any specimens whose female sexuality was indicated by the presence of ova: of these, however, we subsequently encountered several; and our observations on them are in accordance with those previously made by Huxley, Busch, and Leuckart and Pagenstecher. In a mature female (fig. 1) the ova are to be seen lying, in great numbers and in various stages of development, in every part of the perivisceral cavity of the body and of its caudal prolongation, and also in the extensions of that cavity into the lateral appendages, including even the basal portion of the second antennæ. From a comparison of the conditions under which they may be seen in one and the same individual, it becomes obvious that they originate in the terminal wall of the cavity of the pinulated appendages,—a fact that seems to have been first recorded by Drs. Leuckart and Pagenstecher, though we learn from Mr. Huxley that he had arrived at the same conclusion ten years ago. This terminal wall, which gives support on its outer side to the bases of the pinnulæ, presents on its inner surface a number of transparent tubercular elevations (fig. 7. *e*), which progressively become hemispherical, then pear-shaped, and finally give exit to peculiar nucleated cells which float in the fluid of the perivisceral cavity. These cells multiply by self-division after the ordinary mode (fig. 13); and it is only after their number has thus been considerably augmented, that they begin to increase in size and to assume the characteristic appearance of ova. It is not only in the lateral appendages of the body, however, that ova thus originate; for it is clear to us that they are developed also in the caudal prolongation; and it would seem probable (though we could not satisfy ourselves of the fact) that they there originate in the corresponding situation—that is, on the terminal walls of those extensions of the perivisceral cavity into the rudimentary appendages, which, as just shown, are the seat of the testes in the male.

It is a fact not to be passed without mention, that rudimentary ovaria are to be seen in mature males,—the terminal walls of the lateral appendages of the body presenting those tubercular elevations whose presence constitutes the first stage in the development of ova in the female. Whether at some other period these may develop ova (as is the case with certain other worms, which are really hermaphrodite, but which mature their male and their female products at different periods), or whether they are merely persistent rudiments not destined to undergo any further development (like the mammary glands of the male mammal), is a question to be determined by future observation.

We have not been able to detect the mode in which the *ova* make their exit from the body,—the transverse fissures in the outer wall of the perivisceral cavity, which are described by Leuckart and Pagenstecher as presenting themselves in the third and fourth segments, not having been noticed by us, probably because they had not yet been formed. Nor have we been able to satisfy ourselves whether the ova are fecundated before their escape, by the entrance of spermatozoa through the ciliated canals into the perivisceral cavity, or whether they receive the fertilizing influence after their emergence.

Although we have had no opportunity of following out the development of this interesting creature *ab ovo*, yet it has been the good fortune of one of us to capture, off the coast of Skye, what we cannot doubt, from the conformity of its general organization to the type we have been describing, to be a very early form of the same *Tomopteris*. This

specimen, represented in fig. 14, was not more than $\frac{1}{25}$ th of an inch in length, and seems to correspond in its grade of development with one which came under the observation of Busch. The following are its most noticeable features of difference from the more advanced form:—The “frontal horns” were entirely wanting. The first antennæ (*a*, *a*) were relatively very long, but presented only a trace of articulation. The second antennæ (*b*, *b*) were relatively very short, and presented a bifid termination which clearly indicated their homology with the ordinary members; only one of the pinnulæ was setigerous, and it would seem as if this alone were destined to undergo further development, while the other becomes obsolete. Behind these were only four pairs of lateral appendages, the fourth being as yet rudimentary; these were formed by pinnulæ only, which were sessile on the trunk of the body, the lateral extensions which bear the pinnulæ at a later period not having been as yet developed. No trace was to be seen either of the ciliated canals or of their rosette-like orifices; near the junction of the pinnulæ, however, in the two most developed pairs of appendages, a single sulphur-yellow “rosettenförmiges Organ” presented itself. The ventral surface of the pinnulæ, and the surface of the whole posterior part of the body, were ciliated. The body was bifurcated at its posterior extremity.

We think it proper to record the fact, that in a single *Tomopteris* of tolerably advanced development (the caudal prolongation beginning to show itself) we found the pinnulæ covered with large trichocysts or thread-cells (fig. 11). Notwithstanding a careful search, we failed to meet with these in any other individual. However strange this circumstance may appear, it is not altogether without parallel,—the trichocysts usually seen in *Paramecium aurelia*, *P. bursaria*, and other Infusoria, having been frequently observed by us to be wanting in those of particular collections of water.

It will, we think, be obvious from the details we have given of the structure of this interesting creature, that it is a degraded form of the *Annelidan* type,—its nearest affinities being (as already pointed out by Drs. Leuckart and Pagenstecher) to the chætopod or setigerous Annelids. Every part of the characteristic organization of that type is here reduced to the extreme of simplicity. The alimentary canal passes in a straight line from one extremity of the body to the other, without either sacculations or glandular appendages. The nutritive fluid which transudes through its walls, and which thus finds its way into the perivisceral cavity, is distributed throughout the body solely by means of extensions of that cavity; through which it is propelled in part by the agency of the cilia that clothe its walls, and in part by the general movements of the body and appendages. This fluid is so obviously the homologue of the blood of higher animals, that we cannot but regard the existence of the type of structure before us (the wonderful transparency of the body not permitting the slightest doubt as to the absence of anything resembling a dorsal vessel) as affording a further confirmation of that view of the (so-called) circulating apparatus of the higher Annelida, which regards their perivisceral cavity and its extensions as representing the proper sanguiferous system, and which looks upon the system of vessels containing coloured fluid as a special arrangement having reference rather to the respiratory function*. The extreme tenuity of the walls of the body and of its appendages, renders it un-

* See Prof. Huxley's Lectures in ‘Medical Times and Gazette,’ July 12 & 26, 1856.

necessary that any special provision should be here made for the aeration of the nutritive fluid; and we accordingly find neither branchiæ nor any trace of what is commonly described as the sanguiferous system in Annelida. The centres of the nervous system would seem to consist solely of the cephalic ganglia,—the absence of the ordinary longitudinal series being apparently related to the very incomplete segmentation of the body, and constituting a link of affinity to the Turbellarian Worms. The ocelli present a condition of extreme simplicity; yet the duplication of the corneule in each of them marks that tendency to repetition which so peculiarly distinguishes the Articulate type. It is, however, the extreme simplicity of its generative apparatus, that constitutes one of the chief points of interest in the organization of *Tomopteris*. It is clear that both ova and spermatozoa are first developed within those prolongations of the general cavity of the body which support the pinnulæ,—the “germ-cells” being certainly, and the “sperm-cells” probably, contained in the substance of their walls. The ova being speedily set free, escape into the general cavity of the body, no proper ovarium being formed; but the spermatozoa remain enclosed within a sac, which is probably formed by an extension of the inner layer of the wall of the perivisceral cavity, and thus constitutes a definite testis. It seems clear that the ciliated canal or “segmental organ” has here only a secondary relation (if any) to the genital apparatus. It has no other character in the ovigerous appendages, than it has in the lateral appendages generally; and if in the spermigerous appendages the contents of the testis escape through its minor orifice, they do so without traversing the principal canal. Whether the spermatozoa, when diffused through the surrounding water, normally pass into the ciliated canals of the female, and thus make their way to the ova contained in the perivisceral cavity, or whether their entrance (as seen by us) was merely accidental, like that of any other minute particles that might be drawn in by the ciliary current, is a point to be determined by further inquiry.

To the notices we have already given of the accounts of *Tomopteris* recorded by previous observers, we have to add that this creature long since presented itself to that indefatigable student of the Marine Zoology of our coasts, the late Sir John G. Dalyell; and that it is described and figured in his work on the ‘Powers of the Creator displayed in the Creation’ (vol. ii. p. 260, plate 36. figs. 16, 17) under the designation of *Nereis phasma*, or the Spectre Nereis. It may be well to cite his account of the animal, for the sake of his vivid description of its extraordinary transparency, and also because comparatively few have access to the work in which it appeared.

“One evening, early in January, while inspecting a vessel of sea-water, my attention was attracted to an indistinct vortex amidst it, without presenting any definite object to the view. This motion was connected, however, with an air-bubble, certainly shifting it to different parts of the vessel. I could account for neither. Nothing else was perceptible; and it seemed still more singular that I should afterwards witness the same by day. But on altering the position of the vessel so as to throw different shades of light upon it and its contents, I discovered with much surprise that the agent was a very active animal, by no means so diminutive as to escape detection, but of such excessive transparency as to

disguise its form. Nor is this any exaggeration of the fact: for having sent the vessel to an accomplished artist already named, Mr. Peter Syme, for the purpose of obtaining a delineation, I found, on reaching him, that he had been unable to discover the object. However, by resorting to similar expedients as practised by myself, he could now represent the most conspicuous parts of the animal.

“ Nearly three years afterwards, I obtained another specimen in November. Both occurred in a capacious jar of sea-water taken from about the same place, Newhaven Pier. But, with ample opportunities, none have been again found there.

“ Twenty years later, six specimens were obtained from the Isle of May, not less than thirty miles distant; and from the whole I have been able to gain some slight acquaintance with this singular animal—singular because human vision can scarcely discover, what is of sufficient size to expose every feature. Hence it is that there must always be slight discrepancies between the drawings of different artists.”

Of the two representations given of the animal in Sir J. G. Dalzell's 36th Plate, that which was drawn by Mr. Syme from the specimen first seen departs greatly from its true proportion,—the pinnulated appendages, of which there are sixteen on either side, being drawn much too long (as in the figure of MM. Quoy and Gaimard), whilst the second antennæ are as much too short. The caudal prolongation in this specimen appears to have been just beginning to show itself. The second figure, which appears to have been drawn from the specimens obtained at a later period, is a much truer representation of a more advanced stage of development, the length of the caudal prolongation being about one-third of that of the body. Some of the specimens are said by Sir J. G. Dalzell to have had only four or five, or seven, pairs of limbs. He remarks that the animal “ can be preserved with difficulty, from being liable to entangle itself in every foreign substance, and is easily mutilated in its struggles for liberation. None have survived longer than twenty-four days; they generally live only a week.” We have not ourselves succeeded in preserving them for more than the shorter of the periods just named.

EXPLANATION OF THE PLATE.

TAB. VII.

Tomopteris onisciformis.

- Fig. 1. Posterior portion of the body, and caudal prolongation, of a female, showing the ova in various stages of development, lying in the perivisceral cavity. Magnified 40 diameters.
- Fig. 2. Caudal prolongation of a male, showing the testes *a*, *a* occupying the cavities of the rudimentary pinnulæ. Magnified 65 diameters.
- Fig. 3. One of the testes, more enlarged, showing at *a* the orifice through which the spermatozoa are discharged externally, at *b* the orifice leading to the perivisceral cavity, and at *c* the larger ridged rosette of the ciliated canal. Magnified 150 diameters.
- Fig. 4. Biflagellated spermatozoa. Magnified 300 diameters.
- Fig. 5. Portion of the head, seen on its dorsal aspect, showing the ciliated epaulettes *a*, *a*. Magnified 65 diameters.

- Fig. 6. Second antenna of a young specimen, showing the terminal portion to be setigerous and to be separated from the basal portion by a constriction at *a*.
- Fig. 7. One of the ordinary lateral appendages, showing the position of the ciliated canal with its two external orifices *a, b*, and its internal orifice *c*, and of the "rosettenförmige Organe" *d, d*; at *e, e* is shown the incipient development of the germ-cells in the terminal wall of the perivisceral cavity.
- Fig. 8. External portion of the ciliated canal, more highly magnified: *a*, larger ciliated rosette; *b*, smaller rosette.
- Fig. 9. Yellow "rosettenförmiges Organ" of Leuckart and Pagenstecher.
- Fig. 10. Corpuscles floating in the fluid of the perivisceral cavity, some of them aggregated into masses.
- Fig. 11. Trichocysts or thread-cells in pinnula of one specimen of *Tomopteris*.
- Fig. 12. Bilobed ganglion, showing the spheroidal cells of which it is composed, with the pair of peculiar nucleated vesicles *a, a* imbedded in its anterior part, and the ocelli *b, b* each with its double lens.
- Fig. 13. Germ-cells multiplying by self-division to produce ova.
- Fig. 14. Very early larva of *Tomopteris*: *a, a*, the long first antennæ; *b, b*, the short second antennæ; *c, d, e, f*, four pairs of sessile pinnulæ, of which *c* and *d* show the "rosettenförmige Organe." Magnified 65 diameters.