On a Cestode from Cestracion.

By

William A. Haswell, M.A., D.Sc., F.R.S.,
Professor of Biology, University of Sydney.

With Plates 22—24.

General Features.

THE Cestode, the results of a study of which are embodied in the present paper, occurs, usually in abundance, in the large intestine of the Port Jackson shark. It is one of these remarkable forms to which attention appears to have been first specially directed by P. J. van Beneden (**1** and **2**), in which the proglottides are set free from the posterior end of the strobila long before full maturity has been reached, and only attain a stage corresponding to that of the "ripe" proglottides of a Tænia after having pursued an independent existence for some considerable time.

The strobila is actively locomotive, and appears to use the suckers more in connection with progression than as organs of permanent attachment. It is only 9 or 10 cm. long in the preserved condition. There is an elongated neck-region with a breadth, in the preserved specimens, of half a millimètre. The four sessile bothridia (fig. 1) are somewhat spoon-shaped, the anterior end being the narrower. The margin of the bothridium is very prominent, finely crenulate, and in the living condition extremely extensile, so that the shape is undergoing constant modification. In preserved specimens they are about 1 mm. in length. Each bothridium is so directed that a line running along the floor of its cavity in the direction of the long axis, and prolonged forwards, would meet the median axis of the neck at an angle of about 45°. The cavity is not divided or reticulated. At its anterior narrower end, where its margin is lowest, each bothridium bears a small circular accessory sucker.

The last segment (fig. 2) is 5 mm. long and 2 mm. in breadth in the preserved specimens; relatively narrower in the extended living condition.

Separated segments are to be found in abundance along with the entire strobilæ, moving actively through the intestinal contents. In the course of these movements the shape undergoes constant alteration, the phases through which it passes being comparable to those of a Ligula in its most active condition. The anterior end becomes thrust sharply forwards until the "head" becomes long and narrow and pointed, and the "neck" constriction becomes more or less completely obliterated. Then suddenly the anterior end becomes drawn together and thickened to form a distinct rounded knob, constricted off from the rest (fig. 3). The part behind this "head" now becomes drawn forwards, the region immediately following on the head gradually becoming thickened, while the head itself becomes gradually retracted until it nearly completely disappears, to become again thrust forwards as before. The effect of these movements is clear enough. By the thrusting forwards of the narrowed head end, the thick matter contained in the intestine is readily penetrated, the subsequently formed knob at the anterior end then forming a point d'appui, towards which the rest of the proglottis becomes drawn forwards.

These independent proglottides attain a relatively considerable size, the largest being about 11 mm. in length and 1·75 mm. in greatest breadth.

Attention has been recently directed by Lühe (**13**) to isolated proglottides from Acanthias, in which there is a distinct mobile "head" similar to that above described, but covered with spinules; and a similar case had previously been observed by Pintner.

The early separation of the proglottides in this and other species is obviously correlated with the free locomotive habits of the strobila. With a much longer train of connected proglottides, the posterior loaded with eggs, such movements would be rendered difficult or impossible. The spiral valve in the intestine of the Elasmobranch renders it possible for the separated proglottides, without definite organs of adhesion, yet with an adaptation for creeping movement, to remain within their host until such time as the uterus has become fully charged with eggs.

This Cestode is to be referred to the genus Phyllobothrium of P. J. van Beneden. In the definition given by that author[1] the bothridia are described as notched externally, but the notch is not present in one of van Beneden's own species (P. auricula), and cannot be looked upon as of generic importance. I propose the name of P. vagans for the Cestracion parasite, which appears to be distinct from all the species described hitherto.[2]

The only species of Phyllobothrium, of the structure of which a detailed account has been published, are P. thridax and P. Dohrnii. These have both been pretty fully described by Zschokke (**20**, p. 327 et seq.); but, as mature segments were not met with by that author, many features of importance, more particularly in the reproductive apparatus, were overlooked.

Integument and Nervous System.

The cuticle (fig. 4, *cu.*) is homogeneous and not divided into layers. Immediately beneath it are the usual external longitudinal (*e. l. m.*) and circular (*e. c. on.*) layers of muscular fibres. The subcuticular cellular layer is much better developed in the strobila than in the free proglottides, in

[1] **1**, p. 120, and **2**, p. 123.

[2] I have not seen the original description of P. gracile, Wedl., from Torpedo marmorata, but only the brief definition given by Lönnberg (**11**).

which it has undergone a reduction in thickness. A similar reduction is observable in the internal longitudinal layer of muscular fibres (*i. l. m.*), which are well developed in all parts of the strobila, and very conspicuous in transverse sections owing to their highly refracting character, whereas in the free proglottides they are barely discernible in transverse sections, and in longitudinal appear as a few inconspicuous, often degenerate, fibres.

The nervous system (fig. 3, fig. 4, *n. c.*) is in no way remarkable, consisting of the usual head-ganglion in the scolex, and the pair of longitudinal nerve-cords with their branches and commissures. In the separate proglottides, owing to the reduction in the thickness of the subcuticular cellular and internal longitudinal muscular layers, the nerve-cords come to be situated more superficially than in the strobila. They meet anteriorly in the "head," where there is a slight thickening of the nature of a rudimentary ganglion.

As in many other forms, two of the four longitudinal excretory vessels of the anterior region—the dorsal pair—become reduced greatly in diameter in the posterior proglottides. In the last proglottis these open on the exterior at the posterior end. In the free proglottides (fig. 3) only the ventral pair remain. These are very narrow towards the anterior end, while posteriorly they are very wide and very sinuous; their external openings are situated near together at the posterior extremity. The excretory vessels in general have a wall consisting of a thin layer of fibrillated protoplasmic material; but in the scolex and neck region the four main vessels have a fairly thick layer of longitudinal muscular fibres.

Reproductive Organs.

The reproductive system will be best described first as it appears in its fully developed condition in the free proglottides.

The testis (fig. 3, *te.*) consists of numerous rounded lobes extending from the neck to behind the genital aperture.

They lie in the central or medullary region, and are thus situated on a deeper plane than the vitelline glands. They average about ·06 mm. in diameter. Each lobe has a fine, thin-walled efferent duct; the ducts of neighbouring lobes anastomose to form a network. From this network are derived larger trunks, which towards the anterior end, and near the ventral surface of the proglottis, combine together to form a single median vas deferens (*s. d.*). The latter is a closely coiled, widish, thin-walled tube, situated in the middle of the region in front of the genital aperture. Its wall consists of a reticulated material with superficially placed nuclei. No muscular layer was definitely made out, but muscular fibres must be present, as in the living condition the tube is observed to undergo peristaltic contractions. The "prostate" cells described by various authors (see Braun, **5**) as occurring in certain Cestodes, are not present. This main testicular duct is always packed full of sperms, and it plays the part of a vesicula seminalis as well as a vas deferens. It terminates by passing through the wall of the cirrus sac and becoming the ejaculatory duct. The cirrus sac has a wall composed of two layers of muscle. Within it, when the cirrus is not protruded, lies coiled up a long tube, continuous internally with the vas deferens. This tube (fig. 5) has a muscular wall, consisting of an outer thicker layer of longitudinal fibres and an inner of circular fibres. Internal to this is a homogeneous cuticular layer, beset on its inner surface in the outer part of the tube with numerous excessively minute spinules. Outside the muscular layer is a layer of cells similar to the myoblasts of the oviduct and vagina. In the space between the wall of the cirrus sac and the enclosed tube are to be observed numerous muscular fibres which appear to run about in every direction.

The outer end of the tube is continuous with the outer extremity of the cirrus sac, and might be described as invaginated within it were it not for the circumstance that its inner end is not free, but passes through the wall of the sac to become continuous with the vas deferens.

The mode of protrusion of the cirrus is rendered evident on an examination of living animals and of sections of specimens with the organs in various states. The strong muscular wall of the cirrus sac contracts, and the narrow outer end with which the invaginated tube is continuous becomes thrust out through the genital opening. Further pressure causes the tube to become evaginated as a narrow cylindrical process, the cirrus, with a double wall, the space between the two walls being continuous with the cavity of the cirrus sac. The retraction takes places through the agency of the muscular fibres that have been above referred to as situated in the cavity of the cirrus sac; when the cirrus is protruded these are put upon the stretch, and each of them is found to be connected internally with one of the myoblasts in the wall of the tube, and to run inwards towards the inner part of the wall of the cirrus sac.

The ovary (figs. 3 and 6, *ov.*), as in many other Cestodes, consists of two large lateral portions and a small median isthmus connecting them together, the whole, on a dorsal or ventral view, resembling a letter **H**, with the limbs thick and near together and the transverse part very short. A transverse section shows that each lateral portion is itself double, consisting of a dorsal and a ventral lamina which coalesce internally towards the isthmus. The margins of the laminæ are divided irregularly into a number of rounded lobes, but these divisions are quite superficial, the substance of the lamina consisting of a mass of ova with no trace of a tubular structure, except that irregular fenestræ occur here and there. The ova are somewhat smaller peripherally, largest in the neighbourhood of the isthmus. The mature ova are ·01 mm. in diameter; their nuclei, ·004 mm.; and their nucleoli, ·002 mm. Their cytoplasm appears homogeneous under the highest powers, binding them together in a small quantity of retiform connective tissue. Enclosing the whole ovary is a membrane having the appearance of a condensation of the parenchyma, but perhaps of muscular character.

The isthmus, or connecting part, differs widely from the rest, and is to be looked upon rather as the beginning of the efferent duct than as part of the ovary proper. It is enclosed in a membrane continuous with that which encloses the lateral portions. The contained ova, instead of being closely aggregated together, are loosely distributed singly or in groups (figs. 11 and 12).

The oviduct begins in a well-developed "swallowing apparatus" (figs. 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, *sw.*), such as has been described in various other Cestodes. This lies on the ventral side of the isthmus of the ovary and opens into its cavity. It is a bell-shaped structure, the wide mouth of which, directed towards the dorsal surface, opens into the cavity of the isthmus of the ovary, while at the opposite extremity a very much smaller aperture leads into the oviduct proper. During life this swallowing apparatus was observed to perform rhythmical pulsating movements, the effect of which must manifestly be to seize the loose ova of the isthmus, one by one, and to pass them backwards along the oviduct. In sections it is found that the wall of the swallowing apparatus is continuous with the investment of the ovary and with the muscular layer of the wall of the oviduct. It has the character of a dense layer of fibres (figs. 13 to 16, *sw. m.*), which, though of extreme fineness, must be muscle-fibres. These are for the most part arranged circularly around the wall of the organ, but some are radial. Surrounding this fibrous layer is a single layer of cells (figs. 13 and 14, *sw. my.*) of irregular shape. Processes pass from these into the fibrous layer, and there can be little doubt that the majority of these cells are the myoblasts of the fibres of the swallowing apparatus. A small number (fig. 13) which give off processes both externally and internally are probably nerve-cells.

Through the oviducal opening of the swallowing apparatus projects for a short distance a sort of plug perforated by a circular aperture. The substance of this plug is continuous with the epithelium of the oviduct; but, though it contains several nuclei (fig. 16), it does not consist, so far as I have been able to ascertain, of definite cells. On its inner surface, i. e. the surface turned towards the ovary, it is fimbriated (fig. 14), and it is doubtless through the agency of these fimbriæ that the ova are seized during the movements of the apparatus.

The oviduct (figs. 6 and 7, *od.'*) runs, at first, nearly straight back from the swallowing apparatus, on the ventral side of the shell-gland and receptaculum seminis, and is joined by the narrow fertilising duct (*f. d.*) from the latter. In this part of its course (fig. 8) it has an epithelium composed of short prismatic cells. Internal to this is a thin cuticle beset on its inner face with numerous slender hairs, resembling cilia in appearance, but non-vibratile, which lie with their apices directed backwards, i. e. away from the ovary, their arrangement thus being such as to prevent the ova received from the swallowing apparatus from passing forwards again towards the ovary. External to the epithelium is a muscular layer composed of external longitudinal and internal circular fibres. Surrounding this is a layer of cells of the same general character as those that surround the muscular layer of the swallowing apparatus. These appear to correspond to the cells which Zschokke (**20**) looks upon as glandular, and to those which Pintner [1] regards as the formative cells of the swallowing apparatus. In view of Blochmann's[2] results on the subcuticular muscle, however, and Sabussow's (**17**) extension of the same view to the reproductive ducts, I am more disposed to look upon these also as myoblasts.

A little behind its point of junction with the fertilising duct the oviduct bends sharply round towards the dorsal side, and is joined by the main vitelline duct at the posterior limit of the shell-gland. From this point it runs forwards for some distance with a sinuous course on the dorsal side of the isthmus of the ovary and of the vagina, and then runs

[1] See Braun, **5**.

[2] F. Blochmann, "Ueber freie Nervenendungen und Sinneszellen bei Bandwürmern," 'Biol. Centralbl.,' xv, 1895.

straight forwards as a cylindrical tube with irregular dilatations. As this part of the oviduct contains fully formed eggs, and is something more than a mere passage, it will be convenient to designate it ootype, or primary uterus. Anteriorly it opens into the secondary uterus by a longitudinal slit, the extent and position of which vary in different specimens, situated on one side of the vagina.

After it becomes joined by the main vitelline duct, the oviduct changes its structure, the cuticular hairs are lost, and there is no epithelium, the wall of the duct now consisting of cuticle, muscular layer, and layer of myoblasts.

The uterus (figs. 3, 6, and 18, *s. u.*) is a cylindrical undivided chamber, extending from the level of the reproductive aperture to the interspace between the anterior portions of the lateral wings of the ovary. It has a lining membrane composed of a single layer of cells. It has no natural external aperture, but dehisces by the formation of a longitudinal slit along nearly the whole, or only a limited part of the length of its ventral surface. This dehiscence readily takes place when the specimen is manipulated, more especially when it is placed in sea-water, when the eggs are observed to be suddenly discharged with the appearance of a white cloud.[1]

The shell-gland is a compact oval body, ·18 mm. in length, which surrounds the oviduct where the vitelline duct joins it.

[1] Shipley, in his description of the worms collected by Dr. Willey (**19**), in referring to a species of Phylobothrium, states that in the oldest proglottides the uterus had ruptured "about the centre of the dorsal surface." But there can be no doubt that the surface on which the dehiscence takes place is the ventral, and not the dorsal. This is made perfectly clear in the case of the Cestracion species by the relative positions of the various parts of the reproductive apparatus—as, for example, the vagina and vas deferens—and by the disposition of the longitudinal vessels of the excretory system. It may be remarked, however, that in the Australian land Planarian (Geoplana Mortoni) Steel has confirmed by observation on the living animal Dendy's description of the rending of the dorsal body-wall on the discharge of the egg-apsules ('Proc. Linn. Soc. N.S.W.,' 1900, p. 573, pl. 34, fig. 10, and pl. 41, fig. 6).

Its cells, several hundred in number, are arranged in a radiating manner round the oviduct, their narrow inner extremities evidently acting as ducts by which the secretion is discharged. Their nuclei are large, a little less than ·005 mm. in diameter. Between the cells are a number of smaller nuclei indicating the presence of a certain amount of intercellular tissue.

The vitelline glands (fig. 3, *v.*) extend throughout a narrow belt of the lateral regions of the body from the neck to the posterior end. The lobes are spherical or subspherical in shape, and average about ·03 mm. in diameter. Each lobe has its slender duct, which joins those of neighbouring lobes to form larger ducts, and these again combine to form the main lateral ducts (fig. 7, *v. d.*). These converge from both sides towards the middle line, running on the ventral side of the ovary, and finally unite to give rise to an impaired main duct, situated slightly to the right of the middle line. This runs backwards and joins the oviduct as already described. Near its termination it is usually distended with yolk, and this dilated part (figs. 7, 8, and 9, *v. r.*) (·03 mm. in diameter) might be looked upon as a yolk-receptacle. It is followed by a constricted part with thickened walls (fig. 8, *v. r. c.*) through which the yolk cells can only pass singly to enter the oviduct. The yolk matter leaves the lobes of the glands in the form of very regular spherical masses ·012 mm. in diameter, each of which contains one, or sometimes two, rounded bodies which, as they are capable of being stained, though only slightly, are very liable to be mistaken for nuclei. These bodies will be further referred to in the description of the egg. Meanwhile it is of importance to emphasise the fact that they are not nuclei, and that the vitelline masses in which they are lodged are not cells.[1]

The wall of the vitelline ducts consists of fibrillated protoplasmic material with nuclei at intervals. In the main duct

[1] This is contrary to what is usually stated of Cestodes in general. Braun, for example, states: "Die Ansicht Moniez's dass die Dotterzellen keine echten sondern nur Scheinzellen seien entbehrt jeder Begründung (**5**, p. 1468).

the wall is thicker, and contains a large number of superficially situated nuclei.

The vagina (figs. 6, 9, and 10, *va.*) opens into the shallow genital cloaca by a narrow aperture immediately in front of the male aperture. The terminal part is somewhat dilated. From this point it bends round the sac of the penis as a narrow tube, which dilates again to a diameter of about ·05 mm., as it runs straight backwards immediately above (i. e. on the dorsal side of) the secondary uterus. When it reaches the region of the ovary it again becomes narrower and more sinuous. Eventually passing backwards on the dorsal side of the isthmus, it becomes somewhat dilated again to form a vesicle, the receptaculum seminis (figs. 6, 7, 9, 10, 11, and 12, *r. s.*). From the rounded posterior end of this a narrow duct, the fertilising duct (*f. d.*), runs to join the oviduct.

In the posterior part of its extent the vagina has a thickish muscular wall consisting of external longitudinal and internal circular layers. Internal to this is a cuticle beset with exceedingly minute spinules. External to the muscle is a layer of cells resembling those cells of the oviduct which I have supposed to be myoblasts. Anteriorly the muscular layers become reduced, and longitudinal fibres alone are present. The fertilising duct resembles the oviduct in structure, but the cuticular hairs are absent. In the posterior proglottides of the strobila (fig. 2) all parts of the reproductive apparatus are represented, though neither the male nor the female organs are mature, and there are no eggs in the uterus. The latter has a comparatively narrow lumen surrounded by a thick layer of small cells; its aperture of communication with the primary uterus is already developed. In more anteriorly situated proglottides the uterus is represented by a solid cord of small cells running along on the ventral side of the vagina.

Development.

In the case of P. Dohrnii, Zschokke (**20**) states that the formation of eggs begins in the posterior proglottides of the strobila. In the form now under consideration this is not the case, eggs only occurring in well-developed free proglottides.

The only recorded observations on the development of any member of the genus appear to be a few notes on P. thridax by Moniez (**14**, p. 28). I can trace no correspondence whatever between the statements there made and what I have been able to observe in the species from Cestracion.

The primary uterus contains only eggs with unsegmented ova. The entire egg is in the form of a thick spindle about ·045 mm. in length and ·021 mm. in greatest breadth. The shell is at this stage not yet fully solidified, so that the shape is readily modified by pressure, and the eggs tend to adhere together in masses. The shell consists of two distinct layers—an outer homogeneous and an inner made up of fine fibrillæ—which run in the direction of the long axis of the egg.

The completed egg in the primary uterus contains (1) the unsegmented ovum; (2) a large number of small, bright globules (3) one, or, more commonly, two, larger rounded masses. The last two are the substance of the vitelline spherule. When the eggs are acted upon by any weak acid the small globules tend to run together into larger (2 [**14**], p. 28) masses, and eventually these pass out through the shell at the ends of the egg, so that in preparations fixed and stained by any of the ordinary methods this constituent of the egg becomes completely lost, there being left behind merely some irregular granular matter, in which, presumably, the globules were enveloped. These globules, from their appearance and behaviour, are most probably composed of oily matter.

The larger bodies derived from the yolk (see fig. 20) are of an entirely different character. They are solid masses having the central hilum and concentric lamination characteristic of the calcareous corpuscles. They become coloured, though not strongly, by staining agents, the central mass colouring first. In fixed and stained preparations they become much altered, having apparently become partly dissolved, and the concentric lamination being no longer discernible, might very easily be taken for nuclei. Like the oil globules, these bodies consist, doubtless, of food materials; but both these ingredients of the yolk persist, not greatly diminished in bulk, to the most advanced stage observed. Nothing was made out with certainty as to the processes of maturation and impregnation. The oosperm does not differ to any appreciable extent from the ovarian ovum.

Very few, if any, unsegmented ova were found in the secondary uterus. No definite history of the process of segmentation could be traced, as there seemed to be great variation in the details. The first two segments (figs. 20 and 21) are equal. One of these, or both, become divided into two equal parts (figs. 22 and 23), and from the three or four equal, or nearly equal cells thus formed, a number of smaller cells become segmented off (figs. 24, 25, and 26). Eventually the larger cells become reduced by division until a blastoderm is formed consisting of a disc of small cells (figs. 27, 28, and 29), which are very irregular in size and shape, and present no definite arrangement. This disc becomes thickened to form a rounded mass, on the surface of which appears here and there a flattened cell. In this stage there appears to be no further cell-differentiation, except that there are present, in the most advanced embryos, one or two pairs of very small cells that become more intensely stained than the rest. It is conjectured, from their arrangement in pairs, that these are the cells destined to develop the hooks.

No hooked embryos were found in the uterus of any of the numerous specimens examined. But of a number of eggs which had been kept in pure sea-water for five days, a large proportion (figs. 30—32) were found to contain fully formed active hexacanth embryos. It would thus appear that passage to the exterior with the fæces is, under normal circumstances, the necessary condition for the development of the hooked embryo.

Literature.

1. Beneden, P. J. Van.—"Recherches sur la faune littorale de Belgique: Les Vers cestoides," 'Nouv. Mém. de l'Acad. Roy. de Belg.,' t. xxv, 1850.

2. Beneden, P. J. Van.—"Mémoire sur les Vers intestinaux," Suppl. aux 'Comptes Rendus de l'Acad. des Sciences,' 1861.

3. Beneden, E. Van.—"Recherches sur le développement embryonnaire de quelques Ténias," 'Archiv. de Biol.,' vol. ii, 1881.

4. Blanchard, —.—"Recherches sur l'organisation des Vers," 'Ann. Sci. Nat.,' 3 sér., t. vii and viii, 1847.

5. Braun, M.—"Vermes" of Bronn's 'Thierreich.'

6. Diesing, C. M.—'Systema helminthum,' 1850.

7. Leuckart, R.—'Die Parasiten des Menschen.'

8. Linton, E.—"Notes on Entozoa of Marine Fishes of New England," 'U.S. Fisheries Reports,' 1886 (publ. 1889).

9. Linton, E.—"Notes on Entozoa of Marine Fishes of New England," part 2, 'U.S. Fisheries Reports,' 1887.

10. Linton, E.—"Notes on Cestode Parasites of Fishes," 'Proc. U.S. National Museum,' vol. xx, 1897.

11. Lönnberg, E.—"Bidrag till Kännedomen om i Sverige förekommande Cestoder," 'Bih. till K. Svenska Vetensk.-Akad. Handlingar,' Bd. xiv, 1889.

12. Lönnberg, E.—"Helminthologische Beobachtungen von der Westküste Norwegens: 1 Thl., Cestoden," 'Bih. till K. Svenska Vetensk.-Akad. Handlingar,' Bd. xvi, 1890.

13. Lühe, M.—"Ueber einen eigenthümlichen Cestoden aus Acanthias," 'Zool. Anz.,' xxiv, 1901.

14. Moniez, R.—"Mémoires sur les Cestodes," 'Travaux de l'Institut Zool. Lille,' t. iii, 1881.

15. Monticelli, F.—"Nota intorna a due forme de Cestodi," 'Bollettino dei Musei di Zoologia ed Anatomia comparata della R. Università di Torino,' vol. vii, 1892.

16. Olsson, P.—"Bidrag till Scandinaviens Helminthfauna II," 'Kgl. Svenska Vetensk.-Akad. Handl.,' Bd. xxv, 1893.

17. Sabussow, H.—"Zur Histologie der Geschlechtsorgane von Triænophorus nodulosus, Rud.," 'Biol. Centralbl.,' Bd. xviii.

18. Schavinsland, H.—"Die embryonale Entwickelung der Bothriocephalen," 'Jen. Zeitschr. f. Naturw.,' Bd. xix, Neue Folge, xii, 1885.

19. SHIPLEY, A. E.—"Description of the Entozoa," A. Willey's 'Zool. Results,' part 5.

20. ZSCHOKKE, F.—"Récherches sur la structure anatomique et histologique des Cestodes" 'Mém. de l'Institut nation. Génévois,' t. xvii, 1886—1889.

21. ZSCHOKKE, F.—"Studien über den anatomischen und histologischen Bau der Cestoden," 'Centralbl. f. Bakteriologie u. Parasitenkunde,' i, 1887.

EXPLANATION OF PLATES 22—24,

Illustrating Prof. William A. Haswell's paper "On a Cestode from Cestracion."

LIST OF REFERENCE LETTERS.

c. Cirrus. *c. s.* Cirrus sheath. *cu.* Cuticle. *d.* Depression at posterior end of free proglottis. *d. v. m.* Dorso-ventral muscular fibres. *e. c. m.* External layer of circular muscular fibres. *e. l. m.* External layer of longitudina muscular fibres. *ex.* Main excretory vessel. *f. d.* Fertilising duct. *h.* "Head" of separate proglottis. *i. l. m.* Internal longitudinal layer of muscle. *n. c.* Nerve cord. *o. d.*[1] First part of oviduct. *o. d.*[2] Second part of oviduct. *ov.* Ovary. *ov. m.* Median part or isthmus of ovary. *p. u.* Ootype or primary uterus. *r. s.* Receptaculum seminis. *s. d.* Sperm duct. *s. g.* Shell-gland. *s. u.* Uterus. *sw.* "Swallowing apparatus." *sw. m.* Muscular layer of swallowing apparatus. *sw. my.* Myoblasts of swallowing apparatus. *te.* Lobes of testis. *v.* Lobes of vitelline glands. *va.* Vagina. *v. d.* Vitelline ducts. *v. r.* Vitelline reservoir. *v. r. c.* Constriction at posterior end of vitelline reservoir. ♂. Male reproductive aperture. ♀. Female reproductive aperture.

PLATE 22.

FIG. 1.—Scolex of Phyllobothrium vagans magnified.

FIG. 2.—Last proglottis of strobila magnified.

FIG. 3.—Free proglottis, dorsal aspect. Nervous system, blue; excretory vessels, green; testicular ducts, red.

FIG. 4.—Portion of transverse section of strobila, showing integument and muscular layers. × 600.

Fig. 5.—Transverse section of cirrus. *cu.* Cuticle, with spinules. *c. m.* Layer of circularly arranged muscular fibres. *l. m.* Layer of longitudinal muscular fibres. *my.* Layer of myoblasts.

Fig. 6.—General view of the female reproductive apparatus as seen from the ventral side.

Fig. 7.—Dorsal view of the median part of the ovary and of the neighbouring ducts.

PLATE 23.

Fig. 8.—From a series of longitudinal (horizontal) sections. Section passing through swallowing apparatus, first part of oviduct and main vitelline duct. × 450.

Fig. 9.—From the same series. Section dorsal to that represented in Fig. 8, showing vagina, receptaculum seminis, and shell-gland. × 450.

Fig. 10.—From the same series. Section dorsal to that represented in Fig. 9, showing receptaculum seminis and fertilising duct. × 450.

Fig. 11.—From a series of transverse sections. Section passing through swallowing apparatus and median part of ovary.

Fig. 12.—Section immediately behind that represented in Fig. 11.

Fig. 13.—From an oblique series. Mouth of swallowing apparatus. × 600.

Fig. 14.—From a transverse series. Showing swallowing apparatus and its relations to ovary. × 600.

Fig. 15.—From a transverse series. Showing relations of swallowing apparatus to oviduct. × 600.

Fig. 16.—From a transverse series. Swallowing apparatus and oviduct. × 600.

Fig. 17.—From a horizontal series. Section of oviduct at the point where the ducts of the shell-gland open into it; an ovum in the act of union with a yolk-cell.

Fig. 18.—Transverse section to show the relations of the primary uterus, the vagina, and the ruptured secondary uterus.

PLATE 24.

All the figures drawn under Zeiss's apochromatic 2·0 mm. objective and compensation ocular 12, magnifying 1100 diameters.

Fig. 19.—Egg with unsegmented ovum. From preserved specimen.

Fig. 20.—Two-celled stage. Fresh specimen, showing the globules and concentrically laminated bodies of the vitelline mass.

Fig. 21.—Two-celled stage. Preserved specimen.

Fig. 22.—Three-celled stage.

Fig. 23.—Four-celled stage.

Fig. 24.—Stage of about eight cells.

Fig. 25.—Surface view of blastoderm of a somewhat later stage than that represented in Fig. 24.

Fig. 26.—Stage of about fourteen cells.

Fig. 27.—Surface view of disc-like blastoderm.

Figs. 28 and 29.—Disc-like stages seen edgewise.

Fig. 30.—Hexacanth embryo with the hooks retracted.

Fig. 31.—Hexacanth embryo with the hooks everted.

Fig. 32.—Egg containing hexacanth embryo. Fresh specimen.

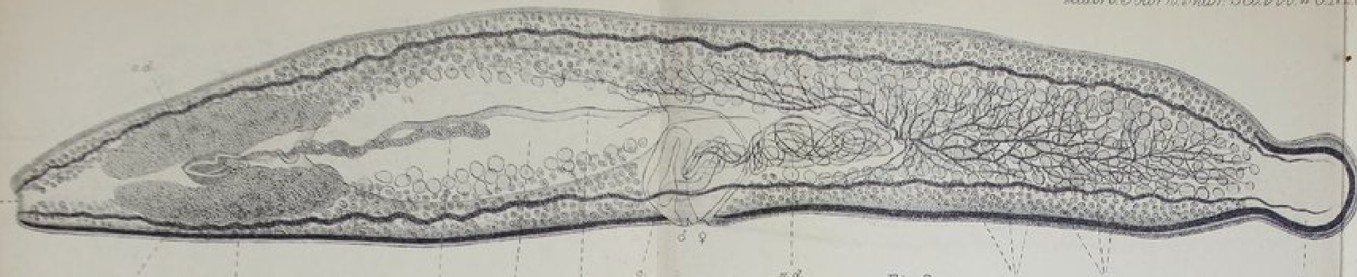

Fig. 3.

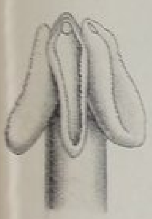

Fig. 1.

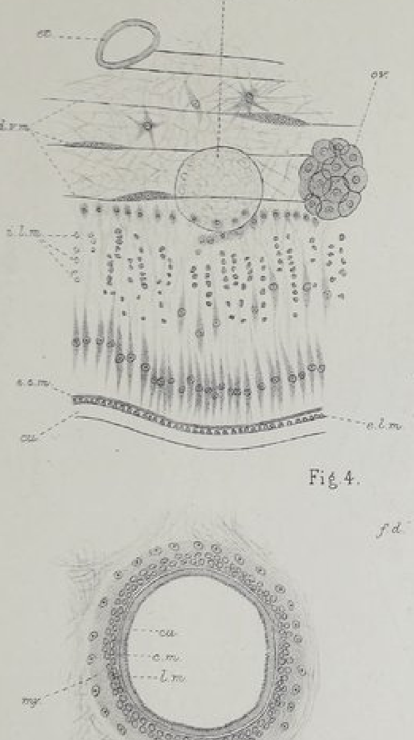

Fig. 4.

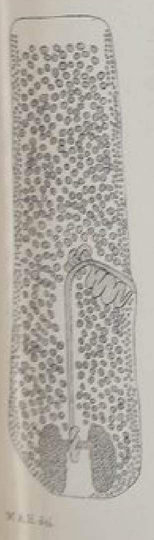

Fig. 2.

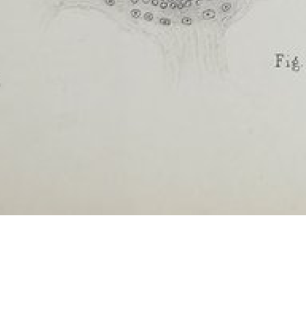

Fig. 5.

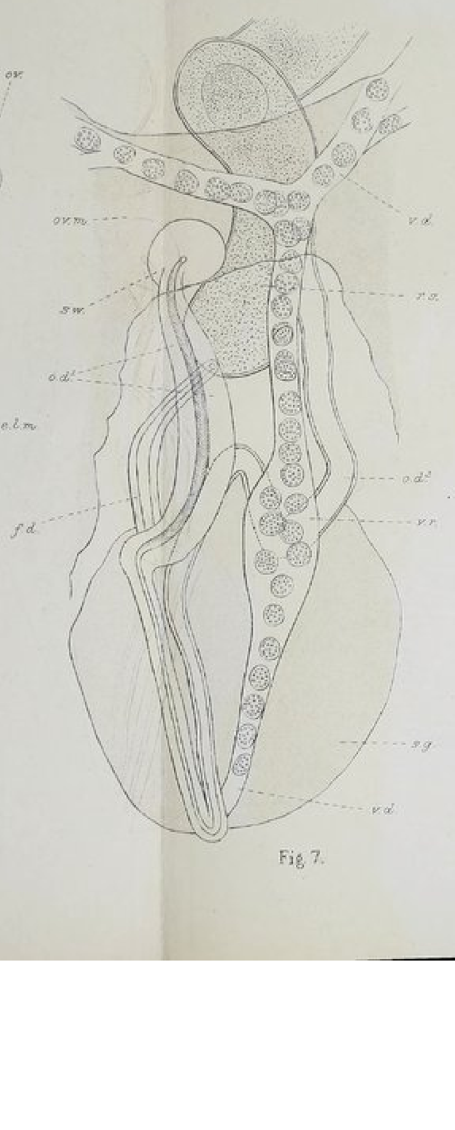

Fig. 7.

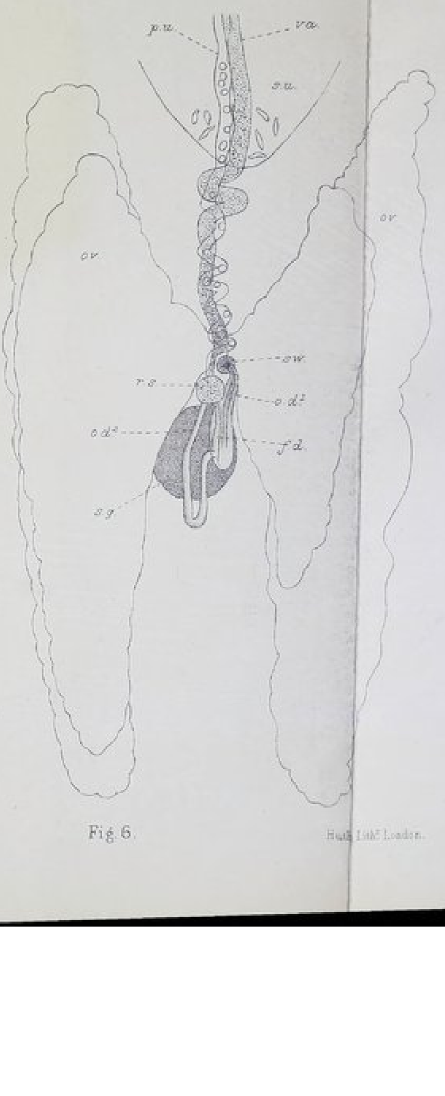

Fig. 6.

W. A. H. del.

Huth Lith.r London.

Quart. Journ. Micr. Sci. Vol. 46, N.S. Pl. 23.

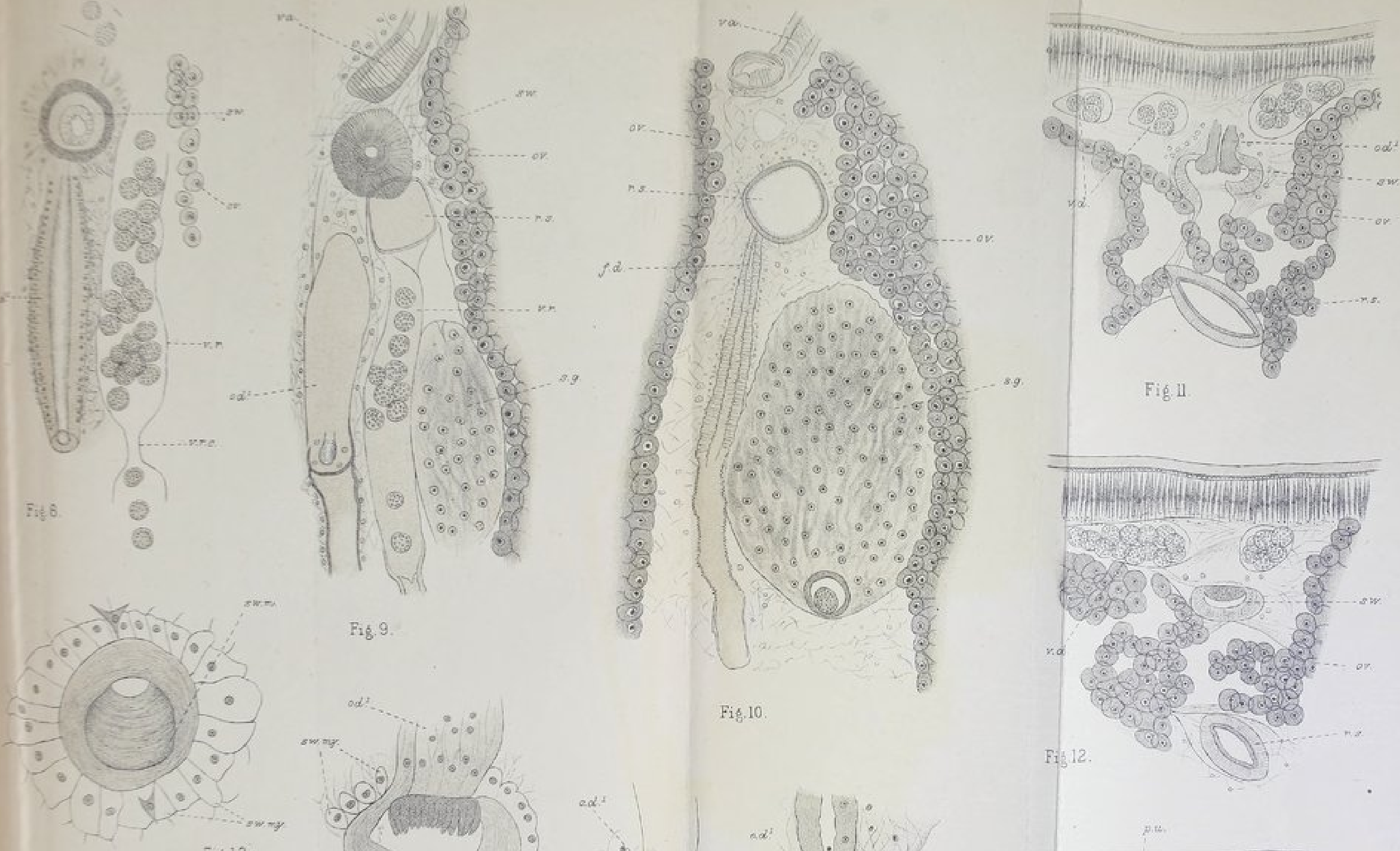


Fig. 19.

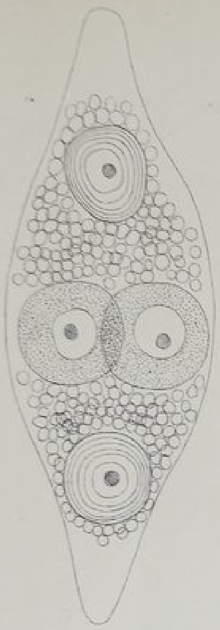
Fig. 20.

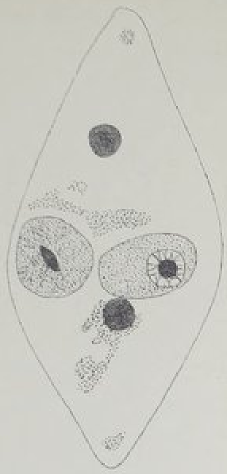
Fig. 21.

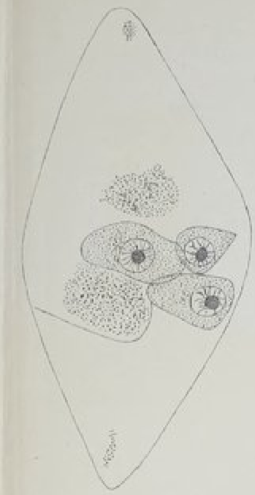
Fig. 22.

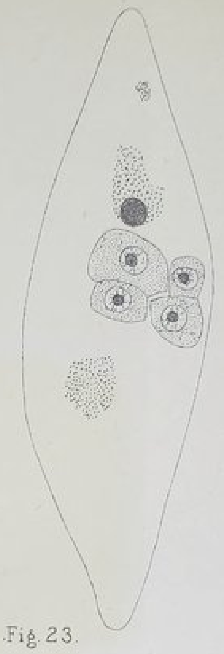
Fig. 23.

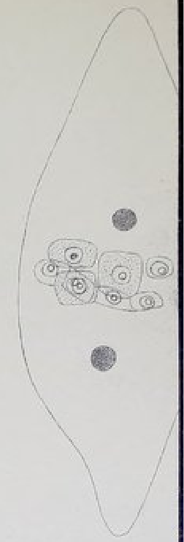
Fig. 24.

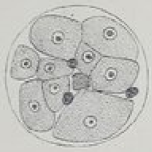
Fig. 25.

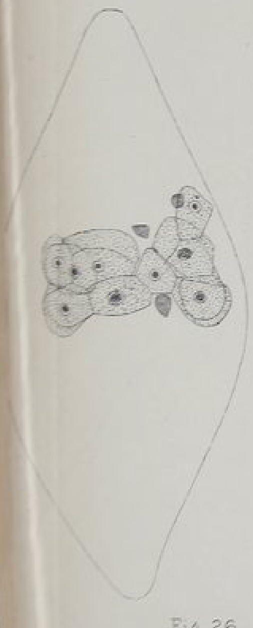
Fig. 26.

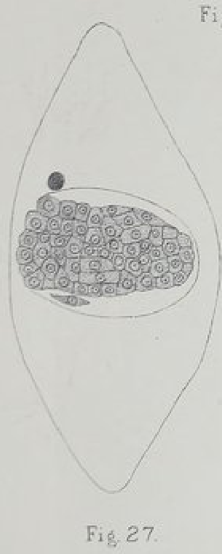
Fig. 27.


Fig. 28.

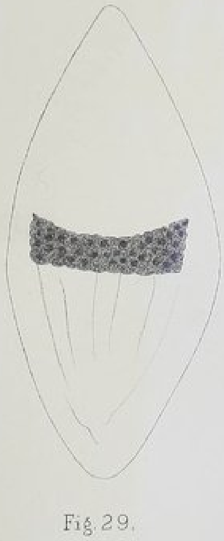
Fig. 29.


Fig. 30.

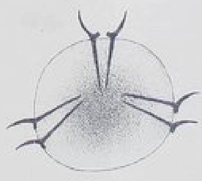
Fig. 31.

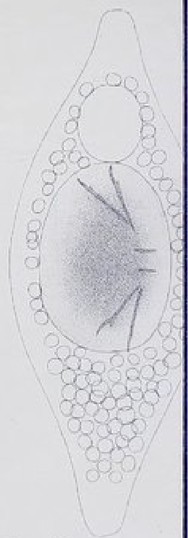
Fig. 32.

Huth, Lith.r Lon