

A CONTRIBUTION TO THE ANATOMY OF DINOBOTHRIUM, A GENUS OF SELACHIAN TAPEWORMS; WITH DESCRIPTIONS OF TWO NEW SPECIES.

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In 1889 P. J. van Beneden described an interesting cestode from the mackerel shark (*Lamna cornubica*) under the name *Dinobothrium septaria*.¹

The species has been recorded from the same host by Loennberg² and by Scott.³ Loennberg gives detailed description of the scolex and of immature proglottides. Scott publishes a brief description of the species and a photograph of a specimen collected by him.

Strobiles with adult, or ripe, proglottides were not seen by any of the above-named authorities.

I am indebted to Dr. Maurice C. Hall, of the Zoological Division of the United States Department of Agriculture, for photographic copies of Loennberg's papers.

This paper is a contribution from the laboratory of the United States Bureau of Fisheries, Woods Hole, Massachusetts, and the zoological laboratory of the University of Missouri.

On September 1, 1903, I collected some cestodes from a small man-eater shark, of which no description was published, but a record was made,⁴ as follows:

Dinobothrium septaria Beneden. Host: *Carcharodon carcharias* Linton, MS

A typographical error appears in the spelling of the generic name, which is printed "*Dinabothrium*."

During the summer of 1920 I obtained three specimens of a cestode from the bone shark, which also belong to the genus *Dinobothrium*. Although at first disposed to refer the cestodes of these two lots to the species *D. septaria*, I found difficulties of two sorts present-

¹ Bull. Acad. roy. d. Belg., vol. 17, pp. 68-74, figs. 1-3.

² Zwei Parasiten aus Walfischen und zwei aus *Lamna cornubica*. K. vet. Akad. Handl., Stockholm, vol. 24, 1898, pp. 25-28, figs. 11 and 12. Ueber einige Cestoden aus dem Museum zu Bergen, 1898, pp. 19-23, fig. 10.

³ Twenty-sixth Ann. Rep. Fisheries Board of Scotland, pt. 2, p. 84, fig. 4, 1898.

⁴ Bull. Bur. Fish. (1911), vol. 31, pt. 2, p. 586.

ing themselves. In the first place the worms of each lot differ slightly but constantly from the figures and description of *D. septaria*. In the second place, when the scoleces of the two lots were compared one with the other they were found to be unlike in many details.

The scoleces of the worms from the bone shark have long strobiles with ripe proglottides attached to them, while those from the man-eater shark are smaller and have short strobiles with only immature proglottides. Consequently one must rely very largely on the scoleces in a comparative study of the two forms.

It should be noted that we are here dealing with cestodes from selachians, which are generically different from each other, and generically different from the host of *D. septaria*. Further, the species *D. plicatum*, whose scolex appears to differ rather more from *D. septaria* than does *D. planum*, is from a host which belongs to the same family as *Lamia*, that is the Lamnidae, or mackerel sharks. On the other hand, *D. planum*, whose scolex resembles *D. septaria* rather more closely than does *D. plicatum*, is from a host which belongs to the family Cetorhinidae, or basking sharks.

The following adaptation from Beneden's description of *D. septaria* is in agreement with the forms from *Carcharodon* and *Cetorhinus* and may be taken, therefore, as characters of the genus *Dinobothrium*: Bothria four, in pairs placed back to back, without hooks, large, oval, attached the entire breadth of the base, the external face concave, and surmounted above by a projection. Above each bothrium there is a little sucker, and outside the sucker the part which supports the lobe is terminated by a short appendage.

Regarding the cestodes, which furnished the basis of this report as new species, the genus *Dinobothrium* is represented by the following species:

Dinobothrium septaria Beneden. Hosts: *Lamna cornubica*.

Dinobothrium plicatum, new species. Hosts: *Carcharodon carcharias*.

Dinobothrium planum, new species. Host: *Cetorhinus maximus*.

DINOBOOTHRIUM PLICITUM, new species.

Figures 1, 4, 5, 6.

Dinobothrium septaria BENEDEN, Linton, Bull. Bur. Fish. (1911), vol. 31, pt. 2, p. 586.

Type.—Cat. No. 7601, U.S.N.M.

The material upon which this description is based was collected from the spiral valve of a small man-eater shark, 4 feet in length, at Woods Hole, Massachusetts, September 1, 1903. The contents of the stomach consisted of fish and squid.

The following are extracts from notes made at the time of collecting:

Bothria four, in pairs corresponding in position with the flat sides of the strobile, and acting as cupping disks. The mucous membrane, upon removal of the worms, was congested, the capillaries showing plainly in four spots where the bothria had been applied. The scoleces changed shape but little when placed in killing fluid. There are small suckers at the anterior ends of the bothria unlike any that I have seen before in selachian cestodes. Strobiles evidently all immature, much contracted, with a tendency to twist and crumple, and difficult to straighten. Ten scoleces were found in the spiral valve of this shark. Associated with them were 50 or more cestodes belonging to the genus *Phyllobothrium*.

No measurements of the strobiles are given in my notes. The longest alcoholic specimen measures about 20 mm. in length.

Scolex.—Details of the structure of the scolex are shown in figure 1, the outlines of which are from a specimen mounted in balsam. A front view of the scolex is shown, and at the same time a full-face view of the bothria. Specimens in alcohol do not differ materially from the sketch, except in the more or less cup-like character of the bothria. In most cases the bothria flare widely so as to look forward, a line normal to their surface making an angle of from 30 to 45 degrees with the axis of the scolex. In all cases the bothria have thin edges and present a characteristically clean-cut appearance. The bothria are dorso-ventrally placed, that is, corresponding with the flat sides of the strobile. The anterior end of the scolex is flat, and, in dorso-ventral view, makes a straight line at right angles with the axis of the scolex. A single bothrium has the following characters: The general shape is like that of a deep scoop, becoming in some cases cup-like. The outer, or lateral, border is convex; the inner, or median, which lies close to the inner border of its mate, is straightish. At the middle of the posterior free border there is a short groove, each of the sides of which rises into a short, almost papillary, projection. The anterior end is thick at the back, where it is continuous from one bothrium to the other of the same pair, and is reflected in a double, shelf-like projection, each portion of which terminates in a pointed tip at the median border. Toward the lateral border the two shelves blend and continue in a curved fold which is bifurcate at the tip. The outer or anterior portion of the projection is thickish and forms a sucker-like depression. The inner portion of the projection is thin edged. The pointed tips appear to be rigid and almost hook-like (fig. 4). Sections of the bothria (fig. 5) show that they are made up, for the most part, of short, thick muscular fibers at right angles to the flat surfaces.

A striking feature of the bothria of this species is the furrow at the middle of the posterior border. This is not an accidental contraction character, but is present in each bothrium in each of the

scolexes of the lot, and is a conspicuous feature which imparts a characteristic accentuation to the outline of all the bothria.

Dimensions of bothria: Length, maximum 4 mm., minimum 2.5 mm.; breadth, maximum 2.5 mm., minimum 1.5 mm. Breadth of scolex in front, maximum 2.5 mm., minimum 2 mm.

Each bothrium is united with its fellow below the free median borders: each is also continuous below with the corresponding bothrium of the opposite pair.

The scolex possesses a very short neck-like portion which ends abruptly, in some cases projecting a little, at the point of junction with the strobile. A transverse section of a scolex is shown in figure 5A. Excretory vessels and a few ganglion cells appear in the parenchyma, and the characteristic musculature of the bothria is represented.

A portion of a bothrium, more highly magnified, is shown in figure 5B. The ganglion cells in the muscle tissue of the bothria are large, branching, and suggest a multipolar structure.

Loennberg⁵ notes the occurrence of such cells in *D. septaria*. He describes them as being of peculiar structure, their cytoplasm coarsely fibrous and without distinct borders. Each cell has a vesicular nucleus, which contains a very small but sharply defined nucleolus.

The ganglion cells in *D. plicatum* agree with Loennberg's description, except that the cytoplasm, instead of appearing to be coarsely fibrous, is rather reticulate; that is, it has somewhat the appearance of an ameba with anastomosing pseudopodia.

Strobile.—The segments begin immediately behind the scolex, the strobile here, and throughout, being relatively flat and thin. In the specimen, from which the sketch for figure 1 was made, the strobile near the scolex measured 1.12 mm. in breadth, and the proglottides are 0.14 mm. in length.

Figure 6 represents a transverse section made at a point where the strobile measures 1.20 mm. in breadth. The excretory vessels and the lateral nerves are shown. The musculature is rather weak, longitudinal fibers being the only ones that could be made out, and the muscular layer is not sharply marked off from the subcuticula. Indeed, under high magnification sections of fine longitudinal muscle fibers appear close to the cuticula. The smaller dorsal excretory vessel lies in a rather close spiral and is often cut in two or three places in the same section. The larger vessel also is spiral, but with looser coils than the smaller vessel.

The strobiles in this lot were all immature. The greatest breadth noted was 1.33 mm., at which point the proglottides averaged 0.25 mm. in length. The strobile appears to have a shallow furrow run-

⁵ K. vet. Akad. Handl. Stockholm, vol. 24, 1898, p. 25, fig. 12.

ning along the median region of one side. The margins are finely crenulated.

DINOBOETHRIUM PLANUM, new species.

Figures 2, 3, 7-13.

Type.—Cat. No. 7602, U.S.N.M.

On June 24, 1920, a bone shark (*Cetorhinus maximus*) was captured in the inlet at Menemsha Bight, island of Martha's Vineyard, Massachusetts. Mr. George M. Gray, of the Marine Biological Laboratory, Woods Hole, Massachusetts, examined the shark for parasites and reports that he found but one species of entozoon parasite, a cestode represented by a few specimens in the spiral valve. Three of these worms were given to me by Mr. Gray, with the information that the length of the shark was 25 feet, and that the only identifiable food which he found was the test of a large species of *Salpa*. In the stomach was "about a half a barrel of red-colored material which looked like tomato ketchup."

My note made after a preliminary examination of the material is as follows:

Lengths in alcohol, 145, 440, and 545 mm.; breadth of scolex of largest specimen, 10 mm.; thickness, 5 mm.; length, 8 mm. This specimen had been preserved in formalin, and was less contracted than the others, which had been fixed in corrosive sublimate. Strobile linear with a shallow furrow along the median line of one of the flat sides. There is a tendency to develop fine longitudinal furrows, which, with the short segments, impart a somewhat checkered appearance to the surface in many parts of the strobile. Breadth immediately behind the scolex, 2 mm.; at posterior end and maximum, 4 mm. The proglottides begin immediately behind the scolex where their length is about 0.4 mm. They remain relatively short throughout the length of the strobile. A piece of strobile from the posterior end, and 15 mm. in length, is made up of 21 proglottides, which are filled with eggs. These proglottides are 4 mm. in breadth and 0.7 mm. in length. The proglottides are distinct throughout, with more or less convex outlines on the margins: genital apertures irregularly alternate and at about the middle or a little anterior to the middle of the length of a proglottis.

Mr. Gray has recently sent me the following additional data:

He has eight specimens with scoleces and one without. Their lengths in millimeters are: 81, 227, 262, 387, 487, 687, and 825, respectively. These were the only internal parasites found. A number of parasitic copepods were obtained.

The shark is being mounted for the Boston Society of Natural History.

Scolex.—Details of structure are shown in figures 2 and 3. The bothria are large and flat, and have thick, entire margins. The anterior edge is not reflected, and is even but slightly projecting. The median margins of a pair fuse together near the anterior ends. In front view the suckers are prominent, the anterior shelf-like projection being represented only by the thickened semicircular border of a sucker. There is lacking the groove at the posterior edge of the bothria and the pseudo-hooklets at the angles. In one of the specimens the outline of the anterior end is elevated in the middle on account of raised median angles of the bothria. This seems to be a contraction character, as in the other two specimens the front ends are flat and practically at right angles to the axis of the scolex.

The breadth of each of the three scoleces in front is 6.5 mm., and the thickness of each is 4 mm. In one the breadth of a bothrium is 3 mm. and the length 7 mm.; in another the breadth is 4 mm. and the length 7 mm.; in the third the breadth is 5 mm. and the length 9 mm. In each of these three scoleces the bothria are nearly parallel with the axis of the scolex, and all are rather shallow and plate-like. This is in contrast with the prevailing cup-like character and widely flaring position of the bothria in *D. plicatum*.

Strobile.—The superficial characters of the strobile have already been described. The most outstanding features are the relative shortness of the proglottides, the linear habit of the strobile, and the development of longitudinal furrows, the most conspicuous being a median furrow on one of the flat surfaces (ventral), especially noticeable in the anterior region. Transverse sections made through unripe sections show a striking waist-like constriction at about the middle, indicating a median furrow on both the dorsal and ventral sides. The shortness of the proglottides as compared with the breadth persist even to ripe ones filled with eggs, which are still only from one-tenth to one-sixth as long as they are broad. This is in marked contrast with Beneden's figure of *D. septaria*, in which the proglottides are represented as becoming squarish, and even longer than broad, toward the end of the strobile.

Anatomy of proglottis.—The different layers of the wall are not sharply marked off from each other. The cuticle in adult segments is thin. The limits between the subcuticula and the layer of longitudinal muscle fibers is not clearly defined, but in a series of sections stained in indigo-carmin, in which the muscles came out a bright blue, and the granular bodies in the subcuticula appeared as red dots on a pale blue field, the two layers were fairly well differentiated. It was noticed that the subcuticula at one region of the sections contained numerous relatively large glandular bodies which lay immediately under the cuticula (figs. 8 and 10 *seg.*). An examination of series of sections, both transverse and sagittal, revealed the interest-

ing fact that this localization of subcuticular glands is limited to the posterior half, or two-thirds, of the right side of the ventral surface of the proglottides. The fibers of the longitudinal muscles are fine and arranged in fascicles.

In a section of a mature proglottis, at a point where the thickness was 0.44 mm., the thickness of the subcuticula was 0.08 mm., and that of the layer of longitudinal muscle fibers 0.06. It should be said in this connection, however, that there is considerable variation in the ratios even of measurements made at different points on the same section.

No layer of circular muscles could be distinguished in any of the sections, so that all the space within the layer of longitudinal muscles is occupied by parenchyma in the immature segments, by the reproductive organs in mature, and by remnants of reproductive organs and eggs in ripe proglottides.

The ventral excretory vessels are relatively large as seen in section, the dorsal are more variable on account of their more tortuous course.

Male reproductive organs.—The cirrus lies beside the vagina, in some cases a little below the level of the vagina, in others a little above. It is rather short, was not seen everted, is armed with straight, slender spines, measuring about 0.015 mm. in length. The cirrus-pouch is cylindrical, and its walls are rather thin. The vas deferens is voluminous, some of its folds lying beside the inner end of the cirrus-pouch, and extending to the median region of the proglottis. The testes are distributed on the dorsal side of the proglottis, from near the margins, and fill more than half of the parenchymatous space on either side of the medianly placed germarium. The voluminous folds of the vas deferens and those of the vagina and seminal receptacle lie close together towards the median portion of the proglottis.

Female reproductive organs.—The vagina lies beside the cirrus-pouch, and opens at the common genital pore, which is situated at about the middle, or a little in front of the middle, of the lateral margin of the proglottis. It lies, in the main, parallel with the cirrus-pouch, both being about at right angles to the margin of the proglottis. In some cases it is a little above the level of the middle of the cirrus-pouch, in others a little below that level. The walls of the vagina are thick and glandular. It is somewhat tortuous for a short distance in the neighborhood of the inner end of the cirrus-pouch, and again, as it approaches the median line, it is thrown into numerous capacious folds which constitute the seminal receptacle. At about the median line it turns abruptly towards the posterior, narrows to a slender tube, and enters the germ duct at a short distance back of the bulbous, thick-walled structure which marks the

beginning of that duct. The short germ duct is joined by the vitelline ducts as it enters the shell gland. It then turns in its course, so that, as the oviduct, it leaves the shell gland, it is near the point where the germ duct has its beginning. These structures form a compact mass and the sections through them are not easy to interpret.

The germarium occupies a little less than the middle third of the posterior portion of a mature proglottis in which but few eggs have accumulated in the uterus. Its antero-posterior diameter is equal to about two-thirds the length of the proglottis. At either side of the median line it fills all the space in a dorso-ventral direction within the layer of longitudinal muscles.

The shell-gland is situated on the median line near the posterior end of the proglottis, and is surrounded by the germarium. It is a compact gland made up of large, oval, or pyriform cells, deeply staining in haematoxylin. The diameter of the cells of the germarium was found to be 0.006 mm., while the cells of the shell-gland were 0.009 and 0.015 mm., in the two principal diameters.

The uterus in immature proglottides is represented by an elongated mass of cells lying on the ventral side along the median line (fig. 11). It comes to occupy more and more space as the proglottides mature, and in ripe proglottides practically all of the interior is filled with eggs. The eggs are very small and nearly circular in outline. They measure from 0.012 to 0.015 mm. in diameter.

The vitellaria are distributed along the ventral side of the proglottis next within the longitudinal muscle layer. In haematoxylin-stained sections they are not differentiated from the testes and germarium, but can be distinguished readily from the former by the smaller follicles, and from the latter by the irregular outlines of the cells, and, in mature proglottides, by the fragmented condition of many of the cells. In a section of a proglottis, in which eggs were beginning to appear, the diameter of the vitelline follicles was about 0.03 mm. while the diameter of the testicular follicles was 0.10 mm. In sections stained with indigo-carmin the vitellaria are well differentiated. Transverse sections show that the vitellaria take up much less of the thickness of the proglottis than do the testes, while their distribution laterally is about the same.

EXPLANATION OF PLATES.

The following letters have the same significance in all the figures :

<i>c</i> , cuticle.	<i>sc</i> , subcuticula.
<i>cp</i> , cirrus pouch.	<i>scg</i> , subcuticular glands.
<i>ev</i> , excretory vessel.	<i>sd</i> , sperm duct.
<i>evd</i> , dorsal excretory vessel.	<i>sg</i> , shell-gland.
<i>evv</i> , ventral excretory vessel.	<i>sr</i> , seminal receptacle.
<i>ga</i> , genital aperture.	<i>t</i> , testes.
<i>gc</i> , ganglion cells.	<i>u</i> , uterus.
<i>gd</i> , germ duct.	<i>v</i> , vagina.
<i>lm</i> , longitudinal muscles.	<i>vd</i> , vas deferens.
<i>n</i> , nerve.	<i>vg</i> , vitellaria.
<i>o</i> , ovary (germarium).	<i>yd</i> , vitelline duct.
<i>ov</i> , oviduct.	

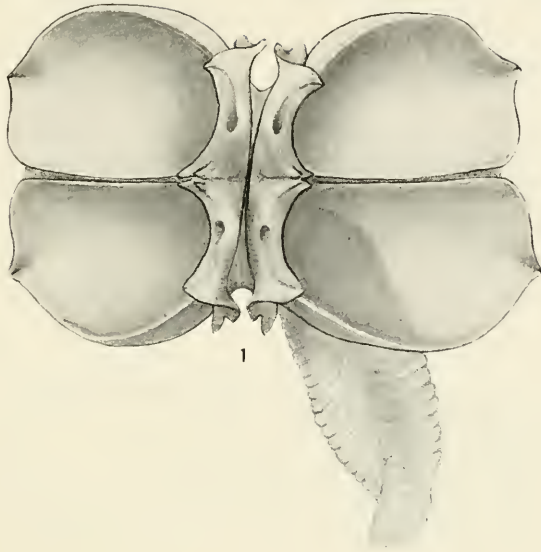
I am indebted to Mr. George T. Kline, biological artist, University of Missouri, for the sketches which accompany this paper.

PLATE 1.

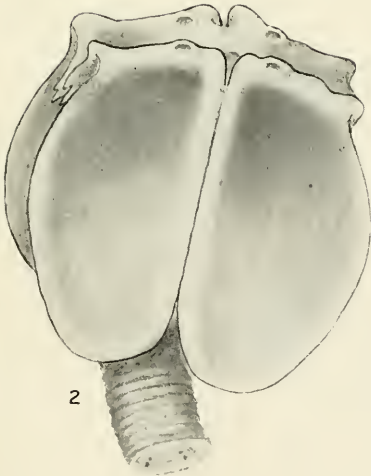
FIG. 1. Scolex of *Dinobothrium plicatum*, from *Carcharodon carcharias*. Front view; outline from specimen mounted in balsam; details added from alcoholic specimens. Breadth of scolex in front 2.5 mm.

FIG. 2. *Dinobothrium planum*, from *Cetorhinus maximus*. Front view of scolex. Length of bothrium 7 mm.

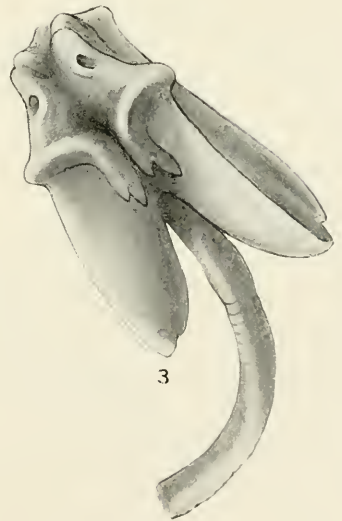
FIG. 3. Scolex of *Dinobothrium planum*. Marginal view. Length of bothrium 7 mm.



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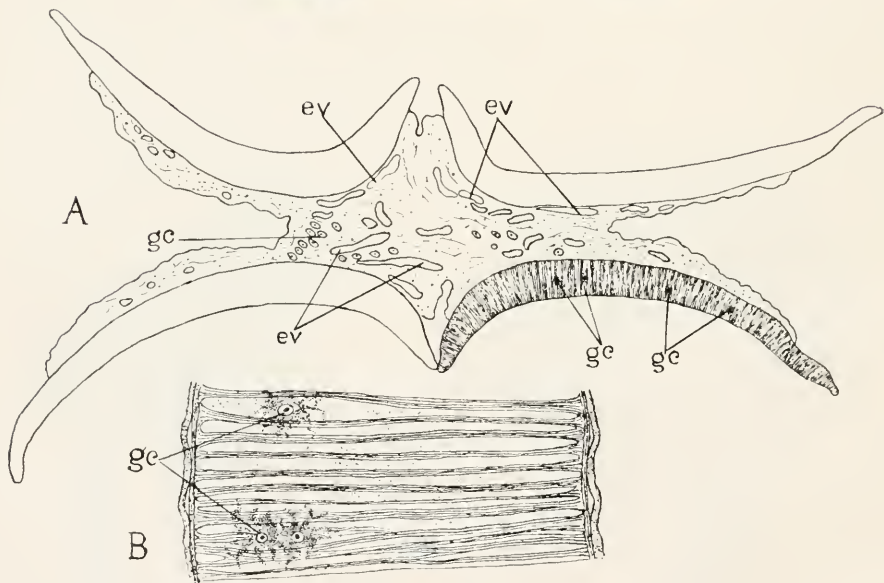
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SCOLECES OF *DINOBOOTHRIUM PLICITUM* AND *D. PLANUM*

FOR EXPLANATION OF PLATE SEE PAGE 10.



DINOBOTHRUM PLICITUM FROM *CARCHARODON CARCHARIAS*

FOR EXPLANATION OF PLATE SEE PAGE 11.

PLATE 2.

FIG. 4. *Dinobothrium plicatum*. Anterior end of a bothrium, in balsam; breadth, 1.25 mm.; *as*, anterior shelf-like projection; *bf*, lateral appendage; *ps*, posterior shelf-like projection; *s*, auxiliary sucker.

FIG. 5. *Dinobothrium plicatum*.

A. Transverse section of scolex. Shorter diameter, 1.20 mm.

B. Transverse section of bothrium, more highly magnified, showing ganglion cells. Thickness of bothrium, 0.18 mm.

For explanation of lettering see p. 9.

FIG. 6. *Dinobothrium plicatum*. Transverse section of proglottis near scolex. Longer diameter, 1.20 mm. For explanation of lettering, see p. 9.

PLATE 3.

FIG. 7. *Dinobothrium planum*.

A. Portion of strobile with ripe proglottides. Breadth, 4 mm. For explanation of lettering see p. 9.

B. Eggs. Diameters, 0.012 to 0.015 mm.

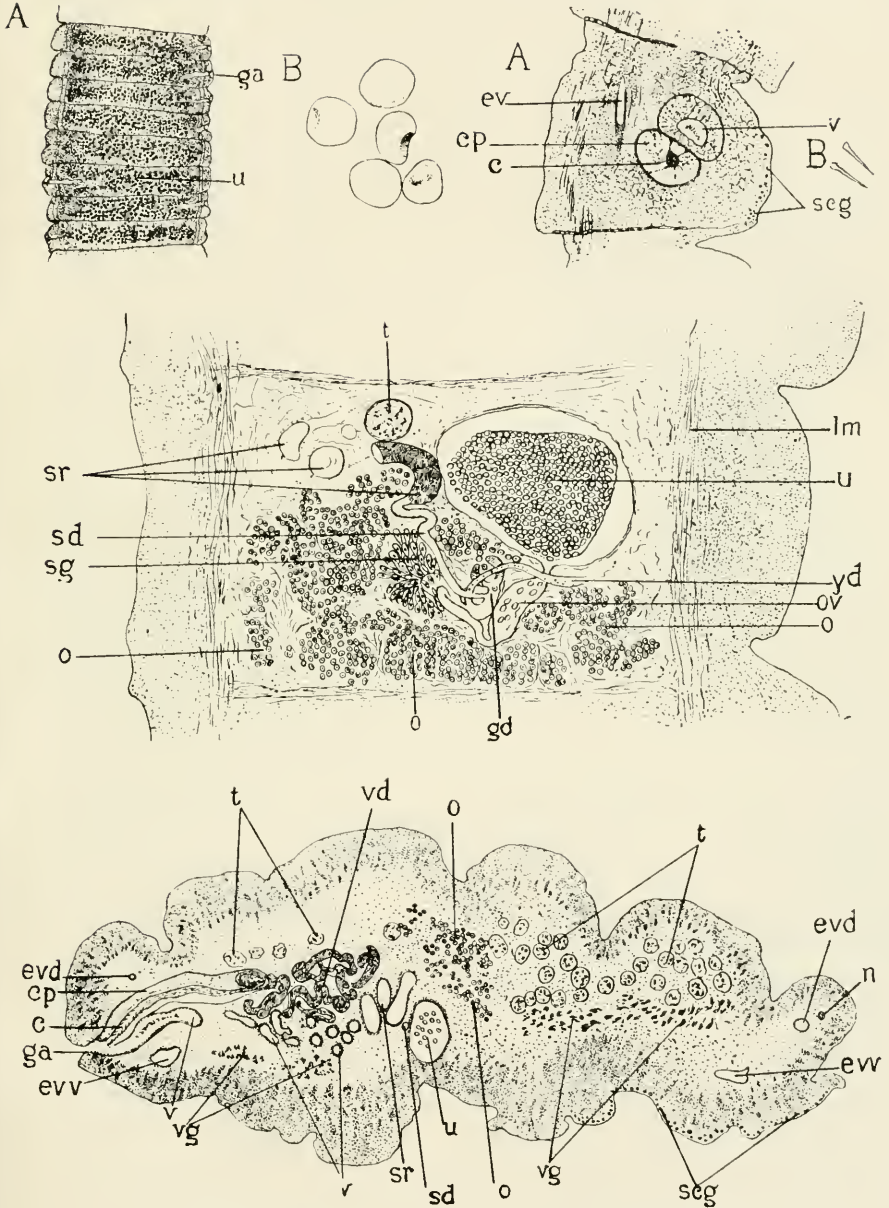
FIG. 8. *Dinobothrium planum*.

A. Sagittal section near lateral margin of proglottis. Length of proglottis, 0.4 mm. For explanation of lettering see p. 9.

B. Spines from cirrus. Length, 0.015 mm.

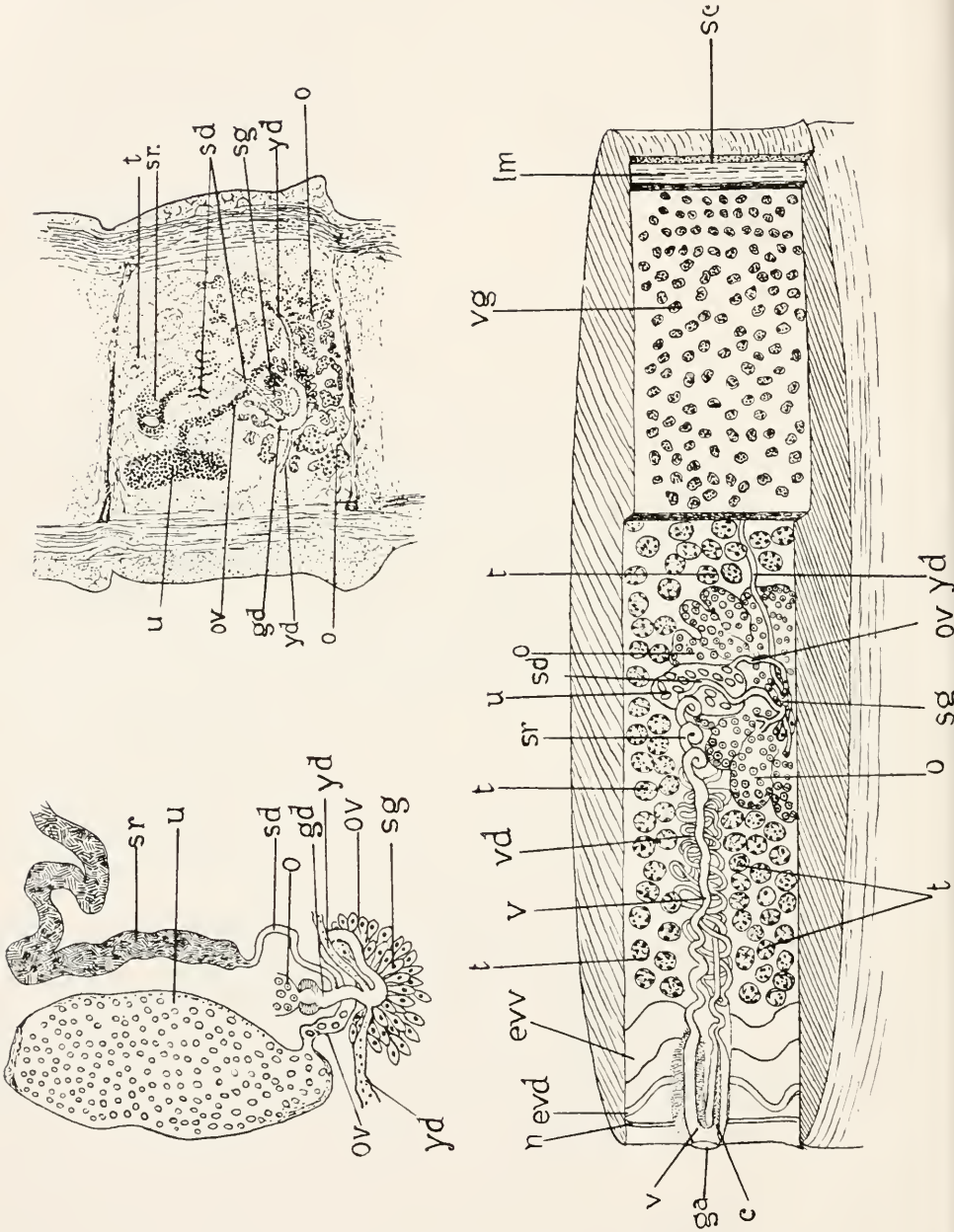
FIG. 9. *Dinobothrium planum*. Median sagittal section of proglottis, partly diagrammatic, more than one section having been used in representing the anatomy in the region of the shell gland. Length of proglottis, 0.4 mm. For explanation of lettering see p. 9.

FIG. 10. *Dinobothrium planum*. Transverse section of mature proglottis, partly diagrammatic, about three sections having been used in representing the vagina and cirrus. Length of longer diameter of section, 3 mm. For explanation of lettering see p. 9.



DINOBOTHRIMUM PLANUM FROM CETORHINUS MAXIMUS

FOR EXPLANATION OF PLATE SEE PAGE 12.



DINOBOTHRUM PLANUM FROM CETORHINUS MAXIMUS

FOR EXPLANATION OF PLATE SEE PAGE 13.

PLATE 4.

- FIG. 11. *Dinobothrium planum*. Median sagittal section of immature proglottis, partly diagrammatic, more than one section having been used in representing the anatomy in the region of the shell gland. Length of proglottis, 0.4 mm. For explanation of lettering see p. 9.
- FIG. 12. *Dinobothrium planum*. Diagram of part of female reproductive organs. For explanation of lettering see p. 9.
- FIG. 13. *Dinobothrium planum*. Stereogram of mature proglottis, view from ventral side. For explanation of lettering see p. 9.