

SOME CESTODES FROM JAPANESE SELACHIANS.

INCLUDING FIVE NEW SPECIES.

BY PROF. SADAŌ YOSHIDA.

(Pathological Department of Osaka Medical Academy.)

(With Plate XXIII and 4 Text-figs.)

CONTENTS.

	PAGE
<i>Phyllobothrium lactuca</i> van Beneden 1850	560
<i>Crossobothrium angustum</i> (Linton 1889)	563
<i>Orygmatobothrium velamentum</i> n.sp.	566
<i>Acanthobothrium coronatum</i> (Rud., 1819) van Beneden 1849	571
„ <i>ijimai</i> n.sp.	573
<i>Calliobothrium eschrechtii</i> (van Beneden 1849)	575
„ <i>verticillatum</i> (Rud., 1819) van Beneden 1850	576
„ <i>convolutum</i> n.sp.	578
„ <i>nodosum</i> n.sp.	585
<i>Rhynchobothrium laciniatum</i> n.sp.	588

SEVERAL years ago I collected cestodes parasitic in Selachians found in Japanese waters. Most of them were mature and well preserved. The specimens are referable to ten species, of which five belong to known species and five are new to science. Since the published descriptions of the known species are not entirely in accord with my observations, and some of the species are not satisfactorily described anatomically, I shall re-describe the known forms briefly in the following pages.

1. ***Phyllobothrium lactuca*** van Beneden, 1850.

Numerous specimens were obtained 10. v. 1911, from the spiral valve of *Cynias manazo* (Bleeker) caught near Hiroshima. They were found associated with some other cestodes, one of which I describe as a new species.

EXTERNAL CHARACTER. Length 60—80 mm. Head subglobular,

2—3 × 2.5—4 mm. Bothridial border strongly folded appearing like a cauliflower. The head agrees well both in size and in shape with the figure given by van Beneden (1850). Neck tolerably long, broadening posteriorly; 10—20 × 0.5—1.1 mm.; the surface bears numerous transverse wrinkles which give rise to an appearance of segmentation.

Strobila short, thick, oval in cross section. The breadth of segments increases gradually towards the posterior end, reaching a maximum near the posterior extremity where it measures 2.7—5.0 mm.; thence it gradually tapers caudally. The length of the segments also gradually increases posteriorly, reaching a maximum in the last segment which is 0.8—1.5 mm. long. The dimensions of various parts of body are as follows (in mm.):

	Head	Neck	First segment	Middle segment	Maximum segment	Last segment	Total
Length	2—3	10—20	very short	0.3—0.5	0.3—0.5	0.8—1.5	60—80
Breadth	2.5—4.0	0.5—1.1	1.5—2.0	2.7—4.5	2.7—5.0	1.5—2.0	

The worm is very thick, especially in mature segments in which the uterus is distended by eggs. The posterior third or fourth of the strobila is atrophied, as the result of the discharge of ova. A series of ruptures, for the discharging of ova, take place in the median ventral line of mature segments. In some specimens the openings enlarge and become continuous with those of the adjacent segments thus forming a shallow groove on the ventral median line. This is the most remarkable external feature of my specimens.

Genital pores lateral, situated in the middle of the segment. Cirrus and distal part of cirrus pouch are often protruded from the genital opening; this is readily seen by the naked eye.

GENITAL ORGANS. Testes oval or spherical in shape, scattered throughout the medullary field excepting the posterior portion where the female organs are situated. Cirrus pouch thin-walled, elongate pyriform in shape, proximally nearly attaining the middle of the segment; opens into the bottom of the distended genital cloaca which is lined with the ciliated cuticular layer. Distal end of pouch sometimes evaginated. Cirrus unarmed, long and slender.

Vas deferens coiled in the cirrus-pouch; its wall very thick, with inner circular and outer longitudinal muscle bundles, and lined with a ciliated cuticular layer, as in the genital cloaca. *Vas deferens* on leaving the cirrus pouch is thin-walled and strongly coiled. In sections of mature segments the loops of the *vas deferens* are often pushed out when the eggs are discharged through rupture of the segment.

Vagina: opens into the bottom of the genital cloaca antero-ventrally to the cirrus opening and runs straight in along the cirrus pouch, passing ventrally to both the lateral nerve cord and dorsal canal of the excretory system; its inner end reaches the median line of the segment and becomes continuous with the oviduct. The vaginal wall thick, with structure similar to vas deferens.

Ovary: consists of four lobes, lying at the dorsal and ventral margins of both halves of the medullary field, being united medially by narrow processes, forming an isthmus. The oviduct arises in the middle of the isthmus, runs ventrally, then posteriorly in a slightly winding course to unite with the inner end of vagina. The united canal runs dorsally to meet the shell gland, which is situated postero-dorsally to the isthmus.

Uterus: lies ventrally and longitudinally in the median line; in gravid segments it occupies a large portion of the medullary field. The connection of uterus and shell gland is not well seen in my sections probably owing to faulty preservation.

Yolk gland: strongly developed, situated in both the lateral extremities of the medullary field. It lies at the margin of the medullary field, and extends into it, occupying the space between the lateral nerve and the region occupied by the excretory canals. Each lateral end of the ovarian lobe comes into contact with the inner end of the yolk gland.

Musculature: the longitudinal muscles are well developed; they occupy nearly all the cortical field; the muscular bundles are numerous and arranged radially.

AFFINITIES. I am inclined to identify this worm with *Phyllobothrium lactuca* van Beneden, although there are some slight differences between my description and that of the author of the species. The chief differences are (1) the smallness of the strobila, and (2) the shortness of the gravid segments. *P. lactuca* is stated to measure 150—350 mm. or more in length and 2—5 mm. in breadth; it is much larger than my specimens, whose segments are always broader than long throughout the whole length of the body. But the last segments of *P. lactuca* are said to be longer than broad. Van Beneden described and figured a very long segment which is $12-15 \times 4-5$ mm. My specimens are shorter than this in total length (including the last gravid segments), but these differences may be due to post-mortem changes. These slight differences, I think, do not suffice to separate my form from *P. lactuca*.

Specimens resembling the above were collected 29. v. 1907, from *Cynias manazo* in Tokyo. Though much narrower they were nearly as long as specimens obtained in Hiroshima; the head is smaller, the border of the bothridia thinner and more loosely folded; the strobila is smooth, without rupture or groove.

2. ***Crossobothrium angustum*** (Linton, 1889).

(Plate XXIII, figs. 1—5.)

Syn. *Orymatobothrium angustum* Linton, 1889.

The material at my disposal was collected by Mr T. Tsuchida from the spiral valve of *Triakis scyllium* Müller and Henle, at Misaki 11. viii. 1906. The characters of this worm agree well in most respects with those of Linton's species and it is reasonable to suppose that they are identical. Linton's statements, made on the several occasions, are based chiefly upon the external characters and not on the internal structures. Therefore, my description which follows is more complete as it includes also a consideration of the internal structures.

EXTERNAL FEATURES. The worm measures 10—30 mm. in length; most specimens attain a length of 25—30 mm. In large specimens the widest posterior segment measures 1.1 mm. in breadth, whilst the narrowest portion at the neck measures 0.1 mm. in breadth. The head (Pl. VII, fig. 1) is generally pyramidal in shape and the size varies slightly according to the state of contraction of the bothridia, being on an average 0.6 mm. \times 0.6 mm. at the posterior widest portion. There are four bothridia, unarmed and elongated oval in shape when at rest; anteriorly narrowed, somewhat roundly pointed, surmounted at the apex by a supplemental disk or accessory sucker (axiliary acetabulum); posteriorly rounded, broader than anteriorly, and flaring away from the neck so as to turn its surface outward. The margin of the bothridium is entire and is more or less thickened. The bothridium is 0.57—0.6 mm. long and 0.3—0.35 mm. broad at the widest part near the posterior extremity. Linton observed in living, actively moving specimens, that the anterior end of the bothridia "frequently elongated and curve outward and back in horn-like prolongation. An opposite movement is that in which the anterior ends of bothridia are closely oppressed and the broadly rounded posterior end are curved outward and forward." Unfortunately I have not had any opportunity to observe living specimens, and in my alcoholic specimens I do not find the prolongation of the anterior ends of bothridia. The

neck (Pl. XXIII, fig. 1) is narrow and long, measuring 0.5×0.17 mm. anteriorly where narrowest; it is marked with closely set transverse rings, giving its edge a serrated outline.

The strobila is tenuous in the anterior part of body and gradually widens posteriorly, reaching its maximum breadth (about 1.1 mm.) at the posterior end (Pl. XXIII, figs. 2 and 3). The segments rapidly increase in length toward the caudal end, the anterior segment measures 0.12×0.12 mm.; the ripe posterior segment attains a length of 3–4 mm., being three or four times longer than broad. The worm's surface is marked by closely set, transverse, slightly notched rings which give its margin a serrated appearance. This appearance, as noticed by Linton, can readily be seen with a low power, and constitutes a good specific character. The genital apertures are situated irregularly and alternately, opening at about the middle of the anterior half of the segment.

Musculature: there are two sets of longitudinal and transverse musculatures, situated as in other cestodes; both sets are weakly developed.

MALE ORGANS. The testes (Pl. XXIII, figs. 4 and 5, *H*) occupy the anterior two-thirds or three-fourths of the medullary field, they are oval in shape, measuring about $0.09\text{--}0.15 \times 0.05\text{--}0.055$ mm. Anteriorly in each segment, the testes spread all through the medullary field, but towards the middle and the posterior segments they are displaced dorsally by the female organs. The cirrus pouch (Pl. XXIII, figs. 4 and 5, *B*) opening into the common genital cloaca, is situated at right angles to body margin; it is oblong in shape, and measures $0.36\text{--}0.43 \times 0.17\text{--}0.25$ mm.; in mature segments the pouch is usually distended by the seminal vesicle enormously enlarged with the spermatozoa, and assumes an unusual form; the pouch wall is very thin and surrounded by a single cell-layer.

The vas deferens (Pl. XXIII, figs. 4 and 6, *L*) in the cirrus pouch is strongly convoluted. In young segments it is of uniform structure throughout its whole length, its wall being surrounded by a layer of cells with distinct nuclei and its diameter being nearly uniform (0.03 mm.) excepting distally, where it enlarges to form the pyriform duct ($0.07\text{--}0.10 \times 0.045\text{--}0.05$ mm.). In mature segments the vas deferens in the cirrus pouch exhibits two easily distinguished parts; (a) the distal part which is thick-walled, lined with minute retrograde spinose projections and surrounded by a thick layer of cells; (b) the proximal part which is thin-walled, its lumen being enormously distended with

the spermatozoa for it functions as a seminal vesicle. On leaving the cirrus pouch the vas deferens is coiled many times basally to the pouch; its further course to the testes has not been traced in my preparations; the vas deferens is surrounded throughout by a cell-layer.

FEMALE ORGANS. The essential parts are situated posteriorly in the segment. The vagina (Pl. XXIII, fig. 5, *V*) beginning at the common genital cloaca, runs towards the median line along the anterior edge of the cirrus pouch, then bending nearly at right angles it runs back to in front of the shell gland where it enlarges and assumes an irregular shape. The narrow proximal part of vagina passes by the shell gland posteriorly and turns again anteriorly to open into the shell gland. Where it bends, it unites with the oviduct. The vaginal wall is of uniform thickness, and is surrounded by a cell-layer with distinct nuclei; its structure is best seen in sections. It is nearly uniform in diameter (about 0.02 mm.) throughout its length, but for the dilated portion lying anterior to the shell gland; the dilated portion may serve as a receptaculum seminis.

The shell gland (Pl. XXIII, fig. 5, *sd*) is spherical, with margins irregularly lobed, and measuring 0.064 mm. It is situated in the median part of the posterior region. Anteriorly, its canal runs forward along the vagina to near the middle of the segment and opens into the uterus, which lies longitudinally in the median field. The canal measures about 0.009 mm. in width and is surrounded by thick masses of cells.

The uterus (Pl. XXIII, fig. 5, *U*), in young segments, appears as a mere longitudinal cell rod, containing a canal which gradually grows larger toward the posterior segments. In the mature segments the uterus is much distended with the ova, and ultimately it completely fills the available space in the segment.

Running forward from the side of the shell gland is the yolk duct (Pl. XXIII, fig. 5, *G*) which forks anteriorly to form two canals running laterally to the yolk glands on both sides of the segment. The yolk glands are situated in the lateral areas, extending dorso-ventrally inside the transverse muscle bundles, which separate the medullary field from the cortical; they occupy the anterior two-thirds or three-fourths of the segment; their arrangement is best seen in sections (Pl. XXIII, fig. 4, *D*).

The ovary (Pl. XXIII, fig. 4, *K*) is situated posteriorly in the segment, its antero-lateral margins being continuous with the posterior end of yolk glands; it is arranged in four groups or laminae, two on each side. The lateral groups are placed on the dorsal and ventral side of medullary

field respectively and the inner ends are continuous with one another before the shell gland, forming a small isthmus. In cross sections through the level of an isthmus, the arrangement of ovarian laminae resembles an H, with the four limbs thickened, the horizontal part being very short or entirely obliterated. Each lamina, moreover, is indented superficially and irregularly into a number of rounded lobes.

The oviduct arises at the middle part of the isthmus, where it forms the "egg-swallowing apparatus"¹ of German authors; thence it runs backward along the vagina to unite with it at some distance from the shell gland. The common duct leads forward into the shell gland. The structure of the oviduct is similar to that of the vagina.

It is not an easy task to find the complicated connections of various parts of the female organs. They are diagrammatically shown in Pl. XXIII, fig. 5.

3. *Orymatobothrium velamentum* n.sp.

(Pl. XXIII, figs. 6—11.)

The material was obtained from the spiral valve of *Cynias manazo* (Bleeker) on 10. v. 1911, in Hiroshima. The specimens were numerous and associated with other Cestodes such as *P. lactuca* (already referred to). Most of them are fully grown and mature, but I have not found gravid segments in any specimens.

EXTERNAL CHARACTERS. The mature form measures 30—40 mm., besides which there are some smaller young-stage specimens. The head (Pl. XXIII, fig. 6) is provided with four cup-like bothridia, disposed crosswise and provided either with very short peduncles or nearly sessile. The bothridia are directed forward and slightly outward, their anterior subcircular surfaces being nearly at right angles to the long axis of the head; each bothridium bears two small accessory suckers of nearly the same diameter, one at the anterior angle, the other central; the anterior sucker is more easily visible than the central one, but by the contraction of the anterior portion of the bothridium, it is often hard to detect; the central sucker is weakly developed and at times difficult to see. This obliteration of the accessory suckers is frequent, and when I first studied the Cestode I falsely concluded that they were absent and that I was dealing with a member of the genus *Anthobothrium*, but the subsequent examination of many good specimens revealed my error. The border of the central accessory

¹ Hereafter called "egg-swallower."

sucker protrudes slightly from the bottom of the bothridium, whose border, in turn, is thickened, entire, and not folded. The bothridium contour is only broken at the anterior sucker, and its thickened margin is surrounded by a second thin membranous fold or velum, which constitutes a noteworthy character peculiar to this species. The head measures 1.6 mm. and each bothridium 0.5—0.6 mm. in diameter.

The strobila is slender and delicate in the anterior third or fourth; it is widest and nearly uniform in breadth at about the middle third and gradually narrows in the last third of its length; anteriorly it is wrinkled irregularly (Pl. XXIII, fig. 6). In some wrinkles—they show irregularity in structure—the posterior border is entire while in others it is slightly lobed. Over about a third of the anterior portion of the body length, the wrinkles gradually grow farther apart (0.07—0.08 mm.), but they soon diminish in length. Over about two-thirds or three-fourths of the body length there are slight cuticular wrinkles, which give a serrated, pseudo-segmented, appearance to the margin.

The slender neck gradually broadens posteriorly; it measures 0.03—0.36 mm. anteriorly and 0.7—0.8 mm. posteriorly.

Anteriorly the segmentation is not visible externally but it is indicated internally by the cell masses of the genital Anlagen. Segmentation begins at a distance of 8—10 mm. from the head. The segments which follow rapidly increase in width, attaining a maximum breadth of 1.1 mm. at a point two-fifths or one-third along the body length. These broadest segments succeed each other for some distance after which the segments gradually taper toward the posterior end (Pl. XXIII, figs. 7 and 8). The length of segments increases toward the posterior end of body, hence they vary in form from the wide rectangles in front to squares in the middle of the body and elongated segments behind. The anterior segments measure 0.2×0.8 — 0.9 mm., the widest 0.8×1.1 mm., whilst the posterior segments are 1.5—2.5 mm. in length and oval in cross-section (Pl. XXIII, figs. 8 and 9).

I possess many other specimens than those above described which are slightly thicker and have shorter necks and posterior segments.

The genital openings are irregularly alternate, lateral, situated a little anterior to the middle or at the anterior third of the segment. The genital organs are only fully developed in a few of the posterior segments, but even here the eggs are not massed in the uterus.

MALE ORGANS. The testes (Pl. XXIII, figs. 8, 9 and 11, *H*) fill the space between the other genital organs in the medullary field; they are absent posteriorly in the segment, which is mainly occupied by the

female organs; each testis is oval in shape, measuring $0.06-0.07 \times 0.04-0.05$ mm.

The vas deferens (Pl. XXIII, fig. 11, *L*) is much coiled anteriorly to the cirrus pouch, the pouch being situated at about the anterior third of the segment. The duct is thin-walled and $0.01-0.023$ mm. in diameter; it enters the cirrus pouch, in which it is coiled many times and enlarges its diameter forming the cirrus distally (Pl. XXIII, fig. 11). In the cirrus pouch the duct has a thick wall consisting of two muscular layers, the inner circular and the outer longitudinal. There are about 50 longitudinal bundles of muscle fibres. The duct wall is lined with chitinous spinules and surrounded by distinctly nucleate cellular masses.

The cirrus pouch (Pl. XXIII, figs. 8 and 11, *B*) is very large, extending from its opening to the other side of the medullary field, it is ovoid in shape and its wall is very thin; it opens into the common very thick-walled genital cloaca, which measures 0.17×0.08 mm.

FEMALE ORGANS. These occupy mainly the posterior part of the segment, the vagina and uterus, however, run through the segment longitudinally. The ovary (Pl. XXIII, figs. 8, 9, 10 and 11, *K*) is situated posteriorly in the segment, it forms four irregular groups of elements extending dorsally and ventrally. Externally each group is continuous with the yolk gland and internally it protrudes into the segment, where the ovarian groups unite midway to form an isthmus (figs. 9 and 10, *I*); the latter communicates with the oviduct by means of the "egg-swallower" (figs. 9 and 10 *E*) which is situated in the middle of the isthmus, its wall being very muscular, it measures 0.04 mm. in diameter.

The oviduct (Pl. XXIII, figs. 10 and 11, *O*) runs ventrally from the "egg-swallower" and soon unites with the proximal end of the vagina coming from the antero-dorsal side, the common duct then running dorsally to open into the shell gland (Pl. XXIII, figs. 10 and 11, *SD*). The oviduct wall and proximal part of the vagina possess the same structure, the muscular wall being lined with cuticular cilia or spinules.

The yolk gland (Pl. XXIII, figs. 8, 9 and 11, *D*) forms four longitudinal columns running forward from the posterior end of segment dorsally and ventrally to the lateral nerve cords, and lying between the marginal and medullary fields. Each column is of elongated oval shape in cross section (Pl. XXIII, fig. 9, *D*). The shell gland (Pl. XXIII, figs. 10 and 11, *SD*) is spherical or ovoid in shape and is situated a little postero-

dorsally to the isthmus. The gland receives the oviduct and yolk duct posteriorly; the other duct arises anteriorly, it is slightly coiled and runs dorsally to the vagina, and, about midway along the segment, it bends to open into the uterus, which is situated ventrally along the median line (Pl. XXIII, figs. 10 and 11, *U*). In my specimens the uterus consists of a mere cell mass with a small central lumen not containing ova even in the posterior segments.

The vagina (Pl. XXIII, figs. 10 and 11, *V*) opens into the common genital cloaca dorsally to the cirrus opening; thence it runs inward in front of the cirrus pouch, bends backward, and upon attaining the ovarian region, it narrows and runs a winding course and unites with the oviduct. The vagina measures 0.04 mm. in width distally and 0.02 mm. in width proximally; it is widest a little in front of the isthmus. The vaginal wall is tolerably thick and is lined with a layer of cuticular spinules.

AFFINITIES. This worm bears some resemblance to *C. laciniatum* Linton, especially in the shape of scolex and in the lacinated border to the segments, it differs, however, chiefly as follows:

The presence of (1) the velum about the bothridial rim, and (2) of a central accessory sucker upon each bothridium; (3) the mode of attachment of the bothridium in respect to the axis of the head; (4) difference in form of lacinated border at the different parts of the strobila; (5) difference in the shape of the last segment (in adult *C. laciniatum* the length and breadth are nearly equal, whereas in my specimens the length is much greater than the breadth); (6) the total length (110–212 mm.) of *C. laciniatum* is much greater than in my specimens.

DIAGNOSIS. Length 30–40 mm. or a little more. Head provided with four cup-like bothridia, measuring 1.6 mm. in diameter. Bothridium sessile or with short peduncle, turning forward and slightly outward, margin entire, thickened, surrounded by second membranous fold or velum; each bothridium measuring 0.5–0.6 mm. in diameter, provided with two accessory suckers, one on the anterior corner and the other central upon the bothridium; central accessory sucker weakly developed, appears as a mere depression or groove on the bottom of the bothridium.

Strobila slender and delicate in the anterior third or fourth, widest and nearly uniform in breadth in the middle third or more, and a little narrower in the posterior third of body length. Cuticular wrinkles on the body are somewhat larger in the anterior, but very minute in the middle and the posterior part of strobila. Neck long, slender,

measuring about 8×0.30 — 0.36 mm. anteriorly where narrowest and 0.7 — 0.8 mm. posteriorly. The segments broaden and lengthen posteriorly for some distance, then slightly decrease in breadth, the last segments being much longer than broad.

Genital openings irregularly alternate, situated a little anterior to the middle of lateral margin or at a distance of one-third of a segment-length from anterior border. Testes distributed throughout the space among the other genital organs; oval in shape, measuring 0.06 — 0.07×0.04 — 0.05 mm. Vas deferens with thin wall; much coiled near the anterior side of cirrus pouch; measuring 0.01 — 0.023 in diameter, much coiled in the cirrus pouch, its muscular wall thickened and lined by a layer of cuticular spinules and surrounded by well nucleated cell masses. Cirrus opens into the common genital cloaca. Cirrus pouch with thin wall, large, oval in shape extending to near aporose side of medullary field.

Ovary situated near the posterior end of segment, consisting of four irregular lobes, each lying on dorsal and ventral sides of segment. Inner ends of ovary converge toward the median line of segment where they unite to form an isthmus of ovarian groups. Yolk glands consist of four longitudinal columns running antero-posteriorly dorsally and ventrally to the lateral nerve cords on both sides; they lie between the marginal and medullary fields; each column elongate oval in cross section. Shell gland spherical or oval and situated a little postero-dorsal to the isthmus. Uterus running longitudinally along ventro-median line of each segment; connected with shell gland by a small duct running from shell gland anteriorly on dorso-median line and opening into uterus about midway along segment. Vagina begins with common genital cloaca at dorsal side of cirrus opening, runs inward along the anterior side of cirrus pouch, bends posteriorly near the inner end of pouch and passes back to the ovarian region where it rapidly narrows, and, pursuing a winding course, unites with the oviduct. United canal runs dorsally to open into shell gland. Wall of vagina and oviduct of similar structure being composed of thick muscular layers and lined with the cuticular spinules.

Host. *Cynias manazo* (Bleeker), spiral valve.

4. ***Acanthobothrium coronatum*** (Rud., 1819) van Beneden, 1849.

Syn. *Bothriocephalus coronatus* Rudolphi, 1819.

B. bifurcatus Leuckart, 1819.

Tetrabothrius coronatum (Rud., 1819) Wagener, 1854.

Calliobothrium coronatum (Rud., 1819) Diesing, 1863.

C. corollatum (Abildg., 1790) Mont., 1887 of Beauchamp, 1905.

The specimens were obtained from the spiral valve of *Dasyatis akabei* (Müller and Henle) on 5. iv. 1913, in Nakatsu, West Japan. They are very abundant and almost all of equal length (200 mm.). This is apparently identical with the well-known species *A. coronatum* (Rud., 1819) van Beneden, but my specimens differ somewhat from the descriptions thereof by the several authors. I shall describe these differences and my observations on this worm.

EXTERNAL CHARACTERS. Dimensions of various parts of worm, fixed by formalin, are as follows (in mm.):

	Head	Hook	Neck	1st segment	Post. segment	Last segment
Length	1.0	0.18—0.19	80—100	0.1	0.3	0.5—0.6
Breadth	1.2	0.03	0.46—0.6	0.75	1.3—1.5	1.3—1.5

The scolex or head is subquadrate, broadening slightly behind. The bothridia are four in number, opposite one another, and of characteristic elongated oval form; each bothridium is divided into three unequal loculi by two transverse costae, the anterior loculus is the largest and deep, the posterior one the smallest and shallow; the bothridium is provided with a pair of bifurcated chitinous hooks at the anterior corner of the first loculus. The hook measures 0.18—0.19 mm. in length from base of the common stalk to the tip of prong; the basal common stalk is shorter than any of the prongs; the inner prong is a little shorter than the outer one; the base of the prong measures 0.03 mm. in diameter. In front of each pair of hooks there is the single accessory sucker, which is more or less muscular and deep.

The neck is widest just behind the head, being nearly as wide as the posterior part of the head; it gradually narrows toward the middle, where it is narrowest, then widens gradually toward the first segment. In my specimens the neck is fairly long, as shown in the above table; this may be due to their preservation in an extended state. All previous authors describe the neck as short. The neck merges insensibly into the strobila, the anterior segmentation being very obscure

and appearing as mere transverse striation, but the segments gradually increase in length and breadth. The last widest segments measure $1.3-1.5 \times 0.5-0.6$ mm. Thus the segments are broader than long throughout the whole length of the body; they number about 450. The genital openings are irregularly alternate.

GENITAL ORGANS. All my specimens are immature and there is no trace of the genital gland excepting the testes. The testes and the genital ducts appear in the posterior segments only and the latter are not as yet differentiated into the male and female ducts, being either mere cell masses or small canaliculated groups of cells. The testes scatter in the medullary portion of segment, being arranged in a single layer. In the anterior section of the segment, they occur in one row, 14 in number being traversed between two lateral excretory canals; in the posterior part of the segment, the transverse row of testes is separated into two lateral parts by the Anlagen of the genital ducts; on the porose side the row consists of 6-10 testes and on the aporose side 8-12. The testis is oval or spherical in shape, measuring $0.03-0.04$ mm. in diameter. The genital ducts are represented at this stage by undifferentiated masses of cells which pass between the dorsal and ventral excretory canals.

Musculature. The longitudinal bundles of muscles are strongly developed, especially in the neck region where they are clearly visible from the exterior in total-preparations. The number of bundles increases in the posterior part of worm there being ca. 110 in all. The muscular bundle is largest along the median line of the segment both ventrally and dorsally, and decreases in size laterally.

Excretory canals. There are four main canals as in other Cestodes; both the dorsal and ventral canals are nearly equal in width anteriorly, measuring $0.022-0.03$ mm.; seen in cross section they are round but in the posterior region they become oblong in cross section; the dorsal canal is much smaller (0.22×0.01 mm.) than the ventral (0.034 mm. \times 0.02 mm.).

AFFINITIES. From the above description it is clear that the worm most resembles *A. coronatum* (Rud.), therefore I provisionally identify it with this species, though there are some points of difference: (1) longer neck, (2) shorter posterior segments due probably to the immature state of my specimens, (3) larger size.

5. *Acanthobothrium ijimai* n.sp.

(Pl. XXIII, figs. 12—13 and Text-figure 1.)

This cestode was collected by Prof. Dr Ijima from the spiral valve of *Dasyatis akaei* (Müller and Henle) in Tokyo, in Feb. 1886. Only three specimens were well preserved in alcohol.

EXTERNAL CHARACTERS. The specimens are all of nearly equal length, about 40 mm. The head (Pl. XXIII, fig. 13) is provided with four bothridia arranged diagonally and directed forward, reminding one of a four-leaved clover viewed frontally; the bothridia are sessile and closely united together for some distance as shown in the figure cited, each bothridium is ovoid in shape, measuring $1.6-1.7 \times 1.2-1.4$ mm. The sucking surface of the bothridium is divided into three unequal loculi by two transverse septa, the anterior loculus is the largest and the posterior the smallest; the bothridial border is entire and fairly thick, the septa well developed.

Anterior to the anterior loculus the bothridium is provided with one pair of bifurcated hooks, which look like the letter (r) under a low magnification. The hook is very small, measuring $0.09-0.11$ mm. in total length. There are three accessory suckers one large (0.1 mm.), and two small (ca. 0.05 mm.) situated in the anterior pad of each bothridium, and disposed as shown in the figures; two smaller accessory suckers, not readily visible, can only be detected by careful examination. The neck varies in length between 0.2 and 0.6 mm. according to the degree of contraction; it forms the narrowest part of the body.

Posteriorly the segments gradually increase in length and breadth, the maximum breadth being reached near the posterior end whilst they taper posteriorly further back. Segments of maximum size measure $0.4-0.6 \times 1.1-1.5$ mm.; their length is greatest in the last segments or segment; here they are longer than broad in one specimen, and slightly broader than long in two others. The genital pores are lateral and irregularly alternate.

GENITAL ORGANS. All three specimens are immature and the genital organs have not as yet been fully developed except the testes. The testes are spherical or oval in shape and scattered throughout the medullary field excepting the space occupied by the female organs. Most of the vas deferens is in the progressive stage of development, its distal part with the cirrus pouch has not yet become differentiated from the cellular mass of the Anlage, which shows a longitudinal central

slit. The vas deferens and vagina pass between the dorsal and ventral longitudinal excretory canals and ventral to the nerve cord.

The female organs are all still young and are presented by cellular masses. The ovarian Anlage is situated posteriorly in the segment and consists of the right and left lobes united in the middle.

The nerve cord is 0.033 mm. in diameter, and runs longitudinally between the medullary and cortical fields.

Musculature. The longitudinal muscles consist of two sets, the one running just beneath the surface (dermal muscle), the other between the marginal and median fields. The dermal muscles consist of about 150—160 bundles of fibres which are smaller than those of the inner set. The latter set consists of about 40—50 bundles, each measuring 0.02—0.04 mm. in diameter. The bundles gradually decrease in size laterally the median portion being the largest.

AFFINITIES. This worm cannot be referred to a known species. It shows a slight resemblance to *Calliobothrium farmeri* Southwell in the shape of the head. Southwell writes: not only are the bothridia “sessile, but they are united together for some distance along their length in such a way that the anterior view of the head is almost that of a square. Each bothridium extends to the centre of the head, becoming produced or lumpy anteriorly, so that all four remain distinct. Between the centre of head and each pair of hooks there is a minute accessory papilliform sucker....” In these respects my specimens differ from Southwell’s, that is, all the bothridia are so closely aggregated that there is no space between any two adjacent bothridia, and only a small area is found at the apex of head between their anterior tips. The accessory suckers of each bothridium are three in number in my species, while there is only one sucker in *C. farmeri*. The hooks of *C. farmeri* are described and figured by the author (fig. 3a Pl. V) as simple, though in his fig. 3b, Pl. V, they are slightly bifurcated.

If the features of head : bothridia and hooks, length of worm,

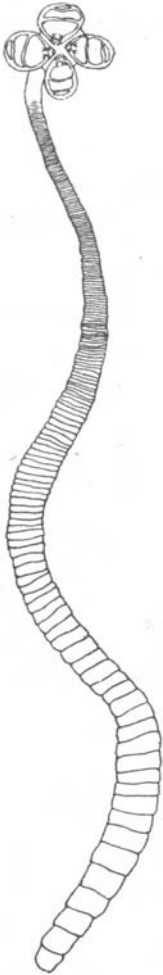


Fig. 1. *A. ijimai*
n. sp. $\times 3$.

and form of segments, etc., are taken together they are sufficient to establish the species as new to science. I accordingly name it *Acanthobothrium ijinai* in honour of the collector of the specimens.

DIAGNOSIS. Length 40 mm. or more (probably longer than this in fully matured form). Head considerably large, provided with 4 sessile bothridia, which are arranged in a diagonal position. All bothridia turn forward and are united together closely by their anterior half, giving a square appearance when seen frontally. The square is placed nearly at right angles to the long axis of the head. Each bothridium is oval in shape, it measures $1.6-1.7 \times 1.2-1.4$ mm. and is divided into three unequal loculi by two transverse septa, the anterior the largest and the posterior the smallest. One pair of bifurcated hooks is planted on the proximal border of the anterior loculus of each bothridium. The hook is small in size and r-shaped. Three accessory suckers occur on the proximal end of each bothridium, one is large and occupies an antero-median position, two are smaller and situated postero-laterally to the first.

Neck varies in length between 0.2 and 0.6 mm. according to the condition of contraction. The segments gradually increase in breadth, reaching a maximum (1.1—1.5 mm. or more) and tapering toward the very end; their length increases progressively along the whole length of body, attaining a maximum at the last segment, which is longer than broad. The genital pores are on the lateral margin and are irregularly alternate.

Host. *Dasyatis akaei* (Müller and Henle), spiral valve.

6. ***Calliobothrium eschrechtii*** (van Beneden, 1849).

Syn. *Acanthobothrium eschrechtii* van Beneden, 1849.

Onchobothrium (Call.) *elegans* Diesing, 1854.

The specimens were obtained from the spiral valve of *Cynias manazo* (Bleeker) in Tokyo, 24. v. 1907; in association with other cestodes (*Acanthobothrium*, *Calliobothrium*, *Rhynchobothrium*, *Phyllobothrium* and *Anthobothrium*).

EXTERNAL CHARACTERS. Length 4—11 mm.; maximum breadth of the posterior segments, 0.25 mm. Head provided with four opposite bothridia measuring 0.44×0.15 mm. Each bothridium armed with two pairs of simple, claw-like, well developed, hollow hooks of equal size and similar shape; the outer hook of each side is slender and slightly curved while the inner hook is stout and strongly curved.

The hook is 0.12 mm. long measured along the curved surface and 0.03 in diameter at the base. Each bothridium is divided into three loculi by two transverse costae, the anterior loculus is largest, the posterior two sub-equal. Anterior to the hooks each bothridium is surmounted by a triangular pad with a single accessory sucker upon it. Posteriorly the bothridium is separated from the neck and slightly turned outward.

Neck slender, 1.2×0.1 mm. anteriorly immediately behind the head. Strobila generally delicate. The neck is followed by quadrate segments, 0.1×0.16 mm., which increase in size posteriorly, the length increasing more rapidly than the breadth, so that the last segments are much elongated, the terminal segment measuring $1.0-1.4 \times 0.25$ mm. In the posterior segments the genital openings are indicated by slight elevations which are readily seen at the posterior half of the lateral margin of each segment; they are irregularly alternate.

Linton recently obtained this species from the spiral valve of *Mustelus canis* at Woods Holl; my specimens are identical with those Linton described, differing only in the dimensions of various parts:

	Head length	Bothrid. length	Bothrid. breadth	Hook length	Neck length	Neck breadth	Last segment length	Last segment
Linton	0.9	0.6—0.64	0.34	0.20—0.24	—	0.2—0.24	1.0	0.32—0.6
Mihi	0.5	0.44	0.15	0.12	1.2	0.1	1.0—1.4	0.24

The above table shows that Linton's specimens are as a rule larger (measurements in mm.).

7. ***Calliobothrium verticillatum*** (Rud., 1819) van Beneden, 1850.

Syn. *Bothriocephalus verticillatus* Rudolphi, 1819.

Onchobothrium verticillatum Rud. of Diesing, 1850.

Acanthobothrium verticillatum (Rud., 1819) van Beneden, 1849.

Tetrabothrium verticillatum (Rud.) Wagener, 1854.

This species is very common in the spiral valve of *Cynias manazo* (Bleeker) in Japan. My specimens were obtained on several occasions at Tokyo, and other parts of Japan, and were generally found associated with other cestodes. In May, 1913, numerous specimens were collected at Nakatsu. They were much larger than any specimens previously collected at either Tokyo or Hiroshima, all measuring about 140 mm. in length. The external characters and internal structures of my

specimens agree well with those of *C. verticillatum* (Rud.); the only differences lie in the dimensions of the various parts of body and the number of segments; my largest specimens consist of 580 segments. Such a number of segments has not so far been recorded.

The anterior part of body is characteristically feeble and filiform, and so delicate that careless collectors usually leave the head attached to the host. The segments grow progressively in length posteriorly, the last segment being longest; the flaps on the posterior borders show slight individual differences; my specimens mostly differ from those previously described in respect to the flaps.

The first segment bears four triangular flaps on each corner of the postero-lateral margin. In the 65th segment, the middle of the posterior margin begins to protrude and soon after it becomes the third flap. This condition (lacinated border) of the segment continues down about 90 segments until about the 150th segment, in which the third flap begins to notch at its tip so as to form a bifid flap; the notch then becomes deeper and deeper, and ultimately the third flap divides into two; when this stage is reached, the posterior margin of each segment bears eight flaps, four on each, situated ventrally and dorsally. Of the four lateral flaps on each flat side, two are a little larger and sharper than the median pair. This arrangement of the flaps prevails in most parts of the strobila. At about the 425th segment, the median flaps become indistinct and are represented only by a slight flexure of the posterior margin. The notch between the two primary flaps is shallow and wide, but it becomes gradually deeper posteriorly as the median flaps disappear. In the last segment, the primary flaps become rounded and convex on its inner side. The dimensions of various parts of a worm, which measures 150 mm. in length and is composed of about 580 segments, are given (in mm.) in the following table:

	Head	Bothr. Hook	1st segmt.	85th segmt.	120th segmt.	150th segmt.	225th segmt.	425th segmt.	last segmt.
Length	0.35—0.38	0.33	0.1 0.1	0.18	0.18—0.20	0.22	0.18	0.1	2.2
Breadth	0.38	0.12	—	0.11—0.16	0.20 0.4	0.5	0.8	0.7	1.1

The measurements taken from a smaller worm (45 mm. long) are as follows:

	Head	Hook	Bothrid.	Anterior segment	Middle segment	Last segment
Length	0.35	0.1	0.35	0.2	0.3	2.0
Breadth	0.25	—	0.14	0.06	0.2	0.75

8. **Calliobothrium convolutum** n. sp.

(Pl. XXIII, figs. 14—19 and Text-fig. 2.)

This species is very commonly found in the spiral valve of *Cynias manazo* (Bleeker) in Japan. The specimens which I examined were obtained from the shark, chiefly on three occasions, viz., 24. and 27. iv., and 9. v. 1907, in Tokyo. I have frequently found them associated with other species of cestodes, some of which I have already described.

EXTERNAL CHARACTERS. Total length 55—110 mm. Head subquadrate and provided with four bothridia; its length and breadth vary naturally according to the state of contraction, on an average it measures ca. 1.0×0.7 — 0.8 mm.

In my largest specimens, the head measures 1.5×1.0 — 1.2 mm. The bothridium is elongated oval in shape, measuring 0.6 — 0.7×0.3 — 0.35 mm. Each bothridium turns outward but not forward, and its face is divided into three loculi by two transverse costae, the anterior costa lying in the middle or a little posterior to the middle of the bothridium; the second costa near the posterior end. Therefore, the anterior loculus is the largest and the posterior the smallest. The wall of the bothridium is somewhat thickened. Each bothridium bears one pair of thorn-like simple dark brown hooks (Pl. XXIII, fig. 15), the one being much larger than the other; the larger hook measures 0.3×0.1 mm. (basal width), and the smaller 0.17×0.06 mm. The paired hooks are closely apposed basally. Each hook is accompanied by a small process situated externally to its base and embedded in the tissue so as to be invisible from exterior.

In front of the hooks each bothridium is surmounted by a subtriangular pad, bearing a small accessory sucker anteriorly. The head is separated from the rest of body by a distinct neck, which may measure 2×0.5 — 0.7 mm., but its shape varies greatly in life.

In the strobila the breadth of the segment is always greater than its length; the breadth gradually increasing toward the middle of the body where it may reach a maximum along a succession of segments after which the breadth again diminishes slightly toward the posterior end. The length of the segments increases gradually and continuously from anterior to posterior end of the strobila. Actual measurements of length and breadth are slightly variable according to the different individuals or to the condition even in the same individual, but in the latter case there is no remarkable variability. Sometimes, though very rarely, we may find that the length is greater than the breadth in the

last few segments. In some specimens the anterior segments measure $0.05-0.085 \times 0.8-1.3$ mm. (the proportion being as 1:15 or 1:16). The widest middle segments measure $0.4 \times 3-4$ mm. (1:75-1:10), and the posterior segments, which are narrow and elongate, measure 0.85×1.7 mm. (1:2) or $1.1-1.5 \times 2.0-2.2$ mm. (1:15-1:2).

The anterior and posterior parts of the strobila can readily be recognized at a glance. Anteriorly the segments are much broader than long, their surface is thin and smooth, and the posterior border

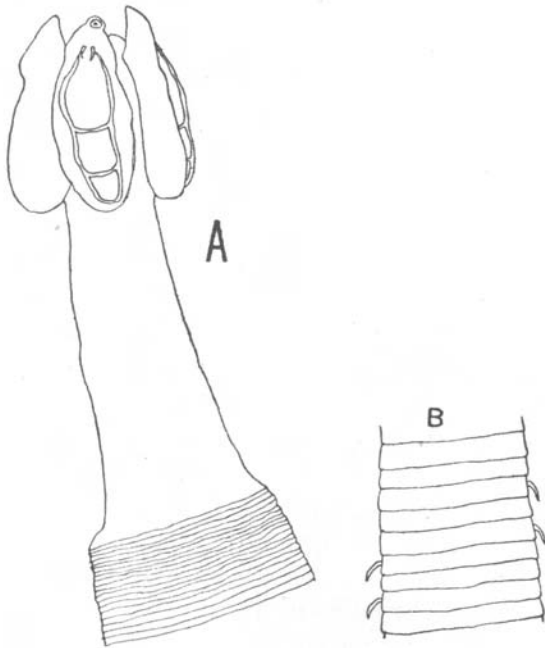


Fig. 2. A. Anterior end. B. Anterior segments. $\times 10$.

of each segment more or less overlaps the following segment, giving a serrate appearance to the lateral margins. Posteriorly the segments become thickened by the accumulation of the ova in uterus, and narrowed at both the anterior and posterior borders, hence the serrated appearance is entirely lost. The most remarkable and peculiar feature of this species lies in the fact that some posterior segments fold ventrally upon themselves along the lateral margins. Posteriorly the folding becomes more and more pronounced and finally both margins meet each other along the ventro-median line making the

worm tubular (Pl. XXIII, fig. 14). Such peculiar terminal segments are somewhat thinner than those that precede them. The flattening of the posterior segments may be due to the discharging of ova from the uterus judging from the fact that the uterine openings are very conspicuous, forming macroscopically visible spots ranged along the ventral median line.

The cirrus openings are irregularly alternate, situated at the middle or a little anterior on the segments. The cirrus is frequently protruded from its pore; it is long, slender, and unarmed. The uterus openings are situated on the ventro-median line, a little anterior to the middle of segment.

INTERNAL STRUCTURE. The parenchymatous tissue is very loose and the cuticular layer is very thin. There is no sharp line of demarcation between the marginal layer and central core, that is, the transverse muscle fibres separating the two fields are very weakly developed. The longitudinal muscle fibres are also not conspicuous. I have found a few bundles of them here and there running through the marginal layer in horizontal and sagittal sections, but it is difficult to find them in cross sections. The fact that this species varies slightly in both length and breadth may be explained by the feebly developed musculature. In the anterior immature segments, the marginal layer is tolerably thick measuring about one-fourth the body thickness, but in the mature segments the central core bulges out the marginal layer by the growth of the reproductive organs, especially the uterus.

EXCRETORY CANALS. As a rule there are two main excretory canals on each side, dorsal and ventral, running throughout the whole length of worm, just inside the yolk glands; the canals are small but distinct.

FEMALE ORGANS. The vagina opens into the common genital cloaca on the antero-dorsal side of the cirrus opening. From the opening, the vagina proceeds inward straight in front of the cirrus pouch. Near the base of the pouch, the vagina rapidly widens, and bends on itself dorso-posteriorly along the basal end of the pouch; and passes dorsally to the excretory canal on the porose side to again run inward to the median part of the segment, where it coils on itself; ultimately it becomes the seminal receptacle, which lies on postero-ventral side of the segment. The proximal end of the seminal receptacle continues to the small duct, which runs dorsally over the ovary and turns again ventrally to unite with the oviduct coming from the ventral side. The united duct runs dorsally to open into the shell gland (Pl. XXIII, figs. 16 and 17). The main portion of the vagina, between its opening and the seminal

receptacle, possesses a nearly uniform diameter of 0.05 mm. The seminal receptacle measures 0.09 mm., and the proximal part of the vagina gradually narrows from the seminal receptacle to the point where it joins the oviduct. The entire length of the vagina is surrounded by a single layer of cells with distinct nuclei.

The oviduct (Pl. XXIII, figs. 16 and 17, *O*) begins with the so-called "egg-swallower" (Pl. XXIII, figs. 17 and 19, *E*) which is continuous with the middle portion of the ovary ventro-posteriorly. The "egg-swallower" is a remarkable organ, shaped like a sphere flattened antero-posteriorly; its lumen is spacious and its muscular wall is very well developed; the radial muscular fibres are the most highly developed. Just outside the muscular wall, the "egg-swallower" is surrounded by a thick layer of distinctly nucleated cells (Pl. XXIII, fig. 19). The oviduct, which follows, runs dorso-ventrally in a pronounced curve within the medio-posterior part of segment. The width of the oviduct is 0.035 mm. proximally, and it gradually broadens distally, its end measuring 0.05 mm.; it narrows again at its junction with the vagina. The lumen of the oviduct also widens gradually from the proximal to the distal end. The wall of the oviduct consists of a homogeneous membrane and two layers (inner thicker and outer thinner) of distinctly nucleated cells; the innermost membranous layer of the wall is provided with minute spinules projecting backward into the cavity. In the outer thinner layer the cell boundaries are not conspicuous.

The shell gland (Pl. XXIII, figs. 16 and 17, *SD*) is spherical or somewhat flattened in shape, measuring 0.2 to 0.14 mm.; it is situated medio-dorsally, posteriorly in each segment; it is composed of spindle-shaped cells with well-defined nuclei which are readily seen under a moderate magnification. At its centre the shell gland receives the yolk duct coming from the ventral side.

The yolk duct has a diameter of 0.007 mm. and bifurcates at the point where it passes across the middle of the ovary, the branches of the duct proceeding right and left to unite with the yolk glands which are situated just outside the excretory canal on each side of body (Pl. XXIII, fig. 16, *D*). The yolk cells are very small, measuring 0.0011–0.0013 mm. in diameter. By the smallness of the yolk cells we can easily distinguish them from the ovarian eggs although both of them look alike.

The ovary (Pl. XXII, figs. 16 and 17, *K*) is irregularly lobed, situated in the posterior part of body, spreading from the median plane to the lateral excretory canals. It lies mainly on the ventral side of the segment, but it extends out to the dorsal, thus occupying an extensive

area at the posterior portion of segment. The lateral halves of the ovary are connected by a comparatively narrow isthmus in the median plane, where the ovary is continuous with the "egg-swallower" whose opening into the ovary is best seen in horizontal and sagittal sections. The ovum in the ovary measures 0.013 mm. in diameter and its nucleus (0.005 mm.) can easily be observed in haematoxylin-eosin preparations.

The uterus (Pl. XXIII, fig. 16, *U*) first makes its appearance transversely on the ventral side of the segment, and later its cavity enlarges more and more as it receives more ova; in gravid segments, it occupies all the available space, the other genital organs being atrophied. It is surrounded by a thin membrane, composed of cells with well-defined nuclei. It opens to the exterior a little anterior to the middle in the medio-ventral line of the segment (Pl. XXIII, fig. 14).

MALE ORGANS. The testes (Pl. XXIII, fig. 16, *H*) are numerous and scattered chiefly anteriorly and dorsally to the female organs; they are oval or spherical in shape, measuring 0.11×0.05 mm. The vas deferens is thin-walled and coiled on itself, more so near the base of the cirrus pouch; it is enlarged by being filled with spermatozoa in the mature segments. On entering the pouch it widens (0.04—0.105 mm.) to form a vesicle-like duct and it is coiled two or more times inside the base of the pouch; the coiled part of the duct is thin-walled, but its distal end is straight, narrow (0.025 mm.) and has a thick muscular wall. The wall of the vas deferens in the pouch is surrounded by a single layer of clearly nucleated cells, like those in the vaginal wall (Pl. XXIII, fig. 18, *L*). The protruded cirrus attains a length of 0.4—0.6 mm.

The cirrus pouch (Pl. XXIII, fig. 18, *B*) is elongate pyriform, it measures 0.5×0.15 mm. basally, and is 0.09 mm. wide distally. Its wall is thin and surrounded by a layer of cells with distinct nuclei. The space between the vas deferens and the wall of the pouch is filled with parenchymatous tissue containing scattered nuclei. The cirrus pouch with the vagina passes dorsally to the excretory canals on the porose side.

AFFINITIES. There are some difficulties in deciding to which genus the worm belongs. The characters of the bothridium and the accessory sucker, the size, form and arrangement of the hooks offer important criteria for the systematic determination of *Phyllacanthinae*. Some differential characters of three genera are here tabulated (other genera of *Phyllacanthinae* may be omitted because of their being decidedly different).

Genera	Bothridium	Hook	Access. sucker
<i>Calliobothrium</i>	Each bothrid. provided with 3 loculi	4 single to each bothrid.	1 or 3 access. suckers in each bothrid.
<i>Onchobothrium</i>	Do.	2 single hooks whose base is continuous	No access. sucker
<i>Acanthobothrium</i>	Do.	2 bifurcated hooks (1 pair to each bothrid.)	1 or 3 access. suckers to each bothrid.

From the above table, it will be seen that our worm differs from two genera, *Calliobothrium* and *Acanthobothrium*, by the number and form of the hooks, but agrees with them in the feature of the bothridium and in the possession of one accessory sucker. The worm agrees with *Onchobothrium* in the character of bothridium and in the number and form of the hooks, but it differs from this genus by the presence of an accessory sucker and by the paired hooks being connected basally. Thus, so far as the characters of the head are concerned, it is difficult to refer it to a known genus. At first I thought of establishing a new genus for it, but now prefer to place it in the genus *Calliobothrium* because:

(1) The features of bothridium and the presence of one accessory sucker agree with the generic characters; (2) in this genus, we find that the hooks vary in number and shape (e.g., *C. aetiobatis* Shipley, from *Aetiobatis narinari* Euphras., is provided with a single pair of bifurcated hooks; *C. farmeri* Southwell, from *Trygon walga*, is provided with a single pair of hooks); (3) each of the two hooks has a small lateral process, which may represent an independent hook in *Calliobothrium*; (4) all the other generic characters agree.

Besides the characters above enumerated the folding of the posterior segments differentiates our worm from any other species belonging to the genus.

DIAGNOSIS. Length 55—80 mm. or 110 mm. Head subquadrate 1.0—1.5 × 0.7—0.8 or 1.2 mm. Bothridia four in number, subelliptical, each divided into three loculi by two transverse costae, the anterior locus largest, the posterior smallest. A single pair of simple hooks on each bothridium, anteriorly on the anterior loculus; hooks dark brown in colour, thorn-like in shape, the one hook slightly larger; each hook accompanied by a small lateral process embedded under the surface and invisible externally. One accessory sucker situated on the anterior subtriangular pad of each bothridium. Head distinctly separated from strobila by the neck which is tolerably long.

Segments always broader than long; their breadth gradually

increases toward the middle portion of body, reaching a maximum of 3—4 mm., and diminishing toward the posterior end; this length gradually increases toward the last segment, attaining a maximum of 1.0—1.5 mm. Anteriorly the strobila is thin and smooth, posteriorly it is swollen and folded to make a tube.

Genital openings lateral and irregularly alternate, situated slightly anterior to the middle of each segment. Uterine pores on the ventral median line.

Musculature weakly developed. Excretory canals two per side, running just inside the yolk glands.

MALE ORGANS. Testes numerous, situated antero-dorsally to female organs, oval or spherical, measuring 0.11—0.15 mm. Vas deferens much coiled on itself near the outside of the basal portion of cirrus pouch, entering the pouch it enlarges to the vesicle-like duct; its distal portion is straight and thick-walled. Cirrus pouch elongate pyriform, measuring 0.5×0.15 mm. basally and 0.09 mm. broad distally. Vas deferens and cirrus pouch surrounded by cell layer with distinct nuclei. Male duct with vagina crosses the longitudinal canals dorsally.

FEMALE ORGANS. Ovary irregularly lobed, extending transversely between the longitudinal canals on either side in posterior part of segment; lying mainly ventrally, but extending dorsally. Ovary united to oviduct by the so-called "egg-swallower" in the median plane. "Egg-swallower" subspherical, depressed antero-posteriorly, its wall with strongly developed radial muscle fibres surrounded by cell groups. Oviduct follows "egg-swallower," its course is strongly curved dorsally to union with proximal end of vagina. Oviduct provided internally with minute spinules, surrounded by two cell-layers with well-defined nuclei. Shell gland spherical or slightly flattened, measuring 0.2×0.14 mm., dorsal to the ovary and on the same level. Yolk duct arising at centre of gland, running ventrally and passing posteriorly to ovary, then crossing ovary and bifurcating, both ducts running outward to meet the yolk glands. Yolk glands situated just outside lateral excretory canals. Vagina runs from its opening inward straight to anterior edge of cirrus pouch; after crossing the longitudinal canals dorsally, it runs to median portion of segment, where it coils several times, and soon enlarges to form the seminal receptacle; the small duct runs dorsally and again bends ventrally to union with oviduct. Vagina surrounded throughout by cell-layer with well-defined nuclei.

Host. *Cynias manazo* (Bleeker), spiral valve.

9. *Calliobothrium nodosum* n.sp.

(Pl. XXIII, figs. 20, 21, and Text-fig. 3.)

The material was found with other cestodes in the spiral valve of *Cynias manazo* (Bleeker) 15. v. 1906.

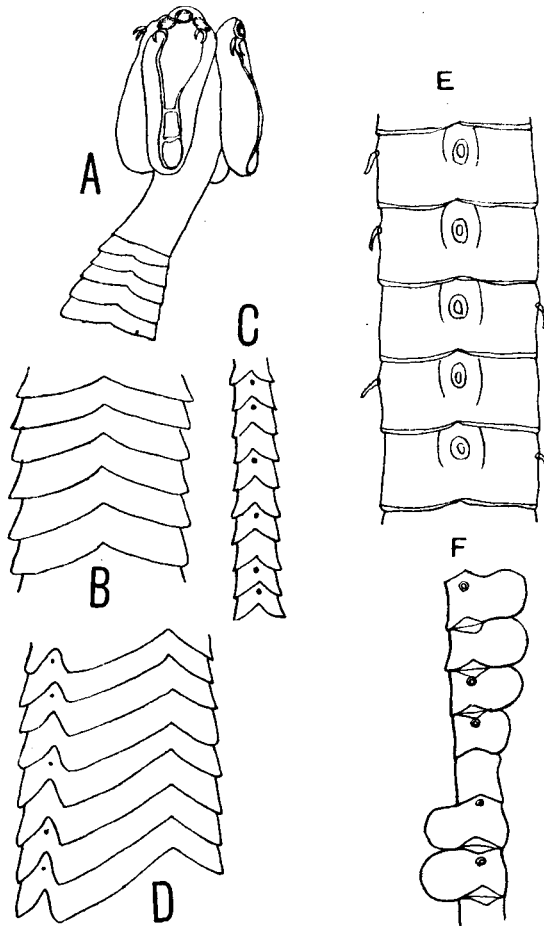


Fig. 3. A. Scolex with the anterior part of the strobila. B. Anterior segments (flat view). C. The same (side view). D. Middle segments. E. Posterior segments. F. Segments near the posterior end. $\times 10$

EXTERNAL CHARACTERS. The largest specimens measure 160 mm. in length. Head subquadrate and provided with four bothridia, which are placed diagonally, neither horizontal nor saggital. Bothridia

large and elongate oval, each measuring 1.1×0.6 mm., divided into three unequal loculi by two transverse costae. The anterior loculus is the largest and at its anterior corner two pairs of hooks are present. Hooks thorn-like, strongly curved, measuring 0.4×0.5 mm. (basal width), the pair on the same side of the bothridium are connected by fibrous tissue. In front of hooks, bothridium carries a pad with three accessory suckers. Neck varies in length according to state of contraction, measuring $1.3-1.5 \times 0.8$ mm. (average width).

The strobila of the largest specimen is widest (4.5 mm.) near the posterior end, narrowest (0.8 mm.) at the neck, the last segment measuring 1.5–2.0 mm. in breadth. The strobila is nearly of uniform thickness (1.0 mm. or more) excepting at the posterior part of the body which is nodularly swollen by the distended uterus (fig. 3, *E* and *F*).

The segments increase gradually in length toward the posterior end, the anterior segment measures 0.2 mm., the middle 0.5 mm. and the posterior 1.0 mm. long. The segments also increase in breadth posteriorly to near the end of the body where they again narrow at the very end. The posterior segmental border is angular or laciniated by emarginations as shown in the accompanying figures; the laciniation differs slightly in different parts of body; the emarginations of the posterior border are generally four in number, two on the dorsal and ventral median lines and one on each side of segment. The posterior border overlaps the next following segment so as to give a serrated appearance to the worm. Serration, emargination or laciniation are conspicuous in the anterior half or more of the worm and are obliterated in the rest of the strobila.

Genital pores irregularly alternate, situated in front of the middle of the lateral margin. Uterine openings placed on median line of the flat surface.

Excretory system. Dorsal canals very small, the ventral larger, measuring 0.046×0.034 mm. Wall of ventral canal well developed, 0.005 mm. in thickness. Transverse commissures of ventral canals absent.

Musculature. Large longitudinal muscle bundles (ca. 100) are somewhat regularly arranged all around the median field. The anterior portion of body is furnished with fewer muscle bundles, but they are well developed (each bundle measuring 0.041 mm. in long and 0.02–0.03 mm. in short diameter).

MALE ORGANS. Cirrus pouch (Pl. XXIII, fig. 21, *B*) oval, 0.28×0.17 mm., surrounded by a thin muscular wall; its cavity is occupied

by parenchymatous tissue in which the vas deferens and cirrus are embedded. The vas deferens in the cirrus pouch passes straight toward the opening of pouch, and becomes a cirrus, which is protrusive. In the anterior segments, the vas deferens coils somewhat in the basal part of the pouch. Leaving the cirrus pouch, the vas deferens runs inward to the median line of the segment taking a slightly winding course, nearly parallel to the vagina (Pl. XXIII, fig. 21, *L*). The further connection to the testes could not be traced. The vas deferens measures 0.02 mm. in diameter within the pouch and 0.022 mm. in diameter outside it.

Testes (Pl. XXIII, fig. 21, *H*) numerous, scattered chiefly dorso-laterally and a few posterior to female organs; oval in shape, measuring 0.115×0.08 mm.

FEMALE ORGANS. Vagina (Pl. XXIII, fig. 27, *V*) opens into common genital cloaca immediately antero-dorsal to the opening; from its orifice it runs inward, then bends backward to unite with the oviduct, coils once, and runs forward to open into the shell gland. The transverse portion of the vagina is of nearly uniform diameter (0.03 mm.), the proximal portion narrows (0.017 mm.); it is lined by a single cell-layer and surrounded by a thick cell-layer.

Ovary (Pl. XXIII, fig. 21, *K*) occupies nearly all the median posterior ventral half of the segment. The oviduct arises midway along the ovary and runs back to unite with the vagina; at its origin is a spherical "egg-swallower" with a muscular wall (0.01 mm. in thickness); oviduct wall of similar structure to vagina. Egg (ovarian): spherical or oval, 0.02×0.013 mm. with nucleus measuring 0.0115 mm. Shell gland (Pl. XXIII, fig. 21, *SD*) situated posterior to the ovary; oval, measuring 0.1×0.065 mm.

Yolk glands (Pl. XXIII, fig. 21, *D*), numerous, longitudinally arranged outside the excretory canals; their main ducts (*G*) run inward posteriorly in the segment, meet in the median line and open into the shell gland by a short duct. Uterus (*U*), lies in the median portion of segment; in anterior segments it is only represented by cell groups within which a lumen appears that subsequently enlarges, ultimately, in the posterior part of the strobila, occupying almost all the median portion of the segment. In mature segments the uterus swells out rendering the segments globose (Text-fig. 3, *F*). The uterine ovum, with shell, is nearly spherical and measures 0.034 mm.

AFFINITIES. The external features of the scolex, such as the number of the hooks, and the bothridium form, are as in the genus *Calliobothrium*,

but the internal structures, especially the genital organs, differ from those of the genus and resemble more those of *Onchobothrium*. The laciniation of the posterior segmental border and the swelling of the posterior gravid segments are characters sufficient to distinguish the worm from any known species of *Calliobothrium*.

DIAGNOSIS. Length 100–160 mm. or a little more. Head subquadrate, with four bothridia situated diagonally. Bothridium large and elongate oval, measuring 1.1×0.6 mm.; its face divided into three loculi by two transverse costae, the anterior loculus is the largest, the other two are of subequal size. Hooks: two pairs of simple hooks at the anterior corner of anterior loculus; they are strongly developed and thorn-like in shape. There are three accessory suckers. Neck variable in length and breadth. Strobila nearly uniform in thickness (1.0 mm. or more) throughout most of the body, but the posterior gravid segments are swollen so as to give a nodular appearance. Segments: their length gradually increases caudally; maximum length in the last segment; maximum breadth near the posterior end; the breadth decreases posteriorly; posterior segmental border laciniated by four emarginations, two lying on the median line of the flat surface and two on the lateral margins. Cirrus openings, on lateral margin, irregularly alternate. Uterine pores situate along median line of flat surface.

Cirrus pouch small, oval, measuring ca. 0.28×0.17 mm. Vas deferens nearly straight from cirrus pouch to median plane. Testes oval, 0.15×0.08 mm., scattered chiefly dorso-laterally to female organs, but a few posterior thereto. Vagina runs nearly parallel and dorsally to vas deferens, proximally it unites with the oviduct and runs to the shell gland. Ovary situate ventrally, occupying nearly all the median posterior half of segment. Yolk glands occur in numerous groups arranged longitudinally outside the lateral canals on both sides. Uterus in the median portion of segment; it swells considerably in the posterior or gravid segments.

Host. *Cynias manazo* (Bleeker), spiral valve.

10. ***Rhynchobothrium laciniatum*** n.sp.

(Text-figure 4.)

A few specimens of this species were obtained from the spiral valve of *Cynias manazo* (Bleeker) on May 1913, at Nakatsu. They were found associated with other species of cestodes.

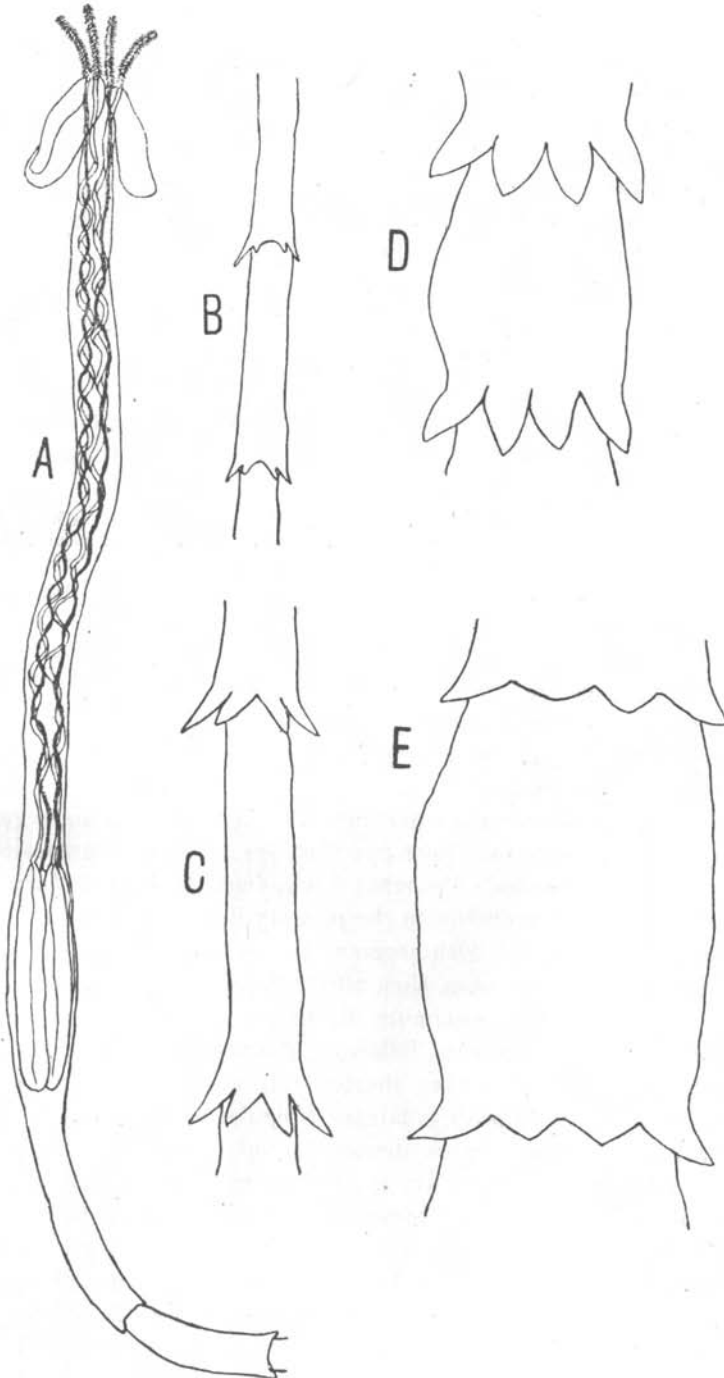


Fig. 4. A. Scolex and anterior segments. $\times 25$. B. 5th segment. $\times 25$. C. 20th segment. $\times 25$. D. 45th segment. $\times 10$. E. Last segment. $\times 10$.

EXTERNAL CHARACTERS. Total length 100 mm.; number of segments ca. 70. Head provided with two oval bothridia, measuring 0.33×0.27 mm.; connected along their anterior half to the head axis, directed antero-laterally, very movable in life; with two openings anteriorly, from which long proboscides protrude. Neck fairly long (3 mm.); breadth 0.13 mm. just behind the head, 0.1 mm. (minimum) anterior to proboscis sac; proboscis sac region slightly swollen, spindle shaped (0.5×0.2 mm.), continuous behind with the first segment (0.1 mm. broad); anterior 20 mm. of strobila, comprising ca. 20 segments, is very slender and delicate in texture; the segments then gradually lengthen and widen proceeding backward, the last segment being largest. The dimensions of various parts of body are given below (in mm.):

	Bothrid.	Neck	Probosc. sac	1st sgmt.	5th sgmt.	20th sgmt.	40th sgmt.	45th sgmt.	Last sgmt.
Length	0.33	3	0.5	0.35	0.7	1.6	1.4	1.5	2.9
Breadth	0.27	0.1—0.13	0.2	0.1	0.1	0.2	0.6	1.2	1.9

Segments, always much longer than broad; anteriorly along the strobila the segments are broadest at their posterior borders whilst in the posterior region of the strobila they are broadest in the middle; each segment bears pointed triangular flaps postero-laterally projecting from its posterior border.

There are usually six flaps per segment but a few anterior segments bear two or six, where they bear two the flaps are small, one projecting on each side of the body; further back, four small secondary flaps appear dorsally and ventrally to the primary flaps; the flaps gradually increase in size. At the 20th segment the secondary flaps are nearly as large as the primary ones, then all six flaps increase equally in size caudally, reaching their maximum dimensions (0.55 mm.), at the 40th segment. In a few segments, following upon the 40th, the flaps are of uniform size, after which they shorten gradually and become smaller and obtuse. Genital openings lateral, irregularly alternate.

GENITAL ORGANS. Testes distorted oval or elliptical; scattered laterally in medullary field; five to seven or more testes visible in cross section of the segment; most testes usually in the aporose half. Cirrus pouch large, elongated pyriform in shape, extending beyond middle of segment; occupying nearly all the porose half of the medullary field, leaving the narrow space at its ventral side where the vagina runs transversely parallel to the pouch; with thick muscular wall. Vas deferens entering the pouch basally, is narrow and strongly coiled in the

base of the pouch, then runs straight (broadening, especially distally) outward to the exterior; deep genital cloaca absent; muscular wall of duct uniformly thick.

Ovary voluminous, situated in middle region of segment, extending dorso-ventrally to occupy the whole thickness of medullary field; divided into two lobes, right and left. Yolk glands numerous, arranged in circular row between the cortical and medullary fields.

DIAGNOSIS. Length 100 mm. or a little more. Head provided with two bothridia, measuring 0.33×0.27 mm. Neck tolerably long. Proboscis sac spindle shaped, 0.5×0.2 mm. Strobila slender and delicate anteriorly, thick in the middle and behind. Segments always longer than broad; their posterior border with six triangular characteristic flaps, which gradually enlarge toward the middle of body, and thence decrease in size posteriorly. Genital openings lateral, irregularly alternate.

Host. *Cynias manazo* (Bleeker), spiral valve.

REFERENCES.

- BEAUCHAMP (1905). Études sur les Cestodes des Selachiens. *Arch. de Parasitol.* IX. No. 4.
- BRAUN, M. (1890–1900). Bronns, *Klassen und Ordnungen des Tierreiches*. IV. Vermes. Abt. I.b, Cestodes.
- CURTIS, W. C. (1903). *Crossobothrium laciniatum* and development stimuli in the Cestoda. *Biol. Bullet. Marine Biol. Laboratory*, Woods Holl, Mass.
- JOHNSTONE, Jas. (1906–1910). Fourteenth, Fifteenth and Eighteenth Annual Reports, Lancashire Sea Fisheries Laboratory. *Trans. Liverpool Biolog. Soc.*
- VON LINSTOW (1878–1889). *Kompendium der Helminthologie*. Nachtrag.
- LINTON, E. (1889). Notes on entozoa of marine fishes of New England with description of several new species. *Annual Rep. Commissioner of Fish and Fisheries for 1886*.
- The same. Part II. *The Annual Report...for 1887*.
- (1901). Parasites of the fishes of the Woods Holl region. *U.S. Fish Commission Bulletin for 1899*.
- PINTNER, Th. (1889). Neue Untersuchungen über den Bau des Bandwurmkörpers. I. *Arb. a. d. zool. Inst. Wien*. VIII. Ht. 3.
- (1913). Vorarbeiten zu einer Monographie der Tetrarhynchoiden. *Stzber. d. K. K. Akadem. Wiss. Wien*. CXXII.
- SHIPLEY, A. (1900). In Willey's *Zoological Results*, part v.
- SHIPLEY, A. and HORNEILL, J. (1904, 1905, 1906). In Herdman's *Ceylon Reports*. Parts II, III and v.
- SOUTHWELL, T. (1911). Description of nine new species of cestode parasites, including two new genera from marine fishes of Ceylon. *Ceylon Marine Biol. Reports*. Part v.

- VAN BENEDEN, P. J. (1850). Recherches sur la faune littorale de Belgique. Les vers cestoides, etc. *Mém. Acad. roy. d. sc. de Belg.*, Brux. xxv.
 — (1858). *Mémoire sur les vers intestinaux*. Paris.
 ZSCHOKKE, F. (1888). *Recherches sur la structure anatomique et histologique des cestodes*. Genève.

EXPLANATION OF PLATE XXIII.

B.	Cirrus pouch	H.	Testis.	SD.	Shell gland.
C.	Cirrus.	K.	Ovary.	U.	Uterus.
D.	Yolk gland.	L.	Vas deferens.	V.	Vagina.
E.	Egg-swallower.	N.	Nerve.	W.	Excretory canal.
G.	Yolk duct.	O.	Oviduct.		

Figures 1—5.

Crossobothrium angustum Linton.

- Fig. 1. Scolex. $\times 30$.
 Fig. 2. Middle segments. $\times 30$.
 Fig. 3. Posterior segments. $\times 30$.
 Fig. 4. Sagittal section through the posterior segment.
 Fig. 5. Diagram showing the interrelation of the genital organs.

Figures 6—11.

Orygmatobothrium velamentum n.sp.

- Fig. 6. Scolex and the anterior part of the body. $\times 20$.
 Fig. 7. Middle segments. $\times 20$.
 Fig. 8. Posterior segments. $\times 20$.
 Fig. 9. Cross section through the level of ovary.
 Fig. 10. Diagram showing the interrelation of the female organs.
 Fig. 11. Horizontal section (semi-diagrammatic).

Figures 12—13.

Acanthobothrium ijimui n.sp.

- Fig. 12. Hooks. $\times 80$.
 Fig. 13. Scolex. $\times 24$.

Figures 14—19.

Calliobothrium convolutum n.sp.

- Fig. 14. Posterior segments. $\times 5$.
 Fig. 15. Hooks. $\times 65$.
 Fig. 16. Cross section through the level of the ovary.
 Fig. 17. Interrelation of female organs.
 Fig. 18. Cirrus pouch. $\times 120$.
 Fig. 19. Egg-swallower. $\times 300$.

Figures 20—21.

Calliobothrium nodosum n.sp.

- Fig. 20. Hooks. $\times 150$.
 Fig. 21. Matured segment.