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NOTES ON THE STRUCTURE, DISTRIBUTION, AND SYNONOMY OF *DIPHYLLOBOTHRIUM LANCEOLATUM*

BY H. W. STUNKARD AND H. W. SCHOENBORN[1]

INTRODUCTION AND METHODS

This investigation was made on some 30 specimens of *Diphyllobothrium lanceolatum* (Krabbe, 1865) which were submitted to us by The American Museum of Natural History for identification (A.M.N.H. Cat. Nos. 180 to 191). The material was collected in 1933 from the intestine of the bearded seal, *Phoca barbata*, in the region of the St. Lawrence Island, off the Alaskan coast.

This species was first described, although very briefly, by Krabbe (1865), from the intestine of *Phoca barbata* collected at Godhavn, near Greenland. Zschokke (1903) gave a detailed description of specimens from the same host, collected at Svalbard, in the Arctic Ocean, which he assigned to the species described by Krabbe. Evidently unaware of Zschokke's description, Cholodkovsky (1914) reported cestodes of *P. barbata* from the Kara Sea which agreed with Krabbe's description and which he referred to *D. lanceolatum*. His description, however, is very superficial. Cooper (1921) recorded this species from Bernard Harbour and from Dolphin and Union Strait, in the Northwest Territories, and noted certain differences between the specimens examined by him and Zschokke's description.

Meggitt (1924*a* and *b*) gave a list of the described species of the genus *Diphyllobothrium*. Included in each list are 23 species which have been found in seals. In one list (1924*a*) he omitted *D. polycalceolum* (which he referred to the genus *Bothriocephalus*) and included *D. antarcticum*. In the other list (1924*b*) he omitted *D. antarcticum* but included *D. polycalceolum*. If both these species belong to the genus *Diphyllobothrium*, it contained, according to Meggitt, 24 species recorded from seals. But since *D. coniceps* and *D. schistochilos* are identical with *D. lanceolatum* (see Discussion), the total number of species is reduced to 22.

[1] Department of Biology, New York University, University College.

DESCRIPTION

The majority of the worms submitted to us were immature and fragmented, and consequently of little value, since specific identification of immature cestodes is impossible. Fixation of the material was so poor that the tissues were unsatisfactory for histological examination. Attempts to refix the worms were ineffectual and it appears that the specimens had undergone partial decomposition before the original fixation.

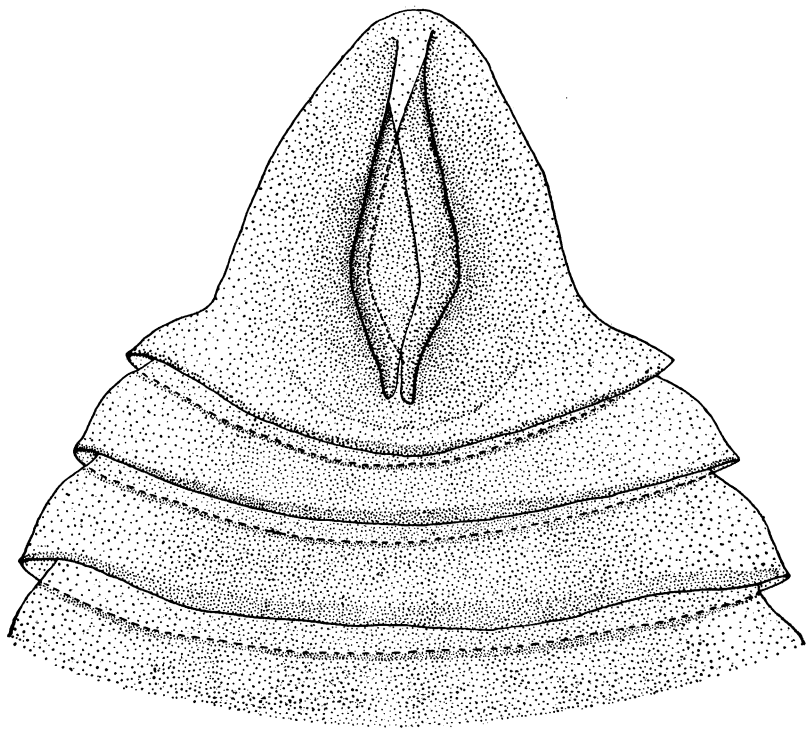

Fig. 1. Dorsal view of scolex and first two proglottids. ×63.

From external examination, there are a few differences between the specimens at our disposal and previous descriptions. Our examples measure 20–28 mm. in length and 3.5–4.0 mm. in width as compared to Zschokke's measurements of 25–45 mm. by 3.0–4.5 mm. Cooper (1921) recorded specimens 50–68 mm. in length and 2.9–4.0 mm. in width, and

Cholodkovsky (1914) found a length of 15–40 mm. with a maximum width of 6 mm.

Another difference is in the size and appearance of the scolex. Zschokke gave 1.3–2.4 mm. in length and 0.8–1.5 mm. in width as measurements of the scolex; the corresponding measurements in our examples are 0.8–1.1 mm. and 0.7–1.4 mm. It is noted that while the width is almost the same in the two cases, the minimal length given by Zschokke is greater than the maximum observed by us. Zschokke's description and figures show that the bothria extend the entire length of the scolex. In our specimens they do not extend the whole length of the scolex, but begin about 40μ from the anterior end and terminate within 68μ of the posterior border. Furthermore, in the examples studied by us, the posterior portion of the scolex forms a projecting edge which somewhat overlies the first proglottid (Fig. 1), but such a condition is not shown in Zschokke's figures. Although Cholodkovsky did not describe the posterior limit of the scolex, his figures show a condition identical with that present in our specimens; he gave 0.5 mm. as the length of the scoleces in his examples. It is difficult to determine whether these differences can be ascribed to degrees of contraction of the scoleces; however, this explanation seems probable. Greater contraction of the scoleces reported by Zschokke would make them shorter and might also give them the appearance of those observed in our specimens. Still further contraction of the scoleces of our examples would make them shorter and wider, and comparable to that figured by Cholodkovsky.

The total number of proglottids in our examples, which varies from 61 to 99, agrees very well with that found by Zschokke since he found 60–96 segments in his specimens. Other workers have failed to record the number of proglottids.

Zschokke gave 0.4–0.7 mm. as the width of proglottids behind the scolex, 3.0–4.5 mm. as the width of proglottids in the middle of the worm, and 1.2–2.0 mm. as the width of those at the posterior end. He stated that the length of segments remains unchanged over long distances of the strobila and that it is only at the posterior end that the proglottids become somewhat longer; in this region they are almost square. However, Zschokke gave no measurements of length of proglottids. In our specimens the length of the posterior segments is only slightly greater than the length of the more anterior ones; also the posterior segments, and especially the terminal one, are more or less square even though their dimensions of length and width are less than the corresponding dimensions given by Zschokke. The size of proglottids of our specimens are as

follows: anterior segments, 0.20–0.28 mm. long and 1.5–2.0 mm. wide; middle segments, 0.31–0.40 mm. long and 3.5–4.0 mm. wide; posterior segments, 0.28–0.45 mm. long by 0.28–0.59 mm. wide.

Although for the most part similar, there are several differences in internal anatomy to be noted between Zschokke's description and the specimens examined by us. The chief differences are in the reproductive systems. Zschokke described the testicular follicles as disposed in 9–13 rows transversely, left and right, from the lateral edge of the proglottid to the uterus, and 10–12 rows from the anterior border to the posterior border of the proglottid. He found them arranged in a single or double layer in the medullary portion—usually there was a double layer near the uterus. In our specimens there are 17–21 rows transversely, left and right, from the lateral edge of the proglottid to the uterus, and 5–7 rows from the anterior to the posterior border of the proglottid. Also, in our specimens, the testes, which measure about 55μ in diameter, are never arranged in a double layer, but they always occupy a single layer in the center of the medullary portion. Fuhrmann (1931) stated: "Es ist klar, dass die Form der Glieder einen bedeutenden Einfluss auf die Anordnung der verschiedenen Geschlechtsorgane hat, indem bei kurzen Gliedern dieselben übereinandergelagert sind, während bei langen Gliedern eine Hintereinanderlagerung erfolgt, und zwar so, dass entweder die weiblichen, seltener die männlichen Geschlechtsdrüsen nach hinten verschoben werden." Evidently the disposition of the testicular follicles is subject to considerable variation due to the contraction of the various sets of muscles within the proglottid.

Zschokke described the cirrus as being long and round; and he stated that the cirrus sac has a very large circumference, is roundish or oval in shape, and takes up the entire thickness of the medullary layer; however, he gave no measurements. In our specimens the cirrus sac has a diameter of about 160μ, lies in the anterior part of the segment, partly in the medullary layer and partly in the cortical layer of the ventral side; usually it does not occupy the entire thickness of the medullary portion, but leaves the dorsal third or more free. The seminal vesicle, as described by Zschokke, is attached dorsally to the cirrus sac; in our examples it measures about 55μ in diameter. The cirrus, which is often protruded, has a length of about 150μ and a width of 75μ.

With respect to the ovary, Zschokke stated: "Das Ovarium charakterisiert sich durch seine seitlich weit ausgezogenen, ausgiebig und locker in Röhren verästelten Flügel." The ovary in our specimens has lateral lobes composed of loosely arranged cells, but there are no finger-like

projections such as are noted and figured by Zschokke. It measures about 575μ from side to side and 200μ in greatest length; however, the ovary varies to some extent in size and shape in different segments of the same strobila.

According to Zschokke, the uterus has 5–7 lateral loops of which the anterior one on each side surrounds the cirrus sac while the remaining loops slant obliquely toward the posterior border of the proglottid. Cooper (1921) stated that the most anterior loops of the uterus, in his examples, did not extend on both sides of the cirrus sac, but rather that they were found behind the middle of it. In our specimens there are

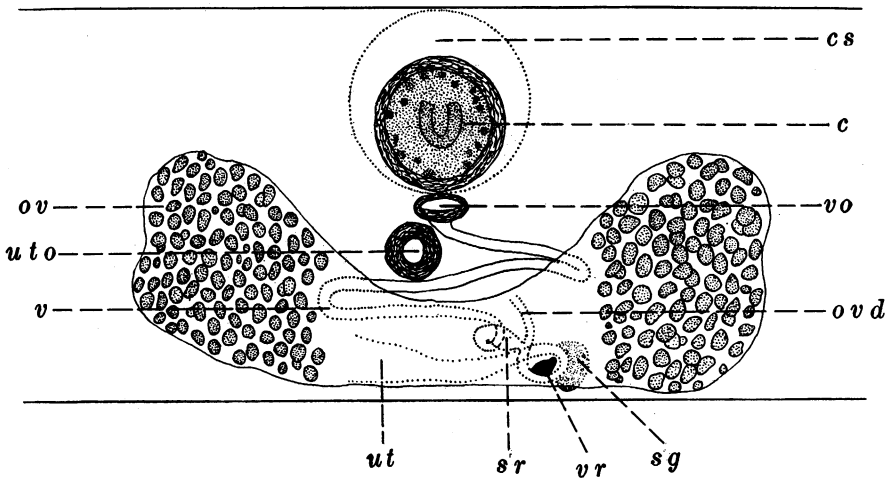

Fig. 2. Ventral view of central region of proglottid. Cells in the middle of the ovary are omitted in order to show the underlying oötype region. Semi-diagrammatic, ×300.

c, cirrus; *cs*, outline of cirrus sac; *ov*, ovary; *ovd*, oviduct; *sg*, shell gland; *sr*, seminal receptacle; *ut*, uterus; *uto*, uterine pore; *v*, vagina; *vo*, vaginal pore; *vr*, vitelline receptacle.

only 3–5 uterine loops on each side, and while the anterior loops surround the cirrus sac, the remaining loops do not always slant obliquely toward the posterior border of the segment. It is possible that the differences which have been observed may be explained by differences in degree of congestion in the uterus and differences in muscular contraction of the proglottid. In case the foremost loops of the uterus contained very few eggs, they might lie behind the cirrus sac as observed by Cooper. On becoming more distended, they would be extended laterally and possibly anteriorly to surround the cirrus sac as observed by Zschokke and by us.

Although the oötype region observed in our examples corresponds with that figured by Zschokke, one difference may be noted: namely, that Zschokke neither mentions nor figures a shell gland nor a vitelline receptacle while these structures were observed in almost every proglottid studied by us. After the opening of the seminal receptacle into the oviduct, the latter proceeds posteriorly and forms a loop dorsally and to the right. The shell gland lies posterior and lateral to the dorsal part of this loop, and the vitelline receptacle is attached anteriorly and dorsally to this same region. The latter structure, about 20μ in length, is distinguished by its deeply staining reaction with haematoxylin while the former structure, which measures about 55μ in diameter, is characterized by its refractory or "brilliant" appearance (Fig. 2).

Considerable variation has been recorded concerning the size of eggs. Some of the measurements which have been given are as follows:

Investigator	Length	Width
Krabbe (1865)	0.055–0.060 mm.	
Zschokke (1903)	0.062 mm.	× 0.040 mm.
Cholodkovsky (1914)	0.056 mm.	× 0.020 mm.
Cooper (1921)	0.064–0.068 mm.	× 0.040 mm.

In our specimens the length varies from 0.055 to 0.069 mm. and the width from 0.032 to 0.042 mm.; the size of the majority of eggs is 0.061 mm. × 0.040 mm.

Krabbe found ripe eggs in the 13th and 14th proglottids, Zschokke in the 30th, Cooper in the 45th to 60th, while in our specimens ripe eggs were first seen in the 15th to 29th segments.

With respect to the nervous system, excretory system, musculature, and calcareous bodies described by Zschokke, our material shows no differences or does not permit comparison.

DISCUSSION

Even though there are certain minor differences between the examples described by Zschokke and those examined by us, these differences are not considered of sufficient importance to justify specific distinction, especially since the two groups of specimens agree so closely in the majority of anatomical features. Therefore these cestodes are assigned to the species *Diphyllobothrium lanceolatum* (Krabbe, 1865). The observations here recorded suggest the amount of variation which occurs in the structure of the species.

Germanos (1895) described *D. schistochilos* as a new species from the

intestine of *Phoca barbata*. Von Linstow (1905) described another new species, *D. coniceps*, from the intestine of the same host. The major differences between these descriptions and the structure of *D. lanceolatum* is in the size and shape of the scolex, and in the size of the proglottids. However, these differences may be due to differences in the degree of contraction of the specimens studied; hence, *D. schistochilos* (Germanos, 1895) and *D. coniceps* (Linstow, 1905) are here considered synonomous with *D. lanceolatum* (Krabbe, 1865).

The following is a list of species of the genus *Diphyllobothrium* found in seals.[1] Several of these species are inadequately described and further study may show them to be invalid.

Species	Host
D. antarcticum (Baird, 1853) (*Bothriocephalus, Dibothriocephalus*, and *Diplogonoporus antarcticus*)	*Ommatophoca rossi, Phoca* sp.
D. archeri (Leiper and Atkinson, 1914) (*Dibothriocephalus archeri*)	*Ogmorhinus weddelli*
D. clavatum Railliet and Henry, 1912	" "
D. coatsi (Rennie and Reid, 1912) (*Dibothriocephalus coatsi*)	" "
D. cordatum (Leuckart, 1863) (*Bothriocephalus, Dibothriocephalus*, and *Dibothrium cordatum*)	*Phoca barbata, P. groenlandica, Trichechus rosmarus*
D. elegans (Krabbe, 1865) (*Bothriocephalus* and *Dibothriocephalus elegans*)	*Cystophora cristata, Phoca vitulina Eumetopias jabata*
D. hians (Diesing, 1850) (*Bothriocephalus phocae foetidae* Creplin 1825, *B. hians, Dibothriocephalus* and *Dibothrium hians*)	*Monachus albiventer, Phoca barbata, P. hispida, P. vitulina*
D. lanceolatum (Krabbe, 1865) (*Bothriocephalus* and *Dibothriocephalus lanceolatus, Diphyllobothrium schistochilos*, and *D. coniceps*)	*Phoca barbata*
D. lashleyi (Leiper and Atkinson, 1914) (*Dibothriocephalus lashleyi*)	*Ogmorhinus weddelli*
D. latum (Linnaeus, 1735) (Synonymy of this species appears in Stiles and Hassall's Index Catalogue of Medical and Veterinary Zoology)	*Cystophora cristata, Monachus albiventer, Phoca barbata, P. hispida, P. vitulina, Trichechus rosmarus*
D. macrophallum (Linstow, 1905) (*Bothriocephalus macrophallus*)	*Phoca barbata, Arctocephalus ursinus*

[1] This list, with the exception of *D. polycalceolum* and the synonymy of *D. lanceolatum*, is taken from Meggitt (1924*a*). In this paper Meggitt considered *D. polycalceolum* as being in the genus *Bothriocephalus*.

Species	Host
D. mobilis (Rennie and Reid, 1912) (*Dibothriocephalus mobilis*)	*Ogmorhinus weddelli*
D. perfoliatum Railliet and Henry, 1912	" "
D. polycalceolum (Ariola, 1896) (*Bothriocephalus* and *Dibothriocephalus polycalceolus*)	*Phoca vitulina*
D. quadratum (Linstow, 1891) (*Bothriocephalus* and *Dibothriocephalus quadratus*)	*Ogmorhinus leptonyx*
D. resimum Railliet and Henry, 1912	*?Hydrurga leptonyx*
D. rufum Leiper and Atkinson, 1914	*Ogmorhinus weddelli*
D. römeri (Zschokke, 1903) (*Dibothriocephalus römeri*)	*Trichechus rosmarus*
D. scoticum (Rennie and Reid, 1912) (*Dibothriocephalus scoticus*)	*Ogmorhinus leptonyx*
D. scotti (Shipley, 1907) (*Dibothriocephalus scotti*)	*Ommatophoca rossi*
D. tectum (Linstow, 1892) (*Bothriocephalus* and *Dibothriocephalus tectus*)	*Macrorhinus leoninus*
D. wilsoni (Shipley, 1907) (*Dibothriocephalus wilsoni*)	*Ogmorhinus weddelli, Ommatophoca rossi*

SUMMARY

1.—Additions are made to Zschokke's (1903) account of the structure of *Diphyllobothrium lanceolatum* (Krabbe, 1865), and some of the variations which have been observed in this species are recorded.

2.—*D. schistochilos* (Germanos, 1895) and *D. coniceps* (Linstow, 1905) are considered synonyms of *D. lanceolatum*.

3.—A check list of the diphyllobothrid species occurring in seals is given.

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