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The First Report of Human Infection with *Diphyllobothrium scoticum* (Rennie et Reid, 1912)

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Abstract

A diphyllobothriid strobila lacking the scolex, measuring 1370 mm in length and 14 mm in maximum width, was expelled from a 30-year-old Japanese seaman after the treatment with bithionol. The specimen revealed several unique morphological characteristics as follows: (1) the trapezoid segments, (2) the small cirrus sac with simple ejaculatory duct, situating obliquely, (3) the relatively large seminal vesicle situated right behind the cirrus sac, connecting with the latter in the same main axis, (4) the terminal part of uterus forming thick-walled pocket, exhibiting a cone or diamond shape when distended with eggs. In these characteristics it was readily distinguished from all the previously known species of diphyllobothriid cestodes excepting *D. scoticum* (Rennie et Reid, 1912). The cestode agree closely with Markowski's description of *D. scoticum* in most morphological details, and it is identified as *D. scoticum* despite lack of the scolex.

Key words: cestodes, diphyllobothriids, *Diphyllobothrium*, human infection, marine species, tapeworm

Introduction

During the course of review studies on diphyllobothriids in Japan, Kamo *et al.* (1972) suspected the occurrence of human infection with some marine species of *Diphyllobothrium*. Since "Koga-Okamura type" (Kamo *et al.*, 1977) was proposed as the first evidence of human infection with *Diphyllobothrium* species of marine origin, the following species have been recorded in Japan: *D. yonagoense* by Yamane *et al.* (1981), *D. cameroni* by Kamo *et al.* (1981), *D. pacificum* by Kamo *et al.* (1982) and by Makiya *et al.* (1987), "Koga-Okamura type" by Hasegawa *et al.* (1984) and by Kagei *et al.* (1987). In addition, a few cases with unidentified species were recorded by Yazaki *et al.* (1986) and Kamo *et al.* (1986).

Careful examinations of our specimen, which was expelled from a 30-year-old seaman after the treatment with bithionol on May 1, 1979, revealed unique morphological characteristics different from those of the above-mentioned species. Moreover, it did not coincide with any description of known diphyllobothriid species except for *D. scoticum* (Rennie et Reid, 1912).

Materials and Methods

A strobila was expelled from a seaman, E. M., 30-year-old, after the treatment with bithionol at Ohmuta Municipal Hospital, Fukuoka Prefecture, on May 1, 1979. The patient had experiences of eating raw euphausiid crustacean on the voyage to the Antarctic Ocean, and of discharging a worm fragment of about 1000 mm long on April 22, 1979. No special symptom was observed, and no abnormality was found on both physical and laboratory examinations.

The yellowish-brown, thick strobila without the scolex, measuring 1370 mm in length and 14 mm in maximum width, has been preserved in 10% formalin solution. Whole mount prepa-

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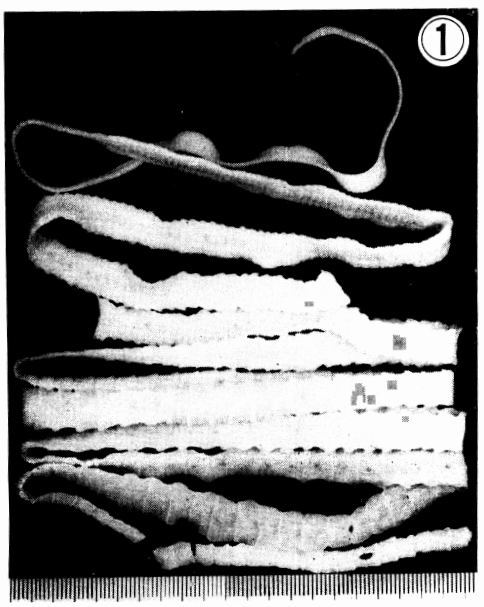
rations of mature and gravid segments were stained with Semichon's acetic carmine. Serial sections of mature segments were prepared in sagittal and transversal planes, being stained with modified trichrome staining solution. The eggshell surface was observed by the crushing method (Maejima *et al.*, 1983) and by the scanning electron microscopy.

Morphological Descriptions

(All measurements given are in millimeters)

The specimen lacking scolex moderately relaxed, body length 1370, comprised of about 500 segments, maximum width 14 attained at middle to posterior part of strobila. Strobila somewhat muscular, with markedly serrate margins. Segments typically trapezoid, wider than long, with length increasing posteriad. Length/width ratio of pregravid segments about 1:4; of gravid segments about 1:1.5; of terminal segments as much as 1:1 (Fig. 1). Excretory system including longitudinal and transverse ducts in parenchyma and numerous interconnected ducts in cortical region. Innermost layer of longitudinal muscle fibers well developed, as much as 0.154–0.206. Adjacent layer of circular fibers fairly developed (Fig. 11). Genital pore visible within 130 posterior to scolex, situated ventrally on midline at somewhat far (about 1/3–1/2 of segmental length) from anterior margin of segment. Genital atrium lined by rounded papillae. Cirrus sac piriform, small (0.216–0.268 long × 0.144–0.165 in diameter), situated obliquely, opening anteriorly into genital atrium. Ejaculatory duct in cirrus sac nearly straight. Seminal vesicle subspherical (0.196–0.278 long × 0.247–0.360 in diameter), with undulating wall, situated right behind cirrus sac, connecting with latter in the same main axis (Figs. 4, 5, 9). Subspherical testes rather few, 0.082–0.144 in greatest diameter, arranged in single layer (Fig. 11). Vagina running anteriad, then turning ventrad along posterior surface of cirrus sac, opening into genital atrium and posterior to opening of cirrus sac (Fig. 5). Bilobed ovary situated transversely near posterior margin of segment, ovarian lobes directed laterad, extending beyond margins of uterine loops. Margins of ovarian lobes usually rounded, and bordered



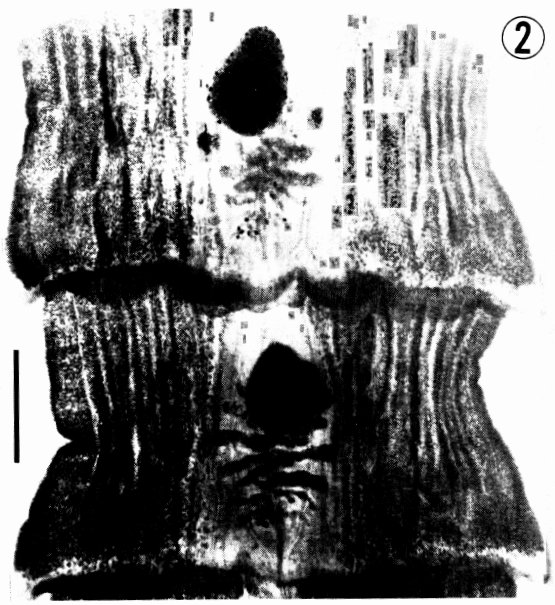


Fig. 1 Whole body.
Fig. 2 Whole mount of gravid segments. Scale bar = 2 mm.

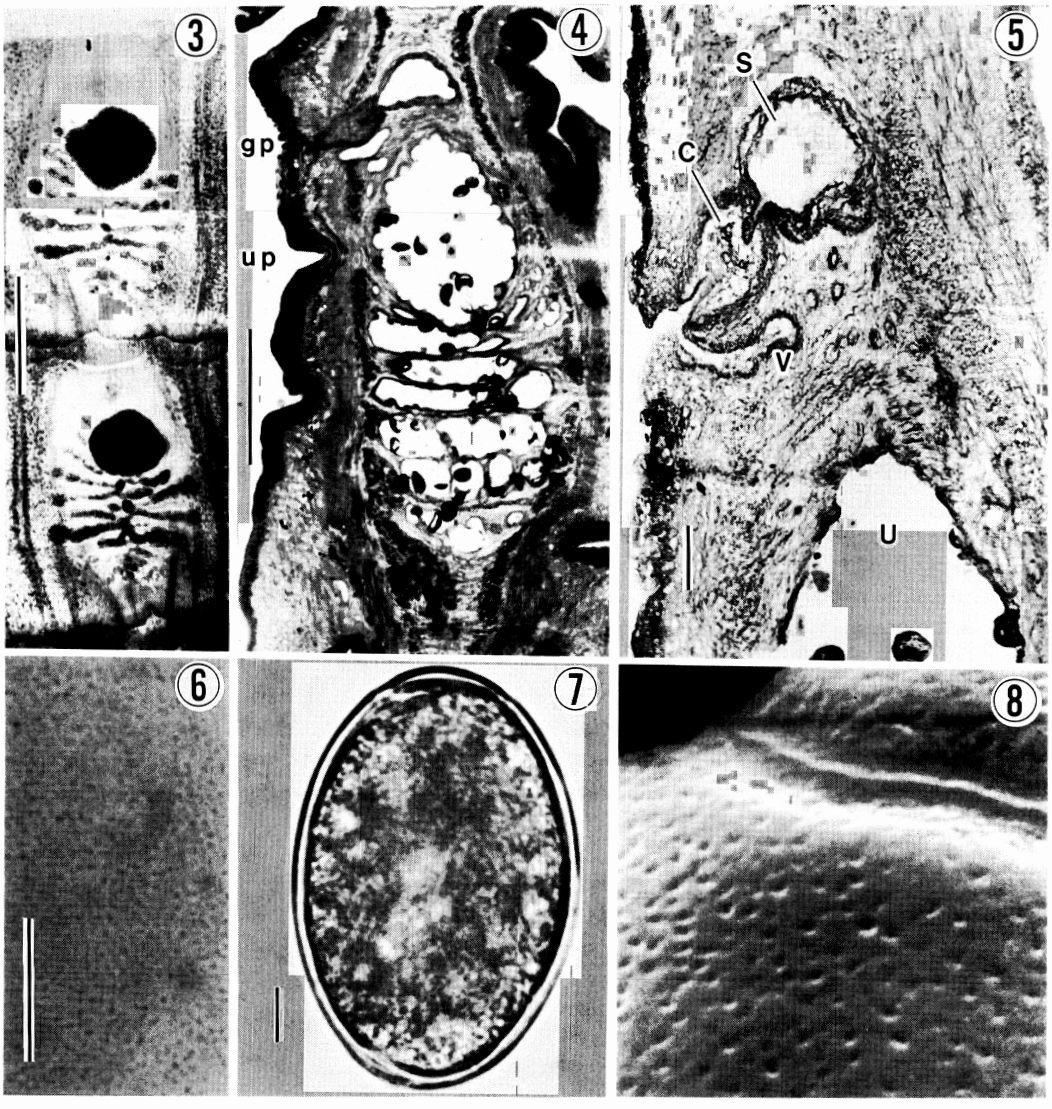


Fig. 3 Uterine field of gravid segments. Scale bar = 2 mm.
Fig. 4 Sagittal section of gravid segment, showing arrangement of genital organs. Scale bar = 0.5 μm. gp: genital atrium, up: uterine pore.
Fig. 5 Sagittal section of gravid segment, showing relative position of cirrus sac to seminal vesicle. Scale bar = 0.1 μm. C: cirrus sac, S: seminal vesicle, U: uterus, V: vagina.
Fig. 6 Eggshell surface by crushing method. Scale bar = 10 μm.
Fig. 7 Egg. Scale bar = 10 μm.
Fig. 8 Eggshell surface by SEM. ×7000.

Fig. 9 Sagittal section enlarged, showing genital atrium. Scale bar = 0.1 μm. C: cirrus sac, gp: genital atrium, S: seminal vesicle, U: uterus, V: vagina.
Fig. 10 Sagittal section enlarged, showing uterine pore and modification of terminal uterus. Scale bar = 0.1 μm. U: uterine pocket, up: uterine pore.
Fig. 11 Cross section of segment through level of ovarian isthmus. Scale bar = 0.5 μm. lm: longitudinal muscle layer, N: nerve trunk, O: ovary, T: testis, tm: transverse muscle layer, vt: vitelline follicle.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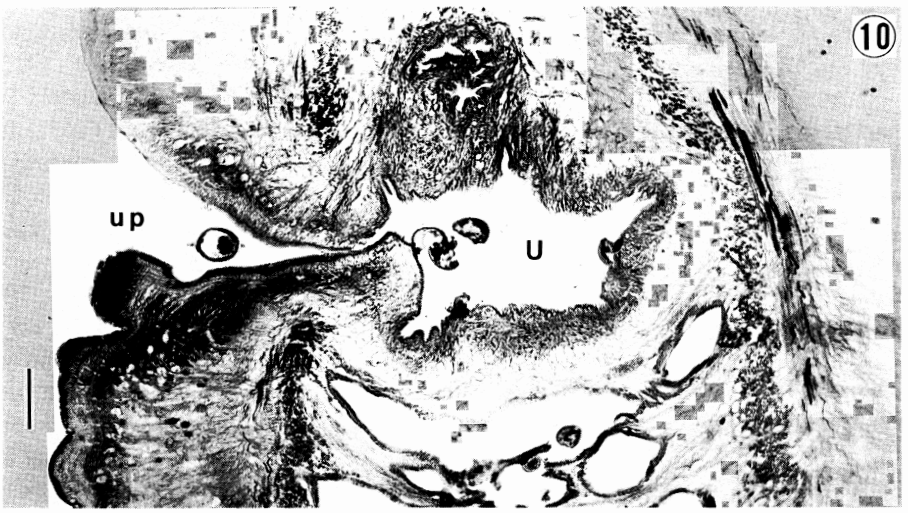
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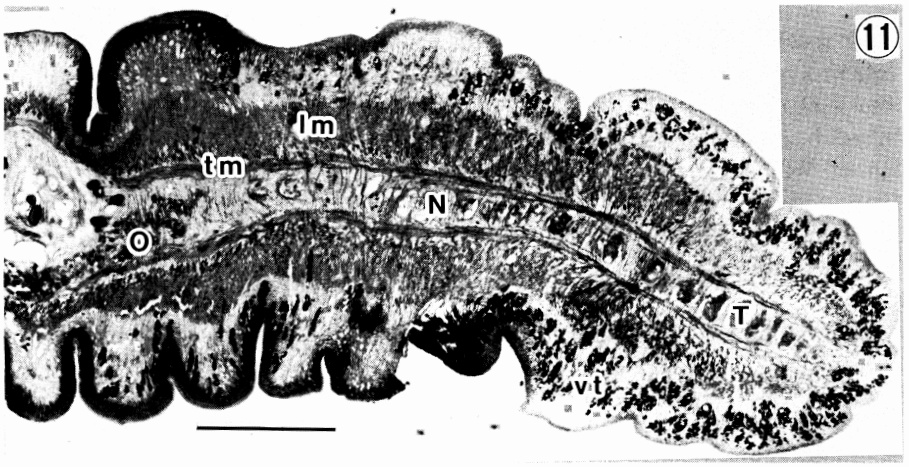
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by longitudinal excretory canals. Vitelline follicles elongate (0.082–0.154 × 0.015–0.031), forming two lateral field (Fig. 11). Uterine loops 6–8 in number on each side, not so much extending laterad. Terminal part of uterus formed thick-walled pocket, exhibiting cone or diamond shape when distended strongly with eggs, but not extending anteriad beyond cirrus sac (Figs. 2, 3). Uterus opening through uterine pore distantly posterior to genital pore at middle of terminal uterine pocket (Figs. 4, 10). Eggs subspherical with or without apical knob, 0.070–0.077 × 0.047–0.054 (avg. 0.074 × 0.050). Surface of thick (0.003–0.004) eggshell distributed densely with small deep pits (Figs. 6–8).

Discussion

The characteristic egg of our specimen, which has the large width, thick eggshell, and eggshell surface densely distributed with small deep pits, enabled us to distinguish it from the so-called freshwater species of the genus *Diphyllobothrium* such as *D. latum* (Linné, 1758), *D. dendriticum* (Nitzsch, 1824), *D. ditremum* (Creplin, 1825), *D. ursi* Raush, 1954, *D. vogeli* Kuhlow, 1953, and also *D. nihonkaiense* Yamane *et al.*, 1986, which have relatively small width, thin eggshell, and smooth eggshell surface sparsely distributed with shallow pits (Hilliard, 1972, Maejima *et al.*, 1983).

The marine species of the genus *Diphyllobothrium* hitherto recorded from human cases were as follows: *D. cordatum* (Leuckart, 1863) from Greenland by Leuckart (1863); *D. alascense* Rausch et Williamson, 1958, *D. dalliae* Rausch, 1956 and *D. lanceolatum* (Krabbe, 1865) from Alaska by Rausch and Hilliard (1970); *D. pacificum* (Nybelin, 1931) from Peru by Baer *et al.* (1967), from Chile by Atias and Cattan (1976), Sagua *et al.* (1976), from Japan by Kamo *et al.* (1982) and Makiya *et al.* (1987); *D. yonagoense* Yamane *et al.*, 1981 and *D. cameroni* Rausch, 1969 from Japan by Yamane *et al.* (1981) and Kamo *et al.* (1981), respectively.

According to Delamure *et al.* (1985), the following 18 species so far recorded from various marine mammals and birds were recognized as valid species in addition to the above-mentioned species from humans: *D. stemmacephalum* Cobbold, 1858; *D. antarcticum* (Baird, 1853); *D. arctocephalinum* Johnston, 1937; *D. elegans* (Krabbe, 1865); *D. fuhrmanni* Hsü, 1935; *D. gondo* Yamaguti, 1942; *D. hians* (Diesing, 1850); *D. lashleyi* (Leiper et Atkinson, 1914); *D. macroovatum* Jurachno, 1973; *D. mobile* (Rennie et Reid, 1912); *D. perfoliatum* (Railliet et Henry, 1912); *D. phocarum* Delamure *et al.*, 1964; *D. polyrugosum* Delamure et A. Skriabin, 1966b; *D. pterocephalum* Delamure et A. Skriabin, 1966a; *D. quadratum* (Linstow, 1892); *D. romeri* (Zschokke, 1903); *D. scoticum* (Rennie et Reid, 1912), and *D. wilsoni* (Shipley, 1907). Besides, *D. colymbi* was described by Yamaguti (1951) from a red-throated driver, *Colymbus stellatus*. Recently Andersen (1987) proposed the following two new species: *D. rauschi* and *D. minutus* from Hawaiian monk seal. She also proposed the reinstatement of *D. scotti* Shipley, 1907.

Of these species only *D. scoticum* resembled our specimen in the modification of the terminal uterine duct, forming a thick-walled pocket, and in the relative position of the cirrus sac to the seminal vesicle, situating in the same main axis. Nevertheless our specimen was different from *D. scoticum* in the following morphological characteristics. The terminal part of the uterus formed a cone or diamond shape when distended with eggs in our specimen, while no such distention was found in *D. scoticum*. Uterine loops were of a "rosette" type but not formed spiral coils in our specimen, while they were not of a "rosette" type but formed spiral coils in *D. scoticum* (Markowski, 1952). However, these differences of the uterine forms in the terminal part and loops are probably attributable to the volume and the site of stored eggs in proportion to the maturation.

Our specimen was easily distinguished from other previously described species of the genus

Diphyllobothrium in its unique morphological characteristics such as trapezoid segments, obliquely situated small cirrus sac with nearly straight ejaculatory duct, relatively large seminal vesicle situated right behind the cirrus sac, connecting with the latter in the same main axis, and a cone- or diamond-shaped distension with eggs of terminal uterus. It was also different from two undetermined species from humans described by Kamo *et al.* (1986) as well as *D.* sp. ind. originated from plerocercoids from Japanese surfsmelt by Yazaki *et al.* (1986).

In conclusion, this specimen should be identified as *Diphyllobothrium scoticum* (Rennie et Reid, 1912) despite lack of the scolex.

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