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Two Piscicolid Leeches (Hirudinida) and their Cocoons on Snow Crabs *Chionoecetes opilio* in Japan, with the First Record of *Johanssonia arctica* from the Sea of Japan

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Abstract. Two piscicolid leeches, *Notostomum cyclostomum* and *Johanssonia arctica*, were found on the exoskeleton of snow crabs *Chionoecetes opilio* from the continental slope in the Sea of Japan off Kyoto, Japan. The finding of *J. arctica* constitutes the first record from the Sea of Japan and extends its southernmost limit of distribution from Funka Bay (Hokkaido, western North Pacific) to the Sea of Japan off central Japan. *Chionoecetes opilio* is recorded as a new substratum for *J. arctica* in Japan to deposit its cocoons. The external morphology of the leeches is briefly described. The cocoons of *N. cyclostomum* mostly occurred on the dorsal carapace surface, whereas those of *J. arctica* on the ventral femoral surface of the walking legs.

Key words: Piscicolid leech, *Notostomum cyclostomum*, *Johanssonia arctica*, snow crab, *Chionoecetes opilio*, cocoon, Sea of Japan.

Introduction

Two species of piscicolid leeches, *Notostomum cyclostomum* Johansson, 1898 and *Johanssonia arctica* (Johansson, 1898), have been reported from deep-sea crabs in Japanese waters. *Notostomum cyclostomum* was first reported by Oka (1910) as *Carcinobdella kanibir* based on specimens from *Chionoecetes* (as "*Chionecetes*") sp. in the Sea of Japan off Fukui. Later, Oka (1927, 1933) described the external and internal morphology of the species from snow crabs *Chionoecetes* (as "*Chionecoetes*" and "*Chionecoectes*") *opilio* (O. Fabricius, 1788). Moore & Meyer (1951) collected *N. cyclostomum* in the Sea of Japan off "Oshima" (36°03′N, 135°52′E), Fukui. Using a sledge net, Ito (1984) sampled non-infecting specimens of the species from the muddy bottom at depths of 200–300 m in the Sea of Japan off Niigata. While cruising on a research submersible, Nagasawa & Yamasaki (1990) observed the behavior of *N. cyclostomum* attached to the dorsal carapace of *C. opilio* at a depth of 270 m in the Sea of Japan off Kyoto. The other leech *J. arctica* was recently reported by Furiness *et al.* (2007) from red snow crabs (as "Beni-zuwai crab") *Chionoecetes japonicus* Rathbun, 1932 collected in Funka Bay (western North Pacific Ocean), Hokkaido. No further report is available on *J. arctica* in Japan.

Snow crabs *Chionoecetes opilio* are commercially caught in the Sea of Japan off central and western Japan (Shinoda, 1982). The species is highly appreciated as food, being one of the most expensive shellfishes in the country. Leech cocoons are often found on the exoskeleton of snow crabs at fish markets and sometimes cause food hygiene problems

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because the public are nervous about the parasites of aquatic animals.

In Japan, our knowledge of the leeches occurring on snow crabs is limited, and there has been no investigation on the cocoons on snow crabs. Thus, as part of studies on piscicolid leech and deep-sea crab association, we made observations on the leeches and their cocoons found on snow crabs from the Sea of Japan off central Japan.

Materials and Methods

Snow crabs *Chionoecetes opilio* were captured at depths of 271 m and 233–237 m on the continental slope in the Sea of Japan (35°59′N, 135°06–09′E; 35°53′N, 134°59′–135°00′E) off Kyoto using conical traps during research cruises of the R/V *Heian maru* on February 20 and April 11, 2007. Water temperature and salinity near the bottom (260 m deep) on February 20, 2007 were 1.03°C and 34.06 *psu*. Snow crabs with leeches and/or cocoons were sorted from the catch, observed, and photographed on board. Leech specimens were collected from the exoskeleton of the infected crabs and fixed in 80% ethanol on board without relaxation. Later, some leeches were transferred to 5% formalin for measurements and observation of the coloration of their body. Measurements (mm) based on 10 adult specimens and 10 cocoons of each leech species include the range, followed by the mean in parentheses. Voucher specimens are deposited in the annelid (An) collection at the National Science Museum, Tokyo, Japan (NSMT-An 383 and 384 for *Notostomum cyclostomum* and *Johanssonia arctica* with their cocoons, respectively).

Results

Leeches of two size-groups were found on the snow crabs examined: the large and small leeches were identified as *Notostomum cyclostomum* (Fig. 1A, Fig. 2A–C) and *Johanssonia arctica* (Fig. 1B, Fig. 2D–F), respectively.

Notostomum cyclostomum was always observed on the dorsal carapace surface. Up to three individuals were attached to a single infected host. The body of specimens is elongate and cylindrical, 58.0–75.0 (66.5) in total length (including both suckers) and 3.5–7.4 (5.7) in maximum body width. The body color in formalin is pale orange with bands of irregu-

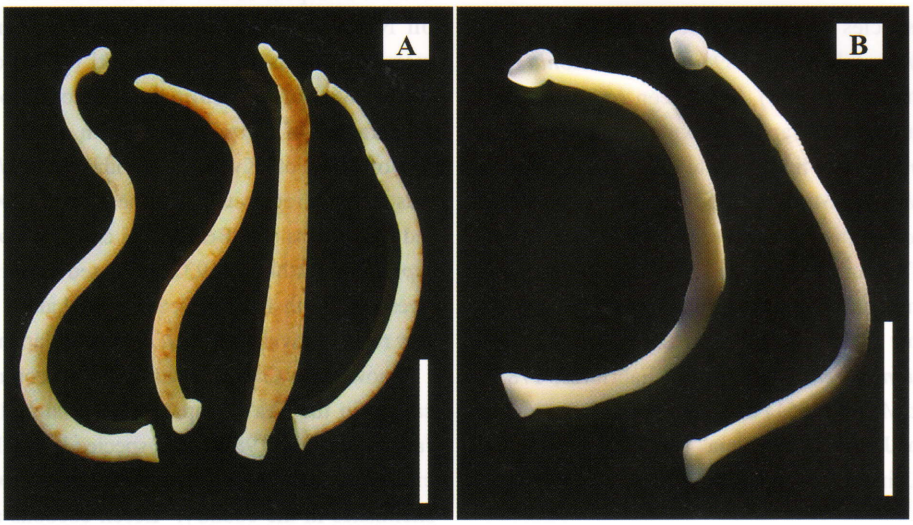

Fig. 1. *Notostomum cyclostomum* (A) and *Johanssonia arctica* (B) from snow crabs in the Sea of Japan off Kyoto, Japan. Scale bars: 20 mm in A; 5 mm in B.

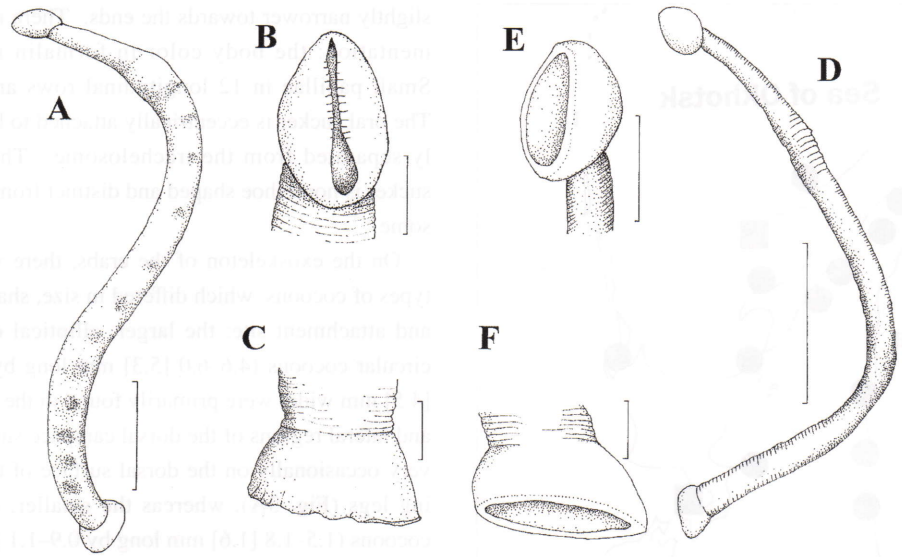

Fig. 2. *Notostomum cyclostomum* (A–C) and *Johanssonia arctica* (D–F) from snow crabs in the Sea of Japan off Kyoto, Japan. A. Whole body, dorsolateral view. B. Oral sucker, ventral view. C. Caudal sucker, lateral view. D. Whole body, lateral view. E. Oral sucker, ventrolateral view. F. Caudal sucker, ventrolateral view. Scale bars: 10 mm in A; 2 mm in B–C; 3 mm in D; 0.4 mm in E–F.

lar brown blotches. No eyes or ocelli are present. The body surface is smooth without tubercles and pulsatile vesicles. There is a distinct clitellum, on which the female gonopore is well visible. There is no obvious division between trachelosome and urosome. The oral sucker is eccentrically attached to the trachelosome and deeply cupped. The caudal sucker is terminal, deeply cupped, and very muscular. The oral and caudal suckers are sharply separated from the trachelosome and urosome, respectively.

Johanssonia arctica was usually found on the ventral surface of the walking legs. One or two individuals were observed on a single infected crab. The body of specimens is subcylindrical, 11.0–22.0 (15.9) in total length (including both suckers) and 0.8–1.7 (1.1) in maximum body width, becoming

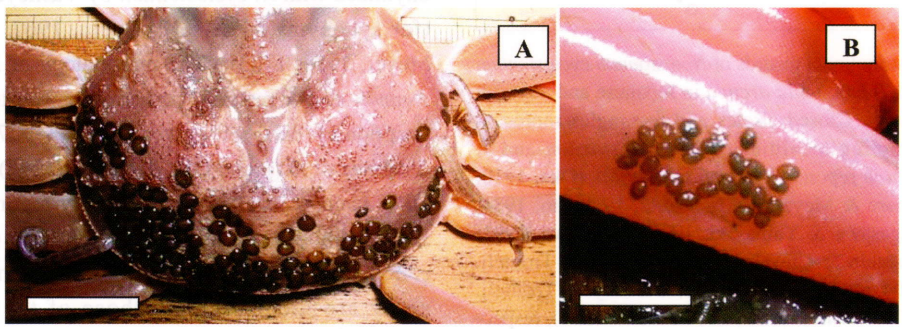

Fig. 3. A. Cocoons and three adults of *Notostomum cyclostomum* attached to the dorsal carapace surface of a snow crab. B. Cocoons of *Johanssonia arctica* on the ventral femoral surface of the third pair of walking legs of a snow crab. Scale bars: 40 mm in A; 8 mm in B.

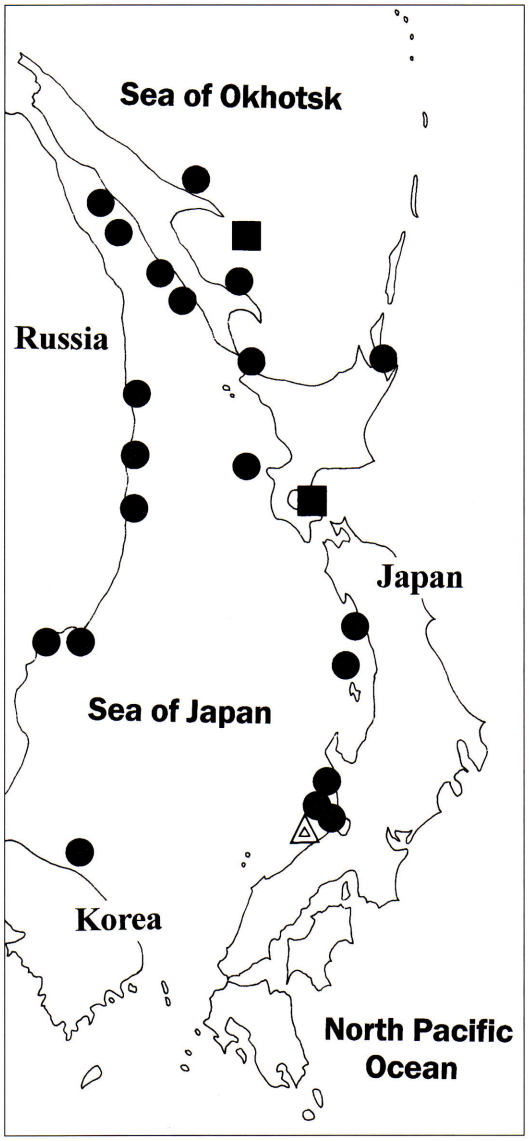

Fig. 4. Distributional records of *Notostomum cyclostomum* and *Johanssonia arctica* in Japanese and adjacent waters. Closed circles and rectangles represent sampling localities of *N. cyclostomum* and *J. arctica* reported by previous authors (Oka, 1910; Moore & Meyer, 1951; Suzuki, 1979; Ito, 1984; Nagasawa & Yamasaki, 1990; Nagasawa, 1991; Epshtein & Utevsky, 1996; Utevsky & Trontelj, 2004 for *N. cyclostomum*; Utevsky & Trontelj, 2004; Furiness *et al.*, 2007 for *J. arctica*), respectively, and a double triangle shows the sampling locality of the two leeches in the present study.

slightly narrower towards the ends. There is no pigmentation: the body color in formalin is white. Small papillae in 12 longitudinal rows are found. The oral sucker is eccentrically attached to but clearly separated from the trachelosome. The caudal sucker is horseshoe shaped and distinct from the urosome.

On the exoskeleton of the crabs, there were two types of cocoons, which differed in size, shape, color and attachment site: the larger, elliptical or nearly circular cocoons (4.6–6.0 [5.3] mm long by 3.8–5.5 [4.5] mm wide) were primarily found in the posterior and lateral regions of the dorsal carapace surface and very occasionally on the dorsal surface of the walking legs (Fig. 3A), whereas the smaller, elliptical cocoons (1.5–1.8 [1.6] mm long by 0.9–1.1 [1.0] mm wide) occurred on the ventral femoral surface of the second and third pairs of walking legs (Fig. 3B). The color of the larger cocoons was dark purple, but that of the smaller ones dark brown. The larger and the smaller cocoons were identified as those depositd by *N. cyclostomum* and *J. arctica*, respectively. The number of cocoons found on a single crab was up to 114 for *N. cyclostomum* and ranged from 1–25 for *J. arctica*.

Discussion

In Japan, *Notostomum cyclostomum* was first described by Oka (1910) as a new genus and species, *Carcinobdella kanibir*, which was, however, synonymized with *N. cyclostomum* by Vasileyev (1939) (for synonymy see also Epshtein, 1967; Khan & Meyer, 1976: 1703). The morphology of *N. cyclostomum* of our material corresponds well to the description of the species given by Oka (1927), Moore & Meyer (1951), and Oka & Nagao (1965). On the other hand, *J. arctica* was currently reported from Japan without morphological information (Furiness *et al.*, 2007). The specimens examined in the present study are identical with those of the species described by previous authors (Moore & Meyer, 1951; Epshtein, 1968; Meyer & Khan, 1979; Appy & Dadswell, 1981; Burreson, 2006). The biology of

J. arctica was reviewed by Sawyer (1986: 622–625) and Burreson (2006: 580–581). The snow crab *Chionoecetes opilio* is herein recorded as a new substratum for *J. arctica* to deposit its cocoons in Japan, where only the red snow crab *C. japonicus* has hitherto been known to harbor the leech (Furiness *et al.*, 2007).

Notostomum cyclostomum is distributed in the northern North Pacific Ocean and adjacent seas, including the Sea of Japan, Sea of Okhotsk, Bering Sea, and off the coast of southeastern Alaska and northwestern British Columbia (Oka, 1910; Moore & Meyer, 1951; Meyer & Barden, 1955; Epshtein, 1961, 1962; Oka & Nagao, 1965; Sloan *et al.*, 1984; Utevsky, 1994; Khan & Paul, 1995; Epshtein & Utvesky, 1996; Utvesky & Trontelj, 2004; Williams & Burreson, 2006; Utvesky *et al.*, 2007). It also occurs in the Arctic Ocean (Madill, 1988). In Japan, six reports are available on localities where the species was collected, all referring to the Sea of Japan (Fig. 4; Oka, 1910; Moore & Meyer, 1951; Suzuki, 1979; Ito, 1984; Nagasawa & Yamasaki, 1990; Nagasawa, 1991). Although no detailed locality information was given, Epshtein & Utevsky (1996: 28) showed two localities off the east and north coasts of Hokkaido in the distribution map of the species. Snow crabs also occur in the western North Pacific Ocean off northern Honshu, Japan (Kitagawa, 2000), but no information is available on leech infection of the crabs in this region. For understanding of the geographical distribution of *N. cyclostomum*, it is desirable to study its occurrence on snow crabs in a wider range of waters around Japan.

Johanssonia arctica is a species with a circumpolar distribution: its occurs in the Arctic Ocean (off Greenland through the Barents Sea, Kara Sea, and Laptev Sea to the East Siberian Sea; Epshtein, 1961, 1962, 1968; Madill, 1988; Karlsbakk *et al.*, 2005), the northern North Pacific Ocean (Stepovak Bay, Alaska Peninsula south to off California; Moore & Meyer, 1951; Sawyer, 1986; Burreson, 2006), the Sea of Okhotsk (Utvesky & Trontelj, 2004) and the northern North Atlantic Ocean (off the east coast of Canada and off Norway; Meyer & Khan, 1979; Khan *et al.*, 1980; Appy & Dadswell, 1981; Khan, 1982*a*, *b*; Khan & Paul, 1995; Williams & Burreson, 2006; Savoie *et al.*, 2007; Utvesky *et al.*, 2007). The finding of *J. arctica* in this study represents the first record from the Sea of Japan (Fig. 4) and extends its distributional range from Funka Bay (Hokkaido: Furiness *et al.*, 2007) further south to the Sea of Japan off Kyoto, which is the southernmost locality for the species. No information is as yet available on its occurrence off the Pacific coast of Honshu, the main island of Japan.

Water temperature may be important in determining the vertical distribution of the leeches in the oceans. For example, fasted individuals of *J. arctica* experimentally kept in jars at 5, 10, and 15°C all died within 14 days but those held at 0°C remained alive (Khan, 1982). This species can also continuously and slowly grow even at 0–1°C (Khan, 1982*a*). In the Sea of Japan, both snow crabs *Chionoecetes opilio* and red snow crabs *C. japonicus* are found (Yosho & Hayashi, 1994; Yosho & Shirai, 2007), but their vertical distribution patterns are different at 200–1,500 m in depth: the former species occurs mostly in less than 300 m, while the latter in more than 800 m (Shinoda, 1982). In this sea, water temperature rapidly decreases between the surface and 200 m but gradually declines to about 0.15°C in the deeper waters (Yosho & Hayashi, 1994). In the present study, water temperature near the bottom (260 m in depth) was 1.03°C. Thus it might be interesting to study utilization of two crabs by the two leeches at different water temperatures and at different depths in the Sea of Japan.

The cocoons of *N. cyclostomum* were primarily found on the dorsal carapace surface of snow crabs. Similar observations were made by several authors (Sloan *et al.*, 1984; Khan & Paul, 1995; Epshtein & Utvesky, 1996). The cocoons of *J. arctica*, unlike those of *N. cyclostomum*, are usually found on the walking legs (Meyer & Khan, 1979; Khan, 1982*a*; Khan & Paul, 1995; this study). The morphology of cocoons of *J. arctica* was described by Meyer & Khan (1979).

Both *N. cyclostomum* and *J. arctica* have been reported to feed on the blood of marine fishes and utilize crabs for cocoon deposition in the deep sea where there are almost no hard substrates on soft and muddy bottoms (Khan, 1982*a*, *b*; Sloan *et al.*, 1984). The leeches are also known to act as vectors of trypanosomes and piroplasms that are transmitted to marine fishes (Khan, 1980, 1982*a*, 1984, 1991; Sloan *et al.*, 1984; Khan *et al.*, 1991; Karlsbakk *et al.*, 2005; Hemmingsen *et al.*, 2005). Such information is not available for Japan although there is a record of *J. arctica* from a sculpin *Icelus cataphractus* (Pavlenko, 1910) (Scorpaeniformes: Cottidae) in Terpenia Bay, southern Sakhalin (Russia), near Hokkaido (Furiness *et al.*, 2007). We need research on fish hosts of the leeches and other aspects of their biology, such as the life history and the role of vectors.

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Literature Cited

Appy, R. G. & Dadswell, M. J., 1981. Marine and estuarine piscicolid leeches (Hirudinea) of the Bay of Fundy and adjacent waters with a key to species. *Can. J. Zool.*, **59**: 183–192.

Burreson, E. M., 2006. Phylum Annelida: Hirudinea as vectors and disease agents. *In* Woo, P. T. K. (Ed.), *Fish Diseases and Disorders*, **1**: 566–591. CAB International, Oxfordshire.

Epshtein, V. M., 1961. A review of the fish leeches (Hirudinea: Piscicolidae) from the northern seas of SSSR. *Dokl. Akad. Nauk SSSR*, **141**: 1501–1511. (English translation).

———, 1962. A survey of fish leeches (Hirudinea: Piscicolidae) from the Bering and Okhotsk Seas and from the Sea of Japan. *Dokl. Akad. Nauk SSSR*, **144**: 1181–1184. (English translation).

———, 1967. On relations and geographic distribution of fish leeches (Hirudinea, Piscicolidae) of the genus *Carcinobdella* Oka, 1910. *Zool. Zh.*, **46**: 1648–1654 (in Russian with English abstract).

———, 1968. Revision of the genera *Oxytonostoma* and *Johanssonia* (Hirudinea, Piscicolidae). *Zool. Zh.*, **47**: 1011–1021. (English translation).

Epshtein, V. M. & Utevsky, S. Y., 1996. The geographical distribution and hosts of the *Notostomum* leeches (Hirudinea, Piscicolidae). *Vest. Zool.*, **30** (3): 26–31 (in Russian with English abstract).

Furiness, S., Williams, J. I., Nagasawa, K. & Burreson, E. M., 2007. A collection of fish leeches (Hirudinida: Piscicolidae) from Japan and surrounding waters, including redescriptions of three species. *J. Parasit.*, **93**: 875–883.

Hemmingsen, W., Jansen, P. A. & MacKenzie, K., 2005. Crabs, leeches and trypanosomes: an unholy trinity? *Mar. Poll. Bull.*, **50**: 336–339.

Ito, K., 1984. Ecological studies on the edible crab, *Chionoecetes opilio* O. Fabricius in the Japan Sea. IV. Distribution and ecology of the larvae at the early bottom life stage in the coastal waters of Niigata Prefecture. *Bull. Japan Sea reg. Fish. Res. Lab.*, **34**: 19–41 (in Japanese with English abstract).

Karlsbakk, E., Haugen, E. & Nylund, A., 2005. Morphology and aspects of growth of a trypanosome transmitted by the marine leech *Johanssonia arctica* (Piscicolidae) from Northern Norway. *Folia parasitol.*, **52**: 209–215.

Khan, R. A., 1980. The leech as a vector of a fish piroplasm. *Can. J. Zool.*, **58**: 1631–1637.

———, 1982*a*. Biology of the marine piscicolid leech *Johanssonia arctica* (Johansson, 1898) from Newfoundland. *Proc. helminth. Soc. Wash.*, **49**: 266–278.

———, 1982*b*. Biology of a leech ectocommensal on the spider crab, *Chionoecetes opilio*. *Alaska Sea Grant Rep.*, **82** (10): 681–694.

———, 1984. Simultaneous transmission of a piscine piroplasm and trypanosome by a marine leech. *J. Wildl. Dis.*, **20**: 339–341.

———, 1991. Trypanosome occurrence and prevalence in the marine leech *Johanssonia arctica* and its host preferences in the northwestern Atlantic Ocean. *Can. J. Zool.*, **69**: 2374–2380.

Khan, R. A. & Meyer, M. C., 1976. Taxonomy and biology of some Newfoundland marine leeches (Rhynchobdellae: Piscicolidae). *J. Fish. Res. Bd Can.*, **33**: 1699–1714.

Khan, R. A. & Paul, A. J., 1995. Life cycle studies on Arcto-boreal leeches (Hirudinea). *J. helminth. Soc. Wash.*, **62**: 105–110.

Khan, R. A., Barrett, M. & Murphy, J., 1980. Blood parasites of fish from the northwestern Atlantic Ocean. *Can. J. Zool.*, **58**: 770–781.

Khan, R. A., Lee, E. M. & Whitty, W. S., 1991. Blood protozoans of fish from the Davis Strait in the northwestern Atlantic Ocean. *Can. J. Zool.*, **69**: 410–413.

Kitagawa, D., 2000. Distribution and some biological characters of the snow crab *Chionoecetes opilio* in the Pacific region of the northeastern Honshu, Japan. *Bull. Tohoku natn. Fish. Res. Inst.*, **63**: 109–118 (in Japanese with English abstract).

Madill, J., 1988. New Canadian records of leeches (Annelida: Hirudinea) parasitic on fish. *Can. Fld Nat.*, **102**: 685–688.

Meyer, M. C. & Barden, Jr., A. A., 1955. Leeches symbiotic on Arthropoda, especially decapod Crustacea. *Wasmann J. Biol.*, **13**: 297–311.

Meyer, M. C. & Khan, R. A., 1979. Taxonomy, biology and occurrence of some marine leeches in Newfoundland waters. *Proc. helminth. Soc. Wash.*, **46**: 254–264.

Moore, J. P. & Meyer, M. C., 1951. Leeches (Hirudinea) from Alaskan and adjacent waters. *Wasmann J. Biol.*, **9**: 11–77.

Nagasawa, K., 1991. Notes on parasites of aquatic organisms-16. Leeches. *Aquabiology*, **13**: 296–297 (in Japanese).

Nagasawa, K. & Yamasaki, A., 1990. Is *Notostomum cyclostomum* a vampire of snow crabs? —Deep-water observations of the leech using a research submersible 'Shinkai 2000'. *Umiushi Tsushin*, **8**: 36–38 (in Japanese).

Oka, A., 1910. Synopsis der Japanischen Hirudineen, mit Diagnosen der Neuen Species. *Annotnes zool. jap.*, **7**: 165–183.

———, 1927. Sur la morphologie externe de *Carcinobdella kanibir*. *Proc. imp. Acad. Japan*, **3**: 171–174.

———, 1933. Sur l'organisation intérieure de la *Carcinobdella kanibir*. *Proc. imp. Acad. Japan*, **9**: 188–190.

Oka, A. & Nagao, Z., 1965. *Carcinobdella kanibir* Oka. *In* Okada, Y., Uchida, S. & Uchida, T. (Eds), *New illustrated Encyclopedia of the Fauna of Japan*, Part 1: 571. Hokuryu-kan Publishing, Tokyo. (In Japanese).

Savoie, L., Miron, G. & Biron, M., 2007. Fouling community of the snow crab *Chionoecetes opilio* in Atlantic Canada. *J. crust. Biol.*, **27**: 10–36.

Sawyer, R. T., 1986. Feeding biology, ecology, and systematics. *Leech Biology and Behaviour*, **2**: 419–793. Oxford Univ. Press, Oxford.

Shinoda, M., 1982. Fisheries for the genus *Chionoecetes* in Southwest Japan Sea. *Alaska Sea Grant Rep.*, **82** (10): 421–441.

Sloan, N. A., Bower, S. M. & Robinson, S. M. C., 1984. Cocoon deposition on three crab species and fish parasitism by the leech *Notostomum cyclostoma* from deep fjords in northern British Columbia. *Mar. Ecol. prog. Ser.*, **20**: 51–58.

Suzuki, S., 1979. *Marine Invertebrates in Yamagata Prefecture, Japan*. 360 pp. Tamakibi-kai, Yamagata. (In Japanese).

Utevsky, S. Y., 1994. New information on the distribution of marine fish leeches of the genus *Notostomum* (Hirudinea: Piscicolidae). *Can. Fld Nat.*, **108**: 370–371.

Utevsky, S. Y. & Trontelj, P., 2004. Phylogenetic relationships of fish leeches (Hirudinea, Piscicolidae) based on mitochondrial DNA sequences and morphological data. *Zoologica Scr.*, **33**: 375–385.

Utevsky, S. Y., Utvesky, A. Y., Schiaparelli, S. & Trontelj, P., 2007. Molecular phylogeny of pontobdelline leeches and their place in the descent

of fish leeches (Hirudinea, Piscicolidae). *Zoologica Scr.*, **36**: 271–280.

Vasileyev, E. A., 1939. The Ichthyobdellidae of the Far East. *Trudy Karels. gosud. Pedagogich. Inst., Biol. Ser.*, **1**: 25–68. (English translation.)

Williams, J. I. & Burreson, E. M., 2006. Phylogeny of the fish leeches (Oligochaeta, Hirudinida, Piscicolidae) based on nuclear and mitochondrial genes and morphology. *Zoologica Scr.*, **35**: 627–639.

Yosho, I. & Hayashi, I., 1994. The bathymetric distribution of *Chionoecetes opilio* and *C. japonicus* (Majidae; Brachyura) in the western and northern areas of the Sea of Japan. *Bull. Japan Sea natn. Fish. Res. Inst.*, **44**: 59–71.

Yosho, I. & Shirai, S., 2007. Bathymetric distribution and migration of *Chionoecetes japonicus* at the northeastern part of Yamato Bank, the Sea of Japan. *Nippon Suisan Gakkaishi*, **73**: 674–683 (in Japanese with English abstract).

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