

New records of a freshwater fish parasite *Argulus japonicus* (Branchiura: Argulidae) from northern Honshu, Japan, with a note on its occurrence in a brackish water lake

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New records of a freshwater fish parasite *Argulus japonicus* (Branchiura: Argulidae) from northern Honshu, Japan, with a note on its occurrence in a brackish water lake

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Abstract.—One and two specimens of *Argulus japonicus* Thiele, 1900 were collected from the body surface of big-scaled redbfin *Pseudaspius hakonensis* (Günther, 1877) (Cypriniformes: Leuciscidae) in the Babame River, Akita Prefecture, and Lake Jusan, Aomori Prefecture, northern Honshu, Japan, respectively. This is two new prefecture records in Japan and a new host record for *A. japonicus*. Lake Jusan is the northernmost collection locality of this parasite in Japan recorded from wild fishes. As Lake Jusan is a brackish water lake and big-scaled redbfin is known to migrate from fresh to salt waters, and since *A. japonicus* completes its life cycle in fresh waters, we infer that the two individuals of *A. japonicus* parasitized the big-scaled redbfin in an inflowing river, then this fish was collected along with the surviving argulid individuals after migrating to the lake. The collection of *A. japonicus* in Lake Jusan represents the second record for the species from brackish water lakes in Japan.

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Key words: parasitic crustacean, fish louse, new locality record, new host record, northern Honshu, big-scaled redbfin

■ Introduction

Argulus japonicus Thiele is an ectoparasite of freshwater fishes (Yamaguti, 1963; Neethling & Avenant-Oldewage, 2016) distributed in East/Southeast Asia (Poly, 2008). This species was originally described by Thiele (1900) from a female specimen collected in Japan, where it has since been studied for various aspects of its biology (Nagasawa, 2009, 2011). In Japan, it is known to occur on all of the four major islands (Hokkaido, Honshu, Shikoku, and Kyushu) (e.g., Nagasawa *et al.*, 1989, 2010, 2012, 2018, 2021, 2023c; Nagasawa & Sato, 2014; Nagasawa, 2017, 2018, 2019, 2021, 2023a, b), but much remains poorly studied on its distribution in the northern region of Honshu. Although there are six prefectures (Aomori, Iwate, Miyagi, Akita, Yamagata, and Fukushima) in this region, *A. japonicus* has been reported only from Miyagi Prefecture (Nagasawa *et al.*, 2022, 2023b). During a parasitological survey of freshwater fishes in northern Honshu, we collected specimens of *A. japonicus* from big-scaled

redfin *Pseudaspius hakonensis* (Günther, 1877) (Cypriniformes: Leuciscidae) from Akita and Aomori prefectures. This represents two new prefecture records in Japan and a new host record for *A. japonicus*.

■ Materials and Methods

Ten individuals of big-scaled redfin were caught with a scoop net in the middle-reaches of the Babame River (39°56'36"N, 140°07'53"E) at Takasaki-Hirogano in Gojome, Akita Prefecture, on 30 July 2015 (Fig. 1, locality 2). These fish were transported frozen to the laboratory of Hiroshima University, where they were thawed, measured for their standard length (SL, mm), and examined for metazoan parasites. Seven individuals of big-scaled redfin were also caught with a small fixed net installed in coastal waters of a brackish water lake, Lake Jusan (41°00'17"N, 140°21'32"E), at Jusan in Goshogawara, Aomori Prefecture, on 26 September 2016 (Fig. 1, locality 1). They were transported alive to the laboratory of Hirosaki University and similarly examined for their SL and metazoan parasites. When crustacean parasites were found at both laboratories, they were carefully taken from the hosts using forceps and preserved in 70% ethanol. Later, these specimens were observed under an Olympus SZX10 stereo microscope and an Olympus BX51 phase-contrast compound microscope at the Aquaparasitology Laboratory. Identification was made using the wooden slide procedure recommended by Humes & Gooding (1964) and Benz & Otting (1996). The specimens were soaked in lactophenol for two hours before observation under the compound microscope, and drawings were made with the aid of a drawing tube attached to this microscope. After the specimens were identified, they were recorded for their sex and total length (TL, from the anterior tip of the carapace to the posterior tip of the abdomen). They have been deposited in the Crustacea (Cr) collection of the National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture (NSMT-Cr 31502, one specimen from the Babame River; NSMT-Cr 31503, two specimens from Lake Jusan). The scientific and common names of fishes mentioned in this paper follow Hosoya (2015), except for those of *P. hakonensis* and the common names of *Carassius cuvieri* Temminck & Schlegel, 1846 and *Cyprinus carpio* Linnaeus, 1758, which are based on Froese & Pauly (2023).

■ Results

Argulus japonicus was collected from one (122 mm SL) of the 10 big-scaled redfin [86–122 (mean = 97) mm SL] in the Babame River, Akita Prefecture, and from two (216 and 230 mm SL) of the seven big-scaled redfin [190–230 (215) mm SL] in Lake Jusan, Aomori Prefecture. The number

of *A. japonicus* per infected fish was one in both localities, and the species was found on the host's operculum (in the Babame River) and body surface (in Lake Jusan).

The collected specimens of *A. japonicus* (Fig. 2) are all females, being 3.1 (from the Babame River), 3.9, and 6.0 mm TL (from Lake Jusan). They are morphologically characterized by a dorsoventrally flattened body; a nearly circular carapace, covering the first to third pairs of legs; compound eyes visible in the frontal region of the carapace; a naupliar eye present dorsally along midline of the carapace; the ventral surface of the frontal and lateral regions of the carapace ornamented with numerous, small sharply pointed spines; posterolateral lobes of the carapace separated by a sinus, ending each in a rounded margin; paired respiratory areas, each comprising a small anterior area and a large posterior area; the thorax consisting of four segments, each bearing a pair of legs; a bilobed abdomen ending in a rounded tip; the first and second antennae found beneath the frontal region of the carapace; the preoral sheath and stylet located along the midline posterior to the second antennae; the mouth tube longer than wide, becoming wider posteriorly; the first maxillae forming cup-like suckers; the second maxillae each with a robust first segment bearing three large projections; the first to fourth pairs of legs biramous, each comprising the coxa, basis, exopod, and endopod; and the fourth pair of legs each with the coxa forming a natatory lobe. In addition, the number of plumose setae on the posterior margin of the coxa in each of the first legs is constantly one (Fig. 3). The number of supporting rods per first maxilla ranges from 45 to 54 (52 and 54 in a specimen from the Babame River; 46 and 46, and 45 and 49, in two specimens from Lake Jusan, respectively).

The body of the frozen-thawed specimen is nearly transparent and its respiratory areas are pale brown (Fig. 2A, B), whereas the body of the ethanol-preserved specimen is white and its carapace and thorax have dark brown dorsal spots (Fig. 2C, D).

Remarks

The morphological characters of the specimens collected in this study are almost identical to those of female *A. japonicus* reported by Tokioka (1936a), Yamaguti (1937), and Nagasawa (2021), and the specimens are herein identified as this species.

In Japan, three species of the genus *Argulus*, i.e., *A. japonicus*, *A. coregoni* Thorell, 1864, and *A. mongolianus* Tokioka, 1939, have been reported from wild freshwater fishes (Nagasawa *et al.*, 2022). Of these species, *A. japonicus* and *A. coregoni* bear a morphological resemblance to each other (Tokioka, 1936a; Yamaguti, 1937) and show no strict host specificity (Nagasawa, 2011, 2021), and the latter species also occurs in northern Honshu (Nagasawa & Ishikawa, 2015; Nagasawa *et al.*,

2019, 2020, 2023a). Thus, it is necessary to distinguish *A. japonicus* from *A. coregoni* using reliable morphological characters. As reported above, the specimens collected in this study have the first pair of legs each with a single plumose seta on the posterior margin of the coxa (Fig. 3), which can be used as is one of the features to differentiate *A. japonicus* from *A. coregoni* (Nagasawa, 2021; Nagasawa *et al.*, 2022, 2023b); the latter species has more than four plumose setae on the same posterior margin (4–7 in Yamaguti, 1937; 4–9 in Hoshina, 1950; 6 in Nagasawa & Taniguchi, 2021). Moreover, the present specimens have 45–54 supporting rods per first maxilla. This number is almost similar to those reported from *A. japonicus* (*ca.* 50 in Tokioka, 1936a; 40–50 in Yamaguti, 1937; 50 and 52 in Nagasawa, 2021; 46–51 in Nagasawa *et al.*, 2023b; 47 and 48 in Nagasawa *et al.*, 2023c). In contrast to this, *A. coregoni* has usually more than 60 supporting rods (*ca.* 60 in Tokioka, 1936a; 60–70 in Yamaguti, 1937; 54–73 in Hoshina, 1950; 67 and 72 in Nagasawa & Taniguchi, 2021).

While there are some records of diseasecausing argulid branchiurans or fish lice in northern Honshu, their identification has not been made based on morphological and/or molecular features (Nagasawa *et al.*, 2023b). In this region, *A. japonicus* is known to occur only in two small lakes (Lake Izunuma and Lake Uchinuma), Miyagi Prefecture (Nagasawa *et al.*, 2022, 2023b), and the present collection of the species extends its distribution range from Miyagi Prefecture northward to Akita and Aomori prefectures (Fig. 1). Furthermore, *A. japonicus* was reported from common carp *Cyprinus carpio* from Hokkaido Island north of Honshu (Nagasawa *et al.*, 1989; Nagasawa, 1994, 2018) but there is no record of this parasite from wild freshwater fishes of the island. Thus, Lake Jusan represents the northernmost collection locality in Japan for *A. japonicus* recorded from wild fishes.

Big-scaled redbfin, from which we collected the specimens of *A. japonicus*, is distributed in East Asia surrounding the Sea of Japan, including the Japanese Archipelago, the eastern Korean Peninsula, Primorsky Kray, and Sakhalin Island (Russia) (Sakai *et al.*, 2002; Watanabe *et al.*, 2018). To date, *A. japonicus* has not been reported from this fish species in Japan (Nagasawa & Katahira, 2013) and the above adjacent regions (*e.g.*, Smirnova, 1971; Sokolov *et al.*, 2012). Here, big-scaled redbfin is regarded as a new host of *A. japonicus*.

■ Discussion

Since *A. japonicus* completes its life cycle in fresh waters (Tokioka, 1936b), it is interesting to

note that this parasite was collected in Lake Jusan, which is connected to the Sea of Japan and its salinity often exceeds 20 psu in coastal waters near the mouth of the Iwaki River, one of the rivers flowing into the lake (Umeda *et al.*, 2008). A similar occurrence in both freshwater and salt waters has been reported in three other *Argulus* species: *A. dartevellei* Braian, 1940 in Congo (Fryer, 1960), *A. kosus* Avenant-Oldewage, 1994 in South Africa (Van As *et al.*, 1999), and *A. flavescens* Wilson, 1916 in North America (Causey, 1960; Cressey, 1972; Suárez-Morales *et al.*, 1998). In Japan, *A. japonicus* was previously collected in droughtinduced brackish waters in Lake Shinji, and Nagasawa (2019) has suggested that this parasite could survive in those lake waters for a certain period along with its euryhaline host, Japanese white crucian carp *Carassius cuvieri* (Cypriniformes: Cyprinidae). This fish usually occurs in fresh waters but can stay even in brackish waters (Suzuki & Kimura, 1977, 1978). As big-scaled redbfin is also a euryhaline species and some individuals migrate from fresh to salt waters for feeding and growth (Nakamura, 1969; Sakai, 1995), *A. japonicus* may be able to survive in brackish waters of Lake Jusan when this parasite is attached on such lake-migrating big-scaled redbfin.

Based on the above consideration, Lake Jusan is not regarded as the habitat constantly utilized by *A. japonicus*, and this parasite is very likely to maintain its populations in the rivers flowing into the lake. The Iwaki River is the largest among those rivers, and at least 20 species of freshwater fishes are found in its middle-reaches, where big-scaled redbfin is the most abundant, followed by fat minnow *Phoxinus lagowskii steindachneri* Sauvage, 1883, pale chub *Opsariichthys platypus* (Temminck & Schlegel, 1846), and ayu *Plecoglossus altivelis altivelis* (Temminck & Schlegel, 1846) (Izumi *et al.*, 2006). It is thus reasonable to infer that big-scaled redbfin serves as a host for *A. japonicus* in the Iwaki River and some of its infected individuals migrate to Lake Jusan. In addition, pale chub has been reported as a host of *A. japonicus* in other localities of Japan (Nagasawa & Sato, 2014; Nagasawa, 2017; Nagasawa *et al.*, 2023c) and this fish may also harbor the parasite in the Iwaki River.

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■ Literature Cited

- Benz, G. W. & Otting, R. L., 1996. Morphology of the fish louse (*Argulus*: Branchiura). Drum and Croaker, 27: 15–22.
- Causey, D., 1960. “Creepin, blastit wonner” or on the misidentification of common *Argulus* of freshwater fish. Turtox News, 38: 70–75.

- Cressey, R. F., 1972. The genus *Argulus* (Crustacea: Branchiura) of the United States. Biota of Freshwater Ecosystems. Identification Manual 2. 14 pp. Environmental Protection Agency, Washington, DC.
- Froese, R. & Pauly, D. (eds.), 2023. FishBase. World Wide Web electronic publication (<http://www.fishbase.org>, version (02/2023). Accessed 5 July 2023.
- Fryer, G., 1960. Studies on some parasitic crustaceans on African freshwater fishes, with descriptions of a new copepod of the genus *Ergasilus* and a new branchiuran of the genus *Chonopeltis*. Proceedings of the Zoological Society of London, 133: 629–647.
- Hoshina, T., 1950. Über eine *Argulus*-Art im Salmonidenteiche. Bulletin of the Japanese Society of Scientific Fisheries, 16: 239–243.
- Hosoya, K., (ed.), 2015. Freshwater Fishes of Japan. 527 pp. Yama-Kei Publishers, Tokyo. [In Japanese with English title]
- Humes, A. G. & Gooding, R. U., 1964. A method for studying the external anatomy of copepods. Crustaceana, 6: 238–240.
- Izumi, M., Ito, R., Yataya, K. & Azuma, N., 2006. Ascending fishes and hydraulic characteristics of the full-cross-sectional overflow stepped-pool type fishway in the Iwaki River diversion weir of the Iwaki River. Transactions of the Japanese Society of Irrigation, Drainage and Rural Engineering, 245: 55–64. [In Japanese with English abstract]
- Nagasawa, K., 1994. Parasitic Copepoda and Branchiura of freshwater fishes of Hokkaido. Scientific Report of the Hokkaido Fish Hatchery, 48: 83–85.
- Nagasawa, K., 2009. A synopsis of branchiurans of the genus *Argulus* (Crustacea, Argulidae), ectoparasites of freshwater and marine fishes, in Japan (1900–2009). Bulletin of the Biogeographical Society of Japan, 64: 135–148. [In Japanese with English abstract]
- Nagasawa, K., 2011. The biology of *Argulus* spp. (Branchiura, Argulidae) in Japan: A review. In: A. Asakura, R. T. Bauer, A. H. Hines, M. Thiel, C. Held, C. Schubart, J. M. Furse, J. Coughran, A. Baeza, K. Wada, T. Yamaguchi, T. Kawai, S. Ohtsuka, M. V. Archdale & M. Moriyasu, (eds.), New Frontiers in Crustacean Biology, Proceedings of the TCS Summer Meeting, Tokyo, 20–24 September 2009, Crustaceana Monographs, 15: 15–21.
- Nagasawa, K., 2017. *Argulus japonicus* (Branchiura: Argulidae) parasitic on a freshwater minnow, *Opsariichthys platypus* (Cyprinidae): the second record from Shikoku, western Japan. Biogeography, 19: 50–52.
- Nagasawa, K., 2018. *Argulus japonicus* (Branchiura: Argulidae) parasitic on a koi carp, *Cyprinus carpio*, reared in Hokkaido, northern Japan. Bulletin of the Biogeographical Society of Japan, 73: 203–205. [In Japanese with English abstract]
- Nagasawa, K., 2019. Survival of *Argulus japonicus* (Branchiura: Argulidae) on a cyprinid in drought-induced brackish waters in a Japanese lake. Crustacean Research, 48: 99–103.

- Nagasawa, K., 2021. *Argulus japonicus* (Branchiura: Argulidae) parasitic on largemouth bass *Micropterus salmoides* in Japan, with the morphology of the adult female of the argulid. Crustacean Research, 50: 119–129.
- Nagasawa, K., 2023a. A freshwater fish parasite *Argulus japonicus* (Branchiura: Argulidae) from Hiroshima Prefecture, western Japan. Nature of Kagoshima, 50: 33–36. [In Japanese with English abstract]
- Nagasawa, K., 2023b. Occurrence of fish parasites *Argulus japonicus* and *Argulus coregoni* (Crustacea: Branchiura: Argulidae) in the Lake Biwa Basin, central Japan. Species Diversity, 28: 217–223.
- Nagasawa, K. & Ishikawa, T., 2015. *Argulus coregoni* (Branchiura: Argulidae) parasitic on the torrent catfish *Liobagrus reini* in Japan. Biogeography, 17: 99–102.
- Nagasawa, K. & Katahira, H., 2013. A synopsis of the parasites from cyprinid fishes of the genus *Tribolodon* in Japan (1908–2013). Biosphere Science, 52: 87–115.
- Nagasawa, K. & Sato, H., 2014. Two crustacean parasites, *Argulus japonicus* (Branchiura) and *Lernaea cyprinacea* (Copepoda), from freshwater fishes in Gunma Prefecture, Japan, with a new host record for *A. japonicus*. Bulletin of Gunma Museum of Natural History, 18: 65–68.
- Nagasawa, K. & Taniguchi, R., 2021. Second record of *Argulus coregoni* (Branchiura: Argulidae) from acheilognathine fish (Cyprinidae): its infection of an oily bitterling *Tanakia limbata* in central Japan. Taxa, Proceedings of the Japanese Society of Systematic Zoology, 51: 29–37. [In Japanese with English abstract]
- Nagasawa, K., Awakura, T. & Urawa, S., 1989. A checklist and bibliography of parasites of freshwater fishes of Hokkaido. Scientific Report of the Hokkaido Fish Hatchery, 44: 1–49.
- Nagasawa, K., Katahira, H. & Mizuno, K., 2010. New host and locality of the fish ectoparasite *Argulus japonicus* (Crustacea, Branchiura, Argulidae) in Japan, with a note on its heavy infection. Biogeography, 12: 17–20.
- Nagasawa, K., Murase, T., Yanagi, S. & Maeno, K., 2012. *Argulus japonicus* Thiele (Crustacea: Branchiura) from Kyushu, western Japan, with a note on its heavy infection of koi carp (*Cyprinus carpio*) and Japanese crucian carp (*Carassius cuvieri*). Biosphere Science, 51: 15–20. [In Japanese with English abstract]
- Nagasawa, K., Nitta, M. & Kawai, K., 2018. *Argulus japonicus* (Branchiura: Argulidae) parasitic on a lakeweed chub, *Ischikauia steenackeri* (Cyprinidae), in northern Kyushu, Japan. Biogeography, 20: 122–124.
- Nagasawa, K., Ishikawa, T. & Gôma, Y., 2019. New record of a freshwater fish parasite *Argulus coregoni* (Branchiura: Argulidae) from Akita Prefecture, northern Honshu, Japan. Biogeography, 21: 51–53.
- Nagasawa, K., Sato, M. & Yagisawa, M., 2020. Record of a skin parasite *Argulus coregoni* from

- wild and farmed salmonids in Akita Prefecture, northern Honshu, Japan. *Nature of Kagoshima*, 47: 91–95. [In Japanese with English abstract]
- Nagasawa, K., Fujino, Y. & Nakano, H., 2021. The three-lips, *Opsariichthys uncirostris uncirostris* (Cyprinidae), a new host of *Argulus japonicus* (Branchiura: Argulidae), with its first host record from Lake Biwa, Japan. *Nature of Kagoshima*, 48: 37–39.
- Nagasawa, K., Asayama, T. & Fujimoto, Y., 2022. Redescription of *Argulus mongolianus* (Crustacea: Branchiura: Argulidae), an ectoparasite of freshwater fishes in East Asia, with its first record from Japan. *Species Diversity*, 27: 167–179.
- Nagasawa, K., Iwashita, M., Kimijima, Y., Kitamura, S. & Itagaki, M., 2023a. New record of *Argulus coregoni* (Branchiura: Argulidae) from Miyagi Prefecture, northern Honshu, Japan. *Nature of Kagoshima*, 49: 153–157. [In Japanese with English abstract]
- Nagasawa, K., Asayama, T., Fujimoto, Y. & Nitta, M., 2023b. The fish louse *Argulus japonicus* (Branchiura: Argulidae) parasitic on common carp *Cyprinus carpio* in Lake Izunuma, Miyagi Prefecture, Japan, and records of argulid branchiurans in northern Honshu. *Nature of Kagoshima*, 50: 55–61. [In Japanese with English abstract]
- Nagasawa, K., Nitta, M. & Kawai, K., 2023c. First specimen-based record of *Argulus japonicus* (Branchiura: Argulidae), an ectoparasite of freshwater fishes, from Okayama Prefecture, western Japan. *Biogeography*, 51: 19–21.
- Nakamura, M., 1969. Cyprinid Fishes of Japan—Studies on the Life History of Cyprinid Fishes of Japan. ii+455 pp., 2 pls. Research Institute for Natural Resources, Tokyo. [In Japanese with English title]
- Neethling, L. A. & Avenant-Oldewage, A., 2016. Branchiuraa compendium of the geographical distribution and a summary of their biology. *Crustaceana*, 89: 1243–1446.
- Poly, W. J., 2008. Global diversity of fishlice (Crustacea: Branchiura: Argulidae) in freshwater. *Hydrobiologia*, 595: 209–212.
- Sakai, H., 1995. Life-history and genetic divergence in three species of *Tribolodon* (Cyprinidae). *Memoirs of the Faculty of Fisheries, Hokkaido University*, 42: 1–98.
- Sakai, H., Goto, A. & Jeon, S. R., 2002. Speciation and dispersal of *Tribolodon* species (Pisces, Cyprinidae) around the Sea of Japan. *Zoological Science*, 19: 1291–1303.
- Suárez-Morales, E., Kim, I.-H. & Castellanos, I., 1998. A new geographic and host record for *Argulus flavescens* Wilson, 1916 (Crustacea, Arguloida), from southwestern Mexico. *Bulletin of Marine Science*, 62: 293–296.
- Smirnova, T. S., 1971. Parasitic Crustacea from fishes of the river Amur's basin. *Akademiya Nauk SSSR, Zoological Institute, Parasitology Paper*, 25: 177–195. [In Russian]
- Sokolov, S. G., Shedko, M. B., Protasov, E. N. & Frolov, E. V., 2012. Parasites of the inland water fishes of Sakhalin Island. In: V. V. Bogatov, V. Yu. Barkalov, A. S. Lelej, E. A. Makarchenko

- & S. Y. Storozhenko, (eds.), Flora and Fauna of North-West Pacific Islands (Materials of International Kuril Island and International Sakhalin Island Projects). Dalnauka, Vladivostok, pp. 179–216. [In Russian with English abstract]
- Suzuki, K. & Kimura, S., 1977. Growth of the crucian carps belonging to the genus *Carassius* in the lower reaches of the Nagara River, central Japan. Japanese Journal of Ichthyology, 24: 199–206. [In Japanese with English abstract]
- Suzuki, K. & Kimura, S., 1978. Fishery biological studies on the maturity and spawning of the crucian carps (genus *Carassius*) in the lower reaches of the Nagara River. Bulletin of the Faculty of Fisheries, Mie University, 5: 65–106. [In Japanese with English abstract]
- Thiele, J., 1900. Diagnoses neuer Arguliden-Arten. Zoologischer Anzeiger, 23: 46–48.
- Tokioka, T., 1936a. Preliminary report on Argulidae in Japan. Annotationes Zoologicae Japonenses, 15: 334–343.
- Tokioka, T., 1936b. Larval development of metamorphosis of *Argulus japonicus*. Memoirs of the College of Science, Kyoto Imperial University, Series B, 7: 93–114.
- Umeda, M., Tanaka, H., Konishi, E. & Sasaki, M., 2008. Spatio-temporal fluctuation of salinity and dissolved oxygen in Lake Jusan. Proceedings of Coastal Engineering, 55: 1051–1055. [In Japanese with English abstract]
- Van As, J. G., Van Niekerk, J. P. & Olivier, P. A. S., 1999. Description of the previously unknown male of *Argulus kosus* Avenant-Oldewage, 1994 (Crustacea: Branchiura). Systematic Parasitology, 43: 75–80.
- Watanabe, K., Sakai, H., Sanada, T. & Nishida, M., 2018. Comparative phylogeography of diadromous and freshwater daces of the genus *Tribolodon* (Cyprinidae). Ichthyological Research, 65: 383–397.
- Yamaguti, S., 1937. On two species of *Argulus* from Japan. In: R.-E. S. Schulz & M. P. Gnyedina, (eds.), Papers on Helminthology Published in Commemoration of the 30 Year Jubileum of the Scientific, Educational and Social Activities of the Honoured Worker of Science K. J. Skrjabin, M. Ac. Sci. and of 15th Anniversary of All-Union Institute of Helminthology, Lenin All-Union Academy of Agricultural Science, Moscow, pp. 781–784.
- Yamaguti, S., 1963. Parasitic Copepoda and Branchiura of Fishes. viii + 390 pp, 333 pls. Interscience Publishers, New York, London, and Sydney.

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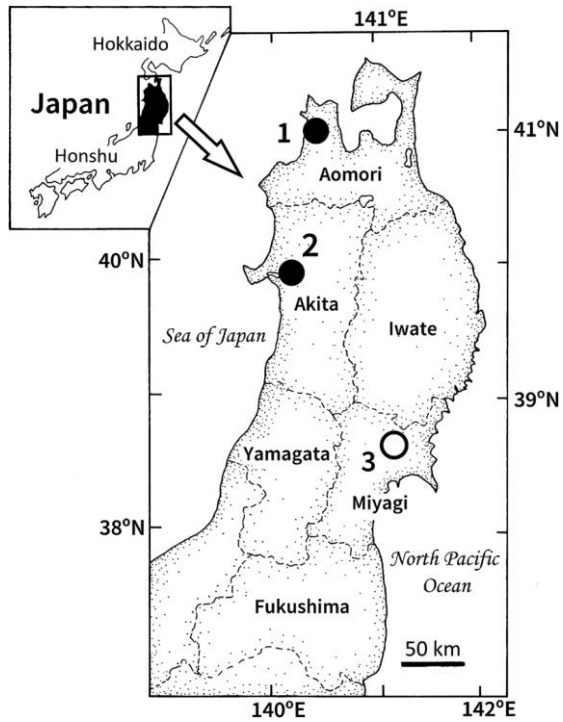


Fig. 1. Map of northern Honshu, Japan, showing the collection localities of *Argulus japonicus* in the previous (open circle) and present (closed circles) studies. 1, Lake Jusan, Aomori Prefecture (this paper); 2, Babame River, Akita Prefecture (this paper); 3. Lake Izunuma and Lake Uchinuma, Miyagi Prefecture (Nagasawa *et al.*, 2022, 2023b).



Fig. 2. *Argulus japonicus* from the body surface of big-scaled redfin *Pseudaspius hakonensis* in northern Honshu. A and B, female, 3.1 mm total length, NSMT-Cr 31502, from the Babame River, Akita Prefecture; C and D, female, 6.0 mm total length, NSMT-Cr 31503, from Lake Jusan, Aomori Prefecture. The frozen-thawed (A and B) and ethanol-preserved specimens (C and D) of *A. japonicus* were photographed. A and C, habitus, dorsal view; B and D, habitus, ventral view. Scale bars: A and B, 1 mm; C and D, 1 mm.

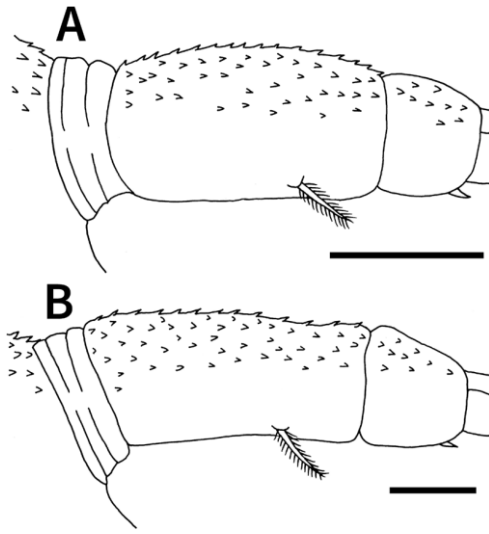


Fig. 3. Coxa (with a plumose seta) and basis of the first leg in *Argulus japonicus* from the body surface of big-scaled redfin *Pseudaspius hakonensis* in northern Honshu, ventral view. A, female, 3.1 mm total length, NSMT-Cr 31502, from the Babame River, Akita Prefecture; B, female, 6.0 mm total length, NSMT-Cr 31503, from Lake Jusan, Aomori Prefecture. Scale bars: A and B, 0.2 mm.