

Marine Fish Parasite *Argulus caecus* (Crustacea: Branchiura: Argulidae) Accidentally Collected from a Fixed Net Caught Squid in Northern Japan

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An ovigerous female of a fish ectoparasite *Argulus caecus* C. B. Wilson, 1922 was collected from a squid, probably *Todarodes pacificus* (Steenstrup, 1880), from a fixed net installed in Otsuchi Bay, an inlet of the northwestern Pacific Ocean, Iwate Prefecture, northern Japan. Since the original description of *A. caecus* was insufficient, this paper reports on the morphology of the species based on a detailed examination of the female. In particular, the first and second antennae, the first and second maxillae, and four pairs of legs, whose features were poorly known, are reported in detail. The specimen of *A. caecus* is inferred to have detached itself and moved from a fish host, perhaps a coastal puffer, to the squid while these two animals were trapped in the net or when they were removed from the net. Following *Argulus scutiformis* Thiele, 1900, *A. caecus* is the second species of *Argulus* found from northern Japan located in the northern temperate or subarctic region, and its occurrence in this region is likely to be affected by the Tsushima Warm Current and its branch, the Tsugaru Warm Current, both of which flow off the coast of the region.

Key Words: parasitic crustacean, fish louse, morphology, new locality record, puffer, *Takifugu*.

Introduction

Branchiurans of the argulid genus *Argulus* Müller, 1785 are skin parasites of freshwater and marine fishes (Yamaguti 1963; Neethling and Avenant-Oldewage 2016). To date, six species of the genus have been reported from marine fishes of Japan: *Argulus scutiformis* Thiele, 1900; *A. caecus* Wilson, 1922; *A. onodai* Tokioka, 1936; *A. matuii* Sikama, 1938; *A. kusafugu* Yamaguti and Yamasu, 1959; and *A. quadristriatus* Devaraj and Ameer Hamsa, 1977 (Yamaguti 1963; Nishimura 1995; Nagasawa 2009, 2011; Uyeno et al. 2017). All of these species are known to occur in southern and central Japan, but only one species, *A. scutiformis*, has been reported from northern Japan (Thiele 1904; Tokioka 1936).

An argulid branchiuran (Fig. 1) was found on the mantle of a squid from a fixed net in coastal Pacific waters of Iwate Prefecture, northern Japan (Kado et al. 2021). Because argulids are fish parasites and can detach themselves from fish hosts, the argulid found is inferred to have moved from a fish host to the squid while these two animals were trapped in the net or when they were removed from the net. As described below, the argulid is identified as *A. caecus*. The species was originally described by Wilson (1922) based on a single specimen from central Japan and has been reported from Japan on a few occasions (Tokioka 1936; Anonymous

1997; Kuramochi and Takahashi 2010; Kondo et al. 2013; Kado et al. 2021). Nonetheless, the original description was insufficient, and the subsequent description by Tokioka (1936) had only one figure showing a ventral view of the habitus. No morphological information was provided by the other authors (Anonymous 1997; Kuramochi and Takahashi 2010; Kondo et al. 2013; Kado et al. 2021). Therefore, based on a detailed examination of the newly collected specimen, this paper reports on the morphology of *A. caecus*, which is the second marine species of the genus from northern Japan.

Materials and Methods

The argulid specimen was collected from the mantle of a squid [most probably *Todarodes pacificus* (Steenstrup, 1880) (Cephalopoda: Teuthida: Ommastrephidae), body size not measured] on 31 July 2013 from a fixed net installed in Otsuchi Bay, an inlet of the northwestern Pacific Ocean, off Hiraisozaki (39°19'59.00"N, 141°55'30.00"E), Otsuchi, Iwate Prefecture, northern Japan. No observation was made of the argulid's attachment on the mantle. The specimen was photographed, fixed, and later preserved in 70% ethanol. It was first examined under an Olympus SZX10 stereo microscope. Then, dissected body parts were cleared in lactophe-



Fig. 1. *Argulus caecus*, ovigerous female, freshly dead specimen, NSMT-Cr 29002. Dorsal view. Scale bar: 5 mm.

nol and examined under an Olympus BX51 phase-contrast compound microscope using the wooden slide procedure (Humes and Gooding 1964; Benz and Otting 1996). All drawings were made with the aid of drawing tubes attached to the microscopes. Morphological terminology follows Benz et al. (1995) and Benz and Otting (1996). The specimen has been deposited in the Crustacea (Cr) collection of the National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture (NSMT-Cr). The scientific and common names of coastal puffers of the genus *Takifugu* Abe, 1949 mentioned in this paper follow Dyldin et al. (2016) and Matsuura (2017), and those of other puffers follow Froese and Pauly (2021).

Results

Argulus caecus C. B. Wilson, 1922 (Figs 1–4)

Argulus caecus C. B. Wilson, 1922: 1–4, figs 1–5; Tokioka 1936: 339–340, fig. 5; Yamaguti 1963: 322, pl. 317, fig. 4

(monograph); Tokioka 1965: 504, unnumbered fig. (encyclopedia); Tokioka 1979: 403, unnumbered fig. (encyclopedia); Nishimura 1995: 113–114, fig. 21–79C (encyclopedia); Anonymous 1997: 47; Nagasawa 2009: 137–138 (list); Kuramochi and Takahashi 2010: 5, figs 1–2; Nagasawa 2011: 19 (review); Kondo et al. 2013: 157–159, figs 1–3; Neethling and Avenant-Oldewage 2016: 1331 (monograph); Kado et al. 2021: 144, unnumbered fig.

Material examined. Ovigerous female, NSMT-Cr 29002, 22.0 mm total length (from anterior tip of carapace to posterior tip of abdomen), 12.5 mm maximum width (around midlength of carapace), from the mantle of a squid caught in Otsuchi Bay, Iwate Prefecture, Japan (photographed by Kado et al. 2021).

Description of ovigerous female. *Carapace* (including posterolateral lobes) elliptical, covering all pairs of legs in dorsal view, 18.9 mm long, comprising 85.9% of total length (Figs 1, 2A). Frontal region of carapace delimited by anterolateral indentations. Compound eyes scarcely visible in freshly dead specimen, and not visible after ethanol preservation. Nauplius eye not visible. Dorsal surface of carapace smooth without spines. Ventral surface of marginal frontal and lateral regions of carapace ornamented with numerous, small sharply pointed spines (Fig. 2B). Posterolateral lobes of carapace 16.9 mm long, comprising 89.4% of carapace length, ending in rounded margin, separated by sinus nearly 1/2 length of carapace. Respiratory areas comprising small, elliptical anterior area and large, reniform posterior area, located at levels of second maxillae and first and second legs, respectively (Figs 2B, 3B). *Thorax* with four segments (Fig. 2A, B). *Abdomen* shield-shaped, slightly longer than broad (6.1×4.9 mm), and partially covered by posterior region of posterolateral lobes of carapace; posterior lobes with weakly pointed tips (Figs 1, 2A, B). Anal indentation 35.6% as long as abdomen. Paired spermathecae elongate in anteroventral region of abdomen (Fig. 2B). Caudal rami located at base of anal indentation with four naked setae on each ramus (Fig. 3A).

First antennae with four segments (Fig. 3C): first segment heavily sclerotized in mesial and posterior regions, with two projections on posterior margin (mesial projection larger than other); second segment also heavily sclerotized, with large projection at about middle of anterior margin, strong apically bent hook at lateral corner, and large ventral projection near posterobasal margin; third segment cylindrical, with naked seta; apical segment shorter than third, with at least four naked setae at tip. *Second antennae* with five segments (Fig. 3C): first segment sclerotized, with stout spine and small swelling bearing four naked setae on posterior margin; second segment ovoid, with two naked setae on posterior margin; third, fourth, and apical segments nearly cylindrical and decreasing in length, possessing, respectively, 14, five, and at least two apical naked setae (Fig. 3D). Postantennal spines large and robust, located posterior each to mesial projection of first segment of first antenna (Fig. 3C). Preoral sheath visible on ventral midline of frontal region of carapace between first maxillae (Fig. 2C). Mouth

tube located just posterior to preoral sheath, nearly cylindrical, composed of small anterior labrum and larger posterior labium (Fig. 2C).

First maxillae forming suckers, 4.1 and 4.3 mm in diameter (32.8 and 34.4% as wide as carapace, respectively), with 54 or 55 supporting rods in sucker membrane (Fig. 3E). Supporting rods becoming slightly wider toward midlength but tapering distally, composed of 27–33 (mean=30, $n=10$) sclerites per rod (Fig. 3F). Sclerites mostly trapezoidal and crescent-shaped, respectively, in basal and other regions of supporting rod, often imbricated around midlength of rod. Outer margin of rim of sucker membrane with numerous tiny projections.

Second maxillae with five segments (Fig. 3G); first segment robust, with three (one anterolateral, one nearly centrolateral, and one posterolateral) blunt projections (anterolateral one largest), corpus of first segment with raised patch of small rectangular denticles in anterior region and apically sharp simple denticles in mid- and posterior regions; second segment elongate with distal raised patch of serrated scale-like denticles (Fig. 3I) in anterior and mid-regions and simple acutely pointed denticles in posterior region; third segment also elongate but narrower than second, with raised patch of serrated scale-like denticles in anterobasal region and simple denticles in mid- and distal regions; fourth segment subquadrate and shorter than third, with raised patch of simple denticles; terminal segment (Fig. 3H) with blunt tip and two spiniform projections, partially surrounded by anterior swelling region. Accessory spines located near ventral midline, slightly apart from first segments of second maxillae (Fig. 2C). Postmaxillary spines small and located anteriorly on first segment of thorax (Fig. 2C).

First to fourth pairs of legs (Fig. 4) biramous and of almost equal size; sympods composed of coxa and basis, those of first to third legs covered with small scale-like projections

anteriorly; sympods of fourth legs and rami with small projections; first legs each possessing flagellum. First leg (Fig. 4A, B) exopod unsegmented, with 17 and 20 plumose setae, respectively, on anterior and posterior margins, and two plumose setae at tip; endopod three-segmented, with 18 and 15 plumose setae, respectively, on anterior and posterior margins of proximal segment, naked seta near anterolateral corner of middle segment, and three short spines at tip of terminal segment; flagellum projecting from exopod and extending to proximal margin of coxa, with seven plumose and two naked setae on anterior margin, 21 plumose and two naked setae on posterior margin, and plumose seta at tip. Second leg (Fig. 4C) basis with 12 plumose setae on posterior margin; exopod unsegmented, with 17 and 20 plumose setae, respectively, on anterior and posterior margins; endopod unsegmented, with 15 and 16 plumose setae, respectively, on anterior and posterior margins. Third leg (Fig. 4D) basis bearing nine plumose setae on posterior margin; exopod unsegmented, with 16 and 18 plumose setae, respectively, on anterior and posterior margins; endopod two-segmented, proximal segment with 13 and 12 plumose setae, respectively, on anterior and posterior margins, terminal segment with naked seta and 11 plumose setae on anterior margin, 11 plumose setae on posterior margin, two short naked setae near tip, and two short naked setae at tip. Fourth leg (Fig. 4E) coxa forming posteriorly expanded natatory lobe bearing three plumose setae on distal margin; basis larger than coxa, bearing four plumose setae on posterior margin; exopod weakly two-segmented, terminal segment with at least nine plumose setae on posterior margin; endopod two-segmented, proximal segment with 11 plumose setae on posterior margin, terminal segment with six plumose setae on posterior margin.

Color. Dorsal surface of freshly dead specimen (Fig. 1) with dark brown pigmentation in carapace, thorax, and

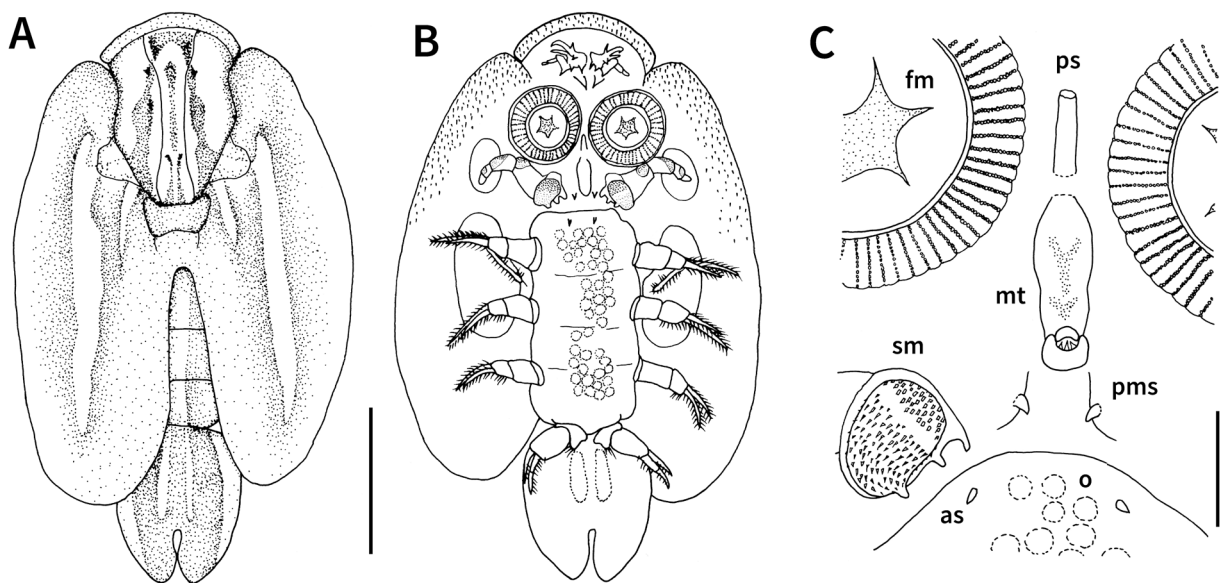


Fig. 2. *Argulus caecus*, ovigerous female, NSMT-Cr 29002. A, Habitus, dorsal view; B, habitus, ventral view; C, central part of body, ventral view. Abbreviations: as, accessory spine; fm, first maxilla; mt, mouth tube; o, ova; pms, postmaxillary spine; ps, preoral sheath; sm, second maxilla. Scale bars: A, B, 5 mm; C, 1 mm.

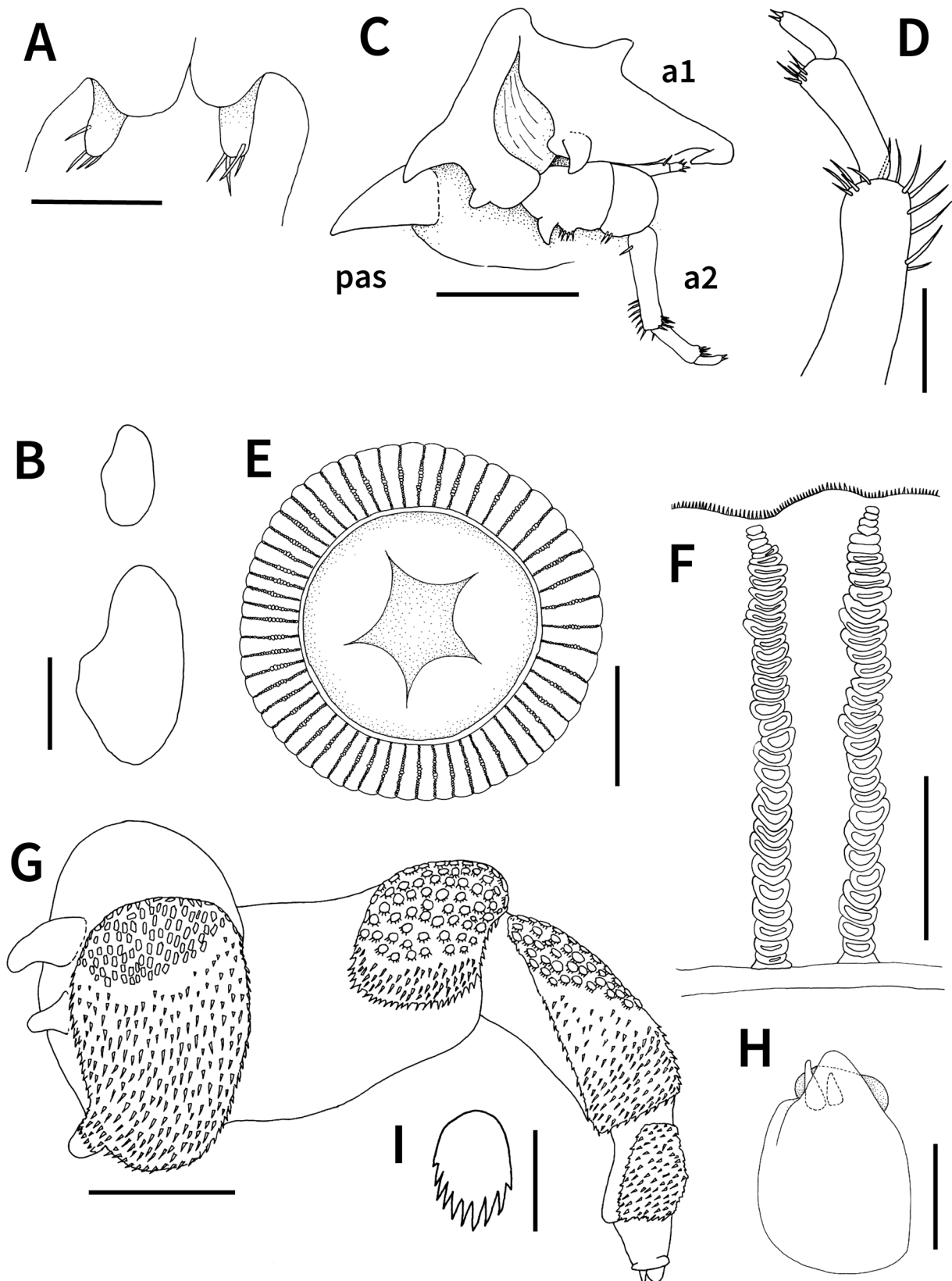


Fig. 3. *Argulus caecus*, ovigerous female, NSMT-Cr 29002. A, Caudal rami, dorsal view; B, respiratory areas, ventral view; C, first and second antennae, ventral view; D, distal part of endopod of second antenna, ventral view; E, first maxilla, ventral view; F, supporting rods each composed of series of sclerites, ventral view; G, second maxilla, ventral view; H, terminal segment of second maxilla, dorsal view; I, serrated scale-like denticle on second segment of second maxilla, ventral view. Abbreviations: a1, first antenna; a2, second antenna; pas, postantennal spine. Scale bars: A, D, F, H, 0.2 mm; B, 2 mm; C, G, 0.5 mm; E, 1 mm; I, 0.02 mm.

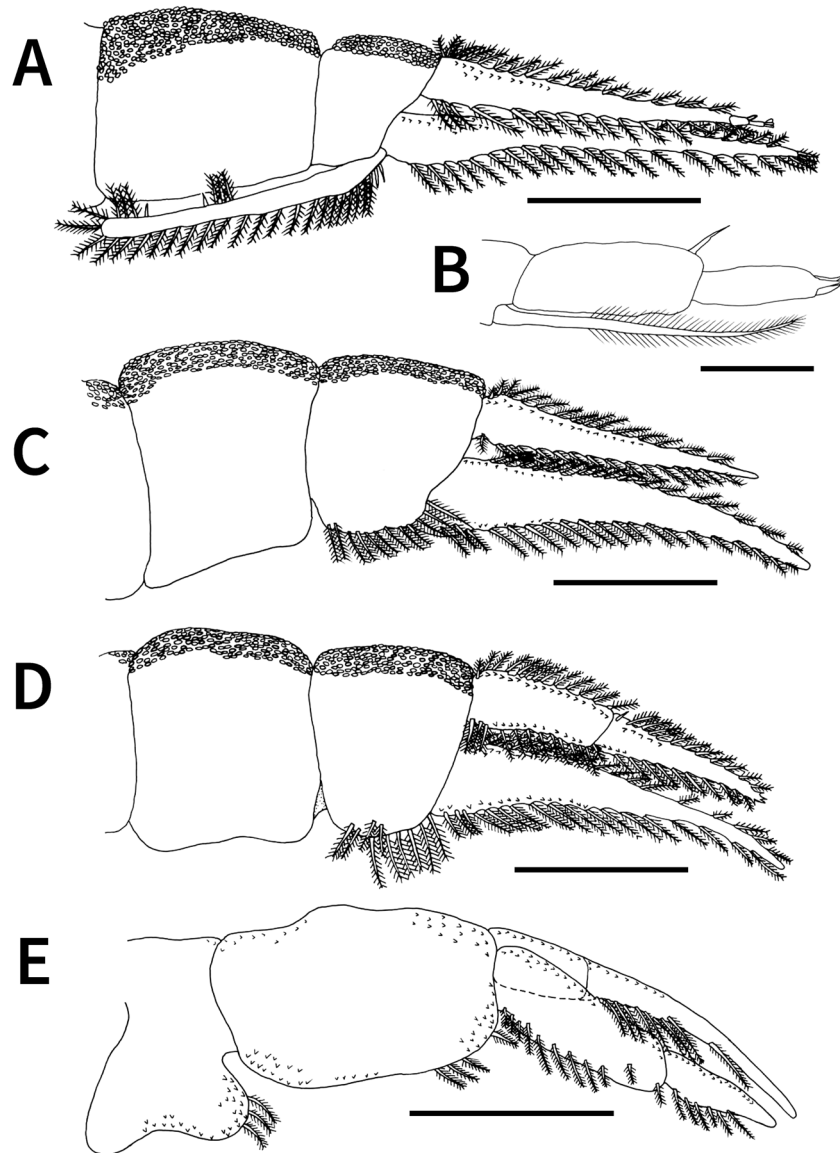


Fig. 4. *Argulus caecus*, ovigerous female, NSMT-Cr 29002. A, First leg, ventral view; B, distal part of endopod of first leg, ventral view; C, second leg, ventral view; D, third leg, ventral view; E, fourth leg, ventral view. Scale bars: A, C–E, 1 mm; B, 0.1 mm.

abdomen, forming three irregularly shaped longitudinal stripes in frontal region of carapace and three wider longitudinal stripes in each posterolateral lobe of carapace (mesial stripe widest and combined with central stripe at mid-length of posterolateral lobe). Unpigmented area found between central and lateral stripes in each posterolateral lobe. Longitudinal stripes also present on thorax and abdomen. Pigmentation of body weakly visible in ethanol-preserved specimen. Respiratory areas fringed by continuous black pigment. Mouth tube with weak ventral pigmentation.

Remarks. Without information on its host, *A. caecus* was originally described by Wilson (1922) based on a single female collected at Aburatsubo (type locality, incorrectly reported as “Aburazubo”), Misaki, Sagami (now Kanagawa Prefecture), Japan. The type locality is located on the southwest coast of the Miura Peninsula, facing Sagami Bay, an inlet of the northwestern Pacific Ocean. There were several problems in the original description of *A. caecus*, especially

regarding projections on the first and second antennae and recognition of segments of both antennae. Wilson (1922) found “two spines” on the “basis” of the “second antenna,” but this is incorrect, and as described above, the “spines” are found as two projections on the posterior margin of the first segment of the first (not second) antenna (Fig. 3C). Wilson (1922) did not differentiate antennal segments and stated that the first antenna had “strong hooks on the anterior and lateral margins, and a stout spine on the posterior margin”. However, the former “hooks” are actually found on the second segment of the first antenna (Fig. 3C), and the latter “spine” is located as a large projection on the posterobasal margin of the same segment (Fig. 3C). In spite of such problems in the original description, *A. caecus* was characterized by a large body (19.0 mm long), invisible compound eyes, about 30 sclerites in each supporting rod, and well-armed second maxillae (Wilson 1922). The female specimen collected in the present study has these characters and is identi-

fied as *A. caecus*.

Tokioka (1936) also reported the morphology of female *A. caecus* from puffers at various localities on the Pacific coast of Japan. His specimens were almost identical to the original description of *A. caecus*, but the sclerites in supporting rods were fewer (20–30) than those recorded in the original description (about 30) and in this paper (27–33, mean=30). This difference may be caused by the fact that his specimens were smaller (up to 16 mm long) than the holotype (19.0 mm long) and the specimen collected in this study (22.0 mm long) because the number of sclerites per supporting rod is known to increase with increasing body size (Benz et al. 1995).

Wilson (1922) reported that the tips of the posterior lobes of the abdomen were rounded, but Tokioka's specimens had posterior lobes with "pointed or blunt" tips. Those lobes of the specimen collected in this study have weakly pointed tips (Figs 1, 2). Tokioka (1936) also noted the presence of a large spine and a process on the first segment of the second antenna. These structures correspond in this paper to a stout spine and a small swelling near the spine on the posterior margin of the same segment (Fig. 3C). In addition, Tokioka (1936) reported on a single seta on the posterior margin of the coxa of the first leg, but no seta was found on the specimen examined (Fig. 4A).

The specimen of *A. caecus* collected in this study carries flagella on the first legs. As known for other *Argulus* species (Boxshall and Jaume 2009), the flagellum originates from the extreme proximal part of the exopod of each leg (Fig. 4A).

Argulus caecus was reported to be beautifully colored when alive: the body was light blue with patterns of brown pigments (Tokioka 1936). However, the freshly dead specimen collected in this study did not have such a colored body, and brilliant coloration perhaps disappeared immediately after its death.

Argulus caecus resembles *A. scutiformis*, one of the six congeneric species reported from Japan, in female's large body [19.0 mm long (Wilson 1922), up to 16.0 mm (Tokioka 1936), 22.0 mm long (this paper) in *A. caecus*, and more than 30.0 mm (Tokioka 1936), 13.6–19.8 mm long (Yamaguti and Yamasu 1959) in *A. scutiformis*]. The female's abdomen, however, differs in shape between these two species: *A. caecus* has an elliptical or shield-shaped abdomen (Wilson 1922; Tokioka 1936; this paper), whereas *A. scutiformis* has a rounded abdomen (Tokioka 1936; Yamaguti and Yamasu 1959). According to Tokioka (1936), the number of sclerites per supporting rod was also different between the two species (20–30 in *A. caecus* vs. 30–40 in *A. scutiformis*), but the specimens of *A. scutiformis* reported by Yamaguti and Yamasu (1959) had fewer sclerites (18–24 per rod), which indicates that the number of sclerites is variable in this species and cannot be always used to differentiate it from *A. caecus*. As stated above, such variations in number of sclerites per supporting rod are closely related to body size in *Argulus* species (Benz et al. 1995), and Yamaguti and Yamasu's specimens were much smaller (13.6–19.8 mm) than those (more than 30.0 mm) collected by Tokioka (1936).

Kuramochi and Takahashi (2010) showed two photo-

graphs of *A. caecus*, one is a ventral view of the habitus of one specimen that resembles the female reported herein. The authors collected their specimens from the vermiculated puffer, *Takifugu snyderi* (Abe, 1988), in coastal waters of Sagami Bay off Ashina, Kanagawa Prefecture, about 8 km north from the type locality (Aburatsubo). The present record of *A. caecus* from Otsuchi Bay (Kado et al. 2021; this paper) has extended its distribution range from Kanagawa Prefecture, northward to Iwate Prefecture, along the Pacific coast of Japan. Tokioka (1936) similarly collected *A. caecus* from the Pacific coast, but no detailed information was provided on the collection localities.

There are two records of *A. caecus* from the Sea of Japan off Honshu, Japan (Anonymous 1997; Kondo et al. 2013) but much remains obscure in the identification of the species from the sea. Without any literature citation and information on its morphology and host, *A. caecus* was listed in a catalogue of the animals collected in coastal waters of Sado Island, Niigata Prefecture (Anonymous 1997). This species was also collected in Hibiki-nada, Yamaguchi Prefecture, from the grass puffer, *Takifugu alboplumbeus* (Richardson, 1845) [Kondo et al. 2013, as *Takifugu niphobles* (Jordan and Snyder, 1901); Masakazu Kondo, National Fisheries University (NFU), Shimonoseki, personal communication], but its morphology was not reported because Kondo et al. (2013) focused on the hemocytes of *A. caecus*. Therefore, no information has been published on the morphology of the argulid from the Sea of Japan, and it is necessary to conduct taxonomic work using the specimens previously reported as *A. caecus* and newly collected material from this sea in order to confirm whether the species actually occurs there.

Discussion

Argulus caecus has so far been reported only from coastal puffers (Tokioka 1936; Kuramochi and Takahashi 2010; Kondo et al. 2013), which suggests that these fishes are preferred hosts of the parasite. Nevertheless, only two species of coastal puffers (*Takifugu snyderi* and *T. alboplumbeus*) are known as the hosts of *A. caecus*. Tokioka (1936) simply reported the infect coastal puffers as "*Spheroides* spp.," and it is impossible to determine the species. To date, as many as 20 species of *Takifugu* have been reported in Japan, and some of them are widely distributed in coastal waters (Yamada and Yagishita 2013). Therefore, for clarifying the host utilization and geographical distribution of *A. caecus*, it is desirable to examine various species of coastal puffers from a wide range of Japanese waters.

In the present study, the female of *A. caecus* was taken from the mantle of a squid caught in a fixed net in Otsuchi Bay. However, as stated in the Introduction, the squid is unlikely to be a true host of *A. caecus*. Three species of *Takifugu*, i.e., the grass puffer, *T. alboplumbeus* (= *T. niphobles*), the panther puffer, *Takifugu pardalis* (Temminck and Schlegel, 1850) (Tatsukawa and Tanaka 1982), and the fine patterned puffer, *Takifugu pardalis* (Temminck and Schlegel, 1850) [Goto et al. 2017, as *Takifugu poecilnotus* (Temminck and

Schlegel, 1850)] have been recorded from Otsuchi Bay, and some other species of puffers [the spottyback puffer, *Takifugu stictonotus* (Temminck and Schlegel, 1850); the yellowfin puffer, *Takifugu xanthopterus* (Temminck and Schlegel, 1850); the purple puffer, *Takifugu porphyreus* (Temminck and Schlegel, 1850); the brown-lined puffer, *Canthigaster rivulata* (Temminck and Schlegel, 1850); the starry toado, *Arothron firmamentum* (Temminck and Schlegel, 1850); the stellate puffer, *Arothron stellatus* (Anonymous, 1798)] are also found in the bay [Naoya Ohtsuchi, International Coastal Research Center (ICRS), Atmosphere and Ocean Research Institute, The University of Tokyo, Otsuchi, personal communication]. These coastal puffers are potential hosts for *A. caecus*.

Two species of *Argulus* have been reported from northern Japan: *A. scutiformis* from Hakodate and an unspecified locality in Hokkaido (Thiele 1904; Tokioka 1936) and *A. caecus* from Otsuchi Bay, Iwate Prefecture (Kado et al. 2021; this paper). Northern Japan lies in the northern temperate or subarctic region, but the seas surrounding this region are affected by two warm currents. The Tsushima Warm Current, a branch of the Kuroshio Current, flows off the west coast of northern Honshu and Hokkaido, and the Tsugaru Warm Current, a branch of the Tsushima Warm Current, flows in the Tsugaru Strait off Hakodate, southern Hokkaido and off the Pacific coast and Otsuchi Bay, northern Honshu (Yasuda et al. 1988). Six species of *Argulus*, including *A. scutiformis* and *A. caecus*, have been reported from southern and central Japan influenced by two warm currents, the Kuroshio and the Tsushima Warm Current. The occurrence of *A. scutiformis* and *A. caecus* in northern Japan may be similarly affected by the Tsushima Warm Current and its branch, the Tsugaru Warm Current.

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References

Anonymous 1997. List of animal specimens with taxonomic code collected at the Sado Marine Biological Station. Special Publication from the Sado Marine Biological Station, Niigata University, Series 7: 11–83. [In Japanese and English]
Benz, G. W. and Otting, R. L. 1996. Morphology of the fish louse (*Argulus*: Branchiura). *Drum and Croaker* 27: 15–22.
Benz, G. W., Otting, R. L. and Case, A. 1995. Redescription of *Argulus melanostictus* (Branchiura: Argulidae), a parasite of California grunion (*Leuresthes tenuis*: Atherinidae), with notes regarding chemical control of *A. melanostictus* in a captive host population. *Journal of Parasitology* 81: 754–761.

Boxshall, G. A. and Jaume, D. 2009. Exopodites, epipodites and gills in crustaceans. *Arthropod Systematic and Phylogeny* 67: 229–254.
Dyldin, Y. V., Matsuura, K. and Makeev, S. S. 2016. Comments on puffers of the genus *Takifugu* from Russian waters with the first record of yellowfin puffer, *Takifugu xanthopterus* (Tetraodontiformes, Tetraodontidae) from Sakhalin Island. *Bulletin of the National Museum of Nature and Science, Series A* 42: 133–141.
Froese, R. and Pauly, D. (Eds) 2021. FishBase. Version (06/2021). Available at <http://www.fishbase.org> (17 July 2021).
Goto, T., Takanashi, A., Tamada, S. and Hayashizaki, K.-I. 2017. Temporal changes in the surf zone fish assemblage in Otsuchi Bay, Pacific coast of northeastern Japan, with comments on influences of the 2011 Tohoku earthquake and tsunami. *Coastal Marine Science* 40: 55–65.
Humes, A. G. and Gooding, R. U. 1964. A method for studying the external anatomy of copepods. *Crustaceana* 6: 238–240.
Kado, R., Okumura, S.-I., Hirose, M. and Miyake, H. 2021. *A Field Guide to the Marine Invertebrates in [sic] the Sanriku Coast, Northern Japan*. Koseisha Koseikaku, Tokyo, 278 pp. [In Japanese]
Kondo, M., Yasumoto, N. and Takahashi, Y. 2013. Morphological characterization of hemocytes of marine fish louse *Argulus caecus* (Arguloida, Branchiura, Maxillopoda, Crustacea). *Journal of National Fisheries University* 61: 157–159. [In Japanese with English abstract]
Kuramochi, T. and Takahashi, K. 2010. [Mimicry of *Argulus caecus* collected from the body surface of vermiculated puffer, *Takifugu Snyderi*]. *Shiosai Dayori* 21: 5. [In Japanese]
Matsuura, K. 2017. Taxonomic and nomenclatural comments on two puffers of the genus *Takifugu* with description of a new species, *Takifugu flavipterus*, from Japan (Actinopterygii, Tetraodontiformes, Tetraodontidae). *Bulletin of the National Museum of Nature and Science, Series A* 43: 71–80.
Nagasawa, K. 2009. 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. Pp. 15–21. In: Asakura, A., Bauer, R. T., Hines, A. H., Thiel, M., Held, C., Schubart, C., Furse, J. M., Coughran, J., Baeza, A., Wada, K., Yamaguchi, T., Kawai, T., Ohtsuka, S., Archdale, M. V., and Moriyasu, M. (Eds) *New Frontiers in Crustacean Biology*. Crustaceana Monographs 15, Brill, Leiden.
Neethling, L. A. and Avenant-Oldewage, A. 2016. Branchiura—a compendium of the geographical distribution and a summary of their biology. *Crustaceana* 89: 1243–1446.
Nishimura, S. 1995. Branchiura. Pp. 113–115. In: Nishimura, S. (Ed.) *Guide to Seashore Animals of Japan with Color Pictures and Keys, Vol II*. Hoikusha, Osaka. [In Japanese with English title]
Thiele, J. 1904. Beiträge zur Morphologie der Arguliden. *Mitteilungen aus dem Zoologischen Museum in Berlin* II 4: 1–51.
Tokioka, T. 1936. Preliminary report on Argulidae found in Japan. *Annotationes Zoologicae Japonenses* 15: 334–343.
Tokioka, T. 1965. *Argulus caecus* Wilson. P. 504. In: Okada, Y., Uchida, S., and Uchida, T. (Eds) *New Illustrated Encyclopedia of the Fauna of Japan, II*. Hokuryu-kan, Tokyo. [In Japanese with English title]
Tokioka, T. 1979. *Argulus caecus* Wilson. P. 403. In: Imajima, M. and Takeda, M. (Eds) *Illustrated Encyclopedia of the Fauna of Japan, Newly Compiled*. Hokuryu-kan, Tokyo. [In Japanese with English title]
Uyeno, D., Miyazaki, W. and Nagasawa, K. 2017. First record of the fish parasite *Argulus quadristriatus* (Crustacea: Branchiura: Argulidae) from Japanese waters, with three new host records. *Species Diversity* 22: 37–44.
Wilson, C. B. 1922. Parasitic copepods from Japan, including five new

- species. *Arkiv för Zoologi* 14: 1–17.
- Yamada, U. and Yagishita, N. 2013. Tetraodontidae. Pp. 1728–1742, 2239–2241. In: Nakabo, T. (Ed.) *Fishes of Japan with Pictorial Keys to the Species, Vol 3*. Tokai University Press, Hadano. [In Japanese with English title]
- Yamaguti, S. 1963. *Parasitic Copepoda and Branchiura of Fishes*. Interscience Publishers, New York, London, and Sydney, 1104 pp.
- Yamaguti, S. and Yamasu, T. 1959. On two species of *Argulus* (Branchiura, Crustacea) from Japanese fishes. *Biological Journal of Okayama University* 5: 167–175.
- Yasuda, I., Okuda, K., Hirai, M., Ogawa, Y., Kudoh, H., Fukushima, S.-I. and Mizuno, K. 1988. Short-term variations of the Tsugaru Warm Current in autumn. *Bulletin of the Tohoku Regional Fisheries Research Laboratory* 50: 153–191. [In Japanese with English abstract]