

Occurrence of the bopyrid isopod *Athelges takanoshimensis* on hermit crabs in a brackish water lake, central Japan

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Abstract

Athelges takanoshimensis Ishii, 1914 was found on the abdomen of an intertidal hermit crab, *Pagurus minutus* Hess, 1865 (Paguridae), in Lake Hamana on the Pacific coast of Shizuoka Prefecture, central Japan. This represents the first record of *A. takanoshimensis* from Shizuoka Prefecture. The species is briefly described. The overall prevalence of infestation from April to December 2019 was low (1.3%). Two other hermit crabs, *Pagurus filholi* (de Man, 1887) (Paguridae) and *Clibanarius infraspinatus* (Hilgendorf, 1869) (Diogenidae), were not infested during the same period. The geographical distribution and known hosts of *A. takanoshimensis* in Japan are also summarized.

Introduction

Athelges takanoshimensis Ishii, 1914 is a bopyrid isopod parasitic on the abdomen of hermit crabs of two families, Paguridae and Diogenidae (Markham, 2003, 2009; McDermott et al., 2010). This species was originally described using specimens from *Pagurus filholi* (de Man, 1887) (reported as *Eupagurus samuelis*) collected at Takanoshima in Tateyama Cove, Tokyo Bay, central Japan (Ishii, 1914). To date, it has been reported from the Russian Far East (Volvenko, 1992; Kornienko et al., 2018), Korea (Kim and Kwon, 1988; Kwon, 2012), China (Markham, 1982, 1990, 1992; Wei, 1991; Li, 2003; An, 2011; An et al., 2011; Cericola and Williams, 2015), Taiwan (Boyko, 2004), Philippines (Williams and Boyko, 2015), Singapore (Markham, 2009), Indonesia (Haig and Ball, 1988; Williams and Boyko, 2015), and Papua New Guinea (Williams and Boyko, 2015).

In Japan, *Athelges takanoshimensis* var. *tenuibrachiatus* Shiino, 1936, and *Athelges japonicus* Shiino, 1958 were also described (Shiino, 1936, 1958), but these taxa have been relegated to junior synonyms of *A. takanoshimensis* (Markham, 1982; Kim and Kwon, 1988; see Markham, 2009 for a synonym list). The species was incorrectly reported as “*Athelgathes takanoshimensis*” (Nunomura, 1995; Imahara, 1996). Also, the bopyrid isopod shown as *A. takanoshimensis* by Nishimura (1983) has been suggested to be *Parathelges aniculi* (Whitelegge, 1897) (Boyko, 2004; Markham, 2009).

Athelges takanoshimensis has been well studied in Japan (Nagasawa, 2020), where most of the works were done by Shiino (1934, 1935, 1937, 1939, 1950, 1958, 1972). Nevertheless, these works were conducted in taxonomic and faunal research, thus, little information is available on the life history, ecology, and associations of *A. takanoshimensis* with its hosts. Prevalence data are one of the most important indices in parasitology to understand the host-parasite relationships (Bush et al., 1997), but, previously in Japan, only one paper based on a small collection from northern Honshu reported on such data (Nagasawa et al., 1996).

During an investigation into the fauna of macroinvertebrates in Lake Hamana, central Japan, we collected two species of bopyrid isopods, *A. takanoshimensis* and *Parathelges* sp., from intertidal hermit crabs. This paper briefly describes *A. takanoshimensis* and reports on its occurrence on the hermit crabs. The morphology of *Parathelges* sp. and its association with the hermit crabs will be reported elsewhere.

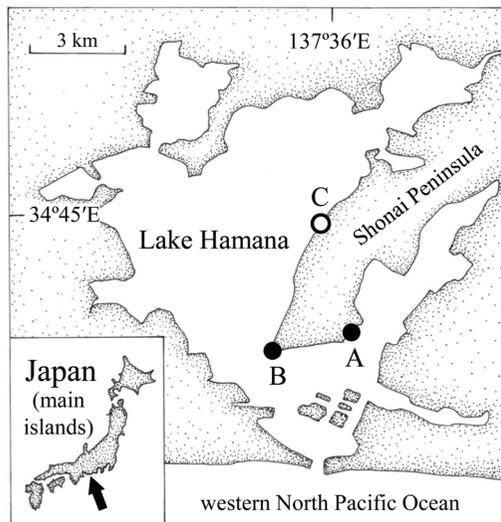


Fig. 1. Map of Lake Hamana, showing three sites (A–C) where hermit crabs were collected. Inset map shows the location of Lake Hamana (arrow) in Japan. The individual of *Pagurus minutus* infested by *Athelges takanoshimensis* was collected at Site C (open circle).

Materials and Methods

Lake Hamana is a brackish water lake (68.8 km² in surface area, 16.6 and 4.8 m in maximum and average depths, respectively) located on the coast of Shizuoka Prefecture, central Japan, and is connected to the western North Pacific Ocean through a short strait (Fig. 1). Many marine and brackish water species are commonly found in the lake (Hamanako Branch of the Shizuoka Prefectural Research Institute of Fishery, 2017).

Hermit crabs were monthly collected from April to December 2019 by hand nets or manually at three intertidal sites in the eastern region of Lake Hamana, Hamamatsu City, Shizuoka Prefecture: Site A (34°42'52"E, 137°36'21"E) on the southeast coast of the Shonai Peninsula; Site B (34°42'38"E, 137°35'02"E) on the south-western tip of the peninsula; and Site C (34°44'51"E, 137°35'49"E) on the west coast of the peninsula (Fig. 1). To prevent the population decline, up to 10 hermit crabs were sampled each month at each site, the bottom of which was sand (Site A), sand with scattered concrete blocks (Site B), or sand with some stones (about 10 cm in diameter) (Site C). Most of the hermit crabs were collected from the intertidal zone but some from the upper subtidal zone.

Hermit crabs were put in plastic bags immediately after collection and transferred in containers with ice to the laboratory of Tokai University, Shizuoka City,

Shizuoka Prefecture, where they were deeply frozen. Later, they were thawed, pulled out of the shells with forceps, measured using a slide caliper for shield length (SL), and identified. When bopyrid isopods were found, they were carefully removed from the hosts, and fixed and preserved in 70% ethanol. These bopyrid specimens were examined for their morphology using an Olympus SZX10 stereo microscope at the Aquaparasitology Laboratory, Shizuoka City. Both the bopyrid and the host specimens kept in the same vial have been deposited in the Crustacea collection of the National Museum of Science and Nature, Tsukuba City, Ibaraki Prefecture (NSMT-Cr 27515). The scientific names of hermit crabs mentioned in this paper follow those recommended by Sandberg and McLaughlin (1993), Komai and Mishima (2003), and WoRMS Editorial Board (2020).

Results

In total, 226 hermit crabs, identified as three species in two families, were collected during this study: they were *Pagurus minutus* Hess, 1865 (Paguridae) (1.1–6.3 [mean = 3.6] mm SL, n = 79), *Pagurus filholi* (de Man, 1887) (1.3–7.0 [4.0] mm SL, n = 65), and *Clibanarius infraspinus* (Hilgendorf, 1869) (Diogenidae) (4.3–39.7 [15.3] mm SL, n = 82). A female of *A. takanoshimensis* was found on one (4.0 mm SL) of the 79 individuals of *P. minutus* (prevalence = 1.3%). The infested *P. minutus* was collected at Site C on 14 July 2019. None of the other two species of hermit crabs was infested by *A. takanoshimensis*.

The female of *A. takanoshimensis* was attached on the abdomen of *P. minutus*. No male was found on the female. The measurements and morphological characters of the female are as follows (Fig. 2): Body length 11.0 mm, maximum width 5.3 mm. Head length and breadth nearly equal with anterior margin flattened, posterior margin rounded. No eyes visible. Pereon of seven pereomeres, broadest across pereomere 7, tapering anteriorly. Brood pouch completely covered by oostegites. Oostegite 1 extended over head. Pereopods increasing in length posteriorly; pereopods 1–3 parallel to head, pereopods 4–7 posterior to head. Pleon with five pleomeres, tapering posteriorly, without lateral plates. Pleomeres 1–4 with elongate-ovate biramous pleopods, all arising from common peduncle; pleomere 5 (= pleotelson) elongated with slightly swollen at distal end. Uropods lacking.

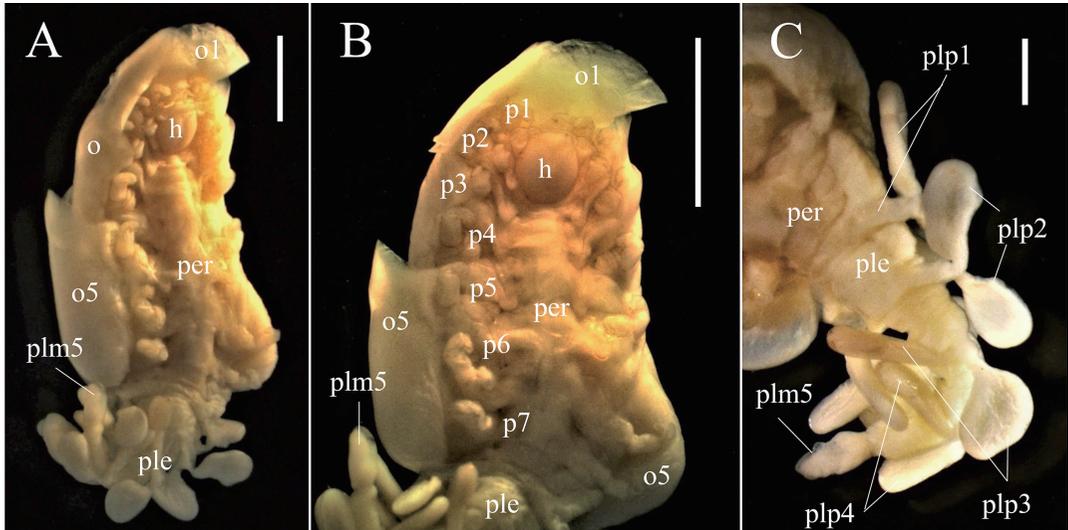


Fig. 2. *Athelges takanoshimensis*, female, NSMT-Cr 27515, 11.0 mm body length, from the abdomen of *Pagurus minutus* in Lake Hamana, central Japan. Ethanol-preserved specimen. A, habitus, laterodorsal view; B, head and pereon, dorsal view; C, pleon, dorsal view. Abbreviations: h, head; o, oostegites; o1, oostegite 1; o5, oostegite 5; p1–p7, pereopods 1–7; per, pereon; ple, pleon; plm5, pleomere 5 (=pleotelson); plp1–4, pleopods 1–4. Scale bars: A, 2 mm; B, 3 mm; C, 1 mm.

Discussion

The present collection of *A. takanoshimensis* in Lake Hamana represents the first record from Shizuoka Prefecture. In Japan, the species is known to widely occur in the subarctic through temperate to subtropical waters (Nagasawa, 2020) with records from the following 14 prefectures (arranged from the north to the south): Hokkaido (Shiino, 1937, 1958; Oguro, 1961), Iwate (Nagasawa et al., 1996), Chiba (Ishii, 1914; Shiino, 1958), Tokyo (reported as Tokyo Bay, Shiino, 1958), Kanagawa (Shiino, 1936; Takai et al., 2019), Shizuoka (this paper), Wakayama (Shiino, 1934; Imahara, 1996), Okayama (Shiino, 1958), Hiroshima (Inaba, 1998), Ehime (Omori, 2012), Fukuoka (Shiino, 1939), Kumamoto (Kikuchi, 1968), Miyazaki (Miura et al., 2014), and Kagoshima (Nunomura, 2011). It is found in the following seas around Japan (Nagasawa, 2020): the western North Pacific Ocean, the Seto Inland Sea, the East China Sea, and the Sea of Japan.

Three sympatric species of hermit crabs from Lake Hamana were examined for *A. takanoshimensis* in this study, but only *P. minutus* was found infested by *A. takanoshimensis*. It is impossible, at present, to state what biotic and abiotic factors contributed to the observed difference in occurrence of the parasite between host species. It, however, does not mean that *A. takanoshimensis* is specific to *P. minutus* because, as stated below, the parasite has been reported from 10 nominal species of hermit crabs in Japan. Similar dif-

ferences in the occurrence of *A. takanoshimensis* between host species at the same site have been reported from China (Cericola and Williams, 2015) and the Russian Far East (Kornienko et al., 2018).

The hermit crabs reported as the hosts of *A. takanoshimensis* from Japan include nine nominal and one unidentified species in the family Paguridae and one nominal species in the family Diogenidae (Shiino, 1972; Saito et al., 2000; Saito, 2002; Nagasawa, 2020): *Pagurus filholi* (Ishii, 1914 [reported as *Eupagurus samuelis*]; Shiino, 1934, 1936, 1958 [reported as *E. samuelis*]; Nagasawa et al., 1996), *Pagurus japonicus* (Stimpson, 1858) (Shiino, 1934, 1958 [reported as *Eupagurus japonicus*]), *Pagurus pectinatus* (Stimpson, 1858) (Shiino, 1937 [reported as *Eupagurus pectinatus*]; Oguro, 1961), *Pagurus constans* (Stimpson, 1858) (Shiino, 1958 [reported as *Eupagurus constans*]), *Pagurus lanuginosus* de Haan, 1849 (Shiino, 1958), *Pagurus middendorffii* Brandt, 1851 (Shiino, 1958), *Pagurus minutus* (Kikuchi, 1968 [reported as *Pagurus dubius*]; this paper), *Pagurus maculosus* Komai and Imafuku, 1996 (Nagasawa et al., 1996), *Pagurus* sp. (Shiino, 1939 [reported as *Eupagurus* sp.]), *Lophopagurus (Australeremus) triserratus* (Ortmann, 1892)? (Shiino, 1936 [reported as *Eupagurus triserratus*?]) in the Paguridae; and *Dardanus megistos* (Herbst, 1804) (Nunomura, 2011) in the Diogenidae. In addition to these hermit crabs, an unknown host (Shiino, 1936) and an unidentified hermit crab (Shiino,

1958) were reported to host *A. takanoshimensis*. Based on these host records, *A. takanoshimensis* is not a host-specific parasite, and pagurid hermit crabs are the major hosts for *A. takanoshimensis* in Japan. Recently, diogenid hermit crabs have been suggested to be important as the hosts of *A. takanoshimensis* in the subtropical and tropical waters of East Asia (Nagasawa, 2020).

In this study, no male of *A. takanoshimensis* was found attached on the female. This is most probably because a male was dropped off and lost when the female was pulled out of the shell using forceps. It is desirable to employ a different method to collect hermit crabs (and bopyrids) from the shells.

Of the three species of hermit crabs examined from Lake Hamana, only *P. minutus* was infested by *A. takanoshimensis*, and the overall prevalence of infested *P. minutus* from April to December 2019 was as low as 1.3%. In Japan, similar low prevalence of infestation by *A. takanoshimensis* was reported for two species of pagurids, *P. filholi* (1.1%) and *P. maculosus* (2.7%) from the Sanriku Coast of Iwate Prefecture, northern Japan (Nagasawa et al., 1996). These data indicate that the populations of *A. takanoshimensis* were quite small at the surveyed sites and, at least in Lake Hamana, occurred only in a limited area. In this lake, 11 species of hermit crabs (5 pagurids and 6 diogenids) are known to occur (Hamanako Branch of the Shizuoka Prefectural Research Institute of Fishery, 2017). For better understanding of the distribution patterns, population size, and host utilization of *A. takanoshimensis* in Lake Hamana, it is necessary to collect and examine more species of hermit crabs for the bopyrid infestation in a wider area of the lake.

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