

Infestation of *Parathelges enoshimensis* (Isopoda: Bopyridae) on *Pagurus minutus* (Anomura: Paguridae) in a brackish water lake, central Japan

Kazuya Nagasawa^{1,2}, Shoya Koyama³ and Fumihito Muto³

¹Graduate School of Integrated Sciences for Life, Hiroshima University, 1-4-4 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8528, Japan

²Aquaparasitology Laboratory, 365-61 Kusanagi, Shizuoka 424-0886, Japan

³School of Marine Science and Technology, Tokai University, 3-20-1 Orido, Shimizu, Shizuoka 424-8610, Japan

Abstract

A female of *Parathelges enoshimensis* Shiino, 1950 was collected from the abdomen of a hermit crab, *Pagurus minutus* Hess, 1865 (Paguridae), in the sandy intertidal zone of Lake Hamana, Shizuoka Prefecture, central Japan. This represents the first and third records of *Parathelges enoshimensis* from Shizuoka Prefecture and Japan, respectively. Only one of the 79 individuals of *Pagurus minutus* examined from April to December 2019 was infested (prevalence, 1.3%). The female of *Parathelges enoshimensis* is briefly described. The collection localities of the species in Japan and Korea are affected by a warm current, the Kuroshio, and its branch, the Tsushima Current, respectively.

Introduction

Parathelges enoshimensis Shiino, 1950 is a poorly known species of bopyrid isopod infesting hermit crabs in East Asia. The species was originally described using female and male specimens from *Pagurus* sp. (reported as *Eupagurus* sp.) collected at Enoshima Island (as Enosima), central Japan (Shiino, 1950). There are some records of *P. enoshimensis* from Korea (Kim and Kwon, 1988a, b; Kwon, 2012) and China (An, 2011; An et al., 2011) but it was very recently rediscovered from Japan (Nagasawa and Nishi, 2020).

In 2019, we conducted an investigation into the fauna of macroinvertebrates of Lake Hamana, a brackish water lake on the Pacific coast of central Japan. During this investigation, we found two species of bopyrid isopods, *Athelges takanoshimensis* Ishii, 1914 and *Parathelges* sp. on intertidal hermit crabs (Nagasawa

et al., 2020). The latter species is herein identified as *P. enoshimensis*. This paper reports on the occurrence of the species on those hermit crabs and briefly describes it.

Materials and Methods

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). Up to 10 hermit crabs were sampled each month at each site not to reduce their populations. The bottom was sand at Site A, sand with scattered concrete blocks at Site B, and sand with some stones (about 10 cm in diameter) at Site C. The procedures for an examination of hermit crabs and bopyrid isopods are the same as those reported by Nagasawa et al. (2020). The bopyrid specimen along with its pagurid host has been deposited in the Crustacea collection of the National Museum of Science and Nature, Tsukuba City, Ibaraki Prefecture (NSMT-Cr 27516). 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

Three species of hermit crabs were collected during this study, consisting of *Pagurus minutus* Hess, 1865

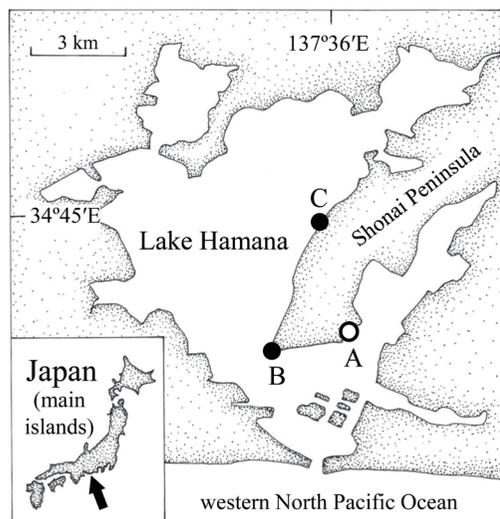


Fig. 1. Map of Lake Hamana, showing three sites (A–C) where hermit crabs were collected. Inset map shows the location of Lake Hamana (arrow) in Japan. The individual of *Pagurus minutus* infested by *Parathelges enoshimensis* was collected at Site A (open circle).

(Paguridae) (1.1–6.3 [mean, 3.6] mm shield length [SL], $n = 79$), *Pagurus filholi* (de Man, 1887) (Paguridae) (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 *Parathelges enoshimensis* was found on one (3.2 mm SL) of the 79 individuals of *Pagurus minutus* (prevalence, 1.3%). The infested host was collected at Site A on 17 December 2019 (Fig. 1). The other two species of hermit crabs from the three sites were not infested by the bopyrid.

The female of *Parathelges enoshimensis* was attached on the abdomen of *Pagurus minutus*. No male was found attached on the female. The measurements and morphological characters of the female of *P. enoshimensis* are as follows (Fig. 2): Body length 9.0 mm, maximum width 4.0 mm. Head length and width nearly equal with anterior margin flattened, lateral margins convex, posterior margin more convex. Eyes lacking. Pereon of seven pereomeres, widest across pereomere 6, tapering anteriorly and posteriorly. Oostegites enclosing brood pouch. Oostegite 1 extended over pereopods 1 and head, anterior lobe expanded laterally. Pereopods nearly equal in length; pereopods 1–2 parallel to head, pereopods 3 immediately posterior to head, pereopods 4–5 posterior to head and located near middle of pereon, pereopods 6–7 separated from preceding pereopods and located in posterior region of pereon. Pleon with five pleomeres, gradually

tapering posteriorly, lacking lateral plates. Pleomeres 1–4 with pear-shaped or ovate biramous pleopods, all arising from common peduncle. Pleomere 5 consisting of anterior rectangular region, mostly found in central part of pleomere 4, and uniramous uropods. Reddish and pale yellow in frozen-thawed and ethanol-preserved specimen, respectively.

Discussion

Only two records exist of *P. enoshimensis* from Japan, where the species was collected from Enoshima Island, Kanagawa Prefecture (Shiino, 1950) and Mikawa Bay, Aichi Prefecture (Nagasawa and Nishi, 2020). The present collection of the species in Lake Hamana represents its first and third records from Shizuoka Prefecture and Japan, respectively.

Parathelges enoshimensis is also known to occur in Korea (Kim and Kwon, 1988a, b; Kwon, 2012) and China (An, 2011; An et al., 2011). The Chinese specimens, however, have been suggested by Nagasawa and Nishi (2020) to be separated from *P. enoshimensis* because the female specimen from China has lateral plates on the pleon (An, 2011, fig. 4–13B; An et al., 2011, fig. 2B). In contrast, no lateral plate is present on the pleon of the female of *P. enoshimensis* from Japan (Shiino, 190; Nagasawa and Nishi, 2020; this paper) and Korea (Kim and Kwon, 1988a; Kwon, 2012).

In the redescription of *Parathelges aniculi* (Whitelegge, 1897), Williams and Boyko (2015) stated that *P. enoshimensis* may be a synonym of *P. aniculi* and included the Chinese record of *P. enoshimensis* reported by An et al. (2011) in the lists of the distribution and hosts of *P. aniculi*. However, Williams and Boyko (2015) did not discuss the morphology of the Chinese specimens described by An et al. (2011) and, as stated above, the Chinese female specimen differs from the female of *P. enoshimensis* from Japan and Korea. Williams and Boyko (2015) also recognized six pleomeres in the pleon of *P. aniculi* but, in our specimen of *P. enoshimensis*, five pleomeres were found because no segmentation was distinct in pleomere 5. Similar five pleomeres have been reported from other specimens of *P. enoshimensis* from Japan (Shiino, 1950; Nagasawa and Nishi, 2020) and Korea (Kim and Kwon, 1988a; Kwon, 2012). Moreover, the female specimen reported as *Athelges takanoshimensis* Ishii, 1914 from Japan (Nishimura, 1983) has been suggested to be *P. aniculi* (Boyko, 2004; Markham, 2009). Based on such information, the status of *P. enoshimensis* still remains unclear, especially in terms of synonymy with *P. aniculi*. We need a detailed morphological study of *P. enoshi-*

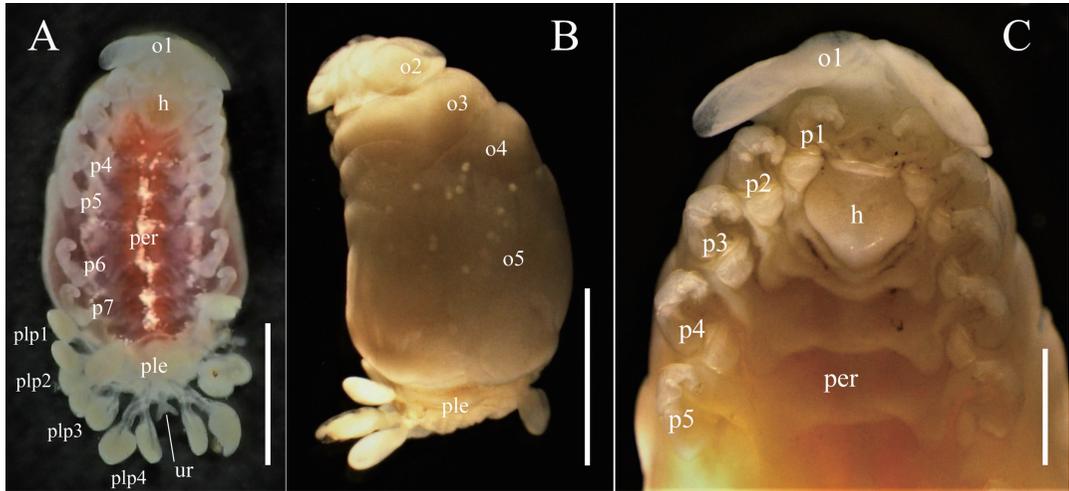


Fig. 2. *Parathelges enoshimensis*, female, NSMT-Cr 27516, 9.0 mm body length, from the abdomen of *Pagurus minutus* in Lake Hamana, central Japan. Frozen-thawed (A) and ethanol-preserved (B, C) specimen. A, habitus, dorsal view; B, habitus, ventral view; C, head and pereon, dorsal view. Abbreviations: h, head; o1–o5, oostegites 1–5; p1–p7, pereopods 1–7; per, pereon; ple, pleon; plp1–4, pleopods 1–4; ur, uropods. Note reddish color in frozen-thawed specimen (A). Scale bars: A, B, 3 mm; C, 1 mm.

ensis from Japan to clarify whether the species is synonymous with *P. aniculi* or not.

The three Japanese prefectures, from which *P. enoshimensis* was collected, are located on the Pacific coast of Honshu Island, which is affected by a warm current, the Kuroshio (Fig. 3). The species also occurs in coastal waters off the southern coast of the Korean Peninsula, which are influenced by the Tsushima Current, a branch of the Kuroshio (Fig. 3). Thus, *P. enoshimensis* may be found in other coastal waters of Japan affected by the two warm currents.

Previously, only an unidentified species of pagurid hermit crab was reported from Japan as a host of *P. enoshimensis* (Shiino, 1950) but, now, *Pagurus minutus* is known to host the bopyrid in the country (Nagasawa and Nishi, 2020; this paper). In Korea, two species of pagurid hermit crabs have been reported to harbor the bopyrid: *P. minutus* and *P. filholi* (as *Pagurus dubius* (Ortmann, 1892) and *Pagurus geminus* McLaughlin, 1976, respectively) (Kim and Kwon, 1988a, b; Kwon, 2012).

According to Shiino (1950, fig. 5B), a male of *P. enoshimensis* is attached on the ventral surface of the pleon of a female of the species. However, we found no male on the female collected in this study. As suggested earlier (Nagasawa et al., 2020), it is most probable that a male was dropped off from the female and lost because the infested hermit crab was taken out by forceps from the gastropod shell.

In our investigation in Lake Hamana, two species of bopyrid isopods, *A. takanoshimensis* and *P. enoshi-*

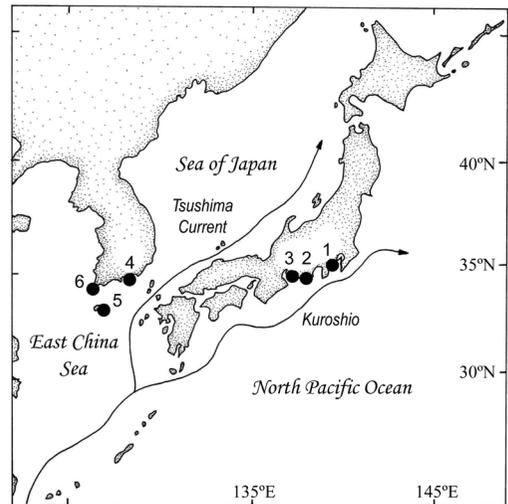


Fig. 3. Map of the Japanese Archipelago and the Korean Peninsula, showing the collection localities of *Parathelges enoshimensis* in the previous and present studies. 1, Enoshima Island (reported as Enosima) (type locality, Shiino, 1950); 2, Lake Hamana (this study); 3, Mikawa Bay (Nagasawa and Nishi, 2020); 4, Namhae Island (Kim and Kwon, 1988b [reported as Hamhaedo Island]; Kwon, 2012); 5, Jeju Island (Kim and Kwon, 1988a, b [reported as Cheju Island]; Kwon, 2012); 6, Sangchuja Island and Hoenggan Island (Kim and Kwon, 1988b [reported as Sangch'ujado Island and Hoenggando Island, respectively]; Kwon, 2012). The routes of a warm current, the Kuroshio, and its branch, Tsushima Current, are also shown.

mensis, were collected from *Pagurus minutus* at Site C and Site A, respectively (Nagasawa et al., 2020; this paper). The overall prevalence of each bopyrid from April to December 2019 was low, being 1.3%. As ear-

lier suggested for *A. takanoshimensis* (Nagasawa et al., 2020), *P. enoshimensis* is also likely to have a small population and occur in a limited area of the lake.

Acknowledgments

We thank Byung-Jik Kim (National Institute of Biological Resources, Incheon, Korea) for his assistance in collecting the literature.

References

- An, J. (ed.) 2011. Taxonomy of Parasitic Isopods from China. Science Press, Beijing, 172 pp. (In Chinese with English title).
- An, J., Williams, J. D. and Yu, H. 2011. Three abdominal parasitic isopods (Isopoda: Epicaridea: Bopyridae: Athelginae) on hermit crabs from China and Hong Kong. *Journal of Natural History*, 45: 2901–2913.
- Boyko, C. B. 2004. The Bopyridae (Crustacea: Isopoda) of Taiwan. *Zoological Studies*, 43: 677–703.
- Kim, H. S. and Kwon, D. H. 1988a. Marine isopod crustaceans from Cheju Island, Korea. *Inje Journal*, 4: 195–220.
- Kim, H. S. and Kwon, D. H. 1988b. Bopyrid isopods parasitic on decapod crustaceans in Korea. *Korean Journal of Systematic Zoology, Special Issue*, 2: 199–221.
- Komai, T. and Mishima, S. 2003. A redescription of *Pagurus minutus* Hess, 1865, a senior synonym of *Pagurus dubius* (Ortmann, 1892) (Crustacea: Decapoda: Anomura: Paguridae). *Benthos Research*, 58: 15–30.
- Kwon, D.-H. 2012. Invertebrate fauna of Korea. Vol. 21, Number 13. Isopods I. National Institute of Biological Resources, Incheon. 93 pp.
- Markham, J. C. 2009. A review of the Bopyridae (Crustacea: Isopoda) of Singapore, with the addition of four species to that fauna. *Raffles Bulletin of Zoology, Supplement 22*: 225–236.
- Nagasawa, K. and Nishi, H. 2020. *Parathelges enoshimensis* (Isopoda: Bopyridae) parasitic on an intertidal hermit crab, *Pagurus minutus*, from Mikawa Bay, Aichi Prefecture, central Japan. *Nature of Kagoshima*, 47: 37–40. (In Japanese with English abstract).
- Nagasawa, K., Koyama, S. and Muto, F. 2020. Occurrence of the bopyrid isopod *Athelges takanoshimensis* on hermit crabs in a brackish water lake, central Japan. *Nature of Kagoshima*, 47: 27–31.
- Nishimura, S. 1983. [Yadokari-no-harayadori *Athelges takanoshimensis*]. Pp. 97 and 321, in Utinomi, H. (ed.), *Gakken Illustrated Nature Encyclopedia, The Aquatic Lower Animals of Japan*. Gakken, Tokyo. (In Japanese).
- Sandberg, L. and McLaughlin, P. A. 1993. Reexamination of *Pagurus minutus* Hess, 1865, and *Pagurus filholi* (de Man, 1887) (Crustacea: Anomura: Paguridae). *Zoologische Mededelingen*, 67: 197–206.
- Shiino, S. M. 1950. Note on some new bopyrids from Japan. *Mie Medical Journal*, 1: 151–167.
- Williams, J. D. and Boyko, C. B. 2015. Abdominal bopyrid parasites (Crustacea: Isopoda: Bopyridae: Athelginae) of diogenid hermit crabs from the western Pacific, with descriptions of a new genus and four new species. *Raffles Bulletin of Zoology*, 64: 33–69.
- WoRMS Editorial Board, 2020. World Register of Marine Species. Available from <http://www.marinespecies.org> at VLIZ. Accessed 2020-06-05. doi:10.14284/170