Nerocila phaiopleura (Isopoda: Cymothoidae): a new record from Ibaraki Prefecture, central Japan, with a discussion of its distribution in Japanese waters

Kazuya Nagasawa, Masato Nitta, Tatsunori Otawa, Takanori Ishikawa

Abstract.—An ovigerous female of Nerocila phaiopleura Bleeker, 1857 was collected from the body surface of a Japanese sardine, Sardinops melanostictus (Temminck & Schlegel, 1846) (Clupeidae), caught in Hitachi Port, Ibaraki Prefecture, central Japan. This collection extends the northern distribution limit of N. phaiopleura from Kujukuri, Chiba Prefecture, to Hitachi Port, Ibaraki Prefecture. In Japan, N. phaiopleura has so far been reported from coastal waters of the western North Pacific ranging from southern Kyushu to central Honshu, the East China Sea off Kyushu, and the Seto Inland Sea. While much remains unknown on its distribution in the southern Sea of Japan, N. phaiopleura is found from waters affected by a warm current, the Kuroshio, and its branch, the Tsushima Current. The species has not been found from subtropical waters of the Ryukyu Islands to date. Due to low water temperatures, the species is not likely to occur in subarctic waters affected by a cold current, the Oyashio, and the Kuroshio-Oyashio transition waters off northeastern Japan.

Key words: fish parasite, new locality record, biogeography, Japanese sardine, Sardinops melanostictus

Isopods of the cymothoid genus Nerocila are skin parasites of marine fishes (Bruce, 1987). Currently, three nominal species of the genus are known from Japan: Nerocila phaiopleura Bleeker, 1857 (see Nagasawa & Isozaki, 2017), N. japonica Schioedte & Meinert, 1881 (Yamauchi & Nagasawa, 2012; Nagasawa & Tawa, 2019), and N. trichiura (Miers, 1877) (Nagasawa & Isozaki, 2019). In 1982, N. phaiopleura was reported for the first time from Japan (Mitani, 1982), where the species has since been recorded from nine species of coastal wild fishes (3 species from the Clupeidae, 1 species from the Dussumieriidae, 1 species from the Engraulidae, 1 species from the Carangidae, 2 species from the Scombridae, 1 species from the Sphyraenidae: Nagasawa & Isozaki, 2017) and from farmed Pacific bluefin tuna, Thunnus orientalis (Temminck & Schlegel, 1844) (Scombridae) (Nagasawa & Shirakashi, 2017).

Recently, we collected a specimen of N. phaiopleura from a Japanese sardine, Sardinops melanostictus (Temminck & Schlegel, 1846) (Clupeidae) in Hitachi Port, Ibaraki Prefecture, central Japan. This collection is reported herein to extend the northern distribution limit of N. phaiopleura from Kujukuri, Chiba Prefecture (Hiramoto, 1996) to Hitachi Port, Ibaraki Prefecture. Moreover, based on the literature of the species published between 1982 and 2020, this paper also discusses its geographical distribution in Japanese waters.

Thirteen individuals of Japanese sardine were caught using rod and line in Hitachi Port (36°29′07.6″N, 140°36′50.3″E), Ibaraki Prefecture, on 5 August 2018, and one (167 mm in total length) of them was parasitized by an isopod on the posterior body surface (Fig. 1A). It was removed carefully and fixed in 99.5% ethanol.
The isopod has been deposited in the invertebrate collection of the Tochigi Prefectural Museum, Utsunomiya, Tochigi Prefecture, Japan (catalogue number: IV-10281). The scientific and common names of fishes mentioned in this paper follow Froese & Pauly (2019), except for Sardinops melanostictus, which follows Nakabo (2013). Previously, the generic name of this fish was incorrectly reported as Sardinopsis by Nagasawa and his coauthors (Nagasawa & Tensha, 2016; Nagasawa & Shirakashi, 2017; Nagasawa & Isozaki, 2017). Sardinops is the correct generic name of Japanese sardine.

The isopod collected is an ovigerous female of Nerocila phaiopleura (21.2 mm in body length, excluding uropods; 9.1 mm in body width), which was firmly attached using its dactyli to the fish with the cephalon being oriented anteriorly. The isopod is morphologically characterized by an elliptical body, the cephalon with a broad anterior margin, large eyes, pereonite 1 with a concaved anterior margin, pleonites 1 and 2 with lateral processes slightly produced, a nearly triangular pleotelson with lateral margins smoothly curved, and uropod rami straight and slender (Fig. 1B–D). Black stripes are present on lateral portions of the pleotelson and the uropod exopods (Fig. 1B, D). These morphological features correspond to those of N. phaiopleura reported from Japan (e.g., Saito & Hayase, 2000; Nagasawa & Tensha, 2016; Nagasawa & Shirakashi, 2017, Australia (Bruce, 1987), and Kuwait (Bowman & Tareen, 1983).

The present collection of N. phaiopleura extends its documented distribution range on the Pacific coast of Japan from Kujukuri, Chiba Prefecture (Hiramoto, 1996) northward to Hitachi Port, Ibaraki Prefecture by 127 km. In both locations, Japanese sardine serve as the host of N. phaiopleura. Before this study, an infection by isopod, most probably N. phaiopleura, was found on Japanese sardine in coastal waters of Ibaraki Prefecture (Hiramoto, 1996) northward to Hitachi Port, Ibaraki Prefecture by 127 km. In both locations, Japanese sardine serve as the host of N. phaiopleura. Before this study, an infection by isopod, most probably N. phaiopleura, was found on Japanese sardine in coastal waters of Ibaraki Prefecture (Yosihitada Ebisawa, Ibaraki Prefectural Fisheries Experimental Station, personal communication). According to Hiramoto (1996), the stock of Japanese sardine occurring off Kujukuri is separated into two groups, an inshore group and an offshore migrating group,

Fig. 1. Nerocila phaiopleura, ovigerous female. A, Japanese sardine Sardinops melanostictus infected by N. phaiopleura on the left posterior body surface, fresh specimen, lateral view; B, body; C, cephalon and pereonites 1–3; D, pleon and pleotelson with uropods, B–D, ethanol-preserved specimen, dorsal views. The fish was collected in Hitachi Port, Ibaraki Prefecture, central Japan, on 5 August 2018. Scale bars: A, 30 mm; B, 5 mm; C, 2 mm; D, 4 mm.
and individuals of only the former group harbor *N. phaiopleura*. The same stock is also found in coastal waters of Ibaraki Prefecture (Kondo et al., 1976; Hiramoto, 1981; Hori, 1995), and the infected fish from Hitachi Port is most probably an individual of the inshore group.

Chiba Prefecture is located south of Ibaraki Prefecture and faces two different seas, Tokyo Bay and the western North Pacific, on the west and east coasts, respectively. Interestingly, the known hosts of *N. phaiopleura* differ between these two seas: four species [Japanese sardine; Japanese sardinella, *Sardinella zunasi* (Bleeker, 1854); dotted gizzard shad, *Konosirus punctatus* (Temminck & Schlegel, 1846); Japanese anchovy, *Engraulis japonicus* Temminck & Schlegel, 1846] are infected by *N. phaiopleura* in Tokyo Bay (Mitani, 1982; Bruce & Harrison-Nelson, 1988; Hiramoto, 1996), while only Japanese sardine in the western North Pacific (Hiramoto, 1996). Ibaraki Prefecture faces the western North Pacific. As little information is available on the hosts of *N. phaiopleura* in the Pacific waters off both Chiba and Ibaraki prefectures, it is desirable to investigate its host range in the waters.

*Nerocila phaiopleura* was originally described from Indonesia (Bleeker, 1857) and since has been reported from South Africa (east coast), Kuwait, Pakistan, India, Thailand, Singapore, Australia, China, and Japan (see Nagasawa & Isozaki, 2017, for the literature). Thus, the species has a wide distribution in tropical through subtropical to temperate waters of the Indo-West Pacific region. Japan is located at the northeastern limit of distribution of *N. phaiopleura*.

Since 1982 when *N. phaiopleura* was reported for the first time from Japan (Mitani, 1982), the species has been reported from various waters around Japan, including coastal waters of the western North Pacific along central and western Japan (localities 1–9 and 15 in Fig. 2), the Seto Inland Sea (localities 10–14 in Fig. 2), and offshore waters of the East China Sea (locality 16 in Fig. 2). A warm current, the Kuroshio, and its branch, the Tsushima Current, flow off western and central Japan (Fig. 2), and part of the waters from these currents intrudes into the Seto Inland Sea through two channels open to the western North Pacific and one strait to the Sea of Japan (Hayami & Unoki, 1970). Therefore, it is reasonable to state that *N.
N. phaiopleura occurs in waters affected by the Kuroshio and the Tsushima Current. In particular, the species is found in coastal Pacific waters along the route of the Kuroshio (Fig. 2). A similar suggestion on its distribution in Japanese waters was preliminarily made by Nagasawa & Shirakashi (2017), and the present paper confirms and supports their suggestion.

To date, N. phaiopleura has not been recorded from subtropical waters of both the Ryukyu Islands (Williams et al., 1996; Daisuke Uyeno, Kagoshima University, personal communication) and Taiwan. The species, however, may occur in these regions, because the subtropical waters are influenced by the Kuroshio and the isopod occurs in the neighboring East China Sea (locality 16 in Fig. 2) and tropical waters at Hong Kong (Morton, 1974; Bruce, 1982) and Guanghai, Guangdong Province (Yu & Li, 2003), China. Kagoshima Bay (locality 15 in Fig. 2) is the presently known southernmost locality of N. phaiopleura in Japan (Williams & Bunkley-Williams, 1986: 654).

No record exists of N. phaiopleura from the Pacific waters of northern Japan, where both a subarctic cold current, the Oyashio, and the Kuroshio-Oyashio transition waters are found off southeastern Hokkaido and northeastern Honshu, respectively. No scientists of fisheries research institutes have found any isopod infection from Japanese sardine in coastal waters of Fukushima, Miyagi, Aomori, Iwate, and Hokkaido prefectures, northern Japan (see the last paragraph for the names of the scientists who gave us the information on isopod infection and their affiliations). Low water temperatures may be one of the factors limiting the distribution of N. phaiopleura in the Pacific waters of northern Japan.

Much remains unknown on the distribution of N. phaiopleura in the southern Sea of Japan, which is influenced by the Tsushima Current (Fig. 2). Saito & Hayase (2000) have suggested that the cymothoid juveniles reported as “Agathoa sp.” by Nunomura (1985, 1999) from Toyama Bay (locality 17 in Fig. 2) are identical as N. phaiopleura. However, the juveniles have not been described for their morphology, and no adult specimen of the species has been reported from the southern Sea of Japan to date. We need a survey in this region to clarify the geographical distribution of N. phaiopleura in waters around the Japanese Archipelago.

We thank the following scientists who provided us with the information on isopod infection of Japanese sardine: Yoshitada Ebisawa, Ibaraki Prefectural Fisheries Experimental Station, Hitachinaka; Kouhei Makabe, Fukushima Prefectural Fisheries and Marine Science Research Center, Iwaki; Mitsuhiro Saeki, Miyagi Prefecture Fisheries Technology Institute, Ishinomaki; Nobuhiko Aioi and Toshiaki Sato, Iwate Fisheries Technology Center, Kamaishi; Kingo Ito, Aomori Prefectural Industrial Technology Research Center, Fisheries Institute, Hiranai; Takayuki Honma, Hiroshi Yamaguchi, and Masayuki Sawamura, Hokkaido Research Organization, Kushiro Fisheries Research Institute, Kushiro. We are grateful to Daisuke Uyeno, Kagoshima University, Kagoshima, for the information on isopod infection of coastal marine fishes of the Ryukyu Islands. We also acknowledge Tomoaki Goto, Sanriku Fisheries Research Center, Iwate University, Kamaishi, for help during the study, and to Yukio Minamiya, Tochigi Prefectural Museum, Utsunomiya, for specimen registration.

**Literature Cited**

Bleeker, P., 1857. Recherches sur les Crustacés de l’Inde Archipelagique. II. Sur les Isopodes Cymothoadiens de l’Archipel Indien. Verhandelingen der Natuurkundige Vereeniging in Nederlandsch-Indië, 2: 20–40, 2 pls.

Bowman, T. E., & Tareen, I. U., 1983. Cymothoidae from fishes of Kuwait (Arabian Gulf) (Crustacea: Isopoda). Smithsonian Contribution to Zoology, 382: 1–30.

Bruce, N. L., 1982. On a small collection of ma-
DISTRIBUTION OF CYMOTHOID IN JAPANESE WATERS

rine Isopoda (Crustacea) from Hong Kong. In: B. S. Morton & C. K. Tseng, (eds.), Proceedings of the First International Marine Biological Workshop: The Marine Flora and Fauna of Hong Kong and Southern China, Vol. 1, Hong Kong University Press, Hong Kong, pp. 315–324.

Bruce, N. L., 1987. Australian species of Nerocila Leach, 1818, and Creniola n. gen. (Isopoda: Cymothoidae), crustacean parasites of marine fishes. Records of the Australian Museum, 39: 355–412.

Bruce, N. L., & Harrison-Nelson, E. B., 1988. New records of fish parasitic marine isopod crustaceans (Cymothoidae, subfamily Anilocrinae) from the Indo-West Pacific. Proceedings of the Biological Society of Washington, 101: 585–602.

Froese, R., & Pauly, D., (eds.), 2019. FishBase: World Wide Web electronic publication. www.fishbase.org, version (08/2019) [accessed 22 December 2019]

Hata, H., Sogabe, A., Tada, S., Nishimoto, R., Nakano, R., Kohya, N., Takeshima, H., & Kawanishi, R., 2017. Molecular phylogeny of obligate fish parasites of the family Cymothoidae (Isopoda, Crustacea): evolution of the attachment mode to host fish and the habitat shift from saline water to freshwater. Marine Biology, 164: 105. DOI 10.1007/s00227-017-3138-5.

Hayami, K., & Unoki, S. 1970. [Exchange of sea water and diffusion of substance in the Seto Inland Sea]. Proceedings of the Conference on Coastal Engineering in Japan, 17: 385–393. [In Japanese]

Hiramoto, K., 1981. Studies on the growth and life-cycle of the Japanese sardine, Sardinops melanosticta (Temminck et Schlegel) in its Pacific sub-population found in Jōban and Bōsō regions. Bulletin of the Chiba Prefectural Fisheries Experimental Station, 39: 1–127. [In Japanese with English abstract]

Hiramoto, K., 1996. [Natural history of Japanese sardine—survival strategy of “marine rice”—]. 183 pp. Chuokoronsha, Tokyo. [In Japanese]

Hori, Y., 1995. [Japanese sardine currently caught in spring and summer seasons in waters around Joban, Kashima-nada, and Cape Inubosaki]. Bulletin of the Ibaraki Prefectural Fisheries Experimental Station, 33: 21–41. [In Japanese]

Kondo, K., Hori, Y., & Hiramoto, K., 1976. Life pattern of the Japanese sardine, Sardinops melanosticta (Temminck et Schlegel), and its practical procedure of marine resources researches of the stock (second edition). 68 pp. Japan Fisheries Resource Conservation Association, Tokyo. [In Japanese with English title]

Mitani, I., 1982. Variations of condition factor of sardine as host by Nerocila phaeopleura Bleeker as parasites. Bulletin of the Japanese Society of Scientific Fisheries, 48: 611–615. [In Japanese with English abstract]

Morton, B., 1974. Host specificity and position on the host in Nerocila phaeopleura Bleeker (Isopoda, Cymothoidae). Crustaceana, 26: 143–148, 1 pl.

Nagasawa, K., 2019. First record of Nerocila phaeopleura (Isopoda: Cymothoidae) in the East China Sea. Nature of Kagoshima, 46: 221–224. [In Japanese with English abstract]

Nagasawa, K., & Isozaki, S., 2017. Three new host records for the marine fish ectoparasite, Nerocila phaeopleura (Isopoda: Cymothoidae), with a list of its known hosts. Crustacean Research, 46: 153–159.

Nagasawa, K., & Isozaki, S., 2019. New record of a marine fish parasite Nerocila trichiura (Crustacea: Isopoda: Cymothoidae) from Japan, with its confirmed distribution in the western North Pacific Ocean. Species Diversity, 24: 195–201.

Nagasawa, K., & Kawai, K. 2018. Nerocila phaeopleura (Isopoda: Cymothoidae) parasitic on chub mackerel Scomber japonicus in the Seto Inland Sea, western Japan, with an observation on a skin wound caused by the isopod. Cancer, 27: 83–85. [In Japanese with English title]
Nagasawa, K., & Nakao, H., 2017. Chub mackerel, *Scomber japonicus* (Perciformes: Scombridae), a new host record for *Nerocila phaiopleura* (Isopoda: Cymothoidae). Biosphere Science, 56: 7–11.

Nagasawa, K., & Shirakashi, S., 2017. *Nerocila phaiopleura*, a cymothoid isopod parasitic on Pacific bluefin tuna, *Thunnus orientalis*, cultured in Japan. Crustacean Research, 46: 95–101.

Nagasawa, K., & Tawa, A., 2019. *Nerocila japonica* (Isopoda: Cymothoidae) parasitic on a Japanese seabass, *Lateolabrax japonicus* (Lateolabracidae), from the Pacific coast of central Japan, with a review of the geographical distribution of the isopod in Japan and East Asia. Nature of Kagoshima, 46: 77–80.

Nagasawa, K., & Tensha, K., 2016. *Nerocila phaiopleura* (Isopoda: Cymothoidae) parasitic on Japanese Spanish mackerel *Scomberomorus niphonius* in the Seto Inland Sea, Japan. Biogeography, 18: 71–75.

Nagasawa, K., Shirakashi, S., & Yamamoto, S., 2019. *Nerocila phaiopleura* and *N. japonica* (Isopoda: Cymothoidae) parasitic on coastal marine fishes off Wakayama Prefecture, central Japan. Nature of Kagoshima, 46: 177–180. [In Japanese with English abstract]

Nakabo, T., (ed.), 2013. Fishes of Japan with Pictorial Keys to the Species. Third Edition. 1 + 2428 pp. Tokai University Press, Hadano. [In Japanese with English title]

Nunomura, N., 1985. Marine isopod crustaceans in [sic] the coast of Toyama Bay. Memoirs of the National Science Museum, Tokyo, 18: 121–139.

Nunomura, N., 1999. Seashore invertebrate fauna of Himi Coast, Toyama Bay 1. Animals except Mollusca. Bulletin of the Toyama Biological Society, 38: 29–39. [In Japanese with English title]

Nunomura, N., 2011. Crustaceans No. 2 (Isopoda). Special Publication of the Toyama Science Museum, 24: 1–133. [In Japanese with English title]

Saito, N., & Hayase, Y., 2000. Note on an aegathoid stage of cymothoid isopod, *Nerocila phaiopleura* Bleeker, 1857 (Crustacea: Isopoda: Cymothoidae) stranded at Miho beach, Suruga Bay, middle of Japan. I. O. P. Diving News, 11(10): 2–6. [In Japanese with English abstract]

Saito, N., & Ogawa, H., 2019. Growth of the aegathoid stage of *Nerocila phaiopleura* (Isopoda: Cymothoidae). Cancer, 28: 21–24. [In Japanese with English abstract]

Saito, N., Yamauchi, T., Ariyama, H., & Hoshino, O., 2014. Descriptions and ecological notes of free-swimming forms of cymothoid isopods (Crustacea: Peracarida) collected in two waters of Japan. Crustacean Research, 43: 1–16.

Williams, E. H. Jr., & Bunkley-Williams, L., 1986. The first *Anilocra* and *Pleopodias* isopods (Crustacea: Cymothoidae) parasitic on Japanese fishes, with three new species. Proceedings of the Biological Society of Washington, 99: 647–657.

Williams, E. H. Jr., Bunkley-Williams, L., & Dyer, W. G., 1996. Metazoan parasites of some Okinawan coral reef fishes with a general comparison to the parasites of Caribbean coral reef fishes. Galaxea, 13: 1–13.

Yamauchi, T., & Nagasawa, K., 2012. Redescription of the fish parasite *Nerocila japonica* Schioedte & Meinert, 1881 (Crustacea: Isopoda: Cymothoidae), with comments on previous records of *N. acuminata* in Japanese waters. Systematic Parasitology, 81: 147–157.

Yu, Y., & Li, X., 2003. Study on the Cymothoidae from Chinese waters. Studia Marina Sinica, 45: 223–228. [In Chinese with English abstract]

**Addresses**

(KN) Graduate School of Integrated Sciences for Life, Hiroshima University, 1–4–4 Kagamiyama, Higashi-Hiroshima, Hiroshima 739–8528, Japan.

(KN’s present address) Aquaparasitology
Laboratory, 365–61 Kusanagi, Shizuoka 424–0886, Japan.
(MN) Graduate School of Science, Kobe University, 1–1 Rokkodai, Nada, Kobe, Hyogo 657–8501, Japan.
(TO) 1788–4 Himuro-machi, Utsunomiya, Tochigi 321–3232, Japan.

(TI) College of Bioresource Sciences, Nihon University, 1866 Kameino, Fujisawa, Kanagawa 252–0880, Japan

E-mail address of corresponding author
(KN) ornatus@hiroshima-u.ac.jp