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

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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.

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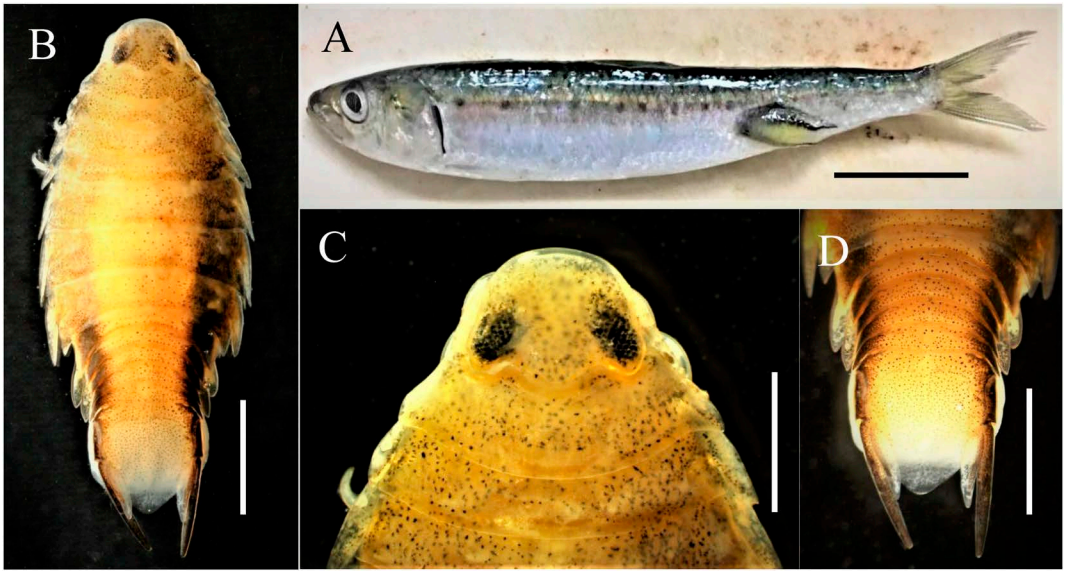

Fig. 1. *Nerocila phaiopleura*, ovigerous female. A, Japanese sardine *Sardinops melanostictus* infected by *N. phaiopleura* on the left posterior body surface, fresh specimen, lateral view; B, body; C, cephalon and pereonites 1–3; D, pleon and pleotelson with uropods, B–D, ethanol-preserved specimen, 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.

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 *N. 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 (Yoshitada 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,

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 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.*

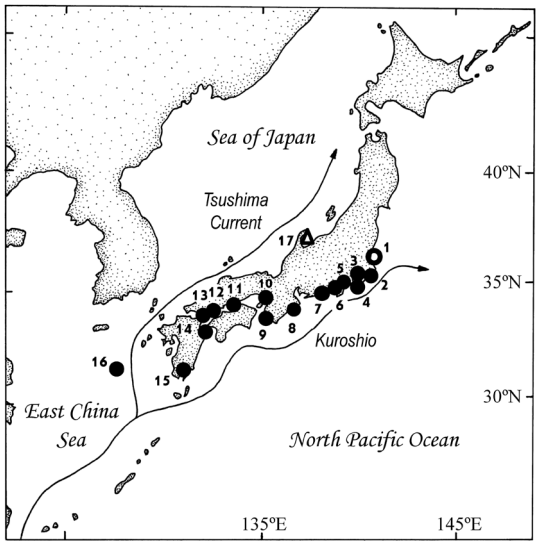

Fig. 2. Map of the Japanese Archipelago, showing the localities where *Nerocila phaiopleura* was collected in the previous (closed circles) and present (open circle) studies (updated from Nagasawa & Shirakashi, 2017). 1, Hitachi Port (this paper); 2, Kujukuri (Hiramoto, 1996); 3, Tokyo Bay (Mitani, 1982; Bruce & Harrison-Nelson, 1988; Hiramoto, 1996); 4, Kaneda Bay or off Misaki (Mitani, 1982; Bruce & Harrison-Nelson, 1988); 5, Sagami Bay and Katase Coast (Hata *et al.*, 2017; Saito & Ogawa, 2019); 6, Suruga Bay (Saito & Hayase, 2000; Saito & Ogawa, 2019); 7, Omaezaki (Saito & Hayase, 2000; Nunomura, 2011); 8, Kowaura Bay (Nagasawa & Isozaki, 2017); 9, Shirahama (Nagasawa & Shirakashi, 2017; Nagasawa *et al.*, 2019); 10, Osaka Bay (Saito *et al.*, 2014; Saito & Ogawa, 2019); 11, Seto Inland Sea (Hata *et al.*, 2017); 12, Hiroshima Bay (Saito & Hayase, 2000; Nagasawa & Kawai, 2018); 13, western Seto Inland Sea (Nagasawa & Tensha, 2016); 14, Hōyo Strait (Nagasawa & Nakao, 2017); 15, Kagoshima Bay (Williams & Bunkley-Williams, 1986); 16, East China Sea (Nagasawa, 2019). Locality 17 (open triangle) is Toyama Bay, where juveniles of cymothoid ("*Aegathoa* sp.," Nunomura, 1985, 1999), possibly those of *N. phaiopleura* (Saito & Hayase, 2000), were collected. The routes of a warm current, the Kuroshio, and its branch, the Tsushima Current, are also shown.

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 "*Aegathoa* 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.

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