**Norileca aff. triangulata** (Isopoda: Cymothoidae), a branchial cavity parasite of the African sailfin flyingfish, *Parexocoetus mento* (Beloniformes: Exocoetidae), from southern Japan, with a new Japanese record of the isopod genus

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**Abstract.**— A single ovigerous female of cymothoid isopod was collected from the branchial cavity of the African sailfin flyingfish, *Parexocoetus mento* (Valenciennes, 1847) in Kadogawa Bay, an inlet of the western North Pacific Ocean, southern Japan. Although the isopod specimen differs from *Norileca triangulata* (Richardson, 1910) in the number of articles of the antennula and the absence of small setae on the propodus of pereopods 1 and 2, it is similar to the species. However, the species was poorly originally described, and there are several differences between the original and subsequent descriptions and the specimen. Thus, this study refrains from identifying the specimen to species and reports it as *N. aff. triangulata*. This represents the first record of *Norileca* from Japan. Five species of cymothoid isopods including *N. aff. triangulata* are now known from Japanese flyingfishes, and a parasite-host list is provided.

**Key words**: isopod, parasitic crustacean, new country record

**Introduction**

The cymothoid isopod genus *Norileca* Bruce, 1990, known as the parasites of marine surface-schooling fishes in the Indo-West Pacific region (Bruce, 1990), are represented by three species: *N. indica* (H. Milne Edwards, 1840), *N. triangulata* (Richardson, 1910), and *N. borealis* Javed and Yasmeen, 1999. *Norileca indica* was originally described by Milne Edwards (1840) as *Livoneca indica* but later transferred by Bruce (1990) to *Norileca*, which was created by the same author. This isopod has a wide distribution range in the Indo-West Pacific region from the Philippines to South Africa and uses a variety of teleosts as its hosts (van der Wal et al., 2017). *Norileca triangulata* was originally described by Richardson (1910) as *Livoneca triangulata* and, together with *L. indica*, transferred to *Norileca* by Bruce (1990). It occurs off the Philippines, Australia, Pakistan, and India and is known to infest three species of teleosts, the sailfin flyingfish, *Parexocoetus brychipterus* (Richardson, 1846) (Beloniformes: Exocoetidae), the Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) (Perciformes: Scombridae), and the goldstripe sardinella, *Sardinella gibbosa* (Bleeker, 1849) (Clupeiformes: Clupeidae) (Bruce, 1990; Ghani & Ali, 1998; Kazmi et al., 2002; Ghani, 2003; Rameshkumar & Ravichandran, 2015; Ravichandran et al., 2019). It was also recorded from the Gulf of Thailand (Purivirojkul & Songsuk, 2020). *Norileca borealis* was described from specimens from the Indian mackerel in the Arabian Sea (Javed & Yasmeen, 1999). To
date, any species of *Norileca* has not been reported from Japan (Yamauchi, 2016).

In 2009, a female specimen of cymothoid isopod (Fig. 1) was collected from the branchial cavity of the African sailfin flyingfish, *Parexocoetus mento* (Valenciennes, 1847), in coastal waters of southern Japan. This fish species is mainly distributed in tropical waters of the Indo-West Pacific region (Froese & Pauly 2019), and its catch in Japanese waters is not common. Due to this, despite subsequent sampling efforts, no additional similar isopod was taken from the fish species. As described below, the isopod specimen is similar to *N. triangulata*, but this species was poorly originally described from the Philippines (Richardson, 1910), and there are several differences between the original and subsequent descriptions (Bruce, 1990; Ravichandran et al., 2019) and also between the specimen and those descriptions. Therefore, the specimen is herein reported as *N. aff. triangulata*, which represents the first record of *Norileca* from Japan.

**Materials and Methods**

The isopod specimen was collected from the branchial cavity of an African sailfin flyingfish (body size unknown) on 7 May 2009 captured in a set net installed in Kadogawa Bay, Miyazaki Prefecture, Kyushu Island, southern Japan. The infested fish was identified by Yukio Iwatsuki, an expert of fish taxonomy, Miyazaki University. Since the isopod was accidentally found from the fish during a faunal study of marine fishes (Iwatsuki et al., 2017), there were no data on prevalence. The specimen was fixed and preserved in 70% ethanol. It was dis-
sected and studied using an Olympus SZX10 stereo microscope and an Olympus BX51 phase-contrast compound microscope. Dissected mouthparts and other appendages were cleared in lactophenol and examined using the wooden slide procedure (Humes & Gooding, 1964). All drawings were made with the aid of drawing tubes attached to the microscopes. The specimen has been deposited in the Crustacea collection of the National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture (NSMT-Cr). The scientific and common names of fishes mentioned in this paper follow Froese & Pauly (2020).

## Taxonomy

**Family** **Cymothoidae** Leach, 1818  
[Japanese name: Uonoe-ka]

**Genus** **Norileca** Bruce, 1990  
[New Japanese name: Sankaku-o-uonoe-zoku]

*Norileca* aff. *triangulata* (Richardson, 1910)  
(Figs. 1–3)

**Material examined**

Ovigerous female (NSMT-Cr 28462), 15.8 mm in body length, 8.1 mm in body width.

**Description of ovigerous female**

Body 2.0 times as long as greatest width, weakly twisted; widest at pereonite 5; dorsum weakly convex. Pereonite lateral margins posteriorly rounded. Cephalon 0.9 times longer than wide, visible in dorsal view, not deeply immersed in pereonite 1; frontal margin slightly triangular. Eyes oval with distinct margins, 0.2–0.3 times width of cephalon, 0.5 times length of cephalon. Pereonite 1 anterior border slightly indented; anterolateral angles weakly acute, extending to posterior of eyes. Coxae all not extending past pereonite margin; 2 as long as segment; 3–7 shorter than respective segments; 5–7 anteriorly concealed each by pereonites 4–6, with posteroventral angles weakly acute.

Pereonite 1 and 3 longest; 2 and 4 longer than 5 and 6, both of the latter subequal; 7 shortest. Pereonites 1–4 increasing in width; 6 and 7 decreasing in width. Posterior margins of pereonites 6 and 7 weakly concave. Posteralateral margins of pereonite 7 extending to pleonite 1. Pleon with pleonites becoming progressively narrower towards posterior; pleonite 1 longest, largely concealed by pereonite 7; 2–4 visible in dorsal view; 5 distinctly narrower than 1 (0.78 wide), with medial posterior portion weakly produced; lateral margins of pleonite 1 rounded, 2–5 weakly acute. Pleotelson 0.7 times as long as anterior width; anterolateral margins weakly curved; posterior portion triangular in dorsal view.

Antennula with 7 articles, bases set wide apart, extending to posterior of eyes; peduncle articles 1 and 2 distinct and articulated; article 2 1.2 times as long as article 1; article 3 1.1 times as long as wide, 0.4 times as long as combined length of articles 1 and 2; flagellum with 4 articles; articles 4–7 with clusters of setae; article 7 with several short simple setae. Antenna with 9 articles, slightly longer than antennula, extending to anterior margin of pereonite 1; peduncle article 1 1.3 times as long as article 2; article 2 1.7 times as long as wide, 1.4 times as long as article 3; article 3 1.2 times as long as wide, 0.7 times as long as article 4; flagellum with 6 articles; article 9 with 4 short simple setae.

Mandible (partially damaged) molar process present, ending in an acute incisor; palp large without setae; palp article 2 flattened and expanded; article 3 rounded, 0.46 times as long as article 2. Maxillula simple (no observation of terminal setae was made because anterior extremity of maxillula was broken). Maxilla mesial lobe with 2 recurved robust setae; lateral lobe with 2 recurved robust setae. Maxilliped palp article 2 without setae; article 3 with
Fig. 2. *Norileca* aff. *triangulata*, ovigerous female, 15.8 mm, NSMT-Cr 28462. A, dorsal view; B, lateral view; C, dorsal view of cephalon and pereopod 1; D, ventral view of cephalon (left pleopod 1 omitted); E, antennula; F, antenna; G, mandible (partially damaged); H, mandible palp; I, maxilliped; J, maxilliped article 3; K, maxilla; L, uropod; M, oostegites. Scale bars: A, B, M, 5 mm; C, 2 mm; D, L, 1 mm; E, F, 0.3 mm; G–I, 0.2 mm; J, K, 0.1 mm.
3 recurved robust setae.

Pereopods all without setae. Pereopod 1 basis 1.6 times as long as greatest width; ischium 0.5 times as long as basis; merus proximal margin with bulbous protrusion; carpus with weakly convex proximal margin; propodus 1.3 times as long as wide; dactylus slender, 2.1 times as long as propodus, 3.7 times as long as basal width. Pereopods 2–5 similar to pereopod 1. Pereopods 6 and 7 similar to each other. Pereopod 7 basis 1.3 times as long as greatest width; ischium 0.8 times as long as basis; merus proximal margin with large bulbous protrusion; carpus proximal margin with slight bulbous protrusion; propodus 0.8 times as long as wide; dactylus slender, 2.8 times as long as propodus, 4.1 times as long as basal width. Brood pouch formed from 4 pairs of alternately overlapping oostegites arising from coxae 2–5.

Pleopods without spines; exopods 1 and 2 as long as endopods 1 and 2; exopods 3–5 longer than endopods 3–5. Pleopod 1 exopod 1.0 times as long as wide, lateral margin strongly convex, distally broadly rounded, mesial margin convex; endopod 1.2 times as long as wide, lateral margin strongly convex, distally narrowly rounded, mesial margin straight; peduncle 4.9 times as wide as long. Pleopods 2–4 similar to pleopod 1. Pleopod 5 exopod 1.3 times as long as wide, lateral margin convex, distally rounded, mesial margin nearly straight; endopod, 1.2 times as long as wide, lateral margin strongly convex, distally medially indented, mesial margin nearly straight; peduncle 4.3 times as wide as long. Pleopods 2–5 peduncles with well-developed lateral lobes. Pleopods 3–5 endopods with folded proximomedial lobes. Pleopod 5 endopod with fleshly folded lobes.

Uropods nearly half length of pleotelson; peduncle 1.0 times longer than rami; peduncle lateral margin without setae; rami not extending beyond pleotelson. Endopod apically rounded, 2.7 times long as greatest width, lateral margin straight, mesial margin weakly convex, terminating without setae. Exopod not extending to apex of endopod, apically rounded, similar length to endopod, 2.7 times long as greatest width, lateral margin weakly convex, mesial margin weakly convex, terminating without setae.

**Color**
Pale brown in ethanol preservative, dark brown chromatophores over dorsal surface, particularly on pleon and pleotelson (Fig. 1).

**Attachment site on host**
Branchial cavity of the African sailfin flyingfish, *Parexocoetus mento* (Valenciennes, 1847) (Beloniformes: Exocoetidae).

**Locality**
Kadogawa Bay (32°28′20″N, 131°39′55″E), an inlet of the western North Pacific Ocean, Kadogawa, Miyazaki Prefecture, Kyushu Island, Japan.

**Japanese name of the genus**
The new Japanese name of the genus *Norileca* is a combination of “sankaku-o”, “uonoe”, and “zoku”, which mean a triangular pleotelson, cymothoid, and genus, respectively.

**Remarks**
The ovigerous female specimen collected in this study is characterized by a weakly twisted body; coxae 3–7 shorter than respective segments; antennula shorter than antenna; bases of antennula set wide apart; mandible palp article 2 flattened and expanded; brood pouch with 4 pairs of alternately overlapping oostegites on coxae 2–5; pleopods 2–5 peduncles with lateral lobe; pleopods 3–5 endopods with folded proximomedial lobe; pleopod 5 endopod distal margin medially indented; and uropods not extending beyond posterior margin of pleotelson. These characters well fit to the diagnosis of the genus *Norileca* defined by Bruce (1990) and van der Wal et al. (2017).
Fig. 3. *Norileca* aff. *triangulata*, ovigerous female, 15.8 mm, NSMT-Cr 28462. A–G, pereopods 1–7, respectively; H–K, ventral views of pleopods 1–4, respectively; L, dorsal view of pleopod 5. Note anterior part of claw of pereopod 5 lost (Fig. 3E). Scale bars: A–G, 0.5 mm; H–L, 1 mm.
Currently, Norileca consists of three species: N. indica, N. triangulata, and N. borealis. The Norileca specimen collected in this study has a weakly twisted body, pleonite 5 narrower than pleonite 1, and 3 recurved robust setae on the maxilliped article 3 and differs from N. indica that has the body twisted to one side, pleonite 5 about as wide as pleonite 1, and 4 recurved robust setae on the maxilliped article 3 (Bruce, 1990; van der Wal et al., 2017; Ravichandran et al., 2019). The specimen also has 2 recurved robust setae each on the mesial and lateral lobes of the maxilla and no spine on the pereopod merus and differs from N. borealis that has 1 and 4 robust setae on respective lobes and a spine on the pereopod merus (Javed & Yasmeen, 1999).

In contrast, the specimen is similar to N. triangulata in the body shape (= a weakly twisted body) and the presence of 2 recurved robust setae each on the mesial and lateral lobes of the maxilla and 3 recurved robust setae on the maxilliped article 3, but is different from the species in the number of articles of the antennula (7 articles in the specimen but 8 articles in N. triangulata) and the presence or absence of small setae on the propodus of pereopods 1 and 2 (no setae in the specimen but 5 and 3 setae, respectively, in N. triangulata) (Bruce, 1990; Ravichandran et al., 2019). Nevertheless, the number of antennal articles is known to be variable (cf. Hadfield et al., 2010), and small setae on the pereopods may be easily lost during long-term preservation of specimens. Thus, it is not appropriate to, using such unstable morphological characters, regard the specimen collected in this study as different from N. triangulata.

Nerocila triangulata was originally described from female specimens from Tonimdao Island, the Philippines (Richardson, 1910). The species was later found off Australia (Bruce, 1990), Pakistan (Ghani & Ali, 1998; Kazmi et al., 2002; Ghani, 2003), India (Rameshkm & Ravichandran, 2015; Ravichandran et al., 2019) and Thailand (Purivirojkul & Songsuk, 2020), and described in detail by Bruce (1990) and Ravichandran et al. (2019) using specimens from Australia and India, respectively. These specimens had the antenna composed of 9 articles (vs. 8 articles in the Philippine specimens), but the authors gave no comment on this difference. Moreover, the original description of H. triangulata was insufficient: no information was given on any mouthpart, and only two figures (dorsal view of the female body and lateral view of pereopod 7) were provided. Bruce (1990) found three syntypes of the species (USNM 40915) at the National Museum of Natural History, the Smithsonian Institution, Washington, D.C. but, strangely, he did not use these types in his paper, which implies that the specimens (collected in 1907–1908) were in poor condition. Although it is necessary to first examine the syntypes, it is also desirable to collect new specimens of the species from the type locality (Tonimdao Island, the Philippines). Based on these considerations, it is better herein to treat the specimen collected in this study as N. aff. triangulata without further discussing whether it is identifiable as H. triangulata or not.

Norileca aff. triangulata represents the first record of the genus from Japan. Since 12 other genera of the Cymothoidae have been found from Japanese marine fishes (Yamauchi, 2016), Nerocila is the 13th genus of the family reported from Japan.

Discussion

The specimen of N. aff. triangulata reported herein was collected from the African sailfin flyingfish (Parexocoetus mento). This fish species is distributed in tropical waters of the Indo-West Pacific region, and Japan is located near the northeasternmost limit of its distribution range (Froese & Pauly, 2019). This indicates that N. aff. triangulata is also a tropical species, which can further emphasize the
above-mentioned importance to collect new material of *N. triangulata* in the Philippines. Although no host information was given in the original description (Richardson, 1910), *N. triangulata* has been reported from the sailfin flyingfish (*Parexocoetus brachypterus*) from Australia (Bruce, 1990), the Indian mackerel (*Rastrelliger kanagurta*) from Pakistan (Ghani & Ali, 1998; Kazmi et al., 2002; Ghani, 2003), and the goldstripe sardinella (*Sardinella gibbosa*) from Australia and India (Bruce, 1990; Rareshkmar & Ravichandran, 2015; Ravichandran et al., 2019). The sailfin flyingfish is a subtropical species (Froese & Pauly, 2019), and flyingfishes of the genus *Parexocoetus* may serve as one of the important hosts for *N. triangulata* and *N. aff. triangulata* in warm waters of the West-Pacific region, including at least Australia (Bruce, 1990) and Japan (this paper).

Purivirojkul & Songsuk (2020) reported *N. triangulata* from the blackbanded trevally, *Seiolina nigrofasciata* (Rüppell, 1829) (Perciformes: Carangidae) in the Gulf of Thailand. However, since their cymothoid specimen was found to be attached to the "skin" of the fish and prevalence of infestation was low (1.11%), the specimen might have been moved from the branchial cavity of other fish species and then accidentally transferred to the skin of the blackbanded trevally during or after fishing operation because the fishes examined by the authors were commercially caught by trawl nets and others. Although the orange-spotted grouper, *Epinephelus coioides* (Perciformes: Serranidae), was also recorded as another host of *N. triangulata* in the Gulf of Thailand (Purivirojkul & Songsuk, 2020: 11), the infested fish was most probably not that species but the blackbanded trevally because the hosts of *N. triangulata* are epipelagic fishes and the orange-spotted grouper is a typical demersal fish.

*Norileca aff. triangulata* is the fifth species of cymothoid isopod reported from flyingfishes (Exocoetidae) of Japan. The known four species of cymothoids are *Mothocya melanosticta* (Schioedte & Meinert, 1884), *Ceratothoa guttata* (Richardson, 1910) (=*Mothocya katoi* Nunomura, 1994; see Hadfield et al., 2015 for synonymy), *Glossobius auritus* Bovallius, 1885 (=*Glossobius ogasawarensis* Nunomura, 1994; see Nunomura, 2005 and Martin et al., 2015 for synonymy), and *Nerocila trichiura* (Miers, 1877), and their hosts, collection localities in Japan, and attachment sites are shown in Table 1. Twenty-eight species of flyingfishes are known to occur in Japanese waters (Mottomura, 2020), where 6 (21%) species of them have been reported to host at least one species of cymothoid isopod (Table 1). The sailfin flyingfish is known to host two cymothoid species, *M. melanosticta* and *C. guttata* (Bruce,
1986; Nunomura, 1994, 2005, 2011).

In Kadogawa Bay, another species of cymothoid isopod **Mothocya collettei** (Bruce, 1986) was discovered as the first Japanese record from the hound needlefish, *Tylosurus crocodilus* (Péron & Lesueur, 1821) (Beloniformes: Belonidae) (Nagasawa, 2017). This indicates that our knowledge is fragmentary regarding the cymothoid isopods parasitic on marine fishes in coastal waters of Kyushu Island including Kadogawa Bay. We need more study to clarify the cymothoid fauna of this region.

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