First Record of the Rare Parasitic Isopod *Elthusa splendida* (Cymothoidae) from the Pacific Ocean, Based on a Specimen Found in a Museum Shark Collection

Ryota Kawanishi1,4 and Shinpei Ohashi2,3

1 Faculty of Environmental Earth Science, Hokkaido University, N10W5, Kita-ku, Sapporo, Hokkaido 060-0810, Japan
E-mail: kawanishi@ees.hokudai.ac.jp
2 Fisheries Science Center, Hokkaido University Museum, 3-1-1 Minato-cho, Hakodate, Hokkaido 041-8611, Japan
3 Present address: 832-10 Nishinosyo, Wakayama 640-0112, Japan
4 Corresponding author

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An ovigerous female of the rare cymothoid isopod, *Elthusa splendida* (Sadowsky and Moreira, 1981) was discovered in a museum specimen of Japanese spurdog *Squalus japonicus* Ishikawa, 1908 collected from the East China Sea. This cymothoid species was previously known only from the type locality, off southern Brazil, the western South Atlantic. Therefore, the new record in the East China Sea represents the almost maximum distribution range extension on the earth (i.e., the antipodes). In addition, the present female is the largest specimen of this species on record (57.9 mm in total length). We described the East China Sea specimen along with verification of the presence of four pits on pereonite 1, an important diagnostic character of the species, using a 3D measurement system.

**Key Words:** Mouth parasite, natural history collection, range extension, dogfish sharks, North Pacific, Japan.

**Introduction**

The family Cymothoidea is one of the most diverse parasitic isopods, with more than 40 genera and 360 species (Smit et al. 2014). Cymothoids are known from various fish hosts from the deep sea to fresh waters, while each cymothoid species exhibits host specificity with a specific attachment site: fish body surface or buccal, gill, or body cavities (Smit et al. 2014). A recent molecular phylogeny based on the sequences of mitochondrial 16S rRNA and COI genes showed that the basal clade of the family consists of a deep-sea species of the genus *Elthusa* Schioedte and Meinert, 1884, suggesting that the family may have originated in the deep sea and subsequently expanded its distribution to shallow seas and fresh waters (Hata et al. 2017). Therefore, distribution range of deep-sea *Elthusa* is a key element for better understanding the diversification of the family, but such information is lacking in many species.

*Elthusa splendida* (Sadowsky and Moreira, 1981) is one of the most poorly known deep-sea species of the genus. There are no records of this species after its original description by Sadowsky and Moreira (1981) from off southern Brazil, the western South Atlantic. The original description suggested that *E. splendida* had rare ecological traits in the family. First, this species parasitises deep-sea elasmobranch fish (Cuban dogfish *Squalus cubensis* Howell Rivero, 1936) while other cymothoids typically use teleosts as hosts. Second, female *E. splendida* attaches itself to the host’s palate, whereas female of the other species of *Elthusa* inhabits the gill cavities of hosts, except for *Elthusa neocytta* (Ardeev, 1975), which attaches to the host's buccal cavity. Although there are many mouth-dwelling species in other cymothoid genera, they typically attach either to the host's tongue or mouth floor, and thus palate-attaching species is very rare even in the family, e.g., *Ceratothoa verrucosa* (Schioedte and Meinert, 1883) (Nagasawa 2017).

In this study, we report the first record of *E. splendida* in the East China Sea (ECS), which considerably extends the known geographical range of the species from the type locality (off southern Brazil). This ECS specimen was found from the buccal cavity of a shark specimen preserved in the Hokkaido University Museum, Hakodate, Japan (HUMZ). Here, we described morphological characteristics of the ECS specimen and compared with the original description of *E. splendida*. In addition, we discussed the potential value of natural-history collections of host taxon for revealing cymothoid biodiversity.

**Materials and Methods**

The cymothoid specimen we examined in this study was found from the buccal cavity of a specimen of Japanese spurdog *Squalus japonicus* Ishikawa, 1908 (HUMZ 189737) during processing fish specimens of the HUMZ. This spurdog specimen was captured from the ECS (no further locality data) on 1 June 2003 and that has been preserved in a tank of 10% formalin. The cymothoid specimen was removed from the spurdog’s mouth and then preserved in 70% ethanol. At that point, the specimen had lost left pereopods 4–7 and some damaged parts. After taking
whole-body photographs of the specimen, some appendages (left and right pereopods 1, right pereopod 7, and right pleopods 1–5) were dissected using tweezers and dissecting needles, and then observed under a stereomicroscope (Leica M165C). Mouth parts were not dissected because they were fragile probably due to a long-term preservation in formalin. The cymothoid specimen was measured using a digital caliper to the nearest 0.1 mm according to van der Wal et al. (2019). Right appendages were used for the measurement. Presence of four pits on pereonite 1, known as a diagnostic character of *E. splendida* (Sadowsky and Moreira 1981), was verified using a 3D measurement system (VR-3000, Keyence). The cymothoid specimen was registered separately as a crustacean specimen of the Hokkaido University Museum, Japan (HUMZ-C 2400). A distribution map of the species was drawn using the ETOPO1 dataset (Amante and Eakins 2009) and functions “geom_raster” (package “ggplot2”) and “getNOAA.bathy” (package “marmaps”) in the R environment (R Core Team 2018). For comparison, an illustration of a syntype (MNHN-IU-2016-9885) of *E. raynaudii* (Milne Edwards, 1840) was made based on a photograph of the syntype [photo credit: RECOLNAT (ANR-11-INBS-0004) –Noémy Mollaret–2017; CC BY] available from the database website of the National Museum of Natural History, Paris (MNHN; http://coldb.mnhn.fr/catalognumber/mnhn/iu/2016-9885).

### Results

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

**Genus Elthusa** Schioedte and Meinert, 1884  
[Standard Japanese name: Eru-uonoe-zoku]

**Elthusa splendida** (Sadowsky and Moreira, 1981)  
[New standard Japanese name: Oo-uonoe]  
(Figs 1–3, 4A, 5)

*Lironeca splendida* Sadowsky and Moreira, 1981: 143 (original description; type locality: Oc/S Prof. W. Besnard St. 2403. Lat. 23°27′S, Long. 43°20′W. 104–108 m depth).  
*Elthusa splendida*: Bruce 1990: 254 (revision of the genus; no new specimens).

**Description of ECS specimen.** Ovigerous female (57.9 mm in total length, TL; 29.1 mm in maximum width; Figs 1, 2). Body elongated oval, almost symmetrical, weakly vaulted dorsally, dorsal surfaces smooth except for pereonite 1, widest at pereonite 4 (Figs 1, 2A, B); TL 1.99 times maximum width. Cephalon 0.73 times as long as width, visible in dorsal view, obtuse sub-triangular; posterior margin not trilobed (Fig. 2A). Frontal margin roundly pointed, ventrally folded (Fig. 2C). Eyes elongated oval with indistinct margins; one eye 0.19 times width of cephalon, 0.52 times length of cephalon. Pereonite 1 smooth except for median

![Image](image-url)  
Fig. 1. *Elthusa splendida* (HUMZ-C 2400, ovigerous female, 57.9 mm TL) from the buccal cavity of Japanese spurdog *Squalus japonicus* collected from the East China Sea. A, Dorsal view; B, ventral view.
four pits; the anterior two pits (0.2–0.3 mm in depth) were slightly deeper than the posterior two pits (0.1 mm); the distance between the anterior two pits was slightly greater than that between the posterior two pits (Fig. 3); anterior end of anterolateral margin rounded, extending to posterior third of eyes.

Coxae 2–3 narrow, with posteroventral angles rounded; coxae 4–7 with rounded point, not extending past respective pereonites (Fig. 2A, B). Pereonites 1–7 in width ratio 1.00: 1.28: 1.44: 1.47: 1.37: 1.27: 1.14. Pleon length 0.42 times TL. Pleonites similar and gradually increasing in width towards posterior (Fig. 2A, D). Pleonite 1 posterior margin concave; lateral margins concealed by pereonite 7 in dorsal view. Pleonite 2 not overlapped by pereonite 7; posterior margin concave; posterolateral angles narrowly rounded. Pleonites 3–4 similar in form to pleonite 2. Pleonite 5 longest, lateral margins not concealed by pleonite 4. Pleotelson length 0.65 times its width, 0.27 times TL; pleotelson width 1.13 times width of pereonite 7; dorsal surface with two shallow depression, without setae; anteromedial margin slightly emarginated, thickened; lateral margins convex; posterior margin evenly rounded.
Antennule consists of 8 articles, shorter than antenna, reaching to anterolateral angle of pereonite 1; bases not in contact (Fig. 2C). Antenna consists of 12 (but the left one consists of 11, due to the lack of the tip) articles, reaching to pereonite 1 (Fig. 2C).

Pereopod 1 basis with very weak carina, 1.59 times its greatest width; ischium 0.50 times as long as basis, distal margin with subacute protrusion; propodus 1.51 times its width; dactylus slender, 0.86 times as long as propodus, 2.31 times its basal width (Fig. 2E). Pereopod 7 basis with strong carina, 1.90 times its greatest width; ischium 0.63 times as long as basis, distal margin with obtuse protrusion; merus distal margin produced; carpus with bulbous protrusion; propodus 1.30 times its width, 0.54 times as long as ischium; dactylus slender, as long as propodus, 1.77 times its basal width (Fig. 2F).

Pleopods all lamellar, gradually decreasing in size posteriorly; exopod larger than endopod, but the difference gradually decreases from pleopod 1 to 5 (Fig. 2G–K). Pleopod 1 exopod length 1.16 times its width, with crenate margin, distally broadly rounded, lateral and mesial margins strongly convex; endopod length 1.51 times its width, with crenate margin, lateral margin convex, distally broadly rounded, mesial margin straight; peduncle length 0.37 times its width, without retinaculae (Fig. 2G). Proximomedial angle of endopod produced into a roundly pointed process, especially prominent at pleopods 4 and 5 (Fig. 2J, K).

Uropod without setae, subequal to half length of pleotelson; peduncle 1.18–1.28 times longer than rami; endopod apically rounded, 2.51 times its greatest width, lateral margin weakly convex, mesial margin straight; exopod not extending beyond end of endopod, 2.07 times its greatest width, apically rounded, lateral margin weakly convex, mesial margin straight (Fig. 2D).

Remarks. According to Bruce (1990) and van der Wal et al. (2019), the ECS specimen clearly belongs to Elthusa in having the following combination of characters: body weakly vaulted dorsally; antennule shorter than antenna, bases not in contact; posterior margin of cephalon not trilobed; pereopods with relatively short dactylus; wide pleon with all lamellar pleopods.

The presence of four pits on pereonite 1 is known as a unique character of *E. splendida* (Sadowsky and Moreira 1981). Using a 3D measurement scanner, we confirmed that the pit arrangement, as well as its presence, of the ECS specimen is also well consistent with that of the holotype (Sadowsky and Moreira 1981). Furthermore, despite the larger size of the ECS specimen (57.9 mm TL) than any known specimens of the species (up to 48.0 mm TL; Sadowsky and Moreira 1981), the ECS specimen is fully consistent with the original description of *E. splendida*: elongated oval body, with the TL/maximum width ratio of approximately 2; obtuse sub-triangular cephalon with ventrally folded frontal margin; antennule bases not in contact; the four well-marked pits on pereonite 1; broadly rounded posterolateral angles of pereonite 7 concealing lateral margins of pleonite 1; lateral margins of pleonite 4 not concealing those of pleonite 5; large pleotelson accounting for approximately one quarter (24–27%) of TL and wider than pereonite 7 (not in-
Elthusa splendida

**Discussion**

*Elthusa splendida* has not been recorded since the original description (Sadowsky and Moreira 1981), thus the type locality, off southern Brazil, the western South Atlantic, has been known as the only habitat of the species. The ECS specimen therefore represents the first record of the species in the Northern Hemisphere as well as outside of the Atlantic, updating our knowledge on its distribution range to the antipodes of the type locality (Fig. 5). Although the genus *Elthusa* occurs worldwide, only *E. raynaudii* has been known from both the Atlantic and the Indo-Pacific Oceans (van der Wal et al. 2019). *Elthusa splendida* is therefore the second species living in both the Atlantic and the Pacific Oceans.

The host species of the ECS specimen, Japanese spurdog *Squalus japonicus*, is belonging to the same genus of the type’s host species, Cuban dogfish *S. cubensis* (see Sadowsky and Moreira 1981). Both hosts inhabit the deep sea at a similar depth (150–300 m) (Compagno 1984). However, Japanese spurdog is distributed in the western Pacific, from southeastern Japan and the ECS to the Arafura Sea, while Cuban dogfish is known from the western Atlantic, from North Carolina (USA) to Argentina (Compagno 1984). Therefore, it seems that there is no overlap of the distribution between these two hosts, and the population connectivity of *E. splendida* between the Atlantic and the Pacific is still unclear. Future study should focus on occurrence of *E. splendida* parasitic on other species of *Squalus* Linnaeus, 1758 as well as other deep-sea sharks (see also Remarks), particularly those living in the eastern Pacific, to further understand the global distribution and population structure of *E. splendida*.

Sadowsky and Moreira (1981) noted that female *E. splendida* typically attaches itself to the palate of host’s buccal cavity (i.e., upside down) with the parasite’s head outward, but a few inward. The present ECS female similarly attached to the palate of host with its head outward. Although *Elthusa* currently consists of more than 30 valid species, most of them are known to parasitize in the gill cavities of their fish hosts. Only two deep-sea species, *E. splendida* and *E. neocyttia*, have been recorded from the buccal cavity of hosts. Furthermore, palate-attaching species are very rare even in the family Cymothoidae although the family contains other genera with many mouth-dwelling species, such as *Cerato-

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Fig. 5. Map showing the distribution of *Elthusa splendida*. T and P indicate the type locality and the present specimen’s locality, respectively.
Some cymothoids, particular those living in shallow seas, are familiar even to the general public such as fishermen because of the large body size. Nevertheless, many scientific aspects of the family, such as species diversity and distribution, are still largely unknown (Smit et al. 2014). The lack of such knowledge is primarily due to the difficulty of collecting host fishes, and the most conspicuous examples are deep-sea sharks. Researchers have often been studied on cymothoids by examining fishery products landed at fish markets (e.g., Trilles et al. 2012; Kawanishi et al. 2019), but the percentage of sharks accounting to the world fish catch is very low in the first place (FAO 2018). Furthermore, among sharks, the deep-sea species targeted by the fishery are highly limited (Compagno 1984). On the other hand, various fish specimens, including such rare species, have been accumulated as part of fish collections in natural history museums of the world, but their potential values from the parasitological perspective have been overlooked. Recently, Welicky et al. (2019) showed that cymothoids unintentionally preserved in museum fish specimens can be valuable to reveal the body size relationships between hosts and cymothoids. Our study suggests that museum fish specimens might be valuable for revealing poorly known cymothoid distribution.

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