A New Species of *Semicytherura* (Crustacea: Ostracoda: Cytheroidea) from Obitsu River Estuary (Central Japan) and Its Microhabitat

Yuriko Nakao¹, ³ and Akira Tsukagoshi²

¹ Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University, 3-25-40 Sakurajousui, Setagaya-ku, Tokyo 156-8550, Japan
E-mail: nakao.yuriko@nihon-u.ac.jp

² Department of Geosciences, Faculty of Science, Shizuoka University, 836 Ohya, Suruga-ku, Shizuoka 422-8529, Japan

³ Corresponding author

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A new ostracod species, *Semicytherura obitsuensis* sp. nov., is described from the intertidal zone of the Obitsu River estuary, Chiba Prefecture, central Japan. As *S. obitsuensis* sp. nov. individuals were collected from muddy sand bottoms in tidal creeks, possess some carapace-features comparable to those of interstitial and infaunal ostracods, and were observed to crawl in detritus rich fine-grained sediment in the laboratory, we concluded that this new species is an infaunal species.

**Key Words:** Crustacea, Ostracoda, *Semicytherura*, infauna, new species, Japan, Obitsu River estuary, microhabitat, tidal flat.

**Introduction**

Benthic organisms are generally divided into two groups, *i.e.*, epifauna and infauna. The epifauna includes organisms crawling on the sediment surface or on plant, coral, or other organisms projecting above the sediment, and some swimming organisms that swim only short distances (Maddocks 1976). Meanwhile, the infauna includes interstitial organisms, mobile endobionts, and sedentary endobionts (Maddocks 1976). Ikeya and Shiozaki (1993) reported that representatives of benthic ostracods living in inner bays mostly occur in the uppermost 1 cm of the surface sediment, especially in the uppermost 0.5 cm. They also investigated in detail the surface sediment structure of inner bays as an ostracod habitat and divided sediments into three parts, *i.e.*, flocculent layer, oxidized layer, and reduced layer, from the top down. Furthermore, they described three lifestyles in these microhabitats: walking through the flocculent layer above the poorly sorted silty bottom, crawling on well-sorted sandy bottom deposited under the flocculent layer, and moving through the spaces in the flocculent layer and sandy oxidized layer. Jöst *et al.* (2017) revealed that deep-sea benthic ostracods mostly live in the uppermost 1 cm of sediment and are either epifauna or infauna. This vertical distribution of deep-sea ostracods corresponds to that of shallow marine ostracods reported by Ikeya and Shiozaki (1993).

Kamiya (1988, 1989) divided ostracod fauna in *Zostera* beds into phytal species and bottom-dwelling species, and reported that bottom-dwelling species comprised species crawling on and in the flocculent layer. Tanaka (2009) divided benthic ostracods into 4 life types based on their microhabitat: (1) living on tall seagrass, (2) burrowing in sediments, (3) crawling on the sediment surface, and (4) living on low-growing plants such as the holdfasts of algae and seaweed and filamentous mats associated with sediments. Furthermore, Tanaka (2009) discussed the relationships among their carapace morphology, phylogeny, and lifestyle.

Though several studies on ostracods microhabitat were carried out, the terminology used in this field of research has always not been consistent. Therefore, in this study, the species crawling on sediments, on plants, and on any other substratum on the sediment are defined as epifaunal species. Contrastingly, species burrowing/crawling in the uppermost layer of sediments with or without flocculent layer are defined as infaunal species. Furthermore, we distinguish interstitial species, inhabiting "the water-filled cavities between the grains of a clastic sediment" (Maddocks 1976: 195), from infaunal species.

More than 30 species of the genus *Semicytherura* Wanger, 1957 including both living and fossil specimens, have been reported from Japan and its adjacent areas (Yamada and Tsukagoshi 2010). Moreover, Yamada and Tanaka (2011, 2013) reported three interstitial species, *i.e.*, *S. mukaishimensis* Okubo, 1980, *S. sagittiformis* Yamada and Tanaka, 2011, and *S. uzushio* Yamada and Tanaka, 2013. Yamada and Tanaka (2011) emphasized the importance of small carapace size in the genus *Semicytherura* for adaptation to the interstitial environment, and suggested that *S. hanaii* Ishizaki, 1981, *S. okinawaensis* Nohara, 1987, *S. polygonoreticulata* Ishizaki and Kato, 1976, *S. ryukyuensis* Nohara, 1987, *S. sabula* Frydl, 1982, *S. skippa* (Hanai, 1957), and *S. yajimae*
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Ikeya and Zhou, 1992 would be interstitial species based on their small carapace size. Contrastingly, some *Semicytherura* species were reported as epifaunal species (Tanaka 2009; Yamada and Tanaka 2011). Although *Semicytherura* species have been reported from various environments (e.g., tidal flat, rocky shore, inner bay, estuary, and infralittoral zones), no species have until now been strictly referred to as infaunal species.

This study reports a new *Semicytherura* species from the Obitsu River estuary, which has a carapace and soft parts that differ in morphology from those of the interstitial and epifaunal *Semicytherura* species reported previously.

**Materials and Methods**

In the present study, the sediment was collected from the intertidal zone of the Obitsu River estuary, Chiba Prefecture, Japan (Fig. 1). Sampling was carried out during low tide in March 2016 and 2018. The uppermost layer (approximately 1 cm) of muddy sand bottom sediment covered with floculcent layer was scooped using a big flat spoon at the tidal creek. In the laboratory, samples were washed through a 63-µm mesh sieve and the carapaces with the chitinous parts of ostracods were stored in 70% ethanol. Then, the chitinous parts were dissected with fine needles and mounted on glass slides with Neo-Shigaral (Shigakonchu Fukyusha). Morphological observations were carried out under a light microscope (Olympus BX51). The uncoated carapaces were air-dried and observed under a scanning electron microscope (HITACHI Microscope TM-1000; SEM). The type series is deposited in the collection of the Shizuoka University Museum, Shizuoka, Japan, identified by numbers with the prefix SUM-CO.

**Taxonomy**

**Genus** *Semicytherura* Wagner, 1957

*Semicytherura obitsuensis* sp. nov. (Figs 2–5)

*Pontocythere* sp. 1: Yajima 1982, pl. 10 7–8, text-fig. 13 5–6.

**Type series.** Holotype: male (SUM-CO-2461; length/height of right valves 0.45/0.17 mm, of left valve 0.45/0.17 mm). Paratypes: 9 males (SUM-CO-2462–2470) and 10 females (SUM-CO-2471–2480).

**Type locality.** Obitsu River estuary, Tokyo Bay, Chiba Prefecture, Japan (35°25′04.9″N, 139°53′57.8″E).

**Etymology.** After the Obitsu River estuary, central Japan.

**Diagnosis.** Carapace thin, weakly arched cylindroid, and elongated. Carapace surface covered with concentric muri and short muri, forming reticulation in anterior area. Concentric muri in antero-dorsal area showing like broken line. Inside valve, depressed triangular lamella of prismatic layer in anteroventral area and broad vestibules in anterior area in both male and female. Fourth and fifth podomeres of antennule fused. All terminal claws of thoracic legs bearing one small spinous process at 1/3 from proximal end. Male copulatory organ bearing sub-oval capsule and biramous distal lobe: one tip sharp and triangular, other one with round tip bent at almost right angle. Copulatory duct short and coiled.

**Description.** Carapace (Figs 2, 3, 4A, B). Carapace small, thin, weakly arched cylindroid, and more elongated outline in lateral view in male than female. Greatest height somewhat behind mid-length; dorsal margin gently arched and ventral margin concave anterior mid-length. Anterior margin gently tapered-off downward. Posterior margin round without caudal process; lower part of posterior mar-

![Fig. 1. Sampling site. A, map of Japan; B, location of Obitsu River estuary (arrowhead); C, sampling point (arrowhead) and sediment distribution of the sampling site. [Adopted from Tsukagoshi (1994)]](image-url)
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Fig. 2. *Semicytherura obitsuensis* sp. nov. A, male right valve in external lateral view; B, male left valve in external lateral view; C, male left valve in internal lateral view; D, male right valve in internal lateral view; E, female right valve in external lateral view; F, female left valve in external lateral view; G, female left valve in internal lateral view; H, female right valve in internal lateral view; I, male carapace in dorsal view; J, female carapace in dorsal view; K, male carapace in ventral view; L, female carapace in ventral view. A–D, paratype, SUM-CO-3462; E–H, paratype, SUM-CO-2471; I, K, paratype, SUM-CO-2463; J, L, paratype, SUM-CO-2472.
Carapace surface with reticulation composed of concentric and short muri in anterior area; obscure reticulation in mid-lateral area; almost smooth in dorsal and posterior area. Concentric muri in antero-dorsal area showing like broken line. Sixty-three pore systems per valve. Eyes present without tubercle.

Lamella of prismatic layer, depressed triangular shape with cleaved sides in antero-ventral area in both male and female; broad in posterior area in male. Vestibules developed in anterior, slightly narrow from ventro-median to posterior area in both male and female.

Muscle scar (Fig. 3E, F). Vertical row of 4 adductor scars in ventro-median area. Uppermost circular; obscure in female. Lower 3 somewhat large; upper one elongate; middle one square; lower one semi-circular. Large circular fulcrum point in front of row of adductor muscle scars. Two large frontal scars in front of fulcrum point; anterior one circular and posterior one kidney-shaped. Two obscure mandibular scars on lamella of prismatic layer.

Hingement (Fig. 3G–J). Lophodont. Hinge line weakly arched. Groove and weakly developed terminal teeth in right valve. Bar and terminal socket in left valve.

Antennule (Fig. 4C). Six articulated podomeres, with 4th and 5th podomeres fused. First podomere with minor assemblage of setulae on anterior-distal and distal margin. Second podomere with 1 very long setulose seta at middle...
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of posterior side, assemblage of short setae on proximal and distal area, and setulae along distal half of anterior margin. Third podomere with 1 medium setulose seta on near distal end, one assemblage of short setae at middle, and setulae along anterior margin. Fourth and 5th podomeres almost fused. Fourth podomere with 2 long simple setae and 1 medium setulose seta on distal end, and row of numerous short setulae on anterior side. Fifth podomere with 2 setulose stout setae, 1 thin short and 1 simple setae on distal end. Sixth podomere with 2 long, 1 medium, and 1 spatulate setae on distal end.

*Antenna* (Figs 4D, E). Five articulated podomeres. First podomere with 1 long stout exopodite (= spinneret seta) and assemblage of short setae on anterior-distal end. Numerous rows of setulae on outer lateral side. Second podomere with 1 setulose and 1 simple short setae on posterior-distal end, assemblage of short setae on antero-proximal end and on outer lateral side, and setulae along anterior margin.
Third podomere with 2 short setulose setae on postero-distal end, setulae along anterior margin, and short setae along proximal half of anterior margin. Fourth podomere with 1 long curved spatulate seta more developed in male near proximal end on outer lateral side, 1 thin seta at middle of anterior margin, 1 stout setulose seta on postero-distal end, and setulae along posterior margin. Fifth podomere with 1 claw-like seta on ledge of posterior margin, 1 short thin seta, and 1 claw-like seta possessing spinous process on distal end. Serrations along distal part of both of claw-like setae.

Mandibula (Fig. 4F). Five articulated podomeres, with 2nd to 5th podomeres fused. First podomere (coxa) with several stout irregular teeth on anterior margin and setulose seta at about 1/3 from dorso-distal end. Second podo-
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| Object | Length | Height | Width |
|--------|--------|--------|-------|
|        | Av     | OR    | n     | Av     | OR    | n     | Av     | OR    | n     |
| Male   |        |       |       |        |       |       |        |       |       |
| RV     | 0.46   | 0.45–0.48 | 5 | 0.18 | 0.17–0.18 | 5 |       |       |       |
| LV     | 0.47   | 0.45–0.48 | 5 | 0.18 | 0.17–0.18 | 5 |       |       |       |
| C      |        |       |       |       |       |       |        |       | 0.16 | 0.15–0.17 | 2 |
| Female |        |       |       | Female |        |       | Female |        |       |       |
| RV     | 0.45   | 0.43–0.48 | 4 | 0.19 | 0.18–0.21 | 4 |       |       |       |
| LV     | 0.45   | 0.43–0.48 | 4 | 0.19 | 0.18–0.21 | 4 |       |       |       |
| C      |        |       |       |        |       |       |        |       | 0.18 | 0.16–0.19 | 6 |

Abbreviations: Av, average; C, carapace; LV, left valve; n, number of specimens; OR, observed range; RV, right valve.
However, the lamella of prismatic layer was not observed or was unclear in some male specimens of *S. obitsuensis* sp. nov. on microscopic observation. Moreover, it was sometimes destroyed after washing our specimens with sodium hypochlorite in preparation for SEM observation. Given those situations, it is reasonable to assume that the lamella of prismatic layer was not preserved in the fossil specimen of Yajima (1982). Thus, we conclude that *Pontocythere* sp. 1 should be recognized as a Pleistocene fossil record of *S. obitsuensis* sp. nov. from the Boso Peninsula, central Japan. Nakao and Tsukagoshi (2002) reported 21 species belonging to 17 genera from the Obitsu River estuary intertidal zone. This new *Semicytherura* species is the twenty-second species reported from the area.

**Discussion**

Yamada and Tanaka (2011) reported *Semicytherura sagittiformis* as the first interstitial *Semicytherura* species from Japan. Besides the small carapace size, both carapace and appendage morphology of *S. sagittiformis* resembles that of other, non-interstitial *Semicytherura* species. The authors claimed that the miniaturization of carapace is an efficient adaptation to the interstitial environment in this genus. Moreover, they suggested a possibility that some *Semicytherura* species with small carapace are interstitial species as well. Particularly, *S. yajimae* and *S. skippa* were considered interstitial because, in addition to their small carapace, they have been obtained from samples containing other interstitial ostracods and from coarse-grained sand, respectively. Yamada and Tanaka (2013) described carapace and appendage morphology of *S. mukaishimensis* and *S. uzushio*, classifying them as interstitial *Semicytherura* species. Sizes (height/width) of *S. mukaishimensis*, *S. sagittiformis*, *S. uzushio*, and *S. skippa*, are approximately 0.18/0.21 mm, 0.15/0.23 mm, 0.16/0.11 mm (Yamada and Tanaka 2013), and 0.14/0.14 mm (Hanai 1957), respectively. Moreover, the carapace height of *S. yajimae* is approximately 0.16 mm (Ikeya et al. 1992). *Semicytherura obitsuensis* sp. nov. has a small carapace (approximately 0.18/0.17 mm), which falls in the size range of interstitial *Semicytherura* species.

Hartman (1973) noted that marine interstitial ostracods inhabit 4 types of environments, namely littoral and sublittoral sands, coralline debris, gravel beach, and root tufts of the marine grass *Posidonia*, i.e., wherever the sediment particles are big enough to form cavities. All reported interstitial *Semicytherura* species have been obtained from coarse-grained sediment (Okubo 1980; Ikeya et al. 1992; Wilkinson and Williams 2004; Yamada and Tanaka 2011, 2013). However, *S. obitsuensis* sp. nov. was collected from intertidal zone sediment samples covering the uppermost 1 cm surface of muddy sand sediment covered by flocculent layer. This mud-rich sediment is different from those deposited in the 4 environments mentioned above and cannot develop cavities suitable for inhabitation of interstitial species.

Maddocks (1976) mentioned that it is difficult to discriminate clearly among epifaunal, infaunal, and interstitial lifestyles with most ostracod sampling methods, and that the exact ostracod life mode can be determined only by direct observation of living specimens or by functional morphologic analysis of carapace and appendages. Living individuals of *S. obitsuensis* sp. nov. were observed to crawl in detritus rich fine-grained sediment in a petri dish under microscopic observation during this study. And, although the carapace of *S. obitsuensis* sp. nov. is small, elongated, translucent, and weakly ornamented (those features are considered as adaptations to the interstitial life; Hartman 1973; Maddocks 1976), unlike interstitial *Semicytherura* species (see above), the carapace and appendage morphology of *S. obitsuensis* sp. nov. is not similar to that of epibenthic non-interstitial species. Considering its morphology, behavior, and also habitat, we concluded that *S. obitsuensis* sp. nov. is an infaunal species. Jöst et al. (2017) reported that infaunal ostracod species living in fine-grained sediment of the deep sea ocean has a smooth and elongated carapace; the smooth and elongated carapace of *S. obitsuensis* sp. nov. could be adaptations to the infaunal environment. Other morphological features of *S. obitsuensis* sp. nov. (i.e., the fusion of antennal 4th and 5th podomeres, small spinous process on the terminal claw of walking legs, and long seta on walking legs), which are unique among congeners, may also be adaptations to infaunal habitats. However, it remains as a matter to be discussed further.

Yamada et al. (2005) and Yamada and Tsukagoshi (2010) has reported 4 benthic *Semicytherura* species. *Semicytherura sasameyuski* Yamada et al., 2005 was collected from the sediment samples of Maizuru Bay, and the other three species, *S. skippai* Yamada et al., 2005, *S. maxima* Yamada and Tsukagoshi, 2010, and *S. ikeyai* Yamada and Tsukagoshi, 2010, were collected from the dredged samples of Akkeshi Bay. Based on the kind of the samples, it is possible that these species are infaunal. However the authors did not mention that these species live in sediments strictly. Thus, to the best of our knowledge, this is the first report of an infaunal *Semicytherura* species from Japan.

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