First Finding of the Mud Shrimp *Upogebia yokoyai* Makarov, 1938 (Crustacea: Decapoda: Upogebiidae) in Korean Waters

Jae-Sang Hong and Chae-Lin Lee

Department of Ocean Sciences, College of the Natural Sciences, Inha University
Incheon 402-751, Korea

**Abstract:** The thalassinidean upogebiid *Upogebia yokoyai* Makarov, 1938 was first collected and described based on the specimens from the upper tidal flat of sandy shores of Jeju Island, Korea. Although this species was already reported in Japan and Russia, this is the first report of its occurrence in Korea. *Upogebia yokoyai* differs clearly from other upogebiid species previously recorded in Korean waters, *U. major* and *U. issaeffi*, by spinulation of the dactylus and propodus of pereiopod 1. In addition, some morphological comparisons are provided for identification of the three *Upogebia* species in Korean waters.

**Key words:** taxonomy, intertidal, estuarine sandy beach, tidal flat, Korea, Northwest Pacific

1. Introduction

Thalassinidean shrimps of the family Upogebiidae are among the most common macro-invertebrates, occurring from estuarine intertidal to marine shallow-water soft bottoms. Due to the size and abundance of the upogebiids in coastal habitats, their ecological functions and roles as an ecosystem engineer have become increasingly important (Griffis and Suschanek 1991; Itani and Kato 2002; Kinoshita 2002; Griffen et al. 2004; Bouma et al. 2009; D’Andrea and DeWitt 2009; Kornienko 2013; Hong 2013). Therefore, these organisms exert considerable influence over the structure of benthic communities via their ability to bioturbate sediments (Posey et al. 1991; Kinoshita et al. 2003), with the effects being felt by infauna and seagrasses in coastal environments (Dumbauld and Wyllie-Echeverria 2003; Griffen et al. 2004; Berkenbusch et al. 2007). However, some species are also considered pests in oyster aquaculture because they reduce the stability of the bottom substrate in which oysters are raised in the western coast of North America (Dumbauld et al. 2001; Dumbauld et al. 2006) and invade clam beds (*Ruditapes philippinarum*). Indeed, fishermen in areas that have been invaded by this shrimp have been suffering from a sudden decrease in production of about 10% over the past three years in some clam beds in Korea (Hong 2013).

In Korean waters, only one species of *Upogebia major* (de Haan 1841) has been reported to date (Kim 1973); however, *U. issaeffi* (Balss 1913) was recently identified and described on Namhae Island (Hong and Lee 2014). Despite this, the species diversity of the family Upogebiidae in Korean waters is still very poorly known compared to those of neighboring Japanese and Chinese waters, from which 15 and 19 species have been reported, respectively (Hong and Lee 2014). The present study was conducted to record and describe *U. yokoyai* Makarov, which is a new record in Korean waters, and to provide detailed morphological comparisons among the three species of *Upogebia* that have been found in Korean waters to date.

2. Materials and Methods

Several specimens of *Upogebia yokoyai* Makarov were collected from the upper estuarine tidal flat of sandy shores of Jeju Island, Korea (Fig. 1A-D). Additional specimens of *U. major* and *U. issaeffi* from Korean waters and several individuals of *U. yokoyai* from Kagoshima,
Japan were also examined for the comparison. Drawings were made with the aid of a drawing tube mounted on Olympus SZH stereo and BH-2 compound microscopes. The carapace length (CL) was measured from the tip of the rostrum to the posterior border of the carapace, while the total length (TL) was measured from the tip of the rostrum to the posterior border of the telson and used to indicate specimen size. Some of the specimens examined have been deposited in the National Institute of Biological Resources (NIBR), Republic of Korea.

3. Results

Systematic Account

Subphylum Crustacea
Class Malacostraca Latreille, 1802
Order Decapoda Latreille, 1802
Family Upogebiidae Borradaile, 1903
Genus Upogebia Leach, 1814

*Upogebia yokoyai* Makarov, 1939
(Figs. 1-6)

*Gebia affinis* Yokoya, 1930, p. 544, text-fig 5 a-d [junior homonym of *Gebia affinis* Say, 1818]

*Upogebia (Upogebia) yokoyai* Makarov, 1938, p.57, text-fig 18; Sakai 1968, p.47, fig 1 E-F; Sakai 1982, p.61, figs 11e, 15a-b, pls. B2, F2; Sakai 1987, p.306 (list)

*Upogebia major*: Koike and Mukai 1983, p.185; Mukai and Koike 1984, p.191; Batang and Suzuki 2003, p.69, fig 1, 3

*Upogebia yokoyai*: Sakai and Mukai 1991, p.317, figs 1-3; Asakura 1995, p.342, pl. 91 fig 9; Itani 2004, p.383, figs 2, 4, tables 1, 2; Sakai 2006, p.144; Miura 2008, p.105

Type locality
Asadokoro, Mutsu Bay, Aomori Prefecture, Japan.

Korean name
‘Yokoya-Ssok’ (= Yokoya, who described the species for the first time + Ssok, which means mud shrimp in Korean)

Materials examined
*Upogebia yokoyai*: Jongdal-ri, Gujwa-eup, Jeju-si, Jeju-
First Finding of the Thalassinid Upogebia yokoyai Makarov in Korean Waters

do, Korea (33°28' 44.66"N, 126°54' 25.92"E), intertidal coarse sandy beach, 07 Sep 2013, Coll. Jae-Sang Hong, 2♂♂, NIBRIV0000287607 (CL 16.90 mm, TL 51.13 mm), NIBRIV0000287608 (CL 14.67 mm, TL 44.09 mm), 3♀♀, NIBRIV0000287609 (CL 16.84 mm, TL 50.57 mm), NIBRIV0000287610 (CL 14.83 mm, TL 46.76 mm), NIBRIV0000287611 (CL 16.08 mm, TL 48.24 mm)

Japanese materials: Kiire, Kagoshima, Japan, 09 Oct 1999, Coll. Prof. Masanori Sato, 1♂, NIBRIV0000287612 (CL 10.29 mm, TL 29.56 mm), 1♀, NIBRIV0000287613 (CL 9.28 mm, TL 28.26 mm).

Comparative materials examined
Upogebia major: 3 ♂♂, NIBRIV0000287177 (CL 19.28 mm, TL 56.90 mm), NIBRIV0000287178 (CL 21.48 mm, TL 61.15 mm), NIBRIV0000287179 (CL

Fig. 2. Upogebia yokoyai Makarov, 1938, ♂ from Jeju, Korea. A, carapace, dorsal; B, anterior part of carapace and cephalic appendages, lateral; C, antennule; D, antenna; E, mandible; F, maxillule; G, maxilla; H, 1st maxilliped (♀); I, 2nd maxilliped (♀); J, 3rd maxilliped; K, 3rd maxilliped (♀). Scale: A-B, J, K = 3 mm; C-D, G = 2 mm; E-F, H-I = 1 mm
23.94 mm, TL 70.33 mm), 2 ♂, NIBRIV0000287180 (CL 19.37 mm, TL 57.72 mm), NIBRIV0000287181 (CL 23.44 mm, TL 69.92 mm), Cheuk-do, Seonjae-ri, Ongjin-gun, Incheon, Korea (37° 14' 02"N, 126° 13' 50"E), intertidal mud flat, 12 June 2013, Coll. Jae-Sang Hong.

*Upogebia issaeffi*: 3 ♂♂, NIBRIV0000282403 (CL 15.37 mm, TL 46.38 mm), NIBRIV0000282404 (CL 17.08 mm, TL 48.43 mm), NIBRIV0000282405 (CL 21.09 mm, TL 64.51 mm), 4 ♀♀, NIBRIV0000282406 (CL 14.74 mm, TL 45.28 mm), NIBRIV0000282407 (CL 16.75 mm, TL 49.06 mm), NIBRIV0000282408 (CL 18.04 mm, TL 57.34 mm), NIBRIV0000282409 (CL 18.48 mm, TL 59.81 mm), Munhang-ri, Namhae-gun, Gyeongsangnam-do, Korea (34° 54' 53.26"N, 127° 55' 50.89"E), intertidal boulder beach, 22 June 2013, Coll. Jae-Sang Hong.

**Description**

Body length 13.59-17.58 mm in carapace length and 38.03-51.32 mm in total length (Fig. 1D). Sexual dimorphism prominent on pereiopod 1.

Antennule and antenna (Fig. 2C-D): Antennule with third segment slightly longer than first and second ones together. Flagella simple, with one slender and longer than

---

*Fig. 3. Upogebia yokoyai* Makarov, 1938, ♂ from Jeju, Korea. A, left 1st pereiopod, outer lateral; B, left dactylus, outer lateral; C, left 1st pereiopod, inner lateral; D, left dactylus, inner lateral; E, right 1st pereiopod, outer lateral (♀); F, right dactylus, outer lateral (♀); G, right 1st pereiopod, inner lateral (♀); H, right dactylus, inner lateral (♀). Scale: A, C = 5 mm; B, D, F = 2 mm; E, G = 3 mm
the other. Antenna with second peduncular segment with 1 spine near distal end of lower margin, flagellum long.

Rostrum and carapace (Figs. 1B, 2A-B): Rostrum somewhat triangular, lower border unarmed, lateral border with 1 spine. Front tridentate with middle lobe broader and more projected. Middle groove narrow and lateral margins each with 1 row of 7-8 teeth, lateral grooves deep and lateral ridges with 10-13 teeth. Carapace broad posteriorly, narrowing anteriorly. Anterolateral surface without tubercles. *Linea thalassinica* distinct. Lateral part of cervical groove without spinules. One row of spines present on mediolateral surface.

**Buccal appendages**

Mandible (Fig. 2E), maxillule (Fig. 2F) and maxilla (Fig. 2G) with no obvious differences from those of other *Upogebia* species. First maxilliped (Fig. 2H) well setose with 1 epipod; exopod 3-segmented, terminal one minute. Second maxilliped (Fig. 2I) well setose, with 1 epipod; exopod with 1 or 2-segmented or not segmented. Third maxilliped (Fig. 2J-K) well setose with 1 small epipod; exopod of 2 or 3 segments, without flagellum; in case of 3-segmented exopod (Fig. 2J), terminal one minute.

**Ambulatory legs**

First pereiopod (Figs. 3A-3H, 5A-H): Left and right pereiopods almost equal in size, well setose.

Dactylus, in males, upper margin on outer side with 6-7 granules proximally; middle margin smooth with 1 row of 6-12 granules, 2 granules proximally or absent below; lower margin with 9-12 granules distally; cutting edge with 2 obtuse teeth less fused to each other (Figs. 3B, 5B). Upper margin on inner side with 1 row of 5-6 granules; middle margin with 1 row of 5-9 distinct rounded granules, two proximalmost ones largest; lower margin with 1 row of 4-5 inconspicuous granules medially (Figs. 3D, 5D). In females, upper margin on outer side with 1-3 granules proximally; middle margin smooth with 1 row of 4-6 inconspicuous small granules proximally; lower margin with 5-7 inconspicuous granules distally; cutting edge with 2 obtuse teeth more fused to each other than in males (Figs. 3F, 5F). Upper margin on inner side with 1 row of 5-6 granules; lower margin with 1 row of 3-5 inconspicuous granules medially (Figs. 3H, 5H).

---

**Fig. 4.** *Upogebia yokoyai* Makarov, 1938, ♂ from Jeju, Korea. A, right 2nd pereiopod, outer lateral; B, right 3rd pereiopod, outer lateral; C, right 4th pereiopod, outer lateral; D, right 5th pereiopod, outer lateral; E, telson. Scale: 5 mm
Propodus: in males, upper margin with 1 large and stout tooth at distal end; longitudinal ridge denticulated; upper margin below with 1 smooth carina on outer side; one series of setae and 1 small spine at distal end on inner side. Fixed finger large and stout; upper and lower margin smooth without spines. Cutting edge with an acute and stout tooth (Figs. 3A, 3C, 5A, 5C).

In females, much more slender than in males; upper margin with 1 spine at distal end instead of 1 large and stout tooth in males; one spine or only few small spines proximally; longitudinal ridge not denticulated. Other characteristics same as in males (Figs. 3E, 3G, 5E, 5G).

Carpus (Figs. 3A, 3C, 3E, 3G, 5A, 5C, 5E, 5G): upper margin with 1 row of 4-8 spines, 1 spine and 3-4 spinules at distal end on outer side; upper-middle margin with 1 acute spine at distal end on inner side; lower margin with 1 spine at distal end.

Merus (Figs. 3A, 3C, 3E, 3G, 5A, 5C, 5E, 5G): One spine near distal end of upper margin and 1 row of 3-9 spines on lower margin.

Ischium (Figs. 3A, 3C, 3E, 3G, 5A, 5C, 5E, 5G): One spine near distal end of lower margin.

Second pereiopod (Fig. 4A): dactylus and propodus very setose but unarmed; carpus with 1 spine distally or unarmed on upper and lower margin; merus long and slender with 1 spine proximally on lower margin and distally on upper margin; coxa, basis, and ischium unarmed.

Third pereiopod (Fig. 4B): dactylus slender, with lower margin finely pectinate; propodus and carpus setose, flattened and unarmed; merus with 3-4 spines on lower margin.

Fourth pereiopod (Fig. 4C): all segments unarmed; lower margin of the dactylus finely pectinate; propodus and carpus very setose.

Fifth pereiopod (Fig. 4D): dactylus short; propodus slender and setose.

Sixth pleonite (Fig. 4E): One helical shaped groove on both sides.

Uropod and telson

Uropod (Fig. 4E) broad; protopod with 1 acute spine posteriorly; endopod rather trapezoid with 2 longitudinal carinae; exopod with 3 carinae and 1 spine on basal part; posterior margin with minute spinules. Telson (Fig. 4E) slightly broader than long; lateral margins slightly convergent; postero-lateral angles rounded. Posterior margin slightly notched; lateral carinae on both sides.

Sex ratio

The sex ratio (females: males) was 4:3 based on 14 individuals examined in the present study, but that of Japanese specimens from the mouth of the Nanakita River, Miyagi Prefecture, in northeastern Japan was 7:3 for shrimp with a carapace length over 0.77 cm (Kinoshita et al. 2010), but Itani (2001) reported that it was not significantly different from 0.5 in specimens larger than 6.5 mm in carapace length.

Color

The live specimens collected from Jeju Island in September 2013 were yellowish live brown, with numerous grey tints along the dorsal crest of the abdomen (Fig. 1A). However, the recent Russian materials had a bluish live coloration (Marin et al. 2013).

Feeding ecology and burrow morphology

U. yokoyai is assumed to be an obligatory suspension feeder based on analysis of C and N stable isotope ratios (Kanaya et al. 2007). The burrows are relatively simple and Y-shaped, with depths exceeding 1.2 m. Burrow diameter and total burrow length are related to shrimp size, and large casts are occasionally connected to others via a narrow horizontal portion, potentially reflecting mating behavior of the shrimp (Kinoshita et al. 2010).

Habitat

The present specimens were collected from the upper part of the intertidal coarse sandy beach influenced by the freshwater inflow in Jeju Island, Korea (Fig. 1C). In Japan, this species is common and most often found on riverside intertidal flats, and the salinity ranges from 0 psu at low tide to 3-15 psu at high tide at the mouth of the Tonda River estuary, Japan (Itani 2001, 2004). However, the species was recently found in the silty bottom at a depth of 0.5-1.0 m in the Volchanka River estuary, Russia (Marin et al. 2013).

Distribution

Japan (data from Yokoya 1930; Makarov 1938; Sakai 1982; Sakai and Mukai 1991; Itani 2004; Sakai 2006): Honshu - Matsu Bay, Orikasa-gawa River estuary (Yamada), Nanakita-gawa estuary (Sendai), Fujimae tidal flat (Nagoya), Tanaka-gawa estuary (Kawage), Tonda-gawa estuary (Shirahama), Kirime-gawa estuary (Inami), Chigusa-gawa estuary (Ako), Tainouchi Bay (Kurahashi-jima Island), Yamaguchi Bay (Yamaguchi), Ohta river estuary (Hiroshima); Shikoku - Shigenobu-gawa estuary (Matsuyama),
First Finding of the Thalassinid Upogebia yokoyai Makarov in Korean Waters

Sakurai (Imabari), Yoshino-gawa estuary (Tokushima), Uranouchi Bay (Suzaki), Fukura-gawa estuary (Sukumo); Kyushu - Sone-higata (Kitakyushu), Hachiman-gawa estuary (Kiire), Kuwanoura Bay (Kamikoshiki Island); Ryukyu - Yanyu-higata (Amami-Oshima Island), Kabira Bay (Ishigaki Island), Funaura Bay (Iriomote Island)

Russia: Volchanka River estuary, Vostok Bay, Russia (Marin et al. 2013)

Korea: Coarse sandy beach, Jongdal-ri, Jeju Island, Korea (the present study)

Fig. 5. Upogebia yokoyai Makarov, 1938; A, male first pereiopod, outer; B, male dactylus and fixed finger of first pereiopod, outer; C, male first pereiopod, inner; D, male dactylus and fixed finger of first pereiopod, inner; E, female first pereiopod, outer; F, female dactylus and fixed finger of first pereiopod, outer; G, female first pereiopod, inner; H, female dactylus and fixed finger of first pereiopod, inner. Scale: A, C = 3.0 mm; E, G = 3.0 mm.
4. Discussion

This species was originally described as a new species by Yokoya (1930) under the name Gebia affinis based on specimens from Mutsu Bay (Asadokoro and Nonai, Aomori-ken), Japan. However, Makarov (1938) later pointed out that the scientific name was a junior homonym of Upogebia affinis (Say, 1818) found off the coast of Georgia in the United States and therefore established a new name U. yokoyai on the basis of the original description of “Gebia affinis” Yokoya (1930) without any comparison with U. major and U. issaeffi.

Yokoya (1930) described only the male, while the female was described later by Sakai and Mukai (1991). Due to the similar general appearance of the rostrum, carapace, abdomen, uropod, and telson among the above mentioned species of Upogebia, the identification of this species has been confusing for a long time. Therefore, special attention should be paid to the descriptions in some publications. Furthermore U. major and U. yokoyai live sympatric in some localities (Itani 2004).

Upogebia yokoyai differs from other species primarily in the shape and spinulation of the first pereiopod, particularly in its dactylus and propodus (Figs. 3, 5); however, it shows marked sexual dimorphism in its morphology. Only a few of the many distinguishing characteristics are discussed here. As additional distinguishing features, the male dactylus of U. yokoyai has 6-7 granules at the proximal portion of the upper margin of the outer side, decreasing in size distally, but U. issaeffi has one longitudinal crest bearing fine transverse striae, decreasing in size distally, and U. major contains one row of 9-10 large quadrangular granules decreasing in size distally, at the same region. Furthermore, in the middle margin of the inner side of the male dactylus, U. yokoyai characteristically has one row of 5-9 granules decreasing in size distally, but U. issaeffi has one row of 10-13 oblique ridges decreasing in size distally and proximally, and U. major bears one row of four large oblique ridges, with the distal one being smallest. The cutting edge of the inner side of the male dactylus is another important distinguishing character, with two teeth fused with the proximal one rudimentary in U. major, but two teeth clearly fused in U. issaeffi, and completely separate in U. yokoyai. In addition, the cutting

Table 1. Morphological comparison of U. yokoyai Makarov with U. issaeffi (Balss) and U. major (de Haan) based on the Korean specimens

|                        | U. yokoyai | U. issaeffi | U. major |
|------------------------|------------|-------------|----------|
| **Body size**          | medium     | medium      | large    |
| **Carapace**           |            |             |          |
| Anterolateral surface  | tubercles absent | tubercles absent | tubercles present |
| 3rd maxillipeds        | Flagellum of exopod absent | present | present |
| **1st pereiopod**      |            |             |          |
| Dactylus               |            |             |          |
| Male                   |            |             |          |
| Outer side             |            |             |          |
| Upper margin           | 6-7 granules at proximal part | 1 longitudinal crest bearing fine transverse striae | 1 row of 9-10 large quadrangular granules |
| Middle margin          | 1 row of 6-12 granules | 2 longitudinal rows of granules | granules absent |
| Lower margin           | 1 row of 9-12 granules at distal part | granules absent | granules absent |
| Inner side             |            |             |          |
| Upper margin           | 1 row of 5-6 rounded granules | 1 row of 12-16 rounded granules | 1 longitudinal ridge of many small granules |
| Middle margin          | 1 row of 5-9 rounded granules, decreasing in size distally | 1 row of 10-13 oblique ridges, decreasing in size distally and proximally | 1 row of 4 large oblique ridges, distal one smallest |
| Lower margin           | 4-5 inconspicuous granules at medio-distal part | granules absent | granules absent |
| Cutting edge           | 2 teeth separate | 2 teeth clearly fused, inner one larger | 2 teeth fused with proximal one rudimentary |
edges in the fixed fingers are quite different, with one acute tooth in *U. yokoyai*, but one blunt tooth in *U. issaeffi*, and *U. major* being vertically denticulated (Table 1; Fig. 6). Characters differentiating *U. yokoyai*, *U. issaeffi*, and *U. major* are summarized and compared in detail in Table 1 and Fig. 6.

Sakai and Mukai (1991) and Marin et al. (2013) described the exopod of the third maxilliped as consisting of a proximal segment and short, three-segmented flagellum. However, in our specimens, the exopod was composed of two or three segments without flagellum (Figs. 2J-K), which is in accordance with the previous records of Sakai (1968, 1982). Therefore, the presence of the flagellum is probably a morphological variation.

*Upogebia yokoyai* is a member of the family Upogebiidae commonly found in Japan (Itani, 2004), and distributed throughout Japan from Mutsu Bay (41°N, 140°E) in the northernmost part of Honshu, including Seto Inland Sea through Shikoku and Kyushu to Funaura Bay of Iriomote Island (24°N, 123°E), Ryukyu Archipelago of Japan (Yokoya 1930; Makarov 1938; Sakai and Mukai 1991; Itani 2004). Biogeographically, Sakai (1987) categorized *Upogebia yokoyai* Makarov in the Central West Pacific group among Japanese thalassinidean shrimps; however,

| Female | U. yokoyai | U. issaeffi | U. major |
|--------|------------|-------------|----------|
| Outer side Upper margin | 1-3 granules at proximal part | 1 row of 14-20 rounded granules | 1 longitudinal row of many small granules |
| Middle margin | 4-6 small granules at proximal part | 1 row of 3-10 rounded granules, 3-4 rounded granules below granules absent | 1 longitudinal row of many small granules |
| Lower margin | 1 row of 5-7 granules at distal part | granules absent | granules absent |
| Inner side Upper margin | 1 row of 5-6 rounded granules | 1 row of 9-13 rounded granules | 1 row of many small granules |
| Middle margin | granules absent | 1 row of 10-12 short oblique ridges | 1 row of many small oblique ridges |
| Lower margin | 4-5 inconspicuous granules at medial part | granules absent | granules absent |

| Propodus | U. yokoyai | U. issaeffi | U. major |
|----------|------------|-------------|----------|
| Outer side Upper margin ($\varphi$) | foremost tooth very well developed and next spines slightly decreasing in size | foremost tooth absent but 1 row of spines decreasing in size proximally, the foremost one largest | 1 large tooth absent but 1 row of spines decreasing in size proximally |
| Middle margin | tubercles, 1 tooth absent near fixed finger | tubercles, 1 tooth near fixed finger | tubercles, 1 tooth near fixed finger |
| Lower margin | unarmed | 1 row of spines | 1 row of spines |
| Inner side Upper margin | 1 row of spines absent | 1 row of spines | 1 row of spines |

| Fixed finger | U. yokoyai | U. issaeffi | U. major |
|--------------|------------|-------------|----------|
| Upper margin | unarmed | 2 teeth (outer one larger, inner one inconspicuous) | unarmed |
| Lower margin | unarmed | usually unarmed or 1-2 spines | 4-5 spines |
| Cutting edge | 1 acute stout tooth | 1 blunt tooth | denticulate without tooth |

| Carpus | U. yokoyai | U. issaeffi | U. major |
|--------|------------|-------------|----------|
| Upper margin | 4-8 spines | 9-12 spines | 6-9 spines |
| Middle margin on outer side | unarmed | usually unarmed or spines indistinct | 1 row of distinct spines |

| Merus | U. yokoyai | U. issaeffi | U. major |
|-------|------------|-------------|----------|
| Subdistal margin | unarmed | unarmed | 2-4 spines |

| Ischium | U. yokoyai | U. issaeffi | U. major |
|---------|------------|-------------|----------|
| Lower margin | 1 spine | 1 spine | 1-2 spines |
it is more frequent in warm temperate to subtropical regions in Japan (Asakura 1995). Interestingly, it was also recently found in the Volchanka River estuary, Vostok Bay, Russia (Marin et al. 2013), which is the known northern limit of its distribution.

The adults of *U. yokoyai* and *U. issaeffi* are moderately sized, while those of *U. major* are large. However, Japanese specimens examined in the present study were smaller in size than Korean ones, and the granules on the dactylus of the first pereiopod were less developed than in the specimens from Korea.

**Acknowledgements**

This work was supported by a grant from the National Institute of Biological Resources (NIBR) funded by the
Ministry of Environment (MOE) of the Republic of Korea (NIBR No. 2013-02-001). The work was also funded in part by the Korea ChungCheong Sea Grant Program 2014. The authors especially thank Prof. Masanori Sato in Kagoshima University, Japan, who kindly provided us with the several Japanese specimens of *Upogebia yokoyai*.

References

Asakura A (1995) Thalassinidea. In: Nishimura S (ed) Guide to Seashore Animals of Japan with Color Pictures and Keys. Vol. II. Hoikusha, Osaka, pp 339-342 (in Japanese)

Balss H (1913) Diagnosen neuer ostasiatischer Macruren. Zool Anz 42:234-239

Batang ZB, Suzuki H (2003) Gill-cleaning mechanisms of the burrowing thalassinidean shrimps *Nihonotrypaea japonica* and *Upogebia major* (Crustacea: Decapoda). J Zool 261:69-77

Berkenbusch K, Rowden AA, Myers TE (2007) Interactions between seagrasses and burrowing ghost shrimps and their influence on infaunal assemblages. J Exp Mar Biol Ecol 341:70-84

Bouma TJ, Olenin S, Reise K, Ysebaert T (2009) Ecosystem engineering and biodiversity in coastal sediments: posing hypotheses. Helgol Mar Res 63:95-106

D’Andrea AF, DeWitt TH (2009) Geochemical ecosystem engineering by the mud shrimp *Upogebia pugetensis* (Crustacea: Thalassinidae) in Yaquina Bay, Oregon: Density dependent effects on organic matter remineralization and nutrient cycling. Limnol Oceanogr 54(6):1911-1932

de Haan W (1841) Crustacea. In: Siebold PF (ed) Fauna Japonica, Batavia. Vol. 1, pp 165

Dumbauld BR, Brooks KM, Posey MH (2001) Response of an estuarine benthic community to application of the pesticide carbaryl and cultivation of Pacific oysters (*Crassostrea gigas*) in Willapa Bay, Washington. Mar Pollut Bull 42(10):826-844

Dumbauld BR, Wylie-Echeverria S (2003) The influence of burrowing thalassinid shrimps on the distribution of intertidal seagrasses in Willapa Bay, Washington, USA. Aquat Bot 77:27-42

Dumbauld BR, Booth S, Cheney D, Suhrbier A, Beltran H (2006) An integrated pest management program for burrowing shrimp control in oyster aquaculture. Aquaculture 261:976-992

Griffen BD, DeWit TH, Langdon C (2004) Particle removal rates by the mud shrimp *Upogebia pugetensis*, its burrow, and a commensal clam: effects on estuarine phytoplankton abundance. Mar Ecol Prog Ser 269:223-236

Griffis RB, Suchanek TH (1991) A model of burrow architecture and trophic modes in thalassinidean shrimp (Decapoda: Thalassinidea). Mar Ecol Prog Ser 79:171-183

Hong JS (2013) Biology of the mud shrimp *Upogebia major* (de Haan, 1841), with particular reference to pest management for shrimp control in manila clam bed in the West Coast of Korea. Ocean and Polar Res 35(4):323-349 (in Korean)

Hong JS, Lee CL (2014) First record of the Thalassinid *Upogebia issaeffi* (Balss, 1913) (Crustacea: Decapoda: Upogebiidae) in Korean waters. Ocean Sci J 49(1):73-82

Itani G (2001) Population characteristics of *Upogebia yokoyai* (Crustacea, Decapoda, Thalassinidea) at a tidal flat in southern Wakayama, Japan. Nanki Seibutsu 43:1-5 (in Japanese)

Itani G (2004) Distribution of intertidal upogebiid shrimp (Crustacea: Decapoda: Thalassinidea) in Japan. Contr Biol Lab Kyoto Univ 29:383-399

Itani G, Kato M (2002) *Cryptomya* (*Venatomya*) *truncata* (Bivalvia: Myidae): Association with Thalassinidean shrimp burrows and morphometric variation in Japanese waters. Venus 61(3-4):193-202

Kenaga T, Takagi S, Nobata E, Kikuchi E (2007) Spatial dietary shift of macrozoobenthos in a brackish lagoon revealed by carbon and nitrogen stable isotope ratios. Mar Ecol Prog Ser 345:117-127

Kim HS (1973) Illustrated encyclopedia of fauna and flora of Korea. Vol. 14, Anomura and Brachyura. Ministry of Education, 694 p (in Korean)

Kinoshita K (2002) Burrow structure of the mud shrimp *Upogebia major* (Decapoda: Thalassinidae: Upogebiidae). J Crust Biol 27:474-480

Kinoshita K, Nakayama S, Furota T (2003) Life cycle characteristics of deep-burrowing mud shrimp *Upogebia major* (Thalassinidae: Upogebiidae) on a tidal flat along the northern coast of Tokyo Bay. J Crust Biol 23:318-327

Kinoshita K, Itani G, Uchino T (2010) Burrow morphology and associated animals of the mud shrimp *Upogebia yokoyai* (Crustacea: Thalassinidae: Upogebiidae). J Mar Biol Ass UK 90(5):947-952

Koike I, Mukai H (1983) Oxygen and inorganic nitrogen contents and fluxes in burrows of the shrimps *Callianassa japonica* and *Upogebia major*. Mar Ecol Prog Ser 12:185-190

Kornienko ES (2013) Burrowing shrimp of the infraorders Gebiidea and Axidea (Crustacea: Decapoda). Russ J Mar Biol Ass UK 40(5):426-436
Biol 39(1):1-14
Makarov VV (1938) Crustacea. Fauna of USSR 10(3):54-61
Marin IN, Kom OM, Kornienko ES (2013) Upogebia yokoyai
Makarov, 1938 (Decapoda: Upogebiidae): a gebid shrimp
species new to the fauna of the Sea of Japan. Biol
Morya 39(3):221-226
Miura T (2008) Illustrated book of tidal flat animals.
Nanpoushinsha, Kagoshima, 197 p (in Japanese)
Mukai H, Koike I (1984) Behavior and respiration of the
burrowing shrimps Upogebia major (De Haan) and
Callianassa japonica (De Haan). J Crust Biol 4:191-200
Posey MH, Dumbauld BR, Armstrong DA (1991) Effects of
a burrowing shrimp, Upogebia pugettensis (Dana), on
abundances of macro-infauna. J Exp Mar Biol Ecol
148:283-294
Sakai K (1968) Three species of the genus Upogebia
(Decapoda, Crustacea) in Japan. J Seika Women Junior
Coll 1:45-50
Sakai K (1982) Revision of Upogebiidae (Decapoda,
Thalassinidea) in the Indo-West Pacific region. Res Crust
Special 1:1-106
Sakai K (1987) Two new Thalassinidea (Crustacea: Decapoda)
from Japan, with the biogeographical distribution of the
Japanese Thalassinidea. Bull Mar Sci 41:296-308
Sakai K (2006) Upogebiidae of the world (Decapoda,
Thalassinidea). Crustaceana Monographs 6, Brill Leiden,
185 p
Sakai K, Mukai H (1991) Two species of Upogebia from
Tokushima, Japan, with a description of a new species,
Upogebia trispinosa (Crustacea: Decapoda: Thalassinidea).
Zool Med 65(24):317-325
Say T (1818) An account of the Crustacea of the United
States. J Acad Nat Sci Philadelphia 1(2):241-243
Yokoya Y (1930) Report of the biological survey of mutsu
Bay 16. Macrura of Mutsu Bay. Sci Rep Tohoku Imp
Univ Ser 5(3):542-546

Received Jul. 23, 2014
Revised Aug. 18, 2014
Accepted Aug. 28, 2014