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A revision of the *Geothelphusa levicervix* species group (Crustacea: Decapoda: Brachyura: Potamidae), with descriptions of three new species

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Abstract

The taxonomy of the *Geothelphusa levicervix* species-group of freshwater crabs (Potamidae), members of which are distributed on five islands in the Ryukyus, Japan, is revised. The present study recognizes five species in the group, three of which are here described as new, and each of which is restricted to its own island. They can be easily distinguished by both carapace and male gonopod characters. On the basis of recent collections, the precise type locality of *G. levicervix* is here determined to be Tokashiki Island. The five species are diagnosed and a key to the species of the species-group is provided.

Keywords: Freshwater crabs, *Geothelphusa levicervix* species-group, new species, Potamidae, Ryukyu Islands, taxonomy

Introduction

The East Asian freshwater potamid genus *Geothelphusa* Stimpson, 1858 (type species *Geothelphusa obtusipes* Stimpson, 1858) is very speciose with 46 species described thus far from Japan and Taiwan (Shy et al. 1994; Shy and Yu 1999; Ng et al. 2001; Shokita et al. 2002; Kasai and Naruse 2003; Naruse et al. 2004a, 2004b; Chen et al. 2005; Shy 2005). The largest member (and also the largest known true freshwater crab in East Asia) is *Geothelphusa levicervix* (Rathbun, 1898) from the Ryukyus, with carapace widths of more than 60 mm. The species can be defined by its relatively large size, the presence of indistinct postorbital crista and a prominently swollen carapace. Rathbun (1898) noted that the holotype of *G. levicervix* was collected from “Loo Choo Islands” by Mr F. Sakamoto. Subsequently, other workers have recorded *G. levicervix* from the Amami and Okinawa Groups (e.g. Miyake and Minei 1965; Sakai 1976; Minei 1981; Shokita 2002). Shokita et al. (2002) also recently described a new species, *G. miyakoensis*, from the island group which, they argued, was similar to *G. levicervix*.

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Recently, we decided to reappraise the identity of what has been called *G. levicervix* in the Ryukyus. While this species has been relatively widely reported, no worker has actually ascertained exactly where in the Ryukyus the holotype was collected, nor has anyone provided detailed information of its morphology. Neither has the holotype been redescribed in detail or compared with the recent material. In this study, we have re-examined the holotype of *G. levicervix* as well as numerous specimens from various parts of the Ryukyus. The precise provenance of *G. levicervix* is established from the evidence of morphological comparison and three new species are described. As such, the *G. levicervix* species-group now contains five species: *G. levicervix* (Rathbun, 1898), *G. miyakoensis* Shokita, Naruse and Fujii, 2002, *G. grandiovata* n. sp., *G. kumejima* n. sp., and *G. iheya* n. sp.

Materials and methods

In addition to fresh material collected from across the Okinawa Group of islands (Figure 1), available specimens in the following museums were examined: Kumejima Natural and Cultural Center, Okinawa, Japan (KNCC); the National Science Museum, Tokyo, Japan (NSMT); the Ryukyu University Museum, Fujukan, Okinawa, Japan (RUMF); the US National Museum of Natural History, Smithsonian Institution, Washington, DC, USA

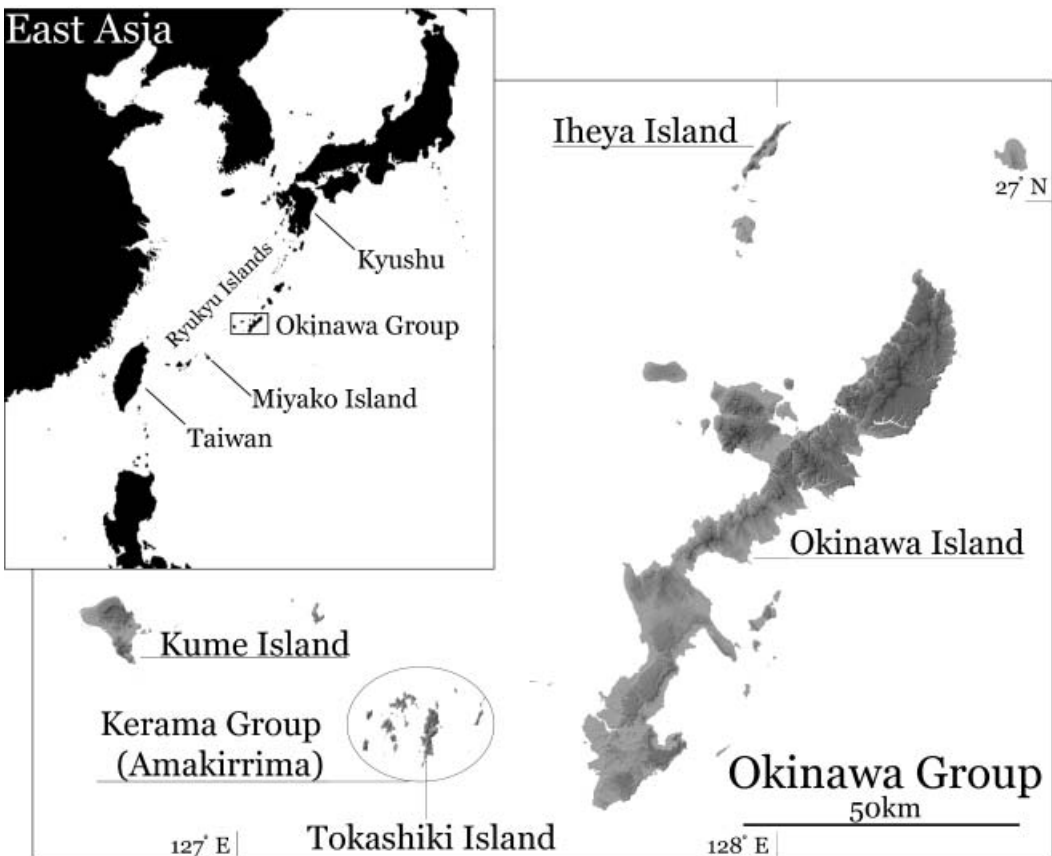


Figure 1. Map of the Okinawa Group in East Asia.

(USNM); Zoological Laboratory, Kyushu University, Fukuoka, Japan (ZLKU) (specimens that have been transferred to the Kitakyushu Museum of Natural History and Human History, Fukuoka, Japan); and the Zoological Reference Collection, Raffles Museum, National University of Singapore, Singapore (ZRC).

The terminology and measurements follow Ng (1988), Dai (1999), Shy and Yu (1999), and Cumberlidge (1999). Abbreviations are as follows: CL, carapace length; G1, male gonopod 1; G2, male gonopod 2. G1 and G2 were measured using a stereomicroscope (Nikon SMZ-10) and an eyepiece micrometer to the nearest 0.01 mm, and all the other characters were measured using a digital slide calliper (Mitsutoyo CD-20C) to the nearest 0.1 mm. For ratio values, both the median and range (in brackets) are provided (Appendix).

To reduce the effect of allometric growth associated with size, only adult specimens were used for the various ratios presented. In the present study, minimum male adult sizes were provisionally defined by the smallest individual whose distal end of G1 exceeds the lower border of thoracic sternite 5, and for females, the smallest individual whose fifth abdominal segment is equal to or wider than the third segment. As a result, the sizes of the smallest adult specimen of each species are as follows: *Geothelphusa levicervix*, male, CL 35.3 mm (ZRC 2006.0074), female, CL 38.3 mm (ZRC 2006.0074); *G. grandiovata*, male, CL 19.5 mm (ZLKU m. 1094), female, CL 27.1 mm (RUMF-ZC-143); *G. kumejima*, male, CL 28.9 mm (RUMF-ZC-147), female, CL 28.8 mm (KNCC); *G. iheya*, male, CL 18.9 mm (RUMF-ZC-150), female, CL 23.9 mm (RUMF-ZC-00153); and *G. miyakoensis*, male, CL 23.2 mm (RUMF-ZC-15), female, CL 17.9 mm (NSMT-Cr 14264).

Taxonomic account

Genus *Geothelphusa* Stimpson, 1858 *Geothelphusa levicervix* (Rathbun, 1898) (Figures 2, 3, 8a)

Potamon (Geothelphusa) levicervix: Rathbun 1898, p 28, Plate 2(5–8); de Man 1899, p 140; Rathbun 1905, p 223, Plate 18(12); Sakai 1940, p 57.

Geothelphusa dehaani: Stimpson 1858, p 101; Stimpson 1907, p 112, Plate 17(2); Balss 1922, p 135.

Thelphusa Dehaanii: A. Milne Edwards 1869, p 174 (partim).

Potamon (Geothelphusa) dehaani: Ortmann 1897, p 313 (partim).

Potamon (Potamonautes) dehaani: Rathbun 1905, p 204 (partim); Shen 1932, p 89 (partim).

Geothelphusa dehaani dehaani: Bott 1967, p 211 (partim).

Geothelphusa levicervix: Bott 1970, p 155, Plate 58(93, 94) (partim); Minei 1973, p 212 (partim); Sakai 1976, p 558 (English text), 346 (Japanese text) (partim); Minei 1981, p 80, Tables 2, 3 (partim); Miyake 1983, p 244; Shokita 1990, Table 2 (partim); Anonymous 1991, p 219 (partim); Suzuki and Tsuda 1994, p 318; Shy et al. 1994, p 784 (partim); Anonymous 1996, p 362 (partim); Yoshigou 1999, p 20 (partim); Suzuki and Okano 2000, p 30; Segawa 2000, Table 1; Shokita 2002, p 167; Shokita et al. 2002, p 446 (partim); Kasai and Naruse 2003, p 283 (partim); Naruse 2005a, p 190 (partim); Shokita 2005b, p 56 (partim).

Geothelphusa sp. (= *G. miyakoensis*): Segawa 2000, p 243, Table 1, Figures 1, 2 (partim).

Non *Potamon (Geothelphusa) levicervix*: Miyake and Minei 1965, p 377.

Non *Geothelphusa levicervix*: Minei 1968, p 99, Figure 11; Gima and Shokita 1980, p 9, Figures 7, 8; Miyake 1983, p 244, Plate 51; Ng and Shokita 1995, p 3; Shokita 1996, p 348, Photograph 1.

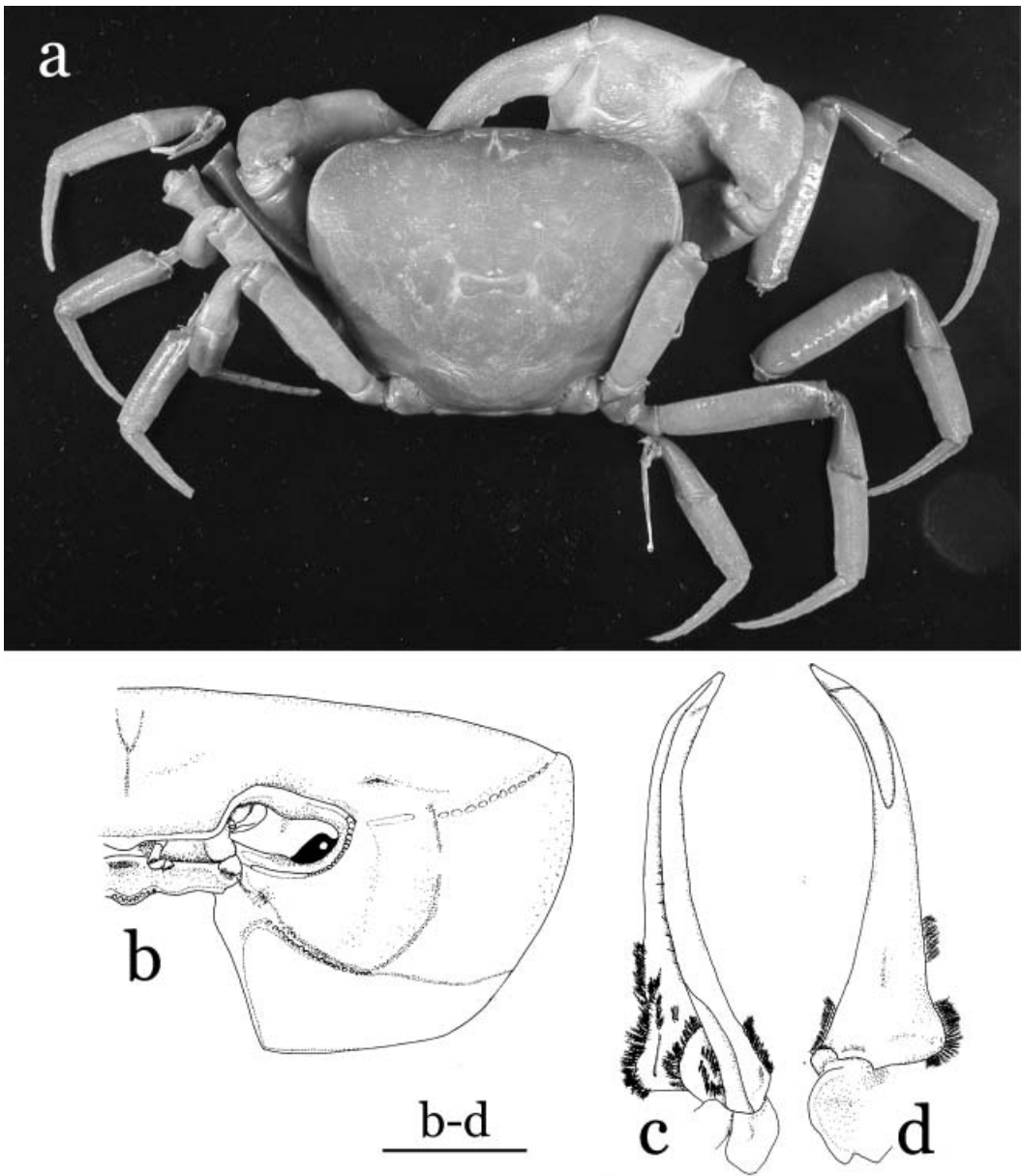


Figure 2. *Geothelphusa levicervix* (Rathbun, 1905), holotype, USNM 20642, male, CL 48.3 mm. (a) Dorsal view; (b) frontal view of carapace; (c) ventral side of left G1; (d) dorsal side of left G1. Scale bars: 10 mm (b); 5 mm (c, d).

Material examined

Holotype: one male, CL 48.3 mm, USNM 20642, Loo Choo Islands (probably Tokashiki), coll. F. Sakamoto. Others: one male, CL 35.3 mm, one female, CL 38.3 mm, ZRC 2006.0074, upstream to headwater of Tokashiki River, coll. H. Sato, 8 July 2001; one male, CL 37.9 mm, RUMF-ZC-137, a stream on the southeastern side of a mountain located between Tokashiki and Tokashiku, coll. T. Naruse and T. Kamijo, 20 November

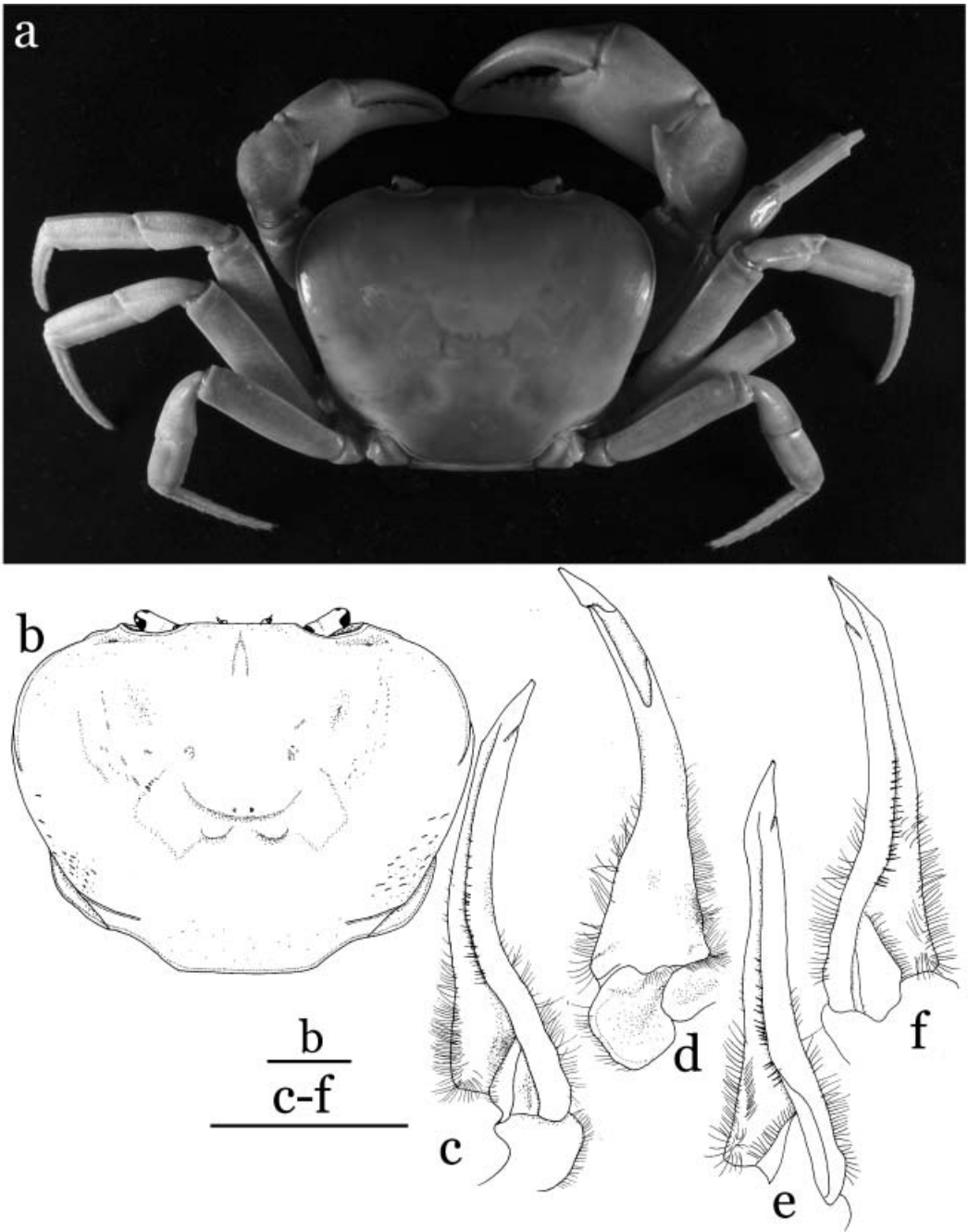


Figure 3. *Geothelphusa levicervix* (Rathbun, 1905). (a) Dorsal view; (b) dorsal view of carapace; (c, e) ventral side of left G1; (d) dorsal side of left G1; (f) ventral side of right G1. (a, e, f) ZRC 2006.0074, male, CL 35.5 mm; (b–d) RUMF-ZC-137, male, CL 37.9 mm. Scale bars: 10 mm (b); 5 mm (c–f).

2000; one male, CL 42.0 mm, one female, CL 40.3 mm, KNCC, headwater of Tokashiki River, coll. H. Sato, 22 May 2001; one male, CL 12.5 mm, RUMF-ZC-138, locality same as RUMF-ZC-137, coll. T. Naruse, 25 April 1999; one male, CL 13.5 mm, RUMF-ZC-139, a stream located on the south of Mt Akama, coll. T. Naruse and T. Kamiyo, 20 November 2000. All specimens from Tokashiki Island.

Description of adult

Carapace (Figures 2a, 3a, b) oval, swollen longitudinally and transversely; surface including anterolateral region smooth, cervical groove shallow, H-shaped gastric groove distinct, postorbital and epigastric cristae absent, postorbital and epigastric regions posteriorly raised, deep pit on posterior part of external orbital angle in some large individuals. Front directed downwards, frontal margin straight, cristate, not granulated; infraorbital margin cristate, granulated on outer third; supraorbital margin cristate, not granulated, L-shaped in dorsal view; external orbital angle obtuse, directed anteriorly; epibranchial tooth demarcated by interrupted crista; very low crista present between external orbital angle and epibranchial tooth, this crista confluent or interrupted with tooth and angle; anterolateral margin cristate, not granulated. Suborbital, subhepatic, and pterygostomial regions (Figures 2b, 8a) smooth, epimeral sulcus granulated on anterior part of joint of epimeral sulcus and vertical groove. Eye with relatively small cornea, subdistal width of cornea as wide as base of peduncle in frontal view.

Chelae of large male (Figures 2a, 3a) asymmetrical in size and shape, relatively smooth, major chela with wide, thick, and reticulated manus, long movable finger directed inwards, immovable finger directed ventrally, forming narrow gape when chela closed.

Ambulatory legs glabrous, propodi with elliptical cross-section, one or no and one or two longitudinal rows of spines on outer and inner margins, respectively; dactyli with rectangular cross-section with four longitudinal margins, each margin lined with short, stout, abraded spines, distal spines strong, subdistal spine of outer dorsal margin of fourth ambulatory dactylus stout, rounded, smaller than terminal spine on outer dorsal margin.

Male abdominal segments and telson triangular, telson triangular, reaching imaginary line joining posterior third of chelipedal coxae.

G1 (Figures 2c, d, 3c–f) very slender, tapering distally, subterminal segment curving outwards medially, with low knob on outer proximal angle; synovial membrane slender; terminal segment directed outwards, proximal part as wide as distal margin of subterminal segment.

Variation

The anterolateral margin of the carapace may be weakly granulated and the cervical groove occasionally undiscernible in some specimens. The outer surface of the chela of smaller specimens is usually rougher (more rugose) than in adults, with the upper region of the carpus granulated.

Colour

Geothelphusa levicervix is khaki in colour on the dorsal surfaces when alive.

Habitat

Geothelphusa levicervix was caught from very small streams less than a metre in width and about 5 cm in depth. They were seen in the streams themselves or along the banks.

Distribution

Tokashiki Island, Kerama Group, Central Ryukyu Islands, Japan.

Remarks

The holotype of *G. levicervix* was collected by a Japanese collector, Mr F. Sakamoto from "Loo Choo Island" (present-day Ryukyus) (Rathbun 1898, p 27; 1905, p 223). It is uncertain where exactly Mr Sakamoto collected the holotype as there was no other information. Although the species has since been reported from various parts of the Ryukyus by Japanese workers (e.g. Sakai 1976; Minei 1981; Shokita et al. 2002; Kasai and Naruse 2003), the holotype has not been directly compared with the recent material. Our study shows that what is presently called *G. levicervix* is actually a mix of four species, three of which are new. The holotype of *Geothelphusa levicervix* agrees well with the specimens from Tokashiki, notably in the form of their slender and gently tapered G1s (Figures 2c, d, 3c, d, f). Thus, we believe the type locality of *G. levicervix* is actually Tokashiki, Kerama Group, Central Ryukyu Islands, Japan. The specimens from three islands, Okinawa, Kume and Iheya, are all distinct from *G. levicervix* s. str. as well as from each other, and are here recognized as different species (see below).

One of the medium-sized specimens of *G. levicervix* collected from Tokashiki Island (ZRC 2006.0074, CL 35.3 mm) shows variation in the form of the G1. The left G1 is sinuous (Figure 3e), but the right G1 is more slender and gently curving outwards (Figure 3f), the typical shape of G1 for the species. The G1s of the other male specimens all agree with the right G1 of this specimen. As such, the unusual form of the left sinuous G1 is almost certainly the result of aberrant regrowth after injury and/or damage.

Stimpson (1858, 1907) recorded *G. dehaani* on the basis of the material collected from the Amakirrima Islands (=Kerama Group) (near Loo Choo) by an officer of the steamer "John Hancock" [Stimpson 1907, p 113; see also Habersham (1857) and Vasile et al. (2005)] and this record has been followed by subsequent authors (A. Milne Edwards 1869; Ortmann 1897; Rathbun 1905; Balss 1922; Shen 1932; Bott 1967). The drawing of this specimen [Stimpson 1907, p 112, Plate 17(2)], however, shows a narrow front and no trace of a postorbital crista. Furthermore, the major chela is very large in relation to the body size. These are not the features of *G. dehaani* s. str. As Minei (1973) and Sakai (1976) have discussed, there is no doubt that Stimpson's (1858) specimen is not *G. dehaani* but *G. levicervix*.

Up to the present, four islands of the Central Ryukyu Islands have been listed as the range of *G. levicervix*, namely Tokashiki (Minei 1973), Okinawa (Minei 1973), Kume (Minei 1981), and Amami-Oshima (Sakai 1976). The specimens from Tokashiki (the actual type locality of *G. levicervix*) are clearly different from those from Okinawa and Kume, and both are regarded as undescribed species (see below). Sakai's (1976, p 581, Plate 198, Figure 2) drawing of *G. levicervix* from Amami-Oshima shows a distinct postorbital crista and wider carapace front. Judging from his drawing, his material from Amami-Oshima is clearly *G. sakamotoana*, not *G. levicervix*. Specimens we have on hand from Kume which are superficially similar to *G. levicervix* are also here referred to as a new species (see below).

Geothelphusa grandiovata new species
(Figures 4, 5a, 8b)

Potamon (*Geothelphusa*) *levicervix*: Miyake and Minei 1965, p 377.

Geothelphusa levicervix: Minei 1968, p 99, Figure 11; Minei 1973, p 211, Figures 6, 9(C, D) (partim); Sakai 1976, p 558 (English text), 346 (Japanese text) (partim); Gima and Shokita 1980, p 9, Figures 7, 8; Minei 1981, p 80, Tables 2, 3 Plate 3 (lower) (partim); Miyake 1983, p 244, plate 51; Shokita 1990, Table 2 (partim); Anonymous 1991, p 219 (partim); Suzuki and Sato 1994, p 114 (partim); Shy et al. 1994, p 784; Ng and Shokita 1995, p 3; Anonymous 1996, p 362 (partim); Shokita 1996, p 348, Photograph 1; Yoshigou 1999, p 20, Plate 1(F) (partim); Segawa 2000, p 243, Table 1, Figures 1, 2 (partim); Shokita et al. 2002, p 446 (partim); Kasai and Naruse 2003, p 283, Figures 67B, 71, 72 (partim); Naruse 2005a, p 190 (partim); Shokita 2005b, p 56 (partim), Plate 3 (middle right).

Material examined

Holotype: one male, CL 40.5 mm, ZLKU m. 1094, Fusato, Tamagusuku Village, coll. H. Minei, 25 June 1972. Paratypes: eight males, CL 8.7–42.7 mm, two females, CL 19.9–34.2 mm, three juveniles, CL 9.6–12.3 mm, ZLKU m. 1094, data same as holotype; one male, CL 43.9 mm, ZRC 2006.0075, Taiho River, Ohgimi Village, coll. S. Shokita et al., 3 December 1994; one male, CL 44.8 mm, ZRC 2006.0076, Ohkuni Forest Road, north of Iji, coll. T. Naruse, 5 July 2001; one male, CL 43.8 mm, RUMF-ZC-140, Yona River, Kunigami Village, coll. S. Shokita, August 1983; two males, CL 29.2–29.7 mm, RUMF-ZC-141, near Ishiyama, Hedo, Kunigami Village, coll. S. Shokita, Y. Fujita, T. Nagai, H. Kawaguchi and Md. S. Islam, December 1998; one male, CL 41.5 mm, RUMF-ZC-142, Oshi River, Ohgimi Village, coll. S. Shokita, Y. Fujita, T. Nagai, H. Kawaguchi, and Md. S. Islam, 27 December 1998; one female, CL 27.1 mm, RUMF-ZC-143, east of Benoki Dam reserve, Kunigami Village, T. Naruse, 27 November 2001; one male, CL 37.6 mm, NSMT, Ohkuni Forest Road, between Hiji and Iji, coll. T. Naruse, 5 July 2001; one female, CL 34.0 mm, NSMT, Ohkuni Forest Road, Kunigami Village, coll. H. Kawaguchi, 8 July 2000. Others: four males, CL 30.0–37.1 mm, three females, CL 32.1–41.5 mm, ZLKU C20007, data same as holotype; two males, CL 38.4–40.6 mm, one female, CL 44.0 mm, ZLKU 10987, Mt Yanbaru-Yama, Tamagusuku Village, coll. H. Minei, 26 June 1962; one female, CL 35.8 mm (31 August 1961), two females, CL 40.9–43.8 mm (26 June 1962), ZLKU 11020, Mt Yanbaru-Yama, Tamagusuku Village, coll. H. Minei; one male, CL 35.2 mm, ZLKU C20004, Fusato, Tamagusuku Village, coll. H. Minei, 25 June 1972; one male, CL 45.8 mm, ZLKU 9666, Mt Meiji-Yama, coll. Kazuo Koba, 5 August 1956; one female, CL 39.4 mm, ZLKU 9667, Mt Meiji-Yama, coll. K. Koba, 5 August 1956. Fossil material: one palm, RUMF, Chinen Village, 2001, coll. M. Moriguchi. All specimens from Okinawa Island.

Comparative material

Geothelphusa tenuimanus: all specimens examined in Naruse et al. (2004a).

Description of adult

Carapace (Figure 4a, b) oval, strongly convex longitudinally; surface including anterolateral margin smooth, cervical groove very shallow, H-shaped gastric groove distinct, postorbital

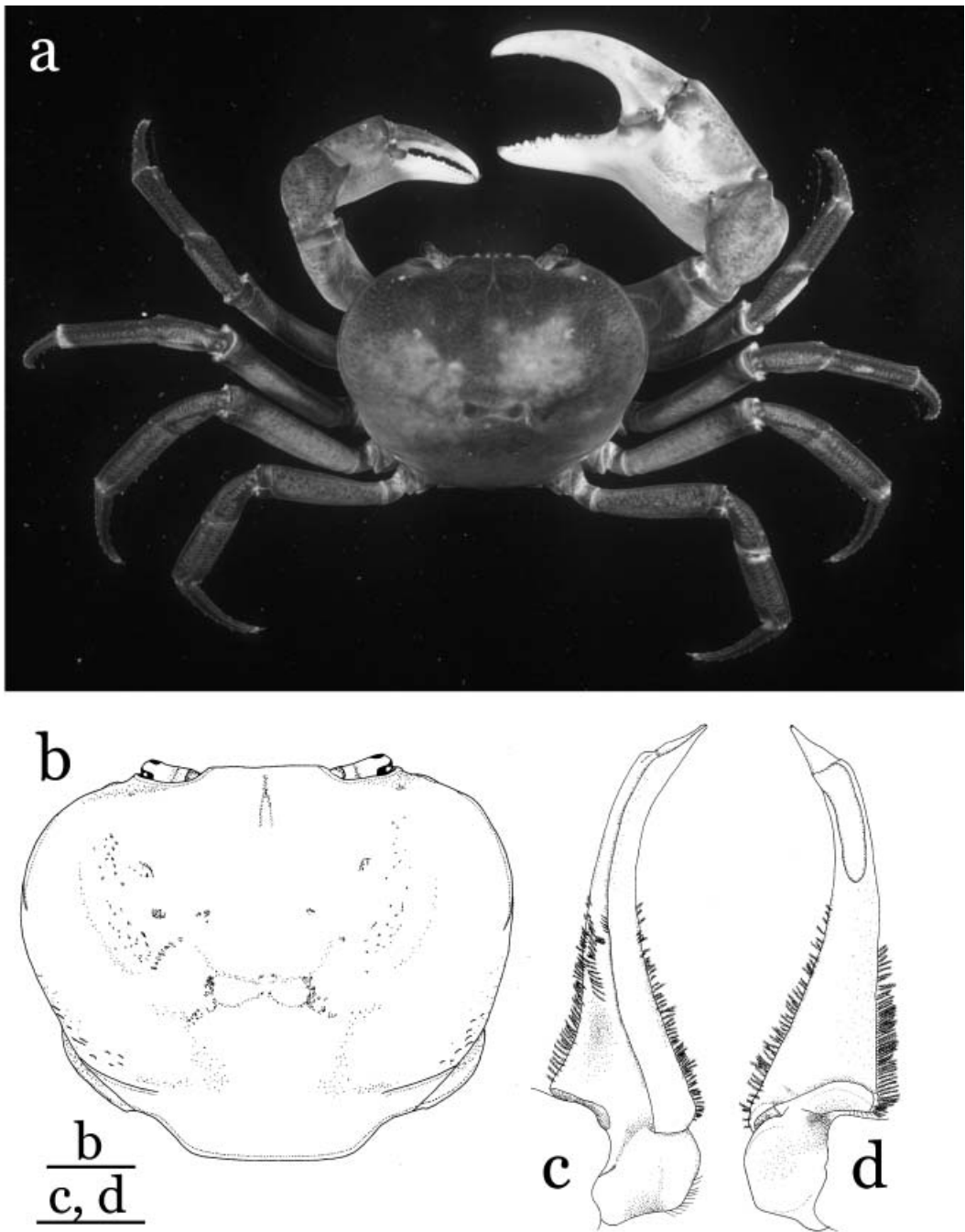


Figure 4. *Geothelphusa grandiovata* new species. (a) Dorsal view; (b) dorsal view of carapace; (c) ventral side of G1; (d) dorsal side of G1. (a) Paratype, ZRC 2006.0076, CL 44.8 mm; (b–d) holotype, ZLKU m. 1094, CL 40.5 mm. Scale bars: 10 mm (b); 5 mm (c, d).

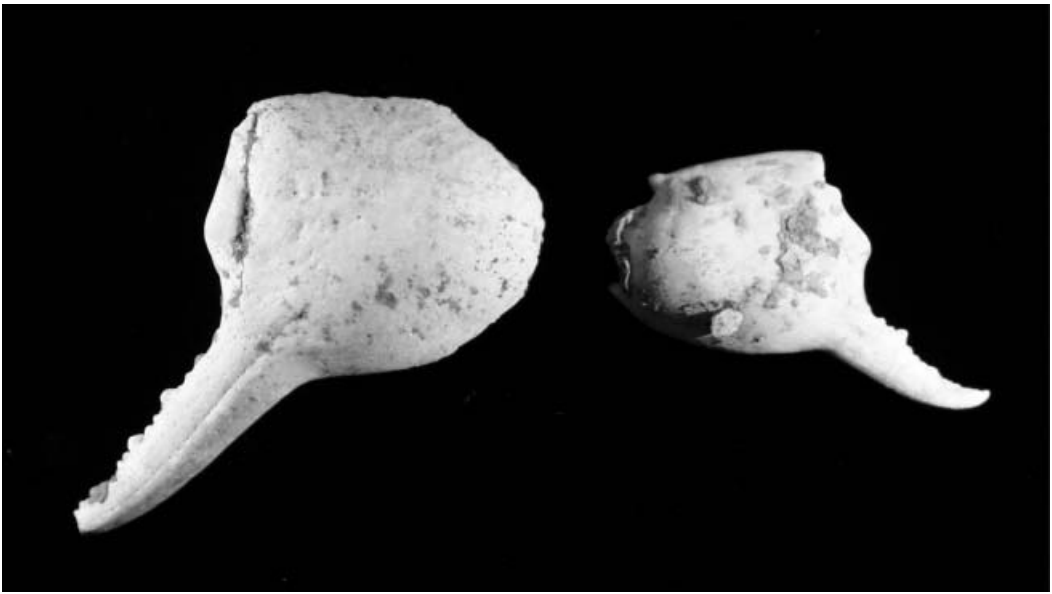


Figure 5. Fossils of *Geothelphusa grandiovata* new species and *G. tenuimanus* (Miyake and Minei, 1965). (a) Chela of *G. grandiovata* (RUMF, palm length 28.6+mm, width 23.7+mm); (b) chela of *G. tenuimanus* (RUMF-GF-11, palm length 18.6 mm, palm width 17.3 mm).

and epigastric cristae absent, postorbital and epigastric regions raised posteriorly gradually, small pit present on posterior part of external orbital angle. Front directed downwards, frontal margin cristate, not granulated; orbital margins cristate, not granulated or granulated on outer third, supraorbital margin L-shaped in dorsal view; epibranchial tooth low, demarcated by interrupted crista, low crista confluent with epibranchial tooth but separate from external orbital angle; anterolateral margin barely cristate, not granulated. Suborbital, subhepatic, and pterygostomial regions (Figure 8b) smooth, no granulation visible on vertical groove and epimeral sulcus. Eye with relatively small cornea, subdistal width of cornea as wide as base of peduncle in frontal view.

Chelae of large male asymmetrical in size and shape, major chela with wide, thick, and reticulated manus, movable finger long, curved, with large gape when fingers closed.

Ambulatory legs glabrous, propodi with elliptical cross-section, two longitudinal rows of spines on inner margins; dactyli with rectangular cross-section, each margin with row of spines, inner margins with short, stout, sharp spines, outer margins with short, stout, rounded spine, subdistal spine of outer dorsal margin of fourth ambulatory dactylus stout, rounded, smaller than terminal spine.

Male abdominal segments and telson triangular, telson slightly bell-shaped, reaching imaginary line joining proximal fifth of chelipedal coxae.

G1 (Figure 4c, d) stout; subterminal segment curving outwards, distal part wider than proximal part, with knob on outer proximal angle; synovial membrane wide; terminal segment directed outwards, subdistal margin narrower than distal margin of subterminal segment, uneven.

Variation

In one female specimen (RUMF-ZC-143, CL 27.1 mm), the carapace is relatively flatter; with frontal margin convex medially and along both outer angles; the external orbital angle and epibranchial tooth are connected by a crista; the anterolateral margin has very low granules; the anterolateral region possesses very shallow grooves, appearing rugose; the pit behind the external orbital angle is relatively shallower; and there is a row of spines present on the outer margin of the ambulatory propodi.

Colour

Geothelphusa grandiovata is maroon to olive in colour in life. Some individuals are coloured a bluish slate-grey on the cardiac region, sides of the carapace, and third maxillipeds.

Habitat

Geothelphusa grandiovata occurs near middle to upper reaches of the banks or along small swamps in submontane areas. It also digs deep burrows adjacent to areas with water seeping out. On the basis of our collections, large individuals seem to prefer burrows which have at least some water in the bottom, but medium-sized individuals (e.g. a female, RUMF-ZC-143, CL 27.1 mm; a male, RUMF-ZC-141, CL 29.7 mm) have been obtained from totally dried burrows (T. Naruse, unpublished data; T. Nagai, personal communication).

Distribution

Okinawa Island, the Central Ryukyu Islands, Japan.

Etymology

The species name is derived from the Latin “*grandis*” (for large) and “*ovatus*” (for oval-shaped), suggesting the large body size and the strongly swollen carapace.

Remarks

Geothelphusa grandiovata has been regarded as *G. levicervix* since Miyake and Minei (1965). However, *G. grandiovata* can clearly be differentiated from *G. levicervix* s. str. by its proportionately wider G1 (versus more slender in *G. levicervix*), the wider synovial membrane of the G1 (versus more slender), and the shape of the inner margin between terminal and subterminal segment of the G1 (uneven versus smooth).

A fossil of a large brachyuran manus (Figure 5a, RUMF, palm length 28.6+ mm, palm width 23.7+ mm) was discovered in the limestone fissure sediments of the southern part of Okinawa Island, where fossils of *G. tenuimanus* have been collected (Naruse et al. 2004a). The discovered manus can be identified as that of *G. levicervix* species group by its large size [versus palm length < 18.6 mm (RUMF-GF-11); palm width < 18.0 mm (MFM142451) in *G. tenuimanus*] (Figure 5b). Since *G. grandiovata* is the only member of *G. levicervix* species group known from Okinawa Island, the fossil manus is most probably that of *G. grandiovata*. Naruse et al. (2004a) estimated that the geological age of the fossils of *G. tenuimanus* was late Pleistocene.

Geothelphusa kumejima new species
(Figures 6, 9a)

Geothelphusa levicervix: Minei 1981, p 80, Tables 2, 3 (partim); Anonymous 1991, p 219 (partim); Anonymous 1996, p 362 (partim); Yoshigou 1999, p 20 (partim); Segawa 2000, Table 1 (partim); Kasai and Naruse 2003, p 283, Figure 67B (partim); Naruse 2005a, p 190 (partim), Plate (Crustacea: upper left); Shokita 2005b, p 56 (partim).

Material examined

Holotype: one male, CL 39.5 mm, RUMF-ZC-144, Shirase River, coll. H. Sato, 5–7 November 1994. Paratypes: one male, CL 15.0 mm, one female, CL 36.8 mm, RUMF-ZC-146, northwest of Higa, coll. T. Naruse and H. Kasai, 11 February 2002; one male, CL 28.9 mm, RUMF-ZC-147, Suhara River, coll. T. Naruse, H. Kasai and her children, 11 February 2002; one male, CL 35.0 mm, ZRC 2006.0077, northwestern Higa, coll. T. Naruse and H. Kasai, 11 February 2002. Others: one male, CL 33.7 mm, four females, CL 22.5–31.7 mm, KNCC, coll. H. Sato, 18 October 1995; one female, CL 36.3 mm, RUMF-ZC-145, Shirase River, coll. H. Sato, 5–7 November 1994; two males, CL 30.0–35.3 mm, NSMT, Suhara, coll. H. Sato, 29 December 1994; one female, CL 37.3 mm, KNCC, coll. H. Sato, 30 March 1994; two females, CL 32.0–36.8 mm, KNCC, coll. H. Sato, 21 October 1995; one male, CL 40.4 mm, KNCC, branch of Shirase River, coll. H. Sato, 9 February 1997. All specimens from Kume Island.

Description of adult

Carapace (Figure 6a, b) oval, convex longitudinally; surface including anterolateral region smooth, cervical groove absent, H-shaped gastric groove shallow, postorbital and epigastric cristae absent, postorbital and epigastric regions gradually raised posteriorly, shallow pit present on posterior part of external orbital angle. Front directed downwards, frontal margin medially concave or straight, not granulated; infraorbital margin cristate, granulated; supraorbital margin cristate, not granulated, L-shaped in dorsal view; external orbital angle obtuse, directed anteriorly, connected with non-granulated crista as far as anterior part of epibranchial tooth; epibranchial tooth demarcated by interruption of crista; anterolateral margin cristate, not granulated. Suborbital, subhepatic and pterygostomial regions (Figure 9a) smooth, sulcus not granulated or granulated on anterior part of joint with vertical groove. Cornea of eye relatively small, subdistal width of cornea as wide as base of peduncle in frontal view.

Chelae of large male asymmetric in size and shape, major chela with wide, thick, reticulated manus, long, nearly straight movable finger, narrow gap when fingers closed.

Ambulatory legs glabrous, propodi with elliptical cross-section, inner margins with no to two longitudinal rows of spines; dactyli with rectangular cross-section, inner margins with short, thin, sharp spines, outer margins with short, stout, rounded spines, outer dorsal margin of fourth ambulatory dactylus with stout, rounded subdistal spine, subequal with terminal one.

Male abdominal segments and telson triangular in general shape, telson triangular, reaching imaginary line joining proximal third of chelipedal coxae.

G1 (Figure 6c, d) relatively slender; subterminal segment curving outwards medially, distal margin slightly wider than proximal part, outer proximal margin uneven, knob on

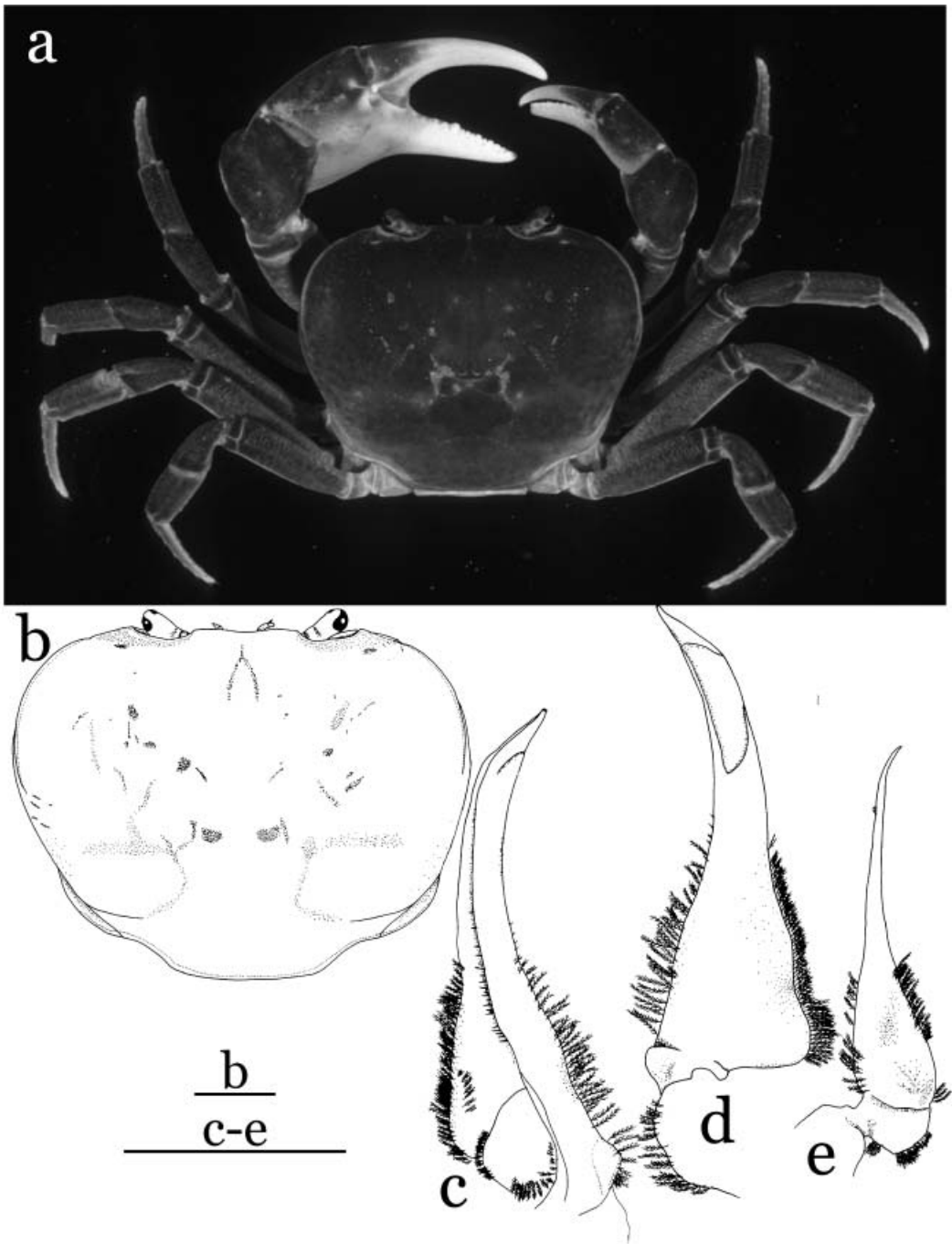


Figure 6. *Geothelphusa kumejima* new species. (a) Dorsal view; (b) dorsal view of carapace; (c) ventral side of G1; (d) dorsal side of G1; (e) G2. (a) Paratype, ZRC 2006.0077, male, CL 35.0 mm; (b–e) holotype, RUMF-ZC-144, male, CL 39.5 mm. Scale bars: 10 mm (b); 5 mm (c–e).

outer proximal angle distinct, especially in dorsal view; synovial membrane wide; terminal segment directed outwards, both inner and outer margins forming smooth lines at articulation of terminal and subterminal segments.

Variation

The epigastric and postorbital cristae may be clearer in smaller individuals (e.g. a female, KNCC, CL 22.5 mm); and the anterolateral crista, crista between the external orbital angle and epibranchial tooth, and vertical groove can be granulated; with small rows of pits on the anterolateral region (e.g. a male, RUMF-ZC-147, CL 28.9 mm).

Habitat

Geothelphusa kumejima occurs near the riverside or banks of the middle to upper reaches of the rivers, where water will seep out if the burrows are dug.

Distribution

Kume Island, Central Ryukyu Islands, Japan.

Etymology

The species name is named after the type locality, “Kume-Jima” (=Island), and is used as a noun in apposition.

Remarks

Several authors have referred *G. kumejima* to *G. levicervix* s. lato (e.g. Minei 1981). Indeed, *G. kumejima* can be morphologically close to *G. grandiovata* in the shape of carapace. However, *G. kumejima* can be easily differentiated from *G. grandiovata* by the presence of a distinct knob on the outer proximal angle of the subterminal segment of the G1 (versus indistinct in *G. grandiovata*).

***Geothelphusa iheya* new species** (Figures 7, 9b)

Geothelphusa sp. 1: Shokita 2002, p 167.

Geothelphusa levicervix: Naruse 2005a, p 190 (partim); Shokita 2005b, p 56 (partim).

Material examined

Holotype: one male, CL 32.6 mm, RUMF-ZC-148, promenade of Mt Koshi-Dake, coll. H. Sato, 1 June 2001. Paratypes: one male, CL 32.2 mm, RUMF-ZC-149, data same as holotype; two males, CL 25.8–28.9 mm, ZRC 2006.0078, southeastern side of Mt Gayou-Zan, coll. T. Naruse, 30 April 2001; one male, CL 32.4 mm, NSMT, downstream of Kamiya River, coll. S. Chiba, 12 November 2000; one male, CL 18.9 mm, six females, CL 6.7–34.6 mm, RUMF-ZC-150, upper reach of dam reserve, northern side of Mt Asa-Dake, coll. T. Naruse, 29 April 2001; three males, CL 8.7–15.9 mm, RUMF-ZC-151, west side of Mt Gayou-Zan, coll. T. Naruse, 30 April 2001; two males, CL 8.7–32.6 mm, three

females, CL 9.1–23.2 mm, RUMF-ZC-152, southeastern side of Mt Gayou-Zan, coll. T. Naruse, 30 April 2001; one male, CL 11.3 mm, two females, CL 8.91–23.9 mm, RUMF-ZC-153, dam reserve, south of Gakiya, coll. T. Naruse, 30 April 2001. Others: six males, CL 24.4–32.3 mm, one female, CL 26.8 mm, KNCC, Dana, coll. H. Sato, 3 June 2001; one female, CL 24.2 mm, KNCC, Mt Koshi-Dake, coll. H. Sato, 10 December 2001; two males, CL 19.7–26.6 mm, two females, CL 30.6–30.8 mm, KNCC, Dana, coll. H. Sato, 11 December 2001. All specimens from Iheya Island.

Description of adult

Carapace (Figure 7a, b) oval, convex longitudinally, surface smooth; anterolateral region with rows of pits or low granules directed obliquely outwards, appears rugose, cervical groove absent, H-shaped gastric groove distinct, postorbital and epigastric cristae very low, without pit behind external orbital angle. Front directed downwards, frontal margin straight, cristate, not granulated; orbital margins cristate, infraorbital and outer part of supraorbital margins granulated, supraorbital margin L-shaped in dorsal view; epibranchial tooth demarcated by a granule on anterolateral margin, low granulated crista between epibranchial tooth and external orbital angle, but not connected to both structures in most individuals; anterolateral margin distinctly cristate on anterior two-fifths of carapace, granulated. Suborbital, subhepatic, and pterygostomial regions (Figure 9b) smooth, vertical groove and anterior part of epimeral sulcus granulated. Antennule reaching inner third of antennal basis when antennule opened outwards. Antenna reaching proximal half of antennal basis when antennule folded inwards. Eye with cornea relatively small, subdistal width of cornea as wide as base of peduncle in frontal view.

Chelae of large male asymmetrical in size and shape, major chela with wide, thick, and reticulated manus, long movable finger.

Ambulatory legs with very short setae, almost glabrous; propodus with elliptical cross-section, with two and one longitudinal rows of spines on inner and outer ventral margins, respectively; dactylus with rectangular cross-section, four longitudinal margins, each margin with thin, sharp spines, distal spines strong, subdistal spine of outer dorsal margin of fourth ambulatory leg thin, sharp, smaller than terminal spine, on outer margin.

Male abdominal segments and telson triangular, telson distinctly bell-shaped; telson reaching imaginary line joining posterior two-fifths of chelipedal coxae.

G1 (Figure 7c, d) stout; subterminal segment nearly straight, but slightly curved outwards on proximal three-quarters, outer proximal angle without knob; synovial membrane wide; terminal segment directed outwards, inner margin slightly concave, terminal segment strongly directed outwards.

Variation

In some specimens, the frontal and anterolateral regions may be rugose; there is no pit behind the eye; the anterior half of the subhepatic region can have numerous clumps of granules; there is no granule on the outer half of the supraorbital margin; the outer to upper surfaces of the cheliped manus and carpus can be granulated; and the outer and inner surfaces of the cheliped merus are rugose (e.g. a male, KNCC, CL 19.7 mm; a female, RUMF-ZC-150, CL 21.0 mm).

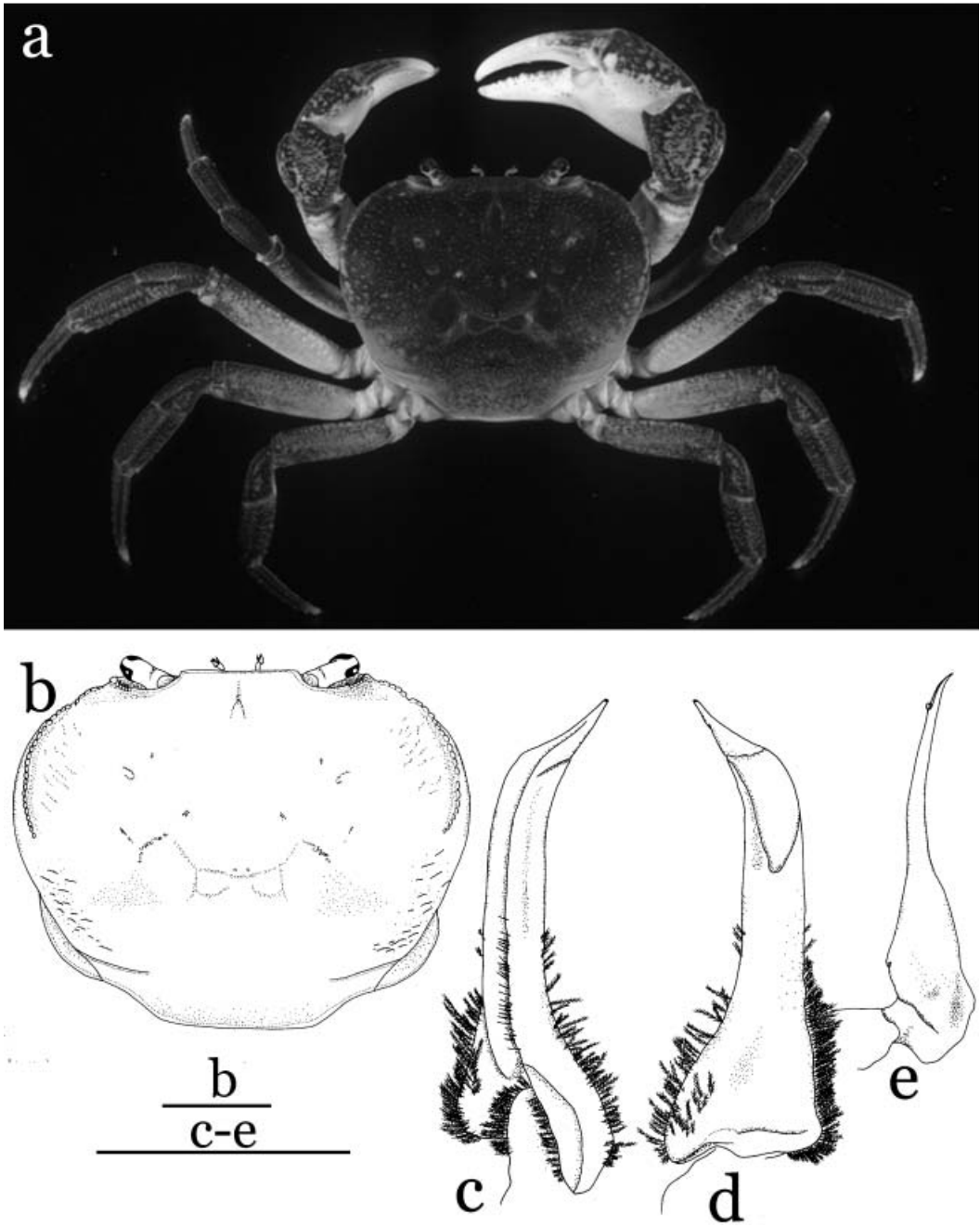


Figure 7. *Geothelphusa iheya* new species. (a) Dorsal view; (b) dorsal view of carapace; (c) ventral side of G1; (d) dorsal side of G1; (e) G2. (a) Paratype, ZRC 2006.0078, male, CL 28.7 mm; (b–e) holotype, RUMF-ZC-148, male, CL 32.6 mm. Scale bars: 10 mm (b); 1 mm (c–e).

Habitat

Geothelphusa iheya has been found along the sides of rivers, on the banks, or within the water of the middle to upper reaches. The species, however, seems to prefer slow-flowing streams.

Disribution

Iheya Island, the Central Ryukyu Islands, Japan.

Etymology

The species name is named after the type locality, "Iheya Island", and is used as a noun in apposition.

Remarks

Geothelphusa iheya n. sp. is morphologically closest to *G. miyakoensis* Shokita, Naruse, and Fujii, 2002, in the granulated anterolateral margin of the carapace. However, *G. iheya* can easily be differentiated from *G. miyakoensis* by the shape of the G1 (stout in *G. iheya* versus relatively slender in *G. miyakoensis*) and the degree of bending of the terminal segment of the G1 (strongly directed outwards versus gently directed outwards).

***Geothelphusa miyakoensis* Shokita, Naruse, and Fujii, 2002**

Geothelphusa sp. 1: Yoshigou 1999, p 21, Plate 2-K.

Geothelphusa sp.: Segawa 2000, p 243, Table 1, Figures 1, 2 (partim).

Geothelphusa sp. 3.: Shokita 2002, p 167, Photograph 3.

Geothelphusa miyakoensis: Shokita et al. 2002, p 443, Figures 1–3; Naruse 2005b, p 190; Shokita 2005a, p 33, Plate 1 (lower right).

Material examined

Holotype: one male, CL 29.4 mm, RUMF-ZC-14, Miyako-Jima, coll. S. Shokita, H. Kamizato, S. Tomari, and K. Arakaki, 14 August 1997. Paratypes: one male, CL 26.6 mm, NSMT-Cr 14263, one female, CL 17.9 mm, NSMT-Cr 14264, locality same with holotype, coll. H. Fujii, 24 January 1997; two males, CL 24.1 mm, ZRC 2001.2251, CL 21.1 mm, ZRC 2001.2252, two females, CL 21.56, ZRC 2001.2253, CL 21.8 mm, ZRC 2001.2254, same data as holotype; one male, CL 23.2 mm, RUMF-ZC-15, one female, CL 24.3 mm, RUMF-ZC-16, coll. Y. Hokama, October 1997; one male, CL 26.6 mm, RUMF-ZC-17, same data as RUMF-ZC-15, 16, coll. Y. Hokama, 14 November 1997. All specimens from Miyako Island.

Remarks

There is no need to redescribe this species as this has been done in detail by Shokita et al. (2002). Segawa (2000) revealed that there is a close relationship in the ND2 gene of mitochondrial DNA between *G. levicervix* (RUMF-ZC-138) and *G. miyakoensis* (R. Segawa, personal communication). However, the morphological differences between these

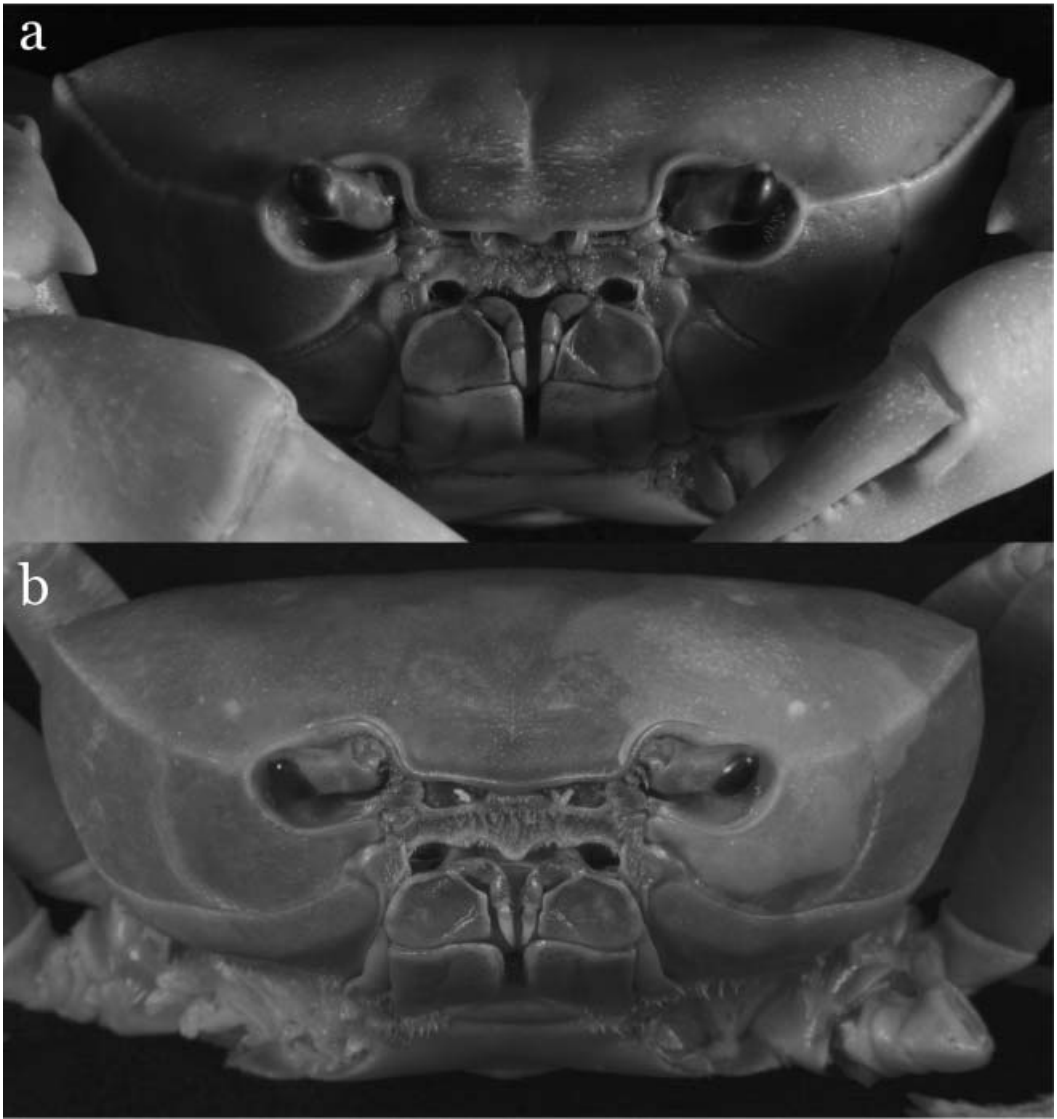


Figure 8. Frontal view of *Geothelphusa levicervix* (Rathbun, 1898) and *G. grandiovata* new species. (a) *Geothelphusa levicervix*, ZRC 2006.0074, male, CL 35.3 mm; (b) *G. grandiovata*, paratype, ZRC 2006.0076, male, CL 44.8 mm.

two species are significant: *G. levicervix* can be differentiated from *G. miyakoensis* by slender G1 (versus proportionately stouter in *G. miyakoensis*) and the shape and structure of the anterolateral margin (faintly cristate, with or without faint granules versus distinctly cristate and granulated).

Key to species of *Geothelphusa levicervix* species-group

- 1. Anterolateral margin faintly cristate or not cristate 2
- Anterolateral margin distinctly cristate 4

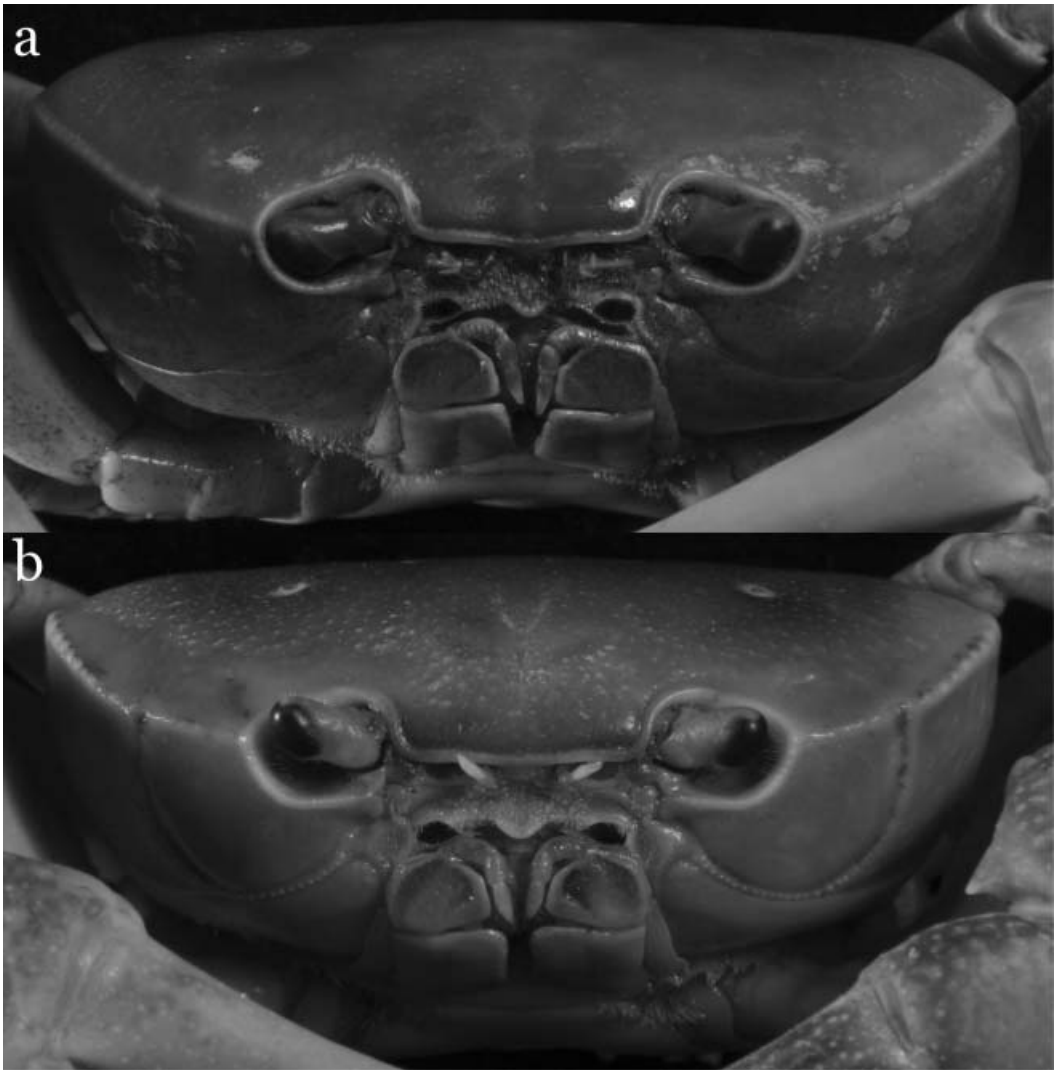


Figure 9. Frontal view of *Geothelphusa kumejima* new species and *Geothelphusa iheya* new species. (a) *Geothelphusa kumejima*, paratype, ZRC 2006.0077, male, CL 35.0 mm; (b) *G. iheya*, paratype, ZRC 2006.0078, male, CL 28.7 mm.

- 2. Male G1 very slender, total length to width ratio of G1 5.45–6.69, distal margin of subterminal segment narrower than middle part *Geothelphusa levicervix* (Rathbun, 1898)
- Male G1 not very slender, distal margin of subterminal segment subequal with middle part 3
- 3. Outer proximal angle of the subterminal segment of G1 with prominent knob *Geothelphusa kumejima* n. sp.
- Outer proximal angle of the subterminal segment of G1 with small knob *Geothelphusa grandiovata* n. sp.

4. G1 stout, terminal segment strongly directed outwards . . . *Geothelphusa iheya* n. sp.
 – G1 slender, terminal segment gently directed outwards
 *Geothelphusa miyakoensis* Shokita, Naruse, and Fujii, 2002

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Appendix. Comparison of ratio characters among five species of the *Geothelphusa levicervix* species-group

	<i>G. levicervix</i> (Rathbun, 1898)			<i>G. grandiovata</i> n. sp.			<i>G. kumejima</i> n. sp.			<i>G. iheya</i> n. sp.			<i>G. miyakoensis</i> Shokita et al., 2002		
	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>
CW/CH	1.97	1.92–2.10	6	1.96	1.81–2.08	27	2.12	2.03–2.21	14	2.03	1.88–2.19	19	2.02	1.91–2.10	6
CW/CL	1.28	1.25–1.32	6	1.24	1.18–1.34	29	1.29	1.26–1.31	15	1.27	1.22–1.34	21	1.24	1.21–1.27	10
CH/CL	0.64	0.61–0.68	6	0.63	0.59–0.69	27	0.60	0.58–0.64	14	0.62	0.59–0.66	19	0.62	0.60–0.64	6
FRW/CW	0.24	0.22–0.25	6	0.24	0.21–0.27	29	0.24	0.23–0.25	15	0.25	0.23–0.27	20	0.25	0.22–0.28	6
FRW/EXW	0.44	0.42–0.46	6	0.43	0.39–0.48	28	0.44	0.42–0.46	15	0.44	0.41–0.46	20	0.41	0.36–0.46	7
Male (telson–sternite 4/sternite 1–3)	1.64	1.36–2.08	4	1.65	1.11–2.16	17	2.05	1.74–2.47	7	1.69	1.42–2.00	13	1.69	1.55–2.00	5
Male telson (L/W)	0.71	0.71–0.75	3	0.71	0.63–0.84	17	0.72	0.68–0.76	7	0.70	0.64–0.76	14	0.74	0.72–0.81	5
Male 6th abd.seg. (L/W)	0.46	0.45–0.49	4	0.52	0.47–0.56	17	0.49	0.48–0.51	7	0.47	0.44–0.56	15	0.44	0.39–0.55	5
Male (telson L/6th abd.seg. L)	1.17	1.11–1.20	3	1.07	0.97–1.19	17	1.08	1.04–1.19	7	1.10	1.06–1.20	14	1.26	1.09–1.62	6
Male (telson W/6th abd.seg. W)	0.77	0.74–0.77	3	0.78	0.71–0.80	17	0.75	0.73–0.78	7	0.76	0.71–0.81	15	0.8	0.77–0.86	6
2nd amb.leg pro. (L/W)	3.03	2.79–3.15	6	3.00	2.38–3.54	27	2.92	2.59–3.43	14	2.63	2.28–2.92	18	2.65	2.57–2.98	5
2nd amb.leg (pro. L/dac. L)	0.85	0.79–0.89	5	0.87	0.80–1.09	26	0.86	0.80–0.89	14	0.90	0.81–0.99	17	0.87	0.85–1.03	6
2nd amb.leg mer. (L/W)	3.82	3.61–3.98	6	3.85	3.27–4.27	28	3.88	3.70–4.65	14	3.52	3.31–4.01	19	3.64	3.45–4.21	5
(2nd amb.leg TL)/CL	2.27	2.17–2.30	5	2.27	2.15–2.45	11	2.19	2.06–2.37	14	2.10	1.90–2.17	17	1.95	1.95–2.08	3
G1 (TL/W)	3.14	3.02–3.55	4	3.34	2.88–4.91	17	2.98	2.65–3.50	7	3.25	2.67–4.27	14	2.94	2.61–3.19	5
G1 ter.seg. (L/W)	1.81	1.47–2.22	4	1.72	1.18–3.43	17	1.71	1.10–3.53	7	1.87	1.47–2.40	14	1.82	1.38–1.96	5
G1 (ter.seg. L/TL)	0.13	0.10–0.14	4	0.15	0.11–0.33	17	0.12	0.11–0.29	7	0.15	0.13–0.17	14	0.14	0.13–0.15	6
G1 sm (L/W)	4.34	3.79–4.60	4	3.89	2.06–7.86	17	4.00	3.29–4.73	7	2.91	2.47–4.00	14	3.36	3.11–3.91	5
G1 (sm L/ter.seg. L)	2.34	2.18–3.29	4	2.18	0.89–4.23	17	2.41	0.87–2.52	7	1.90	1.22–2.48	14	1.73	1.58–2.15	6
G2 (flag./TL)	0.15	0.09–0.18	4	0.14	0.10–0.26	16	0.15	0.15–0.19	7	0.13	0.10–0.20	14	0.18	0.16–0.19	6
G2 TL/G1 TL	0.80	0.79–0.89	4	0.85	0.54–0.89	16	0.90	0.86–0.97	7	0.83	0.56–0.88	14	0.89	0.85–0.90	6
(2nd amb.leg TL)/(3rd amb.leg TL)	1.05	1.03–1.06	5	1.05	1.04–1.07	7	1.06	0.98–1.08	13	1.08	0.99–1.11	17	1.06	1.05–1.08	3

Abbreviations: abd.seg., abdominal segment; amb.leg, ambulatory leg; CH, carapace height; CL, carapace length; CW, carapace width; dac., dactylus; EXW, the width between external orbital angles; flag., flagellum of G2; FW, frontal width; G1, first gonopod; G2, second gonopod; L, length; mer., merus; pro., propodus; ter.seg., terminal segment; TL, total length; W, width.