Two new species of eyeless amphipods from a coastal area in Japan (Crustacea: Amphipoda: Hadziidae, Melitidae), with reinstatement of the genus Paraniphargus Tattersall, 1925

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ABSTRACT
Two new species of eyeless amphipods are described from coastal Japan. Dulzura projecta sp. nov. (Hadziidae) was collected under large stones and in coarse sand from Osaka to Mie Prefectures. Dulzura projecta can be distinguished from the other Dulzura species by the distinct projection on article 1 of the male pleopod 3 inner ramus and the very long carpus of male gnathopod 1. Paraniphargus shiosai sp. nov. (Melitidae) was collected in coarse sand from Mie Prefecture, and can be differentiated from the other two species in the genus by the dorsal teeth on the pleonites, the smaller coxa 4 with shallow excavation and the shorter antenna 1 flagellum. Paraniphargus is reinstated as a distinct genus, following observation of the gnathopods, which revealed sexual monomorphism between males and females.

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Introduction
The order Amphipoda is a large group in Crustacea comprising approximately ten thousand described species (Ahyong et al. 2011). Amphipod species display a high plasticity in morphological characters; for example, eyes vary among species from a total absence of ommatidia to truly enormous hypertrophy with complex visual systems (Bellan-Santini 2015). In the terrestrial aquatic environments, many eyeless amphipods inhabit caves or subterranean water, and several comparative studies on morphology and behaviour of the amphipods have been carried out (e.g. Culver et al. 2010; Fišer et al. 2016). However, in marine species, knowledge of the eyeless species is poorly documented. Thurston and Bett (1993) suggested that 17.8% of marine amphipods are eyeless with most of the eyeless species being correlated positively with depth and latitude; however, formal ecological studies of eyeless amphipods are scarce. Although ‘cobble or beach interstitial’ species were excluded in their analysis, many eyeless amphipods do occur in shallow and also temperate waters. In Japan, 14 eyeless species were recorded from shallow seas (< 100 m in depth) including Bogidiellidae: Bollegidia takedai Ariyama, 2012; Eriopisidae: Paraflagitopisa excavata Ariyama, 2015; Psammogammarus mawatarii Tomikawa et al., 2010; Psammogammarus
lobatus Ariyama, 2015; Victoriopisa wadai Ariyama, 2015; Hadziidae: Metaniphargus shiroi Vonk and Gable, 2014; Ingolfiellidae: Ingolfiella inermis Shimomura et al., 2006; Phoxocephalidae: Harpiniopsis mihiaraensis (Nagata, 1960); Harpiniopsis vadiculus Hirayama, 1987; Sebidae (Ariyama 2009): Seba chiltoni Moore, 1987; Seba ekepuu Barnard, 1970; Seba latiquinta Ariyama, 2009; Seba latisexta Ariyama, 2009; Synopiidae: Syrrhoites pacifica Nagata, 1965. Five these species, B. takedai, Ps. mawatarii, M. shiroi, I. inermis and S. ekepuu, are apparently interstitial. During a survey of the marine amphipod fauna of Japan, two more eyeless species were collected from interstitial environments. A closer examination revealed that they are new species of the hadziid genus Dulzura Barnard, 1969 and the melitid genus Paraniphargus Tattersall, 1925, and these species are described herein. Moreover Paraniphargus, synonymized by Sawicki et al. (2005), is reinstated as a valid genus based on a new finding.

Material and methods

Specimens were collected from coastal areas, intertidal to 4 m depth, from Osaka, Wakayama and Mie Prefectures. The main collecting sites were benthic sediments in the subtidal zone. Approximately one litre of the sediment was collected using a net while snorkelling. Small amounts of the sediment and seawater were put into a plastic beaker. Then the water was stirred vigorously, and the suspended material was immediately decanted through a fine-meshed sieve, with this process being repeated three to five times. Sieved samples were fixed in a 5–10% formalin–seawater solution. Samples were also collected by hand from the underside of large stones in the intertidal zone. Specimens were dissected and illustrated using a phase-contrast microscope. Body length was measured from the apex of the rostrum along the dorsal margin to the distal end of the telson. Type material is deposited in the Osaka Museum of Natural History, Japan (OMNH).

Systematics

Family HADZIIDAE Karaman, 1943
Genus Dulzura Barnard, 1969

Dulzura Barnard, 1969: 114; Barnard and Barnard, 1983: 655, figs. 12–14, 41, map 53; Springthorpe and Lowry, 2009: 434; Lowry and Myers, 2013: 36.
Protohadzia Zimmerman and Barnard, 1977: 569; Barnard and Barnard, 1983: 653, map 56; Lowry and Myers, 2013: 36.

Type species
Dulzura sal Barnard, 1969 by monotypy.

Emended diagnosis

Head, rostrum absent, eyes absent or poorly developed. Antennae slender; antenna I peduncular articles 1–2 long, article 3 short, accessory flagellum 2-articulated; antenna 2 shorter than 1. Mandibular palp long, with 3 articles; article 2 weakly setose; article 3 slightly falcate, subequal to or longer than article 2, with marginal and terminal setae. Lower lip without inner lobes. Maxilla 1, inner plate triangular, setose medially; outer plate with
serrate robust setae distally; palp 2-articulated, with apical robust setae. Maxilla 2, inner plate with medial setae and oblique facial row of setae. Coxae medium-sized, coxa 4 unlobed. Gnathopod 1 small, subchelate; carpus unlobed; propodus shorter than carpus, palm short, almost transverse. Male gnathopod 2 enlarged, subchelate; carpus unlobed, setose posteriorly; propodus long, posterior margin setose, palm very oblique. Female gnathopod 2 feeble, almost simple; propodus smaller than that of male. Pereopods 3–7 slender, bases of pereopods 5–7 relatively expanded. Uropods biramous; uropod 2 peduncle with mediiodistal comb of setae [not recognized in *Dulzura melitaformis* (Ledoyer, 1979)]; uropod 3 elongate, parviramous [inner ramus much shorter than outer ramus and lacking medial armaments (Barnard and Barnard, 1983)], outer ramus with 2 articles, article 2 less than 20% as long as article 1, inner ramus shorter than half length of outer. Telson of ordinary length, cleft, apical end with robust setae.

**Remarks**
Springthorpe and Lowry (2009) synonymized *Protohadzia* with *Dulzura* for the reason that distinctions between them have never been strong. However, Lowry and Myers (2013) left *Protohadzia* unsynonymized.

**Included taxa**
Nine species: *D. sal* Barnard, 1969; *D. hamakua* (Barnard, 1970); *D. schoenerae* (Fox, 1973); *D. gal* Barnard, 1979; *D. melitaformis* (Ledoyer, 1979); *D. paucispinosa* Ledoyer, 1982; *D. lobata* Stock and Vonk, 1991; *D. taylorae* Springthorpe and Lowry, 2009; *D. projecta* sp. nov.

**Dulzura projecta** sp. nov.
(Figures 1–5)

![Figure 1. Dulzura projecta sp. nov. Holotype, male (OMNH-Ar-9974), 6.6 mm. Habitus, lateral view.](image-url)
Material examined

Holotype: male (OMNH-Ar-9974), 6.6 mm, Jogasaki coast, Wakayama City, Wakayama Prefecture, 34°17′06″ N, 135°04′08″ E, lower intertidal zone, reverse surface of large stone, 11 June 2006, coll. H. Ariyama. Paratypes: 2 males and 1 ovigerous female (OMNH-Ar-9975–9977), 5.2, 3.9, 4.4 mm, same data as holotype; 4 males and 1 ovigerous female (OMNH-Ar-9978–9982), 4.0, 3.5, 2.9, 2.9, 3.1 mm, Nagasaki coast, Osaka Prefecture, 34°19′49″ N, 135°09′08″ E, 4 m depth, coarse sand, 9 October 2003, coll. H. Ariyama; 2 males and 1 ovigerous female (OMNH-Ar-9983–9985), 3.7, 2.7, 3.6 mm, southeastern coast of Kamishima Island, Toba City, Mie Prefecture, 34°32′36″ N, 136°59′00″ E, 2.5 m depth, coarse sand, 26 July 2014, coll. H. Ariyama.

Description

Male [based on holotype, 6.6 mm (OMNH-Ar-9974), paratype, 5.2 mm (OMNH-Ar-9975) for pleopod 3, and paratype, 4.0 mm (OMNH-Ar-9978) for antenna 1 and lower lip]. Body (Figure 1) slender; head small, antennal sinus present; pereonite 7 wider than anterior pereonites; pleonites wide; urosomites narrow, without dorsal robust setae.

Antenna 1 (Figure 2(a)) long, with ratio of lengths of peduncular articles 1–3 1 : 0.9 : 0.3, peduncular article 1 with strong robust seta posterodistally, laterodistal surface setose; accessory flagellum short, with 4 setae; primary flagellum with 19 articles (probably regenerated), tip of flagellum with short article and long setae (Figure 2(a1)).

Antenna 2 (Figure 2(b)) relatively short, with ratio of lengths of peduncular articles 3–5 1 : 2.8 : 2.6; flagellum with 15 articles.

Upper lip (Figure 2(c)), ventral margin rounded, setose. Mandible (Figure 2(d,d1,d2,e,e1)), incisor bearing 5 and 4 cusps in left and right, respectively, left lacinia mobilis long, 4-dentated, right lacinia mobilis with wide denticulate and narrow triangular lobes, number of accessory blades 8 on left side and 6 (2 thick and 4 thin) on right side; molar developed; palp article length ratio 1 : 3.2 : 3.3 in right, article 2 with 1 short and 1 long seta, article 3 bearing many setae on ventral margin and 1 thick and 2 thin long setae on tip, distal two-thirds of lateral surface covered with many tiny setae. Lower lip (Figure 2(f)), medial margins of outer lobes setose, mandibular processes small. Maxilla 1 (Figure 2(g,g1–g3)), inner plate with 12 plumose setae medially; distal margin of outer

Figure 2. Dulzura projecta sp. nov. All except for (a2) and (f) holotype, male (OMNH-Ar-9974), 6.6 mm; (a2, f) paratype, male (OMNH-Ar-9978), 4.0 mm. (a) Right antenna 1, lateral view; (a1) accessory flagellum of right antenna 1, medial view; (a2) tip of left antenna 1 flagellum, lateral view; (b) left antenna 2, lateral view; (c), upper lip, posterior view; (d) left mandible, lateral view; (d1), palp of left mandible, lateral view; (d2) incisor, lacinia mobilis and accessory blades of left mandible, lateral view; (e) right mandible, medial view; (e1) incisor, lacinia mobilis and accessory blades of right mandible, medial view; (f) lower lip, dorsal view; (g) right maxilla 1, ventrolateral view; (g1) inner plate of right maxilla 1, ventrolateral view; (g2) distal part of right maxilla 1 palp, ventrolateral view; (g3) palp article 2 of left maxilla 1, ventral view; (h) left maxilla 2, dorsal view; (i) right maxilliped, ventral view; (i1) distal part of right maxilliped outer plate, ventral view, normal setae omitted; (i2) distal part of right maxilliped inner plate, ventral view, normal setae omitted. Scale: a, b, 0.50 mm; a1, a2, 0.25 mm; c–e, g–i, d1, g3, 0.22 mm; f, 0.16 mm; d2, e1, g1, g2, i1, i2, 0.11 mm.
Figure 3. *Dulzura projecta* sp. nov. Holotype, male (OMNH-Ar-9974), 6.6 mm. (a, b) Left gnathopods 1–2, lateral views; (a1) propodus and dactylus of left gnathopod 1, lateral view, normal setae omitted; (b1), proximal part of palm on left gnathopod 2, lateral view, normal setae omitted; (c–g) left pereopods 3–7, lateral views. Scale: a–g, 0.50 mm; a1, b1, 0.25 mm.
plate with 11 robust setae; palp article 2 narrow (left) or wide (right), distal end with 7 thin (left) or thick (right) robust setae. Maxilla 2 (Figure 2(h)), both plates about same length, terminal ends bearing many setae. Maxilliped (Figure 2(i,i1,i2)), inner plate truncate, distal margin with 4 robust setae; outer plate small, distal margin with 4.
long thick setae, medial margin with 8 robust setae; palp stout, ventral surface of article 3 covered with short setae, article 4 with nail.

Gnathopod 1 (Figure 3(a,a1)), coxa rhomboid, anterior and ventral margins with several short setae; basis stout, middle of posterior margin swollen, with 3 setae; ischium

Figure 5. Dulzura projecta sp. nov. All except for (e–h), paratype, female (OMNH-Ar-9982), 3.1 mm; (e–f) paratype, male (OMNH-Ar-9978), 4.0 mm; (g–h) paratype, male (OMNH-Ar-9981), 2.9 mm. (a, b) Left gnathopods 1–2, lateral views: (a1, b1) propodi and dactyli of left gnathopods 1–2, lateral views, normal setae omitted; (c) right pleonal epimera 1–3, lateral view; (d) left pleopod 3, posterior view; (e, g) carpi–dactyli of left gnathopods 1, lateral views, normal setae omitted; (f, h) propodi and dactyli of left gnathopods 2, lateral views, normal setae omitted. Scale: e, f, 0.20 mm; a, b, d, 0.16 mm; c, g, h, 0.133 mm; a1, b1, 0.08 mm.
bearing 3 setae on posterodistal margin; merus short, posterodistal margin with 1 long and many short setae; carpus very long, straight, posterolateral surface with numerous long setae, medial surface sparsely setose; propodus short, about 0.4 times as long as carpus, anterodistal corner setose, posterodistal corner with 3 short robust setae, otherwise poorly setose; dactylus very short, tip slightly curved. Gnathopod 2 (Figure 3(b,b1)) large; coxa roundish trapezoidal, produced posterodorsally, anterior and ventral margins with several short setae, gill large, subquadrate; basis relatively slender, middle of posterior margin slightly swollen, with 4 setae; merus short, posterodistal margin bearing 2 setae; carpus pyriform, posterior margin heavily setose; propodus very long, about 2.3 times as long as carpus, posterior margin slightly excavated at a point two-thirds, posterior and medial margins bearing numerous long setae, palm with 2 marginal and 4 + 2 medial small robust setae; dactylus robust, strongly curved, posterior margin lined with tiny curved setae.

Pereopods 3–4 (Figure 3(c,d)) subequal; coxae roundish trapezoidal, ventral margins with several short setae, gills very large; bases straight, anterior margins with robust seta distally, posterior margins with 1–2 long setae and 3–4 short robust setae; meri anterior margins bearing 2 short robust setae; carpi with robust seta posterodistally; propodi bearing 4 pairs of short robust setae on posterior margins; dactyli short, almost straight. Pereopod 5 (Figure 3(e)) longer than pereopods 3–4; coxa lobate, anterior half longer than posterior half, ventral margin with several short setae, posterior margin with seta, gill large; basis expanded, a little lobate posterodistally, with slightly serrate margin, anterior margin with 3 small robust setae, anterodistal corner setose; merus bearing long and short setae on anterodistal corner, posterior margin with 3 robust setae, posterodistal corner with 4 robust setae; carpus bearing 3 groups of setae on anterior margin, posterior margin with pair of short robust setae, posterodistal corner with several robust setae; propodus with seta and 3 groups of setae on anterior margin, posterior margin with 4 groups of robust setae; dactylus short, almost straight. Pereopod 6 (Figure 3(f)) about 1.3 times as long as pereopod 5; coxa with small anteroventral lobe, posterior margin with seta, gill relatively small; basis expanded, posterodistal corner lobate, with slightly serrate margin, anterior margin with 7 small robust setae, anterodistal corner setose; merus bearing robust seta on middle anterior margin, anterodistal corner setose, posterior margin with 1 + 1 + 2 robust setae, posterodistal corner with 4 robust setae; carpus bearing seta and 3 groups of setae on anterior margin, posterior margin with 1 + 3 short robust setae, posterodistal corner with many robust setae; propodus, anterior and posterior margins with 5 and 4 groups of setae, respectively; dactylus short, almost straight. Pereopod 7 (Figure 3(g)) slightly longer than pereopod 6; coxa flattened-triangular, posterior margin with 3 setae; basis expanded, posterodistal corner lobate, with serrate margin, anterior margin with 6 small robust setae, anterodistal corner setose; merus without robust seta on anterior margin, anterodistal corner setose, posterior margin with 1 + 2 + 2 robust setae, posterodistal corner with 4 robust setae; carpus bearing 3 groups of setae on anterior margin, posterior margin with 1 + 3 short robust setae, posterodistal corner with many robust setae; propodus, anterior and posterior margins each with 5 groups of setae; dactylus short, almost straight.

Pleonal epimera (Figure 4(a)), epimeron 1 slightly produced on posteroventral corner, ventral margin bare; epimeron 2 produced posteroventrally, ventral margin with 2 robust setae; epimeron 3 rounded on posteroventral corner, but posterodorsal corner
sharply projected, ventral margin bearing many robust setae. Pleopods 1–2 (Figure 4(b, c)) subequal, slender; peduncles long, each with 2 coupling hooks and posterodistal projection; outer rami shorter than inner, outer and inner rami with 12 and 11 articles in pleopod 1 and both with 10 articles in pleopod 2, respectively. Pleopod 3 (Figure 4(d,e)), peduncle bearing lateral robust seta and anterodistal projection, medial surface with 2 coupling hooks and short seta; outer and inner rami each with 9 articles, outer ramus broad, article 1 with vertical ridge posteriorly, article 1 of inner ramus curved, with large outward projection distally. Uropod 1 (Figure 4(f)) stout; peduncle with 1 basofacial, 4 dorsolateral and 3 dorsomedial robust setae, laterodistal end bearing extremely large robust seta; both rami almost same length, about 0.7 times as long as peduncle, outer ramus with 4 marginal and 5 terminal setae, inner ramus with 5 marginal and 5 terminal setae. Uropod 2 (Figure 4(g,g1)) short, about 0.6 times length of uropod 1; peduncle bearing 4 dorsolateral and 1 dorsodistal robust setae, mediiodistal corner with robust seta and comb of short setae; outer and inner rami each with 9 articles, outer ramus broader, article 1 with vertical ridge posteriorly, article 1 of inner ramus curved, with large outward projection distally. Uropod 3 (Figure 4(h)) very large, about 1.6 times length of uropod 1; peduncle short, dorsal surface, lateral margin, mediiodistal margin and ventrodistal margin with 3, 2, 3 and 10 robust setae, respectively; outer ramus long, about 3.2 times as long as peduncle, article 1 broad, lateral and medial margins each with 4 groups of robust setae, distal margin with many robust setae, article 2 narrow, dorsi-shaped, 15% length of article 1, tip with 3 minute setae; inner ramus short, 28% as long as outer ramus, bearing 1 lateral and 2 medial robust setae, tip acutely projected. Telson (Figure 4(i)) wider than long, deeply cleft, tips of both halves produced triangularly, both sides of projections each with 2 robust setae, lateral robust setae lacking.

**Female [paratype, 3.1 mm (OMNH-Ar-9982)].** Gnathopod 1 (Figure 5(a,a1)), coxa produced posterodorsally, anterior margin with several short setae, ventral margin with 2 long and 2 short setae; basis swollen on middle posterior margin, with 5 long setae; ischium bearing 3 setae on posterodistal margin; merus short, posterodistal margin with 1 long and several short setae; carpus not long, straight, posterior margin and mediiodistal surface setose; propodus short, about 0.8 times as long as carpus, anterodistal corner setose, posterodistal corner with 2 short robust setae; dactylus very short, tip slightly curved. Gnathopod 2 (Figure 5(b,b1)) smaller than that of male; coxa produced posterodorsally, anterior margin with 2 short setae, ventral margin with 2 long and 2 short setae, gill very large, ovoid, oostegite narrow, with 4 setae; basis slightly swollen on middle posterior margin, with 4 setae; merus short, posterodistal margin bearing 3 setae; carpus longish pyriform, posterior margin with many bundles of setae; propodus slightly long, about 1.1 times as long as carpus, posterior margin with 4 bundles of setae, anterodistal corner setose, palm bearing 2 robust setae medially; dactylus slender, weakly curved. Pleonal epimera (Figure 5(c)), epimera 1–2 slightly produced posteroventrally, ventral margin bare in epimeron 1 and with robust setae in epimeron 2; epimeron 3 acutely projected on posteroventral corner, ventral margin bearing 2 robust setae. Pleopod 3 (Figure 5(d)), lateral margin of peduncle with robust seta, mediiodistal corner with 2 coupling hooks and short seta; outer and inner rami each with 7 articles, both rami slender, article 1 of inner ramus without projection. Other parts generally similar to male except for oostegites.
**Small males.** Paratype, 4.0 mm (OMNH-Ar-9978): gnathopod 1 (Figure 5(e)), propodus about half length of carpus; gnathopod 2 (Figure 5(f)), excavation and robust setae on palm almost same as holotype. Paratype, 2.9 mm (OMNH-Ar-9981): gnathopod 1 (Figure 5(g)), propodus about 0.7 times as long as carpus; gnathopod 2 (Figure 5(h)), excavation on palm absent, number of robust setae same as holotype, but proximal 2 setae larger.

**Coloration in life**
Whole body faintly yellowish white.

**Etymology**
From the Latin *projecta* (= projected), referring to the shape of male pleopod 3.

**Remarks**
In *Dulzura projecta* sp. nov. the inner ramus of male pleopod 3 has a projection on article 1 which differentiates it from other species in the genus. Such sexual dimorphism in pleopod 3 is also known for *D. lobata*, where the male pleopod 3 has a swelling on articles 1 in both rami (Stock and Vonk 1991). The very long carpus of male gnathopod 1 is also unique to *D. projecta* with other species of *Dulzura* having a shorter carpus. In *D. projecta* the bases of pereopods 5 to 7 are lobate, which is also seen in *D. lobata*, and the male epimeron 3 has a sharp projection on the posterodorsal corner which is shared with *D. hamakua* and *D. paucispinosa*.

**Distribution**
From Osaka Prefecture to Mie Prefecture in Japan.

**Habitat**
Under large stones and in coarse sand, probably interstitial; from the lower intertidal zone to 4 m depth.

**Family** MELITIDAE Bousfield, 1973
**Genus** Paraniphargus Tattersall, 1925

*Paraniphargus* Tattersall, 1925: 241; Barnard and Barnard, 1983: 675, fig. 5, map 54.
*Melita*: Sawicki et al., 2005: 66 (in part) [not Leach, 1814: 403].

**Type species**
*Paraniphargus annandalei* Tattersall, 1925 by monotypy.

**Emended diagnosis**
Head, rostrum weak, eyes absent. Antennae slender; antenna I peduncular article 1 longer than article 3, accessory flagellum 2- or 3-articulated; antenna 2 shorter than 1, flagellum short. Mandibular palp slender, with 3 articles; article 1 short, articles 2–3 long, article 3 linear, weakly setose. Lower lip with developed inner lobes. Maxilla 1, inner plate ovate, with 3–4 apical setae, not setose medially; outer plate
with 6–9 robust setae distally; palp 2-articulated, with apical robust setae. Maxilla 2, inner plate without facial or medial setae. Coxae relatively long, coxa 4 lobate. Gnathopod 1 small, subchelate; carpus weakly elongate, unlobed; propodus shorter than carpus, trapezoidal, palm transverse, dactylus fitting palm; no sexual dimorphism. Gnathopod 2 enlarged, subchelate; carpus of medium length, weakly lobate; propodus large, roundish rectangular, palm oblique; dactylus long, curved posteriorly; no sexual dimorphism. Pereopods 3–4 slender; bases of pereopods 5–7 relatively expanded, slightly lobate posterodistally, posterior margins serrate. Uropods biramous; uropods 1–2 rami extending subequally, with robust setae marginally; uropod 3 elongate; peduncle short; parviramous, outer ramus long, 1-articulated, with marginal and terminal setae, inner ramus shorter than 20% length of outer. Telson of ordinary length, fully cleft, lobes tapering, each with 2 apical robust setae.

Remarks
Four species have been described in the genus Paraniphargus: P. annandalei Tattersall, 1925 from a freshwater stream in the Andaman Islands; Paraniphargus ruttneri Schellenberg, 1931 from a freshwater lake in Java; Paraniphargus leleuporum Monod, 1970 from groundwater in the Galapagos Islands; Paraniphargus vermiamicus Bamber, 2003 from marine waters in Hong Kong. Paraniphargus leleuporum was subsequently transferred to a new genus, Galapsiellus Barnard, 1976 by Barnard (1976), and P. vermiamicus was transferred to Tegano Barnard and Karaman, 1982 by Horton and Lowry (2012), leaving only two species in the genus.

Several studies have dealt with the difference between Paraniphargus and the related genus, Melita Leach, 1814. Schellenberg (1931) pointed out that they differ only in the 1-articulated outer ramus of the uropod 3, the lack of the anteroventral cusp on the head, the weak mandibular palp, and the naked medial margin of the inner lobes of both maxillae. Barnard and Barnard (1983) stated that many species of Melita have lost article 2 on the uropod 3 outer ramus, and that Paraniphargus differs from Melita in the loss of eyes and medial maxillary setae. Stock and Ilife (1995) suggested that there were only slight differences between Paraniphargus, Melita and a third genus Josephosella Ruffo, 1985. More recently, Sawicki et al. (2005) synonymized Paraniphargus with Melita citing a lack of distinction in the setation of maxilla 2 and the number of articles in the uropod 3 outer ramus between these genera. The present study recognizes the sexually monomorphic gnathopod 2 as a distinctive generic character of Paraniphargus separating it from Melita species that have a sexually dimorphic gnathopod 2 (Barnard and Barnard 1983; Jarrett and Bousfield 1996). Although the original description of P. annandalei and P. ruttneri by Tattersall (1925) and Schellenberg (1931), respectively, do not include details of the presence or absence of sexually dimorphic characters, Barnard (1976) proposed the absence of sexual dimorphism in the gnathopods without stating the basis for this observation. The medial margin of the maxilla 2 inner plate is quite bare of setae in all species of Paraniphargus including P. shiosai sp. nov., whereas in the Melita species, number of setae on the medial margin varies from very many to a few but never without setae. Based on the above characters Paraniphargus is here reinstated as a distinct genus from Melita.
Included taxa
Three species: P. annandalei Tattersall, 1925; P. ruttneri Schellenberg, 1931; P. shiosai sp. nov.

Paraniphargus shiosai sp. nov.
(Figures 6–9)

Material examined
Holotype: male (OMNH-Ar-9986), 1.7 mm, southeastern coast of Kamishima Island, Toba City, Mie Prefecture, 34°32′36″N, 136°59′00″E, 2.5 m depth, coarse sand, 26 July 2014, coll. H. Ariyama. Paratypes: 2 males, 1 ovigerous female and 1 juvenile (OMNH-Ar-9987–9990), 1.9, 1.8, 1.8, 1.4 mm, same data as holotype.

Description
Male [based on holotype, 1.7 mm (OMNH-Ar-9986), and paratype, 1.9 mm (OMNH-Ar-9987) for uropod 1 and telson]. Body (Figure 6) very flattened laterally; head small, antennal sinus absent; pereonite 7 wider than anterior pereonites; pleonites wide, dorsodistal margins with 1, 3 and 3 small teeth in pleonites 1–3, respectively; pleonal epimera 1–2 slightly produced, epimeron 3 acutely produced on each posteroventral corner, each ventral margin bare; urosomite 1 wide, urosomites 2–3 narrow, dorsodistal margin of urosomite 2 with pair of robust setae.

Antenna 1 (Figure 7(a)) with ratio of lengths of peduncular articles 1–3 1 : 0.8 : 0.6, peduncular article 1 with 3 long and 1 short robust setae on posterior margin; accessory flagellum with 2 short and 1 minute articles, longer than article 1 of primary flagellum, tip setose; primary flagellum with 6 articles, last article minute, tip with several long setae. Antenna 2 (Figure 7(b)) about 0.8 times as long as antenna 1; ratio of lengths of peduncular articles 3–5 1 : 2.5 : 2.2, article 3 with robust seta on each anterior and posterior surfaces; flagellum with 4 articles, last article minute, tip with several long setae.

Upper lip (Figure 7(c)), ventral margin a little hollowed, bare. Mandible (Figure 7(d,d1, d2,e,e1)), both incisors bearing 4 cusps, lacinia mobilis slender, 4-dentate on left side,

Figure 6. Paraniphargus shiosai sp. nov. Holotype, male (OMNH-Ar-9986), 1.7 mm. Habitus, lateral view. Scale: whole body, 0.25 mm; magnified parts, 0.08 mm.
Figure 7. Paraniphargus shiosai sp. nov. Holotype, male (OMNH-Ar-9986), 1.7 mm. (a) Right antenna 1, medial view; (b) left antenna 2, lateral view; (c) upper lip, anterior view; (d) right mandible, medial view; (d1) palp of right mandible, medial view; (d2) incisor, lacinia mobilis and accessory blades of right mandible, medial view; (e) left mandible, lateral view; (e1) incisor, lacinia mobilis and accessory blades of left mandible, lateral view; (f) lower lip, dorsal view; (g) left maxilla 1, ventral view; (g1), distal part of left maxilla 1, ventral view; (h) left maxilla 2, ventral view; (i) right maxilliped, dorsal view. Scale: a, b, 0.10 mm; c–i, d1, 0.05 mm; d2, e1, g1, 0.025 mm.
Figure 8. Paraniphargus shiosai sp. nov. Holotype, male (OMNH-Ar-9986), 1.7 mm. (a, b) Left gnathopods 1–2, lateral views; (c) left pereopod 3, lateral view; (d) right pereopod 4, lateral view; (e–g), right pereopods 5–7, lateral views; (g1), left coxa 7, lateral view.
2-dentate on right side, both accessory blades 6 in number, right second blade thick; molar medium-sized; palp article length ratio 1 : 2.0 : 1.5 in right, articles 2–3 with 1 and 4 setae, respectively. Lower lip (Figure 7(f)), mediodistal corners of outer lobes each with small notch and 1 thick and 1 thin seta, mandibular processes small. Maxilla 1 (Figure 7(g, g1)), inner plate with 3 setae distally; outer plate with 7 robust setae, some of them

Figure 9. Paraniphargus shiosai sp. nov. (a–c, e–g) holotype, male (OMNH-Ar-9986), 1.7 mm; (d, h) paratype, male (OMNH-Ar-9987), 1.9 mm; (i–k) paratype, female (OMNH-Ar-9989), 1.8 mm. (a) Right pleopod 1, lateral view; (b) left pleopod 2, posterior view; (c) left pleopod 3, anterior view; (d) left uropod 1, dorsolateral view; (e, f) right uropods 2–3, dorsal views; (g) telson, lateral view; (h) telson, dorsal view; (i, j) left gnathopods 1–2, lateral views; (k) left coxa 6, lateral view, gill omitted. Scale: d–h, 0.125 mm; a–c, i–k, 0.10 mm.
bearing acute spine; palp with 6 distal setae. Maxilla 2 (Figure 7(h)), outer plate longer than inner, terminal ends of both plates bearing many setae. Maxilliped (Figure 7(i)), inner plate truncate, distal margin with several normal setae; outer plate small, distal margin with 4 long thick setae, medial margin with robust seta; palp large, article 2 long, articles 2–3 poorly setose, article 4 with nail, covered with short setae on ventromedial surface.

Gnathopod 1 (Figure 8(a)), coxa longish rhomboid, anterior margin with short seta, ventral margin with 1 medium and 2 short setae; basis almost straight, anterior margin with 2 long setae; ischium setose on posterodistal margin; merus setose on posterior margin and posteromedial surface; carpus bearing several long setae on anterodistal corner and posterior margin, anterodistal surface with many short setae medially; propodus about 0.9 times as long as carpus, anterodistal corner and posterior margin setose, posterodistal corner with several short setae (not robust), anteroproximal surface with many short setae medially; dactylus short, curved. Gnathopod 2 (Figure 8(b)), coxa longish rhomboid, anterior margin with short seta, ventral margin with 1 medium and 2 short setae, posterior margin bearing medium seta, gill small; basis relatively stout, anterior and posterior margins with 4 and 1 short setae, respectively; merus slightly projected posterodistally; propodus long, about 2.1 times as long as carpus, posterior margin gradually curved, distal half of anterior margin bearing several setae, palm defined by 1 long and 1 short robust seta, with many short setae, posterior margin except palm bearing sparse setae; dactylus slender, with several short setae.

Pereopods 3 (Figure 8(c)), coxa longish rhomboid, posterior margin slightly excavated, ventral and posterior margins with 2 and 1 setae, respectively, gill large; basis slender, slightly curved anteriorly, posterior margin without long setae (lost?), merus–propodus slender, poorly setose; dactylus short, distal one-third curved. Pereopods 4 (Figure 8(d)) same length as pereopod 3; coxa subquadrate, posterior margin excavated, ventral and posterior margins with 4 and 1 setae, respectively, gill large; basis slender, slightly curved anteriorly, posterior margin with 2 long setae, merus–dactylus similar to pereopod 3. Pereopod 5 (Figure 8(e)), coxa lobate, anterior half longer than posterior half, ventral and posterior margins with 2 and 1 short setae, respectively, gill medium-sized; basis relatively wide, anterior margin with 3 short robust setae, anterodistal corner bearing 1 robust and 2 normal setae, posterior margin with 6 serrations each accompanied by short seta; merus, anterodistal and posterodistal corners each with robust seta. Pereopod 6 (Figure 8(f)), coxa lobate, anterior lobe longer than posterior, ventral and posterior margins each with short seta, gill small; basis relatively wide, anterior margin with 3 short robust setae, anterodistal corner bearing robust seta, posterior margin with 9 serrations each accompanied by short seta; merus bearing posterior robust seta, anterodistal and posterodistal corners each with robust seta. Pereopod 7 (Figure 8(g,g1)) long; coxa slightly lobate, margins bare; basis wide, anterior margin with 3 short robust setae, anterodistal corner bearing robust seta, posterior margin with 6 serrations each accompanied by short seta; merus with posterior robust seta, anterodistal and posterodistal corners with 2 and 1 robust setae, respectively; carpus bearing 1 + 2 robust setae on anterior margin, anterodistal and posterodistal corners with 2 and 1 robust setae, respectively; propodus, anterior and posterior margins with 1 + 2 and 2 + 2 robust setae, respectively, anterodistal corner bearing robust seta; dactylus short, almost straight, tip slightly curved.

Pleopods (Figure 9(a–c)) subequal, slender; peduncles long, each with 2 coupling hooks, peduncle of pleopod 3 with medial seta; both rami almost same length, outer
and inner rami both with 5 articles in pleopod 1, 5 and 4 articles in pleopods 2–3, respectively. Uropod 1 (Figure 9(d)) stout; peduncle with 1 basofacial, 2 dorsolateral and 2 dorsomedial robust setae, laterodistal end bearing 1 large and 1 small robust seta; outer ramus about 0.6 times as long as peduncle, with 4 terminal setae, inner ramus a little longer than outer, about 0.7 times as long as peduncle, with 1 marginal and 5 terminal setae. Uropod 2 (Figure 9(e)) short; peduncle with 3 dorsal robust setae; outer ramus about 0.9 times as long as peduncle, with 2 marginal and 5 terminal robust setae, inner ramus longer than outer, almost same length as peduncle, with 1 marginal and 5 terminal robust setae. Uropod 3 (Figure 9(f)) slender; dorsolateral surface of peduncle with 2 robust setae; outer ramus long, about 2.4 times as long as peduncle, lateral and medial margins with $2 + 2 + 2$ and $1 + 2 + 2$ robust setae, respectively, distal margin with 4 robust setae; inner ramus rounded, 13% as long as outer ramus, with robust seta on tip. Telson (Figure 9(g,g1)) short, wider than long, cleft to base, both halves narrowed distally, each with 2 short sensory setae on dorsal surface, 2 robust setae on tip, and 1 small seta on ventral surface.

**Female [paratype, 1.8 mm (OMNH-Ar-9989)].** Gnathopod 1 (Figure 9(i)) subequal to that of male, but coxa larger, posterior margin of basis with 4 long setae. Gnathopod 2 (Figure 9(j)) almost the same as for male, but narrow oostegite present. Coxa 6 (Figure 9(k)) without hook often occurring in *Melita* females, anterior lobe narrower than that of male. Other parts generally similar to male except for oostegites.

**Coloration in fixed specimen**
Whole body white.

**Etymology**
Shiosai is the name of a famous Japanese novel by Yukio Mishima. The setting for the novel is Kamishima Island, the type locality of this new species.

**Remarks**
*Paraniphargus shiosai* sp. nov. differs from *P. annandalei* and *P. ruttneri* in (1) the dorsal teeth on pleonites, (2) the smaller coxa 4 with shallow excavation, (3) the 3-articulated accessory flagellum, and (4) in having a shorter antenna 1 flagellum. *Paraniphargus shiosai* can also be distinguished from *P. annandalei* by the smooth posteroventral margins of pleonal epimera. In addition, *P. shiosai* was collected from marine habitats whereas *P. annandalei* and *P. ruttneri* are freshwater species.

**Distribution**
Only Kamishima Island in Mie Prefecture, Japan.

**Habitat**
In coarse sand, interstitial; 2.5 m depth. This species occurs together with *Dulzura projecta* sp. nov.
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Disclosure statement

No potential conflict of interest was reported by the author.

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References

Ahyong ST, Lowry JK, Alonso M, Bamber RN, Boxshall GA, Castro P, Gerken S, Karaman G, Goy JW, Jones DS, et al. 2011. Subphylum Crustacea Brünich, 1772. In: Zhang ZQ, editor. Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. Zootaxa. 3148:165–191.

Ariyama H. 2009. Four species of the genus Seba from Japan, with descriptions of two new species (Crustacea: Amphipoda: Sebidae). Zootaxa. 2159:44–68.

Ariyama H. 2012. A new species of Bollegidia (Crustacea: Amphipoda: Bogidiellidae sensu lato) from Kushimoto coast, central Japan. In: Komatsu H, Okuno J, Fukuoka K, editors. Studies on Eumalacostraca: a homage to Masatsune Takeda (Crustaceana Monographs 17). Leiden: Brill; p. 71–80.

Ariyama H. 2015. Three new species of the Eriopisa group (Crustacea: Amphipoda: Eriopisidae) from Japan, with the description of a new genus. Zootaxa. 3949:91–110.

Bamber RN. 2003. New species of Amphipoda from Hong Kong shores. In: Morton B, editor. Perspectives on marine environmental change in Hong Kong and Southern China, 1997–2001. Hong Kong: Hong Kong University Press; p. 195–207.

Barnard JL. 1969. Gammaridean Amphipoda of the rocky intertidal of California: Monterey Bay to La Jolla. Bull US Nat Mus. 258:1–230.

Barnard JL. 1970. Sublittoral Gammaridea (Amphipoda) of the Hawaiian Islands. Smith Cont Zool. 271:1–149.

Barnard JL. 1976. Affinities of Pararniphargus lelouparum Monod, a blind anchialine amphipod (Crustacea) from the Galapagos Islands. Proc Biol Soc Wash. 89:421–432.

Barnard JL. 1979. Littoral gammaridean Amphipoda from the Gulf of California and the Galapagos Islands. Smith Cont Zool. 271:1–149.

Barnard JL, Barnard CM. 1983. Freshwater Amphipoda of the World, I. Evolutionary patterns and II. Handbook of bibliography. Mt. Vernon, VA: Hayfield Associates.

Barnard JL, Karaman GS. 1982. Classificatory revisions in gammaridean Amphipoda (Crustacea), part 2. Proc Biol Soc Wash. 95:167–187.

Bellan-Santini D. 2015. Order Amphipoda Latreille, 1816. In: Von Vaupel Klein JC, Charmantier-Daures M, Schram FR, editors. Treatise on zoology – anatomy, taxonomy, biology. The Crustacea, Volume 5. Leiden: Brill; p. 93–248.

Bousfield EL. 1973. Shallow-water gammaridean Amphipoda of New England. Ithaca & London: Comstock Publishing Associates, Cornell University Press.

Culver DC, Holsinger JR, Christman MC, Pipan T. 2010. Morphological differences among eyeless amphipods in the genus Stygobromus dwelling in different subterranean habitats. J Crust Biol. 30:68–74.
Fišer Ž, Novak L, Luštrik R, Fišer C. 2016. Light triggers habitat choice of eyeless subterranean but not of eyed surface amphipods. Sci Nat. [Internet]. [cited 2016 Feb 10]. Available from: http://link.springer.com/article/10.1007/s00114-015-1329-9

Fox RS. 1973. *Ceradocus shoemakeri* and *Eriopisa schoenerae*, new amphipods (Crustacea: Gammaridae) from the Bahama Islands. J Elisha Mitchell Sci Soc. 89:147–159.

Hirayama A. 1987. Taxonomic studies on the shallow water gammaridean Amphipoda of west Kyushu, Japan. VII. Melitidae (*Melita*), Melphidippidae, Oedicerotidae, Phliantidae [sic] and Phoxocephalidae. Publ Seto Mar Biol Lab. 32:1–62.

Horton T, Lowry J. 2012. WoRMS taxon details: *Tegano vermiamicus* (Bamber, 2003) [Internet]. [cited 2016 Feb 10]. Available from: http://www.marinespecies.org/aphia.php?p=taxdetails&id=537259

Jarrett NE, Bousfield EL. 1996. The amphipod superfamily Hadzioidae on the Pacific coast of North America: family Melitidae. Part I. The *Melita* group: systematics and distributional ecology. Amphipacifica. 2:3–74.

Karaman S. 1943. Die unterirdischen Amphipoden Südserbiens. Srpska Akademya Nauka, Posebna Izdana, 135 (Prirodn’achki i Mathematicki Spici). 34:161–312. [not seen].

Leach WE. 1814. Crustaceology. In: Brewster D, editor. The Edinburgh encyclopædia, Volume 7. Edinburgh: William Blackwood; p. 383–437.

Ledoyer M. 1979. Les gammariens de la pente externe du Grand Récif de Tuléar (Madagascar) (Crustacea Amphipoda). Mem Mus Civ Stor Nat Verona (2a Serie), Sez Sci Della Vita. 2:1–150.

Ledoyer M. 1982. Crustacés amphipodes gammariens. Familles des Acanthonotozomatidae à Gammaridae. Faune de Madagascar. 59:1–598.

Lowry JK, Myers AA. 2013. A phylogeny and classification of Senticaudata subord. nov. (Crustacea: Amphipoda). Zootaxa. 3610:1–80.

Monod T. 1970. Sur quelques crustacés Malacostracés des Iles Galapagos récoltés par N. et J. Leleup (1964-1965). Mission zoologique belge aux îles Galapagos et en Ecuador (N. et J. Leleup, 1964-1965). 2:11–53.

Moore PG. 1987. Taxonomic studies on Tasmanian phytal amphipods (Crustacea) the families Anamixidae, Leucothoidae and Sebidae. J Nat Hist. 21:239–262.

Nagata K. 1960. Preliminary notes on benthic gammaridean Amphipoda from the *Zostera* region of Mihara Bay, Seto Inland Sea, Japan. Publ Seto Mar Biol Lab. 8:163–182.

Nagata K. 1965. Studies on marine gammaridean Amphipoda of the Seto Inland Sea. II. Publ Seto Mar Biol Lab. 13:171–186.

Ruffo S. 1985. Nuovi Anfipodi mesopsammici delle Isole Andamane (Crust. Amphipoda). Boll Mus Civ Stor Nat Verona. 10:485–509.

Sawicki TR, Holsinger JR, Iliffe TM. 2005. New species of amphipod crustaceans in the genera *Tegano* and *Melita* (Hadzoidea: Melitidae) from subterranean groundwaters in Guam, Palau, and the Philippines. J Crust Biol. 25:49–74.

Schellenberg A. 1931. Amphipoden der Sunda-Expeditionen Thienemann und Rensch. Arch Hydrobiol. Suppl. 8:493–511.

Shimomura M, Ohtsuka S, Tomikawa K. 2006. *Ingolfiella inermis* n. sp., a new interstitial ingolfiellid amphipod from Okinawa, southern Japan (Peracarida, Amphipoda). Crustaceana. 79:1097–1105.

Springthorpe RT, Lowry JK. 2009. Hadziidae. In: lowry JK, Myers AA, editors. Benthic Amphipoda of the Great Barrier Reef, Australia. Zootaxa. 2260:434–439.

Stock JH, Iliffe TM. 1995. Melitidae (Crustacea, Amphipoda) from anchialine limestone caves in New Caledonia. Cont Zool. 65:245–269.

Stock JH, Vonk R. 1991. Une espèce nouvelle de *Dulzura*, genre d’Amphipodes hadziidés connu jusqu’ici seulement de l’Indo-Pacifique, découverte aux îles du Cap-Vert (océan Atlantique). Cah Biol Mar. 32:477–486.

Tattersall WM. 1925. Freshwater Amphipoda from the Andaman Isles. Rec Ind Mus. 27:241–247.

Thurston MH, Bett BJ. 1993. Eyelessness in marine gammaridean Amphipoda (Crustacea): geographical, bathymetrical and taxonomic considerations. J Nat Hist. 27:861–888.
Tomikawa K, Kakui K, Yamasaki H. 2010. A new species of *Psammogammarus* (Amphipoda: Melitidae) from Kuchinoerabu Island, Japan, with a note on its feeding habits. Zool Sci. 27:615–626.

Vonk R, Gable M. 2014. Infaunal zoogeography and intergeneric character blending: the case of *Metaniphargus shiroi* sp. nov. (Crustacea: Amphipoda: Hadziidae), from interstitial beach water on Akajima Island, the Kerama Islands, Southwestern Japan. Zool Sci. 31:491–499.

Zimmerman RJ, Barnard JL. 1977. A new genus of primitive marine hadziid (Amphipoda) from Bimini and Puerto Rico. Proc Biol Soc Wash. 89:565–580.