

Two Species of the Genus *Petrolisthes* (Decapoda: Anomura: Porcellanidae) from the Ryukyu Islands, Southwestern Japan, with Description of a New Species

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Abstract A new porcellanid crab, *Petrolisthes cyanochir*, is described on the basis of specimens from Okinawa and Miyako Islands of the Ryukyus, southwestern Japan. The new species morphologically resembles *P. bifidus* Werding and Hiller, 2004, *P. borradailei* Kropp, 1984, *P. haswelli* Miers, 1884, and *P. lamarckii* (Leach, 1820), but is distinguished by characters of the carapace and ambulatory legs, and coloration of the chelae. *Petrolisthes bifidus* is recorded from Japanese waters for the first time. A brief diagnosis and a description of the coloration in life are provided for *P. bifidus*.

Key words: Decapoda, Anomura, Porcellanidae, *Petrolisthes*, new species, Ryukyu Islands, Japan.

Petrolisthes Stimpson, 1858 is the most species-rich genus in the family Porcellanidae, with 102 species currently recognized in the world, of which 45 species are known from the Indo-West Pacific (Osawa and McLaughlin, 2010). Those porcellanids primary occur in intertidal zone of tropical and subtropical regions, and inhabit depressions under rocks and excavations or narrow spaces on coral reefs. Most species are free-living, but *P. carinipes* (Heller, 1861), *P. masakii* Miyake, 1943, and *P. virgatus* Paulson, 1875 live in association with brittle stars or sea urchins (Miyake, 1998; Osawa, 1998).

During ongoing studies on the porcellanid fauna in the Ryukyu Islands, southwestern Japan, a number of undescribed or poorly known species have been found. Amongst them, a new species of *Petrolisthes* is described in the present paper. Furthermore, *P. bifidus* Werding and Hiller, 2004, a congener allied to the new species, is reported from Japanese waters for the first time, with a description of the coloration in life.

The specimens examined including the type material of the new species are deposited in the National Museum of Nature and Science, Tokyo (NSMT) and Fujukan (University Museum, University of the Ryukyus; RUMF), Okinawa. Carapace length (cl), an indication of specimen size, was measured from the anterior median tip of the rostrum to the posteromedian margin of the carapace. Measurements of the cheliped and ambulatory legs are cited in Osawa (2007). Terminology follows that of Osawa and Chan (2010).

Taxonomy

Family **Porcellanidae** Haworth, 1825

Genus ***Petrolisthes*** Stimpson, 1858

Petrolisthes cyanochir sp. nov.

[New Japanese name: Aoheri-kanidamashi]

(Figs. 1, 2, 4A–C)

? *Petrolisthes borradailei*: Hsieh *et al.*, 1997: 315, figs. 14H, 22. Not *P. borradailei* Kropp, 1984. See Remarks.

Material examined. Holotype: NSMT-Cr 21458 male (cl 14.4 mm), Inanse, Urasone, Okinawa Island, Ryukyu Islands, intertidal, under rock, 27 March 2010, coll. T. Maenosono.

Paratypes: NSMT-Cr 21459, 3 females (cl 13.2–15.1 mm), Inanse, Urasone, Okinawa Island, Ryukyu Islands, intertidal, under rocks, 16 December 2009, coll. T. Maenosono. NSMT-Cr 21460, 1 female (cl 9.0 mm), 1 ovigerous female (cl 9.1 mm), Benoki, Kunigami, Okinawa Island, Ryukyu Islands, intertidal, under rocks, 16 October 2009, coll. M. Osawa. URMF-ZC 01326, 4 males (cl 9.4–13.5 mm), Nagayama Port, Irabu Islet, Miyako Island, Ryukyu Islands, intertidal, under rocks, 22 July 2010, coll. T. Maenosono.

Description. Carapace (Fig. 1A–C) as long as broad; dorsal surface flattish; frontal, gastric, cardiac, and anterior branchial regions covered with short, weak, minutely granulate transverse striae; posterior branchial regions with long oblique ridges; intestinal region punctate; protogastric ridges blunt but distinct; cervical grooves shallow, each with or without very short epibranchial spine at anterior end; no other spines on margins or surface. Branchial margins strongly convex, broadest on posterior to median part, each demarcated by longitudinal crest. Rostrum (Fig. 1D) relatively narrow, sinuously triangular; median lobe bent ventrally, rounded on anterior margin; distinct doromedian groove extending onto protogastric ridges. Orbits shallow; supra-orbital margins roundly elevated, straight or weakly convex, unarmed; outer orbital angles each terminating in small, roundly triangular projection.

Pterygostomial flap (Fig. 1C) with longitudinal ridges bearing granules and short plumose setae on anterior margins; anterior margin rounded.

Third thoracic sternite (Fig. 1E) with ventral surface weakly convex medially; anterior margin trilobate, with row of short setae; median lobe broadly rounded; lateral lobes narrow, each with rounded apex, exceeding apex of median lobe. Fourth thoracic sternite with row of short striae or pits along concave anterior margin.

Ocular peduncles (Fig. 1H) comparatively large; dorsal surface with long striae on proximal

part; dorsal extension onto cornea rounded, with short striae.

Basal article of antennular peduncles (Fig. 1G) approximately as long as broad; ventral surface convex, with transverse ridges on median lateral part; anterolateral margin broadly rounded, laminated, with small triangular tooth at lateral angle; lateral margin ending in somewhat concave ridge

Antennal peduncles (Fig. 1H) short, moderately slender, with second to fourth articles freely accessible to orbit. First article broad, with spine at anterodistal end. Second article with distinct, laminate lobe on anterior margin, lobe with proximal shallow concavity or notch but no distinct spines on anterior margin; dorsal surface with delicate, very short striae. Third article transversely subrectangular; anteroproximal margin slightly produced; anterior surface granular; lateral surface with oblique ridges on proximal half. Fourth article short, with short striae.

Third maxilliped (Fig. 1I) with coxa bearing small, distal subtriangular projection on flexor margin, distomedian projection not basally articulated. Basis not fused with ischium, roundly triangular. Ischium broad, ovate; lateral surface with transverse, short and long ridges and longitudinal ridge along extensor margin; distal extensor projection rounded. Merus with laminate, broad, roundly subtriangular lobe bearing small subacute or blunt apex on flexor margin; lateral surface with transverse ridges. Carpus with roundly subtriangular projection on median part of flexor margin, lateral surface with longitudinal ridges. Propodus somewhat tapering distally, lateral surface with long ridges on extensor surface. Dactylus short, roundly subtriangular, nearly smooth on lateral surface. Merus to dactylus with long setae on flexor margin. Exopod with proximal article small, rounded; distal article laminated, relatively narrow, reaching to proximal part of carpus; proximal part of distal article somewhat inflated; flagellum well developed.

Chelipeds (first pereopods) (Fig. 2A–E) subequal in size and shape, flattened. Merus weakly convex, with rows of short transverse ridges on dorsal surface; dorsoflexor margin with rounded

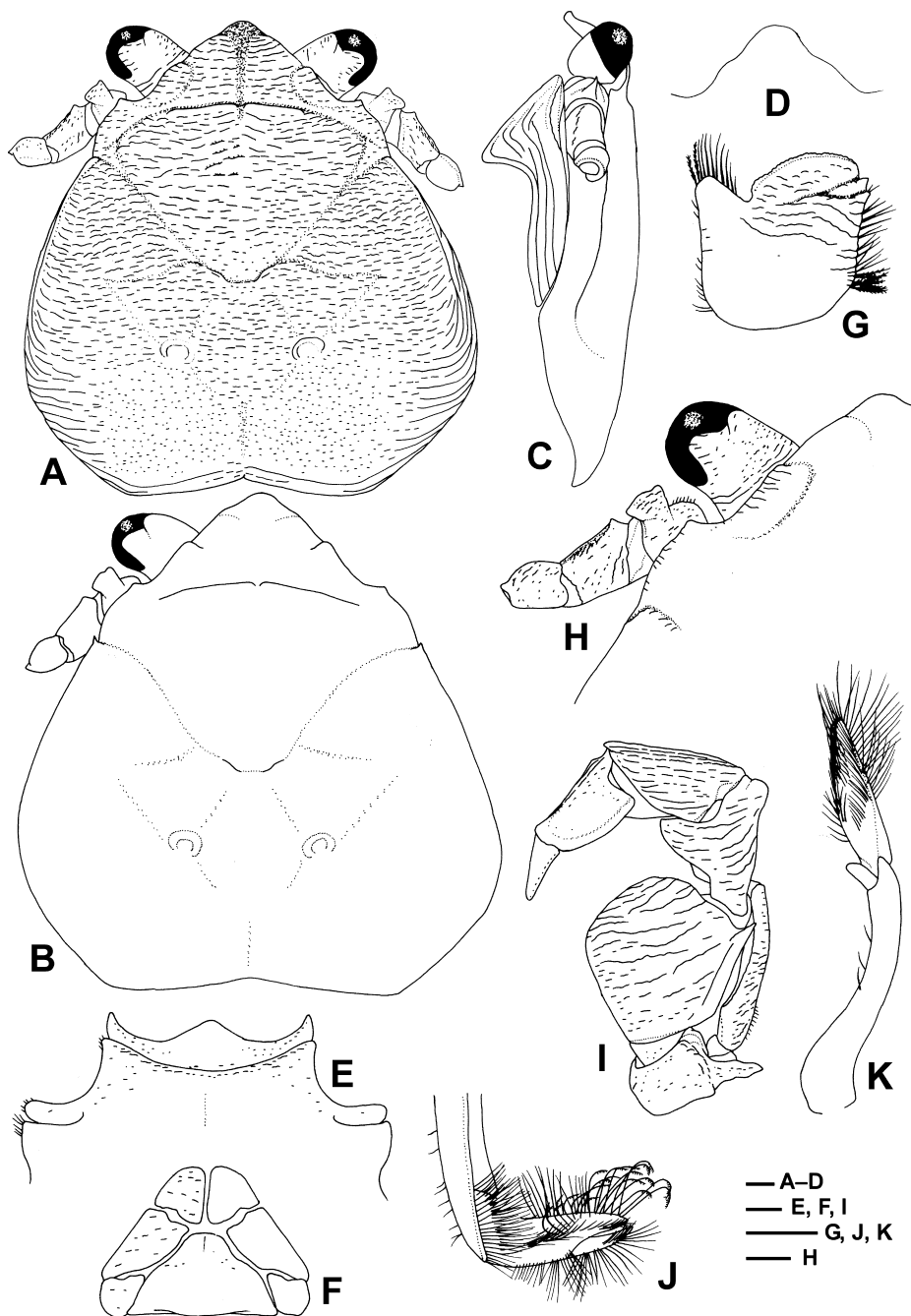


Fig. 1. *Petrolisthes cyanochir* sp. nov. Holotype, male (cl 14.4 mm), NSMT-Cr 21458 (A, C–K); paratype, female (cl 15.1 mm), NSMT-Cr 21459 (B). A, B, carapace and ocular and antennal peduncles, dorsal view (surface structure mostly omitted in B); C, same, left, lateral view; D, rostrum, anterodorsal view; E, third and fourth thoracic sternites, ventral view; F, telson, extensor view; G, basal article of left antennular peduncle, ventral view; H, anterior part of carapace and left ocular and antennal peduncles, dorsal view; I, left third maxilliped, lateral view (flexor setae omitted); J, chela and distal part of carpus of left fifth pereopod, flexor view; K, left gonopod, internal view. Scales equal 1.0 mm.

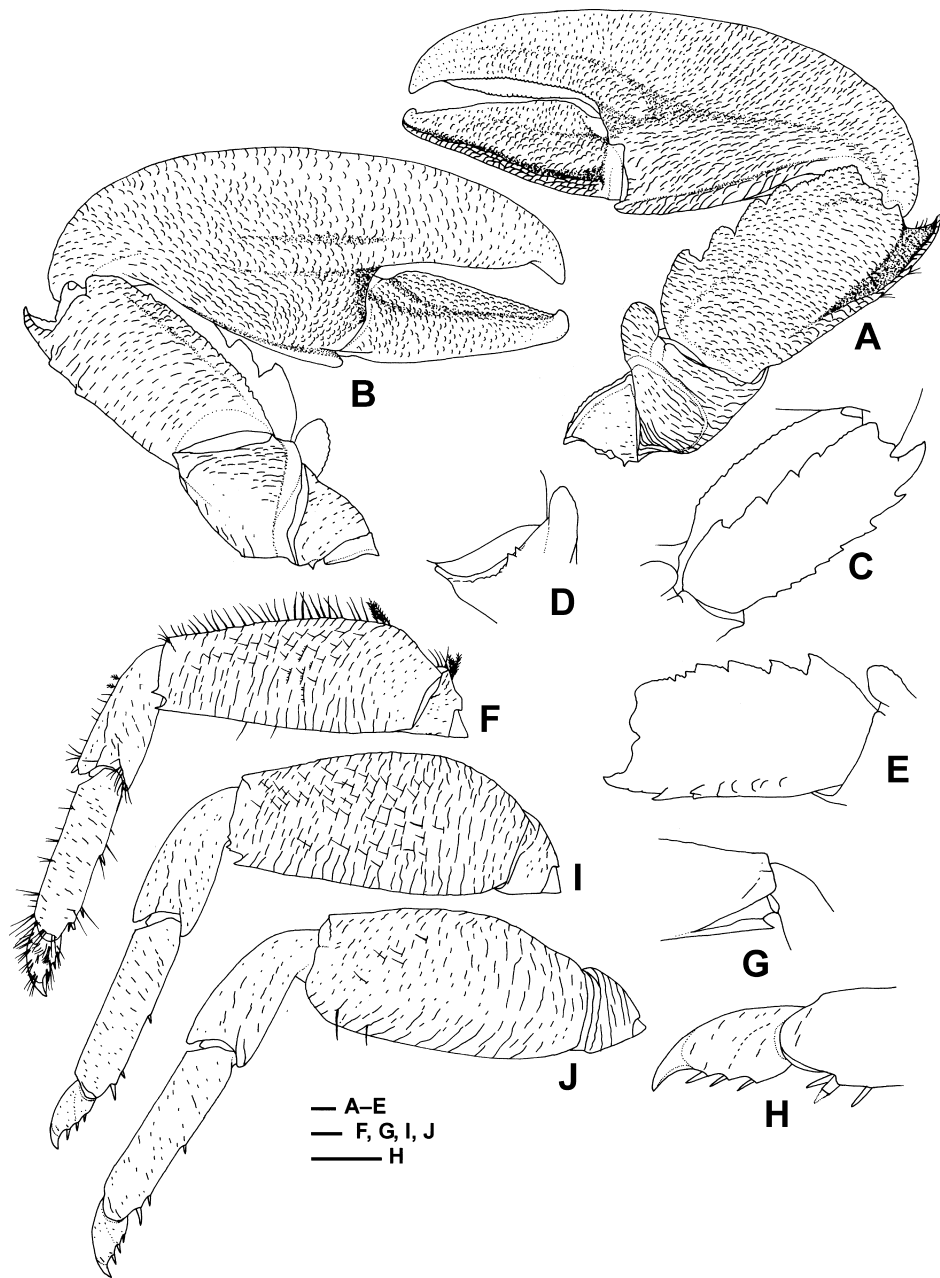


Fig. 2. *Petrolisthes cyanochir* sp. nov. Holotype, male (cl 14.4 mm), NSMT-Cr 21458. A, right cheliped, dorsal view; B, same, ventral view; C, same, carpus, dorsoflexor view; D, same, posterior part of carpus, ventroflexor view; E, carpus and distal part of merus of left cheliped, dorsal view (surface structure mostly omitted); F, left second pereopod, lateral view; G, same, distal part of merus, mesial view; H, same, dactylus and distal part of propodus, lateral view (setae omitted); I, left third pereopod, lateral view (marginal setae omitted); J, left fourth pereopod, lateral view (marginal setae omitted). Scales equal 1.0 mm.

or roundly subrectangular lobe devoid of distinct spines; ventral surface with short ridges on distoflexor half; ventrodistal margin with 1 or 2 small tuberculate spines near flexor end. Carpus 1.8–2.1 times as long as broad; dorsal surface weakly convex, with numerous, short and very short, arcuate and transverse ridges marginally bearing minute granules and with broad sulcus along extensor margin; dorsoflexor margin with 3–5 (usually 4) broad teeth marginally bearing small tubercles (proximal tooth occasionally terminating in small, acute or subacute spine) and with 0–3 much smaller teeth; dorso-extensor margin with blunt crest composed of row of 2 or 3 spines (usually 3, including strong, acute distal projection) proximally followed by elevated short ridges; ventral surface with numerous, short transverse ridges; ventroflexor margin crenulated. Chela relatively broad, elongate, 2.0–2.3 times as long as carpus, 2.4–2.9 times as long as broad; dorsal surface covered with short to very short, arcuate, transverse or oblique ridges marginally with minute granules; extensor margin gently convex, thin, unarmed; ventral surface flattish on extensor half and convex on flexor half, with numerous, short and very short, arcuate, oblique and transverse ridges. Palm weakly convex on dorsal surface; dorsomedian longitudinal crest obsolete; dorsoflexor margin weakly elevated, with row of short oblique ridges. Fingers without hiatus when closed; fixed finger with curved distal claw, cutting edge nearly straight, with row of small rounded tubercles. Dactylus 0.4–0.5 length of chela, opening at slight oblique angle, with curved distal claw; dorsal surface weakly convex, with numerous, short and very short, arcuate, oblique and transverse ridges marginally with minute granules and with shallow sulcus along weakly elevated extensor (posterior) margin; cutting edge nearly straight, with row of small tubercles; ventral cutting region weakly concave, with numerous small tubercles but no dense setae.

Ambulatory legs (second to fourth pereopods) (Fig. 2F–J) moderately slender, third pereopod longest, second pereopod usually slightly longer

than fourth pereopod (in holotype, third and fourth pereopods subequal in length, longer than second pereopod). Meri somewhat compressed laterally, elongated subrectangular, longest on third pereopod, second and fourth pereopods usually subequal in length; extensor margin weakly crenulated, with row of plumose setae; lateral surface with numerous, short transverse ridges each partially bearing short plumose seta; lateral flexor margin with few short simple setae, distal corner with spine on second and third pereopods but unarmed on fourth pereopod; distolateral margin usually with small spine at flexor end on second and third pereopods, but unarmed on fourth pereopod; mesial flexor margin unarmed on all three pereopods. Carpi elongate; lateral surface with 2 rows of short ridges on midline; extensor surface with scattered short, plumose and simple setae; disto-extensor margin with spine on second pereopod, but unarmed on third and fourth pereopods; distal, extensor and flexor margins rounded. Propodi 2.0–2.6 times as long as dactyli, 4.1–4.9 times as long as broad, not tapering distally; surfaces with scattered short ridges bearing simple setae; flexor margin with 4 corneous spines including paired spines at distal angle, distolateral spine largest. Dactyli each terminating in curved claw; surfaces with scattered tufts of short simple setae; flexor margin with 3 small corneous spines.

Striae and ridges on carapace and pereopods with sparse, very short setae on anterior margins.

Fifth pereopod (Fig. 1J) short, slender, chelate; propodus with tuft of dense short simple setae on distal flexor part; palm with irregular rows of simple setae on margins; fixed finger and distal part of palm with about 30 scythe-like setae on flexor surface; dactylus with row of short simple setae on extensor surface.

Abdominal segments with tufts of plumose setae on lateral margins; dorsal surface with rows of scattered, short setae along anterior and posterior margins. Telson (Fig. 1F) composed of 7 plates, much broader than long; posterior plates broader in female than male.

Male with pair of pleopods modified as

gonopods on second abdominal segment (Fig. 1K); protopod with few short setae; endopod lanceolate, narrowly rounded on distal margin, internal surface concave, bearing numerous short, simple setae, margins with long simple setae; exopod small, elongate oval. No traces of rudiments of pleopods on third to fifth abdominal segments in male. Female with pairs of developed pleopods on third to fifth abdominal segments, fifth pairs largest.

Coloration in life (Fig. 4A–C). Carapace, antennal peduncle, and pereopods generally reddish or greenish brown, with numerous, small pale brown markings on dorsal surface. Ventral surfaces of sternites and chelipeds and mesial surface of ambulatory legs dark red. Third maxilliped purple on lateral surface and dark red on mesial surface; dactylus and flexor margins of merus, carpus, and propodus orange. Chelipeds with blue line interrupted by small reddish brown marks along extensor margin on dorsal surface of each chela; fingers orange on distal parts of claws; dactyli each with small orange mark proximally on cutting region. Ambulatory legs dark red on lateral surfaces of carpi, propodi, and dactyli; meri bearing pale brown mark on distal extensor part of lateral surface; propodi with pale brown or white band each on subproximal and distal parts of lateral surface; dactyli also with pale brown band each on proximal and subdistal part of lateral surface.

Distribution. At present, only known from Okinawa Island and Miyako Island of the Ryukyu Islands, southwestern Japan, and possibly from Taiwan (see Remarks).

Habitat. Intertidal, under large rocks on exposed shores which are strongly influenced by waves. The present new species occurred together with congeners such as *Petrolisthes asiaticus* (Leach, 1820), *P. borraidailei* Kropp, 1984, *P. hastatus* Stimpson, 1858, *P. haswelli* Miers, 1884, *P. lamarckii* (Leach, 1820), and *P. unilobatus* Henderson, 1888, but seemed to be much fewer than the other species in the collection sites.

Remarks. The new species morphologically resembles *Petrolisthes bifidus*, *P. borraidailei*, *P. haswelli*, and *P. lamarckii*. Although *P. lamarckii* currently recognized is considered as a species complex by Osawa (2007) and Osawa and Chan (2010), the characters possessed by the five species can be shown as follows: the carapace has numerous short, weak transverse striae on the dorsal surface, but lacks supra-ocular and branchial marginal spines and a covering of short plumose setae; the carpus of the cheliped is usually armed with three to five broad teeth on the dorsoflexor margin and two or three spines including a strong, acute distal projection along the distal half of the dorso-extensor margin (in *P. borraidailei*, dorso-extensor subdistal spines are occasionally reduced to short, blunt elevated ridges); the palm of the cheliped is devoid of a distinct fringe of plumose setae on the extensor margin; and the ambulatory legs lack spines on the extensor margins of the meri. *Petrolisthes bifidus* is readily distinguished from the other four species by the carapace being clearly longer than broad and the dactyli of the ambulatory legs each with two corneous spines on the flexor margin, the distal spine arising from a produced base and showing a bifurcate appearance with the terminal claw. In all of *P. borraidailei*, *P. haswelli*, *P. lamarckii*, and *P. cyanochir* sp. nov., the breadth of the carapace is as broad as or slightly broader than the length and the dactyli of the ambulatory leg have three corneous spines on the flexor margin, of which the distalmost spine arises from a non-produced base. *Petrolisthes cyanochir* sp. nov. differs from *P. borraidailei* in having a distal spine on the extensor margin of the carpus of the second pereopod (first ambulatory leg). Such a spine is absent in *P. borraidailei*. The short striae and ridges on the carapace and chelipeds are also stronger in *P. cyanochir* sp. nov. than in *P. borraidailei*. The new species is distinguished from *P. haswelli* and *P. lamarckii* by the carapace being comparatively broader in the posterior part, thus with a narrower rostrum, and the epi-branchial spine on each side being very small or absent instead of rather distinct. *Petrolisthes*

haswelli further differs from *P. lamarckii* and *P. cyanochir* sp. nov. in that the dorsal surface of the carapace is comparatively more convex and more strongly striate, and those striae bear more numerous minute plumose setae, showing setose appearance.

The coloration in life of the chelae is also clearly different between *P. cyanochir* sp. nov. and the four allied species mentioned above. The dorsal surface of each chela has a blue line interrupted by small brown marks along the extensor margin in the new species, but it has not been reported to possess such a line in *P. bifidus*, *P. borradailei*, *P. haswelli*, and *P. lamarckii* (see Miyake, 1942; Haig, 1965; Kropp, 1984; Osawa and Chan, 2010; present study). On the fresh coloration of the chelae, *P. miyakei* Kropp, 1984 is described to have an azure blue stripe along the extensor margin extending from near the joint of the carpus to tip of the immovable finger (Kropp, 1984). The stripe may be similar to that of *P. cyanochir* sp. nov. However, the general coloration of the carapace and chelipeds (tan with a prominent reddish purple reticulated pattern) and presence of a subdistal spine on the extensor margin of each merus of the ambulatory leg readily distinguish *P. miyakei* from the new species.

Hsieh et al. (1997) reported *P. borradailei* from Lauyu Island, southeastern Taiwan. The specimens are described to have a disto-extensor spine on the carpus of the first ambulatory leg. This character agrees with that of *P. cyanochir* sp. nov. rather than *P. borradailei*. Although examination of the Taiwanese specimens is needed, they are likely referred to the present new species. The record from Taiwan by Hsieh et al. (1997) is only questionably included in the synonymy of the new species.

Etymology. The specific name is derived from a combination of the Latin, *cyaneus* (blue) and *chir* (hand), referring the characteristic coloration of the chelae of the new species.

Petrolisthes bifidus Werding and Hiller, 2004

[New Japanese name: Doroiwa-kanidamashi]

(Figs. 3, 4D)

Petrolisthes bifidus Werding and Hiller, 2004: 258, figs. 1–5, 5a (type locality: Chuuk Islands, Micronesia).

Material examined. NSMT-Cr 21461, 3 males (cl 9.6–10.9 mm), Shirahama, Iriomote Island, Ryukyu Islands, intertidal, under rocks, mud tidal flat, 28 December 2005, coll. M. Osawa.

Diagnosis. Carapace (Fig. 3A) longer than broad, with numerous, short weak striae on dorsal surface; no supra-ocular spine; distinct epi-branchial spine present at anterior end of cervical groove. Rostrum (Fig. 3B) sinuously triangular. Third thoracic sternite (Fig. 3C) with lateral lobes slightly exceeding apex of median lobe. Basal article of antennular peduncle (Fig. 3D) with broadly rounded on anterolateral margin, anterolateral angle bluntly ridged. Antennal peduncle (Fig. 3A) with distinct anterior lobe bearing small spine at proximal end on second article; third article somewhat produced at antero-proximal end. Merus of third maxilliped (Fig. 3E) with laminate suboval or roundly triangular lobe on flexor margin. Chelipeds (Fig. 3F–H) with numerous, short ridges on dorsal surface, those ridges longer on median longitudinal region of carpus and flexor half of palm than on other parts; merus with rounded or roundly triangular lobe on dorsoflexor distal margin, dorsodistal margin with small spine near extensor end; carpus armed with 3 or 4 broad teeth on dorsoflexor margin, proximal 2 teeth each occasionally terminating in small spine, other teeth low and obsolete, dorso-extensor margin with 3 spines including distal acute projection on distal third; palm without spines on extensor margin but with few short plumose setae on proximal part; dactylus without tufts of dense setae ventrally on cutting part. Ambulatory legs (Fig. 3I–L) moderately slender; meri each with row of short plumose setae but without spines on extensor margin, lateral surface with numerous, short and long transverse ridges; lateral distoflexor margin with strong spine on second and third

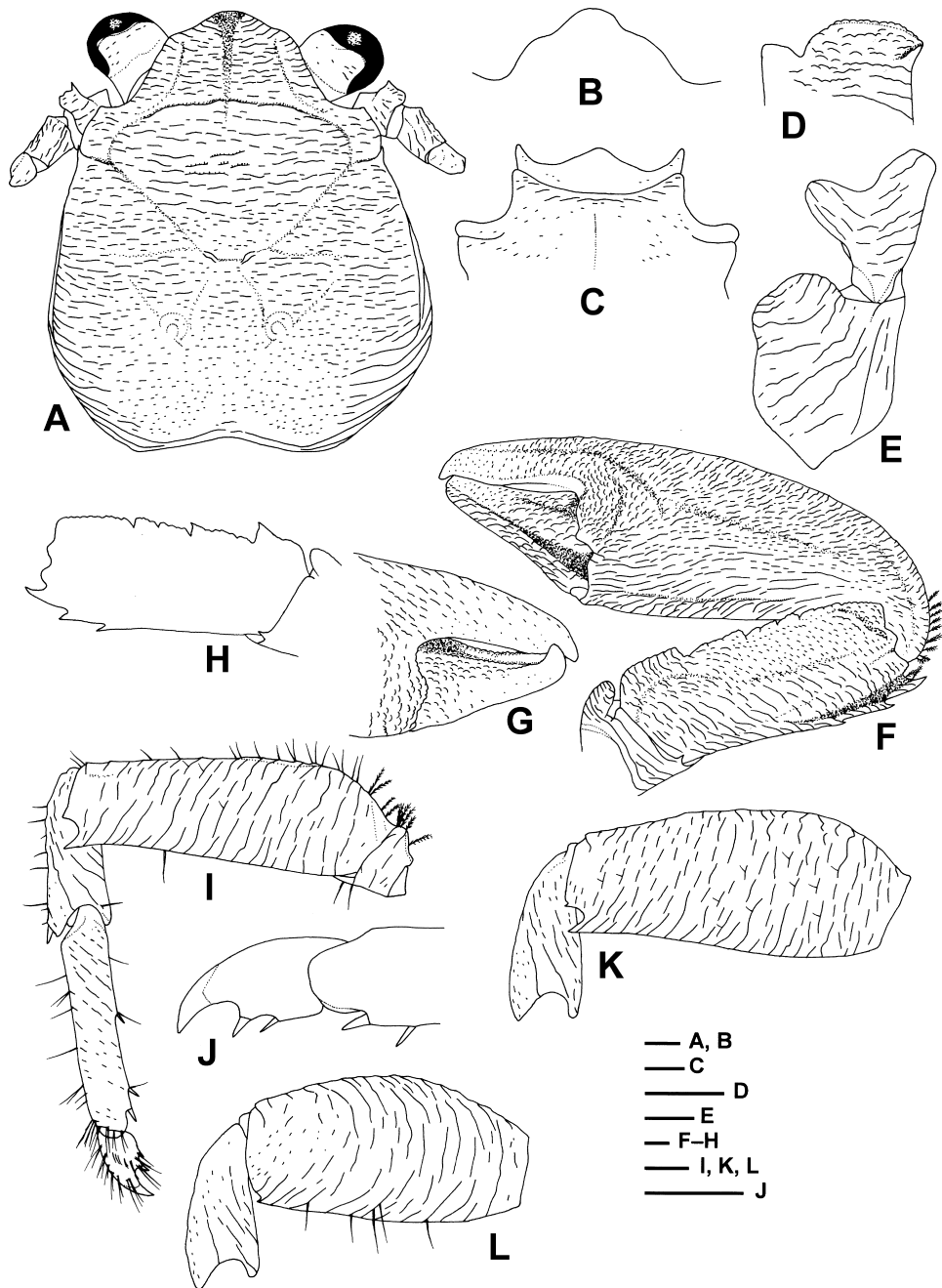


Fig. 3. *Petrolisthes bifidus* Werding and Hiller, 2004. Male (cl 10.9 mm), NSMT-Cr 21461. A, carapace and ocular and antennal peduncles, dorsal view; B, rostrum, anterodorsal view; C, third and fourth thoracic sternites, ventral view; D, anterior part of basal article of left antennular peduncle, ventral view; E, ischium and merus of left third maxilliped, lateral view; F, right cheliped, dorsal view; G, same, fingers, ventral view; H, carpus and distal part of merus of left cheliped, dorsal view (surface structure mostly omitted); I, left second pereopod, lateral view; J, same, dactylus and distal part of propodus, lateral view (setae omitted); K, merus and carpus of left third pereopod, lateral view (marginal setae omitted); L, merus and carpus of left fourth pereopod, lateral view (marginal setae omitted). Scales equal 1.0 mm.

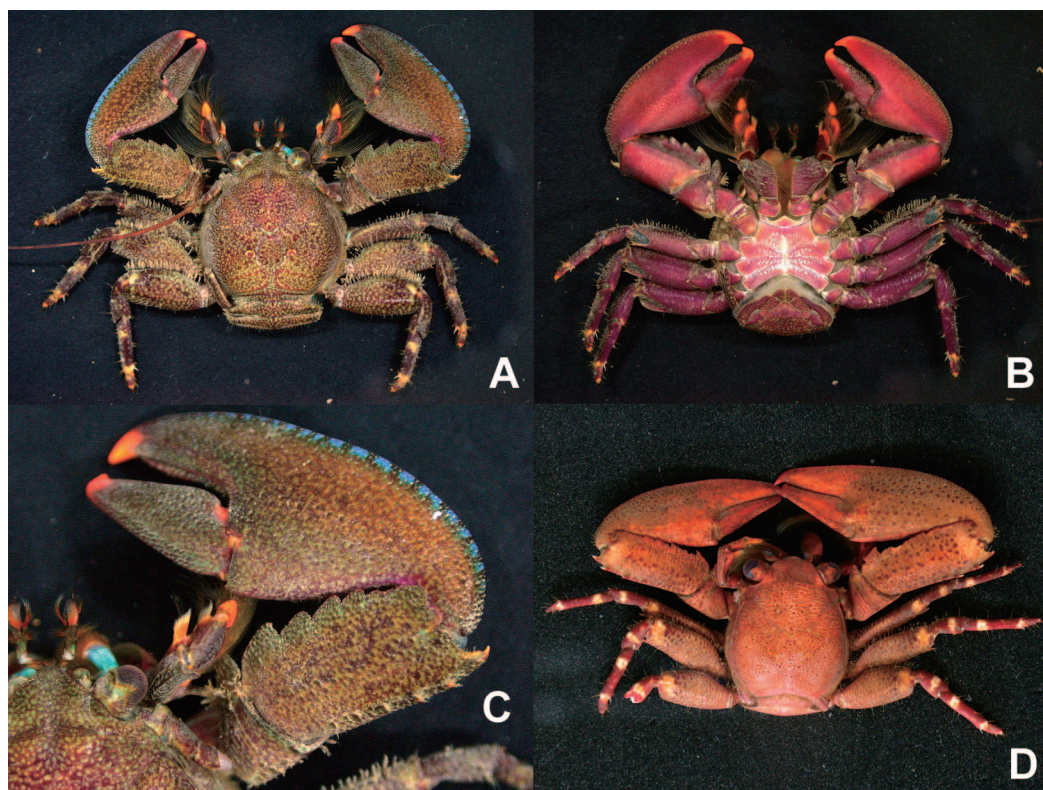


Fig. 4. Fresh specimens. *Petrolisthes cyanochir* sp. nov., holotype male (cl 14.4 mm), NSMT-Cr 21458 (A–C); *Petrolisthes bifidus* Werding and Hiller, 2004, male, not examined (D). A, D, entire animal, dorsal view; B, same, ventral view; C, anterior part of carapace and right cheliped, dorsal view.

pereopods and with small spine or unarmed on fourth pereopod, distolateral margin with small spine or subacute or blunt projection on second pereopod and third pereopods but unarmed on fourth pereopod; mesial distoflexor margin unarmed on all legs; carpi with disto-extensor spine on second pereopod but unarmed on third and fourth pereopods; propodi with 4 corneous spines including distal paired spines on flexor margin; dactyli with 2 corneous spines on flexor margin, distal spine larger and arising from produced base. Striae and ridges on carapace and pereopods with sparse, very short setae on anterior margins.

Coloration in life (Fig. 4D). Carapace brown or bluish brown, with numerous small, dark brown or reddish marks of irregular shapes on

dorsal surface. Chelipeds brown or greenish brown, with dark brown or reddish marks on dorsal surfaces of carpi and palms; marks on dorsal midline on carpus usually larger than others. Ambulatory legs also brown or greenish brown on lateral surface, with white and dark brown or reddish marks on distal third of each merus; carpi, propodi, and dactyli dark brown or reddish; carpi each with white ring in submedian part; propodi also with white rings on subproximal and distal parts.

Distribution. Previously known from the Chuuk (Truk) Islands in Micronesia, Tahiti Island in French Polynesia, and Palawan Island of the Philippines. The present specimens from the Ryukyu Islands greatly extend the distributional range of *P. bifidus* to north.

Habitat. The present specimens were found from an assemblage of rocks covered with unidentified oysters in muddy intertidal flat. This species occurred together with *P. haswelli* and *P. japonicus* (De Haan, 1849) in the collection site.

Remarks. The present specimens agree well with the original description of *P. bifidus* by Werding and Hiller (2004). The morphological characters discriminating this species from four allied congeners are discussed above in the Remarks of *P. cyanochir* sp. nov. Besides the allied species, *P. bifidus* is similar to large males of *P. obtusifrons* Miyake, 1937 in having some short plumose setae on the proximal extensor margin of the chela in addition to the ornamentation of the carapace (see Osawa, 1998, as *P. varicolor* Osawa, 1998). However, the setae on the chelae are comparatively shorter and restricted to more proximal part in *P. bifidus* than in *P. obtusifrons*. These two species are further distinguishable by the shape of the carapace and rostrum, and armatures of the antennular basal article and ambulatory legs.

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