

Hermit crabs of the family Paguridae (Crustacea: Decapoda: Anomura) from Christmas and Cocos (Keeling) Islands, Indian Ocean Territory of Australia, with descriptions of three new species and reappraisal of the genus *Kumepagurus* Komai & Osawa, 2012

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Abstract. A small collection of pagurid hermit crabs, collected from coral reefs and marine caves on Christmas and Cocos (Keeling) Islands, Indian Ocean Territory of Australia, was studied. The following 11 species, including three new to science, were identified: *Eutrichopagurus granulimanus*, new species; *Kumepagurus noelensis*, new species; *Micropagurus polynesiensis* (Nobili, 1906); *Pagurixus carinimanus* Komai & Osawa, 2006; *P. depressus*, new species; *P. haigae* Komai & Osawa, 2007; *P. maorus* (Nobili, 1906); *P. nomurai* Komai & Asakura, 1995; *P. tweediei* (Forest, 1956); *Pylopaguropsis bellula* Osawa & Okuno, 2007; and *P. keijii* McLaughlin & Haig, 1989. At Christmas Island, where the major part of the collection was done, seven of the eight species, including the three new species, are reported for the first time. Four species are recorded from Cocos (Keeling) Islands, of which three species of *Pagurixus* Melin, 1939, are reported for the first time. The generic assignment of *E. granulimanus*, new species, is considered provisional, because only the male holotype was available for study, and the original generic diagnosis was based only on female characters. The discovery of *K. noelensis*, new species, led the authors to reassess the generic assignment of *K. kaikata* Komai, 2020, for which a new genus *Vounopagurus* is proposed.

Key words. Christmas Island, Cocos (Keeling) Islands, *Eutrichopagurus granulimanus*, *Kumepagurus noelensis*, new species, marine cave, *Pagurixus depressus*, *Vounopagurus*, new genus

INTRODUCTION

The pagurid hermit crabs (Decapoda: Anomura) of the two Australian Indian Ocean territories, Christmas Island and Cocos (Keeling) Islands, have been reviewed by Morgan (1992), in which altogether eight species were recorded. Later, Morgan (2000) added five unidentified species assigned to the Paguridae from Christmas Island. Recently, Tan et al. (2014a) reported the occurrence of *Pagurixus nomurai* Komai & Asakura, 1995, and two unidentified species of the family from the marine caves of Christmas Island.

This study deals with a small collection of hermit crabs of the family Paguridae, made by parties from the Australian Museum, Queensland Museum, and the Lee Kong Chian

Natural History Museum, National University of Singapore, in Christmas Island and Cocos (Keeling) Islands in 2010–2012. The following 11 species are represented in the collection: *Eutrichopagurus granulimanus*, new species; *Kumepagurus noelensis*, new species; *Micropagurus polynesiensis* (Nobili, 1906); *Pagurixus carinimanus* Komai & Osawa, 2006; *P. depressus*, new species; *P. haigae* Komai & Osawa, 2007; *P. maorus* (Nobili, 1906); *P. nomurai* Komai & Asakura, 1995; *P. tweediei* (Forest, 1956); *Pylopaguropsis bellula* Osawa & Okuno, 2007; and *P. keijii* McLaughlin & Haig, 1989. All but *P. nomurai* are newly recorded from Christmas Island (cf. Morgan, 1992, 2000; Tan et al., 2014a), while three species of *Pagurixus*—*P. carinimanus*, *P. haigae*, and *P. maorus*—are newly recorded from Cocos (Keeling) Islands (cf. Morgan, 1992) (Table 1). *Eutrichopagurus granulimanus*, new species, for which only the male holotype is available for study, is provisionally assigned to the genus, because male characters of the type species of the heretofore monotypic *Eutrichopagurus* remain unknown. The discovery of *Kumepagurus noelensis*, new species, for which both male and female specimens are available for study, led the authors to assess the status of *K. kaikata* Komai, 2020, provisionally assigned to *Kumepagurus* in the original description. As a result, a new genus, *Vounopagurus*, is established for *Kumepagurus kaikata*.

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Table 1. Species of pagurid hermit crabs recorded from Christmas Island and Cocos (Keeling) Islands, for which the specific identities are confirmed or are of little doubt.

Species	Christmas Island	Cocos (Keeling) Islands	Reference(s)
<i>Eutrichopagurus granulimanus</i> , new species	P	-	This study
<i>Kumepagurus noelensis</i> , new species	P	-	This study
<i>Micropagurus polynesiensis</i> (Nobili, 1906)	-	P	Morgan (1992); this study
<i>Nematopagurus gardineri</i> Alcock, 1905	-	P	Morgan (1992); McLaughlin (2004)
<i>Paguritta harmsi</i> (Gordon, 1935)	P	-	Gordon (1935); Morgan (1992); McLaughlin & Lemaitre (1993)
<i>Pagurixus anceps</i> (Forest, 1954)	-	P	Morgan (1992)
<i>Pagurixus carinimanus</i> Komai & Osawa, 2006	P	P	This study
<i>Pagurixus depressus</i> , new species	P	-	This study
<i>Pagurixus haigae</i> Komai & Osawa, 2007	-	P	This study
<i>Pagurixus maorus</i> (Nobili, 1906)	-	P	This study
<i>Pagurixus nomurai</i> Komai & Asakura, 1995	P	-	Tan et al. (2014a); this study
<i>Pagurixus tweediei</i> (Forest, 1956)	P	P	Forest (1956); this study
<i>Pylopagurosis bellula</i> Osawa & Okuno, 2007	P	-	This study
<i>Pylopagurosis keijii</i> McLaughlin & Haig, 1989	P	P	Morgan (1992); this study

MATERIAL AND METHODS

Detailed information of the study sites on Christmas and Cocos (Keeling) Islands are referred to in Tan et al. (2014a, b). One of the two unidentified species mentioned in Tan et al. (2014a: fig. 13) is now under study by M. Osawa (pers. comm.). The voucher specimen of the other unidentified species (Tan et al., 2014a: fig. 14) remains to be located, and was unavailable for our study.

The specimens examined are deposited in the following institutions: Queensland Museum, Brisbane (QM), and the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum, National University of Singapore (LKCNHM). General terminology follows McLaughlin (2003) and McLaughlin et al. (2007), except for the use of 'article' for 'segment', 'occlusal margin' for 'cutting edge', and the numbering of thoracomeres, appendages, and articles of appendages. The shield length (sl) is measured from the tip of the rostrum to the midpoint of the posterior margin of the shield.

TAXONOMIC ACCOUNT

Genus *Eutrichopagurus* Komai, 2015

Eutrichopagurus granulimanus, new species (Figs. 1–3)

Material examined. Holotype: QM W29558, male (sl 1.5 mm), CI-D17-2011, Thunderdome Cave, Christmas Island, 10°27.906'S, 105°36.465'E, 3–16.6 m, 30 March 2011.

Description. Eleven pairs of deeply quadriserial gills.

Shield (Fig. 1A) subtriangular in general outline, approximately as long as wide; anterior margin between rostrum and lateral projections gently concave; anterolateral margins sloping; posterior margin roundly truncate; dorsal surface slightly convex transversely, with 1 median and 3 lateral pairs of tufts of short setae. Rostrum triangular, terminating in acute tip, distinctly overreaching lateral projections. Lateral projections obtusely triangular, each with stout marginal spine. Posterior carapace (Fig. 1B) with lateral lobes very narrow. Cardiac sulci not discernible. Sulci cardiobranchiales extending to posterior carapace margin, converging posteriorly. Posteromedian and posterolateral plates poorly calcified; branchiostegites membranous, almost glabrous.

Ocular peduncle (including cornea) (Fig. 1A) stout, about half-length of shield, widest at about midlength; no setae on surfaces; cornea well developed, but not inflated, slightly narrower than peduncle. Ocular acicle subtriangular, not elongate, terminating acutely, reaching proximal 0.2 of ocular peduncle; dorsal surface flat. Interocular lobe separated from ocular acicles, overhung by rostrum, but partially visible in dorsal view; anterior surface slightly convex.

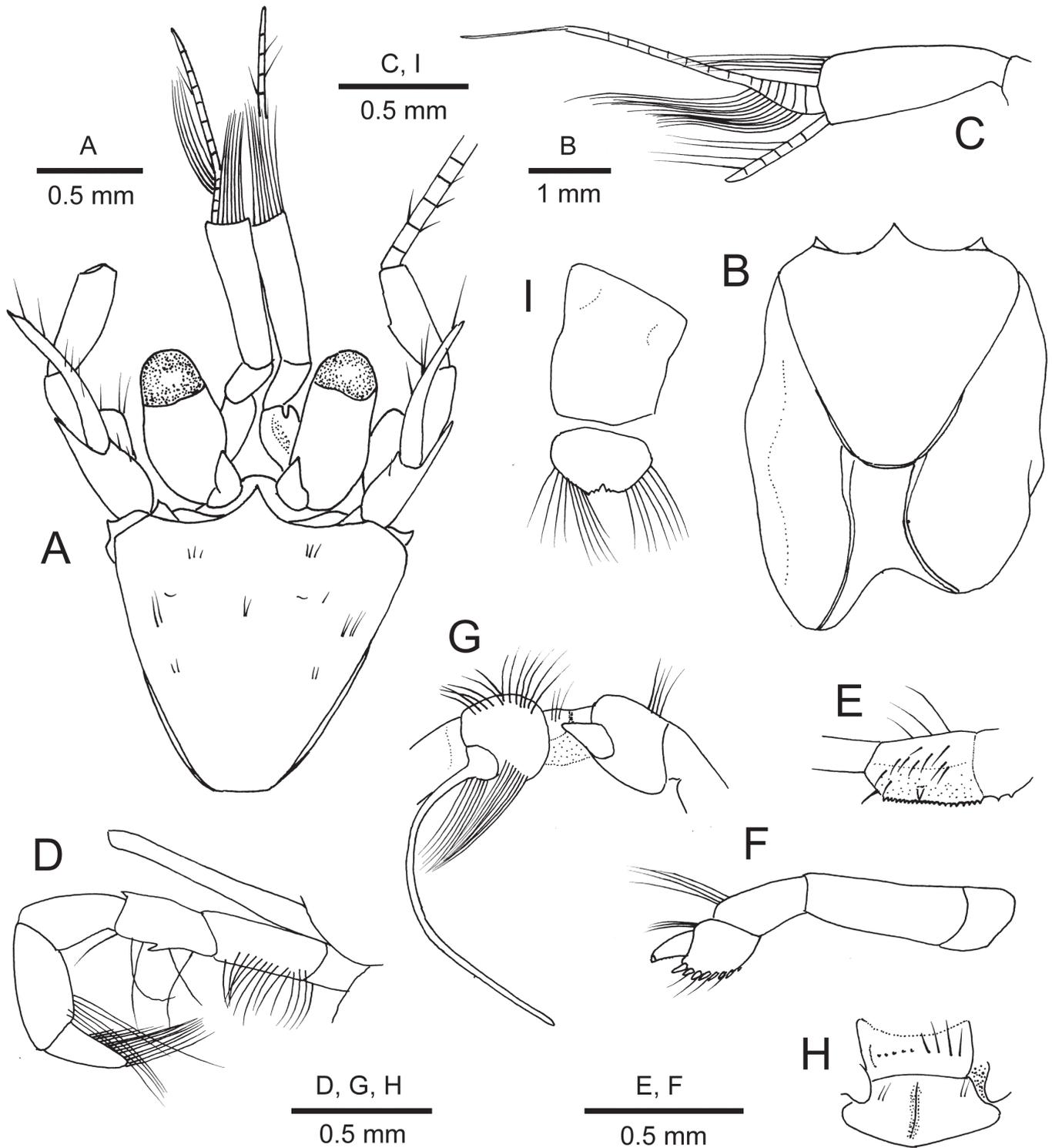


Fig. 1. *Eutrichopagurus granulimanus*, new species, holotype, male (sl 1.5 mm), QM W29558. A, shield and cephalic appendages, dorsal view; B, carapace, dorsal view (setae omitted); C, left antennule, ultimate peduncular article and flagella, lateral view; D, left maxilliped 3, lateral view (flagellum of exopod concealed); E, same, ischium and basis, ventral view; F, left pereopod 4, lateral view; G, coxae of pereopods 5 and thoracic sternite 8, ventral view; H, thoracic sternite 6, ventral view; I, telson, dorsal view.

Antennular peduncle (Fig. 1A, C) rather stout, when fully extended, overreaching distal corneal margin by approximately full length of article 3. Article 3 2.8 times as long as high, 1.7 times as long as article 2, slightly widened distally, with prominent tuft of long setae (length subequal to that of ultimate segment) arising on dorsodistal margin, partially masking flagella in dorsal view. Article 1 with distolateral margin not markedly produced; statocyst

lobe slightly inflated, with small spine on lateral face. Dorsal flagellum (Fig. 1C) longer than peduncular article 3, consisting of very short aesthetasc-bearing portion (7 articles) and long distal portion (7 articles, more than twice of aesthetasc-bearing portion); ventral flagellum (Fig. 1C) less than half of dorsal flagellum in length, peduncular segment, consisting of 6 articles.

Antennal peduncle (Fig. 1A) overreaching distal corneal margin by full length of article 5. Article 5 slightly flattened. Article 4 with few setae mesially. Article 3 unarmed on ventromesial distal margin. Article 2 dorsolateral distal angle produced, reaching midlength of fourth segment, terminating in simple spine; dorsomesial distal angle with small spine; mesial surface with few short setae. Article 1 unarmed on lateral face; ventromesial distal margin somewhat produced anteriorly, but without armature. Antennal acicle overreaching distal corneal margin by half-length and reaching midlength of peduncular article 5, terminating in small spine; dorsomesial margin with row of sparse setae. Antennal flagellum about 2.5 times of shield length, overreaching extended right cheliped; each article with few short setae on distal margin.

Mouthparts not dissected. Maxilliped 3 (Fig. 1D) moderately stout; carpus unarmed on dorsodistal margin; merus with small dorsodistal spine and ventral spine arising at midlength; ischium with crista dentata composed of minute, closely set corneous teeth and 1 accessory tooth (Fig. 1E); basis-ischium fusion incomplete; basis with few minute denticles on ventromesial margin; exopod reaching slightly beyond distal margin of merus.

Chelipeds unequal in length, dissimilar with right much more robust than left. Right cheliped (Figs. 2A, B, 3A, B) moderately stout, fairly large compared to body. Chela elongate suboval in dorsal view, 2.3 times as long as wide (greatest width at midlength of palm). Dactylus 0.4 length of palm, noticeably curved in dorsal view, weakly curved in mesial view, with scattered short setae on surfaces; dorsal surface with coarse granules laterally, smooth otherwise, dorsomesial margin not delimited; mesial face with few granules medially; occlusal margin with 2 obtuse calcareous teeth, terminating in small corneous claw. Palm elongate subovate in dorsal view, 1.6 times as long as wide, slightly longer than carpus, with very few short setae on surfaces; dorsomesial and dorsolateral margins not delimited, surfaces with covering of coarse granules, except for nearly smooth fixed finger; dorsal and ventral surfaces gently convex. Fixed finger with broad obtuse calcareous tooth in proximal half of occlusal margin, terminating on blunt calcareous claw. Carpus slightly widened distally in dorsal view, subequal in length to merus; dorsomesial and dorsolateral margins not delimited, dorsal surface with 2 small spines mesial to midline, and few minute tubercles or granules; lateral and mesial faces with covering of coarse granules and latter also with sparse setae; ventral surface nearly smooth, gently convex, with few long setae, ventrolateral and ventromesial margins spineless. Merus with very low, short transverse ridges and some short stiff setae on dorsal surface, dorsodistal margin unarmed; lateral surface with scattered granules in distal half, otherwise nearly smooth, ventrolateral margin with row of 4 small spines in distal half; mesial surface smooth, with several stiff setae ventrally, ventromesial margin with row of 4 small spines in distal half; ventral surface slightly convex, with few granules. Ischium with set of 3 spiniform setae on lateral surface; ventromesial margin unarmed. Coxa unarmed.

Left cheliped (Figs. 2C, D, 3C, D) moderately slender. Chela about 3.8 times longer than wide (greatest width at base of dactylus). Dactylus 1.5 times longer than palm, without conspicuous armature on surfaces, terminating in small corneous claw; dorsomesial margin not delimited; surfaces with sparse short setae; occlusal margin with row of minute corneous teeth (teeth in proximal 0.6 narrowly spaced, those in distal 0.4 contiguous). Palm about 1.6 times as long as carpus; dorsal surface gently convex, nearly smooth, with sparse short setae; no delineation of dorsolateral or dorsomesial margins; lateral and mesial faces with few inconspicuous granules; ventral surface gently convex, with few long setae. Fixed finger nearly straight, with scattered short setae on surfaces; occlusal margin bordered with thin corneous plate. Carpus about 0.85 length of merus, slightly widened distally in dorsal view, 2.9 times as long as distal width; dorsolateral and dorsomesial margins not delimited, dorsal surface devoid of conspicuous spines, but with few short to long, bristle-like setae laterally and mesially; lateral and mesial faces smooth, ventrodial angles spineless; ventral surface slightly convex, with few long setae. Merus with double row of short, bristle-like setae on dorsal surface, dorsodistal margin unarmed, but also with short bristle-like setae; lateral surface with row of short, bristle-like setae adjacent to ventral margin, ventrolateral margin with row of 3 widely spaced small spines in distal half; mesial surface with longitudinal row of short bristle-like setae along midline and much longer bristle-like setae adjacent to ventral margin, ventromesial margin with 4 small, widely spaced spines; ventral surface also with short to long bristle-like setae. Ischium unarmed, with few setae; lateral face with 1 short spiniform seta at ventrolateral distal angle. Coxa unarmed.

Ambulatory legs (Fig. 3E–H) moderately long and slender. Dactyli 1.1 times as long as propodi, in dorsal view straight, in lateral slightly curved; dorsal margins each with double row of short setae; lateral and mesial faces almost glabrous; ventral margins each with 8 or 9 moderately long, slender corneous spines. Propodi distinctly longer than carpi, slightly narrowing distally; dorsal surfaces each with sparse setae; lateral and mesial faces glabrous; ventral margins each with 1 slender corneous spine at distal margin, followed by 2 or 3 widely separated, corneous spines becoming shorter proximally. Carpi unarmed on dorsal margins, almost glabrous; ventrodial angle with conspicuous corneous spine. Meri each with widely spaced small corneous spines or spiniform setae on dorsal surface; lateral surfaces with few minute spiniform setae (second) or almost glabrous (third); ventral margin slightly sinuous, spineless, with few setae. Ischia unarmed, with sparse setae on dorsal and ventral margins.

Pereopod 4 (Fig. 1F) semichelate. Dactylus slightly curved. Propodus with rasp consisting of single row of corneous scales. Carpus with prominent tuft of setae at dorsodistal angle.

Pereopods 5 chelate. Coxae (Fig. 1G) asymmetrical; right coxa with long, filamentous sexual tube (about 4 times of

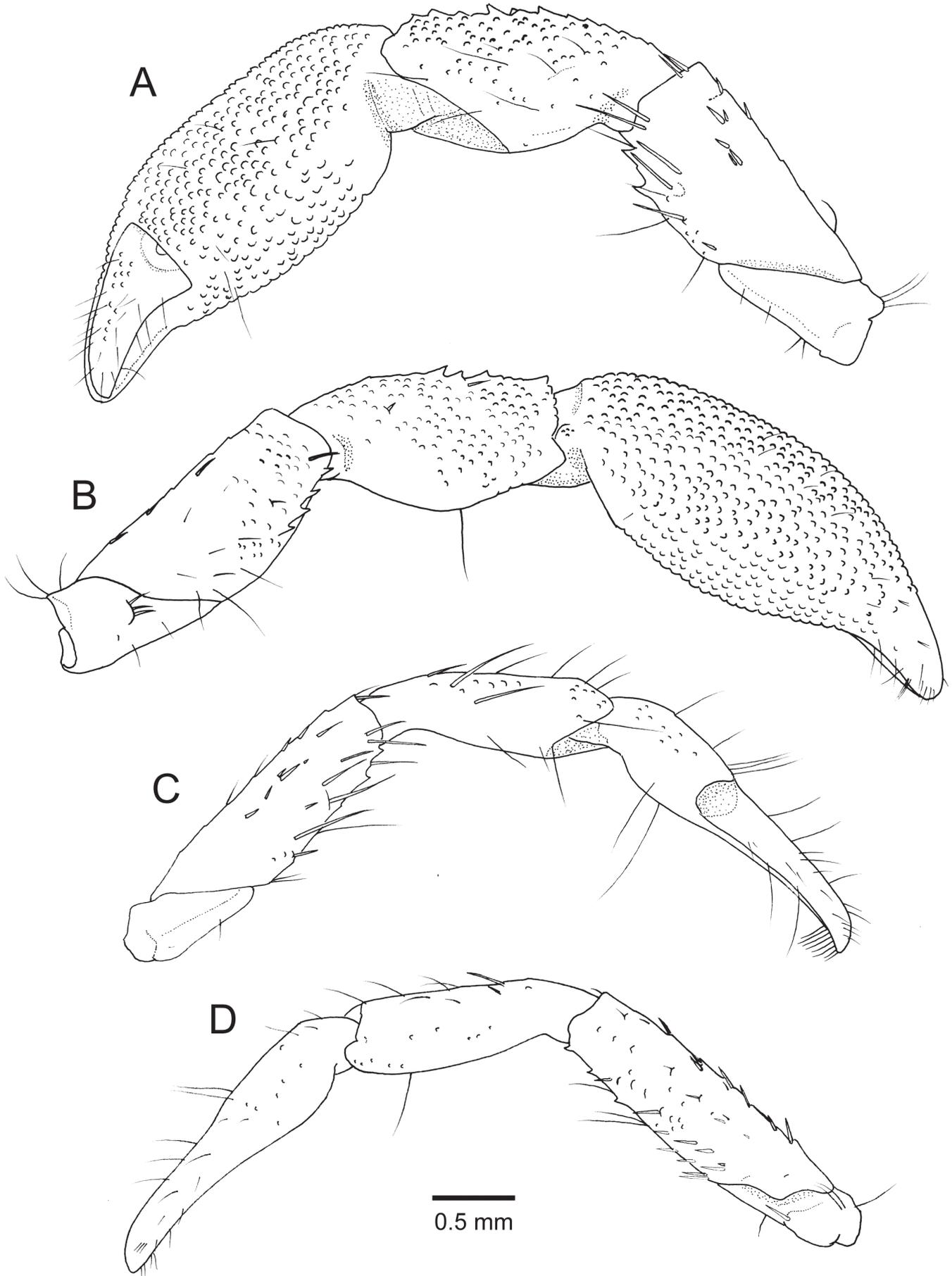


Fig. 2. *Eutrichopagurus granulimanus*, new species, holotype, male (sl 1.5 mm), QM W29558. A, right cheliped, mesial view; B, same, lateral view; C, left cheliped, mesial view; D, same, lateral view.

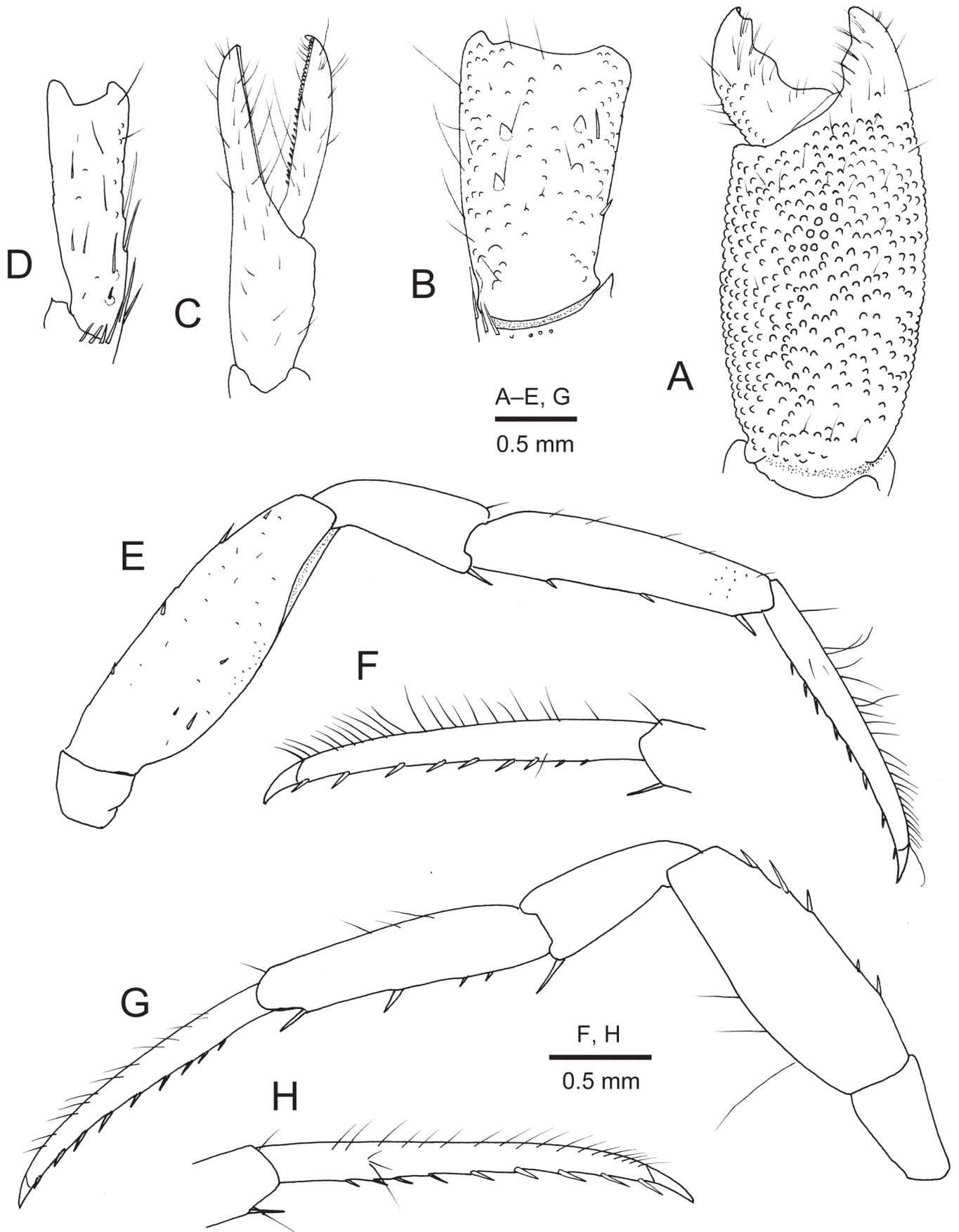


Fig. 3. *Eutrichopagurus granulimanus*, new species, holotype, male (sl 1.5 mm), QM W29558. A, chela of right cheliped, dorsal view; B, carpus of right cheliped, dorsal view; C, chela of left cheliped, dorsal view; D, carpus of left cheliped, dorsal view; E, right pereopod 2, lateral view; F, same, dactylus, mesial view; G, left pereopod 3, lateral view; H, same, dactylus, mesial view.

coxal length) directed posterolaterally and with prominent tuft of setae at base of sexual tube; left coxa with very short sexual tube, directed mesially and tapering distally.

Thoracic sternite 6 anterior lobe (Fig. 1H) poorly defined, with transverse row of short setae. Thoracic sternite 8 (Fig. 1G) consisting of two contiguous lobes.

Pleon dextrally twisted. Male with 3 unpaired, unequally biramous left pleopods (third to fifth).

Uropods markedly asymmetrical; protopods unarmed.

Telson (Fig. 1I) with faint lateral indentations at anterior one-third; posterior lobes obtuse, terminal margins slightly oblique, left with 3 minute spines, right with few minute spines, posterolateral margins each with fringe of long setae.

Colouration in life. Not known.

Distribution. Presently known only from Christmas Island; found in marine cave, connected to anchialine environments; collected at depth between 3 and 16.6 m.

Remarks. Determination of the generic assignment of this new species is not easy, because only the male holotype is available for study. Among the genera characterised by the possession of 11 pairs of deeply quadriserial gills, the ischium of the maxilliped 3 having at least one accessory tooth and a well-developed crista dentata, and the possession of prominent right and short left sexual tubes, the new species appears close to *Cestopagurus* Bouvier, 1897, for which both male and female characters have been well documented (cf. de Saint Laurent, 1968; Komai & Takeda, 2005; Komai & Poupin, 2012; Komai et al., 2014). However, the structure of the right sexual tube is considerably different between the new species and species of *Cestopagurus*. In the new species, the right sexual tube is directed posterolaterally and filamentous in shape. In contrast, in species of *Cestopagurus*, the right sexual tube is moderately slender and oriented toward the left across the ventral body surface, although the length is quite variable according to species. Consequently, the new species cannot be assigned to *Cestopagurus* satisfactorily. The other genus characterised by the possession of 11 pairs of quadriserial gills and the well-developed crista dentata and accessory tooth on the maxilliped 3 ischium is *Eutrichopagurus* Komai, 2015, represented only by its type species, *E. shirakawai* Komai, 2015. Unfortunately, no information on the male of *E. shirakawai* is available so far. Similarities between the new species and *E. shirakawai* are also seen in the triangle-shaped shield and the presence of a prominent tuft of setae on the article 3 of the antennular peduncle; those features are not seen in species of *Cestopagurus*. Thus, the new species is assigned to *Eutrichopagurus*, although only provisionally. Collection of a male specimen of *E. shirakawai* and a female specimen of the new species will fully clarify the problem of the generic assignment of the present new species.

Eutrichopagurus granulimanus, new species, differs markedly from *E. shirakawai* in many respects, outlined as follows: the eyes are less reduced in *E. granulimanus*, new species, than in *E. shirakawai* (Fig. 1A versus Komai, 2015: fig. 1B); the ocular acicles are short, oval in shape in *E. granulimanus*, new species (Fig. 1A), while they are elongate, spike-like in *E. shirakawai* (cf. Komai, 2015: fig. 1B); the article 3 of the antennular peduncle has a prominent tuft of setae arising from the entire dorsodistal margin in *E. granulimanus*, new species (Fig. 1A, C), whereas there is a tuft of long setae at the distolateral angle of the article in *E. shirakawai* (cf. Komai, 2015: fig. 1B, D); the chela and carpus of the right cheliped is covered with coarse granules in *E. granulimanus*, new species (Figs. 2A, B, 3A), rather than being only sparsely granulate in *E. shirakawai* (cf. Komai, 2015: fig. 2); the carpus of the left cheliped is unarmed on the dorsolateral and dorsomesial margins in *E. granulimanus*, new species (Figs. 2C, D, 3D), rather than armed with some spines on the respective margins in *E. shirakawai* (cf. Komai, 2015: fig. 3A–C); surfaces of the dactyli and propodi are smooth in *E. granulimanus*, new species (Fig. 3E, G), while microscopically granulate in *E. shirakawai* (cf. Komai, 2015: fig. 4A, C); carpi of the pereopods 2 and 3 are each armed with one long spiniform seta at the ventrodistal angle in *E. granulimanus*, new species (Fig. 3E, G), whereas such a spiniform seta is absent in each carpus of those pereopods in *E. shirakawai* (cf. Komai, 2015: fig. 4A, C).

Etymology. The specific epithet refers to the coarsely granulated right palm, a combination of the Latin *granulis* (= granular) and *manus* (= palm). Used as a noun in apposition.

Genus *Kumepagurus* Komai & Osawa, 2012

Type species. *Kumepagurus cavernicolus* Komai & Osawa, 2012.

Emended diagnosis. Gills biserial, 13 pairs (2 arthrobranches above bases of maxilliped 3 and pereopods 1–4, and pleurobranch on thoracomeres 5–7). Ocular acicles simple. Maxilliped 3 with crista dentata consisting of widely spaced teeth; no accessory tooth. Right cheliped massive, chela operculiform; dactylus articulating obliquely with palm. Left cheliped fixed finger terminating in 2 tiny corneous claws. Pereopods 4 simple, with propodal rasp consisting of single row of corneous scales; no preungual process. Male with medium, coiled, laterally oriented sexual tube on coxa of right pereopod 5; left coxa with short sexual tube, directed posteriorly or posterolaterally, tapering distally to slender, acute tip. Male with unpaired left pleopods 3–5. Female with paired pleopods 1, modified as gonopods; unpaired left pleopods 2–5; paired gonopores on pereopods 3 coxae. Pleon dextrally twisted. Pleomere 6 tergite not strongly calcified. Telson with terminal margins oblique; anterior lobe posterolateral margins each with conspicuous tuft of setae.

Composition. *Kumepagurus cavernicolus* (type species of the genus) and *K. noelensis*, new species.

Remarks. *Kumepagurus* was originally established for *K. cavernicolus* Komai & Osawa, 2012, described from a unique male holotype from a marine cave on Kume Island, Ryukyu Islands. Subsequently, Komai (2020) described a new species, *K. kaikata*, on the basis of material from sublittoral water on Kaikata Seamount, Ogasawara Islands, Japan, although the generic assignment was considered provisional because of the difference in the gill number (13 pairs in *K. cavernicolus* versus 11 pairs in *K. kaikata*). The assignment was based on the lack of an accessory tooth on the maxilliped 3 ischium, the operculiform right chela, the presence of two distal corneous claws on the left chela fixed finger, the simple pereopods 4, and the development and structure of the male sexual tubes on both coxae of pereopods 5 (Komai, 2020); all shared by the type species of the genus, although the gill number has been one of the critical characters to diagnose paguroid genera (cf. McLaughlin, 2003). The discovery of the present new species, for which both male and female specimens are available for study, confirms that *Kumepagurus kaikata* Komai, 2020, is indeed generically distinct from the other two species of *Kumepagurus*. In addition to the difference in gill number, *Kumepagurus kaikata* differs from *Kumepagurus noelensis*, new species, in the absence of paired pleopods 1 in the female, which are present in the new species. A new genus, *Vounopagurus*, is established for *Kumepagurus kaikata* (see below).

***Kumepagurus noelensis*, new species**
(Figs. 4–7)

Material examined. Holotype: QM W29559, male (sl 1.5 mm), CI-D12-2011, Thunderdome Cave, Christmas Island, 10°27.906'S, 105°36.465'E, 3–16.6 m, 28 March 2011.

Paratypes: CHRISTMAS ISLAND. ZRC 2021.0630, 3 males (sl 1.2–1.3 mm), 2 females (sl 1.0, 1.1 mm), 3 ovigerous females (sl 1.1–1.3 mm), CI-D02-2010, Thunderdome Cave, 10°27.906'S, 105°36.465'E, 25 January 2010; QM W29560, 1 ovigerous female (sl 1.3 mm), same data; QM W29561, 1 ovigerous female (sl 1.1 mm), CI-D09-2011, same cave, 27 March 2011; ZRC 2021.0631, 2 males (sl 1.4, 1.4 mm), same data as holotype.

Description. Shield (Fig. 4A) 1.0–1.1 times as long as broad; anterior margins between rostrum and lateral projections concave; anterolateral margins sloping, posterior margin roundly truncate; dorsal surface almost glabrous. Rostrum triangular, terminating in tiny spine. Lateral projections triangular, not reaching level of rostral tip; each with small submarginal spine. Posterior carapace membranous; with pair of tufts of short setae at level of midlength; posteromedian plate moderately wide, with slightly convex lateral margins; sulci cardiobranchiales parallel, extending to midlength between cervical groove and posteromedian margin of carapace.

Ocular peduncle (Fig. 4A) 0.6–0.7 times as long as shield, moderately stout, not tapering distally or inflated basally, almost glabrous; cornea slightly dilated, corneal width about 0.4 times peduncular length. Ocular acicle narrowly

triangular, directed forward, terminating in acute point. Interocular lobe small, partially visible in dorsal view.

Antennular peduncle (Fig. 4A), when fully extended, overreaching ocular peduncle by full length of ultimate article. Basal article with small spine on lateral margin located slightly distal to midlength; distolateral angle produced in small lobe. Ultimate article elongate, 0.8 times as long as shield, slightly broadened distally in lateral view, with few long setae dorsally; no tuft of setae at dorsolateral distal angle. Dorsal flagellum (Fig. 4A) with distal portion much longer than proximal, aesthetasc-bearing portion.

Antennal peduncle (Fig. 4A) overreaching distal corneal margin by half-length of article 5. Article 1 unarmed on lateral face, ventromesial distal margin produced, with bifid spinule just lateral to antennal gland opening. Article 2 with dorsolateral distal angle produced, not reaching midlength of article 4, terminating in simple spine; dorsomesial distal angle with small spine. Article 3 with 1 small spine on ventrodistal margin. Articles 4 and 5 with few short individual or tufts setae mesially, article 5 slightly longer than article 4. Antennal acicle overreaching distal corneal margin by about 0.2 own length, not reaching distal end of article 5, terminating in small spine, bearing tufts of moderately long to long setae. Antennal flagellum very long, each article with few short to long setae distally.

Maxilliped 3 (Fig. 4B) with endopod moderately long and slender; carpus unarmed; merus with small dorsodistal spine; ischium and basis incompletely fused; crista dentata on ischium consisting of row of about 10 evenly spaced, sharply pointed corneous teeth, accessory tooth absent; basis with 1 tiny denticle on mesial margin (Fig. 4C).

Male right cheliped (Figs. 5A, B, 6A–C) massive. Chela suboperculiform, subrectangular in general outline in dorsal view, about 1.8 times longer than wide; propodal-carpal articulation rotated clockwise about 20° from perpendicular. Dactylus subequal in length to palm, articulating obliquely, noticeably curved ventrally; dorsal surface nearly flat, with scattered short setae, dorsomesial margin sharply carinate, faintly granulate; ventral face slightly elevated along midline, almost glabrous; occlusal margin strongly sinuous, with obtuse tooth subdistally, terminating in minute corneous claw. Palm longer than carpus, widest at about midlength, 1.1 times as long as wide; dorsal surface slightly convex longitudinally and transversely in general, with few granules and few short setae; dorsolateral margin delimited by carina extending onto fixed finger, becoming obsolescent proximally on palm; dorsomesial margin slightly upturned, delimited proximally by distinct, faintly granulate carina; mesial surface sparsely granular, with some short setae adjacent to dorsal margin; ventral surfaces (including fixed finger) evenly convex, almost glabrous with sparse minute granules. Fixed finger slightly deflexed, broad at base, tapering to rounded tip bearing 2 minute, subterminal corneous claws; ventral surface sloping to occlusal margin; oblique occlusal margin with 1 prominent, rounded tooth accommodated into concavity on occlusal margin of dactylus, distal part further with few much smaller

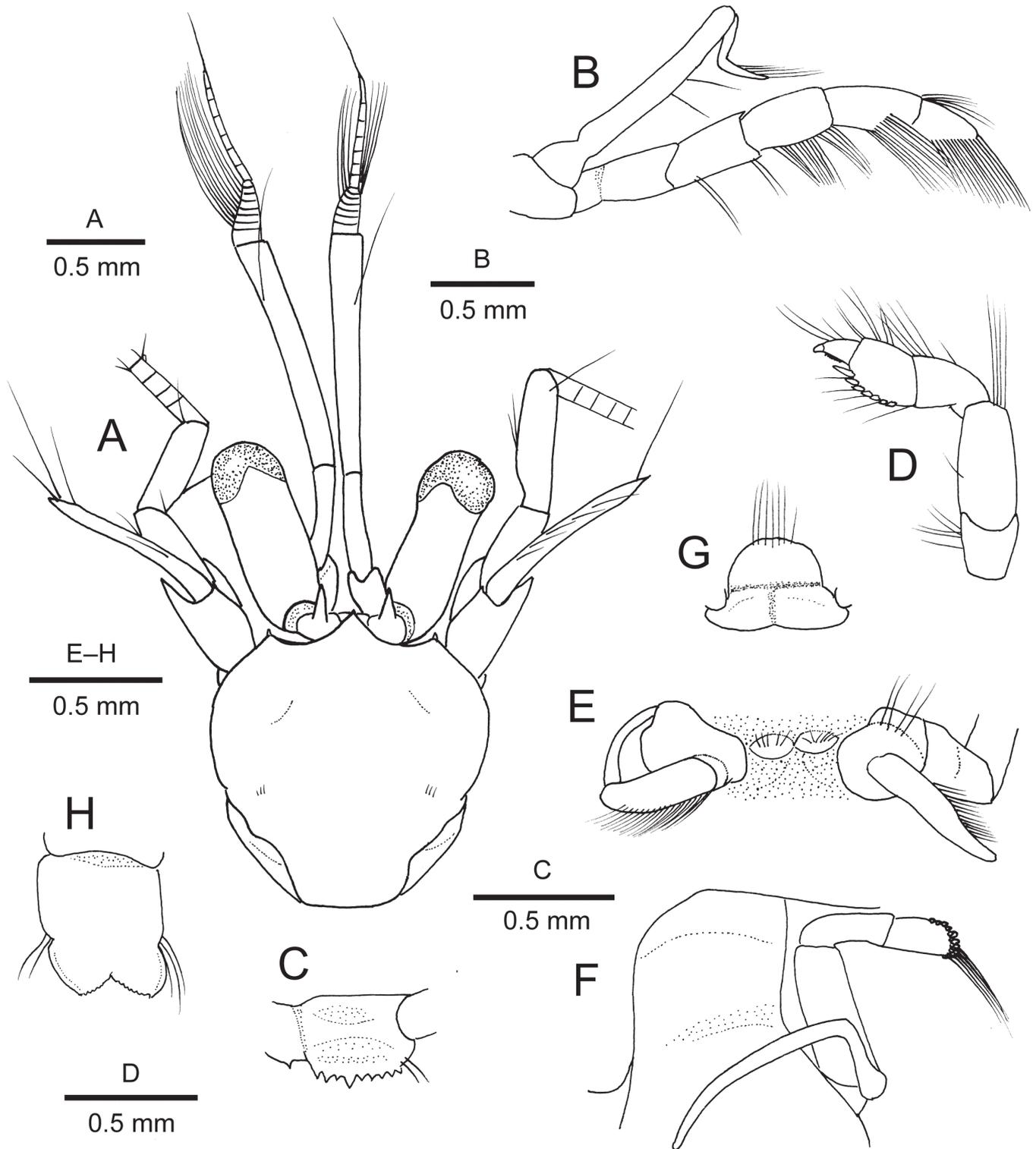


Fig. 4. *Kumepagurus noelensis*, new species, holotype, male (sl 1.5 mm), QM W29559. A, shield and cephalic appendages, dorsal view; B, right maxilliped 3, lateral view; C, same, ischium and basis, ventral view; D, left pereopod 4, lateral view; E, coxae of pereopods 5 and thoracic sternite 8, ventral view; F, dorsal extension of right sexual tube, anterior part of pleon and right pereopod 5 also shown; G, thoracic sternite 6, ventral view; H, telson, dorsal view.

blunt calcareous teeth. Carpus longer than merus, noticeably widened distally; dorsal surface elevated and carinate in midline, with row of small spines, sloping lateral and mesial sides each with scattered granules (granules more numerous and fine on lateral side) and some setae adjacent to midline; lateral margin not delimited, mesial margin sharply delimited by spinulose carina; ventrolateral face smooth; ventromesial

face almost glabrous, slightly concave, ventromesial margin weakly denticulated; ventral surface elevated transversely at middle, anterior half shallowly concave transversely, posterior part weakly calcified. Merus with slightly granulate dorsal margin, dorsodistal margin unarmed; lateral surface with minute granules, almost glabrous, ventrolateral margin with row of setae and with minute denticle at rounded distal

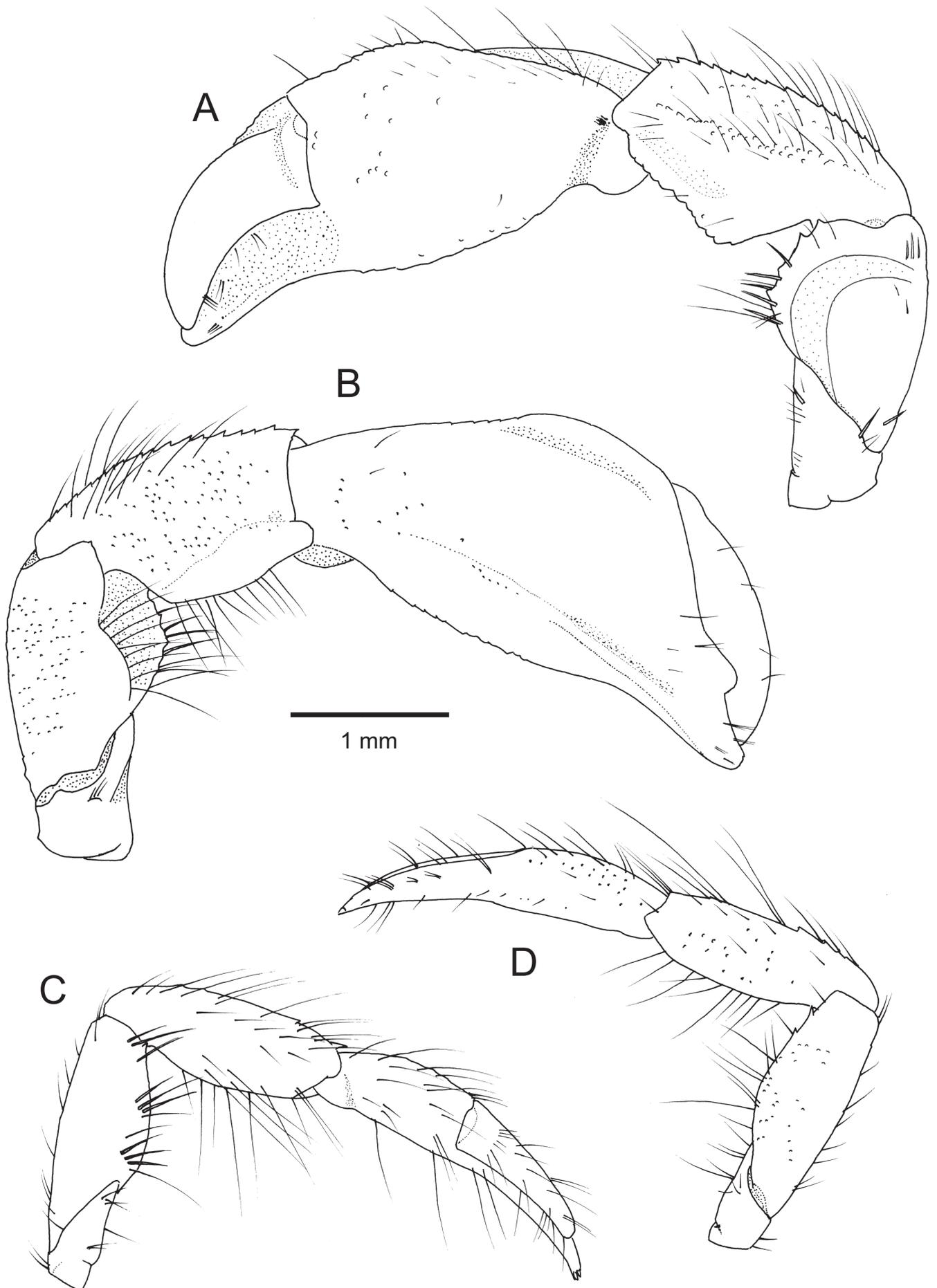


Fig. 5. *Kumepagurus noelensis*, new species, holotype, male (sl 1.5 mm), QM W29559. A, right cheliped, mesial view; B, same, lateral view; C, left cheliped, mesial view; D, same, lateral view.

angle; mesial surface almost glabrous except for few short stiff setae near dorsal margin, ventromesial margin strongly convex, with 2 small, subdistal spines and with stiff setae; ventral surface deeply excavated to accommodate ventral surface of carpus. Ischium unarmed, almost glabrous except for few short stiff setae. Coxa unarmed.

Female right cheliped generally similar to male right cheliped. Chela (Fig. 6A) 1.6 times as long as wide; granules on dorsomesial margin of dactylus and palm of right cheliped more pronounced than in males.

Left cheliped (Figs. 5C, D, 6D, G) moderately slender, reaching level of base of dactylus of right cheliped when stretched, without noticeable rotation from perpendicular between chela and carpus. Chela about 4.1 times longer than wide and 1.4 times longer than carpus. Fingers slightly curved ventrally, without hiatus between them; fixed finger with sparse setae on surfaces and 2 tiny corneous claws at tip (Fig. 6E), cutting edge with row of minute corneous teeth; dactylus 1.2–1.4 times longer than palm (distal part damaged in holotype), with sparse tufts of short to moderately long setae on surfaces, terminating in tiny corneous claw; dorsomesial margin not delimited; occlusal margin with row of closely set, minute corneous teeth at least in distal half. Palm 1.5 length of carpus; dorsal surface gently convex, with sparse granules laterally and sparse tufts of short to moderately long setae, without delineation of dorsolateral and dorsomesial margins; lateral, mesial, and ventral faces generally smooth, with scattered setae. Carpus widened distally, length about 3 times of distal width; dorsal surface sloping to lateral and mesial faces, with 2 tiny spines distomesially (1 spine near dorsodistal mesial angle) and tufts of short to long stiff setae; lateral face with sparse granules and few short setae; mesial face with short to long stiff setae dorsally; ventral surface slightly convex, with sparse short to long setae. Merus with row of widely spaced, short setae on dorsal surface, dorsodistal margin unarmed; lateral face with sparse granules, ventrolateral margin with 2–4 small spines in distal 0.4; mesial face smooth, with stiff setae ventrally, ventromesial margin with 1 distal spine, otherwise unarmed; ventral surface with sparse tufts of long setae. Ischium unarmed, with sparse short setae. Coxa unarmed.

Ambulatory legs (Fig. 7A–D) relatively slender, slightly overreaching tip of outstretched right cheliped. Dactyli 1.3–1.5 (second) or 1.6–1.7 (third) length of propodi, about 10.3–12.7 times longer than wide, slightly curved ventrally in lateral view, nearly straight in dorsal view, terminating in long, slender corneous claws; dorsal margins each with row of short setae; lateral faces smooth; mesial faces each with row of 7–9 corneous spinules and row of short setae adjacent to dorsal margin; ventral margins each with 7–12 slender corneous spines increasing in size distally. Propodi slightly curved ventrally, those of second longer than those of third; dorsal margins each with row of setae, lateral and mesial faces almost glabrous; ventral margins with few short setae, ventrodistal margins each armed with 1 slender corneous spine. Carpi with or without spinule at dorsodistal angle and with few setae on dorsal surface; lateral and mesial

faces smooth. Meri unarmed, with sparse setae on dorsal and ventral surfaces; ventrolateral distal margins shallowly concave in distal 0.2. Ischia unarmed. Distinct concavity on ventral margin around articulation between merus and ischium in pereopods 2.

Pereopods 4 (Fig. 4D) simple. Dactyli each with row of minute corneous teeth on ventral margin; dorsal margin with few long setae. Propodi each with tuft of setae distally on dorsal margin; rasp consisting of single row of corneous scales increasing in size distally; carpus with tufts of setae in distal half of dorsal margin.

Coxae of male pereopods 5 (Fig. 4E) slightly dissimilar in shape, almost glabrous. Right sexual tube medium in length, oriented toward exterior then recurved over anterior part of pleon, extending beyond midline (Fig. 4F); distal part tapering distally; basal portion without covering of short setae. Left sexual tube short (about twice length of coxal length), directed posterolaterally, distinctly extending beyond posterior margin of coxa, somewhat flattened, tapering distally to subacute tip; some short setae present on dorsal side.

Anterior lobe of thoracic sternite 6 (Fig. 4G) subsemicircular, with row of setae on anterior margin, setae longest in medial portion. Thoracic sternite 8 (Fig. 4E) with 2 compressed lobes, each lobe bearing marginal setae.

Pleon dextrally twisted. Male with relatively long, unequally biramous pleopods 3–5; pleopod 4 longest, with elongate exopod. Female with pleopods 2–5, without paired pleopods 1.

Telson (Fig. 4H) with slightly asymmetrical posterior lobes separated by very small median cleft; terminal margins oblique, microscopically denticulate; transverse indentations weakly delimited, each with tuft of short setae.

Colouration in life. Not known.

Distribution. Presently known only from Christmas Island; marine cave, connected to anchialine environments, collected at depth between 3 and 16.6 m.

Remarks. *Kumepagurus noelensis*, new species, is generally similar to the sole congeneric species, *K. cavernicolus*, but differentiating characters are seen in the relative length of the antennal acicle and the shape and ornamentation of the right chela. In *K. noelensis*, new species, the antennal acicle is subequal in length to the ocular peduncle (Fig. 4A), but it is elongate, being distinctly longer than the ocular peduncle in *K. cavernicolus* (cf. Komai & Osawa, 2012: fig. 1A). The right chela is less operculiform with a nearly straight to distally convex lateral margin in *K. noelensis*, new species (Fig. 6A), rather than distinctly sinuous in *K. cavernicolus* (cf. Komai & Osawa, 2012: fig. 3A, D); the dorsomesial margin of the palm is regularly carinate in *K. noelensis*, new species (Figs. 5A, 6A), whereas that margin is furnished with a short, distinct crest proximally in *K. cavernicolus* (cf. Komai & Osawa, 2012: fig. 3B); the ventral surface

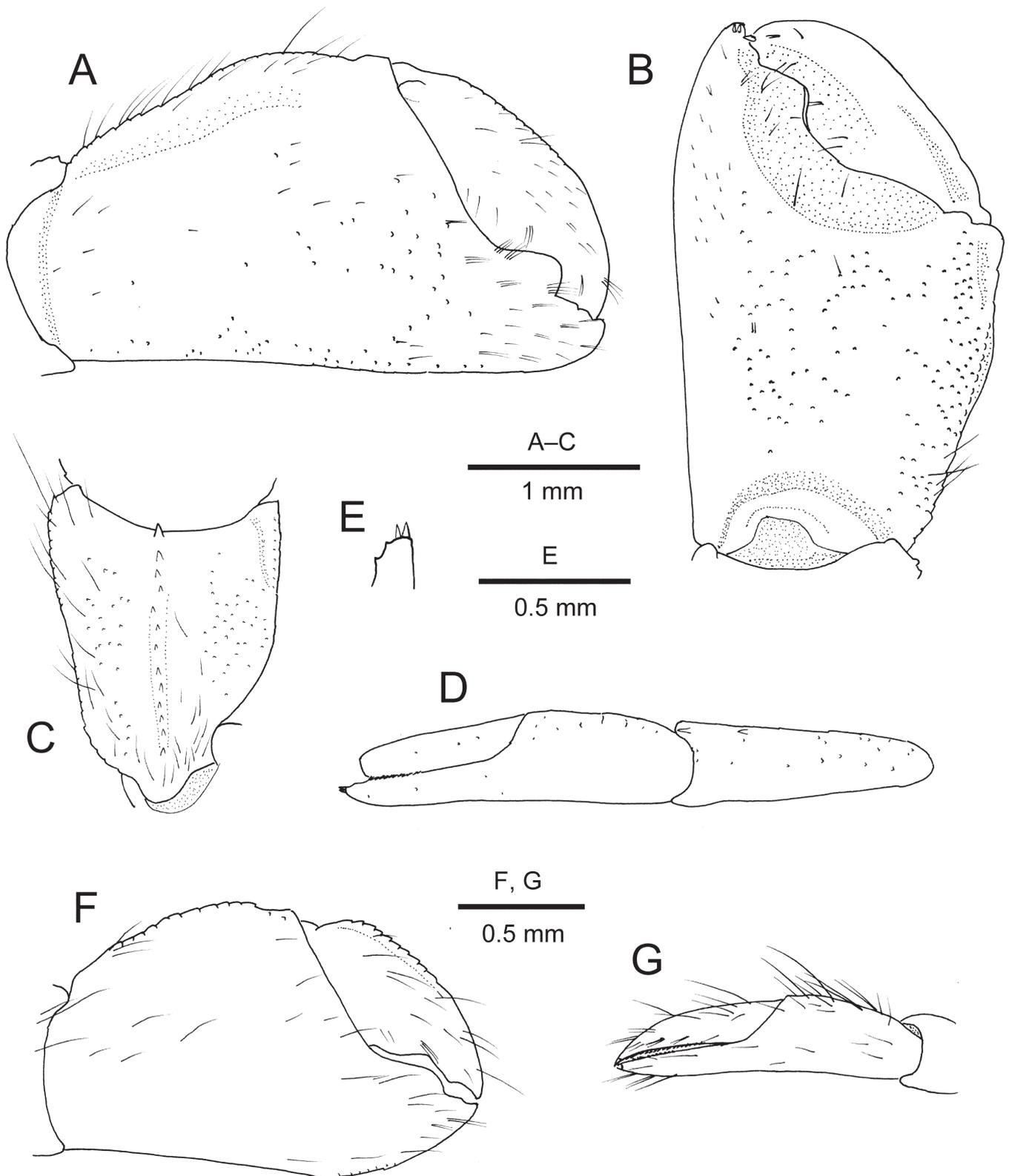


Fig. 6. *Kumepagurus noelensis*, new species. A–E, holotype, male (sl 1.5 mm), QM W29559; F, G, paratype, ovigerous female (sl 1.1 mm), ZRC 2021.0630. A, F, chela of right cheliped, dorsal view; B, same, ventral view; C, carpus of right cheliped, dorsal view; D, chela and carpus of left cheliped, dorsal view (setae omitted; distal part of dactylus damaged); E, distal part of fixed finger, ventral view, showing the presence of 2 corneous claws; G, left chela, dorsal view.

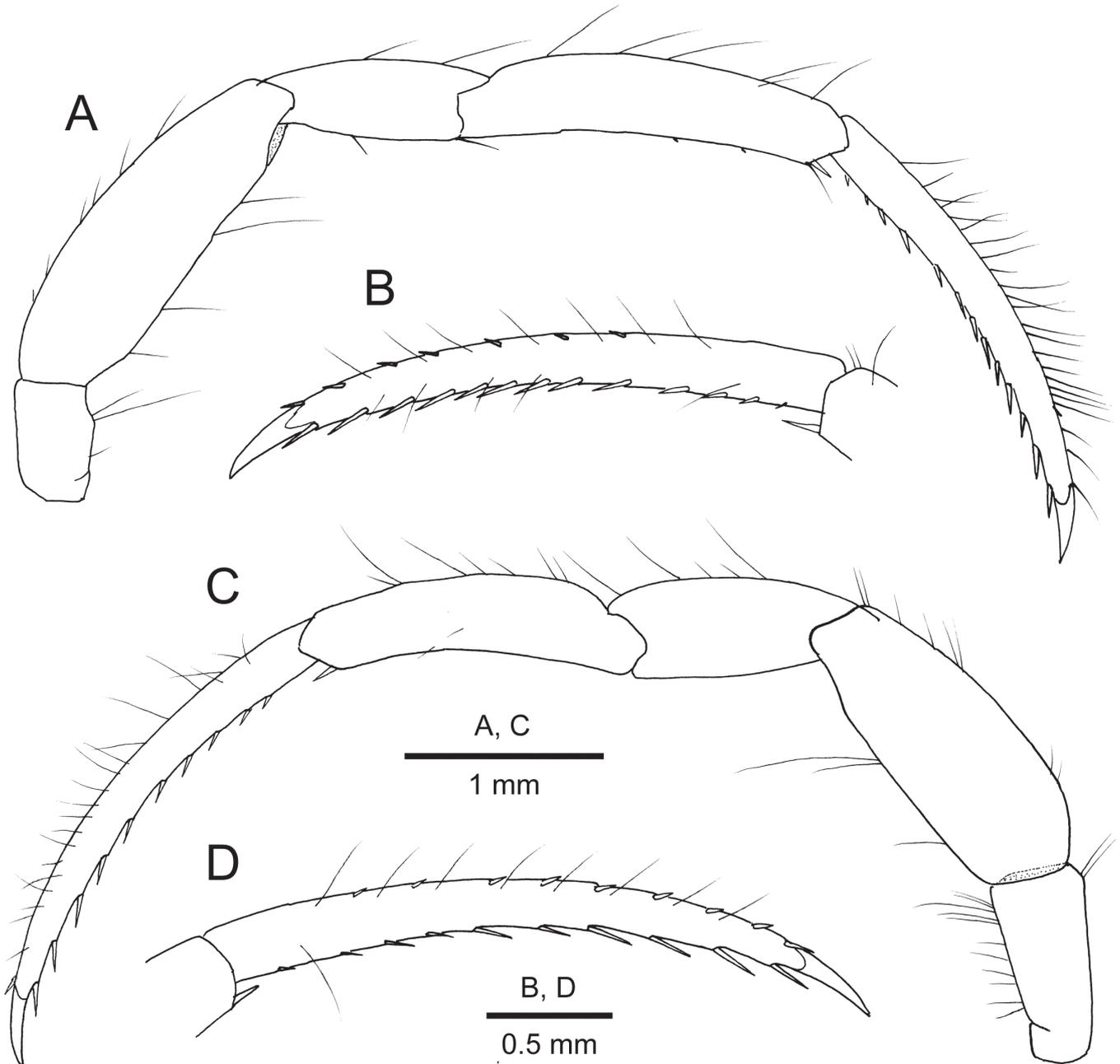


Fig. 7. *Kumepagurus noelensis*, new species, holotype, male (sl 1.5 mm), QM W29559. A, right pereopod 2, lateral view; B, same, dactylus, mesial view; C, left pereopod 3, lateral view; D, same, dactylus, mesial view.

of the palm is smooth to slightly granular in *K. noelensis*, new species (Fig. 6B), while there are several blister-like tubercles on the ventral surface in *K. cavernicolus* (cf. Komai & Osawa, 2012: fig. 3D).

All specimens came from Thunderdome Cave, suggesting that the new species is restricted to cave environments.

Etymology. The name refers to Christmas Island, the type locality of the new species. ‘Noël’ is a French word meaning Christmas.

***Vounopagurus*, new genus**

Type species. *Kumepagurus kaikata* Komai, 2020, by monotypy.

Diagnosis. Gills biserial, 11 pairs (2 arthrobranches above bases of maxilliped 3 and pereopods 1–4, and pleurobranch on thoracomere 7). Ocular acicles simple. Maxilliped 3 with crista dentata consisting of moderately spaced teeth; no accessory tooth. Right cheliped massive, chela operculiform; dactylus articulating obliquely with palm. Left cheliped fixed finger terminating in 2 tiny corneous claws. Pereopods 4 simple, with propodal rasp consisting of single row of corneous scales; no preungual process. Male with medium, coiled, laterally oriented sexual tube on coxa of right pereopod 5; left coxa with short sexual tube, directed posteriorly or posterolaterally, tapering distally to slender, acute tip. Male with unpaired left pleopods 3–5. Female without pleopods 1; unpaired left pleopods 2–5; paired gonopores on pereopods 3 coxae. Pleon dextrally twisted. Pleomere 6 tergite not strongly

calcified. Telson with terminal margins oblique; anterior lobe posterolateral margins each with conspicuous tuft of setae.

Remarks. *Kumepagurus kaikata*, originally described on the basis of material containing both male and female, was provisionally assigned to *Kumepagurus* because of the lack of an accessory tooth on the maxilliped 3 ischium, the operculiform right chela, the presence of two distal corneous claws on the left chela fixed finger, the simple pereopods 4, and the similar development and structure of the sexual tubes, in spite of the different gill formula (11 pairs versus 13 pairs). *Kumepagurus noelensis*, new species, agrees well with the type species of *Kumepagurus*, *K. cavernicolus*, in every diagnostic aspect, including the gill number (13 pairs). There is little doubt that the two species are congeneric. It is remarkable that female specimens of *K. noelensis*, new species, have paired pleopods 1 modified as gonopods. In contrast, in female specimens of *K. kaikata*, there are no paired pleopods 1. The differences in the gill formula (11 pairs in *K. kaikata* versus 13 pairs in *K. cavernicolus* and *K. noelensis*, new species) and the development of female pleopods 1 (absent in *K. kaikata* versus present in *K. noelensis*, new species) fully warrant the establishment of a new genus for *K. kaikata* following the current criteria in the generic classification of the Paguridae (cf. McLaughlin, 2003). Here, *K. kaikata* is reassigned to a new genus, *Vounopagurus*, as *Vounopagurus kaikata*, new combination.

Etymology. The name is a combination of the Greek ‘vouno’ (= mountain), referring to the seamount (Kaikata Seamount) where the type species was found, and combined with *Pagurus*. The gender is masculine, as in *Pagurus*.

***Vounopagurus kaikata* (Komai, 2020) new combination**

Kumepagurus kaikata Komai, 2020: 242, figs. 1–5.

Material examined. See Komai (2020).

Description. See Komai (2020).

Distribution. Presently known only from Kaikata Seamount, Ogasawara Islands, Japan; at depths of 172–165 m.

Genus *Micropagurus* McLaughlin, 1986

***Micropagurus polynesiensis* (Nobili, 1906)
(Fig. 8A)**

Anapagurus polynesiensis Nobili, 1906: 260; 1907: 372, pl. 1 fig. 10; Forest, 1956: 1056.

Micropagurus polynesiensis – Haig & Ball, 1988: 184; Asakura, 2005: 21, figs. 14–18, 19A–C, 20; Arima, 2014: 202, unnumbered figs.

Micropagurus vexatus Haig & Ball, 1988: 181, figs. 11, 12; Morgan, 1992: 165; Davie, 2002: 80.

Material examined. COCOS (KEELING) ISLANDS. ZRC 2021.0632, 1 male (sl 1.7 mm; photo), CK11, Lion Cave Point, W of Direction Island, 12°05.335'S, 96°52.353'E,

30.9 m, 21 March 2011; QM W29562, 1 male (sl 1.4 mm), CK18, the Rip, SW of Direction Island, 12°05.675'E, 96°53.175'E, 5.7 m, 22 March 2011.

Distribution. Widely distributed in the Indo-West Pacific: Seychelles, Indonesia, the Philippines, Japan, Loyalty Islands, and New Caledonia; shallow subtidal to 55 m (Asakura, 2005). Morgan (1992) recorded this species from Cocos (Keeling) Islands (as *M. vexatus*) and Davie (2002) included Christmas Island in the distribution of the species (as *M. vexatus*).

Remarks. In his revision of *Micropagurus*, Asakura (2005) clarified that *M. polynesiensis* was a junior subjective synonym of *M. vexatus*. Consequently, previous records of *M. vexatus* from the study area (Morgan, 1992; Davie, 2002) are referred to *M. polynesiensis*.

As has been demonstrated by Asakura (2005), the living colouration of the species is substantially variable. The specimen shown in Fig. 8A (ZRC 2021.0632, male, sl 1.7 mm) shows generally whitish overall colour.

Genus *Pagurixus* Melin, 1939

***Pagurixus carinimanus* Komai & Osawa, 2006
(Fig. 8B)**

Pagurixus cf. *tweediei* – McLaughlin & Haig, 1984: 134, fig. 4; Rahayu, 2000: 394; Paulay et al., 2003: 490.

Pagurixus sp. 3 (slate) – Paulay et al., 2003: 490.

Pagurixus carinimanus Komai & Osawa, 2006: 71, figs. 29–32, 45B, 48; Poupin et al., 2013: 44, fig. 23B, C; Osawa et al., 2013: 323, fig. 2A.

Material examined. CHRISTMAS ISLAND. QM W29563, 1 male (sl 1.6 mm), CI-D10-2011, West White Cave, off West White Beach, 10°27.733'S, 105°35.054'E, 1–12.3 m, 27 March 2011; QM W29564, 2 females (sl 1.1, 1.7 mm), CI-D15-2011, Boat Cave, 29 January 2011; ZRC 2021.0633, 1 male (sl 1.4 mm; photo), CI-D16-2011, Flying Fish Cove, 10°25.815'S, 105°40.180'E, 29 March 2011; QM W29565, 2 males (sl 1.2, 1.9 mm), 1 ovigerous female (sl 1.4 mm), CI-D18-2011, Rhoda Wall, off Rhoda Beach, 10°27.729'S, 105°37.283'E, 5–16 m, 30 March 2011; ZRC 2021.0634, 1 male (1.7 mm), 1 female (sl 1.2 mm), 1 ovigerous female (sl 1.2 mm), CI-D19-2011, Flying Fish Cove, 10°25.815'S, 105°40.180'E, 30 March 2011; ZRC 2021.0635, 1 male (sl 2.0 mm), no station data.

COCOS (KEELING) ISLANDS: ZRC 2021.0636, 1 male (sl 2.0 mm; photo), CK19, S of Direction Island, 12°05.503'S, 96°52.904'E, 6.9 m, 22 March 2011.

Distribution. Widely distributed in the Indo-West Pacific: Mayotte and Glorioso Islands, Japan (Ryukyu Islands), Guam, and the Philippines, at depths of 1–30 m (Komai & Osawa, 2006; Osawa et al., 2013; Poupin et al., 2013). Newly recorded from Christmas and Cocos (Keeling) Islands; at depths of 1–12.3 m.

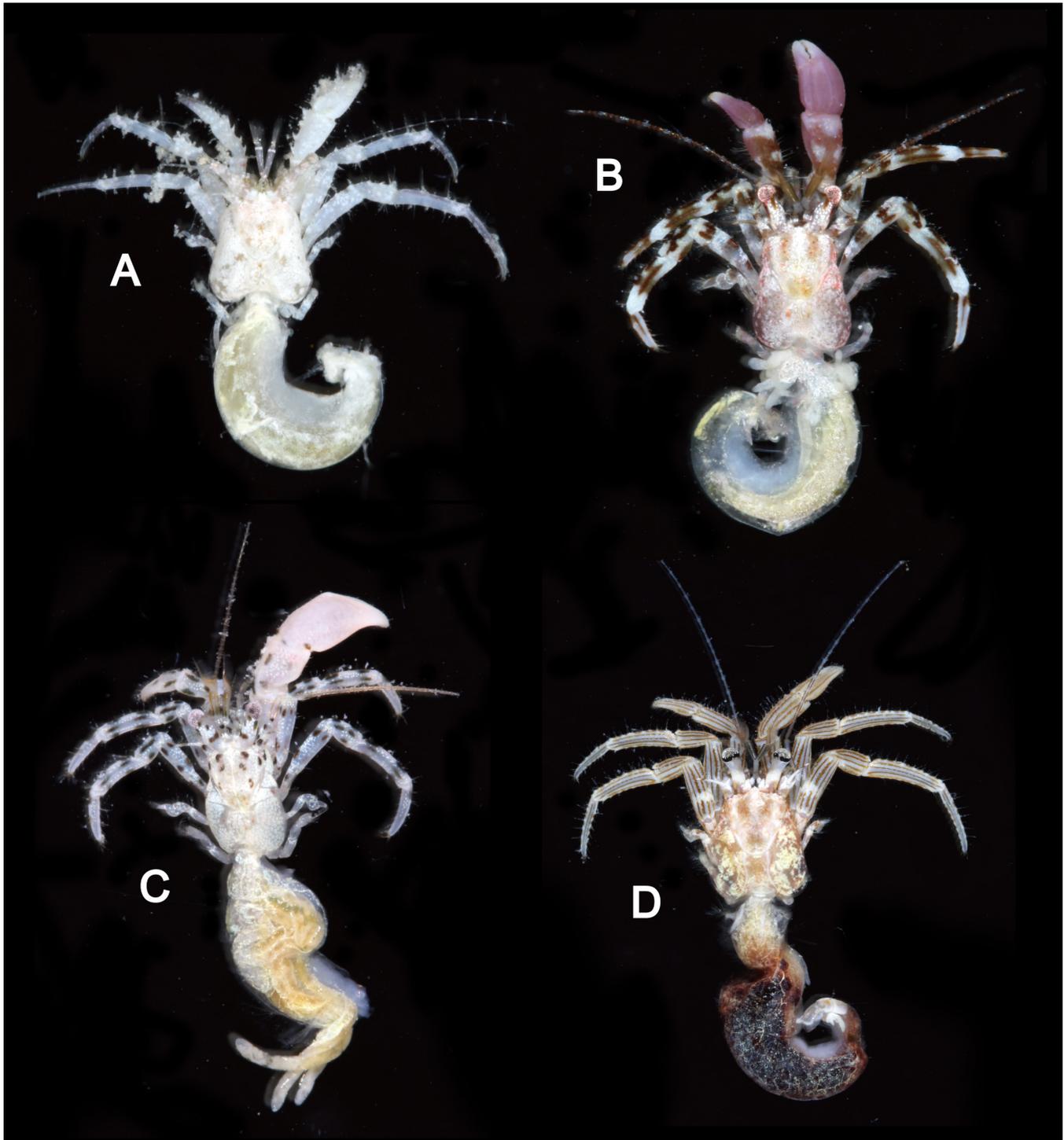


Fig. 8. Habitus in dorsal view, showing living colouration. A, *Micropagurus polynesiensis* (Nobili, 1905), ZRC 2021.0632, male (sl 1.7 mm); B, *Pagurixus carinimanus* Komai & Osawa, 2006, ZRC 2021.0635, male (sl 2.0 mm); C, *Pagurixus haigae* Komai & Osawa, 2007, ZRC 2021.0647, male (sl 1.4 mm); D, *Pagurixus maorus* (Nobili, 1906), ZRC 2021.0638, female (sl 3.9 mm). Photographs by LKCNHM.

Remarks. The specimens examined agree well with the original description by Komai & Osawa (2006) in both morphology and living colouration.

***Pagurixus depressus*, new species**
(Figs. 9–11)

Material examined. Holotype: QM W29566, 1 female (sl 1.4 mm), CI-D16-2011, Flying Fish Cove, Christmas Island, 10°25.815'S, 105°40.180'E, 29 March 2011.

Paratype: CHRISTMAS ISLAND: QM W29567, CI-D15-2011, 1 male (sl 1.2 mm), Boat Cave, 29 March 2011; ZRC 2021.0637, 1 female (sl 1.0 mm), CI-D17-2011, Thunderdome Cave, 20°27.906'S, 105°36.465'E, 3–16.6 m, 30 March 2011.

Description. Gills biserial, 11 pairs.

Cephalothorax somewhat depressed dorsoventrally. Shield (Fig. 9A) approximately as long as wide; anterior margin

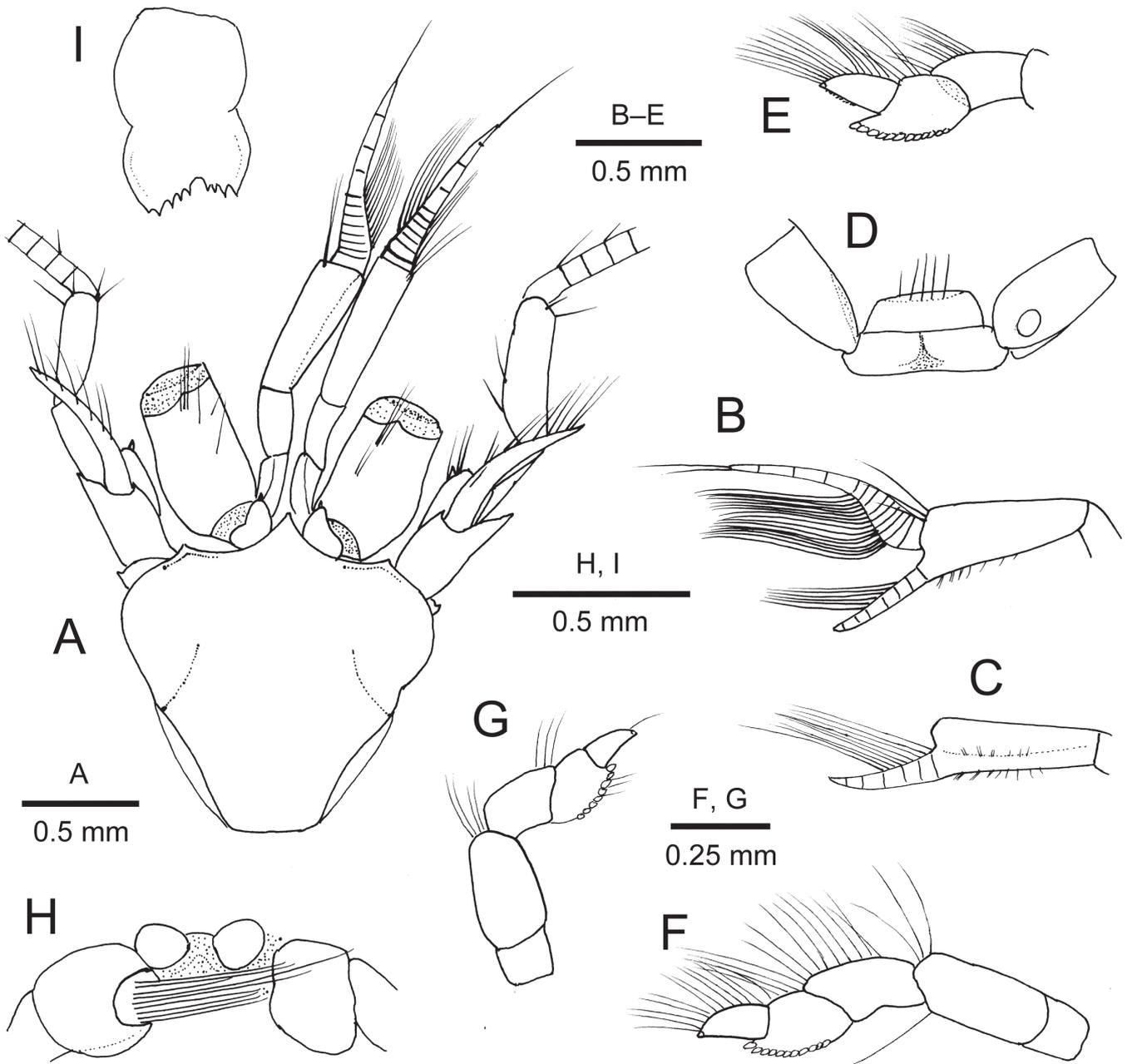


Fig. 9. *Pagurixus depressus*, new species. A–E, holotype, female (sl 1.4 mm), QM W29566; F, G, paratype, female (sl 1.0 mm), ZRC 2021.0637; H, I, paratype, male (sl 1.2 mm), QM W29567. A, shield and cephalic appendages, dorsal view (corneas artificially shrunk); B, ultimate peduncular article and flagella of left antennule, lateral view; C, same, ventrolateral view, showing ventral setation of ultimate article (dorsal flagellum omitted); D, coxae of pereopods 3 and thoracic sternite 6, ventral view; E, distal articles of left pereopod 4, lateral view; F, left pereopod 4, lateral view; G, left pereopod 5, lateral view; H, coxae of pereopods 5 and thoracic sternite 8, ventral view; I, telson, dorsal view.

between rostrum and lateral projections concave; anterolateral margins sloping; dorsal surface glabrous. Rostrum triangular, reaching level of midlength of ocular acicles, terminating acutely. Lateral projections slightly produced, with submarginal spinule.

Ocular peduncle (Fig. 9A) moderately long and stout, 0.6–0.7 length of shield, slightly widened proximally, with row of tufts of setae on dorsal surface mesially; cornea artificially shrunk in all specimens examined. Ocular acicle subtriangular, with small submarginal spine.

Antennular peduncle (Fig. 9A) overreaching base of cornea by full length of ultimate article. Ultimate article with tufts

of long setae at dorsolateral angle; ventral surface with 2 setal rows, each consisting of tufts of few short setae or individual seta (Fig. 9B, C). Basal article with small lateral spine on statocyst lobe. Ventral flagellum (Fig. 9B) with numerous long setae on lateral and mesial margins.

Antennal peduncle (Fig. 9A) overreaching basal margin of cornea by full length of article 5. Articles 5 and 4 with few setae. Article 3 with small spine at ventromesial distal angle. Article 2 with small spine at dorsomesial distal angle; distolateral projection short, not reaching midlength of article 4, terminating in bifid spine. Article 1 with small laterodistal spine; ventromesial distal margin produced, unarmed. Antennal acicle arcuate, overreaching distal margin

of article 4; mesial margin with row of tufts of stiff setae. Flagellum moderately long, exceeding 4.0 length of shield.

Maxilliped 3 normal for genus; ischium with well-developed crista dentata consisting of row of closely spaced small corneous teeth and 1 accessory tooth. Merus and carpus unarmed.

Right cheliped of female holotype (Fig. 10A–C) moderately long, stout. Chela subovate in dorsal view, 1.8 times as long as wide. Dactylus 0.7 length of palm; dorsomesial margin not delimited, with tufts of short setae on surfaces, arranged in longitudinal rows; dorsomesial surface granular; occlusal margin with 2 widely separated, blunt calcareous teeth and row of minute corneous teeth in distal 0.2, terminating in small corneous claw. Palm shorter than carpus; gently convex dorsal surface with scattered, coarse granules, dorsolateral and dorsomesial margins not delimited; lateral, mesial, and ventral surfaces with only few granules and few short setae. Occlusal margin of fixed finger with row of blunt calcareous teeth, terminating in calcareous claw. Carpus subequal in length to merus, slightly flattened dorsoventrally; dorsolateral and dorsomesial margins not delimited, with few small spines dorsomesially; dorsal surface with sparse granules and short setae; mesial surface with scattered long setae and granules, ventromesial margin unarmed; lateral surface with scattered granules and few setae, without longitudinal ridge, ventrolateral margin with few minute granules distally; ventral surface gently convex, glabrous. Meral-carpal articulation lacking any pronounced clockwise rotation; dorsal surface of merus almost smooth, dorsodistal margin unarmed; lateral face with scattered, very short vertical ridges, ventrolateral margin with 1 subdistal spine; mesial face almost glabrous, ventromesial margin faintly denticulate distally; ventral surface slightly convex, with sparse short to long setae. Ischium unarmed.

Right cheliped of male paratype (Fig. 11A–C) not particularly elongate, moderately stout. Chela subovate in dorsal view, 2.1 times as long as wide. Dactylus 0.8 length of palm; dorsomesial margin not delimited, with tufts of short setae on surfaces, arranged in longitudinal rows; dorsomesial surface granular; occlusal margin with 2 widely separated, blunt calcareous teeth and row of minute corneous teeth in distal 0.2, terminating in small corneous claw. Palm shorter than carpus; gently convex dorsal surface with scattered, coarse granules and sparse short setae, dorsolateral and dorsomesial margins not delimited; lateral, mesial, and ventral surfaces also with scattered granules and few short setae. Occlusal margin of fixed finger with row of blunt calcareous teeth in proximal half, no tooth on distal half, terminating in calcareous claw. Carpus 0.8 length of chela, subequal in length to merus, somewhat flattened dorsoventrally; dorsolateral and dorsomesial margins not delimited, with some small spines dorsomesially; dorsal surface with sparse granules and short setae; mesial surface with sparse long setae and granules, ventromesial margin unarmed; lateral surface with scattered granules, without longitudinal ridge, ventrolateral margin with few minute granules distally; ventral surface only slightly convex, glabrous. Meral-carpal

articulation lacking any pronounced clockwise rotation; dorsal surface of merus almost smooth, dorsodistal margin unarmed; lateral face with scattered granules, ventrolateral margin with 1 distal spine; mesial face almost glabrous, ventromesial margin unarmed; ventral surface nearly flat, almost glabrous. Ischium unarmed.

Left cheliped (Fig. 10D–F) moderately slender. Chela 2.2 times longer than wide. Dactylus subequal in length to palm, with scattered tufts of short setae on surfaces; dorsal surface smooth, dorsomesial margin not delimited; occlusal margin with row of small corneous teeth in distal 0.3, terminating in small corneous claw. Palm half-length of carpus; dorsal surface with sparse short setae, slightly elevated in midline and bearing longitudinal row of small tubercles, with granules mesial to midline, dorsolateral and dorsomesial margins not delimited; lateral face with short oblique ridges; mesial face smooth; ventral surface gently convex, with scattered long setae. Occlusal margin of fixed finger with row of small calcareous teeth in distal half, terminating in small corneous claw. Carpus subequal in length to chela and merus; length about 2.4 of distal width and 2.7 of greatest height; dorsal surface with longitudinal row of tiny spines dorsomesially, rounded dorsolaterally; lateral surface having scattered row tubercles, lacking median ridge; ventrolateral distal angle unarmed; mesial surface smooth, with several long stiff setae, particularly along dorsal margin; ventral surface with long setae distally. Merus glabrous on dorsal surface, dorsodistal margin unarmed; lateral surface glabrous, ventrolateral margin with 2 subdistal spines; mesial surface also glabrous, ventromesial margin with 1 minute distal spine and faintly denticulate thereafter; ventral surface with few short setae. Ischium unarmed.

Ambulatory legs (Fig. 11D–G) moderately long and slender, similar from right to left. Dactyli subequal in length to propodi, about 6.1 times longer than high, terminating in large corneous claws; dorsal surfaces each with row of tufts of moderately spaced setae; lateral surfaces with row of shorter setae adjacent to dorsal margins; mesial surfaces with only few short setae, unarmed; ventral margins each with 6 or 7 corneous spines notably increasing in size distally. Propodi not tapering distally, about 4 times longer than high; dorsal surfaces each with tufts of long setae; lateral surfaces with sparse setae; ventral margins each with 2 corneous spinules, ventrodiscal margins each with paired corneous spines. Carpi each without dorsodistal spine; dorsal surfaces with row of tufts of setae; lateral faces with few short setae. Meri with row of tufts or individual setae (setae shorter than in third); lateral surfaces glabrous; ventral margins glabrous, ventrolateral parts each with small subdistal spine (second) or unarmed (third), faintly granulated (second) or smooth (third). Unpaired gonopore on left coxa of pereopod 3 in females (Fig. 9D).

Pereopods 4 (Fig. 9E–G) markedly dissimilar, left larger and more setose on dactylus to carpus. Dactyli nearly straight with arcuate dorsal margins, terminating in small corneous claws; left dactylus much broader than right. Propodi each with single row of corneous scales in distal 0.8, without

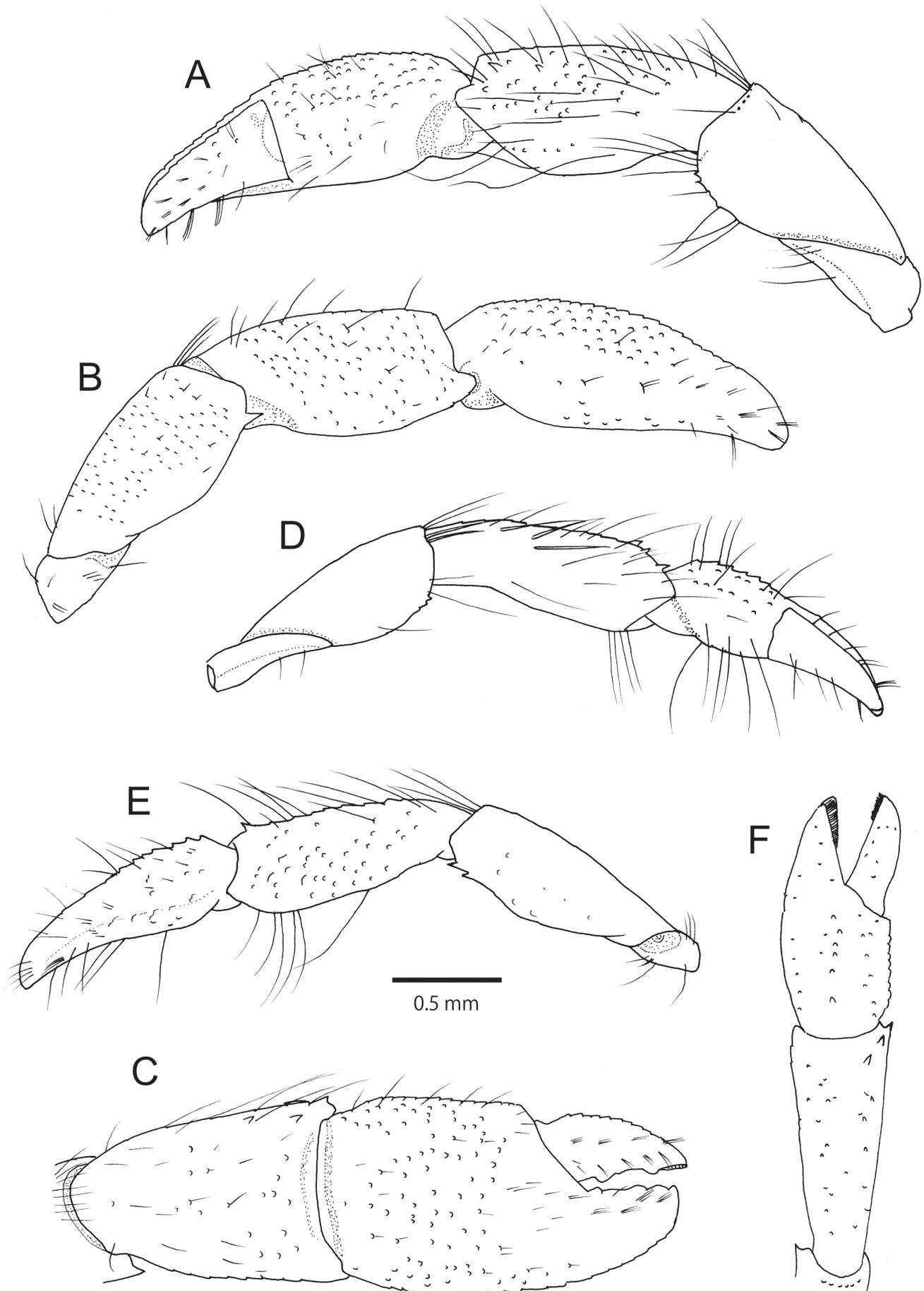


Fig. 10. *Pagurixus depressus*, new species, holotype, female (sl 1.4 mm), QM W29566. A, right cheliped, mesial view; B, same, lateral view; C, chela and carpus of right cheliped, dorsal view; D, left cheliped, mesial view; E, same, lateral view; F, chela and carpus of left cheliped, dorsal view.

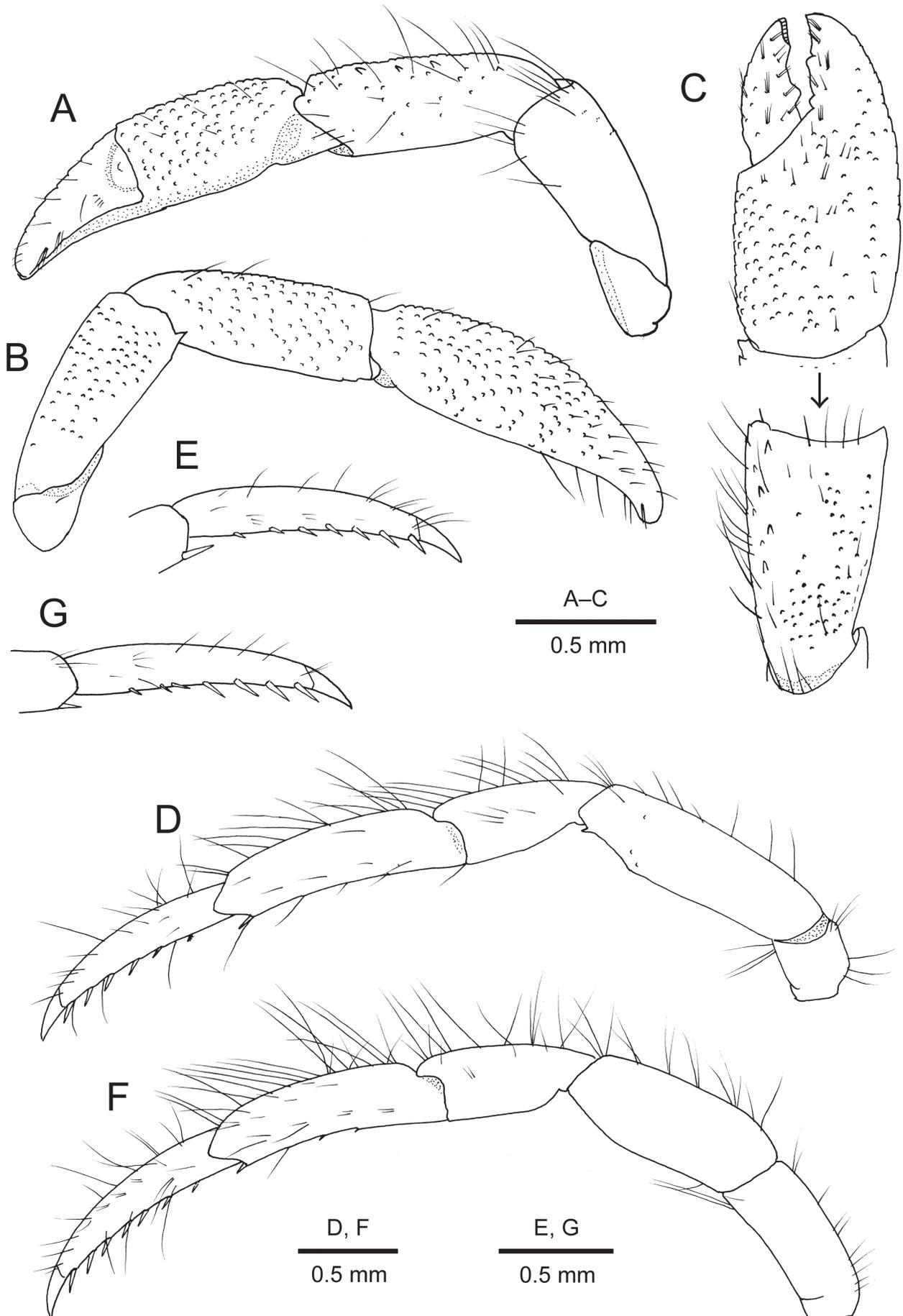


Fig. 11. *Pagurixus depressus*, new species. A–C, paratype, male (sl 1.2 mm), QM W29567; D–G, holotype, female (sl 1.4 mm), QM W29566. A, right cheliped, mesial view; B, same, lateral view; C, chela and carpus of right cheliped, dorsal view; D, left pereopod 2, lateral view; E, same, dactylus, mesial view; F, left pereopod 3, lateral view; G, same, dactylus, mesial view.

conspicuous tuft of setae on mesial face on either side. Right carpus only with few short setae on dorsal margin distally.

Male with coxae of pereopods 5 markedly unequal (Fig. 9H). Right coxa without protrusion, but with rounded demarcation outside of gonopore; prominent setal tuft consisting of long stiff setae arising from demarcated area and passing to left coxa. Left coxa lacking gonopore.

Anterior lobe of thoracic sternite 6 (Fig. 9D) broadly subtrapezoidal, with anterolateral angles rounded, anterior margin with row of short setae. Thoracic sternite 8 (Fig. 9H) composed of two subequal, clearly separated, rounded lobes.

Pleon dextrally twisted. Female (holotype) with 4 unpaired pleopods 2–5; male (paratype) with 3 unpaired pleopods 3–5.

Telson (Fig. 9I) terminal margins moderately oblique, each bearing 4 small spines, no spinules interspersing those spines.

Colouration in life. Not known.

Distribution. Presently known only from Christmas Island; at depths of 3–16.6 m.

Remarks. *Pagurixus depressus*, new species, is referable to the subgroup B of the *P. boninensis* species group because of the combination of the presence of ventral setal rows on the antennular peduncle ultimate article, and the lack of a division of the lateral face of the carpus of the left cheliped (Komai & Osawa, 2006). It appears close to *P. paulayi* Komai & Osawa, 2006, so far known only from Guam, Mariana Islands. Shared characters of the two species include: the palm of the right cheliped bears scattered coarse granules on the dorsal surface; the carpus of the male right cheliped is armed with some spines dorsomesially; the left pereopod has prominent tufts of setae on the dactylus; and the male left gonopore is absent. The new species, however, can be distinguished from *P. paulayi* by the somewhat depressed carpus of the right cheliped, which is more pronounced in the male (Fig. 11A, B). Such a condition is not seen in *P. paulayi* (cf. Komai & Osawa, 2006: fig. 34B–D), as well as in other congeneric species. Furthermore, the following features would seem to warrant the recognition of the new species: ventral setae on the ultimate article of the antennular peduncle are much fewer, arranged in series of tufts, in *P. depressus*, new species (cf. Fig. 9C versus Komai & Osawa, 2006: fig. 33B, C); there is no ventromesial protrusion on the coxa of the left pereopod 5 in the male of *P. depressus*, new species (Fig. 9H) (versus present in *P. paulayi*; cf. Komai & Osawa, 2006: fig. 33G); and the anterior lobe of the thoracic sternite 6 is proportionally wider in *P. depressus*, new species, than in *P. paulayi* (Fig. 9D versus Komai & Osawa, 2006: fig. 33F).

***Pagurixus haigae* Komai & Osawa, 2007**
(Fig. 8C)

Pagurixus laevimanus – McLaughlin & Haig, 1984: 142, fig. 7.
Not *Pagurixus laevimanus* (Ortmann, 1892).

Pagurixus haigae Komai & Osawa, 2007: 97, figs. 1–4; Komai, 2010: 1287; Komai & Poupin, 2013: 192, fig. 1A; Komai & Rahayu, 2013: 134; Arima, 2014: 188, unnumbered figs.; Bourjon et al., 2018: 454, table 1.

Material examined. COCOS (KEELING) ISLANDS. QM W29568, 1 male (sl 1.3 mm), CK08, Trannies Beach, West Island, 12°08.507'S, 96°49.095'E, 20 March 2011; ZRC 2021.0647, 1 male (sl 1.4 mm; photo), 1 female (sl 1.2 mm), CK19, S of Direction Island, 12°05.503'S, 96°52.904'E, 6.9 m, 22 March 2011.

Distribution. Widely distributed in the Indo-West Pacific: Japan (Ryukyu Islands), Guam, the Philippines, Indonesia, New Guinea, Malaysia, New Caledonia, Phuket (Thailand), Europa Island (Mozambique Strait), and Réunion; coral reef, intertidal to 20 m (Komai & Osawa, 2007; Komai, 2010; Komai & Poupin, 2013; Komai & Rahayu, 2013; Bourjon et al., 2018). Newly recorded from Cocos (Keeling) Islands, intertidal to 6.9 m.

Remarks. The specimens examined agree well with the original description of *Pagurixus haigae* (cf. Komai & Osawa, 2007).

***Pagurixus maorus* (Nobili, 1906)**
(Fig. 8D)

Eupagurus maorus Nobili, 1906: 259; 1907: 371, pl. 1 fig. 9.
Pagurixus maorus – McLaughlin & Haig, 1984: 127, fig. 2; Komai & Asakura, 1995: 347, figs. 4–6; Komai & Osawa, 2006: 17, figs. 4–7, 44A, 47; Komai, 2010: 1313; Komai & Rahayu, 2013: 135; Arima, 2014: 187, unnumbered figs.
? *Pagurixus* cf. *maorus* – Morgan, 1992: 165.

Material examined. COCOS (KEELING) ISLANDS. ZRC 2021.0638, 2 females (sl 2.9, 3.9 mm; larger one photo), CK19, S of Direction Island, 12°05.503'S, 96°52.904'E, 6.9 m, 22 March 2011; QM W29569, 1 female (sl 2.2 mm), CK23, off North Point, 12°07.670'S, 96°51.813'E, 13.1 m, 23 March 2011.

Distribution. Widely distributed in the West Pacific: Japan (Ryukyu Islands), the Philippines, Indonesia, Marshall Islands, New Caledonia, and French Polynesia; coral reef, intertidal to 20 m deep (McLaughlin & Haig, 1984; Komai & Asakura, 1995; Komai & Osawa, 2006; Komai, 2010; Komai & Rahayu, 2013; Poupin et al., 2013).

Remarks. The present specimens agree well with the descriptions of *Pagurixus maorus* by McLaughlin & Haig (1984), Komai & Asakura (1995), and Komai & Osawa (2006), and confirm the occurrence of this species in Cocos (Keeling) Islands.

Morgan (1992) recorded *Pagurixus* cf. *maorus* from Christmas and Cocos (Keeling) Islands, but noted that the dactyli of pereopods 2 and 3 were shorter than the propodi, and the male right cheliped was much less elongate than that illustrated for *P. maorus* by McLaughlin & Haig (1984). The

real identity of the specimens reported by Morgan (1992) needs to be verified.

***Pagurixus nomurai* Komai & Asakura, 1995**

Pagurixus nomurai Komai & Asakura, 1995: 341, figs. 1–3; Komai & Osawa, 2006: 32, figs. 12–14, 44C, 47; Osawa & Chan, 2009: 329, fig. 7E; Komai, 2010: 1314; Komai & Rahayu, 2013: 135; Poupin et al., 2013: 45, fig. 23D, E; Arima, 2014: 179, unnumbered figs.; Tan et al., 2014a: 411, fig. 12; Osawa & Fujita, 2016: 17, 20, fig. 6B; 2019: 472, figs. 2C, D, 5A, B.

Material examined. CHRISTMAS ISLAND. QM W29570, 1 male (sl 2.1 mm), CI-D10-2011, West White Cave, off West White Beach, 10°27.733'S, 105°35.054'E, 1–12.3 m, 27 March 2011; ZRC 2021.0639, 5 males (sl 1.4–3.6 mm), 2 females (sl 1.7, 2.0 mm), 1 ovigerous female (sl 1.9 mm), CI-D16-2011, Flying Fish Cove, 10°25.815'S, 105°40.180'E, 29 March 2011; QM W29571, 1 male (sl 2.4 mm), CI-D18-2011, Rhoda Wall, off Rhoda Beach, 10°27.729'S, 105°37.283'E, 5–16 m, 30 March 2011.

Distribution. Widely distributed in the Indo-West Pacific: Mayotte, Réunion, the Philippines, Taiwan, Japan (Ryukyu Islands), Guam, northwestern Australia, Samoa, Cook Islands, and French Polynesia; subtidal to 60 m (Komai & Osawa, 2006; Komai, 2010; Komai & Rahayu, 2013; Tan et al., 2014a).

Remarks. Osawa & Fujita (2019) remarked that individuals inhabiting cave environments are different from those inhabiting coral reef environments in the overall colouration (reddish brown versus generally brown, olive, or bluish gray) and the more proportionally slender carpus of the left cheliped. Molecular comparison between the two forms is now in progress (Osawa & Fujita, 2019). Our specimens are referred to as *P. nomurai* for the time being.

***Pagurixus tweediei* (Forest, 1956)**
(Fig. 12A)

Eupagurus (*Pagurixus*) *tweediei* Forest, 1956: 50, pl. 4 [type locality: Cocos (Keeling) Islands].

Pagurus (*Pagurixus*) *tweediei* – Dehancé, 1964: 38; Ball & Haig, 1972: 103; Lewinsohn, 1982: 58.

Pagurixus tweediei – Komai & Osawa, 2006: 25, figs. 8–11, 44B, 47; Osawa et al., 2013: 357, fig. 2D.

Material examined. CHRISTMAS ISLAND. QM W29572, 1 male (sl 3.4 mm), CI-D03-2010, Coconut Point, 10°24.741'S, 105°41.868'E, 27 January 2010; ZRC 2021.0640, 1 male (sl 3.6 mm; photo), CI-D05-2011, West White Cave, off West White Beach, 1–12.3 m, 10°27.733'S, 105°35.054'E, 25 March 2011; ZRC 2021.0641, 1 male (sl 2.0 mm), Thunderdome Cave, Christmas Island, 10°27.906'S, 105°36.465'E, 3–16.6 m, 30 March 2011.

COCOS (KEELING) ISLANDS. ZRC 2021.0642, 1 ovigerous female (sl 3.5 mm; photo), CK18, the Rip, SW of Direction Island, 12°05.675'E, 96°53.175'E, 5.7 m, 22 March 2011.

Distribution. Previously known with certainty from Cocos (Keeling) Islands (type locality); Japan (Ogasawara Islands and Ryukyu Islands), Mariana Islands (Guam), and French Polynesia (Society Islands) in the western Pacific Ocean; intertidal to 91.3 m (Komai & Osawa, 2006; Osawa et al., 2013). Newly recorded from Christmas Island, at depths of 1–16.6 m.

Remarks. *Pagurixus tweediei* was originally described on the basis of material from Cocos (Keeling) Islands (Forest, 1956). Komai & Osawa (2006) reexamined the two syntypes, and clarified that *P. cf. tweediei* of McLaughlin & Haig (1984) might actually represent *P. carinimaus* instead.

The present specimens, including the topotypic specimen from Cocos (Keeling) Islands, differ from specimens from the Ryukyu Islands (Japan) and Society Islands (French Polynesia), referred to as *P. tweediei* by Komai & Osawa (2006) and Osawa et al. (2013), in the lack of proximal and distal white rings on the propodi of the ambulatory legs (Fig. 12A versus Komai & Osawa, 2006: fig. 44B; Osawa et al., 2013: fig. 2D), although they are morphologically similar to one another. In this colour pattern of the ambulatory legs, the present specimens are rather similar to *P. formosus* Komai, 2010 (cf. Osawa et al., 2013: fig. 2B, C), but seem to differ from the latter taxon in the possession of distinct spines on the dorsolateral and dorsomesial margins of the left cheliped carpus (in *P. formosus*, there are only rows of small tubercles or granules there; Komai, 2010; Osawa et al., 2013). Molecular genetic analyses would be advisable to fully clarify the status of the western Pacific populations referred to as *P. tweediei* and of *P. formosus*.

Morgan (1992) recorded *P. tweediei* from Christmas and Cocos (Keeling) Islands, but his identification seems to have been based on McLaughlin & Haig's (1984) account. Komai & Osawa (2006) argued that Morgan's specimens did not represent the true *P. tweediei*, although the identity was not established.

Genus *Pylopaguropsis* Alcock, 1905

***Pylopaguropsis bellula* Osawa & Okuno, 2007**
(Fig. 12B)

Pylopaguropsis bellula Osawa & Okuno, 2007: 31, figs. 1–5, 6A, B, 7A, B (type locality: Kume Island, Ryukyu Islands); Arima, 2014: 175, unnumbered figs.; Osawa & Fujita, 2016: fig. 6C; 2019: 473, fig. 3A.

Material examined. COCOS (KEELING) ISLANDS. ZRC 2021.0643, 1 female (sl 3.0 mm; photo), CK17, Lion Cave Point, W of Direction Island, 12°05.722'N, 96°52.893'E, 28.9 m, 22 March 2011; QM W29573, 1 male (sl 3.2 mm; photo), CK19, S of Direction Island, 12°05.503'S, 96°52.904'E, 6.9 m, 22 March 2011; ZRC 2021.0644, 1 female (sl 2.7 mm), CK21, Lion Cave Point, W of Direction Island, 12°05.722'S, 96°52.893'E, 29.1 m, 23 March 2011.

Distribution. Previously known from Japan (Ryukyu Islands), at depths of 15–35 m (Osawa & Okuno, 2007;

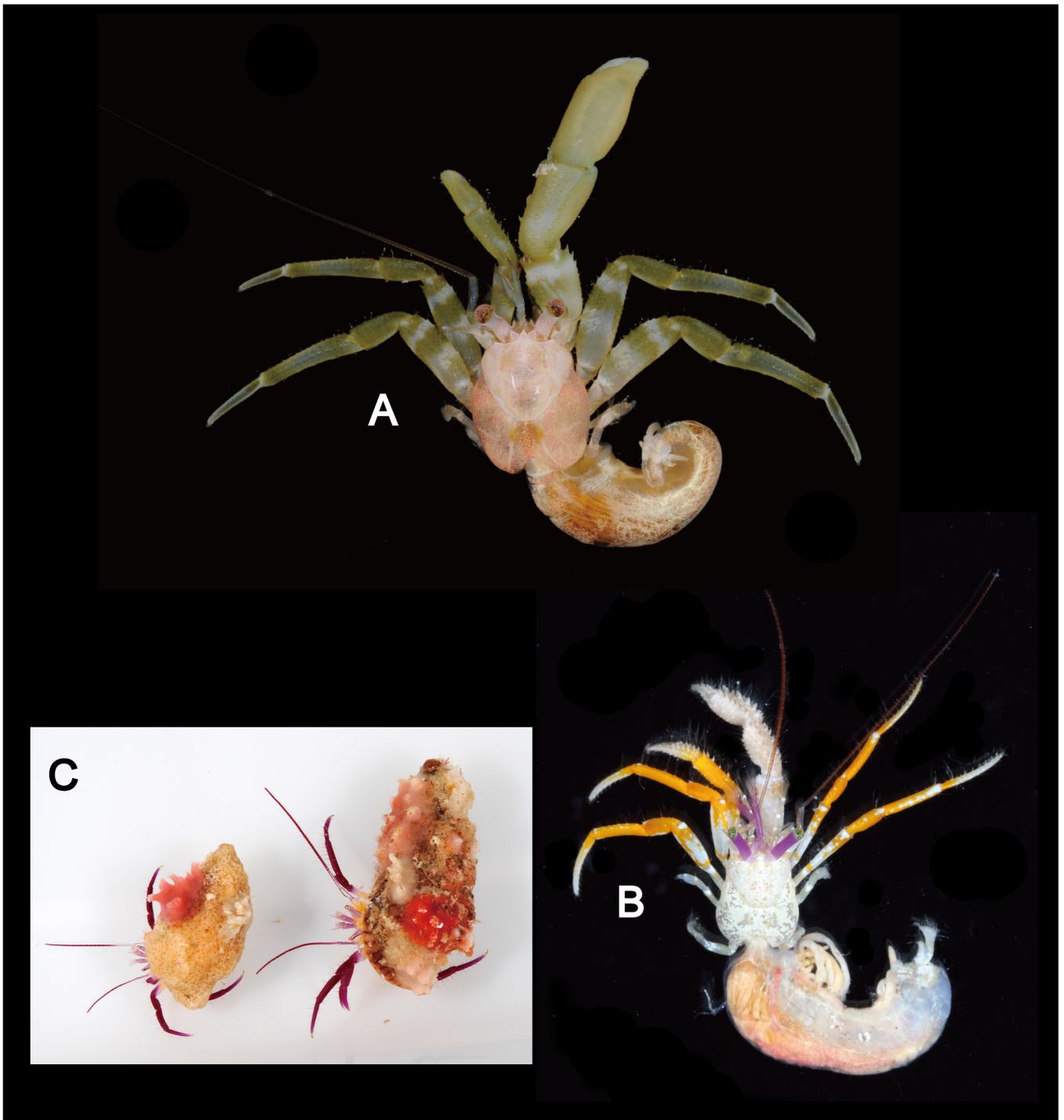


Fig. 12. Habitus in dorsal view, showing living colouration. A, *Pagurixus tweediei* (Forest, 1956), ZRC 2021.0640, male (sl 3.6 mm); B, *Pylopaguropsis bellula* Osawa & Okuno, 2007, ZRC 2021.0643, female (sl 3.0 mm); C, *Pylopaguropsis keijii* McLaughlin & Haig, 1989, ZRC 2021.0645. Photographs by LKCNHM.

Osawa & Fujita, 2019). Newly recorded from the eastern Indian Ocean, 6.9–28.9 m deep.

Remarks. The specimens examined agree morphologically well with the original description of *Pylopaguropsis bellula* by Osawa & Okuno (2007). The photographed specimen (Fig. 12B) shows somewhat faint colour on the right cheliped and ambulatory legs, compared with the published photographs of *P. bellula* (cf. Osawa & Okuno, 2007; Arima, 2014; Osawa & Fujita, 2016). We consider that the colour difference could be intraspecific.

***Pylopaguropsis keijii* McLaughlin & Haig, 1989**
(Fig. 12C)

Pylopaguropsis keijii McLaughlin & Haig, 1989: 150, figs. 2i, 3d, 5d, 7e, 9d, 11d, 13d (type locality: Oahu, Hawai'i); Morgan, 1992: 172; 2000: 119; Asakura, 2000: 82, figs. 6, 7, 19B, C, 20; Okuno & Arima, 2006: 40, fig. 3K; Poupin et al., 2013: 47, fig. 26A, C; Arima, 2014: 173, unnumbered figs.; Osawa & Fujita, 2019: 475, figs. 3D, 5F.

Material examined. CHRISTMAS ISLAND. ZRC 2021.0645, 1 male (sl 2.2 mm; photo 139), CI-D03-2011, Ethel Beach, 10°27.805'S, 105°42.443'E, 3–27.5 m, 24 March 2011; QM W29574, 1 female (sl 2.4 mm), CI-D17-2011, Thunderdome Cave, 10°27.906'S, 105°36.465'E, 3–16.6 m, 30 March 2011.

COCOS (KEELING ISLANDS). ZRC 2021.0646, 4 males (sl 1.6–3.0 mm), 1 ovigerous female (sl 2.7 mm), CK2-18, North Keeling Island, 9 February 2012.

Distribution. Widely distributed in the Indo-West Pacific: Zanzibar, Mayotte, Maldives, Christmas Island, Guam, Caroline Islands, Japan (Ryukyu and Izu Islands), and Hawaii; 2.5–30 m (McLaughlin & Haig, 1989; Asakura, 2000; Morgan, 2000; Okuno & Arima, 2006; Poupin et al., 2013).

Remarks. The present specimens are identified as *Pylopagurosis keijii* in reference to McLaughlin & Haig (1989) and Asakura & Paulay (2003).

CONCLUDING REMARKS

Records of pagurid species from Christmas and Cocos (Keeling) Islands, including the newly recorded ones by the present study, are summarised in Table 1. Altogether, 14 species are enumerated, although only two species are common on both islands. This might reflect the differences between environments where collections were made. In Christmas Island, primarily marine caves and adjacent sites were investigated by our team, while in Cocos (Keeling) Islands, mainly coral reefs were surveyed.

As mentioned above, the pagurid fauna of those islands has been reviewed by Morgan (1992). Taxonomic clarifications have been made for some recorded species since then. McLaughlin & Lemaitre (1993) reviewed the genus *Paguritta* Melin, 1939, confirming the occurrence of *P. harmsi* (Gordon, 1935) in Christmas Island with the addition of further specimens from the island. In her revision of *Nematopagurus* A. Milne-Edwards & Bouvier, 1892, McLaughlin (2004) referred Morgan's (1992) record of *Nematopagurus* cf. *muricatus* to *N. gardineri* Alcock, 1905. Morgan (1992) recorded four species of *Pagurixus* from Christmas and/or Cocos (Keeling) Islands: *P. anceps* (Forest, 1954), *P. tweediei* (Forest, 1956), *P. cf. boninensis* (Melin, 1939), and *P. cf. maorus* (Nobili, 1906) (Table 1). Of these, the real identities of *P. cf. boninensis* and *P. cf. maorus* remain to be reassessed (Komai & Osawa, 2006). Komai & Osawa (2006) argued that Morgan's *P. tweediei* did not represent the true *P. tweediei*. Morgan (2000) recorded five unidentified species of Paguridae, but the identities of those taxa remain unknown. These five unidentified taxa are not considered herein.

Among the 14 species recorded, 10 species are widely distributed in the Indo-West Pacific. The present new record of *Pylopagurosis bellula* suggests that the species is also widely distributed in the Indo-West Pacific, although it was

heretofore known only from the Ryukyu Islands (Osawa & Okuno, 2007; Osawa & Fujita, 2016, 2019). Actual distribution of the three new species remains unknown.

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