

## New records of Alvinocarididae (Crustacea: Decapoda: Caridea) from the southwestern Pacific hydrothermal vents, with descriptions of one new genus and three new species

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Three new species of the caridean family Alvinocarididae are described from hydrothermal vents in the Southwest Pacific, namely, *Chorocaris parva* sp. nov. (Manus Basin, 1305–1684 m), *Chorocaris variabilis* sp. nov. (Manus and North Fiji basins and Vanuatu, 1305–2480 m) and *Manuscaris acuminatus* gen. et sp. nov. (Manus Basin, 1310 m). Morphological affinities of these three species are discussed. Molecular genetic analysis using partial sequences of the mitochondrial cytochrome c oxidase subunit I (COI) gene supports the recognition of the two new species assigned to *Chorocaris* Martin and Hessler, 1990. The generic diagnosis of *Chorocaris* is slightly emended to accommodate the two new species. *Opaepele susannae* Komai, Gierre and Segonzac, 2007 is transferred to *Chorocaris*. *Alvinocaris komai* Zelnio and Hourdez, 2009, originally described from the Lau Basin, is newly recorded from the North Fiji Basin and Vanuatu (Nifonea vent field), at depths of 1740–2750 m.

<http://zoobank.org/urn:lsid:zoobank.org:pub:4BFC8C31-C006-4738-BED7-B13D3296A7CA>

**Keywords:** *Chorocaris*; *Manuscaris*; Manus Basin; North Fiji basin; Vanuatu

### Introduction

Members of the caridean family Alvinocarididae exclusively occur in reducing environments in deep water, e.g. hydrothermal vents, brine, sulphide or hydrocarbon seeps (Lunina and Vereshchaka 2014). Most species appear to be restricted to a particular ridge, seamount or seep system, and recent samplings in these habitats have yielded continuous discoveries of new taxa and/or new locality records of this caridean family, which are of considerable interest in systematics and ecology (e.g. Martin and Haney 2005; Komai et al. 2005, 2006, 2007; Ah Yong 2009; Zelnio and Hourdez 2009; Komai and Chan 2010; Lunina and Vereshchaka 2010; Nye et al. 2012).

This study reports on new taxa and new records of Alvinocarididae from recent collections made at hydrothermal vent sites in the Southwest Pacific. Three new species are described and illustrated: *Chorocaris parva* sp. nov. from the Manus Basin; *Chorocaris variabilis* sp. nov. from the Manus Basin, North Fiji Basin and Vanuatu; and *Manuscaris acuminatus* gen. nov. et sp. nov. from the Manus Basin. The generic diagnosis of *Chorocaris* is slightly emended to accommodate the two new

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species, *C. parva* and *C. variabilis*, and *Opaepele susannae* Komai et al. 2007; is transferred to *Chorocaris*. New locality records from the North Fiji Basin and Vanuatu are provided for *Alvinocaris komaii* Zelnio and Hourdez, 2009; which was originally described from the Lau Basin. Molecular genetic analysis using partial sequences of the mitochondrial cytochrome c oxidase subunit I (COI) gene was performed to confirm the validity of the two new species assigned herein to *Chorocaris*.

### Material and methods

Collections studied in this work came from various diving cruises organized by American, French, German and Japanese teams: the Japanese YK06-13 cruise to the Manus and North Fiji Basins by DS *Shinkai 6500*/RV *Yokosuka* (chief scientist Y. Suzuki, 8 September to 4 October 2006); the American Wave Mercury 2007 (Luk Luk) Campaign to the Manus Basin (chief scientist Cindy Van Dover, Duke University Marine Laboratory); the French–German BIOLAU cruise to the Lau Basin by DS *Nautille*/RV *Nadir* (chief scientist A.-M. Alayse, Ifremer, 17 April to 10 May 1989); the French–Japanese STARMER II cruise to the North Fiji Basin by the deep tow camera/RV *Kaiyo* (chief scientists D. Desbruyères, Ifremer, and S. Ohta, Ocean Research Institute, University of Tokyo, 30 June to 19 July 1989); and the German RV *Sonne* SO229 cruise to Vanuatu (chief scientist Karsten Haase, Friedrich-Alexander Universität, 24 June to 26 July 2013). The material examined in this study is deposited in the following institutions: Japan Agency for Marine Science and Technology, Yokosuka, Japan (JAMSTEC); Muséum national d'Histoire naturelle, Paris, France (MNHN); Natural History Museum and Institute, Chiba, Japan (CBM); and Oxford University Museum of Natural History, UK (OUMNH). Specimens used for morphological examination are all preserved in 70% ethanol. The postorbital carapace length (cl) is used as a standard measurement indicating the size of specimens.

Partial sequences of mitochondrial COI for 16 alvinocaridid taxa are available in the GenBank database. Two specimens of *C. parva* sp. nov. from the Manus Basin and four specimens of *C. variabilis* sp. nov. (three from the Manus Basin and one from the North Fiji Basin) were used. No specimens of *M. acuminatus* gen. nov. et sp. nov. were available for DNA extraction, because only a single, formalin-fixed specimen was available for study. Genomic DNA of these specimens, stored at  $-30^{\circ}\text{C}$  or preserved in 99% ethanol at room temperature, was extracted from pleonal muscles using the DNeasy Blood & Tissue Kit (Qiagen, Valencia, CA, USA). Partial sequences of the COI gene (658 bp) were amplified by polymerase chain reaction (PCR) using the universal primers HCO2198 (TAA ACT TCA GGG TGA CCA AAA AAT CA) and LCO1490 (GGT CAA CAA ATC ATA AAG ATA TTG G) (Folmer et al. 1994). The PCR was performed using Ex *Taq* polymerase (TaKaRa, Tokyo, Japan) with 25- $\mu\text{l}$  reaction mixtures containing 2.5  $\mu\text{l}$  of 10 $\times$  Ex *Taq* Buffer, 2  $\mu\text{l}$  dNTP solution, 10 pmol of each primer, 1.25 U of Ex *Taq* polymerase and sterile water to the final volume. Thermal cycling was carried out on a TaKaRa PCR Thermal Cycler Dice with the following cycle parameters: 95 $^{\circ}\text{C}$  for 60 s, followed by 35 cycles of 95 $^{\circ}\text{C}$  (60 s), 48 $^{\circ}\text{C}$  (60 s), 72 $^{\circ}\text{C}$  (90 s); ending with 7 min at 72 $^{\circ}\text{C}$ . Sequences of PCR products were obtained using the ABI PRISM 3100 DNA Analyzer and the BigDye Terminator Cycle Sequencing Ready Reaction Kit, version 3.1 (PE Biosystems, Foster City, CA, USA). The sequences obtained in this study were deposited in the database of the DNA Data Bank of Japan (DDBJ) under

accession nos. AB772278–AB772283 and compared with those available in databases using the Basic Local Alignment Search Tool (BLAST) network service to determine approximate phylogenetic affiliations. Sequences were manually aligned, and phylogenetic analyses were restricted to nucleotide positions that were unambiguously alignable in all sequences. Phylogenetic trees based on partial COI sequences (460 bp) were constructed by three methods: (1) maximum likelihood (ML) programmed by the PhyML ver. 3.0, and the bootstrap values were calculated by the same program with the GTR nucleic substitution matrix, four rate categories, BIONJ tree as a starting point for 500 replicates (Guindon et al. 2010); (2) maximum parsimony (MP) estimated using the branch-and-bound search with 1000 replicates bootstrap values by the PAUP 4.0b10 (Swofford 2002); and (3) neighbour-joining (NJ) method using CLUSTAL X 2.1 with 1000 replicates bootstrap values (Thompson 1997). Pairwise estimates of the Kimura-2-Parameter (K2P) distance (Kimura 1980) for inter-specific and intra-specific genetic divergence of the two new species referred to *Chorocaris* and other closely allied species were calculated by CLUSTAL X 2.1 (Thompson 1997).

For comparison, the following material was examined.

*Opaepele loihi* Williams and Dobbs, 1995: RV *Natsushima*, NT10-13 cruise, ROV *Hyper-Dolphin*, dive #1161, NW Rota, Mariana Arc, 14°36.071' N, 144°46.522' E, 550 m, 26 July 2010, 3 males (cl 7.8–8.7 mm), 7 females (cl 7.0–9.5 mm), JAMSTEC 081482; same cruise, ROV *Hyper-Dolphin*, dive #1164, Nikko Seamount, Mariana Arc, 23°04.831' N, 142°19.566' E, 471 m, 30 July 2010, 6 males (cl 7.1–9.9 mm), 23 females (cl 7.2–11.3 mm), 1 juvenile (cl 5.0 mm), JAMSTEC 081512.

*Opaepele vavilovi* Lunina and Vereshchaka, 2010: R/V *Akademik Mstislav Keldysh*, 50th cruise, DS *Mir-1* and *Mir-2*, stn 4797, Broken Spur, Mid-Atlantic Ridge, 3350 m, 25 August 2005, 2 females (cl 7.7, 10.9 mm), paratypes, OMNH 2009-15-0001.

## Systematics

Family ALVINOCARIDIDAE Christoffersen, 1986

Genus *Chorocaris* Martin and Hessler, 1990

*Rimicaris*: Williams and Rona 1986: 447 (in part).

*Chorocaris* Martin and Hessler, 1990: 2; Komai and Segonzac 2008: 32.

*Opaepele*: Komai et al. 2007: 239 (in part).

### Type species

*Chorocaris vandoverae* Martin and Hessler, 1990.

### Composition

In addition to the type species, the following five species are here assigned to *Chorocaris*: *Chorocaris chacei* (Williams and Rona 1986), *C. parva* sp. nov., *Chorocaris paulexa* (Martin and Shank 2005), *Chorocaris susannae* (Komai et al. 2007) comb. nov. and *C. variabilis* sp. nov.

*Emended diagnosis*

Rostrum reaching or falling short of midlength of first segment of antennular peduncle, dorsoventrally flattened, triangular to rounded in dorsal view; dorsal surface usually non-carinate, always unarmed; ventral surface nearly flat or slightly convex, unarmed. Carapace without postrostral carina; shallow longitudinal depression on either side of midline in spawning females; antennal tooth distinct, varying from acute to blunt; pterygostomial angle produced anteriorly or non-produced; anterior part of branchial region not strongly inflated; pair of dorsal organs evident in postorbital region in living specimens. Pleon with third pleuron unarmed; fourth pleuron unarmed or with one or more denticles posteroventrally; fifth pleuron with posteroventral tooth and occasionally with additional teeth or denticles on posterolateral margin. Telson with dorsolateral spines arranged in sinuous row with second and/or third spines located distinctly mesial to other spines; posterior margin convex, with row of plumose setae flanked by two pairs of lateral spines. Eyes broadly fused, with faint median notch; anterior surface of each eye flat anteriorly, unarmed. Antennular stylocerite clearly separated from first peduncular segment. Antennae usually not forming operculate structure (see Martin and Hessler 1990); antennal scale with sharp to blunt distolateral tooth, clearly separated from lamella or closely approximated to it; transverse suture present, extending mesially from base of distolateral tooth. First maxilliped with rudimentary bud of flagellum on exopod. First pereopod with well-developed grooming apparatus on carpus. Second pereopod without spine on ischium. Third to fifth pereopods increasing in length posteriorly; dactyli each with two or more rows of accessory spinules on flexor surfaces; meri of third and fourth pereopods unarmed; ischia of third and fourth pereopods unarmed (except for males of *C. variabilis* sp. nov.). No strap-like epipods on third maxilliped or first to fourth pereopods. Appendix interna on fourth pleopod without terminal cluster of coupling hooks. Uropodal exopod with two posterolateral spines mesial to posterolateral tooth; protopod sharply to bluntly pointed posterolaterally.

*Distribution*

Hydrothermal vents in the western and eastern Pacific and on the Mid-Atlantic Ridge; 1305–3650 m.

*Remarks*

The genus *Chorocaris* was established by Martin and Hessler (1990) to accommodate the type species *C. vandoverae* from hydrothermal vents in the Mariana Back Arc Basin, and *Rimicaris chacei* Williams and Rona, 1986 from hydrothermal vents along the Mid-Atlantic Ridge. *Chorocaris* was differentiated from *Rimicaris* by the more-developed rostrum, the non-inflated branchial regions of the carapace, the cylindrical fused eyestalks and the non-operculate antennae (Martin and Hessler 1990). A new species *Chorocaris fortunata* Martin and Christiansen, 1995 was subsequently described from the Lucky Strike vent field on the Mid-Atlantic Ridge, but this species was later transferred to *Mirocaris* by Vereshchaka (1997). Based on analyses of the COI gene (600 bp), Shank et al. (1999) proposed that *Chorocaris* is a paraphyletic assemblage with *C. chacei* being more closely related to

*Rimicaris exoculata* than to *C. vandoverae*. Martin and Shank (2005) described a new species, *C. paulexa*, from the Rapa Nui Homer Vent Site on the southern East Pacific Rise. Komai et al. (2007) then described a new species, *Opaepele susannae* Komai et al. 2007, from the southern Mid-Atlantic Ridge, and suggested that their new species appears to be intermediate between *Chorocaris* and *Opaepele*. Komai and Segonzac (2008) reviewed *Chorocaris* and *Rimicaris*, and took a conservative approach by recognizing three species in *Chorocaris*, namely, *C. chacei*, *C. paulexa* and *C. vandoverae*; these authors maintained the genus despite the possibility of it being paraphyletic. Recently, a new species, *Rimicaris hybisae* Nye, Copley and Plouviez, 2012, was described from the Mid-Cayman Spreading Centre, in the Caribbean; this species was provisionally referred to *Rimicaris*, but exhibits some similarities to *C. chacei* (see Nye et al. 2012).

The discovery of the two new species, herein referred to *Chorocaris*, led us to reassess the characters that differentiate the genera *Chorocaris* and *Opaepele*. Comparison of *C. vandoverae* and *Opaepele loihi*, the type species of the respective genera, has confirmed the following morphological differences: (1) the rostrum is devoid of a dorsal carina or dorsal teeth or denticles in *C. vandoverae*, whereas in *O. loihi*, the rostrum has a distinct dorsal carina, extending to the postrostral part of the carapace, and occasionally bears minute denticles; (2) the uropodal exopod always bears two movable spines at the posterolateral angle in *C. vandoverae*, whereas there is usually one, rarely two, movable spines just mesial to the fixed posterolateral tooth in *O. loihi*. The two previously known species of *Chorocaris* (*C. chacei* and *C. paulexa*), *O. susannae* and the two new species of *Chorocaris* described herein are morphologically akin to *C. vandoverae* in these regards.

The lack of a dorsal carina on the rostrum and the possession of two posterolateral spines on the uropodal endopod are presumed to be apomorphic within the Alvinocarididae (cf. Komai and Segonzac 2003, 2004, 2008). Consequently, *Opaepele loihi* is set apart from a group, which includes *Opaepele susannae*, *Chorocaris* species including the two new species described herein, and *Rimicaris* species. Despite the suggested paraphyly of *Chorocaris*, we recognize *Chorocaris* as a valid genus for the time being, including *C. vandoverae*, *C. chacei*, *C. paulexa*, *C. parva* sp. nov., *C. variabilis* sp. nov. and *C. susannae* comb. nov. until thorough phylogenetic analysis is performed.

In addition, *Opaepele vavilovi* has a number of presumably plesiomorphic characters, such as the dorsolateral spines on the telson being arranged in a linear row, the presence of a spiniform tubercle on the rounded anterior surface of each eye, the possession of meral and/or ischial spines on the second to fourth pereopods and the presence of a single row of accessory spinules on the dactyli of the third to fifth pereopods. In these regards, *O. vavilovi* is similar to species of *Alvinocaris*, and could be excluded from a group of genera containing *Alvinocaridinides*, *Chorocaris*, *Opaepele*, *Rimicaris* and *Shinkaicaris*. Future study has the potential to warrant the establishment of a separate genus for *O. vavilovi*.

***Chorocaris parva* sp. nov.**  
(Figures 1–5)

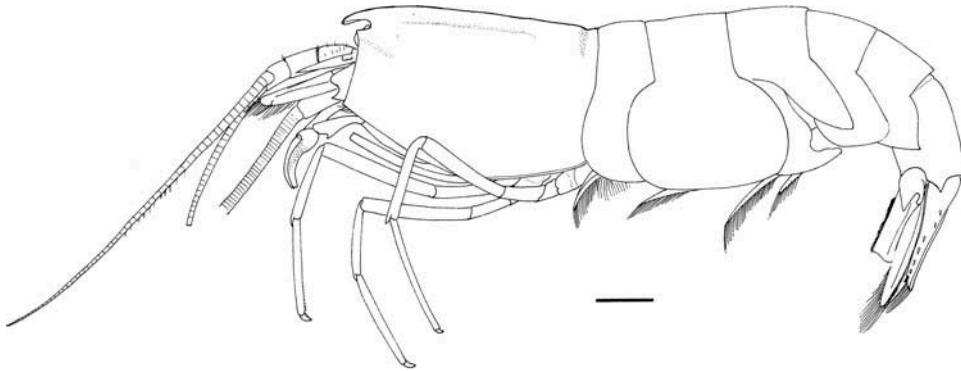


Figure 1. *Chorocaris parva* sp. nov., holotype, ovigerous female (carapace length 8.0 mm), CBM-ZC 11939, entire animal in lateral view (third and fourth pleonal pleura and left uropod partially damaged). Scale bar = 2 mm.

#### *Material examined*

*Holotype.* Wave Mercury 2007 (Luk Luk) Campaign, dive 28, South Su site, Manus Basin, Bismarck Sea, 03°08.09' S, 152°10.5' E, 1310 m, 10 April 2007, ovigerous female (cl 8.0 mm), CBM-ZC 11,939.

#### *Paratype*

**Manus Basin.** Same data as holotype, 1 male (cl 6.9 mm), CBM-ZC 11940; same data as holotype, 33 males (cl 4.3–6.8 mm), CBM-ZC 11941; same data as holotype, 18 females (cl 4.5–7.8 mm), 5 ovigerous females (cl 5.7–6.7 mm), CBM-ZC 11942; dive 30, South Su, 3°08.09' S, 152°10.5' E, 1305 m, 11 April 2007, 2 males (cl 5.2, 5.9 mm), 1 female (cl 7.1 mm), CBM-ZC 11944; dive 34, same site, 1310 m, 14 April 2007, 14 males (cl 4.3–6.8 mm), 11 females (cl 4.0–7.5 mm), 3 ovigerous females (cl 5.5–6.5 mm), OUMNH.ZC.2014–01-014. RV *Yokosuka*, YK06-13 cruise, DS *Shinkai 6500*, dive #982, PACMANUS site, 03°43.608' S, 151°40.328' E, 1684 m, 20 September 2006, 2 specimens (not measured; DNA extracted, preserved in frozen condition), JAMSTEC 070101–070102.

#### *Description*

Body integument with scattered minute setae.

Rostrum (Figures 2A, B; 5A, B) reaching (males) or falling short of (females) midlength of first segment of antennular peduncle, tip blunt in dorsal view; ventral surface slightly convex; lateral margin merging into orbital margin. Carapace (Figures 1, 2A–C; 5A, B) with dorsal surface slightly sloping down anteriorly to rostrum, almost glabrous or with few minute setae anteriorly; orbital margin evenly concave; antennal tooth acute or subacute; pterygostomial angle not markedly produced, terminating in subacute or acute point.

Third pleonal pleuron (Figures 1, 2D) broadly rounded; fourth pleuron with blunt or subacute posteroventral angle, no additional denticles; fifth pleuron with

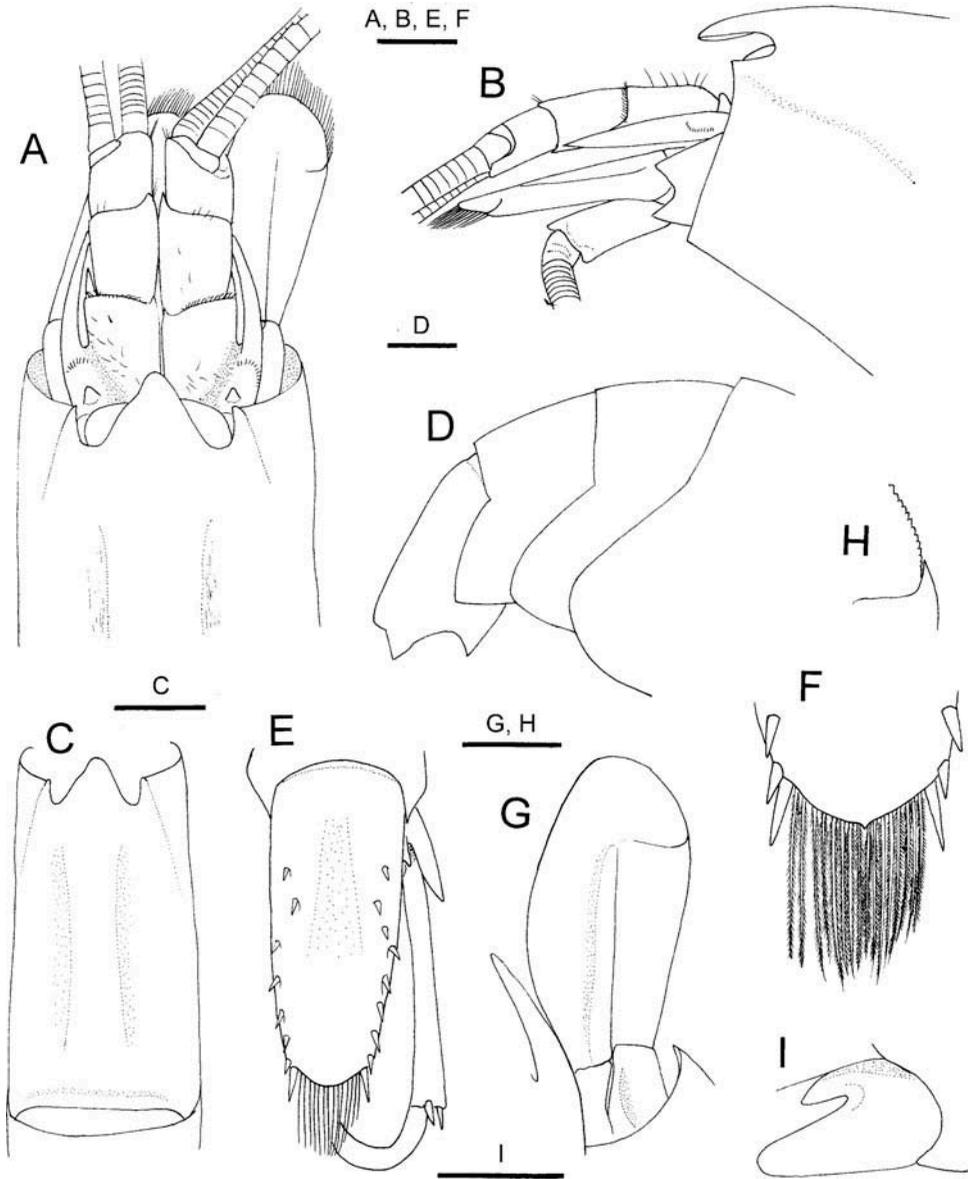


Figure 2. *Chorocaris parva* sp. nov., holotype, ovigerous female (carapace length 8.0 mm), CBM-ZC 11939. (A) Anterior part of carapace and cephalic appendages, dorsal view; (B) same, lateral view; (C) carapace, dorsal view; (D) fourth to sixth pleomeres, right side, lateral view; (E) telson and right uropod, dorsal view (marginal setae on uropod omitted); (F) posterior margin of telson, dorsal view; (G) right antennal scale, dorsal view (setae omitted); (H) distolateral tooth of right antennal scale, dorsal view; (I) protopod of right uropod, dorsolateral view. Scale bars: 2 mm for C; 1 mm for A, B, D, E, G, I; 0.5 mm for F, H.

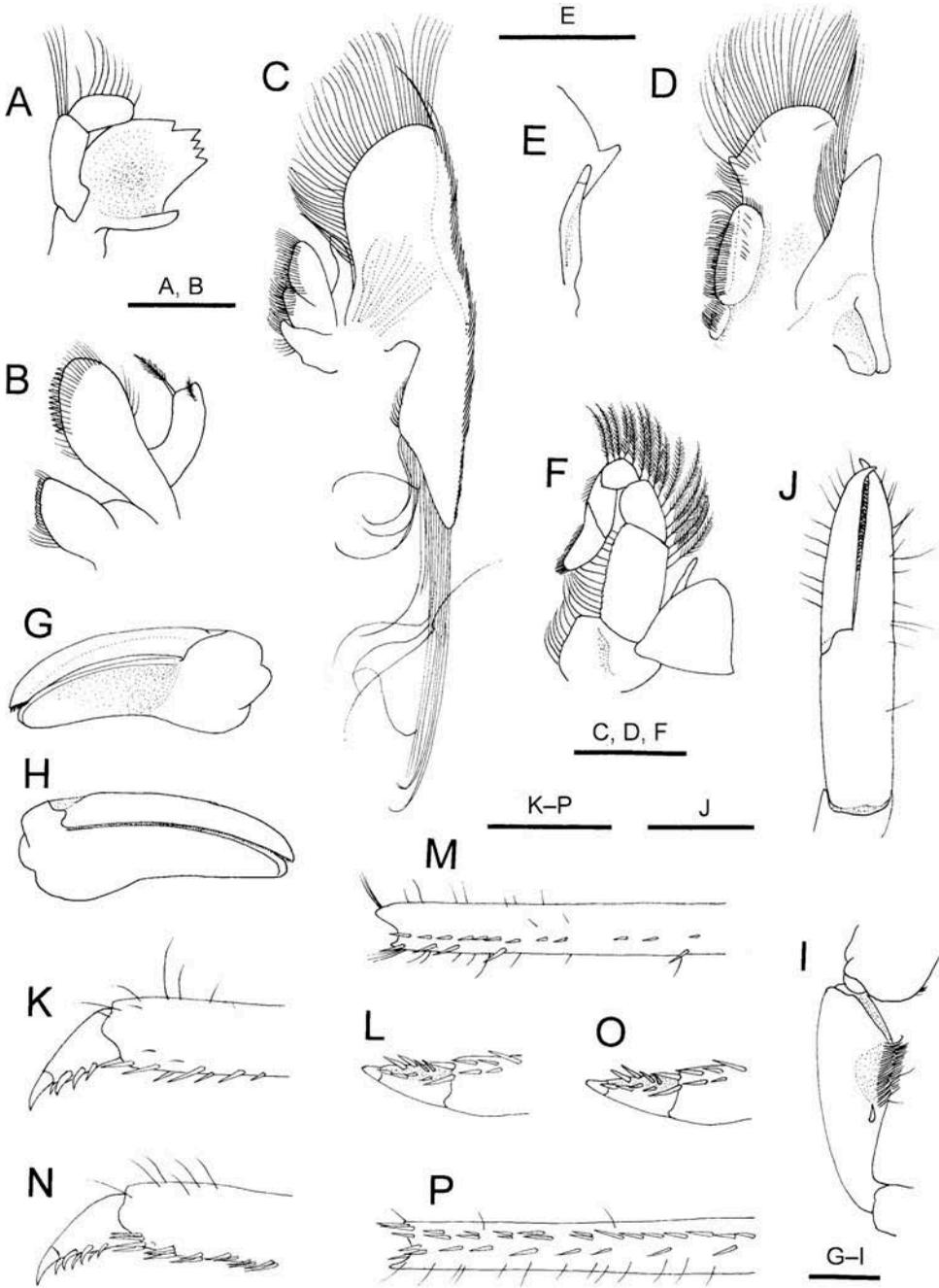


Figure 3. *Chorocaris parva* sp. nov., holotype, ovigerous female (carapace length 8.0 mm), CBM-ZC 11939. (A) Left mandible, inner view; (B) left maxillule, outer view; (C) left maxilla, outer view; (D) left first maxilliped, outer view; (E) same, endopod, inner view; (F) left second maxilliped, outer view; (G) chela of left first pereopod, inner (flexor) view; (H) same, outer (extensor) view; (I) carpus of left first pereopod, mesial view, showing grooming apparatus; (J) chela of left second pereopod, extensor view; (K) dactylus and propodus of left third pereopod, lateral view; (L) same, flexor view; (M) distal part of propodus of left third pereopod, obliquely flexor view; (N) dactylus and distal part of propodus of left fifth pereopod, lateral view; (O) same, flexor view; (P) propodus of left fifth pereopod, flexor view. Scale bars: 1 mm for C–F; 0.5 mm for A, B, G–P.

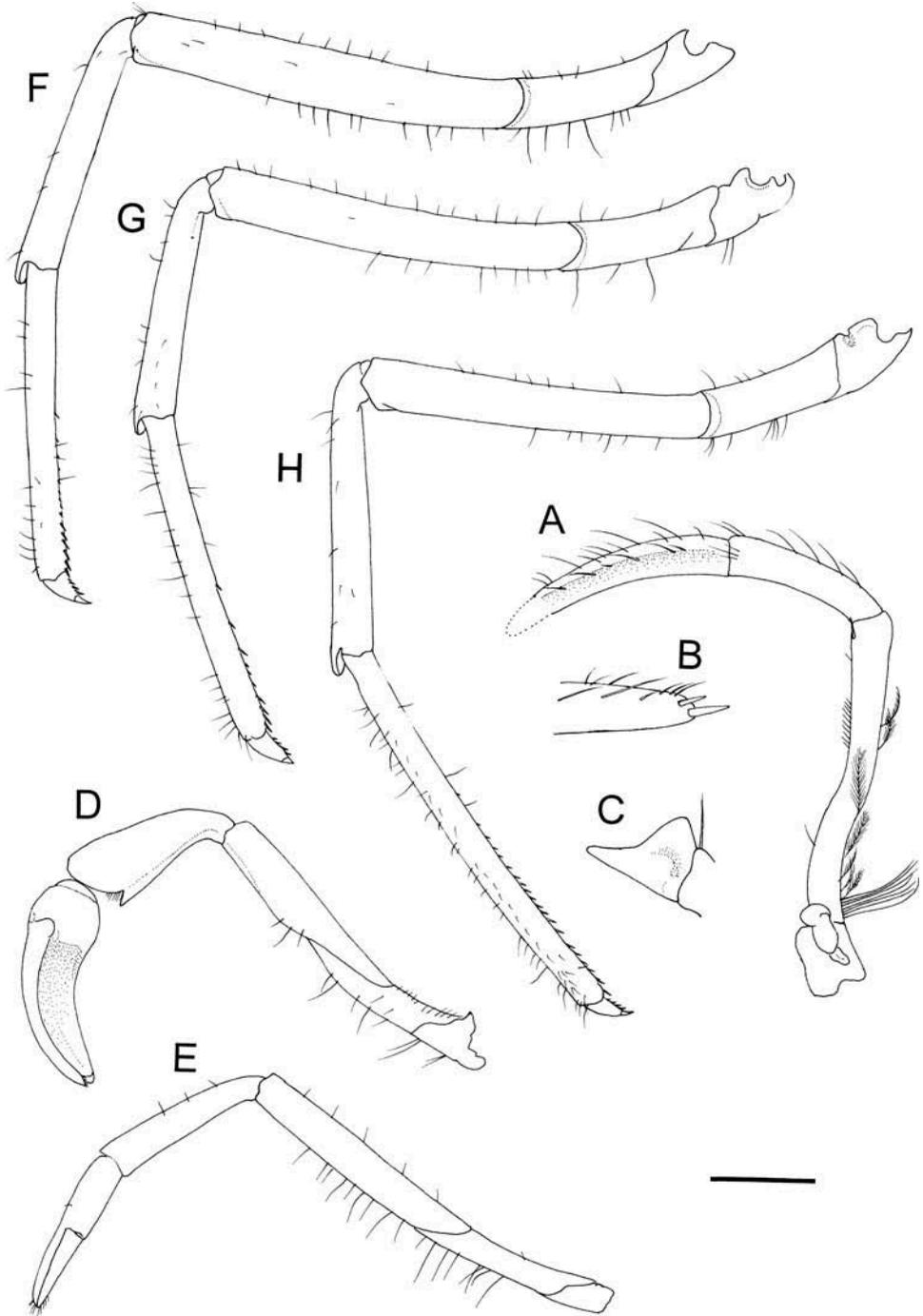


Figure 4. *Chorocaris parva* sp. nov., holotype, ovigerous female (carapace length 8.0 mm), CBM-ZC 11939. (A) Left third maxilliped, lateral view (distal part of ultimate segment damaged); (B) close up of distal part of ultimate segment of right third maxilliped, lateral view; (C) epipod of left third maxilliped, dorsal view; (D) left first pereopod, lateral view; (E) left second pereopod, lateral view; (F) left third pereopod, lateral view; (G) left fourth pereopod, lateral view; (H) left fifth pereopod, lateral view. Scale bars: 1 mm for A, D–H; 0.5 mm for B, C.

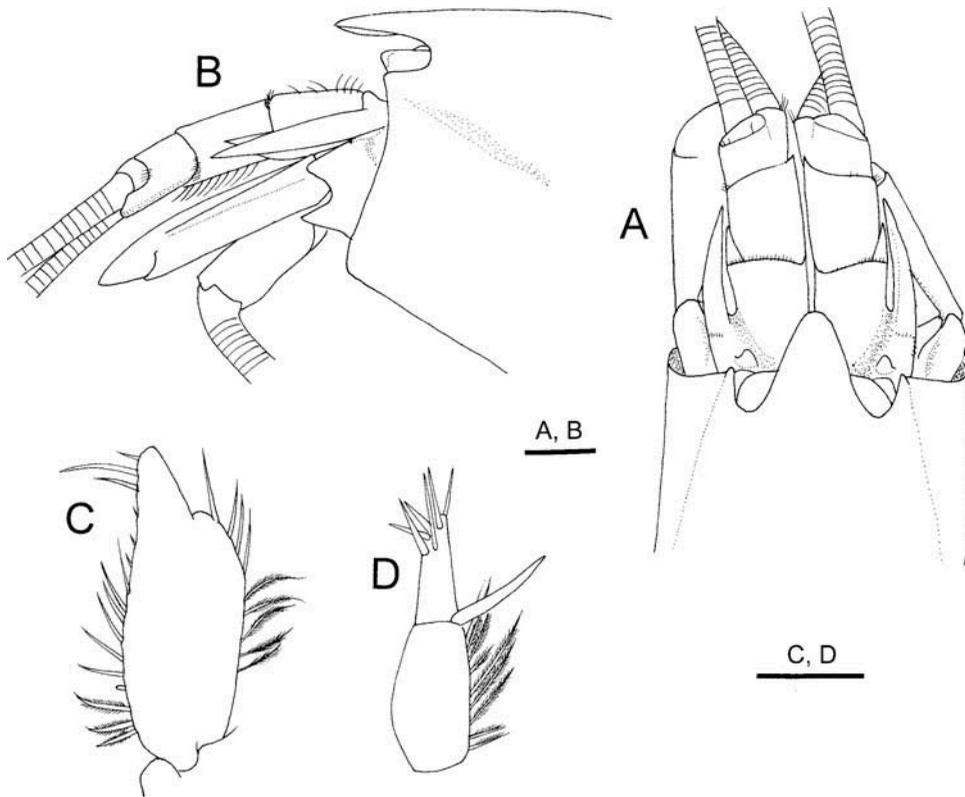


Figure 5. *Chorocaris parva* sp. nov., paratype, male (carapace length 6.9 mm), CBM-ZC 11940. (A) Anterior part of carapace and cephalic appendages, dorsal view (setae on antennal scale omitted); (B) same, lateral view; (C) endopod of left first pleopod, dorsal view; (D) appendices interna and masculina of left second pleopod, mesial view. Scale bars: 1 mm for A, B; 0.5 mm for C, D.

posterolateral angle produced into sharp or blunt tooth (sometimes different between right and left), posterior margin above angle slightly sinuous or slightly convex, unarmed. Sixth pleomere 1.4–1.5 times longer than fifth pleomere and 1.4–1.5 times longer than high, with acute posteroventral tooth, posterolateral process terminating in sharp tooth. Telson (Figure 2E) falling well short of posterior margins of uropods, slightly narrowed posteriorly, about 2.5 times longer than anterior width, armed with six to eight dorsolateral spines; posterior margin convex, with two pairs of spines at lateral angles (mesial pair longer than lateral pair), minute median tooth, and 20–24 long plumose setae (Figure 2F).

Eyes (Figure 2A,B) broadly fused with faint median notch, lacking setae on anterior surface.

Antennular peduncle (Figure 2A, B) stout, falling slightly short of or reaching distal margin of antennal scale. First segment with moderately large distolateral tooth and small distomesial tooth and blunt proximolateral tubercle; stylocerite slender, slightly curved mesially, nearly reaching distal margin of second segment.

Second segment with distomesial tooth larger than corresponding tooth on first segment.

Antennal peduncle (Figure 2A, B, G) stout. Basicerite with ventrodistal tooth extending as far as dorsodistal projection and often with blunt tooth arising from ventral surface. Fifth segment (= carpocerite) slightly overreaching midlength of antennal scale. Antennal scale suboval, 0.3–0.4 times as long as carapace, about 2.0 times longer than wide; distolateral tooth acute or subacute, closely approximated to lamella (Figure 2H).

Mouthparts typical of family (for detailed description, see Komai and Segonzac 2003, 2005; Komai et al. 2007), as figured (Figure 3A–F). Endopod of maxillule with one apical plumose seta at inner distal angle and one subterminal seta arising from base of outer lobule (Figure 3B). Maxilla (Figure 3C) with moderately broad scaphognathite, devoid of bacteriophore setae on ventral surface; posterior lobe elongate, triangular. Endopod of first maxilliped somewhat compressed, two-articulated (Figure 3E). Second maxilliped (Figure 3F) with moderately stout endopod; epipod roundly triangular, with simple rudimentary podobranch. Third maxilliped (Figure 4A) not reaching distal margin of antennal scale, moderately slender; ultimate segment tapering distally in subtruncate tip bearing two unequal spines (Figure 4B), with row of spiniform setae on lateral ridge; epipod unequally bilobed (Figure 4C).

First pereopod (Figure 4D) moderately slender, not polymorphic, reaching beyond antennal carpocerite by length of fingers, otherwise typical of family; chela (Figure 3G, H) subequal in length to carpus. Second pereopod (Figure 4E) extending to near distal end of antennal scale; chela and carpus about equal in length; fingers each terminating in distally curved, crossing tip, cutting edge pectinated with row of minute spinules; dactylus about 1.1 times as long as palm (Figure 3J). Third pereopod (Figure 4F) overreaching antennal scale by full length of propodus; dactylus somewhat compressed laterally, 0.15–0.20 times as long as propodus, terminating in strong, curved unguis, flexor surface with six to ten spinules arranged in two rows (Figure 3K, L); propodus with two rows of spinules on flexor surface, mesial row with fewer spinules (Figure 3M); carpus 0.70–0.75 times as long as propodus; ischium usually unarmed, but rarely with one minute spine ventrolaterally. Fourth pereopod (Figure 4G) similar to third pereopod in structure; ischium always unarmed. Fifth pereopod (Figure 4H) generally similar to third and fourth; dactylus similar to those of third and fourth pereopods (Figure 3N, O); propodus with lateral row of spinules consisting of six sets of two or three spinules followed by a single row of spinules, mesial row consisting of more widely spaced spinules (Figure 3P); propodus and carpus combined distinctly longer than merus and ischium combined; ischium always unarmed.

Endopod of male first pleopod (Figure 5C) bilobed distally, mesial lobe prominent, with three or four long spiniform setae directed mesially, lateral lobe obsolete; mesial margin with row of spiniform setae, proximal few plumose, lateral margin with four spiniform setae in distal 0.3 and with some plumose setae in proximal 0.6. Appendix masculina of second pleopod (Figure 5D) stout, subequal in length to appendix interna, armed distally with six to eight spiniform setae. Uropod (Figure 2E) with protopod bearing terminally blunt posterolateral process; exopod with two subequal spines at posterolateral angle.

*Size*

Males cl 4.3–6.8 mm; females cl 3.2–7.8 mm, ovigerous females cl 5.7–6.7 mm.

*Coloration*

Not known.

*Distribution*

Known only from two hydrothermal vent sites in Manus Basin, southwestern Pacific: South Su site, 1305–1310 m; PACMANUS site, 1684 m depth.

*Remarks*

*Chorocaris parva* sp. nov. is morphologically most similar to *C. susannae* comb. nov. known from the southern Mid-Atlantic Ridge in having the pterygostomial angle of the carapace only slightly produced, having less numerous accessory spinules on the flexor faces of the third to fifth pereopods (six to eight arranged in two rows versus 10–16 arranged in three or four rows) and in its relatively small body size (maximum cl < 8.0 mm). In the other four species of *Chorocaris*, the pterygostomial angle of the carapace is produced into a prominent tooth (*C. paulexa*, *C. vandoverae* and *C. variabilis* sp. nov.) or a broadly rounded lobe (*C. chacei*); and the body size is larger (attaining more than 8.0 mm cl). This new species is morphologically distinguished from *C. susannae* by the following characters: (1) the fourth pleonal pleuron is unarmed in *C. parva*, rather than armed with a posteroventral tooth and additional marginal denticles as in *C. susannae*; (2) the fifth pleonal pleuron bears only a posteroventral tooth in *C. parva*, whereas it is armed with up to three denticles on the posterolateral margin in addition to having a posteroventral tooth in *C. susannae*, is frequently only bluntly pointed in *C. parva*, rather than terminating in an acute tooth in *C. susannae*.

*Etymology*

The Latin *parvus* (= small), in reference to the small body size of this new species.

***Chorocaris variabilis* sp. nov.**  
(Figures 6–10)

*Chorocaris* sp. – Zelnio and Hourdez 2009: 52.

*Material examined*

*Holotype*. Wave Mercury 2007 (Luk Luk) Campaign, dive 28, South Su, Manus Basin, Bismarck Sea, 03°08.09' S, 152°10.5' E, 1310 m, 10 April 2007, female (cl 13.6 mm), CBM-ZC 11,945.

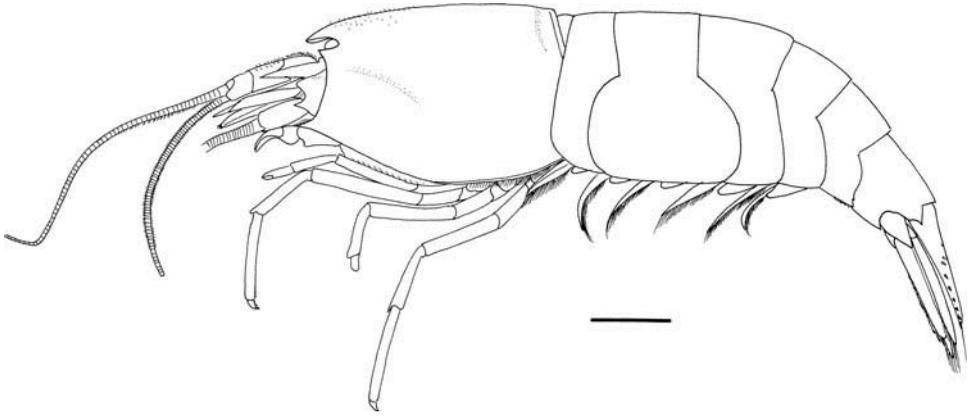


Figure 6. *Chorocaris variabilis* sp. nov., holotype, female (carapace length 13.6 mm), CBM-ZC 11945, entire animal in lateral view (fourth pereopod in process of regeneration). Scale bar: 5 mm.

#### *Paratypes*

**Manus Basin.** Wave Mercury 2007 (Luk Luk) Campaign, same data as holotype, 10 males (cl 5.2–9.1 mm), CBM-ZC 11946; same data as holotype, 14 females (cl 6.5–12.9 mm), 6 ovigerous females (cl 10.7–13.5 mm), CBM-ZC 11947; dive 30, South Su, 3°08.09' S, 152°10.5' E, 1305 m, 11 April 2007, 9 males (cl 10.6–11.9 mm), CBM-ZC 11948; same data, 6 females (cl 13.3–15.0 mm), 1 ovigerous female (cl 12.8 mm), CBM-ZC 11949; dive 34, same site, 1310 m, 14 April 2007, 13 males (cl 6.6–9.0 mm), 9 females (cl 5.0–12.0 mm), 1 ovigerous female (cl 9.6 mm), CBM-ZC 11950; dive 53, Solwara 1, 03°07.91' N, 152°09.1' E, 1570 m, 25 April 2007, 27 males (cl 5.1–7.5 mm), CBM-ZC 11951; same data, 26 females (cl 4.4–10.4 mm), 14 ovigerous females (cl 6.7–9.4 mm), CBM-ZC 11952; same data, 22 males (cl 4.8–7.2 mm), 14 females (cl 5.2–12.0 mm), 3 ovigerous females (cl 9.6–14.0 mm), OUMNH.ZC.2014–01–015. RV *Yokosuka*, YK06-13 cruise, DS *Shinkai 6500*, dive #978, PACMANUS site, 03°43.60' S, 151°40.32' E, 1683 m, 16 September 2006, 1 male (cl 8.2 mm), 1 female (cl 7.6 mm), 1 ovigerous female (cl 10.8 mm), JAMSTEC 066720–066722; DS *Shinkai 6500*, dive #981, Vienna Woods, 03°09.813' S, 151°16.737' E, 2480 m, 14 September 2006, 1 ovigerous female (cl 10.3 mm), JAMSTEC 068873; DS *Shinkai 6500* dive #982, PACMANUS site, 03°43.608' S, 151°40.328' E, 1684 m, 20 September 2006, 3 specimens (not measured; DNA extracted, preserved in frozen condition), JAMSTEC 070103–070105. **North Fiji Basin.** RV *Yokosuka*, YK06-13 cruise, DS *Shinkai 6500*, dive #985, Mussel Hill site, 16°54.444' S, 173°54.895' E, 1988 m, 2 October 2006, 8 males (cl 4.9–7.1 mm), 2 females (cl 5.4, 7.0 mm), JAMSTEC 070543–070552; same data, 1 specimen (not measured; DNA extracted, preserved in 99% ethanol), JAMSTEC 070543. **Vanuatu.** RV *Sonne*, SO229-060-N201, Nifonea vent field, 18°07.735' S, 169°31.112' E, 1873 m, 14 July 2013, 9 males (cl 6.6–9.3 mm), 3 females (cl 6.7–7.7 mm), 1 ovigerous female (cl 7.6 mm), CBM-ZC 12,481.

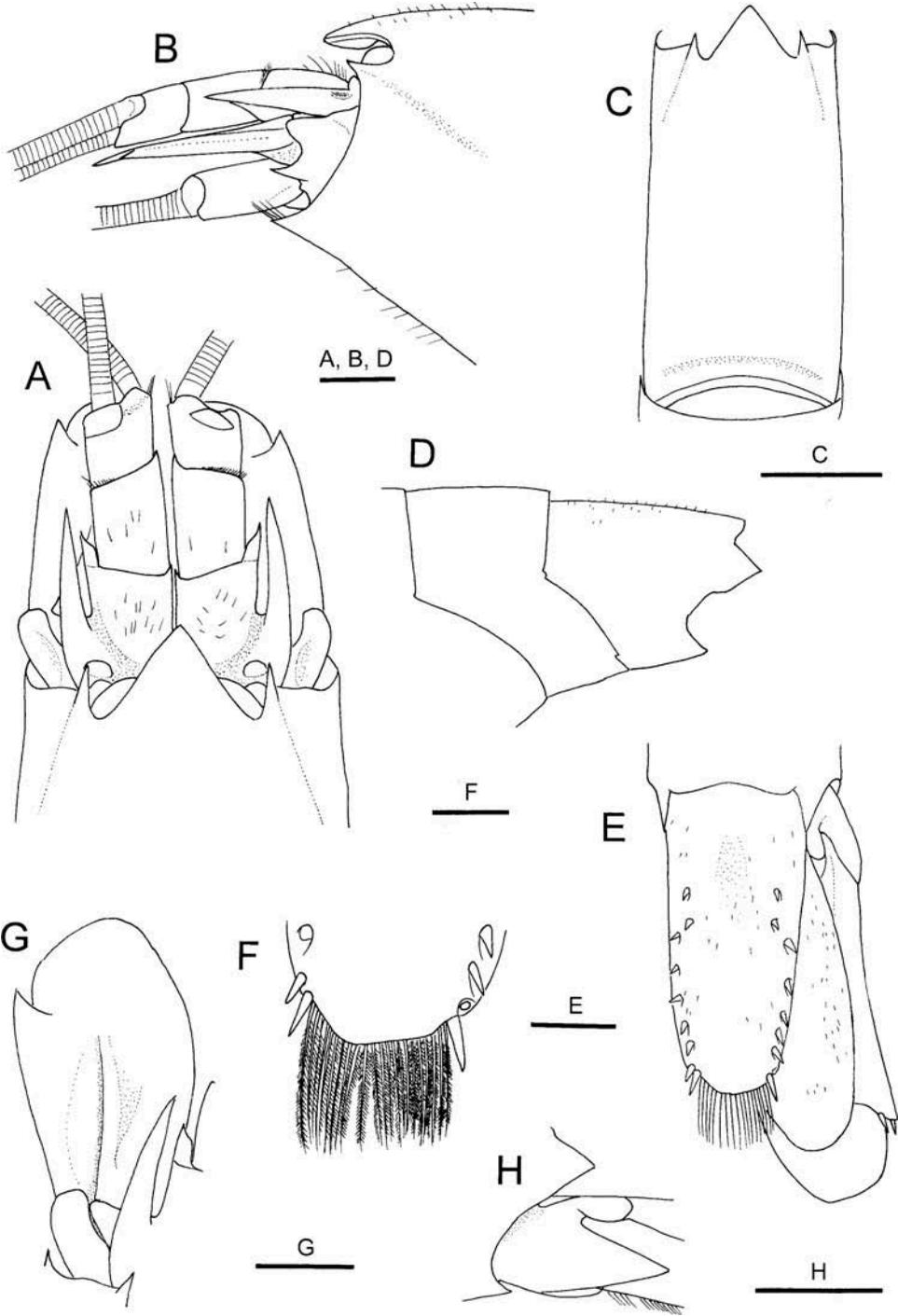


Figure 7. *Chorocaris variabilis* sp. nov., holotype, female (carapace length 13.6 mm), CBM-ZC 11945. (A) Anterior part of carapace and cephalic appendages, dorsal view; (B) same, lateral view; (C) carapace, dorsal view; (D) fifth and sixth pleomeres, left side, lateral view; (E) telson and right uropod, dorsal view (marginal setae on uropod omitted); (F) posterior part of telson, dorsal view (slightly deformed); (G) left antennal scale, dorsal view (setae omitted); (H) protropod of right uropod, dorsolateral view. Scale bars: 5 mm for C; 2 mm for A, B, D, E, G, H; 1 mm for F.

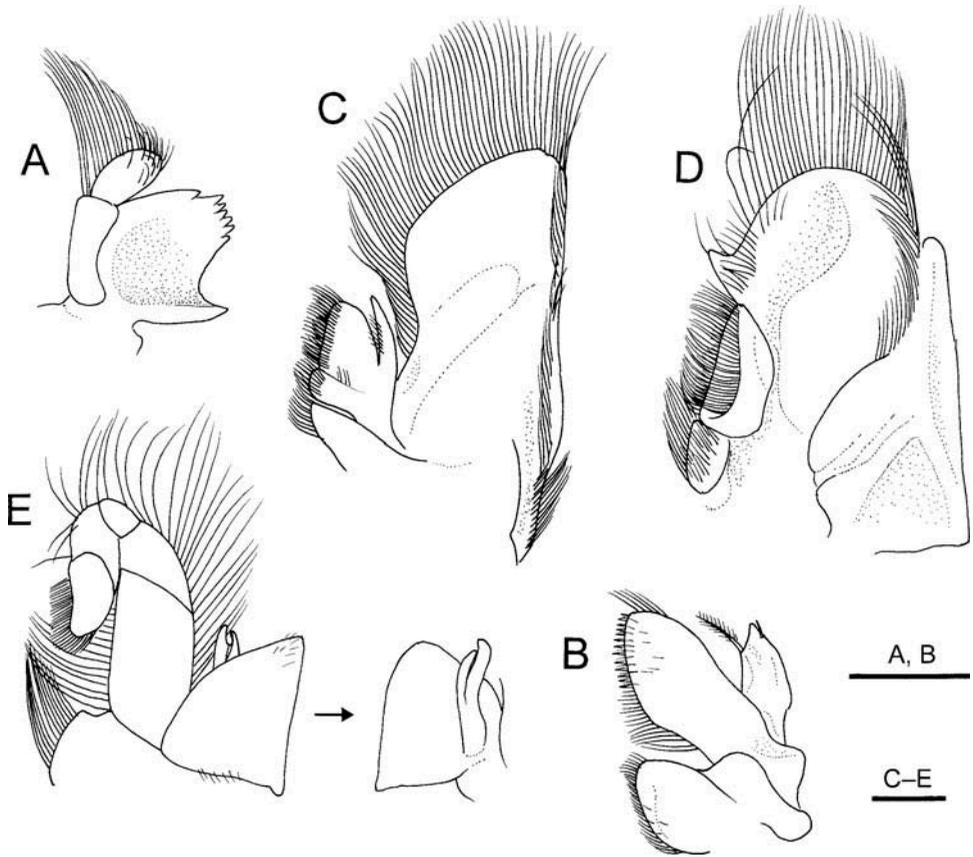


Figure 8. *Chorocaris variabilis* sp. nov., holotype, female (carapace length 13.6 mm), CBM-ZC 11945. Left mouthparts. (A) Mandible, inner view; (B) maxillule, outer view; (C) maxilla, outer view (posterior lobe of scaphognathite broken off); (D) first maxilliped, outer view; (E) left second maxilliped, outer view; inset, epipod and podobranch, inner view. Scale bars: 1 mm.

*Non-type*. Vanuatu: same data as CBM-ZC 12481, 2 juveniles (cl 3.8, 3.9 mm), CBM-ZC 12,482.

### Description

*Females*. Body integument smooth, shiny, fairly thin, with scattered short setae, more numerous on dorsal side.

Rostrum (Figure 7A–C) falling slightly short of midlength of first segment of antennular peduncle, triangular in dorsal view; tip varying from blunt (ovigerous females) to acute or subacute (non-ovigerous females); dorsal surface smooth. Carapace (Figures 6, 7A–C, 10G–J) compressed laterally; dorsal surface sloping down anteriorly to rostrum; antennal tooth triangular, acute (non-spawning females) or acute to blunt (spawning females); pterygostomial angle strongly produced

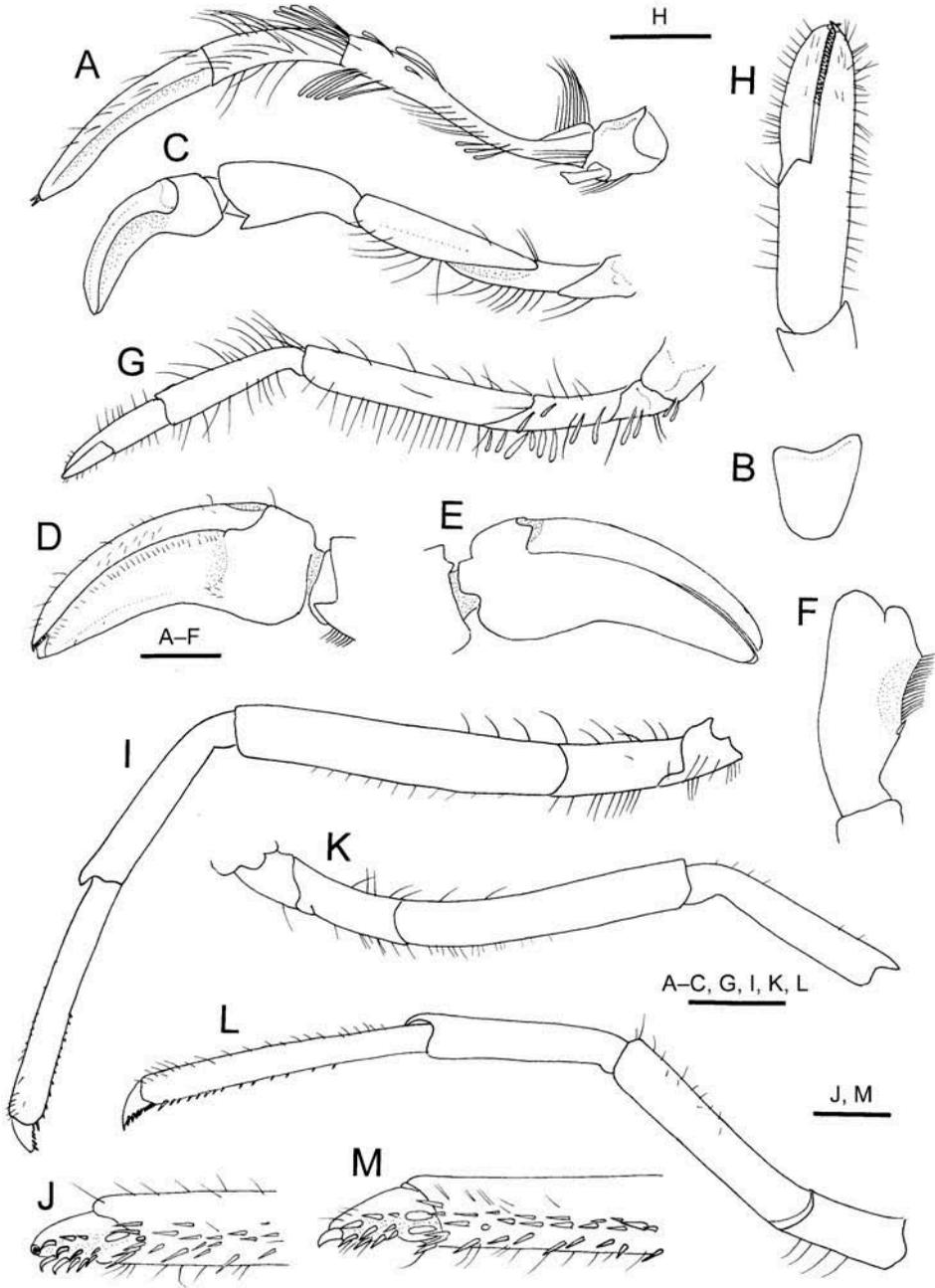


Figure 9. *Chorocaris variabilis* sp. nov., holotype, female (carapace length 13.6 mm), CBM-ZC 11945. (A) Left third maxilliped, lateral view; (B) same, epipod, dorsal view; (C) left first pereopod, lateral view; (D) same, chela, inner (flexor) view; (E) same, chela, outer (extensor) view; (F) same, carpus, mesial view, showing grooming apparatus; (G) left second pereopod, lateral view; (H) same, chela, extensor view; (I) left third pereopod, lateral view; (J) same, dactylus and distal part of propodus, flexor view; (K) right fourth pereopod (distal 2 segments missing); (L) left fifth pereopod, lateral view; (M) same, dactylus and distal part of propodus, flexor view. Scale bars: 2 mm for A–C, G, I, K, L; 1 mm for D–F, H; 0.5 mm for J, M.

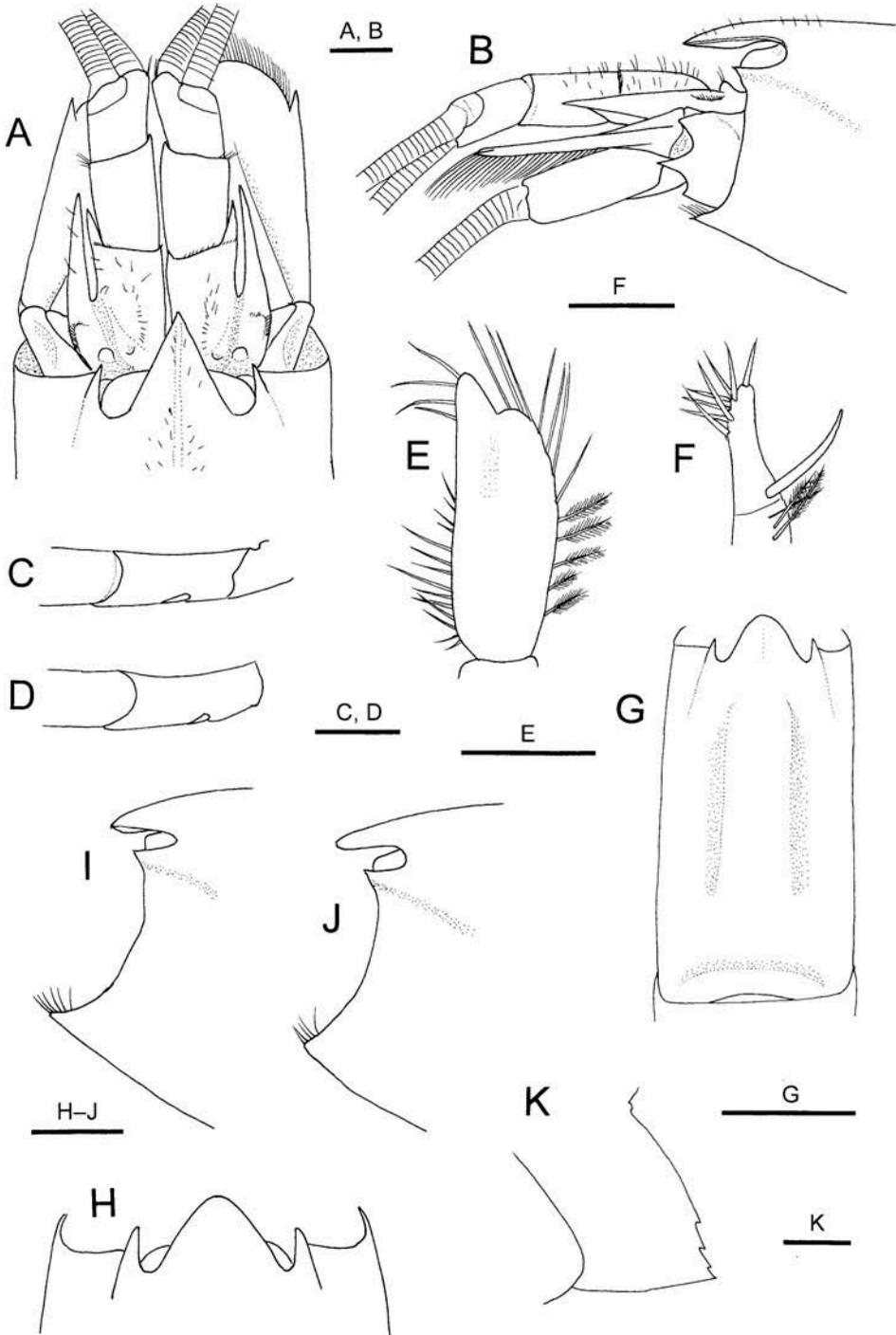
anteriorly in acute or subacute tooth extending as far as dorsolateral process of antennal basicerite.

Third pleonal pleuron (Figure 6) broadly rounded, always unarmed; fourth pleuron rounded or bluntly angular posteroventrally, without sharp tooth (Figures 7D, 10K); fifth pleuron usually with small posteroventral tooth and with zero to four tiny denticles on sinuous to convex posterolateral margin (Figures 7D, 10K). Sixth pleomere (Figure 7D) about 1.2 times longer than fifth pleomere and about 1.1 times longer than high, having acute or subacute posteroventral tooth, posterolateral process terminating in sharp tooth. Telson (Figure 7E) about 2.2 times longer than anterior width, falling short of posterior margins of uropods, very slightly narrowed posteriorly, normally armed with six to eight dorsolateral spines arranged in sinuous row; posterior margin convex, occasionally with minute median denticle or tooth and with two pairs of spines at lateral angles and 20–24 long plumose setae (Figure 7F).

Eyes (Figure 7A, B) lacking setae on anterior surface. Antennular peduncle (Figure 7A, B) stout, reaching distal margin of antennal scale; first segment with moderately large distolateral and small distomesial teeth and prominent, blunt proximolateral tubercle; stylocerite slender, nearly straight, falling slightly short of distal margin of second segment; second segment 1.0–1.1 times as long as wide, with distomesial tooth subequal in size to corresponding tooth on first segment; flagella moderately slender. Antennal peduncle (Figure 7A, B, G) stout; basicerite with ventrodistal tooth overreaching dorsodistal projection; fifth segment (= carpocerite) slightly overreaching midlength of antennal scale; antennal scale suboval, about 0.4 times as long as carapace, 1.6 times longer than wide, lateral margin almost straight, but convex near distolateral tooth, distolateral tooth acute or subacute, clearly separated or approximated to lamella.

Mouthparts generally similar to those of *C. parva* sp. nov., as figured (Figures 8A–E, 9A). Second maxilliped (Figure 8E) relatively stout. Epipod of third maxilliped nearly trapezoidal, slightly unequally bilobed (Figure 9B).

First pereopod (Figure 9C–E) reaching or slightly overreaching midlength of antennal scale, moderately slender to robust, polymorphic as in *C. vandoverae* and *C. paulexa*. Second to fifth pereopods relatively stout. Second pereopod (Figure 9G) reaching as far as first pereopod; chela 0.6–0.8 times as long as carpus; dactylus 1.1–1.2 times longer than palm (Figure 9H). Third pereopod (Figure 9I) overreaching antennal scale by half to full length of propodus; dactylus somewhat compressed laterally, 0.15–0.20 times as long as propodus, terminating in strong, curved unguis, flexor surface with 10–16 accessory spinules arranged in three or four irregular rows (Figure 9J); propodus with spinules arranged in two separate rows or double row on flexor surface (Figure 9J); carpus 0.75–0.90 times as long as propodus; merus unarmed; ischium usually unarmed, but rarely with one tiny spine. Fourth pereopod (Figure 9K) similar to third pereopod in structure; ischium always unarmed. Fifth pereopod (Figure 9L) generally similar to third and fourth; propodus with both lateral and mesial rows of spinules, each arranged into double row (spinules more numerous in lateral row than mesial row) (Figure 9M); propodus and carpus combined distinctly longer than merus and ischium combined; carpus 0.6–0.7 times as long as propodus; ischium always unarmed.



Appendices internae on second to fourth pereopods simple, on fifth pereopod normally developed, bearing terminal cluster of coupling hooks. Uropod (Figure 7E) with protopod (Figure 7H) bearing subacute to acute posterolateral process; rami both overreaching posterior margin of telson; exopod slightly longer than endopod, with subequal posterolateral spines.

*Males.* Body less robust than in females. Rostrum (Figure 10A, B) acutely pointed, occasionally faintly carinate on dorsal midline. Carapace with sharp antennal tooth (Figure 10B); pterygostomial process narrower than in females, sharply pointed (Figure 10B). Pleon with fourth pleuron armed with small acute posteroventral tooth; fifth pleuron also with sharp posteroventral tooth and additional one to three small teeth or denticles on posterolateral margin. Antennal scale 1.8–1.9 times longer than wide; distolateral tooth more slender than in females, always clearly separated from lamella, acute (Figure 10A). Pereopods more slender than in females; ischium of third pereopod unarmed or armed with one spine, of fourth pereopod usually unarmed, but rarely armed with one spine (Figure 10C, D), and of fifth pereopod always unarmed. Endopod of first pleopod (Figure 10E) bilobed distally, mesial lobe prominent, with three or four long spiniform setae mesially, lateral lobe rather obsolete, also with row of spiniform setae extending onto lateral margin, proximal four or five of these setae bearing setules; mesial margin with row of spiniform setae. Appendix masculina of second pleopod (Figure 10F) stout, slightly longer than appendix interna, armed with about 10 spiniform setae distally. Posterolateral process of uropodal protopod acuminate.

*Juveniles.* Generally similar to adults, but body more compressed laterally. Rostrum rounded distally. Eyes each with minute tubercle on anterior surface dorsomesially.

#### *Size*

Males cl 4.8–11.9 mm; females cl 4.4–15.0 mm, ovigerous females cl 6.7–13.5 mm.

#### *Coloration in life*

Not known.

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Figure 10. *Chorocaris variabilis* sp. nov. (A–F) Paratype, male (carapace length 8.3 mm), JAMSTEC 066720–066722; (G–I, K) paratype, ovigerous female (carapace length 12.0 mm), OUMNH.ZC.2014-01-015; (J) paratype, ovigerous female (carapace length 12.1 mm), OUMNH.ZC.2014-01-015. (A) Anterior part of carapace and cephalic appendages, dorsal view; (B) same, lateral view; (C, D) ischia of third and fourth pereopods, lateral view; (E) endopod of left first pleopod, dorsal view; (F) appendices interna and masculina of left second pleopod, mesial view; (G) carapace, dorsal view; (H) anterior part of carapace, dorsal view; (I, J) same, lateral view; (K), fifth pleonal pleuron, left side, lateral view. Scale bars: 5 mm for G; 2 mm for H–J; 1 mm for A–E, K; 0.5 mm for F.

### Distribution

Hydrothermal vents in southwestern Pacific. Manus Basin: South Su, 1305–1310 m; Solwara 1, 1570 m; PACMANUS, 1683–1684 m; Vienna Woods, 2480 m. North Fiji Basin: Mussel Hill, 1988 m. Vanuatu: Nifonea vent field, 1873 m.

### Remarks

The material of this new species came from three hydrothermal vent sites in the southwestern Pacific, i.e. Manus Basin, North Fiji Basin and Vanuatu. The specimens from the three locations are morphologically very similar. Of the four specimens used in the molecular phylogenetic analysis (see below), three specimens came from the Manus Basin, and one specimen was from the North Fiji Basin. The maximum genetic divergence among the four specimens is 1.8% (Table 1). Consequently it is reasonable to consider that these specimens represent a single species.

*Chorocaris variabilis* sp. nov. exhibits a substantial degree of variation in the shape of the rostrum and of the carapace teeth (see above). Males and non-spawning females differ from spawning females in having an acuminate rostrum with an occasionally faintly carinate dorsal surface (males), a sharply pointed antennal tooth and branchiostegal tooth on the carapace, and a clearly separated distolateral tooth on the antennal scale. Spawning females are characterized by the bluntly pointed rostrum, and antennal and branchiostegal teeth on the carapace.

*Chorocaris variabilis* sp. nov. is morphologically very similar to *C. paulexa* and *C. vandoverae* particularly in the prominent pterygostomial tooth on the carapace and the possession of 10–16 accessory spinules arranged in three or four rows on the flexor faces of the dactyli of the third to fifth pereopods. Nevertheless, *C. variabilis* differs from these two species in the possession of a conspicuous posteroventral tooth and additional denticles on the fifth pleonal pleuron and in the absence of setae on the anterior face of each eye. In *C. paulexa* and *C. vandoverae*, the posteroventral angle of the fifth pleonal pleuron is rounded or at most angular and the eye has several stiff setae on the anterior face. Furthermore, although somewhat variable in *C. variabilis*, the ventral surface of the rostrum is usually less convex than in *C. paulexa* and *C. vandoverae*.

*Chorocaris vandoverae* does not exhibit strong variation between males and non-spawning females on the one hand, and spawning females (Komai and Segonzac 2008). Hence, males and non-spawning females of this new species are readily distinguished from those of *C. vandoverae* by the acuminate rostrum and sharply pointed antennal and pterygostomial teeth on the carapace. In *C. vandoverae*, the rostrum is rounded distally, the pterygostomial tooth is more bluntly pointed, and the posterolateral angle of the fifth pleonal pleuron is at most subacute and devoid of additional denticles on the posterolateral margin. Furthermore, the armature of the appendix masculina of the second pleopod may be different between *C. variabilis* and *C. vandoverae*. In the new species, spiniform setae are restricted to the distal half of the appendix masculina, while similar spiniform setae form a row extending proximally beyond the midlength of the appendix masculina in *C. vandoverae*. With regard to spawning females, *C. variabilis* is distinguished from *C. vandoverae* in possessing a sharp posteroventral tooth on the fifth pleonal pleuron and a more sharply pointed protopod of the uropod.

Table 1. Pairwise nucleotide divergences with Kimura two-parameter distance of the partial cytochrome c oxidase subunit I (COI) sequences among the seven alvinocaridid species clustered in a single clade.

	<i>Chorocaris parva</i> sp. nov.	<i>Chorocaris variabilis</i> sp. nov.	<i>Chorocaris vandoverae</i>	<i>Chorocaris chacei</i>	<i>Rimicaris exoculata</i>	<i>Rimicaris hybisae</i>	<i>Opaepele loihi</i>
<i>Chorocaris parva</i> sp. nov.	0.005	0.055–0.067	0.066–0.070	0.079–0.083	0.070–0.074	0.095–0.098	0.111–0.115
<i>Chorocaris variabilis</i> sp. nov.		0.003–0.018	0.064–0.070	0.070–0.081	0.061–0.072	0.090–0.100	0.094–0.100

Note: Seven species are, *Chorocaris variabilis* sp. nov., *Chorocaris parva* sp. nov., *Chorocaris vandoverae* Martin and Hessler, 1990, *Chorocaris chacei* (Williams and Rona 1986), *Rimicaris exoculata* Williams and Rona, 1986, *Rimicaris hybisae* Nye, Copley and Plouviez, 2012 and *Opaepele loihi* Williams and Dobbs, 1995.

No information on the male is available for *C. paulexa* (cf. Martin and Shank 2005). Therefore variability between males and females in this species remains unknown. Nevertheless, the rostrum is proportionally narrower in *C. variabilis* than in *C. paulexa* (see Martin and Shank 2005; Komai and Segonzac 2008). In addition, the third to fifth pereopods seem to be more slender in this new species than in *C. paulexa*, but the significance of this character may be questionable because of intraspecific variation (as seen in other confamilial or congeneric species; see Komai and Segonzac 2003, 2004, 2008).

Records of *C. vandoverae* from hydrothermal vents on the North Fiji Basin (Desbruyères et al. 1994) and the Lau Basin (Desbruyères et al. 1994; Zelnio and Hourdez 2009) are referred to *C. variabilis* on the basis of the close morphological similarity between *C. vandoverae* and this new species, and their geographical distribution. *Chorocaris* sp. 2 reported from the Manus Basin by Zelnio et al. (2010) corresponds to *C. variabilis*. Consequently the occurrence of *C. vandoverae* outside the Mariana Back Arc Basin is unconfirmed.

*Etymology.* From the Latin *variabilis* (= variable) in reference to the substantial morphological variation seen in this new species.

#### *Manuscaris* gen. nov.

##### *Type species*

*Manuscaris acuminatus* sp. nov.

##### *Composition*

Monotypic

##### *Diagnosis*

Rostrum narrowly triangular in dorsal view, slightly overreaching distal margin of first segment of antennular peduncle; dorsal margin sharply carinate, armed with row of conspicuous teeth, posteriormost tooth located just posterior to rostral base; ventral margin nearly flat, with minute denticle subterminally. Carapace with low, blunt postrostral carina not extending to midlength; antennal tooth acuminate, with small lobe ventromesial to its base; pterygostomial tooth strong, acuminate; anterior part of branchial region not inflated. Third to fifth pleonal pleura at least with posteroventral tooth. Telson with dorsolateral spines in linear row; posterior margin convex, with row of plumose setae flanked by two pairs of lateral spines. Eyes fused, though shallow median notch evident; anterior surface of each eye flat, unarmed. Antennular stylocerite well separated from first peduncular segment. Antenna not forming operculate structure (see Martin and Hessler 1990); antennal scale with sharp distolateral tooth clearly separated from lamella; no transverse suture extending mesially from base of distolateral tooth. First maxilliped with rudimentary bud of exopodal flagellum. First pereopod with well-developed grooming apparatus on carpus consisting of patch of setae and one small spine. Second pereopod with

spine on ischium. Third pereopod shorter than fifth pereopod; dactyli with accessory spinules on flexor margins arranged in two rows; meri of third and fifth pereopods unarmed; ischia of third pereopods with two spines. No strap-like epipods on third maxilliped to fourth pereopods. Appendix interna of fourth pleopod without terminal cluster of coupling hooks. Uropodal exopod with one spine just mesial to sharp posterolateral tooth; protopod terminating posterolaterally in sharp tooth.

#### Remarks

*Manuscaris* gen. nov. appears to be close to a group of genera that includes *Alvinocaridinides*, *Shinkaicaris*, *Opaepele*, *Chorocaris* and *Rimicaris* based on sharing the following apparently apomorphic characters: rostrum more or less reduced in length with reduced ventral limb; eyes broadly fused with shallow median notch, each anterior surface rather flat and unarmed; dactyli of third to fifth pereopods each with accessory spinules arranged in two or more rows; and meri of third to fifth pereopods devoid of spines. Nevertheless, the new genus is excluded from this group by the dorsolateral spines on the telson arranged in a linear row and the presence of spines on the ischia on the third and fourth pereopods, which are presumably plesiomorphic characters (cf. Komai and Segonzac, 2005).

#### Etymology

A combination of the name of the type locality (Manus Basin) and the Greek *caris* (= shrimp). Gender: masculine.

#### *Manuscaris acuminatus* sp. nov. (Figures 11–14)

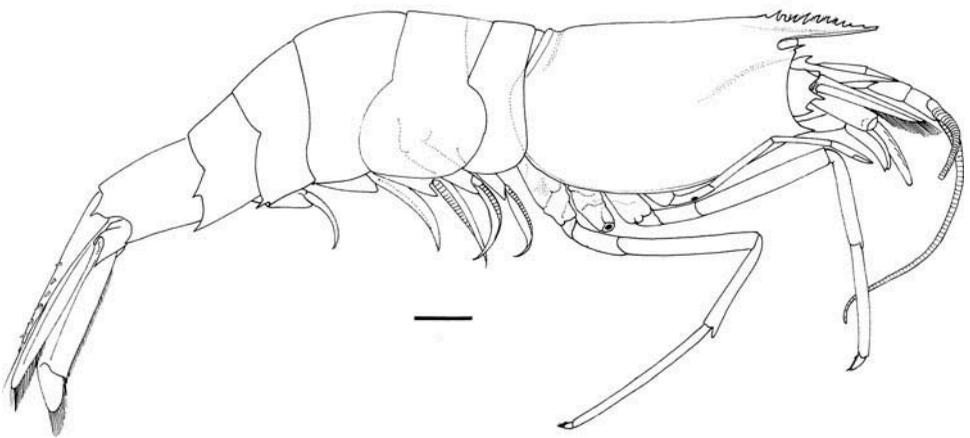
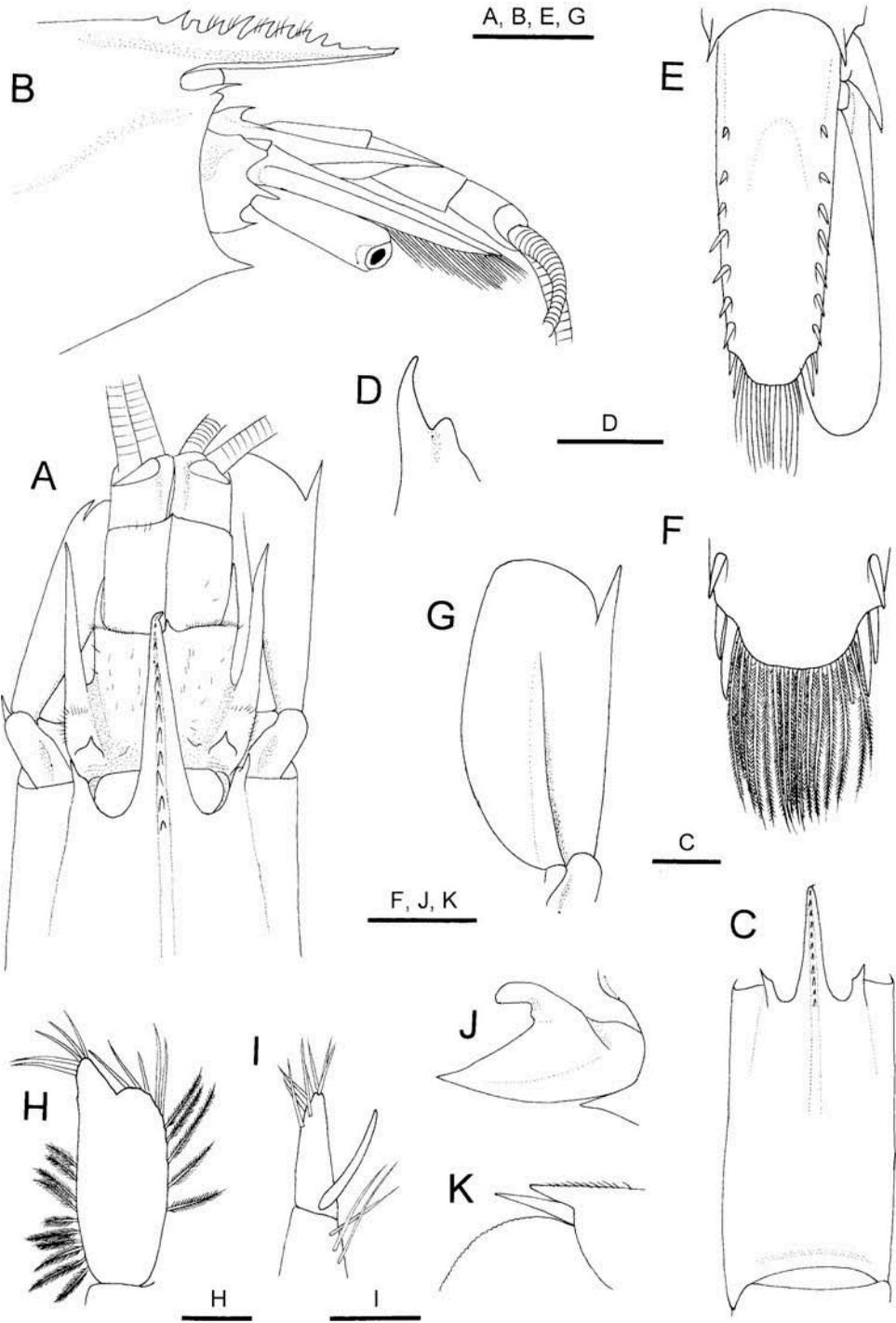


Figure 11. *Manuscaris acuminatus* gen. et sp. nov., holotype, male (carapace length 8.4 mm), CBM-ZC 11955, entire animal in lateral view. Scale bar: 2 mm.



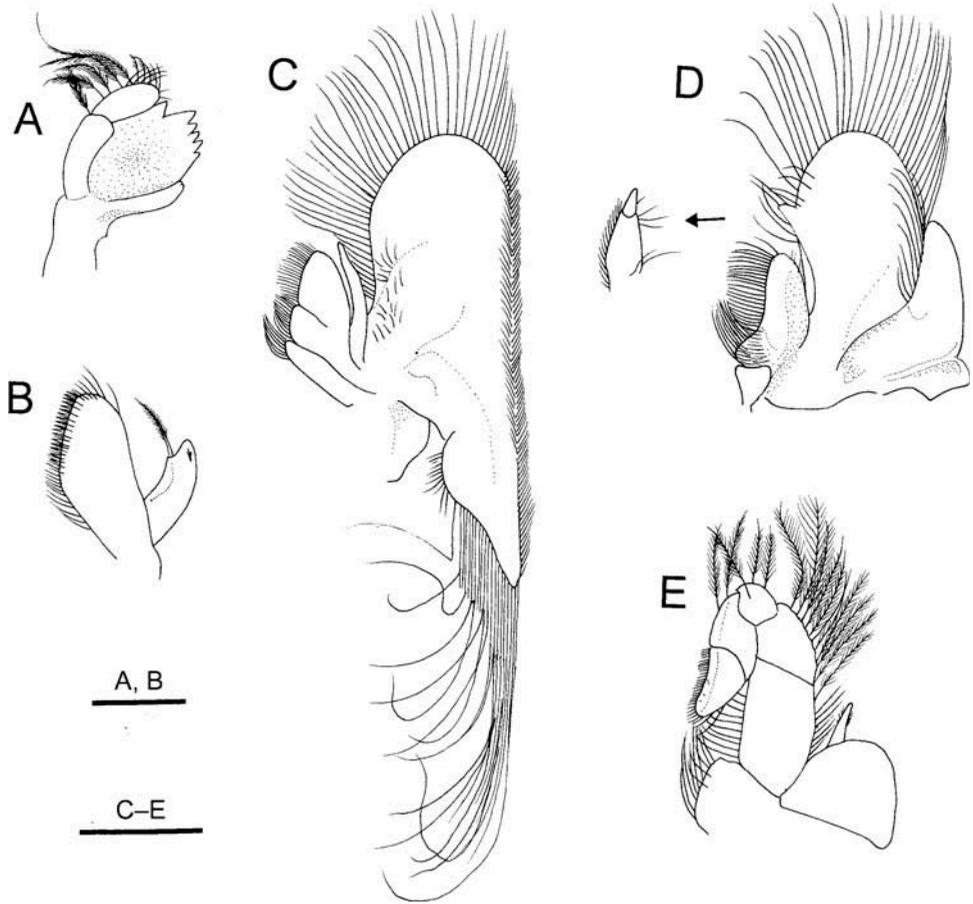
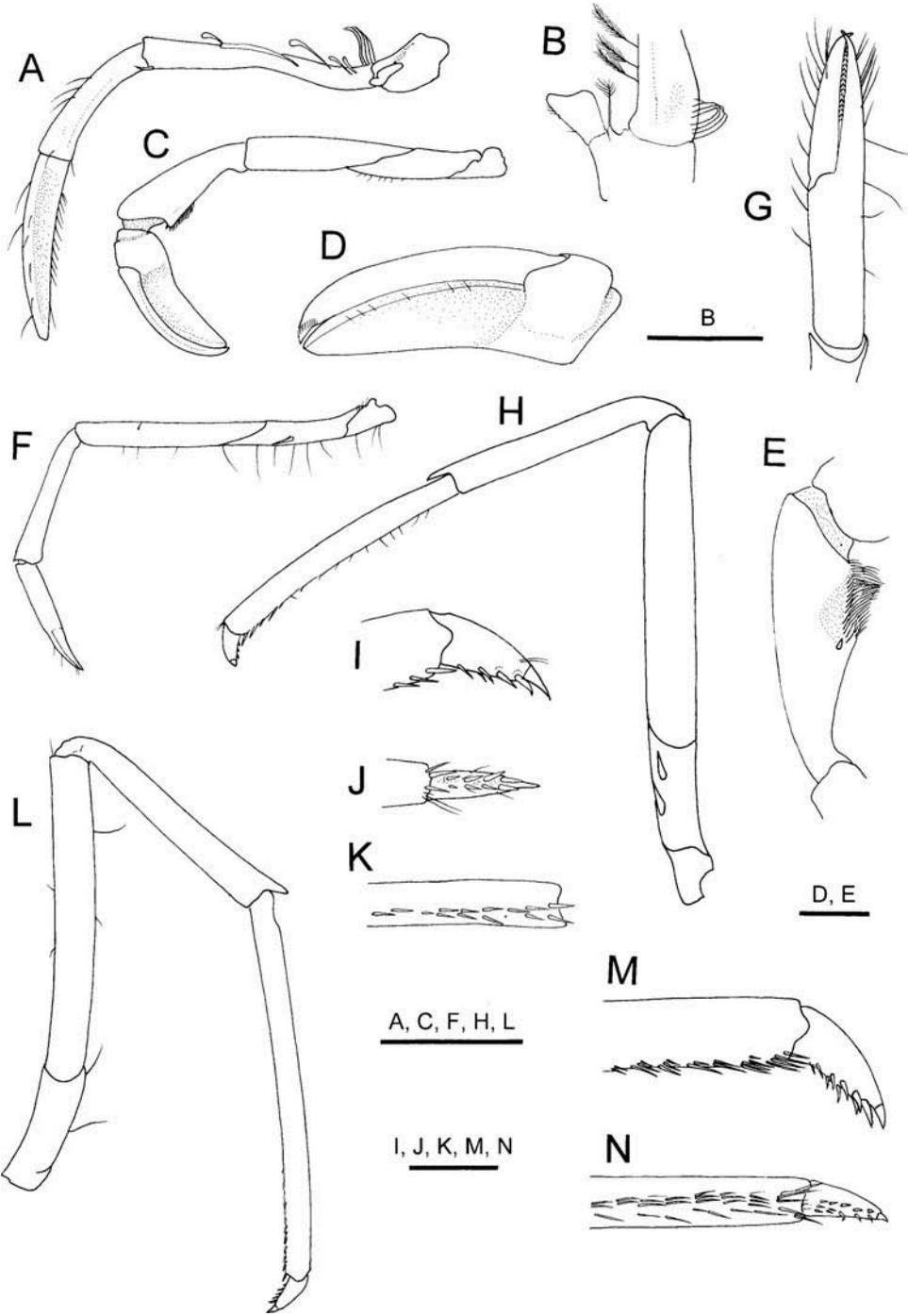


Figure 13. *Manuscaris acuminatus* gen. et sp. nov., holotype, male (carapace length 8.4 mm), CBM-ZC 11955. Left mouthparts. (A) Mandible, inner view; (B) maxillule, outer view (coxal endite missing); (C) maxilla, outer view; (D) first maxilliped, outer view; inset, endopod, inner view; (E) left second maxilliped, outer view. Scale bars: 1 mm for C–E; 0.5 mm for A, B.

#### Type material

Holotype. Wave Mercury 2007 Campaign, dive 35, South Su, Manus Basin, 3°08.09' N, 152°10.5' E, 1310 m, 15 April 2007, male (cl 8.4 mm), CBM-ZC 11,955.

Figure 12. *Manuscaris acuminatus* gen. et sp. nov., holotype, male (carapace length 8.4 mm), CBM-ZC 11955. (A) Anterior part of carapace and cephalic appendages, dorsal view; (B) same, lateral view; (C) carapace, dorsal view; (D) left antennal tooth on carapace, dorsal view; (E) telson and right uropod, dorsal view (marginal setae on uropod omitted); (F) posterior part of telson, dorsal view; (G) right antennal scale, dorsal view (setae omitted); (H) endopod of left first pleopod, dorsal view; (I) appendices interna and masculina of left second pleopod, mesial view; (J) protopod of right uropod, dorsolateral view; (K) posterolateral part of left uropodal exopod, dorsal view. Scale bars: Scale bars: 2 mm for A–C, E, G; 1 mm for F, J, K; 0.5 mm for D, H, I.



*Description of holotype*

Body integument fairly thin, almost glabrous on surface.

Rostrum (Figure 12A, B) narrowly triangular in dorsal view, slightly overreaching distal margin of first segment of antennular peduncle, about 0.4 times as long as carapace; dorsal margin carinate, with 11 unequal teeth, posteriormost and distal two teeth distinctly smaller than other teeth, posteriormost tooth located slightly posterior to orbital margin; sparse short setae on proximal five teeth; ventral surface nearly flat (non-carinate), with minute denticle subterminally; ventrolateral carina sharply defined, merging into orbital margin. Carapace (Figures 11, 12C) with low, blunt postrostral carina not extending to midlength, so dorsal margin in lateral view nearly straight; antennal tooth slender, acuminate, with small blunt lobe ventromesial to its base; pterygostomial tooth strong, reaching slightly beyond tip of antennal tooth; anterior part of branchial region not inflated.

Pleon as figured (Figure 11). Third pleuron with one small posteroventral tooth; fourth pleuron with one rather strong posteroventral tooth and one much smaller additional tooth anterior to it on ventral margin; fifth pleuron with strong posteroventral tooth and one additional conspicuous tooth on posterolateral margin. Sixth pleomere 1.6 times as long as fifth pleomere and 1.2 times longer than high, with strong, acute posteroventral tooth; posterolateral process terminating in sharp tooth. Telson (Figure 12E) 3.1 times longer than anterior width, armed with seven dorso-lateral spines arranged in linear row on either side and two pairs of posterolateral spines; posterior margin with 14 long plumose setae (Figure 12F).

Eyes (Figure 12B) broadly fused, but with shallow median groove, closely approximated to ventral face of rostrum; each anterior surface nearly flat, unarmed.

Antennular peduncle (Figure 12A, B) reaching distal margin of antennal scale. First segment with forwardly directed, spiniform proximolateral tubercle; distolateral tooth long, slender, reaching beyond midlength of second segment, distomesial margin with small tooth; stylocerite slender, slightly diverging, reaching nearly to distal margin of second segment. Second segment 1.6 times as long as wide, with small distomesial tooth.

Antenna (Figure 12A, B) with basicerite bearing a slender ventrolateral tooth and a sharp ventral tooth. Carpocerite moderately stout, slightly overreaching midlength of antennal scale. Antennal scale about 0.5 times as long as carapace and 2.2 times longer than wide; lateral margin nearly straight; distolateral tooth slender, clearly separated from distal lamella by rather narrow, deep notch, tooth reaching distal margin of lamella; no suture mesial to base of distolateral tooth; dorsal carina distinct, slightly diverging from lateral margin; distal lamella rounded.

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Figure 14. *Manuscaris acuminatus* gen. et . sp. nov., holotype, male (carapace length 8.4 mm), CBM-ZC 11955. (A) Left third maxilliped, lateral view; (B) same, epipod, dorsal view; (C) left first pereopod, lateral view; (D) same, chela, inner (flexor) view; (E) same, carpus, mesial view, showing grooming apparatus; (F) left second pereopod, lateral view; (G) same, chela, extensor view; (H) left third pereopod, lateral view; (I) dactylus and distal part of propodus of right third pereopod, lateral view; (J) dactylus of right third pereopod, flexor view; (K) distal part of propodus of right third pereopod, flexor view; (L) right fifth pereopod, lateral view; (M) same, dactylus and distal part of propodus, lateral view; (N) same, flexor view. Scale bars: 2 mm for A, C, F, H, L; 1 mm for B; 0.5 mm for D, E, I–K, M, N.

Mandible (Figure 13A) with terminally blunt molar process; incisor process with six triangular teeth mesially. Maxillule (Figure 13B) endopod slightly bilobed, distomesial lobe with one apical plumose seta, distolateral lobe with two minute submarginal setae. Maxilla (Figure 13C) with scaphognathite moderately broad, with some short facial setae restricted to mesial part. First maxilliped (Figure 13D) with rudimentary bud of flagellum on mesial margin of broad exopod; endopod (Figure 13D, inset) short, bi-articulated. Second maxilliped (Figure 13E) with relatively stout endopod; epipod subsemicircular, bearing slender, rod-like, non-lamellate podobranch.

Third maxilliped (Figure 14A) typical of alvinocaridid, slightly overreaching distal margin of antennal scale. Distal two segments combined gently arcuate, ultimate segment tapering distally, trigonal in cross-section, about 1.2 times as long as penultimate segment (= carpus). Antepenultimate segment with slender ventrolateral distal spine and prominent tuft of setae on dorsomesial proximal part. Epipod widened distally, slightly bilobed, lacking strap-like process (Figure 14B).

First pereopod (Figure 14C) slightly falling short of distal margin of antennal scale; dactylus 5.5 times longer than palm; chela (Figure 14D) slender, 2.8 times longer than wide; carpus (Figure 14E) relatively slender, with blunt ventrodiscal tooth; mesial surface ventrally with grooming apparatus consisting of patch of short stiff setae and one small spine proximal to patch of setae (Figure 14E). Second pereopod (Figure 14F) not reaching distal margin of antennal scale; chela 0.8 times as long as carpus; dactylus subequal in length to palm (Figure 14G); ischium with one spine laterally. Third pereopod (Figure 14H) overreaching antennal scale by full length of dactylus and propodus combined; dactylus (Figure 14I, J) 0.2 times as long as propodus, terminating in strong, clearly demarcated unguis, bearing four pairs of accessory spinules on flexor surface; propodus (Figure 14K) with two rows of slender spinules on flexor surface in distal half; carpus 0.9 times as long as propodus; merus 6.6 times longer than wide; ischium with two spines ventrolaterally. Fourth pereopod missing. Fifth pereopod (Figure 14L) longer than third pereopod, overreaching antennal scale by about 0.8 length of propodus; dactylus (Figure 14M, N) with 12 accessory spinules arranged in two or three rows on flexor surface (Figure 14N); propodus with three or four irregular rows of slender spines or spiniform setae on flexor surface (Figure 14N); carpus 1.6 times as long as propodus; merus about 7.3 times longer than wide; ischium unarmed.

Endopod of male first pleopod (Figure 12H) with inner lobe produced, far exceeding outer lobe, bearing cluster of five spiniform setae distally; outer lobe broadly rounded, with five spiniform setae; lateral margin slightly convex, with five stout plumose setae; mesial margin faintly sinuous, with 10 stout plumose setae. Appendices internae of second to fifth pleopods normally developed, with terminal cluster of coupling hooks, while that on fifth pleopod lacking coupling hooks. Appendix masculina on second pleopod (Figure 12I) tapering distally, slightly longer than appendix interna, armed with about seven spiniform setae distally. Uropodal rami (Figure 12E) both overreaching posterior margin of telson; exopod with one slender spine just mesial to sharp posterolateral tooth (Figure 12K).

#### *Coloration in life*

Not known.

*Distribution*

Known only from the type locality, South Su hydrothermal vent field, Manus Basin, 1310 m depth.

*Etymology*

From the Latin, *acuminatus* (= sharp), in reference to the sharp stylocerite and proximolateral tubercle on the first segment of the antennular peduncle.

**Genus *Alvinocaris*** Williams and Chace, 1982  
***Alvinocaris komaii*** Zelnio and Hourdez, 2009

*Alvinocaris komaii* Zelnio and Hourdez, 2009: 55, figs. 1–6.

*Material examined*

*Non-type*. **Lau Basin**. BIOLAU, BL 08, site Vailili, 23°13' S, 176°38' W, 1740 m, 18 May 1989, slurp gun, 1 male (cl 12.2 mm), MNHN; BL 10, same site, 22 May 1989, 1 female (cl 15.2 mm), CBM-ZC 11,956. **North Fiji Basin**. STARMER II, RV *Kaiyo*, dive 19, site *White Lady*, 18°50' S, 173°29' E, 2750 m, July 1989, 1 female (cl 14.6 mm), MNHN. **Vanuatu**. RV *Sonne*, SO229-061-N202, Nifonea vent field, 18°07.735' S, 169°31.018' E, 1871 m, 19 July 2013, 1 female (cl 19.5 mm), CBM-ZC 12,483.

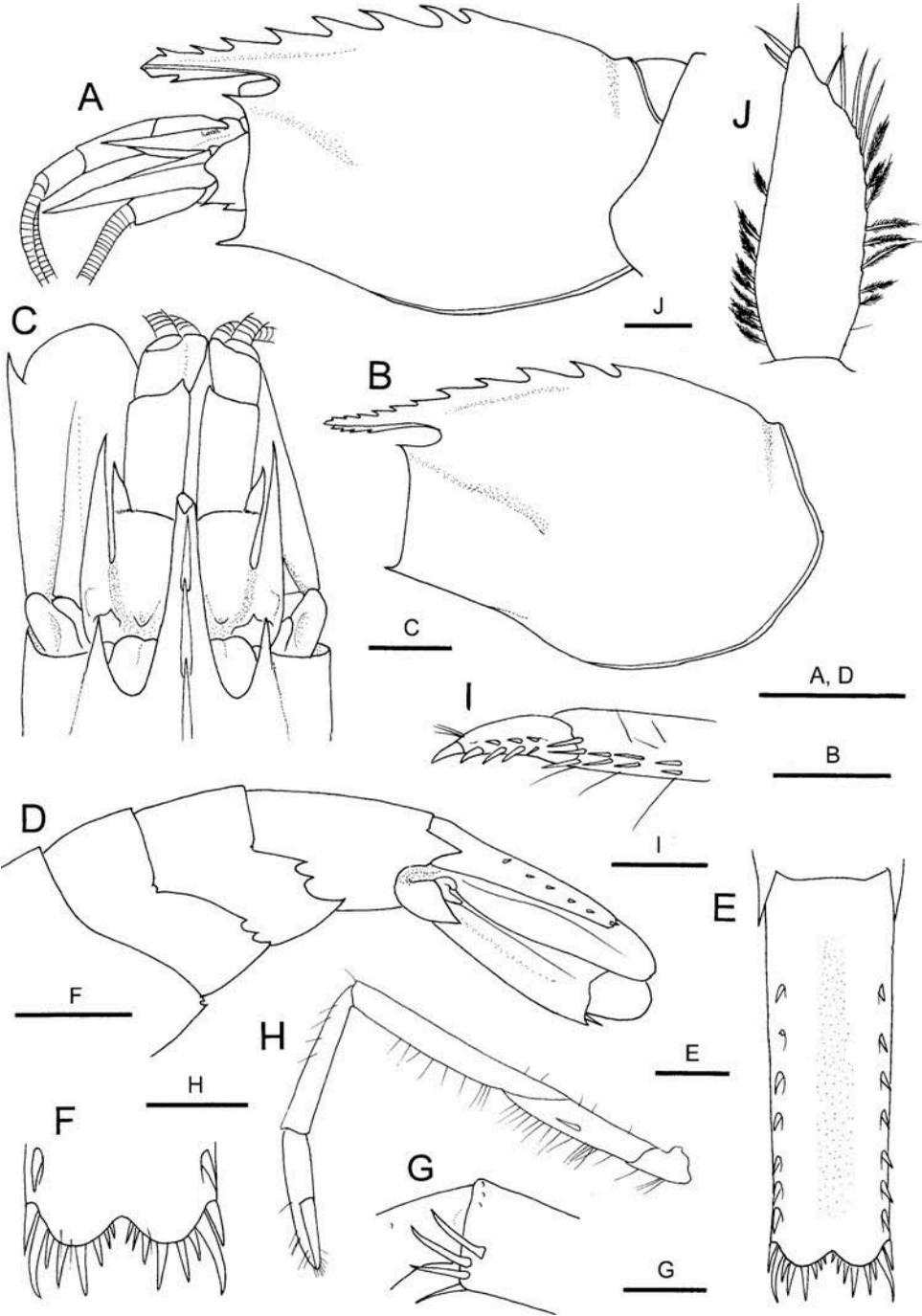
*Supplemental description*

Rostrum (Figure 15A–C) slender, terminating acutely, reaching or overreaching distal margin of first segment of antennular peduncle; dorsal margin sharply carinate, armed with row of teeth becoming larger posteriorly and extending beyond midlength of carapace (five postrostral teeth present); ventral ridge well developed, armed with one or more teeth; lateral carina conspicuous. Carapace (Figure 15A, B) with distinct postrostral carina extending beyond midlength; dorsal margin of carapace in lateral view gently arcuate, with peak at posteriormost tooth of dorsal rostral series; no longitudinal depression on either side of midline even in spawning females; antennal tooth acuminate; pterygostomial tooth strong, acuminate; anterior part of branchial region not strongly inflated; dorsal organ absent.

Third pleomere (Figure 15D) armed with one or more denticles posteroventrally on pleuron; fourth pleuron armed with sharp posteroventral tooth and additional denticles or teeth on posterolateral and/or ventral margins; fifth pleuron with posteroventral tooth and additional teeth on posterolateral margin. Telson (Figure 15E) with dorsolateral spines in linear row; posterior margin distinctly bilobed, with row of spines (Figure 15F).

Eyes fused, though distinct median notch present; anterior surface rounded, unarmed (Figure 15C).

Antennular stylocerite slender, narrowly separated from first peduncular segment (Figure 15C). Antenna not forming operculate structure; antennal scale with sharp distolateral tooth clearly separated from lamella; no transverse suture extending mesially from base of distolateral tooth (Figure 15C).



First maxilliped without rudimentary bud of exopod. Third maxilliped with two or more slender spines at ventrodistal margin of antepenultimate segment (Figure 15G).

First pereopod with short grooming setae on flexor surface of palm; carpus with well-developed grooming apparatus consisting of patch of short setae and one or two spinules proximal to setal patch. Second pereopod (Figure 15H) with one spine on ischium. Third to fifth pereopods increasing in length posteriorly; dactyli each with seven or eight accessory spinules arranged in two longitudinal rows on flexor surface (Figure 15I); meri of third and fourth pereopods each with one to three spines on lateral faces, that of fifth pereopod unarmed; ischia of third and fourth pereopods each with one or two spines, that of fifth pereopod unarmed. No strap-like epipods on third maxilliped or first to fourth pereopods.

Endopod of male first pleopod not bilobed distally, with three stiff setae distomesially; lateral margin with six or seven stiff setae in distal 0.3. Appendix interna of fourth pleopods without terminal cluster of coupling hooks. Uropodal exopod with one spine just mesial to base of posterolateral tooth; protopod sharply pointed posterolaterally.

#### Distribution

Lau Basin (Zelnio and Hourdez 2009; this study), 1740–2700 m depths; North Fiji Basin, 2750 m depth (new record); and Vanuatu, Nifonea vent field, 1871 m depth (new record).

#### Remarks

The present specimens are consistent with the original description of *Alvinocaris komaii* in every diagnostic aspect.

Molecular phylogenetic analysis based on 600 bp of the mitochondrial COI nucleotide by Zelnio and Hourdez (2009) suggested that *A. komaii* was clustered with the *Opaepele/Chorocaris/Rimicaris* clade, although the bootstrap support was very low (39.7%). As described previously by Zelnio and Hourdez (2009), *A. komaii* differs from other species of *Alvinocaris* in the accessory spinules on the dactyli of the third to fifth pereopods arranged in two or more rows and the unarmed anterior face of each eye. These characters, and the molecular analysis presented herein support the closer relationship of the species to a group including *Alvinocaridinides*, *Chorocaris*, *Opaepele*, *Shinkaicaris* and *Rimicaris*. Furthermore, *A. komaii* has two unique characters within the family, namely, the distinctly bilobed posterior margin of the telson

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Figure 15. *Alvinocaris komaii* Zelnio and Hourdez, 2009. (A, C, D, G–I) Male (carapace length 12.2 mm), MNHN (rostrum damaged); (B, E, F) female (carapace length 14.6 mm), MNHN. (A) Carapace and cephalic appendages, lateral view; (B) carapace, lateral view; (C) anterior part of carapace and cephalic appendages, dorsal view; (D) posterior part of pleon, lateral view (posterior part of telson broken off); (E) telson, dorsal view; (F) posterior part of telson, dorsal view; (G) distal part of antepenultimate segment of left third maxilliped, lateral view; (H) left second pereopod, lateral view; (I) same, dactylus and distal part of propodus, flexor view. Scale bars: 5 mm for A, B, D; 2 mm for C, E, H; 0.5 mm for G, I, J.

and the multiple spines on the ventrodistal margin of the antepenultimate segment of the third maxilliped. Future study may potentially warrant the establishment of a separate genus for *A. komaii*.

**Genetic divergence of the two new species of *Chorocaris***

The ML tree inferred from partial COI sequences (460 bp) for 18 identified species (including the two new species referred to *Chorocaris*) and two unidentified species of the Alvinocarididae is shown in Figure 16. At present, COI sequences are not

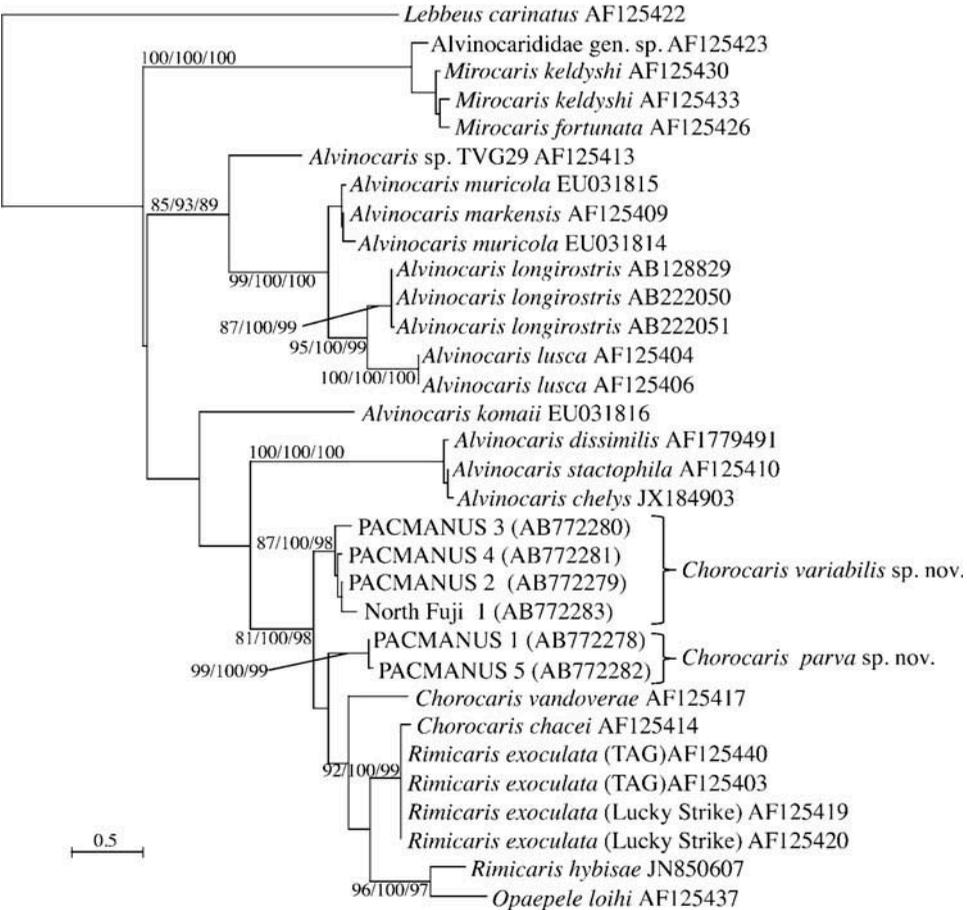


Figure 16. Molecular tree of the Alvinocarididae based on partial cytochrome c oxidase subunit I (COI) sequences (460 bp), constructed by the maximum likelihood (ML) method. *Lebbeus laurentae* Wicksten, 2010 (registered as *L. carinatus* in GenBank) used as an outgroup. Bootstrap values greater than 70% are given for branches with 500 replicate sampling in the sequence of ML, maximum parsimony (MP) and neighbour-joining (NJ). Note that *Mirocaris keldyshi* Vereshchaka, 1997 is a junior synonym of *Mirocaris fortunata* (Martin and Christiansen, 1995).

available for the following 13 formally described species: *Alvinocaridinides formosa* Komai and Chan, 2010, *Alvinocaris alexander* Ahyong, 2009, *Alvinocaris brevitelsonis* Kikuchi and Hashimoto, 2000, *Alvinocaris methanophila* Komai, Shank and Van Dover, 2005, *Alvinocaris niwa* Webber, 2004, *Alvinocaris williamsi* Shank and Martin, 2003, *Chorocaris paulexa*, *Chorocaris susannae*, *Manuscaris acuminatus* gen. et sp. nov., *Mirocaris indica* Komai et al. (2006), *Nautilocaris saintlaurentae* Komai and Segonzac, 2004, *Rimicaris kairei* Watabe and Hashimoto, 2002, and *Shinkaicaris luerokolos* (Kikuchi and Hashimoto, 2000).

The two new species of *Chorocaris* are clustered in a clade consisting of *C. chacei*, *C. vandoverae*, *Opepele loihi*, *Rimicaris exoculata* and *Rimicaris hybisae* with relatively high bootstrap support (88%, 93% and 100% in ML, MP and NJ, respectively) (Figure 16). The relationship among these species could not be fully resolved, because some inner branches have weak bootstrap support (less than 70%; e.g. the position of *C. parva* sp. nov., *C. vandoverae* and *C. variabilis* sp. nov.). The monophyly of *Chorocaris* is not supported, with the two *Rimicaris* species and *O. loihi* subordinated within *Chorocaris*.

Interspecific divergence among these seven species is summarized in Table 1. The minimum divergence is seen between *C. variabilis* sp. nov. and *C. parva* sp. nov. (5.5–6.7%), whereas the maximum divergence is seen between *C. variabilis* sp. nov. and *O. loihi* (11.0–11.5%). Previous studies on decapod crustaceans [e.g. Jones and Macpherson 2007 (Anomura: Munidopsidae: *Munidopsis*); Cabezas et al. 2009 (Anomura: Munididae: *Munida* and allied genera); Tsoi et al. 2011 (Achelata: Palinuridae: *Limuparus*); Chang et al. 2014 (Astacidea: Nephropidae: *Thaumastocheles*)] have shown that COI divergence of more than 10% is indicative of species level differentiation, although lower divergence (> 4.0%) could also be of specific significance [(e.g. Davie et al. 2010 (Brachyura: Micytllidae: *Mictylis*); Yang et al. 2010 (Caridea: Pandalidae: *Heterocarpus*)]. Together with the morphological evidence, we consider that full species status is warranted for the two new taxa described in this study.

Four specimens of *C. variabilis* sp. nov. (three from the Manus Basin and one from the North Fiji Basin) are clustered with well-supported bootstrap value (93%, 96% and 100% in ML, MP and NJ, respectively). The intraspecific divergence in the four specimens is 0.3–1.8 %, and there is little doubt that they belong to the same species.

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