

Two new deep-water species of *Caecoserolis* Wägele, 1994 (Isopoda, Sphaeromatidea, Serolidae) from off North Island, New Zealand*

NIEL L. BRUCE¹

Marine Biodiversity and Biosecurity, National Institute of Water and Atmospheric Research Ltd., Private Bag: 14901, Kilbirnie, Wellington, New Zealand.

¹ Present address: Museum of Tropical Queensland, Queensland Museum and School of Marine and Tropical Biology, James Cook University; 70–102 Flinders Street, Townsville, 4810 Australia; email: niel.bruce@qm.qld.gov.au.

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Abstract

Two species of Serolidae, *Caecoserolis carinata* sp. nov. and *Caecoserolis bicolor* sp. nov. are described from northern New Zealand waters, the first record of the genus from New Zealand. A third species, a juvenile is recorded as *Caecoserolis* sp. All are deep-water species. *C. carinata* can be identified by the median row of prominent tubercles, and was collected from the southern New Caledonia Trough, Tasman Sea at depths of 2930–3184 m; *C. bicolor* has paired nodules on the head linked by a V-shaped ridge, a broad body, widest at pereonites 3 and 4, and occurs off Hawkes Bay, off eastern North Island, at depths of 2119–2337 m.

Key words: Isopoda, Serolidae, *Caecoserolis*, taxonomy, New Zealand, Pacific Ocean

Introduction

The family Serolidae is reasonably well known world wide, particularly Antarctica and the Southern Ocean (recent titles being: Brandt 1988, 1991, 2003; Held 2003; Luxmoore 1982a, b, Nunomura 2005, Wägele 1986a, b, c, 1994), and to a much lesser degree in Australia (Harrison & Poore 1984; Poore 1987) and the tropical southwestern Pacific (Poore & Brandt 1997).

In contrast New Zealand Serolidae are effectively unstudied, with a single title in the last century (Hurley 1961), recording a species later shown by Poore and Brandt (1997) to be a misidentification of an Antarctic species that they transferred to *Acutiserolis* Brandt, 1988. All other records date from the nineteenth century, despite the relatively large size of many species and the frequency of species of Serolidae in trawls and other sampling (e.g. unpublished NIWA expedition reports). Knowledge of New Zealand's serolids currently rests with one named species recorded from off Auckland Island, namely the widely reported *Spinoserolis latifrons* (Miers, 1875) (see Carvacho 1977, Kussakin & Vasina 1982, Wägele 1994), though the identity and name of the Auckland Island species is not certain as the species was based on syntypes from two localities (Auckland Island and Kerguelen Island in the southern Indian Ocean), and no type locality was stated.

Material held in the NIWA Invertebrate Collections indicates that there are at least four genera, and some 20 species in the New Zealand region. The greatest diversity of species lies within the genera *Acutiserolis* and *Caecoserolis* Wägele, 1994. This contribution describes two new species and records a third species of deep-water *Caecoserolis*, all from depths in excess of 2000 m.

Methods

Dissected appendages were, whenever possible, removed from the right hand side of the specimen; both mandibles were always dissected. Specimens from the U-series stations had been previously extensively dissected from the left hand side. All material is held in the NIWA invertebrate collection, at NIWA, Greta Point, Wellington.

Species descriptions were prepared from Serolidae character sets (under development) using the program DELTA (Dallwitz *et al.* 1977).

Family-level character states as given by Brandt and Poore (2003) are excluded from the species description, but as generic boundaries are less clear, potential generic-level states may be included.

Abbreviations: NIWA—National Institute of Water and Atmospheric Research Ltd., Wellington, New Zealand; PMS—plumose marginal setae; RS—robust setae.

Taxonomy

Serolidae Dana, 1852

***Caecoserolis* Wägele, 1994**

Caecoserolis Wägele, 1994: 10, 50, 55.—Poore & Brandt, 1997: 161.

Type species: *Serolis brinki* Kensley, 1978, original designation (Wägele 1994).

Remarks. Poore and Brandt (1997) gave a revised diagnosis to *Caecoserolis*, and discussed some of the difficulties presented by the serolid genera recently established by Brandt (1988, 1991) and Wägele (1994). Those issues are not reappraised here, and the two new species described here are considered to generally accord well with the genus *sensu* Poore and Brandt (1997), but more particularly ally closely with *Caecoserolis novacaledoniae* Poore and Brandt, 1997 rather than with the type species, *Caecoserolis brinki* (Kensley, 1978).

Caecoserolis brinki differs notably from the other species currently placed in the genus in having considerably broader antennal peduncular article 5 (less than 5.0 times as long as greatest width compared to more than 8.6–10.3 times as long as greatest width for other species currently placed in the genus), a posteriorly rounded and apparently dorsally flat (lacking median or sublateral carinae) pleotelson, and the coxal plates of pereonite 6 not extending posteriorly beyond the pleonites. Expanded antennule peduncle articles 4 and 5 is an infrequent character state within the family that also occurs in *Thysanoserolis* Brandt, 1991 and *Glabroserolis* Menzies, 1962; that state could be of sufficient significance to warrant separation of the type species from those others in the genus which lack this presumed derived character state, but have coxae 6 extending posteriorly beyond the pleonites.

The generic placement of the very briefly described *Caecoserolis monodi* (Cals, 1979) is be regarded as uncertain as the pleotelson shape appears unique within the family and the dorsolateral insertion of the uropods is not consistent with that of the type species or other species of the genus, which is ventrolateral. The type material for this species is not held at the Muséum national d'Histoire naturelle in Paris, and deposition of the material was not indicated by Cals (1979). The whereabouts of the type material is at present unknown. Although not discussed by Poore and Brandt (1997) *Serolis antarctica* Beddard, 1884 (see figures in Schotte 1992) is sufficiently similar to warrant inclusion, and that species is here transferred to *Caecoserolis*.

Species included in *Caecoserolis*: *C. apheles* (Schotte, 1992), *C. bicolor* sp. nov., *C. brinki* (Kensley, 1978) type species, *C. carinata* sp. nov., *C. novacaledoniae* Poore and Brandt, 1997, and provisionally *C. antarctica* (Beddard, 1884a) comb. nov.—a probable species complex with attributed specimens from the southern Indian Ocean, tropical western Atlantic off Brazil, and tropical western Indian Ocean (see Beddard 1884b, Schotte 1992). Excluded from the genus is *Serolis monodi* Cals, 1979, here regarded as *incertae sedis*.

Caecoserolis carinata sp. nov. (Figs 1–3)

Material. All Tasman Sea, New Zealand.

Holotype: ♂ (19.8 mm), New Caledonia Trough, 34.5250°S, 166.3500°E, 23 Sep 1982, stn. U195, 2930 m (NIWA 27939).

Paratypes: 2 ♂ (17.0, 19.4 [pre-dissected] mm), ♀ (ovig. 23.3 mm), plus two heads and one body piece, same data as holotype (NIWA 27534). 2 ♂ (17.3, imm 13.6 mm), New Caledonia Trough, 35.5850°S, 160.9517°E, 27 Sep 1982, stn. U0200, 3180–3184 m (NIWA 27533).

Description. Body 1.3 as long as wide, widest at coxae 3, dorsal surfaces coarsely pitted. Head anterolateral lobes weakly convex, anterior submarginal 'ridge' entire; dorsally without tubercles, posterior margin with prominent blunt median tubercle. Eyes minute (less than 5% greatest width of head), elliptical (lenticular/ovoid), ommatidia not distinct. Pereonites 5–7 fused mid-dorsally; pereonite 1 anterolateral margin continuously convex; dorsally with median tubercle on all pereonites and pleonites. Coxae of pereonites 2–4 articulated, with dorsal sutures, distal margins weakly convex; coxae 4 extending to mid-pleonite 2; 5 extending posteriorly along 0.2 of pleotelson length; 6 extending to between posterior of uropods and pleotelson posterior margin, and along 0.7 of pleotelson length. Ventral coxal plates 2–4 mesially strongly punctate. Pleonites extending posteriorly along 0.6 pleotelson lateral margin; pleonite 1 sternal plates 3-cornered, with acute median point, sternal plate 1 with median ridge and 2 sub-median depressions. Pleotelson 1.0 as long as anterior width, dorsal surface with median longitudinal carina, with paired sublateral carinae; lateral margins weakly sinuate, posterior margin converging to angled caudomedial point, without distinct median excision. Antennule peduncle article 2 1.9 as long as wide; articles 3 and 4 2.7 as long as article 2; article 3 10.5 as long as wide; flagellum 2.4 as long as peduncle articles 3 and 4, with ~58 articles, extending to pereonite 5. Antenna peduncle article 4 5.9 as long as wide, 3.1 as long as article 3; article 5 1.2 as long as article 4, 8.6 as long as wide; antennal flagellum 1.1 as long as peduncle article 5, with ~16 articles, extending to posterior of pereonite 4.

Epistome with obtuse median point. *Mandible incisor* with single posterior cusp, left mandible lacinia mobilis 0.8 as wide as incisor, right mandible lacinia mobilis distally multicuspid, mandibular spine simple. *Maxilla* mesial lobe with 12 long, finely serrate setae; middle lobe with 5 long simple setae (1 mesial, 4 terminal); lateral lobe with 2 distal simple setae. *Maxilliped palp* article 2 proximomesial margin with 6 setae, distomesial margin with 146 setae, lateral margin distally with 2 setae; article 3 lateral margin with 5 setae, distal margin with 12 setae; endite distal margin RS simple.

Pereopod 1 carpus RS simple; propodus 2.1 as long as wide, inferior margin with ~66 robust setae; wide RS with serrate margins, narrow RS distally bifid, with simple flagellum; dactylus with acute unguis. *Pereopod 2 basis* 5.0 as long as wide; 0.7 as long as basis, ischium 3.5 as long as wide; *merus* 0.5 as long as ischium, 2.0 as long as wide, inferior margin with 2 clusters of setae (as 1 and 3), superior distal angle with 1 seta; *carpus* 0.5 as long as ischium, 2.3 as long as wide, inferior margin with 1 cluster of setae (as row of 10); *propodus* 0.7 as long as ischium, 2.2 as long as wide, inferior margin with indistinct heel, palm weakly concave, inferolateral margin with 3 RS (and 5 setae), inferomesial margin with 6 RS (and 6 setae), inferior margin RS simple, blunt, distally pilose, distal margin with ~10 setae; unguis simple, slender. *Pereopod 6 basis* 3.9 as long as greatest width; *ischium* 0.7 as long as basis, 3.8 as long as wide, inferior margin with 1 cluster of setae (2), superior distal angle with 0 robust setae; *merus* 0.5 as long as ischium, 2.5 as long as wide, inferior margin with 3 clusters of setae (as 1, 1, and 3), superior distal angle with 0 RS; *carpus* 0.6 as long as ischium, 3.0 as long as wide, inferior margin with 7 clusters of setae (as 2, 2, 1, 4, 5, 7 and 6), superior distal angle with 3 setae; *propodus* 0.5 as long as ischium, 3.0 as long as wide, inferior margin with 6 clusters of setae (as 1, 1, 2, 3, 4, 3), distal margin with ~14 setae, inferior distal angle with 1 RS; *dactylus* 5.5 as long as proximal width. *Pereopod 7* similar to, but 0.9 as long as pereopod 6. Setae on inferior margins of pereopods 4–7 finely plumose. Inferior margins of pereopods 2–7 setulose fringe weakly developed.

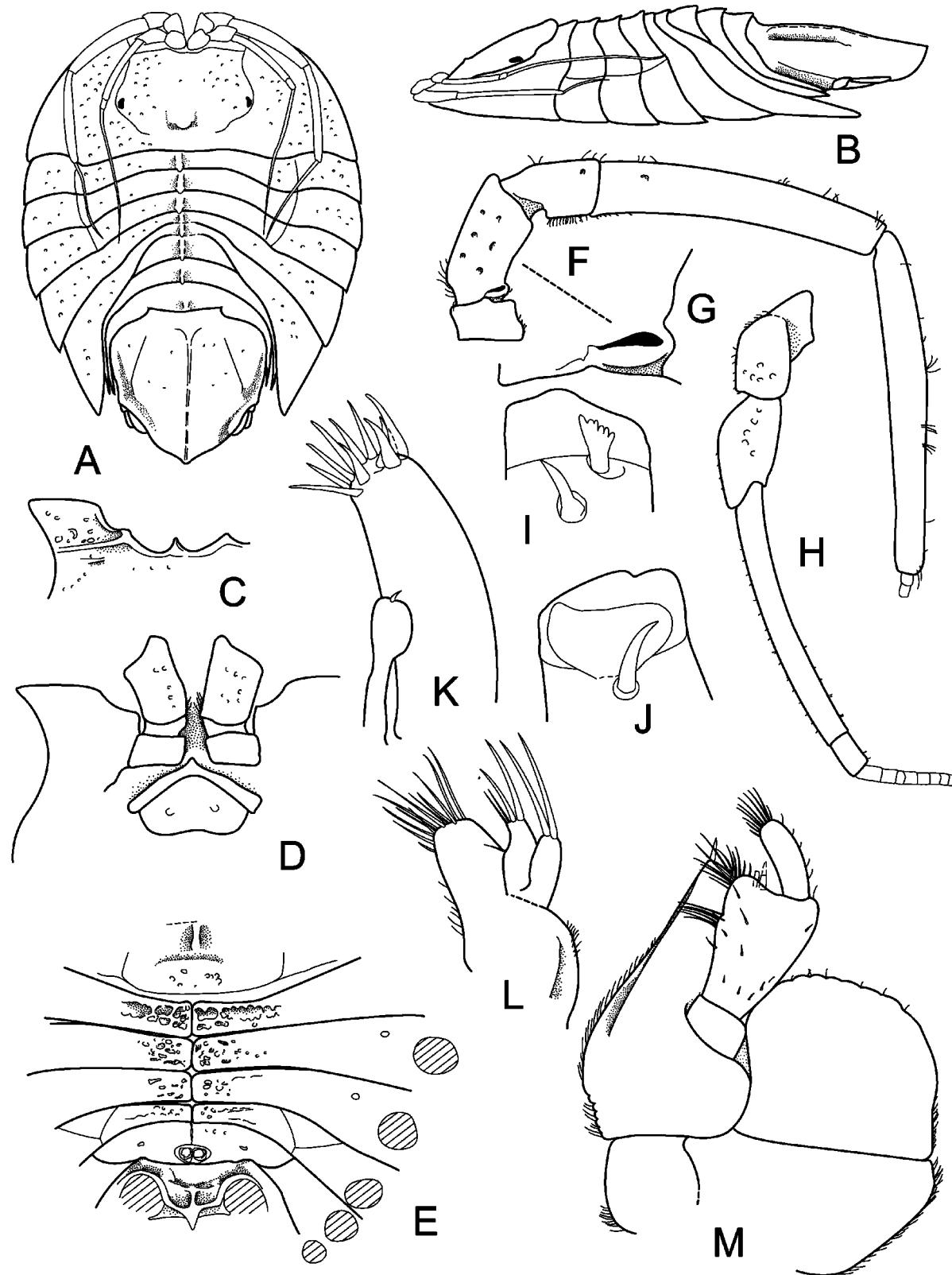


FIGURE 1. *Caecoserolis carinata* sp. nov. A–E holotype, remainder ♂ paratype 19.4 mm, NIWA 27534. A, dorsal view; B, lateral view; C, anterior margin, pereonite 1; D, frons; E, pereonal and pleonal sternites; F, antenna; G, antenna, base of peduncular article 2; H, antennule; I, right mandible apex; J, left mandible apex; K, maxillule; L, maxilla; M, maxilliped.

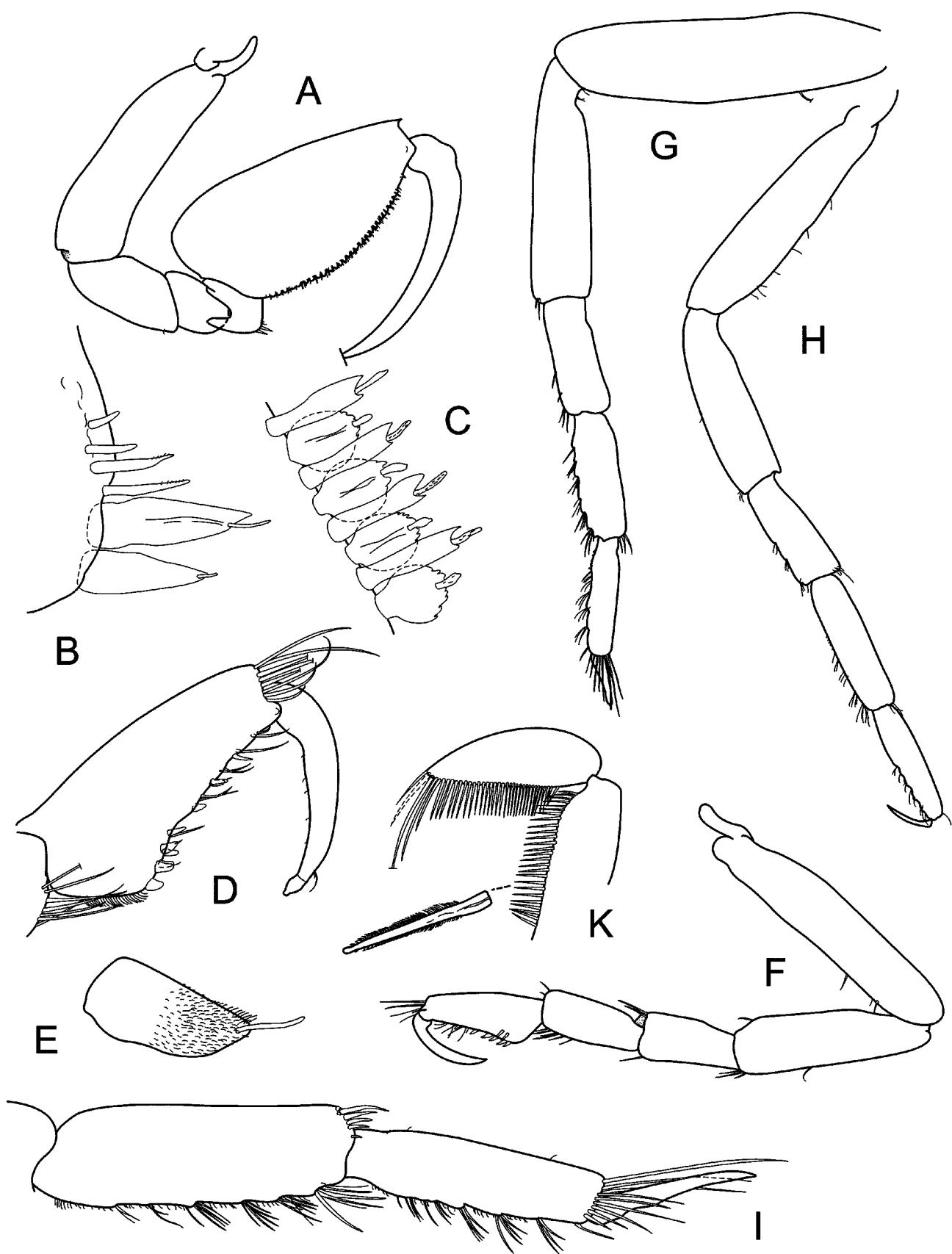


FIGURE 2. *Caecoserolis carinata* sp. nov. Paratype ♂ 19.4 mm, NIWA 27534. A, pereopod 1; B, pereopod 1, carpal setae; C, pereopod 1, propodal setae; D, propodus and dactylus; E, pereopod 2, propodal robust seta; F, pereopod 2; G, pereopod 6; H, pereopod 7; I, pereopod 6, distal articles; K, mandibular palp, article 3.

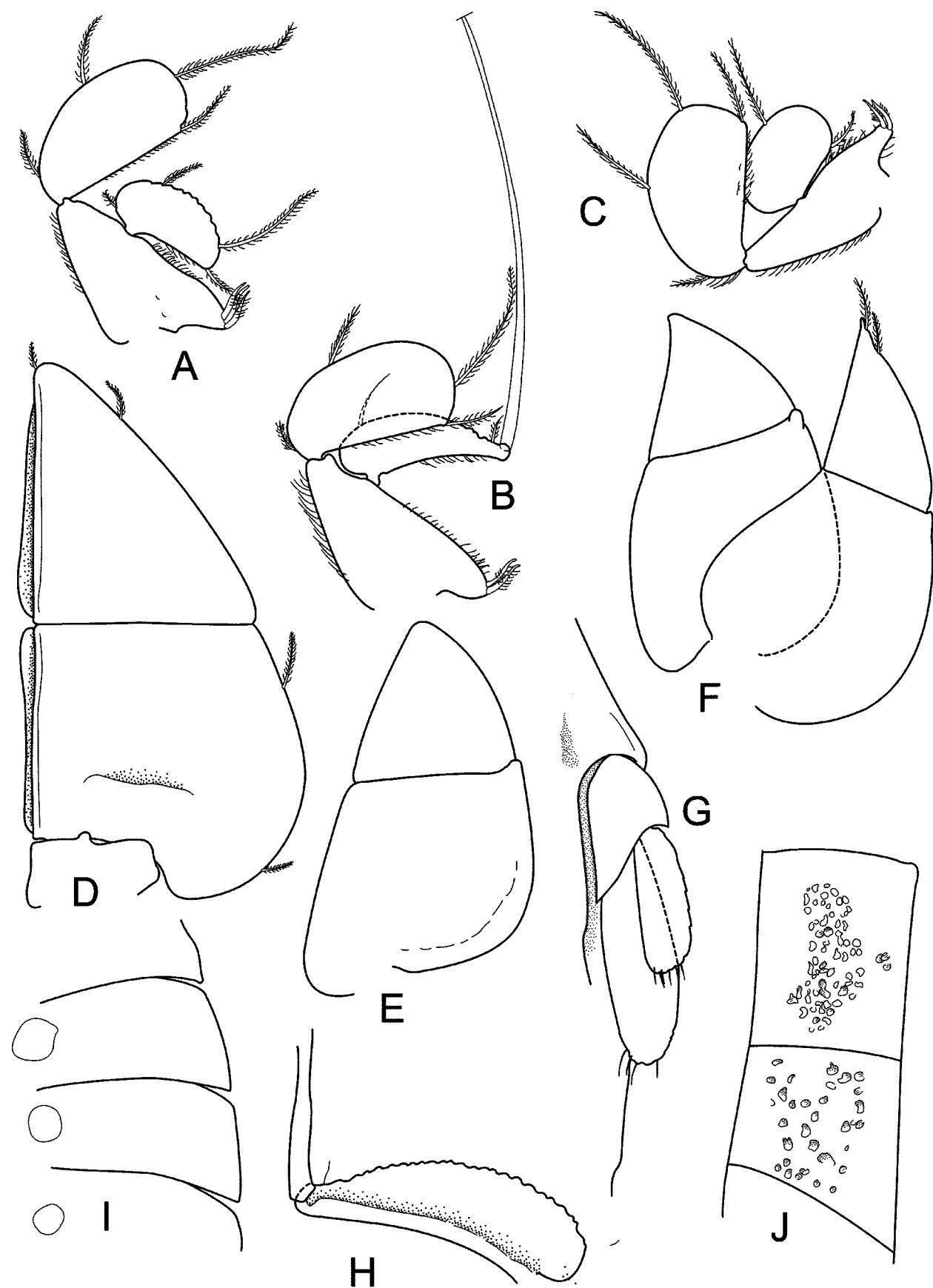


FIGURE 3. *Caecoserolis carinata* sp. nov. Paratype ♂ 19.4 mm, NIWA 27534; G, holotype. A–F, pleopods 1–5 (D and E endopod and exopod of 4); G, uropods, ventral view; H, pleopod 2 endopod, dorsal view; I, ventral view, coxae 2–4; J, cuticle, dorsal pitting on coxae 4 and 5.

Penial openings mutually adjacent, *penes* opening flush with surface of sternite 7.

Pleopod 1 peduncle 1.7 as long as wide, mesial margin with 3 coupling setae; exopod 1.9 as long as wide, with 42 PMS; endopod 2.2 as long as wide, 0.7 as long as exopod, with 26 PMS. *Pleopod 2* peduncle 1.7 as long as wide, mesial margin with 2 coupling setae; exopod 1.5 as long as wide, with 42 PMS; endopod 3.3 as long as greatest width, lamellar part 4.3 as long as wide, with 26 PMS; *appendix masculina* greater than 2.8 as long (tips broken) as endopod. *Pleopod 3* exopod with 52 PMS, endopod with 32 PMS. *Pleopod 4* exopod with complete transverse suture, endopod with complete transverse suture. *Pleopod 5* exopod with complete transverse suture, endopod with complete transverse suture.

Uropods (rami + peduncle) 0.3 as long as pleotelson, peduncle 0.7 as long as endopod. *Endopod* 3.0 as long as wide; distally broadly rounded. *Exopod* 0.7 as long as endopod, 2.8 as long as wide, distally broadly rounded.

Size: Adult males 17.0 to 19.8 mm, females to 23.3 mm.

Colour: Brown, narrow pale bands on dorsal somites and coxae.

Variation: Dorsal fusion of pereonites 5–7: in the holotype the suture line is indistinct between 5 and 6, in the 17.3 mm male (NIWA 27533) all suture lines are evident; in all others both suture lines indistinct to absent. Extent of coxae 6: in all specimens coxae 6 extend to about the point of the uropod peduncle. Robust setae of pereopod 2: variation could not be reliably assessed as no male had both pereopods 2, and many setae were missing; indications suggest that some variation is present.

The relative size of pereopod 7 in relation to pereopod 6 appears to increase with increasing size. In the two largest specimens pereopods 6 and 7 are similar in appearance, with pereopod 7 just a little shorter (0.9) than pereopod 6. In smaller specimens, including mature males, pereopod 7 is weakly pigmented, less setose and evidently shorter (0.8) than pereopod 6.

Remarks. *Caecoserolis carinata* sp. nov. can be readily identified and distinguished from all other species in the genus by the presence of a distinct median nodule on the posterior margins of the head, pereonites 2–4 and 7 and pleonite 1, with an indistinct nodule on each of the remaining segments; these nodules giving the appearance of an articulating longitudinal median ridge. Other characters that support identification of this species are the large size for the genus (approximately 2 cm body length); long antennule and antennal flagellae extending to pereonites 4 and 5 respectively; distinct lateral and median carinae on dorsum of pleotelson; coxae 6 not strongly produced, extending to position of uropodal peduncle; coarsely pitted dorsal surfaces, including coxal plates medially; and a relatively prominent rostrum.

One character is inconsistent with the other species of the genus. The maxilla middle lobe has 5 setae rather than the more usual 2.

Etymology. Derived from the Latin *carina* ('keel-shaped ridge or structure'), alluding to the longitudinal row of median tubercles giving a keel-like appearance to the dorsum.

Distribution. Southern New Caledonia Trough, at depths of 2930–3184 m.

Caecoserolis bicolor sp. nov. (Figs 4–7)

Material. All Hawkes Bay, eastern North Island, New Zealand.

Holotype: ♂ (14.1 mm), 39.4017°S–39.3955°S, 179.9062°E–179.9013°E, 21 Nov 2004, 2337–2363 m, stn. TAN0413/205 (NIWA 25903).

Paratypes: ♂ (14.4 mm [dissected]), 39.4408°S–39.4373°S, 179.9508°E–179.9442°E, 21 Nov 2004, 2255–2220 m, stn. TAN0413/206 (NIWA 25904). 2♂ (~12.5, 14.1 [A1, A2 dissected] mm), 39.4488°S–39.4497°S, 179.9062°E–179.9212°E, 19 Nov 2004, 2182–2119 m, TAN0413/192 (NIWA 25901). 3♂ (12.6 mm, 2 anterior portions only) 39.4532°S–39.3530°S, 179.9623°E–179.9482°E, 19 Nov 2004, 2308–2207 m, stn. TAN0413/193 (NIWA 25902).

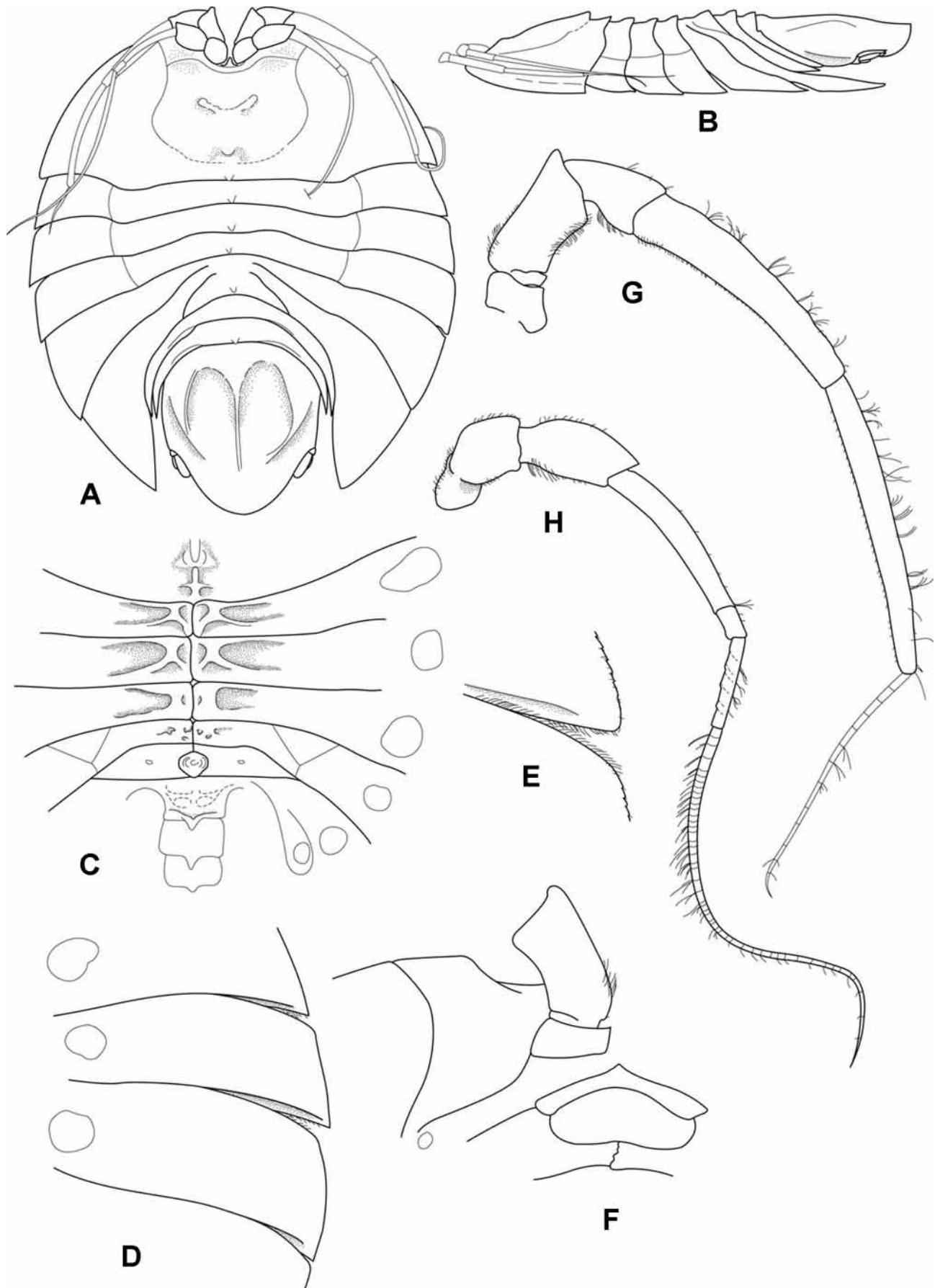


FIGURE 4. *Caecoserolis bicolor* sp. nov. A–E holotype; G, H, ♂ 14.1 mm, NIWA 25901. A, dorsal view; B, lateral view; C, pereonal and pleonal sternites; D, ventral view, coxae 2–4; E, detail of coxal join, coxae 1 and 2; F, frons; G, antenna; H, antennule.

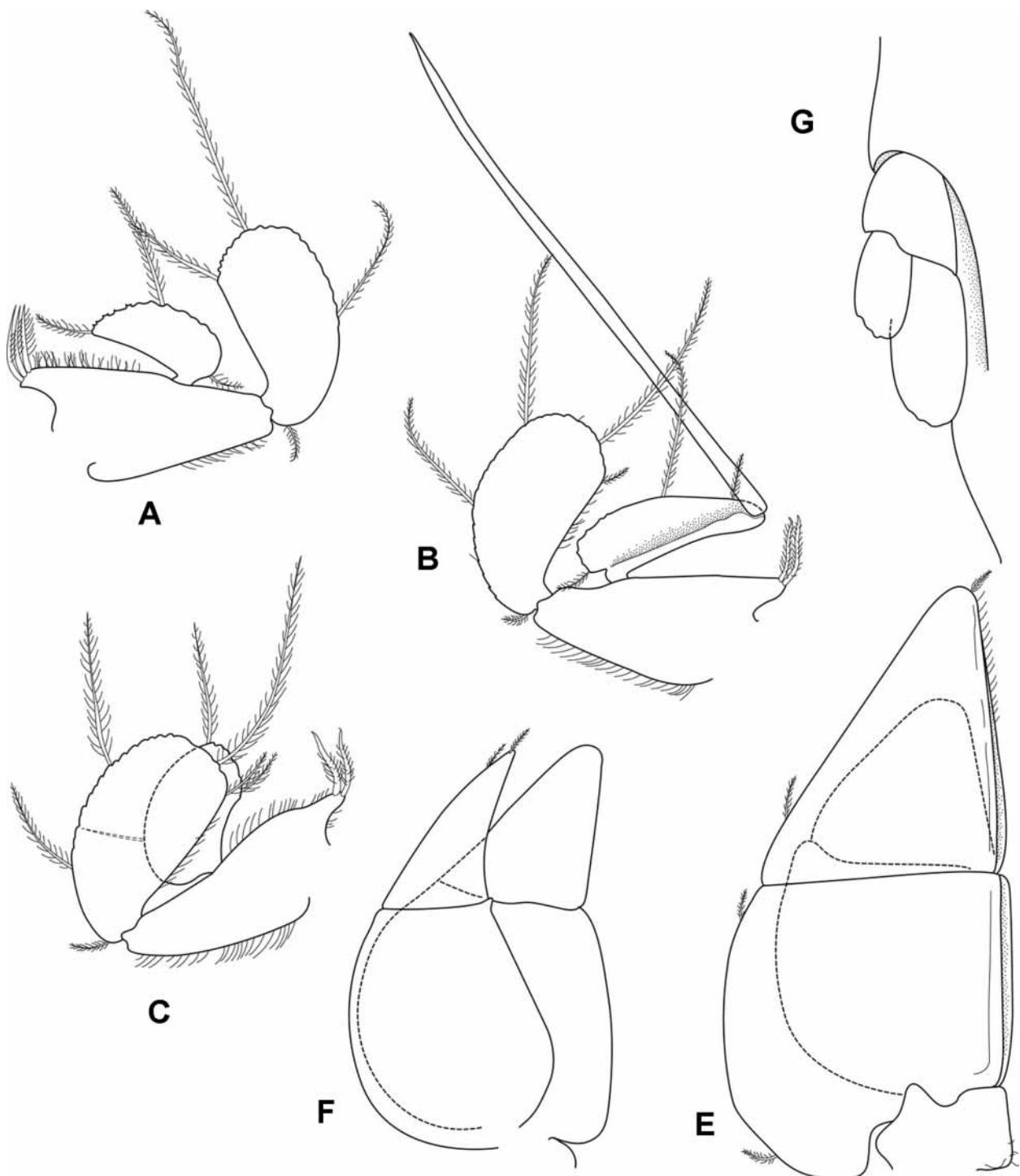


FIGURE 5. *Caecoserolis bicolor* sp. nov. A–G, paratype ♂ 14.4 mm, NIWA 25904; H–I, holotype. A, maxilliped; B, maxilliped palp; C, maxilla; D, maxillule (endite lost); E, mandible palp and seta from article 2; F, left mandible apex; G, right mandible apex; H, pereopod 6, distal articles; J, distal setal cluster, pereopod 6 carpus; I, distal setal cluster, pereopod 6 propodus.

Description. Body 1.1 as long as wide, widest at coxae 4, dorsal surfaces smooth. Head anterolateral lobes weakly convex, anterior submarginal 'ridge' entire; dorsally with submedian pair of tubercles joined by indistinct V-shaped ridge, posterior margin with low rounded median tubercle. Eyes absent. Pereonites 5–7 fused mid-dorsally; pereonite 1 anterolateral margin continuously convex; dorsally with median tubercles on

pereonites 1–4 and 7 and pleonites 1 and 2. *Coxae* of pereonites 2–4 articulated, with dorsal sutures, distal margins weakly convex; coxae 4 extending to mid-pleonite 1; 5 extending posteriorly along 0.4 of pleotelson length; 6 extending to between posterior of uropods and pleotelson posterior margin, and along 0.9 of pleotelson length. *Ventral coxal plates* 2–4 mesially elevated, mesially with ridges forming X-shape. *Pleonites* extending posteriorly along 0.4 pleotelson lateral margin; pleonite 1 sternal plates 3-cornered, with acute median point, sternal plate 1 with weak median ridge. *Pleotelson* 1.1 as long as anterior width, dorsal surface with median longitudinal carina, with paired sublateral carinae; lateral margins convex, posterior margin evenly rounded, without distinct median excision.

Antennule peduncle article 2 2.0 as long as wide; articles 3 and 4 1.8 as long as article 2; article 3 6.5 as long as wide; flagellum 2.4 as long as peduncle articles 3 and 4, with ~38 articles (articles 1–4 or 5 fused), extending to pereonite 4. *Antenna* peduncle article 4 5.2 as long as wide, 3.3 as long as article 3; article 5 1.1 as long as article 4, 10.3 as long as wide; antennal flagellum 1.1 as long as peduncle article 5, with ~13 articles, extending to middle of pereonite 3.

Epistome with obtuse median point. *Mandible incisor* even or minutely irregular, left mandible lacinia mobilis 0.8 as wide as incisor, right mandible lacinia mobilis distally multicuspid, mandibular spine simple; palp article 2 with 24 distolateral setae, article 3 with 36 biserrate setae. *Maxilla* mesial lobe with 12 long, finely serrate setae; middle lobe with 2 long simple setae; lateral lobe with 2 distal simple setae. *Maxilliped palp* article 2 proximomesial margin with 6 setae, distomesial margin with 16 setae, lateral margin distally with 3 setae; article 3 lateral margin with 5 setae, distal margin with 11 setae; endite distal margin RS simple.

Pereopod 1 carpus RS distally pilose; *propodus* 2.2 as long as wide, inferior margin with ~58 robust setae; wide RS with finely ridged margins, narrow RS distally bifid, with pilose flagellum; *dactylus* with acute unguis. *Pereopod 2 basis* 3.3 as long as greatest width; *ischium* 0.6 as long as basis, 3.8 as long as wide; *merus* 0.5 as long as ischium, 1.8 as long as greatest width, inferior margin with 1 cluster of setae (of 2), superior distal angle with 3 setae; *carpus* 0.5 as long as ischium, 2.0 as long as wide, inferior margin with 9 clusters of setae (as 1, 1, 2, 1, 1, 2, 1, 1); *propodus* 0.6 as long as ischium, 2 as long as wide, inferior margin with indistinct heel, palm weakly concave, inferolateral margin with 6 RS (2 acute), inferomesial margin with 4 RS, inferior margin RS simple, blunt, smooth, distal margin with ~14 setae; *dactylus* 0.9 as long as propodus, unguis simple, slender. *Pereopod 6 basis* 5.3 as long as greatest width; *ischium* 0.7 as long as basis, 3.6 as long as wide, inferior margin with 1 cluster of setae (1 distal), superior distal angle with 0 robust setae; *merus* 0.6 as long as ischium, 2.3 as long as wide, inferior margin with 5 clusters of setae (as 1, 2, 1, 2, 3), superior distal angle with 2 RS; *carpus* 0.9 as long as ischium, 3.7 as long as wide, inferior margin with 8 clusters of setae (as 1, 2, 4, 3, 2, 3, 3 and 5), superior distal angle with ~10 setae; *propodus* 0.8 as long as ischium, 5.8 as long as wide, inferior margin with 8 clusters of setae (1, 1, 2, 2, 3, 3, 3 and 1), distal margin with ~12 setae, inferior distal angle with 1 RS; *dactylus* 9.5 as long as proximal width. *Pereopod 7* similar to, but 0.7 as long as pereopod 6. Setae on inferior margins of pereopods 4–7 distally rough and distally flexible. Inferior margins of pereopods 2–7 setulose fringe weakly developed.

Penial openings fused, *penes* opening flush with surface of sternite 7.

Pleopod 1 peduncle 1.9 as long as wide, mesial margin with 3 coupling setae; exopod 2.0 as long as wide, with 36 PMS; endopod 1.8 as long as wide, 0.7 as long as exopod, with 19 PMS. *Pleopod 2* peduncle 2.1 as long as wide, mesial margin with 2 coupling setae; exopod 1.9 as long as wide, with 41 PMS; endopod 2.9 as long as greatest width, lamellar part 3.6 as long as wide, with 20 PMS; *appendix masculina* 3.3 as long as endopod. *Pleopod 3* exopod with 42 PMS, endopod with 26 PMS. *Pleopod 4* exopod with complete transverse suture, endopod with complete transverse suture. *Pleopod 5* exopod with complete transverse suture, endopod with complete transverse suture.

Uropods (rami + peduncle) 0.2 as long as pleotelson, peduncle 0.7 as long as endopod. *Endopod* 2.2 as long as wide; distally broadly rounded. *Exopod* 0.6 as long as endopod, 1.9 as long as wide, distally broadly rounded.

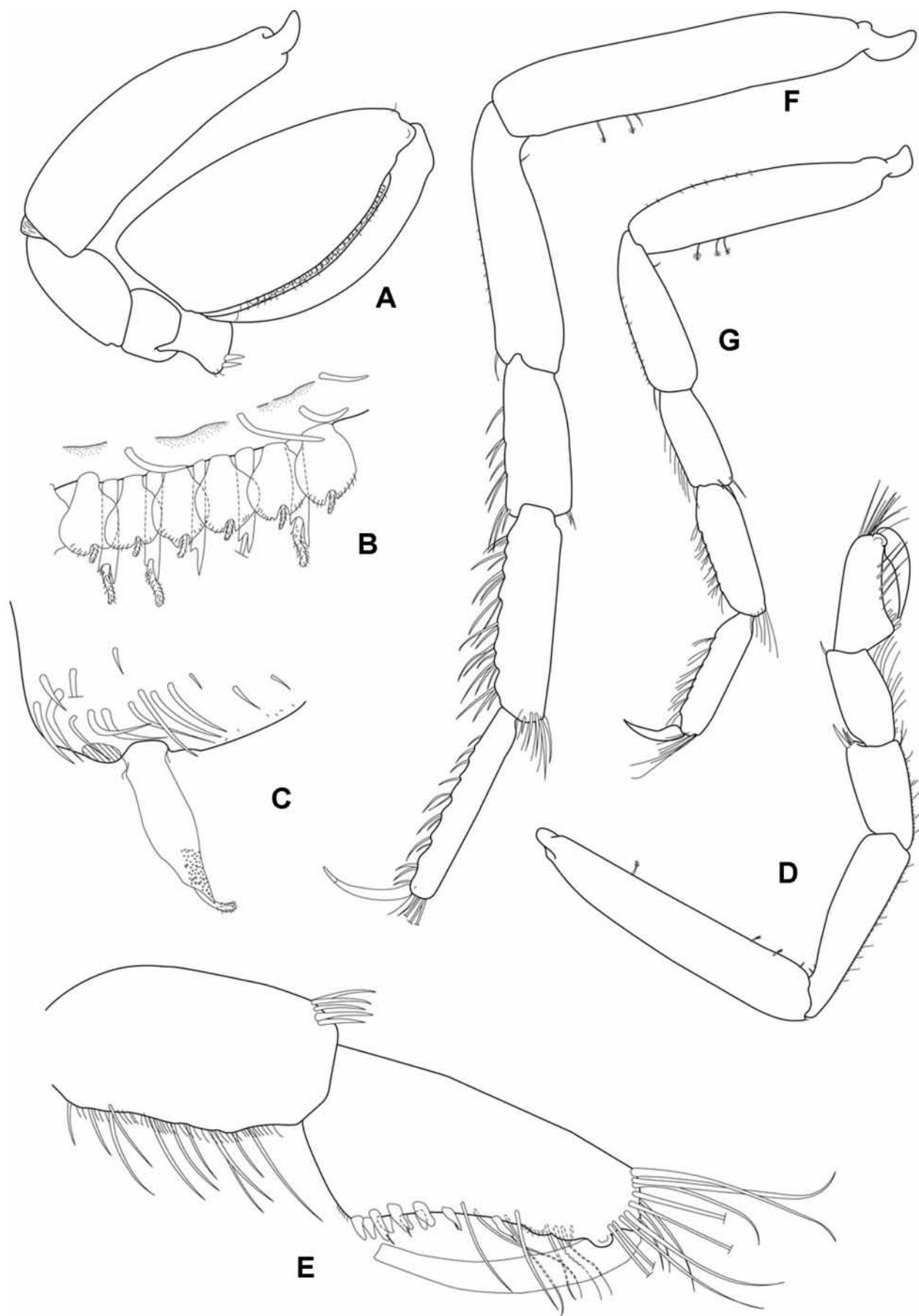


FIGURE 6. *Caecoserolis bicolor* sp. nov. Paratype ♂ 14.4 mm, NIWA 25904. A, pereopod 1; B, pereopod 1, propodal setae; C, pereopod 1, carpal setae; D, pereopod 2; E, pereopod 2, carpus and propodus; F, pereopod 6; G, pereopod 7.

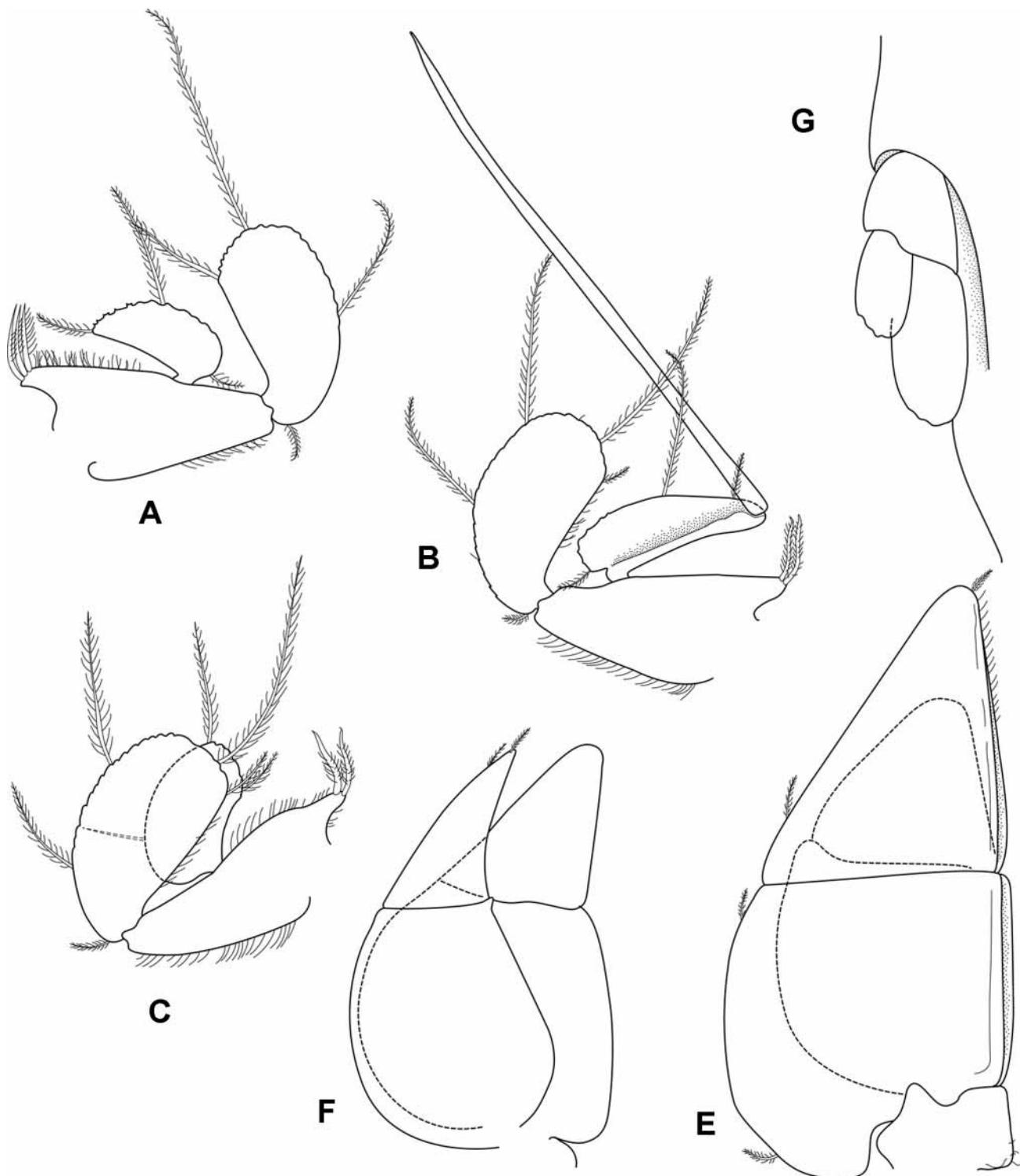


FIGURE 7. *Caecoserolis bicolor* sp. nov. Paratype ♂ 14.4 mm, NIWA 25904. A–E, pleopods 1–5; F, uropods, ventral view.

Size: Males 12.5–14.4 mm (mean 13.5 mm); females not known.

Colour: Anteriorly (head to pereonites 1–4) dark slate grey, posteriorly white.

Remarks. *Caecoserolis bicolor* sp. nov. is a distinctive member of the genus bearing no close resemblance to other species of the genus. It is entirely without eyes or traces of ocular lobes, and is further readily identi-

fied by the irregular nodules on the head (appearing like a shallow 'V'); wide body shape (only just longer than wide) widest at pereonites 3 and 4, colour pattern (anteriorly dark, posteriorly pale); fused penial processes; relatively short antennule peduncle; pereopods 5–7 with a somewhat curved dactylus; small median nodules on pereonites 1–4, 7 and the pleonites; and the cuticle being moderately pitted rather than polished.

Distribution: Off Hawkes Bay, North Island, eastern New Zealand; 2119–2337 m.

***Caecoserolis* sp.**

Material. ♀ (imm. 16.5 mm), Bellona Trough, 41.37°S 166.74°E, 23 Apr 1980, stn P940, 2092 m (NIWA 27532).

Remarks. This species is similar to *C. carinata* sp. nov., but is smaller, distinctly reddish in colour in preserved specimens rather than olive, has shorter coxae 6, the pleotelson apex less acute, there are no nodules on pereonites, and the antennule flagellum extends only to the posterior of pereonite 1. I believe this to be a distinct species, but mature adults are necessary in order to characterise the species.

Acknowledgements

The impetus for this contribution came from my participation in the March 2007 CeDAMar Isopod workshop held at the Deutsches Zentrum für Marine Biodiversität (DZMB) in Wilhelmshaven, Germany, organized by Saskia Brix (DZMB). Drawings were made while at the Muséum national d'Histoire naturelle, Paris, and I thank Dr Danielle Defaye for the provision of facilities for the duration of my visit. Remaining time was supported by the Foundation for Research Science and Technology (FRST) contract C01X0502 held at NIWA, Greta Point, New Zealand.

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