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New genera of Bogidiellidae (Amphipoda: Gammaridea) from SW Pacific and Mediterranean marine caves

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Abstract

Two new genera and species of the stygobiont gammaridean amphipod family Bogidiellidae are described from anchialine or fully marine subterranean habitats in Mediterranean and SW Pacific Islands. *Fidelidiella pectinata*, from a littoral cave in Lifou (Loyalty Islands), differs from any other bogidiellid known thus far by the presence on the left mandible of a modified lacinia which is hypertrophied and expanded laterally, and by the possession of a transverse row of strong rounded processes on the anterior side of the distomedial corner of the fourth segment of the maxillipedal palp. This is the most easterly record of bogidiellid amphipods in the SW Pacific. *Racovella uniramea*, discovered in a Mallorcan anchialine cave, is remarkable among the Bogidiellidae in exhibiting a combination of only six distal spines on the basal endite of the maxillule, and presence of coxal gills on pereopods 3–6. We place particular emphasis on the determination of segmental homologies of all limbs and on the resolution of fine-scale integumentary details, in order to provide a sound basis for future comparison with other family members.

Keywords: *Amphipoda, anchialine, Balearic Islands,* Fidelidiella, *Loyalty Islands, new genera, new species,* Racovella, Stygofauna

Introduction

Bogidiellid amphipods are one of the most characteristic inhabitants of groundwaters, ranging from the marine sublittoral to mountain springs at an altitude of 2500 m (Koenemann and Holsinger 1999). The family is strictly stygobiont and most of its members are restricted to freshwater, although recent explorations of the marine interstitial medium and anchialine caves have unveiled a number of new taxa. The family was initially considered to be a remarkable example of a taxon of ancient freshwater origin (Stock 1978), with some of its members becoming adapted progressively to brackish and marine conditions (Koenemann and Holsinger 1999). Nevertheless, the increasing number of forms discovered in insular territories never connected to continental landmasses renders it more probable that

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bogidiellids are a thalassoid lineage (Stock 1981; Notenboom 1991). This interpretation is supported by evidence from the distributions of many taxa on continental landmasses (i.e. falling within zones previously flooded by ancient epicontinental seas), suggesting that they are derived from marine/brackish water ancestors by stranding, in accord with the so-called regression model (Holsinger 1986; Notenboom 1991). Unfortunately, no soundly based phylogenetic analysis exists to support either of these two competing hypotheses since most available taxonomic descriptions are too poor as to provide sufficient morphological characters for use in such an analysis (see Koenemann and Holsinger 1999).

If bogidiellids were a primary marine group, we might expect to find the more primitive taxa in the sea. So, any report of new marine or anchialine bogidiellids is interesting in its potential to shed light on the historical zoogeography of this group of amphipods. Regrettably, relatively few species of bogidiellids are anchialine (e.g. *Antillogidiella* Stock, 1981, *Bermudagidiella* Koenemann and Holsinger, 1999, *Bogidiella balearica* Dancau, 1973, *Xystriogidiella* Stock, 1984, and *Stygogidiella purpuriae* Stock, 1988), and even rarer are fully marine, sublittoral forms. Spooner (1959) recorded an unnamed "*Bogidiella*" species at 42–51 m depth in the English Channel, and two sublittoral taxa are known to occur in the Bay of Naples (Mediterranean): *Marinobogidiella thyrrenica* (Schiecke, 1978) and *Aurobogidiella italica* (Karaman, 1979) (see Schiecke 1978; Karaman 1988).

Here we describe two new genera and species of bogidiellids from anchialine or fully marine groundwater habitats in Mediterranean and SW Pacific islands. We place particular emphasis on the determination of the segmental homologies of all limbs and on the resolution of the finer integumentary details, in order to provide a better basis for comparison with other taxa in the family.

Material and methods

Material was collected with baited traps set for several days in the cave lakes using specialized cave-diving techniques (in the case of the Mallorcan cave), or directly with a hand-held plankton net after stirring up the bottom sediment (in the case of the cave in Lifou). Once in the laboratory, amphipods were sorted under the stereomicroscope. Detailed studies were made after their internal tissues had been partially digested with lactic acid to facilitate observation. Drawings were prepared using a camera lucida on an Olympus BH-2 microscope equipped with Nomarski differential interference contrast. Body measurements were derived from the sum of the maximum dorsal dimensions of individual somites and exclude the telson. Appendages preserved in permanent slides were mounted in lactophenol and the coverslips sealed with nail varnish. Materials are deposited in the Crustacea collections of both the Museum National d'Histoire Naturelle, Paris (MNHN) and The Natural History Museum, London (BMNH).

Taxonomy

Order AMPHIPODA
Suborder GAMMARIDEA
Family BOGIDIELLIDAE Hertzog, 1936 emend. Koenemann and Holsinger, 1999
Fidelidiella gen. nov.

Diagnosis

Mandibles with non-triturative molar; lacinia on left mandible modified, hypertrophied, expanded laterally. Coxal endite (=inner lobe) of maxillule unarmed. Fourth segment of maxillipedal palp (=propodus) with transverse row of four strong, rounded processes on anterior side of distomedial corner. Posterodistal corner of carpus of first gnathopod extended into finger-like process. Coxal gills present on pereopods 4–6. Pleopods with no trace of endopod and apparently lacking any secondary sexual modification. Uropods aequiramous, unmodified, rami unisegmented; basofacial spine present on protopod of first uropod. Telson wider than long, shallowly excavate.

Etymology

Generic name derived by combination of the Latin *fidelitas* (=loyalty; alluding to the type locality, the Loyalty Islands) and the ending of *Bogidiella* (the name of the type genus of the family Bogidiellidae).

Type species

Fidelidiella pectinata sp. nov., described herein, by original designation.

Fidelidiella pectinata sp. nov.
(Figures 1–7)

Material examined

Littoral cave (*sensu* Stock et al. 1986) at the base of Ihnig cliffs, Tingeting Tribu, NW Lifou (Loyalty Islands). UTM coordinates (Datum WGS84): 7706536/58 736772. Single chamber roughly 10×3 m, entirely occupied by lake about 0.5 m deep subject to strong swell. Hyperbenthic haul with hand-held net above coral rubble after stirring up bottom with feet. Holotype: 1.76 mm, sex unknown, completely dissected and mounted on four slides (reg. no. MNHN-Am7459). Paratype: 2.11 mm, sex unknown, pereopods 6 and 7 missing; partially dissected in ethanol vial, internal tissue preserved (i.e. not treated with hot lactic acid) (BMNH reg. no. 2006.1125). Collected by authors, 28 October 2000.

Description of holotype

Head (Figure 1A) longer than wide, with hardly developed rostrum, evenly rounded lateral lobe and no trace of post-antennal sinus (terms *sensu* Lincoln 1979, p 15); eyes absent. Body unpigmented, smooth, with sparsely set long sensillae distributed as figured over tergites. Slender seta present at posteroventral corner of each of fifth to seventh pereonites. Epimeral plates with small but distinct posterodistal corners and with 2-2-1 setae on posterior margin, respectively (Figure 1E); ventral margin of plates fringed with microspinules.

Antennule (Figure 1B) about 35% of body length. Proximal peduncle segment twice as long as wide, with two strong flagellate spines on posterior margin. Second peduncle segment three times longer than wide, 78% length of proximal segment. Third peduncle segment 51% length of preceding segment. Main flagellum shorter than peduncle, six-articulate, with slender aesthetasc on each of articles 4, 5, and 6. Accessory flagellum

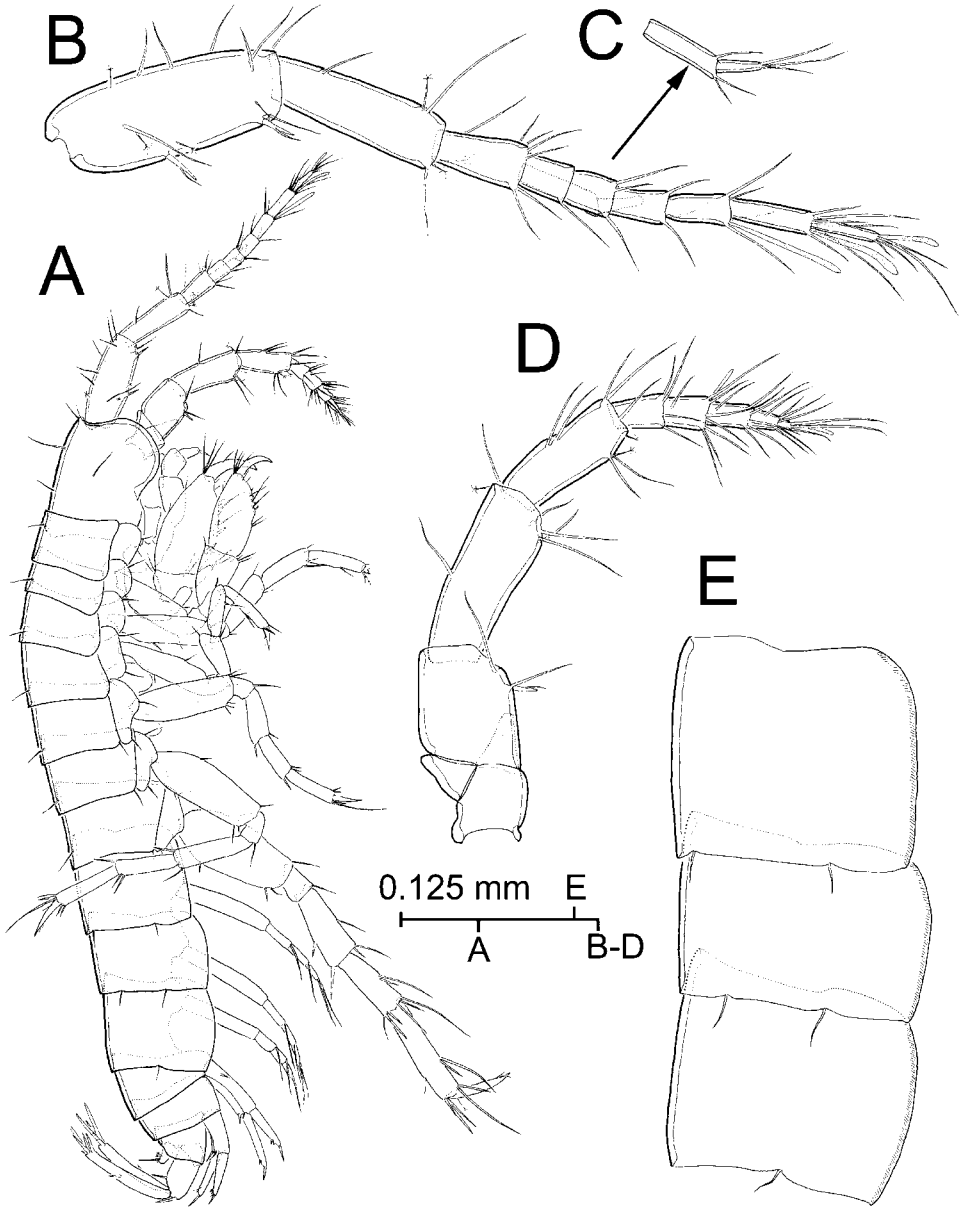

Figure 1. *Fidelidiella pectinata* gen. et sp. nov. (holotype). (A) Body, lateral aspect; (B) right antennule, lateral; (C) detail of accessory flagellum of latter; (D) right antenna, lateral; (E) detail of right epimeral plates, lateral.

(Figure 1C) two-articulate, not reaching distal margin of third article of main flagellum; proximal article twice as long as distal.

Antenna (Figure 1D) about 80% length of antennule. Fourth peduncle segment longest, 2.7 times longer than wide. Fifth peduncle segment 71% length of preceding segment, 2.5 times longer than wide. Flagellum slightly shorter than third peduncle segment, five-articulate; tiny aesthetasc on articles 2 and 5.

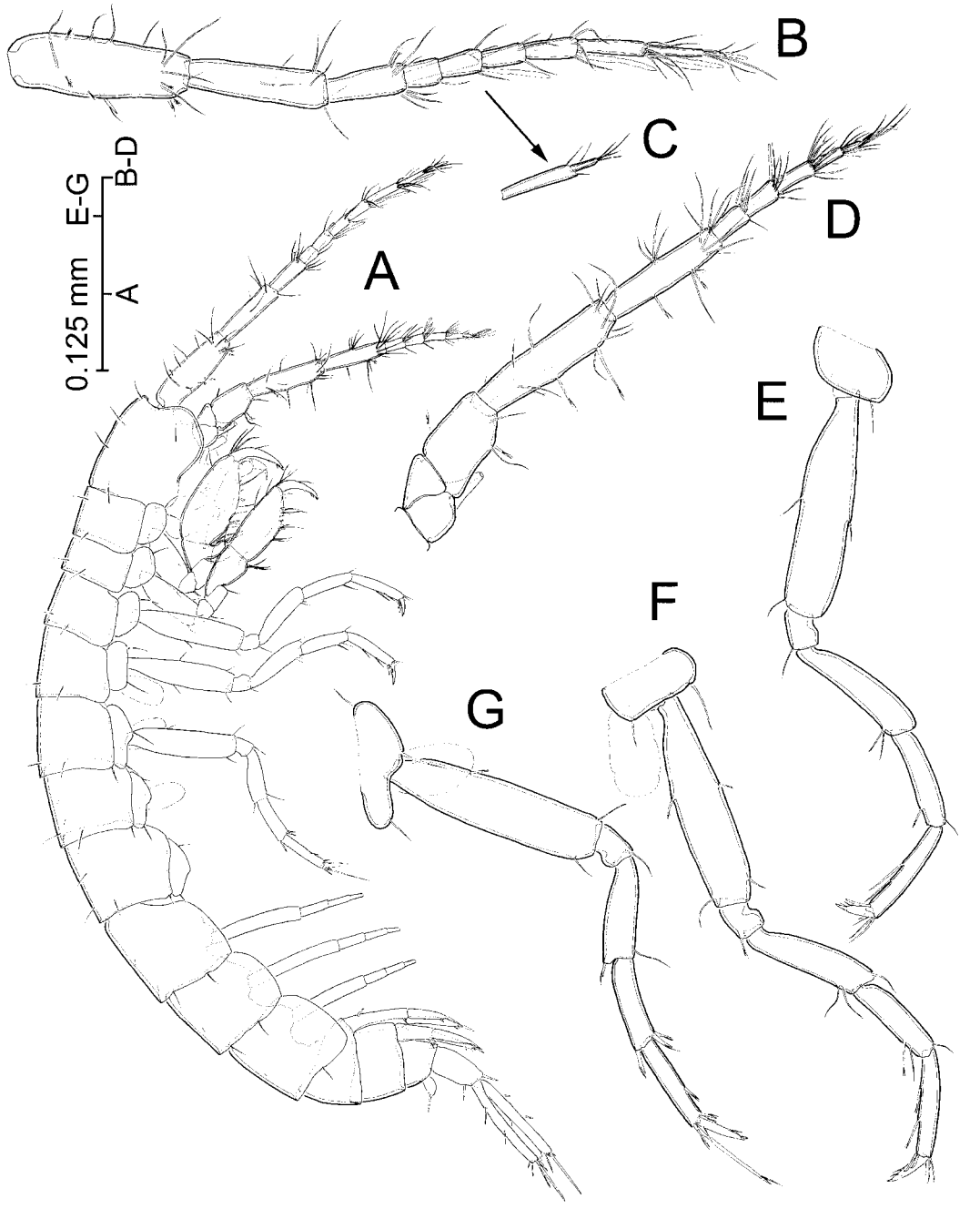

Figure 2. *Fidelidiella pectinata* gen. et sp. nov. (paratype). (A) Body, lateral; (B) right antennule, lateral; (C) detail of accessory flagellum of latter; (D) right antenna, lateral; (E) right third pereopod, lateral; (F) right fourth pereopod, lateral; (G) right fifth pereopod, lateral.

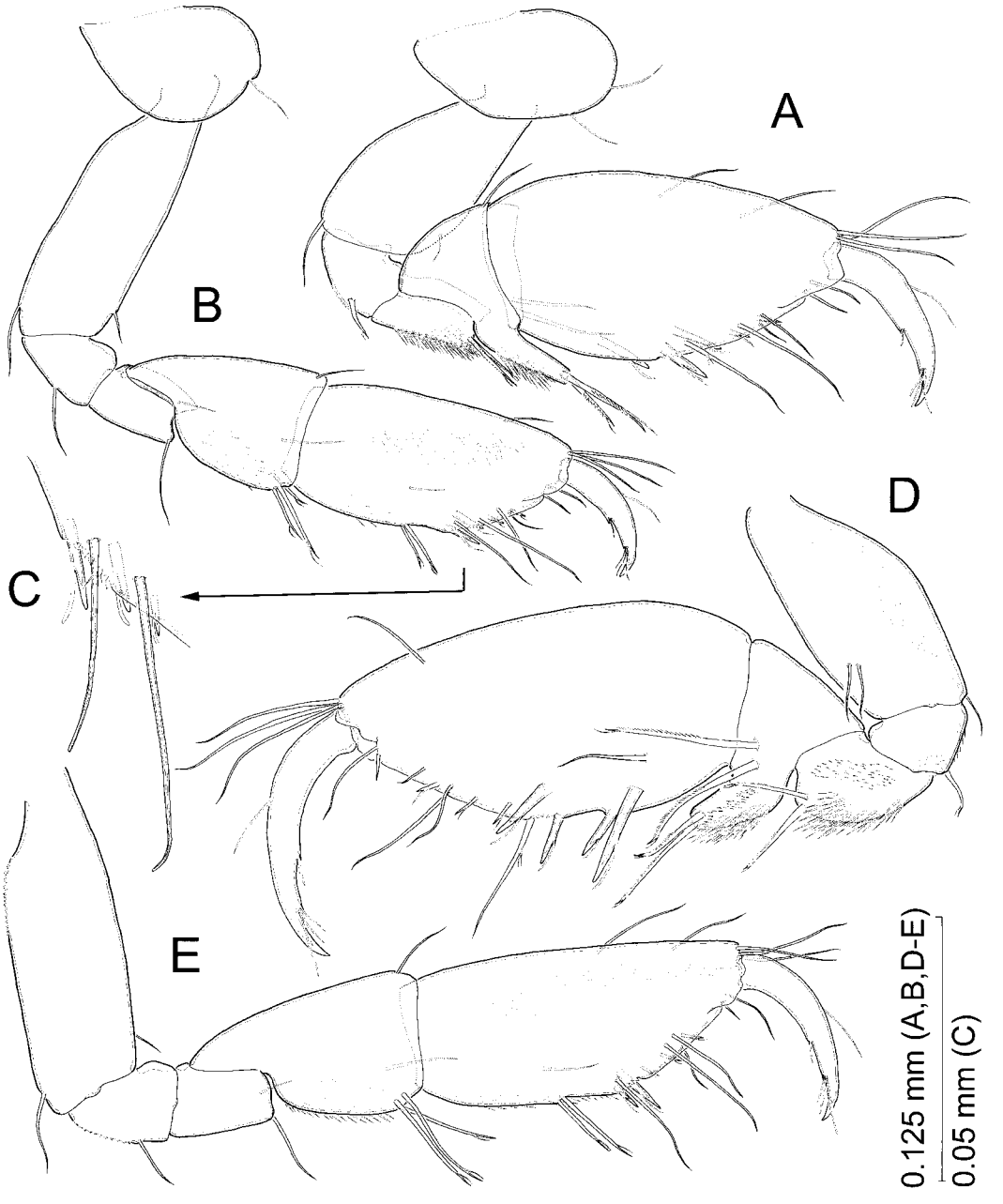

Figure 3. *Fidelidiella pectinata* gen. et sp. nov. (A–C) Holotype; (D, E) paratype. (A) Right first gnathopod, lateral; (B) right second gnathopod, lateral; (C) detail of palm angle of latter, lateral; (D) right first gnathopod, medial; (E) right second gnathopod, lateral.

Labrum (Figure 5A) trapezoid, slightly constricted at two-thirds of total length, with straight, hardly setulose distal margin. Paragnaths (Figure 6A) bilobed, outer lobe with long setules distally on inner margin; inner lobe with sparsely set short setules distally.

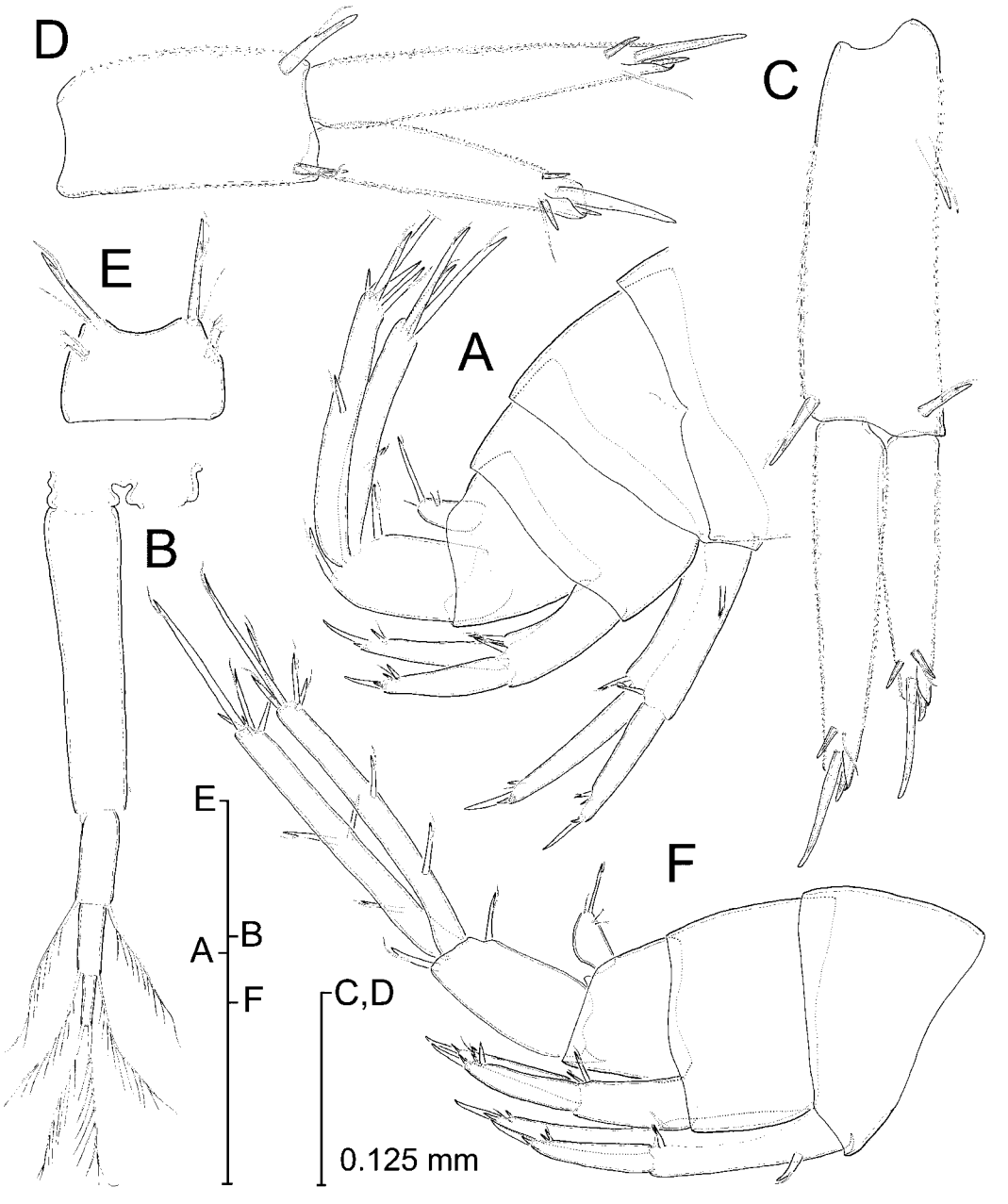

Figure 4. *Fidelidiella pectinata* gen. et sp. nov. (A–E) Holotype; (F) paratype. (A) Urosome, lateral; (B) left first pleopod, anterior; (C) right first uropod, posterior; (D) left second uropod, posterior; (E) telson, posterior (=dorsal); (F) urosome, lateral.

Left mandible (Figure 5B) with subrectangular incisor bearing three major unequal denticles, innermost largest, plus two intercalated serrate portions (Figure 5C). Lacinia hypertrophied, wider than long, lateral half of distal margin smooth, inner half with six unequal rounded denticles (Figure 5D). Spine row composed of four short, stiff unipinnate

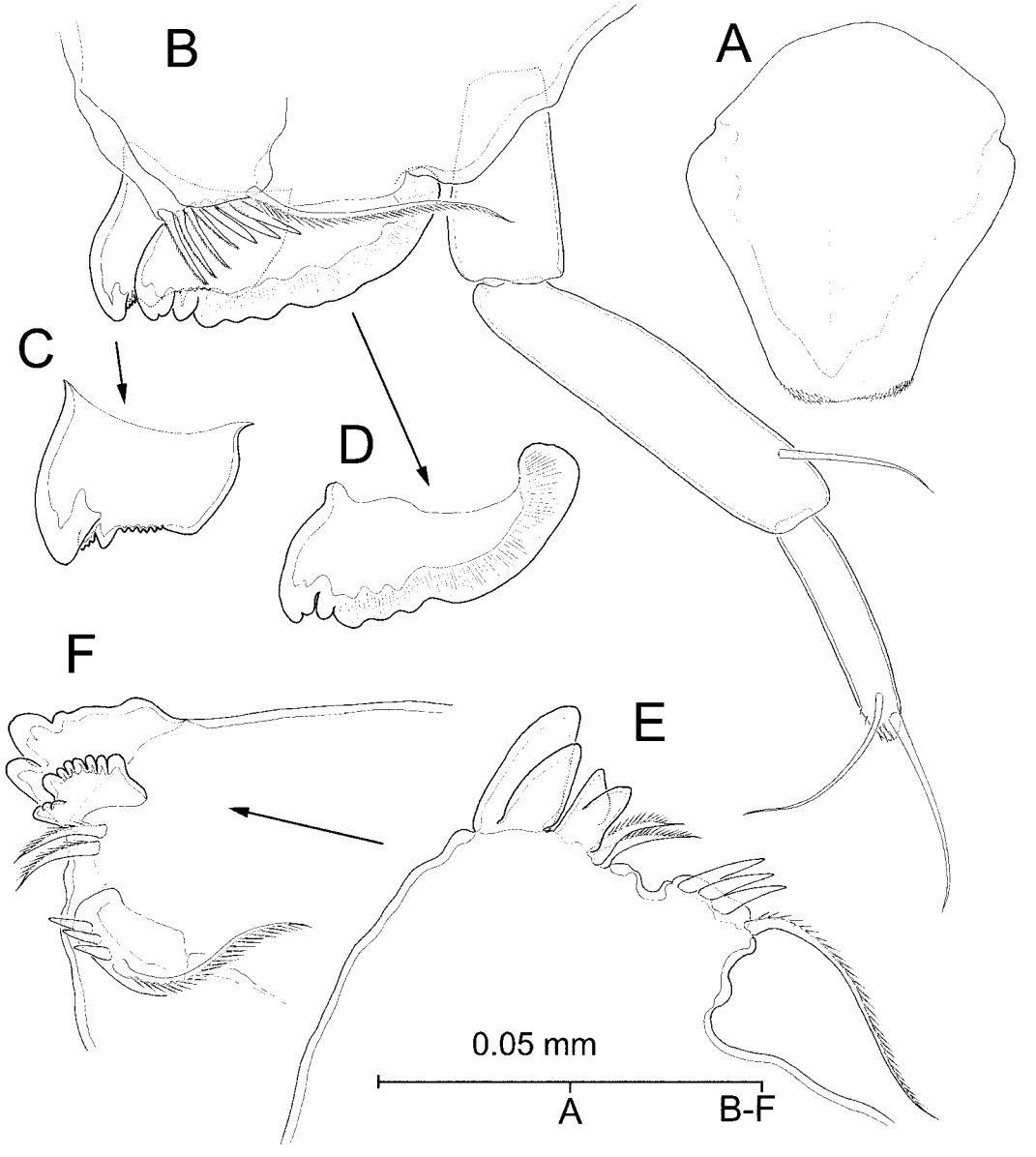

Figure 5. *Fidelidiella pectinata* gen. et sp. nov., holotype. (A) Labrum, anterior; (B) left mandible, medial (distal segment of palp oriented medially); (C) detail of incisor; (D) detail of lacinia; (E) right mandible, lateral (palp omitted); (F) same, medial.

elements. Molar non-triturative, reduced to narrow lappet crowned with three lanceolate denticles plus long unipinnate molar seta. Palp three-segmented, second segment with subdistal seta, third segment with two (apical and subapical) setae, and patch of short spinules on tip.

Right mandible (Figure 5E, F) differing from left counterpart in reduced spine row (comprising two spines only) and morphology of incisor and lacinia. Former indistinctly

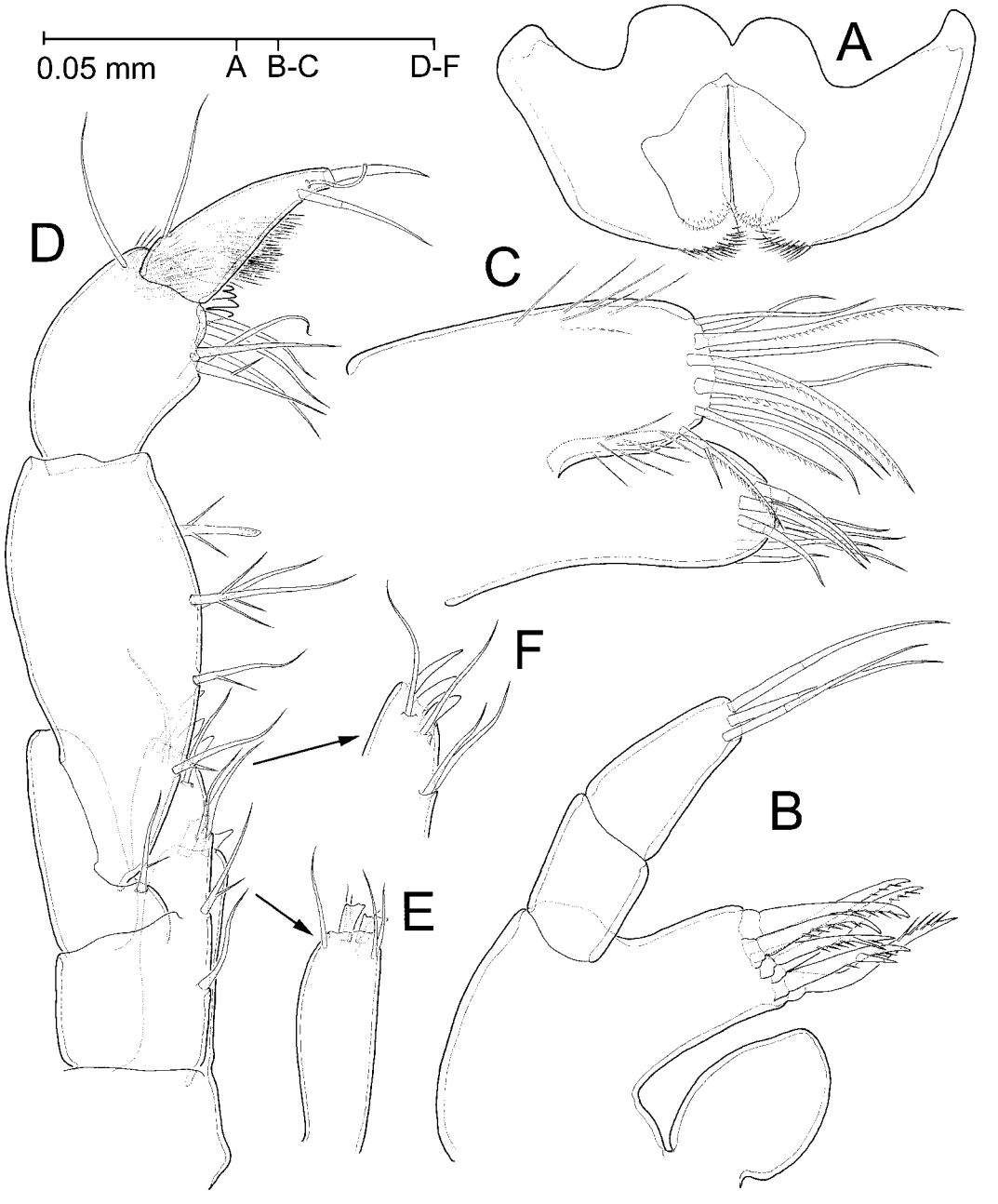

Figure 6. *Fidelidiella pectinata* gen. et sp. nov., holotype. (A) Paragnaths, anterior; (B) maxillule; (C) maxilla; (D) right maxilliped, posterior; (E) detail of basal endite (=inner lobe); (F) detail of endite of ischium (=outer lobe).

five-denticulate; latter reduced, not expanded laterally, with eight distal denticles, inner six subequal and rounded, outer two larger, outermost tricuspidate.

Maxillules (Figure 6B) symmetrical, with two-segmented endopod (=palp), distal segment bearing two distal and one distolateral setae. Coxal endite (=inner lobe) ovoid

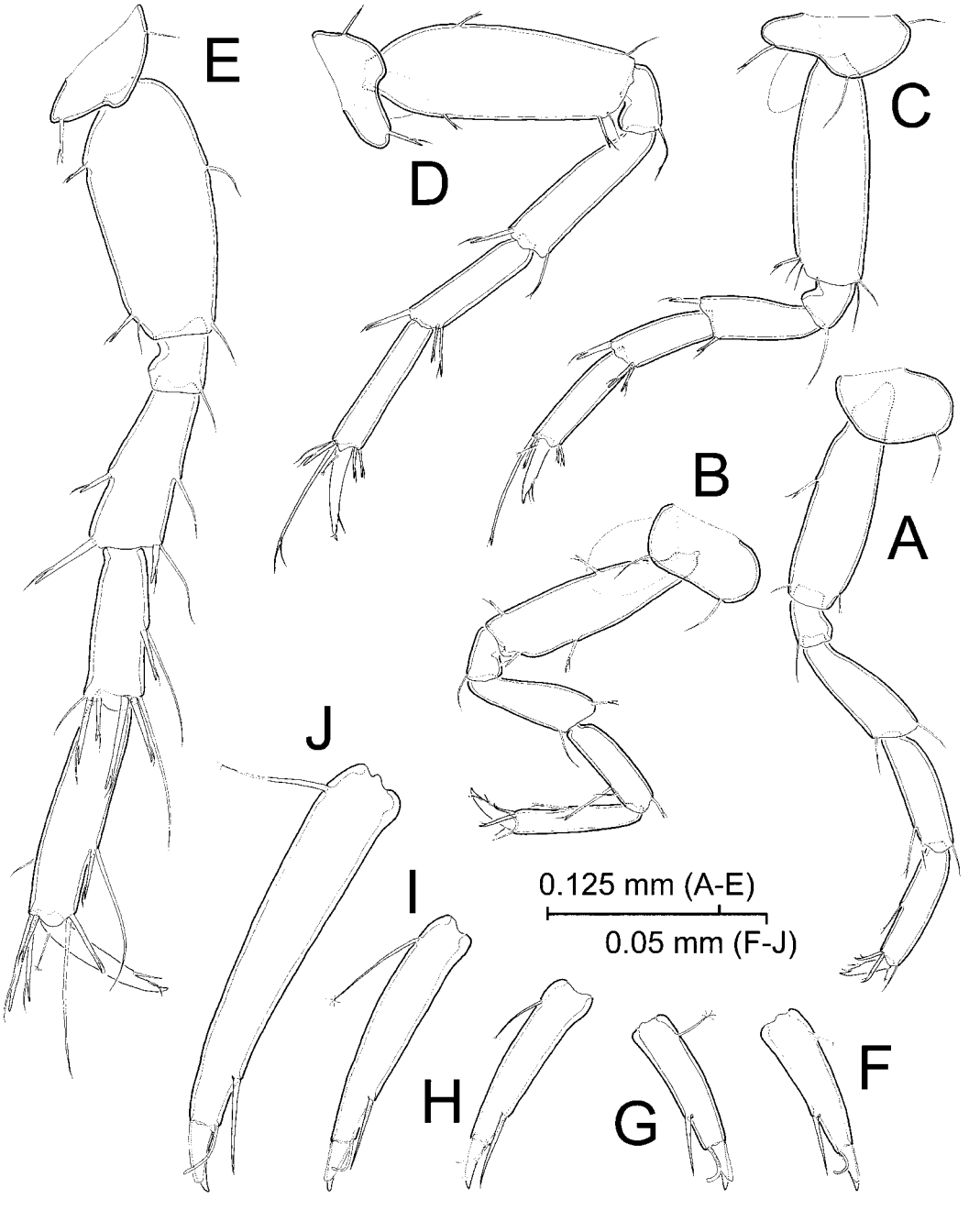

Figure 7. *Fidelidiella pectinata* gen. et sp. nov., holotype. (A–E) Right pereopods 3–7, respectively; (F–J) nail of pereopods 3–7, respectively.

and unarmed. Basal endite (=outer lobe) with seven unipinnate spines distally, two of them bearing hypertrophied pinnule.

Maxilla (Figure 6C) somewhat reduced, with coxal endite (=inner lobe) slightly longer than basal endite (=outer lobe). Coxal endite with eight setae; basal endite with 11 setae distally, innermost seta with hypertrophied pinnule proximally on margin.

Maxilliped (Figure 6D) with short endites. Distal margin of basal endite (=inner lobe) with two stout spines expanded distally, innermost bicuspidate, outermost tricuspidate, and six subdistal setae (Figure 6E). Endite of ischium (=outer lobe) with three unequal spines distally and two setae subdistally on posterior surface, and four setae along inner margin (Figure 6D, F); one of marginal setae with hypertrophied pinnule on medial margin. Merus (=proximal segment of four-segmented palp) strongly oblique, distomedial corner bearing seta with hypertrophied pinnule. Carpus (=palp segment 2) with five setae along medial margin, each with one or two hypertrophied pinnules proximally on margin(s), distalmost seta with expanded tip. Propodus (=palp segment 3) with six distomedial setae (one with hypertrophied pinnule) and single distolateral seta; four strong rounded processes on anterior side of distomedial corner; tuft of long spinules on anterior side of distolateral corner. Dactylus with one proximolateral seta; two unequal setae, one long and stiff, other slender, subdistally on medial margin; tuft of long spinules on anterior surface of segment. Unguis slender, about half length of preceding segment.

Coxal plates (Figure 1A) wider than long, plates 2–5 each with anterior margin overlapping one in front, plates 5–6 with posterior margin overlapping one to rear. Coxal gills apparently unstalked, on pereopods 4–6 (Figures 1A, 7B–D).

Coxa of first gnathopod (Figure 3A) roughly trapezoid, about 1.7 times wider than long, with evenly rounded anterior margin and two setae close to anterodistal corner. Basis short and stout, about 1.8 times longer than wide. Merus with posteromedial surface densely spinulose. Carpus posterodistal corner produced into digitiform process crowned with two pinnate flagellate spines; posteromedial surface of segment with patch of long spinules. Propodus larger than second gnathopod counterpart, ellipsoidal, about 1.9 times longer than wide, with palm angle placed at about 54% of maximum length of segment. Two stout flagellate spines sparsely set around palm angle on medial surface of segment, plus submarginal spine about midway along posterior margin, also on medial surface of segment. Palm margin convex, hyaline, smooth except for short row of tiny serrations near palm angle; two short flagellate spines on medial side of margin, and seta with two minute pinnae on lateral side. Nail short, not reaching palm angle, with two indentations along posterior margin harbouring one and three short setae, respectively.

Coxa of second gnathopod (Figure 3B) roughly ovoid, about 1.5 times wider than long, with seta on anterodistal corner. Basis longer and proportionally more slender than in gnathopod 1 (about 2.9 times longer than wide and 1.4 times longer than basis of first gnathopod). Merus with hardly developed posterodistal lobe. Carpus about 1.6 times longer than wide, with subparallel anterior and posterior margins, and with patch of long spinules on posteromedial surface. Propodus 1.9 times longer than wide, with subparallel anterior and posterior margins, 1.3 times longer than carpus; posterior margin with two slender bifid spines at about two-thirds of length of margin. Palm angle placed at 61% maximum length of segment, with two strong bifid spines submarginally on medial surface of segment (see Figure 3C). Palm margin hyaline, smooth except for proximal serrate portion (see Figure 3C); armature comprising three short flagellate spines along medial side. Medial surface of propodus with longitudinal patch of long spinules close to anterior margin, and with patch of sparsely set spinules near posterior margin. Nail as in gnathopod 1.

Pereopods 3–5 with narrow bases, those of pereopods 6–7 slightly expanded proximally. Pereopod 3 (Figure 7A) with coxa roughly ovoid, about twice as wide as long, with evenly rounded anterior margin and slightly convex distal margin; seta placed on anterodistal corner of plate. Two stout recurved flagellate spines on posterodistal corner of propodus.

Coxa of pereopod 4 (Figure 7B) roughly rectangular, twice as wide as long, with evenly rounded anterior margin and convex posterior margin; seta present at antero- and posterodistal corner of plate. Rest of limb about similar to preceding pereopod except for shorter length (attaining only 92.4% of third pereopod length, mainly due to shorter basis, merus, and carpus).

Pereopod 5 (Figure 7C) as long as preceding limb. Coxa with proximal seta implanted submarginally near anterior margin on medial surface, distal seta on anterior lobe, and flagellate spine on posterodistal corner. Stout flagellate spine(s) at antero- and posterodistal corner of merus, carpus, and propodus; one of spines on anterodistal corner of propodus elongate, widely surpassing nail tip.

Pereopod 6 (Figure 7D) about 1.3 times longer than preceding limb. Coxa with slender flagellate spine on anterior margin and at distolateral corner. Armature of rest of pereopod similar to preceding limb.

Pereopod 7 (Figure 7E) elongated, about 1.2 times longer, and bearing more spines than preceding pereopod.

Relative length of nail (dactylus + unguis) of pereopods 3–7 as follows: 43:41:51:67:100 (see Figure 7F–J). Each with part corresponding to dactylus bearing stiff seta subdistally and slender seta distally on posterior margin, and with penicillate seta proximally on anterior margin. Unguis part almost completely covered anteriorly by hyaline scar. Pereopods lacking any trace of lenticular (=Hertzog's) organs.

Pleopods 1–3 (Figures 1A, 4B) sub-similar, uniramous, lacking secondary sexual characters. Protopod with two retinacles subdistally on medial margin. Presumed exopod three-articulate, with two plumose setae per article. Third pleopod with exopodal articles comparatively shorter and thicker than counterparts of preceding pleopods.

Uropod 1 (Figure 4A, C) biramous, exopod shorter than endopod, both shorter than protopod (67 and 90% of protopod length, respectively). Protopod elongate, about three times longer than wide, with basofacial (=proximolateral) spine, and with flagellate spine on dorsolateral (=posterolateral) and dorsomedial (=posteromedial) corner. Exopod with two distal spines (inner elongate) and one subdistal spine dorsomarginally on each side, outer flagellate, inner simple. Endopod with same armature as exopod except for outer subdistal spine substituted here by slender simple seta. Lateral and medial margins of protopod and rami covered with short denticles.

Uropod 2 (Figure 4A, D) protopod with flagellate spine on dorsolateral and dorsomedial corner. Exopod attaining 80% of endopod length, being slightly longer than protopod. Two distal spines (inner elongate) and one subdistal spine arrayed dorsomarginally at each side; slender simple seta near insertion of outer subdistal spine. Endopod with same armature as exopod except for lack of outer subdistal spine. Lateral and medial margins of protopod and rami covered with short denticles.

Uropod 3 (Figure 4A) long, with unisegmented rami, endopod 89% length of exopod. Protopod 65% length of exopod, with stout flagellate spine on dorsolateral and dorsomedial corner. Exopod with flagellate spine at about 57% of distance along lateral margin and with five apical spines, three of them flagellate, other two simple. Endopod with flagellate spine at 39% of distance along medial margin and with three flagellate spines on tip.

Telson (Figure 4E) wider than long, with distal margin shallowly excavate. Long bifid spine and slender simple seta at each distal corner, plus two tiny penicillate setae at each lateral margin.

Description of paratype

Body about 20% larger than holotype, with pereopods 6 and 7 missing (Figure 2A). Differing from holotype as follows: (1) aesthetasc present on second article of main flagellum of antennule (Figure 2B; aesthetasc apparently absent in holotype); (2) fourth and fifth peduncle segments of antenna proportionally more slender and elongate (4.2 and 4.4 times longer than wide, respectively; fifth segment 84% length of fourth segment; see Figure 2C; corresponding values for holotype 2.7, 2.5, and 71%, respectively); (3) first gnathopod with one additional spine on posterior margin of propodus, and additional short flagellate spine on palm margin (compare Figure 3D and 3A); (4) propodus of second gnathopod (Figure 3E) proportionally longer (2.3 times longer than wide versus 1.9 in holotype), with slightly more spinulose posterior margin, and with one additional short flagellate spine on palm margin; (5) propodus of third and fourth pereopods with two spines on posterior margin (Figure 2E, F; only one spine present in holotype); (6) rami of third uropods (Figure 4F) differing in number of armature elements: two flagellate spines on outer margin of exopod (only one in holotype); three flagellate spines on inner margin of endopod, two of them inserted close together (versus only one in holotype); and five terminal spines on endopod (only three in holotype).

Etymology

Species name derived from the Latin *pecten* (=comb), and referring to the peculiar row of stout rounded processes that the new taxon displays anteriorly on the distomedial corner of the fourth segment of the maxillipedal palp.

Variability

The paratype of *Fidelidiella pectinata* gen. et sp. nov. differs from the holotype in several respects, most probably linked to differences in body size (namely the marginal armature of rami of the third uropods; see Hovenkamp et al. 1983 for a similar situation described in *Bogidiella cyrnensis* Hovenkamp, Hovenkamp and van der Heide, 1983). Since both specimens share remarkable features, such as the peculiar mouthparts mentioned in the generic diagnosis, plus other characters such as the presence of a seta anteriorly on the inner surface of the coxa of the fifth pereopod, an elongate slender flagellate spine on the propodus of the same pereopod, and a seta with two minute pinnae on the palm margin of the first gnathopod (see Figure 3A, D), we tentatively consider both specimens to be conspecific.

Remarks

The new taxon from Lifou conforms precisely to the restricted concept of the Bogidiellidae as introduced by Koenemann and Holsinger (1999, p 784). With regard to its generic assignment, neither of the two specimens collected displays penile papillae, oostegites, or any secondary sexual characters on the pleopods and/or uropods permitting their

unequivocal sexing. This could represent a taxonomic handicap since many bogidiellid genera are defined on the basis of secondary sexually dimorphic characters only (Stock 1981; Koenemann and Holsinger 1999). Nevertheless, the new taxon shows a combination of non-sexually dimorphic characters shared only by members of three out of the 36 genera comprising the family (see Koenemann and Holsinger 1999, Table I, Appendix B): (1) *Actogidiella* Stock, 1981, a monotypic genus from the marine interstitial medium of the British Virgin Islands (Stock 1981); (2) *Bogidiella* Hertzog, 1933 of the so-called "*albertimagni*-group", or "group A" (*sensu* Koenemann and Holsinger 1999), a cluster of 14 Palaearctic species with a single outlier in South America; and (3) *Bogidomma* Bradbury and Williams, 1996, a monotypic genus from inland groundwaters of Barrow Island, NW Australia (Bradbury and Williams 1996). This shared set of characters comprises: (1) two-articulate accessory flagellum of antennule; (2) two-segmented endopod of maxillule; (3) endopod of pleopods 1–3 wanting; (4) third uropod with aequiramous rami; (5) coxal gills present on pereonites 4–6 only; (6) coxal plates wider than long; and (7) telson lacking subapical spines.

Despite these shared similarities, the new taxon from Lifou differs from any bogidiellid known thus far in the possession of a modified lacinia on the left mandible, hypertrophied and expanded laterally, and of a transverse row of strong rounded processes on the anterior side of the distomedial corner of the fourth segment of the maxillipedal palp (latter character shared only with the monotypic *Cabogidiella* Stock and Vonk, 1992). Since the taxonomy of the family at the genus level is rather confused, with many genera and species showing numerous parallelisms and mosaic patterns of character expression, we consider that the erection of a new genus is fully justified by the apomorphies exhibited by the mouthparts of the new taxon.

Additional differences between the new taxon and the species of the *Bogidiella albertimagni*-group include the morphology of the molar process of the mandibles, reduced to a narrow lappet instead of being columnar and triturative, and the unarmed condition of the coxal endite of the maxillule. The new taxon differs from *Actogidiella cultrifera* Stock, 1981 also in the unarmed condition of the coxal endite of the maxillule, as well as in the possession of an unmodified, instead of an inflated, second segment of the mandibular palp (see Stock 1981). Apart from the modified left lacinia mobilis and the row of rounded processes present on the fourth segment of the maxillipedal palp, *Fidelidiella* differs from *Bogidomma australis* Bradbury and Williams, 1996 in the lack of eyes and in the unmodified condition of the accessory flagellum of the antennule (versus eyes well developed and flagellum with posterior distal corner of proximal article extending to mid-length of the tiny distal article in *Bogidomma*). In addition, the propodus of the first and second gnathopods of *Bogidomma* is comparatively more elongated and has a more oblique palm margin than in the new taxon. Nevertheless, the condition of the posterior margin of the propodus of the second gnathopod of the paratype (Figure 3D) is reminiscent of the condition displayed in *Bogidomma*, where this margin is produced about midway into a pointed process with two huge spines.

As stated above, *Cabogidiella littoralis* Stock and Vonk, 1992, from the shallow marine interstitial of the Cape Verde Islands, displays a row of stout processes on the fourth segment of the maxillipedal palp, a feature shared only with the new taxon, although *Bogidiella balearica* Dancau, 1973 (a member of the *albertimagni*-group), and perhaps also the monotypic *Actogidiella* Stock, 1981 display a row of short, stout spines in a position homologous to that occupied by the integumentary processes mentioned above (see Stock 1981, Figure 11h; Jaume 1990, Figure 1g; Stock and Vonk 1992). However, *Cabogidiella*

differs from the new taxon in: (1) the presence of coxal gills on gnathopod 2 and pereopods 3–6 (gills present only on pereopods 4–6 in *Fidelidiella* gen. nov.); (2) uropod 1 of both sexes with both rami styliform (versus rami unmodified in known, unsexed specimens of *Fidelidiella*); (3) protopod of uropod 1 lacking basofacial spine (versus spine present in *Fidelidiella*); (4) telson non-excavate (shallowly excavate in *Fidelidiella*); (5) coxal endite of maxillule with two setae (unarmed in *Fidelidiella*); and (6) segment 2 of mandibular palp swollen distally (not swollen in *Fidelidiella*), among other features.

This is the third and most easterly record of bogidiellid amphipods from the SW Pacific: other records from the region are *Xystriogidiella capricornea* (Stock 1984) from Heron Island, NE Australia (see Stock 1984), and unidentified putative bogidiellids reported from interstitial waters of river alluvia in New Caledonia (Mary and Marmonier 2000).

Racovella gen. nov.

Diagnosis

Mandibular molar columnar, triturative; palp three-segmented, second segment unarmed. Fifth segment (=dactylus) of maxillipedal palp with row of lamellar spinules along posteromedial margin; unguis with row of rounded denticles on proximal half. Basal endite (=outer lobe) of maxillule with six distal spines; endopod (=palp) two-segmented. Posterodistal corner of carpus of first gnathopod not produced into finger-like process. Coxal gills on pereopods 3–6. Endopod of pleopods 1–3 reduced and lacking annulations, each shorter than proximal article of corresponding exopod. Characteristic array of serrations present terminally on both rami of uropods 1–2 and on endopod of uropod 3; uropod 1 lacking basofacial spine; uropod 3 aequiramous. Telson wider than long, deeply excavate.

Etymology

Genus named after the Romanian zoologist Emil G. Racovitza, in commemoration of the centenary of his biospeleological exploratory trip to Mallorca (1904).

Type species

Racovella birramea sp. nov., described herein, by original designation.

Racovella birramea sp. nov.
(Figures 8–14)

Material examined

Cova des Coll (Portocolom, Mallorca, Balearic Islands). UTM coordinates (Datum Europe 50): 4364500/31 522770. Anchialine cave with submarine entrance comprising 6294 m of flooded plus 726 m terrestrial passages. Topography and description of fauna from the cavity published in Gràcia et al. (2005). Holotype: single specimen 1.47 mm, sex unknown, captured 400 m inland in waters of 33‰ salinity; completely dissected and mounted in lactophenol on two slides; slides sealed with nail varnish (BMNH reg. no. 2006-1126). Collected by authors, 21 December 2004.

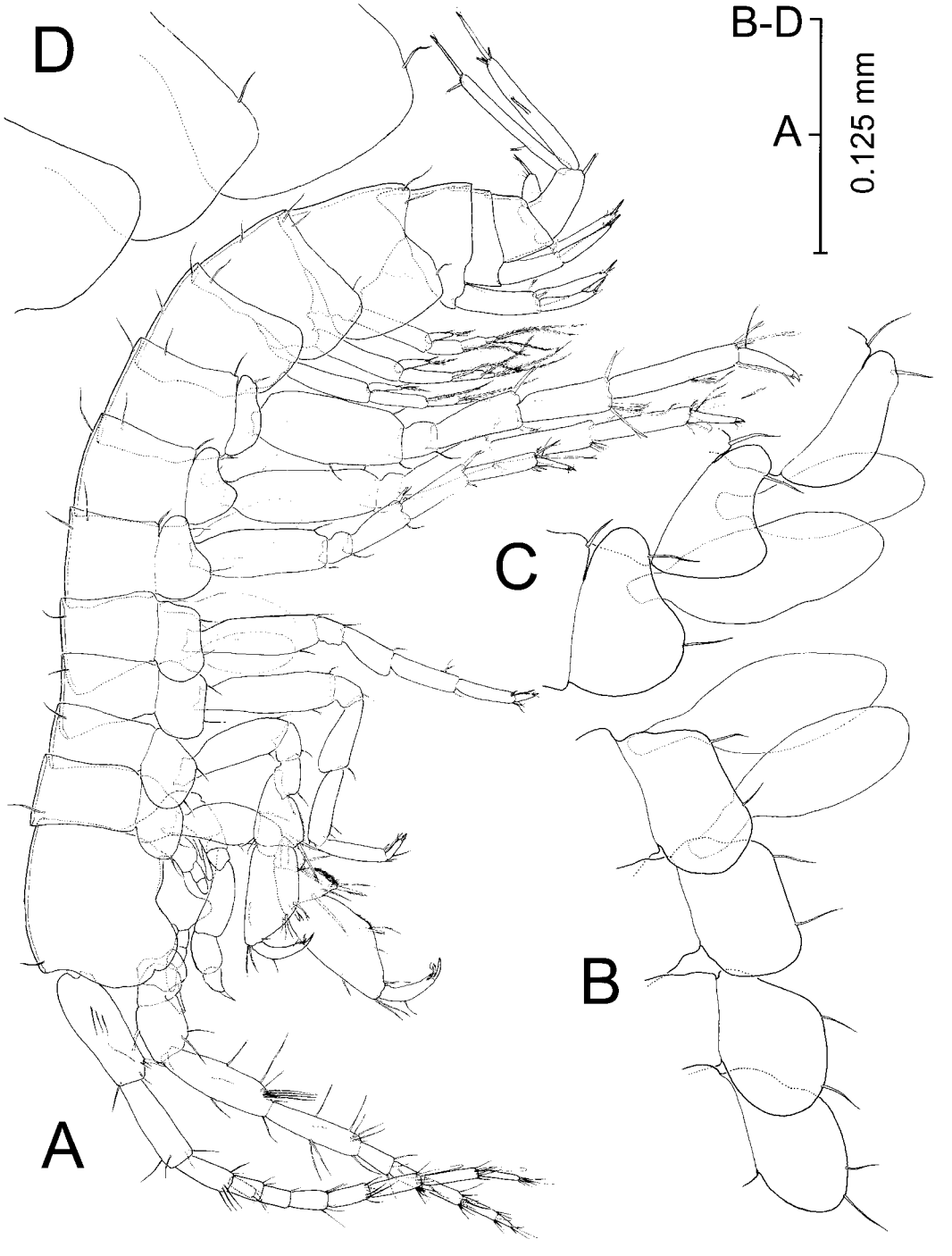

Figure 8. *Racovella birramea* gen. et sp. nov., holotype. (A) Body general aspect, lateral; (B) coxae of pereopods 1–4, latter two with coxal gill attached; (C) coxae of pereopods 5–7 with coxal gills attached on coxae 5 and 6; (D) inset of epimeral plates.

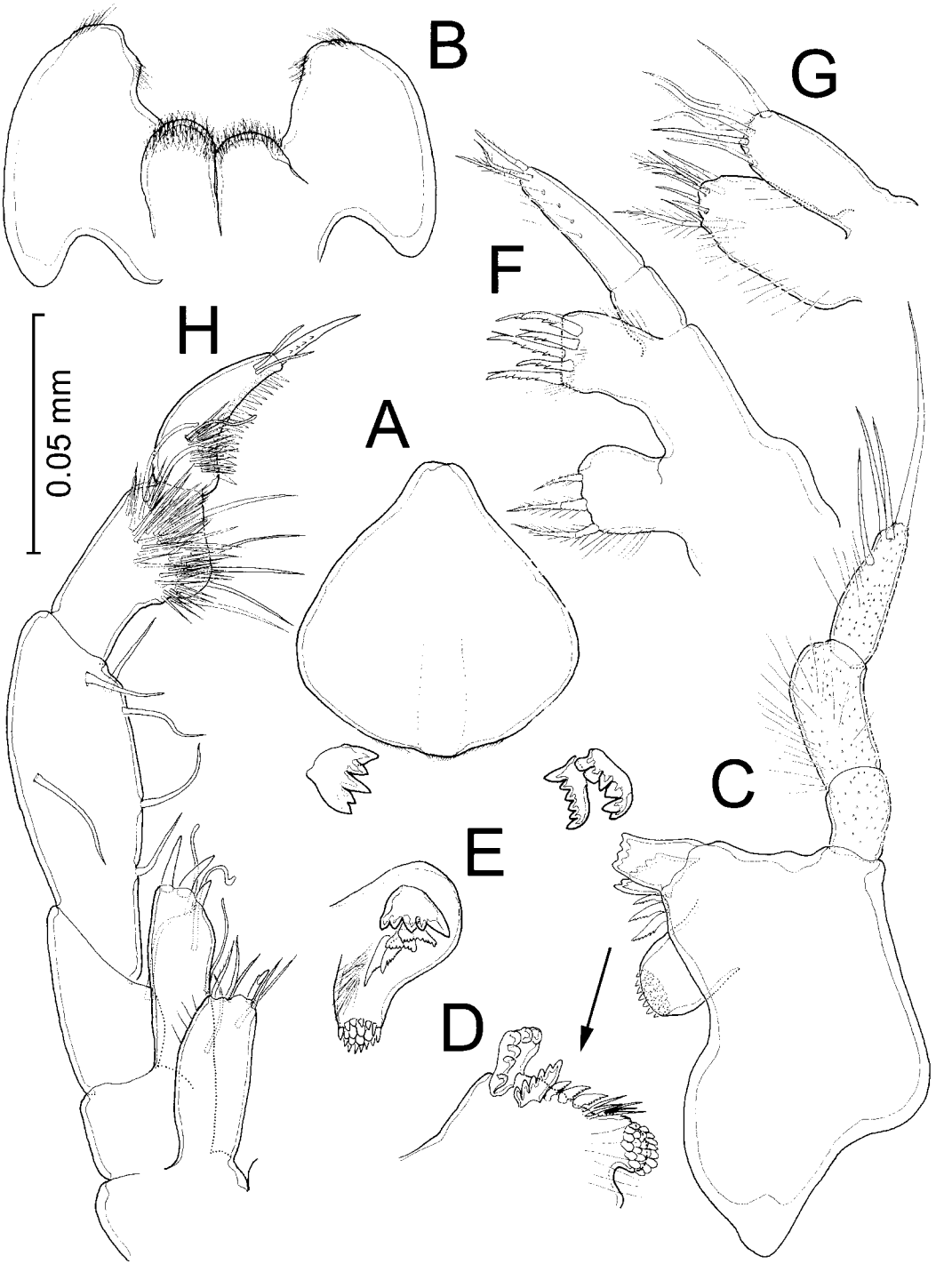

Figure 9. *Racovella birramea* gen. et sp. nov., holotype. (A) Labrum, and incisor and lacinia mobilis of both mandibles, ventral (=anterior); (B) paragnaths, ventral (=posterior); (C) left mandible, lateral; (D) detail of distal portion of latter, medial; (E) same of right mandible; (F) maxillule; (G) maxilla; (H) left maxilliped, anterior.

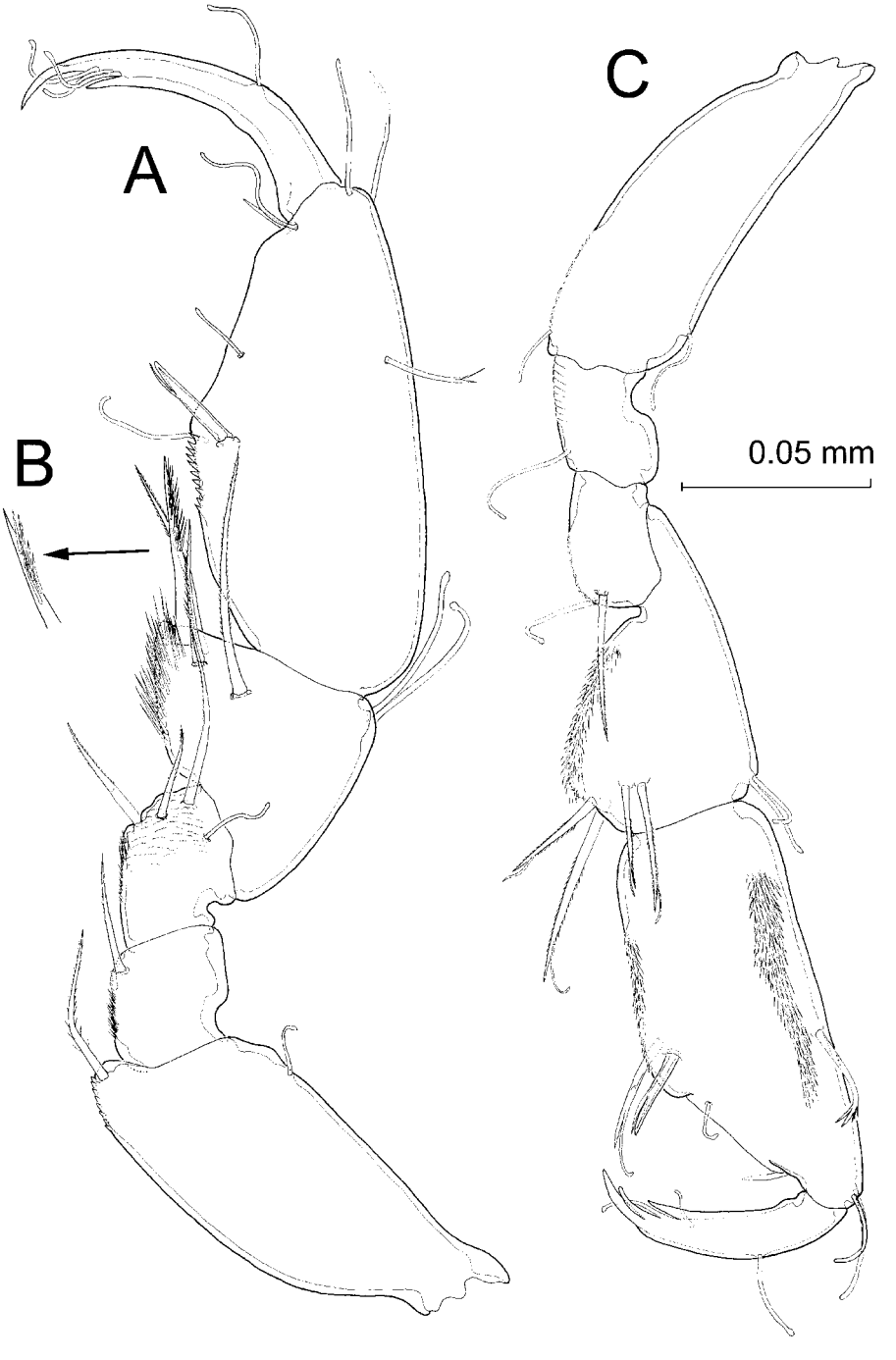

Figure 10. *Racovella birramea* gen. et sp. nov., holotype. (A) Right first gnathopod, medial; (B) detail of tip of stout terminal seta on carpus (not to scale); (C) left second gnathopod, medial.

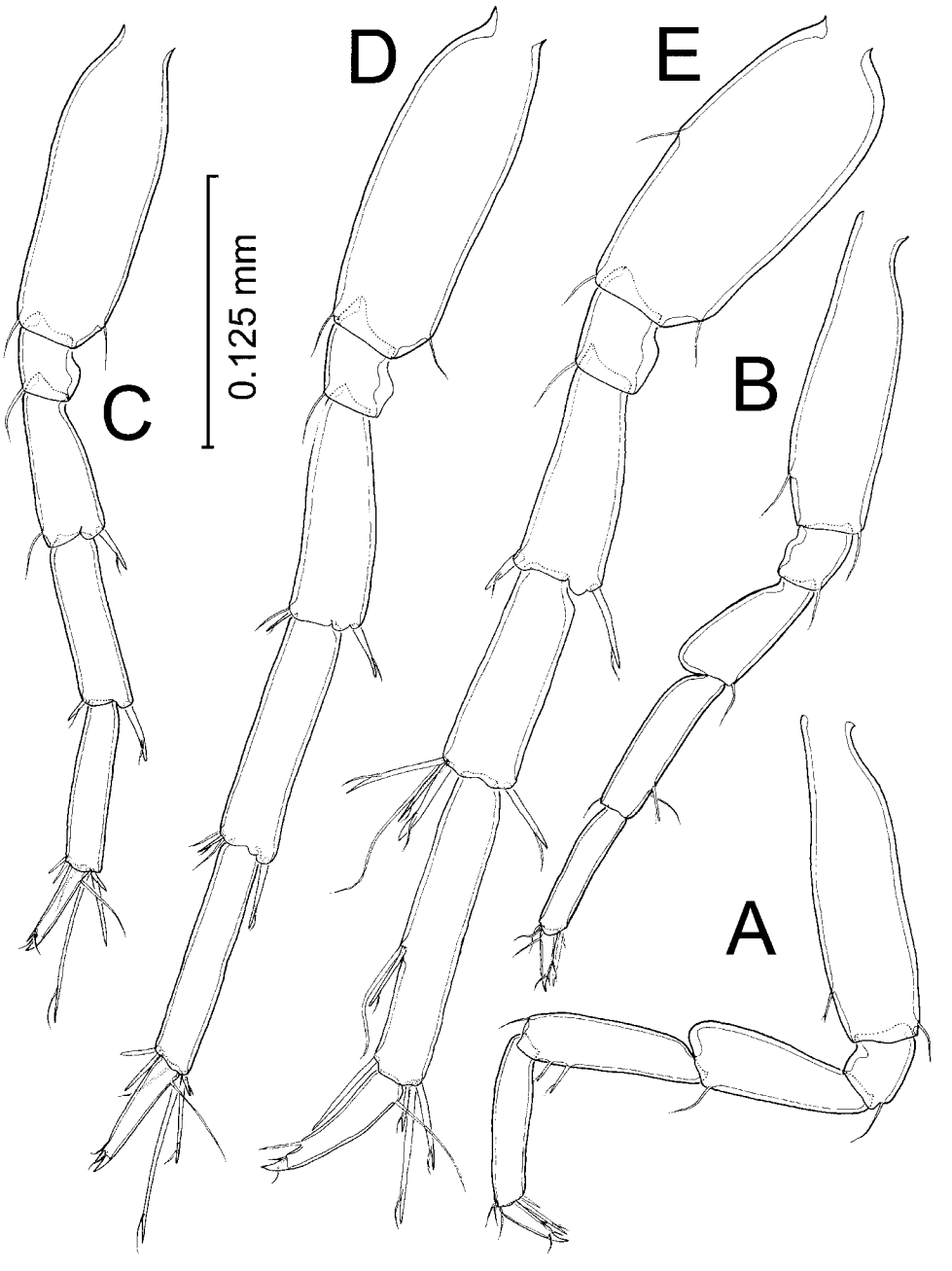

Figure 11. *Racovella birramea* gen. et sp. nov., holotype. (A–E) Left third to seventh pereopods, respectively.

Description

Eyeless and unpigmented. Head (Figure 8A) about as long as wide, with hardly developed rostrum, lateral lobe, and postantennal sinus (terms *sensu* Lincoln 1979, p 15). Body tergites with sparsely set long sensillae as figured. Slender seta present at posteroventral

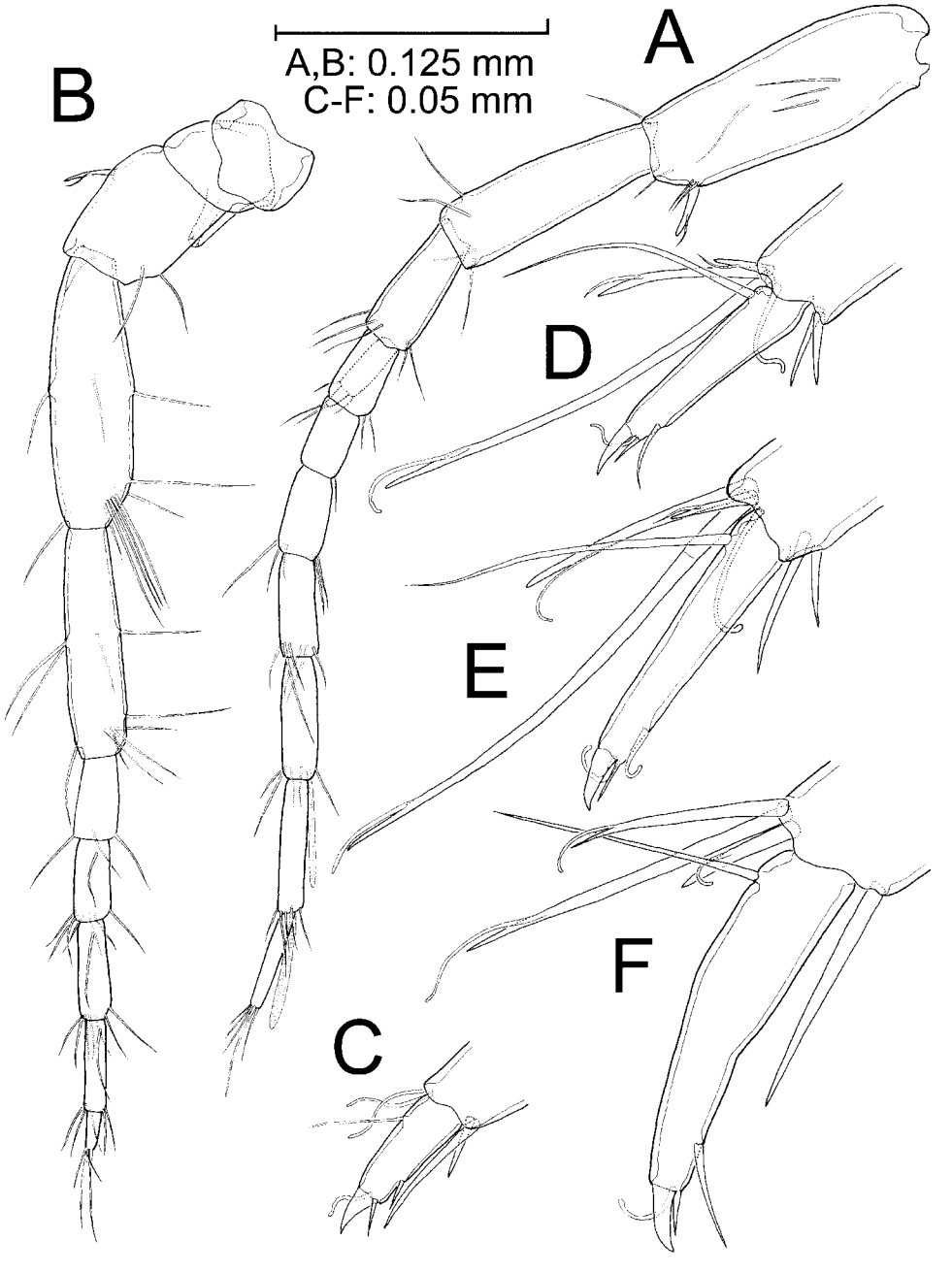

Figure 12. *Racovella birramea* gen. et sp. nov., holotype. (A) Antennule, lateral; (B) antenna, lateral; (C–F) detail of distal parts of pereopods 4–7, respectively.

corner of each of fifth to seventh pereonites (Figure 8C). Epimeral plates (Figure 8D) with rounded posterodistal corners; seta present on posterior margin of plates 2 and 3.

Antennule (Figure 12A) about 43% of body length. Proximal peduncle segment 2.7 times longer than wide, with strong flagellate spine on posterior margin. Second peduncle

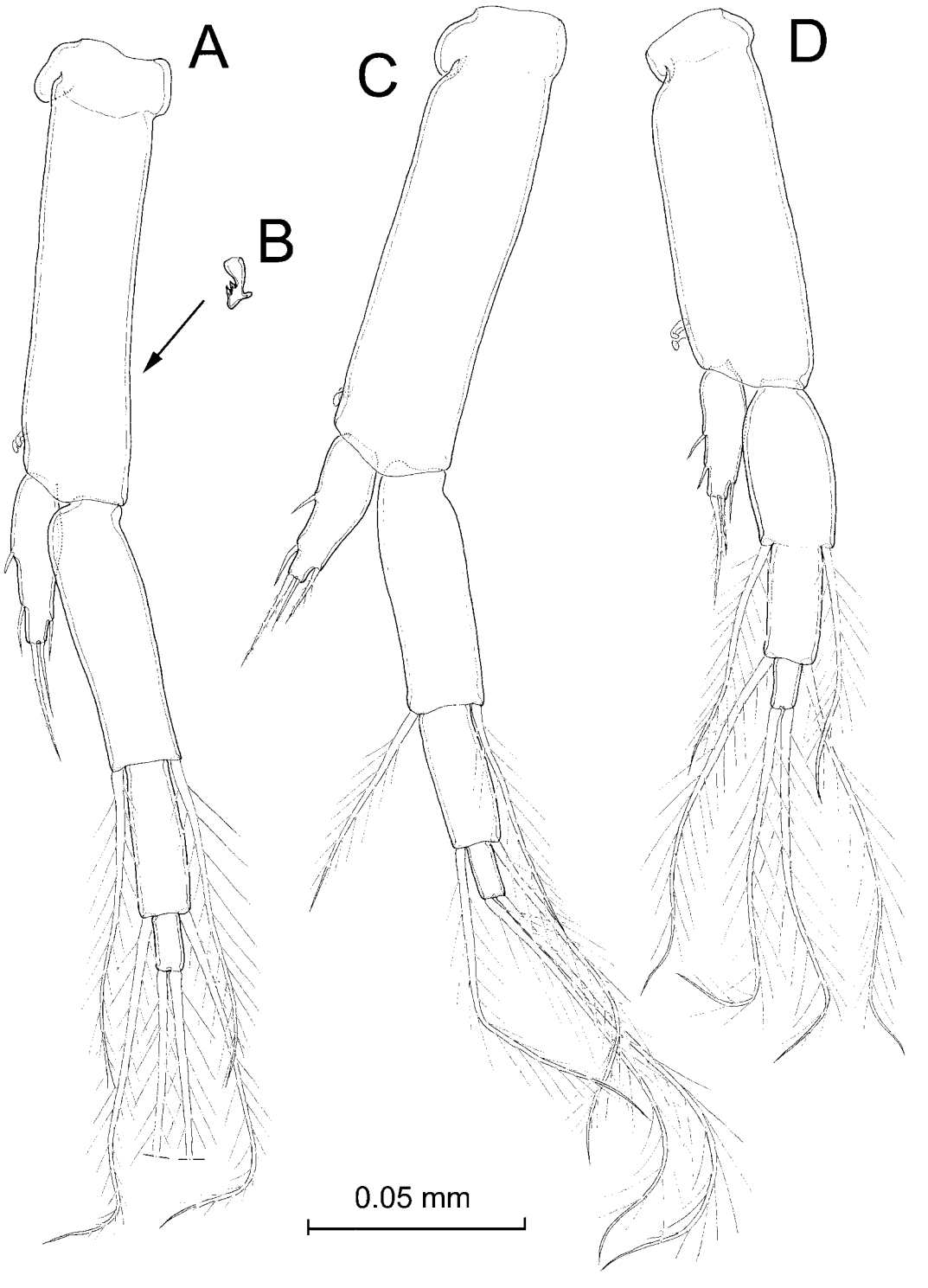

Figure 13. *Racovella birramea* gen. et sp. nov., holotype. (A) Left first pleopod, anterior; (B) detail of retinacle of latter (not to scale); (C, D) left pleopods 2 and 3, respectively, anterior.

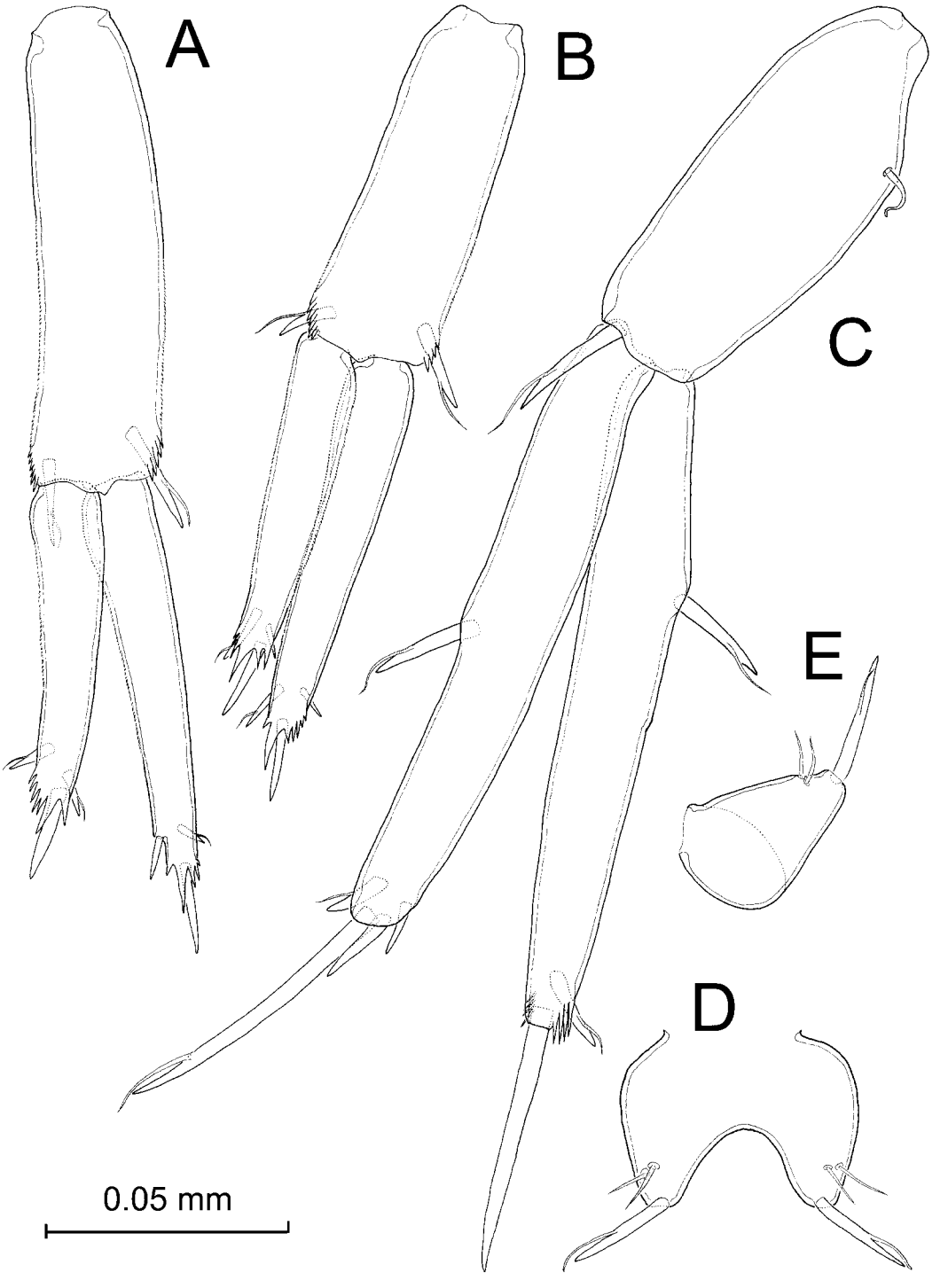

Figure 14. *Racovella birramea* gen. et sp. nov., holotype. (A–C) Right first to third uropods, anterior; (D) telson, dorsal; (E) same, lateral.

segment about 3.3 times longer than wide, attaining 77% length of proximal segment. Third peduncle segment 58% length of preceding segment. Main flagellum longer than peduncle, seven-articulate, with aesthetascs on articles 5 and 6. Accessory flagellum two-articulate, hardly reaching distal margin of proximal article of main flagellum; proximal article three times longer than distal article.

Antenna (Figure 12B) slightly shorter than antennule, peduncle segment 3 with flagellate spine on anterior margin; segment 4 longest, 3.3 times longer than wide; fifth segment 80% length of preceding segment, 3.8 times longer than wide. Flagellum five-articulate, shorter than two distal segments of peduncle combined, apparently lacking aesthetascs.

Labrum (Figure 9A) globose with setulose distal margin. Paragnaths (Figure 9B) bilobed, outer lobes hardly setulose distally, inner lobes densely setulose.

Left mandible (Figure 9C) with subrectangular, similar coarsely six-denticulate incisor and lacinia (Figure 9A, D). Spine row comprising three elements serrated distally along one margin only. Molar triturative, columnar, with patch of stiff coarse setules basally close to spine row (Figure 9D); molar seta apparently absent. Palp three-segmented, proximal two segments naked, distal segment with three apical and one subapical seta; segments 2 and 3 sparsely setulose.

Right mandible (Figure 9E) similar to left counterpart except for incisor (five-denticulate), lacinia, and spine row. Presumed lacinia with finely serrated, expanded distal margin, similar to distal element of spine row. Spine row composed of three elements, two more proximal serrated along one margin only.

Maxillules (Figure 9F) symmetrical. Coxal endite with three setae. Basal endite with six dentate spines. Distal segment of two-segmented endopod carrying three distal setae.

Maxilla (Figure 9G) reduced, both endites similar in length. Coxal endite with eight unequal setae; basal endite with six setae.

Maxilliped (Figure 9H) with short endites. Basal endite with single stout spine and four smooth setae on distal margin, and with single smooth seta subdistally on posterior surface of segment. Endite of ischium with three stout spines distally, two smooth setae on posterior surface, and two others along inner margin. Merus and carpus with one and six smooth setae, respectively. Propodus with distal portion of anterior surface densely spinulose; seven smooth setae, two of them with rounded tip, subdistally on segment as figured. Dactylus with row of lamellar spinules along posteromedial margin and with patch of slender spinules proximally on anterior surface. Unguis with row of rounded denticles on proximal half.

Coxal plates (Figure 8A–C) wider than long, plates 2–5 with anterior margin overlapping one in front, plates 5–6 with posterior margin overlapping one to rear. Coxal gills (Figure 8A–C) on pereopods 3–6, stalked.

Coxa of first gnathopod (Figure 8B) 1.8 times wider than long, with evenly rounded, convex anterior margin and oblique, slightly concave posterior margin; distal margin convex, with seta on anterodistal corner and about midway along margin. Basis (Figure 10A) 3.1 times longer than wide, with posterodistal corner projecting into lobe with stout seta. Ischium and merus with posterior margin finely spinulose. Carpus with posterodistal corner protruding, but not finger-like as in preceding taxon, with stout spinulose seta subsdistally on lobe (Figure 10B); posterior margin of segment spinulose. Propodus (Figure 10A) larger than second gnathopod counterpart, about 2.2 times longer than wide, with oblique, slightly concave, smooth palm margin; palm angle at 45% of maximum length of segment, with single flagellate spine on medial margin; distal portion of posterior margin of segment serrate. Nail long, overreaching palm angle, with single subterminal indentation harbouring three setae.

Coxa of second gnathopod (Figure 8B) 1.4 times wider than long, similar to that of preceding pereopod but with more convex anterior margin, oblique posterior margin, and with seta located at posterodistal corner of segment instead of midway along distal margin. Basis (Figure 10C) slender, 2.8 times longer than wide and as long as basis of first gnathopod. Merus with hardly developed posterodistal lobe. Carpus about 1.7 times longer than wide, with oblique posterior margin; patch of spinules on posteromedial surface. Propodus about 2.3 times longer than wide and 1.4 times longer than carpus, with parallel anterior and posterior margins; palm angle positioned at 55% maximum length of segment, with one long and slender flagellate spine at each side; palm margin straight, almost devoid of armature, smooth; patch of spinules submarginally on medial surface of segment close to anterior margin; posterior margin spinulose midway, serrate distally. Nail bearing two deep indentations subdistally on posterior margin.

Pereopods 3–4 (Figure 11A, B) similar, pereopod 3 longer due to proportionally longer basis and propodus. Coxae of both limbs (Figure 8B) similar, roughly rectangular, 1.6 times wider than long, with convex anterior margin, oblique, slightly concave posterior margin, and straight distal margin with seta at anterodistal and posterodistal corners; plate 4 with comparatively more rounded anterior margin.

Pereopods 5–7 (Figure 11C–E) slender, pereopod 5 shorter than others, pereopods 6–7 similar in length. All with slender basis, although that of pereopod 7 comparatively more expanded (2.3 times longer than wide). One flagellate spine at anterodistal corner of propodus of pereopods 5 and 6 elongate, surpassing tip of respective nail. Coxae 5–7 similar (Figure 8C), with anterodistal lobe progressively shorter towards posterior, posterodistal lobe wanting; all coxae with seta at posterodistal corner; coxa 5 with one seta at anterodistal corner.

Relative length of nail (dactylus + unguis) of pereopods 4–7 as follows: 40:60:90:100 (Figure 12C–F). Pereopods lacking lenticular organs.

Pleopods 1–3 (Figure 13A, C, D) biramous, similar except for somewhat shorter third pleopod, all lacking secondary sexual characters. Protopod with two retinacles (Figure 13B) subdistally on medial margin. Exopod three-articulate, with pair of plumose setae per article; endopod unisegmented, shorter than proximal article of corresponding exopod, with two short, unequal terminal setae, single seta subdistally on outer margin, and two setae along inner margin.

Uropod 1 (Figure 14A) biramous, exopod shorter than endopod, and both rami shorter than protopod (65 and 81% of protopod length, respectively). Protopod elongate, about 3.9 times longer than wide, lacking basofacial spine and with flagellate spine on dorsolateral and dorsomedial corner; distal corners of segment serrate. Tips of rami serrate, with three spines around tip. Uropod 2 (Figure 14B) similar to preceding limb except for proportionately shorter protopod and endopod. Uropod 3 (Figure 14C) longest, with unisegmented rami subequal in length. Protopod 66% length of rami, with stout flagellate spine at lateral corner and short smooth seta proximally on medial margin. Exopod with smooth tip bearing four unequal spines, and single spine about midway along lateral margin. Endopod with terminal serrations and two unequal setae on tip; single spine located at two-fifths of distance along medial margin of segment.

Telson (Figure 14D, E) wider than long, with deeply excavate distal margin and single flagellate spine on tip of each lobe; two short and smooth setae placed subdistally on outer margin of each lobe.

Etymology

Species named after the biramous condition of the pleopods, a feature unrecorded to date in Balearic bogidiellids.

Remarks

This new taxon is remarkable among the Bogidiellidae *sensu stricto* (see Koenemann and Holsinger 1999 for a restricted diagnosis of the family) in exhibiting a combination of only six distal spines on the basal endite (=outer lobe) of the maxillule, plus coxal gills on pereopods 3–6. The former feature is shared only with *Mexigidiella* Stock, 1981, since all other bogidiellids display seven spines at this position. The condition of the coxal gills is shared with *Aequigidiella* Botosaneanu and Stock, 1989, *Aurobogidiella* Karaman, 1988, *Marinobogidiella* Karaman, 1982, and *Nubigidiella* Karaman, 1988. Of these five genera, only *Aurobogidiella* and *Marinobogidiella* share with the new taxon the reduced endopod of pleopods 1–3 (non-articulate and about equal in length to the proximal article of the corresponding exopod). Both genera are monotypic and restricted to the Western Mediterranean (Bay of Naples), where they inhabit the interstices of coarse marine sand at depths of 1–6 m. Irrespective of the close geographical and phenetic affinity, both of these taxa differ markedly from the new taxon in many respects. *Aurobogidiella*—known from the female only—displays a four-articulate exopod of pleopod 2, lacks a strong spine on the carpal lobe of gnathopod 1, and bears one seta on the second segment of the mandibular palp (Karaman 1979, 1988). *Marinobogidiella* is known from the male only, and displays a unisegmented endopod (=palp) on the maxillule, a hardly excavated telson and, as in the preceding species, one seta on the second segment of the mandibular palp (Schiecke 1978; Karaman 1982). Neither of these two taxa displays the characteristic array of serrations present terminally on both rami of uropods 1–2, and on the endopod of uropod 3 of the new taxon.

Other genera of bogidiellids are known to occur in the peri-Mediterranean area (namely *Bogidiella*, *Hebraegidiella* Karaman, 1988, *Maghrebidiella* Diviacco and Ruffo, 1985, and *Medigidiella* Stock, 1981) or in islands of the NE Atlantic (namely *Bogidiella*, *Cabogidiella*, *Stygogidiella* Stock, 1981, and *Xystriogidiella*). Of them, only *Hebraegidiella*, *Stygogidiella*, and some *Bogidiella* species display a non-articulate endopod on pleopods 1–3 which is shorter than the proximal article of the exopod. These three genera differ from the new taxon in having a different number of coxal gills and seven distal spines (instead of six) on the basal endite of the maxillule, among other features.

Apart from the new taxon described above, two other bogidiellids are known to occur in Balearic groundwaters. *Bogidiella balearica* Dancau, 1973 is a cave-dwelling anchialine species distributed along the SE coast of Mallorca and the neighbouring Cabrera archipelago. *Bogidiella torrenticola* Pretus and Stock, 1990 is an interstitial species known only from the type locality, the hyporheic zone of a stream on the west coast of Mallorca. Both species clearly differ from the new taxon in the display of lenticular organs on the pereopods and of a basofacial spine on the protopod of uropod 1, among many other features (see Stock and Iliffe 1987; Jaume 1990; Pretus and Stock 1990). In addition, Pretus (1991) reported the occurrence of at least three other bogidiellid taxa in Balearic groundwaters, which remain undescribed.

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