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Resolving the *Lourinia armata* (Claus, 1866) complex with remarks on the monophyletic status of Louriniidae, Monard 1927 (Copepoda: Harpacticoida)

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Abstract

An attempt was made to test if *Lourinia armata* (Claus, 1866)—as it is currently diagnosed—represents a species complex. Detailed examination and comparisons of several specimens collected from different localities suggest that *L. armata* indeed represents a complex of four closely related morphospecies that can be differentiated from one another by only detailed observations. One of the four species is identified as *Lourinia* aff. *armata* and the other three species are described as new to science and named as *Lourinia wellsi* **sp. nov.**, *L. gocmeni* **sp. nov.**, and *L. aldabraensis* **sp. nov.** Detailed review of previous species records indicates that the genus *Lourinia* Wilson, 1924 is distributed worldwide. *Ceyloniella nicobarica* Sewell, 1940, originally described from Nicobar Island and previously considered a junior subjective synonym of *L. armata* is reinstated as *Lourinia nicobarica* (Sewell, 1940) **comb. nov.** on the basis of the unique paddle-shaped caudal ramus seta V. It is postulated that almost all of these records are unreliable in terms of representing true *Lourinia* aff. *armata* described herein. On the other hand, the comparative evaluation of the illustrations and descriptions in the published literature indicates the presence of several new species waiting to be discovered in the genus *Lourinia*.

It has been determined that, according to updated modern keys, the recent inclusion of the monotypic genus *Archeolourinia* Corgosinho & Schizas, 2013 in the Louriniidae is not justified since *Archeolourinia shermani* Corgosinho & Schizas, 2013 does not belong to this family but should be assigned to the Canthocamptidae. On the other hand, it has been argued that the exact phylogenetic position of the Louriniidae still remains problematic since none of the diagnostic characters supports the monophyly of the family within the Oligoarthra. It has also been argued that the close relationship between Louriniidae and Canthocamptidae is supported since both families share the homologous sexual dimorphism (apophysis) on P3 endopod. The most important characteristic that can possibly be used to define Louriniidae is the reduction of maxilliped.

Key words: cryptic speciation, Harpacticoida, Louriniidae, new species, taxonomy

Introduction

The family Louriniidae is taxonomically and phylogenetically one of the least known families in the Harpacticoida and therefore its relationship with other harpacticoid taxa has not been well defined. The taxonomic and nomenclatural history of the family and its taxa is complicated and problematic (see Huys 2009: 94 for a review). *Lourinia armata* (Claus, 1866) was originally described as *Jurinia armata* by Claus (1866). Later, Thompson & Scott (1903) described *Ceylonia aculeata* (included by the authors in the family Harpacticidae) but soon after Isaac Thompson's unexpected death his co-author noted that *J. armata* and *C. aculeata* Thompson & Scott, 1903 are conspecific (Scott 1909). He also noted that the generic name *Jurinia* Claus, 1866 was preoccupied by a dipteran genus and consequently used the junior synonym *Ceylonia* Thompson & Scott, 1903 as the replacement name and established the new family Ceyloniidae. Later Wilson (1924) pointed out that the generic name *Ceylonia* was also preoccupied, and renamed

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it *Ceyloniella* Wilson, 1924; interestingly, in the same paper, Wilson (1924) also proposed the new replacement name *Lourinia* Wilson, 1924 for the preoccupied *Jurinia*. The succession of these nomenclatural acts has created a long list of synonymies and considerable confusion in the correct use of the names for lourinid taxa. Sewell (1940) adopted the generic name *Ceyloniella* and the family name Ceyloniellidae which was first proposed by Monard (1937). Nicholls (1941) also believed that *Ceyloniella* should stand as the correct generic name and accepted the family-group name as Ceyloniellidae. On the other hand, according to the First Reviser Principle (ICZN, 1999, Art. 25), the action made by Monard (1927) as a first reviser should be adopted and Monard's (1927) proposal of the family name Louriniidae should be followed as used by some authors (*e.g.* Lang 1948; Vervoort 1964; Yoo & Lee 1994; Huys *et al*. 1996; Boxshall & Halsey 2004; Wells 2007; Huys 2009; Corgosinho & Schizas 2013). The names *Lourinia* and Louriniidae are also adopted in this study.

The family Louriniidae currently contains only two monotypic genera, *Lourinia* and *Archeolourinia* Corgosinho & Schizas, 2013. The genus *Archeolourinia* is still represented by only one species and has not been reported since its original description (Corgosinho & Schizas 2013). On the other hand, since its original description as *Jurinia armata* from Nice (France) by Claus (1866), *L. armata* has been reported from several localities, either as simple records or redescriptions or by the description of synonymised specific/subspecific taxa which have created a long list of synonymies (see results and discussion). Comparisons of all previous reports concerning *L. armata* point to abnormally high levels of morphological variability, which are generally regarded as indicative of the existence of species complexes rather than typical for individual species. In this study, we attempt to test whether *L. armata* is a species complex or not.

Materials and methods

We re-examined (see results) specimens collected from the Mediterranean coasts of Turkey (deposited in the collection of Mersin University and Balıkesir University) as well as some material from Egypt and Aldabra (deposited in the collection of the Natural History Museum, London). Olympus BX–50 and BX–53 binocular microscopes were used to examine and draw the specimens in detail. Selected specimens were dissected under an Olympus SZX–12 stereomicroscope and parts were mounted on slides in lactophenol mounting medium. Glass fibres were used to prevent the specimens and dissected appendages from being squashed by the coverslips and to facilitate rotation and manipulation, allowing observation from all angles. Measurements were taken with the aid of an ocular micrometer. Illustrations of the specimens were drawn with Photoshop CS2 or Inkscape v0.91 by using a Wacom Cintiq Pro 13 graphic tablet. Scale bars in illustrations are given in μm. Some specimens were examined with a Zeiss SUPRA 55VP (FESEM) scanning electron microscope at the Mersin University Advanced Technology Education, Research, and Application Centre (MEITAM). Kaymak & Karaytuğ (2014) were followed to prepare the specimens for SEM study. All dissected specimens prepared for light microscopy were sealed with Entellan (Merck) after examination; whole specimens were preserved in 70% ethanol in small tubes. Huys *et al*. (1996) were followed for the terminology used in the text. Abbreviations used in the text are: *P1–P6*, first to sixth swimming legs; *ae*, aesthetasc; *enp*, endopod; *exp*, exopod. All material, except for the specimens deposited in the Natural History Museum, London, is incorporated in the collection of Mersin University Biology Department.

Results

Taxonomic account

Order Harpacticoida Sars, 1903

Family Louriniidae Monard, 1927

Ceyloniidae Scott, 1909, p. 227.
Ceyloniellidae Monard, 1937 p. 83

Amended diagnosis. Copepoda Harpacticoida. Body slender and more or less cylindrical, without prominent

distinction between prosome and urosome, first thoracic somite fused to cephalosome. Urosome 5-segmented in female; comprising fifth pedigerous somite, genital double-somite and three free abdominal somites. Genital double-somite longer than wide, subdivided by discontinuous lateral sutures. Paired genital apparatus located ventrally on genital double-somite; copulatory pore located on ventral midline. Anal operculum straight. Urosome 6-segmented in male; comprising fifth pedigerous somite, genital somite and four free abdominal somites. Caudal rami with six setae. Rostrum well developed, with rounded tip, anteroventrally directed. Antennule 7-segmented; third segment longest; fourth segment with aesthetasc fused basally to seta and arising from pedestal. Antennule 9-segmented in male; haplocer. Antenna biramous; with separate coxa; allobasis unarmed; endopod 1-segmented; exopod 1-segmented with two setae. Mandible with well developed coxal gnathobase; palp reduced. Maxillule with well developed praecoxal arthrite; with coxa. Maxilla with two syncoxal endites; allobasis represented by claw. Maxilliped vestigial, represented by tapering process, unsegmented with a seta distally. P1–P4 with 3-segmented exopods and 2-segmented endopods. Male P3 with 3-segmented endopod; second segment with apophysis. Spine and setal formula of P1–P4 as follows:

	Exopod	Endopod
P1	0.0.112	1.210
P2	0.1.123	1.321
P3	0.1.123	1.3(2)21[1.apo.2 in ♂]
P4	0.1.123	1.121

P5 confluent; with well developed baseoendopod; exopod separate. Male P5 confluent, exopod fused to baseoendopod.

Genus *Lourinia* Wilson, 1924

Jurinia Claus, 1866
Ceylonia Thompson & Scott, 1903
Ceyloniella Wilson, 1924.

Diagnosis. As for family.

Type species. *Jurinia armata* Claus, 1866 = *Lourinia armata* (Claus, 1866) (by monotypy).

Other species. *L. aldabraensis* **sp. nov.**, *L. gocmeni* **sp. nov.**, *Lourinia wellsi* **sp. nov.**, *Lourinia nicobarica* (Sewell, 1940) comb. nov. [= *Ceyloniella nicobarica* Sewell, 1940].

Species inquirendae. *Ceylonia aculeata* Thompson & Scott, 1903; *Ceylonia aculeata* Scott, 1909; *Ceylonia aculeata* var. *adriatica* Brian, 1923 [*nomen nudum*]; *Ceyloniella aculeata* var. *adriatica* Brian, 1928; *Ceyloniella armata* sensu Willey (1930); *Ceyloniella armata* sensu Monard (1935); *Ceyloniella armata* sensu Monard (1937); *Ceyloniella armata f. major* Sewell, 1940; *Ceyloniella armata f. minor* Sewell, 1940; *Ceyloniella*; *Ceyloniella nicobarica* var. Sewell, 1940; *Ceyloniella armata* sensu Nicholls (1941); *Lourinia armata sulamericana* Jakobi, 1954; *Lourinia armata* sensu Noodt (1955); *Lourinia armata* sensu Petkovski (1955); *Lourinia armata* sensu Pesta (1959); *Lourinia armata* sensu Vervoort (1964); *Lourinia armata* sensu Yoo & Lee (1993).

Lourinia aff. *armata* (Claus, 1866)

(Figs. 1–5)

Original description. *Jurinia armata* Claus, 1866: 25, plate ii, figs. 15–24.

Synonym. *Ceylonia armata* (Claus, 1866) sensu Gurney (1927).

Material examined. One ♀ dissected on nine slides, one ♂ dissected on seven slides; six ♀♀ and one ♂ preserved in alcohol; collected from Mersin Province, in washings of macroalgae from İncekum Beach/Silifke/Mersin/Turkey (N36.2849000°, E33.8321333°), 10 April 2007. One ♀ dissected on nine slides, two ♀♀ and two ♂♂ preserved in alcohol; from interstitial habitat at Büyükboncuklu beach/Fethiye/Muğla/Turkey (N36.6275000°,

E29.0772222°), 17 May 2012. Two ♂♂ preserved in alcohol; collected in washings of macroalgae from İncekum Beach/Silifke/Mersin/Turkey (N36.2849000°, E33.8321333°), 27 November 2007. One ♂ preserved in alcohol; collected in washings of macroalgae from Akçagerme Beach/Kaş/Antalya/Turkey (N36.2065833°, E29.6014500°), 02 December 2007. One ♀ and one copepodid V ♀, preserved in alcohol; collected from Egypt, Port Said, Kabret, Gulf of Suez, Cambridge Suez Canal Expedition; initially identified as *Ceylonia armata*, the specimens were deposited in The Natural History Museum (London) under registration number BMNH 1928.4.2. 131–133.

Description of female. Body cylindrical (Fig. 1A), tapering posteriorly; without prominent distinction between prosome and urosome, first thoracic somite fused to cephalosome. Total body length: 1,112 μm (mean = 867 μm; *n* = 11). Maximum width: 218 μm (mean = 195 μm; *n* = 11). Rostrum sinusoidal, defined at base, with two apically serrate sensillae (Fig. 1C). Hyaline frills of somites smooth. Surface of all somites ornamented partly with microspinules as figured. Urosome 5-segmented comprising fifth pedigerous somite, genital double-somite and three free urosomites. Genital double-somite longer than wide, without intersomitic division. Genital double-somite, third and fourth urosomites with paired spinule rows ventrolaterally (Fig. 5A). Anal somite with one pair of sensilla dorsally; anal operculum straight, margin naked (Fig. 1A).

Antennule (Fig. 2A) 7-segmented. First segment ornamented with spinule rows as figured, with one seta. Second segment with nine setae. Third segment longest, with six setae. Fourth segment with one seta and with aesthetasc fused basally to seta and originating from common pedestal. Fifth and sixth segments small, with one seta each. Last segment with seven setae and apical acrothek consisting of an aesthetasc and two setae. Setal formula of antennule: 1–[1]; 2–[9]; 3–[6]; 4–[1 + (1 + ae)]; 5–[1]; 6–[1]; 7–[6 + acrothek].

Antenna (Fig. 2B). Coxa rectangular, ornamented with a spinule row as figured. Allobasis ornamented with a spinule row as figured. Exopod 1-segmented; with one apical and one subapical bipinnate seta. Endopod 1-segmented, ornamented with spinule rows as figured; lateral armature consisting of two bipinnate spines, distal armature consisting of four bipinnate spines (outer one fused basally to a small seta).

Mandible (Fig. 2C). Coxa elongate, forming gnathobase provided with series of multicuspidate teeth distally and unipinnate seta at dorsal corner. Palp uniramous, consisting of basis and endopod. Basis with one pinnate and one plumose seta distally. Endopod 1-segmented, with one lateral plumose seta and two naked terminal setae.

Maxillule (Fig. 2D–E). Praecoxa with few spinules around inner margin; arthrite with two setae on anterior surface and seven elements around distal margin. Coxal endite cylindrical; with one naked seta. Basis and rami fused into elongate palp (Fig. 2E) represented by single segment; with tiny spinule rows as figured, and with one semispinulose and five naked setae apically; endopod completely fused to the segment, with two naked lateral setae; exopod also fused to segment, with one plumose and two naked lateral setae.

Maxilla (Fig. 2F) comprising syncoxa and allobasis. Syncoxa with spinule row as figured; with two cylindrical endites; each endite with two naked setae and spinulose stout spine. Allobasis forming acutely recurved spinous endite with spinules along lateral surface; accessory armature represented by two naked setae; endopod completely incorporated into allobasis, represented by two naked setae arising from membranous area.

Maxilliped (Fig. 2G) reduced, represented by small triangular lobe ornamented with several spinules as figured and with one seta apically.

P1 (Fig. 3A). Praecoxa well developed and ornamented with spinules along distal margin. Coxa rectangular, with tube-pore near distal margin at anterior surface. Basis ornamented with spinule rows along distal margin as figured; with one outer seta and one robust bipinnate inner spine that extends beyond end of the first endopodal segment. Exopod 3-segmented, all segments ornamented with strong spinules along outer margins; first and second segments without inner armature; distal segment with one inner geniculate seta, one apical geniculate seta and two outer spines. Endopod 2-segmented, ornamented with spinules as figured, shorter than exopod; first segment with one inner, distally pectinate seta; distal segment with setules along inner margin, with two inner setae (proximal one distally pectinate) and one apical bipinnate spine.

P2–P4 (Figs. 3B; 4A–D). Intercoxal sclerites naked; praecoxae well developed, ornamented with spinule row as figured. Coxae with tube-pore near distal margin of anterior surface. Bases ornamented with spinule rows along distal margin as figured; with naked outer seta. Exopods 3-segmented, all segments with strong spinules along outer margins; inner margin of second and third segments ornamented with setules; second segment with one short plumose (P2) (Fig. 3B) or one long plumose (P3–P4) (Fig. 4A–B) inner seta; distal segment with one short plumose (P2) or one long plumose (P3–P4) inner seta, two apical setae and three outer spines. Endopods 2-segmented, shorter than corresponding exopods; first segment with one distally pectinate, inner seta (Figs. 3B; 4C–D);

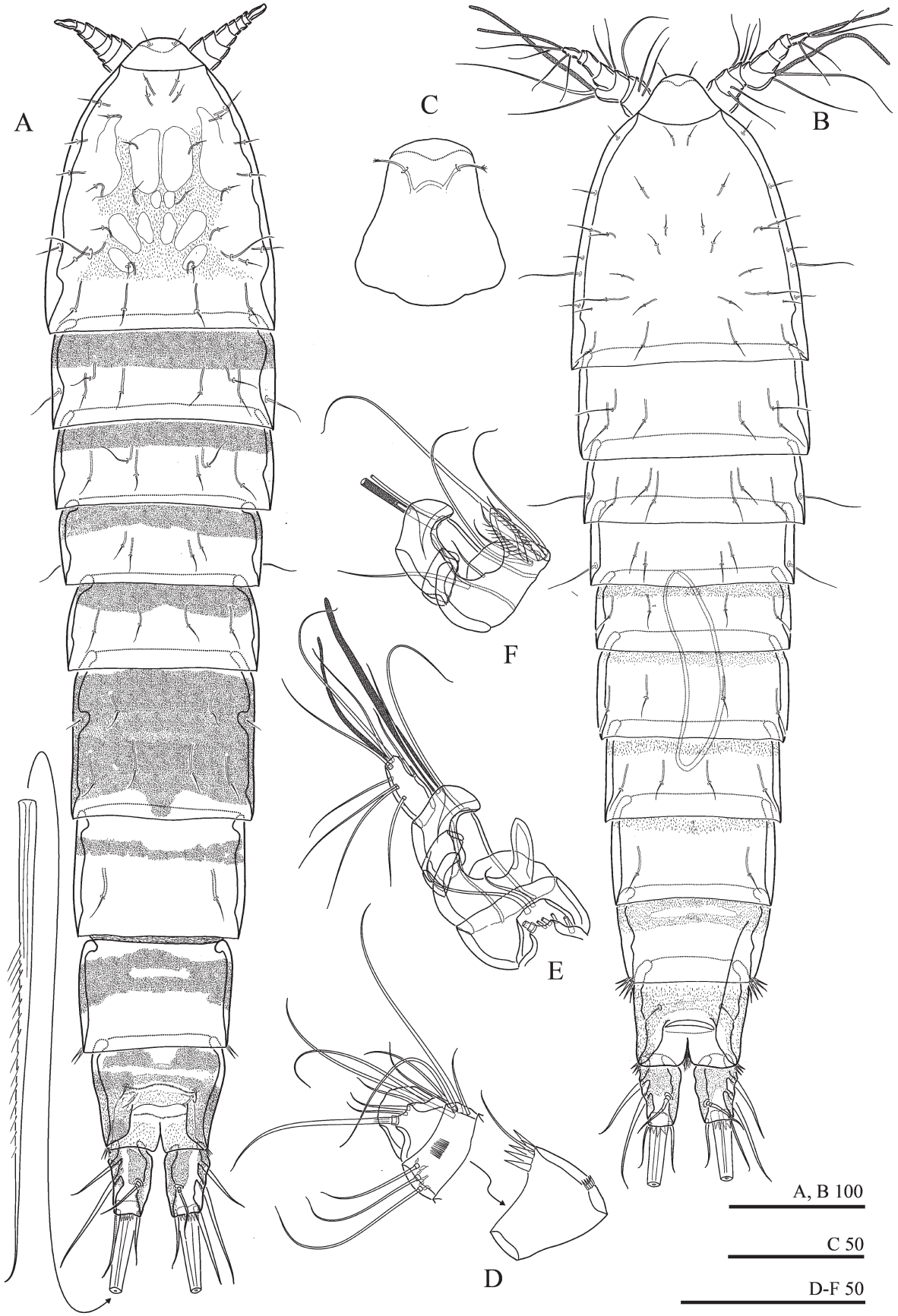

FIGURE 1. *Lourinia* aff. *armata* (Claus, 1866) (♀: A, C) (♂: B, D–F): A, habitus, dorsal; B, habitus, dorsal; C, rostrum, dorsal; D, antennule, segments 1–4, ventral; E, antennule, segments 3–9, ventral; F, antennule, segments 6–8, ventral.

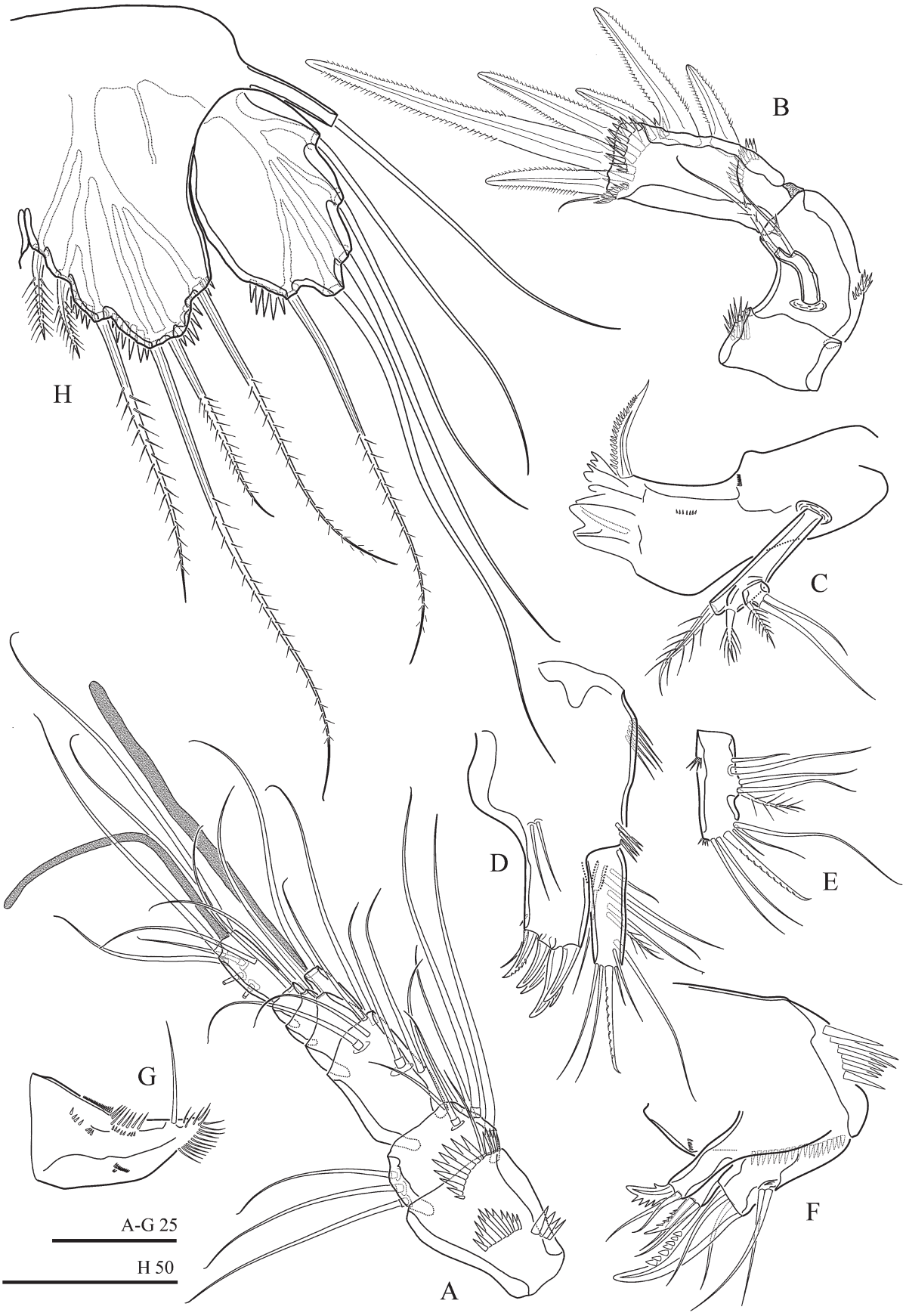

FIGURE 2. *Lourinia* aff. *armata* (Claus, 1866) (♀): A, antennule, ventral; B, antenna, lateral; C, mandible, anterior; D, maxillule, anterior; E, maxillulary palp, lateral; F, maxilla, ventral; G, maxilliped, ventral; H, P5, anterior.

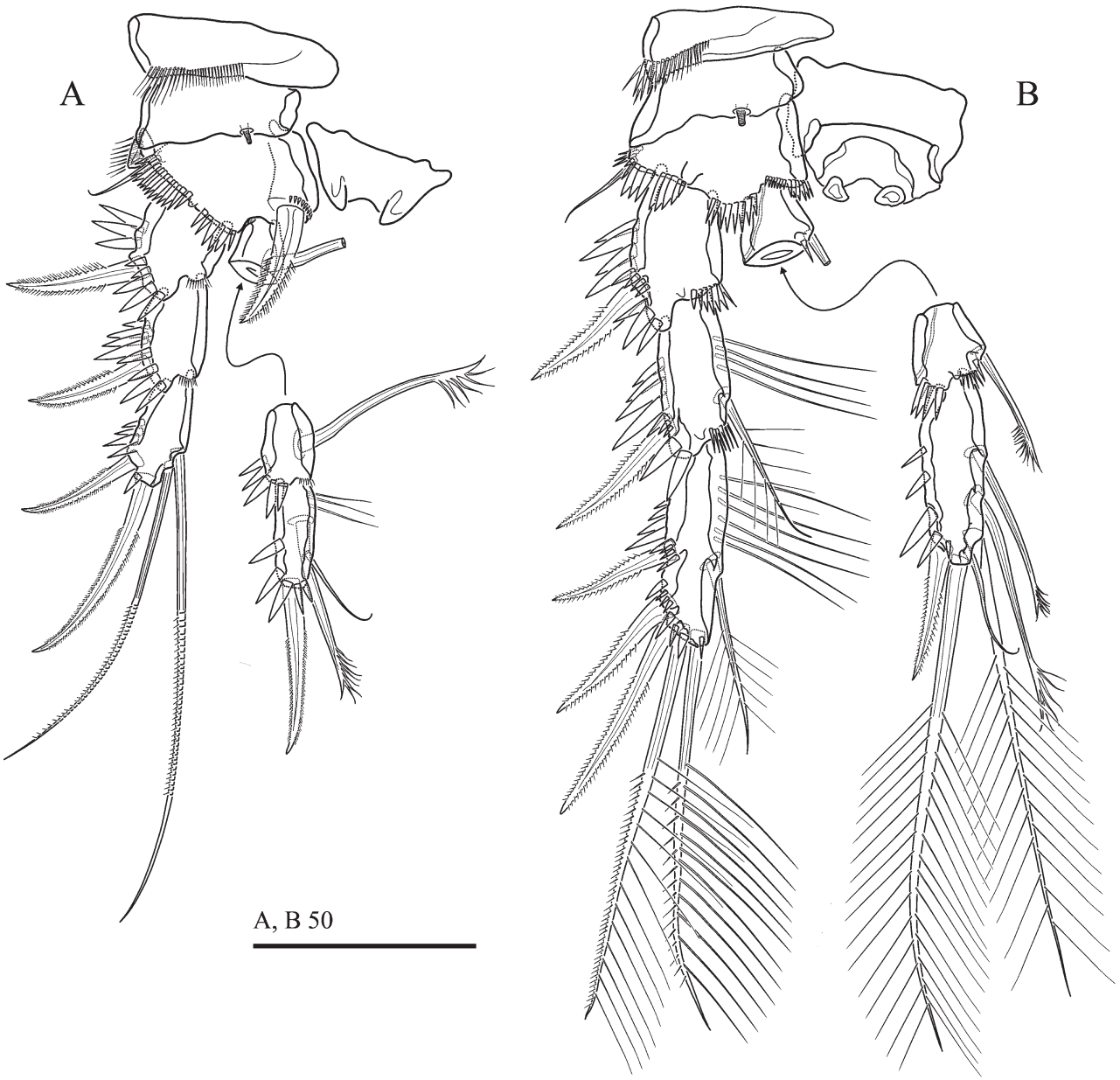

FIGURE 3. *Lourinia* aff. *armata* (Claus, 1866) (♀): A, P1, anterior; B, P2, anterior.

second segment ornamented with spinules along outer margin as figured, with three inner setae (two distally pectinate and one long plumose), two apical setae (one short naked and one long plumose) and one outer spine (P2) (Fig. 3B) or two plumose inner setae (one short and one long), two plumose apical setae and one outer spine (P3) (Fig. 4C) or one inner, distally pectinate seta, two plumose apical setae and one outer spine (P4) (Fig. 4D).

Fifth pair of legs (Figs. 2H; 5A) fused, baseoendopod well developed. Endopodal lobe bears six bipinnate elements; setae I–II short, spiniform; setae III–VI long; seta IV longest. Exopod distinct, ovoid, with five long setae (innermost bipinnate).

Sixth pair of legs (Fig. 5C) covered by P5, with one bifid outer element, one seta and two small, apically serrate, inner elements.

Caudal rami (Fig. 1A) about 1.75 times as long as broad, with spinular ornamentation at distal margin ventrally (Fig. 5A), with six setae. Setae II–III located laterally; seta IV and VI located at outer and inner distal corners, respectively; seta V longest, medially unipinnate; seta VII triarticulated at base and located dorsally.

Description of male. Body (Fig. 1B) cylindrical, tapering posteriorly; with microspinular ornamentation partly on surface of urosomites. Total body length about 988 µm (mean = 752 µm, *n* = 8). Maximum width: 210 µm (mean = 177 µm; *n* = 8). Sexual dimorphism in body size, number of somites, spinular/microspinular ornamentation on

urosomites, antennule, P3 endopod, P5 and P6. Urosome 6-segmented, comprising fifth pedigerous somite, genital somite and four free urosomites. Ventral posterior margin (Fig. 5B) of third and fourth urosomites with continuous row, fifth urosomite with paired rows of spinules; spinules irregular in size, displaying peculiar pattern.

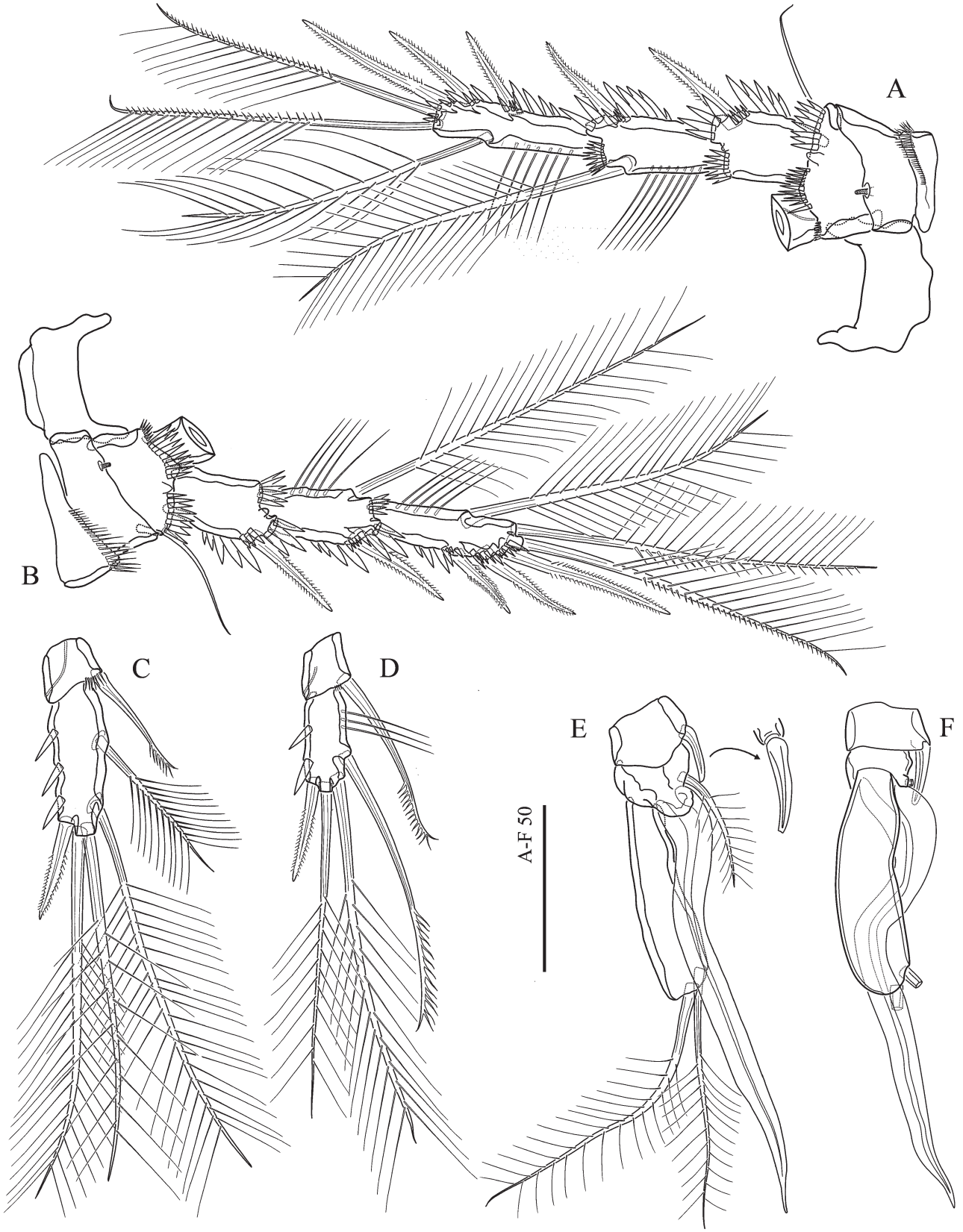

FIGURE 4. *Lourinia* aff. *armata* (Claus, 1866) (♀: A–D) (♂: E–F): A, P3 exopod, anterior; B, P4 exopod, anterior; C, P3 endopod, anterior; D, P4 endopod, anterior; E, P3 endopod, anterior; F, P3 endopod, lateral.

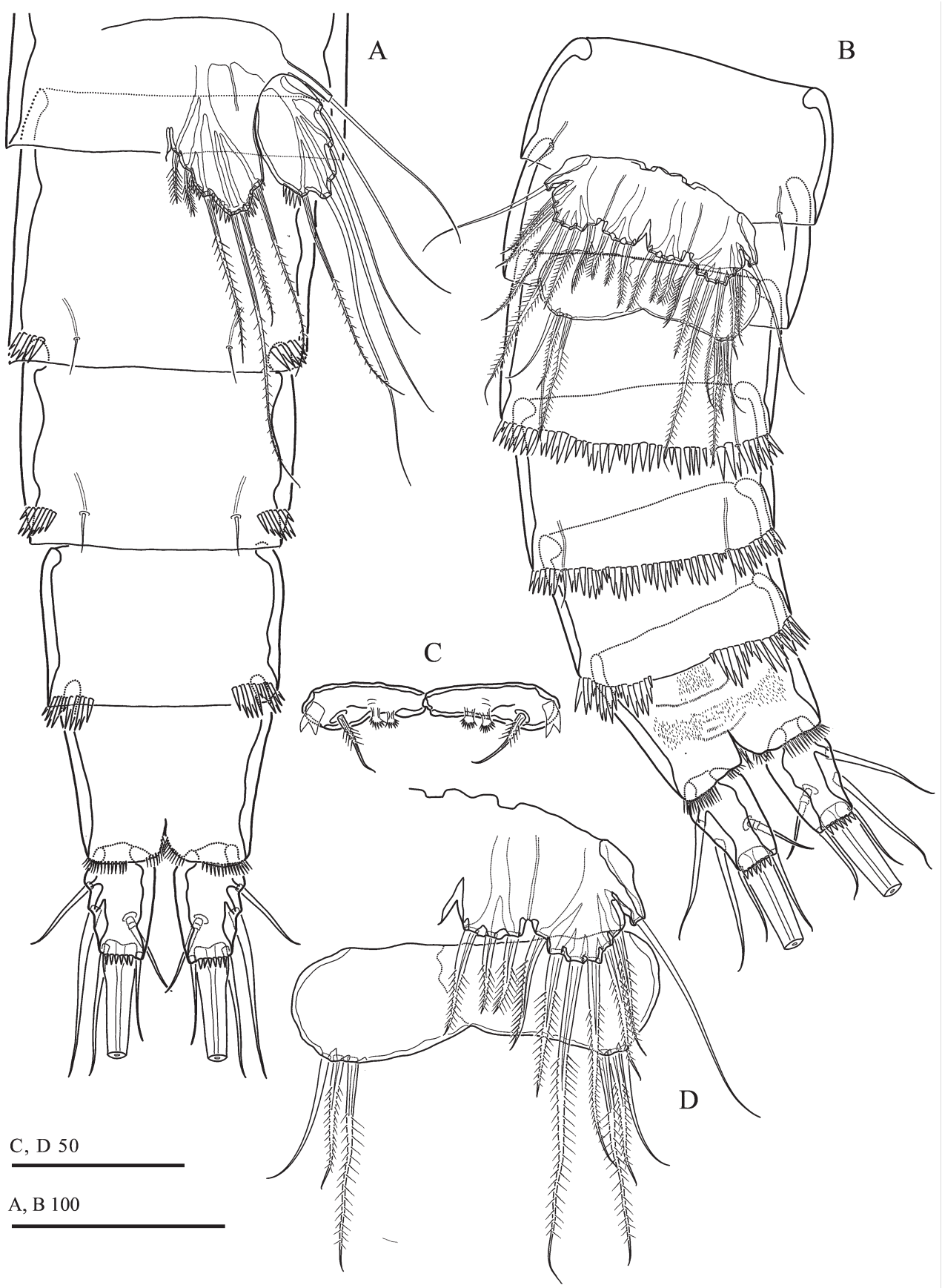

FIGURE 5. *Lourinia* aff. *armata* (Claus, 1866) (♀: A, C) (♂: B, D): A, urosome, ventral; B, urosome, ventral; C, P6, anterior; D, P5 and P6, anterior.

Antennule (Fig. 1D–F) 9-segmented, subchirocer. First segment ornamented with spinule rows as figured, with bare seta at inner distal corner. Second segment with nine setae. Third and fourth segments small, with five and two setae, respectively (Fig. 1D–E). Fifth segment (Fig. 1E) with aesthetasc fused basally to a seta on an elongate pedestal. Sixth segment (Fig. 1F) with eight elements (six naked setae and two pectinate setae). Seventh segment small and naked. Eighth segment with one seta. Distal segment (Fig. 1E) with six setae and apical acrothek consisting of aesthetasc fused basally with two setae. Armature formula of antennule: 1–[1]; 2–[9]; 3–[5]; 4–[2]; 5–[1 + ae]; 6–[8]; 7–[0]; 8–[1]; 9–[6 + acrothek].

P3 endopod (Fig. 4E–F) 3-segmented. First segment with one blunt inner spine; second segment small, with one plumose inner seta and dagger-shaped, proximally recurved apophysis. Length of the apophysis about twice longer than distal segment. Distal segment longest, rectangular, with two apical plumose setae.

Setal formula of swimming legs:

	Exopod	Endopod
P1	0.0.112	1.210
P2	0.1.123	1.321
P3	0.1.123	1.221[1.1 + apo.020 in ♂]
P4	0.1.123	1.211

Fifth pair of legs (Fig. 5B, D) fused; baseoendopod and exopod forming a common plate. Exopodal lobe with one unipinnate and five bipinnate setae, endopodal lobe with three bipinnate setae; outer basal seta naked. Comparison of relative length of exopodal setae as follows: III>IV>II>V>VI>I.

Sixth pair of legs (Fig. 5D) asymmetrical; fused medially to form single plate, with three setae each (inner longest, bipinnate; outer naked).

Lourinia wellsi sp. nov.

(Figs. 6–11)

Synonym. *Lourinia armata* (Claus, 1866) sensu Alper *et al.* (2015); Karaytuğ & Koçak (2018).

Type locality. Turkey, Aydın province, intertidal zone of Dipburun Beach/Kuşadası (N37.6634167°, E27.0090556°); collected on 25 October 2012.

Type material. Holotype ♀ dissected on nine slides. Allotype ♂ collected on 25 November 2012, dissected on nine slides. Paratypes represented by six ♀♀ and three copepodids. The holotype and allotype are deposited in the NHM, London.

Additional material examined. All additional samples mentioned below were obtained from washings of the macroalgae which were collected from the localities. One ♀ in washings of *Posidonia oceanica*, collected at 1 m depth from a beach located at northwest of Seddülbahir Village/Eceabat/Çanakkale (40.051212°, 26.167424°); collected on 05 July 1995. Three ♀♀ from Tınaztepe cove/Urla/İzmir/Turkey (N38.4013056°, E26.4882778°); collected on 24 May 2012. Three ♀♀ and two ♂♂ from Çanak cove/Foça/İzmir/Turkey (N38.6666111°, E26.7428333°); collected on 25 May 2012. One ♂ from Bademli beach/Dikili/İzmir/Turkey (N39.0388333°, E26.8253611°), collected on 25 May 2012. Two ♀♀ from beach of Burcu holiday site/Çeşme/İzmir/Turkey (N38.3472222°, E26.4505000°); collected on 16 June 2013. One ♀ from Tınaztepe cove/Urla/İzmir/Turkey (N38.4013056°, E26.4882778°), collected on 16 June 2013. One ♂ from the sandy beach at İkiz Cove/Eceabat/Çanakkale/Turkey (N40.06317°, E26.17724°); collected on 28 September 2013. One ♀ from a beach located at west of Sazlıdere/Keşan/Edirne/Turkey (N40.64288°, E26.72029°); collected on 29 September 2013. One ♀ from beach of Kumlimanı holiday site/Eceabat/Çanakkale/Turkey (N40.16248°, E26.24680°); collected on 29 September 2013. One ♀ from Kanlısırt Beach/Eceabat/Çanakkale/Turkey (N40.16248°, E26.24680°); collected on 23 February 2014.

Description of female. Body shape (Fig. 6A–B) similar to that of *L.* aff. *armata*. Total body length: 1,094 μm (mean = 962 μm; *n* = 21); maximum width: 212 μm (mean = 215 μm; *n* = 21). Rostrum triangular, defined at base with two sensillae with serrate tip (Fig. 6C). Dorsal surface of genital double-somite, third urosomite and anal somite ornamented with microspinules as figured. Spinular ornamentation of genital double-somite, third and fourth

urosomites similar to *L.* aff. *armata* (Figs. 6B; 11A). Anal somite with one pair of sensilla dorsally; anal operculum straight, margin ornamented with short setules.

Antennule (Fig. 7A) 7-segmented. First segment ornamented with spinule rows as figured, with one seta. Second segment with nine setae. Third segment longest, with six setae. Fourth segment with one seta and with aesthetasc fused basally to seta arising from common pedestal. Fifth and sixth segments with one and two setae, respectively (Fig. 7B). Distal segment with six setae and with apical acrothek consisting of an aesthetasc and two setae. Setal formula of antennule: 1–[1]; 2–[9]; 3–[6]; 4–[1+ (1 + ae)]; 5–[1]; 6–[2]; 7–[6 + acrothek].

Antenna (Fig. 7C). Coxa rectangular, ornamented with spinule row as figured. Allobasis ornamented with spinule row as figured. Exopod 1-segmented, with two bipinnate setae apically. Endopod 1-segmented, ornamented with spinule rows as figured; protruding at outer corner apically; lateral armature consisting of two spines (distal one bipinnate), distal armature consisting of one long bipinnate spine and three naked spines (outer one fused basally to a small seta).

Mandible, maxillule, maxilla and maxilliped as in *L.* aff. *armata*.

P1 (Fig. 8A). Spinular ornamentation of praecoxa, coxa and basis similar to *L.* aff. *armata*. Inner spine of basis extending at most to end of first endopodal segment. Exopod 3-segmented, inner margin of second segment ornamented with setules; first and second segments without inner armature; distal segment with one inner, one apical seta and two outer spines. Endopod 2-segmented, shorter than exopod; first segment with one inner, distally pectinate seta; distal segment with two inner setae (proximal one distally pectinate) and one apical spine.

P2–P4 (Figs. 8B; 9A–D). Intercoxal sclerites, praecoxae, coxae and bases similar to *L.* aff. *armata*. Exopods 3-segmented, inner margin of second and third segments ornamented with setules; first segment without inner armature; second segment with one plumose (P2) (Fig. 8B) or one bare (P3) (Fig. 9A) or one long plumose (P4) (Fig. 9B) inner seta; distal segment with one plumose inner seta, two apical setae and three outer spines. Endopods 2-segmented, shorter than exopods; first segment with one distally pectinate (P2) (Fig. 8B) or one bipinnate (P3) (Fig. 9C) or one long, distally unipinnate (P4) (Fig. 9D) seta; second segment with three inner (two distally pectinate and one plumose), two apical setae (one naked and one plumose) and one outer spine (P2) (Fig. 8B) or three inner setae (two plumose, one distally pectinate), two plumose apical setae and one outer spine (P3) (Fig. 9C) or one distally pectinate inner seta; two plumose apical setae and one outer spine (P4) (Fig. 9D).

Fifth pair of legs (Figs. 7D; 11A) fused, baseoendopod well developed, outer basal seta naked. Endopodal lobe with six bipinnate elements; setae I–II spiniform, seta IV longest. Exopod distinct, ovoid, with five long bare setae.

Sixth pair of legs (Fig. 11B) covered by P5, with one spiniform outer element, one seta and three small, apically serrate, inner elements.

Caudal rami (Fig. 6D–F) about 1.6 times as long as broad, bearing six setae. Position of setae similar to *L.* aff. *armata*. Seta V naked. Spinules around ventral distal margin smaller than in *L.* aff. *armata*.

Description of male. Body (Fig. 10A) cylindrical, tapering posteriorly. Total body length about 712 μm (mean = 880 μm, *n* = 5). Maximum width: 152 μm (mean = 206 μm; *n* = 5). Ventral posterior margin of third and fourth urosomites with continuous row, fifth urosomite with paired rows of spinules, spinules regular in size (Fig. 11C). Sexual dimorphism in body size and spinular/microspinular ornamentation, antennule, P2–P3 endopods, and P5 and P6.

Antennule (Fig. 10B) 9-segmented, subchirocer. First segment ornamented with spinule rows as figured, with a bare seta at inner distal corner. Second segment with nine setae. Third and fourth segments small (Fig. 10C), with six and two setae, respectively. Fifth segment (Fig. 10D) with aesthetasc fused basally to seta on common elongate pedestal. Sixth segment (Fig. 10E) with seven elements (four naked setae and three pectinate setae with tube-like extension distally). Seventh segment naked. Eighth segment with one seta (Fig. 10E). Distal segment (Fig. 10F) with six setae and apical acrothek consisting of aesthetasc fused basally with two setae. Armature formula of antennule: 1–[1]; 2–[9]; 3–[6]; 4–[2]; 5–[1 + ae)]; 6–[7]; 7–[0]; 8–[1]; 9–[6 + acrothek].

P2 endopod (Fig. 8C). Proximal inner seta of enp-2 semiplumose along distal half and length slightly exceeding that of outer terminal spine. Inner apical seta of enp-2 about three times as long as length of outer terminal spine.

P3 endopod (Fig. 9E) 3-segmented. First segment with one bipinnate inner seta; second segment small, with one plumose inner seta and elongate apophysis forming harpoon-like tip. Length of apophysis about 4.2 times longer than distal segment. Distal segment longest, rectangular, with two plumose apical setae.

Setal formula of swimming legs:

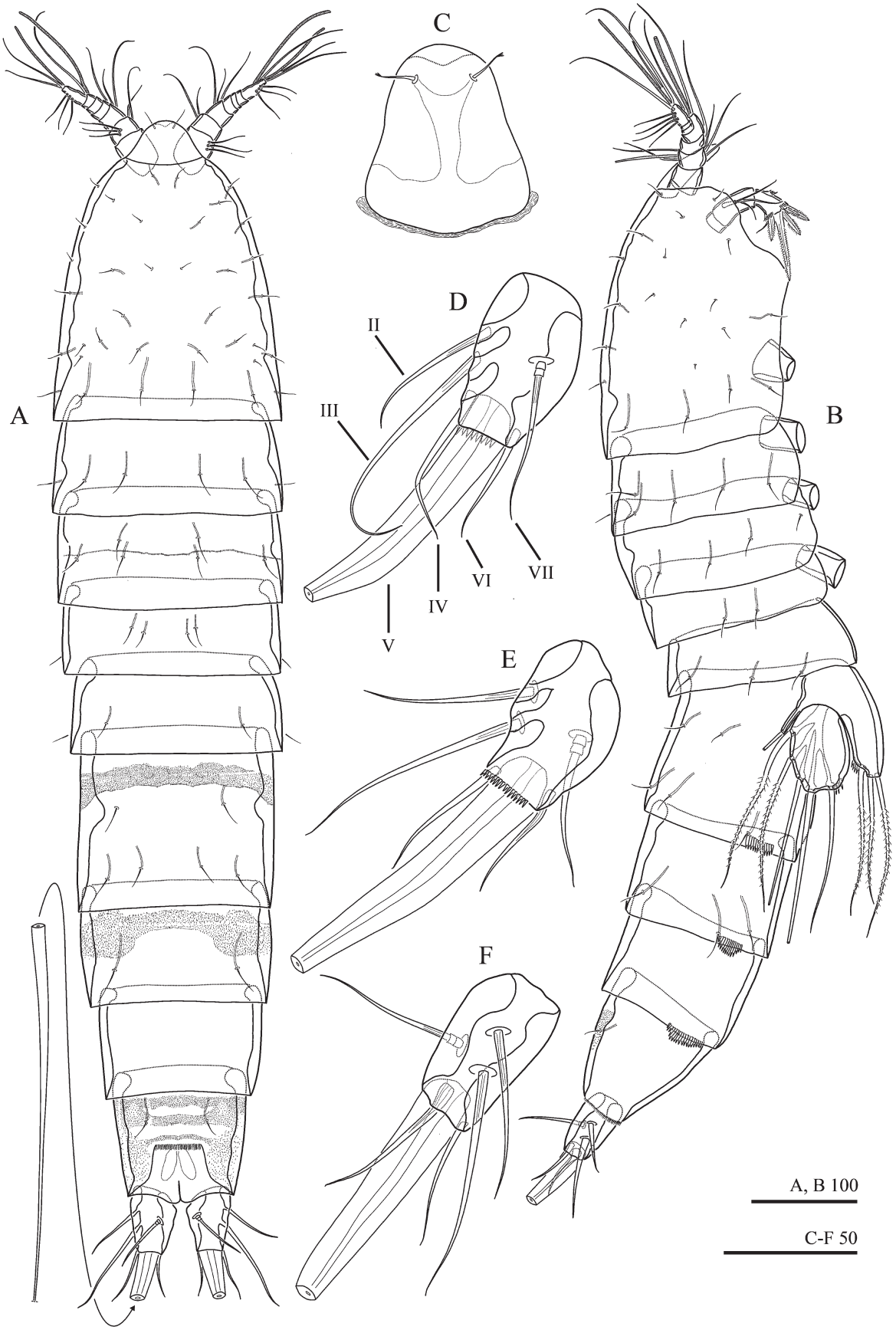

FIGURE 6. *Lourinia wellsi* **sp. nov.** (♀): A, habitus, dorsal; B, habitus, lateral; C, rostrum, dorsal; D, caudal ramus, dorsal; E, caudal ramus, ventral; F, caudal ramus, lateral.

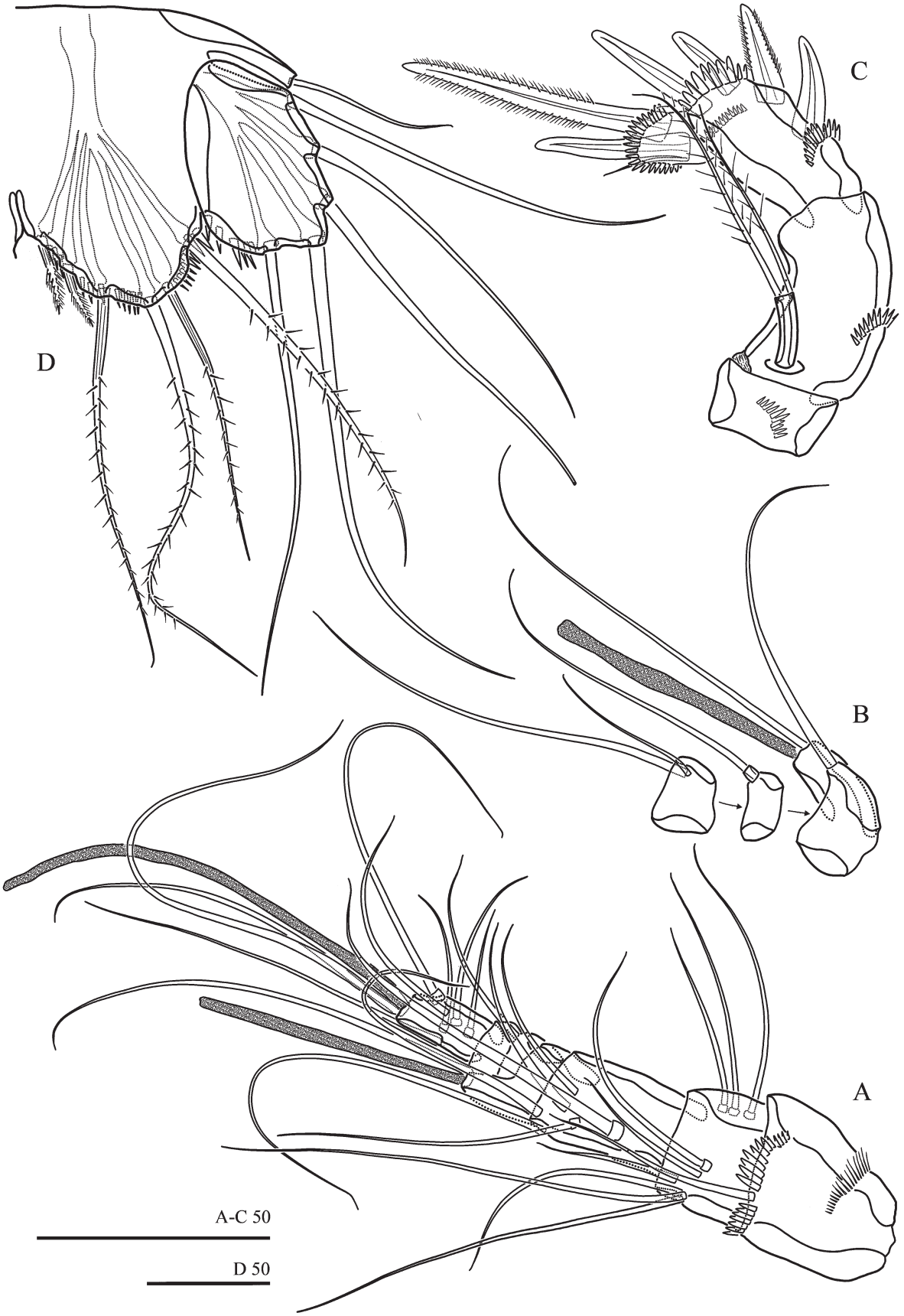

FIGURE 7. *Lourinia wellsi* **sp. nov.** (♀): A, antennule, ventral; B, antennule, segments 4–6; C, antenna, lateral; D, P5, anterior.

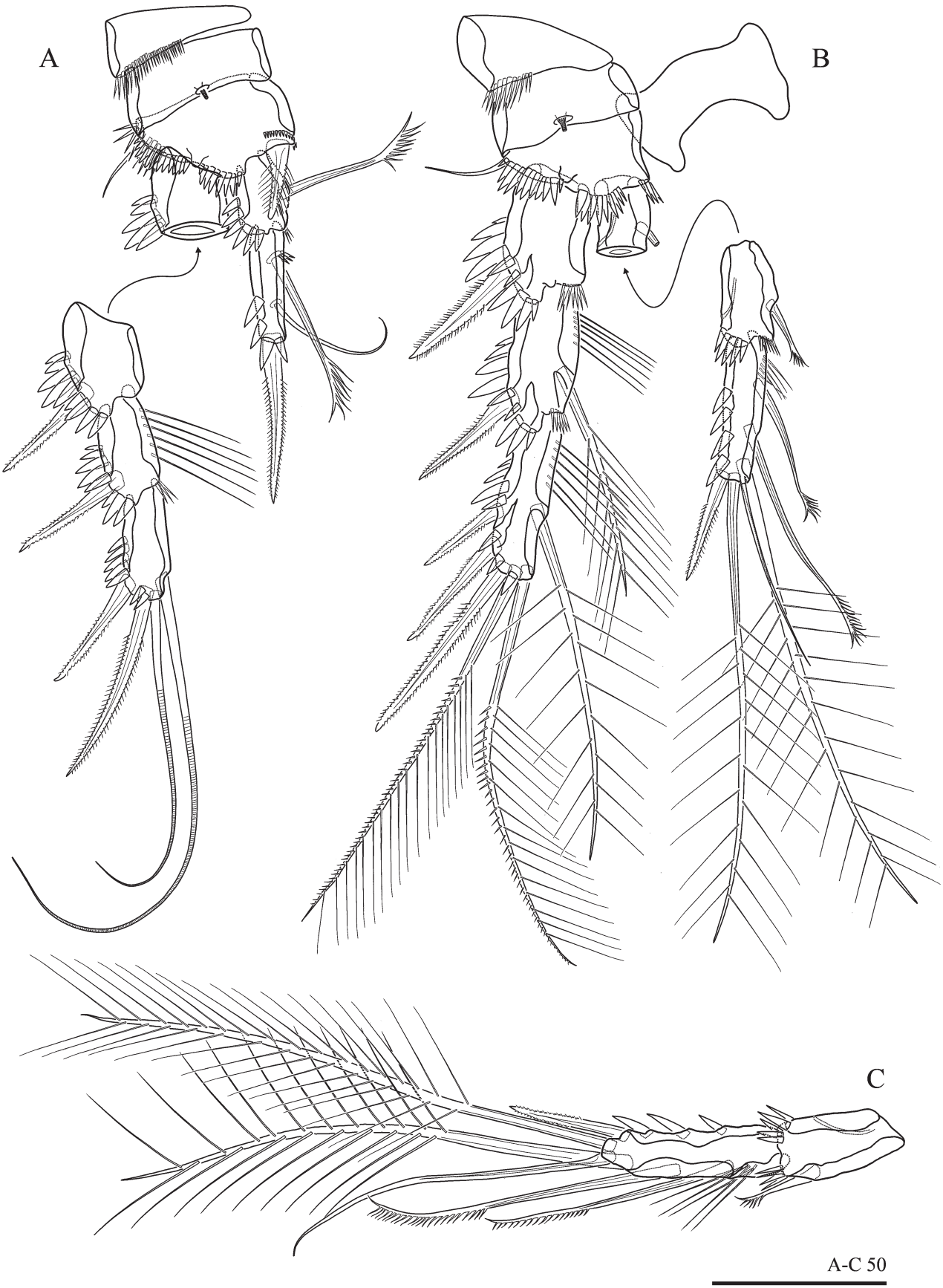

FIGURE 8. *Lourinia wellsi* **sp. nov.** (♀: A–B) (♂: C): A, P1, anterior; B, P2, anterior; C, P2 endopod, anterior.

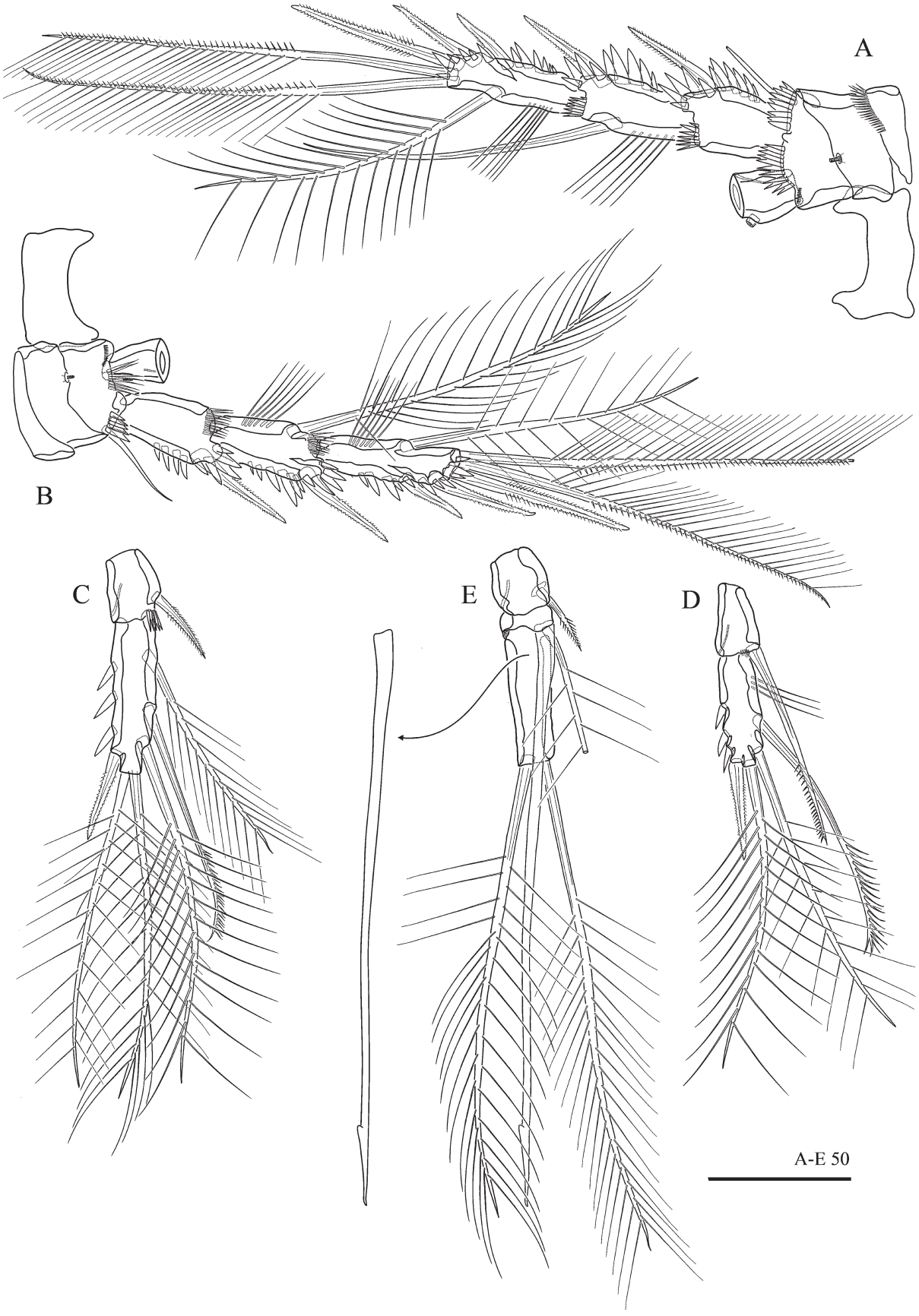

FIGURE 9. *Lourinia wellsi* **sp. nov.** (♀: A–D) (♂: E): A, P3 exopod, anterior; B, P4 exopod, anterior; C, P3 endopod, anterior; D, P4 endopod, anterior; E, P3 endopod, anterior.

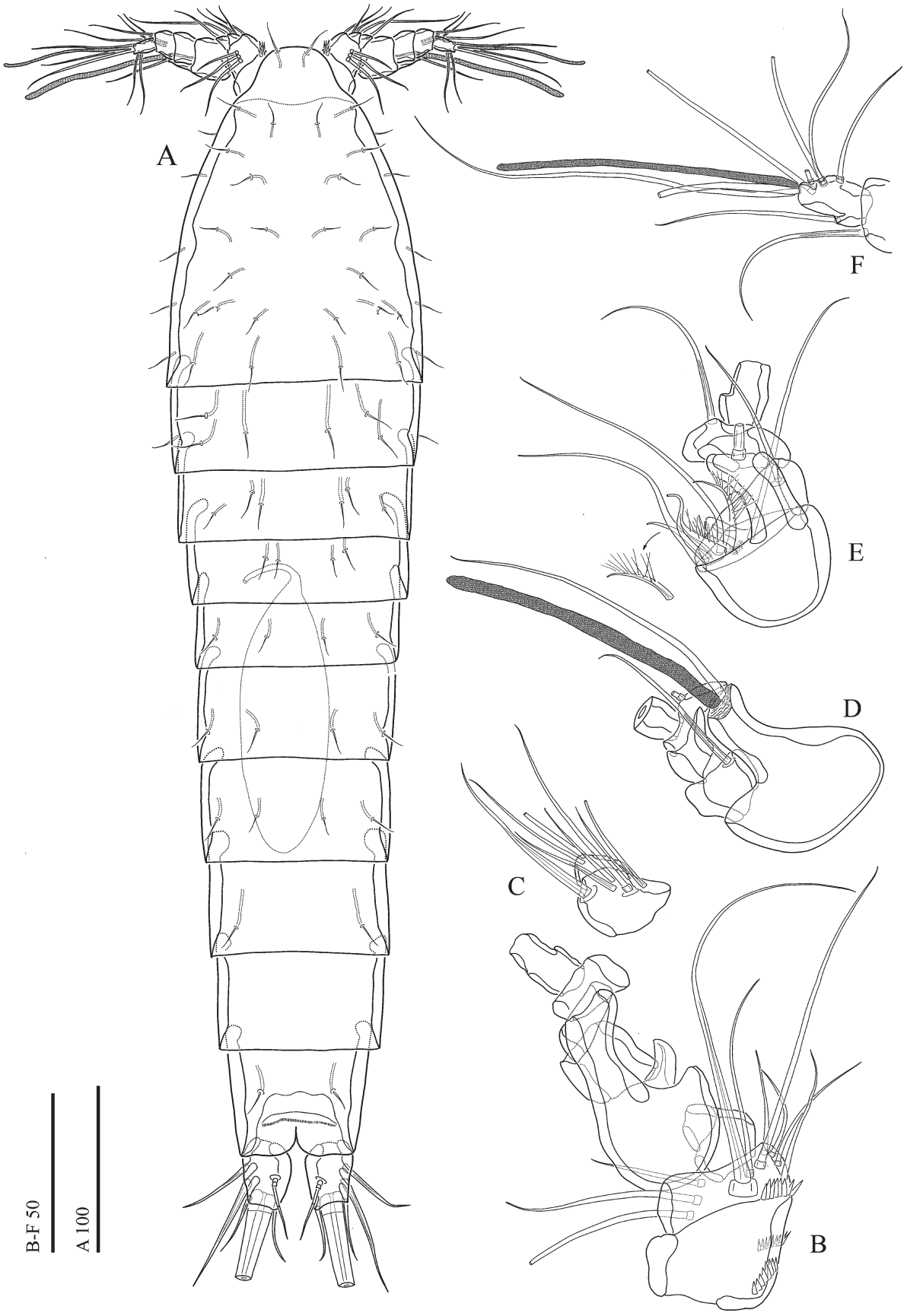

FIGURE 10. *Lourinia wellsi* **sp. nov.** (♂): A, habitus, dorsal; B, antennule, ventral; C, antennule segments 3–4, dorsal; D, antennule, segments 5–8, dorsal; E, antennules, segments 6–9, dorsal; F, antennule, segment 9, dorsal.

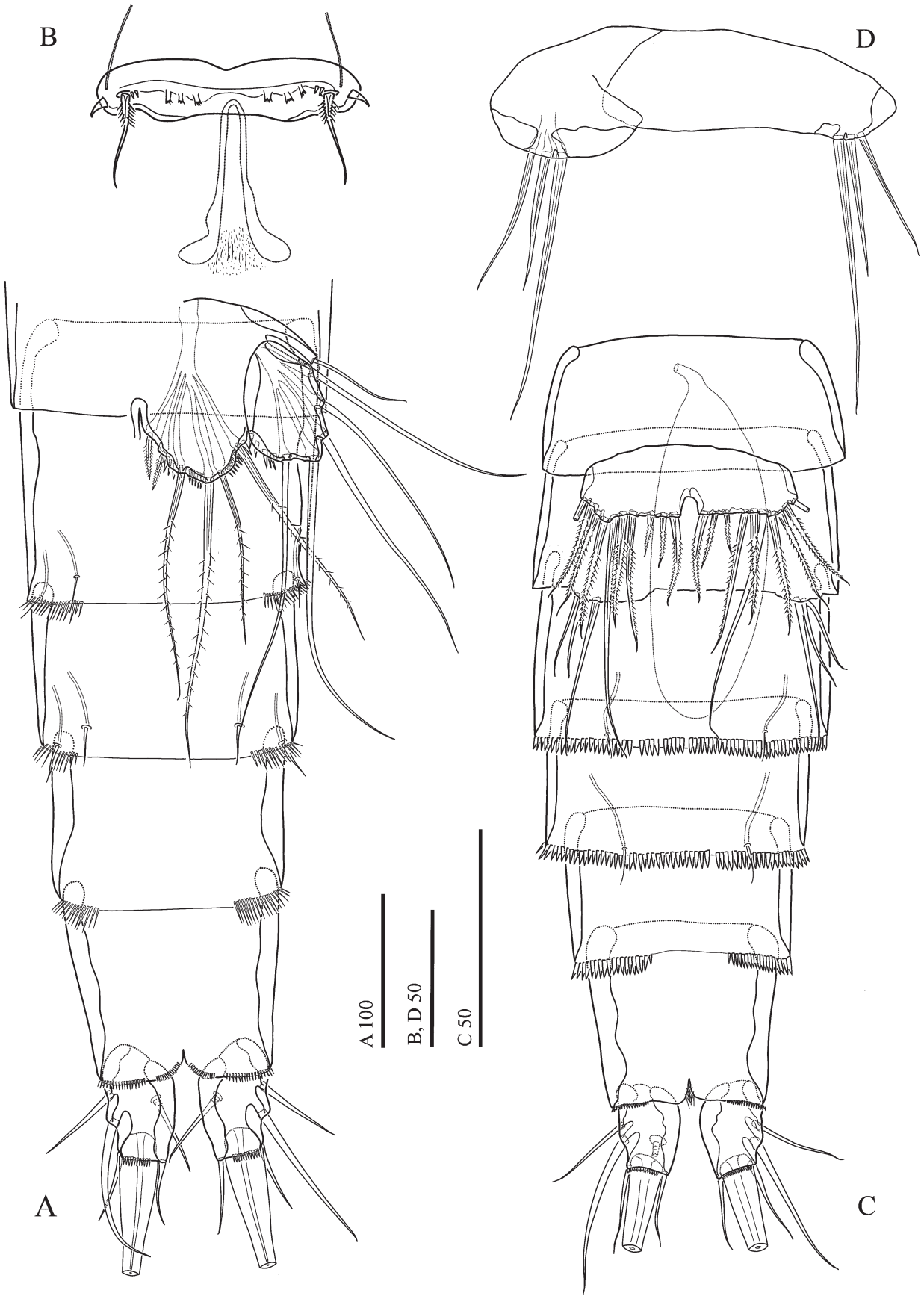

FIGURE 11. *Lourinia wellsi* **sp. nov.** (♀: A–B) (♂: C–D): A, urosome, ventral; B, P6, anterior; C, urosome, ventral; D, P6, anterior.

	Exopod	Endopod
P1	0.0.112	1.210
P2	0.1.123	1.321
P3	0.1.123	1.321[1.1 + apo.020 in ♂]
P4	0.1.123	1.211

Fifth pair of legs (Fig. 11C) fused; baseoendopod and exopod forming common plate; lobes not prominent. Exopodal lobe with one long bare seta medially, one unipinnate inner seta and four bipinnate setae; endopodal lobe with one long and two short bipinnate setae. Comparison of relative length of exopodal setae as follows: III>I>IV>II>V>VI.

Sixth pair of legs (Fig. 11D) asymmetrical; bearing three bare setae each, inner seta longest.

Etymology. The new species is named in honour of the late Prof. John Wells for his contribution to harpacticoid taxonomy.

***Lourinia gocmeni* sp. nov.**
(Figs. 12–19)

Synonym. *Lourinia armata* (Claus, 1866) sensu Alper *et al.* (2010).

Type locality. Turkey, Çanakkale province, in washings of macroalgae from Karaağaçlı Cove/Gelibolu (N40.43955°, E26.45517°).

Type material. Holotype ♀ collected on 29 September 2013, dissected on eight slides. Allotype ♂ collected on 29 September 2013, dissected on nine slides. Type material are deposited in the Natural History Museum, London.

Additional material examined. One ♂ from intertidal zone of Mandalya beach/Datça/Muğla/Turkey (N36.703047°, E27.677761°), collected on 15 April 2007. One ♀ in washings of the macroalgae from Denizyıldızı beach/Demircili/Urla/İzmir (N38.209161°, E26.693545°), collected on 23 May 2012. One ♂ from a pebbly beach/Cunda Island/Ayvalık/Balıkesir/Turkey (N39.358361°, E26.623611°), collected on 06 July 2005.

Description of female. Body shape (Figs. 12A; 18A–C) similar to that of *L.* aff. *armata*. Total body length: 963 μm (mean = 917 μm; *n* = 2). Maximum width: 263 μm (mean = 237 μm; *n* = 2). Rostrum triangular, defined at base with two sensillae with serrate tip (Fig. 12C–E). Surface of somites without microspinular ornamentation except for anal somite and caudal rami. Spinular ornamentation of genital double-somite, third and fourth urosomites similar to *L.* aff. *armata* (Figs. 12B; 17A). Anal somite with one pair of sensilla dorsally; anal operculum straight, margin ornamented with setules (Fig. 18E).

Antennule (Fig. 13A) 7-segmented. First segment ornamented with spinule row as figured, with one seta. Second segment with eight setae. Third segment longest, with four setae. Fourth segment with one seta and with aesthetasc fused basally to seta on common pedestal. Fifth and sixth segments small, with one and two setae, respectively. Last segment with six setae and apical acrothek consisting of aesthetasc and two setae. Setal formula of antennule: 1–[1]; 2–[8]; 3–[4]; 4–[1 + (1 + ae)]; 5–[1]; 6–[2]; 7–[6 + acrothek].

Antenna (Fig. 13B) coxa squarish, ornamented with spinule rows as figured. Allobasis ornamented with spinule row as figured. Exopod 1-segmented; with two apical setae. Endopod 1-segmented, ornamented with spinule rows as figured, lateral armature consisting of two spines, distal armature consisting of four spines (outer one fused basally to a small seta).

Mandible, maxillule, maxilla and maxilliped as in *L.* aff. *armata*.

P1 (Fig. 14A). Spinular ornamentation of praecoxa, coxa and basis similar to *L.* aff. *armata*. Inner spine of basis extending to middle of second endopodal segment. Exopod 3-segmented; distal segment with one unipinnate inner seta, one unipinnate apical seta and two outer spines. Endopod 2-segmented, shorter than exopod; first segment with one distally pectinate inner seta; distal segment with two inner setae (proximal one distally pectinate) and one apical spine.

P2–P4 (Figs. 14B; 15A–E). Intercoxal sclerites, praecoxae, coxae and bases similar to *L.* aff. *armata*. Exopods 3-segmented; inner margin of second and third segments ornamented with setules; second segment with one short

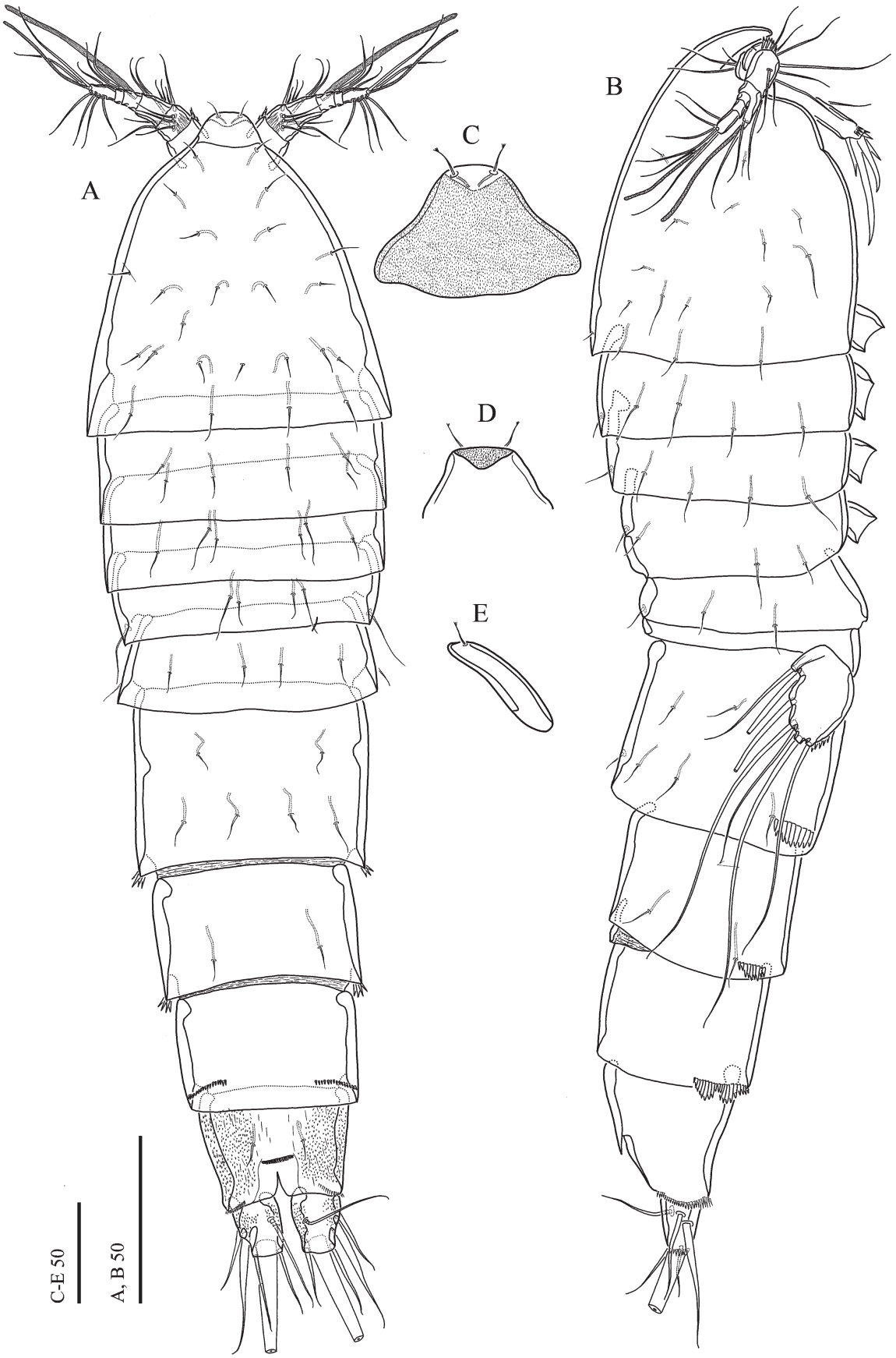

FIGURE 12. *Lourinia gocmeni* **sp. nov.** (♀): A, habitus, dorsal; B, habitus, lateral; C, rostrum, dorsal; D, rostrum, ventral; E, rostrum, lateral.

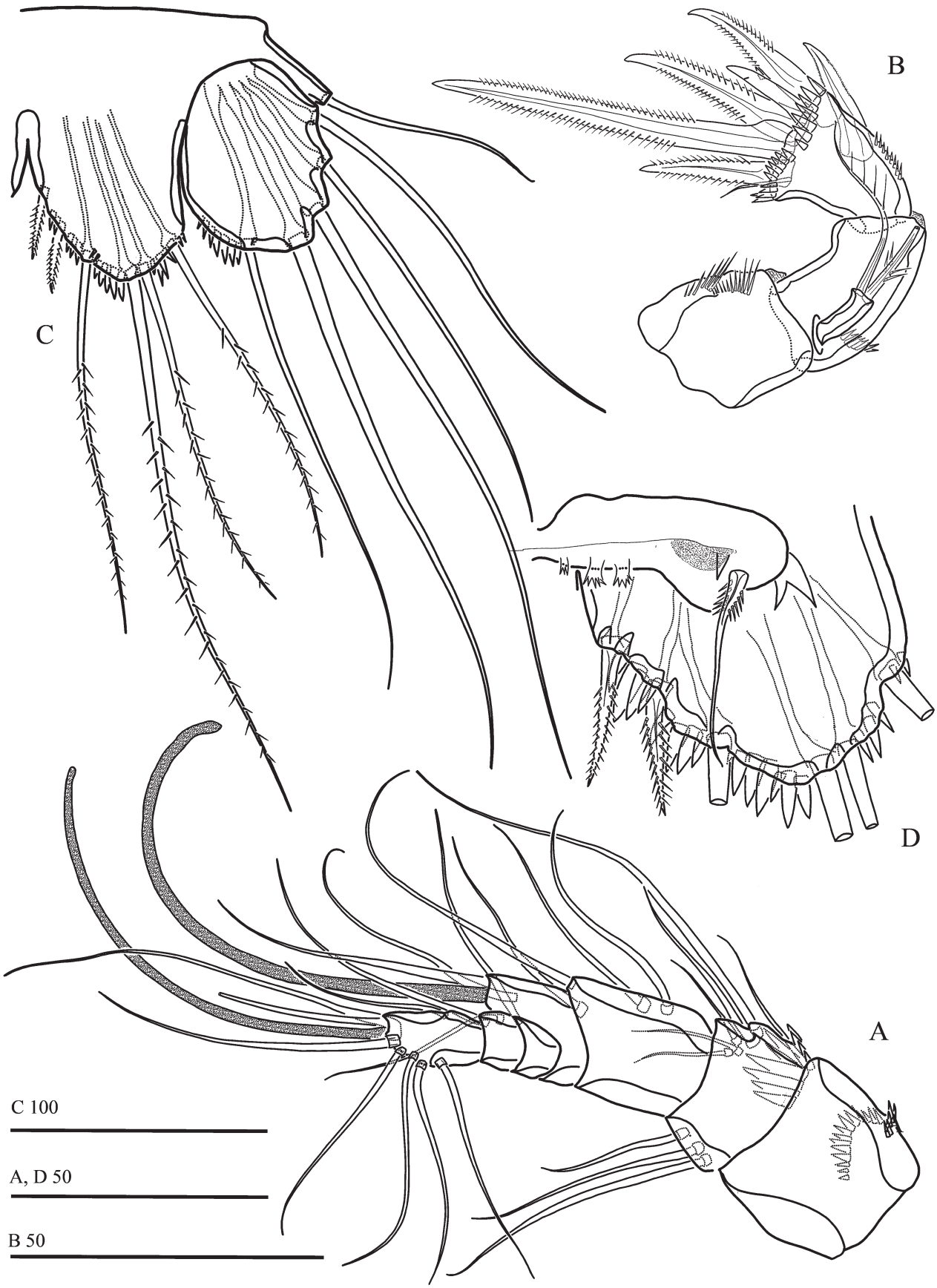

FIGURE 13. *Lourinia gocmeni* **sp. nov.** (♀): A, antennule, ventrolateral; B, antenna; C, P5, anterior; D, P5 baseoendopod and P6, posterior.

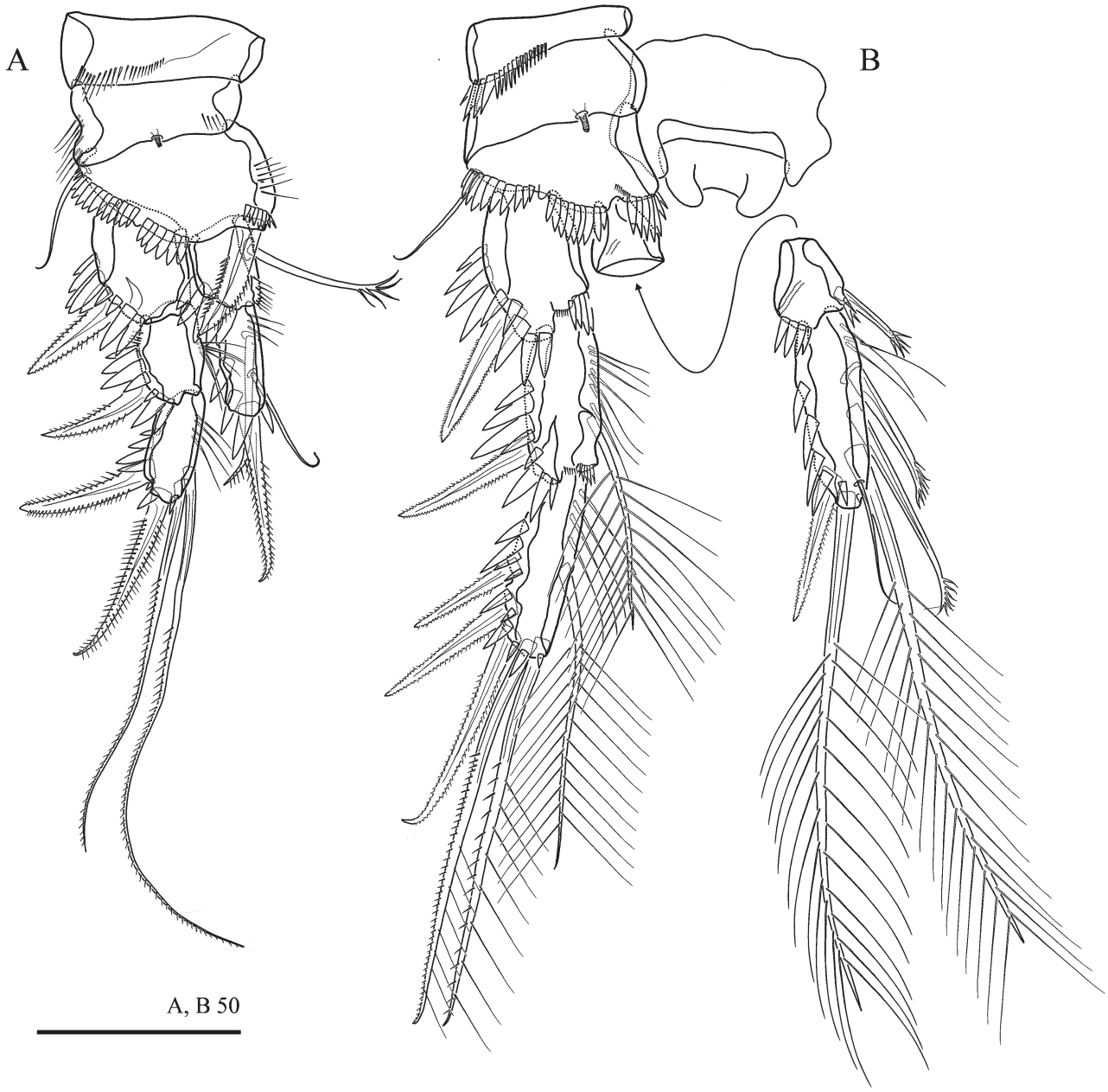

FIGURE 14. *Lourinia gocmeni* **sp. nov.** (♀): A, P1, anterior; B, P2, anterior.

plumose (P2) (Fig. 14B) or one long, plumose (P3–P4) (Fig. 15A–B) inner seta; distal segment with one plumose inner seta, two apical setae and three outer spines. Endopods 2-segmented, shorter than exopods; first segment with one short, distally pectinate (P2–P3) (Figs. 14B; 15C) or one long, bipinnate seta (P4) (Fig. 15E); second segment with three inner setae (two distally pectinate and one plumose), two apical setae (one short, naked and one long, plumose) and one outer spine (P2) or two plumose inner setae, two apical plumose setae and one outer spine (P3) or one distally pectinate inner seta, two apical plumose setae and one outer spine (P4).

Fifth pair of legs (Figs. 13C; 18D) fused, baseoendopod well developed, outer basal seta naked. Endopodal lobe with six bipinnate elements; setae I–II spiniform; seta IV longest. Exopod distinct, ellipsoidal, with five long bare setae, seta III longest.

Sixth pair of legs (Fig. 13D) covered by P5, with one bifid outer element, one proximally bipinnate seta and three small, apically serrate, inner elements.

Caudal rami (Figs. 12A; 18E–F) about 1.3 times as long as broad, with six setae. Position of the setae similar to *L*. aff. *armata*. Spinules around ventral distal margin (Fig. 17A) smaller than in *L*. aff. *armata*.

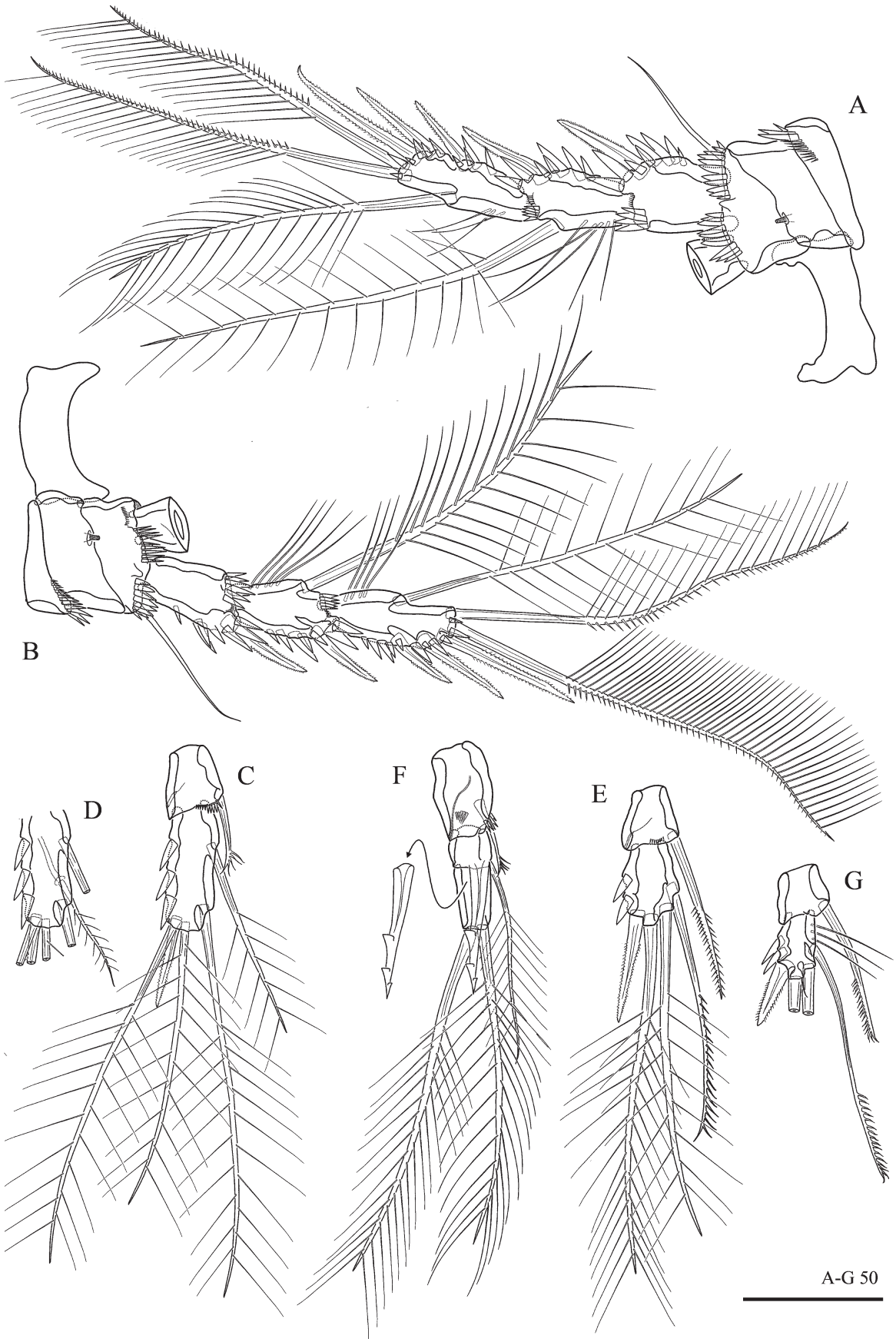

FIGURE 15. *Lourinia gocmeni* **sp. nov.** (♀: A–E) (♂: F–G): A, P3 exopod, anterior; B, P4 exopod, anterior; C, P3 endopod, anterior; D, abnormal form of second endopod of P3, anterior; E, P4 endopod, anterior; F, P3 endopod, anterior; G, P4 endopod, anterior.

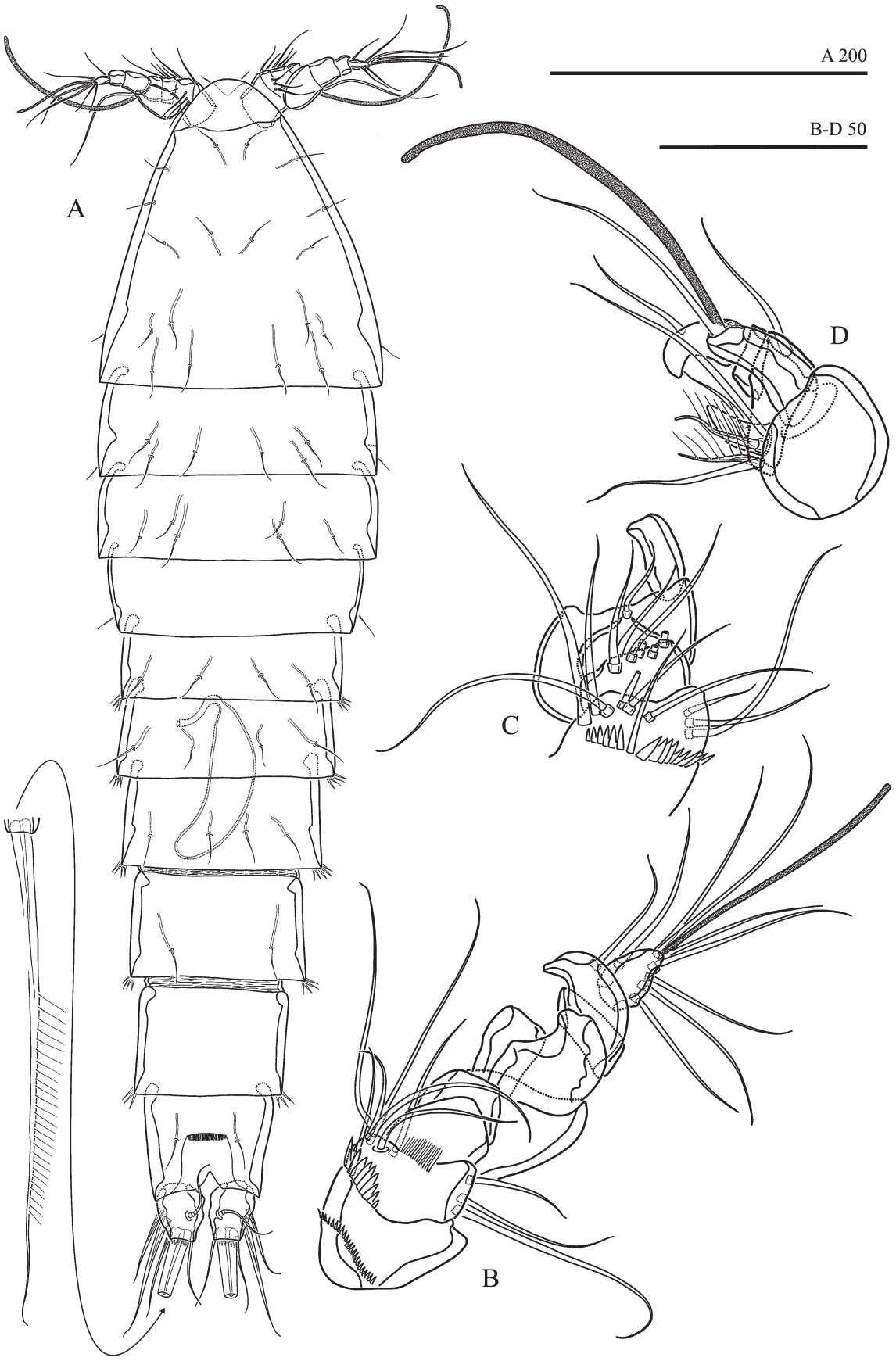

FIGURE 16. *Lourinia gocmeni* **sp. nov.** (♂): A, habitus, dorsal; B, antennule, ventrolateral (armature elements not shown on segments 3–6); C, antennule, segments 2–5, lateral; D, antennule, segments 5–8, lateral.

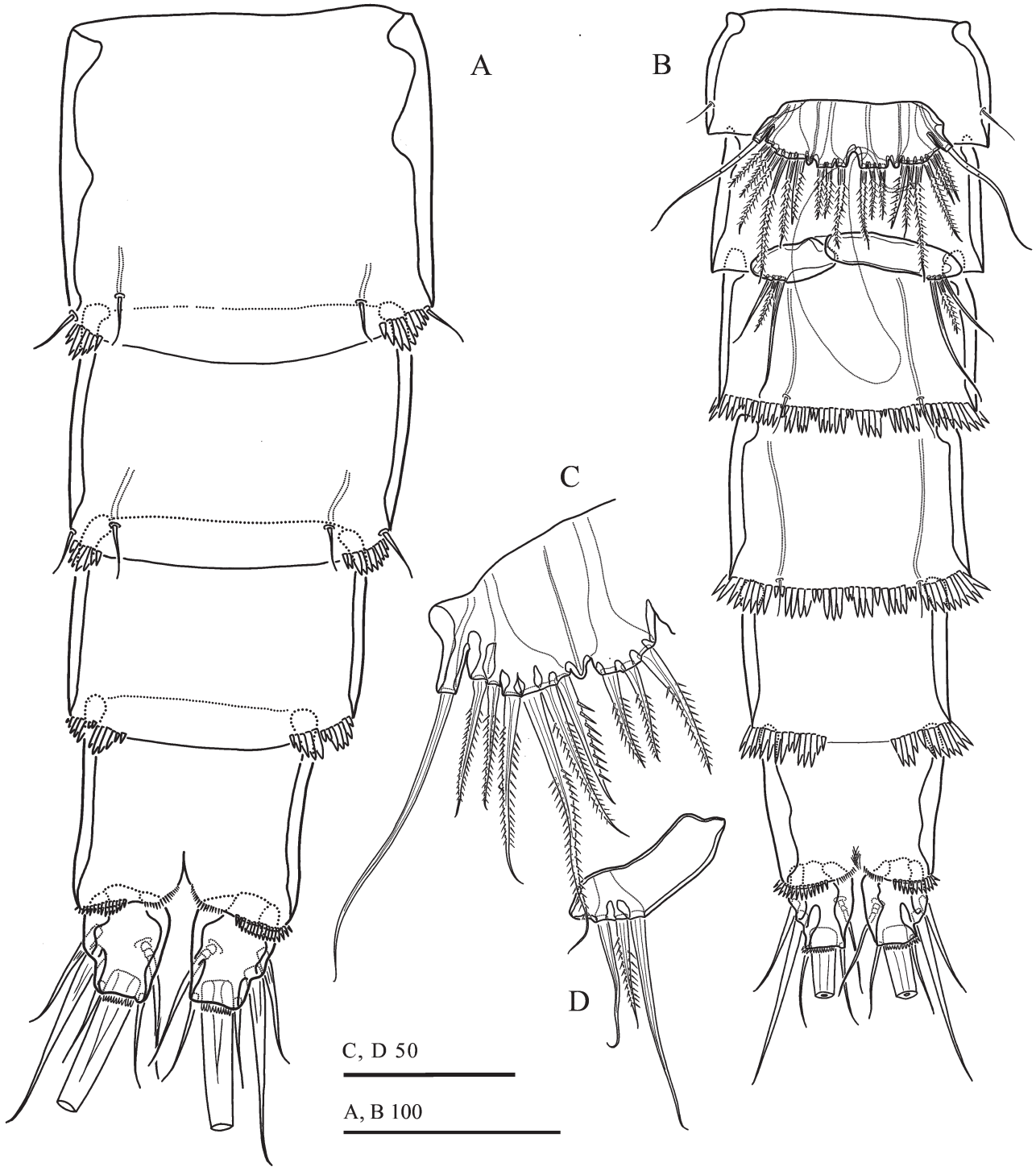

FIGURE 17. *Lourinia gocmeni* **sp. nov.** (♀: A) (♂: B–D): A, abdomen, ventral; B, urosome, ventral; C, P5, anterior; D, P6, anterior.

Description of male. Body (Figs. 16A; 19A) cylindrical, tapering posteriorly; without microspinular ornamentation. Total body length about 733 µm (mean = 721 µm, *n* = 3). Maximum width: 180 µm (mean = 193 µm; *n* = 3). Ventral posterior margin (Fig. 17B) of third and fourth urosomites with continuous row, fifth abdominal somite with paired rows of spinules; spinules irregular in size displaying peculiar pattern (Fig. 19D). Sexual dimorphism in body size and spinular/microspinular ornamentation, antennule, P3–P4 endopods, P5 and P6.

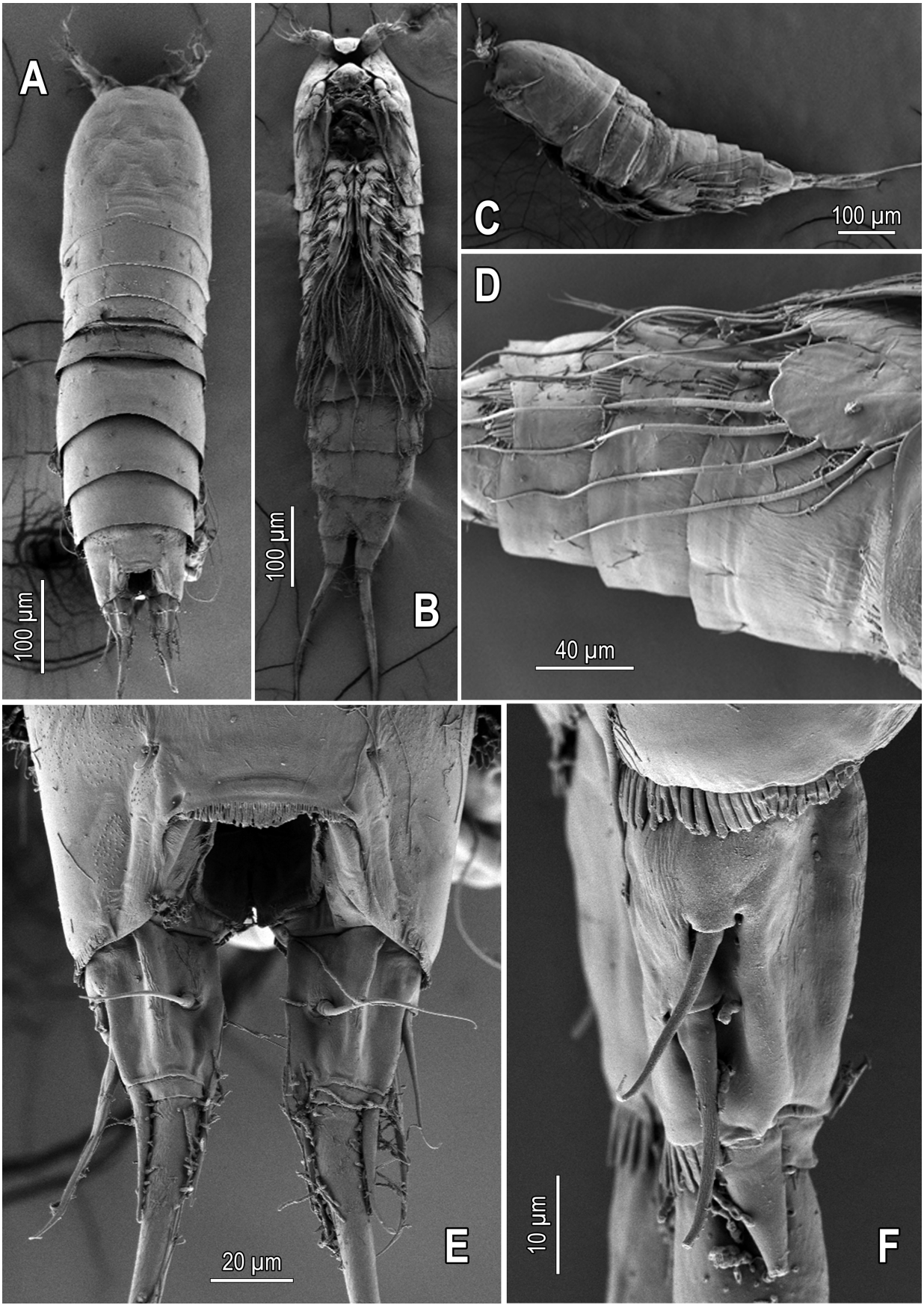

FIGURE 18. *Lourinia gocmeni* **sp. nov.** (♀): A, habitus, dorsal; B, habitus, ventral; C, habitus, lateral; D, P5 exopod, lateral; E, anal operculum and caudal rami, dorsal; D, caudal ramus, lateral.

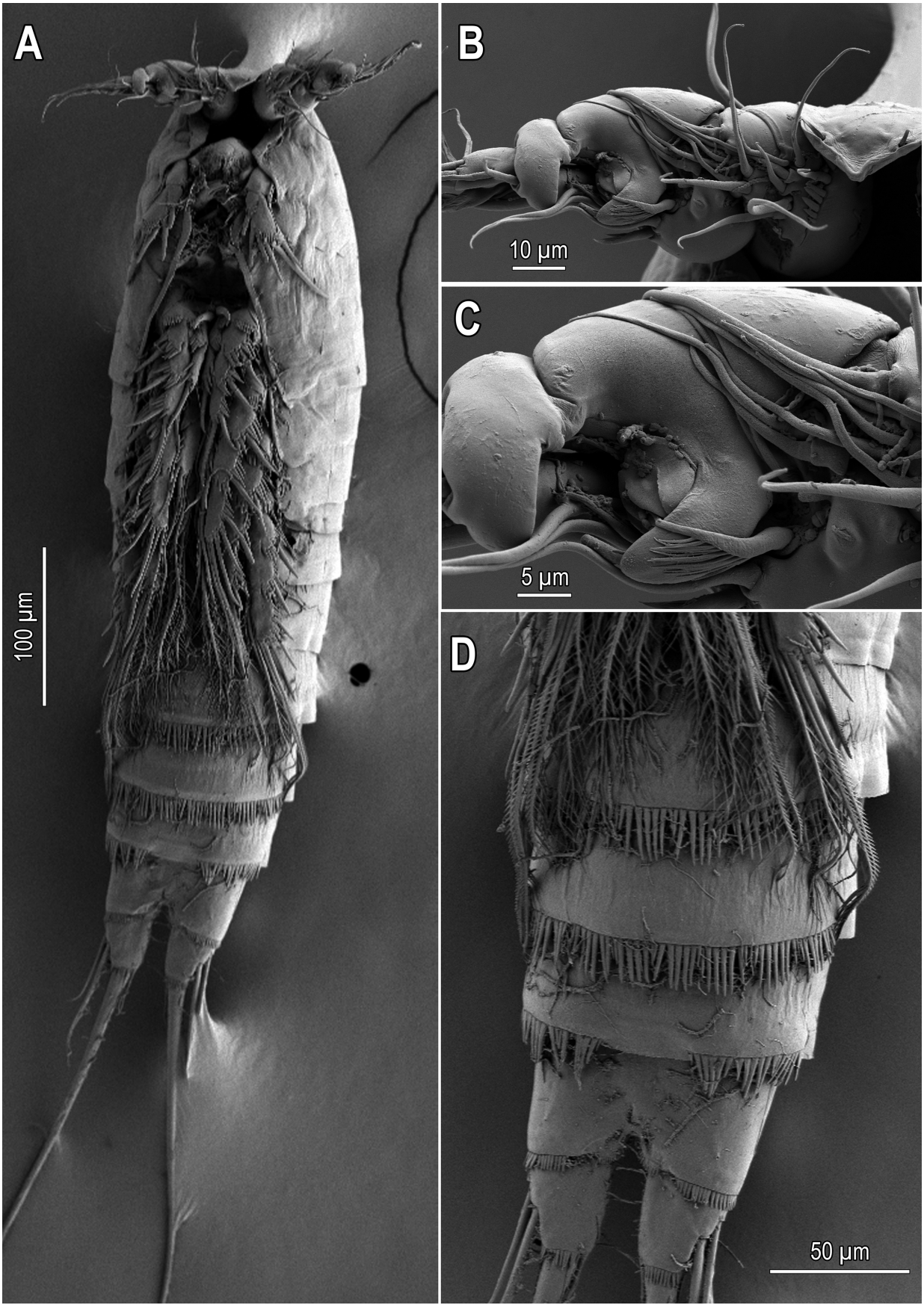

FIGURE 19. *Lourinia gocmeni* **sp. nov.** (♂): A, habitus, ventral; B, antennule and rostrum, ventral; C, antennule, segment 6, ventral; D, Abdomen, ventral.

Antennule (Figs. 16B–D; 19B–C) 9-segmented, subchirocer. First segment ornamented with spinule rows as figured, with bare seta at inner distal corner. Second segment with nine setae. Third and fourth segments small, with six and one seta, respectively (Fig. 16C). Fifth segment (Fig. 16D) with aesthetasc fused basally to seta on common elongate pedestal. Sixth segment (Fig. 16D) with six elements (four naked setae and two pectinate setae with tube-like extension distally). Seventh segment naked. Eighth segment with one seta. Distal segment (Fig. 16B) with six setae and apical acrothek consisting of aesthetasc fused basally with two setae. Armature formula of antennule: 1–[1]; 2–[9]; 3–[6]; 4–[1]; 5–[1 + ae]; 6–[6]; 7–[0]; 8–[1]; 9–[6 + acrothek].

P3 endopod (Fig. 15F) 3-segmented. First segment well developed, rectangular, with 1 short, distally pectinate, inner seta; second segment squarish, with one plumose inner seta and short harpoon-like apophysis. Length of apophysis about twice longer than distal segment. Distal segment rectangular, with two long, plumose apical setae.

P4 endopod (Fig. 15G) 2-segmented. First segment squarish, with one distally pectinate, inner seta; second segment narrower than in female, ornamented with setules on inner margin, with two inner setae, two apical setae (one of them being minute) and one outer spine. Length of outer spine shorter than in female.

Setal formula of swimming legs as in *L.* aff. *armata*.

Fifth pair of legs (Fig. 17B–C) fused; baseoendopod and exopod forming common plate. Exopodal lobe with five bipinnate and one inner unipinnate setae; endopodal lobe with three bipinnate setae; outer basal seta naked. Comparison of relative length of the exopodal setae as follows: III>IV>II>VI>I>V.

Sixth pair of legs (Fig. 17B, D) asymmetrical; with three setae each (inner longest, medial seta bipinnate).

Variation. One female had an extra inner seta on the distal segment of the P3 endopod (Fig. 15D).

Etymology. The new species is named in honour of the late Prof. Dr Bayram Göçmen for his contribution to reptile taxonomy.

Lourinia aldabraensis sp. nov.

(Figs. 20–24)

Synonym. *Lourinia armata* (Claus, 1866) sensu Wells & McKenzie (1973).

Type locality. Aldabra, Indian Ocean; West Island settlement, saline tide influenced pool; *cf.* station 71 in Wells & McKenzie (1973).

Type material. Holotype ♀ dissected on five slides. Allotype ♂ preserved in alcohol. Paratypes are three ♂♂ and three copepodids preserved in alcohol. Collected and preserved by K.G. McKenzie in 1968. Determined as *Lourinia armata* by J.B.J Wells in 1971 and deposited in the Natural History Museum (London) under registration numbers NHMUK 1972.6.14.11–15.

Description of female: Body (Fig. 20A–B) shape similar to *L.* aff. *armata*. Total body length: 844 µm. Maximum width: 178 µm. Surface of prosome, free somites and caudal rami ornamented with microspinules as figured (Figs. 20A–B, D; 23A). Spinular ornamentation of genital double-somite, third and fourth urosomites similar to that of *L.* aff. *armata* (Figs. 20B; 23A). Anal somite with one pair of sensilla dorsally; anal operculum straight, margin ornamented with setules (Fig. 20D).

Antennule. Segmentation and setation similar to those of *L.* aff. *armata*.

Antenna (Fig. 20C). Coxa ornamented with spinule rows as figured. Allobasis ornamented with spinule row as figured. Exopod 1-segmented; with two bipinnate apical setae. Endopod 1-segmented, ornamented with spinule rows as figured, lateral armature consisting of two bipinnate spines, distal armature consisting of four bipinnate spines (outer one fused basally to seta).

Mandible, maxillule, maxilla and maxilliped as in *L.* aff. *armata*.

P1 (Fig. 21A). Ornamentation of praecoxa, coxa and basis similar to that in *L.* aff. *armata*. Inner spine of basis extending beyond end of first endopodal segment. Exopod 3-segmented; distal segment with one inner seta, one apical seta and two outer spines. Endopod 2-segmented, shorter than exopod; first segment with one distally pectinate, inner seta; distal segment with two inner setae (proximal one distally pectinate) and one apical spine.

P2–P4 (Figs. 21B; 22A–D). Praecoxae, coxae and bases similar to those in *L.* aff. *armata*. Exopods 3-segmented; inner margin of second and third segments ornamented with setules; second segment with one plumose (P2) or one long plumose (P3–P4) inner seta; distal segment with one short plumose (P2) or one long plumose inner (P3–P4),

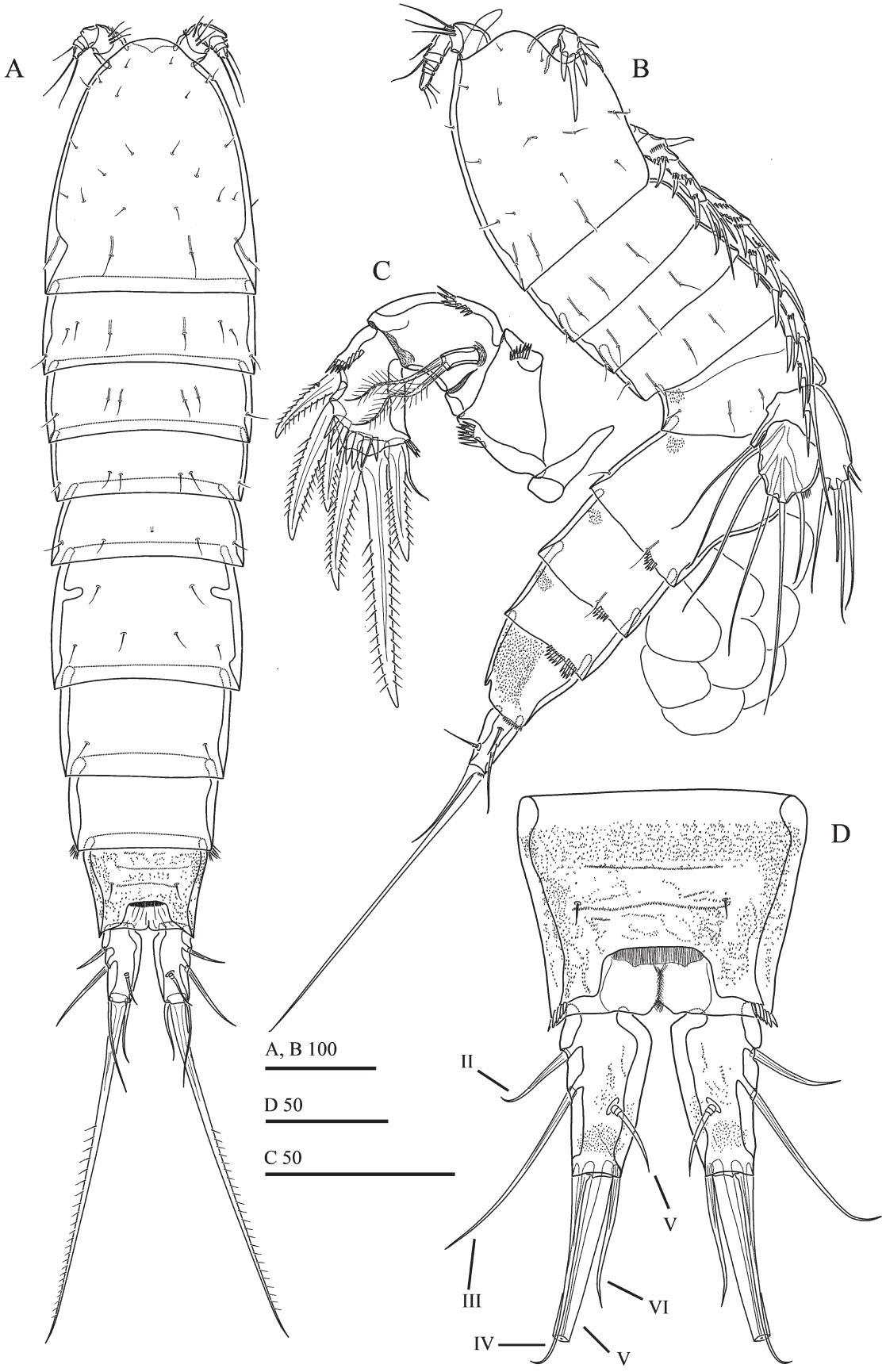

FIGURE 20. *Lourinia aldabraensis* **sp. nov.** (♀): A, habitus, dorsal; B, habitus, lateral; C, antenna, lateral; D, anal somite and caudal rami, dorsal.

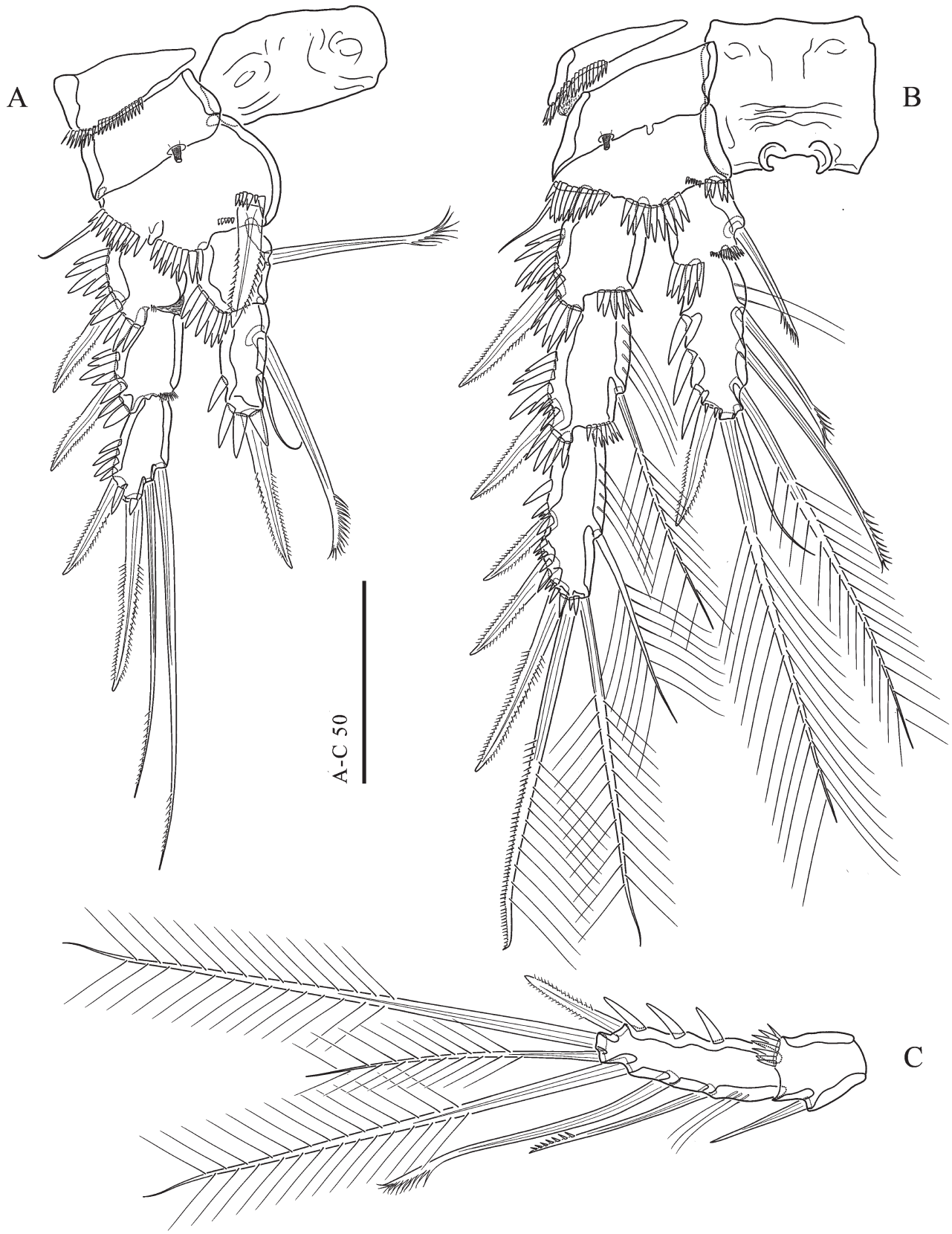

FIGURE 21. *Lourinia aldabraensis* **sp. nov.** (♀: A–B) (♂: C): A, P1, anterior; B, P2, anterior; C, P2 endopod, anterior.

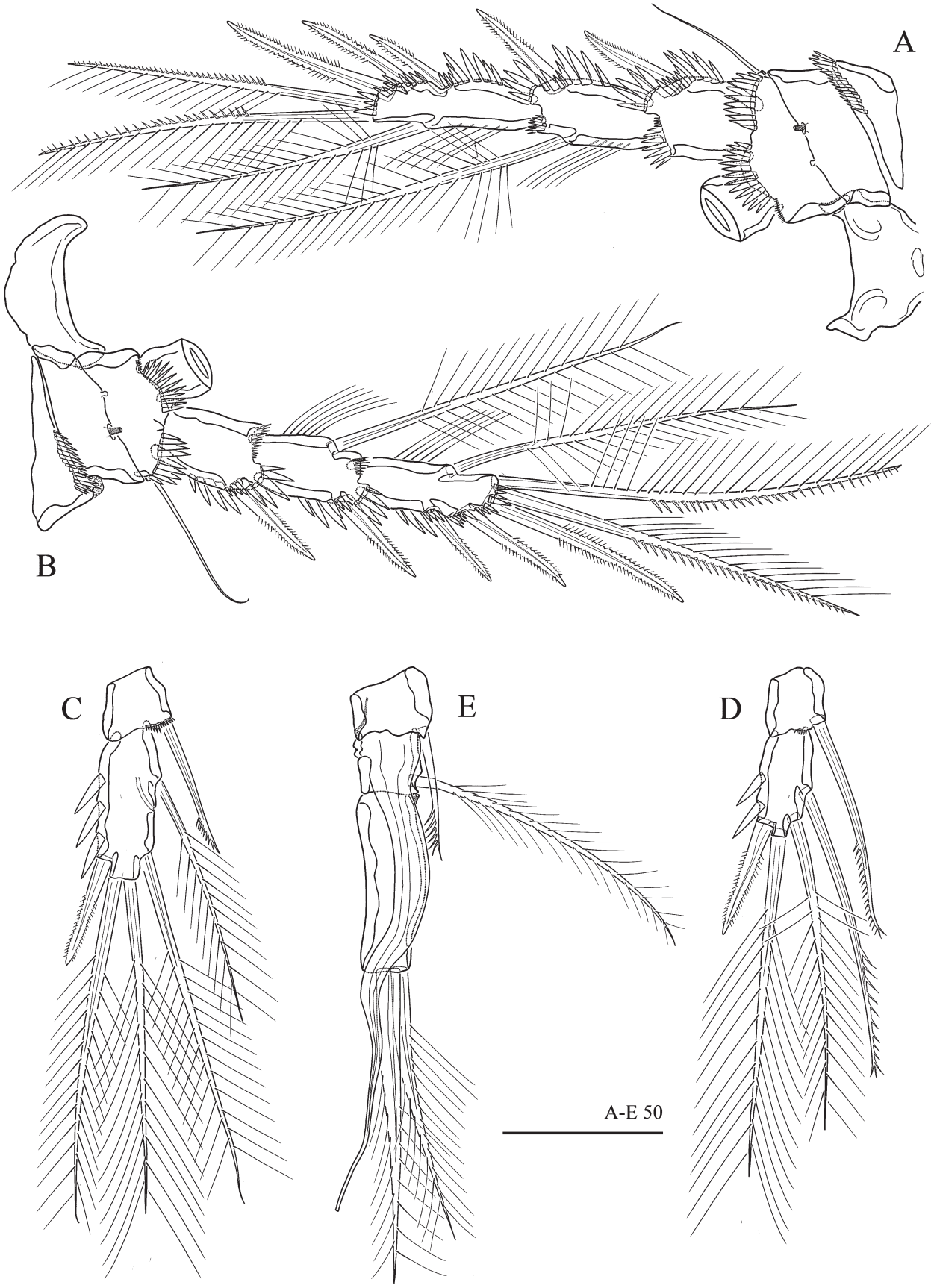

FIGURE 22. *Lourinia aldabraensis* **sp. nov.** (♀: A–D) (♂: E): A, P3 exopod, anterior: B, P4 exopod, anterior; C, P3 endopod, anterior; D, P4 endopod, anterior; E, P3 endopod, anterior.

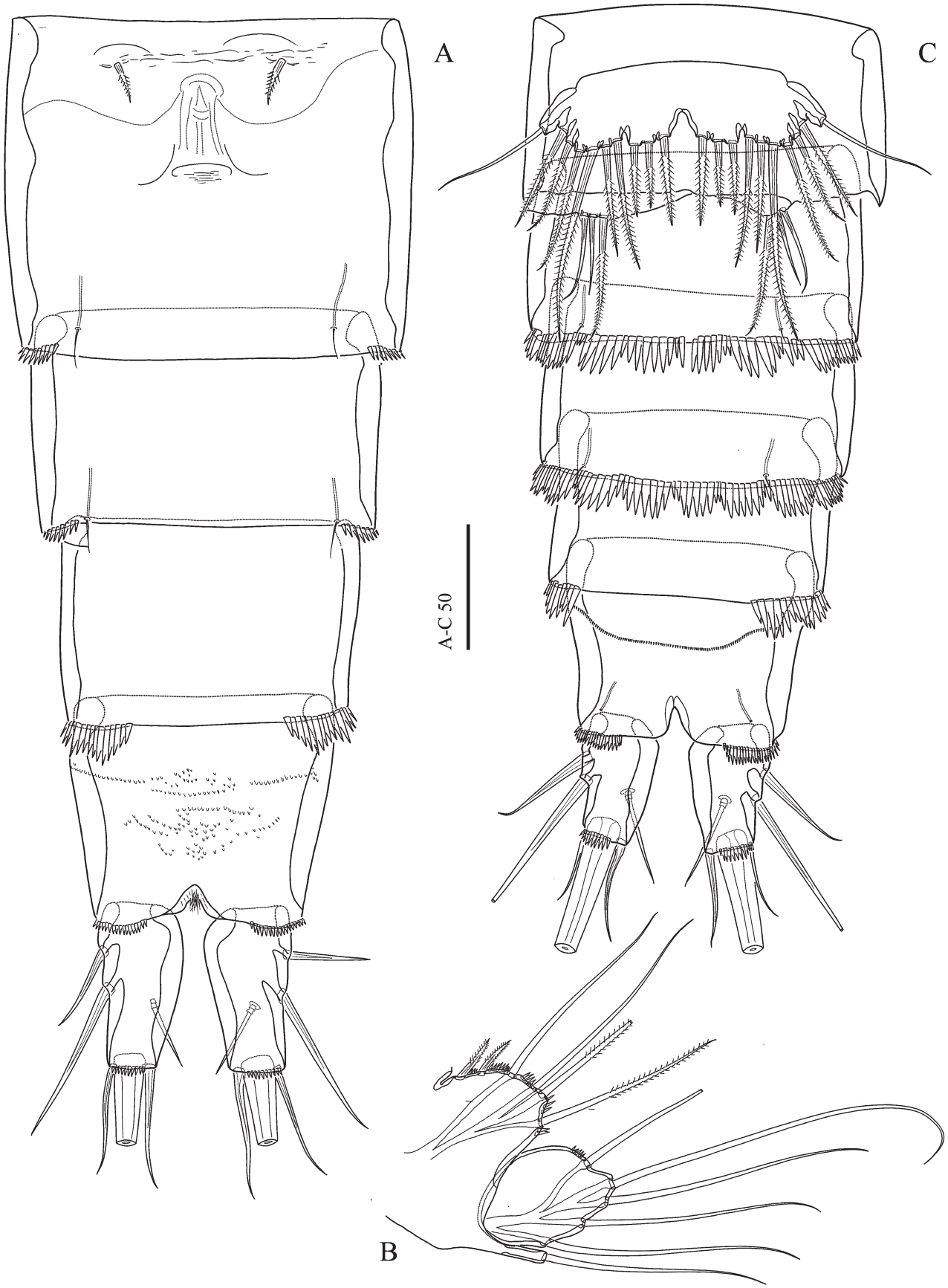

FIGURE 23. *Lourinia aldabraensis* **sp. nov.** (♀: A–B) (♂: C): A, female, abdomen, ventral; B, P5, anterior; C, urosome, ventral.

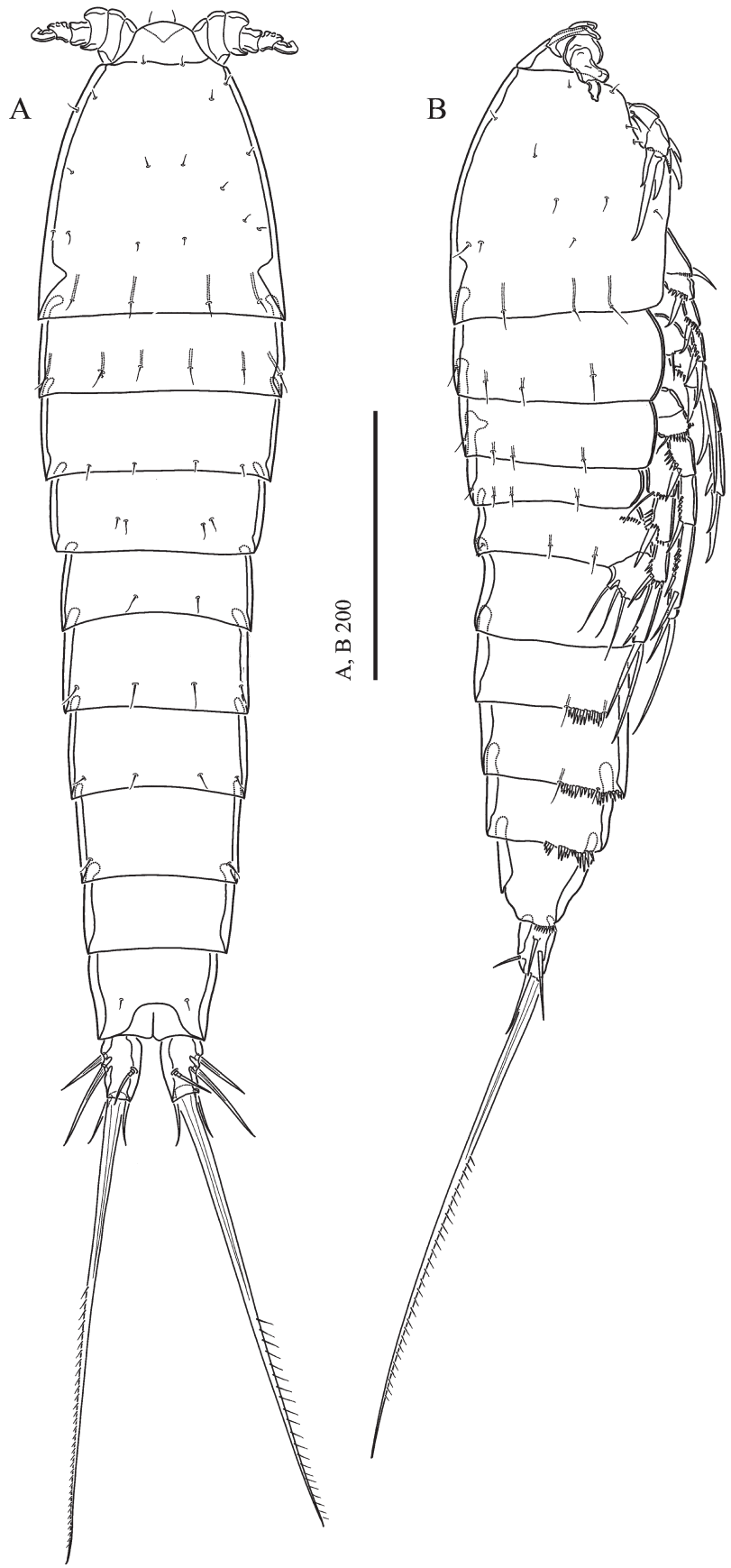

FIGURE 24. *Lourinia aldabraensis* **sp. nov.** (♂): A, habitus, dorsal; B, habitus, lateral.

two apical setae and three outer spines. Endopods 2-segmented, shorter than exopods; first segment with one short, distally pectinate (P2–P3) (Figs. 21B; 22C) or one long, distally pectinate (P4) (Fig. 22D) seta; second segment with three inner setae (two distally pectinate and one plumose), two apical setae (one naked and one plumose) and one outer spine (P2) or two plumose inner setae, two plumose apical setae and one outer spine (P3) or two inner setae (proximal one distally pectinate), one apical plumose seta and one outer spine (P4).

Fifth pair of legs (Fig. 23B) fused medially, baseoendopod well developed. Endopodal lobe with six elements; setae I–II spiniform, bipinnate; setae V–VI bipinnate. Exopod distinct, ellipsoidal, with five long naked setae.

Sixth pair of legs (Fig. 23A) with one bipinnate seta each.

Caudal rami (Figs. 20D) about 1.75 times as long as broad, with six setae. Position of setae similar to *L*. aff. *armata*. Seta IV fused basally to seta V. Size of spinules around ventral distal margin (Fig 23A) smaller than in *L*. aff. *armata*.

Description of male. Body (Fig. 24A–B) cylindrical, tapering posteriorly; without microspinular ornamentation except for ventral surface of the anal somite (Fig. 23C). Total body length about 811 μm (mean = 643 μm, *n* = 5). Maximum width: 184 μm (mean = 174 μm; *n* = 5). Ventral posterior margin (Fig. 23C) of third and fourth urosomites with continuous row, fifth abdominal somite with paired rows of spinules. Spinules irregular in size, displaying peculiar pattern. Sexual dimorphism in body size and spinular/microspinular ornamentation, antennule, P2–P3 endopod, P5 and P6.

P2 endopod (Fig. 21C). Inner seta on first segment without ornamentation; inner apical seta of distal segment plumose and longer than in female.

P3 endopod (Fig. 22E) 3-segmented. First segment squarish with one distally pectinate inner seta; second segment squarish, with one plumose inner seta and recurved apophysis. Length of apophysis about 2.6 times longer than distal segment. Distal segment longest, rectangular, with two plumose apical setae.

Setal formula of swimming legs as in *L.* aff. *armata*.

Fifth pair of legs (Fig. 23C) fused; baseoendopod and exopod forming common plate. Exopodal lobe with six bipinnate setae, endopodal lobe with three bipinnate setae; outer basal seta naked. Comparison of relative length of exopodal setae as follows: III>I>IV>II>VI>V.

Sixth pair of legs (Fig. 23C) asymmetrical; with three setae each, inner seta longest, bipinnate.

Etymology. The new species is named after its type locality.

Discussion

The examination and detailed comparison of the material used in this study demonstrated that the previously published wide variation attributed to *Lourinia armata* sensu lato in reality points to a complex of closely related species all currently housed under the name *L. armata*. Consequently, four different morphologically closely related species have been identified based on the examined material. The original description of *Jurinia armata* by Claus (1866) provides illustrations of the last two abdominal somites including the caudal rami, antennules of both sexes, antenna, mandible, maxillule, maxilla and maxilliped, P1, and P5 of both sexes. Unfortunately, these illustrations are insufficiently detailed so that none of the species, including *L.* aff. *armata* described herein, can be assigned with certainty to *J. armata* of Claus (1866). On the other hand, the presence of four setae on the inner lobe of the male P5 in Claus' (1866: Tafel II, Fig. 24b) illustration is noteworthy because only three setae have been observed on this lobe in all other studies including the present one. It is possible that Claus (1866) inadvertently included the innermost seta belonging to the endopodal lobe of the other side.

Examination of previous records/reports/descriptions attributed to *L. armata* sensu lato has revealed that none of these can be considered conspecific with *L.* aff. *armata* described in this study except for the report of Gurney (1927) which we were able to examine based on Gurney's material obtained from the Natural History Museum London. Therefore, almost all other previous records should be considered doubtful (see below).

Lourinia aff. *armata* described herein can easily be differentiated from *L. wellsi* **sp. nov.**, *L. gocmeni* **sp. nov.** and *L. aldabraensis* **sp. nov.** on the basis of the following characters: i) the shape of the apophysis on the male P3 endopod, ii) naked and spiniform blunt seta on the inner margin of male P1 enp-1, iii) lateral seta on the exopod of antenna originates from indentation, the other seta located apically in both sexes, and iv) the combination of other characters listed in Table 1. *Lourinia* aff. *armata* is morphologically most closely related to *L. aldabraensis*

sp. nov., but in addition to the above mentioned distinguishing characters, it can also be separated from the latter species by the proportional length of the inner setae on P2 exp-2 and exp-3 in both sexes, the elongate prominent P5 baseoendopod in the female, and the more robust (spiniform) and heavily ornamented innermost two setae of the P5 baseoendopod in the female. *Lourinia* aff. *armata* can readily be differentiated from *L. wellsi* **sp. nov.** by the presence of five setae/spines on P3 enp-2 instead of six in the female, and by having a squarish P2 enp-1 instead of a rectangular one in both sexes. *Lourinia* aff. *armata* also differs from *L. gocmeni* **sp. nov.** by the proportional length of P4 enp-2/enp-1 in both sexes with enp-2 being rectangular and twice as long as enp-1 in *L.* aff. *armata* but squarish and as long as enp-1 in *L. gocmeni* **sp. nov.**

The new species *Lourinia wellsi* **sp. nov.** can easily be differentiated from *L.* aff. *armata*, *L. gocmeni* **sp. nov.** and *L. aldabraensis* **sp. nov.** by having six setae/spines instead of five on P3 enp-2 in the female (the characteristically pectinate seta is lost in the other three species). It is also unique in the structure of the apophysis on the male P3 endopod which is setiform and extremely long while in *L.* aff. *armata*, *L. gocmeni* **sp. nov.** and *L. aldabraensis* **sp. nov.** the apophysis is represented by a spiniform process (compare Figs. 4E–F; 15F; 22E). The derived condition of these two distinguishing characters can be considered as synapomorphies for the clade comprising *L.* aff. *armata*, *L. gocmeni* **sp. nov.** and *L. aldabraensis* **sp. nov.** and should be taken into consideration in future descriptions, in particular the structure of the apophysis on the male P3 endopod. Other differentiating characters are summarised in Table 1.

Lourinia gocmeni **sp. nov.** differs from other species of the genus by the distinctly shorter P4 enp-2 which is only as long as P4 enp-1 in both sexes. The new species has also a uniquely shaped apophysis on the male P3 endopod which readily differentiates it from other congeners in *Lourinia*. Other distinguishing characters are summarised in Table 1.

Lourinia aldabraensis **sp. nov.** can easily be differentiated from *L.* aff. *armata*, *L. wellsi* **sp. nov.** and *L. gocmeni* **sp. nov.** by the shape of the apophysis on the male P3 endopod. It is morphologically closest to *L.* aff. *armata*, however, in addition to the shape of the apophysis on the male P3 endopod, it can also be separated from *L.* aff. *armata* by the proportional length of the inner setae on P2 exp-2 and exp-3, the oval-shaped P5 baseoendopod, and the weakly ornamented innermost two setae of P5 baseoendopod. *Lourinia aldabraensis* **sp. nov.** also differs from *L. wellsi* **sp. nov.** by displaying only five setae/spines instead of six on P3 enp-2, and a squarish instead of a rectangular P2 enp-1. Additional discriminating characters are summarised in Table 1.

In his comprehensive study on the copepod fauna of Mediterranean coast of Nice (France), Claus (1866) described *Lourinia armata* under the name of *Jurinia armata* which was later sighted in several other, distantly related localities, all over the world (see below). A significant number of partial or complete redescriptions of *Lourinia armata* sensu lato has led to the attribution of wide variation to a single harpacticoid species. This led us to test whether this variation is either real or can be explained by the potential presence of an underlying complex of closely but geographically disjunct species. The results of this study revealed the presence of four different morphospecies of *Lourinia* that closely resemble each other. However, each of these species can easily be separated from one another by few significant morphological characteristics (especially the structure of the apophysis on the male P3 endopod) that were overlooked in previous studies (see Table 1 and remarks on the species).

Ceylonia aculeata is the earliest synonym assigned to *Lourinia armata* sensu lato. Thompson & Scott (1903) examined several females and two males collected by W.A. Herdman in the Gulf of Mannar off the west coast of Sri Lanka. The specimens were obtained from washings of young pearl oysters and deep water dredgings at Point de Galle in February–March 1902. Six years later *C. aculeata* was also recorded by Scott (1909) who examined three female specimens in the washings from dredged materials collected from off Pulu Jedan, East coast of Aru Islands, from a depth of 11 meters (Pearl Banks). Scott (1909) commented that the females were identical with *C. aculeata* from Sri Lanka and remarked on the significant differences between *Jurinia armata* and *C. aculeata*. The illustrations provided by Thompson & Scott (1903) are remarkably detailed by contemporary standards and for that reason led subsequent researchers to accept their description as the standard base of reference for *L. armata* sensu lato. Ironically, the original illustrations and description of *C. aculeata* provide us with significant evidence to support the claim that it possibly represents a distinct species. Evidence in support of this claim include i) the presence of six setae instead of the typical number of five on the P5 exopod, ii) the shape of the apophysis on the male P3 endopod, and iii) the relative length of the setae on the male P5 (especially the shorter inner spine on the endopodal lobe).

Brian (1923) introduced the name *Ceylonia aculeata* var. *adriatica* as a *nomen nudum* in his report on the

copepods from the Limski Channel, Rovinj, Croatia and Punta Scottile (Mugia) Italy. In a subsequent publication, Brian (1928) also reported this form (cited this time in combination with the generic name *Ceyloniella*) among the macroalgae *Cystoseira* and *Sargassum* collected from the Greek islands Stampalia (Astipalea), Jali (Nisiros) and Tilos (Piscopi) in the Aegean Sea. Brian (1923) remarked that *C. aculeata* var. *adriatica* resembles Thompson & Scott's *C. aculeata* but was initially reluctant about creating the variety *adriatica*. Subsequently, Brian (1928) was convinced that the very long and slender apophysis exhibited on the male P3 endopod and the proportional lengths of the spines and setae of the male P5 were sufficient enough for the establishment of *C. aculeata* var. *adriatica*. Although this variety resembles *L. wellsi* **sp. nov.** in the male characteristics mentioned above, the description provided by Brian (1928) is inadequate for any meaningful comparisons to be made, including confirmation of the potential conspecificity of *C. aculeata* var. *adriatica* and *L. wellsi* **sp. nov.**

Gurney (1927) also listed *Ceylonia armata* in his report on "littoral and semiparasitic Copepoda on Cambridge Expedition to Suez Canal". We were able to examine one female and one copepodid V female from Port Said, Kabret, Gulf of Suez, deposited in the Natural History Museum (London) and collected by Gurney (1927) during the Cambridge Suez Canal Expedition. The female matches well with the species identified here as *Lourinia* aff. *armata*. This is the only confirmed record of *L.* aff. *armata* in this study.

Willey (1930) reported *Ceylonia armata* collected from rock scrapings among sea urchins (*Arbacia*) at low tide on Bermuda Island. The very long and recurved apophysis (Willey 1930: 112, fig. 76) on the male P3 endopod seems to be unique to the Bermuda specimens. This character, in conjunction with the geographical isolation of the "population", supports the idea that *C. armata* sensu Willey (1930) may not be *Lourinia armata* sensu lato but represents a new species of *Lourinia*. Pending detailed examination of newly collected material the true identity of Bermuda specimens has to remain unconfirmed.

Monard (1935) examined louriniid specimens collected from rocky shores of Cape Carthage (Salammbô, Tunisia) and provided illustrations of the female. The setal formulae of P2 and P3 are different but it is highly possible that P2 and P3 were labelled incorrectly. Otherwise the female characteristics of Monard's Mediterranean material of *Ceyloniella armata* matches well with the *L.* aff. *armata* described in this study. Monard (1937) later gave another report of *Ceyloniella armata* from Castiglione, Bou Ismail, Algeria but this report also requires confirmation.

In his important paper, mostly based on the material collected during John Murray Expedition, Sewell (1940) made a significant contribution to the taxonomy of the Louriniidae (as Ceyloniellidae) by discussing the variability he observed between "four different taxa": i) *Ceyloniella armata* f. *major* (collected from west Nicobar Islands among algal samples); ii) *Ceyloniella armata* f. *minor* (collected from west side of Nicobar Island among algal samples); iii) *Ceyloniella nicobarica* (collected from west side of Nicobar Island among the specimens obtained from algal washings); and iv) *Ceyloniella nicobarica* var. (collected from Nankauri Harbour, Nicobar Islands and Addu Atoll, Maldive Archipelago among the specimens obtained from algal washings). *Ceyloniella armata* f. *major* and *C. armata* f. *minor* are almost certainly not conspecific with any of the species described herein, including *L.* aff. *armata*, since the shape of the apophysis is quite different in these two forms by having a series of three small curved hooks on its outer margin about halfway along its length. In addition, the inner spines are equal in length in these two forms and leaf-shaped. On the other hand, there are also significant differences between *C. armata* f. *major* and *C. armata* f. *minor*, especially the shape of caudal ramus seta V in *C. armata* f. *minor* which is markedly swollen in its basal part and for about one-fourth of its length, and then abruptly narrows and continues as a normal seta. In addition, Sewell (1940) remarked on some other differences in *C. armata* f. *minor* including i) the shorter and straight inner distal basal spine of P1, ii) the straight and naked nature (not pectinate at tip) of the inner seta on P1 enp-1, and iii) the serrated terminal spine at the tip of the P1 endopod. These differences cannot be underestimated in the present day's concept of harpacticoid taxonomy, and unlike in Sewell's (1940) interpretation, should not be classified as "slight differences". It is highly possible that *C. armata* f. *major* and *C. armata* f. *minor* both represent two different species of *Lourinia*. As for *Ceyloniella nicobarica*, this species must be reinstated as *Lourinia nicobarica* (Sewell, 1940) **comb. nov.** on the basis of the unique paddle-shaped (with broadened proximal half) caudal ramus seta V. The following combination of characters easily differentiate *L. nicobarica* from other species in the genus: i) paddle-shaped caudal ramus seta V, ii) less curved apophysis on male P3 endopod (Sewell 1940: 334, Fig. 80I), iii) leaf-shaped inner spines on P5 baseoendopod, and iv) the length of the terminal spine on P1 enp-2. *Lourinia nicobarica* **comb. nov.** is morphologically closest to *L. aldabraensis* **sp. nov.** in having a similar apophysis (recurved and length about 2.6 times longer than distal segment) on the male P3 endopod. Finally, Sewell (1940: 336) recognized a variety of *Ceyloniella nicobarica* based on a few females but did not name it. No male was

described for this form. Sewell (1940) noted some significant differences between this form and *L. armata* sensu lato: i) third somite of abdomen longer, and anal somite slightly shorter, ii) caudal rami tapering more abruptly, and iii) P1 enp-2 with only one plumose seta along its inner margin, and without the second proximal pectinate seta. The combination of these characters suggests that the variety (*e.g. L. nicobarica* sp. nov., var.) described by Sewell (1940) may also represent a distinct species of *Lourinia*.

Nicholls (1941) worked on the littoral harpacticoids of South Australia and collected material of *Ceyloniella armata* at Sellicks Beach. This Australian population also may represent another distinct species based on the combination of the following characters: i) unusually developed seta III on the female caudal ramus, ii) presence of five setae on the terminal segment of P2 endopod (the usual number of seta/spines on this segment being six, this is the only record that has five setae/spines on this segment; however, it is highly possible that the smaller and thinner terminal seta was overlooked by the author), iii) strong, long and recurved shape of the apophysis on the male P3 endopod (Nicholls 1941: 424, Fig. 23), and iv) relative length of the setae/spines on the male P5.

In his continuing research series on the phytal Harpacticoida of Brazil (Paraná and Santa Catarina States) Jakobi (1954) established the subspecies *Lourinia armata sulamericana*. The description of this subspecies is very confusing, especially the setal formulae of the endopods of P1–P4; Jakobi (1954) possibly counted the large spinules on the endopodal segments as setal elements. His illustrations are too inadequate for reliable comparisons with the species described herein as well as with the previous records to be made. Therefore, *L. a. sulamericana* is best placed as *species inquirenda* in the genus *Lourinia*.

The taxonomic identity of *Lourinia armata* reported from Tenerife, Canary Islands by Noodt (1955) cannot be discerned since the author only described the female P5; therefore this record should be considered very doubtful.

The specific identity of *Lourinia armata* reported from the Adriatic coast (Split, Croatia) must also be confirmed since Petkovski (1955) only examined a single female and figured only the dorsal view of the caudal ramus, without any accompanying description of the species.

Similar comments about the unclear specific identity of *Lourinia armata* collected by Pesta (1959) among the red algae *Digenea simplex* from the Sorrento Peninsula, Quercio Bay, Italy can be made since only the female P5 and the caudal ramus in dorsal view were illustrated in the publication.

Vervoort (1964) gave one of the most interesting reports on *Lourinia armata* from Ifaluk Atoll, Caroline Islands in the Pacific Ocean, but he was inclined not to attach too much importance on the differences found in the setal formula of the P2–P4 enp-2, and other differences such as the divergent caudal rami, the relative length of the male P5 setae and the shape of the apophysis on the male P3 endopod. The slender and long apophysis in the Pacific material is also displayed in *L. wellsi* **sp. nov.**

Yoo & Lee (1993) provided a redescription of *L. armata* based on Korean material collected from Namea and Cheju harbours. Their specimens appear to have some unique characters such as i) the leaf-shaped caudal ramus seta III, and ii) the hook-shaped apophysis on the P3 endopod of the male. Although these unique characters, in combination with the setal formula, may be sufficient to create a new species of *Lourinia* from Korea, they will have to be authenticated first before such a course of action can be undertaken.

The possibility of additional, as yet unrecognized, new taxa in the literature mentioned above must be tested by examining new material from the same localities and by describing the species according to modern standards. Historically, small morphological details have not always received the attention they deserve although their significance has now become apparent in delimiting new taxa in copepod taxonomy. Based on the review given above it is conceivable there are many more *Lourinia* species to be discovered in other parts of the world.

The other records of *Lourinia armata* from Rovinj, Croatia (Vàtova 1928), Inhaca Island, Mozambique (Wells 1967), Bermuda (Coull & Herman 1970), Sinai, Red Sea (Por 1977), Cook Strait, New Zealand (Hicks 1977a), Island Bay, Wellington, New Zealand (Hicks 1977b) Tampa Bay, Florida (Bell *et al*. 1987), Long Island and Havelock Island, Andaman (Wells & Rao 1987), Brazil (Reid 1998), Arraial do Cabo, Rio de Janeiro, Brazil (Sarmento *et al*. 2012), Porto de Galinhas coral reefs, northeastern Brazil (Sarmento & Santos 2012a, 2012b), Zanzibar Island, Tanzania (Gheerardyn 2007; Gheerardyn *et al*. 2008; Callens *et al*. 2012), Easter Island, Chile (Goddard 2003; Ríos-Escalante & Barrera 2013), Mexico (Suarez-Morales *et al.* 2006), Raoul and Satellite Islands, New Zealand (Keable & Reid 2015) are impossible to confirm since they do not contain sufficient descriptive information or illustrations.

TABLE 1. Morphological comparison of the *Lourinia* species described in this study.

Female				
Species	*Lourinia* aff. *armata*	*Lourinia wellsi* **sp. nov.**	*Lourinia gocmeni* **sp. nov.**	*Lourinia aldabraensis* **sp. nov.**
Microspinular integumental ornamentation on somites	on all somites	on genital double-somite, second urosomite and anal somite	only on anal somite	fifth prosomite, genital double-somite, second and third urosomites (laterally) and anal somite.
Antennary exopod and position of the setae	lateral seta originates from indentation, the other seta located apically	no indentation, all setae located apically	no indentation, all setae located apically	no indentation, all setae located apically
P1 basis inner margin	naked	naked	ornamented with setules	naked
P1 basis inner spine length	considerably longer than exp-1	shorter than exp-1	considerably longer than exp-1	slightly longer than exp-1
P1 exp-2 inner margin	naked	with setules	with setules	naked
P1 enp-2 inner margin	with long setules	with small spinules	with short setules	without setules
P1 enp-2 proximalmost penicillate seta length	reaches only halfway the terminal spine	reaches only halfway the terminal spine	reaches only along the terminal spine	reaches to the tip of the terminal spine
P2 basis innermost spinular row	with relatively shorter spinules	with long spinules	with long spinules	with relatively shorter spinules
P2 enp-1	squarish	rectangular	squarish	squarish
P2 exp-2 inner seta	reaches to middle of exp-3	reaches end of exp-3	nearly reaches to end of exp-3	reaches to end of exp-3
P2 exp-3 inner seta	shorter than exp-3	about twice as long as exp-3	about 1.5 times as long as exp-3	about as long as exp-3
P3 enp-2 total number setae/spines	five	six	five	five
P4 enp-2/enp-1	enp-2 rectangular and twice as long as enp-1	enp-2 rectangular and twice as long as enp-1	enp-2 squarish and as long as enp-1	enp-2 rectangular and twice as long as enp-1
P4 enp-1 seta	distally pectinate	distally pectinate	pinnate	distally pectinate
P5 baseoendopod	elongate, prominent	oval	oval	oval
P5 baseoendopod innermost two setae	robust (spiniform) and heavily ornamented	weakly ornamented	weakly ornamented	weakly ornamented
P5 exopod shape	ellipsoidal	ovoid	ovoid	ellipsoidal
	Male			
P5 exopod setae length	III>I>IV>II>V>VI	III>IV>II>V>VI>I	III>IV>II>VI>I>V	III>I>IV>II>VI>V
Ventral spinular ornamentation on posterior margin of abdominal somites	spinules of similar length	robust spinules of different length	robust spinules of different length	robust spinules of different length
Apophysis on P3 endopod	with specific shape as figured	with specific shape as figured	with specific shape as figured	with specific shape as figured

Taxonomic status of *Archeolourinia* and phylogenetic considerations

The basis of all taxonomic and phylogenetic research on harpacticoids until now still relies on the study by Karl Lang (1944, 1948). Since then about 3,500 new taxa have been described and established (Wells 2007; Huys 2009). Therefore, a revision of Lang's system has become necessary. Some revisionary attempts at family-group level have been made by several authors (Por 1986; Huys & Böttger-Schnack, 1994; Martínez & Moura 1994; Willen 2000; Seifried & Schminke 2003). However, the phylogenetic status of many families including the Louriniidae is still doubtful. A historical review about the phylogenetic position of the Louriniidae has recently been well documented and discussed by Corgosinho & Schizas (2013) in their study on the proposal of a new louriniid genus *Archeolourinia* from mesophotic coral ecosystems in southwestern Puerto Rico. Corgosinho & Schizas (2013) assigned the new genus *Archeolourinia* to the family Louriniidae on the basis of the following familial synapomorphic characters: "(a) well-developed rostrum with rounded tip; (b) 7-segmented female antennule; (c) antenna with separate coxa and allobasis armed with an outer spine; (d) antennary endopod with at least 5 strongly developed elements; (e) mandible with well-developed gnathobasis and reduced palp; (f) maxillule with well-developed praecoxal arthrite bearing about 6 distal elements, enp and exp absent; (g) maxilla with two basal endites, enp-1 drawn into a strong claw, enp-2 represented by 3 setae; (h) P2 to P4 typically with 2 segmented enp; (i) P5 benp of female confluent, intercoxal sclerite absent, exp 1-segmented; (j) eggs retained in a single ventral egg sac; (k) body cylindrical with inconspicuous podoplean boundary; (l) telson shorter than the last urosomite, slightly tapering posteriorly; and (m) furca short and with 6 setae". Unfortunately, none of the characters mentioned above can be accepted as synapomorphic for the Louriniidae since they are found in many other harpacticoid families such as the Canthocamptidae. On the other hand, the inclusion of the monotypic genus *Archeolourinia* in the Louriniidae is hard to defend, because according to the latest identification keys (Huys *et. al*., 1996; Wells, 2007; Boxshall & Halsey, 2004) *Archeolourinia shermani* does not key out to the family Louriniidae but to the Canthocamptidae. On the other hand, the close morphological resemblance of *A. shermani* and *Nannomesochra arupinensis* sensu lato is interesting to note since these two species can only be separated from each other by minor details. Unfortunately, *A. shermani* was described on the basis of single female and no male was found (Corgosinho & Schizas 2013). The description of the male of *A. shermani* will be crucial to determine the exact taxonomic position of the genus *Archeolourinia*. As result, *A. shermani* may have to be removed from Louriniidae and transferred to the genus *Nannomesochra* within the family Canthocamptidae.

The presence of an apophysis on the three-segmented P3 endopod in the male is one of the most important lines of evidence that the family Louriniidae is phylogenetically related to the Canthocamptidae. However, this modification cannot be considered as a synapomorphy for a (Canthocamptidae + Louriniidae) clade since it is also encountered in other families such as the Cylindropsyllidae, Huntemanniidae and Rhizothrichidae (Huys *et. al*. 1996). There is little doubt about the homology of this apophysis in these families (Martínez-Arbizu & Moura 1994; Huys & S. Conroy-Dalton, 2006). Therefore, the presence of the apophysis on the three-segmented P3 endopod in the male is a plesiomorphic character and can only be used as evidence to hypothesize that all of these families originated from the same ancestral stock. On the other hand, the exact phylogenetic position of the Louriniidae remains problematic and may not get resolved especially until the phylogeny of the polyphyletic family Canthocamptidae is fully elucidated. The most important characteristic that can possibly be used to define the Louriniidae is the reduction of maxilliped. Phylogenetic affinities with the families Darcythompsoniidae and Louriniidae were noted because of the reduced or absent maxilliped but this reduction has possibly occurred as a result of convergent evolution under similar selective pressures. On the other hand, the apophysis on the P3 endopod in the male is not expressed in the Darcythompsoniidae. Consequently, the suggestion of a possible phylogenetic affinity and even sistergroup relationship between Darcythompsoniidae and Louriniidae (Corgosinho & Schizas 2013) based on other plesiomorphic or convergent features such as similar body shape, similar armature of antennule, antenna, mandible, maxillule, maxilla, P1–P4, reduction of the maxilliped, and the modified (pectinate) setae occurring in more or less the same positions on P2–P4 is unfounded. An alternative supposition made by Corgosinho & Schizas (2013) that "… similar structures convergently evolved in Louriniidae and Darcythompsoniidae [as an adaptation] to similar habitats in shallow waters and associated with phytal substrata or decaying leaves…" appears more plausible.

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