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Three new Canuellidae (Copepoda: Canuelloida) from Iran

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Abstract

A survey of copepods from intertidal zone of the Persian Gulf and the Gulf of Oman resulted in discovery of three new species belonging to the family Canuellidae Lang, 1944. This work contributes to the final aim to describe meiobenthic copepods from this region and is the first description of meiobenthic copepods from Iranian coastline. The new species belong to the genera *Brianola* Monard, 1926, *Canuella*, T. & A. Scott, 1893, and *Scottolana* Huys, 2009. Compared to other congeners, *Brianola haliensis* **sp. nov.** is unique in the armature of the first leg, number of segments and setation of the antennary endopod and exopod. *Canuella persica* **sp. nov.** is easily distinguishable from its congeners by the shape of furcal rami and male genitalia. *Scottolana gomezi* **sp. nov.** is assigned to the *longipes*-group by the presence of two and three post-genital somites in the female and male, respectively. It is closely related to *S. geei* (Mu & Huys, 2004) recorded from the Bohai Sea, China, but can be distinguished by its eight-segmented antennary exopod, mouthparts setation, and shape of the furcal rami.

Key words: *Brianola*, *Canuella*, Gulf of Oman, intertidal zone, Persian Gulf, *Scottolana*, shallow water

Introduction

Copepods have rarely been reported from the Persian Gulf and the Gulf of Oman, and only recently their taxonomic study was undertaken. Copepods have not yet been recorded from meiofauna and have rarely been reported from planktonic habitats (Peyghan *et al*. 2011). During a short-term study of their diversity along the Iranian coastline, interesting collections of meiobenthic copepods were sampled from more than thirty localities. This report deals with descriptions of three new species belonging to the family Canuellidae.

Lang (1948) separated the family Canuellidae Lang, 1944 from the rest of Harpacticoida and placed together with the family Longipediidae Boeck, 1865 into Polyarthra, a new subdivision in Harpacticoida. Recently, a molecular study has confirmed the polyphyly of Harpacticoida (Khodami *et al*. 2017). So, Polyarthra and Oligoarthra are not sister-groups, although each of them is monophyletic. Canuellidae and Longipedidae (Polyarthra) were placed into a new Order, called Canuelloida.

The family Canuellidae has about 54 species, classified into 19 genera (Huys 2009). The family shows wide variety of life styles, from free-living to symbiotic. Free-living species are mostly found in intertidal area (Boxshall & Halsey 2004) and symbiotic species are related with hermit crabs (Huys 2016). Por (1984) suggested that Canuellidae is a polymorphic assemblage of species. He found only one potential synapomorphy for the whole family: the reduced, non-sexually dimorphic P5. The monophyly of the family can only be solved with a comprehensive molecular and morphological revision.

We report three new species, belonging to three different genera.

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Material and methods

Specimens were collected during a sampling survey in 2014 and 2015 from the sub-littoral zone of Iranian coastline of the Persian Gulf and the Gulf of Oman. They were removed from sediment using a 38µm sieve. Copepods were then sorted using a stereo microscope and preserved in 96% ethanol prior to further investigation. Before dissection, photographs were taken from dorsal, lateral, and ventral view by Confocal Laser Scanning Microscope (CLSM) (Leica TCS SP5 equipped with a Leica DM500 B). The dissected parts were mounted in glycerin on slides. Observation and drawings were made using a Leica microscope equipped with Differential Interference Contrast (DIC) at 1000× magnification. Holotype and paratypes were deposited in the collection of German Center for Marine Biodiversity Research (DZMB), Senckenberg am Meer in Wilhelmshaven, Germany. Abbreviations used in the text and tables: EXP, exopod; ENP, endopod; P1–P6, first to sixth swimming legs.

Taxonomy

***Brianola haliensis* sp. nov.**
(Figs. 1–11)

Type locality. Intertidal zone at Northern Haleh, Nayband, Iran, 27°24'6.12"N 52°38'41.16"E.

Type material. Holotype: ovigerous female, dissected on 16 slides (SMF 37140/1-16). Paratypes: one male allotype (SMF37141/1-16) dissected on 16 slides, 3 females and 2 males preserved in alcohol (SMF37142/1).

Diagnosis. First pedigerous somite fused to cephalosome, four-segmented antennules in female, antennary exopod eight-segmented, P1 exp-2 without inner seta.

Description of holotype female. Habitus (Figs. 1–3A). Body length measured from tip of rostrum to posterior margin of furcal rami, ranging from 1.1mm to 1.25mm. First pedigerous somite fused to cephalosome. Entire body minutely punctuates. Cephalic shield furnished with fine spinules along ventral margin. Urosome (Fig. 4B) consisting of rectangular somites; ornamented with rows of fine spinules and incised hyaline frills, ventrally and dorsally. Genital double-somite fused, marked by discontinuous internal cuticular band laterally. Penultimate somite carrying a deeply-incised pseudoperculum (Fig. 11A).

Rostrum (Fig. 4A) very large, bell-shaped, and defined at base, exceeding length of antennules, without setules.

Furcal rami (Figs. 4B, D, 11A) slightly divergent; anterior face prolonged into a spiniform process; surface covered with fine pointed scales; two rows of spinules on outer margin; with seven setae on distal margin of ramous. Seta I spiniform, located at outer margin and close to seta IV, seta II smooth and positioned ventrally on inner margin; seta III minute and smooth and positioned dorsally as in male (Fig. 11A); setae IV and V well-developed and unipinnate; seta V 1.5 times as long as seta IV; seta VI short and smooth and positioned at base of seta V; seta VII plumose, short, bi-articulate at base and displaced to inner margin.

Antennule (Fig. 5) four-segmented. First segment with rows of spinules on dorsal surface with one pinnate and two naked setae. Second segment with 22 setae/spines and two aesthetascs. Third segment bearing two spinulated setae and one naked seta. Last segment with six spinulated, six naked and one plumose setae.

Antenna (Figs. 6A, B) coxa and basis distinct. Basis with fine setules along inner margin. Endopod three-segmented; enp-1 with one pinnate seta; enp-2 with four pinnate and one naked setae; enp-3 bearing six pinnate and one naked setae. Exopod consisting of eight segments; segments 3–7 each with one naked seta; ultimate segment with three pinnate and one naked setae.

Mandible (Fig. 6C) gnathobase with two rows of strong teeth in difference size; dorsal corner with pinnate spine. Basis bearing two pinnate setae and several rows of spinules. Endopod two-segmented; enp-1 with three pinnate setae and row of spinules; enp-2 with seven pinnate and one plumose setae. Exopod one-segmented; with five plumose and one pinnate setae.

Maxillule (Fig. 7B) praecoxa arthrite with two juxtaposed slender setae on anterior face and 10 distal spines; row of spinules on posterior face. Coxal endite cylindrical, bearing three pinnate setae; epipodite represented by three plumose setae. Basis composed of two closed endites, each bearing three pinnate and one tiny smooth setae; with row of strong spinules on posterior surface. Endopod two-segmented; enp-1 with three pinnate and two

smooth setae; enp-2 bearing two pinnate and four plumose setae. Exopod one-segmented; with six plumose and one strongly pinnate setae.

Maxilla (Fig. 7A) comprising praecoxa, coxa, allobasis and three-segmented endopod. Praecoxa bearing rows of spinules; proximal endite with four pinnate and one smooth tiny setae; distal endite with two pinnate setae. Coxa bearing two endites, each with three pinnate setae. Allobasis endite extended into a strong claw; accompanied by a stout spine covered with coarse spinules and five pinnate setae. Endopod three-segmented; enp-1 with two setae, enp-2 with four setae; enp-3 small, bearing two setae.

Maxilliped (Fig. 7C) phyllopodial; three-segmented. Praecoxa and coxa fused; coxa with row of spinules on surface, with two groups of spines/setae, proximal group composed of one seta and two spines, distal group with six spines/setae; basis bearing three setae; with rows of small spinules on surface; outer margin covered with long setules. Endopod with three pinnate and four plumose setae.

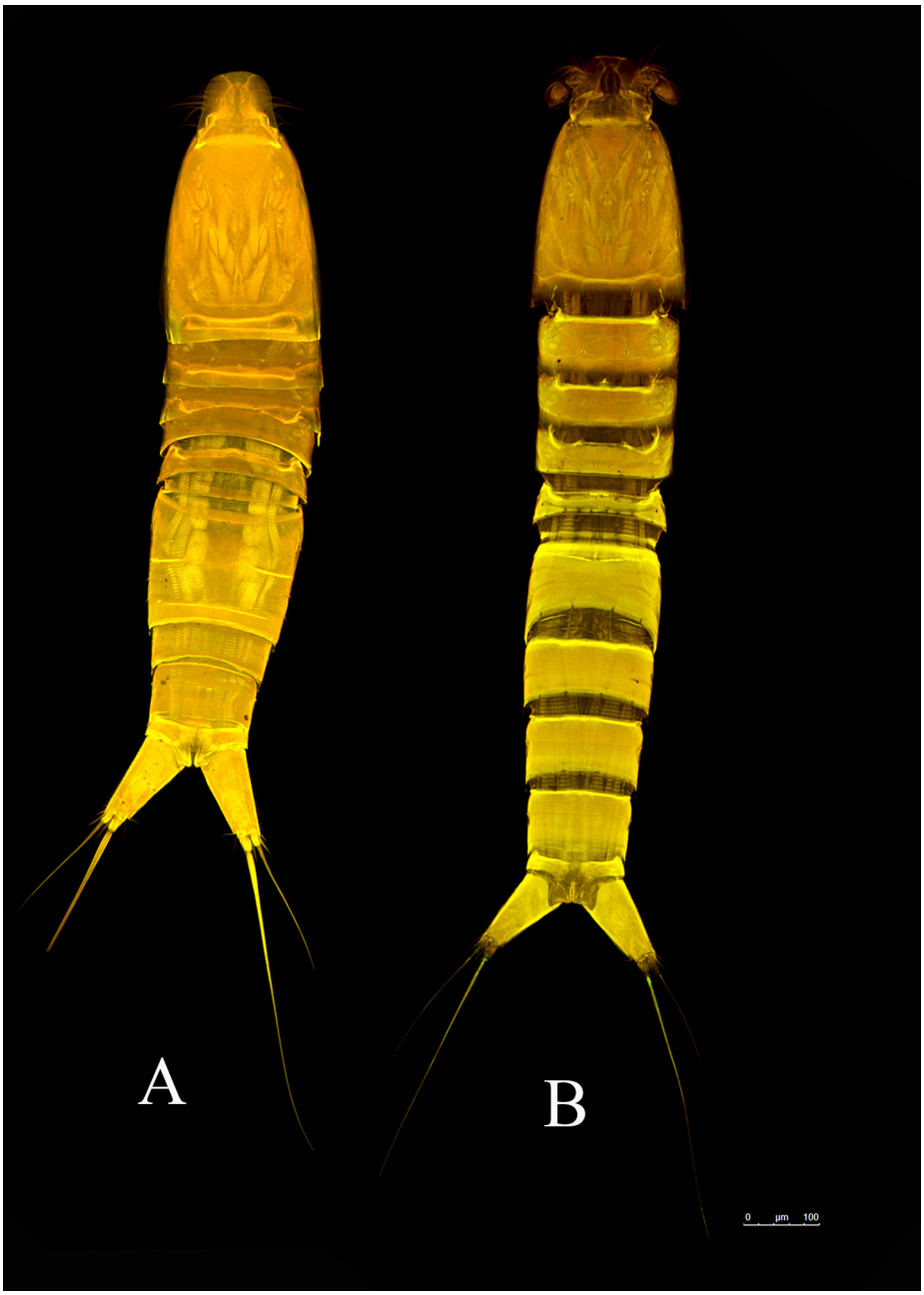

FIGURE 1. *Brianola haliensis* **sp. nov.,** habitus, dorsal (CLSM); (A) female; (B) male.

FIGURE 2. *Brianola haliensis* **sp. nov.**, habitus, lateral (CLSM); (A) female; (B) male.

Swimming legs (Figs. 8–9, Table 1) with three-segmented rami. Coxa with distinct spinular pattern on anterior surface as figured, third endopodal segment longest.

P1 (Fig. 8A) coxa with inner pinnate spine and inner margin with long setules. Basis with stout inner pinnate spine and outer pinnate seta. Row of spinules on outer margin of exopod segments; outer spine of exp-1 and -2 strongly pectinate; exp-3 with one pectinate and three pinnate spines and one inner pinnate seta. Enp-1 with row of strong spinules and pore on anterior face and inner pinnate seta; enp-2 bearing inner pinnate seta, inner distal corner forming spinous process and covered with stout spinules, pore on anterior face; enp-3 with spinules in outer and inner margins, three pinnate spines and three pinnate setae (innermost seta shorter than others).

P2 (Fig. 8B) coxa unarmed. Basis with outer pinnate seta; anterior face on outer corner ornamented with stout spinules; anterior surface extended into a long mucroniform process between two rami. Exp-1 and -2 with pinnate outer spine and spinular patch at their base, outer distal corner of both segments forming spinous process; exp-2 with inner pinnate seta; exp-3 with three pinnate spines and one pinnate seta; spinous process between second and third spine; with row of spinules on outer margin; all three exopodal segments with pore near outer spine. Enp-1

and -2 with spinous process on outer distal corner and inner pinnate seta; enp-1 with spinular rows on outer margin; enp-2 with rows of spinules on inner and outer margin; with a pore near outer margin; enp-3 with three pinnate spines and two pinnate setae; with rows of spinules on outer and inner margin; anterior face forming spinous process between second and third spine; with a pore near to second spine.

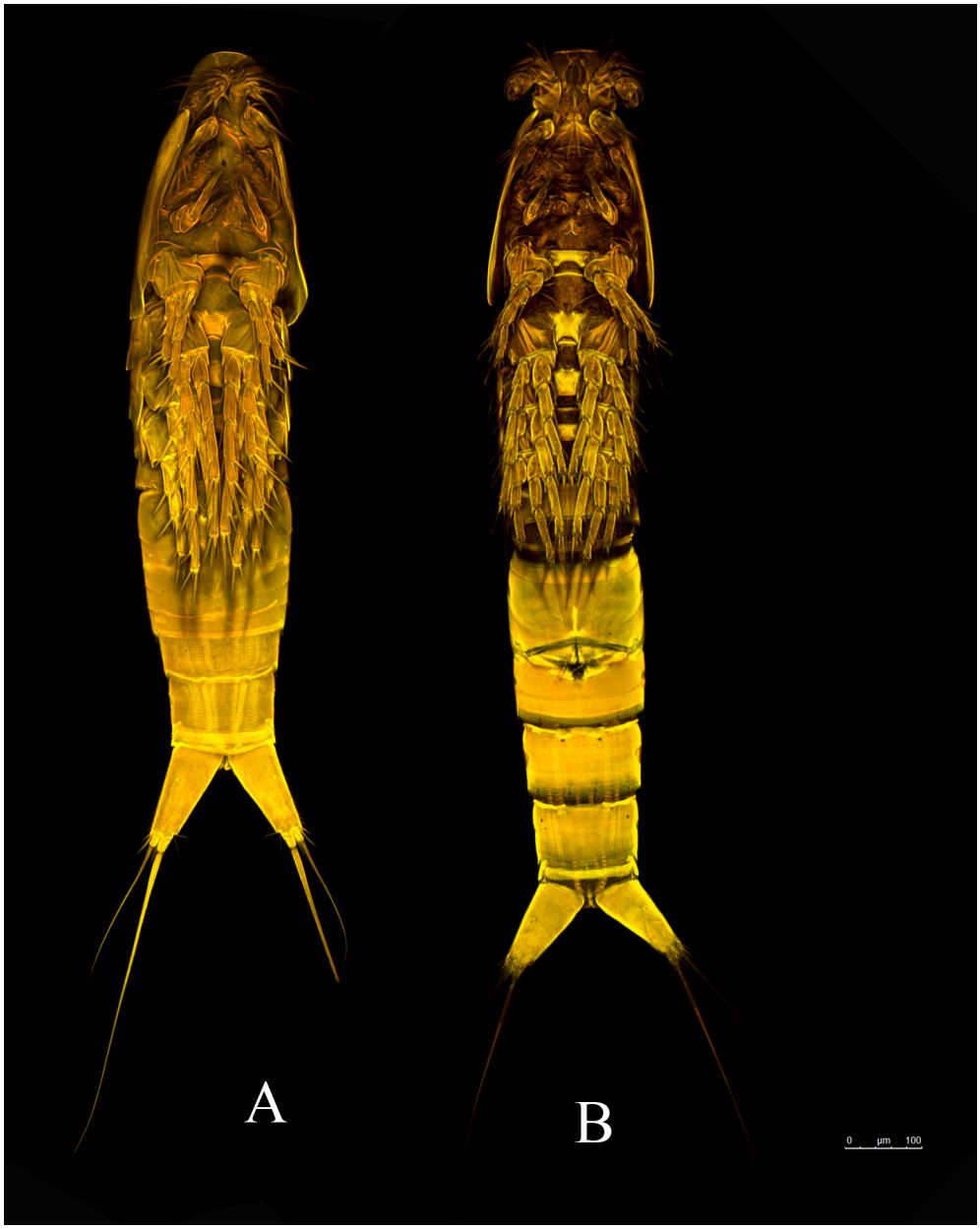

FIGURE 3. *Brianola haliensis* **sp.nov.,** habitus, ventral (CLSM); (A) female; (B) male.

P3 (Fig. 9A) fairly similar to P2 except for setal formulae. Enp-3 with three pinnate spines and one pinnate seta.

P4 (Fig. 9B) coxa and basis ornamentation similar to P2 and P3. Exp-1 and 2 with pinnate outer spine and spinular patch at their base, outer distal corner of both segments forming spinous process; exp-3 with four pinnate setae, terminal spine longest; with rows of spinules on inner and outer margins; a pore at base of third spine. Enp-1 with short stout inner spine; with pore and spinules on outer distal corner; enp-2 outer distal corner prolonged into spinous process; with rows of spinules on inner and outer margin; enp-3 with four pinnate spines, terminal spine longest; anterior face produced into spiniform process; with pore and rows of spinules on inner and outer margins.

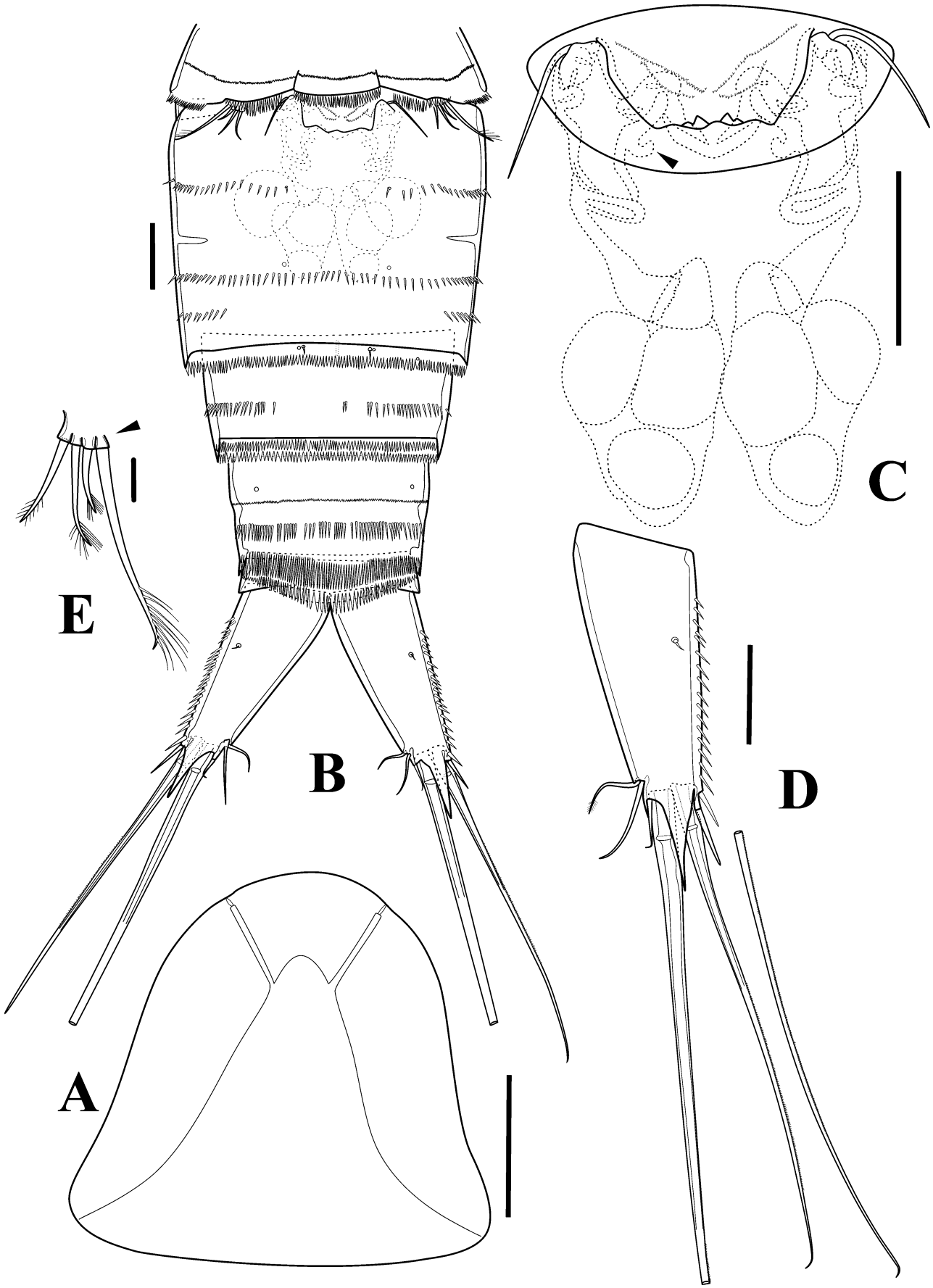

FIGURE 4. *Brianola haliensis* **sp. nov.,** female: (A) rostrum, dorsal; (B); urosome, ventral (C) genital field (copulatory pore arrowed), (D) furcal ramus, left (E) P5 (outer basal seta arrowed). Scale bars: A–D: 50μm; E: 10μm.

FIGURE 5. *Brianola haliensis* **sp.nov.,** Female: antennule (disarticulated). Scale bars: 50µm.

Spine and seta formulae as follows:

	Exopod	Endopod
P1	0.0.1.2.2	1.1.2.2.2
P2	0.1.1.2.1	1.1.2.2.1
P3	0.1.1.2.1	1.1.1.2.1
P4	0.0.1.2.1	1.0.1.2.1

P5 (Fig. 4E) reduced; incorporated into somite; connected by a deeply-incised hyaline frill; with four setae; external seta longest (homologue to outer basal seta; as showed by arrow in Fig. 4E).

Genital field (Fig. 4B, C) located at mid-ventral side of anterior half of genital double-somite; furnished with denticles. Copulatory pores paired (arrowed in Fig. 4C), covered with a membrane and leading via copulatory duct to seminal receptacle. Gonopores closed off by P6 bearing smooth seta. Ventral surface clothed with spinule rows.

Description of allotype male. Habitus (Figs. 1–3B) as in female but genital double-somites separated. Total body length 1mm. Antenna, mouthparts, swimming legs and furcal rami as female, sexual dimorphism observed in antennule and abdomen.

Antennule (Fig. 10) five-segmented. First segment with two unipinnate and one smooth setae, with row of long spinules on dorsal surface. Second segment with 11 pinnate and eight smooth setae/spines and two aesthetascs. Third segment small with one plumose seta, one spinous spine and one smooth seta. Forth segment large and swollen, with eight pinnate setae, distal margin with modified element, covered with small pimples (arrowed in Fig. 10). Segment five with seven smooth setae.

TABLE 1. Features discriminating *Brianola* species.

	curvirostris	*elegans*	*exigua*	*hamondi*	*stebleri*	*sydneyensis*	*vangoethmi*	*haliensis*
Size (µm) f#	700	970	810	942	950	1430	1140	1100-1250
m#		800	810	637	750	1380	780	1000
Antennule: segmentationf#	5	5	5	4-5	5	4-5	4-5	4
m#	-	-	6-7	-	5	-	3	5
A2 endopod: segmentation	-	2	3	3	-	3	3	3
A2 exopod segmentation	7	6	6	6	6	6	7	8
Mandibular endopod: segmentation	2	2	1	1	-	1	2	2
Mandibular exopod: segmentation	1	1	2	2	-	2	2	1
P1 exp1-3 outer spines	finely pinnate	finely pinnate or smooth	finely pinnate	heavily pectinate	-	finely pinnate	heavily pectinate	heavily pectinate
P1 enp-3 inner seta	very long	very long	long	short	-	long	very short	very short
P1 exp-2 inner seta	1	1	0	1	1	1	1	0
P1 exp-3 number of seta	6	6	4	4	5	5	5	5
P1 enp-3 number of seta	6	6	6	6	4	6	5	6
P2 enp-1 inner seta	-	serrate	spinulate	Serrate	-	serrate	serrate	Spinulate
P4 enp-1 inner spine/seta	long pinnate spine	long smooth spine	long curved pinnate spine	very short stout spine	very short stout spine	slender spine	0	very short stout spine

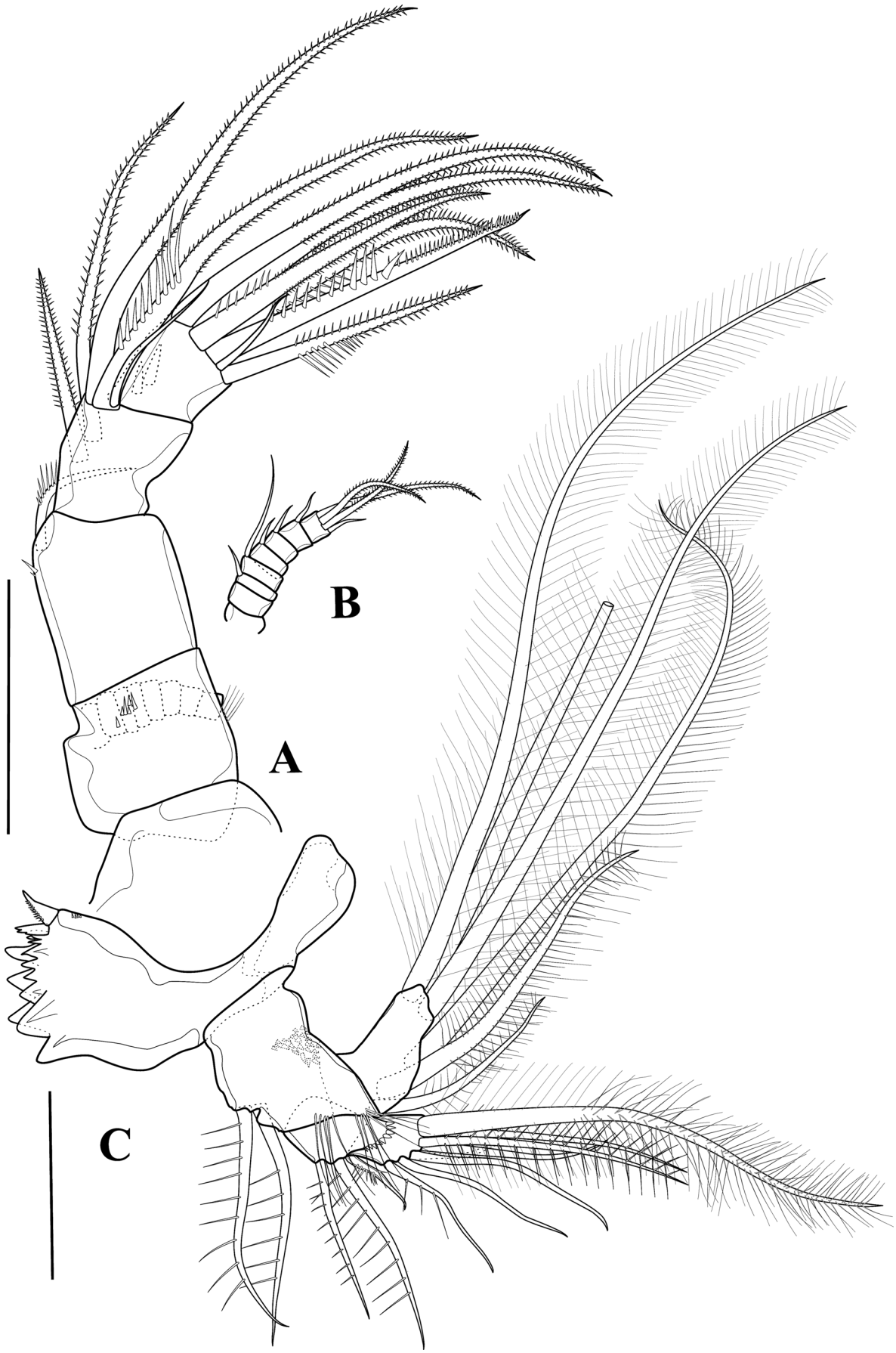

FIGURE 6. *Brianola haliensis* **sp. nov.,** female: (A) antenna; (B) antennary exopod; (C) mandible. Scale bars: 50μm.

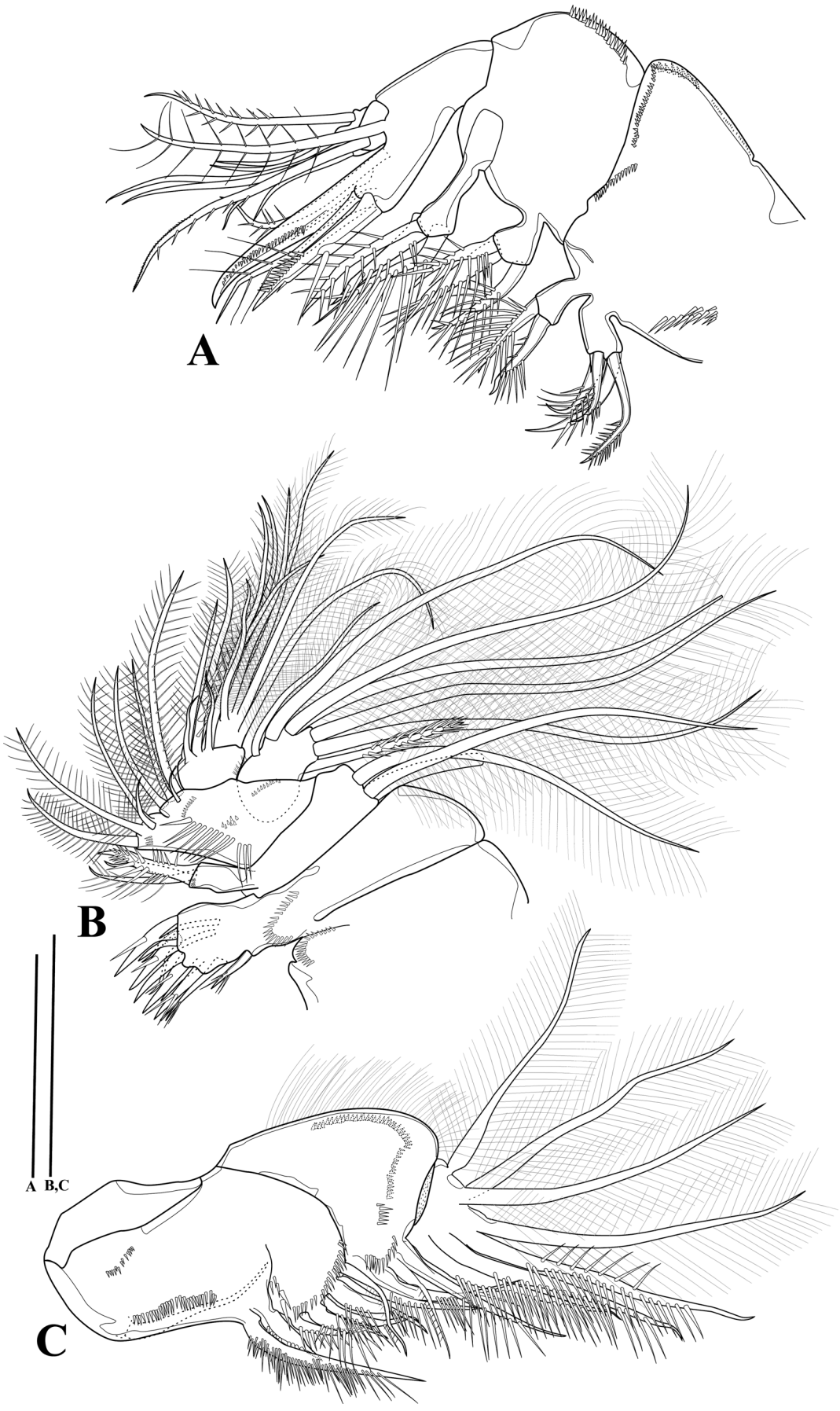

FIGURE 7. *Brianola haliensis* **sp. nov.,** female: (A) Maxilla; (B) Maxillule; (C) maxilliped. Scale bars: 50μm.

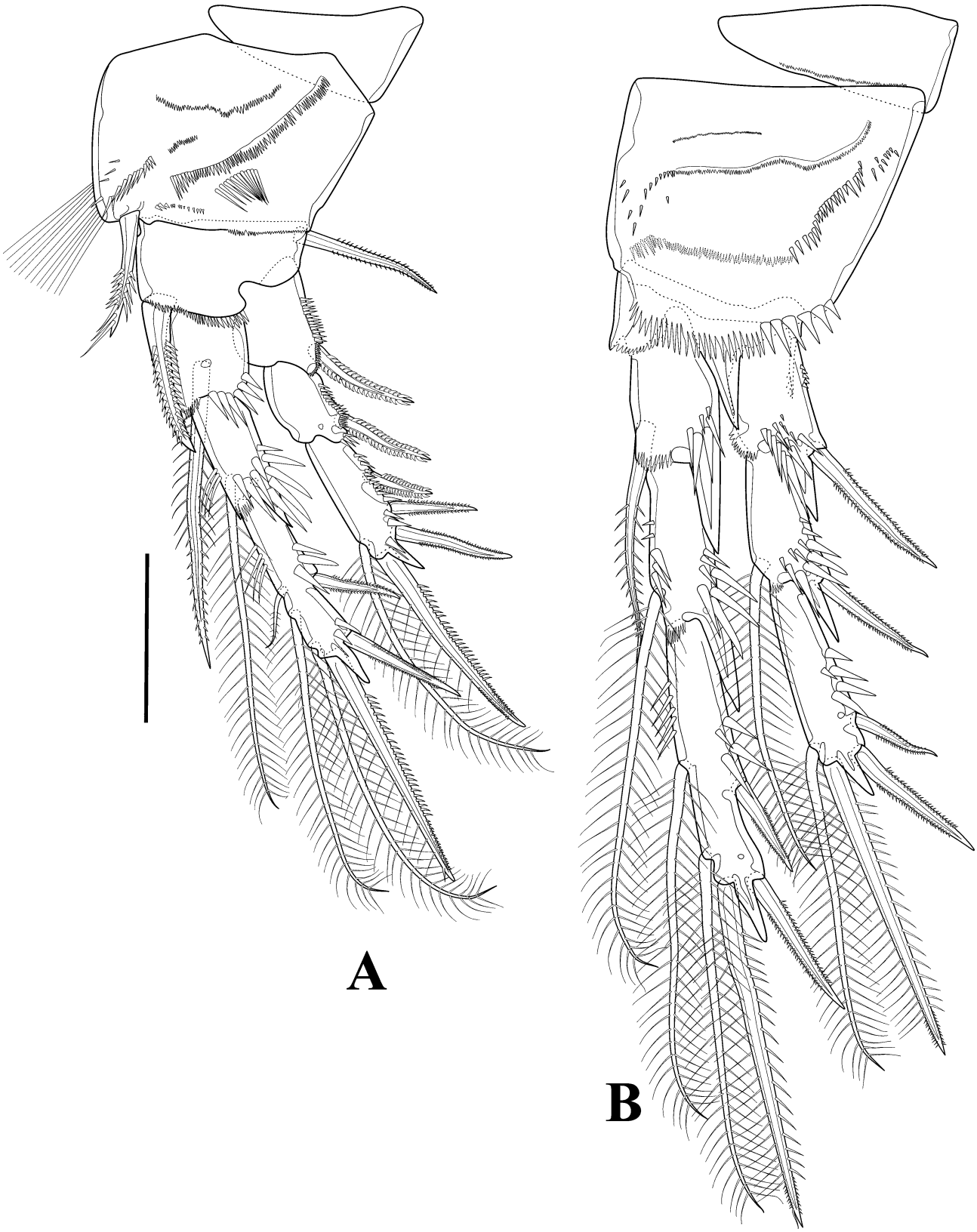

FIGURE 8. *Brianola haliensis* **sp. nov.,** female: (A) P1, anterior; (B) P2, anterior. Scale bar: 50μm.

Genital field and P6 (Fig. 11B) eye-shaped and symmetrical, with rows of stout spinules. Spermatophores paired. P6 seta bipinnate and strong.

Etymology. This species name *haliensis* makes reference to the type locality, "Northern Haleh".

Remarks. The genus *Brianola* Monard, 1926 was erected to accommodate a new species, *B. stebleri* (Monard

1926), which was found off the Étang des Eaux Blanches, France. Hamond (1973) revised the genus and prepared a key for five species. He concluded that *B. reichi* should have been removed from the genus despite including it in the key. Later, Por (1984) redefined the genus *Brianola* on the basis of combination of characters. He removed *B. pori* (currently *Coullana pori* (Hamond, 1973)) from the genus based on observed dissimilarities. Also, he suggested separating *Brianola* and *Canuellina* into different families. Huys *et al*. (1996) made a brief revision of the genus with undescribed species drawings. Also, Huys (2016) discussed and corrected some errors in relation to *Brianola* species, which were illustrated and described by former authors. Moreover, he prepared an updated key to the genus and mentioned seven species for *Brianola*. At present, *Brianola* contains eight species: *B. curvirostris* (Bozic, 1968), *B. elegans* (Hamond, 1973), *B. exigua* (Por, 1967), *B. hamondi* (Wells & Rao), 1987, *B. stebleri* (Monard, 1926), *B. sydneyensis* (Hamond, 1973), *B. vangoethmi* (Fires, 1982) and *B. haliensis* **sp. nov.** (present study).

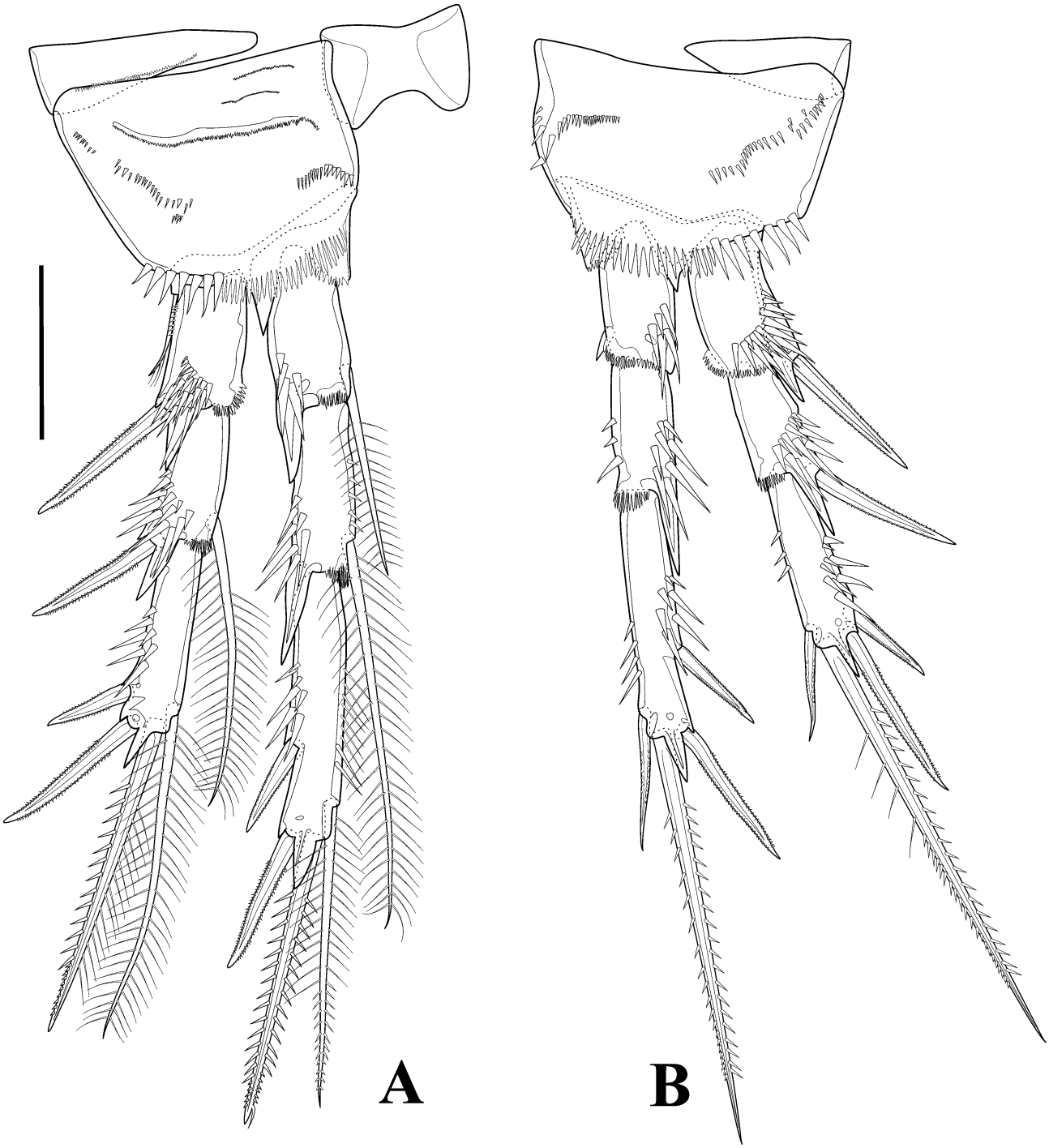

FIGURE 9. *Brianola haliensis* **sp. nov.,** female: (A) P3, anterior; (B) P4, anterior. Scale bar: 50µm.

FIGURE 10. *Brianola haliensis* **sp. nov.,** male: antennule (disarticulated, modified element arrowed). Scale bar: 50µm.

Brianola haliensis shows all the diagnostic characters of the genus: first pedigerous somite fused to the cephalosome; operculum ornaments; P1–P4 exp-3 with 5, 4, 4, 4 setae/spines respectively; P2–P4 enp-3 with 5, 4, 4, 4 setae/spines, respectively and swimming legs without sexual dimorphism. It can be easily discriminated from its congeners by four-segmented antennule in female, eight-segmented antennary exopod, P1 exp-2 without inner seta, very short inner seta on P1 exp-3 and short inner spine on P4 enp-1. These and the additional differences are summarized in Table 1.

In *B. haliensis*, P1 exp-2 is lacking an inner seta. The absence of this seta is reported for *B. exigua* by Por (1967). Hamond (1973) discussed that this absence might be due to the seta either having been broken off or to

genuine absence due to abnormality. In *B. haliensis,* both male and female, holotype and paratypes are without seta on P1 exp-2. It is clear that the absence of the seta cannot be an abnormality. Also, there is no scar to show that the seta has been broken off. Therefore, this absence is genuine and is considered as similar character between these two species. Moreover, several specimens of *B. haliensis* have been observed with aberrant swimming legs. The entire leg has been replaced by at most three large blunt spines. Such abnormality was reported by Fiers (1982) in *B. elegans* as well.

The eight-segmented antennary exopod, which was found in *B. haliensis*, was shown in *Brianola* sp. (Huys *et al*. 1996), but they never described the species based on this material. Wells (2007) considered it as species *inquirenda*. Therefore, this character can be seen as an autapomorphy for *B. haliensis.*

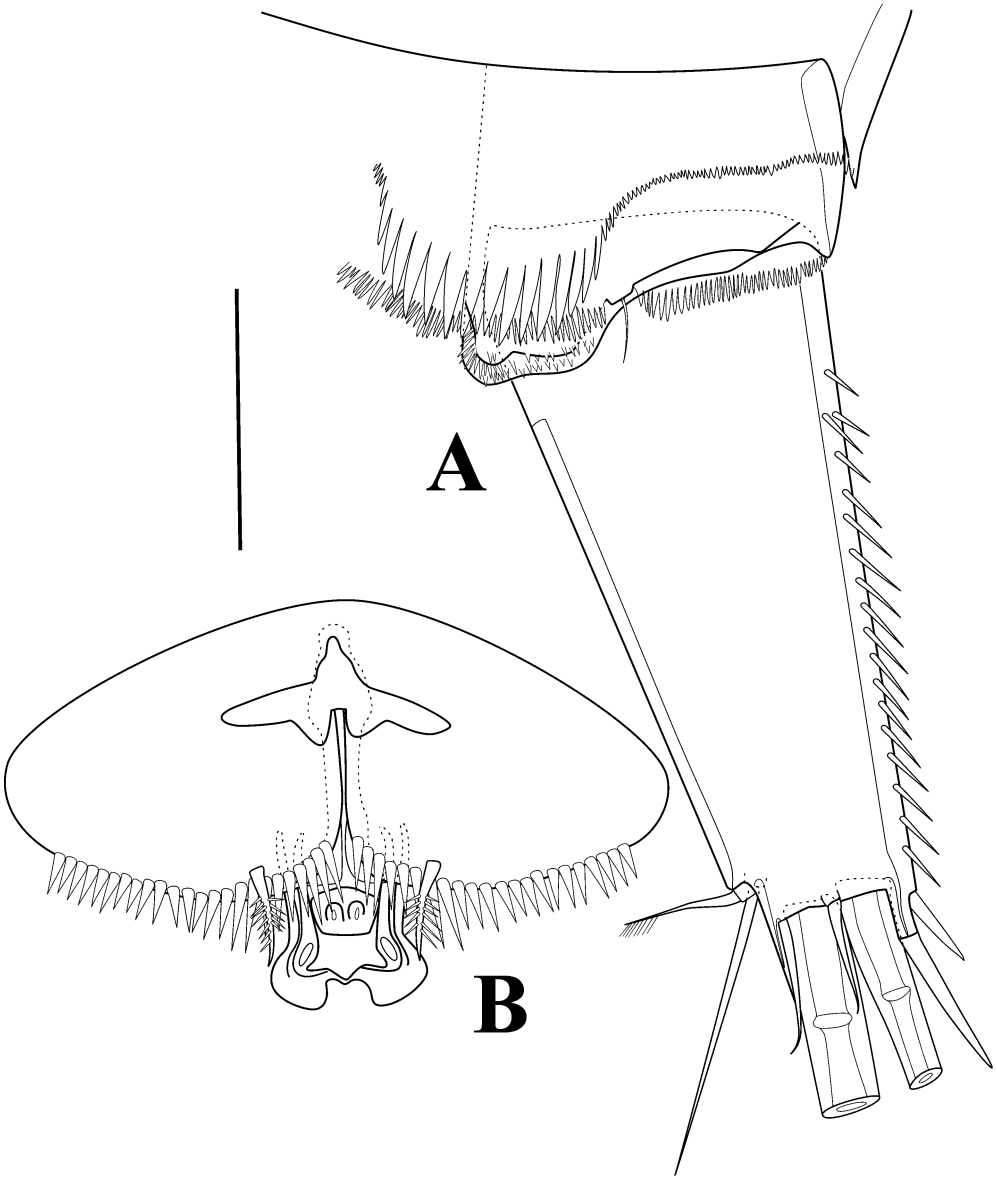

FIGURE 11. *Brianola haliensis* **sp. nov.,** male: (A) left half of anal somite and left furcal ramus; dorsal (B) genital field, ventral.

***Canuella persica* sp. nov.**
(Figs. 12–22)

Type locality. Intertidal zone at Genaveh, Iran, 29°35'0.50"N 50°30'0.14"E.

Type material. Holotype: ovigerous female, dissected on 16 slides (SMF37143/1-16) Paratypes: one male allotype (SMF37144/1-16) dissected on 16 slides, 5 females and 7 males preserved in alcohol (SMF37145/1).

Diagnosis. First pedigerous somite not fused to cephalosome, strong and coarsely pectinate seta on antennules, eight-segmented antennary exopod, three-segmented mandibular exopod, depression on furcal rami inner side, spine IV modified in female furcal rami.

Description of holotype female. Habitus (Figs. 12A, 13B, 14A). Total body length measured from rostrum tip to posterior margin of furcal rami 1.9 mm. Body robust, slightly tapering from fifth thoracic segment towards anal segment. Body covered with minute spinules and pimples in different size and shape. P1-bearing somite not fused to cephalosome. Cephalosome distinctly defined from first pedigerous somite. Genital double-somite fused, showing a discontinuous internal band laterally (Figs. 12A, 13B, 15A). Anal operculum weakly developed (Fig. 12A). Hyaline frills smooth (Fig. 15A).

Rostrum (Fig. 16A) elongate; bell-shaped; with two tiny lateral sensillae.

FIGURE 12. *Canuella persica* **sp. nov.,** habitus, dorsal (CLSM); (A) female; (B) male.

FIGURE 13. *Canuella persica* **sp. nov.,** habitus, lateral (CLSM); (A) male; (B) female.

Furcal rami (Fig. 15A, C; 19B) divergent; broad at base; sexually dimorphic; with very deep depression in inner side distally; with pore on ventral surface and seven setae. Seta I spiniform, multipinnate, located on outer margin; seta II bipinnate, bulbiform at base and positioned ventrally on inner margin; seta III naked, displaced on dorsal surface; seta IV very short, ungoiform, bifid and naked (arrowed in Fig. 15C); seta V very long, pinnate, approximately 5 times as long as seta VI, seta VI short and unipinnate; seta VII plumose, short and bi-articulate at base, implanted into inner margin depression.

Antennule (Fig. 16B–D) five–segmented. First segment largest, with row of spinules ventrally; with two bipinnate articulate setae and one unipinnate spinous seta. Second segment with one large bipinnate seta, one strong and coarsely pectinate seta and one pinnate seta. Segment three with 21 setae/spines (four strong and coarsely pectinate setae, as arrowed in Fig. 16 B) and two aesthetascs. Segment four short, with two spinulate setae and one smooth seta. Distal segment with one short plumose seta, nine spinulate setae and four smooth setae.

Antenna (Fig. 17A–B) comprising coxa-basis, endopod indistinctly three-segmented, eight-segmented exopod. Coxa-basis produced into pedestal supporting exopod; with fine setule on inner margin. First endopod segment

with one minute and one pinnate setae; second segment small, with four pinnate setae. Last segment with six pinnate and one tiny smooth setae. Exopod comprising of eight distinct segments; First segment bearing one pinnate seta; segments 2–7 each with one spinulate seta; distal segment with four spinulate setae.

Mandible (Fig. 17C) gnathobase with a row of six strong teeth and second row of smaller teeth underneath; one tripinnate spine on dorsal corner; ornamented with spinules around gnathobasal teeth and dorsal margin. Basis with two pinnate setae and two rows of small spinules on anterior and posterior face. Endopod two-segmented; first segment with three pinnate setae; second segment with six pinnate and two plumose setae. Exopod three-segmented; first segment with two, second segment with one and third segment with three plumose setae.

FIGURE 14. *Canuella persica* **sp. nov.,** habitus, ventral (CLSM); (A) female; (B) male.

Maxillule (Fig. 18A) praecoxal arthrite with 11 armed spines and two setae; with row of spinules on anterior and posterior surface. Coxal epipodite represented by two plumose setae; coxal endite cylindrical, with one spinulate spine and five pinnate setae. Basis with two closely situated endites, with three and four pinnate setae, respectively; rows of spinules on posterior surface. Exopod foliaceous; inner margin armed with four pinnate setae;

with six plumose setae around distal margin; row of small spinules on posterior surface and fine setules on inner margin. Endopod two-segmented; four pinnate setae on first segment; second segment with four pinnate and two plumose setae.

Maxilla (Fig. 18B) praecoxal endites ornamented with spinules at base; proximal endite with four pinnate and one short smooth setae; distal endite with two pinnate setae. Coxa with two cylindrical endites, with row of spinules around base of endites, each with three pinnate setae. Allobasis with pinnate claw and 6 elements (two strong pinnate spines and four pinnate setae). Endopod three-segmented, with 2, 4, 2 setae distally to proximally respectively.

Maxilliped (Fig. 18C) phyllopodial, three-segmented, comprising syncoxa, basis and one-segmented endopod. Inner margin of syncoxa with 10 setae/spines; with rows of spinules on surface. Basis with two pinnate setae, with spinule rows on surface, row of long setules and spinules on outer margin. Endopod with seven pinnate and four plumose setae.

All swimming legs with well-developed praecoxa, endopod and exopod three-segmened, anterior surface furnished with spinules.

P1 (Fig. 19A) coxa with very long heavily ornamented inner seta, extended beyond enp-2; row of spinules on anterior and posterior surface. Basis armed with strongly ornamented outer seta and strong bipinnate inner spine. Coxa and basis inner margin ornamented with long setules. Exp-1 largest segment; with long outer pinnate spine; outer margin clothed with rows of coarse spinules and inner margin with long setules. Exp-2 smallest segment; with long pinnate inner seta and pinnate outer spine. Exp-3 with four pinnate spines and three pinnate setae. Enp-1 with inner pinnate seta and row of long setules on outer margin. Enp-2 with internal pinnate seta and three rows of stout spinules on outer margin. Enp-3 with three pinnate spines and three pinnate setae; rows of strong spinules on outer margin.

P2 (Fig. 20A–B) coxa with special inner spine bearing apical flagellum (Fig. 20B). Basis with very stout spinule on inner margin dorsal surface, with long pinnate outer seta; pore at base of outer seta. Long setules on inner margin of coxa and basis. Exp-1 and -2 equal in size, shorter than third; outer distal corner forming a blunt projection; with pinnate outer spine; close to outer margin rows of spinules of different size. Inner margin of Exp-1 covered with row of long setules. Exp-2 with pinnate inner seta. Exp-3 elongate; with four spines and three setae; a pore near outer margin. Enp-1 with very long inner pinnate seta; anterior surface extended into a long and sharp process which lies over the second segment; patch of spinules ornamented anterior surface. Enp-2 with inner pinnate seta; distal corner produced into a blunt process; outer margin with stout spinules along mucroniform process. Enp-3 with three pinnate spines and two pinnate setae; with a pore at base of terminal spine.

P3 (Fig. 20C) coxa with small inner spine. Basis with external heavily ornamented seta; internal margin covered with long setules. First and second exopodal segments equal in size; with outer pinnate spine and rows of spinules near external margin; outer distal corner produced into a blunt process. Exp-2 with very long pinnate seta. Third segment the longest; with four pinnate spines and one pinnate seta. Enp-1 and -2 with inner pinnate setae; outer distal corner produced into a long and blunt process. Enp-1 with a spinular patch on anterior surface near distal corner Enp-3 with four pinnate spines.

P4 (Fig. 21A) coxa with short inner spine, ornamented with minute spinules. Basis with long spinulated outer seta. Exp-1 and -2 with outer spine and spinular patch on anterior surface. Exp-2 with short inner seta; outer distal corner forming spinous process. Exp-3 with four pinnate spines and one pinnate seta. Enp-1 with very long inner pinnate seta, extending over enp-3; outer distal corner extending into a blunt process; spinular rows on anterior surface, near outer margin. Enp-2 without inner seta; outer distal corner forming blunt process. Enp-3 with three pinnate spines and one pinnate seta.

Spine and seta formulae as follows:

	Exopod	Endopod
P1	0.1.2.2.3	1.1.2.2.2
P2	0.1.2.2.3	1.1.2.2.1
P3	0.1.2.2.1	1.1.1.2.1
P4	0.1.1.2.2	1.0.1.2.1

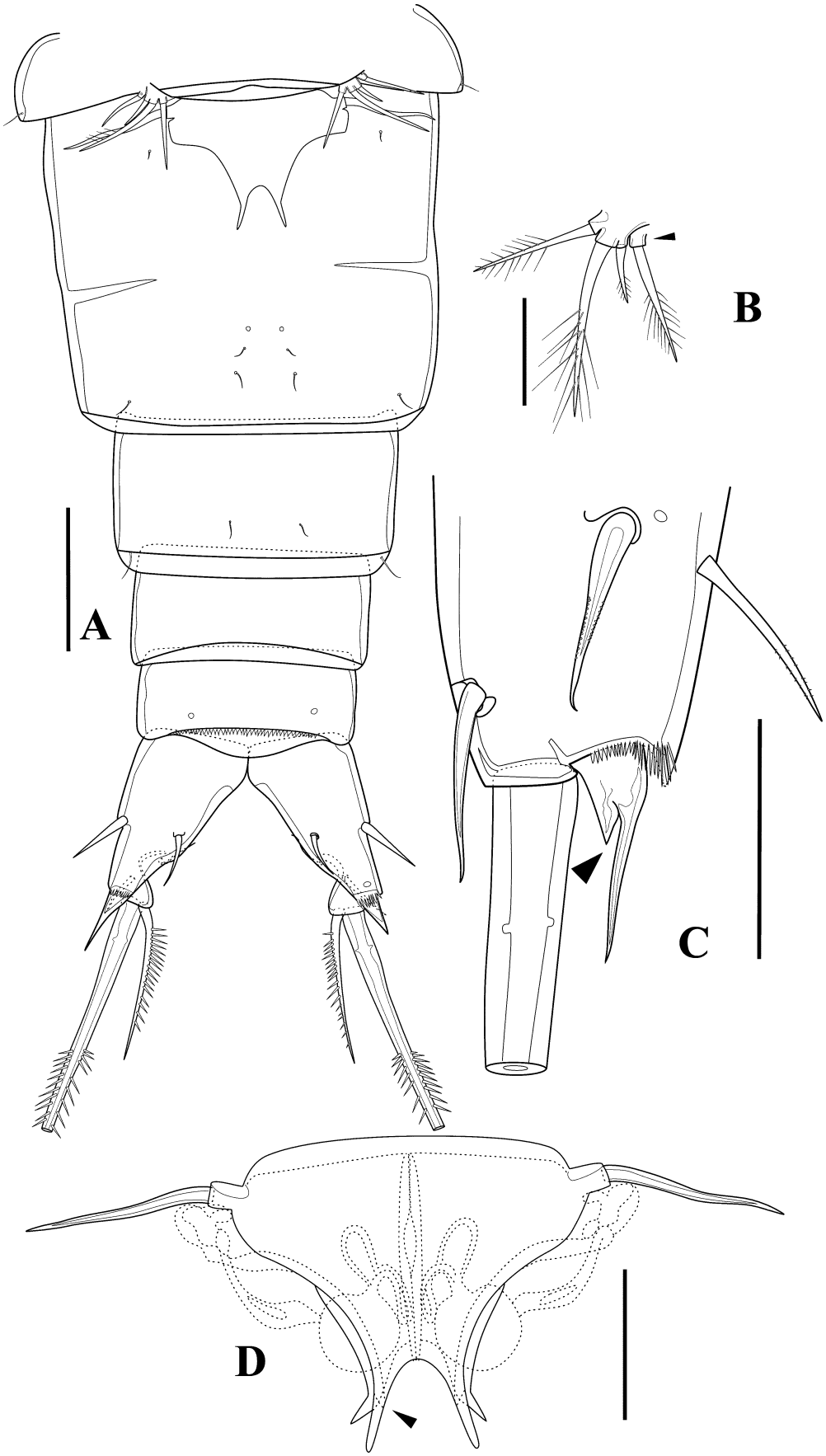

FIGURE 15. *Canuella persica* **sp. nov.,** female (A) urosome, ventral; (B) P5 (outer basal seta arrowed); (C) furcal ramus, lateral (bifid seta IV arrowed); (D) genital (copulatory pore arrowed). Scale bars: A: 100μm, B–D: 50μm.

FIGURE 16. *Canuella persica* **sp. nov.,** female: (A) rostrum, dorsal; (B–D) antennulary segments, dorsal. Scale bar: 50µm.

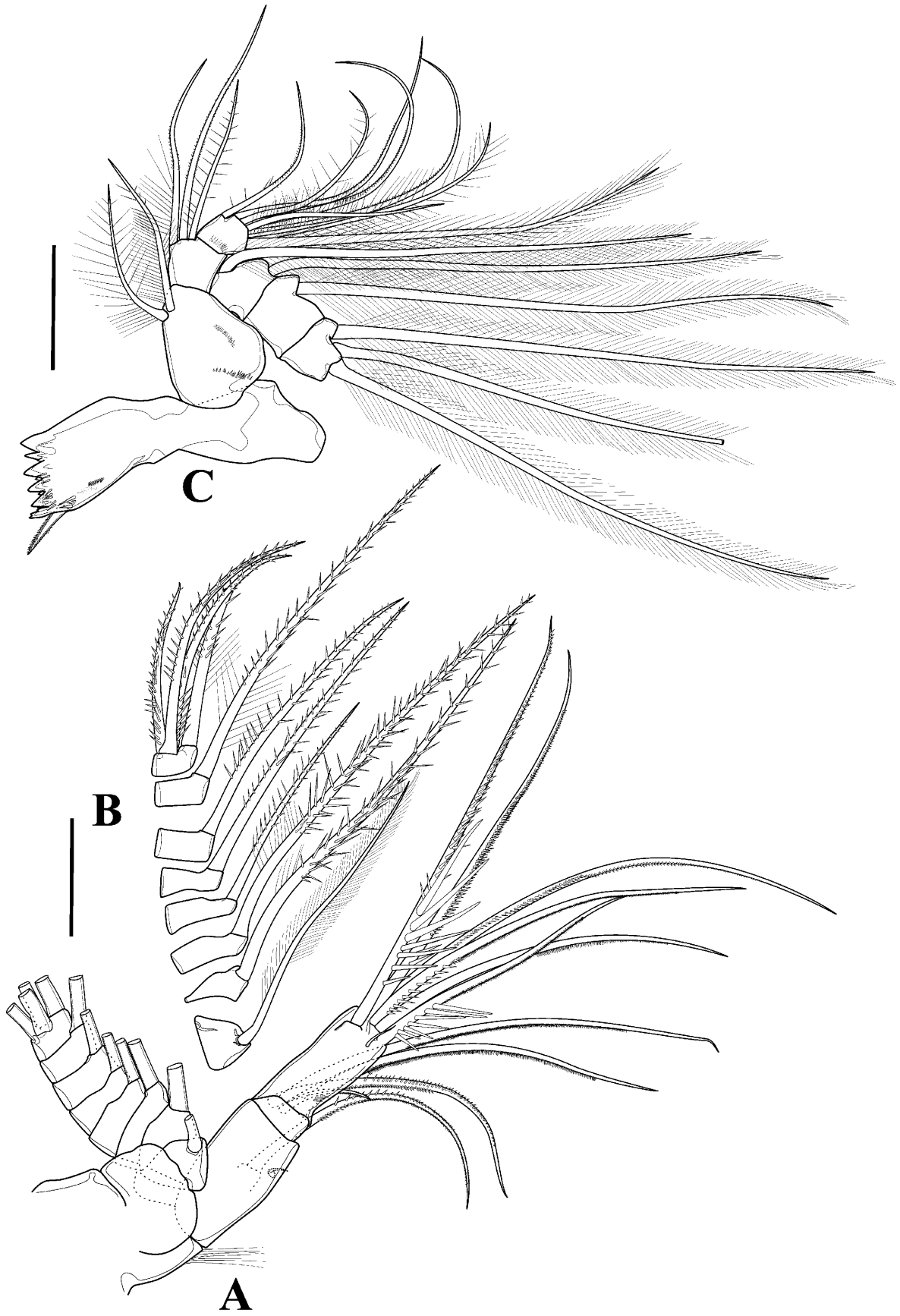

FIGURE 17. *Canuella persica.* **sp. nov.,** female: (A) antenna; (B) antennary exopod, disarticulated; (C) mandible. Scale bars: 50μm.

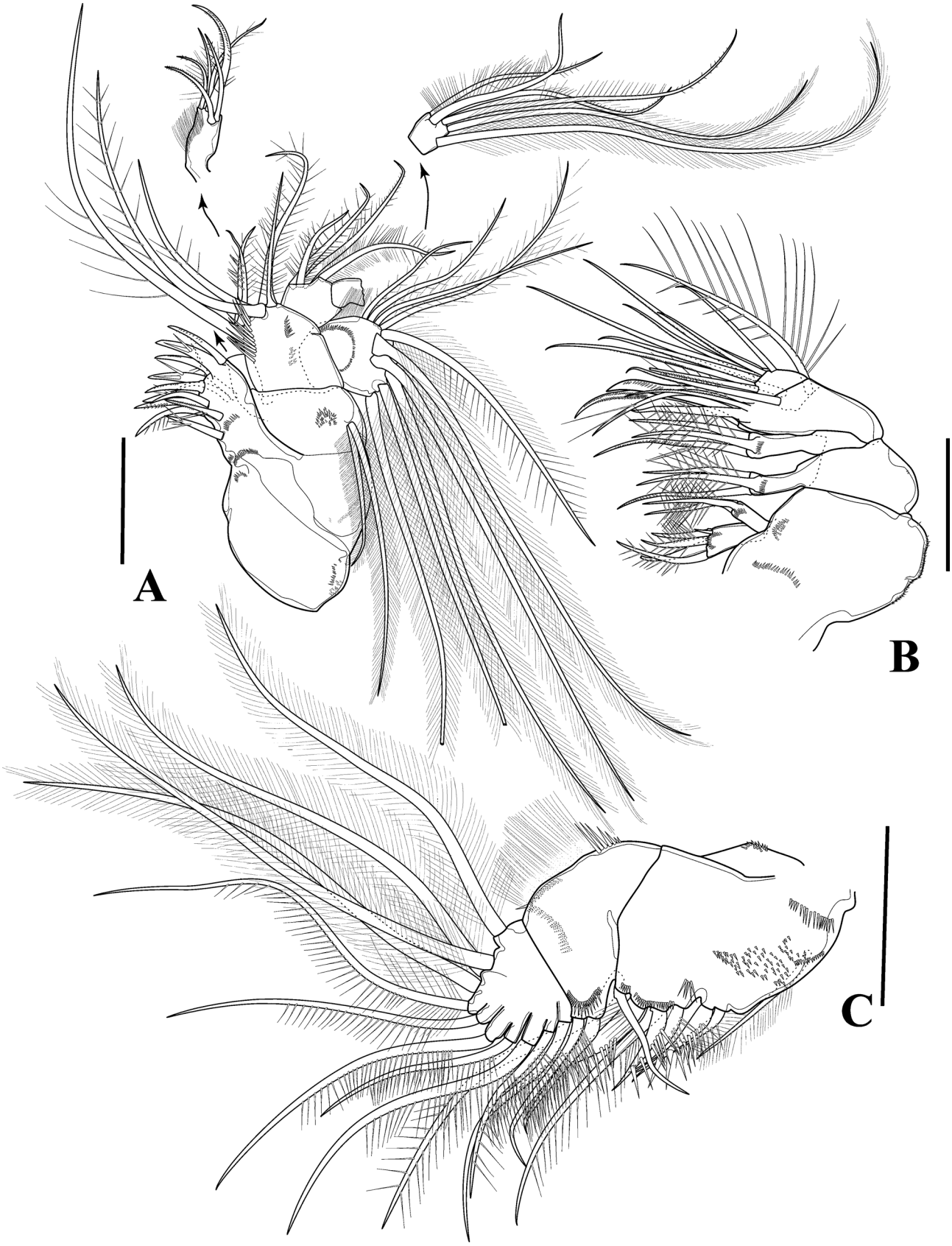

FIGURE 18. *Canuella persica* **sp. nov.,** female: (A) maxillule; (B) maxilla;(C) maxilliped. Scale bars: 50µm.

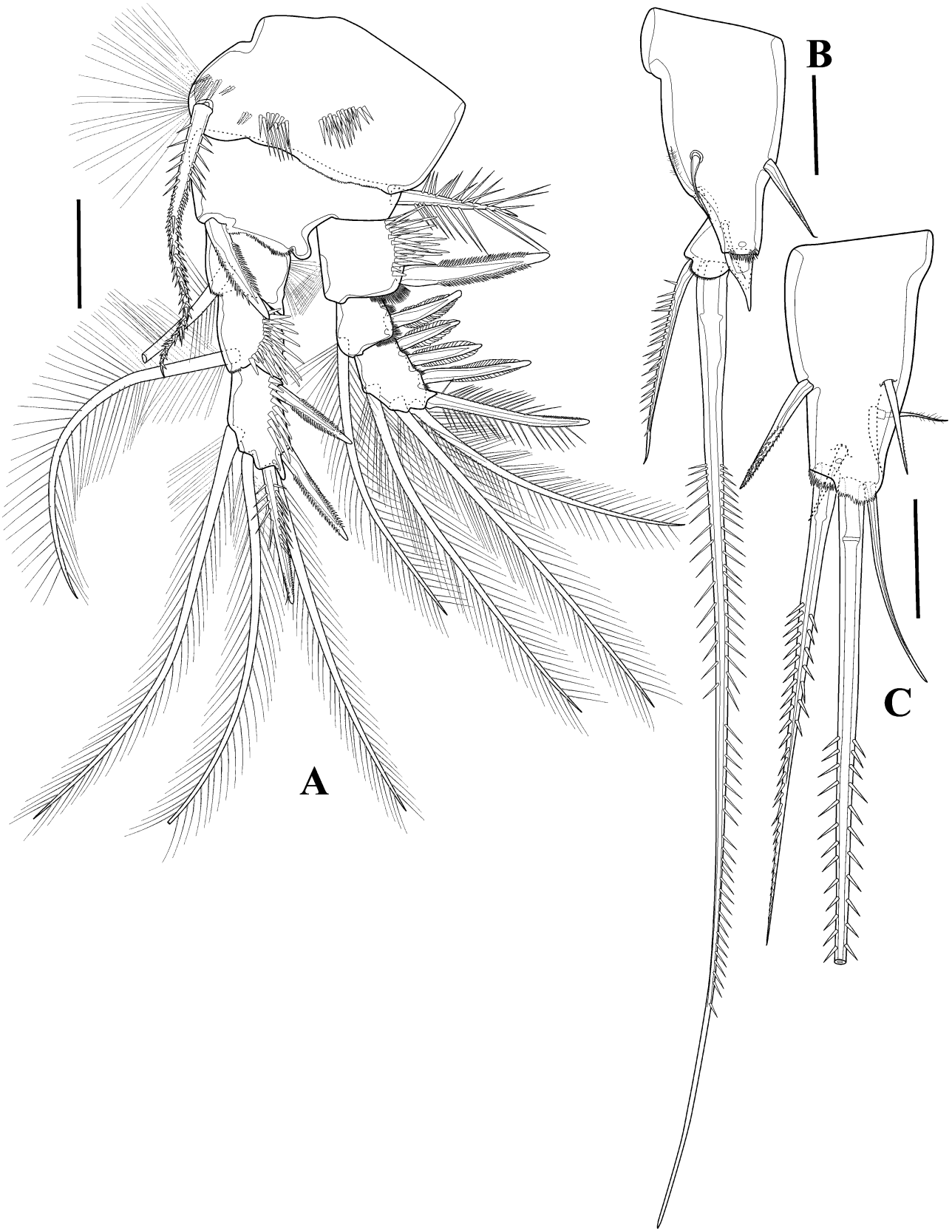

FIGURE 19. *Canuella persica* **sp. nov.,** female: (A) P1, anterior; (B) left furcal rami, ventral; (C) male: right furcal rami, ventral. Scale bars: 50μm.

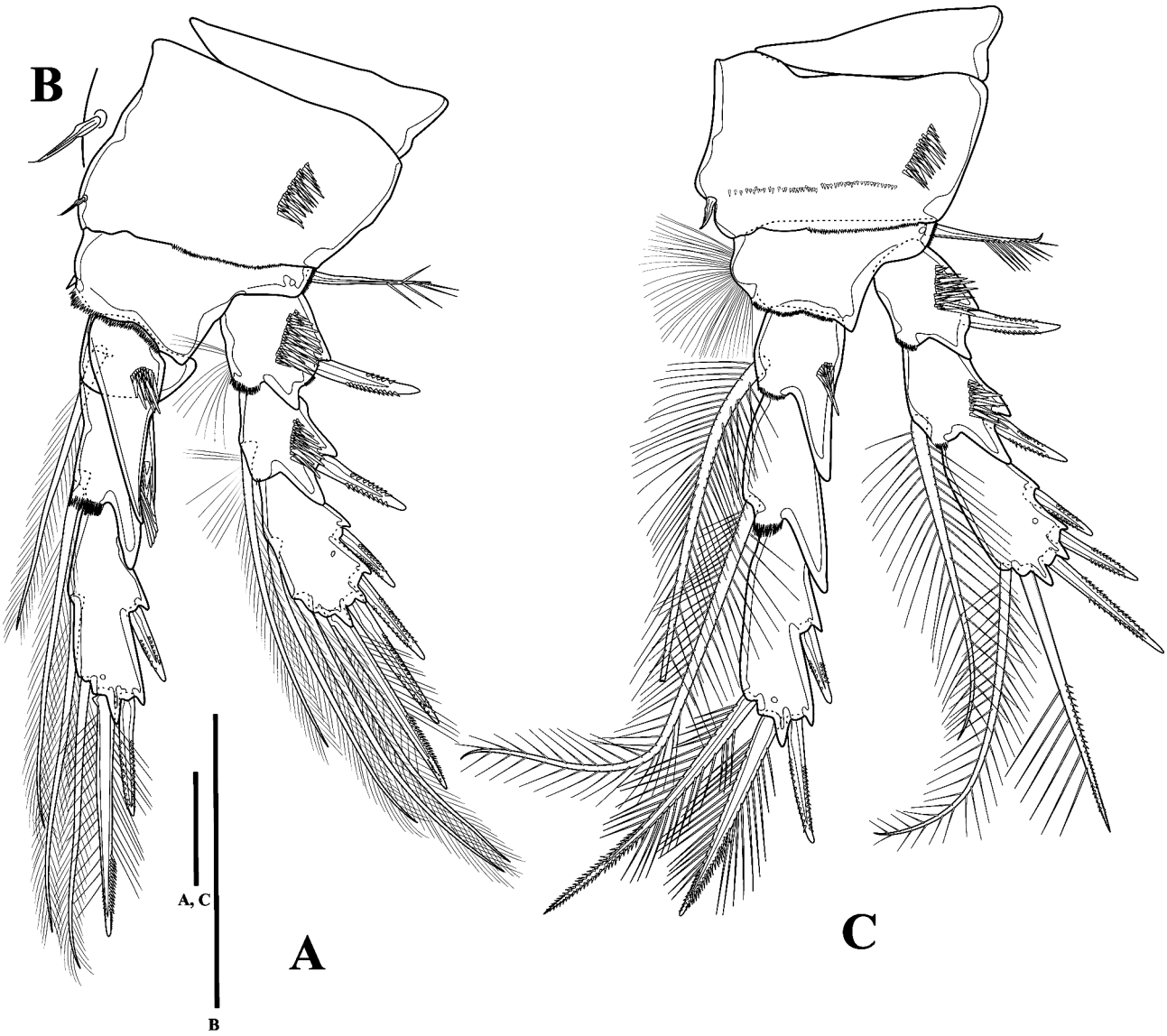

FIGURE 20. *Canuella persica* **sp. nov.,** female: (A) P2, anterior; (B) P2 coxa inner seta; (C) P3, anterior. Scale bars: 50μm.

P5 (Fig. 15B) represented by four pinnate setae; incorporated into somite; external seta (=homologue to outer basal seta; arrowed in Fig. 15B) somewhat separated from others.

Genital field (Fig. 15D) composed of a plate, situated in the mid-ventral side of anterior half of genital double-somite; with wing-like processes. Copulatory pores paired (arrowed in Fig. 15D), connecting to seminal receptacle via copulatory ducts. Gonopores closed off by P6 bearing one long smooth seta.

Description of allotype male. Habitus (Figs. 12B, 13A, 14B) as in female but slightly smaller and genital double somites separated. Total body length 1.05mm. Antenna, mouthparts, and swimming legs as female, sexual dimorphism in antennule, genital segment and furcal rami.

Antennule (Fig. 22) five-segmented, with geniculation between segments 4 and 5. First segment with three pinnate setae (two bi-articulate), with row of spinules in proximal part; segment 2 with 20 setae and two aesthetascs; segment 3 short, with three setae; segment 4 large and swollen, with heart shape element (arrowed in Fig. 22), with six pinnate and one smooth setae; last segment with two pinnate and five smooth setae.

Genital field and P6 (Fig. 21B) large, with two setae, proximal seta very long and barbed, distal seta articulated and pinnate. Inner margin of plate introduced into membranous flap. Distal margin with long extension. Mid-ventral spinulose ridge on third abdominal segment.

Furcal rami (Fig. 19C) as in female except seta IV not modified, pinnate and long; seta VI smooth; inner margin depression not as deep as female.

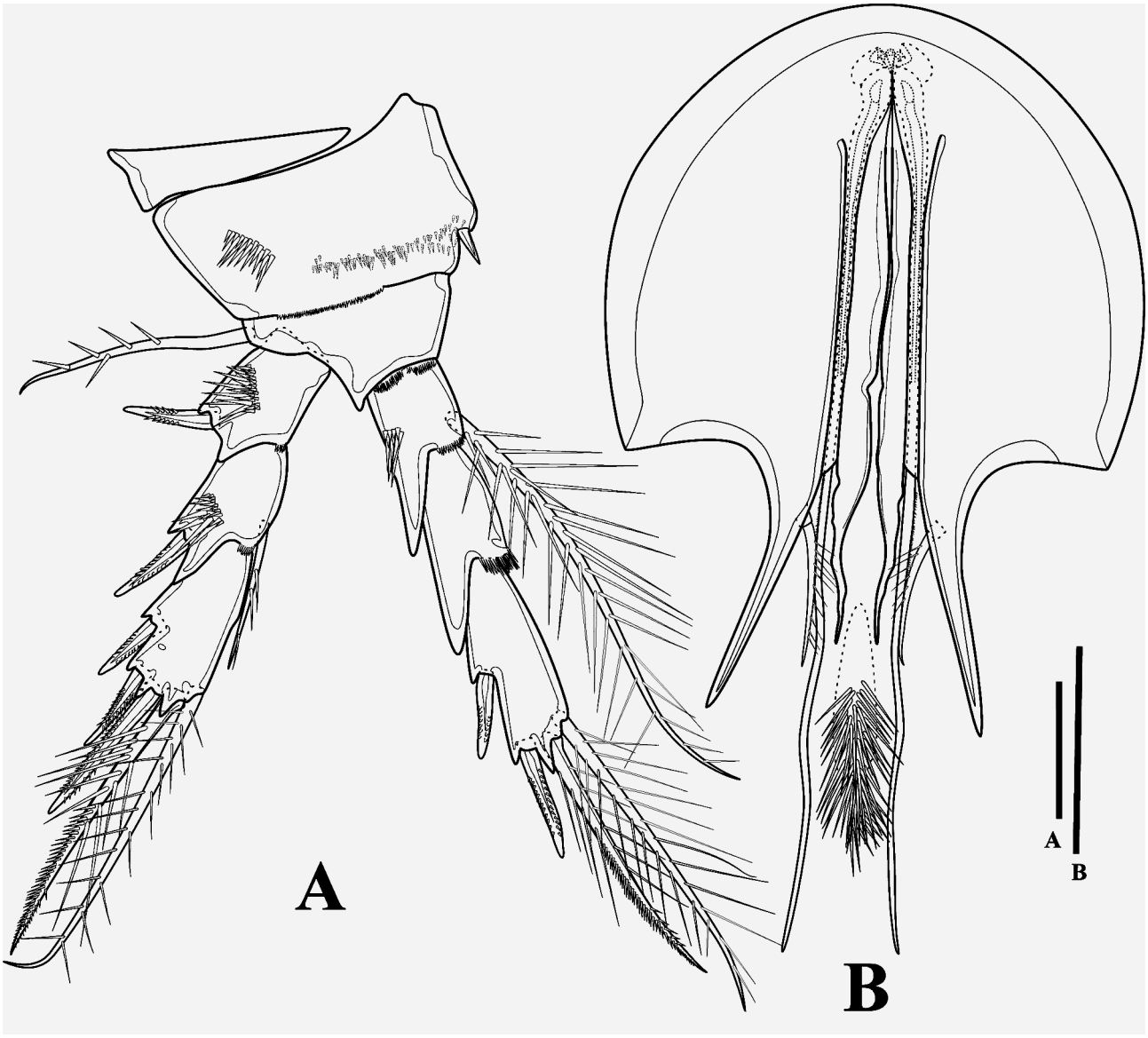

FIGURE 21. *Canuella persica* **sp. nov.,** female: (A) P4, anterior, (B) male: genital.

Etymology. This species is named after the Persian Gulf, in which it was found.

Remarks. The new species is placed in the genus *Canuella* T. Scott & A. Scott, 1893 because its first pedigerous somite is not fused to cephalosome, P4 exp-3 is with five armatures and P4 enp-2 is without inner seta (Huys *et al*. 1996).

The genus *Canuella* was established based on the five-segmented antennule, furcal rami length equal to last two abdominal segments and considerably divergent. Later, Sars (1903) added the complete separation of the somite bearing P1 as a new apomorphy. This character was drawn by T. & A. Scott (1893), but it was not described. Por (1984) diagnosed several apomorphies: (1) first pedigerous somite not attached to cephalosome, (2) eight-segmented antennary exopod, (3) P1-P4 exp-3 with 7, 7, 5, 5 and enp-3 with 6, 5, 4, 4, setae/spines, respectively, (4) swimming legs without sexual dimorphism and (5) male genital with long seta. At present, the genus contains five species (including the new one described here).

In the original description of *C. furcigera* (Sars 1903), species details were neither figured nor mentioned. He diagnosed that the length of furcal rami was the most important character which could separate this species from *C. perplexa*. Lang (1948) in his re-description of *C. furcigera* illustrated some details. Glatzel (1988) could distinguish *C. furcigera* from *C. perplexa* by comparative morphology of the genital field using SEM. In his opinion, these two closely related species only can be recognized based on furcal rami size and genital field shape. So, it's seven-segmented antennary exopod, as stated by Lang (1948), is congruent with Por's apomorphies. Based

FIGURE 22. *Canuella persica* **sp. nov.,** male: antennules (disarticulated; ribbed heart-shaped element on penultimate segment arrowed). Scale bars: 50μm.

on Lang (1948) description of *C. furcigera*, it is obvious that *C. persica* can be easily distinguished from the former by eight-segmented antennary exopod and three-segmented antennary endopod (seven and two segments, respectively, in *C. furcigera*); mandibular exopod three-segmented (instead of one segment); shape of furcal rami and furcal setae; shorter furcal rami; shape of male genital field.

Within the genus *Canuella*, *C. persica* appears to be most closely related to *C. perplexa* (T. Scott & A. Scott, 1893) but differs from the later in several characters. In *C. persica* and the other species which is described here as *S. gomezi*, there is a strong and heavily pectinated seta in antennules (arrowed in Fig. 16B), which prior to current study has not been described or figured in any *Canuella* species. However, due to the large size of the seta, it might not have been overlooked by former authors. Additional differences are found in the (1) Antennary enp-1 with two setae and enp-2 with four setae, (2) mandible exopod three-segmented, (3) mandible enp-2 with eight setae, (4) P2-P4 basis inner spine-like seta is very short, (5) deep depression on furcal rami inner margin, (6) furcal rami fourth armature is a strong and bifid spine-like seta, (7) furcal rami broader, (8) shape of genital field in male and female, (9) two setae in male genital field.

Por (1984) included *C. perplexa* and *C. furcigera* in the genus based on apomorphies. He mentioned that the status of *C. pontica* (Apostolove 1971) need to be checked. According to Apostolov's description, this species has seven-segmented antennary exopod and eight setae in P1 exp-3, while Por (1984) defined eight-segmented antennary exopod and seven setae in P1 exp-3. Unfortunately, the original description of *C. pontica* and the drawings are not informative about male and female genital field. Therefore, the position of this species has to be under question. Moreover, the status of seven segments in antennary exopod can be found in *C. furcigera* (based on Lang's (1948) description). Therefore, the genus *Canuella* needs to be revised.

***Scottolana gomezi* sp. nov.**
(Figs. 23–33)

Type locality. Intertidal zone at Bandar Abbas, Iran, 27°10'59.01"N, 56°19'10.19"E

Type Material. Holotype: ovigerous female, dissected on 16 slides (SMF37146/1-16). Paratypes: one male allotype dissected and mounted on 13 slides (SMF37147/1-13), 3 females and 3 males preserved in alcohol (SMF37148/1)

Diagnosis. First pedigerous somite not fused to cephalosome, eight-segmented antennary exopod, two post genital segments in female, modification of seta V in female furcal ramus.

Description of holotype female. Habitus (Figs. 23A, 24B, 25A). Total length, including rostrum and furcal rami, ranging from 1.19 to 1.25mm. Largest width at the posterior margin of the cephalosome. Body robust, slightly tapering from the fifth thoracic segment towards the anal segment, consisting of cephalosome, five pedigerous somites and three-segmented urosome. Urosome comprising of genital double-somite and two post-genital somites (Fig. 32A). Whole body covered with minute spinules and pimples of different size and shape. First thoracic segment bearing P1 separated from the cephalosome but covered by cephalic shield in dorsal view (Fig. 23). Genital double-somite fused, showing a discontinuous internal band laterally (Fig. 24B). Anal operculum weakly developed (Figs. 25, 32C). Hyaline frills smooth (Fig. 32A); intersomitic membranes well developed (Fig. 23–25).

Rostrum (Fig. 26D) large; articulating with the cephalosome, bell-shaped, tapering towards the apex; without sensilla.

Furcal rami (Figs. 32A, 32C, 34C) short; internal margin strongly curved; external margin with patch of strong spinules on distal corner; with two pores on ventral surface; bearing seven setae. Seta I positioned ventrally on outer margin near pore, spiniform, mutltipinnate, with suapical tubular extension; Seta II pinnate, located ventrally near inner margin; Seta III pinnate, implanted on dorsal surface, Seta IV well-developed and strongly pinnate, seta V small, with a swollen basis; Seta VI very short and smooth, fused at base to seta V; Seta VII located to inner margin, bi-articulate, short and plumose.

Antennule (Fig. 26A–C) three-segmented. First segment largest, with three incomplete sutures around posterior margin; proximal part with setule and spinule rows ventrally; with three strong and coarsely pectinate setae, 14 pinnate or spinulose setae/spines, 11 naked setae and two aesthetascs. Second segment short, with four pinnate setae. Last segment with two long plumose setae apically, a plumose seta posteriorly, five naked and six pinnate setae.

FIGURE 23. *Scottolana gomezi* **sp. nov**: habitus, dorsal; (A) female; (B) male.

Antenna (Fig. 27) coxa-basis produced into pedestal supporting exopod; with setular patch on anterior face. Endopod two-segmented; with two setae on proximal segment, one minute and smooth and the other long and pinnate; distal segment with four lateral and seven apical setae, six of them pinnate and one short and smooth. Exopod with eight distinct segments; segments 1–3 and 7 each with one plumose seta; segments 4, 5 and 6 with pinnate seta; terminal segment with one plumose and three pinnate setae.

Mandible (Fig. 28A) gnathobase with a row of six strong teeth on second row of smaller teeth; with one tripinnate spine on dorsal corner; with spinules furnished around gnathobasal teeth and dorsal margin. Basis with two pinnate setae and row of small spinules dorsally. Endopod two-segmented; first segment with three pinnate setae; second segment with six pinnate and two plumose setae. Exopod indistinctly four-segmented indicating ancestral four-segmented condition; with a total of six plumose setae as figured.

Maxillule (Fig. 29A) praecoxa and coxa slightly fused. Praecoxal arthrite armed with nine distal spines and two setae and two surface setae; with row of spinules on posterior surface. Coxa with epipodite represented by two plumose setae; endite cylindrical, with five pinnate setae. Basis with two closely situated endites, each with four

pinnate setae; row of spinules on posterior surface. Exopod foliaceous; with two smooth and three pinnate setae on inner margin, six plumose setae around distal margin and one small pinnate seta on outer margin; row of fine setules on inner margin. Endopod two-segmented; enp-1 with five pinnate setae laterally; enp-2 with four pinnate and two plumose setae.

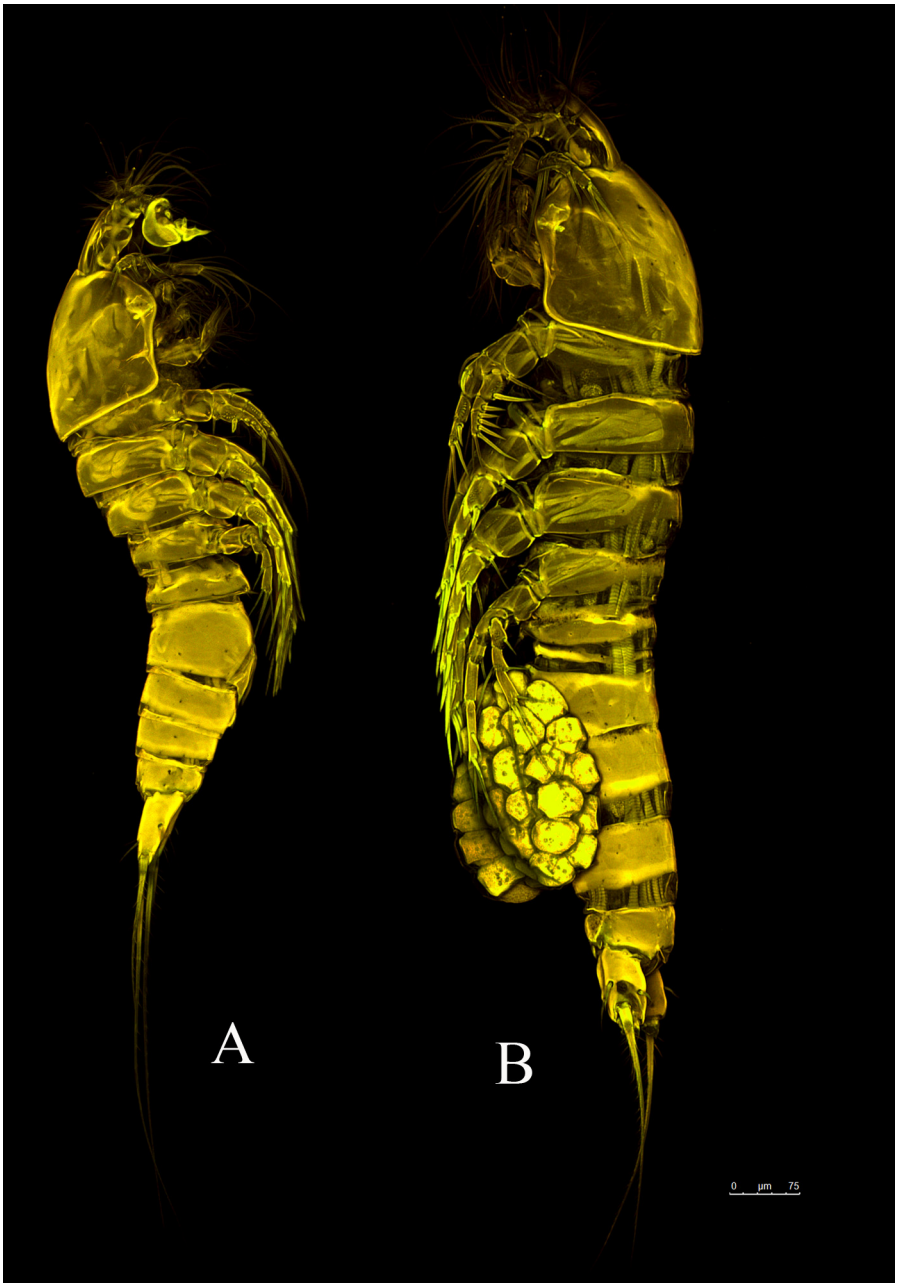

FIGURE 24. *Scottolana gomezi* **sp. nov.:** habitus, lateral; (A) male; (B) female.

Maxilla (Fig. 28B) of the primitive structure typical of the family. Comprising praecoxa, coxa, allobasis and three-segmented endopod. Praecoxa with rows of spinules; proximal endite with five (four pinnate, one smooth), distal with two pinnate setae. Coxa with two cylindrical endites, each with three pinnate setae. Allobasis produced into endite, bearing fused pinnate claw, two strong pinnate spines and four pinnate setae. Endopod three-segmented, enp-1 and 2 each with three setae, and enp-3 with two setae.

Maxilliped (Fig. 29B) phyllopodial, two-segmented; incomplete sutures indicating boundary between praecoxa, coxa and basis. Inner margin of first segment with 13 setae/spines; with rows of small spinules on surface and row of long setules on outer margin. Endopod with six pinnate and four plumose setae.

Swimming legs with well–developed praecoxa, three–segmented rami; surface more or less completely covered with minute spinules and pimples.

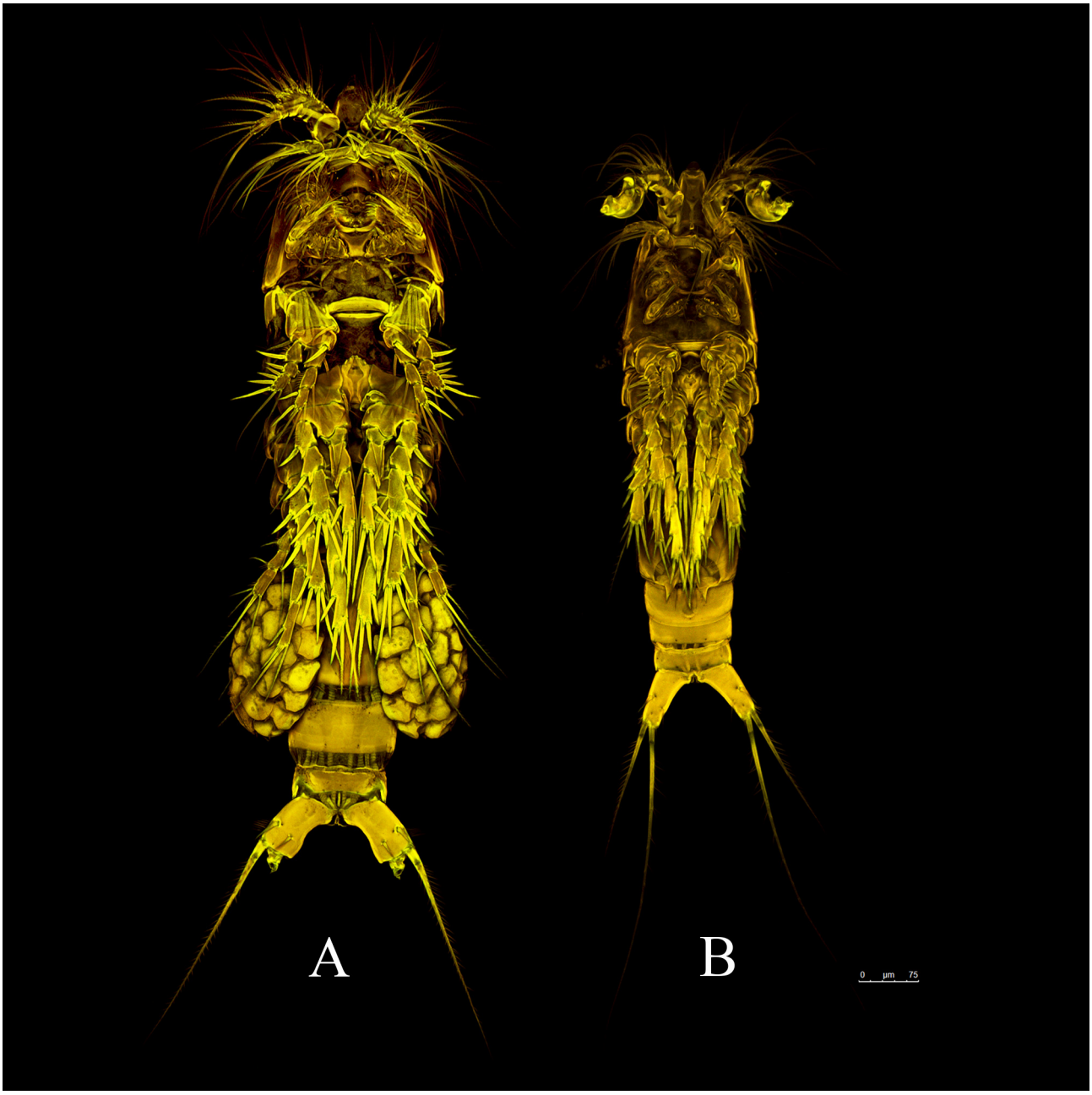

FIGURE 25. *Scottolana gomezi* **sp. nov.:** habitus, ventral; (A) female; (B) male.

P1 (Fig. 30A) smallest swimming leg. Coxa with well-developed inner pinnate seta and row of spinules on anterior and posterior surface. Basis with long, strongly ornamented outer seta and stout bipinnate inner spine. Both coxa and basis with long setules on inner margin. First exopodal segment with bipinnate outer spine, outer margin ornamented with coarse spinules; second segment outer spine bipinnate, inner seta plumose reclined under rami; third segment with three pinnate spines along outer margin, one bipinnate and two plumose setae along inner margin and one apical spine ornamented with combination of setules and spinules. Enp-1 with a plumose inner seta inserting proximally; second segment with rows of coarse spinules along outer margin and one inner plumose seta; third segment with strong spinules along outer margin, two bipinnate spines in outer margin, two bipinnate setae bearing combination of setules and spinules, one plumose seta along inner margin and one short spine with subterminal tubular extension at apex.

P2 (Fig. 30B) coxa with inner pinnate seta; sharp teeth on inner distal corner; row of spinules on anterior face. Basis bearing one external bipinnate seta; posterior surface with re-curved process, row of spinules and a pore near

outer distal corner. Exp-1 with pinnate outer spine and strong spinular patch at its base, outer distal corner of exp-1 and -2 forming spinuous process; exp-2 with dentate outer spine and bipinnate inner seta reclined under rami; exp-3 with four spines and three setae. First endopodal segment with inner pinnate seta; anterior surface extended into a long mucroniform process which lies over the second segment and fits into a spinule groove on outer spinous process; second segment with inner pinnate seta; third segment with three spines and two setae, anterior surface with a pore near inner distal setae.

P3 (Fig. 31A) coxa rectangular; with internal pinnate seta; external margin with row of spinules; sharp teeth on inner margin. Basis bearing pinnate outer seta; with a pore at base of seta, posterior surface with re-curved process. First and second segment of exopod with spinular patch at base of outer spine; outer distal corner forming spinous process; first segment with pinnate outer spine; second segment with dentate outer spine, also with inner pinnate seta; third segment bearing three dentate spines, one pinnate spine and one pinnate seta. Endopod longer than exopod; first segment with developed inner seta ornamented with minute spinoules and outer distal corner extend into a process furnished with strong and long spinules; second segment bearing pinnate inner seta and an extension on outer distal corner with strong spinules; third segment with four spines and a pore on anterior surface.

P4 (Fig. 31B) coxa bearing short pinnate inner spine and row of spinules on outer margin. Basis elongate, displacing exopod to marginal position; with long pinnate outer seta; anterior surface with small pore, with re-curved process on posterior surface. First and second exopodal segment bearing pinnate outer spine accompanied by strong spinular patch at base, outer spine in exp-2 much longer and slender; second segment also with very long inner pinnate seta; third segment with three pinnate setae and one slender spine, strong spinular patch and a pore on anterior face. Endopod much longer than exopod; strong spinules around inner distal margin of first and second segment; first segment with very long pinnate inner seta; second segment unarmed; third segment bearing two dentate spines and two pinnate setae, with pore on anterior face.

P1–P4 setal formulae as follows:

	Exopod	Endopod
P1	0.1.3.1.3	1.1.2.2.2
P2	0.1.3.2.2	1.12.2.1
P3	0.1.1.2.2	1.1.1.2.1
P4	0.1.1.2.1	1.0.1.2.1

P5 (Fig. 32B) reduced to four plumose setae incorporated into somite; external seta separated from the others (homologue of basal seta, arrowed in Fig. 32B); third seta ornamented with very long setules.

Genital field (Fig. 32A, D) reduced, situated in the mid-ventral side of anterior half of the genital double-somite; with small wing-like processes. Copulatory pores paired (arrowed in Fig. 32D) leading via copulatory duct to two sleepers' shoes-like seminal receptacle. Gonopores closed off by P6 bearing one long smooth seta.

Description of allotype male. Habitus (Figs. 23B, 24A, 25B) as in female but smaller and genital double somites separated. Total body length 0.86mm. Antenna, mouthparts and swimming legs as female, sexual dimorphism in antennule, P5, abdomen, genital segment and furcal rami.

Antennule (Fig. 33) four-segmented. Segment I largest, with spinule row in proximal part; with sutures indicating ancestral segmentation; with 23 setae (seven bi-articulate at base) and two aesthetascs. Second segment short, with two pinnate setae and one bi-articulate plumose seta. Third segment swollen; with modified element (arrow in Fig. 33A, D) on inner side; with three smooth and five pinnate setae. Ultimate segment arrow shape and small; bearing one pinnate and three smooth setae.

Urosome (Fig. 34A) consisting of P5-bearing somite, genital somite and three post genital somite. Genital somite largest. Genital apertures closed off by modified P6 (Fig. 34A, B). P6 fused to genital somite, original demarcation marked by membranous zone; produced into triangular extension; with two setae, one long naked seta at apex, one short naked seta in distal part. Mid-ventral spinulose ridge on first postgenital segment.

Furcal rami (Fig. 34A) as in female except internal and external margin almost straight; setae II and VII much closer to inner margin; seta V not modified, longest and pinnate.

Etymology. The species is named in honor of Professor Samuel Gómez, in recognition of his excellent contributions to systematics of harpacticoid copepods.

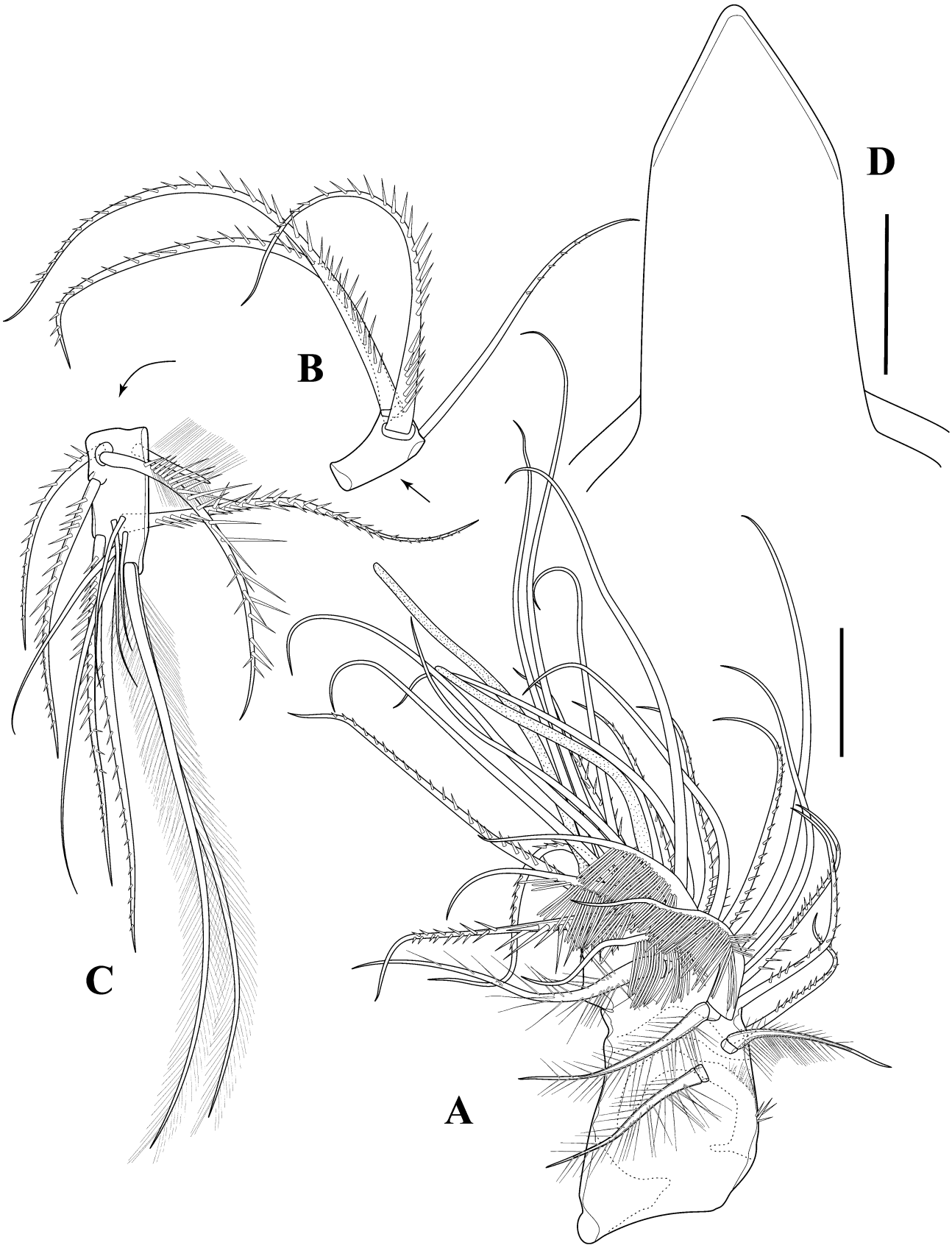

FIGURE 26. *Scottolana gomezi* **sp. nov.,** female: (A–C) antennule (disarticulated), (D) rostrum, dorsal. Scale bars: 50µm.

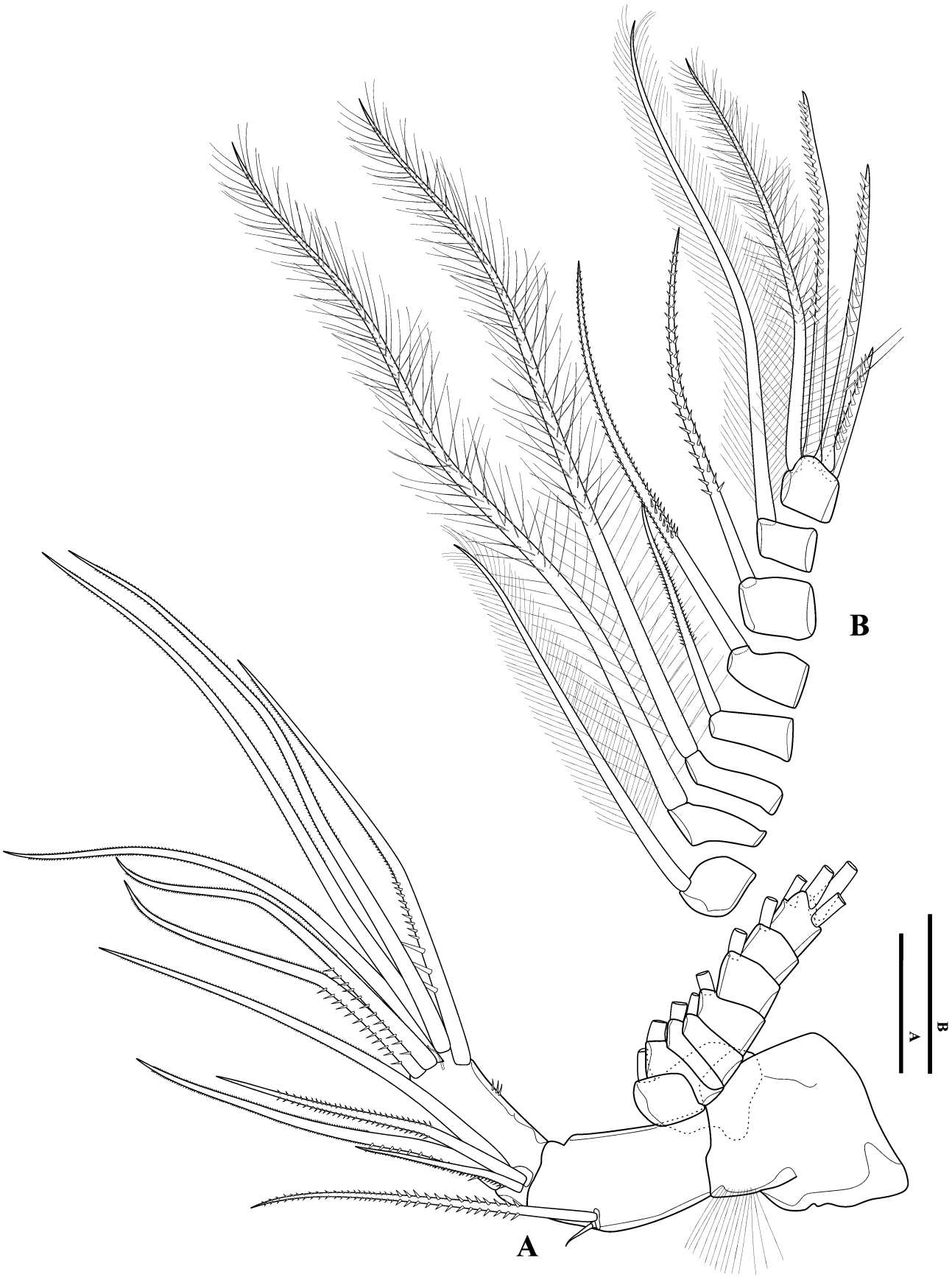

FIGURE 27. *Scottolana gomezi* **sp. nov.,** female: (A) antenna; (B) antennary exopod (disarticulated). Scale bars: 50µm.

FIGURE 28. *Scottolana gomezi* **sp. nov.,** female: (A) mandible; (B) maxilla. Scale bars: 50μm.

FIGURE 29. *Scottolana gomezi* **sp. nov.,** female: (A) maxillule (armature of coxal endit shown in insert); (B) maxilliped. Scale bars: 50μm.

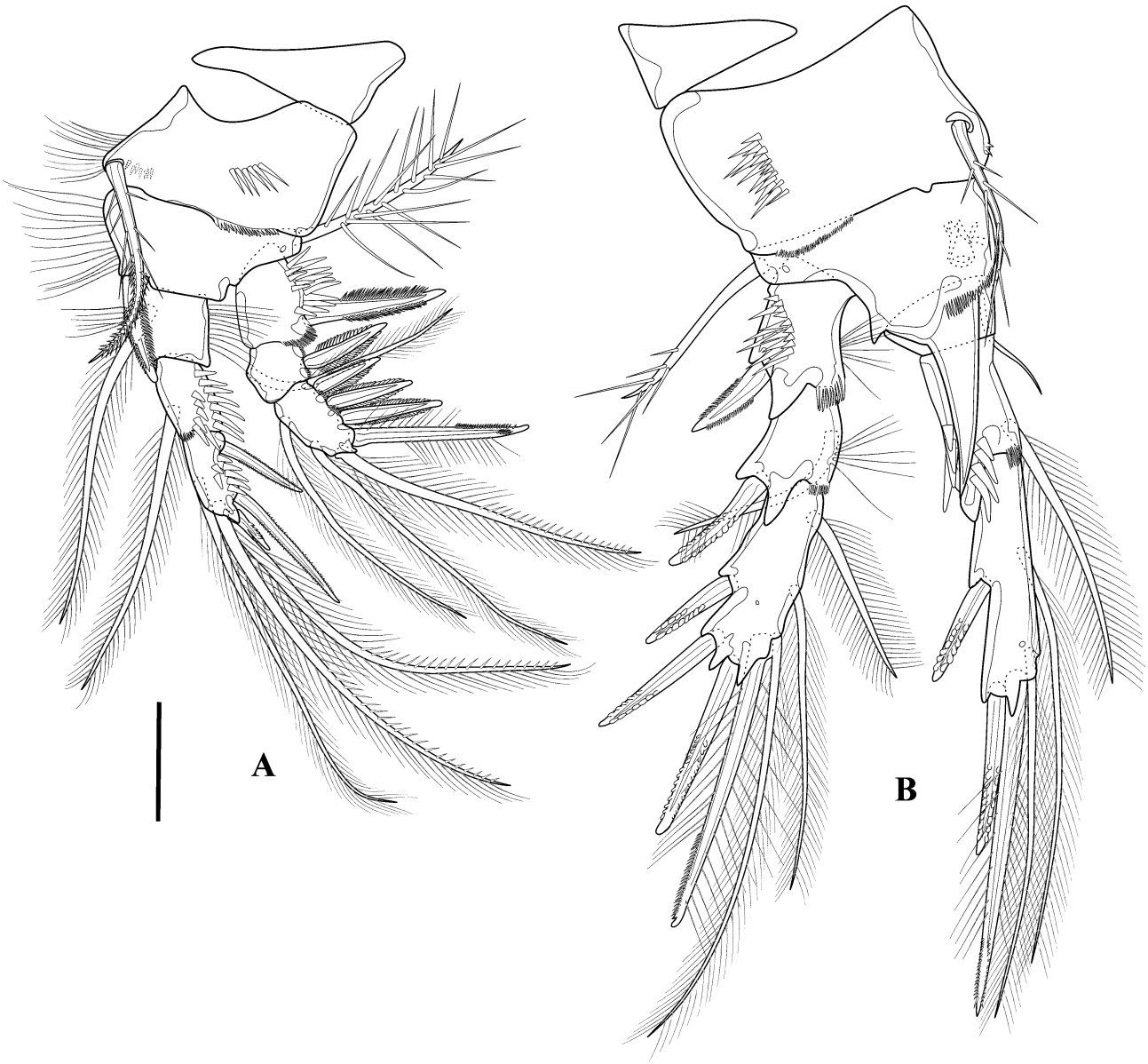

FIGURE 30. *Scottolana gomezi* **sp. nov.,** female: (A) P1, anterior; (B) P2, anterior. Scale bar: 50μm.

Remarks. *Scottolana gomezi* **sp. nov.** is placed in the genus *Scottolana* based on the following synapomorphies: (1) P1–P4 exp-3 with 7,7,5,4/ enp-3 6,5,4,4 setae/spines, respectively; (2) eight-segmented antennary exopod; (3) somite bearing P1 not fused to cephalosome; (4) sexual dimorphism of the furcal rami inner seta; (5) morphology of P4; and (6) male genital field morphology (Por, 1984).

Mu & Huys (2004) recognized different evolutionary lineages within the genus *Scottolana*. They defined the *longipes*-group according to the following apomorphies: (1) two postgenital segments in female urosome and three segments in male; (2) P4 displaced outwardly in both sexes, secondary elongation of endopod and elongation of exp-2 outer spine and enp-1 inner seta (Fig. 31B); (P3) modified tube-pore along inner margin of P3 enp-3 in male; (4) re-curved spinous process on posterior surface of P2–P4 basis; (5) hook-like extension along anterior inner margin of furcal rami and spinular patch near distal outer corner; (6) sexual dimorphism in furcal ramus including modification of seta II in female. It is clear that *S. gomezi* belongs to the *longipes*-group, although some apomorphies are not attributable to this species.

S. gomezi is closely allied to *S. gee* within the *longipes*-group, but differs from the later in (1) shape of rostrum (triangular and without setule); (2) eight-segmented antennary exopod (instead of nine-segmented); (3) armature of maxillule basis and exopod; (4) P1–P4 endopod and exopod shorter; (5) P1 and P2 exp-2 inner seta reclined under rami; (6) P2 enp-1 inner seta shorter and slender; (7) P3 coxa inner seta shorter and enp-1 inner seta stronger and

spinulated, in male without modified tube-pore along exp-3 inner margin; (8) P4 coxa inner spine too short, basis outer seta smaller and thinner; (9) genital field in female and male reduced (10) furcal rami without hook-like extension along anterior inner margin; (11) furcal rami seta II on anterior face without sexual dimorphism; (12) sexual dimorphism in seta V in furcal rami that in female modified to a bulbous process.

Furcal rami seta V morphology, position and shape of seta II, and also the absence of modified tube-pore on male P3 in *S. gomezi* is remarkable since two latter characters are synapomorphies for the *longipes*-group (Mu & Huys 2004). Therefore, by adding this new species to the group, apomorphies should be revised for phylogenetic analysis.

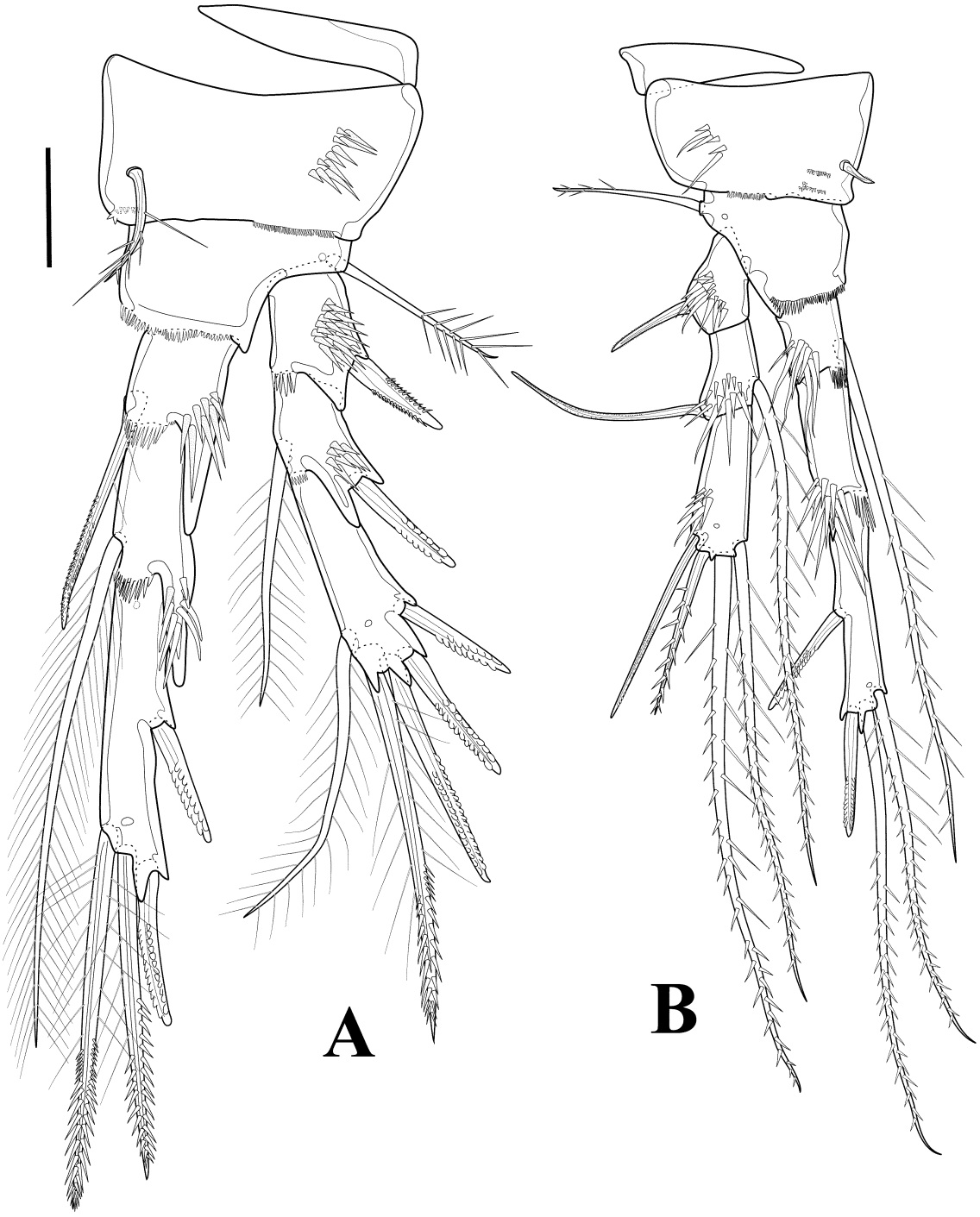

FIGURE 31. *Scottolana gomezi* **sp. nov.,** female (A) P3, anterior; (B) P4, anterior. Scale bar: 50µm.

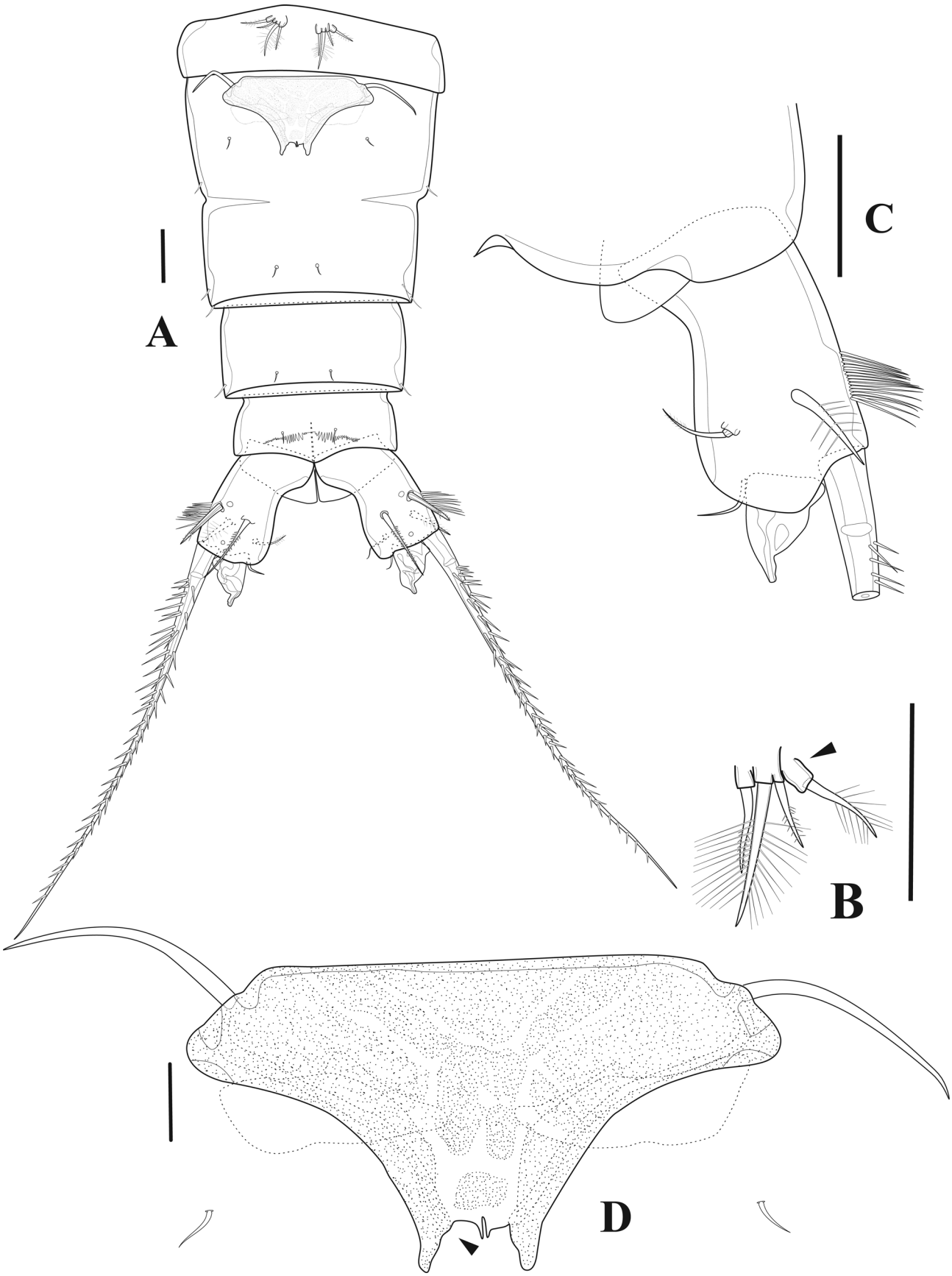

FIGURE 32. *Scottolana gomezi* **sp. nov.,** female: (A) urosome, ventral; (B) P5 (outer basal seta arrowed); (C) furcal ramus, dorsal, (D) genital (copulatory pore arrowed). Scale bars: A–C: 50µm, D: 20µm.

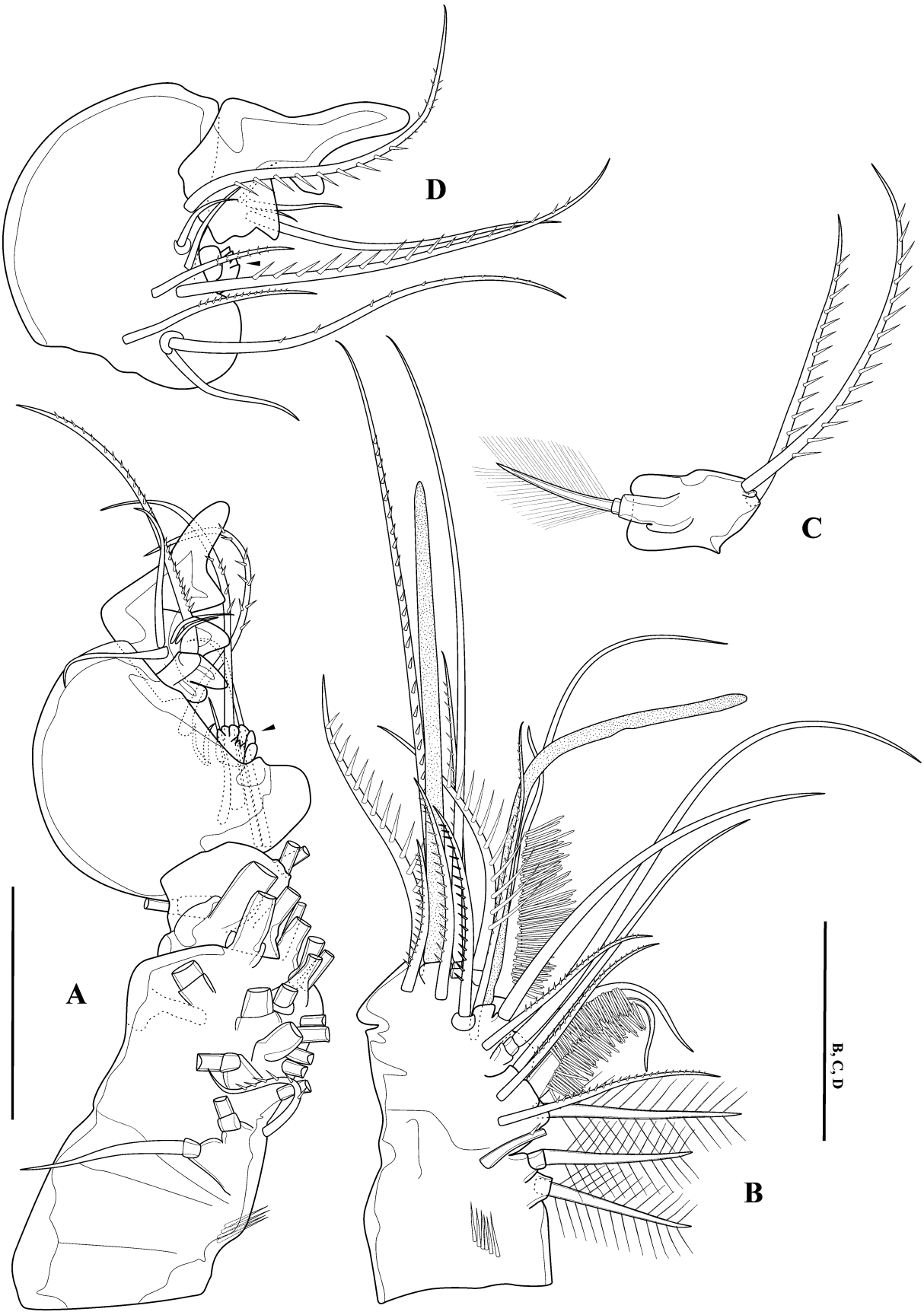

FIGURE 33. *Scottolana gomezi* **sp. nov.,** male: (A) antennules (armature largely omitted; illustrated completely on segment 3 and 4; modified element arrowed on swollen segment); (B–D) armature of disarticulated antennules (modified element arrowed on segment 3). Scale bars: 50µm.

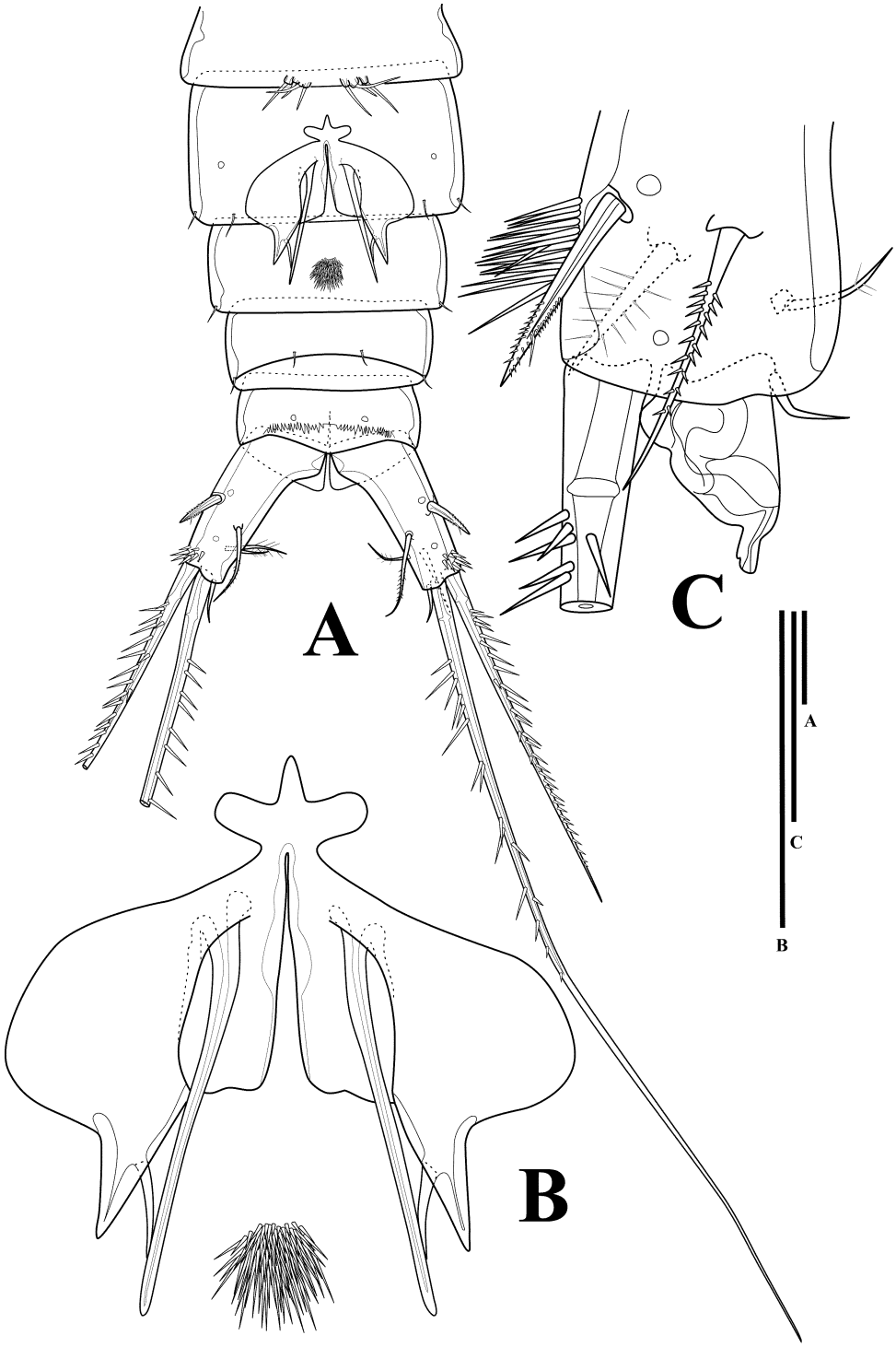

FIGURE 34. *Scottolana gomezi* **sp. nov.,** male: (A) Urosome, ventral; (B) Genital field; (C) female: furcal ramus, ventral. Scale bars: 50μm.

Conclusions

At present these three new species represent the first record of the family Canuellidae from northwest indo-pacific region and also Iranian waters. They were found in shallow marine habitats with sandy sediments. They all can be easily distinguished from their congeners. *Brianola haliensis* **sp. nov.** is unique becuase of four-segmented female antennules and no inner seta in P1 exp-2. The unique furcal rami shape and bified furcal seta in *Canuella persica* **sp. nov.** is not present in other congeners. Depression on the inner margin of female furcal ramus is deep. Possibly,

it can be used by males for grasping females during mating. *Scottolana gomezi* **sp. nov.** can be recognized easily by the position of furcal seta II, which is on anterior face, shape of seta V, and female genital field. This paper is part of an extensive study of the copepod fauna along the northern coasts of the Persian Gulf and Gulf of Oman. Nevertheless, it is just the beginning of research on taxonomy of meiofauna in Iranian waters.

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