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Five new species of the genus *Nannopus* (Copepoda: Harpacticoida: Nannopodidae) from intertidal mudflats of the Korean West Coast (Yellow Sea)

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Abstract

Five *Nannopus* Brady, 1880 species that are new to science are described from the intertidal mudflats of the Korean West Coast, Yellow Sea (South Korea). *Nannopus minutus* **sp. nov.** and *N. dimorphicus* **sp. nov.** belong to a group of species defined by seven elements on P4 exp-3, and these two species are unique by the pinnate caudal seta III. These species differ in the number of dorsal integumental windows on the cephalothorax (three in *N. minutus*, one in *N. dimorphicus*), shape of the distal small seta on the P4 endopod (naked in *N. minutus*, pinnate in *N. dimorphicus*), shape of the caudal seta IV (inflated and leaf-shaped in *N. minutus*, with a globular expansion at its insertion and slender in *N. dimorphicus*), and shape of the caudal seta V (anterior part cylindrical in *N. minutus*, inflated and bulbous in *N. dimorphicus*). The males of *N. minutus* and *N. dimorphicus* differ in the number of dorsal integumental windows on the cephalothorax (without any in *N. minutus*, with one integumental window in *N. dimorphicus*), number of outer spines on P2–P3 exp-3 (three in *N. minutus*, four in *N. dimorphicus*), shape of the inner seta on P3 enp-2 (naked in *N. minutus*, pinnate in *N. dimorphicus*), and shape of the outer medial and outermost setae on the P5 endopod (pinnate in *N. minutus*, naked in *N. dimorphicus*). *Nannopus serratus* **sp. nov.** and *N. unisegmentatus* Shen & Tai, 1964 share the presence of two setae on P2 enp-2 but differ in ornamentation and position of the setae on the mandibular palp, shape of the inner seta on P3 enp-2, and shape of distal seta on P4 enp-2. *Nannopus parvus* **sp. nov.** and *N. bulbiseta* **sp. nov.** belong to the group of species with the female P5 exopod fused, but these two species can be separated from the others by the presence of two bulbiform pinnate setae on the second segment of the antennule, as well as by the relative length and shape of the inner subdistal pectinate seta of P4 exp-3 (pectinate and 0.5 to 0.7 times as long as those in other congeners), and the shape of outer medial and outermost setae on the P5 endopod (naked only in female). However, they both display unique characters among all congeners. The caudal ramus of *N. parvus* is trapezoidal or square-shaped, and 0.4 to 0.5 times as long as those in other congeners, and the caudal seta V is very short and spine-like. *Nannopus bulbiseta* has four and five setae on P2 and P4 exp-3 respectively, the caudal ramus is sub-cylindrical or sub-rectangular, and the proximal part of the female caudal seta V is bulbous and very slender distally. A key to 14 valid species of *Nannopus* is provided.

Key words: Benthic copepods, East Asia, sexual dimorphism, SEM, taxonomy

Introduction

The Korean West Coast has extensive mudflats that provide suitable habitat for a variety of invertebrate fauna. Harpacticoid copepods are ubiquitous and typically the most abundant group of marine meiofauna aside from nematodes (Coull *et al.* 1983; Warwick & Gee 1984; Huys *et al.* 1996; Giere 2009). Among the harpacticoids from the intertidal mudflats of the Korean West Coast, the genus *Nannopus* was also reported (Yoo & Lee, 1995). *Nannopus* can be found in a wide range of salinities from hypersaline in intertidal mudflats (*N. didelphis* Fiers & Kotwicki, 2013), to brackish waters in estuaries (*N. palustris* Brady, 1880, *N. scaldicola* Fiers & Kotwicki, 2013, *N. procerus* Fiers & Kotwicki, 2013, and *N. hirsutus* Fiers & Kotwicki, 2013) and freshwater lakes (*N. flexibilis* Lilljeborg, 1902, *N. perplexus* Sars, 1909b).

The genus *Nannopus* was established by Brady (1880) as the type of the family Nannopodidae. At present, the genus contains nine valid species: *Nannopus palustris*, *N. flexibilis*, *N. perplexus*, *N. unisegmentatus* Shen & Tai, 1964, *N. didelphis*, *N. scaldicola*, *N. procerus*, *N. hirsutus*, and *N. ganghwaensis* Vakati, Kihara & Lee, 2016. Despite its cosmopolitan distribution (Garlitska *et al.* 2012), our knowledge of *Nannopus* from East Asia is very poor, with the exception of several reports, such as *N. unisegmentatus* from China (Shen & Tai, 1964), *N. ganghwaensis* from South Korea (Vakati *et al.* 2016), and *N. palustris* from China (Tai & Song 1979), Japan (Kikuchi & Yokota 1984), and Korea (Yoo & Lee 1995). However, the last three populations (*N. palustris sensu lato*) were incorrectly identified and only partially described, as explained by Fiers & Kotwicki (2013). The genus *Nannopus* has been suggested to have a global distribution, but this is mainly based on several misidentifications of individuals as *N. palustris*. Among those misidentified populations, some have been subsequently synonymized with other valid congeners (see Fiers & Kotwicki 2013), and some of them are suggested to be conspecific with the recently described species by Fiers & Kotwicki (2013).

During a series of sampling campaigns of the benthic meiofauna community, some sediment samples were collected in 2013 and 2015 from several intertidal mudflats on the Korean West Coast (Yellow Sea). Harpacticoids of the genus *Nannopus* were highly abundant. The present study aims to describe both sexes of five new species. A global key to species of *Nannopus,* which now includes 14 valid species, is provided.

Materials and methods

Sediment samples were collected from three intertidal mudflats of Yellow Sea: (1) Yangdo-myeon, Ganghwa Island, (2) Gilsang-myeon, Ganghwa Island and (3) Seocheon-gun, Chungcheongnam-do, South Korea (Fig. 1A–C). Meiofauna was extracted from the sediments using the Ludox method (Burgess 2001) with a 38µm sieve and stored in 99% ethanol. Harpacticoids of interest were sorted under a dissecting microscope (Olympus SZX12) and stored in 99% ethanol at 4ºC.

All specimens of the five species presented here were first prepared for DNA extraction in a tissue lysis buffer. Later they were all transferred back to 99% ethanol for line drawings and SEM analysis. The specimens for line drawings were dissected and mounted on glass slides in lactophenol; coverslips were sealed with transparent nail varnish. Microscopic observation and drawings were prepared under an Olympus BX51 microscope equipped with a drawing tube. We followed Huys & Boxshall (1991) for the descriptive terminology. Abbreviations used in the text are as follows: A1, antennule; A2, antenna; ae, aesthetasc; exp, exopod; exp-1 (-2, -3); enp, endopod; enp-1 (-2) to denote the proximal (middle, distal) segments of exopods and endopods; P1–P6, first to sixth thoracopod.

Specimens for SEM micrographs were dehydrated through a graded ethanol series, critical point dried, mounted on stubs and sputter-coated with platinum. The material was photographed using a Hitachi S-4700 scanning electron microscope at Eulji University, Seoul, Korea. Digital photographs were processed and combined into plates using Adobe Photoshop CS6. All specimens are deposited in the collection of National Institute of Biological Resources (NIBR). All maps were obtained from Quantum GIS Geographic information System and all figures were combined into a final plate in Adobe Photoshop CS6.

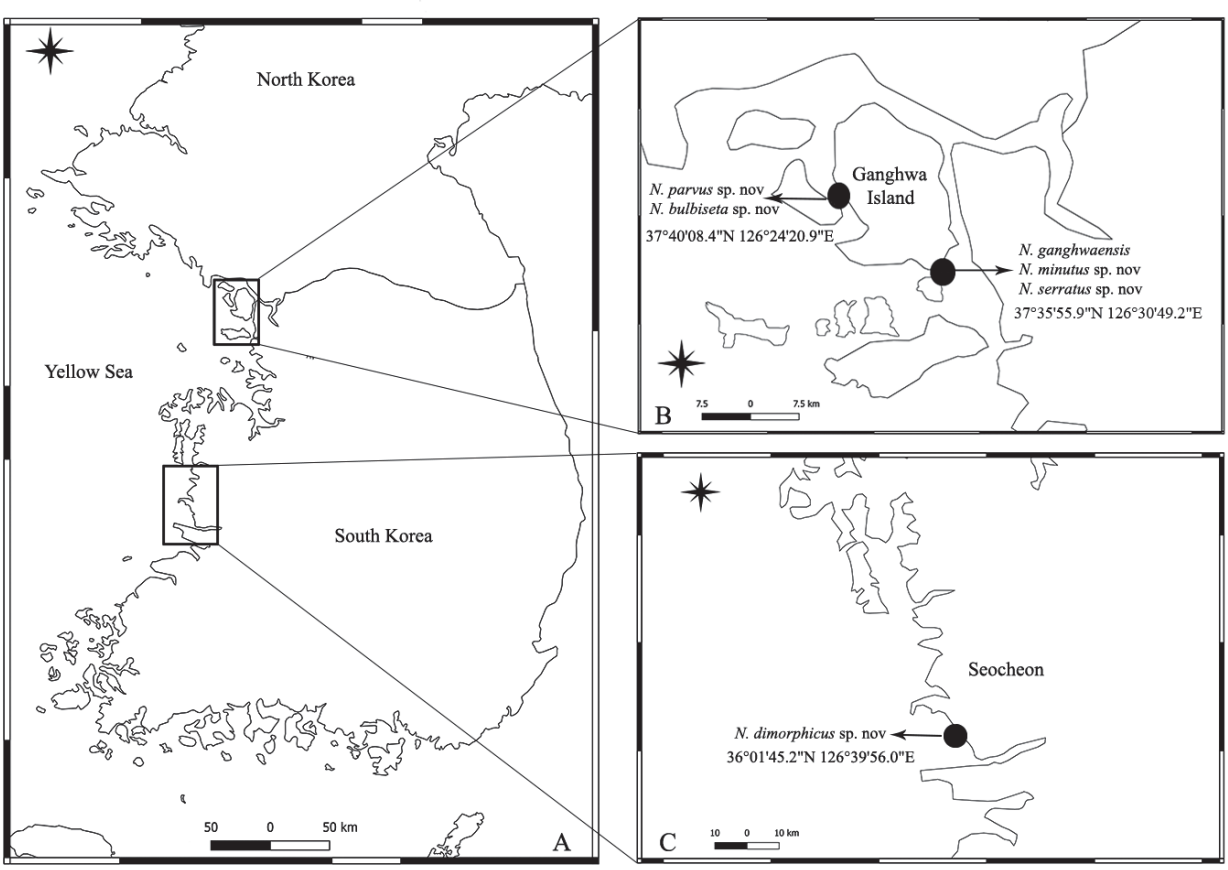

FIGURE 1. A–C, Map showing the type localities of all Korean species.

Systematics

Family Nannopodidae Brady, 1880

Genus *Nannopus* Brady, 1880

Redefined diagnosis. Body fusiform, ovate or cylindrical, and dorsoventrally depressed somites with 2 egg sacs. Rostrum fused at base, prominent, deeply recurved downwards, anterior margin densely hirsute. Anal somite with pair of dorsal sensilla, with or without pair of dorsal pore, and anal operculum with dense carpet of setules. Caudal rami small, rectangular, or sub-rectangular, and with 7 setae. Antennule 5-segmented in female and 6 to 7-segmented in male. Antenna with at most 2 abexopodal setae on allobasis, and exopod 1-segmented. Mandible uniramous, exopod and endopod fused, and with 4 to 5 setae. Maxillule praecoxal arthrite with at most 8 sturdy spines/setae and 1 to 2 pinnate recurved setae at distal margin. Maxillary syncoxa with 2 endites bearing 3 elements, allobasis with claw and 1 accompanying seta, and endopod incorporated into basis represented by 2 setae. Maxilliped syncoxa with 1 distal seta, endopod 2-segmented, and distal segment with 1 claw and 2 accessory setae at proximal region. P1–P4 exopod 3-segmented. P1–P3 endopod at most 2-segmented and P4 endopod 1-segmented. P3 enp-2 with distal apophysis in males. P4 exp-3 with or without inner subdistal pectinate seta. P5 exopod separated or fused to baseoendopod in female, always fused in males, both baseoendopods confluent or separated in females, and always confluent in males. P5 exopod with 4–5 setae, endopod with 3–4 setae. P6 with 1 seta set on peduncle in female, and 2–3 setae in males.

***Nannopus minutus* sp. nov.**
(Figs. 2–8)

Type locality. Intertidal mudflat, Gilsang-myeon, Ganghwa Island, South Korea, Yellow Sea, 37°35'55.9"N 126°30'49.2"E (Fig. 1A, B).

Type material. Holotype: 1 female adult in 70% ethanol (NIBRIV0000753983). Allotype: 1 male adult in 70% ethanol (NIBRIV0000810831). Paratypes: 2 females dissected on 4 and 3 slides (NIBRIV0000810828 – 29),1 male dissected on 5 slides (NIBRIV0000810832); 2 females on an SEM stub (NIBRIV0000810830). All samples were collected by Vinod Vakati, 20 November 2013.

Etymology. The species epithet is derived from the Latin "minutus", small, and alludes to the small size of the species (both sexes).

Description of female (based on holotype and paratypes). Body (Fig. 2A, B) fusiform narrow, total body length ranged from 498 to 504 µm (mean = 500 µm, n = 3; holotype: 504 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 140 to 151 µm (mean 146 µm, n = 3; holotype: 140 µm, measured at posterior margin of cephalothorax). Boundary between prosome and urosome clearly visible, urosome/prosome length ratio 0.65, and body length/width ratio about 3.3. Body ornamentation (Fig. 6A–D) consisting of dorsal denticles, and horizontal row of setules. Cephalothorax (Figs. 2A, B, 6C) anteriorly attenuated in dorsal view, almost as long as wide, comprising 29% of total body length, posterior margin serrated, with few paired sensilla, 1 row of sensilla, and 3 integumental windows (1 large medial posterior and 1 pair of small dorsolateral windows, arrowed in Fig. 6C).

Rostrum (Fig. 2C) prominent (not visible from dorsal view), deeply recurved downwards, fused to cephalothorax, anterior margin densely hirsute, and with pair of sensilla (not figured).

Prosome (Fig. 2A) 4-segmented, comprising cephalothorax and 3 subequal pedigerous somites. P1-bearing somite fused to cephalothorax, posterior margin of free pedigerous somites serrated, and with row of sensilla posteriorly.

Urosome (Figs. 2A, B, 5A, 6C) tapering posteriorly, comprising P5-bearing somite, genital double-somite, 2 free abdominal somites and anal somite. Posterior margin of P5-bearing somite and first half of genital double-somite serrated dorsally, second half of genital double-somite, fourth and fifth urosomites with posterior margin serrated dorsally and ventrally, each somite with sensilla dorsally except for penultimate somite and 1 row of spinules ventrally.

Genital double-somite (Figs. 2A, B, 5A, 6C) almost 1.7 times as wide as long (ventral view), completely fused ventrally, distinct dorsally and laterally, with serrated posterior margin dorsally, and smooth ventrally except for spinular row along posterior margin, and copulatory pore not visible (completely translucent).

Anal somite (Figs. 5A–C, 6C, D) with well-developed operculum, covered with setules posteriorly, almost as long as wide, with pair of dorsal sensilla, and with 1 row of spinules on either side of somite ventrally.

Caudal rami (Figs. 5A–C, 6A, B) cylindrical, with clear separation from anal somite, 1.3 (in dorsal view) and 2 (in ventral view) times as long as width. Ornamentation consisting of setules (Fig. 6A, B), and row of spinules along posterior margins dorsally and ventrally (Fig. 5A, C). Caudal ramus bearing 7 setae: seta I naked, shorter than ramus width, located anterodorsally; seta II naked, almost as long as ramus width, inserted anterodorsally midway and close to inner margin; seta III bipinnate, almost as long as ramus length, and inserted anterolaterally midway along outer margin; seta IV bipinnate, 0.2 times as long as seta V, inflated, leaf-shaped, located distally, and dorsal to seta V; seta V longest, bipinnate, anterior part wide and smooth, located distally, and ventral to seta IV; seta VI small, and naked; seta VII triarticulate, naked, and located midway along inner margin.

Antennule (Fig. 3A) 5-segmented, first and second segments strongest and widest, third segment with aesthetasc fused basally to 1 naked seta, fourth segment smallest, short and compact, and fifth segment with apical acrothek consisting of 1 slender aesthetasc fused basally to 2 long naked setae. All segments smooth except for spinular row on first and third segments. Armature formula: [1], 2-[6 + 3 pinnate], 3-[6 + (1 + ae)], 4-[1], 5-[8 + acrothek].

Antenna (Fig. 3B) comprising allobasis and free 1-segmented endopod. Allobasis with 2 abexopodal pinnate setae. Free endopodal segment 1.8 times as long as wide, with long medial outer spinules, with some spinules on inner and outer distal corners, with 5 strong, rigid naked elements and 1 long naked (innermost element), relatively slender element. Exopod 1-segmented, small, as long as wide, and with 4 elements (1 sparsely bipinnate and 3 naked).

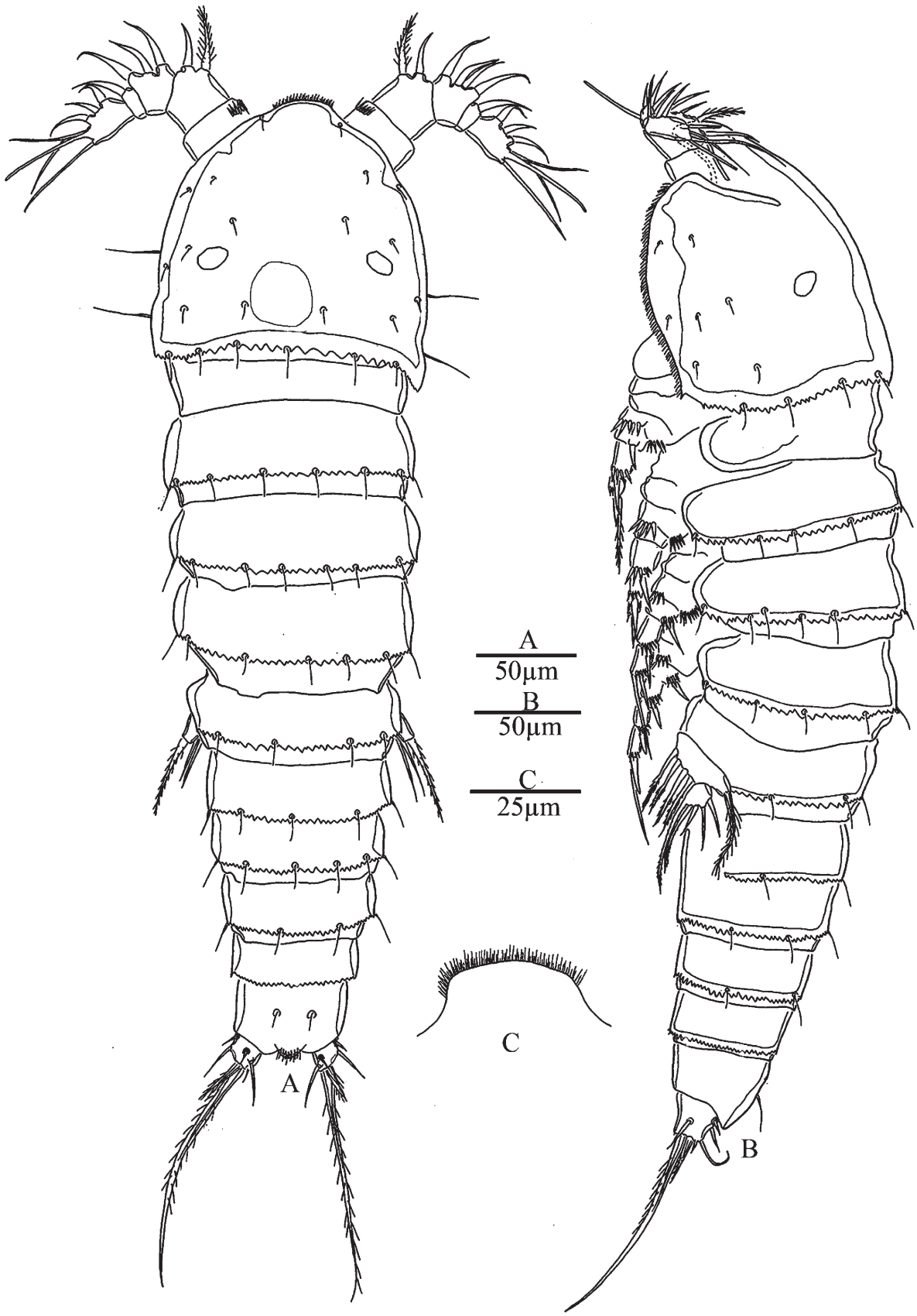

FIGURE 2. *Nannopus minutus* **sp. nov.,** line drawings, holotype ♀: A, habitus, dorsal; B, habitus, lateral; C, rostrum, dorsal.

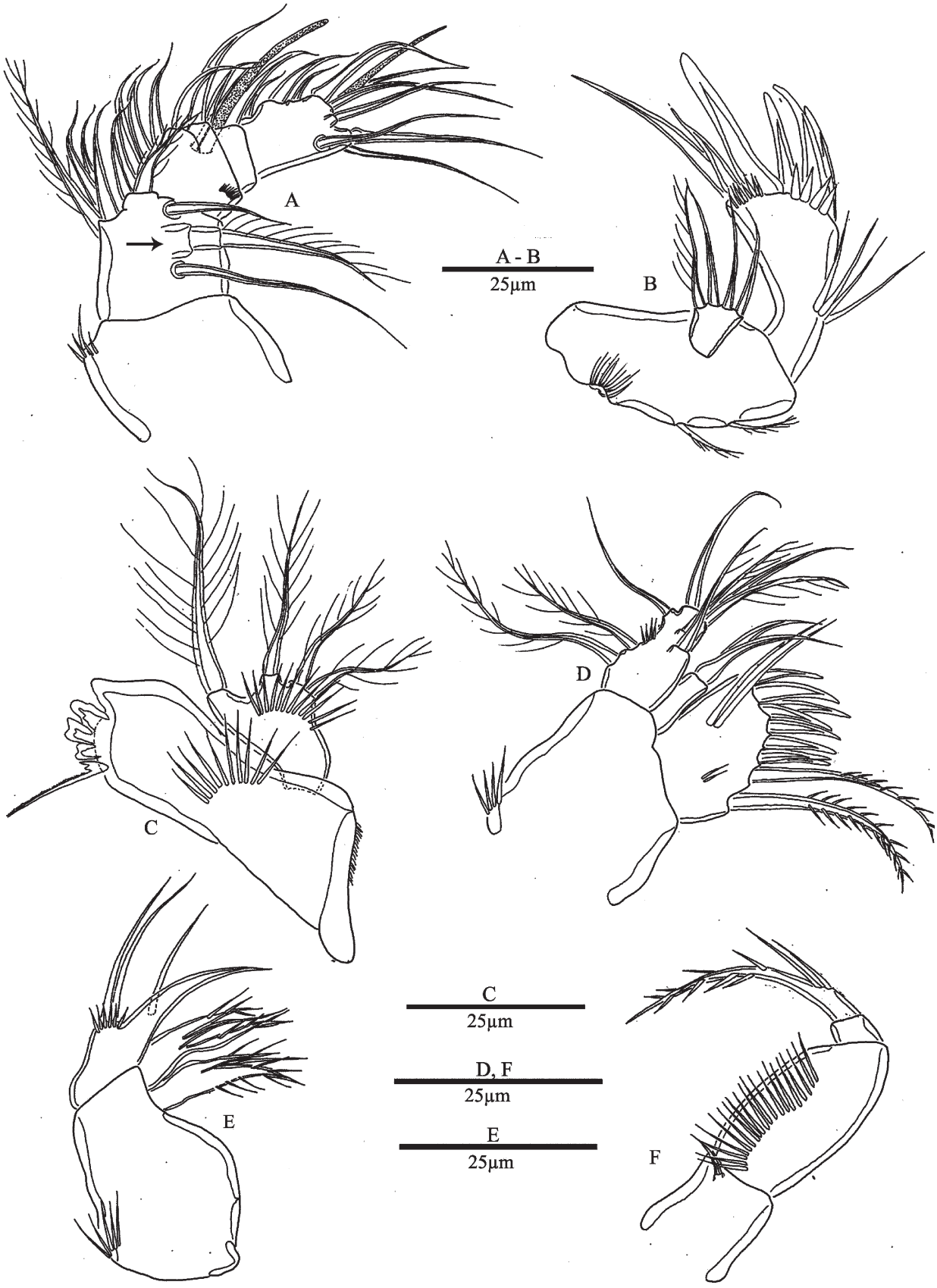

FIGURE 3. *Nannopus minutus* **sp. nov.,** line drawings, paratype ♀2: A, antennule (triarticulate seta on second segment arrowed); B, antenna; C, mandible; D, maxillule; E, maxilla; F, maxilliped.

Mandible (Fig. 3C) with well-developed gnathobasis, bearing several multicuspidate teeth distally, 1 small pinnate seta, and with 1 row of medial spinules near basis. Mandibular palp 1-segmented and incorporated into basis, armed with 4 bipinnate setae (1 basal, 2 exopodal and 1 endopodal), and 1 row of slender medial spinules.

Maxillule (Fig. 3D) praecoxa with few outer spinules proximally. Praecoxal arthrite well developed with few spinules, 2 naked surface setae, 8 stout naked spines/setae, and 2 bipinnate lateral setae. Syncoxa with cylindrical coxal endite bearing 2 naked setae. Basis and rami fused, outer margin with few spinules, and with 8 setae [5 basal (3 naked, 1 pinnate, 1 unipinnate), 1 endopodal unipinnate, and 2 exopodal bipinnate setae].

Maxilla (Fig. 3E) with large syncoxa bearing 1 row of outer spinules proximally, 2 subequal endites, and each with 3 elements fused to segment (2 spinulose and 1 slender naked). Allobasis into long naked curved claw with 1 accompanying naked seta. Endopod incorporated into basis, and represented by 2 naked setae.

Maxilliped (Fig. 3F) comprising syncoxa, basis, and 2-segmented endopod. Syncoxa shorter than basis, with 1 short distal naked seta. Basis almost 2 times as long as width with longitudinal row of medial spinules. Endopod 2-segmented, distal segment with 1 strong curved claw ornamented with rigid spinules in distal half, and 2 naked accessory setae at proximal region.

P1–P4 (Fig. 4A–D) with smooth and short concave intercoxal sclerite (P2 and P3 illustrated). Praecoxa somewhat triangular and shorter than coxa, with 1 row of outer spinules. Coxa with 1 (P1, P2 and P3) or 2 (P4) spinular rows on anterior surface, and row of strong outer spinules (P2, P3 and P4). Basis with 1 row of strong outer spinules near insertion of exopod and 1 row of distal spinules near insertion of endopod. Basal outer seta naked (P1, P2 and P4) or bipinnate (P3), and inner spine (with few spinules) on P1. Exopod 3-segmented, and all segments subequal. Exp-1 to -3 with robust outer spinules. Exp-2 (P1) and exp-1 to -3 (P2, P3 and P4) with inner setules. Exp-2 (P1, P2, P3 and P4) with pinnate inner seta, and exp-3 (P1, P2, P3 and P4) with pinnate inner subdistal, distal and outer terminal setae. P4 exp-3 with 1 inner subdistal pectinate seta. Endopod 2-segmented in P1, P2 and P3 or 1-segmented in P4. Enp-1 to -2 (P1, P2 and P3) with robust outer spinules. Enp-1 to -2 (P1), enp-2 (P2 and P3) with slender inner setules. All setae on P1–P4 endopods pinnate except for inner apical short seta on P4 endopod (Fig. 4D). Armature formula as follows:

	Exopod	Endopod
P1	0.1.013	0.111
P2	0.1.123	0.111
P3	0.1.223	0.111
P4	0.1.223	020

P5 (Fig. 5D) with separate baseoendopod and exopod. Baseoendopod transversely elongated, with inner spinules on endopodal lobe and close to exopod, with 2 pectinate and 2 pinnate setae. Exopod squarish, almost as long as wide, with 5 elements (innermost element longest, bipinnate, and fused to segment, medial 2 setae pinnate and outermost 2 setae naked).

P6 (Fig. 5A, E) with 1 small flap bearing 1 small pinnate seta.

Description of male (based on allotype and paratypes). Body (Fig. 7A) as in female except for total body length ranged from 428 to 434 µm (mean = 431 µm, n = 2; allotype: 428 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 118 to 123 µm (mean 120 µm, n = 2; allotype: 118 µm, measured at posterior margin of cephalothorax). Urosome/prosome ratio about 0.7, and body length/width ratio about 3.5. Cephalothorax (Fig. 7A) without integumental windows. Body ornamentation (not illustrated), rostrum (Fig.7A), antenna (not illustrated), mouth parts (not illustrated), P1 and P4 (not illustrated) as in female.

Prosome 4-segmented (Fig. 7A), comprising cephalothorax (bearing first pedigerous somite), and 3 free somites. Posterior margin of prosomites serrated and with sensilla as in female.

Urosome 6-segmented (Fig. 7A, B), comprising P5-bearing somite, genital somite and 3 free abdominal somites and anal somite. Posterior margin of urosomites serrated except for anal somite and with sensilla as in female**,** P6-bearing somite and urosomite 3 to 5 with longitudinal row of spinules close to posterior margin ventrally.

Genital somite (Fig. 7A, B) homologous to anterior part of genital double-somite in female. P6-bearing somite and third urosomite well segmented ventrally, 3.3 times as wide as long in ventral view, and with 1 spermatophore located on right side extending from posterior part of P4-bearing somite to posterior part of genital somite.

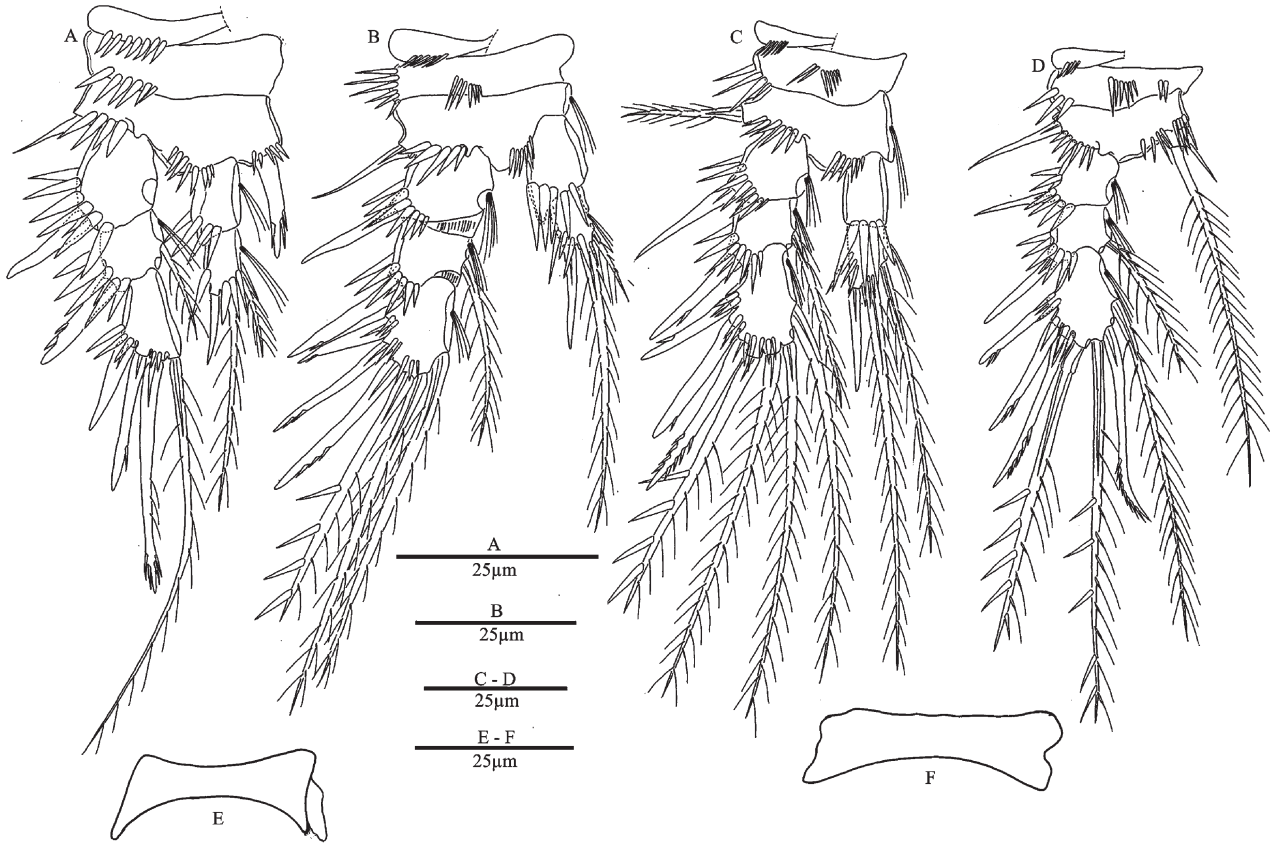

FIGURE 4. *Nannopus minutus* **sp. nov.,** line drawings, A–B, paratype ♀1; C–D, paratype ♀2: A, P1; B, P2; C, P3; D, P4; E–F, P2 and P3 intercoxal sclerite.

Anal somite (Fig. 7A) as in female except for anal operculum deeply protruded downwards.

Caudal rami (Fig. 7A–D) as in female except for small inner projection (arrowed in Fig. 7B). Seta IV 0.4 times as long as seta V, but twice as long as one in female, seta V anterior part as in female, and posterior part more flexible than in female.

Antennule (Fig. 8E) chirocer, 7-segmented, with strong geniculation between segments 5 and 7. Segment 1 with 1 row of spinules along inner margin. Segment 2 longer than segment 1. Segment 4 represented by 1 small sclerite located posteriorly, with 1 seta. Armature formula as follows: 1-[1], 2-[6 + 3 pinnate], 3-[3], 4-[1], 5-[6], 6-[9(1 + ae)], 7-[7 + acrothek]. Apical acrothek consisting of 1 minute aesthetasc and 2 naked setae.

P2–P3 (Fig. 8A, B) almost as in female except for P3 praecoxa without spinular row. P2 coxa with only 1 spinular row along anterior surface. Exopod 3-segmented, P2 exp-1 with pinnate outer spine, and exp-2 inner seta extremely smaller than in female (arrowed in Fig. 8A). Endopod 2-segmented, P3 enp-2 inner seta extremely short and naked (arrowed in Fig. 8B), and outer spine fused to segment forming sharp and naked apophysis (arrowed in Fig. 8B).

P5 (Fig. 8C) fused with somite, exopod and baseoendopod fused, and both baseoendopods confluent. Baseoendopod with distal spinules, and outer basal bipinnate seta. Endopodal lobe with 2 sub-equal pectinate and 2 bipinnate setae. Exopodal lobe with 5 elements (3 bipinnate and 2 naked, and outer naked seta smallest).

P6 (Figs. 7B, 8D) asymmetrical, only right flap functional, and with row of spinules distally. Each P6 with 3 bipinnate setae, medial element longest, and each seta arising from cylindrical peduncle.

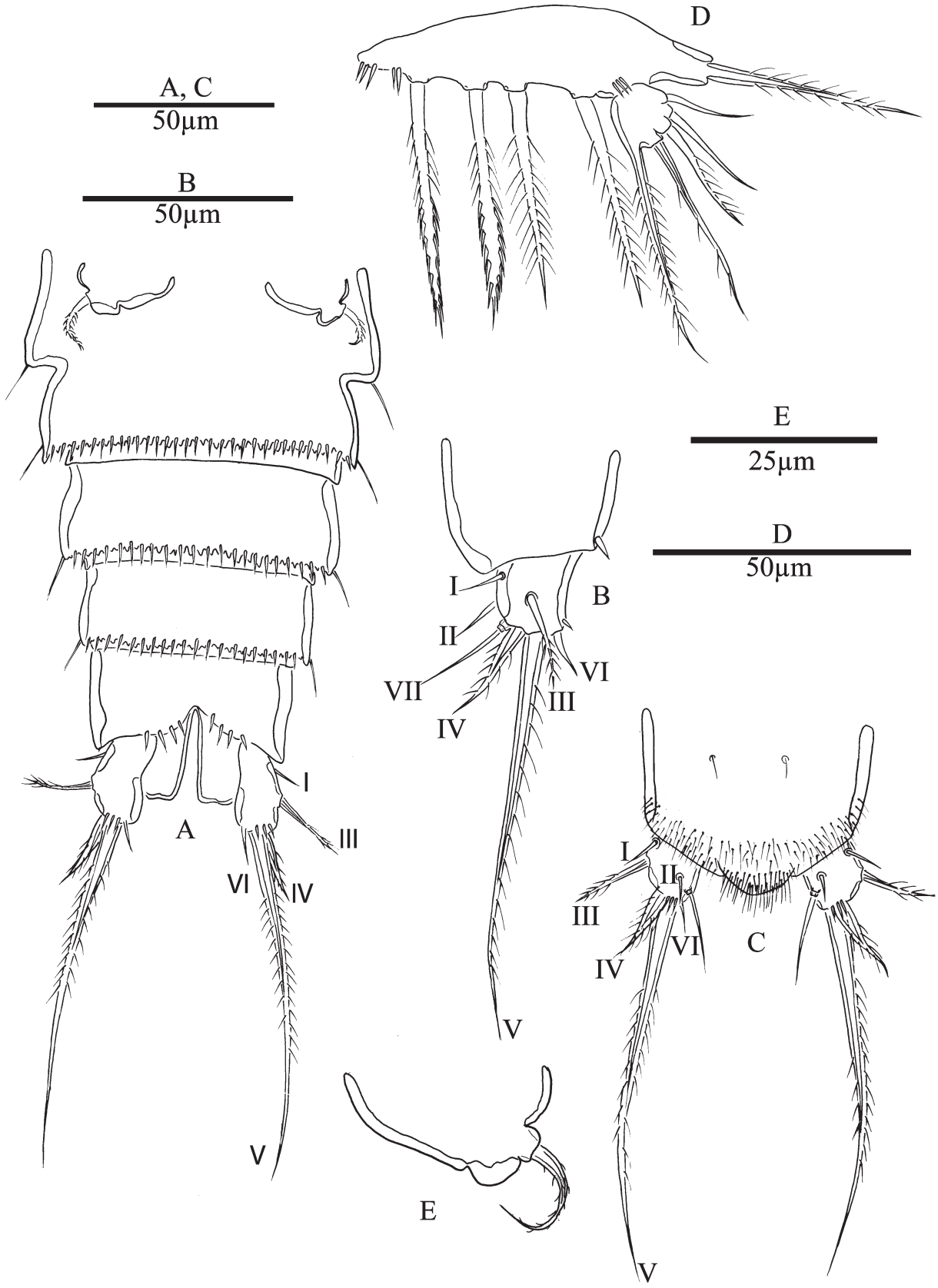

FIGURE 5. *Nannopus minutus* **sp. nov.,** line drawings, paratype ♀1: A, urosome, P5-bearing somite omitted and caudal rami, ventral; B, anal somite and caudal ramus, lateral; C, anal somite and caudal rami, dorsal; D, P5; E, left P6.

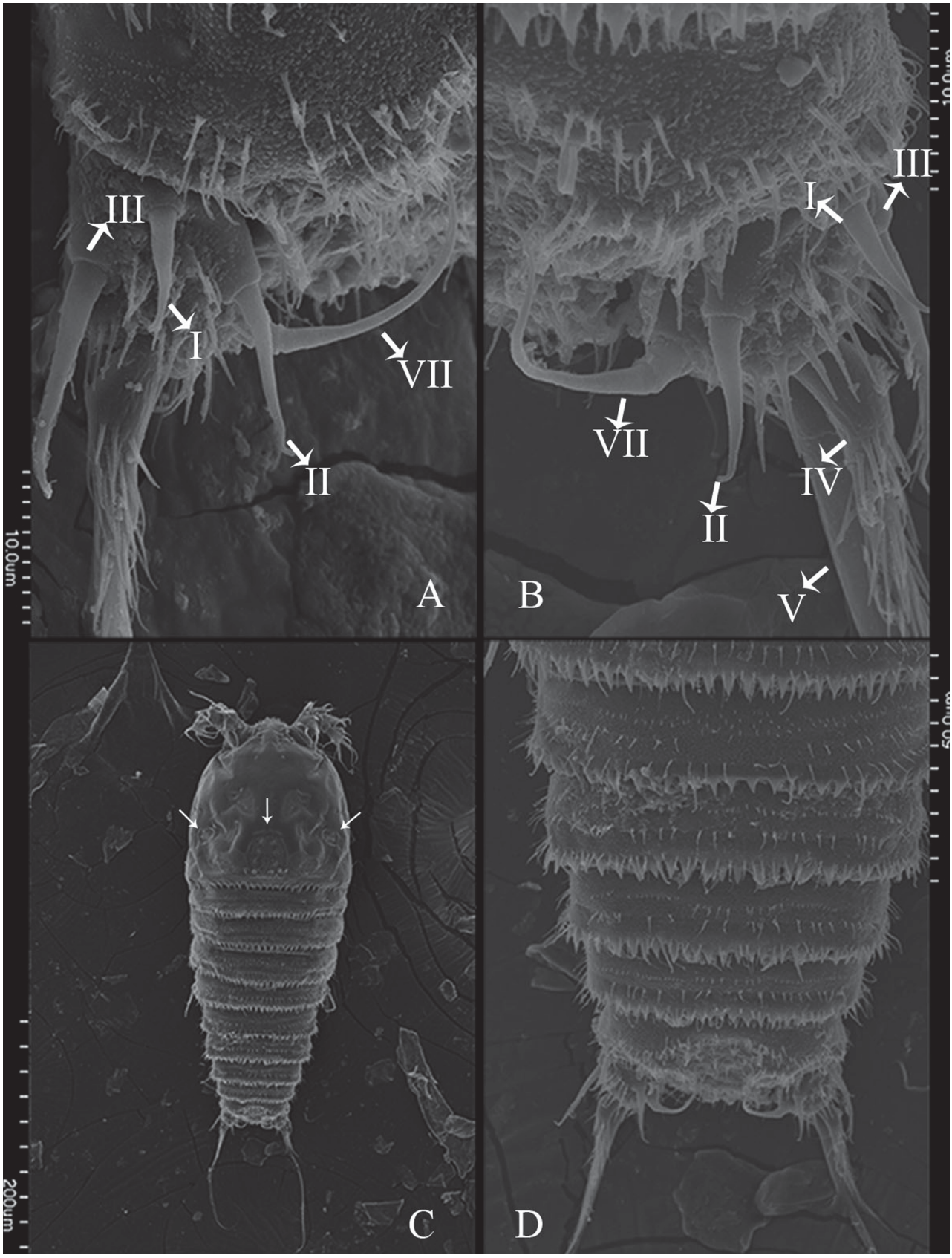

FIGURE 6. *Nannopus minutus* **sp. nov.,** SEM photographs, paratype ♀3: A–B, anal somite and caudal rami, dorsal; C, habitus, dorsal; D, urosomite, dorsal.

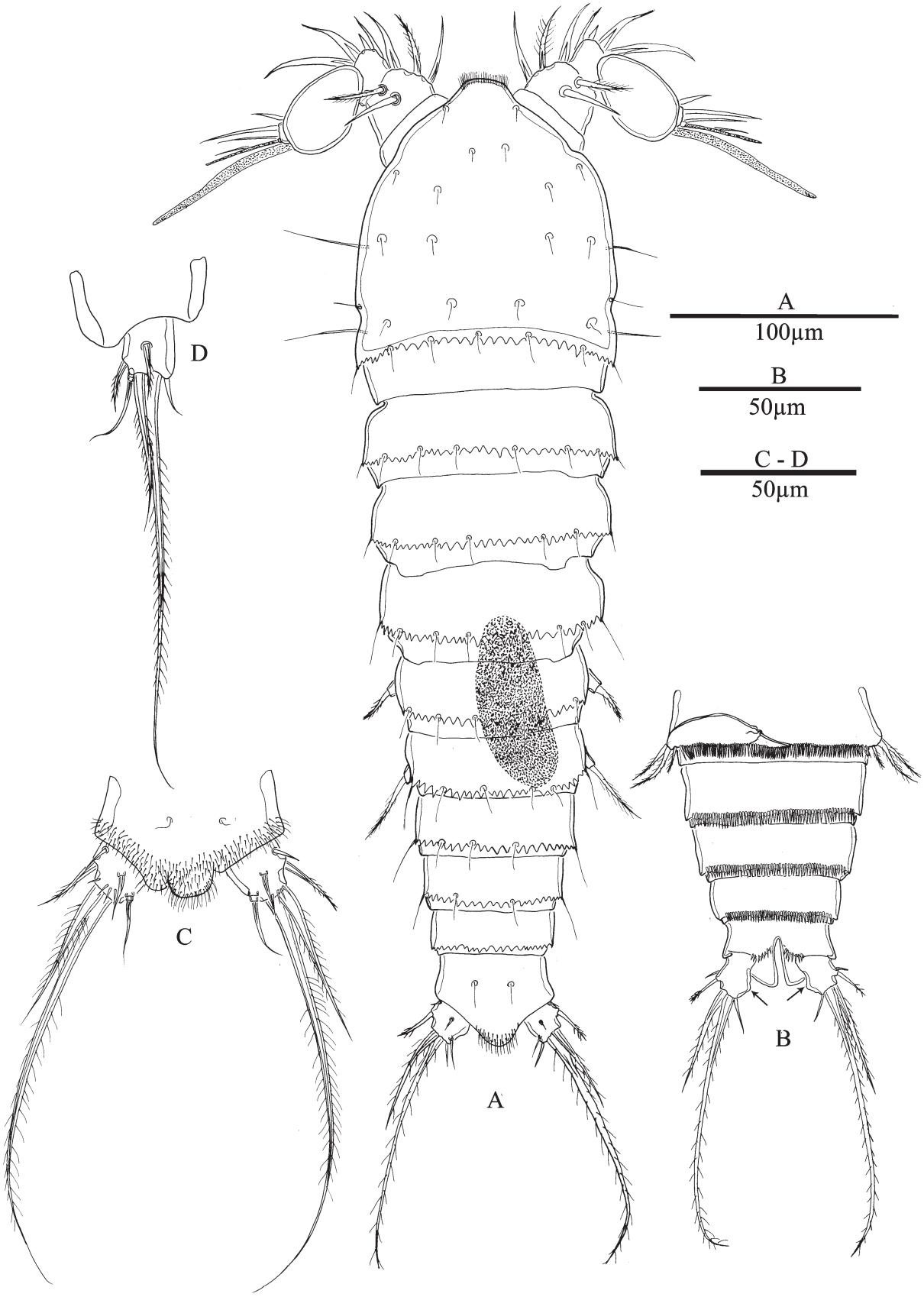

FIGURE 7. *Nannopus minutus* **sp. nov.,** line drawings, A, allotype ♂; B–D, paratype ♂1: A, habitus, dorsal; B, urosome, P5-bearing somite omitted and caudal rami (arrow indicates projections along the inner margins), ventral; C, anal somite and caudal rami, dorsal; D, right caudal ramus, lateral.

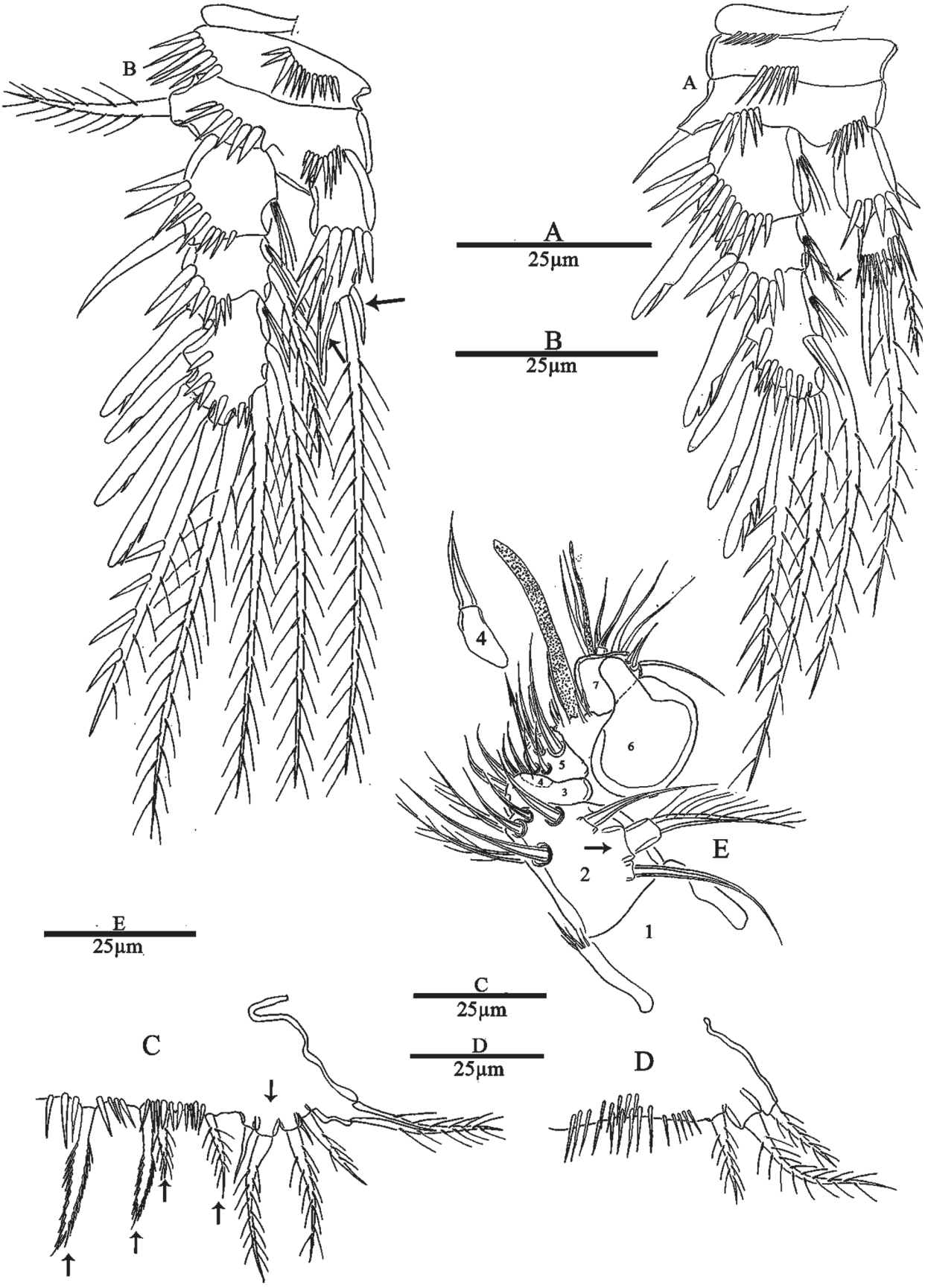

FIGURE 8. *Nannopus minutus* **sp. nov.,** line drawings, A–B & D–E, paratype ♂1; C, allotype ♂: A, P2 (dimorphic inner seta arrowed); B, P3 (sexual dimorphisms arrowed); C, P5 (sexual dimorphisms arrowed); D, P6; E, antennule (triarticulate seta on second segment arrowed).

***Nannopus dimorphicus* sp.nov.**
(Figs. 9–15)

Type locality. Intertidal mudflat, Seocheon-gun, Chungcheongnam-do, South Korea, Yellow Sea, 36°01'45.2"N 126°39'56.0"E (Fig. 1A, C).

Type material. Holotype: 1 female adult in 70% ethanol (NIBRIV0000753984). Allotype: 1 male adult in 70% ethanol (NIBRIV0000810836). Paratypes: 2 females dissected on 5 and 2 slides (NIBRIV0000810833 – 34) 1 male dissected on 4 slides (NIBRIV0000810837); 2 females and 2 males on SEM stub (NIBRIV0000810835). All samples were collected by Vinod Vakati, 27 May 2015.

Etymology. The species epithet is derived from the Greek "dimorphicus" referring to the sexual dimorphism in shape of caudal seta V.

Description of female (based on holotype and paratypes). Body (Fig. 9A, B) fusiform and broad along posterior region of cephalothorax, total body length ranged from 400 to 420 μm (mean = 408 μm, n = 3; holotype: 400 μm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 132 to 136 μm (mean 134 μm, n = 3; holotype: 135 μm, measured at posterior margin of cephalothorax). Boundary between prosome and urosome clearly visible, urosome/prosome length ratio 0.62, and body length/width ratio about 3.1. Body ornamentation (Fig. 10A, B) as in *N. minutus*. Cephalothorax (Figs. 9A, 10A, B) anteriorly attenuated in dorsal view, 0.9 times as long as wide, comprising 38% of total body length, with several paired sensilla as figured, 1 row of sensilla along serrated posterior margin, and 1 medial integumental window close to posterior margin dorsally (arrowed in Fig. 10B).

Rostrum (Fig. 9C) as in *N. minutus* and with pair of sensilla anteriorly.

Prosome (Fig. 9A) 4-segmented, comprising cephalothorax and 3 subequal free pedigerous somites. P1-bearing somite fused to cephalothorax, posterior margin of free pedigerous somites serrated, and with row of sensilla as figured.

Urosome (Figs. 9A, 12A) tapering posteriorly, consisting of P5-bearing somite, genital double-somite, 2 abdominal somites, and anal somite. P5-bearing somite and first half of genital double-somite with serrated posterior margin dorsolaterally, and sensilla along posterior margin dorsally except for penultimate urosomite. Genital double-somite, following 2 urosomites with serrated posterior margin dorsally and ventrally, and with additional medial row of spinules ventrally.

Genital double-somite (Figs. 9A, 12A) almost 1.4 times as wide as long (ventral view), completely fused ventrally, with original segmentation indicated by serrated surface ridge dorsally, and copulatory pore located between both P6 with median depression.

Anal somite (Figs. 10A, 12A–C) almost as long as width with well-developed operculum, dense carpet of setules, pair of dorsal sensilla and pore, setules and denticles produced randomly, and 1 row of spinules on either side of anal segment ventrally.

Caudal rami (Figs. 10C, D, 12A–C) cylindrical, 1.8 times as long as wide in dorsal and ventral view, and ornamentation consisting of setules (Fig. 10C, D). Each ramus bearing 7 setae: seta I naked, shorter than ramus width, and located anterodorsally; seta II naked, as long as ramus width, and inserted anterodorsally midway along inner margin; seta III bipinnate, almost as long as ramus length, and anterolaterally midway along outer margin; seta IV bipinnate, 0.27 times as long as seta V, located at outer margin distally (arrowed in Fig 12A) but inserted at dorsal proximal area of seta V (visible in lateral view, arrowed in Fig. 12C), and with globular expansion at proximal region (arrowed in Fig. 12A, B); seta V strongest, bipinnate, located at distal inner margin, inflated, and extremely bulbous at proximal region; seta VI small, and naked; seta VII triarticulate, naked, and located midway along inner margin.

Antennule, antenna, and mouth parts as in *N. minutus*.

P1–P4 (Fig. 11A–E) with smooth and short concave intercoxal sclerite (not illustrated). Praecoxa somewhat triangular and shorter than coxa, and with 1 row of outer spinules (P1, P2 and P4). Coxa with 1 spinular row on anterior surface, and row of outer strong spinules (P1, P2, P3 and P4). Basis with 1 row of strong outer spinules near insertion of exopod, and 1 row of distal spinules near insertion of endopod (P1, P2, P3 and P4). Basal outer seta naked (P1 and P2) or bipinnate (P3 and P4), and P1 with inner strong pinnate spine. Exopod 3-segmented, all segments subequal in length, and with spinules and setules along outer and inner margins as figured. Endopod 2-segmented in P1, P2 and P3 or 1-segmented in P4. All setae on P1–P4 endopods pinnate. Armature formula as in *N. minutus*.

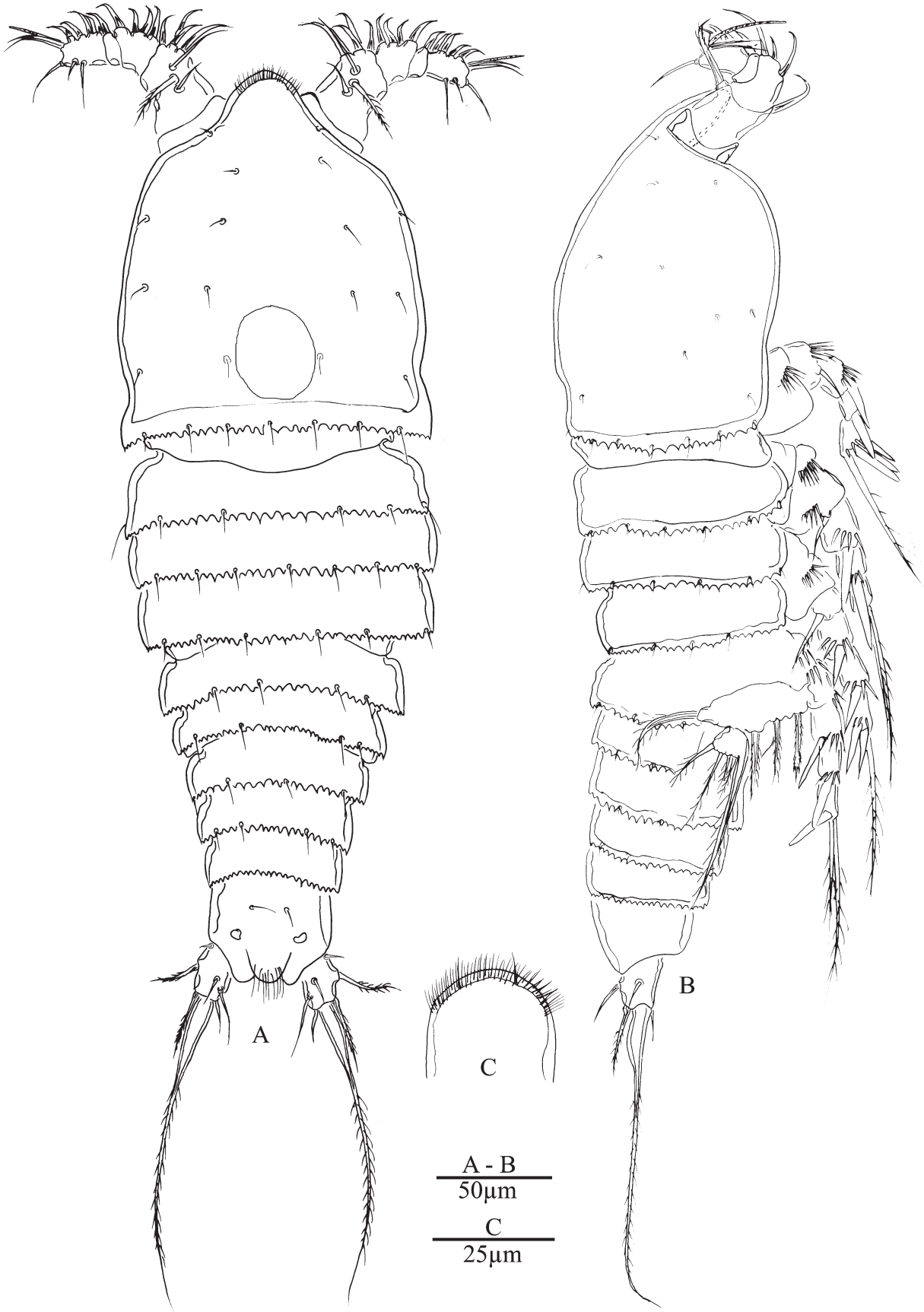

FIGURE 9. *Nannopus dimorphicus* **sp. nov.,** line drawings, holotype ♀: A, habitus, dorsal; B, habitus, lateral; C, rostrum, dorsal.

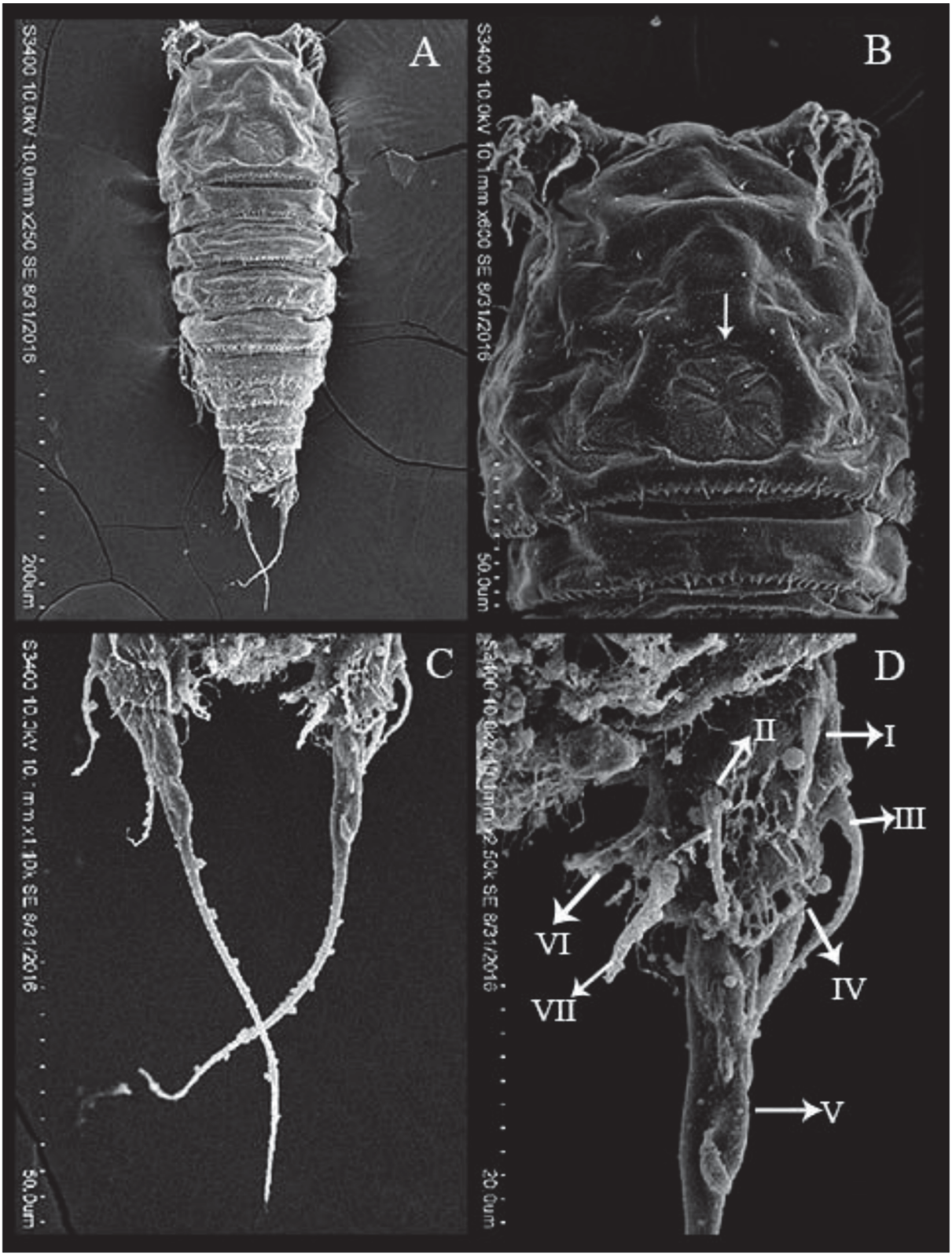

FIGURE 10. *Nannopus dimorphicus* **sp. nov.,** SEM photographs, paratype ♀3: A, habitus, dorsal; B, cephalothorax (integumental window arrowed), dorsal; C, caudal rami, dorsal; D, right caudal ramus, dorsal.

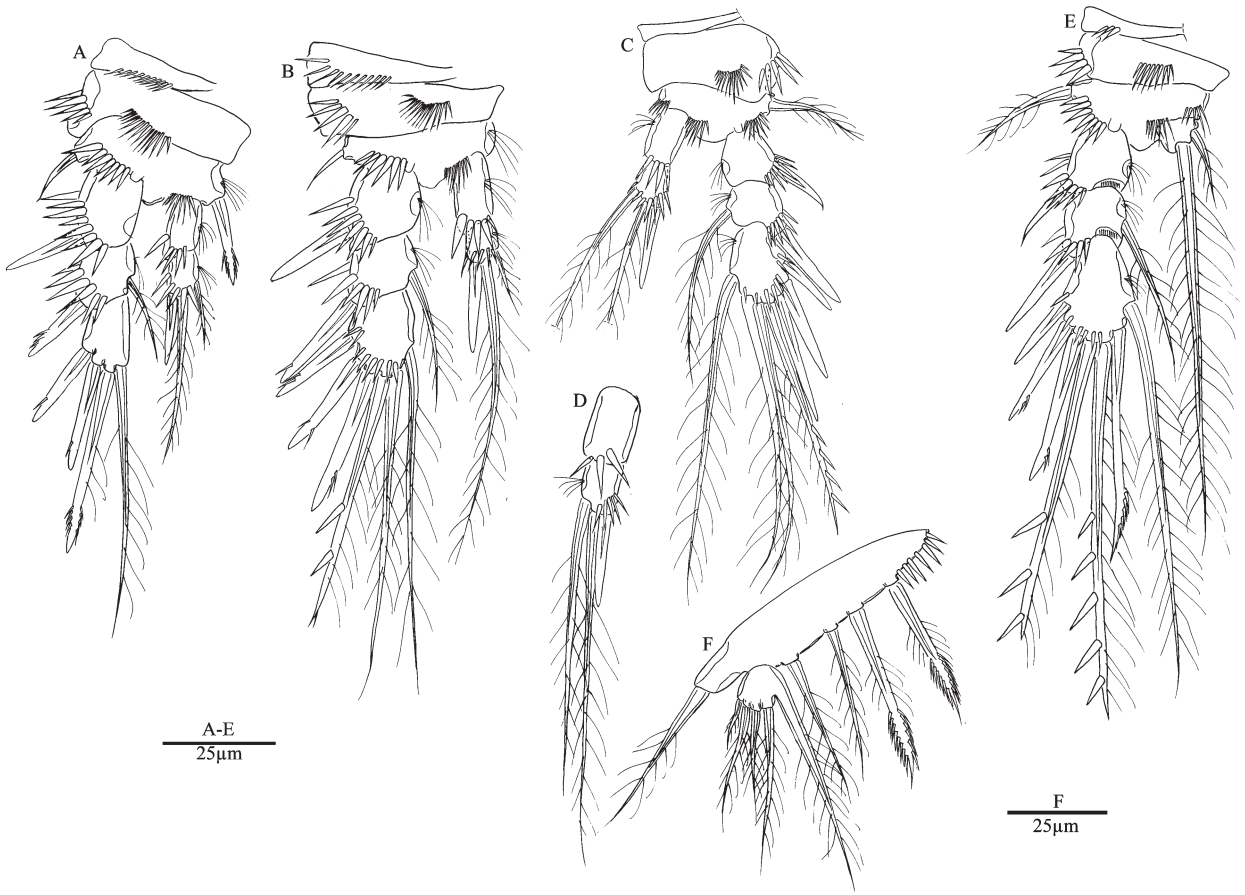

FIGURE 11. *Nannopus dimorphicus* **sp. nov.,** line drawings, A–C & E–F, paratype ♂1; D, paratype ♂2: A, P1; B, P2; C, P3; D, left P3 endopod; E, P4; F, P5.

P5 (Fig. 11F) with separate baseoendopod and exopod. Baseoendopod transversely elongated, with 1 row of spinules along inner distal margin, and endopodal lobe with 2 pectinate and 2 pinnate setae. Exopod squarish, almost as long as width, and with 5 pinnate setae (innermost element longest and fused to segment).

P6 (Fig. 12A, D) with semi circular flap bearing 1 small pinnate distal seta.

Description of male (based on allotype and paratypes). Body (Fig. 13A) as in female, total body length ranged from 325 to 410 µm (mean = 377 µm, n = 2; allotype: 325 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 119 to 125 µm (mean 122 µm, n = 2; allotype: 120 µm, measured at posterior margin of cephalothorax). Urosome/prosome length ratio 0.5 in dorsal view and body length/width ratio about 2.5 in dorsal view. Cephalothorax (Figs. 13A, 14B) 0.8 times as long as wide, comprising 29% of total body length, and with 1 integumental window as in female (arrowed in Fig. 14B). Body ornamentation (not illustrated), anal somite (Fig. 13A), rostrum (Fig.13A), and P1 (not illustrated) as in female. Antennule (not illustrated) as in male *N. minutus*. Antenna (not illustrated) and mouth parts (not illustrated) as in *N. minutus*.

Prosome 4-segmented (Fig. 13A), comprising cephalothorax (bearing first pedigerous somite), and 3 free somites. Posterior margin of prosomites serrated, and with sensilla as in female.

Urosome 6-segmented (Fig. 13A, B), comprising P5-bearing somite, genital somite, 3 free abdominal somites and anal somite. Posterior margin of urosomites serrated except for anal somite, and with sensilla as in female**.** P6-bearing somite, and urosomite 3 to 5 with longitudinal row of spinules along posterior margin ventrally.

Genital somite (Fig. 13A, D) homologous to anterior part of genital double-somite in female, and second and third urosomite well segmented in ventral view. Posterior margins of each somite serrated dorsally with few sensilla.

Caudal rami (Figs. 13A–D, 14C–D) almost as in female except for seta IV and V without modifications (normal type) at its base.

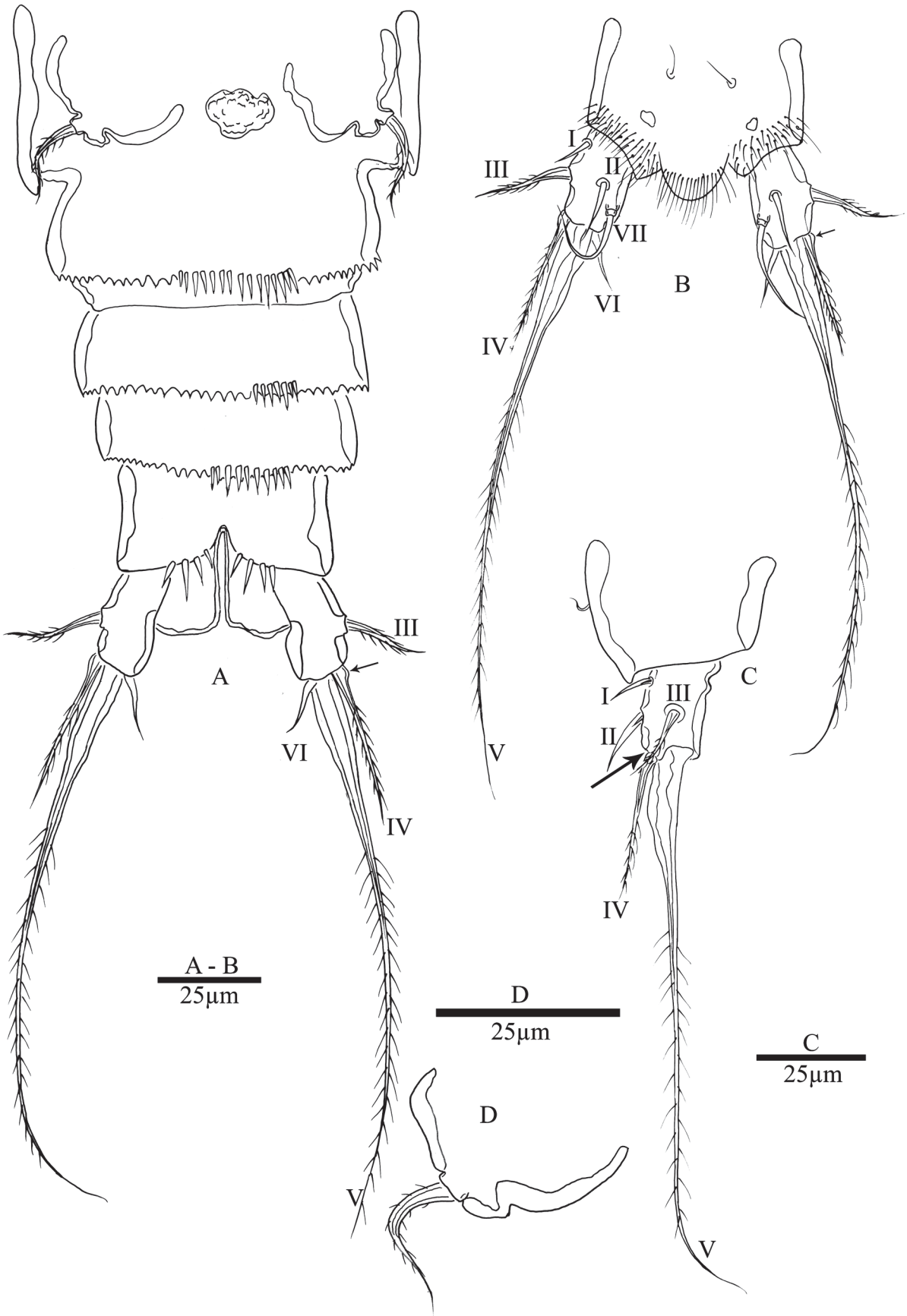

FIGURE 12. *Nannopus dimorphicus* **sp. nov.,** line drawings, paratype ♂1: A, urosome, P5-bearing somite and caudal rami, ventral; B, anal somite and caudal rami, dorsal; C, anal somite and caudal ramus, lateral (seta IV insertion site arrowed); D, right P6.

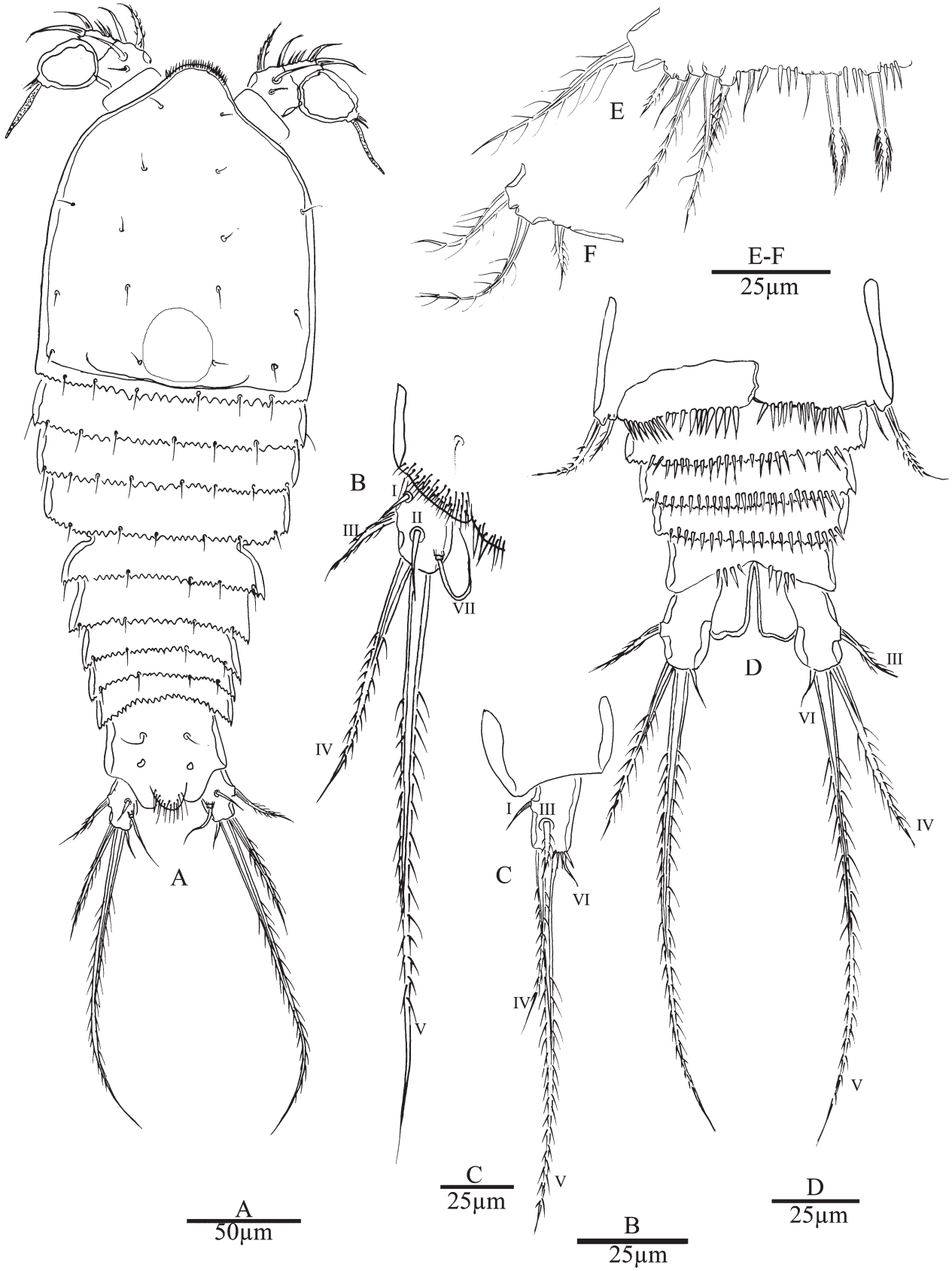

FIGURE 13. *Nannopus dimorphicus* **sp. nov.,** line drawings, A, allotype ♂; B–F, paratype ♂1: A, habitus, dorsal; B, anal somite and caudal ramus, dorsal; C, anal somite and caudal ramus, lateral; D, urosome, P5-bearing somite and caudal rami, ventral; E, P5; F, P6.

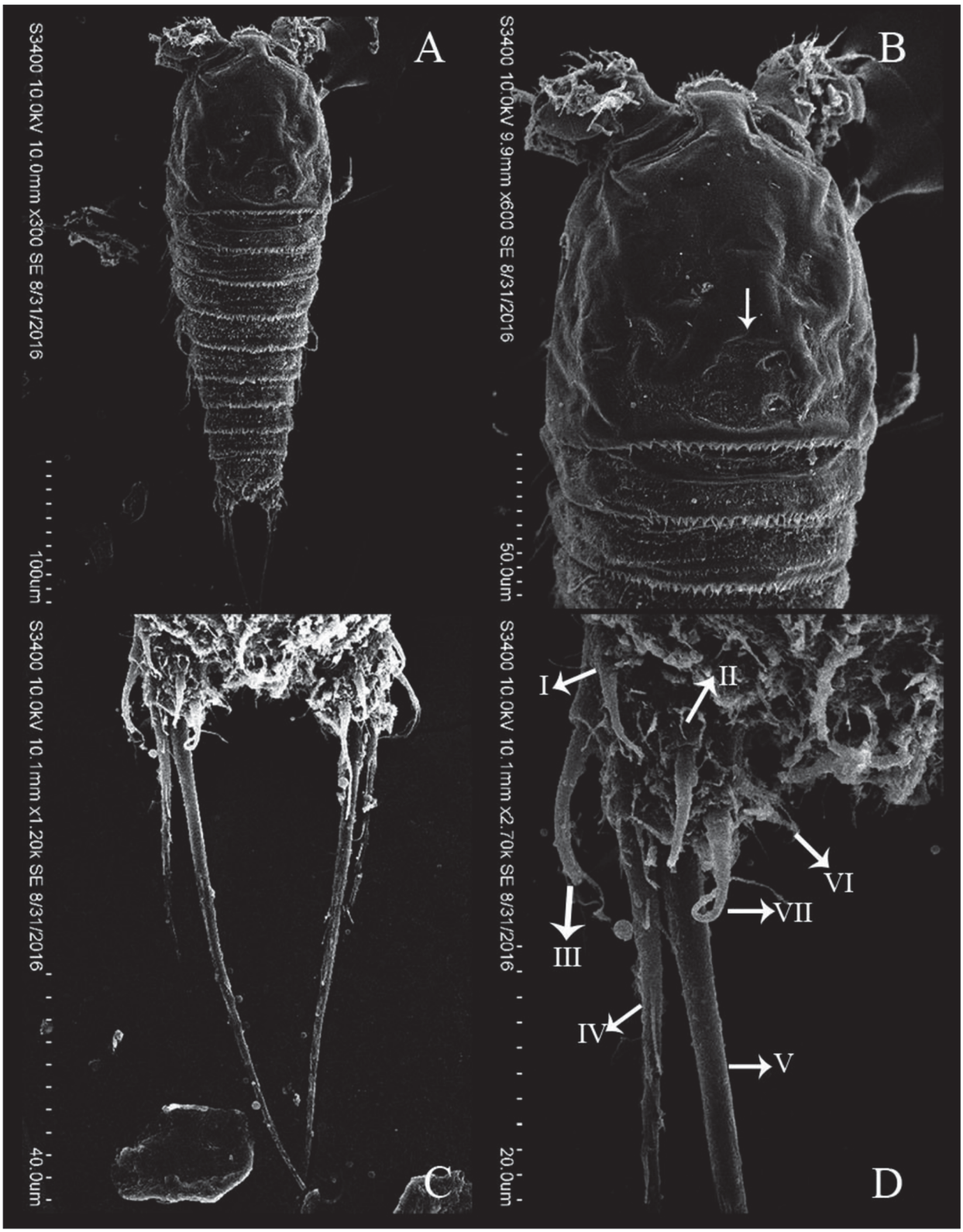

FIGURE 14. *Nannopus dimorphicus* **sp. nov.,** SEM photographs, paratype ♂2: A, habitus, dorsal; B, cephalothorax (integumental window arrowed), dorsal; C, caudal rami, dorsal; D, left caudal ramus, dorsal.

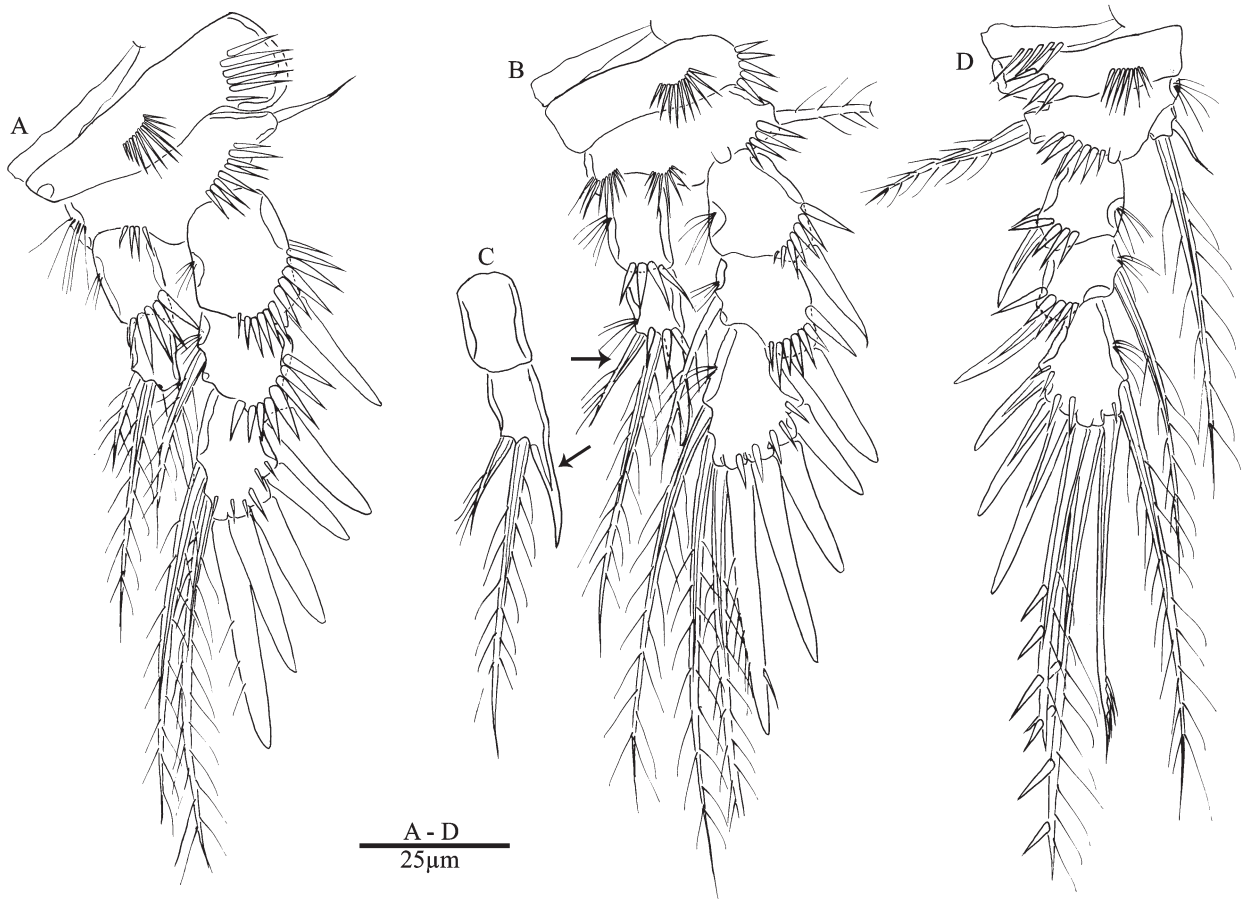

FIGURE 15. *Nannopus dimorphicus* **sp. nov.,** line drawings, paratype ♂1: A, P2; B, P3 (inner seta arrowed); C, P3 endopod without surface ornamentation (outer apophysis arrowed); D, P4.

P2–P4 (Fig. 15A–D). P2 praecoxa without spinules. P4 basis without spinules near insertion of endopod, and with inner setules. Apical outer spine of exp-3 in P2–P3 with inner setules, and 1 subdistal spinule on distal outer spine of exp-3 in P3. Endopod 2-segmented in P2 and P3 or 1-segmented in P4. P2 enp-1 with distal spinules. P3 enp-2 with short inner pinnate seta (arrowed in Fig. 15B), and outer spine fused to enp-2 forming sharp apophysis (arrowed in Fig. 15C). P4 endopod with naked inner seta.

P5 (Fig. 13E) baseoendopod confluent with somite, and spinules along posterior margin. Endopodal lobe armed with 2 pectinate, and 2 naked setae. Exopod completely fused with baseoendopod, and with 5 elements (4 bipinnate, and 1 naked setae, and outer most one smallest).

P6 (Fig. 13F) asymmetrical, only right flap operational, and with 3 bipinnate setae (medial one longest).

***Nannopus serratus* sp. nov.**
(Figs. 16–22)

Type locality. Intertidal mudflat, Gilsang-myeon, Ganghwa Island, South Korea, Yellow Sea, 37°35'55.9"N 126°30'49.2"E (Fig. 1A, B).

Type material. Holotype: 1 female in 70% ethanol (NIBRIV0000753985). Allotype: 1 male in 70% ethanol (NIBRIV0000810841). Paratypes: 2 females dissected on 5 and 2 slides (NIBRIV0000810838 – 39), 2 males dissected on 1 and 1 slides (NIBRIV0000810842 – 43); 2 females and 1 male on SEM stub (NIBRIV0000810840). All samples were collected by Vinod Vakati, 20 November 2013.

Etymology. The species epithet is derived from the Latin "serratus" referring to the strong bipinnate spines on the antennary endopod, and outer exopodal spines of P1–P4 in both sexes.

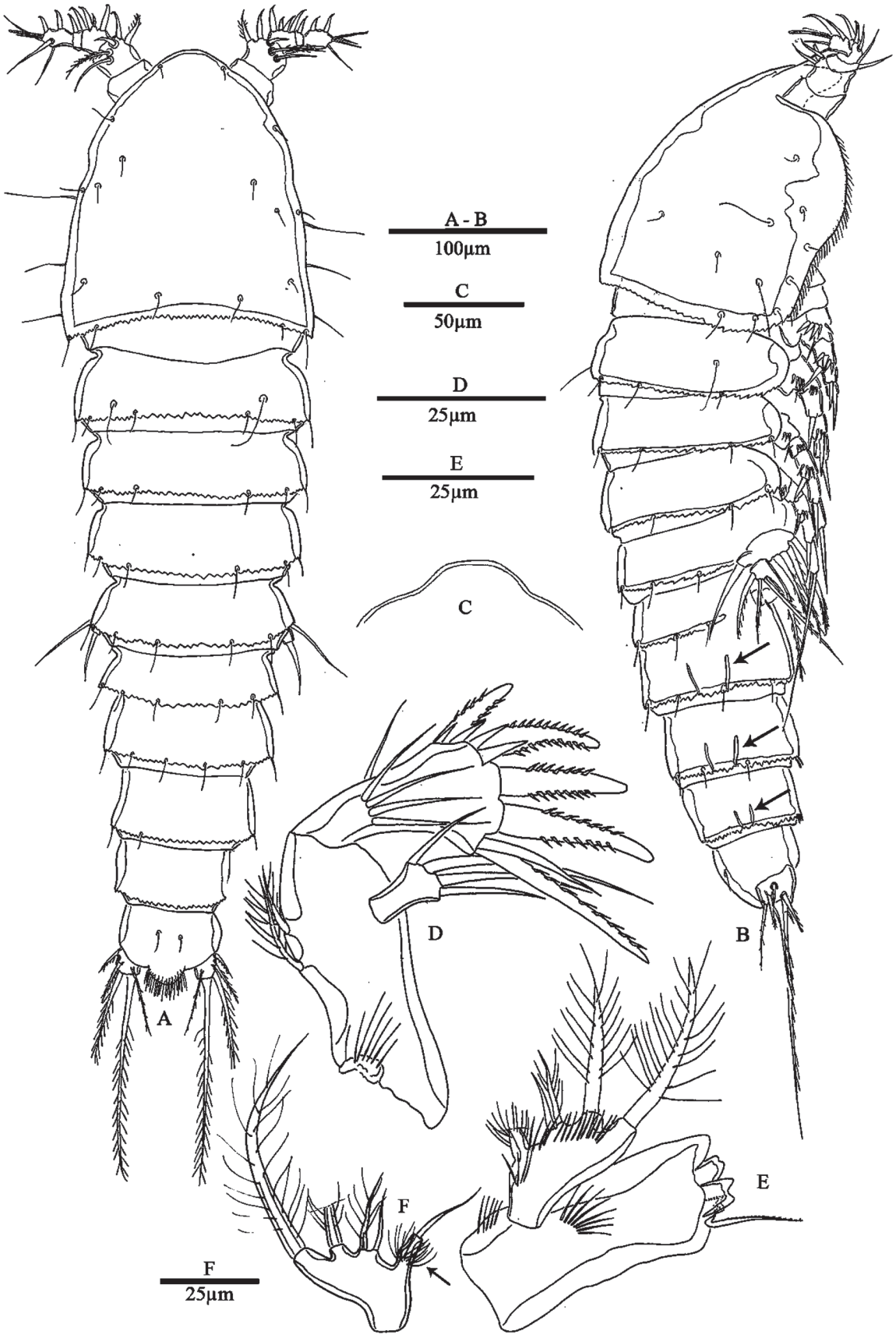

FIGURE 16. *Nannopus serratus* **sp. nov.,** line drawings, A–C, holotype ♀; D–F, paratype ♀2: A, habitus, dorsal; B, habitus (small projection on second, third and fourth urosomites arrowed), lateral; C, rostrum, dorsal; D, antenna; E, left mandible; F, right mandible (posterior side, seta on proximal protrusion arrowed).

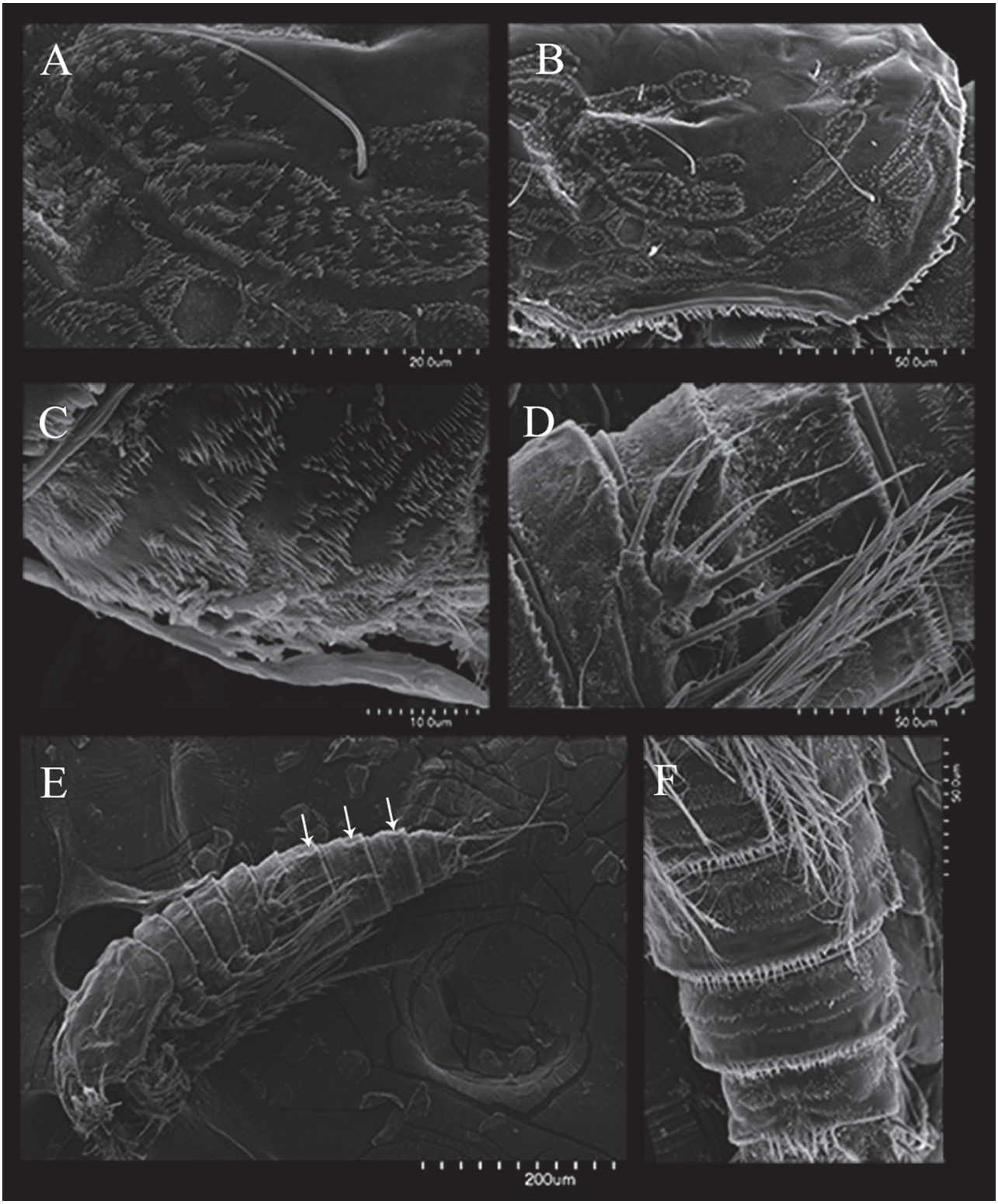

FIGURE 17. *Nannopus serratus* **sp. nov.,** SEM photographs, A–B & D–F, paratype ♀3; C, paratype ♀4: A–B, cephalothorax ornamentation, dorsolateral; C, anal somite, lateral; D, urosomite ornamentation, lateral; E, habitus ornamentation (small projection on second, third and fourth urosomites arrowed), lateral; F, urosomite ornamentation, ventral.

Description of female (based on holotype and paratypes). Body fusiform (Fig. 16A, B) narrow, total body length ranged from 556 to 566 µm (mean = 562 µm, n = 3; holotype: 566 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 166 to 173 µm (mean 169 µm, n = 3; holotype: 166 µm, measured at posterior margin of cephalothorax). Body slightly slender, tapering towards posterior, and inner

cuticle relatively thicker. Urosome/prosome length ratio 0.73 (Fig. 16A) and body length/width ratio about 3.4. Body ornamentation (Figs. 17A–F, 19A–D) almost as in *N. minutus* except for denticles arranged in unique pattern of patches on cephalothorax and anal somite. Each urosomite with rows of slim setules ventrally (Fig. 17F). Cephalothorax (Fig. 16A) bell shaped, slightly narrow, 0.8 times as wide as long, comprising 31% of total body length, with several paired sensilla, and serrated posterior margin.

Rostrum (Fig. 16B, C) prominent, deeply recurved downward than in *N. minutus*, anterior margin densely hirsute, and with 1 pair of dorsal sensilla (not visible in dorsal view).

Prosome (Fig. 16A, B) 4-segmented, comprising cephalothorax and 3 subequal free pedigerous somites. P2-bearing somite with 2 long medial sensilla dorsally, posterior margins of prosomites serrated, and with few sensilla as figured.

Urosome (Figs. 16A, B, 17E, 20A) 5-segmented, comprising P5-bearing somite, genital double-somite, 2 free abdominal somites and anal somite. Posterior margins of urosomites serrated dorsally and ventrally. Posterior margin of genital double-somite and following somite with pair of strong sensilla ventrally (arrowed in Fig 20A). Each somite with transverse row of spinules along posterior margin ventrally. Lateral margin of second to fourth urosomites with small projection (Figs. 16B, arrowed in 17E).

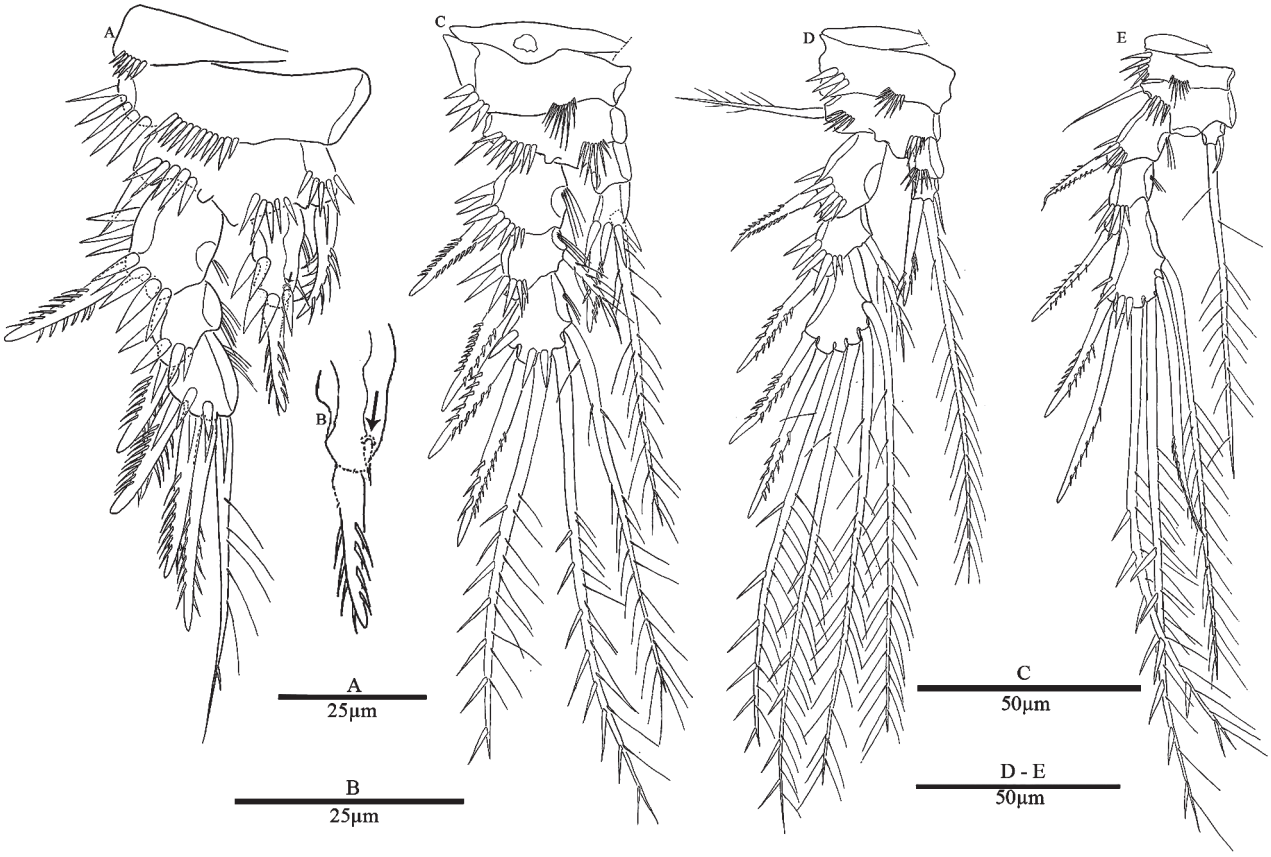

FIGURE 18. *Nannopus serratus* **sp. nov.,** line drawings, paratype ♀1: A, P1; B, P1 endopod in enlarged view (small seta on posterior surface of endopodal segment arrowed); C**,** P2; D, P3; E, P4.

Genital double-somite (Fig. 20A) 1.6 times as wide as long, completely fused ventrally, clearly distinct dorsally, with serrated dorsal posterior margin, copulatory pore located between both P6, and with slight median depression.

Anal somite (Figs. 19A–D, 20A, C) almost as long as width with unique pattern of surface ornamentation dorsally and ventrally.

Caudal rami (Figs. 19A–D, 20A–C) square (dorsally) or sub-cylindrical (ventrally) shaped, as long as wide (in dorsal view), twice as long as wide (in ventral view), and with row of spinules along posteroventral margins. Caudal ramus bearing 7 setae: seta I pinnate, shorter than ramus width, and located anterolaterally; seta II pinnate, almost as long as ramus length, and inserted anterolaterally midway along outer margin; seta III pinnate, as long as

ramus length, and inserted anterolaterally midway along outer margin; seta IV slender, bipinnate, 0.4 times as long as seta V, located at outer posterior margin, and wide at proximal region; seta V strongest, bipinnate with proximal part rather wide and smooth, and located at inner posterior margin; seta VI pinnate, small, and located at inner posterior corner; seta VII slender, flexible, triarticulate, pinnate, located midway along inner margin, and relatively longer than in *N. minutus*.

Antennule, maxillule, maxilla, and maxilliped as in *N. minutus*.

Antenna (Fig. 16D) same as in *N. minutus* except for endopod with few spinules at outer distal corner, spines rigid and blunt than in *N. minutus*. All distal spines denticulated except for inner subdistal spine. Exopod 1.3 times as long as width, and with 4 naked elements.

Mandible (Fig.16E) same as in *N. minutus* except for mandibular palp with 1 basal (pinnate), 1 endopodal (naked seta arising from stem like protrusion), and 3 exopodal elements (2 pinnate and 1 naked).

P1–P4 (Fig. 18A–E) with smooth and short concave intercoxal sclerite (not illustrated). Praecoxa somewhat triangular and shorter than coxa, distal margin smooth (P2, P3 and P4) or ornamented with 1 row of spinules (P1). Coxa with 1 spinular row on anterior surface and with 1 row of strong outer spinules. Basis with 1 row of strong outer spinules near insertion of exopod, and 1 row of distal spinules near insertion of endopod except for P4. P1 with row of distal spinules near insertion of inner spine. Basal outer seta naked (P1, P2 and P4) or bipinnate (P3), and inner pinnate spine present on P1. Exopod 3-segmented, and all segments subequal in length. Each exopodal segment with robust outer spinules except for P3 exp-3. Exp-1 to -3 (P1 and P2) and exp-1 to -2 (P4) with row of inner setules. P2 and P3 exp-2 with pinnate inner setae. Exp-3 (P1, P2, P3 and P4) with pinnate inner subdistal, distal, and outer terminal setae. P4 exp-3 with 1 inner subdistal pectinate seta. Endopod 1-segmented in P1 and P4 or 2-segmented in P2 and P3. P1 endopod, P2 enp-2 and P3 enp-1 with robust outer distal spinules. P1 endopod with inner setules. All endopodal setae on P1–P4 pinnate except for naked inner short seta on P4 endopod (Fig. 18E). Armature formula as follows:

	Exopod	Endopod
P1	0.0.022	110
P2	0.1.212	0.110
P3	0.1.222	0.111
P4	0.0.222	110

P5 (Fig. 20D) with separate baseoendopod and exopod. Baseoendopod transversely elongated, confluent with somite, almost rectangular, and scattered setules along anterior surface. Endopodal lobe with 1 pectinate and 2 bipinnate setae. Exopod squarish, almost as long as width, and with rows of setules and 4 pinnate setae (innermost element longest, strongest, bipinnate and fused to exopod).

P6 (Fig. 20A, E) linguiform and outer distal edge bearing 1 pinnate seta.

Description of male (based on allotype and paratypes). Body (Fig. 21A) as in female except for total body length ranged from 492 to 594 µm (mean = 538 µm, n = 2; allotype: 528 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 163 to 178 µm (mean 171 µm, n = 2; allotype: 172 µm, measured at posterior margin of cephalothorax). Urosome/prosome length ratio 0.86 (Fig. 21A) and body length/width ratio about 3.7. Cephalothorax (Fig. 21A) as in female except for 1.1 times as long as wide and comprising 30.7% of total body length. Body ornamentation (not illustrated), anal somite (Fig. 21A), caudal rami (Fig. 21A–D), rostrum (not illustrated), antenna (not illustrated), mandible (not illustrated), P1 and P4 (not illustrated) as in female. Antennule (not illustrated) as in male *N. minutus* and remaining mouth parts (not illustrated) as in *N. minutus*.

Prosome 4-segmented (Fig. 21A), comprising cephalothorax (bearing first pedigerous somite), and 3 free somites. Posterior margin of prosomites serrated and with sensilla as in female except for second prosomite without long sensilla.

Urosome 6-segmented (Fig. 21A, B), comprising P5-bearing somite, genital somite, 3 free abdominal somites, and anal somite. Posterior margin of urosomites serrated except for anal somite, and with sensilla as in female. Urosomite 3 to 5 with longitudinal row of spinules along posterior ventral margin.

Genital somite (Fig. 21B) homologous to anterior part of genital double-somite in female, and second and third urosomites clearly segmented ventrally.

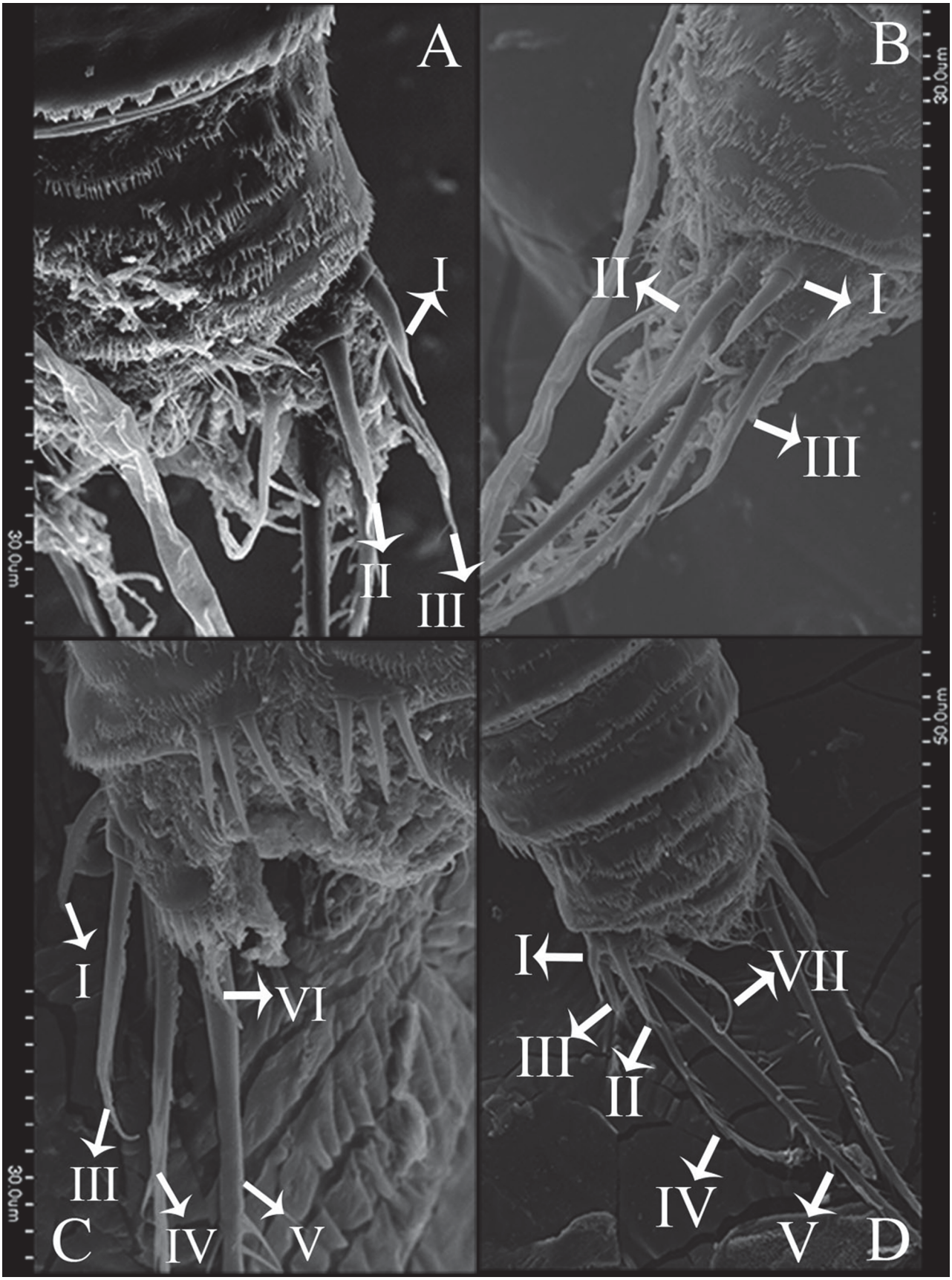

FIGURE 19. *Nannopus serratus* **sp. nov.,** SEM photographs, A–C, paratype ♀4; D, paratype ♂3: A, anal somite and caudal ramus, dorsal; B, anal somite and caudal ramus, lateral C, anal somite and caudal ramus, ventral; D, anal somite and caudal rami, dorsal.

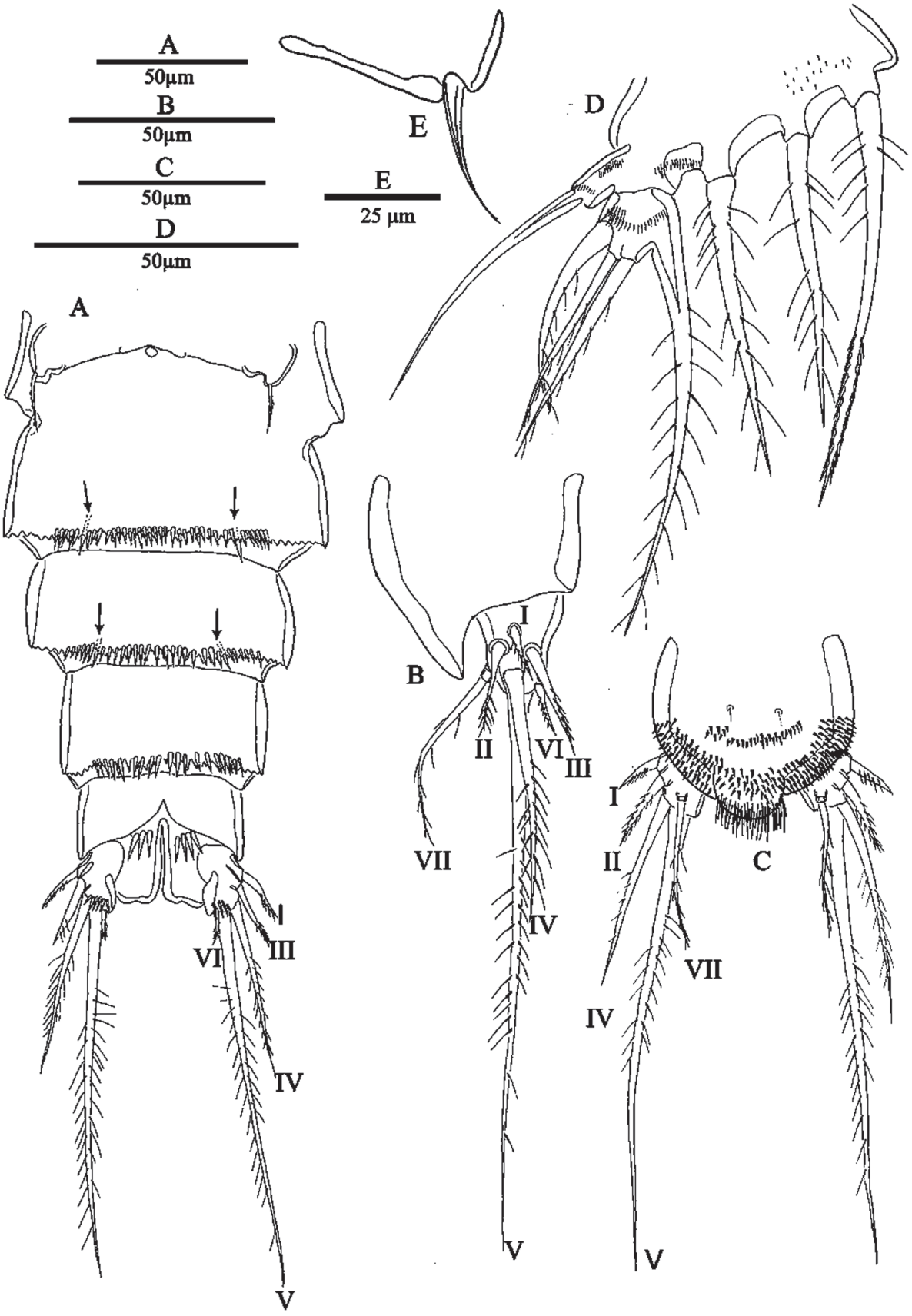

FIGURE 20. *Nannopus serratus* **sp. nov.,** line drawings, paratype ♀1: A, urosome, P5-bearing somite omitted (pair of strong sensilla on second and third urosomites arrowed) and caudal rami, ventral; B, anal somite and caudal ramus, lateral; C, anal somite and caudal rami, dorsal; D, P5; E, left P6.

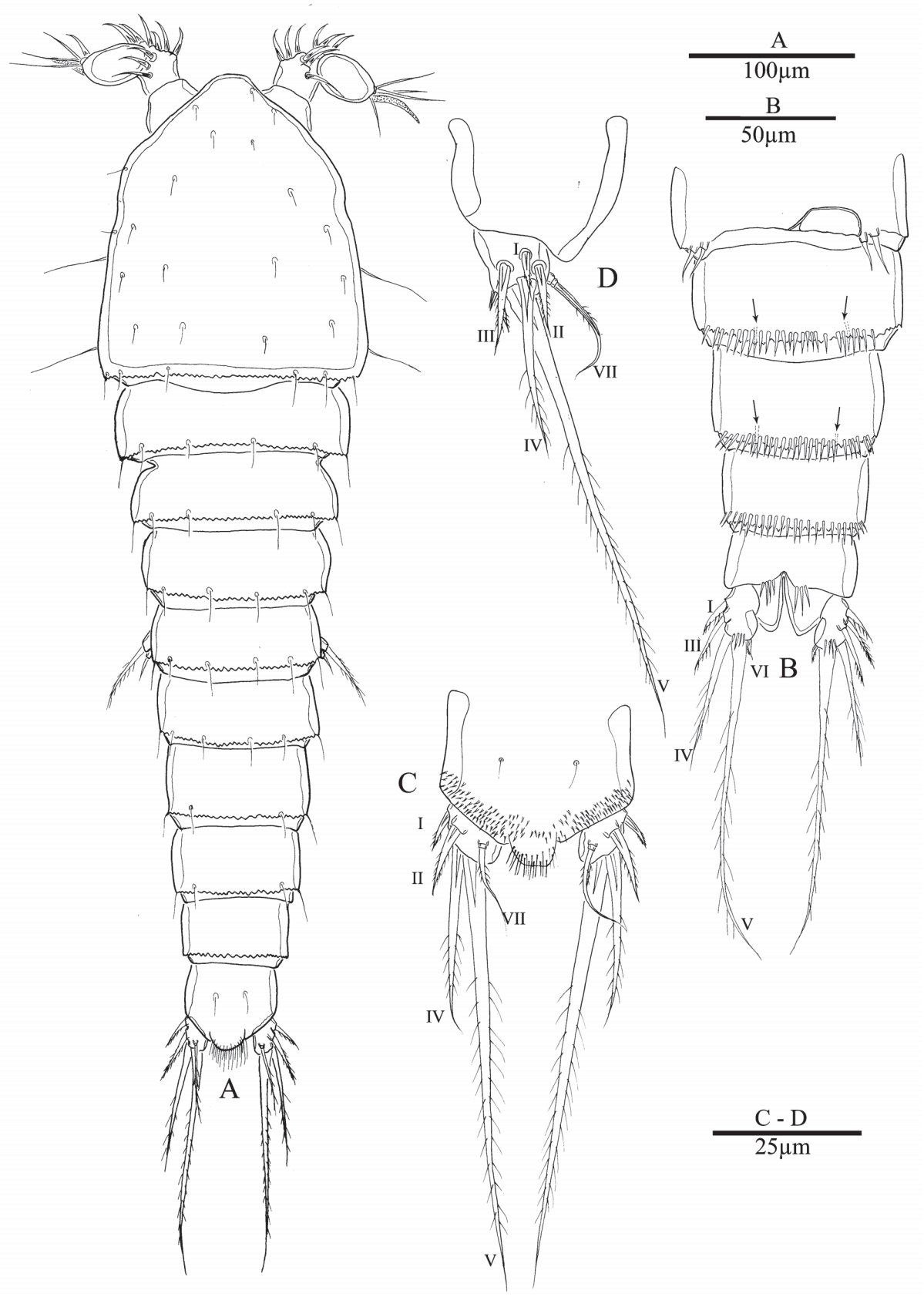

FIGURE 21. *Nannopus serratus* **sp. nov.,** line drawings, A, allotype ♂; B–D, paratype ♂1: A, habitus, dorsal; B, urosome, P5-bearing somite and caudal rami, ventral (pair of strong sensilla on third and fourth urosomites arrowed); C, anal somite and caudal rami, dorsal; D, anal somite and caudal ramus, lateral.

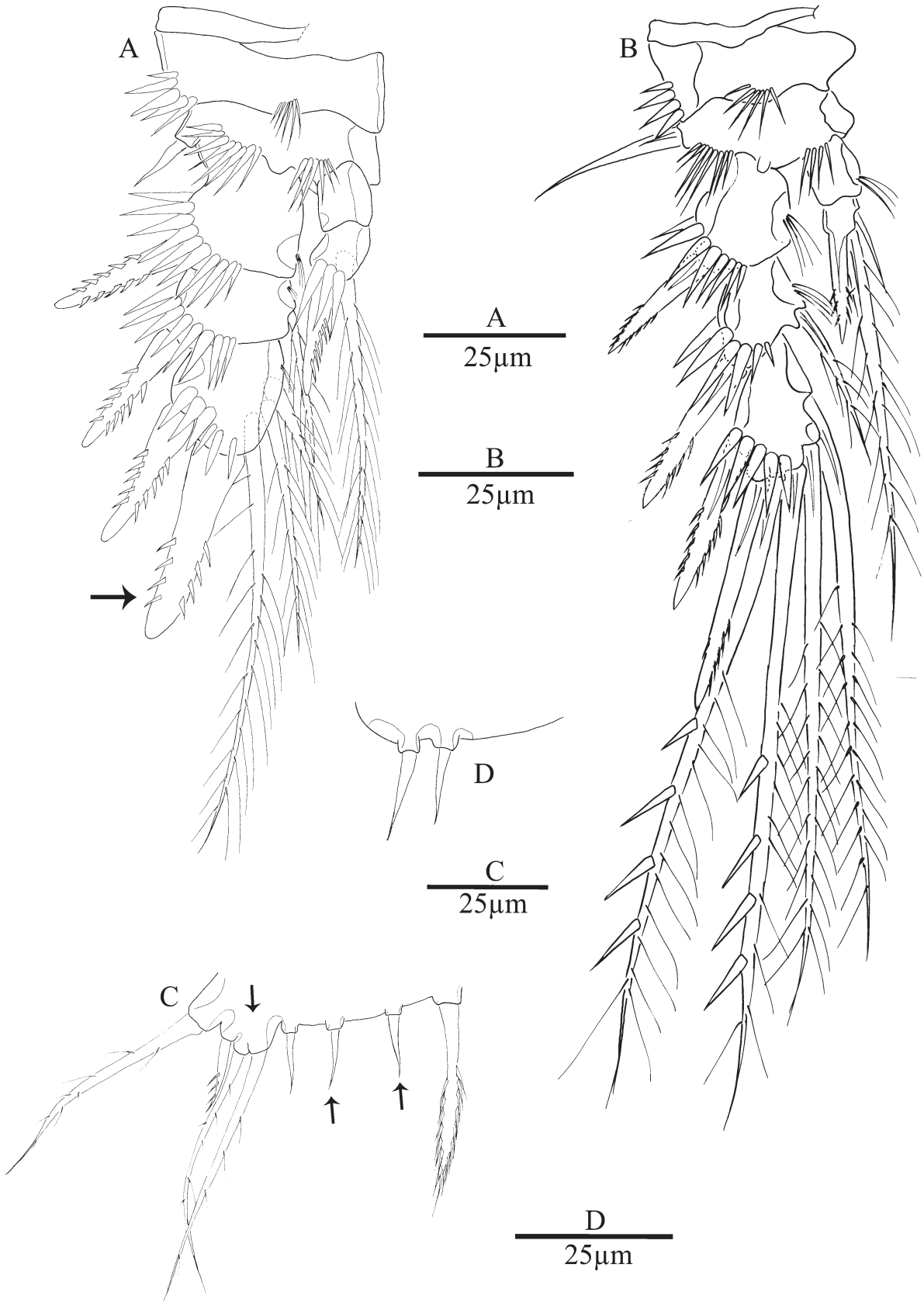

FIGURE 22. *Nannopus serratus* **sp. nov.,** line drawings, A & C–D, paratype ♂1; B, paratype ♂2: A, P2 (sexually dimorphic spine arrowed); B, P3; C, P5 (sexual dimorphisms arrowed); D, P6.

P2–P3 (Fig. 22A, B) with smooth and short concave intercoxal sclerite (not illustrated). Exopod 3-segmented. P2 exopod more robust than in female and P2 exp-3 outer spines stronger than in female (arrowed in Fig. 22A). P3 exopod as in female except for exp-3 with outer spinules. P3 enp-1 without outer spinules. P3 enp-2 modified with outer spine fused to segment forming bipinnate apophysis, 1 short naked inner, and 1 long pinnate distal setae.

P5 (Fig. 22C) baseoendopod confluent with somite. Endopod with 1 pectinate and 2 naked setae (arrowed in Fig. 22C). Exopod fused with baseoendopod bearing 4 elements (3 pinnate and 1 naked), and 2 medial setae subequal in length (arrowed in Fig. 22C).

P6 (Figs. 21B, 22D) asymmetrical with simple operational flap at left side and each flap with 2 short naked setae.

Nannopus parvus sp. nov.

(Figs. 23–31)

Type locality. Intertidal mudflat, Yangdo-myeon, Ganghwa Island, South Korea, Yellow Sea, 37°40'08.4"N 126°24'20.9"E (Fig. 1A, B).

Type material. Holotype: 1 female adult in 70% ethanol (NIBRIV0000753986). Allotype: 1 male adult in 70% ethanol (NIBRIV0000810848). Paratypes: 3 females dissected on 6, 3 and 2 slides (NIBRIV0000810844 – 46), and 1 male dissected on 4 slides (NIBRIV0000810849); 3 females and 3 males together on SEM stub (NIBRIV0000810847). All samples were collected from the type locality by Vinod Vakati, 5 March 2015.

Etymology. The species epithet is derived from the Latin “parvus” referring to the small caudal seta V in both sexes.

Description of female (based on holotype and paratypes). Body fusiform (Fig. 23A, B), total length ranged from 404 to 416 µm (mean = 428 µm, n = 4; holotype: 404 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 136 to 168 µm (mean = 151 µm, n = 4; holotype: 145 µm, measured at posterior margin of cephalothorax). Boundary between prosome and urosome clearly visible, urosome/prosome length ratio 0.7 and body length/width ratio about 2.7. Body ornamentation (Fig. 23A, B, 24A–D, 26C, 27A, B) consisting of dorsal denticles, and 2 to 3 transverse rows of denticles in unique pattern. P2-bearing somite with 1 transverse row of frill anteriorly. Urosomites with horizontal row of setules ventrally (Fig. 27A). Anal somite with 1 or 2 horizontal row of setules (Figs. 23A). Cephalothorax (Fig. 23A) bell shaped, almost as long as wide, comprising 35.4% of total body length, with few paired sensilla, and posterior margin serrated.

Rostrum (Fig. 23B, C) triangular with round tip, with pair of dorsal sensilla, recurved downward as in *N. minutus*, and terminal margin densely hirsute.

Prosome (Fig. 23A, B) 4-segmented, comprising cephalothorax and 3 subequal free pedigerous somites. P1-bearing somite fused to cephalothorax, pedigerous somites serrated, and row of sensilla posteriorly. P2-bearing somite with pair of very long sensilla.

Urosome (Figs. 23A, B, 26C) 5-segmented, posteriorly tapering, comprising P5-bearing somite, genital double-somite, 2 free abdominal somites, and anal somite. Posterior margins serrated dorsally and ventrally. Each somite with row of sensilla along dorsal posterior margin except for penultimate somite, and row of spinules along ventral posterior margin.

Genital double somite (Figs. 23B, 26C) 2.2 times wider than long, with original segmentation indicated by transverse, serrated surface ridge dorsally, and completely fused ventrally. Copulatory pore located medially, and with obscure shape.

Anal somite (Figs. 23A, 26A) twice wider than long, with well-developed anal operculum presenting dense carpet of setules along posterior margin, and pair of dorsal sensilla.

Caudal rami (Figs. 26A–C, 27A, B) trapezoidal or square shaped (ventral view), 1.2 to 1.3 times as long as width, with 1 medial spinular row at midway of outer margin laterally and ventrally, and distal spinular row dorsally and ventrally. Caudal ramus bearing 7 setae: seta I naked, shorter than ramus width, and located anterolaterally; seta II naked, almost as long as ramus width, and located dorsolaterally at midway along outer margin; seta III bipinnate, almost as long as ramus length, and located posterolaterally; seta IV bipinnate, stout, 0.2 times as long as seta V, and located at outer posterior margin; seta V strongest, bipinnate, with anterior part rather wide and smooth, located at inner posterior margin, and spine-shaped; seta VI bipinnate and almost as long as seta I; seta VII biarticulate, pinnate, and located at midway along dorsal side.

Antennule (Figs. 25A) almost as in *N. minutus* except for segments 2 and 4 presenting cluster of tiny setules. Segment 2 with 5 pinnate setae (2 setae proximally bulbiform, arrowed in Fig. 25A). Armature formula: 1-[1], 2-[4 + 5 pinnate], 3-[6+ (1 + ae)], 4-[1], 5-[8 + acrothek].

Antenna (Fig. 25B) almost as in *N. minutus* except for abexopodal setae ornamentation (1 pinnate and 1 naked).

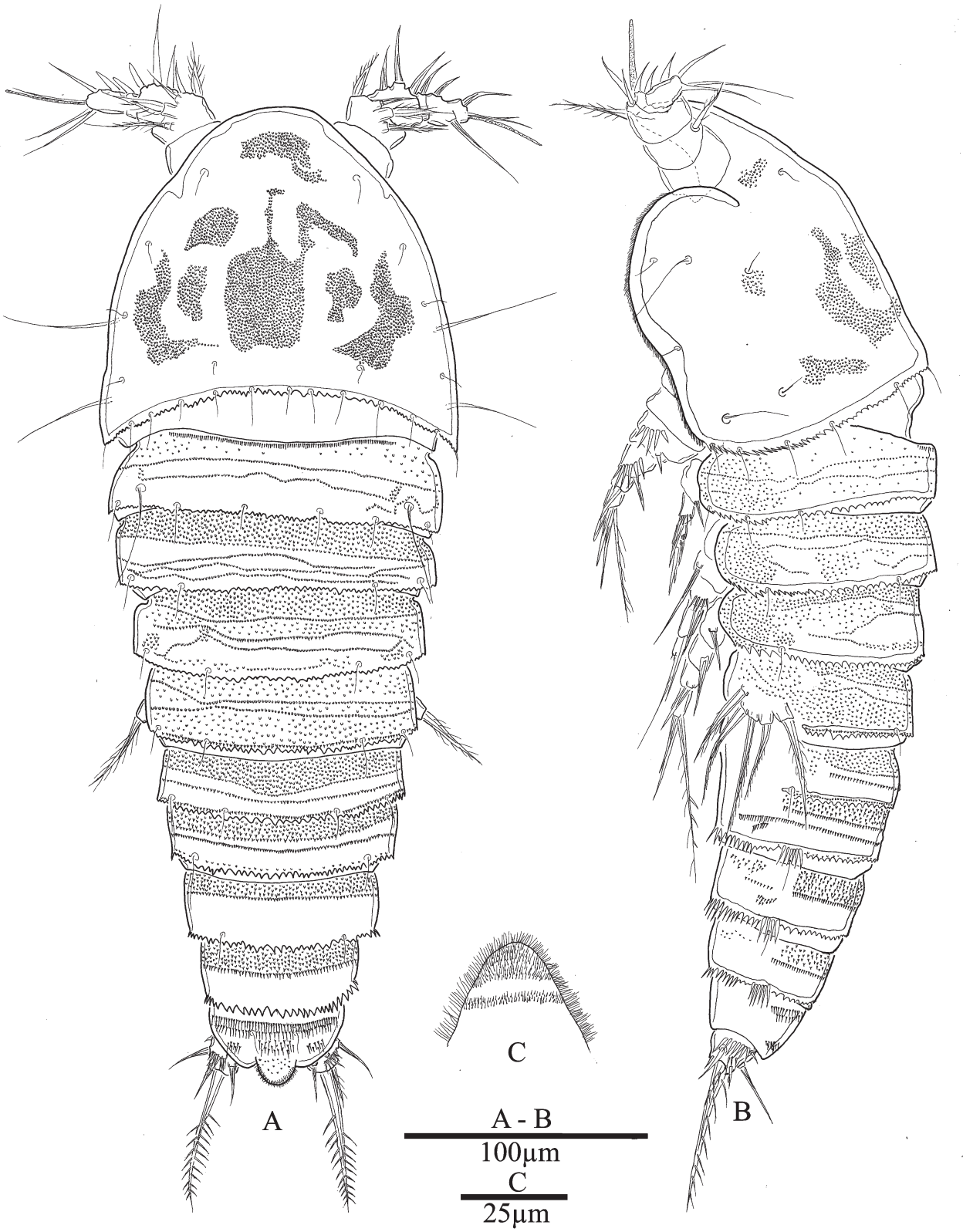

FIGURE 23. *Nannopus parvus* **sp. nov.,** line drawings, holotype ♀: A, habitus, dorsal; B, habitus, lateral; C, rostrum, dorsal.

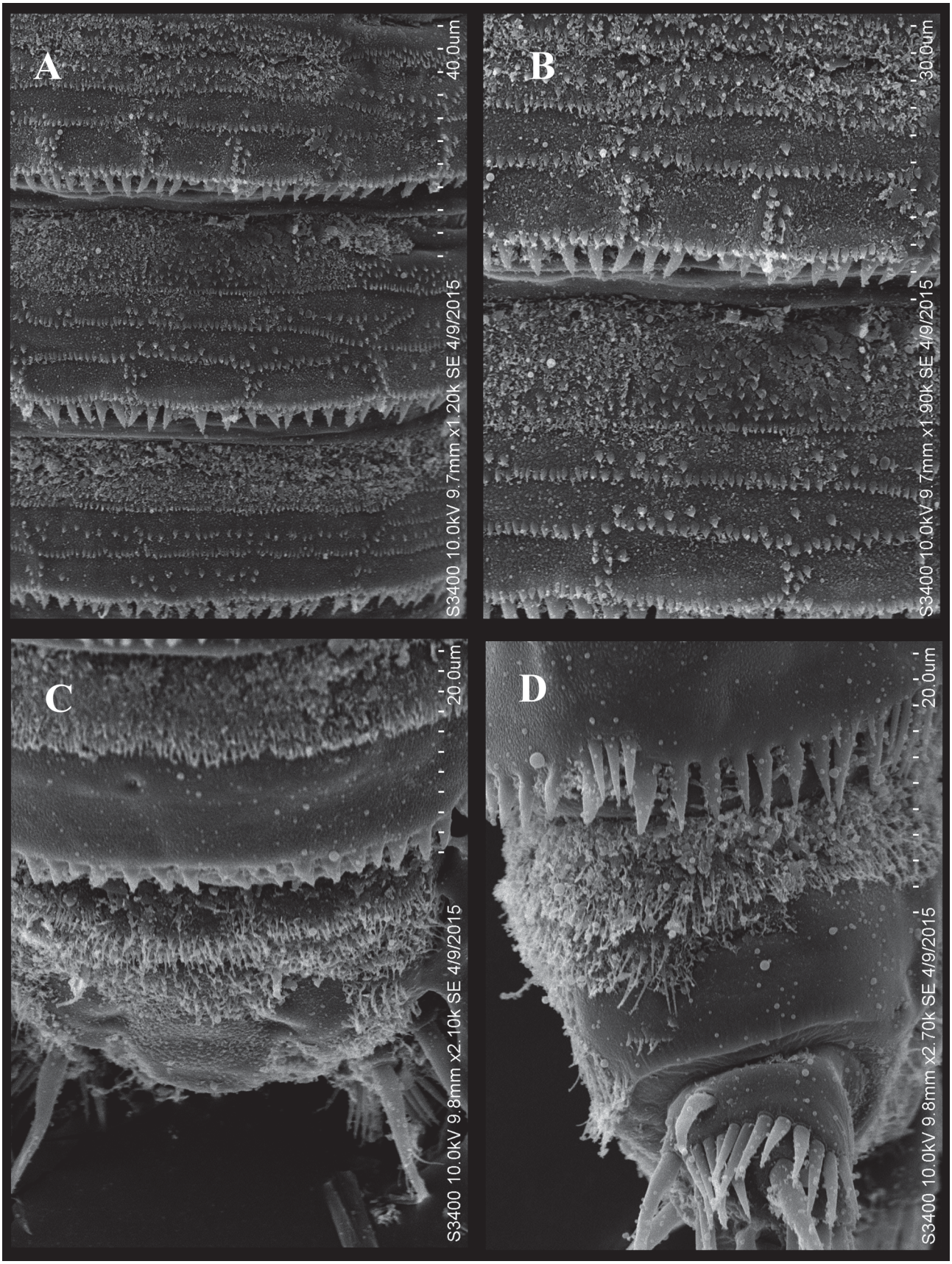

FIGURE 24. *Nannopus parvus* **sp. nov.,** SEM photographs, A–C, paratype ♀4; D, paratype ♀5: A–B, prosomites surface ornamentation, dorsal; C, penultimate and anal somite surface ornamentation, dorsal; D, penultimate and anal somite surface ornamentation, lateral.

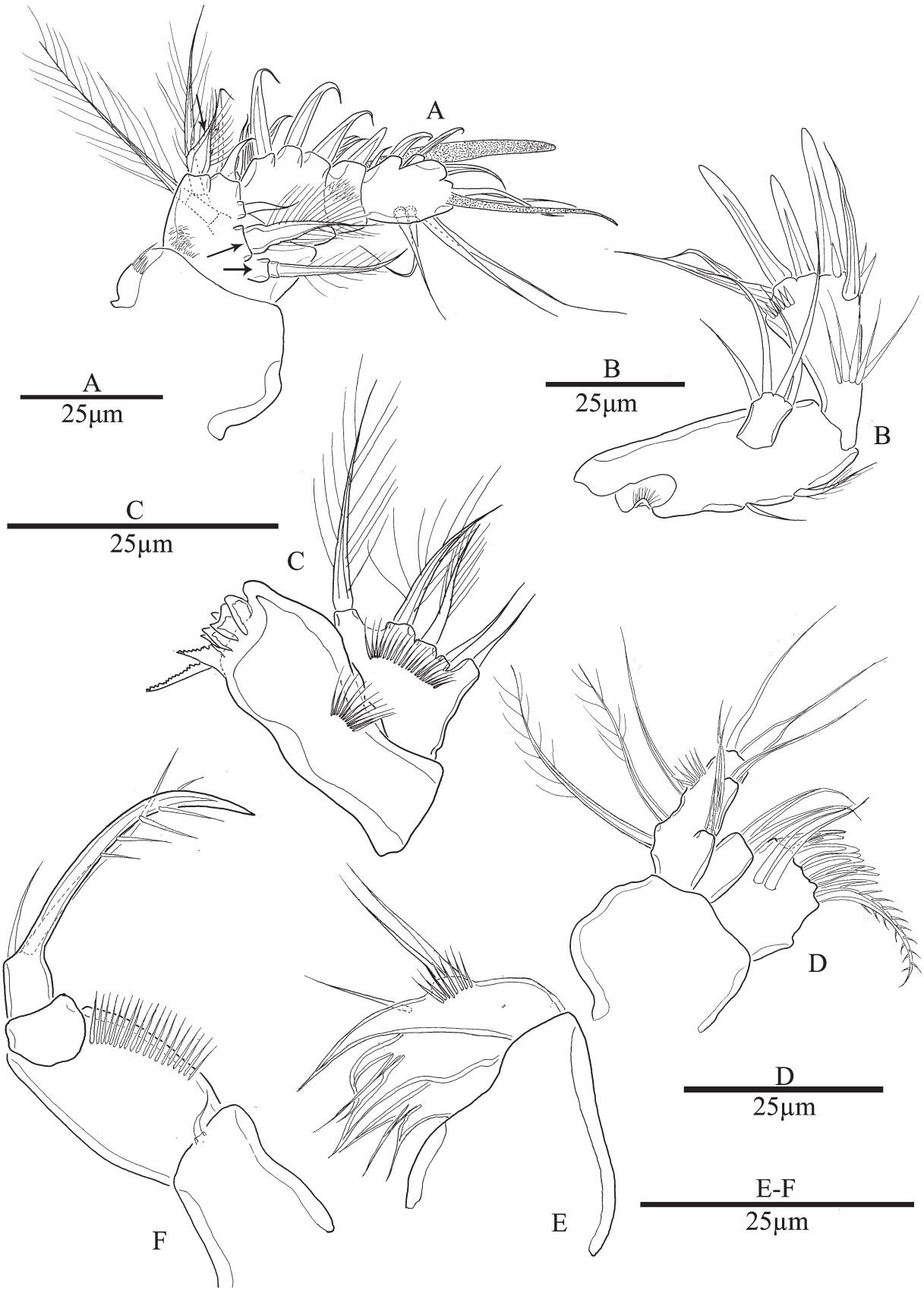

FIGURE 25. *Nannopus parvus* **sp. nov.,** line drawings, A–B, paratype ♀1; C, paratype ♀3; D–F, paratype ♀2: A, antennule (triarticulate seta and two bulbiform setae on second segment arrowed), dorsal; B, antenna; C, mandible; D, maxillule; E, maxilla; F, maxilliped.

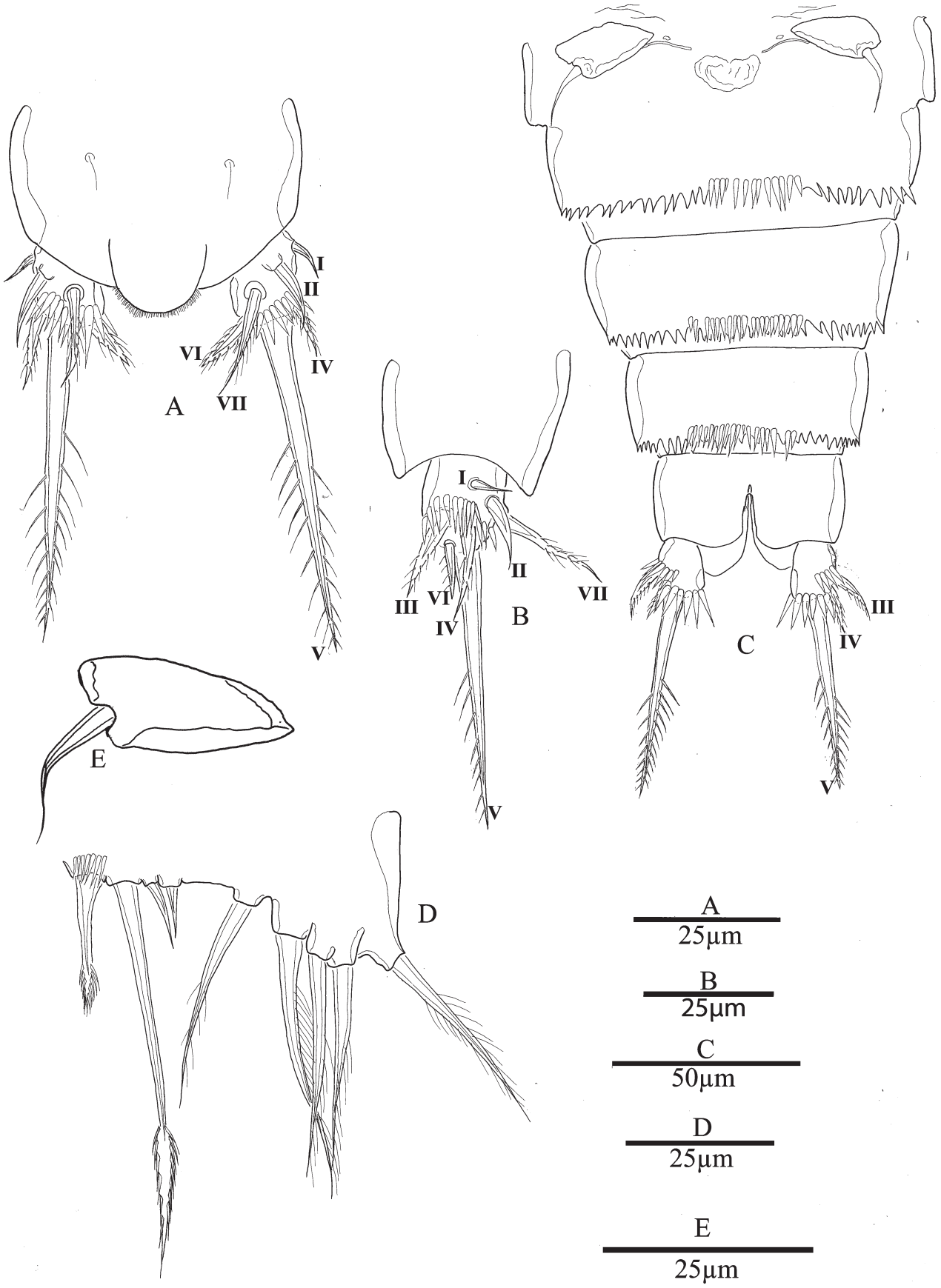

FIGURE 26. *Nannopus parvus* **sp. nov.,** line drawings, paratype ♀1: A, anal somite and caudal rami, dorsal; B, anal somite and caudal ramus, lateral; C, urosome, P5-bearing somite omitted and caudal rami, ventral; D, P5; E, right P6.

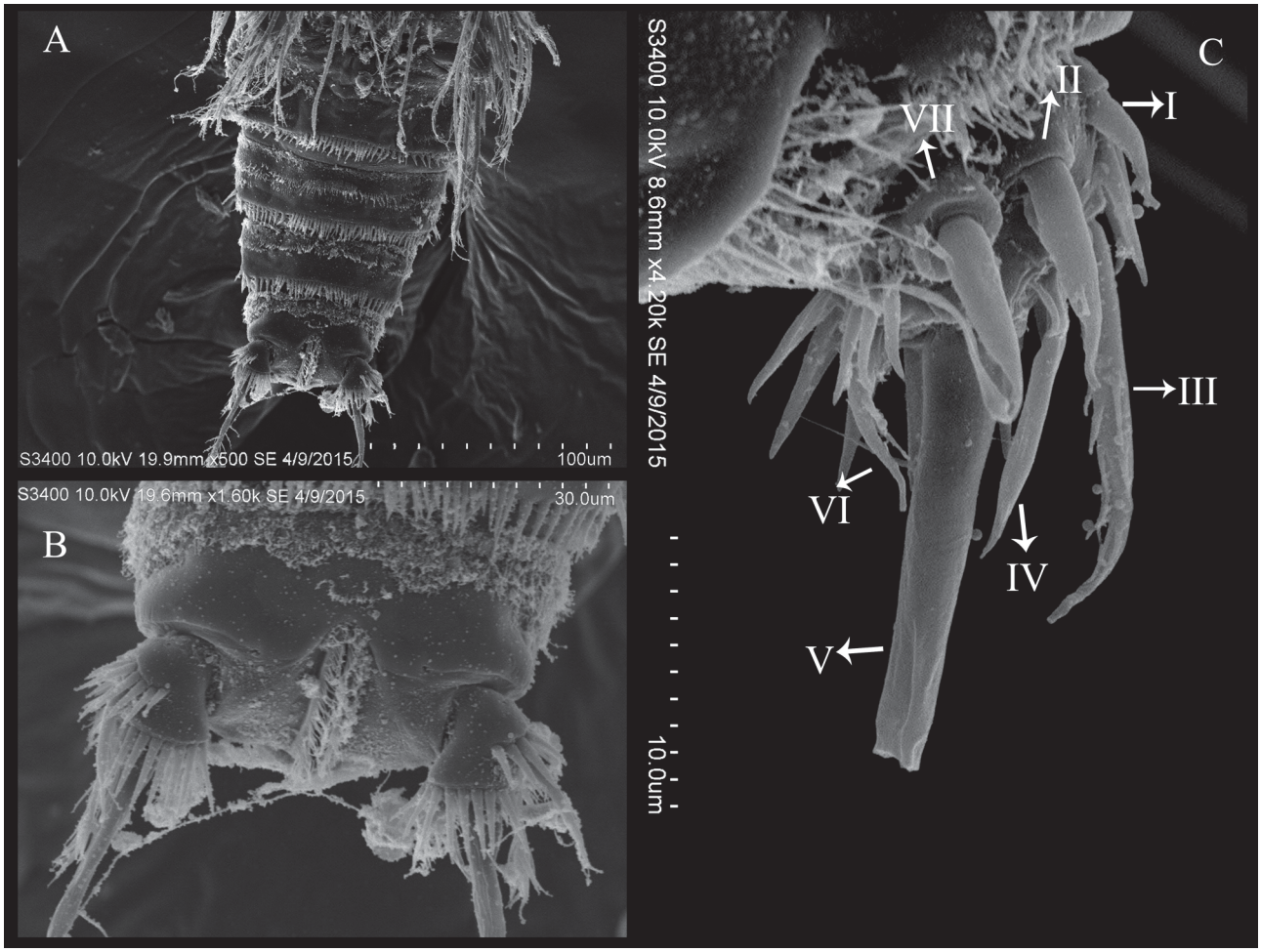

FIGURE 27. *Nannopus parvus* **sp. nov.,** SEM photographs, A–B, paratype ♀6; C, paratype ♂2: A, copulatory pore and urosome ornamentations, ventral; B, caudal rami, ventral; C, caudal ramus, dorsal.

Mandible (Fig. 25C) almost as in *N. minutus* except for mandibular palp size (relatively broad), with 5 setae [1 basal (pinnate), 3 exopodal (2 pinnate and 1 naked), and 1 endopodal (naked)].

Maxillule (Fig. 25D) almost as in *N. minutus* except for total number of elements along distal margin of praecoxal arthrite (8 stout naked spines/setae and 1 bipinnate seta). Ornamentation of 5 basal setae naked.

Maxilla (Fig. 25E) almost as in *N. minutus* except for elements of syncoxal endites without spinular ornamentation at distal margin.

Maxilliped (Fig. 25F) almost as in *N. minutus* except for length of 1 accessory seta (reaching to distal margin of claw) at proximal region of distal endopod segment.

P1–P4 (Fig. 28A–D) with smooth and short concave intercoxal sclerite (not illustrated). Praecoxa somewhat triangular, shorter than coxa, and without spinules except for P1. Coxa with 1 spinular row (P2, P3 and P4) on anterior surface, and row of strong outer spinules (P1, P2, P3 and P4). Basis with row of strong outer spinules near insertion of exopod, and row of very small (P1) and long distal spinules (P1, P2, P3 and P4) near insertion of endopod. Additional ornamentations including row of inner spinules (P1) or setules (P2 and P3). Outer seta naked (P1 and P2) or bipinnate (P3 and P4), and inner spine present on P1. Exopod 3-segmented, all segments subequal, and exp-1 to -3 (P1, P2, P3 and P4) with robust outer spinules. Exp-1 to -3 (P1 and P3), and exp-1 to -2 (P4) with row of inner setules. Exp-1 to -3 (P1, P2 and P3) and exp-2 to -3 (P4) with pinnate outer spines. Exp-2 (P2, P3 and P4), and exp-3 (P1, P2, P3 and P4) with pinnate inner subdistal, distal and outer terminal setae. P4 exp-3 with short inner subdistal pectinate spine. Endopod 2-segmented in P1–P3 or 1-segmented in P4. Enp-1 to -2 (P1, P2 and P3)

with robust outer distal spinules. Enp-1 to -2 (P1), and enp-2 (P3) with row of inner setules. All setae on P1, P2, P3 and P4 endopods pinnate including inner apical short seta on P4 endopod (Fig. 28D). Armature formula as follows:

	Exopod	Endopod
P1	0.0.022	0.111
P2	0.1.122	0.111
P3	0.1.222	0.111
P4	0.1.222	020

P5 (Fig. 26D) fused with somite, exopod and baseoendopod fused, both baseoendopod confluent, and baseoendopod with inner spinules posteriorly. Endopodal lobe with 2 pectinate (1 short and 1 extremely long), and 2 small sub-equal naked setae. Exopodal lobe with 4 pinnate setae.

P6 (Fig. 26C, E) with small triangular flap, and each flap bearing 1 small distal naked seta. **Description of male (based on allotype and paratypes).** Body (Fig. 29A) as in female except for total body length ranged from 426 to 313 µm (mean = 369 µm, n = 2; allotype: 313 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 132 to 156 µm (mean 144 µm, n = 2; allotype: 132 µm, measured at posterior margin of cephalothorax). Urosome/prosome length ratio 0.6 and body length/width ratio about 3.1. Cephalothorax (Fig. 29A) almost as in female, as long as width, and comprising 31.2% of total body length. Body ornamentation (Fig. 29A), anal somite (Fig. 29A), rostrum (not illustrated), antenna (not illustrated), mouth parts (not illustrated), P1–P2, and P4 (not illustrated) as in female.

Prosome 4-segmented (Fig. 29A), comprising cephalothorax (bearing first pedigerous somite), and 3 free somites. Posterior margin of prosomites serrated, and with sensilla as in female.

Urosome 6-segmented (Fig. 29A, B) comprising of P5-bearing somite, genital somite, 3 free abdominal somites, and anal somite. Posterior margin of urosomites serrated except for anal somite, and with sensilla as in female. Urosomite 3 to 5 with longitudinal row of spinules along ventral posterior margin.

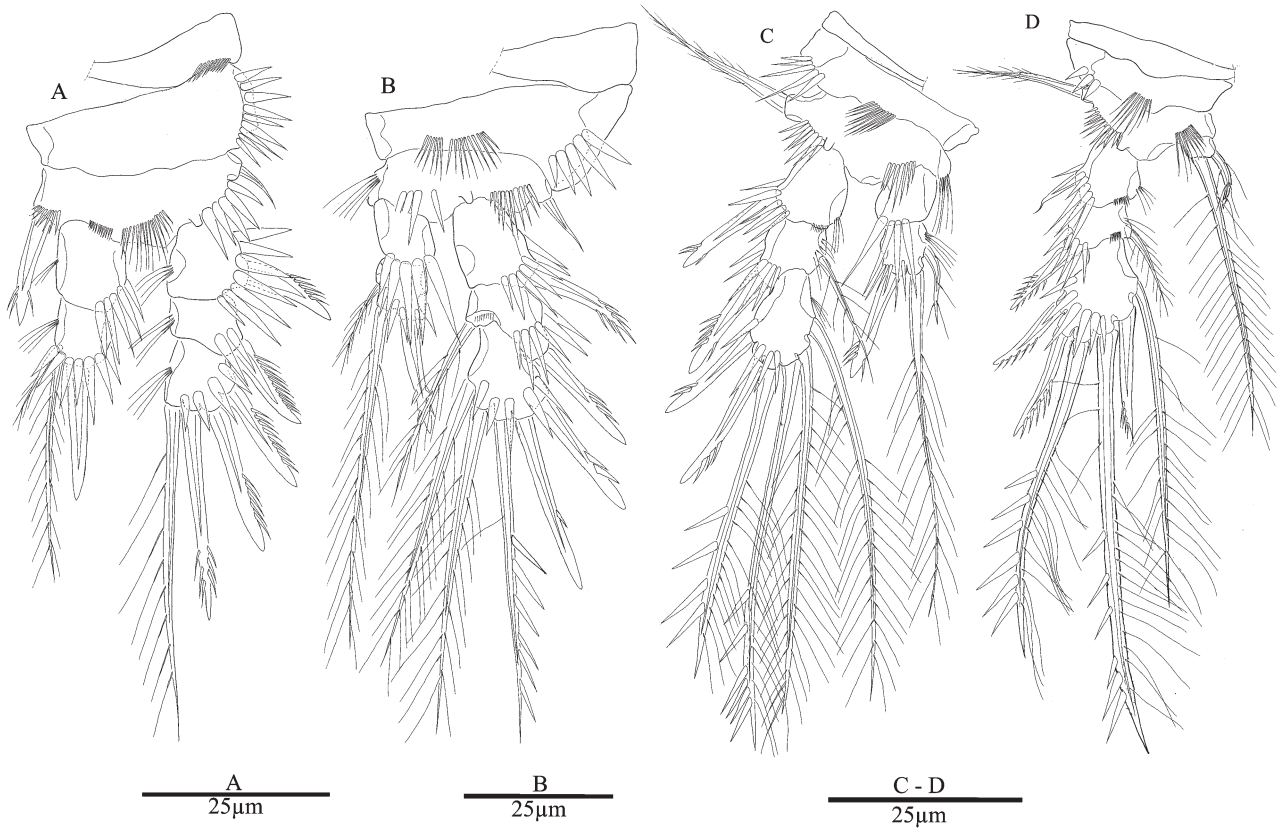

FIGURE 28. *Nannopus parvus* **sp. nov.,** line drawings, A–B & D, paratype ♀1; C, paratype ♀2: A, P1; B, P2; C, P3; D, P4.

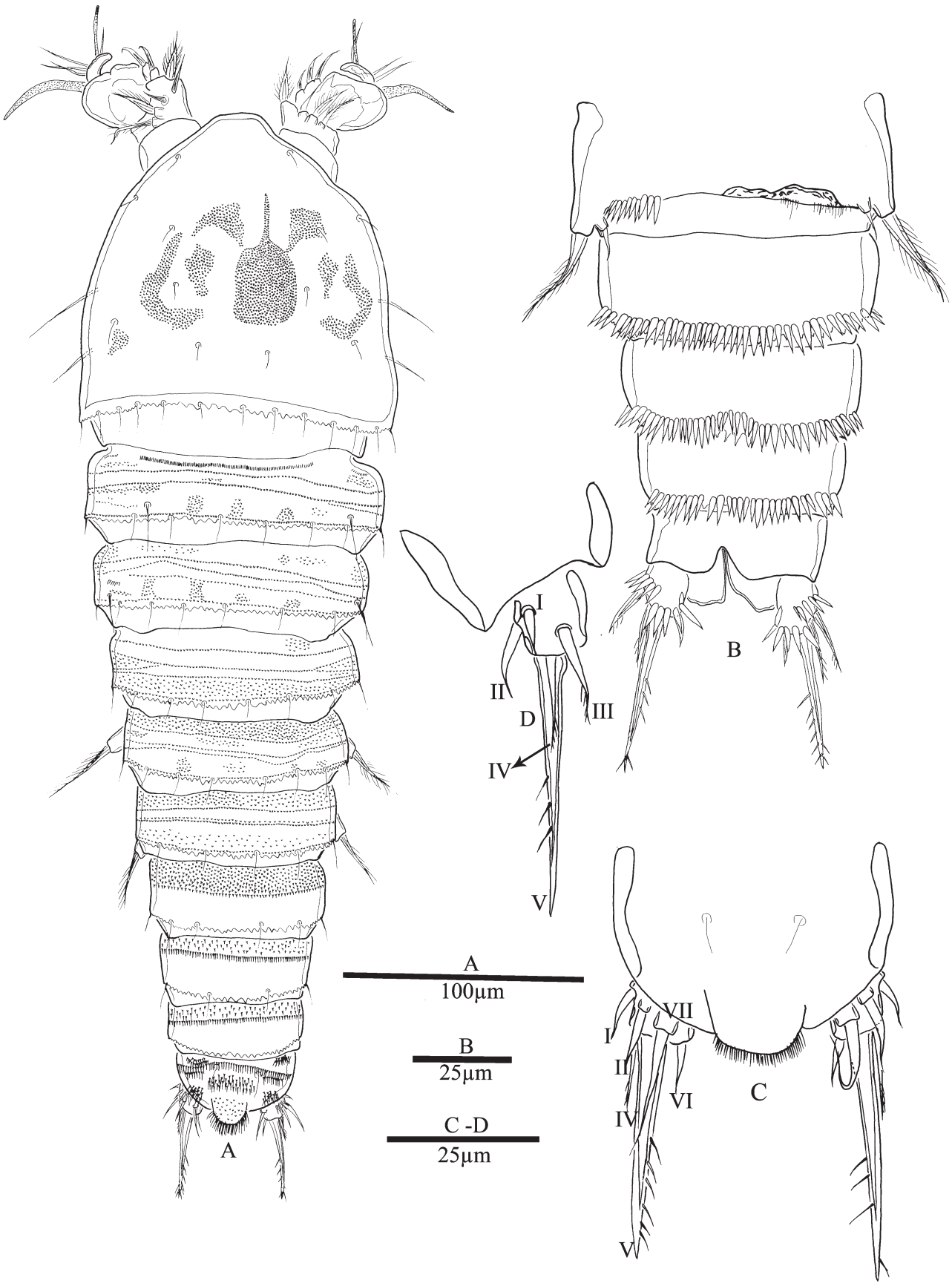

FIGURE 29. *Nannopus parvus* **sp. nov.,** line drawings, A, allotype ♂; B–D, paratype ♂1: A, habitus, dorsal; B, urosome, P5-bearing somite and caudal rami, ventral; C, anal somite and caudal rami, dorsal; D, anal somite and caudal ramus, lateral.

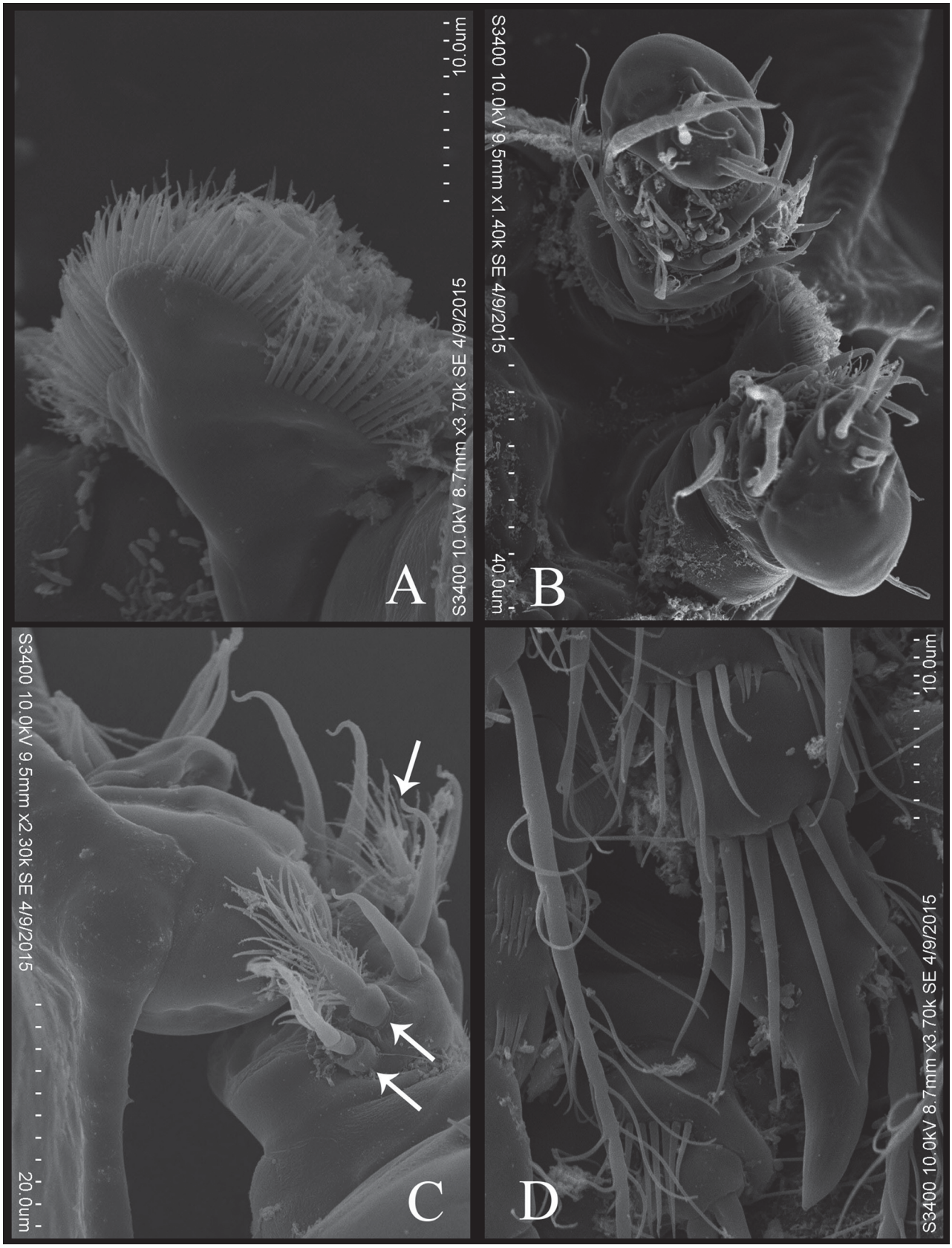

FIGURE 30. *Nannopus parvus* **sp. nov.,** SEM photographs, A, paratype ♂4; B & D, paratype ♂3; C, paratype ♂2: A, rostrum, ventral; B, rostrum, ventral; C, second segment of the antennule (triarticulate seta and two bulbiform seta arrowed), dorsal; D, P3 endopod.

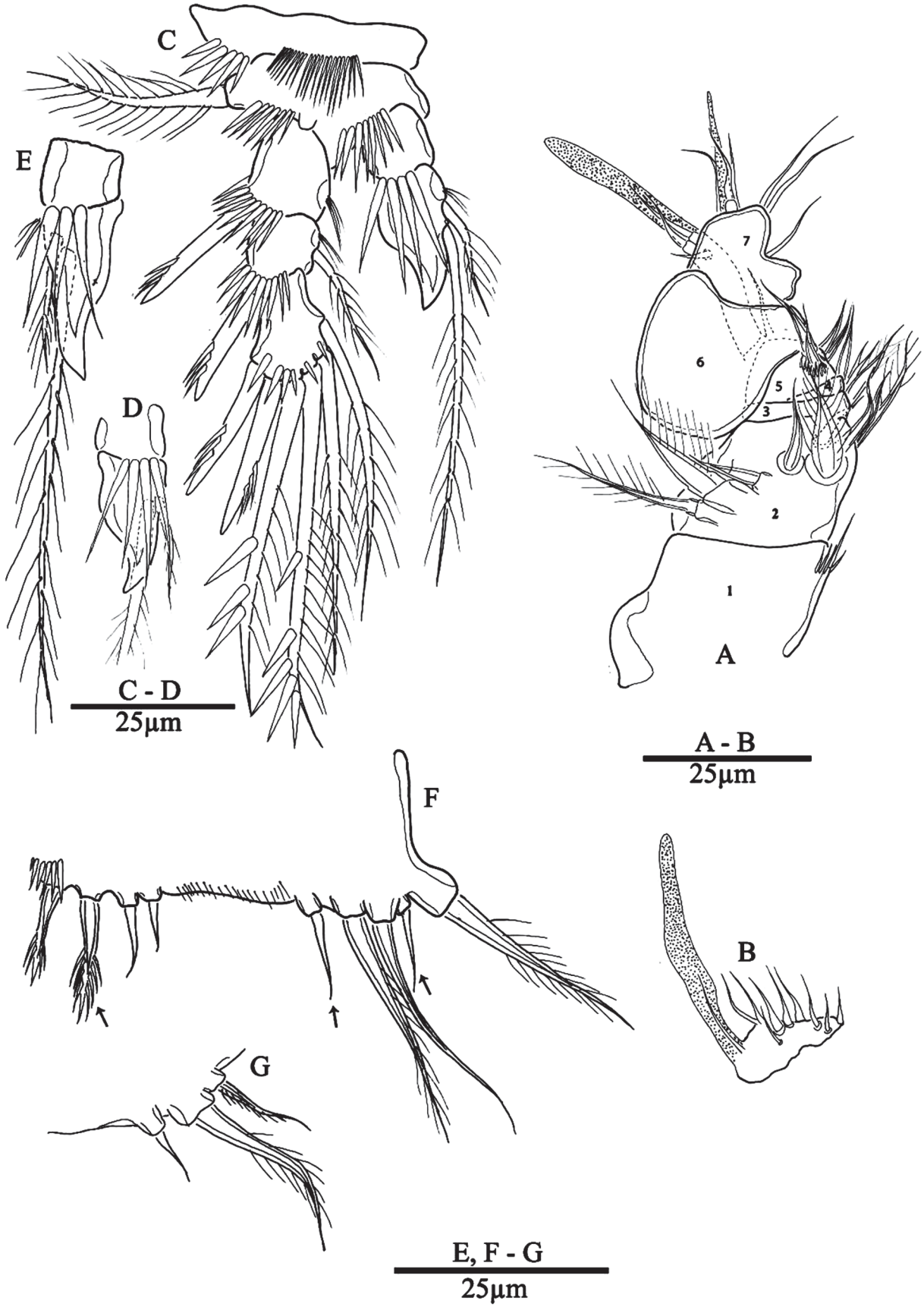

FIGURE 31. *Nannopus parvus* **sp. nov.,** line drawings, paratype ♂1: A, antennule (triarticulate seta on second segment arrowed), dorsal; B, fifth segment of the antennule, lateral; C, P3; D, left P3 endopod; E, right P3 endopod, another view; F, P5 (sexual dimorphisms arrowed); G, P6.

Genital somite (Fig. 29B) homologous to anterior part of genital double-somite in female, second and third urosomite well segmented in ventral view.

Caudal rami (Fig. 29B, C, D) presenting seta IV sparsely pinnate and slender, seta V shorter than in female, and seta VI and VII naked.

Antennule (Figs. 30C, 31A, B) chirocer, 7-segmented with strong geniculation between segments 5 and 6. Segment 4 representing by small incomplete segment with only 1 naked seta. Armature formula as follows: 1-[1], 2-[4 + 5 pinnate], 3-[3], 4-[1], 5-[6], 6-[9 + (1+ae)], 7-[7 + acrothek]. Apical acrothek consisting of minute aesthetasc and 2 naked setae.

P3 (Figs. 30D, 31C, D, E) exopod 3-segmented, and exp-1 to -2 with row of inner setules. Endopod 2-segmented, enp-2 outer spine fused to segment forming short apophysis with sharp and curved tip, and inner 2 setae pinnate as in female.

P5 (Fig. 31F) fused with somite, exopod and baseoendopod fused, and both baseoendopods confluent. Baseoendopod with inner spinules, and row of setules posteriorly. Endopodal lobe with 2 sub-equal pectinate setae (outer pectinate seta 0.3 times as long as one in female, arrowed in fig. 31F) and 2 sub-equal naked setae. Exopodal lobe with 4 unequal elements [outermost and innermost setae naked (arrowed in Fig. 31F) and medial 2 setae bipinnate].

P6 (Figs. 29B, 31G) asymmetrical with small functional flap on left side, with 3 elements (2 bipinnate and 1 naked), and median element longer than remaining 2 elements.

Nannopus bulbiseta sp. nov.

(Figs. 32–38)

Type locality. Intertidal mudflat, Yangdo-myeon, Ganghwa Island, South Korea, Yellow Sea, 37°40'08.4"N 126°24'20.9"E (Fig. 1A, B).

Type material. Holotype: dissected on 2 slides (NIBRIV0000753987). Allotype: dissected on 2 slides (NIBRIV0000810823). Paratypes: 3 females dissected on 2, 2 and 1 slides (NIBRIV0000810820, 22, 24), and 1 male dissected on 1 slides (NIBRIV0000810827), 1 female in 70% ethanol (NIBRIV0000810821), 1 male in 70% ethanol (NIBRIV0000810826), and 2 females and 2 males together on SEM stub (NIBRIV0000810825). All samples were collected from the type locality by Vinod Vakati, 5 March 2015.

Etymology. The specific epithet refers to the bulbous shape of caudal seta V in female.

Description of female (based on holotype and paratypes). Body (Fig. 32A) fusiform, total body length ranged from 416 to 455 µm (mean = 437 µm, n = 4; holotype: 455 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 161 to 152 µm (mean = 159 µm, n = 4; holotype: 165 µm, measured at posterior margin of cephalothorax). Boundary between prosome and urosome clearly present, urosome/prosome length ratio 0.36, and body length/width ratio about 2.6. Surface ornamentation as in *N. parvus*. Cephalothorax (Fig. 32A) almost as long as width, comprising 34.1% of total body length, posterior margin serrated, and with several sensilla, and denticles.

Rostrum as in *N. parvus.*

Prosome (Fig. 32A, B, 33A) 4 segmented, comprising cephalothorax, and 3 pedigerous somites. All prosomites subequal, serrated posterior margins, and with row of sensilla. P2 and P3 bearing prosomites with very long sensilla on either side of dorsolateral margins, and P2-bearing somite with 1 row of short frills along anterior margin (Figs. 32A, arrowed in 33A).

Urosome (Figs. 32A, B, 33B, 35C) 5-segmented, posteriorly tapering, comprising P5-bearing somite, genital double-somite, 2 free abdominal somites, and anal somite. Posterior margins of urosomites serrated dorsally and ventrally. Row of sensilla along posterior margins dorsally except for penultimate somite. Row of spinules on third somite ventrally.

Genital double-somite (Figs. 32B, 33B, 35C) 2.4 times wider than long (ventral view), with original segmentation indicated by transverse, serrated surface ridge dorsally, and completely fused ventrally. Copulatory pore located medially, and with round shape.

Anal somite (Figs. 32A, 33D) twice wider than long, with well-developed operculum presenting row of dense setules along distal margin, 1 pair of dorsal sensilla, and denticles scattered randomly.

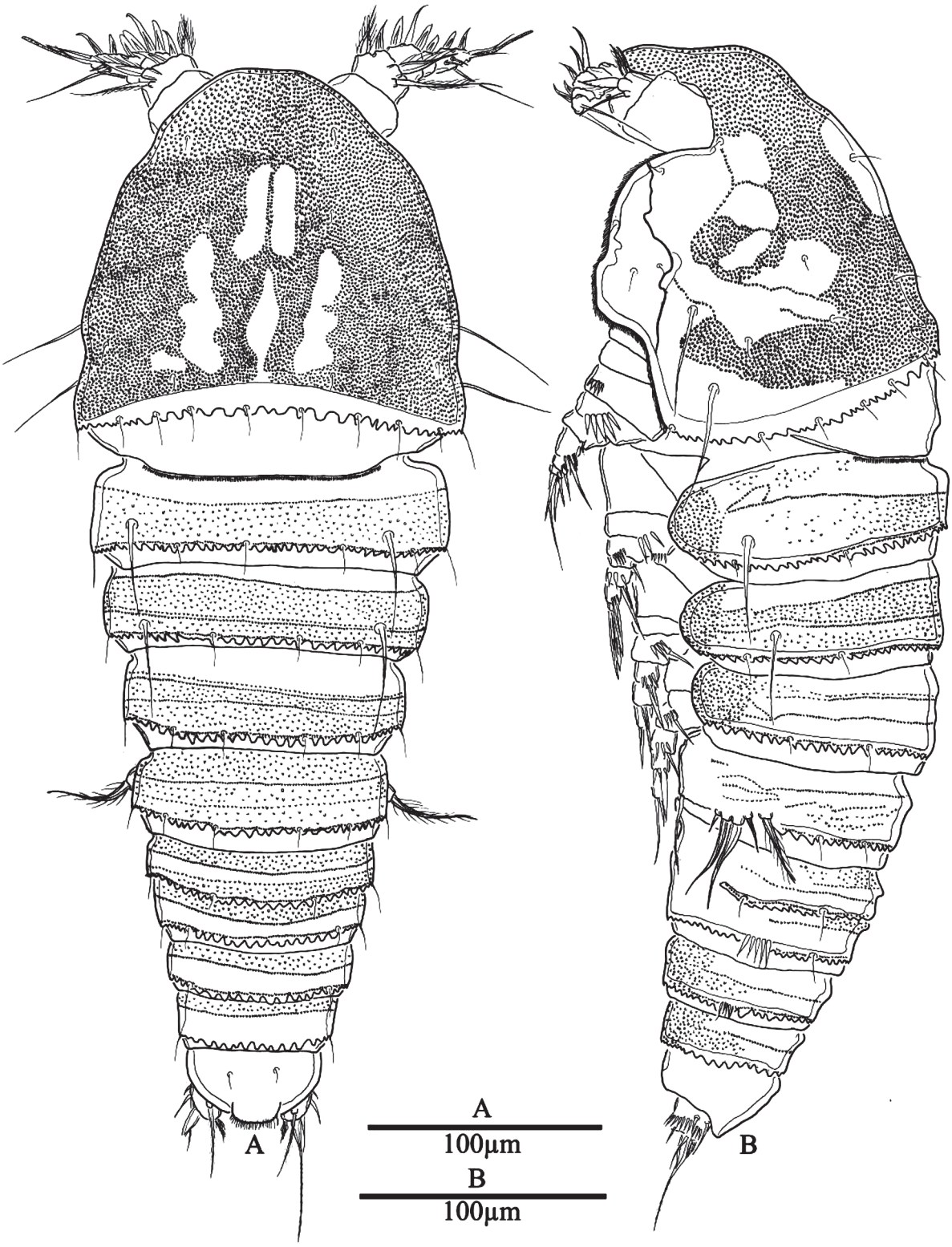

FIGURE 32. *Nannopus bulbiseta* **sp. nov.,** line drawings, holotype ♀: A, habitus, dorsal; B, habitus, lateral.

FIGURE 33. *Nannopus bulbiseta* **sp. nov.,** SEM photographs, A & D, paratype ♀4; B & C, paratype ♀5: A, surface ornamentation of somites (transverse row of frill on P2-bearing somite arrowed), dorsal; B, urosome, ventral; C, caudal ramus, ventral; D, caudal seta V arrowed, dorsal.

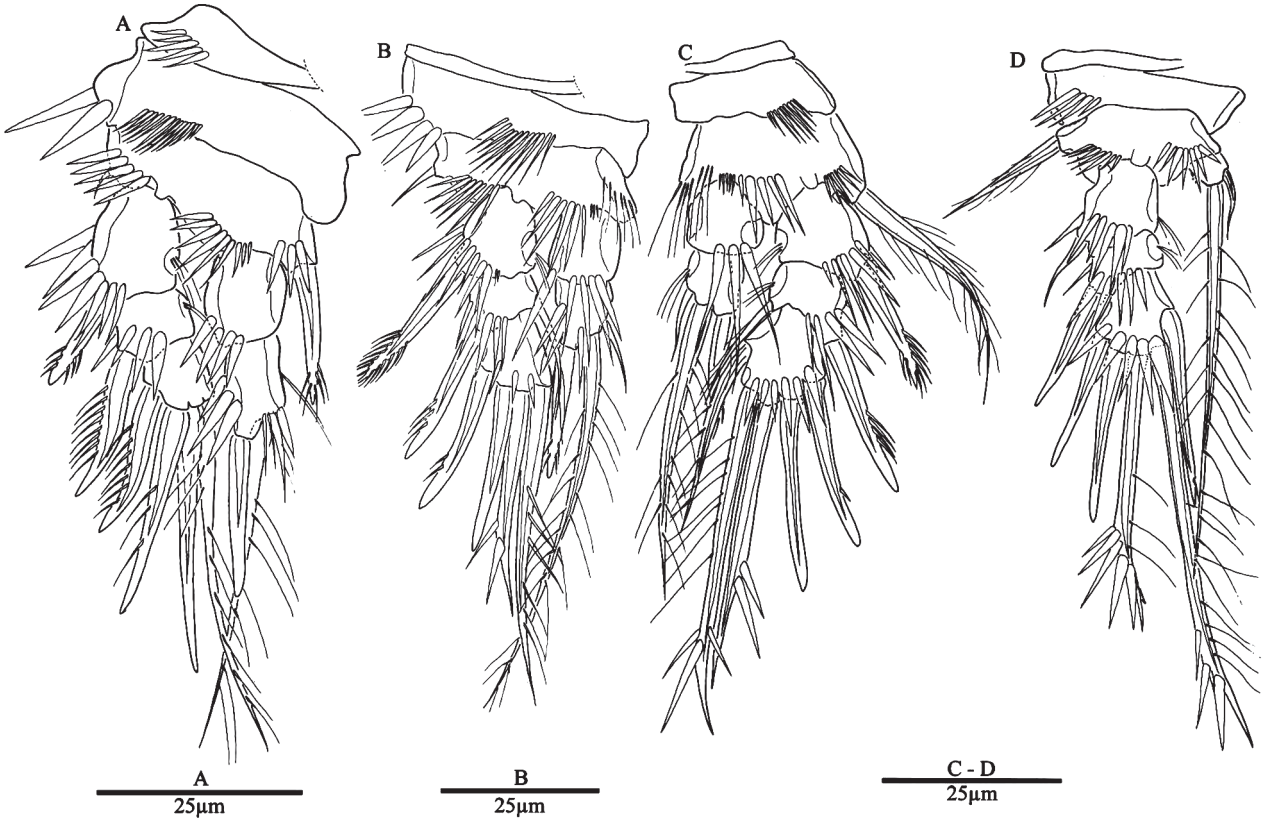

FIGURE 34. *Nannopus bulbiseta* **sp. nov.,** line drawings, A–B, paratype ♀1; C, holotype ♀; D, paratype ♀2; E, paratype ♀3: A, P1; B, P2; C, P3; D, P4; E, right P4 exp-3.

Caudal rami (Fig. 35A–C) nearly incorporated into anal somite but with clear separation between anal somite and each ramus. Medial spinular row located midway of outer margin laterally and ventrally. Distal spinular row dorsally and ventrally, and 0.9 (dorsal view) and 1.9 (ventral view) times as long as width. Caudal ramus bearing 7 setae: seta I naked, shorter than ramus width, and located dorsolaterally at anterior region; seta II naked, almost as long as ramus length, and located anterodorsally; seta III naked, almost as long as ramus length, and located laterally along posterior region; seta IV naked, 0.3 times as long as seta V, located at outer posterior margin, and proximal area slightly inflated; seta V longest, pinnate, bulbous anteriorly, and extremely thin posterior half; seta VI pinnate, almost as long as seta II and III; seta VII biarticulate, pinnate, and located at midway along inner margin.

Antennule, Antenna, and mouth parts as in *N. parvus*.

P1–P4 (Fig. 34A–E) with smooth and short concave intercoxal sclerite (not illustrated). Praecoxa somewhat triangular, shorter than coxa, and ornamented with row of spinules in P1. Coxa with 1 spinular row (P1, P2 and P3) on anterior surface, and row of strong outer spinules (P1, P2 and P4). Basis with row of strong outer spinules near insertion of exopod, and row of distal spinules near insertion of endopod (P1, P2, P3 and P4). Row of inner spinules (P1) or setules (P2 and P3). Basal outer seta naked (P1 and P2) or bipinnate (P3 and P4). Basal inner robust spine present on P1. P3 outer basal setae very robust and reaching to distal margin of exp-3. Exopod 3-segmented, and all segments sub-equal. Exp-1 to -2 (P1) and exp-1 to -3 (P2, P3 and P4) with robust outer spinules. Exp-1 to -2 (P1, P3 and P4) and exp-1 (P2) with row of inner setules. Exp-1 to -3 (P1–P3) with pinnate outer spines. Exp-2 (P2 and P3) with pinnate inner setae. Exp-3 (P1, P2, P3 and P4) with pinnate inner subdistal, distal and outer terminal setae. P4 exp-3 with short inner subdistal pectinate spine (Paratype presenting 1 minute spinule along inner margin near distal end, fig. 34D). Endopod 2-segmented in P1, P2 and P3 or 1-segmented in P4. Enp-2 (P1 and P3) with robust outer distal spinules, and enp-2 (P1 and P3) with row of inner setules. Setae on endopods of P1–P4 mostly pinnate except for 2 naked inner setae on enp-2 of P2–P3, and inner apical small seta of P4 endopod. Armature formula as follows:

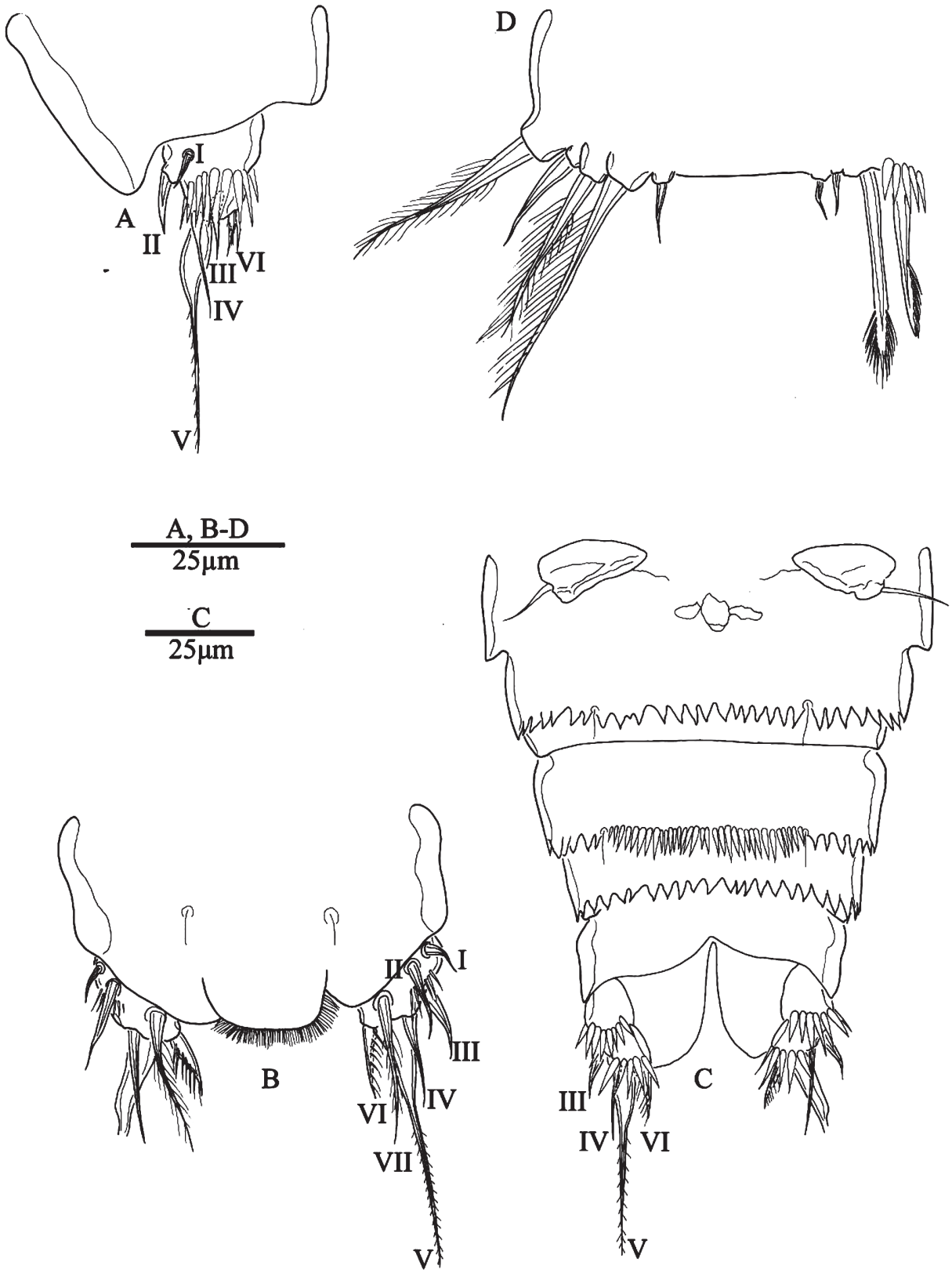

FIGURE 35. *Nannopus bulbiseta* **sp. nov.,** line drawings, holotype ♀: A, anal somite and caudal ramus, lateral; B, anal somite and caudal rami, dorsal; C, urosome, P5-bearing somite and caudal rami, ventral; D, P5; E, right P6.

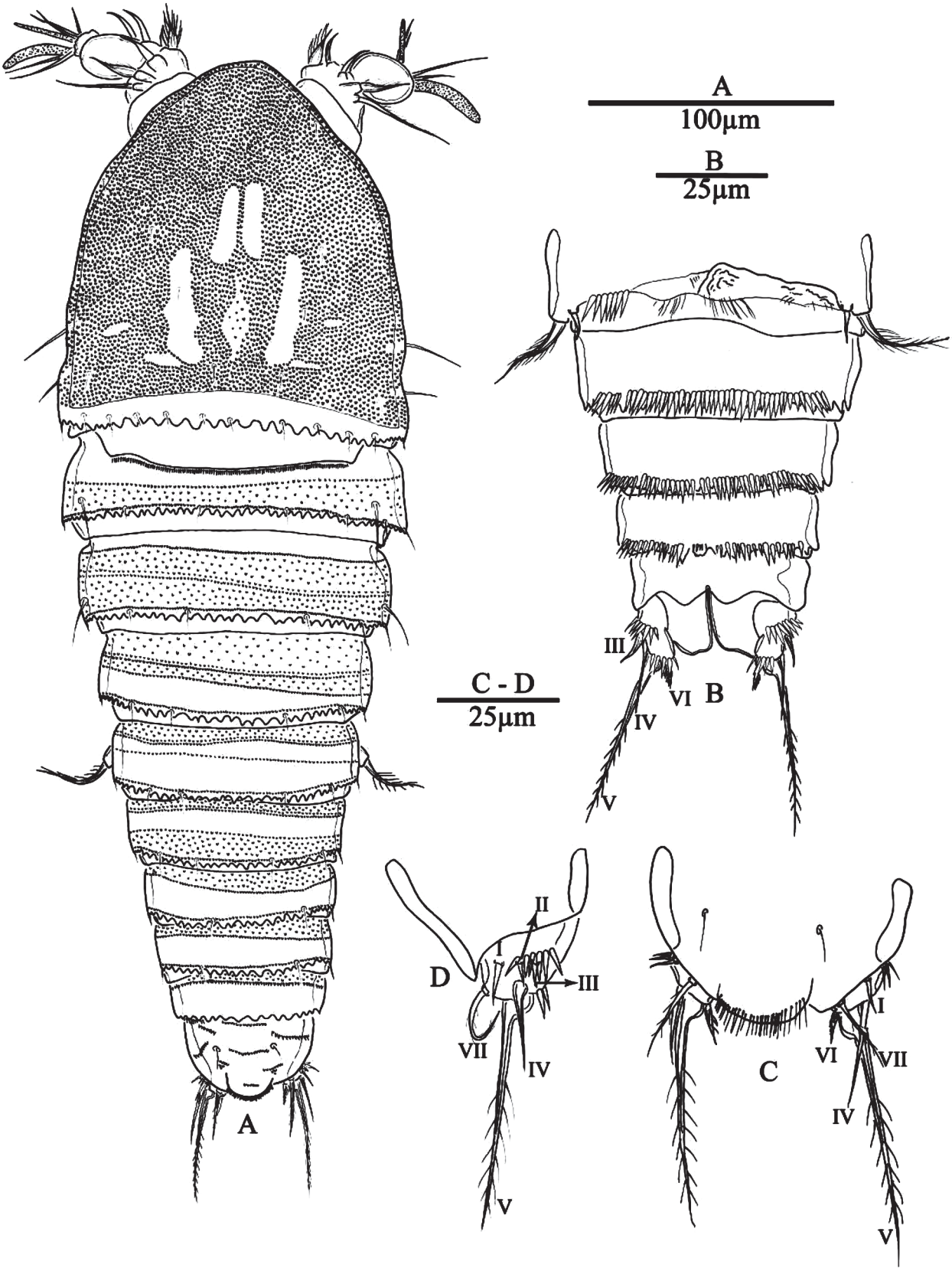

FIGURE 36. *Nannopus bulbiseta* **sp. nov.,** line drawings, allotype ♂: A, habitus, dorsal; B, urosome, P5-bearing somite and caudal rami, ventral; C, anal somite and caudal rami, dorsal; D, anal somite and caudal ramus, lateral.

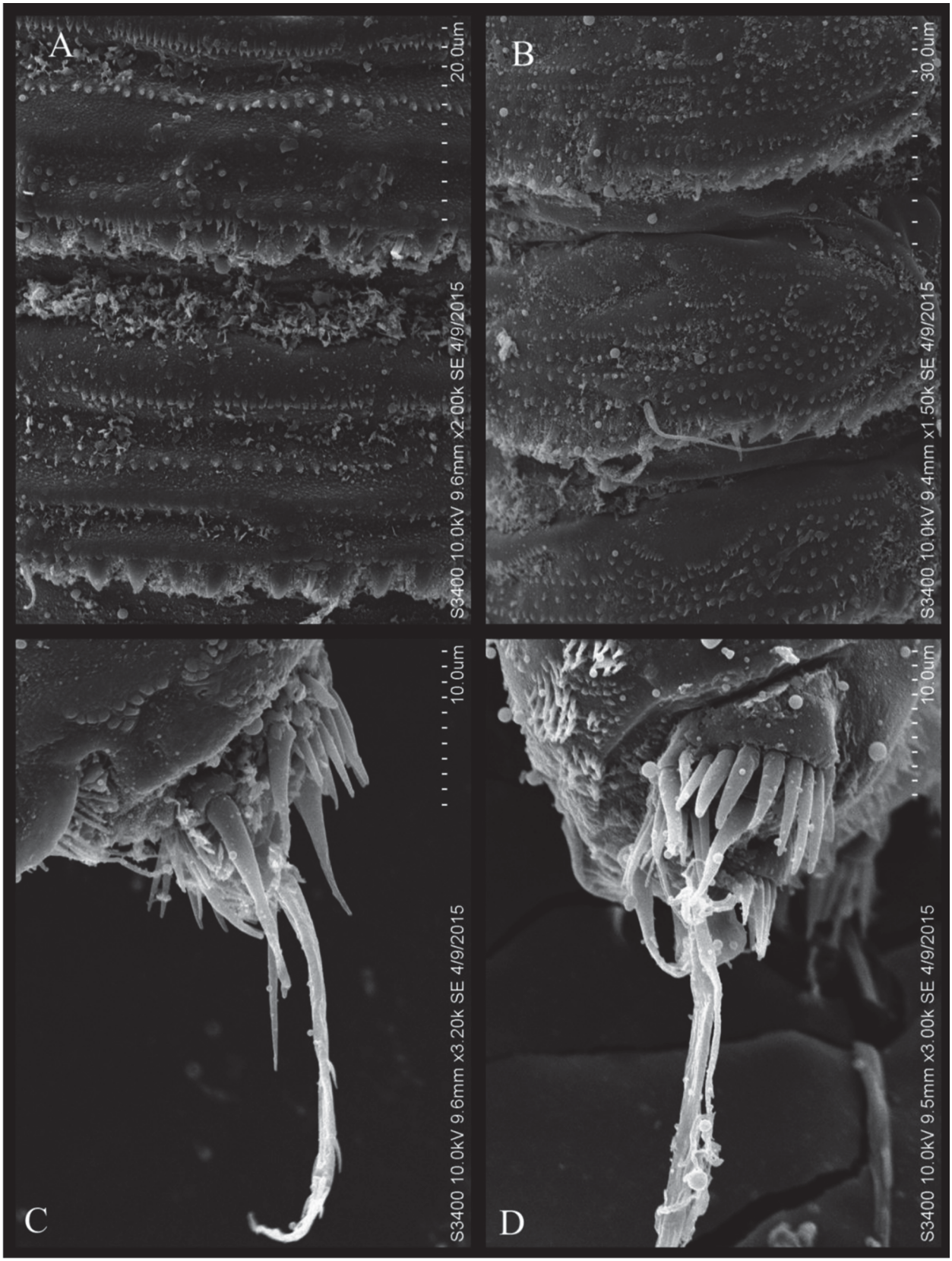

FIGURE 37. *Nannopus bulbiseta* **sp. nov.,** SEM photographs, A & C, paratype ♂2; B & D, paratype ♂3: A, surface ornamentation of prosomites, dorsal; B, surface ornamentation of prosomites, lateral; C, caudal ramus, dorsal; D, caudal ramus, lateral.

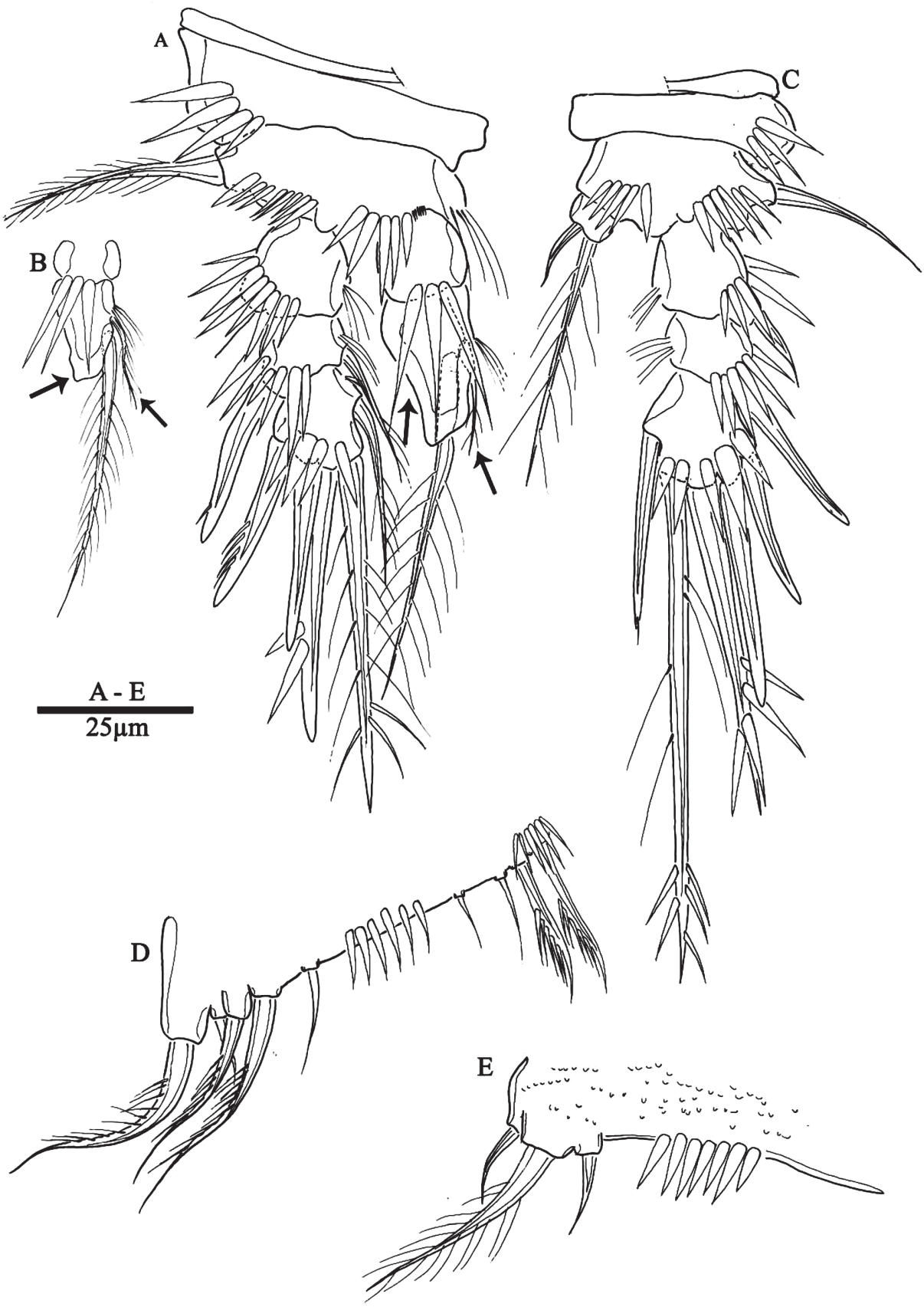

FIGURE 38. *Nannopus bulbiseta* **sp. nov.,** line drawings, A–B & D–F, allotype ♂; C, paratype ♂1: A, P3 (outer spine of first exopod broken); B, P3 endopod with a slight movement (sexual dimorphic elements/segments arrowed); C, P4; D, P5; E, P6; F, left P3 first exopod.

	Exopod	Endopod
P1	0.0.022	0.111
P2	0.1.022	0.111
P3	0.1.122	0.111
P4	0.1.122	110

P5 (Fig. 35D) almost as in *N. parvus* except for endopod with 2 inner sub-equal pectinate spines, and 2 small sub-equal naked setae. Exopod with 2 pinnate and 2 naked setae.

P6 (Fig. 35C, E) as in *N. parvus*.

Male (based on allotype and paratypes). Body (Fig. 36A) smaller than female, body length ranged from 411 to 386 µm (mean = 401 µm, n = 3; allotype: 408 µm, measured from tip of rostrum to posterior margin of caudal rami). Maximum width ranged from 137 to 152 µm (mean 149 µm, n = 3; allotype: 137 µm, measured at posterior margin of cephalothorax). Urosome/prosome length ratio 0.5 and body length/width ratio about 2.8. Cephalothorax (Fig. 36A) almost as in female, as long as wide, and comprising 36.2% of total body length. Body ornamentation (Fig. 36A), anal somite (Fig. 36A), rostrum (not illustrated), P1–P2 (not illustrated) as in female. Antennule (not illustrated) as in male *N. parvus*, antenna (not illustrated), and other mouth parts (not illustrated) as in *N. parvus*.

Prosome 4-segmented (Fig. 36A), comprising of cephalothorax (bearing first pedigerous somite), and 3 free somites. Posterior margin of prosomites serrated, and with sensilla as in female.

Urosome 6-segmented (Fig. 36A, B), comprising of P5-bearing somite, genital somite, 3 free abdominal somites and anal somite. Posterior margin of urosomites serrated except for anal somite, and with sensilla as in female**.** Urosomite 3 to 5 with longitudinal row of spinules near ventral posterior margin.

Genital somite (Fig. 36A) homologous to anterior part of genital double-somite in female, second and third urosomites well segmented in ventral view.

Caudal rami (Fig. 36B, D) almost as in female except for seta V inflated with globular expansion at its insertion site.

P3–P4 (Fig. 38A–F) intercoxal sclerite, praecoxa, coxa, basis, and ornamentation of setae on endopods as in female. P3 outer basal seta reduced (half as long as in female), P3 enp-2 outer spine fused to segment forming apophysis armed blunt tip, slightly curved along outer margin (arrowed in Fig. 38A, B), and 2 pinnate setae (1 long, and 1 short arrowed in Fig. 38A, B). P4 basal seta naked, endopod distal pinnate seta shorter than in female, and only reaching distal margin of exp-3 (Fig. 38C).

P5 (Fig. 38D) fused with somite, exopod and baseoendopod fused, and both baseoendopods confluent. Endopodal lobe with 2 sub-equal small pectinate spines, 2 sub-equal small naked setae, and rows of spinules near posterior margin. Exopodal lobe bearing 2 pinnate and 2 naked setae.

P6 (Figs. 36B, 38E) asymmetrical, with functional flap located at left side, with some spinules along posterior margin, with 3 setae (1 bipinnate and 2 naked), and median one twice as long as remaining 2 setae.

Discussion

The genus *Nannopus* is difficult to study at species level due to the repository of misidentifications in the past. However, based on the recent studies by Garlitska *et al.* (2012) and Fiers & Kotwicki (2013), it is clear that *N. palustris* is composed of several sibling or pseudo-sibling species. Some of the individuals that are reported and/or identified as *N. palustris* are highly different from Brady's (1880) description, and some individuals are conspecific with the species described by Fiers & Kotwicki (2013). For example, the specimens identified by Chislenko (1967), Mielke (1974), Kotwicki (2002), and Wojtasik & Kur (2007) are suggested to be conspecific with *N. didelphis* (see Fiers & Kotwicki 2013; 37, 46, 59). The individuals reported by Sars (1909a, b), Klie (1929), Willey (1929), Pesta (1932), Lang (1936a,b, 1948), Chislenko (1967), Letova (1982), and Garlitska *et al.* (2012) are suggested to be conspecific with *N. procerus* (see Fiers & Kotwicki 2013; 50, 59, 62). *N. flexibilis* was considered a synonym of *N. palustris* (Lang 1936b, 1948; Borutzky 1952; Wells 1971), however recently, Fiers & Kotwicki (2013) reinstated *N. flexibilis* as a valid species. Further, Fiers & Kotwicki (2013) postulated that the specimens

identified as *N. palustris tiberiadis* Por, 1968, and *N. palustris sensu* Sars, 1927, Hemsen, 1952, and Damian-Georgescu, 1970 are junior synonyms of *N. flexibilis*. The specimens recognized as *N. palustris* by Canu (1892), Scott (1902), Gurney (1932), Tai & Song (1979), Kikuchi & Yokota (1984), Coull & Fleeger (1977), and Fiers & Rutledge (1990) are clearly different from Brady (1880)'s description (see Fiers & Kotwicki 2013; 54, 59, 60, 63). Also, Coull & Fleeger's (1977) specimens (*N. palustris*) from South Carolina turned out to be two different species (Staton *et al.* 2005). Also, Vakati *et al.* (2016) suggested that the specimens Yoo & Lee (1995) identified are different species from Brady's (1880) description and need to be revised. The individuals identified by Kunz (1935), Schäfer (1936), Jakubisiak (1938), Montschenko & Polishchuk (1969), Wells (1971), Arlt (1983), and Kornev & Chertoprud (2008) are not provided with explicit descriptions and remain puzzling (see Fiers & Kotwicki 2013). Staton *et al.* (2005) and Garlitska *et al.* (2012) clearly presented the existence of sympatric cryptic species of this genus from South Carolina.

The present five new species clearly belong to the genus *Nannopus* based on three strong synapomorphies: (1) rostrum fused at base, prominent, deeply recurved downwards, with pair of sensilla, anterior margin densely hirsute, (2) antennule second segment with a triarticulate seta inserted dorsally, (3) P4 exp-3 with inner subdistal pectinate seta. For Character 1, rostrum with dense hirsute at the anterior margin and deeply downward recurved nature is highly characteristic and considered to be unique to *Nannopus* (see Fig. 30A–B) within Nannopodidae. For character 2, the pinnate seta on the second segment of antennule is set on two cylindrical peduncles (see Fig. 30C); such triarticulate nature is also considered to be a derived feature. Although this element is translocated in some species, such as in *N. parvus* and *N. bulbiseta*, they seem to be constantly present on the dorsal side of every species. It seems that the genus *Talpacoxa* has this type of seta on the dorsal side of second segment of the antennule, but this is not very clear in the figure plate presented by Corgosinho (2012). For character 3, the inner subdistal pectinate seta on P4 exp-3 is also present only in *Nannopus*, however replaced with a setiform element in some species. Based on the recent hypothesis by Fiers & Kotwicki (2013), the type species (*N. palustris s. str.*) does not have this element. Since this pectinate seta was first noticed in *Ilyophilus*, Fiers & Kotwicki (2013) postulated that *Nannopus* can be separated into two different lineages such as *Ilyophilus* Lilljeborg, 1902 with *I. flexibilis* as the type and *Nannopus* Brady, 1880 with *N. palustris* as the type, along with the differences noticed in male genital apparatus. However, this is not supported with the morphology of *N. ganghwaensis* (see Vakati *et al.* 2016) and the present five new species. The asymmetrical P6 presenting a functional valve in only one side, and the symmetrical P6 that both sides are confluent are present in both lineages (see Table 2). It is also difficult to rely on a single character, the pectinate seta on the P4 exp-3 for splitting *Nannopus* by re-instating *Ilyophilus*, and at least *N. palustris* has to be re-described based on the topotypic materials and molecular phylogenetics.

Among the nine valid species, only five are described based on both sexes and four are known only from the females. So the relationship between the five new species and their congeners is studied here based on the available descriptions of the females only. While establishing close relationships of these species, we considered the morphological features suggested for recognizing *N. palustris* by Fiers & Kotwicki (2013; 57, 58).

The six species, *N. flexibilis*, *N. didelphis*, *N. hirsutus*, *N. ganghwaensis, N. minutus* **sp. nov.** and *N. dimorphicus* **sp. nov.**, share the presence of seven elements on P4 exp-3 (See Table 1). Among them, *N. minutus* and *N. dimorphicus* seem to be closely related by sharing the pinnate caudal seta III (see Table 2). They also share the insertion site of caudal setae II, III and VII. Caudal seta II is inserted dorsally in *N. minutus* and *N. dimorphicus*, but it is inserted laterally in the other species; caudal seta III of *N. minutus* and *N. dimorphicus* occupies the place of caudal seta II in the other species; seta VII is inserted on the inner margin in *N. minutus* and *N. dimorphicus*, but it is inserted dorsally in the other species.

The females of *N. minutus* and *N. dimorphicus* differ in the number of dorsal integumental windows on the cephalothorax (three in *N. minutus*, but only one in *N. dimorphicus*, see Table 2), the shape of inner small seta on P4 endopod (naked in *N. minutus*, pinnate in *N. dimorphicus*, see Table 1), the shape of caudal seta IV (inflated and leaf-shaped in *N. minutus*, with a globular expansion basally and relatively slender in *N. dimorphicus*, see Table 2), and the shape of caudal seta V (normal type and anterior part wide in *N. minutus*, bulbous and anterior part heavily inflated in *N. dimorphicus*, see Table 2).

The males of *N. minutus* and *N. dimorphicus* differed in the number of dorsal integumental windows on the cephalothorax (without integumental windows in *N. minutus*, but with one in *N. dimorphicus*, see Table 3), the number of outer spines on P2–P3 exp-3 (three in *N. minutus*, four in *N. dimorphicus*, see Table 3), the shape of inner seta on P3 enp-2 (naked in *N. minutus*, pinnate in *N. dimorphicus*, see Table 3), and the shape of outer medial and outermost seta of P5 endopod (pinnate in *N. minutus*, naked in *N. dimorphicus,* see Table 3).

TABLE 1. Armature formula and ornamentation of P1–P5 in valid species of *Nannopus*. Roman letters: spines, Arabic letter: seta, N: naked seta, P: pinnate seta, Pe: pectinate seta, X: absent, F: fused, ?: details should be confirmed, #: ornamentation and setae number is variable in P5 endopod, a) *N. palustris* Brady, 1880, plate 77 Fig. 19 considered as P2, Fig. 20 considered as P4 (see Fiers & Kotwicki, 2013: 58), b) The setal ornamentation of swimming legs in *N. flexibilis* are not clear except pectinate seta in P4 exp-3 (see Lilljeborg, 1902), therefore, only armature formula is included for *flexibilis*.

Characters			*N. palustris* s. str. Brady (1880)	*N. scaldicola* Fiers & Kotwicki (2013)	*N. procerus* Fiers & Kotwicki (2013)	*N. flexibilis* Lilljeborg (1902)	*N. didelphis* Fiers & Kotwicki (2013)	*N. hirsutus* Fiers & Kotwicki (2013)	*N. ganghwaensis* Vakati *et al.* (2016)
P1:P2:P3:P4 inner seta ornamentation ♀		Exp-2	? : 1N : 1N : 1N	1P : 1P : 1P : 1P	1P : 1N : 1P : 1P	1 : 1 : 1 : 1	1P : 1P : 1P : 1P	1P : 1P : 1P : 1P	1P : 1P : 1P : 1P
Setal formula and ornamentation (order goes from outer margin to inner margin) ♀	P1	Exp-3		II, I +1P, 0 = 4	II, I +1P, 0 = 4	II, I +1, 0 = 4	II, I +1P, 0 = 4	II, I +1P, 0 = 4	III, 1P, 0 = 4
		Enp							
		Enp-2		I,1P,1P = 3	I,1P,1P = 3	I, 1, 1 = 3	I,1P,1P = 3	I,1P,1P = 3	I,1P,1P = 3
	P2	Exp-3	III, 2P,1P = 6	III, 2P, 1P = 6	III, I+1P, 1P = 6	III, 2, 1 = 6	III, 2P,1P = 6	III, 1P+1P, 1P = 6	III, 2P, 1P = 6
		Enp-2	I, 1N, 1N = 3	I, 1P, 1P = 3	I, 1P, 1P = 3	I, 1, 1 = 3	I, 1P, 1P = 3	I, 1P, 1P = 3	I, 1P, 1P = 3
	P3	Exp-3		III, 2P, 2P = 7	III, I+1P, 1P = 6	III, 2, 2 = 7	III, 2P, 2P = 7	III, 1P+1P, 2P = 7	III, 2P, 2P = 7
		Enp-2		I, 1P, 1P = 3	I, 1P, 1P = 3	I, 1, 1 = 3	I, 1P, 1P = 3	I, 1P, 1P = 3	I, 1P, 1P = 3
	P4	Exp-3	II, 2P, 2N? = 6	III, 1P+1P, 1P = 6	III, 2P, 1Pe = 6	III, 2, 2(Pe+?) = 7	III, 2P, 2(Pe+P) = 7	III, 2P, 2(Pe+P) = 7	III, 2P, 2(Pe+P) = 7
		Enp	0, 1P, 0 = 1	0, 2P, 0 = 2	0, 1P+1P, 0 = 2	0, 2, 0 = 2	0, 2P, 0 = 2	0, 2P, 0 = 2	0, 1P+1N, 0 = 2
Total no of elements(outer margin to inner margin) and ornamentation ♀	P5	Exp		P, P, P, P, P = 5	P, P, N, N, P(F) = 5	= 5	P, P, P, P, P(F) = 5	P, P, P, P, P = 5	N, N, P, P, P(F) = 5
		Enp		P, P, Pe, Pe = 4	P, P, Pe, Pe = 4	= 4	P, P, Pe P, Pe, Pe, Pe = 3 to 4 (#) P, Pe, Pe	P, P, Pe, Pe =3 to 4(#) P, P, Pe	P, P, Pe, Pe = 4

... ...continued on the next page

TABLE 1. (Continued)

Characters			*N. minutus* **sp. nov.**	*N. dimorphicus* **sp. nov.**	*N. perplexus* Sars (1909b)	*N. parvus* **sp. nov.**	*N. bulbiseta* **sp. nov.**	*N. nisegmentatus* Shen & Tai (1964)	*N. serratus* **sp. nov.**
P1:P2:P3:P4 inner seta ornamentation ♀		Exp-2	1P : 1P : 1P : 1P	1P : 1P : 1P : 1P	× : 1N : 1N : 1N	X : 1P : 1P : 1P	× : 1P : 1P : ×	× : 1P : 1P : ×	× : 1P : 1P : ×
Setal formula and ornamentation (order goes from outer margin to inner margin) ♀	P1	Exp-3	III, 1P, 0 = 4	III, 1P,0 = 4	II, I+1P,0 = 4	II, I+1P, 0 = 4	II, I+1P, 0 = 4	III, 1P, 0 = 4	II, I+1P, 0 = 4
		Enp						0, I, 0 = 1	0, I, 1N = 2
		Enp-2	I,1P,1P = 3	I,1P,1P = 3	I, 0, 0 = 1	I,1P,1P = 3	I,1P,1P = 3		
	P2	Exp-3	III, 2P, 1P = 6	III, 2P, 1P = 6	II, 2P, 2P = 6	II, 2P, 1P = **5**	II, I+1P, 0 = **4**	II+1P, 1P, 1P = 5	II, 1P, 2P = 5
		Enp-2	I, 1P, 1P = 3	I, 1P, 1P = 3	I, 1P, 1N = 3	I, 1P, 1P = 3	I,1P,1N = 3	I, 1P, 0 = 2	0, I, 1P = 2
	P3	Exp-3	III, 2P, 2P = 7	III, 2P, 2P = 7	II, 2P, 2P = 6	II, 2P, 2P = 6	II, 2P, 1P = **5**	II, 2P, 2P = 6	II, 2P, 2P = 6
		Enp-2	I, 1P, 1P = 3	I, 1P, 1P = 3	I, 1P, 1N = 3	I, 1P, 1P = 3	I,1P,1N = 3	I, 1P, 1P = 3	I, 1P, 1N = 3
	P4	Exp-3	III, 2P, 2(Pe+P) = **7**	III, 2P, 2(Pe+P) = **7**	II, 2P, 2(Pe+P) = 6	II, 2P, 2(Pe+P) = 6	II, 2P, 1(Pe) = **5**	II, 2P, 2(Pe+P) = 6	II, 2P, 2(Pe+P) = 6
		Enp	0, 1P+1N, 0 = 2	0, 1P+1P, 0 = 2	0, 1P, ? = 1	0, 1P+1N, 0 = 2	0, 1P, 1N = 2	0, 2P, 0 = 2	0, 1, 1N = 2
Total no of elements (outer margin to inner margin) and ornamentation ♀	P5	Exp	N, N, P, P, P(F) = 5	P, P, P, P, P(F) = 5	P, P, P, P = 4	P, P, P, P = 4	N, P, P, N = 4	P, P, P, P = 4	P, P, P, P = 4
		Enp	P, P, Pe, Pe = 4	P, P, Pe, Pe = 4	P, P, P? =3	N, N, Pe, Pe = 4	N, N, Pe, Pe = 4	P, P, P? = 3	P, P, Pe = 3

TABLE 2. Relevant morphological characters of the species of *Nannopus*. N: naked seta, P: pinnate seta,?: details should be confirmed.

Characters	*N. palustris* s. str. Brady (1880)	*N. scaldicola* Fiers & Kotwicki (2013)	*N. procerus* Fiers & Kotwicki (2013)	*N. flexibilis* Lilljeborg (1902)	*N. didelphis* Fiers & Kotwicki (2013)	*N. hirsutus* Fiers & Kotwicki (2013)	*N. ganghwaensis* Vakati *et al.* (2016)
Shape of habitus (dorsally) ♀	Fusiform and broad at posterior region of cephalothorax	Ovate, dorsoventrally depressed	Fusiform narrow	Fusiform and broad at posterior region of cephalothorax	Fusiform and broad at posterior region of cephalothorax	Fusiform and broad at posterior region of cephalothorax	Fusiform and broad at posterior region of cephalothorax
Body Length (µm) ♀ and ♂		460-515µm and 460µm	615-635µm and 510-525 µm		538-698µm and 505-528 µm	445µm and male unknown	772µm (n=22) and 667 µm (n=10)
A1 no of segments ♀	5	5	5	5	5	5	5
A1 armature formula ♀		1-[1], 2-[9], 3-[6+ (1+ae)], 4-[1], 5-[8 + acrothek]			1-[1], 2-[9], 3-[6+ (1+ae)], 4-[1], 5-[8 + acrothek]		
A2 exopodal setae ♀		4 (3N + 1P)	4 (3N + 1P)	4 (?)	4 (3N + 1P)	4 (3N + 1P)	4 (3N + 1P)
A2 endopodal spines ♀		6 (unmodified)	6 (unmodified)	6 (unmodified)	6 (unmodified)	6 (unmodified)	6 (unmodified)
A2 abexopodal seta		2 (P)	2 (P)	2 (?)	2 (P)	2 (P)	2 (P)
Mandibular palp total no. of elements ♀		3 to 4 (P)	3 to 4 (P)	4 (?)	3 to 4 (P)	3 to 4 (P)	4 (P)
Maxillule praecoxal arthrite no of elements at distal margin ♀		10 (8 smooth and stout spines + 2 long recurved pinnate element)	10 (8 smooth and stout spines + 2 long recurved pinnate element)		10 (8 smooth and stout spines + 2 long recurved pinnate element)	10 (8 smooth and stout spines + 2 long recurved pinnate element)	10 (8 smooth and stout spines + 2 long recurved pinnate element)
Integumental windows on cephalothorax ♀		1 integumental window	Absent	1 integumental window	Absent	Absent	Absent
P1-P4 endopod segments	?:2:1:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented
P2 enp-2 inner most seta ♀		2.6 times as long as the outer spine of its segment	0.5 times as long as the outer spine of its segment		Almost as long as the outer spine of its segment	0.8 times as long as the outer spine of its segment	1.7 times as long as the outer spine of its segment
P2-P3 exp-3 outer spines ♀ : ♂		3-3 : 4-4	3-3 : 3-3		3-3 : 4-4		3-3 : 4-4

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TABLE 2. (Continued)

Characters	*N. palustris* s. str. Brady (1880)	*N. scaldicola* Fiers & Kotwicki (2013)	*N. procerus* Fiers & Kotwicki (2013)	*N. flexibilis* Lilljeborg (1902)	*N. didelphis* Fiers & Kotwicki (2013)	*N. hirsutus* Fiers & Kotwicki (2013)	*N. ganghwaensis* Vakati *et al.* (2016)
P3 enp-2 ♂			Rectangular, and distal spine fused forming sharp apophysis	Square or globular, and distal spine fused forming triangular apophysis	Rectangular, and distal spine fused forming sharp apophysis		Rectangular, and distal spine robust, fused forming sharp apophysis
P4 exp-3 inner subdistal element	Setiform (males unknown)	Setiform in both sexes	Pectinate seta in both sexes	Pectinate seta in both sexes	Pectinate seta on both sexes	Pectinate seta (males unknown)	Pectinate seta in both sexes
P5 exopod articulation to baseoendopod ♀		Not fused	Not fused	Not fused	Not fused	Not fused	Not fused
P6 articulation ♂		Asymmetrically confluent	Symmetrically Confluent		Symmetrically Confluent		Asymmetrically confluent
Caudal rami setae IV : V ♀	Normal : Globular inflated	Normal : Normal	Normal : Anteriorly swollen and notched	Globular at its insertion site : Heavily globular and inflated	Normal : Inflated and with a restricted globular expansion	Globular at its insertion site : Semi cylindrical and densely hirsute at the anterior region	Inflated : Inflated
Caudal rami setae ornamentation I:II:III:IV:V:VI:VII ♀	N:N:?:N:N:?:?	N:N:N:P:P:P:N	N:N:N:P:P:N:N	N:N:N:N:P:N:N	N:N:N:P:P:N:N	N:N:N:P:P:N:N	N:N:N:P:P:N:N
Shape of caudal rami ♀ and ♂	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
Caudal rami ventrally ♀ and ♂	Half of the rami is hanging out of the anal somite on the ventral view						

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TABLE 2. (Continued)

Characters	*N. minutus* **sp. nov.**	*N. dimorphicus* **sp. nov.**	*N. perplexus* Sars (1909b)	*N. parvus* **sp. nov.**	*N. bulbiseta* **sp. nov.**	*N. nisegmentatus* Shen & Tai (1964)	*N. serratus* **sp. nov.**
Shape of habitus (dorsally) ♀	Fusiform narrow	Fusiform and broad at posterior region of cephalothorax	Fusiform , nearly cylindrical	Fusiform and broad at posterior region of cephalothorax	Fusiform and broad at posterior region of cephalothorax	Fusiform and broad at posterior region of cephalothorax	Fusiform narrow
Body Length (µm) ♀and ♂	500µm (n=3) and 431 µm (n=2)	408µm(n=3) and 377µm (n=2)	490µm and male unknown	428µm (n=4) and 369µm (n=2)	437µm (n=4) and 401µm (n=3)	540µm and male unknown	562µm (n=3) and 538µm (n=2)
A1 no of segments ♀	5	5	5	5	5	5	5
A1 armature formula ♀	1-[1], 2-[9], 3-[6+ (1+ae)], 4-[1], 5-[8 + acrothek]			1-[1], 2-[9], 3-[6+ (1+ae)], 4-[1], 5-[8 + acrothek]			1-[1], 2-[9], 3-[6+ (1+ae)], 4-[1], 5-[8 + acrothek]
A2 exopodal setae ♀	4 (3N + 1P)	4 (3N + 1P)	3 (N)	4 (N)	4 (N)	4 (N)	4 (N)
A2 endopodal spines ♀	6 (unmodified)	6 (unmodified)	7 ? (unmodified)	6 (unmodified)	6 (unmodified)	6 (modified)	6 (modified)
A2 abexopodal seta	2 (P)	2 (P)	1 (N)	2 (1P+1N)	2 (1P+1N)		2 (P)
Mandibular palp total no. of elements ♀	4 (P)	4 (P)	3 (N)	5 (3P+2N)	5 (3P+2N)	5 (2P+3N)	5 (3P + 2N)
Maxillule praecoxal arthrite no of elements at distal margin ♀	10 (8 smooth and stout spines + 2 long recurved pinnate element)	10 (8 smooth and stout spines + 2 long recurved pinnate element)	7 ? (6 ? smooth and stout spines + 1 ? long naked element)	9 (8 smooth and stout spines + 1 long recurved pinnate element)	9 (8 smooth and stout spines + 1 long recurved pinnate element)		10 (8 smooth and stout spines + 2 long recurved pinnate element)
Integumental windows on cephalothorax ♀	3 integumental window	1 integumental window	1 integumental window	Absent	Absent	Absent	Absent
P1-P4 endopod segments	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	2:2:2:1-segmented	1:2:2:1-segmented	1:2:2:1-segmented
P2 enp-2 inner most seta ♀	0.7 times as long as the outer spine of its segment	0.7 times as long as the outer spine of its segment	0.5 times as long as the outer spine of its segment	0.6 times as long as the outer spine of its segment	0.5 times as long as the outer spine of its segment	Absent	Absent

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TABLE 2. (Continued)

Characters	*N. minutus* **sp. nov.**	*N. dimorphicus* **sp. nov.**	*N. perplexus* Sars (1909b)	*N. parvus* **sp. nov.**	*N. bulbiseta* **sp. nov.**	*N. nisegmentatus* Shen & Tai (1964)	*N. serratus* **sp. nov.**
P2-P3 exp-3 outer spines ♀ : ♂	3-3 : 3-3	3-3 : 4-4		2-2 : 2 -2	2-2 : 2 -2		2-2 : 2 -2
P3 enp-2 ♂	Rectangular, and distal spine fused forming sharp apophysis	Rectangular, and distal spine fused forming sharp apophysis		Square or globular, and distal spine fused forming wide and hook shaped apophysis	Square or globular, and distal spine fused forming wide and hook shaped apophysis		Square, and distal spine fused forming sharp apophysis
P4 exp-3 inner subdistal element ♀and ♂	Pectinate seta in both sexes	Pectinate seta in both sexes	Pectinate seta (males unknown)	Pectinate seta/spine in both sexes	Pectinate seta/spine in both sexes	Pectinate seta (males unknown)	Pectinate seta in both sexes
P5 exopod articulation to baseoendopod ♀	Not fused	Not fused	Fused	Fused	Fused	Not fused	Not fused
P6 articulation ♂	Asymmetrically confluent	Asymmetrically confluent		Asymmetrically confluent	Asymmetrically confluent		Asymmetrically confluent
Caudal rami setae IV : V ♀	Slightly bulbous : Normal	Globular at its insertion site : Heavily bulbous and inflated	? : Hook Shaped leaving slender and flexible edge	Normal : Unique seta (very short, spine like appearance)	Normal : Unique seta (bulbous anteriorly, and extremely slender posteriorly)	Normal : Normal	Normal : Normal
Caudal rami setae ornamentation I:II:III:IV:V:VI:VII ♀	N:N:P:P:P:N:N	N:N:P:P:P:N:N	?:?:? ?:N:?:?	N:N:P:P:P:P:P	N:N:N:N:P:P:P	N:N:?:P:P:N:?	P:P:P:P:P:P:P
Shape of caudal rami ♀ and ♂	Cylindrical	Cylindrical	Cylindrical	Trapezoidal or square	Sub-cylindrical	Cylindrical	Cylindrical
Caudal rami ventrally♀ and ♂	Half of the rami is outside of anal somite			Half of the rami is hanging out of the ramus	Strongly or Completely attached to the anal somite until the terminal margin of the rami		Half of the ramus is hanging out of the rami

TABLE 3. Sexual dimorphisms of the species of *Nannopus*. N: naked seta, P: pinnate seta, ✓: present, X, absent.

Characters	*N. scaldicola*		*N. procerus*		*N. flexibilis*		*N. didelphis*		*N. ganghwaensis*		*N. minutus* **sp. nov**		*N. dimorphicus* **sp. nov**		*N. parvus* **sp. nov.**		*N. bulbiseta* **sp. nov.**		*N. serratus* **sp. nov.**	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Integumental windows on cephalothorax	1	?	Absent		1	?	Absent		Absent		3	Absent	1	1	Absent		Absent		Absent	
P2 exp-2 inner seta	✓	✓	✓	✓	✓	?	✓	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
P3 exp-2 inner seta ornamentation	P	N	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
P2–P3 exp-3 no. of spines	3	4	4	4	3	4	3	4	3	4	3	3	3	4	2	2	2	2	2	2
P2 exp-3 outer apical spine shape or robustness	Normal type		Normal type		Normal type		Normal type		Normal type		Normal type		Normal type		Normal type		Normal type		Normal type	2 to 3 times robust
P2 enp-2 distal seta length ratio	Same length among both sexes		♂ seta twice as long as in ♀ seta				♂ seta half as long as in ♀ seta		♂ seta half as long as in ♀ seta		Same length among both sexes		Same length among both sexes		Same length among both sexes		Same length among both sexes		Same length among both sexes	
P2 enp-2 innermost distal seta ornamentation and length ratio	P	P	P	P			P	N	P	P	P	P	P	P	P	P	N	N		
	Length ratio is same in both sexes		♂ seta twice as long as in ♀				♂ seta half as long as in ♀		♂ seta half as long as in ♀		Length ratio is same in both sexes		Length ratio is same in both sexes		Length ratio is same in both sexes		Length ratio is same in both sexes		Absent in both sexes	
P3 enp-2 innermost distal seta ornamentation and length ratio	P	N	P	N	P	N	P	N	P	N	P	N	P	P	P	P	N	P	N	N
	♀ seta 5 times as long as in ♂		♀ seta 0.3 times as long as in ♂		♀ seta 5 times as long as in ♂		♀ seta 4.7 times as long as in ♂		♀ seta 6.9 times as long as in ♂		♀ seta 6.9 times as long as in ♂		♀ seta 3.2 times as long as in ♂		Length ratio is same in both sexes		Length ratio is same in both sexes		Length ratio is same in both sexes	
P3 enp-2 distal spine	♀ spines are always articulated from enp-2 Vs ♂ spines are always fused forming apophysis																			
P4 endopod distal small seta	P	P	P	P			P	N	N	N	N	N	P	N	N	N	N	N	N	N
P5 exopod articulation	♀ exopods are always articulated with baseoendopod Vs ♂ exopods are always fused to baseoendopod														Fused in both sexes				♀ exopods are always articulated from baseoendopod Vs ♂ exopods are always fused to baseoendopod	

……*continued on the next page*

TABLE 3. (continued)

Characters	*N. scaldicola*		*N. procerus*		*N. flexibilis*		*N. didelphis*		*N. ganghwaensis*		*N. minutus* **sp. nov**		*N. dimorphicus* **sp. nov**		*N. parvus* **sp. nov.**		*N. bulbiseta* **sp. nov.**		*N. serratus* **sp. nov.**	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
P5 endopod outer medial and outermost setae ornamentations	Pinnate setae in both sexes		Pinnate setae in both sexes				Pinnate setae in both sexes		♀ setae pinnate Vs ♂ setae naked		Pinnate setae in both sexes		♀ setae pinnate Vs ♂ setae naked		Naked setae in both sexes		Naked setae in both sexes		♀ setae pinnate Vs ♂ setae naked	
P5 endopod outer medial and outermost setae length ratio	♀ setae 2 times longer than in ♂						♀ setae 3 to 2 times longer than in ♂								The length ratio is more or less same among both sexes				♀ setae 5 times longer than in ♂	
P5 endopod innermost and inner medial pectinate setae length ratio	♀ setae 2 times longer than in ♂						♀ setae 4 to 5 times longer than in ♂								Innermost one is same in both sexes, but the medial one in ♂ 0.3 times as long as in ♀		The length ratio is more or less same among both sexes		♀ inner medial seta longer than in ♂ (innermost seta absent in both sexes)	
P6 no. of setae	1	3	1	3			1	3	1	3	1	3	1	3	1	3	1	3	1	2
Caudal Seta IV ornamentation, shape and length ratio	Pinnate, wide at anterior region and length ratio is more or less same among both sexes		Pinnate, slender and normal type and length ratio is more or less same among both sexes		♀ seta is naked, with a small globular expansion at its insertion site and 0.5 times as long as in ♂ Vs ♂ seta is pinnate, without globular expansion and twice as long as in ♀		Pinnate, slender and normal type and length ratio is more or less among both sexes		Pinnate, inflated and length ratio is more or less same among both sexes		♀ seta is pinnate, inflated at its base and leaf-shaped, and half as long as in ♂ Vs ♂ seta is pinnate, inflated at its base and twice as long as in ♀		♀ seta is pinnate, with a globular expansion at its insertion site ♂ Vs ♂ seta is pinnate, normal type and ♀ Length ratio is more or less same among both sexes		♀ seta is strongly pinnate and stout Vs ♂ sparsely pinnate and slender Length ratio is more or less same among both sexes		Naked, slightly inflated anteriorly, slender and length ratio is more or less same among both sexes		Pinnate, normal type and length ratio is more or less same among both sexes	

……*continued on the next page*

TABLE 3. (continued)

Characters	*N. scaldicola*		*N. procerus*		*N. flexibilis*		*N. didelphis*		*N. ganghwaensis*		*N. minutus* **sp. nov**		*N. dimorphicus* **sp. nov**		*N. parvus* **sp. nov.**		*N. bulbiseta* **sp. nov.**		*N. serratus* **sp. nov.**	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Caudal seta V ornamentation and shape	Pinnate and cylindrical at anterior region in both sexes		♀ seta pinnate and with a notch at anterior region Vs ♂ seta pinnate and without a notch at anterior region		Pinnate, inflated and globular at its insertion in both sexes		♀ seta pinnate, globular inflated, with circlet of setules Vs ♂ seta pinnate and without globular inflation, and circlet of setules		Pinnate and inflated at anterior region in both sexes		Pinnate and wide at anterior region in both sexes		♀ seta pinnate, heavily inflated, bulbous Vs ♂ seta pinnate and wide at anterior region, normal type.		Pinnate and anterior part wide in both sexes		♀ seta pinnate and bulbous at anterior region and very slender from mid half posterior region Vs ♂ seta pinnate and with a restricted globular expansion at insertion site and very slender		Pinnate and wide at anterior region in both sexes	
Caudal seta VI ornamentation	♀ seta with circlet or spur at anterior region Vs ♂ seta without circlet or spur and completely naked		Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		♀ seta pinnate Vs ♂ seta naked		Pinnate in both sexes		Pinnate in both sexes	
Caudal seta VII ornamentation	Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		Naked in both sexes		♀ seta pinnate Vs ♂ seta naked		Pinnate in both sexes		Pinnate in both sexes	

Nannopus serratus **sp. nov.**, and *N. unisegmentatus* share the presence of two setae in P2 enp-2 (see Table 1). However, *N. serratus* and *N. unisegmentatus* are easily distinguished from each other by the ornamentation of setae on mandibular palp (with three pinnate and two naked setae in *N. serratus*, but two pinnate and three naked setae in *N. unisegmentatus,* see Table 2), the insertion pattern of outermost seta on mandibular palp (raised from a cylindrical protuberance in *N. serratus,* arrowed in Fig. 16F, arises directly from the palp in *N. unisegmentatus*), the shape of P3 enp-2 inner seta (extremely slender, naked and very small in *N. serratus*, but robust, longer and pinnate in *N. unisegmentatus*, see Table 1 and Tai & Song 1979), the shape of P4 endopod distal small seta (naked in *N. serratus*, strongly pinnate in *N. unisegmentatus*, see Table 1). The inner small naked seta on the P1 endopod of *N. serratus* (arrowed in Fig. 18A–B) could have been overlooked by Shen & Tai (1964) in *N. unisegmentatus* and making it an unreliable character to separate these two species.

Nannopus parvus **sp. nov.**, *N. bulbiseta* **sp. nov.**, and *N. perplexus* are unique within the genus by having fused P5 exopod and baseoendopod in the females (see Table 2) and seem to constitute a separate group of species within *Nannopus*. Within this group, *N. parvus* seems to be more closely related to *N. bulbiseta* than to *N. perplexus*. The former two species share the second segment of antennule with five pinnate setae, of which two setae are bulbous (arrowed in Figs. 25A, 30C), the short inner subdistal pectinate spine of P4 exp-3 (this element is longer and strongly pectinate in *N. flexibilis*, *N. perplexus, N. unisegmentatus*, *N. didelphis*, *N. hirsutus, N. procerus*, and *N. ganghwaensis*, and is missing or setiform in *N. palustris s. str.*, and *N. scaldicola*), the two outermost small subequal endopodal setae of the female P5, the distal strong outer apophysis (see Figs. 30D, 31C–E, 38A–B) on the male P3 enp-2 (which have not been observed before in the males of other species of *Nannopus*), and the biarticulate caudal seta VII (the condition of this seta is uncertain for some species and is clearly triarticulate in most species of the genus).

Nannopus parvus and *N. bulbiseta* can be separated by the armature formula of P2–P4 exp-3 (5:6:6 in *N. parvus*, 4:5:5 in *N. bulbiseta*), the shape of inner setae in P2 and P3 enp-2 (pinnate in *N. parvus*, naked in *N. bulbiseta*), the shape of caudal rami ventrally (trapezoidal or squarish in *N. parvus*, sub-rectangular or sub-cylindrical in *N. bulbiseta*), the shape of caudal seta V (strong, wide at anterior region, sharp spine-like, and pinnate in *N. parvus*, bulbous at anterior region, very flexible, and pinnate in *N. bulbiseta*), the shape of female and male caudal setae VI and VII (sexually dimorphic, pinnate (female), or naked (male) in *N. parvus*, not sexually dimorphic, and pinnate in both sexes of *N. bulbiseta* (see Table 1–3).

Nannopus bulbiseta differs from all other species of *Nannopus* in the combination of the following characters: the number of elements on P2 and P4 exp-3 (4:5 setae/spines in *N. bulbiseta*, but 5-6:6-7 setae/spines in the other species, see Table 1), the entire caudal ramus (until distal margin) strongly incorporated into the anal somite ventrally (see Fig. 33C, Table 2), and the caudal seta V bulbous proximally, and very slender distally (see Table 2).

The presence of sexual dimorphism in harpacticoid copepods is highly common and more pronounced than in any other copepod orders (Huys 1988), but the range of variations is random and depending on the group. For instance, Falck & Bowman (1994) reported *Parasunaristes chelicerata* (Por & Marcus 1972) from shallow water of red sea with profound sexual dimorphism of the maxilla basis of the male with a relatively thin hooked process. The redescription of *Aegisthus mucronatus* Giesbrecht, 1891 revealed the presence of several prominent sexual dimorphisms on cephalosomic appendages (see Huys, 1988). Whereas *Bulbamphiascus plumosus* Mu & Gee, 2000 and *B. spinulosus* Mu & Gee, 2000 are also reported with several sexual dimorphisms such as in caudal ramus, P1 basis, P2 endopod, P3 exp-3 and P5 (see Mu & Gee 2000). Also, *Neomiscegenus indicus* Karanovic & Ranga Reddy, 2004 was identified with a sexually dimorphic pore on P3 exp-3 in males. Nevertheless, *Mesocletodes elmari* Menzel, 2011 is reported with more affected characters (P1–P4 enp-2 setal number) in males and which are considered as sexual dimorphisms (see Menzel, 2011). Several reports on sexual dimorphisms are already published and are scattered across the literature (see Coull 1976; Boxshall, 1979; Becker *et al.* 1979; Schriever 1983; Mielke 1984; Decho & Fleeger, 1986; Soyer *et al.* 1987; Gee & Fleeger, 1990; Veit-Köhler, 2000; Sevastou *et al.* 2012; Back & Lee, 2014). Even *Nannopus* including present five new species have several profound sexual dimorphisms such as:

(1) The Number of integumental windows—The female of *N. minutus* has three integumental windows on the dorsal surface of the cephalothorax, while the male has no integumental windows.
(2) The inner seta of P2 exp-2—*N. didelphis* with pinnate inner seta on P2 exp-2 in the female but without seta in the male (see Fiers & Kotwicki 2013: 43 fig. 6D, H).

(3) The inner seta of P3 exp-2—*N. scaldicola* seems to be unique by the pinnate inner seta on P3 exp-2 in the female but naked in the male (see Fiers & Kotwicki, 2013: 50).

(4) The outer spines of P2–P3 exp-3—The females of *N. didelphis*, *N. scaldicola*, *N. ganghwaensis*, and *N. dimorphicus* have total three spines, while the males of these four species have total four spines. The difference is mainly due to the female outer terminal seta being modified to a short spine in the male. In contrast, few species share the same number of spines in both sexes (e.g., *N. procerus*, *N. minutus*, *N. serratus*, *N. parvus*, and *N. bulbiseta*). The female of *N. minutus* and *N. dimorphicus* are very similar but can be separated based on sexually dimorphic characters in the male: there is no sexual dimorphism in the total number of spines in P2–P3 exp-3 of *N. minutus* but sexual dimorphism is present in *N. dimorphicus*.

(5) The outer apical spine of P2 exp-3—In the male of *N. serratus*, an outer apical spine of P2 exp-3 is almost two to three times longer and stronger than the one in the female.

(6) The distal seta of P2 enp-2—The distal seta of the male P2 enp-2 is twice as long as the homologous seta of the female in *N. procerus*. In contrast, the distal seta on the male P2 enp-2 of *N. didelphis* and *N. ganghwaensis* is only half the length than in the female.

(7) The inner distal seta of P2 enp-2—The inner seta of the male P2 enp-2 is naked but pinnate in the female of *N. didelphis*. In the male, it reaches only to the midlength of the homologous seta in the female of *N. didelphis* (see Fiers & Kotwicki 2013: 43 fig. 6D, G, I) and *N. ganghwaensis*. Whereas *N. procerus* male seta is twice as long as the homologous seta in the female.

(8) The inner seta of P3 enp-2—Sexual dimorphism is expressed in the shape of the inner seta on P3 enp-2 in most species of *Nannopus* (*N. flexibilis, N. didelphis*, *N. scaldicola*, *N. ganghwaensis,* and *N. minutus*) being well-developed and bipinnate in the female, but small and naked in the male. On the contrary, the inner seta on P3 enp-2 is non-dimorphic in other species. For example, this seta is short and pinnate in both sexes of *N. parvus,* and short and naked in both sexes of *N. serratus*. Also, sexual dimorphism can be expressed either in the relative length of this seta or in its ornamentation. For example, the length ratio of this seta is the same in the male and female of *N. bulbiseta*, but it is naked in the female and pinnate in the male; this seta is almost 3 times longer in the female than in the male, but it is pinnate in both sexes of *N. dimorphicus*.

(9) The outer spine of P3 enp-2—Sexual dimorphism is always expressed in the outer distal apophysis on the male P3 enp-2.

(10) The inner small seta of P4 endopod—This seta is bipinnate in the female, but naked in the male of *N. didelphis* (see Fiers & Kotwicki, 2013: 43) and *N. dimorphicus*. In some species it is naked (*N. ganghwaensis*, *N. minutus*, *N. serratus*, and *N. bulbiseta*) and pinnate (*N. parvus*) in both sexes. Whereas for *N. scaldicola* and *N. procerus* it is not clear, because the authors say that the female leg 4 of these two species as in *N. didelphis* and did not explain about inner seta of P4 endopod (Fiers & Kotwicki 2013). It is difficult to assume that this element in *N. scaldicola* and *N. procerus* is either pinnate or naked in both sexes or sexually dimorphic.

(11) P5 exopod articulation—sexual dimorphism is expressed always in the fusion of the exopod and baseoendopod of the male P5 (these rami are always separated in the female). But in some species, the exopod of P5 is fused in both sexes (*N. parvus* and *N. bulbiseta*).

(12) The setae of P5 endopod—The two outermost endopodal setae of P5 are pinnate in the female, but naked in the male of *N. ganghwaensis, N. serratus*, and *N. dimorphicus*. The length of these outermost endopodal setae in male is 0.1 to 0.3 times as long as in the female of *N. didelphis*, *N. scaldicola*, *N. procerus*, *N. ganghwaensis*, *N. minutus, N. dimorphicus,* and *N. serratus*. The inner most pectinate setae in male are 0.2 to 0.5 times as long as in the female of *N. scaldicola*, *N. procerus*, *N. didelphis*, *N. ganghwaensis*, *N. minutus,* and *N. dimorphicus*. *N. serratus* possesses three pinnate setae on the endopodal lobe, being the innermost pectinate seta in the male is 0.5 times as long as in the female. In *N. parvus* only the medial pectinate seta of male is 0.3 times as long as in the female.

(13) P6 setae—Sexual dimorphism is expressed also in P6 presenting a small seta in the female, while it has two (*N. serratus*) or three (*N. didelphis*, *N. scaldicola*, *N. procerus*, *N. ganghwaensis*, *N. minutus*, *N. dimorphicus*, *N. parvus*, *N. bulbiseta*) well-developed setae in the male.

(14) The caudal setae (ornamentation, shape, and length ratio):

a. *N. flexibilis*: Caudal seta IV is highly dimorphic. It is reduced to a small naked seta with a globular expansion proximally in the female, but well-developed, bipinnate in the male.

b. *N. minutus*: The female and male caudal seta IV is inflated and leaf-shaped, but it is 2 times longer in the male than in the female.

c. *N. dimorphicus*: The female caudal seta IV has a globular expansion at its base, but it is normal type in the male. Also, the caudal seta V is inflated and bulbous proximally in the female, but normal and widest anteriorly in the male.

d. *N. parvus*: The female caudal seta IV is strongly pinnate and stout, but it is sparsely pinnate or naked and slender in the male.

e. *N. procerus*: The female caudal seta V has a blunt tooth or notch proximally, but this tooth or process is missing in the male.

f. *N. didelphis*: The female caudal seta V is inflated, with a restricted globular expansion and with a circlet of setules at its base, but it is not inflated, without a restricted globular expansion, and circlet of setules in the male.

g. *N. bulbiseta*: The female caudal seta V is bulbous at its base, but it is not bulbous rather with a restricted globular projection at its base in the male.

h. *N. scaldicola*: The female caudal seta VI is having a circlet of setules or spur at its base, but smooth in the male.

i. *N. parvus*: The female caudal seta VI and VII are strongly pinnate, but they are naked in the male.

The caudal seta IV and V are modified across several species in both sexes. For example, the female caudal seta V of *N. palustris s. str.* has an inflated process at its base. The female caudal seta V of *N. perplexus* is unique by having a hook-like process at the midlength of the seta, and slender process terminates from the ventral side. The female caudal seta V of *N. hirsutus* is heavily cylindrical, and inflated proximally. In addition, insertion sites of caudal setae are also different in some congeners such as caudal seta IV in *N. dimorphicus* is inserted dorsal to seta V. Insertion sites of caudal seta II, III and IV in *N. minutus* and *N. dimorphicus* is already explained above. These differences in caudal setae are also observed frequently among the congeners, and seem to be species-specific (Fiers & Kotwicki 2013). These characters could be important for taxonomic analysis, especially when cryptic species are encountered. Considering all the morphological features, the species of *Nannopus* must be described carefully in detail to understand their phylogenetic aspects.

All Korean *Nannopus* species (including the present five new species and *N. ganghwaensis* were sequenced for the mitochondrial cytochrome oxidase one (mtCOI), following the protocol suggested by Easton & Thistle (2014) and Cornils (2015), but using lysis buffer (Williams *et al.* 1992). Later, all the specimens of both sexes are retrieved back from the lysis buffer and confirmed with universal barcode (mtCOI). This approach is mainly applied to pair females and males of each species, and to identify the cryptic diversity of this genus. Finally, all these specimens of six species are prepared for descriptions (line drawings and SEM imaging). All Korean species of both sexes are well confirmed genetically prior to the formal descriptions. The molecular aspects of these Korean species will be soon released with additional datasets.

Despite the fact that type locality of *N. minutus*, *N. serratus*, and *N. ganghwaensis* is different from the type locality of *N. parvus* and *N. bulbiseta*, their geographical distance is only 15 to 20 km away. On the other hand, *N. dimorphicus* is collected 180 to 200 km away from the type localities of the remaining species. This indicates that they are distributed all over the West Coast of Korea. A large-scale taxonomical survey will probably further reveal the diversity of *Nannopus* from Korean West Coast (Yellow Sea).

A key to the species of *Nannopus* is presented below. Based on Fiers & Kotwicki (2013: 58), the inner subdistal pectinate seta on P4 exp-3 is considered as replaced with a setiform element in *N. palustris* Brady, 1880.

1)	P4 exp-3 without inner subdistal pectinate seta	2
-	P4 exp-3 with inner subdistal pectinate seta	3
2)	P2 and P4 exp-2 inner seta naked; male unknown	*N. palustris* Brady, 1880
–	P2 and P4 exp-2 inner seta pinnate in both sexes	*N. scaldicola* Fiers & Kotwicki, 2013
3)	P1 endopod 1-segmented	4
-	P1 endopod 2-segmented	5
4)	Inner seta on P3 enp-2 robust, relatively longer and pinnate, distal seta on P4 endopod small and pinnate; male unknown	*N. unisegmentatus* Shen & Tai, 1964
-	Inner seta on P3 enp-2 extremely slender, very small and naked in both sexes; distal seta on P4 endopod small and naked in both sexes	*N. serratus* **sp. nov.**

5) P5 exopod and baseoendopod fused in females 6
- P5 exopod and baseoendopod distinct in females 8
6) Second segment of A1 with normal setae only; A2 with 1 abexopodal seta, exopod with 3 elements; mandibular palp with 3 setae; inner subdistal element on exopod of P4 strongly pectinate; endopod of P4 with 1 seta; endopodal lobe of P5 with 3 setae; male unknown . . . . . *N. perplexus* (Sars, 1909b)
- Second segment of A1 with 2 unique pinnate setae (leaf-shaped) in both sexes; A2 with 2 abexopodal setae, exopod with 4 elements in both sexes; mandibular palp with 5 setae in both sexes; inner subdistal element on exopod of P4 weakly pectinate in both sexes; endopod of P4 with 2 setae in both sexes; endopodal lobe of P5 with 4 setae in both sexes 7
7) P2–P4 exp-3 with 5:6:6 elements in both sexes . . . . . *N. parvus* **sp. nov.**
- P2–P4 exp-3 with 4:5:5 elements in both sexes . . . . . *N. bulbiseta* **sp. nov.**
8) P4 exp-3 with 6 elements in both sexes; female caudal seta V with, male caudal seta V without notch-like process at the anterior third. . . . . *N. procerus* Fiers & Kotwicki, 2013
- P4 exp-3 with 7 elements in both sexes; caudal seta V without notch-like process at the anterior third in both sexes 9
9) Lateral margins of urosomites densely hirsute; caudal seta V long, inflated, semi-cylindrical, pinnate, densely hirsute proximally; male unknown . . . . . *N. hirsutus* Fiers & Kotwicki, 2013
- Lateral margins of urosomites are not densely hirsute; caudal seta V long, with or without inflated, with or without globular expansion at its base, pinnate, without hirsute proximally in both sexes 10
10) Caudal seta IV naked in females, but pinnate in males; male P3 enp-2 with short triangular apophysis. . . . . *N. flexibilis* (Lilljeborg, 1902)
- Caudal seta IV pinnate in both sexes; male P3 enp-2 with relatively long apophysis 11
11) Caudal seta III pinnate in both sexes. 12
- Caudal seat III naked in both sexes 13
12) Caudal seta IV leaf-shaped in both sexes; caudal seta V normal and wide proximally in both sexes; P2–P3 exp-3 with three outer spines in both sexes; distal seta on P4 endopod small and naked in both sexes . . . . . *N. minutus* **sp. nov.**
- Caudal seta IV with globular expansion at its base in female, but normal in male; caudal seta V heavily inflated and bulbous proximally in females, but normal in males; P2–P3 exp-3 with total three spines in female, but four spines in male, the P4 endopod distal small seta is pinnate in female, but naked in male . . . . . *N. dimorphicus* **sp. nov.**
13) Innermost seta and outer spines on P2 enp-2 subequal in female, but 0.5 times as long as the outer spine in male; innermost seta on P2 enp-2 pinnate in female, but naked in male; P2 exp-2 with inner pinnate seta in female, but without inner seta in male; caudal seta V with a spur, globular inflated at its base in female, but without spur and globular inflated in male; male with two spermaducts and symmetrical P6, distal margin of P6 with a small notch-like process. . . . *N. didelphis* Fiers & Kotwicki, 2013
- Inner most seta 1.7 times as long as the outer spine on P2 enp-2, but 0.7 times as long as the outer spine in male; innermost distal seta on P2 enp-2 pinnate in both sexes; P2 exp-2 with inner pinnate seta in both sexes; caudal seta V with only inflated nature at its base in both sexes; male with one spermaduct and asymmetrical P6, and P6 distal margin without notch like process in male . . . . . *N. ganghwaensis* Vakati *et al.* (2016)

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