



Two new species of *Apodopsyllus* (Copepoda, Harpacticoida) from Jeju Island, Korea*

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*In: Karanovic, T. & Lee, W. (Eds) (2012) Biodiversity of Invertebrates in Korea. *Zootaxa*, 3368, 1–304.

Abstract

A study of harpacticoid copepods from the intertidal zone of Jeju Island in the South Sea of Korea resulted in the discovery of two new paramesochrid species. They are placed in the genus *Apodopsyllus* Huys, 2009 on account of the following combination of characters: the absence of P2–P4 endopods, the poorly defined body segmentation, the two-segmented P1 endopod and exopod, and the fusion of the P2–P4 coxae with the respective body somites. *Apodopsyllus gwakjiensis* sp. nov. is most closely related to *A. bermudensis* (Coull & Hogue, 1978), but clearly distinguishable from it by the following characters: the concave shape of the baseoendopod with two bare setae, P4 basis without endopodal seta, and certain detailed characteristics of the mouthparts. *Apodopsyllus unisetosus* sp. nov. is easily distinguished from its congeners by the antennary exopod, which is armed with a single apical seta. In addition, *A. unisetosus* has the baseoendopod of P5 fused with somite, the P1 armed with one inner and one outer basal seta, and the unique shape of the male P6. Keys to genera of the family Paramesochridae Lang, 1944, as well as to species of the genus *Apodopsyllus* Huys, 2009 are provided.

Key words: Paramesochridae, new taxa, taxonomy, copepods, harpacticoids, South Korea

Introduction

The family Paramesochridae currently contains 13 valid genera (Wells 2007; Huys 2009). They have successfully colonized subtidal and intertidal sandy substrates by way of miniaturization, or by adopting a vermiform body shape. Kunz (1962) proposed the generic name *Apodopsyllus* and allocated four species to it (*Leptopsyllus littoralis* Nicholls, 1939; *L. spinipes* Nicholls, 1939; *L. arenicola* Chappuis, 1954; and *L. reductus* Petkovski, 1955). However, he did not designate a type species for the genus. As a consequence, the generic name *Apodopsyllus* Kunz, 1962 [*nomen nudum*] remained unavailable until Huys' (2009) reinstatement of *Apodopsyllus* Huys, 2009 and the designation of the type species, *Apodopsyllus panamensis* (Mielke, 1984), which was originally described from Panama (Mielke 1984). To date, 26 species have been described within this genus and they have been reported from all over the world. Synapomorphies for the genus include the following: (1) body somites are poorly demarcated from each other, (2) P2–P4 endopods are absent, and (3) exopods of P2–P4 are three-segmented. In addition, Seifried (2003) mentioned the ground pattern, including the mouthparts of Paramesochridae.

Coull & Hogue (1978) proposed two species groups, the '*madrasensis*-group' (which included *A. madrasensis* (Krishnaswamy, 1951) and *A. unguiformis* (Coull & Hogue, 1978)) and the '*littoralis*-group' (which included 10 species: *A. adaptatus* (Krishnaswamy, 1957), *A. africanus* (Kunz, 1962), *A. arenicolus* (Chappuis, 1954), *A. bermudensis* (Coull & Hogue, 1978), *A. camptus* (Wells, 1971), *A. depressus* (Krishnaswamy, 1957), *A. littoralis littoralis* (Nicholls, 1939), *A. schulzi* (Noodt, 1964), *A. spinipes* (Nicholls, 1939), and *A. vermiculiformis* (Lang, 1965)), based on two characteristics of P1, 1) length ratio between endopod and exopod, and 2) last segment of endopod armed with two claw-like setae or long non-claw-like setae. Gómez (2002) discussed three species, *A. arcuatus* (Mielke, 1984), *A. chilensis* (Mielke, 1987), and *A. cubensis* (Mielke, 1988), within a lineage based on the presence of well-defined plate-structures on the body somites. In addition, he mentioned the Neotropics lineage

within these three species. However, *A. arcuatus* is the one species included within the *madrasensis*-group. Gómez (2002) considered the ratio of P1 endopod and exopod to be symplesiomorphic characteristic and thus of limited potential use for distinguishing these two species groups within *Apodopsyllus*.

So far only two paramesochrids, *Paramesochra taeana* Back & Lee, 2010, and *Remanea naksana* Back, Lee & Huys, 2011, were reported from Korea (Back & Lee 2010; Back et al. 2011). However, an ongoing survey of the harpacticoid copepod fauna off Jeju Island, Korea, resulted in the discovery of two new paramesochrids that can be placed in the genus *Apodopsyllus*. We herein describe both as new species and provide updated keys to genera within Paramesochridae and to species within *Apodopsyllus*.

Materials and Methods

Samples were collected at Gwakji sand beach in the subtidal zone near Seogwipo port on Jeju Island, Korea. Sediment samples were obtained by sand scooping and with a van Veen grab (surface area: 0.1 m²). Samples were preserved in 99% ethanol. Specimens were dissected in lactic acid, and the dissected parts were mounted on slides in lactophenol mounting medium. Preparations were sealed with transparent nail varnish. All drawings were prepared using a camera lucida on an Olympus BX51 differential interference contrast microscope.

The descriptive terminology is adopted from Huys et al. (1996). Abbreviations used in the text are: A1, antennule; A2, antenna; ae, aesthetasc; exp, exopod; enp, endopod; P1–P6, first to sixth thoracopod; exp (enp)-1(2, 3), proximal (middle, distal) segment of a three-segmented ramus; CR, caudal rami. The term ‘acrothek’ denotes the trifold setal structure found on the apical margin of the distal antennular segment (Huys & Iliffe 1998). Body length is measured from the anterior margin of the cephalic shield to the posterior margin of the caudal rami (excluding caudal setae). Specimens are deposited at the National Institute of Biological Resources, Incheon, Korea (NIBR). Scale bars in figures are indicated in µm.

Systematics

Order Harpacticoida G.O. Sars, 1903

Family Paramesochridae Lang, 1944

Genus *Apodopsyllus* Huys, 2009

Updated generic diagnosis. Paramesochridae with cylindrical and dorsoventrally depressed habitus; body somites poorly defined; rostrum small, fused with cephalothorax. Anal operculum not present. Caudal rami with six or seven setae, seta I absent or small. Antennule seven- or eight-segmented in female, chirocer in male; without seta on segment 1 in female and male. Antennary exopod one-segmented (except for *A. vermiculiformis*, two-segmented) with one to four setae. Maxilla with three endites on syncoxa; endopod one- or two-segmented. P1 biramous, with two-segmented endopod; P2–P4 uniramous, with exopods three-segmented; P1–P4 armature formulae as follows:

	Exopod	Endopod
P1	0.022	0.[010]020
P2	0.0.011	-
P3	0.0.011	-
P4	0.0.011	[0–1]

Type species. *Apodopsyllus panamensis* (Mielke, 1984).

Additional species. *Apodopsyllus littoralis* (Nicholls, 1939); *A. spinipes* (Nicholls, 1939); *A. madrasensis* (Krishnaswamy, 1951); *A. arenicola* (Chappuis, 1954); *A. adaptatus* (Krishnaswamy, 1957); *A. depressus* (Krishnaswamy, 1957); *A. africanus* (Kunz, 1962); *A. perplexus* (Wells, 1963); *A. schulzi* (Noodt, 1964); *A. vermiculiformis* (Lang, 1965); *A. lynceorum* (Cottarelli, 1973); *A. camptus* (Wells, 1971); *A. africanus listensis*

(Mielke, 1975); *A. bermudensis* (Coull & Hogue, 1978); *A. unguiformis* (Coull & Hogue, 1978); *A. aberrans* (Mielke, 1984); *A. arcuatus* (Mielke, 1984); *A. biarticulatus* (Cottarelli & Altamura, 1986); *A. chilensis* (Mielke, 1987); *A. cubensis* (Mielke, 1988); *A. melitae* (Kunz, 1992); *A. alejandrovillalobosi* (Gómez, 2002); *A. pseudocubensis* (Gómez, 2002); *A. samuelgomezi* (Gómez, 2002), *A. gabesensis* Amorri et al., 2010; *A. gwakjiensis* **sp. nov.**; and *A. unisetosus* **sp. nov.**

***Apodopsyllus gwakjiensis* sp. nov.**

(Figs. 1–4)

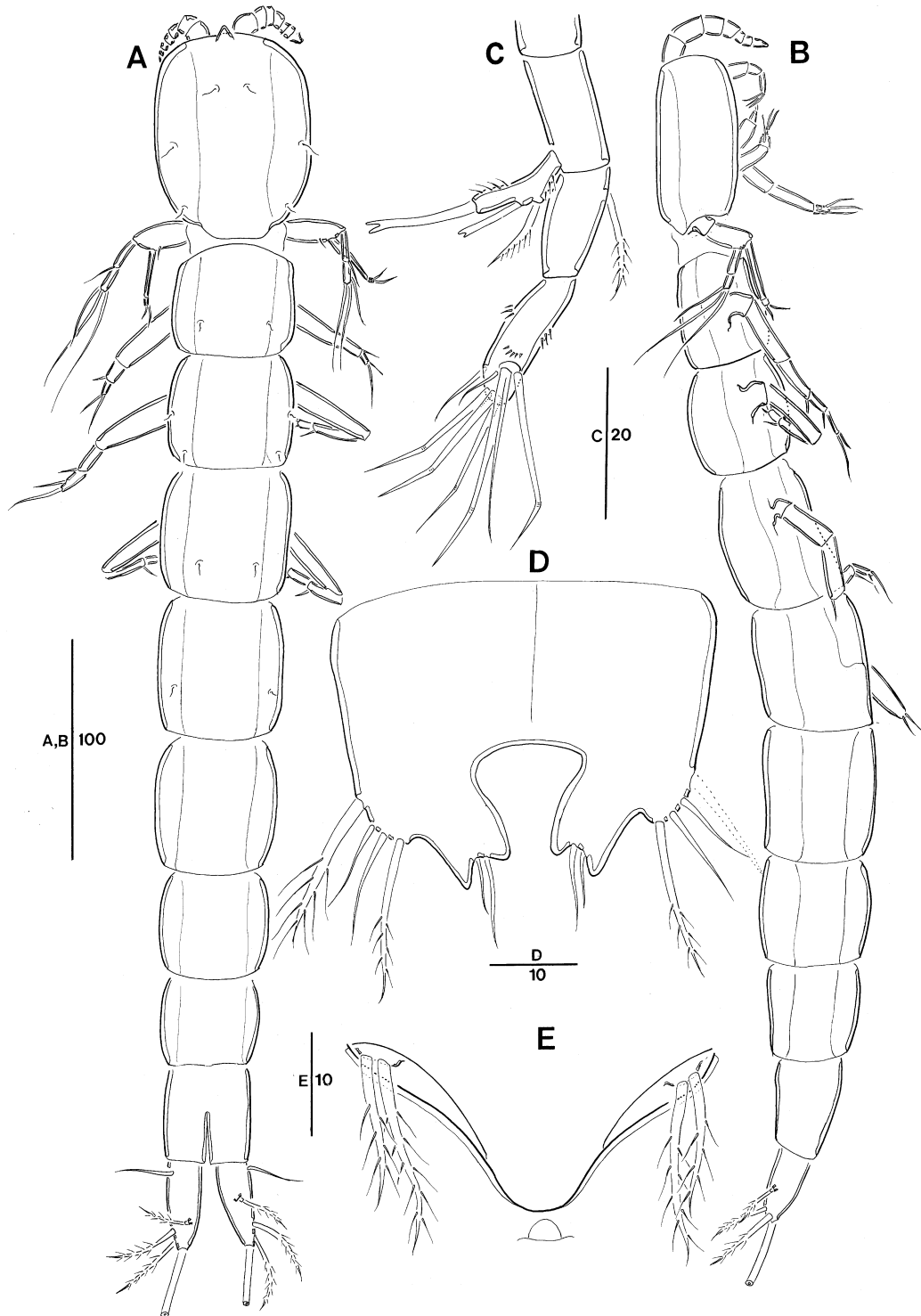


FIGURE 1. *Apodopsyllus gwakjiensis* **sp. nov.**, holotype female: A, habitus, dorsal; B, habitus, lateral; C, antenna; D, P5; E, P6 and genital field. All scales in μm .

Type locality. An upper intertidal zone at Gwakji sand beach on Jeju Island, Korea (33° 27' 04"N 126° 18' 19"E).

Material examined. Holotype, 1 female (NIBRIV0000245112) dissected on 7 slides. Paratypes: 1 male (NIBRIV0000245113) dissected on 5 slides, and 6 females (NIBRIV0000245114) and 7 males (NIBRIV0000245115) in 70% alcohol. All samples are from the type locality collected by J. Back, by sand rinsing on 3 June 2010.

Description of female (holotype). Body (Fig. 1A–B). Elongate, cylindrical, slightly depressed dorsoventrally, and somites not clearly demarcated from each other. Total body length 550 µm (n=6, mean=556 µm); measured from tip of rostrum to posterior margin of caudal rami; largest width 70 µm measured midway along cephalothorax. Few sensilla present as illustrated in figure 1A.

Rostrum (Fig. 1A) diminutive, triangular, bare, fused with cephalic shield. Cephalothorax quadrangular, with few sensilla; pleural areas weakly developed, posterior margin smooth.

Prosome and urosome with plate-like structures dorsally and laterally except for anal somite. Genital somite and first abdominal somite completely fused forming genital double-somite. Genital field (Fig. 1E) located at anterior third of genital double-somite. Copulatory pore observed, and covered by small process. Each P6 (Fig. 1E) represented by chitinous out-growth armed with one longer inner and one shorter outer pinnate setae. Penultimate somite without pseudoperculum; anal somite deeply cleft and operculum not developed.

Caudal rami damaged during dissection (figured in male).

Antennule (Fig. 2A) eight-segmented, short, robust. Segment-1 longest, with row of spinules on lateral margin; segment-4 forming sub-cylindrical process armed with one long slender seta fused basally to aesthetasc; segment-6 armed with one slender bare seta arising from sub-cylindrical process; armature formula: 1–[0], 2–[7+2 pinnate], 3–[6], 4–[2+(1+ae)], 5–[1], 6–[5], 7–[1], 8–[5+acrothek], apical acrothek consisting of well-developed aesthetasc fused basally to two slender, naked setae.

Antenna (Fig. 1C) with coxa, basis, and two-segmented endopod. Coxa small and bare. Basis, approximately twice as long as wide, without any surface ornamentation. Exopod one-segmented, with one pinnate seta and two bifurcate setae. Proximal endopodal segment with one pinnate abexopodal seta; distal endopodal segment armed with three geniculate setae, one small seta, apically; one lateral bare seta, one lateral geniculate seta, and one geniculate seta fused basally to one slender seta.

Mandible (Fig. 2B), coxa with well-developed gnathobase bearing one slender bare seta at dorsal corner and eight spinous overlapping teeth. Palp biramous, comprising basis, one-segmented exopod, and two-segmented endopod. Basis widening distally, with one pinnate seta. Exopod with two lateral and two apical bare setae. Endopod long; enp-1 with two bare seta on distal margin; enp-2 as long as exp, apically with five bare setae, two of which basally fused.

Maxillule (Fig. 2C), praecoxal arthrite well developed, with five geniculate spines, one slender seta on distal corner, and two juxtaposed slender bare setae on anterior surface near outer margin. Coxa with cylindrical endite bearing four apical bare setae. Basis cylindrical, endites fused, collectively two pinnate and three bare setae apically. Exopod one-segmented, small, with one stout pinnate and one slender bare setae. Endopod one-segmented, rectangular, with six bare setae around distal margin.

Maxilla (Fig. 2D), syncoxa with three cylindrical endites; first and second coxal endites armed with two bare setae each; third coxal endite with two apical pinnate setae. Allobasis with one stout unipinnate, one slender distal setae, and one bare seta near base of endopod. Endopod one-segmented, indistinctly subdivided, with four bare setae around distal margin.

Maxilliped (Fig. 2E), four-segmented comprising syncoxa, basis, and two-segmented endopod. Syncoxa and elongate basis without ornamentation. Enp-1 about 2.8 times as long as wide, with one minute bare and one stout distal setae. Enp-2 with two long naked apical setae.

Coxa of P1–P4 fused to posterior lateral margin of cephalosome (P1), or free pedigerous somites (P2–P4).

P1 (Fig. 3A), basis with one pinnate inner seta and row of spinules near base of exopod. Exopod two-segmented; exp-1 about 1.7 times longer than exp-2, with one outer unipinnate seta and ornamented with row of spinules along outer margin; exp-2 with two terminal unipinnate and two outer bare setae. Endopod 1.7 times as long as exopod; enp-1 elongate, bare, 7 times as long as wide; enp-2 with two apical setae and ornamented with row of spinules along inner margin.

P2–P4 (Fig. 3B–D), basis with 1 pinnate outer seta. Exopod three-segmented; exp-1 with one outer spine; exp-2 inner distal corner forming spinous projection and with one outer spine; exp-3 with one long apical seta and one outer spine. Endopod absent.

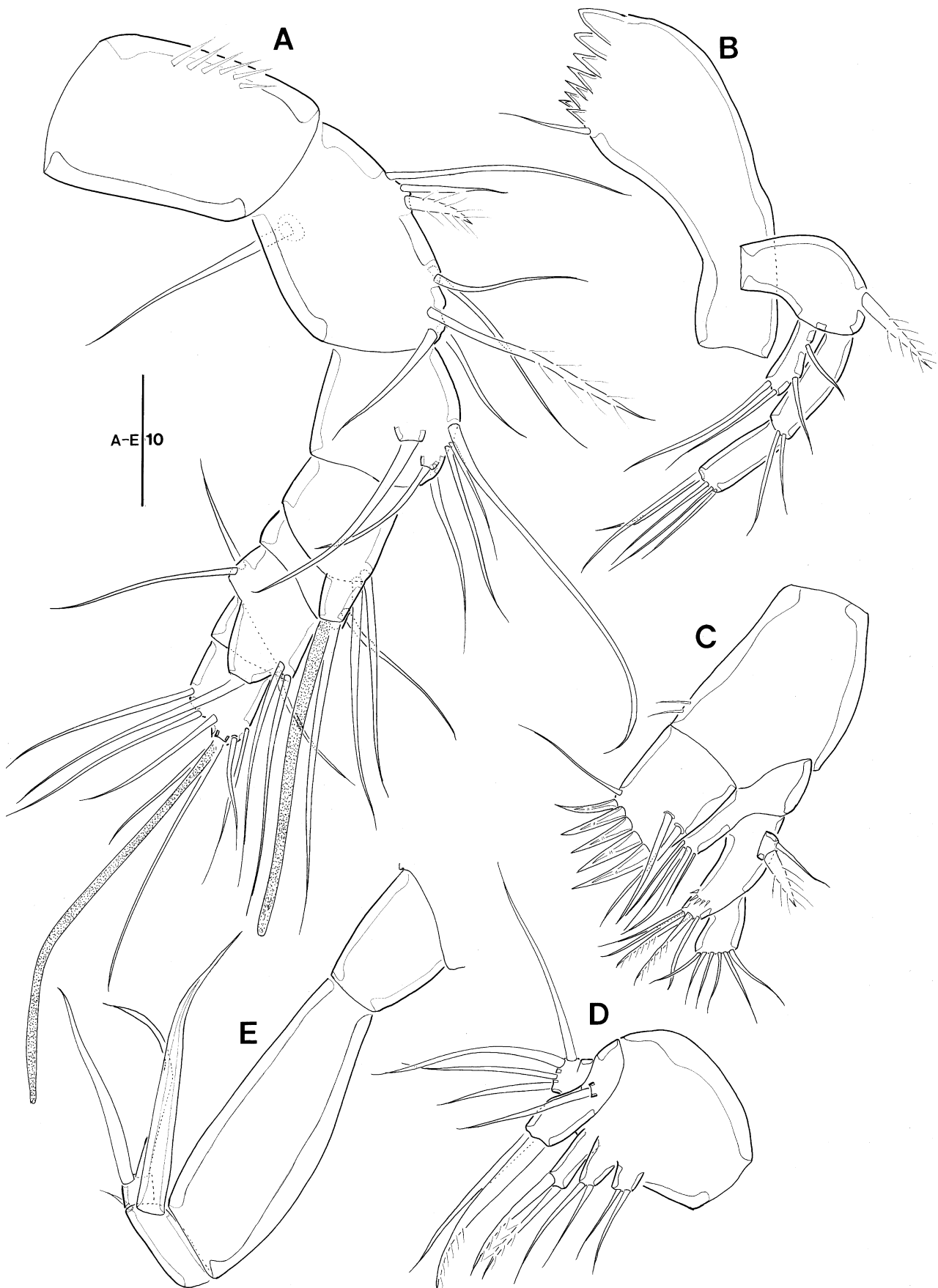


FIGURE 2. *Apodopsyllus gwakjiensis* sp. nov., holotype female: A, antennule; B, mandible; C, maxillule; D, maxilla; E, maxilliped. Scale in μm .

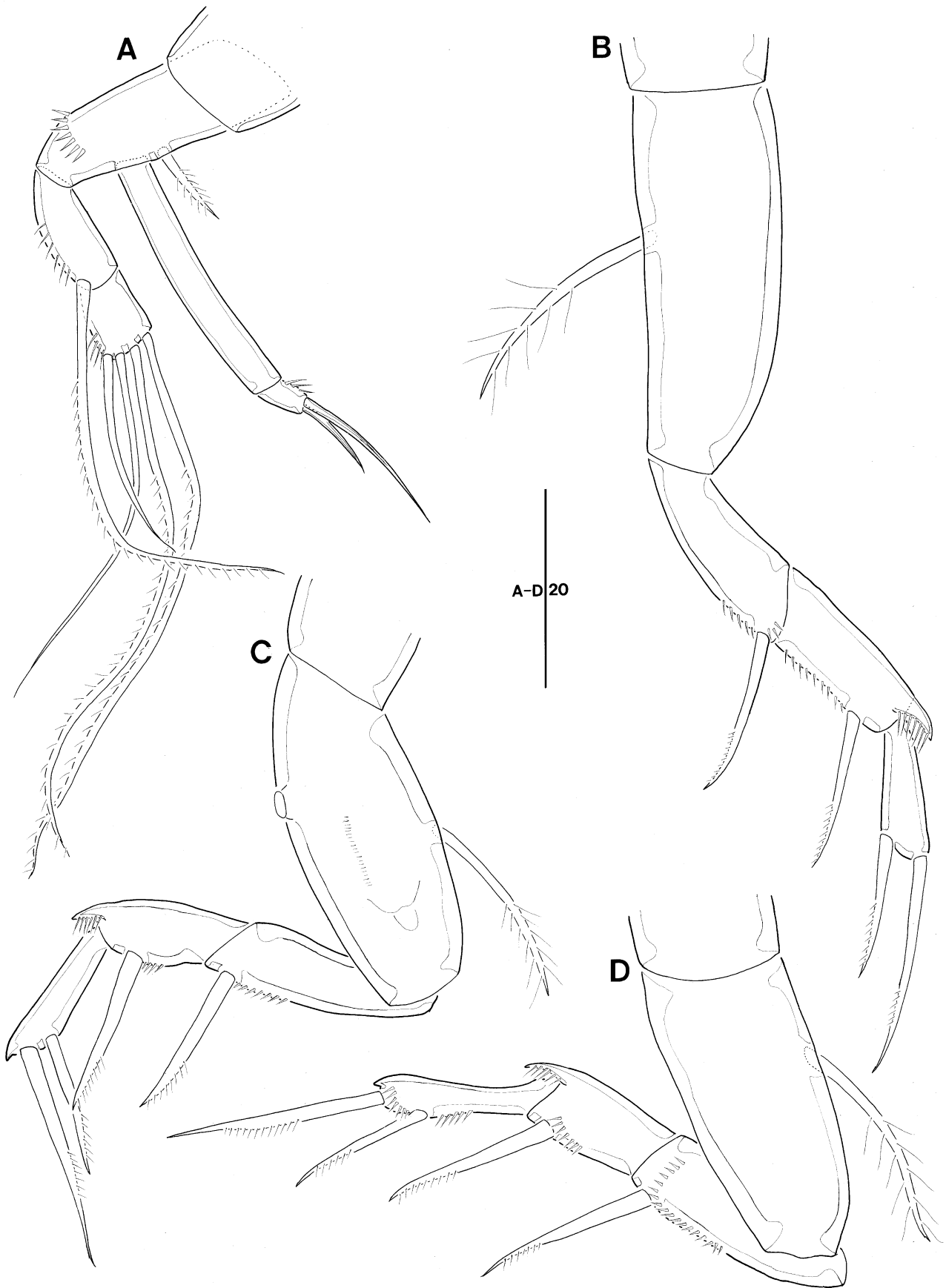


FIGURE 3. *Apodopsyllus gwakjiensis* sp. nov., holotype female: A, P1; B, P2; C, P3; D, P4. Scale in μm .

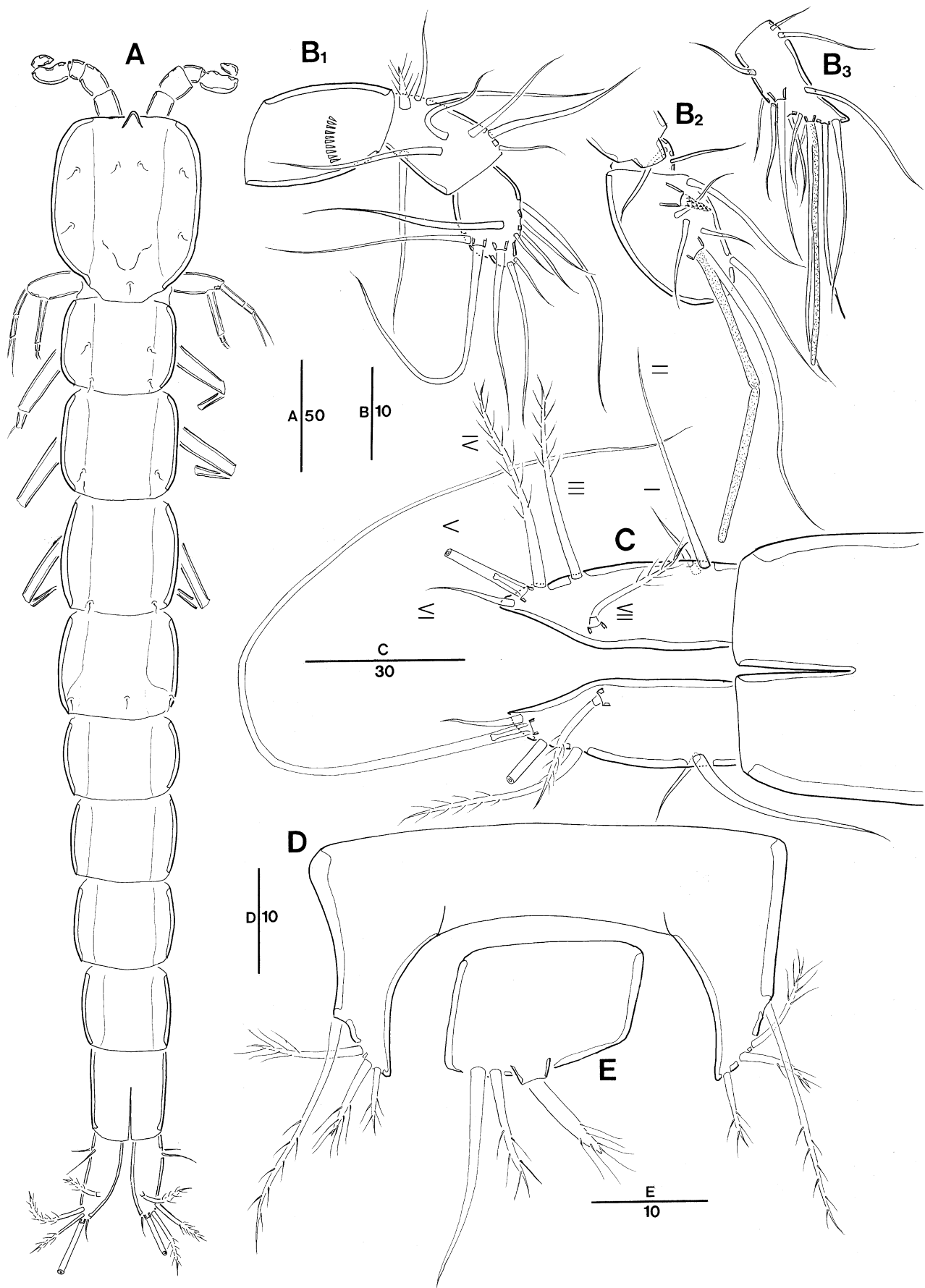


FIGURE 4. *Apodopsyllus gwakjiensis* sp. nov., paratype male: A, habitus; B, Antennule (B1, segments 1–3; B2, segments 4–5; B3, segment 6); C, caudal rami, dorsal; D, P5; E, P6. All scales in μm .

Armature formula as follows:

	Exopod	Endopod
P2	0.0.011	-
P3	0.0.011	-
P4	0.0.011	-

P5 (Fig. 1D). Baseoendopods confluent, forming large plate, exopod fused with baseoendopod, with one outer basal pinnate seta proximally; endopodal lobe with distinct concave shape with two naked setae; exopod represented by weak protrusion near basal seta, armed with two naked and one pinnate setae.

Description of male (paratype). Smaller and more slender than female. Body (Fig. 4A) length 510 μm (n=7, mean = 519 μm). Largest width measured near middle of cephalic shield : 65 μm . General body shape and ornamentation as in female except for separation of genital and first abdominal somites; additional sexual dimorphism in A1, P5, and P6.

Antennule (Fig. 4B₁-B₃), six-segmented, short, robust, chirocer; segment-5 swollen, largest; Armature formula: 1-[0], 2-[8+1 pinnate], 3-[10], 4-[2], 5-[5+1 pinnate+(1+ae)], 6-[11+acrothek], apical acrothek consisting of aesthetasc fused basally to two slender, naked setae.

P5 (Fig. 4D), conical, with medially fused baseoendopods. Baseoendopod and exopod fused, with four pinnate setae along outer margin.

P6 (Fig. 4E), both legs distinct, represented by thin plate; armature consisting of one bare longest and two short pinnate setae.

Caudal rami (Fig. 4C), juxtaposed, about 2.5 times as long as wide, conical, distal margin acutely pointed; each ramus armed with seven setae; seta I bare, short and located ventrally; seta II bare; seta III and IV pinnate; seta V longest, bare; seta VI short, bare and located sub-apically; seta VII bi-articulated, pinnate, and inserted on short peduncle.

Etymology. The specific name refers to the type locality.

Remarks. The new species *Apodopsyllus gwakjiensis* is most closely related to *A. bermudensis* Coull & Hogue, 1978 on account of seta formula of A2 exopod, P1 basis without outer seta, and P1 enp-1 longer than exopod. However, the new species is clearly distinguished from the congener by the combinations of characters: 1) concave shape of baseoendopod with two bare setae (baseoendopodal plate of *A. bermudensis* is confluent, without seta), 2) P4 basis without any elements at the endopodal location, while *A. bermudensis* armed with a minute spinule at that location. Other differences appear in the mouth parts, for example, *A. gwakjiensis* has a one-segmented mandibular exopod with four setae, while *A. bermudensis* has a two-segmented exopod in mandibular palp, and exp-1 with one seta. Nearly all species of Paramesochridae have a one-segmented exopod on the mandibular palp.

***Apodopsyllus unisetosus* sp. nov.**

(Figs. 5-9)

Type locality. Subtidal zone near Seogwipo port on Jeju island, Korea (33° 13' 33"N 126° 34' 39"E), depth 15-20m, sand.

Material examined. Holotype, 1 female (NIBRIV0000245116) dissected on 5 slides. Paratypes: 1 male (NIBRIV0000245117) dissected on 6 slides, 1 female (NIBRIV0000245118) and 2 males (NIBRIV0000245119) in 70% alcohol. All samples are from the type locality collected by J. Back, using a van Veen grab from a fishing boat on 4 June 2010.

Description of female (holotype). Body (Fig. 5A-B) elongate, cylindrical, depressed dorsoventrally, and somites weakly separated dorsally. Total body length 655 μm (n= 3, mean= 653); measured from tip of rostrum to rear margin of caudal rami. Largest width 70 μm measured near middle of cephalothorax.

Rostrum (Fig. 5A) diminutive, triangular, bare, fused to cephalic shield. Cephalothorax bare with depressions dorsally; pleural areas weakly developed, posterior margin smooth. Prosome and urosome with plate-like structures dorsally and laterally except for anal somite. Genital somite and first abdominal somite completely fused forming genital double-somite. Genital field (Fig. 7C) located midventrally at anterior fourth of genital double-somite. No

discrete copulatory pore observed, presumably covered by process. P6 represented by two bare setae. Penultimate somite with well-developed, smooth, and thin pseudopericulum; anal somite with deep median cleft and operculum not developed.

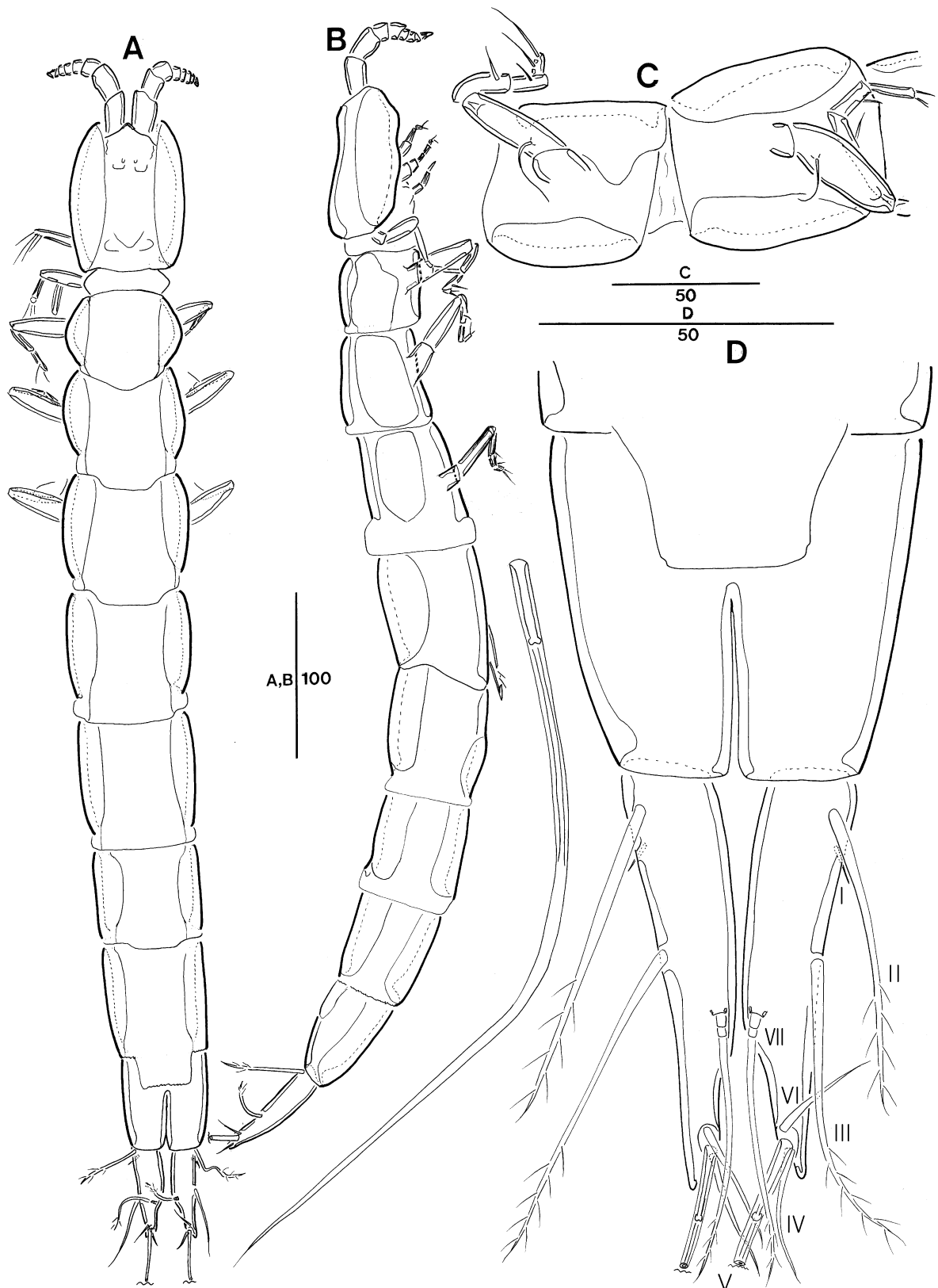


FIGURE 5. *Apodopsyllus unisetosus* sp. nov., holotype female: A, habitus, dorsal; B, habitus, lateral; C, P2- and P3-bearing somites, lateral; D, pseudopericulum, anal somite and caudal rami, dorsal. All scales in μm .

Caudal rami (Fig. 5D), juxtaposed, about 4.5 times as long as wide, conical, distal margin acutely pointed; each ramus armed with seven setae; seta I shortest, bare, ventrally; seta II, III pinnate, of similar length; seta IV bare; seta V longest, bare; seta VI bare, as long as seta IV; seta VII pinnate, tri-articulate at base on dorsal surface, inserted on small pedestal.

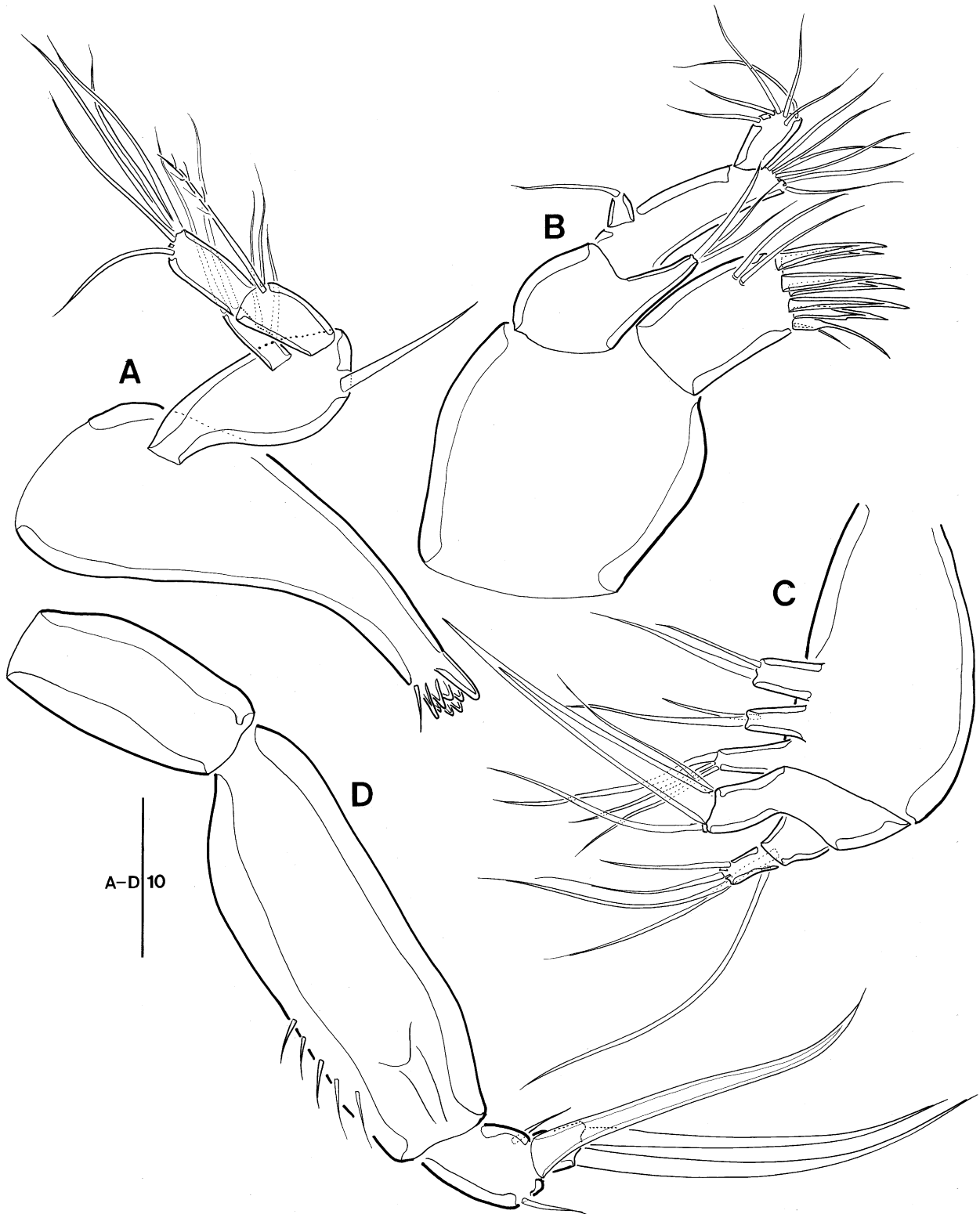


FIGURE 6. *Apodopsyllus unisetosus* sp. nov., holotype female: A, mandible; B, maxillule; C, maxilla; D, maxilliped. Scale in μm .

Antennule (Fig. 7A₁–A₃), eight-segmented, short, robust. Segment-1 longest, with row of spinules along anterior margin, without seta; segment-4 forming sub-cylindrical process armed with one long slender seta fused basally to aesthetasc; segment 6 armed with one slender pinnate seta arising from sub-cylindrical process; armature formula: 1–[0], 2–[8+1 pinnate], 3–[8], 4–[2+(1+ae)], 5– [1], 6–[1+1 pinnate], 7–[4], 8–[4+acrothek], apical acrothek consisting of well-developed aesthetasc fused basally to two slender, naked setae.

Antenna (Figs. 7B₁, B₂), basis approximately twice as long as wide, without surface ornamentation. Exopod one-segmented, with one apical bare seta. Proximal endopodal segment with one pinnate abexopodal seta and ornamented with row of spinules near distal inner corner; distal endopodal segment armed with three bare, one pinnate, and one geniculate setae laterally, one geniculate seta fused basally to one slender naked seta, and three geniculate and one bare setae apically.

Mandible (Fig. 6A), coxa with developed gnathobase bearing one slender bare seta at dorsal corner and eight spinous overlapping teeth. Palp biramous, comprising of basis, one-segmented exopod and two-segmented endopod. Basis widening distally, with one naked seta. Exp-1 as long as enp-1, with two lateral and two apical bare setae. Endopod longer than exopod; enp-1 with one pinnate and one bare setae; enp-2 of about same size of exp-1, with two bare setae and three basally fused setae at apex.

Maxillule (Fig. 6B), praecoxal arthrite well developed, with six spines, one modified, one bare, and two juxtaposed slender bare setae. Coxa with cylindrical endite, armed with three apical bare setae. Basis endites fused, armed with six bare setae apically. Exopod one-segmented, small, with one bare seta on distal margin. Endopod one-segmented, rectangular, with six bare setae.

Maxilla (Fig. 6C), syncoxa with three cylindrical endites; praecoxal and proximal coxal endites with two bare setae each; distal coxal endite with three bare setae. Allobasis with one stout blade-like seta and two slender bare setae around distal margin. Endopod two-segmented; enp-1 with one bare seta distally; enp-2 with one lateral longest and four distal bare setae.

Maxilliped (Fig. 6D), four-segmented, comprising syncoxa, basis and two-segmented endopod. Syncoxa bare, twice as long as maximum width. Basis elongate, 2.8 times as long as wide, with row of spinules along distal half; enp-1 with two small, bare, lateral setae and one long, stout, naked distal seta; enp-2 with two naked apical setae.

P1 (Fig. 8A), coxa fused to lateral side of cephalosome. Basis with one pinnate inner and one bare outer setae. Exp-1 about 1.2 times longer than exp-2, with one outer pinnate seta and with row of spinules along outer margin; exp-2 with four unipinnate setae. Endopod 1.2 times as long as exopod; enp-1 elongate, 7 times as long as wide, ornamented with row of spinules along outer margin; enp-2 with two apical geniculate setae.

P2–P3 (Figs. 5C, 8B–C), coxa fused to lateral side of free pedigerous somites. Basis with one bare (P2) or pinnate (P3) outer seta. Endopod absent. Exopod three-segmented; exp-1 with one outer spine and ornamented with row of spinules along outer margin; exp-2 inner distal corner forming spinous projection, with one outer spine; exp-3 with one outer spine and one apical geniculate seta.

P4 (Fig. 8D), basis with one pinnate outer seta. Endopod represented by one small naked seta near of basis. Exopod three-segmented; exp-1 with one outer spine; exp-2 inner distal corner forming spinous projection with spinules, with one outer spine; exp-3 with one outer spine and one apical geniculate seta.

Armature formula as follows:

	Exopod	Endopod
P2	0.0.011	-
P3	0.0.011	-
P4	0.0.011	- (1 seta)

P5 (Fig. 7C), baseoendopod partly incorporated into somite, with one basal bare seta. Exopod completely fused with baseoendopodal lobe, represented by rounded depression armed with two slender bare setae. Baseoendopodal lobe conical, armed with one subapical naked seta.

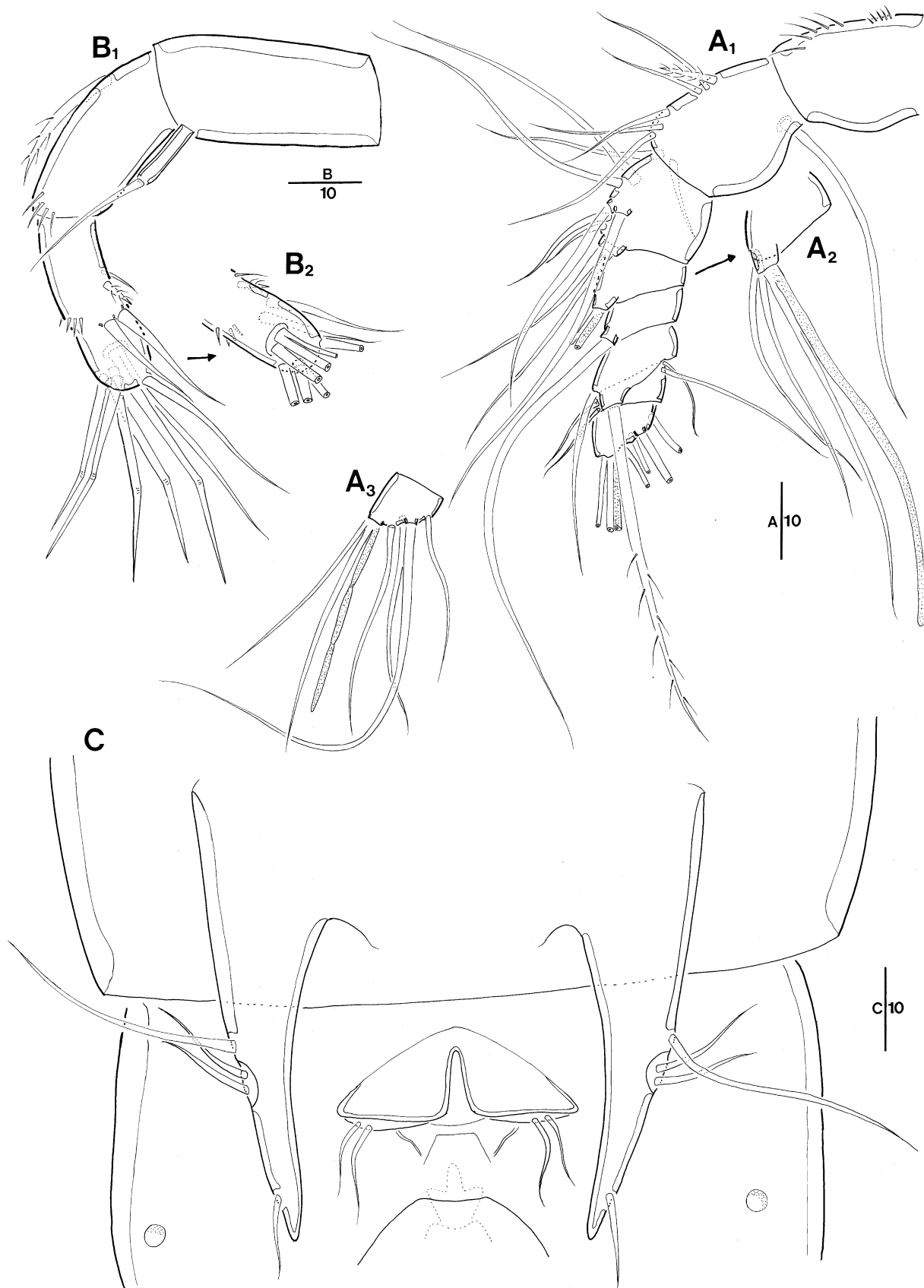


FIGURE 7. *Apodopsyllus unisetosus* sp. nov., holotype female: A, antennule (A1, antennule with armature of segments 4 and 8 omitted; A2, segment 4; A3, segment 8); B, antenna; C, P5, P6 and genital field. All scales in μm .

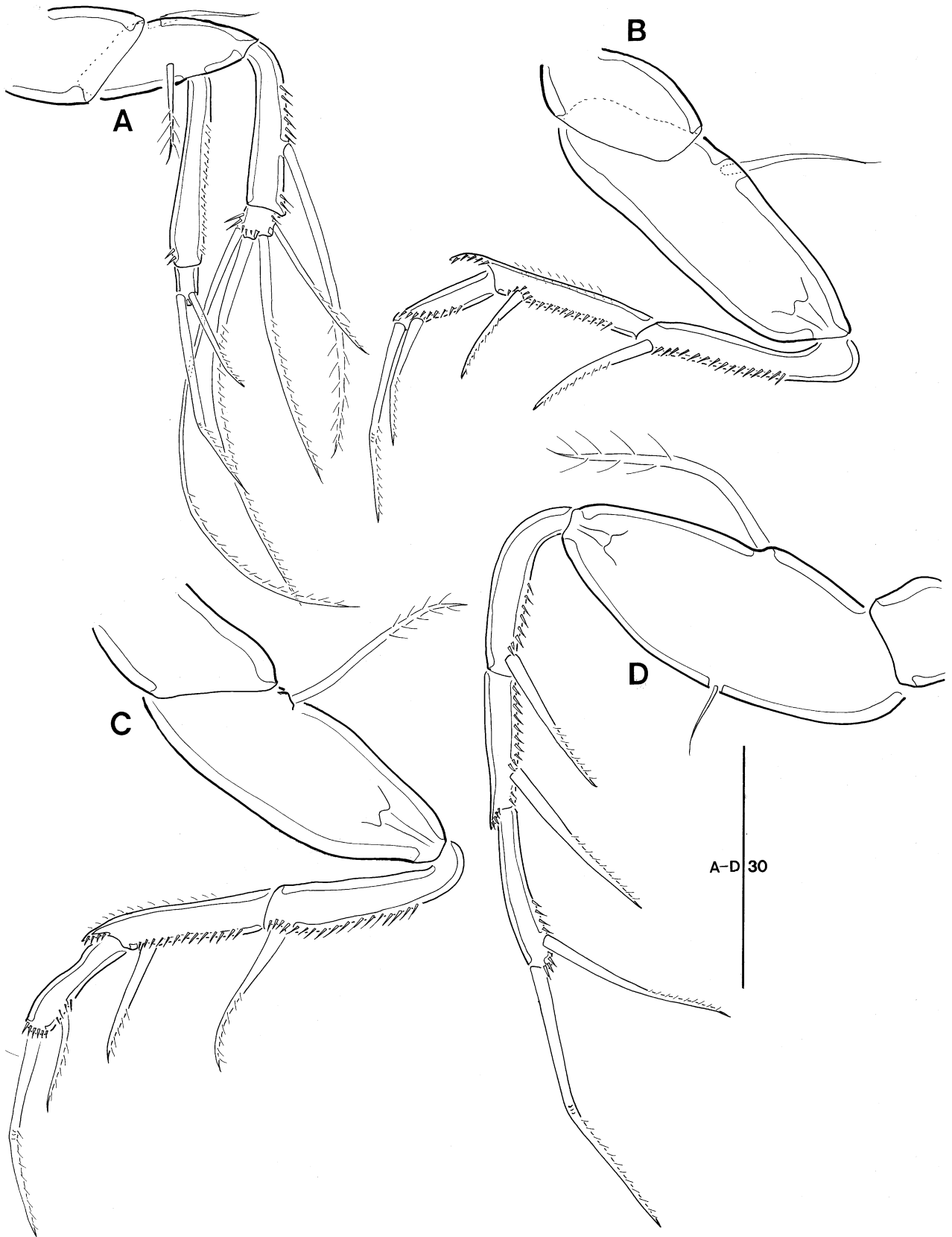


FIGURE 8. *Apodopsyllus unisetosus* sp. nov., holotype female: A, P1; B, P2; C, P3; D, P4. Scale in μm .

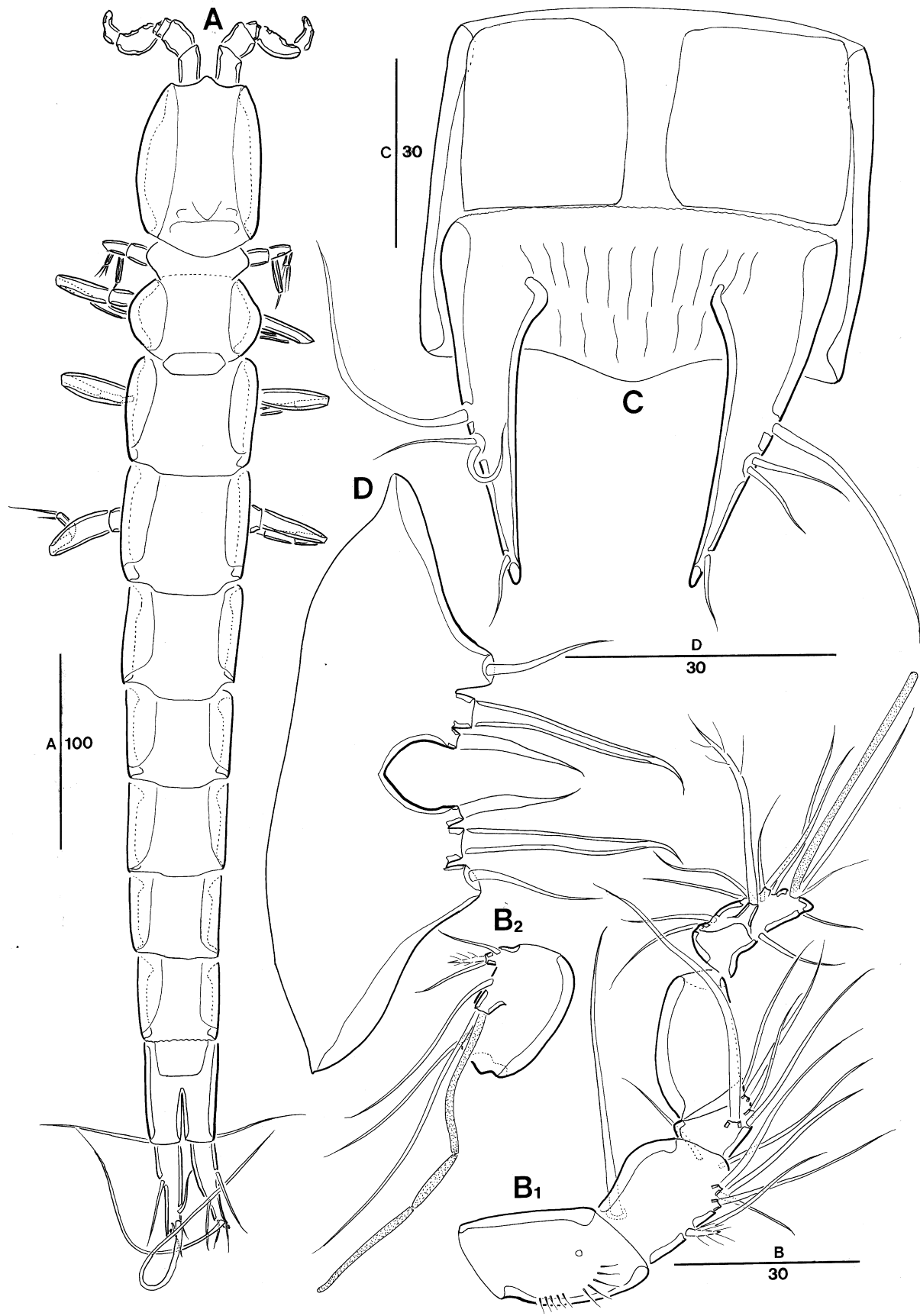


FIGURE 9. *Apodopsyllus unisetosus* sp. nov., paratype male: A, habitus, dorsal; B, antennule (B1, antennule with armature of segment 5 omitted; B2, segment 5; C, P5; D, P6. All scales in μm .

Description of male (paratype). Smaller and more slender than female (Fig. 9A). Body length 600 μm ($n=3$, mean=595). Largest width measured at cephalic shield : 65 μm . General body shape and ornamentation as in female except for separation of genital and first abdominal somites; additional sexual dimorphism in A1 and P6.

Antennule (Fig. 9B₁-B₂), six-segmented, short, robust, subchirocer; segment-5, swollen, largest; Armature formula: 1-[0], 2-[8+1 pinnate], 3-[4], 4-[1], 5-[4+1 pinnate + (1+ae)], 6-[9+1 pinnate+acrothek], apical acrothek consisting of well-developed aesthetasc fused basally to two naked setae].

P5 (Fig. 9C), shape as in female, fused with ventral plate, with one outer basal seta proximally; endopodal lobe developed, with one small naked setae; exopod completely fused with endopodal lobe, represented by round depression, with two naked setae.

P6 (Fig. 9D), represented by one plate, fused medially, but separated by rounded median cleft; each with one stout bare seta in middle and two naked setae.

Etymology. The specific name refers to the characteristic of antennary exopod armed with one seta.

Remarks. The new species is clearly distinguished from its congeners by the following combination of characters: 1) exopod of antenna with one apical seta (this is the only species in the genus *Apodopsyllus*), 2) P5 fused with somite, 3) P1 armed with one inner and one outer basal setae, and (4) male P6 well-developed and with a unique shape.

Discussion

The species of the genus *Apodopsyllus* display special characters. Kunz (1981) mentioned the presence/absence of the element at the location of endopod on the basis of P4. The genus *Apodopsyllus* consists of 13 species armed with one inner seta, four species ornamented with a minute spinule, eight species without an element, and three species with deficient descriptions of the P4 basis. Huys (1988) pointed out that within the genus *Apodopsyllus*, each caudal ramus bears six elements (seta I vestigial), with seta IV reduced. However, the two new species each have seven elements (with seta I present). *Apodopsyllus* includes species with one- or two-segmented exopod of P1 (one-segmented exopod in *A. camptus*, *A. depressus*, *A. littoralis*, and *A. lynceorum*; two-segmented in all other species). Gómez (2002) mentioned that three species (*A. arcuatus*, *A. chilensis*, *A. cubensis*) are clearly grouped together by the presence of well-defined plate structures on the somites. Reduction in appendages, unusual plate like structure on the body somites, and fusion of segments might be synapomorphies in *Apodopsyllus*. These characters probably facilitate adaptation to the interstitial habitat by enhancing wriggling ability (Huys 1988).

Amorri et al. (2010) mentioned that *A. gabesensis* shows slight sexual dimorphism in P2-P4. They described all the outer spines on the exopods of P2-P4 as pinnate in the male, while they are all naked in the female. Two new species, *A. gwakjiensis* and *A. unisetosus* do not display this slight sexual dimorphism in the swimming legs. Both new species have unipinnate outer spines in the exopods of P2-P4 in both sexes.

Since the endopods of P2-P4 are reduced and mouthparts were described poorly in the genus *Apodopsyllus*, the shape and the seta numbers of P5 are important and provide useful information for species identification. Based on differences in the P5, three groups can be suggested within the genus, as following: (1) exopod defined and baseoendopodal lobe well-developed (*A. adaptatus* and *A. spinipes*); (2) exopod fused with baseoendopod and baseoendopodal lobe developed (*A. africanus listensis*, *A. africanus africanus*, *A. arcuatus*, *A. bermudensis*, *A. cubensis*, *A. gabesensis*, *A. littoralis*, *A. madrasensis*, *A. pseudocubensis*, *A. schulzi*, *A. vermiculiformis*, and *A. gwakjiensis* **sp. nov.**); and (3) exopod fused and baseoendopodal lobe fused with somite (*A. alejandrovillalobosi*, *A. arenicola*, *A. biarticulatus*, *A. camptus*, *A. chilensis*, *A. depressus*, *A. lynceorum*, *A. melitae*, *A. panamensis*, *A. unguiformis*, and *A. unisetosus* **sp. nov.**). In the remaining species, the female P5 has not been described (*A. perplexus* and *A. samuelgomezi*) or has a unique shape (P5 of *A. aberrans* represented by two small processes). In addition *A. africanus africanus*, *A. alejandrovillalobosi*, and *A. gwakjiensis* **sp. nov.** have a vestigial exopod, represented by a blunt process. In the case of *A. unisetosus*, the baseoendopodal lobe is completely fused to the body somite in both sexes.

The key to genera of Paramesochridae by Boxshall & Halsey (2004) contains an error in the identification step towards *Leptopsyllus*, which states that the P2 exopod is two-segmented (derived by fusion of the second and third segment). However, almost all species of *Leptopsyllus* have a 3-segmented P2 exopod (*L. abyssalis* is the only species with two-segmented P2 exopod). There is also erroneous combination of characters in the key to the genera *Kunzia* and *Emertonia*. The key describes 'A2 exopod 1-segmented; P4 with 1-segmented endopods and P2

endopod 1-segmented', however they are not the only paramesochrids sharing those characters, since many species of *Wellsopsyllus* also have this character combination.

Key to genera of Paramesochridae (amended from Boxshall & Halsey 2004)

1.	P1 exopod 3-segmented, apophysis on the male P3 endopod	<i>Remanea</i> Klie, 1929
—	P1 exopod 1- or 2-segmented	2
2.	P3 endopod 3-segmented ... (Diarthrodellinae Huys, 1987)	3
—	P3 endopod 1- or 2-segmented ... (Paramesochrinae Lang, 1944)	5
3.	A2 exopod 3-segmented; endopod of P2 3-segmented	<i>Tisbisoma</i> Bozic, 1964
—	A2 exopod at most 2-segmented; endopod of P2 2-segmented	4
4.	Distal endopodal segment of P3 with 3 setae	<i>Rossopsyllus</i> Soyer, 1975
—	Distal endopodal segment of P3 with 4 setae	<i>Diarthrodella</i> Klie, 1949
5.	P2 and P3 endopods 2-segmented	<i>Paramesochra</i> T. Scott, 1892
—	P2 and P3 endopods 1-segmented at most	6
6.	P1 endopod absent	<i>Meiopsyllus</i> Cottarelli & Forniz, 1995
—	P1 endopod present	7
7.	A2 exopod 1-segmented; P2 and P4 endopods 1-segmented	8
—	These characters not combined	10
8.	P1 endopod represent by unarmed lobe	<i>Kunzia</i> Wells, 1967
—	P1 endopod 2-segmented	9
9.	Distal segment of P2 and P3 exopod with 2 setae	<i>Wellsopsyllus</i> Kunz, 1981* & <i>Scottopsyllus</i> Kunz, 1962
—	Distal segment of P2 and P3 exopod with 3–4 setae	<i>Emertonia</i> Wilson, 1932
10.	Body dorsoventrally compressed, P4 exopod 1-segmented	<i>Caligopsyllus</i> Kunz, 1975
—	Body cylindrical, P4 exopod 2- or 3-segmented at least	11
11.	P4 endopod absent or represent by 1 seta	<i>Apodopsyllus</i> Kunz, 1962
—	P4 endopod present	12
12.	P4 exopod 2-segmented	<i>Biuncus</i> Huys, 1996
—	P4 exopod 3-segmented	<i>Leptopsyllus</i> T. Scott, 1894**

* *Wellsopsyllus (Intermediopsyllus) antoniae* (Plum and George 2009) is the single species in the genus armed with three setae on the distal exopodal segment of P2 and P3. *Wellsopsyllus (I.) antoniae* can be clearly distinguished from the genus *Emertonia* by the two-segmented P4 exopod, which is the diagnostic character for the genus *Wellsopsyllus (Intermediopsyllus)*.

** *Leptopsyllus (Leptopsyllus) abyssalis* Becker, Noodt & Schriever, 1979 is the single species within *Leptopsyllus* with two-segmented exopods of P1–P4.

Key to species of the genus *Apodopsyllus*

Including *A. gwakjiensis* **sp. nov.** and *A. unisetosus* **sp. nov.**, the number of valid species in the genus *Apodopsyllus* has increased to 28. Since the dichotomous key by Coull & Hogue (1978), 14 species have been newly described in this genus. Wells' (2007) tabular key is very useful to identify *Apodopsyllus* species. After Wells (2007), *A. gabesensis* is added in the genus *Apodopsyllus*. Therefore an updated key including *A. gabesensis* and the two new species is provided herein. This key does not include *A. perplexus* which was described only from the male. This species is very difficult to identify without information on the female P5. Unfortunately, Gómez (2002) did not describe the P5 of females. He stated that *A. samuelgomezi* was unique within an *arcuatus-chilensis-cubensis* clade as the male P6 carries two long inner setae. It is impossible to identify species without characteristics of the female P5 in this key. Therefore, this key does not include the species *A. samuelgomezi*. It is based on females.

1.	P1 exp 1-segmented	2
—	P1 exp 2-segmented	7
2.	P1 endopod-2 with 3 setae/spines; female A1 9-segmented and male 6-segmented	<i>A. littoralis</i>
—	P1 endopod-2 with 2 setae/spines, character not combined	3
3.	A2 exp 2-segmented	<i>A. arenicola</i> ***
—	A2 exp 1-segmented	4
4.	A2 exp with 2 setae	<i>A. depressus</i>
—	A2 exp with 3 setae at least	5

5.	P1 enp-2 with 2 claw-like setae; enp and exp of maxillule absent	<i>A. madrasensis</i>	6
—	These characters not combined		
6.	Outer lobe of P5 benp with 4 outer setae proximally, and 1 inner seta (or 1 projection)	<i>A. camptus</i> ****	6
—	Outer lobe of P5 benp with 3 setae proximally and 1 seta sub-apically	<i>A. lynceorum</i>	
7.	P5 exp separated		8
—	P5 exp fused		9
8.	P5 exp with 3 setae and benp inner lobe with 1 seta	<i>A. adaptatus</i>	
—	P5 exp with 2 setae and benp inner lobe without seta	<i>A. spinipes</i>	
9.	A2 exp with 1 seta	<i>A. unisetosus</i>	
—	A2 exp with 3 setae at least		10
10.	Enp-1 shorter than exp		11
—	Enp-1 longer than exp		15
11.	A2 exp with 3 setae	<i>A. schulzi</i>	
—	A2 exp with 4 setae		12
12.	P4 basis without inner seta; P5 benp not developed	<i>A. aberrans</i>	
—	P4 basis with 1 inner seta; P5 benp developed		3
13.	Inner lobe of P5 benp not confluent	<i>A. gabesensis</i>	
—	Benp plate of left and right P5 confluent		14
14.	End of P5 benp rounded; P5 exp represented by small protrusion	<i>A. africanus listensis</i>	
—	End of P5 benp pointed; P5 exp completely fused with benp	<i>A. biarticulatus</i>	
15.	P1 enp-1 1.3 times longer than exp at least		16
—	P1 enp-1 1.1 times longer than exp at most		20
16.	A2 exp with 3 setae		17
—	A2 exp with 4 setae		19
17.	P1 enp-1 2.4 times longer than exp; P1 basis with 1 outer seta	<i>A. unguiformis</i>	
—	These characters not combined		18
18.	P5 benp bluntly pointed median plate without seta	<i>A. bermudensis</i>	
—	P5 benp divided in middle with concave median incision with 2 setae	<i>A. gwakjiensis</i>	
19.	P1 enp-1 1.3 times longer than exp	<i>A. alejandrovillalobosi</i>	
—	P1 enp-1 1.7 times longer than exp at least		20
20.	Inner lobe of left and right P5 confluent, with 2 almost same length setae each	<i>A. pseudocubensis</i>	
—	Inner lobe of left and right P5 completely divided, with 1 shorter inner seta and 1 longer outer seta each	<i>A. arcuatus</i>	
21.	A2 exp 2-segmented	<i>A. vermiculiformis</i>	
—	A2 exp 1-segmented		22
22.	A2 exp with 3 setae		23
—	A2 exp with 4 setae		24
23.	P4 basis with 1 small inner seta	<i>A. panamensis</i>	
—	P4 basis without seta	<i>A. melitae</i>	
24.	Inner lobe of benp P5 developed; P5 benp with 3 setae at middle margin and 1 seta sub-apically	<i>A. cubensis</i>	
—	These characters not combined		25
25.	Lobe of P5 benp triangular shape, with 4 outer and 1 inner setae	<i>A. chilensis</i>	
—	Lobe of P5 benp rounded shape, with 4 outer setae	<i>A. africanus</i>	

*** Chappuis (1954) figured the female P5 with three setae. However, Bodin (1979) redescribed P5 with four setae (one basal seta, and exopodal setae).

**** Wells (1971) described the antennary exopod with two setae in the figure, but he stated three setae in the text description.

Acknowledgements

This research was supported by the Basic Science Research Program of the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2009-0075502), the Discovery of Korean Indigenous Species Project, NIBR (National Institute of Biological Resources), and the National Investigation of Marine Ecosystems of the National Fisheries Research and Development Institute (NFRDI). The authors are grateful to two anonymous reviewers for their comments and suggestions.

References

- Amorri, J., Veit-Köhler, G., Drewes, J. & Aïssa, P. (2010) *Apodopsyllus gabesensis* n. sp.: a new species of Paramesochridae (Copepoda: Harpacticoida) from the Gulf of Gabès (south-eastern Tunisia). *Helgolander Marine Research*, 64, 191–203.

- Back, J. & Lee, W. (2010) A new species of the genus *Paramesochra* (Copepoda: Harpacticoida) from Korean waters. *Proceedings of the Biological Society of Washington*, 123, 47–61.
- Back, J., Lee, W. & Huys, R. (2011) A new species of *Remanea* Klie, 1929 (Copepoda: Harpacticoida: Paramesochridae) with a redescription of the type species. *Journal of Natural History*, 45, 2939–2964.
- Bodin, P. (1979) Copépodes Harpacticoides Marins des Environs de la Rochelle 5. Espèces Nouvelles ou incertaines. *Vie et Milieu*, 3, 311–357.
- Boxshall, G.A. & Halsey, S.H. (2004) *An Introduction to Copepod Diversity*. Ray Society, London, 966 pp.
- Chappuis P.A. (1954) Harpacticides psammiques récoltés par CL. Delamare Debutteville en Méditerranée. *Vie et Milieu*, 4, 254–276.
- Coull, B.C. & Hogue, E.W. (1978) Revision of *Apodopsyllus* (Copepoda, Harpacticoida) including two new species and a redescription. *Transactions of the American Microscopical Society*, 97, 149–159.
- Gómez, S. (2002) Some additions to the Mexican fauna: The family Paramesochridae (Copepoda: Harpacticoida). *Journal of Crustacean Biology*, 22, 627–641.
- Huys, R. (1988) A redescription of the presumed associated *Caligopsyllus primus* Kunz, 1975 (Harpacticoida, Paramesochridae) with emphasis on its phylogenetic affinity with *Apodopsyllus* Kunz, 1962. *Hydrobiologia*, 162, 3–19.
- Huys R. (2009) Unresolved cases of type fixation, synonymy and homonymy in harpacticoid copepod nomenclature (Crustacea: Copepoda). *Zootaxa*, 2183, 1–99.
- Huys, R., Gee, J.M., Moore, C.G. & Hamond, R. (1996) *Synopses of the British Fauna (New Series) No. 51. Marine and Brackish Water Harpacticoids, Part 1*. Field Studies Council, Shrewsbury, 352 pp.
- Huys, R. & Iliffe, T.M. (1998) Novocrinidae, a new family of harpacticoid copepods from anchihaline caves in Belize. *Zoologica Scripta*, 27, 1–15.
- Kunz, H. (1962) Revision der Paramesochridae (Crust. Copepoda). *Kieler Meeresforschungen*, 18, 245–257.
- Kunz, H. (1981) Beitrag zur Systematik der Paramesochridae (Copepoda, Harpacticoida) mit Beschreibung einiger neuer Arten. *Mitteilungen aus dem Zoologischen Museum der Universität Kiel*, 1(8), 1–33.
- Mielke, W. (1984) Interstitielle Fauna von Galapagos. XXXI. Paramesochridae (Harpacticoida). *Microfauna Marina*, 1, 63–147.
- Seifried, S. (2003) *Phylogeny of Harpacticoida (Copepoda): Revision of “Maxillipedasphalea” and Exanechentera*. Cuvillier, Göttingen. 259 pp.
- Wells, J.B.J. (1971) The Harpacticoida (Crustacea: Copepoda) of two beaches in south-east India. *Journal of Natural History*, 5, 507–520.
- Wells J.B.J. (2007) An annotated checklist and keys to the species of Copepoda Harpacticoida (Crustacea). *Zootaxa*, 1568, 1–872.