



Two new species of *Paracyclops* (Copepoda: Cyclopoida, Cyclopidae) from Africa

Süphan Karaytug¹, Danielle Defaye² & Geoffrey A. Boxshall^{3,*}

^{1,3}Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.; ²Museum national d'Histoire naturelle, Laboratoire de Zoologie-Arthropodes (Crustaces), 61 rue de Buffon, F-75005 Paris, France; ³School of Biological Sciences, Queen Mary and Westfield College, Mile End Road, London E1 4NS, U.K.
*Corresponding author: Tel. 44 171 9389489; Fax 44 171 9389158; e-mail address: gab@nhm.ac.uk

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Abstract

Paracyclops longispina n. sp. and *Paracyclops altissimus* n. sp. are described. New characters derived from detailed examination of body and limb ornamentation are used to differentiate them from other *Paracyclops* species. *Paracyclops longispina* n. sp. resembles *Paracyclops fimbriatus* (Fischer, 1853) and *Paracyclops imminutus* Kiefer, 1929. It differs from the former by the presence of a well-developed spinular row near the base of the inner setae on the antennal coxobasis in both sexes, and from the latter in the structure of the seminal receptacle and the position of the mid-distal spinular row on the posterior surface of the coxa of leg 1. *Paracyclops altissimus* n. sp. can be distinguished from other members of genus mainly by the structure of the seminal receptacle and leg 5.

Introduction

According to published records the genus *Paracyclops* is represented on the African continent by six species: *Paracyclops fimbriatus* (Fischer, 1853), *Paracyclops poppei* (Rehberg, 1880), *Paracyclops chiltoni* (Thomson, 1882), *Paracyclops affinis* (G. O. Sars, 1863), *Paracyclops oligarthrus* (G. O. Sars, 1909) and *Paracyclops fimbriatus euchaetus* Kiefer, 1939. Most records of *Paracyclops* refer to *P. fimbriatus* and *P. affinis*, both of which have been reported from wide range of habitats in Africa as well as on other continents (see Dussart & Defaye, 1985).

After detailed comparative study of extensive *Paracyclops* material from numerous localities (Karaytug, 1998) it has become apparent that a great deal of taxonomic confusion exists surrounding the identity of some *Paracyclops* species, especially *P. fimbriatus*, *P. chiltoni* and *P. poppei*. The discovery of new characters has helped to raise the level of taxonomic resolution above that afforded by the use of traditional characters alone. This increased resolution has necessitated the redescription and rediagnosis of *P.*

fimbriatus and *P. chiltoni* and places in doubt the presence of *P. fimbriatus* in Africa (Karaytug & Boxshall, 1998). Similarly, the presence of *P. poppei* in Africa requires confirmation (Karaytug & Boxshall, 1998).

The apparent cosmopolitan distribution of some *Paracyclops* species is due in part to the high level of significance that has traditionally been placed on characters such as proportions of the terminal endopodal segment of leg 4 and proportional lengths of caudal rami and caudal setae. These characters are useful to differentiate between some species but are inadequate to differentiate between others, especially closely related species that can be very similar in gross morphology (Karaytug, 1998). Taxonomic accounts of freshwater cyclopoids from the two last decades have shown a clear trend toward the inclusion of fine ornamentation detail, as emphasised firstly in studies of *Mesocyclops* (Dussart & Fernando, 1988; Van de Velde, 1984a,b), of the Cyclopidae in general (Fiers & Van de Velde, 1984) and, more recently, of the genera *Microcyclops* (Rocha, 1998) and *Acanthocyclops* (Reid, 1998). Such detail is now revealed as essential

for discriminating between closely related species and can also provide phylogenetically informative characters (Karaytug, 1998). Similar studies at the species level have also been carried out for other copepod taxa, including the harpacticoids (Clément & Moore, 1995; Huys, 1992; Huys & Conroy-Dalton, 1996; Wells, 1980) as well as other microcrustaceans, such as the cladocerans (Frey, 1980, 1988).

In the present paper two new species of *Paracyclops* are described in detail, and several fine scale characters are identified that are important in differentiating them from other *Paracyclops* species.

Material and methods

Specimens were dissected and mounted in lactophenol. Broken glass fibres were added to prevent the appendages from being compressed by the coverslip and to facilitate rotation and manipulation which allowed viewing from all sides. All drawings were made with the aid of a camera lucida using an Olympus BH-2 microscope equipped with Nomarski differential interference contrast and all measurements made with an ocular micrometer. Body lengths were measured from the base of the rostrum to the posterior edge of the caudal rami. Body width is given as the widest part of the cephalothorax. In the spine and seta formula of the swimming legs Roman numerals and Arabic numerals are used for spines and setae, respectively. The terminology used by Huys & Boxshall (1991) is adopted. The terms 'frontal' and 'caudal' introduced by Van de Velde (1984a) to denote the anterior and posterior surface of the antennary coxobasis are also adopted here.

The type material is deposited in the The Natural History Museum, London (*P. longispina*) and in the Muséum National d'Histoire Naturelle, Paris (*P. altissimus*)

Subfamily EUCYCLOPINAE

Paracyclops longispina sp. n. (Figures 1–7)

Material examined

Holotype. BMNH Reg. No: 1997. 1772, female dissected on slides. Collected from Lake Hohnel, Mount Kenya, Kenya by Miss W. E. Frost on 18 August 1948. *Paratypes*. BMNH Reg. No: 1997. 1773–1780, five females, three males, same locality and collection data.

Etymology

The name of the new species is derived from Latin *longus* meaning long and *spina* meaning spine. It refers to the unusual elongation of the outer exopodal spines of the swimming legs.

Description

Adult female. Body length (μm) not including caudal setae, 851–1026, mean = 919, $n = 5$; body width 309–354, mean = 333, $n = 3$. Third pedigerous somite with minutely denticulate hyaline frill along the posterior margin (Figure 1A). Fourth pedigerous somite with patch of spinules at each posterolateral corner (Figure 1A). Urosomal somites (Figure 3A,B) without ornamentation of surface pits on dorsal and ventral surfaces. Seminal receptacle as figured (Figure 3A). Anal somite with distal spinular row ventrally, extending dorsally to either side of anal operculum. Caudal rami (Figure 3A,B) about 4.5 times longer than broad; broadest distally. Terminal accessory seta (VI) slightly longer than posterolateral seta (III); dorsal seta (VII) slightly longer than III and VI.

Antennule eight-segmented (Figure 2C). Segment 3 with partial suture line and spiniform seta. Segment 5 with characteristic short aesthetasc. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 2A,B) with complex ornamentation on caudal and frontal surfaces as figured and with spinular row on caudal surface near base of two inner setae (arrowed in Figure 2A), and armed with two inner spinulose setae plus very long outer spinulose seta representing exopod. First endopodal segment with inner distal spinulose seta and spinules along outer margin. Second endopodal segment with nine setae and; ornamented with spinules along outer margin. Third endopodal segment armed with seven setae around apex; outer margin ornamented with short spinules proximally and long spinules distally. Anterior surface of labrum ornamented with paired groups of long spinules (Figure 1B). Palp of mandible represented by three plumose setae, two of which long and one short (Figure 1E). Praecoxal arthrite of maxillule (Figure 1F) armed with eight setae articulating at base and three spines fused to segment. Proximal segment of maxillular palp representing fused coxa and basis, bearing one strong spine and two naked setae apically, plus outer spinulose seta representing exopod (Figure 1F). Distal segment of maxillular palp, representing endopod, armed with three setae, outermost seta spinulose (Figure 1F).

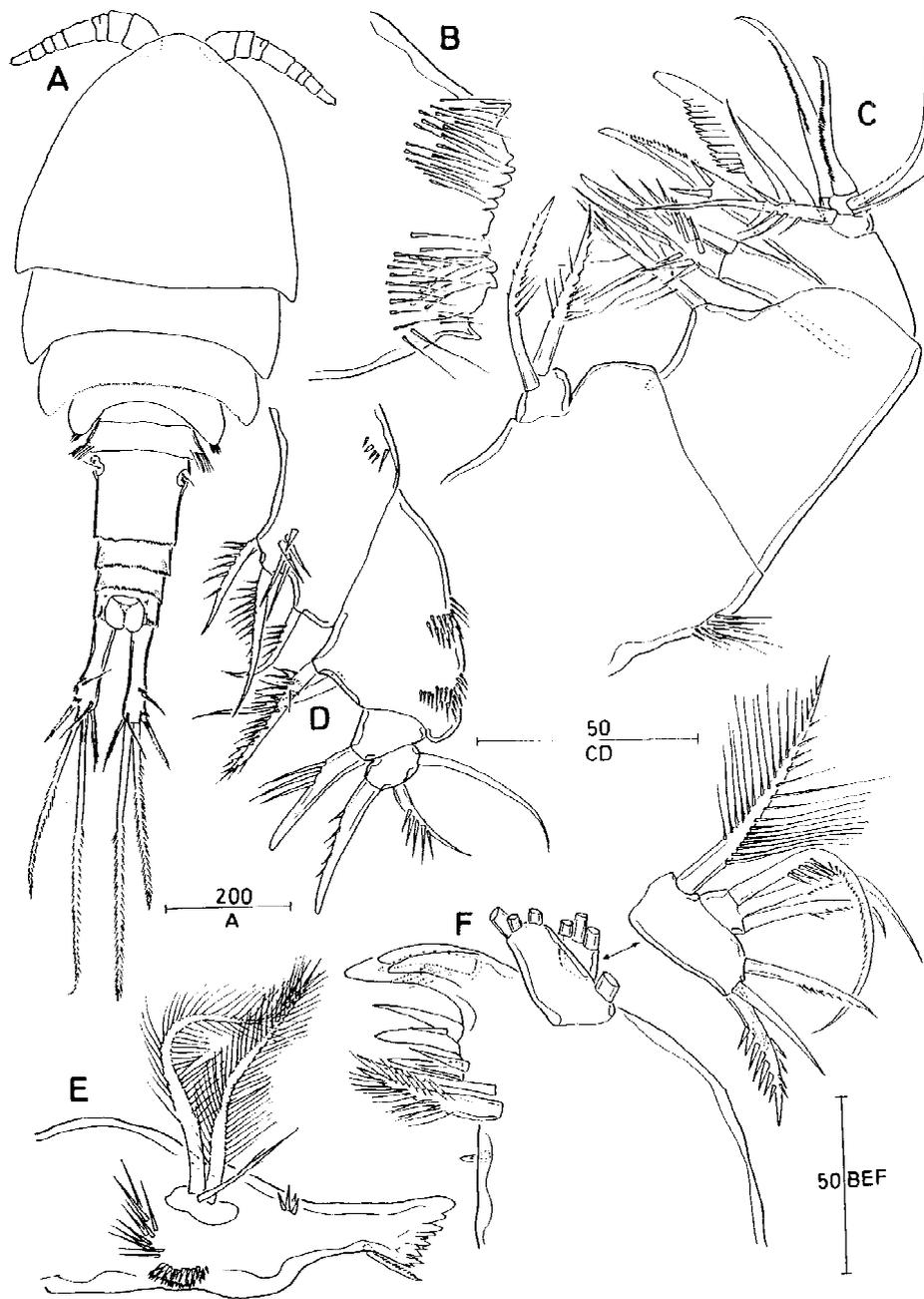


Figure 1. *P. longispina* sp. n. Adult female. (A) Body, dorsal; (B) labrum; (C) maxilla; (D) maxilliped; (E) mandible; (F) maxillule with inset showing maxillulary palp. Scale bars in μm .

Maxilla five-segmented (Figure 1C) comprising praecoxa, coxa, basis and two-segmented endopod. Praecoxa with spinular rows on outer margin. Praecoxal endite with two spinulose setae. Coxa with proximal endite represented by single spinulose seta;

distal endite cylindrical, with strong spinulose spine and naked seta apically. Basis drawn out into powerful curved claw bearing coarse spinules along middle part of inner margin; accessory armature consisting of strong spine; with spinular row along convex margin

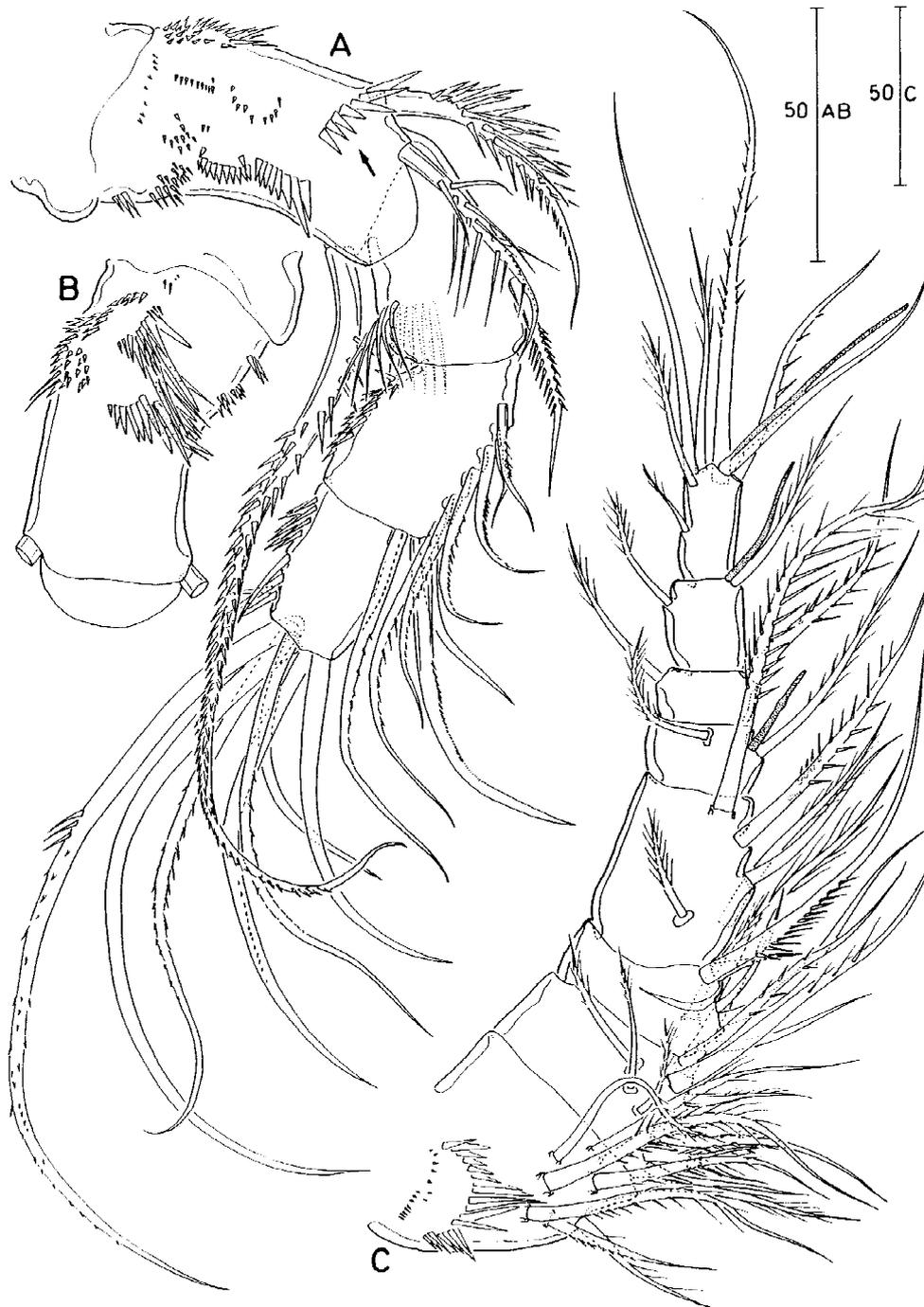


Figure 2. *P. longispina* sp. n. Adult female. (A) Antenna, caudal; (B) antenna, coxobasis, frontal; (C) antennule. Scale bars in μm .

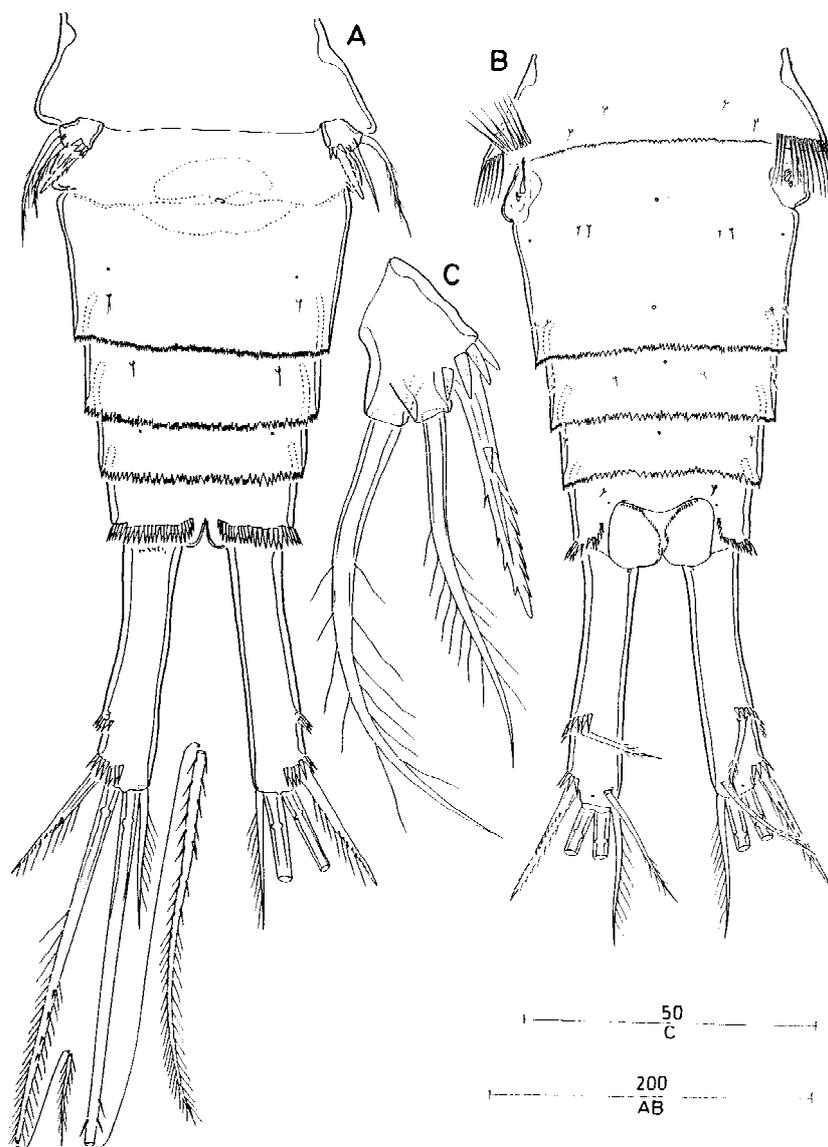


Figure 3. *P. longispina* sp. n. Adult female. (A) Urosome, ventral; (B) urosome, dorsal; (C) leg 5, ventral. Scale bars in μm .

and naked seta. First endopodal segment carrying two setae, second with three setae.

Maxilliped four-segmented (Figure 1D) comprising syncoxa, basis, and two-segmented endopod. Syncoxa armed with three spinulose setae representing endites, few long spinules arranged near base of setae; ornamented with spinular row near outer distal angle. Basis armed with one spinulose and one naked seta; ornamented with two transverse rows of spinules near outer margin. First endopodal segment bearing claw-like seta with spinules at midlength. Second endopodal

segment with three setae, one of which naked; other spinulose.

Legs 1–4 with three-segmented protopod (Figures 4B–C, 5A–D). Praecoxa represented by triangular sclerite at outer proximal angle; each protopodal segment with row of setules on outer corner of margin. Coxa with complex ornamentation on posterior surface as figured. Basis with plumose outer seta. Endopodal segments with long spinules along outer margins. All spines on segments of both rami with spinules at their bases. Exopodal segments 1 and 2

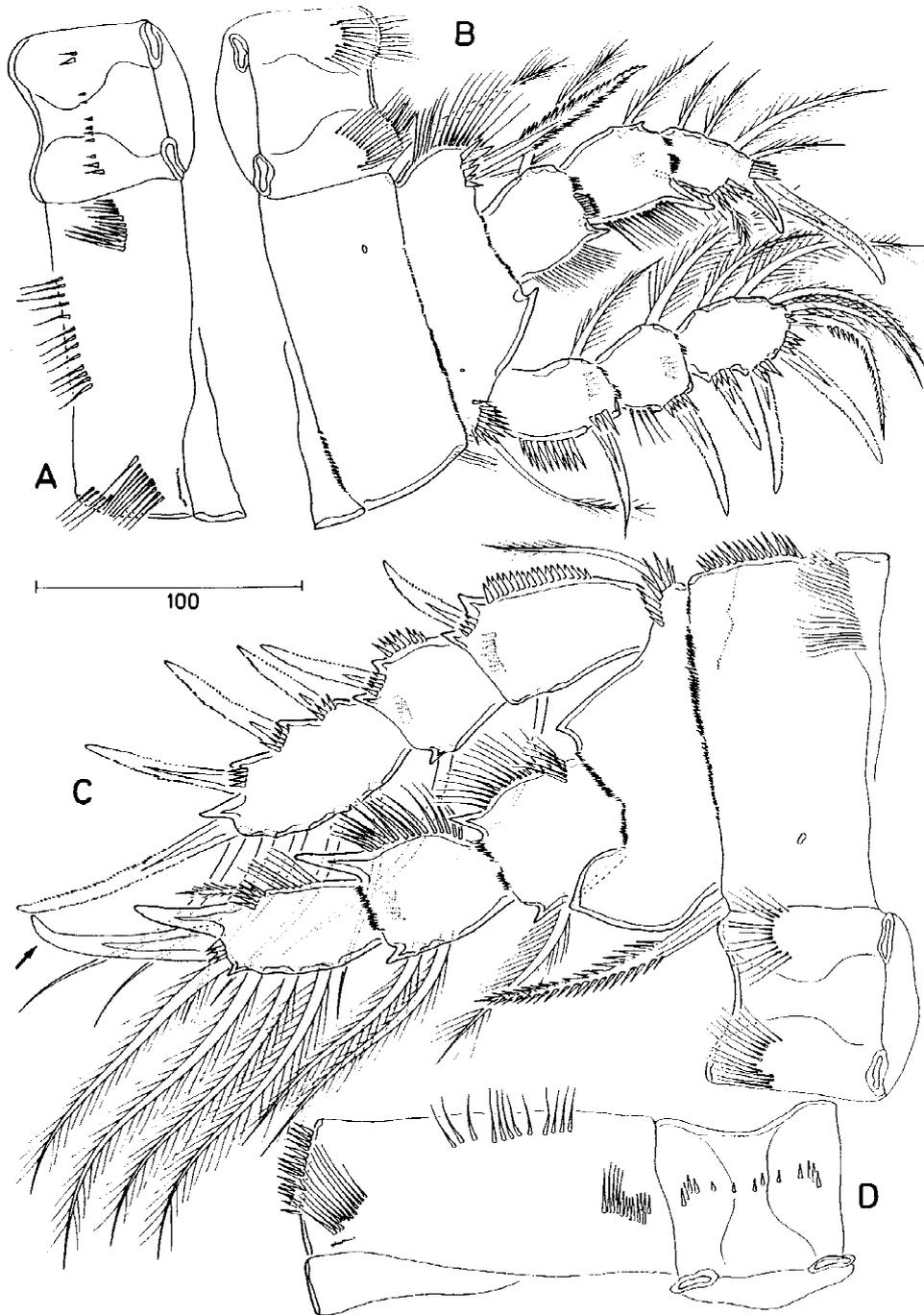


Figure 4. *P. longispina* sp. n. Adult female. (A) Intercoxal sclerite and coxa of leg 1, posterior; (B) leg 1, anterior; (C) leg 2, anterior; (D) intercoxal sclerite and coxa of leg 2, posterior. Scale bar in μm .

with short spinules along outer margins. Legs 2–4 each with spinular rows on anterior surface of endopodal segments 1 and 2 and exopodal segment 1 and posteri-

only on exopodal segments 1 and 2. Legs 2 and 3 with posterior spinular rows on endopodal segment 2.

Exopodal spines and terminal endopodal spine of leg 1 (Figure 4B) elongate; intercoxal sclerite orna-

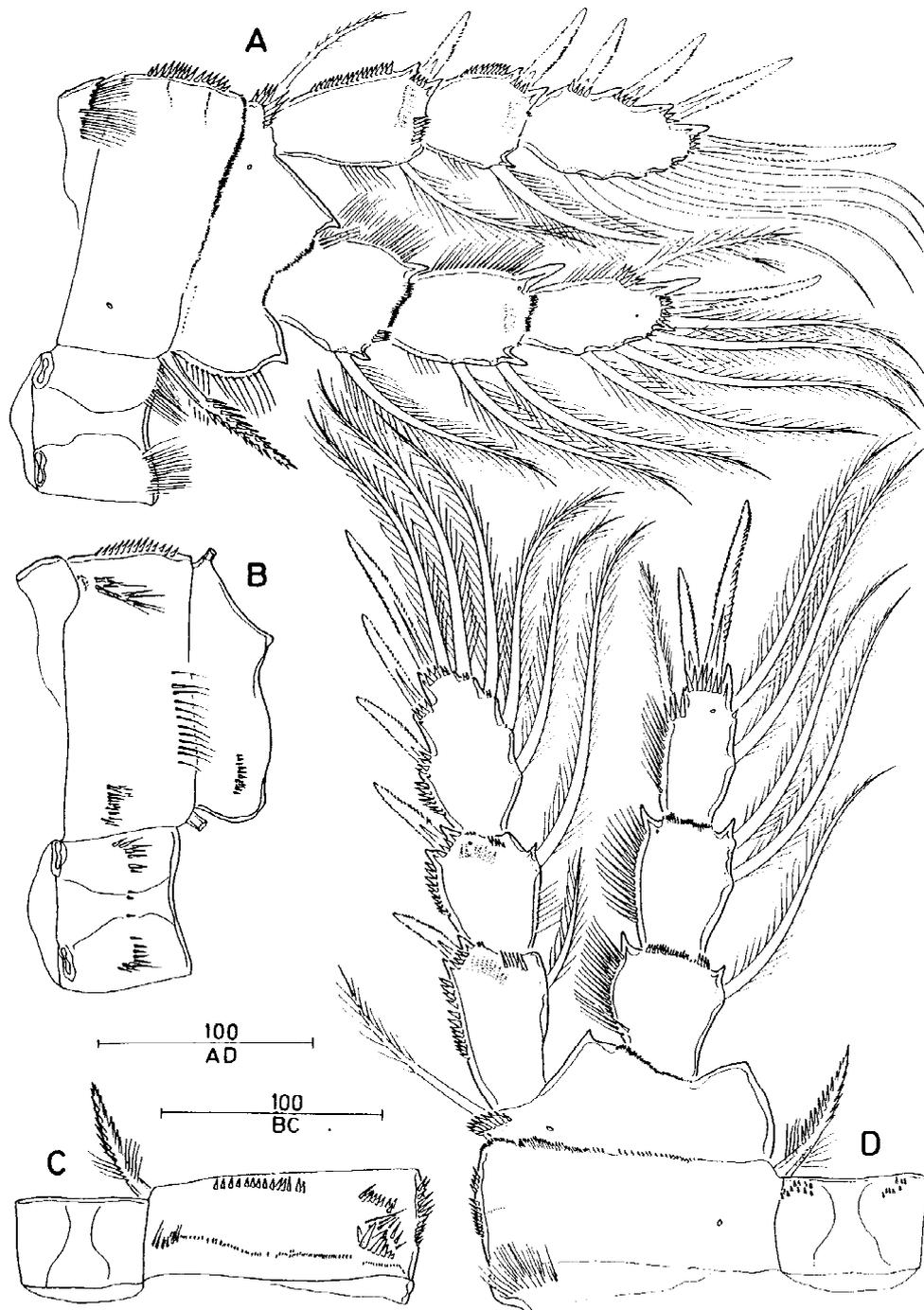


Figure 5. *P. longispina* sp. n. Adult female. (A) Leg 3, anterior; (B) intercoxal sclerite, coxa and basis of leg 3, posterior; (C) intercoxal sclerite and coxa of leg 4, posterior; (D) leg 4, anterior. Scale bars in μm .

mented with spinular rows on anterior and posterior surfaces (Figure 4A,B); basis with spinulose spine on inner margin bearing two groups of spinular rows

at base, one of which long and fringe-like; also ornamented with spinular rows anteriorly near base of endopod; exopodal segments 1 and 2 and endopodal

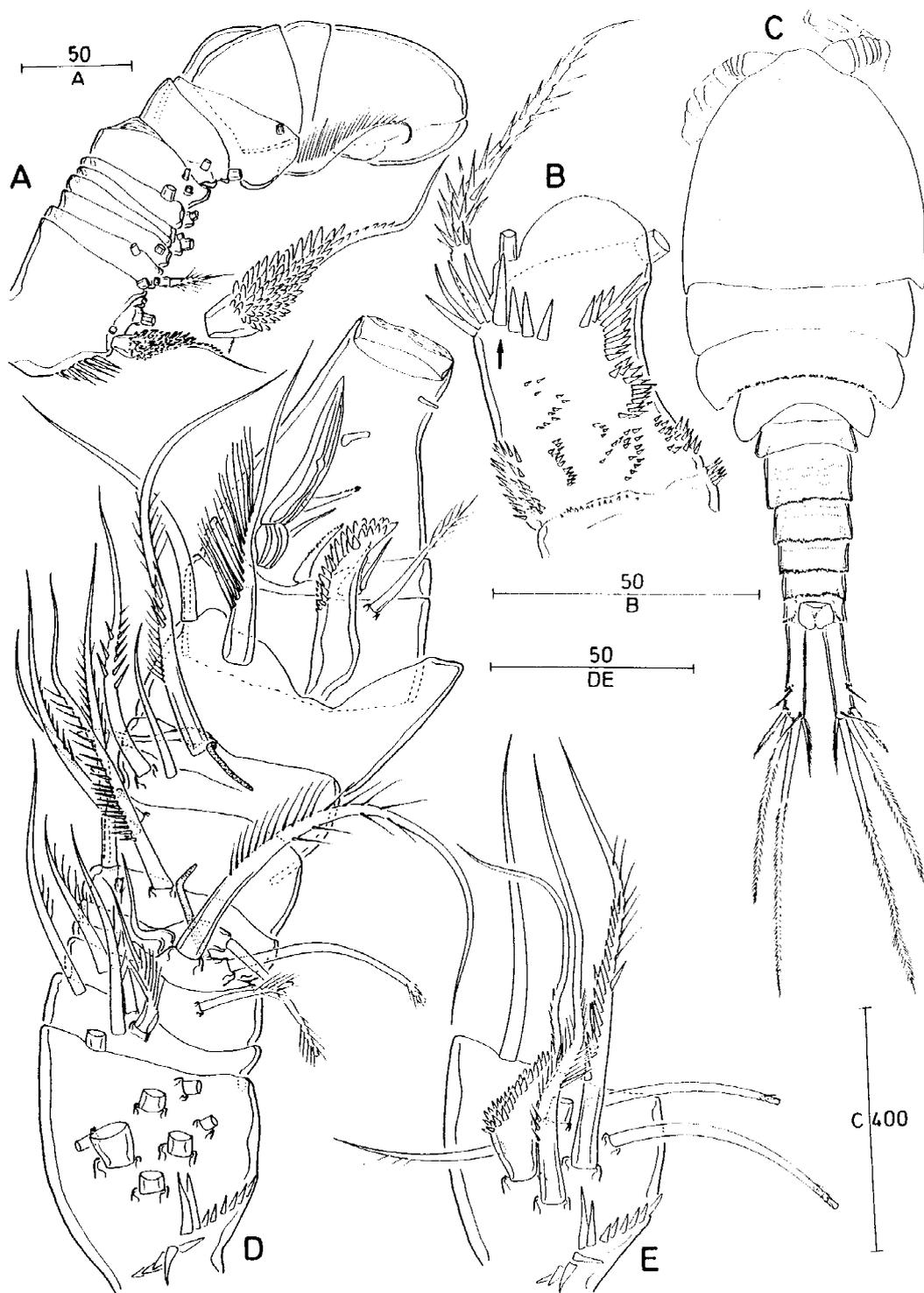


Figure 6. *P. longispina* sp. n. Adult male. (A) Antennule showing segmentation and with inset showing seta A, dorsal; (B) antenna, coxobasis, caudal; (C) body, dorsal; (D) antennule showing setation, anteroventral; (E) antennule, anteroventral view of first segment showing setae. Scale bars in μm .

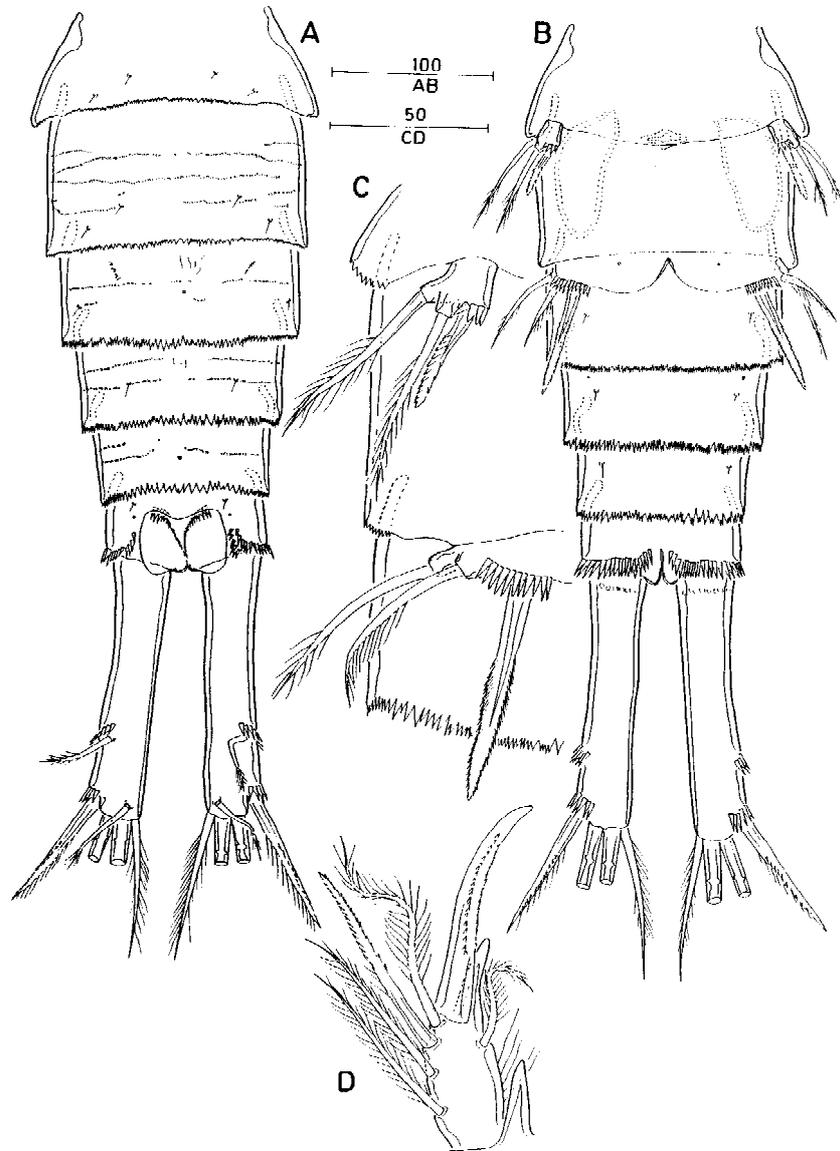


Figure 7. *P. longispina* sp. n. Adult male. (A) Urosome, dorsal; (B) urosome, ventral; (C) detail of legs 5 and leg 6, anteroventral; (D) terminal endopodal segment of leg 1, posterior. Scale bars in μm .

segment 2 with spinular rows posteriorly; spine of exopodal segment 1 with flagellate apex. Seta next to outermost spine of terminal exopodal segment semi-spinulose (Figure 4B). Intercoxal sclerite of leg 2 ornamented with spinular rows on anterior and posterior surfaces (Figure 4C,D); inner coxal spine long, reaching almost middle of second endopodal segment; terminal spine of exopod stout and naked (arrowed in Figure 4C); exopodal spines elongate. Intercoxal sclerite of leg 3 without spinular row on anterior surface

(Figure 5A) and with spinular row on posterior surface (Figure 5B); inner coxal spine thin and long; exopodal spines elongate (Figure 5A). Intercoxal sclerite of leg 4 with patch of spinules on anterior surface (Figure 5D) and without spinular row on posterior surface (Figure 5C); inner coxal spine of leg 4 with group of setules mainly originating posteriorly; exopodal spines elongate (Figure 5D).

Spine and seta formula are shown in Table 1.

Table 1. Spine and seta formula

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-I	I-1;I-1;III,5	0-1;0-1;1,I,4
Leg 2	0-I	1-0	I-1;I-1;III,1,5	0-1;0-2;1,I,4
Leg 3	0-I	1-0	I-1;I-1;III,1,5	0-1;0-2;1,I,4
Leg 4	0-I	1-0	I-1;I-1;II,I,5	0-1;0-2;1,II,2

Leg 5 (Figure 3C) armed with one long (almost twice as long as inner spine) well-developed, outer plumose seta, one inner spine and one plumose seta in centre. Leg 6 (Figure 3B) represented by one plumose seta and one tiny spinule dorsolaterally.

Adult male. Body length (μm), not including caudal setae, 874–909, mean = 890, $n = 3$; body width 294–314, mean = 305, $n = 3$. Genital, first, second and third abdominal somites ornamented with cuticular pits on dorsal surface (Figure 7A).

Antennule (Figure 6A) indistinctly 15-segmented. Segment 1 armed with eight setae; one seta large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally (Figure 6A,D); aesthetasc absent from segment 1 (Figure 6D, E). Segment 2 with four setae (Figure 6D). Segment 3 with two setae. Segment 4 with two setae plus aesthetasc. Segments 5 and 6 each with two setae. Segment 7 with two setae, segment 8 with two setae. Segment 9 with two setae plus a short aesthetasc, fused to segment 8. Segment 10 (= ancestral segment XV) produced on one side into sheath enclosing segment 11 ventrally; armed with two setae, one ornamented with long setules unilaterally, other longer and naked. Segment 11 bearing curved seta ornamented with double row of strong denticles, plus one plumose seta (Figure 6D). Segment 12 armed with minute naked seta, plus short, highly chitinized spine. Segment 13 armed with one short spinulate seta proximally, four short naked setae, plus one modified element attached to segment by short stalk (Figure 6D); main part of modified element lying along surface of segment and ornamented with longitudinal ridges and small central pore. Geniculation located between segments 13 and 14. Segment 14 armed with two setae and two modified elements each ornamented with longitudinal ridges and a central pore (as proximal element on segment 13). Apical segment tapering distally; armed with 11 setae and one aesthetasc, mostly originating on outer (= posterior) surface. Segmental fusion pat-

tern as follows I–V, VI–VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII–XX, XXI–XXIII, XXIV–XXVIII.

Coxobasis of antenna with spinular row near base of two inner spinulose setae (arrowed in Figure 6B). One seta on terminal endopodal segment of leg 1 spinulose (Figure 7D). Outer seta of fifth leg less developed (Figure 7C) than in female. Sixth leg (Figure 7C) armed with one inner spine slightly longer than second urosomal somite, and two outer plumose setae; middle seta as long as inner spine.

Remarks

P. longispina sp. n. and *P. imminutus* Kiefer 1929 (as redescribed by Karaytug & Boxshall, 1998a) are closely related. Both species possess a well-developed spinular row near the base of the two inner setae of the antennal coxobasis in both sexes (arrowed in Figures 2A–6B). *P. longispina* differs from *P. imminutus* particularly in the position of the mid-distal spinular row on the posterior surface of the coxa of leg 1 (Figure 4A), the longer spines on the exopodal segments of the swimming legs, the stout and naked terminal endopodal spine of leg 2 (arrowed in Figure 4C), and the long inner coxal spines of legs 2–4.

Paracyclops longispina also resembles *P. fimbriatus* but can be distinguished by the presence of a well-developed spinular row near the base of the two inner setae of the antennal coxobasis in both sexes (arrowed in Figures 2A & 6B), the elongate spines on the exopodal segments of the swimming legs, the absence of spinular ornamentation on the posterior surface of the intercoxal sclerite of leg 4, the stout and naked terminal endopodal spine of leg 2 (arrowed in Figure 4C) plus the long inner coxal spine, and in the shape of the seminal receptacle.

The absence of the aesthetasc on the first segment of the male antennule in *P. longispina* is noteworthy, it is the only setal element that is ever absent on the male antennules of any *Paracyclops* species. The number of all other setal elements is exactly the same in every species of the genus (Karaytug, 1998). The presence of a well-developed spinular row near the base of the two inner setae of the antennal coxobasis in both sexes (arrowed in Figures 2A & 4B) is one of the important new diagnostic characters of *Paracyclops* species, and it is a character that is sexually dimorphic in *P. fimbriatus*, *P. poppei* and *P. chiltoni* (Karaytug, 1998). The presence of cuticular pits on the urosomal somites

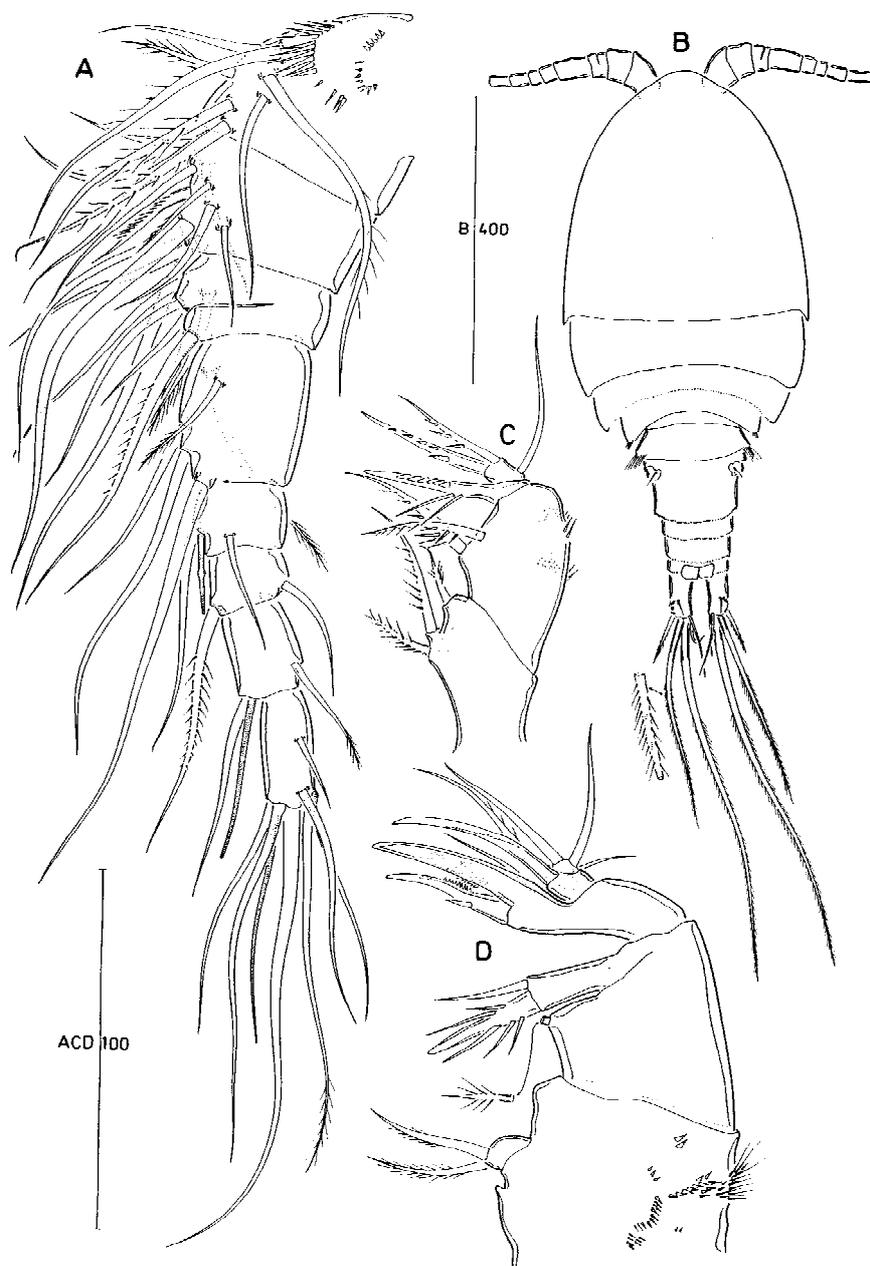


Figure 8. *P. altissimus* sp. n. Adult female. (A) Antennule; (B) body, dorsal; (C) maxilliped; (D) maxilla. Scale bars in μm .

of male and their absence in the female might be a particular trait of the species but needs to be confirmed on other populations.

Paracyclops altissimus n. sp. (Figures 8–13)

Holotype. (MNHN - Cp 1484) female dissected on slides.

Type locality. Africa, Bujuku River, 4000 m, 28 -I -1994, Schiemen coll.

Paratypes. (MNHN - Cp 1485) five females, three males (ethanol).

Etymology. The name of the new species refers to the extreme altitude at which the new species was found.

Description

Adult female. Body length (μm) not including caudal setae, 600–747, mean = 692, $n = 3$. Urosomal somites without ornamentation of surface pits on dorsal (Figure 9A) and ventral (Figure 9C) surfaces. Seminal receptacle divided into small anterior and broad ellipsoid posterior lobes as figured (Figure 9A). Anal somite with spinular row ventrally, not extending to either side of anal operculum on dorsal surface (Figure 9C).

Caudal rami (Figure 9A,C) short, about 1.8 times as long as broad; plumose seta (II) on dorsolateral surface with spinules near base laterally; terminal accessory seta (VI) plumose and slightly shorter than posterolateral seta (III); outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 9A). Dorsal seta (VII) clearly longer than anterolateral seta (II) and posterolateral seta (III), thin and plumose at tip.

Antennule eight-segmented (Figure 8A). Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc.

Coxobasis of antenna with complex ornamentation on caudal (Figure 10A) and frontal surfaces (Figure 10B) and with well-developed spinular row on caudal surface near base of two strong inner setae (arrowed in Figure 10A).

Palp of mandible (Figure 11G) represented by three plumose setae. Maxillule (Figure 10E, F) armed with eight setae on praecoxal arthrite, spinulose seta ornamented differently from that of *P. longispina*, and three spines fused to segment; maxillary palp as in Fig 10E.

Maxilla (Figure 8D) five-segmented comprising praecoxa, coxa, basis and two-segmented endopod. Praecoxa with complex ornamentation of spinules (Figure 8D). Coxa with proximal endite represented by small spinulose seta. Other armature and structure on same pattern as in *P. longispina*.

Maxilliped four-segmented (Figure 8C) consisting of syncoxa, basis and two-segmented endopod, the proximal fused to its claw-like seta. Syncoxa armed with three spinulose setae, with two long spinules inserted near base of setae. Basis armed with one spinulose and one naked seta and ornamented with two simple row of spinules on outer margin. Second endopodal segment with one naked outer seta and two spinulose setae.

Coxa of leg 1 without mid-distal spinular row on posterior surface (arrowed in Figure 10C); intercoxal sclerite ornamented with spinular row on anterior sur-

face (Figure 10D); lacking row on posterior surface (Figure 10C). Intercoxal sclerite of leg 2 ornamented with spinular rows on anterior (Figure 11C) and posterior (Figure 11D) surfaces; coxa without mid-distal spinular row on posterior surface (Figure 11D). Intercoxal sclerite of leg 3 without spinular row on anterior surface (Figure 11A) and with two spinular rows on posterior surface (Figure 11B); coxa without mid-distal spinular row on posterior surface (Figure 11B). Intercoxal sclerite of leg 4 with two spinular rows on posterior surface (Figure 11F); first and second exopodal segments without spinular row on posterior surface. Coxal spines; seta-like on leg 1, thick with strong spinules in distal part on legs 2 and 3, heteronomous on leg 4 (Fig 11E).

Spine and seta formula are shown in Table 2.

Table 2. Spine and seta formula

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-I	I-1;I-1;III,5	0-1;0-1;1,I,4
Leg 2	0-I	1-0	I-1;I-1;III,I,5	0-1;0-2;1,I,4
Leg 3	0-I	1-0	I-1;I-1;III,I,5	0-1;0-2;1,I,4
Leg 4	0-I	1-0	I-1;I-1;III,5	0-1;0-2;1,II,2

Leg 5 (Figure 9B) comprising single free segment, armed with one outer seta spinulose mainly at apex, as figured, and longer than inner spine, one inner spine, one plumose seta in centre; middle seta longest.

Adult male. Body length (μm) not including caudal setae, 580–700, mean = 640, $n = 2$. Urosomal somites without surface pits (Figure 12B,C). First segment of antennule (Figure 13D,E) armed with eight setae plus an aesthetasc; one seta large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally (Figure 13B); segmental fusion pattern as follows I–V, VI–VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII–XX, XXI–XXIII, XXIV–XXVIII. Coxobasis of antenna with well developed spinular row on caudal surface near base of two inner setae (arrowed in Figure 12E). Outer seta of fifth leg sparsely plumose (Figure 12D). Sixth leg (Figure 12D) armed with one inner spine and two outer plumose setae.

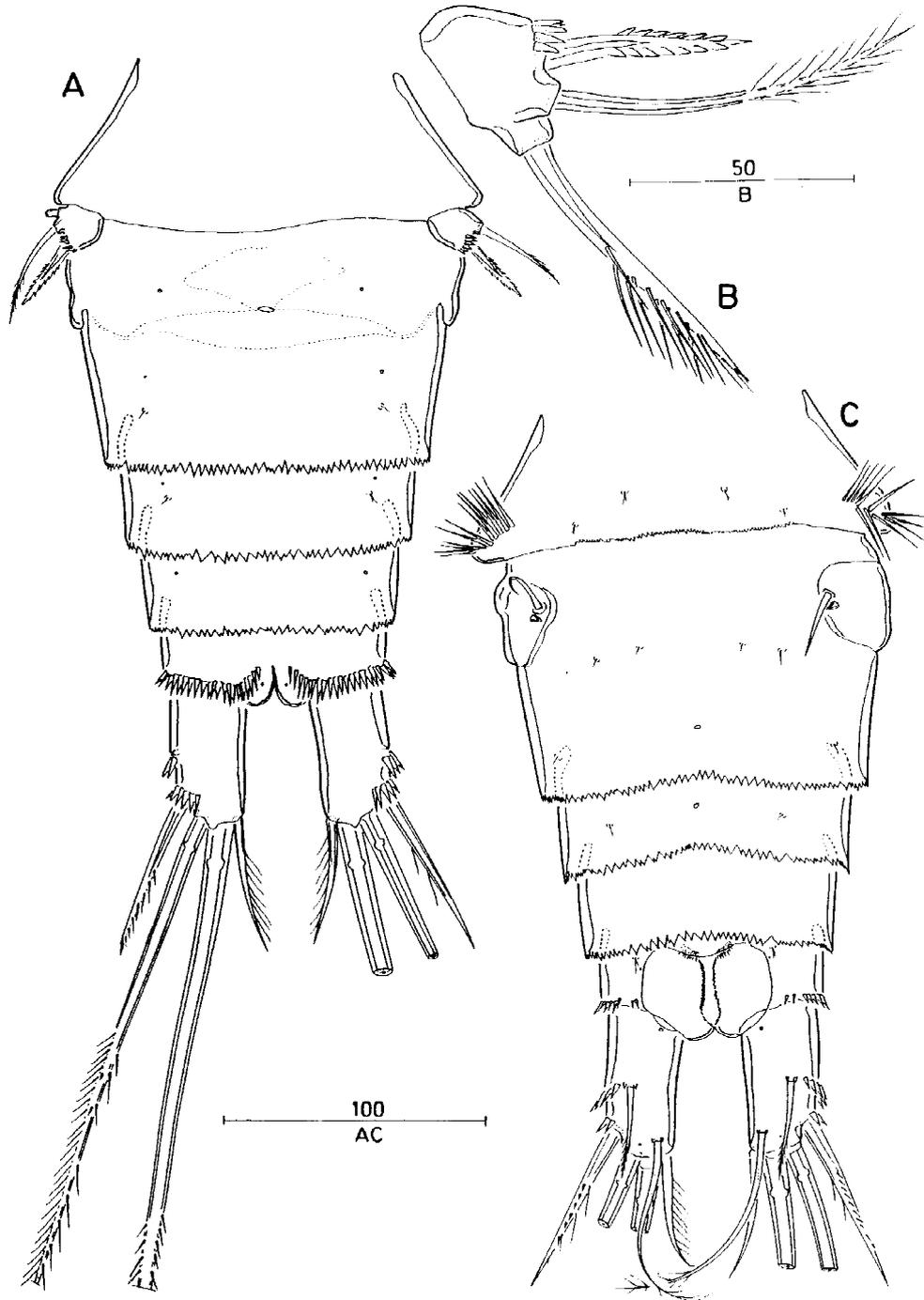


Figure 9. *P. altissimus* sp. n. Adult female. (A) Urosome, ventral; (B) leg 5, ventral; (C) urosome, dorsal. Scale bars in μm .

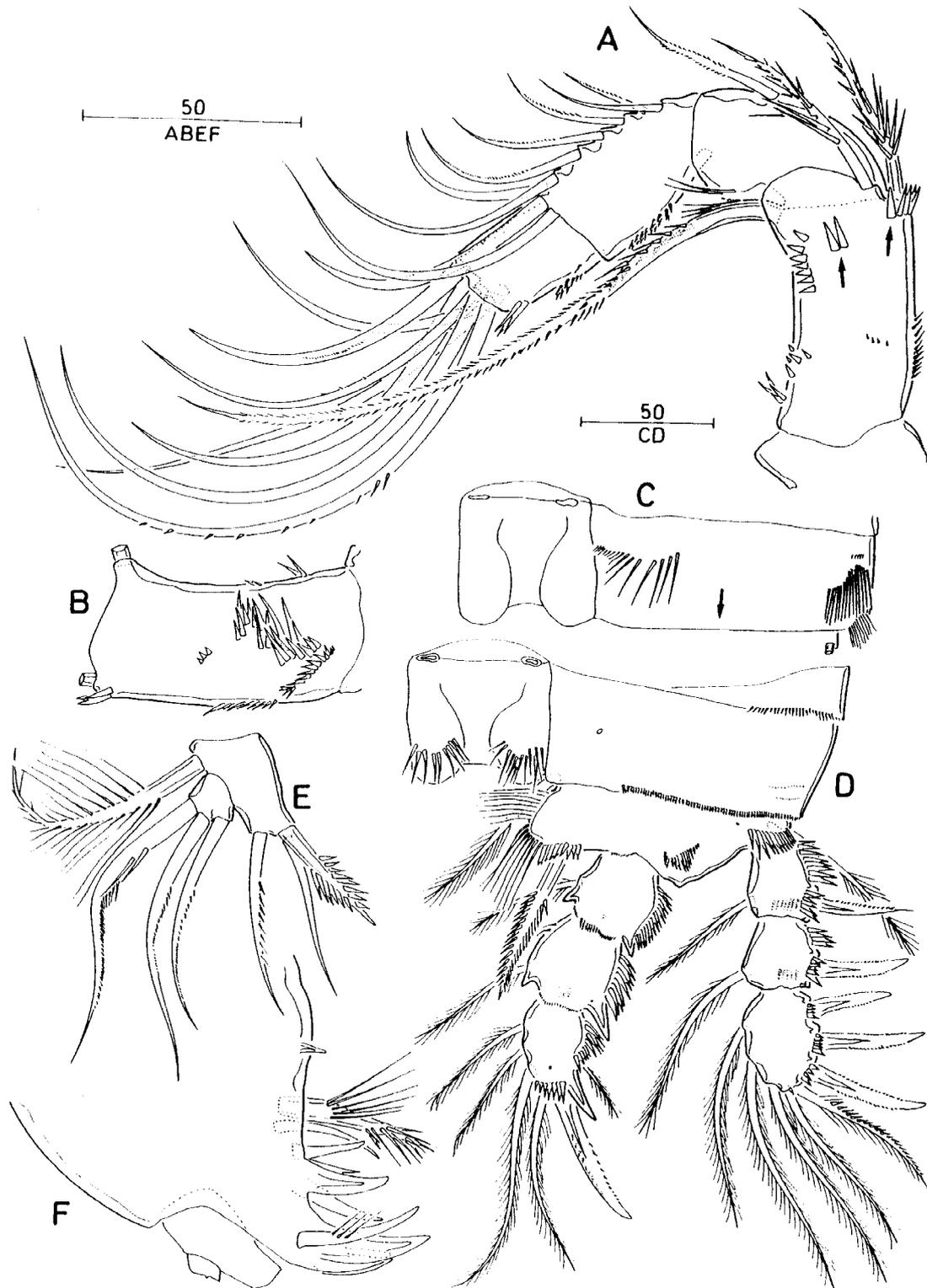


Figure 10. *P. altissimus* sp. n. Adult female. (A) antenna, caudal; (B) antenna, coxobasis, frontal; (C) intercoxal sclerite and coxa of leg 1, posterior; (D) leg 1, anterior; (E) maxillary palp; (F) maxillule. Scale bars in μm .

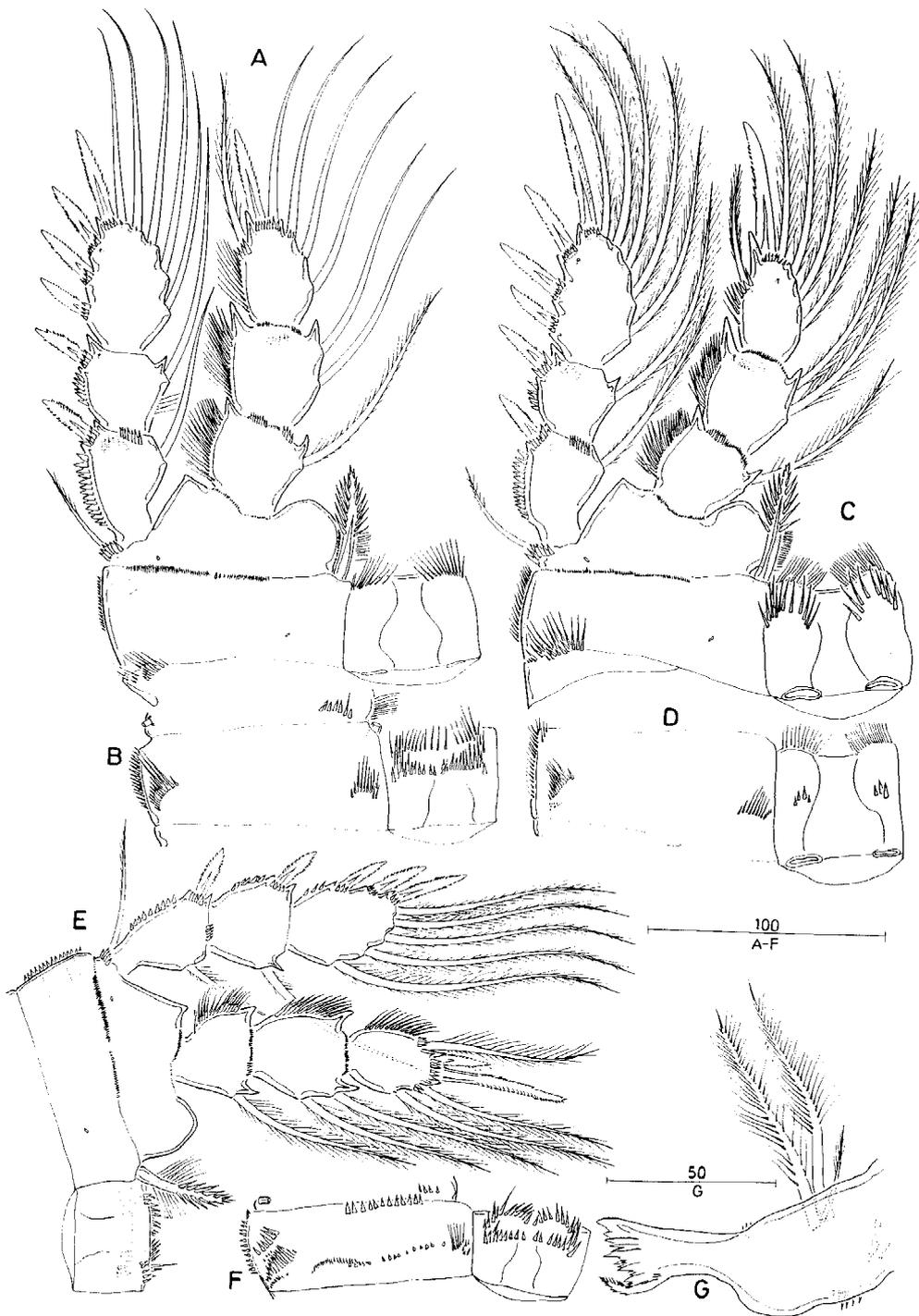


Figure 11. *P. altissimus* sp. n. Adult female. (A) Leg 3, anterior; (B) intercoxal sclerite and coxa of leg 3, posterior; (C) leg 2, anterior; (D) intercoxal sclerite and coxa of leg 2, posterior; (E) leg 4, anterior; (F) intercoxal sclerite and coxa of leg 4, posterior; (G), mandible. Scale bars in μm .

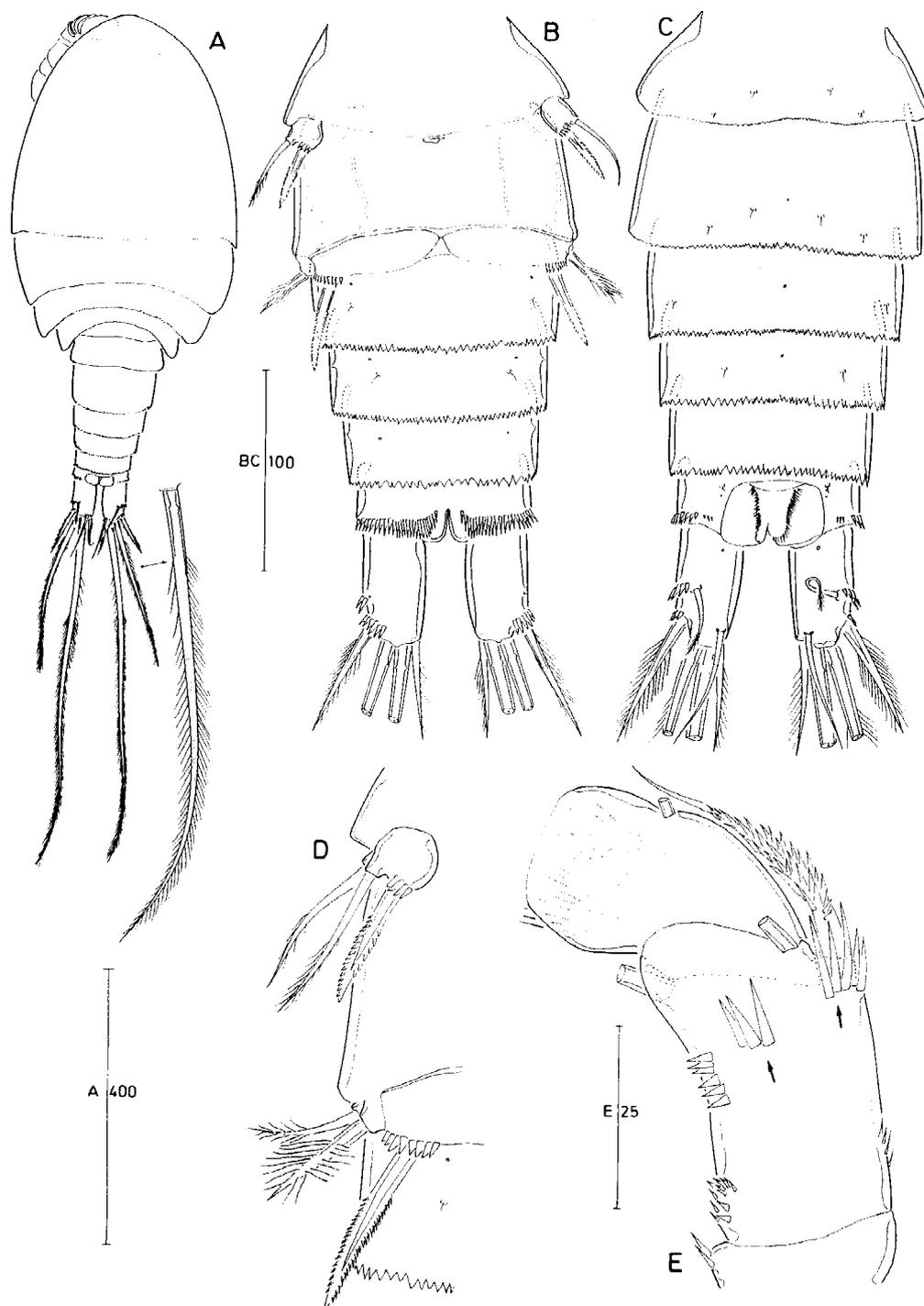


Figure 12. *P. altissimus* sp. n. Adult male. (A) body, dorsal; (B) urosome, ventral; (C) urosome, dorsal; (D) detail of legs 5 and 6, ventral; (E) antenna, coxobasis and first endopodal segment, caudal. Scale bars in μm .

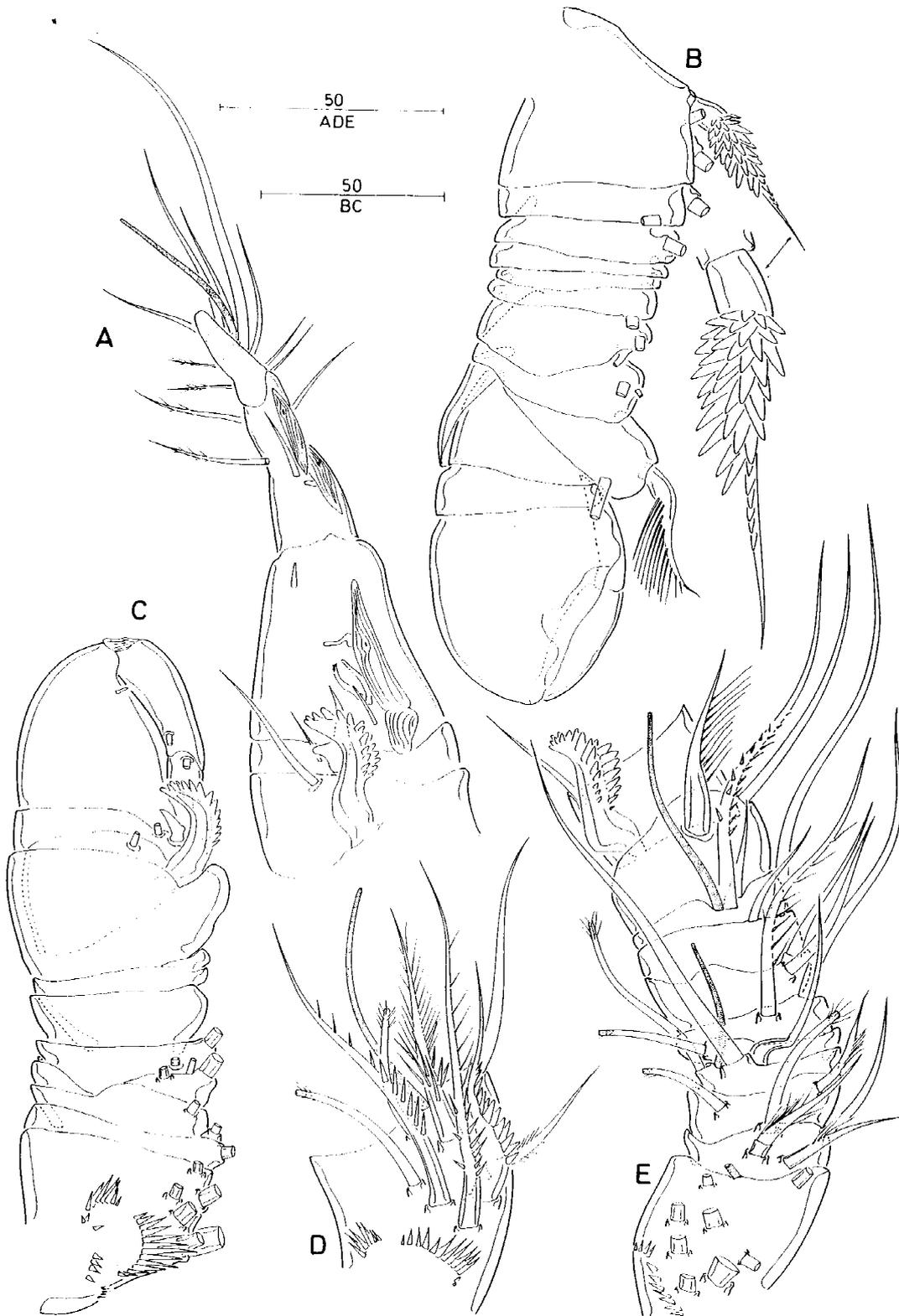


Figure 13. *P. altissimus* sp. n. Adult male. Antennule. (A) detail of segments 13 to 17 showing setation, anteroventral; (B) dorsal showing segmentation and with inset showing seta (A); (C) ventral showing segmentation; (D) first segment showing setation, anteroventral; (E) segments 1–13 showing setation, anteroventral. Scale bars in μm .

Remarks

Paracyclops altissimus sp. n. can easily be differentiated from other *Paracyclops* species by the combination of the following characters: in female by the structure of leg 5 (Figure 9B), the structure of the seminal receptacle (Figure 9A), in both sexes by the absence of spinules either side of the anal operculum (Figure 9B), in both sexes by the absence of a mid-distal spinular row on the coxae of legs 1–3 on the posterior surface (Figures 10C–11B,D), in both sexes by the relatively short caudal rami and the presence of a spinular row near the base of two inner setae of the coxobasis of the antenna in both sexes (arrowed in Figures 10A & 12E).

Acknowledgements

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References

- Clément, M. & C.G. Moore., 1995. A revision of the genus *Halectinosoma* (Harpacticoida: Ectinosomatidae): a reappraisal of *H. sarsi* (Boeck) and related species. *Zool. J. Linn. Soc.* 114: 247–306.
- Dussart, B. H. & D. Defaye, 1985. Répertoire mondial des Copépodes Cyclopoïdes. C.N.R.S., Paris, 236 pp.
- Dussart, B. H. & C.H. Fernando, 1988. Sur quelques Mesocyclops (Crustacea, Copepoda). *Hydrobiologia* 157: 241–264.
- Fiers, F. & I. Van de Velde, 1984. Morphology of the antenna and its importance in the systematics of the Cyclopidae. In *Studies on Copepoda II. Proceedings of the First International Conference on Copepoda*, Amsterdam, The Netherlands, 24–28 August 1981. *Crustaceana*, Leiden, suppl. 7: 182–199.
- Frey, D. G., 1980. On the plurality of *Chydorus sphaericus* (O.F. Müller) (Cladocera, Chydoridae) and designation of a neotype from Sjaels, Denmark. *Hydrobiologia* 69: 83–123.
- Frey, D. G., 1988. Separation of *Pleuroxus laevis* Sars, 1861 from two resembling species in North America: *Pleuroxus stramineus* Birge, 1879 and *Pleuroxus chiangi* n. sp. (Cladocera, Chydoridae). *Can. J. Zool.* 66: 2534–2563.
- Huys, R., 1992. The amphiatlantic distribution of *Leptastacus macronyx* (T. Scott, 1892) (Copepoda: Harpacticoida): a paradigm of taxonomic confusion; and a cladistic approach to the classification of the Leptastacidae Lang, 1948. *Meded. K. Acad. Wetens. Lett. Schone Kunsten Belg.* 54(4): 21–196.
- Huys R. & G. A. Boxshall, 1991. *Copepod Evolution*. The Ray Society, London, 1–468.
- Huys, R. & S. Conroy-Dalton, 1996. A revision of *Leptopontia* T. Scott (Copepoda: Harpacticoida) with description of six new species. *Zool. J. Linn. Soc.* 118: 197–239.
- Karaytug, S., 1998. The genus *Paracyclops* (Copepoda: Cyclopoida): Taxonomy, Phylogeny and Zoogeography. Ph.D. Thesis. University of London 1–473.
- Karaytug, S. & G. A. Boxshall, 1998. Partial revision of *Paracyclops* Claus, 1893 (Copepoda, Cyclopoida, Cyclopidae) with description of four new species. *Bull. Nat. Hist. Mus. Lond. (Zool.)* 64: 111–205.
- Karaytug, S. & G. A. Boxshall, 1998. The *Paracyclops fimbriatus*-complex (Copepoda: Cyclopoida): a revision. *Zoosystema* (in press)
- Reid, J. W., 1998. How 'cosmopolitan' are the continental cyclopoid copepods? Comparison of the North American and Eurasian faunas, with description of *Acanthocyclops parasensitivus* sp.n. (Copepoda: Cyclopoida) from the U.S.A. *Zool. Anz.* 236: 109–118.
- Rocha, C. E. F., 1998. New morphological characters useful for the taxonomy of the genus *Microcyclops* (Copepoda, Cyclopoida). *J. Mar. Systems* 15: 425–431.
- Van De Velde, I., 1984a. Introduction of new diagnostic characters in *Mesocyclops*, with African species as an example. In *Studies on Copepoda II. Proceedings of the First International Conference on Copepoda*, Amsterdam, The Netherlands, 24–28 August 1981. *Crustaceana*, suppl. 7: 404–419.
- Van De Velde, I., 1984b. Revision of the African species of the genus *Mesocyclops* Sars, 1914 (Copepoda: Cyclopidae). *Hydrobiologia*, 109: 3–66.
- Wells, J. B. J., 1980. A revision of the genus *Longipedia* Claus (Crustacea: Copepoda: Harpacticoida). *Zool. J. Linn. Soc.* 70: 103–189.