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Partial revision of *Paracyclops* Claus, 1893 (Copepoda, Cyclopoida, Cyclopidae) with descriptions of four new species

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CONTENTS

Synopsis. A partial revision of the genus *Paracyclops* is made based on type material and on collections from numerous localities around the world. The following *Paracyclops* species are redescribed: *P. affinis* (G.O.Sars, 1863), *P. poppei* (Rehberg, 1880), *P. oligarthrus* (G.O.Sars, 1909), *P. canadensis* (Willey, 1934), *P. dilatatus* Lindberg, 1952, *P. hardingi* nomen novum, *P. baicalensis* Mazepova, 1961, *P. yeatmani* Daggett & Davis, 1974, *P. waiariki* Lewis,1974, *P. pilosus* Dussart, 1984, *P. carectum* Reid, 1987, *P. novenarius* Reid, 1987 and *P.smileyi* Strayer, 1988. Four species are described as new to science: *P. reidae* sp. nov., *P. rochai* sp. nov., *P. punctatus* sp. nov., and *P. bromeliacola* sp. nov.

Detailed descriptions of these species are given including several previously overlooked microcharacters, such as the ornamentation of the coxobasis of antenna, the cuticular ornamentation of urosomal somites and the posterior spinular ornamentation of the swimming legs, that are shown to have significant taxonomic value at species level. The detailed description of males is revealed to be important in differentiating between closely related species.

The geographical distributions of the species are re-evaluated on the basis of examined material and verifiable published records. It is revealed that *P. affinis* does not occur in North America and all previous records of *P. affinis* in North America refer to the newly discovered *P. canadensis*.

INTRODUCTION

The genus *Paracyclops* Claus, 1893 is one of nine genera currently recognised as constituting the sub-family Eucyclopinae (Dussart & Defaye, 1985; Pospisil & Stoch, 1997). All species are known to be benthic although they can sometimes occur in the water column in the littoral zone. *Paracyclops* species are distributed worldwide and have been recorded in all types of freshwater habitats (Karaytug, 1998): *P. dilatatus* Lindberg, 1952 was found in the Dniester estuary (Ukraine) on the Black Sea (Monchenko, 1977), *P. baicalensis* Mazepova, 1961 was collected from great depths in Lake Baikal (Mazepova, 1978), and *P. bromeliacola* sp. nov. and *P. reidae* sp. nov. inhabit pools in the leaf axils of terrestrial Bromeliads. *P. chiltoni* (Thomson, 1882) was recently collected from freshwater bodies on Easter Island and is the only freshwater copepod on this

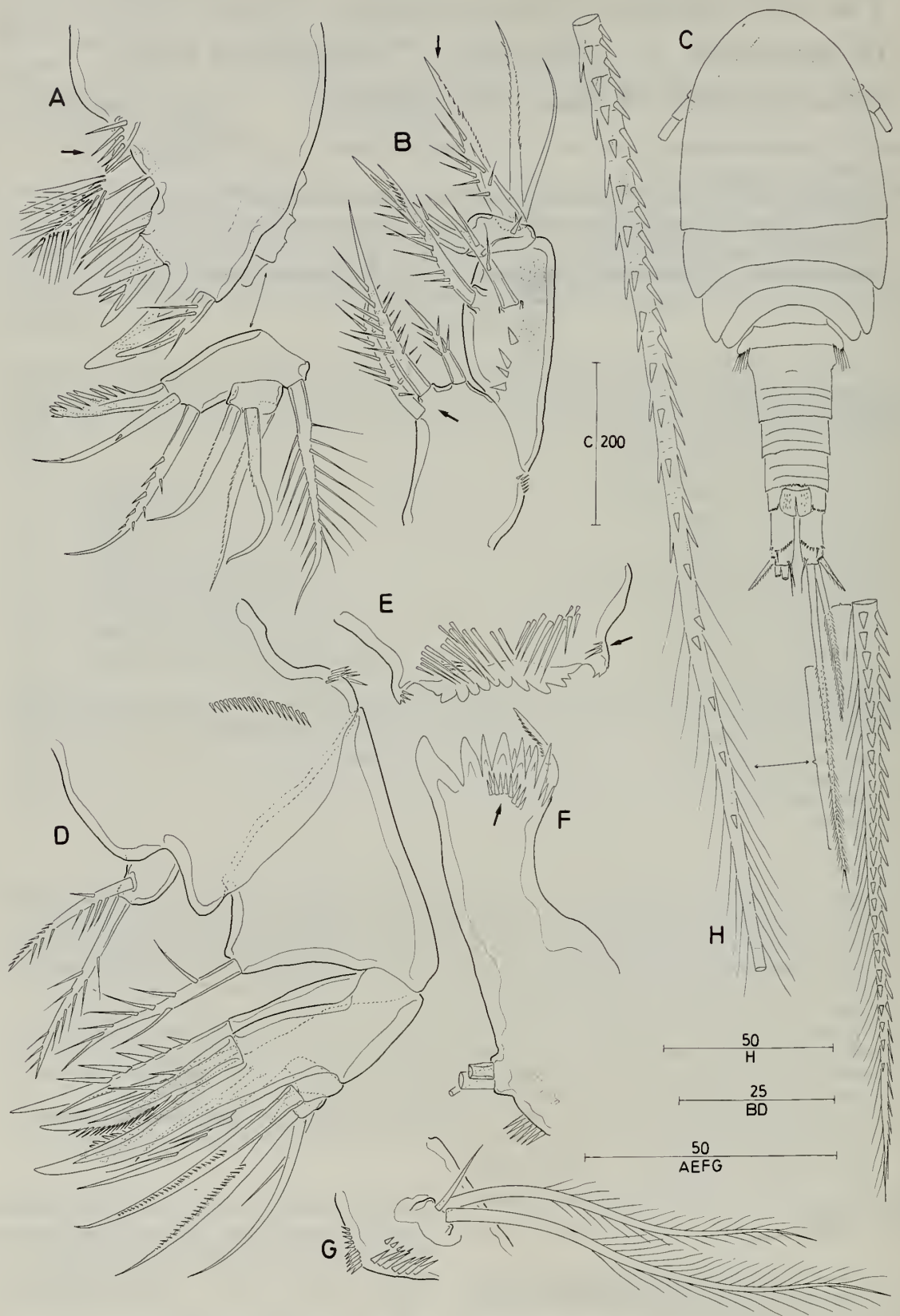

Fig. 1 *P. affinis*. Adult female. A, maxillule; B, maxilliped; C, body, dorsal; D, maxilla; E, labrum; F,G, mandible; H, detail of caudal seta. Scale bars in μm.

remote island (Dumont & Martens, 1996). *P. oligarthrus* (G. O. Sars, 1909) occurs only in Lake Tanganyika.

The lack of sufficient detail in the original description of the type-species *P. fimbriatus* (Fischer, 1853) and the publication of various incompletely described species or forms that are closely related to the type-species has created considerable taxonomic confusion. This has been exacerbated by the use of a limited set of traditional characters for differentiating between species within the genus, such as the morphology of the caudal rami and leg 5. The *P. fimbriatus* complex is a particular problem and has been addressed in a separate paper in which a neotype is designated for *P. fimbriatus* and *P. fimbriatus*, *P. chiltoni* and *P. imminutus* Kiefer, 1929 are all redescribed (Karaytug & Boxshall, in press a). Most early records of *Paracyclops* species are unreliable (Karaytug, 1998).

The genus now contains 26 species and 2 subspecies. *P. fimbriatus* is the type species of the genus. The redescription of *P. fimbriatus* (Karaytug & Boxshall, in press a) from a neotype collected from one of the type localities has stabilised the taxonomy of *P. fimbriatus* and its closely related species *P. chiltoni* (Thomson, 1882) and *P. imminutus* Kiefer 1929. Two new species, *P. longispina* and *P. altissimus*, from Africa are described elsewhere (Karaytug et al., in press). No material of *P. aioiensis* Itô, 1957, *P. uenoi* Itô, 1962, *P. timmsi* Kiefer, 1969, *P. fimbriatus paropamisi* Lindberg, 1960, *P. eucyclopoides* Kiefer, 1929, *P. fimbriatus euchaetus* Kiefer, 1939 could be obtained. The remaining species of *Paracyclops* are examined in this paper in detail including numerous previously overlooked microcharacters that have significant taxonomic value at the species level. Only partial redescriptions of *P. smileyi* Strayer, 1988, *P. dilatatus* Lindberg, 1952 and *P. pilosus* Dussart, 1984 were possible due to the poor condition of the original slides. Four new species are recognized; *P. reidae* sp. nov., *P. rochai* sp. nov., *P. punctatus* sp. nov., and *P. bromeliacola* sp. nov.

MATERIALS 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 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 proposed by Huys & Boxshall (1991) is adopted. The new nomenclature system for the setation elements of caudal rami was established by Huys (1988) who identified 7 setae (Figure 2B): anterolateral accessory seta (I) is usually missing in members of the family Cyclopidae but is present in some, for example *Metacyclops pseudoanceps* (Boxshall & Braide, 1991), II – the anterolateral seta, III – the posterolateral seta, IV – the outer terminal seta, V – the inner terminal seta, VI – the terminal accessory seta, VII – the dorsal seta. The terminology proposed by Karaytug & Boxshall (in press b) to identify the individual setae on the first segment of male antennule is used. The terms 'frontal' and 'caudal' introduced by Van de Velde (1984) to denote the anterior and posterior surfaces of the antennary coxobasis are adopted here.

SPECIES DESCRIPTIONS

Paracyclops affinis (G. O. Sars, 1863)

(Figures 1–7)

Cyclops affinis Sars, 1863: Brady (1878), Vosseler (1886), Schmeil (1892), Brady (1892), Van Douwe (1909), Lilljeborg (1901).
Cyclops pygmaeus Rehberg, 1880
Cyclops (Heterocyclops) affinis Sars, 1863: Claus (1893a)
Platycyclops affinis (Sars, 1913–18): Lowndes (1930, 1932)
Paracyclops sitiseiensis Harada, 1931: Kiefer (1938)
Cyclops (Paracyclops) affinis Sars, 1863: Gurney (1933)

ORIGINAL DESCRIPTION. *Cyclops affinis* Sars, 1863: *Forh. Videnskab.-Selskab. Christiana* (Jahr 1862); p. 256.

TYPE LOCALITY. Norway

TYPE MATERIAL. Three specimens of *P. affinis* collected by Sars including 1 slide (1 female, Reg. No: F 7380 Zool. Mus. Oslo); one tube with 1♂and 1 cop. V♀(Reg. No: F 20480) examined. Since the locality data of Sars' material are not known precisely, the redescription of *P. affinis* is based on all material examined.

OTHER MATERIAL EXAMINED

- The Natural History Museum, London: 22♀♀, 1♂ from Ringmere, England, Reg. No: 1950. 9. 20. 194. Coll: R. Gurney; Calthorpe, England, 3♀♀, 1♂, BMNH 1950. 9. 20. 193; Norfolk, England, 16♀♀, 2♂♂, BMNH 1937. 11. 16. 619; Devon, England, 2♀♀, Norman coll., BMNH 1911. 11. 8. 40555–556.
- Germany, Karlsruhe, 1♀ dissected on 2 slides, coll: Kiefer in 1935.
- The Natural History Museum, London: 1♀, 1♂ from Upsala, Sweden, Norman coll., BMNH 1911. 11. 8. 40550–554.
- The Natural History Museum, London: 1♂ from Palestine, BMNH1938. 3. 9. 83–89 (1030).
- Japan, 3♀♀, Hokkaido, coll: T. Ishida on 4 Nov 1987; 2♀♀, Ryuky; Lake Biwa, 5♀♀ dissected on 5 slides; Desaru Beach, Malaya (0°21'N, 104°4'E), 2♀♀ undissected and mounted on 1 slide, 1♀ dissected on 1 slide; Abiro, Hokkaido, 1♀ dissected on 1 slide (42°48'N, 141°50'E); R. Hichi, 2♀♀, 1♂ dissected on 3 slides.
- Ethiopia, 1 slide (1 &), Lac Haik. Coll: C. H. Fernando on 11 Aug. 1984. Dissected on 1 slide: Urosome (dorsally), leg 4 (anteriorly) and antennule could be examined but all other appendages were in poor condition.

REDESCRIPTION OF ADULT FEMALE

Body length and width not including caudal setae given in Table 1. Genital double-somite, second and third abdominal somites with dorsal surface ridges extending round sides to ventral surface as figured (Figure 2A,B). Seminal receptacle divided into broad butterfly-shaped anterior and posterior lobes (Figure 2A). Anal cleft with irregularly arranged spinules (Figure 2B,D). Caudal rami short, about twice as long as broad (Figure 2A,B); outer terminal seta (IV) and inner terminal seta (V) with complex spinular ornamentation (Figure 1C); spinular row at base of anterolateral seta (II) extending proximally near inner margin, almost halfway along ramus; terminal accessory seta (VI) shorter than posterolateral seta (III).

Antennule 11-segmented (Figure 3C). Segment 6 with spiniform seta. Segment 9 with aesthetasc (Figure 3C). Setal formula 8, 4, 2, 6, 4, 2, 2, 3, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna with complex ornamentation on caudal and frontal surfaces as figured (Figure 3A,B); with spinular row near inner setae (arrowed

in Figure 3B). First endopodal segment with spinular row near base of inner distal seta caudally (arrowed in Figure 3B).

Labrum with 3 spinules at either side of free posterior margin (arrowed in Figure 1E). Mandible with spinular row near base of gnathobasic blades (arrowed in Figure 1F). Maxillule with proximalmost spine ornamented with spinules (arrowed in Figure 1A). Maxilla (Figure 1D) with praecoxa bearing spinular row dorsally and with spinular row on outer margin. Coxa with scattered spinules along outer edge. Syncoxa of maxilliped without spinules near base of 3 setae (arrowed in Figure 1B); basis with spinular row on anterior surface and 2 diffuse groups of spinules on posterior surface. First endopodal segment with 2 tiny spinules on anterior surface. Strong seta fused to second endopodal segment, claw-like and ornamented with spinules (arrowed in Figure 1B).

Legs 1 to 3 without mid-distal spinular row on posterior surface of coxa (arrowed in Figures 4B,C; 5C). Coxae of legs 2–4 with spinular row on anterior surface and with inner spine bearing large posterolateral spinule (arrowed in Figures 4A; 5A,B); basis with spinular row on anterior surface near inner margin (arrowed in Figures 4A; 5A,B). Inner coxal seta of leg 1 semispinulose (arrowed in Figure 4D). Terminal endopodal segment of leg 3 with spine about half as long as segment (Figure 5B). Coxa of leg 4 with complex ornamentation on posterior surface; intercoxal sclerite with spinular rows on anterior and posterior surfaces, and along distal margin (Figure 5A,D).

Spine and seta formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–1	1–1	1–1;1–1;111,5	0–1;0–1;1,1,4
Leg 2	0–I	1–0	1–1;1–1;III,1,5	0–1;0–1;1,1,4
Leg 3	0–1	1–0	I–1;1–1;III,5	0–1;0–2;1,I,4
Leg 4	0–1	1–0	1–1;1–1;111,5	0–1;0–1;1,11,2

Leg 5 (Figure 2C) with long inner spine, about 4 times as long as segment; outer seta simple, just less than half as long as inner spine and with spinules at base (arrowed in Figure 2C).

Description of adult male

Body length of specimen from England (Norfolk): 619 µm and body width: 213 µm. Differing from adult female as follows: Genital somite separate, ornamented with 3 complete, I incomplete dorsal surface ridges and 4 incomplete ventral surface ridges; first, second and third free abdominal somites each with 2 complete dorsal and ventral surface ridges (Figure 6A,B).

Antennule digeniculate (Figure 7A,B), indistinctly 16-segmented. Segment 1 armed with 8 setae; setaA simple (arrowed in Figure 7E). Segment 10 (= ancestral segment XV) produced on one side into sheath enclosing segment 11 ventrally: armed with 2 setae, one of which pear-shaped and constricted apically, constricted part bent slightly inwards and with small terminal seta-like process, other seta long and naked. Segment 11 bearing curved seta ornamented with double row of strong denticles but not as strong as in *P. fimbriatus* group; plus 1 naked seta (Figure 7E,F). Segment 12 armed with curved seta similar to that of eleventh segment, plus short highly chitinized seta. Segment 13 armed with 2 short naked setae. Segment 14 armed with 1 short spinulate setae proximally, 2 short naked setae, plus 1 modified element (Figure 7F), main part of element lying along surface of segment and ornamented with longitudinal ridges and small central pore. Segmental fusion pattern as follows I–V, VI–VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX–XX, XXI–XXIII, XXIV–XXVIII.

Coxobasis of antenna with spinules near base of inner setae but spinules smaller than those of female (Figure 6E). Sixth leg (Figure 6C) armed with 1 inner spine surrounded by spinules at base; middle seta plumose and as long as inner spine; outer seta naked and about half as long as inner spine.

Variability, females.

Arrangements of spinules on anal cleft may vary (Figure 2D). Coxobasis of antenna sometimes with extra spinular row on caudal surface (Figure 3D).

Differential diagnosis, female.

P. affinis is distinguished from other *Paracyclops* species by the combination of its 11-segmented antennule; the surface ridges on the urosomal somites, the spinular ornamentation of the anal cleft, and the presence of 1 seta on the second endopodal segment of leg 4.

P. affinis and *P. canadensis* are very closely related, but *P. affinis* can easily be differentiated from *P. canadensis* by the possession of three spines on the terminal exopodal segment of leg 3 (Figure 5B), by the presence of spinules at the base of the outer seta of leg 5 (arrowed in Figure 2C); by having fewer surface ridges on the genital, second and third free abdominal somites (Figure 2A,B); by the spinular row not extending either side of anal cleft (Figure 2B,D); by the structure of the inner coxal spines of legs 2 to 4; and by the presence of a spinular row on the anterior surface of the basis of legs 2 to 4 near to the inner margin (Figures 4A; 5A,B).

Remarks and comparisons

Historically there has been some disagreement about the taxonomic position of *P. affinis*. This species was originally published by Sars (1863) under the name *Cyclops affinis* and this name was used by several subsequent authors (Brady, 1878, 1892; Vosseler, 1886; Schmeil, 1892; Van Douwe, 1909) even though Sars (1863) did not mention the ornamentation of the caudal rami and did not include any drawings in the original publication. Rehberg (1880) described *Cyclops pygmaeus* as a new species on the basis of the length of the caudal setae and the ornamentation of the caudal rami which he used to distinguish it from *C. affinis*. *C. pygmaeus* was regarded by Sars (1913–18) as a synonym of *C. affinis* and is here also considered to be a synonym of *P. affinis*. Claus (1893a) placed *C. affinis* in a new subgenus, *Heterocyclops* on the basis of the pattern of development of the antennule. Later Sars (1913–18) included *C. affinis* in a new genus, *Platycyclops*, but ignored or overlooked earlier work by Claus (1893). *Platycyclops* is a synonym of *Paracyclops* Claus, 1893. The inadequacy of Sars's description of *C. affinis* (Sars, 1913–18) prompted Lowndes (1932) to redescribe *C. affinis*, correcting some errors in Sars's descriptions. Harada (1931) distinguished *P. sitiseiensis* from *P. affinis* on the basis of the proportional length of the spines of leg 4 and the stronger inner spine of leg 5, however, these characters are not significantly different from *P. affinis* described herein. Therefore *P. sitiseiensis* is regarded as a synonym of *P. affinis*, as already indicated by Monchenko (1974). The length of the inner spines of fifth and sixth legs of male *P. affinis* from Lake

Table 1 Body length (BL) and width (BW) measurements (in µm) of *P. affinis* from various localities (N = number of specimens measured)

Locality	Sex	BL (mean ± SD)	Range	BW(mean ± SD)	Range	N
England (Ringmere)	♀	709 ± 12	684–723	267 ± 5.5	254–272	10
England (Norfolk)	♀	692 ± 20.2	657–731	261 ± 11.7	244–281	13
Sweden (Upsala)	♀	827 ± 60	753–877	269 ± 7.8	262–277	4

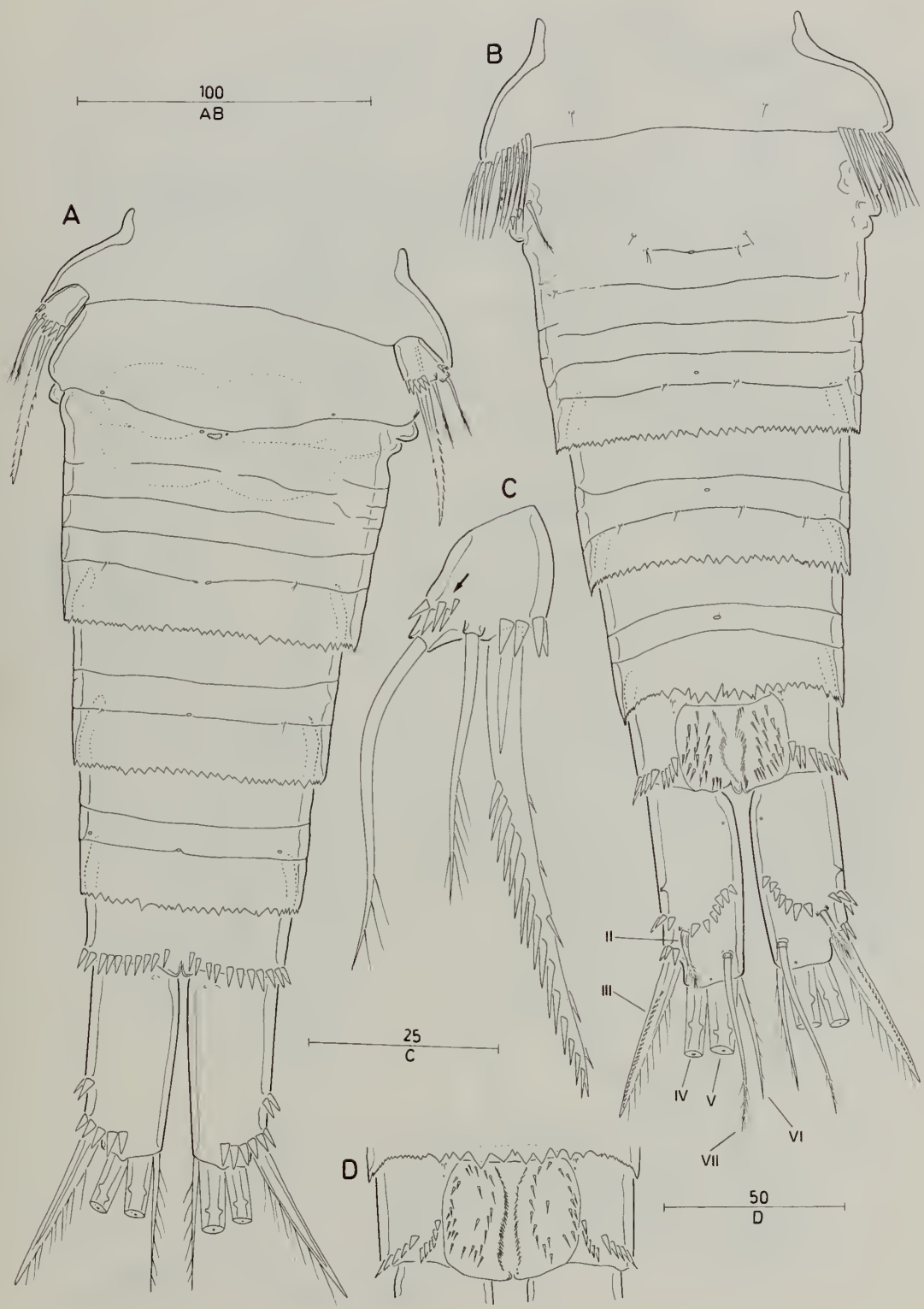

Fig. 2 *P. affinis*. Adult female. A, urosome, ventral; B, urosome, dorsal; C, leg 5, ventral; D, anal somite, dorsal. Scale bars in μm.

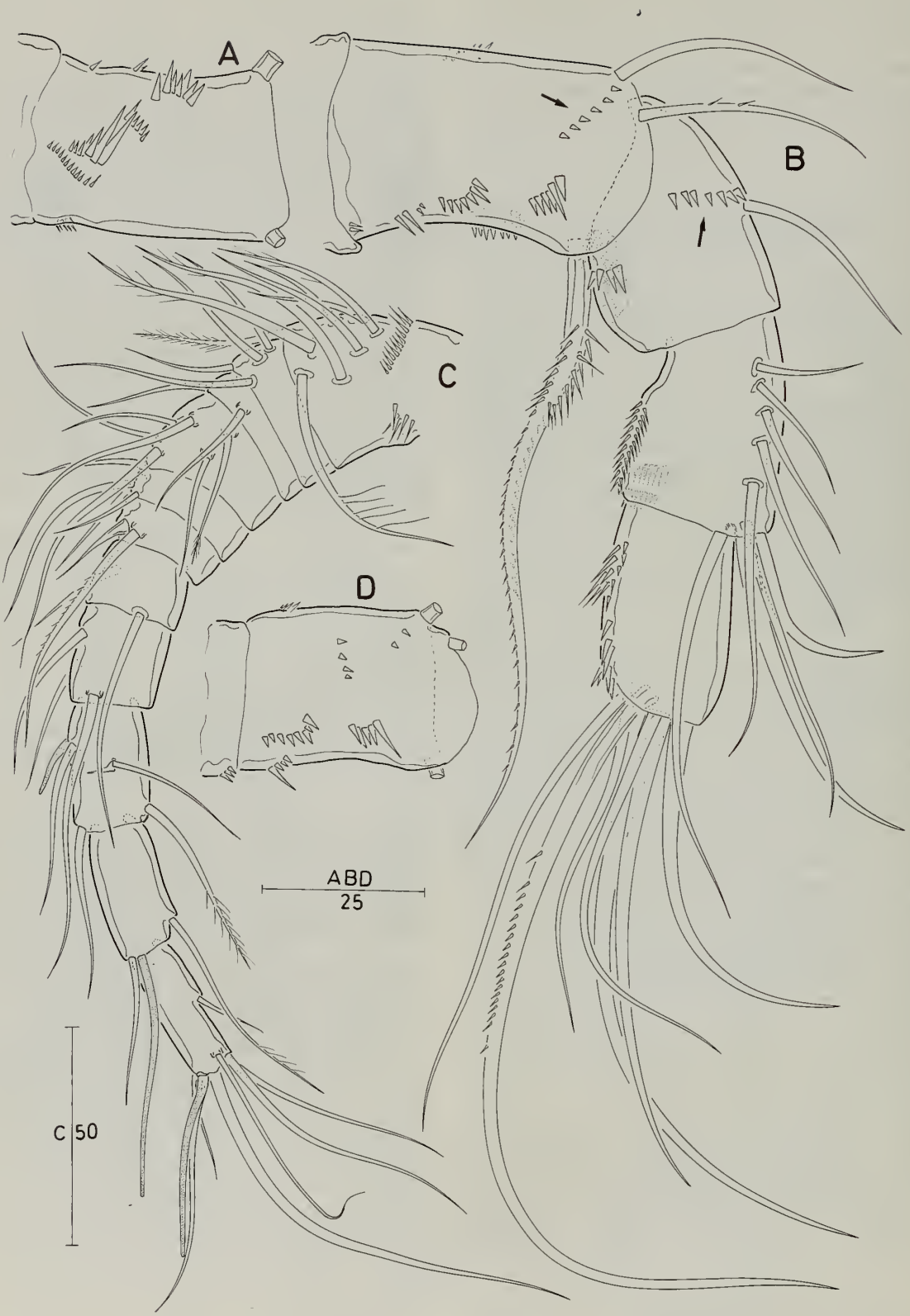

Fig. 3 *P. affinis*. Adult female. A, antenna, coxobasis, frontal; B, antenna, caudal showing typical spinulation; C, antennule; D, antenna, coxobasis, caudal showing variant pattern of spinulation. Scale bars in μm.

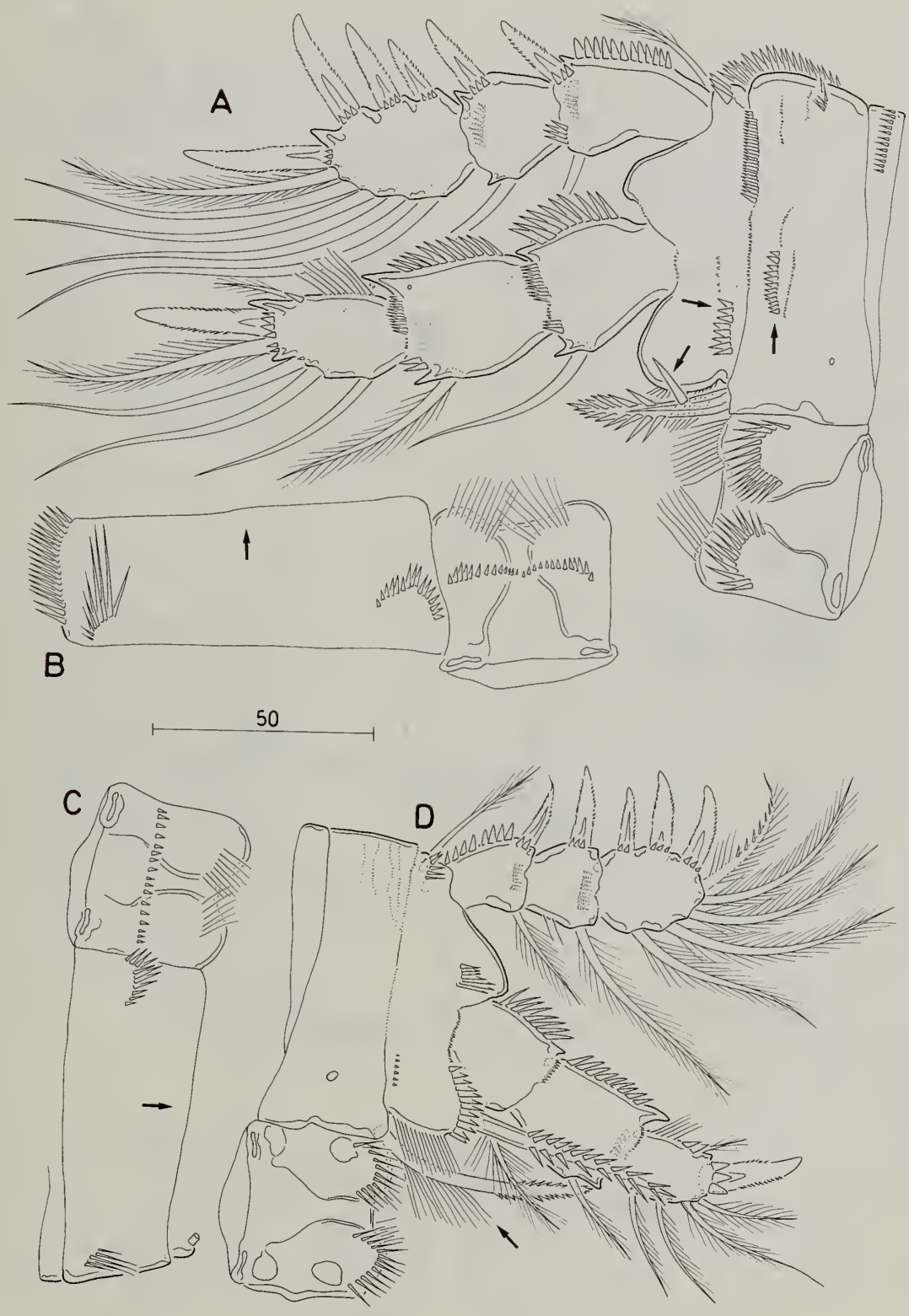

Fig. 4 *P. affinis*. Adult female. A, leg 2, anterior; B, intercoxal sclerite and coxa of leg 2, posterior; C, intercoxal sclerite and coxa of leg 1, posterior; D, leg 1, anterior. Scale bar in μm.

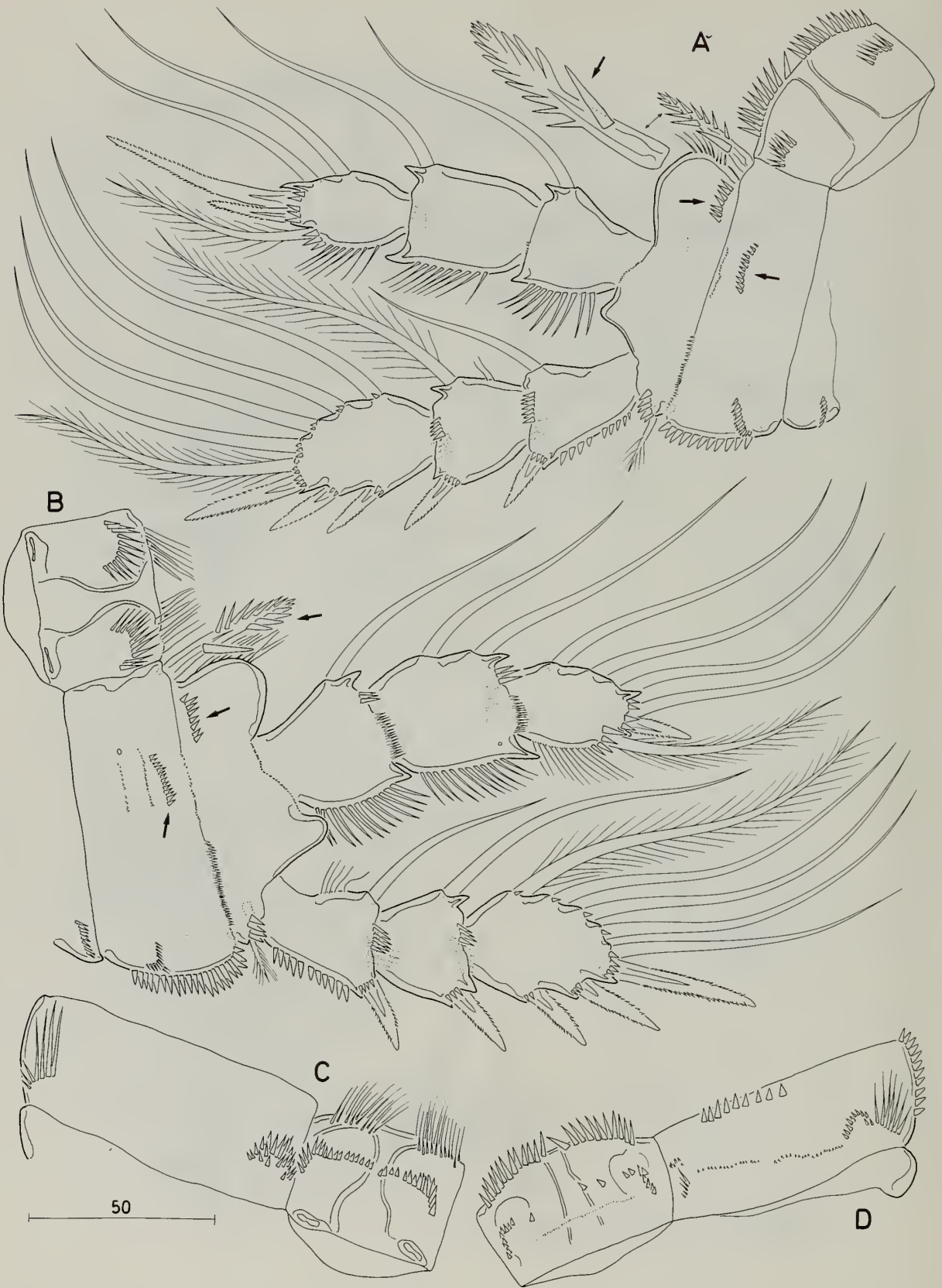

Fig. 5 *P. affinis*. Adult female. A, leg 4, anterior; B, leg 3, anterior; C, intercoxal sclerite and coxa of leg 3, posterior; D, intercoxal sclerite and coxa of leg 4, posterior. Scale bar in µm.

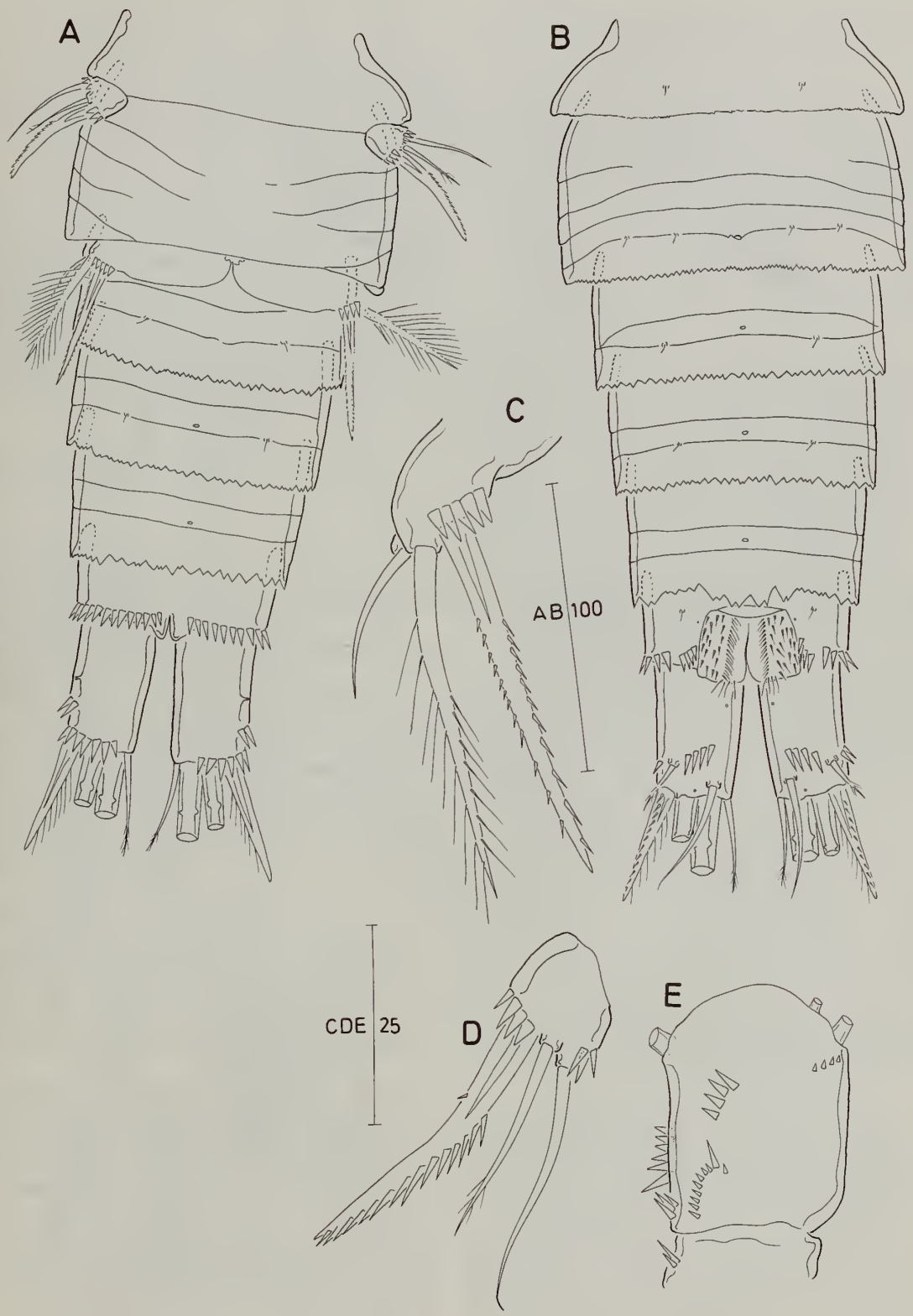

Fig. 6 *P. affinis*. Adult male. A, urosome, ventral; B, urosome, dorsal; C, detail of leg 6, ventral; D, detail of leg 5, ventral; E, antenna, coxobasis, caudal. Scale bars in µm.

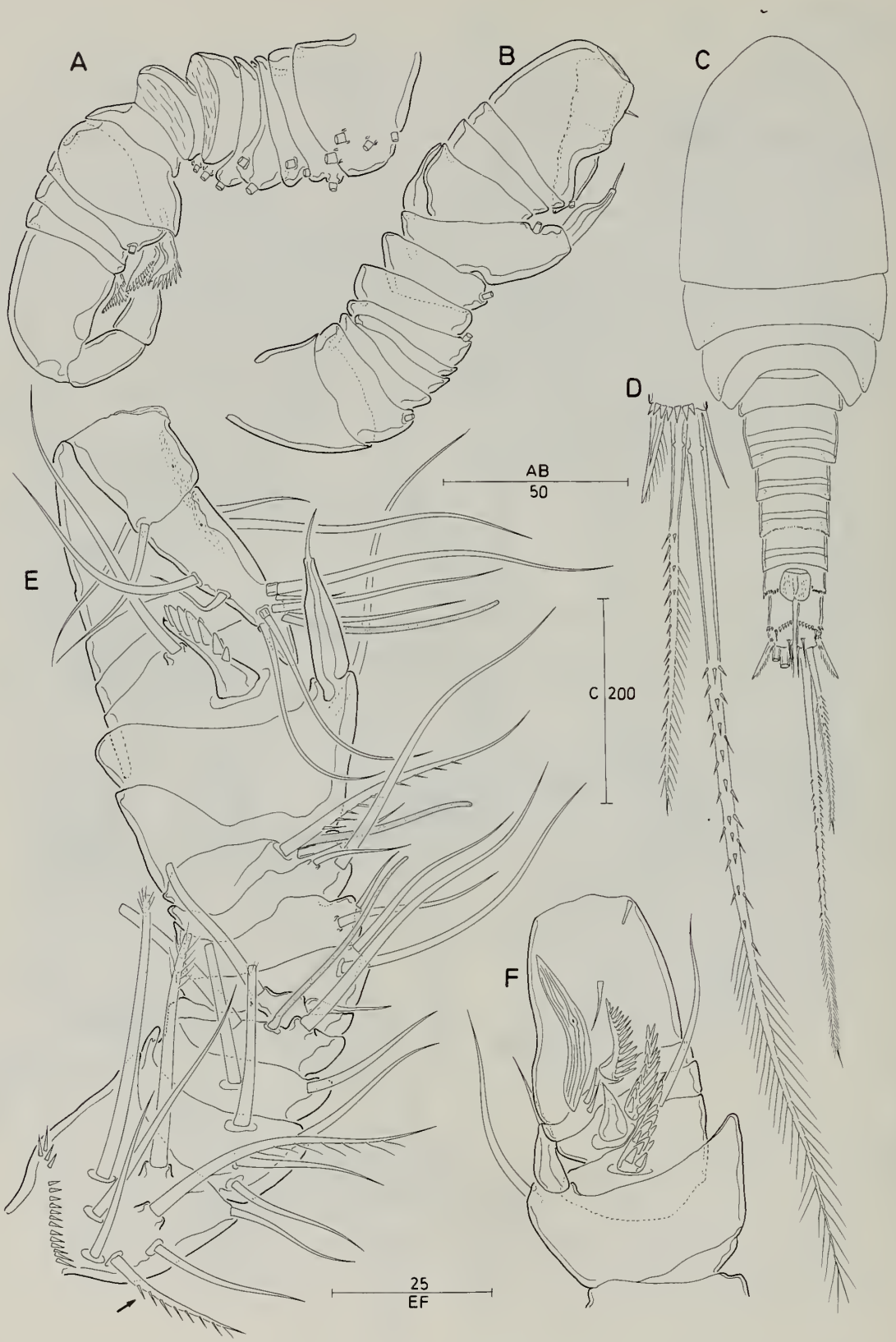

Fig. 7 *P. affinis*. Adult male. A, antennule, ventral showing segmentation; B, dorsal showing segmentation; C, body, dorsal; D, detail of setation elements of caudal rami; E, anteroventral showing setation; F, detail of segments 12 to 15. Scale bars in μm.

Tanganyika given by Lindberg (1951) is significantly shorter than in the material upon which this description is based. It is possible that Lindberg (1951) was dealing with a new species, but Lindberg's (1951) description is based on the male only and lacks sufficient detail to make further comparisons.

P. yeatmani is another species of *Paracyclops* possessing an 11-segmented antennule, however, analysis of segmental homologies between *P. canadensis*, *P. affinis* and *P. yeatmani* has revealed that the antennulary segments in *P. yeatmani* are not all homologous with those of *P. affinis* and *P. canadensis* (Karaytug & Boxshall, 1998).

DISTRIBUTION: This revision has indicated that *P. affinis* does not occur in North America. All existing records of *P. affinis* from North America refer to the newly re-discovered *P. canadensis*, however the presence of *P. affinis* in Africa as well as in Europe, Japan and Malaya has been confirmed. This species is probably widely distributed throughout the Palaearctic region but is not found in the Nearctic. Australian records (Sars, 1913–1918; Timms & Morton, 1988) of this species must be confirmed. For detailed references concerning the distribution of *P. affinis*, see Karaytug (1998).

Paracyclops poppei (Rehberg, 1880)

(Figures 8–13)

Cyclops poppei Rehberg, 1880
Cyclops crassicornis O. F. Müller, 1785 *sensu* Herrick (1882)
Cyclops fimbriatus Fischer, 1853 *sensu* Herrick (1884), Schmeil (1891), Marsh (1892, 1910), Byrnes (1909)
Cyclops fimbriatus var *Poppei* Rehberg, 1880: Schmeil (1892), Van Douwe (1909)
Cyclops (Paracyclops) fimbriatus poppei Rehberg, 1880: Gurney (1933)
Cyclops fimbriatus poppei Rehberg, 1880: Harding & Smith (1960).
Paracyclops fimbriatus poppei (Rehberg, 1880): Yeatman (1959)

ORIGINAL DESCRIPTION. *Cyclops poppei* Rehberg, 1880: *Abh. Natur. Ver. Bremen*, 6, p. 550, Taf. VI, figs. 9–11.

TYPE LOCALITY. Bremen, Germany

TYPE MATERIAL. Lost

MATERIAL EXAMINED
- Germany, Oldenburg, 4♀♀, 1♂, collected by T. Ishida on 2 Aug. 1996.
- The Natural History Museum, London: Derby, Mauchline, Catrine: 2♂♂, 8♀♀, collected by M.A. Learner. BMNH 1968. 8. 19. 3–6.
- National Museum of Natural History, Smithsonian Institution, Washington: Louisiana, New Orleans, E. New Orleans, in tyre at Grant Street near Old Gentilly Road and Almonaster Avenue (21 June 1988), USNM cat: 252018, Acc. No: 373882, 7♀♀, 5♂♂, 6 copepodids were examined and one of each sex was dissected; Louisiana, New Orleans, in tree hole at Louisiana Science and Nature Center, 8♀♀, 5♂♂, 2 copepodids (1 female dissected), USNM cat: 252019; Virginia, Giles C., Hillside seep near mountain lake, tiny pool on path around lake (37°21'33"N, 080°32'11"W), 100 + ♀,♂ collected by J. W. Reid on 15 June 1990 (1♀ and 1♂ dissected), USNM cat: 250443, Acc. No: 359834; New York, Pond at town landfill, town of Northeast, Dutchess ca., NY, 1♂ and 1♀ mounted on 1 slide, collected by D. Strayer on 8 Oct 1985, USNM cat: 235366; New Mexico, Guadalupe River, Jemez National Forest about 40 km NE of San Ysidro, 1♀ (35°45'N 106°50'W), 26 May 1991, USNM cat: 251151; Mexico, Aguascalientes, Calvillo, Presa Penuelas (23 March 1987), 2 ♀♀, 3 copepodids, USNM cat: 234218; Japan, Lake Biwa, Shiga Prefecture, 3♀♀ and 1♂ mounted on 1 slide collected by T. Ishida on 17 March 1986, USNM cat: 250682.
- Russia, R. Ravan 100 km East of St.Petersburg district, 7♀♀, 3♂♂, collected by V. Alekseev (22 July 96).
- Canadian Museum of Nature: Ontario, Frontenac Cty, near Arden on Hwy. 7, pond, collected by Brenda J. Hann (2 June 1972), 2♀♀ and 1♂, CMNC: 1984–0348, Acq: IZ 1984–064; Ontario, New Islands, collected by L. Kerr (29Aug 1969), 2♀♀, CMNC: 1984–0370, Acq: 1969–227.
- Japan, Lake Biwa, Honshu, T. Ishida collection (17 March 1986), 2♀♀ dissected on 2 slides; 2♂♂ dissected on 2 slides.

REDESCRIPTION OF ADULT FEMALE

Body length and width given in Table 2. Urosome (Figure 8A,B) with genital double-somite and second and third abdominal somites ornamented with fine pits on dorsal surface as figured (Figure 8B). Anal operculum smooth; spinular rows present on either side of anal cleft as figured (Figure 8B). Caudal rami length and width given in Table 3. Caudal rami parallel, with fine cuticular depressions on ventral surface. Dorsal row of spinules on rami extending proximally, nearly reaching base of rami (Figure 8B).

Antennule 8-segmented. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc; coxobasis of antenna without spinular row on caudal surface near base of inner spinulose setae (arrowed in Figure 9H).

Terminal endopodal segment of leg 2 (Figure 10D) with stout spine, as long as segment; intercoxal sclerite of leg 3 with spinular row on anterior surface (Figure 11A) and with 3 spinular rows posteriorly (Figure 11C); intercoxal sclerite of leg 4 with patch of spinules on anterior surface and with 3 spinular rows on posterior surface (Figure 11D,E).

Spine and seta formula as follows:

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

Leg 5 (Figure 8C) comprising single free segment, armed with 1 inner spine, well developed outer spinulose seta as long as inner spine, 1 plumose seta in middle.

DESCRIPTION OF ADULT MALE

Body length and width given in Table 2. Caudal rami short (Figure 12C,D), about 2.5 times longer than broad; coxobasis of antenna with spinular row on caudal surface at base of inner spinulose setae (arrowed in Figure 12F), first endopodal segment with 2 spinular rows on frontal surface.

Antennule digeniculate (Figure 13A–F), indistinctly 15-segmented. Segment 1 armed with 8 setae; setae (A) and (C) are large and modified (arrowed in Figure 13E) by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally (Figure 13A,E,F). 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.

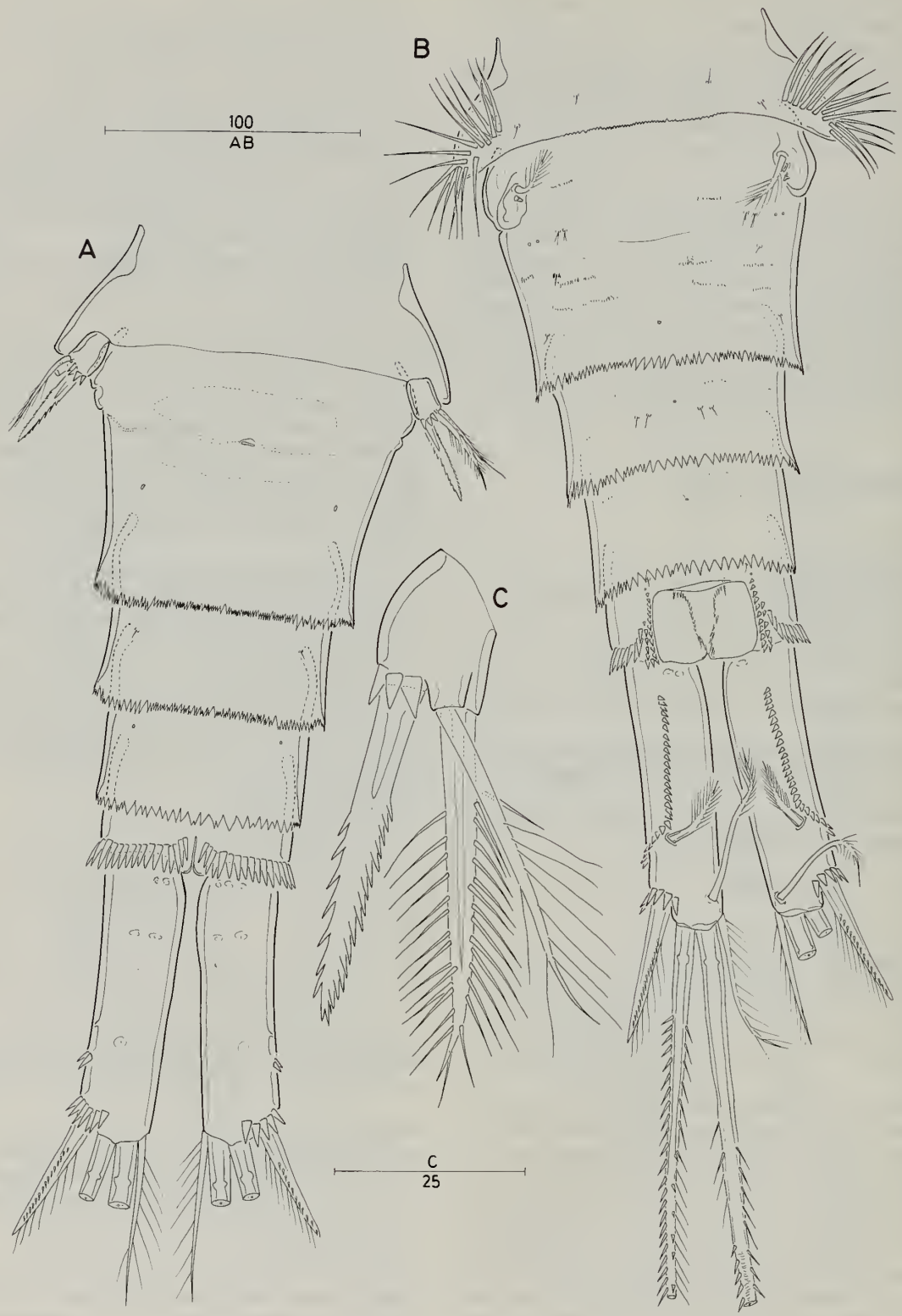

Fig. 8 *P. poppei*. Adult female. A, urosome, ventral; B, urosome, dorsal; C, leg 5, ventral. Scale bars in μm.

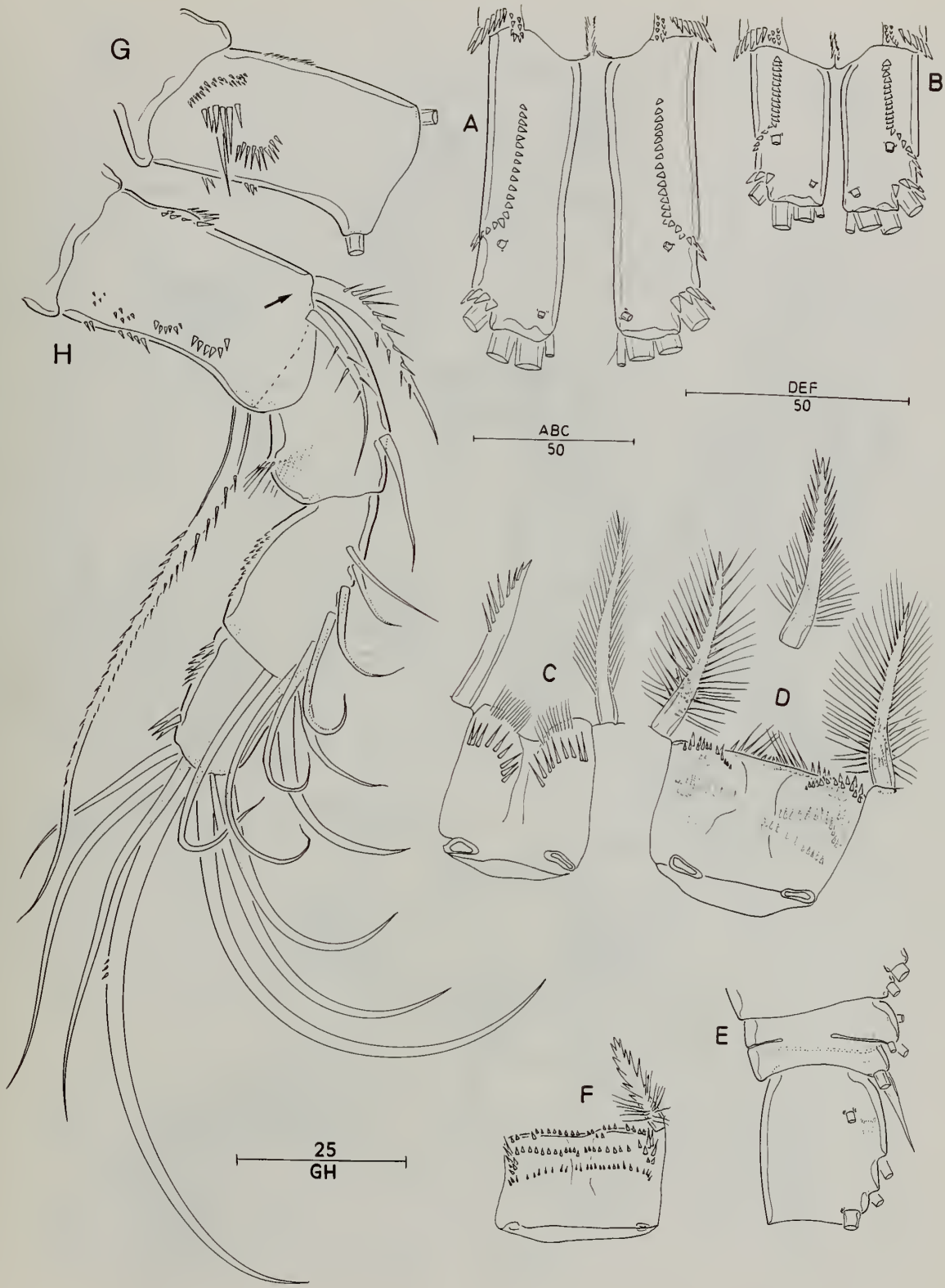

Fig. 9 *P. poppei*. Adult female. A (Virginia, U.S.A.), caudal ramus, dorsal; B (New Orleans, U.S.A.), caudal ramus, dorsal; C (Lake Biwa, Japan), leg 2, intercoxal sclerite, anterior; D (Lake Biwa, Japan), leg 4, intercoxal sclerite, anterior; E (Lake Biwa, Japan), antennule, segments 2 to 4, showing incomplete suture; F (Virginia, U.S.A.), leg 4, intercoxal sclerite, posterior; G, antenna, coxobasis, frontal; H, antenna, caudal. Scale bars in μm.

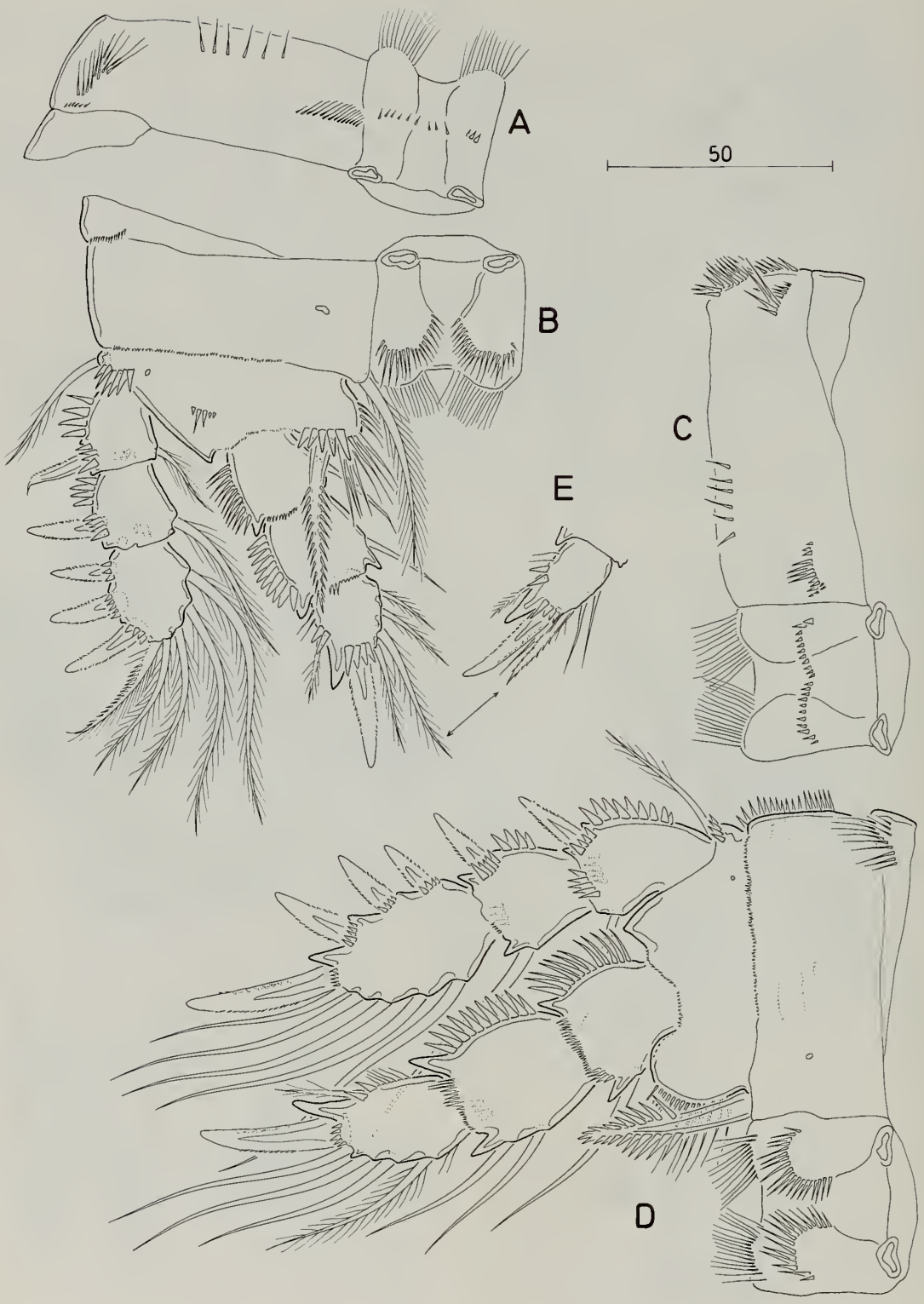

Fig. 10 *P. poppei*. Adult female. A, intercoxal sclerite and coxa of leg 1, posterior; B, leg 1, anterior; C, intercoxal sclerite and coxa of leg 2, posterior; D, leg 2, anterior; E, adult male, third endopodal segment of leg 1. Scale bar in μm.

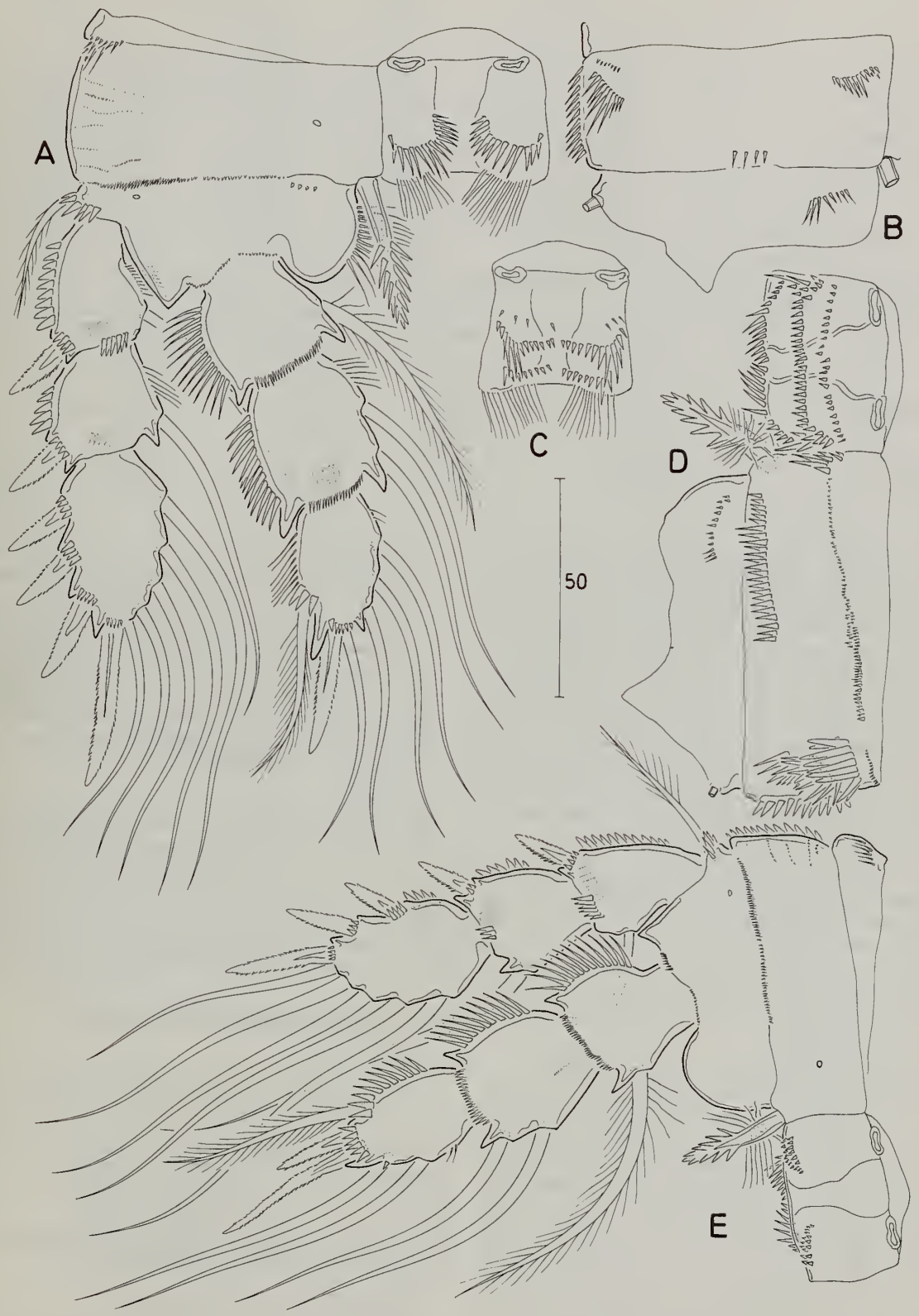

Fig. 11 *P. poppei*. Adult female. A, leg 3, anterior; B, coxa and basis of leg 3, posterior; C, intercoxal sclerite of leg 3, posterior; D, intercoxal sclerite and coxa of leg 4, posterior; E, leg 4, anterior. Scale bar in µm.

Table 2 Body length (BL) and width (BW) measurements (in μm) of *Paracyclops poppei* in various localities. (N = number of specimens measured)

Locality	Sex	BL (mean ± SD)	Range	BL (mean ± SD)	Range	N
Germany	♀	756 ± 34.7	728–806	282 ± 8	276–283	4
	♂	736		282		1
England	♀	758 ± 16.7	736–778	288 ± 11.7	274–309	4
Russia (St-Petersburg)	♀	828 ± 43.6	786–913	297 ± 12.9	278–317	6
	♂	655 ± 21.4	641–680	236 ± 3	233–239	3
United States (Virginia)	♀	725 ± 66	640–849	261 ± 19.4	230–291	10
	♂	601 ± 33.8	538–615	219 ± 17.8	198–235	5
United States (New Orleans)	♀	741 ± 50	691–822	239 ± 19.8	217–272	5
	♂	613 ± 8.5	605–622	207 ± 15.5	198–225	3
Canada	♀	819 ± 109.6	741–896	286 ± 2.8	284–288	2

Table 3 Caudal rami length (CL) and width (CW) measurements (in μm) of *Paracyclops poppei* in various localities. L:W, ratio of length to width. (N = number of specimens measured)

Locality	Sex	CL (mean ± SD)	Range	CW (mean ± SD)	Range	N	L:W
Germany	♀	95 ± 6.7	86–102	28 ± 0.8	27–29	4	3.4
England	♀	102 ± 5.7	94–112	30 ± 0.8	28–31	8	3.4
Russia (St-Petersburg)	♀	99 ± 9.2	80–111	29 ± 1.2	27–31	6	3.4
Mexico	♀	95 ± 7	90–100	29 ± 0.7	28–29	2	3.2
U.S.A. (New Orleans)	♀	60 ± 7.9	48–72	25 ± 1.3	23–28	12	2.4
U.S.A. (Virginia)	♀	84 ± 8.3	70–97	26 ± 1.2	24–28	11	3.2
Japan (Lake Biwa)	♀	104 ± 14.7	86–120	31 ± 4	25–33	4	3.4

VARIABILITY, FEMALES. The length and width of the caudal rami varied considerably especially in American specimens (Figure 9A,B), and measurements are given in Table 3. One female from England and one from Lake Biwa (Figure 9E) had antennules with an incomplete suture line on the posterior margin subdividing segment 3. In some specimens from Virginia, U.S.A., the spinular rows on the intercoxal sclerite of leg 4 were unusually small (Figure 9F). Finally, in specimens from Lake Biwa (Japan), the dorsal spinular row of the caudal rami reached almost midway along the ramus in some specimens and the inner coxal spines of legs 2 and 4 were ornamented with longer setules (Figure 9C,D) than in material from elsewhere. However no other consistent variation was observed and these few slight differences do not justify the creation of a new taxon.

DIFFERENTIAL DIAGNOSIS. *P. poppei* can easily be distinguished from its congeners by the continuous line of spinules on the dorsal surface of the caudal rami (Figure 8B) and by the possession of 2 large modified setae (setae A and C arrowed in Figure 13E) on the first segment of male antennule (Figure 13E,F). *P. poppei* also differs from *P. fimbriatus*, *P. chiltoni* and *P. imminutus* in the form of the spinular rows on either side of the anal operculum in the female (Figure 8B).

REMARKS AND COMPARISONS

P. poppei was originally described by Rehberg (1880) but subsequently some authors considered that the differences between *C. fimbriatus* and *P. poppei* were not significant and therefore assigned this taxon firstly to *Cyclops crassicornis* O. F. Müller, 1785 (Herrick, 1882) and then to *C. fimbriatus* Fischer, 1853 (Herrick, 1884; Schmeil, 1891; Byrnes, 1909; Marsh, 1892, 1910). Schmeil (1892) claimed that the differences could allow *P. poppei* to be recognized as a variety of *P. fimbriatus* and this opinion was shared by Van Douwe (1909). Gurney (1933) had doubts as to its status as subspecies and species, but its rank as subspecies was accepted by Lindberg (1958), Yeatman (1959) and Harding & Smith (1960). It was Kiefer (1929b) who first re-established *P. poppei* as a valid species and in subsequent publications *P. poppei* gradually became accepted (Rylov, 1963; Dussart, 1969; Einsle, 1993; Ishida, 1993).

The material identified by Sars (1927) as *Platycyclops poppei* from South Africa is not *P. poppei* nor can it be assigned to any other species of the genus. In fact, his material probably represents a new species. Sars assigned his specimens to *P. poppei* on the presence on the caudal rami of a single oblique row of small spinules across the dorsal surface, and he noted similarities in outward appearance to *P. affinis*. Indeed, the dorsal spinular rows across the caudal rami are rather like *P. affinis*, however as Sars (1927) also stated, his species can easily be distinguished from *P. affinis* by its 8-segmented antennule. Sars's species is also different from *P. poppei* as described herein in the structure of leg 5.

DISTRIBUTION. *P. poppei* was considered to have a wide distribution (Dussart & Defaye, 1985). Although its presence in Europe, North America and Japan has been confirmed, other records of *P. poppei*, especially from Brazil and Paraguay (Lowndes, 1934), East Africa (Van Douwe, 1912), Tunisia (Dumont et al., 1979) and Hawaii (Sars, 1927) should be confirmed since there is insufficient description provided for unequivocal identification. For detailed references concerning the distribution of *P. poppei*, see Karaytug (1998).

Paracyclops oligarthrus (G. O. Sars, 1909)

(Figures 14–20)

Cyclops oligarthrus, Sars, 1909: Cunnington (1920)
Platycyclops oligarthrus (Sars, 1909): Gurney (1928)

ORIGINAL DESCRIPTION. *Cyclops oligarthrus* Sars, 1909: *Proc. zool. Soc. Lond.*: 31–77, pl. XXI. figs. 195–202.

TYPE LOCALITY. Lake Tanganyika, Africa.

MATERIAL EXAMINED. G. O. Sars, Lake Tanganyika 13♀♀, 5♂♂(Syntypes). BMNH 1909. 6. 24. 224–233.

REDESCRIPTION OF ADULT FEMALE

Body length (mean ± SD) 555 ± 32.6, range = 517–598, n = 8. Body width 220 ± 8, range = 206–233, n = 8. Prosome (Figure 14C) produced frontally, forming prominent rostral area. Fifth pedigerous somite with strong fringe of elongate setules at posterior margin

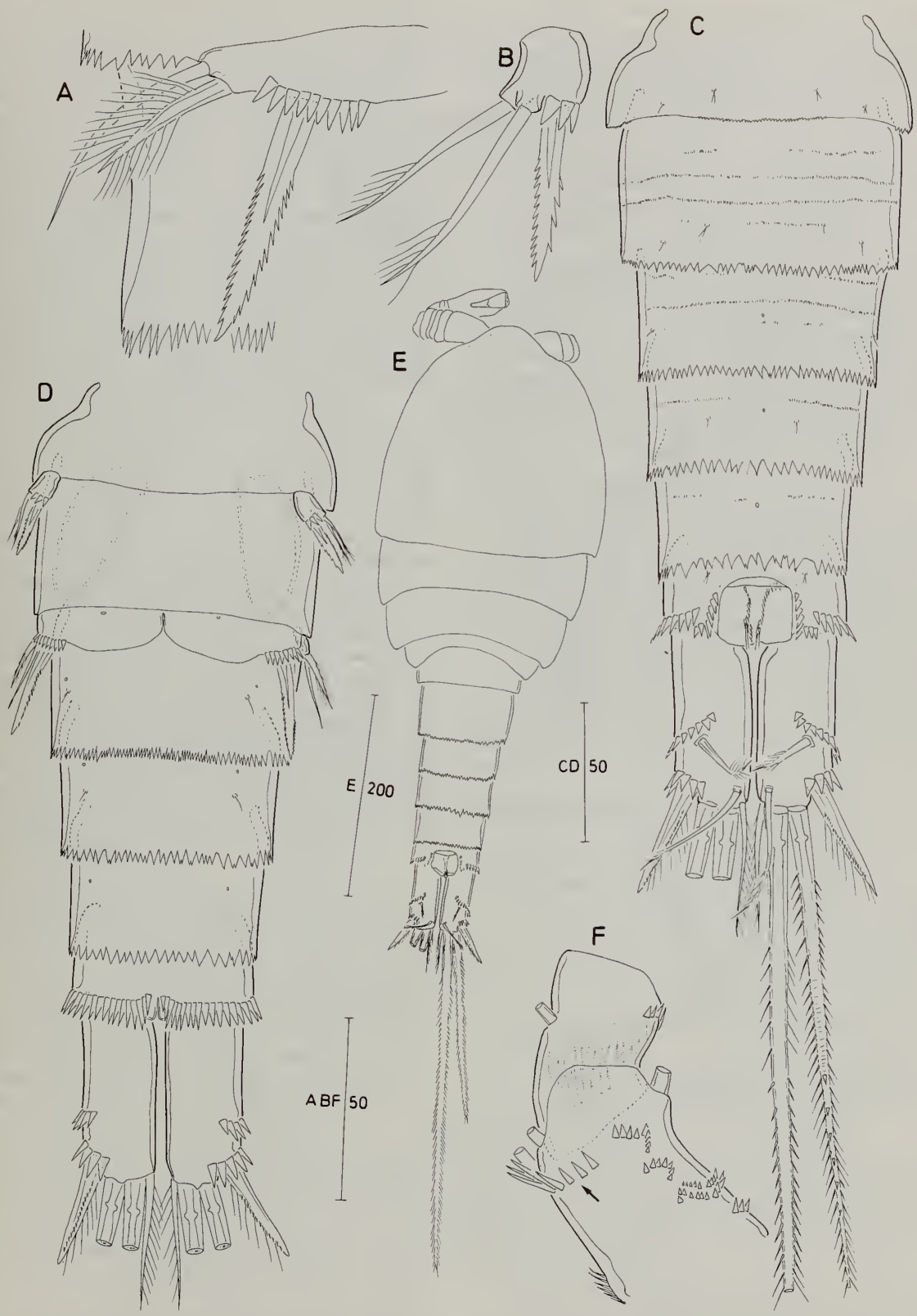

Fig. 12 *P. poppei*. Adult male. A, detail of leg 6, anteroventral; B, leg 5, ventral; C, urosome, dorsal; D, urosome, ventral; E, body, dorsal; F, antenna, coxobasis and first endopodal segment, caudal. Scale bars in µm.

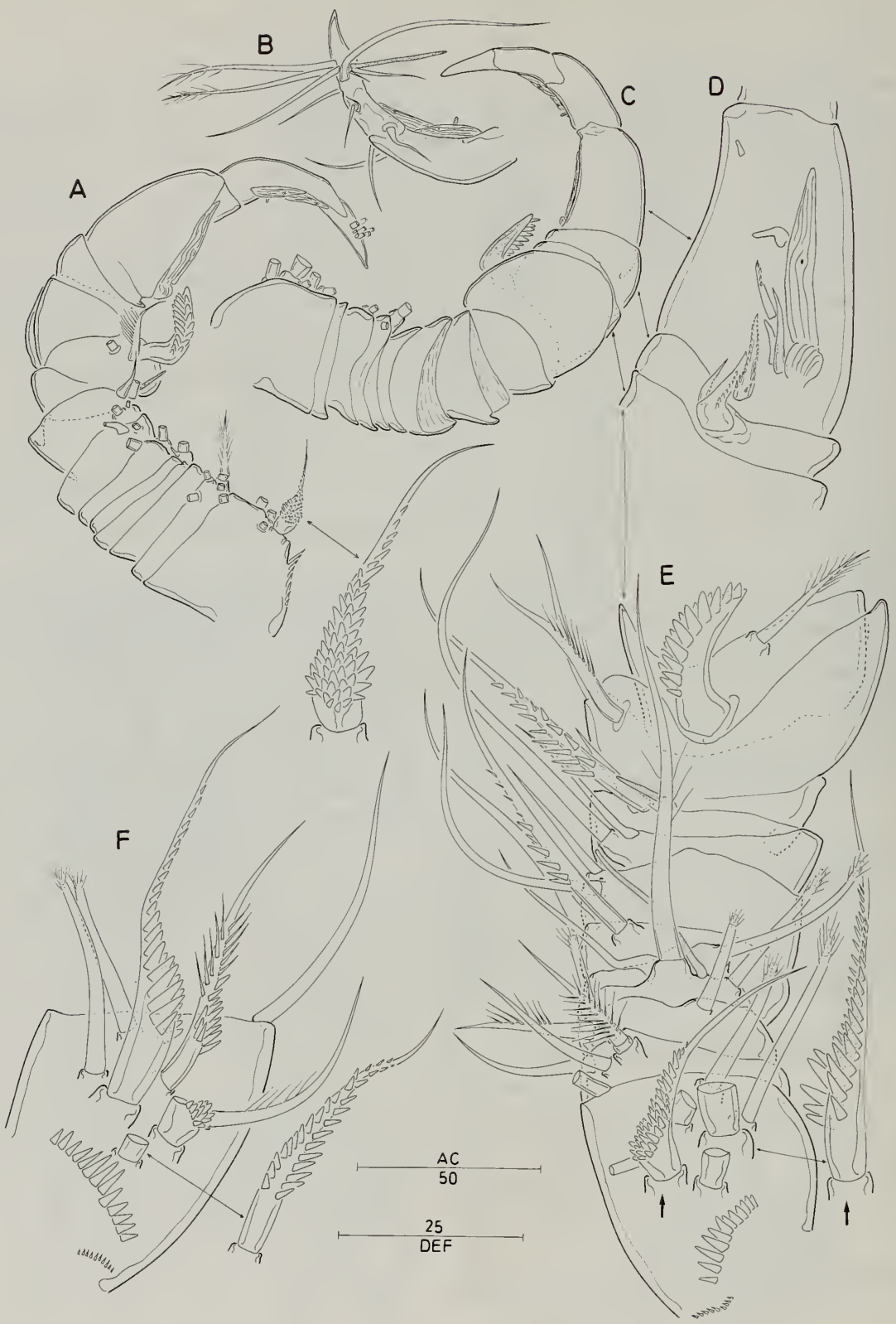

Fig. 13 *P. poppei*. Adult male. Antennule. A, dorsal showing segmentation and with inset showing seta A; B, detail of terminal segments; C, ventral showing segmentation; D, anteroventral view of segments 14 and 15; E, anteroventral view of segments 1 to 12 with inset showing detail of seta C; F, anteroventral view of first segment with inset showing detail of seta B. Scale bars in μm.

(Figure 15A). Genital double-somite, second and third abdominal somites lacking pits on dorsal and ventral surfaces (Figure 15A,B). Seminal receptacle divided into complex anterior and posterior lobes (Figure 15B). Caudal rami slightly divergent and 3.5 times longer than broad (Figure 15A,B). Posterolateral seta (IV) and inner terminal seta (V) with complex spinular ornamentation as figured (Figure 14C); terminal accessory seta (VI) strong and plumose.

Antennule (Figure 16A) compact and 7-segmented; first (ancestral segments I–V) and second (ancestral segments VI–XI) segments separated ventrally but incompletely separated dorsally. First and second segments here treated as distinct segments. Segment 3 with partial suture line (indicating boundary between ancestral segments XIII and XIV) and spiniform seta. Segment 5 with partial suture line (indicating boundary between ancestral segments XXI and XXII) and with characteristic short aesthetasc. Short aesthetasc located distally on anteroventral margin of segment 6. Setal formula 8, 12, 6, 5, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna lacking spinular row near base of inner setae caudally (arrowed in Figure 16C); with complex ornamentation on caudal (Figure 16C) and frontal (Figure 16B) surfaces as figured.

Terminal exopodal segments of legs 2–4 each with two semispinulose setae (arrowed in Figures. 17A; 18A,D). Praecoxa of leg 1 (Figure 17D) without spinular row at outer corner; basis with setiform spine on inner margin not extending beyond distal margin of second endopodal segment; intercoxal sclerite without spinular row on posterior surface (Figure 17E); terminal endopodal segment with 3 inner setae. Terminal endopodal spine of leg 2 (Figure 18A) strong, about as long as segment; coxa with complex ornamentation on posterior surface (Figure 18B). Intercoxal sclerite of leg 3 with spinules on anterior surface (Figure 18D) and with spinular row on posterior surface (Figure 18C); coxa with complex ornamentation on posterior surface (Figure 18C). Intercoxal sclerite of leg 4 with row of setules on anterior surface (Figure 17A) and with two spinular rows on posterior surface (Figure 17B); distal row well developed; inner coxal spine without cluster of setules posteriorly (Figure 17A); basis with long plumose outer angle seta; lacking setules along inner margin (Figure 17A); coxa with complex ornamentation on posterior surface (Figure 17B); exopodal spines with dense spinules along margins (Figure 17A).

Spine and seta formula as follows:

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

Leg 5 (Figure 15C) comprising single free segment, armed with 1 short well developed outer spinulose seta, 1 strong inner spine and 1 strong plumose seta (slightly longer than inner spine) centrally.

DESCRIPTION OF ADULT MALE

Body length (mean ± SD) 444 ± 14.8, range = 433–454, n = 2. Body width 179 ± 2.8, range = 177–181, n = 2. Urosomal somites without surface ornamentation (Figure 19A,B). Caudal rami short about 2 times longer than broad.

Antennule digeniculate (Figure 20A,B), indistinctly 15-segmented. Segment 1 armed with 8 setae (Figure 20E,F); seta A large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally; aesthetasc absent. Segment 11 bearing strongly curved seta ornamented along convex surface with double row of strong denticles, plus 1 plumose seta (Figure 20E). 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.

One seta on terminal exopodal segment of leg 1 semispinulose (Figure 17C). Intercoxal sclerite of leg 4 with stronger terminal spinular row than in female (Figure 19D). Fifth leg with strong inner spine and reduced outer and middle setae (Figure 19E). Sixth leg (Figure 19A,C) armed with 1 strongly developed inner spine surrounded by spinules at base, and 2 outer setae, outermost seta shorter than middle seta.

VARIABILITY. Inner margin of basis of leg 4 lacks setules in most females examined and in one of the two males but was ornamented with setules in some females and the other male.

DIFFERENTIAL DIAGNOSIS. *P. oligarthrus* can be distinguished from other *Paracyclops* species by the structure of the fifth leg in both sexes (Figures 15C; 19A,E), by the structure of the seminal receptacle (Figure 15B), by the 7-segmented antennule (Figure 16A and see remarks), by the absence of the proximal inner seta on the terminal endopodal segment of leg 1 (Figure 17D), by carrying 2 semispinulose setae on the terminal exopodal segment of legs 2–4 (Figures 18A,D; 17A) and by the sixth leg of the male being fully incorporated into the genital somite (Figure 19A).

REMARKS AND COMPARISON

P. oligarthrus is unique in the loss of the proximal inner seta on the terminal endopodal segment of leg 1 (Figure 17D). This segment carries 4 inner setae in all other species. *P. oligarthrus* also has 2 semispinulose setae on the terminal exopodal segment of legs 2–4 (arrowed in Figures 17A; 18A,D). The male sixth leg is unusual in the relatively large size of the inner spine and in being fully incorporated into the genital somite (Figure 19A).

Sars's (1909) interpretation of the antennule as 6-segmented is incorrect. He appears to have overlooked the partial division of the proximal segments.

DISTRIBUTION. *P. oligarthrus* is endemic to Lake Tanganyika, Africa.

Paracyclops canadensis (Willey, 1934)

(Figures 21–25)

Cyclops affinis var. *canadensis* Willey, 1934
Paracyclops affinis (Sars, 1863) *sensu* Smith & Fernando (1977, 1978)

ORIGINAL DESCRIPTION. *Cyclops affinis* var. *canadensis* Willey, 1934: *Trans. R. Can. Inst.* 20 (1): 77–98.

TYPE LOCALITY. Canada, Quebec (no other detail is given in the original paper)

TYPE MATERIAL. The type material of Willey (1934) could not be located. It is not deposited in the CMNC or the USNM.

MATERIAL EXAMINED

The redescription of *P. canadensis* is based on 2 ♀ ♀ which were obtained from Canadian Museum of Nature. Catalogue number: CMNC 1996–0019. Locality: Canada, Ontario, Parry Sound District, 40 km N of Parry Sound on Hwy 69; collected by C. H. Fernando on 7 July 1972.

- U.S.A, West Virginia; 8 ♀ ♀ collected on 23 May 1995 in Big Run Bog in the Monongahela National Forest by Robert Hamilton, Tucker County, 39°07′ N, 79°35′ W. USNM Acc. 417235.
- CANADA, Jack Lake, Nova Scotia 3 ♀ ♀ dissected and mounted on 1 slide, 2 ♀ ♀ undissected and mounted on 1 slide, 1 ♀ dissected and mounted on 1 slide, 2 ♀ ♀ and 1 ♂ undissected and mounted

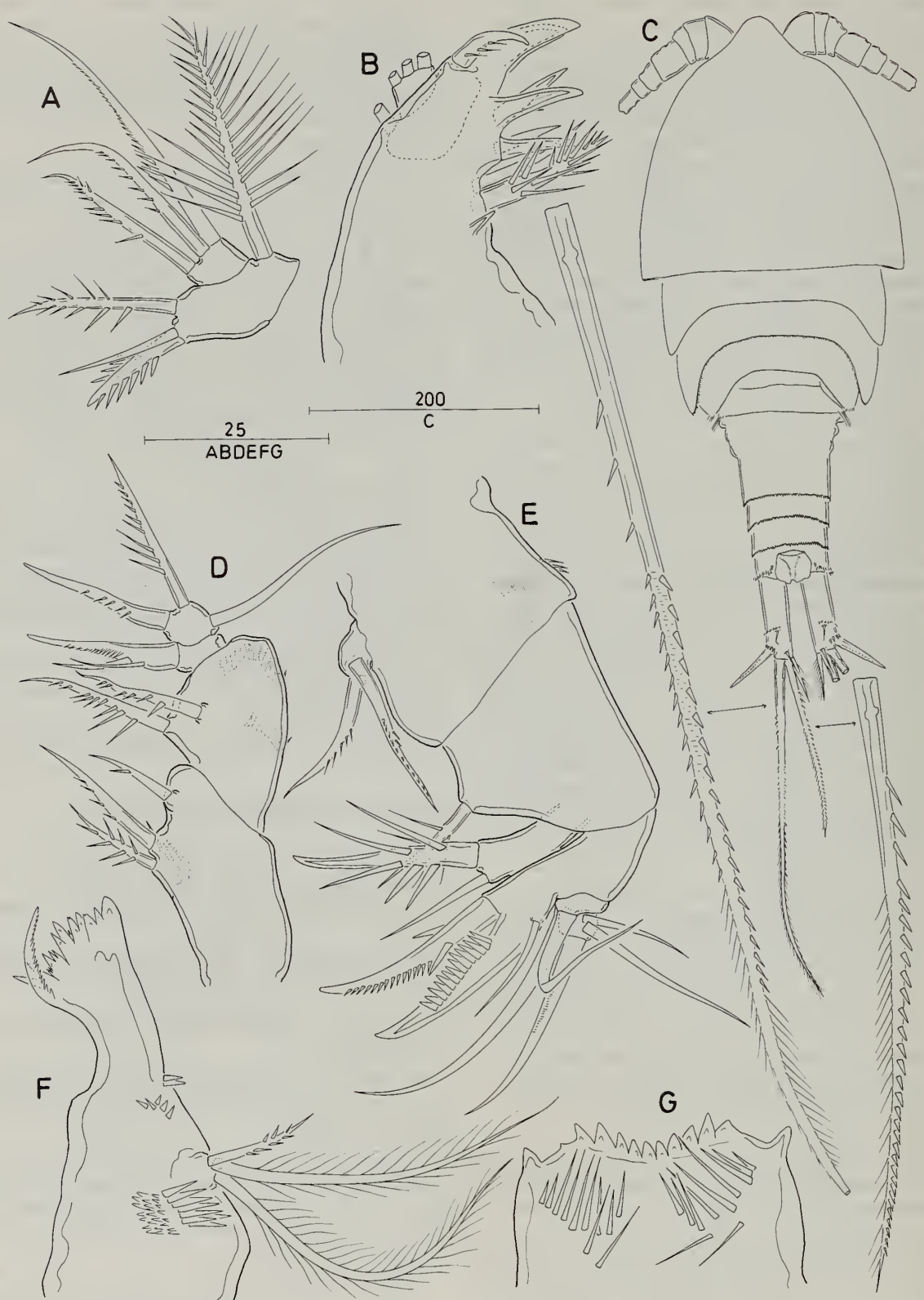

Fig. 14 *P. oligarthrus*. Adult female. A, maxillulary palp; B, maxillule; C, body with inset showing the detail of setal elements IV and V of caudal rami, dorsal; D, maxilliped; E, maxilla; F, mandible; G, labrum. Scale bars in μm.

Fig. 15 *P. oligarthrus*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral. Scale bars in μm.

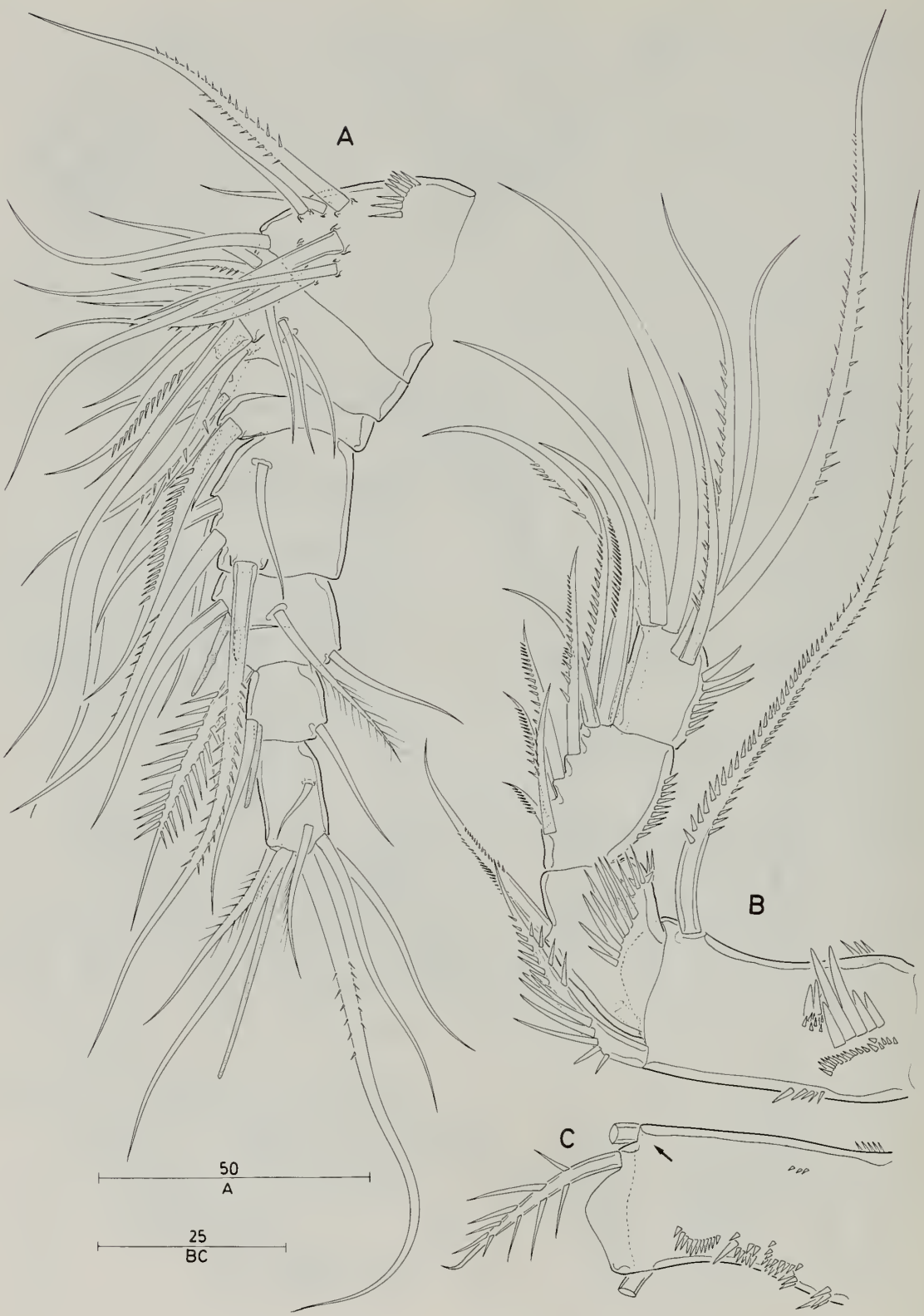

Fig. 16 *P. oligarthrus*. Adult female. A, antennule; B, antenna, frontal; C, antenna, coxobasis, caudal. Scale bars in μm.

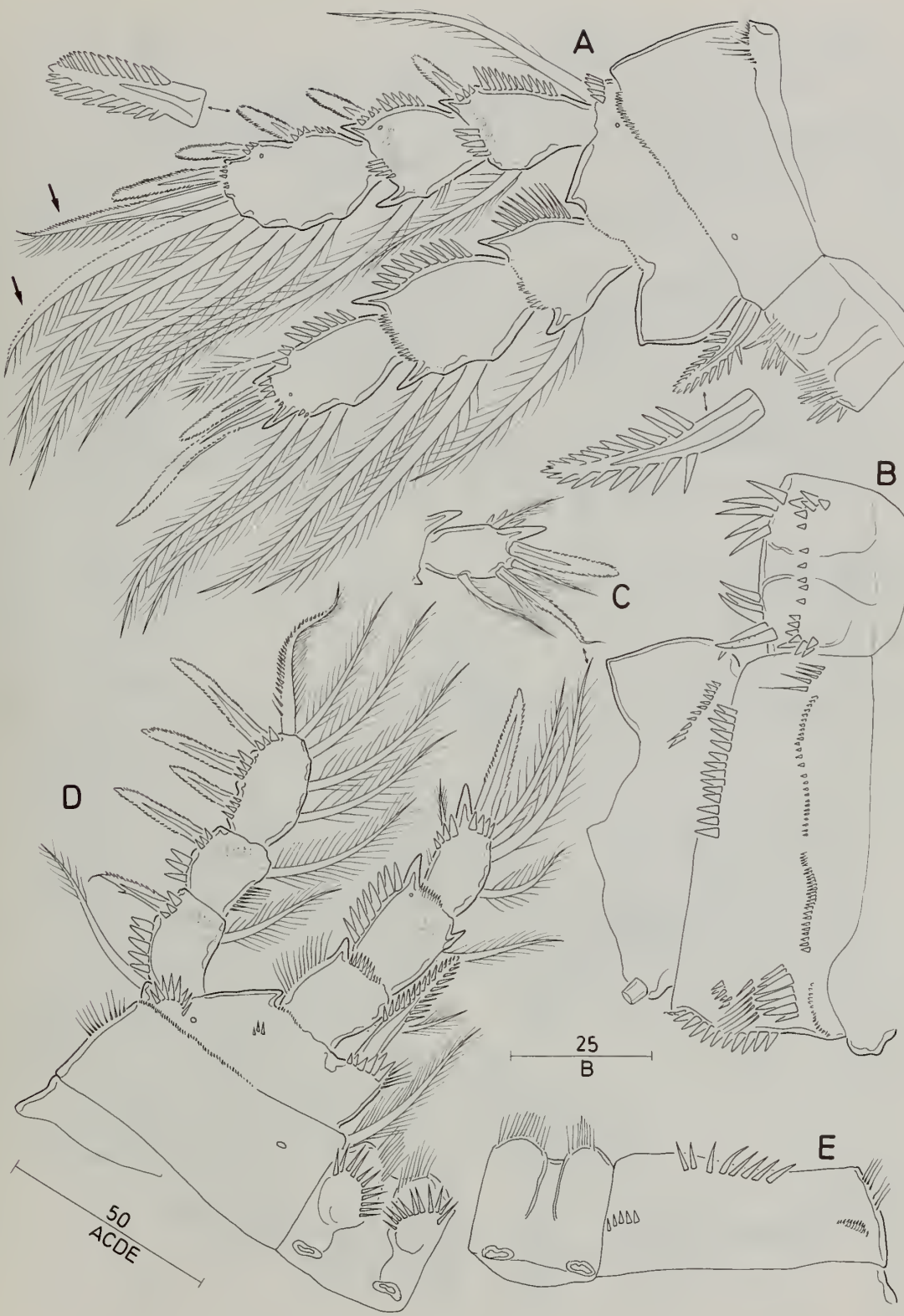

Fig. 17 *P. oligarthrus*. Adult female. A, leg 4 with inset showing the inner coxal spine, anterior; B, intercoxal sclerite, coxa and basis of leg 4, posterior; C, adult male, terminal endopodal segment of leg 1, posterior; D, female, leg 1, anterior; E, intercoxal sclerite and coxa of leg 1, posterior; Scale bars in μm.

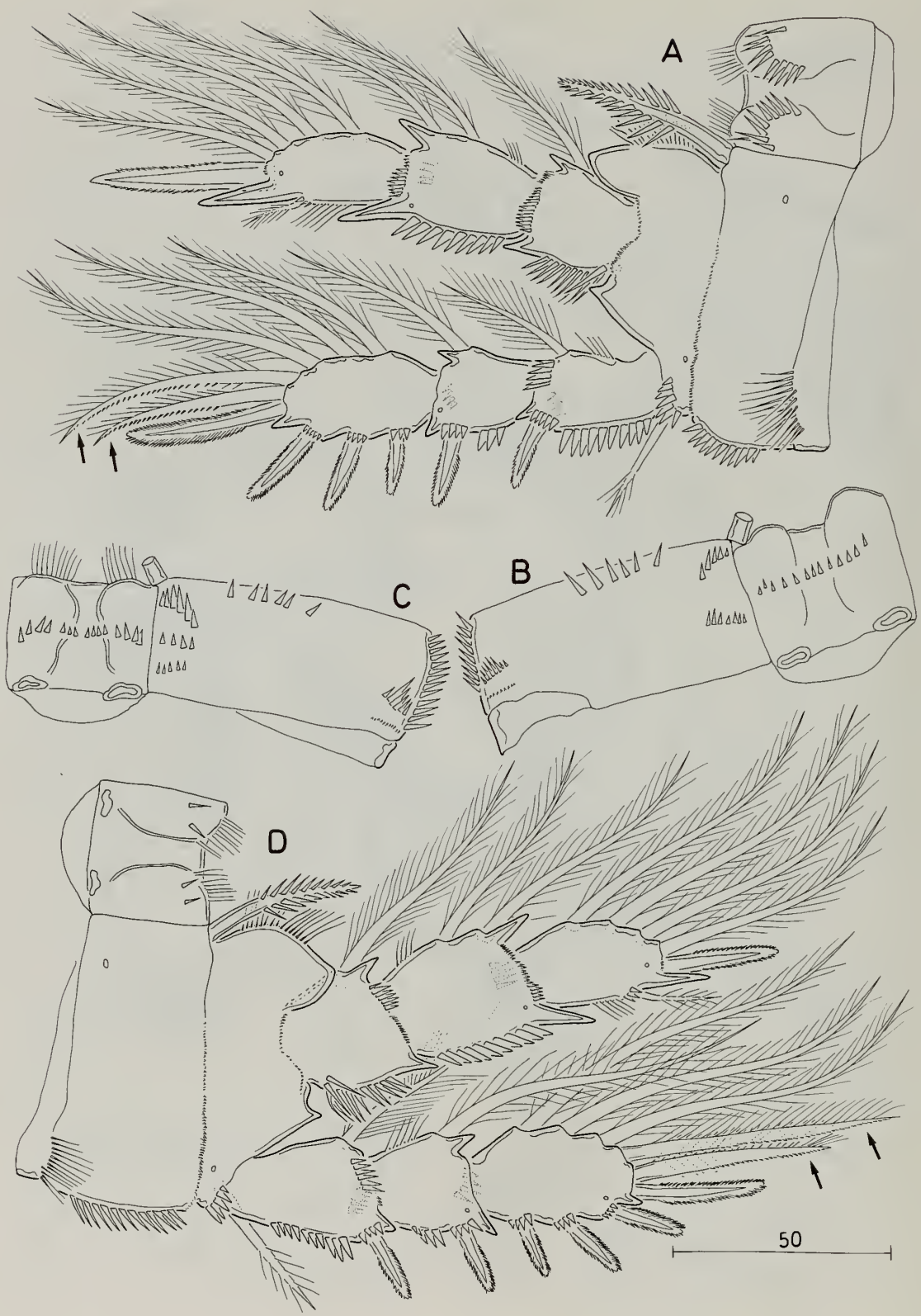

Fig. 18 *P. oligarthrus*. Adult female. A, leg 2, anterior; B, intercoxal sclerite and coxa of leg 2, posterior; C, intercoxal sclerite and coxa of leg 3, posterior; D, leg 3, anterior. Scale bar in μm.

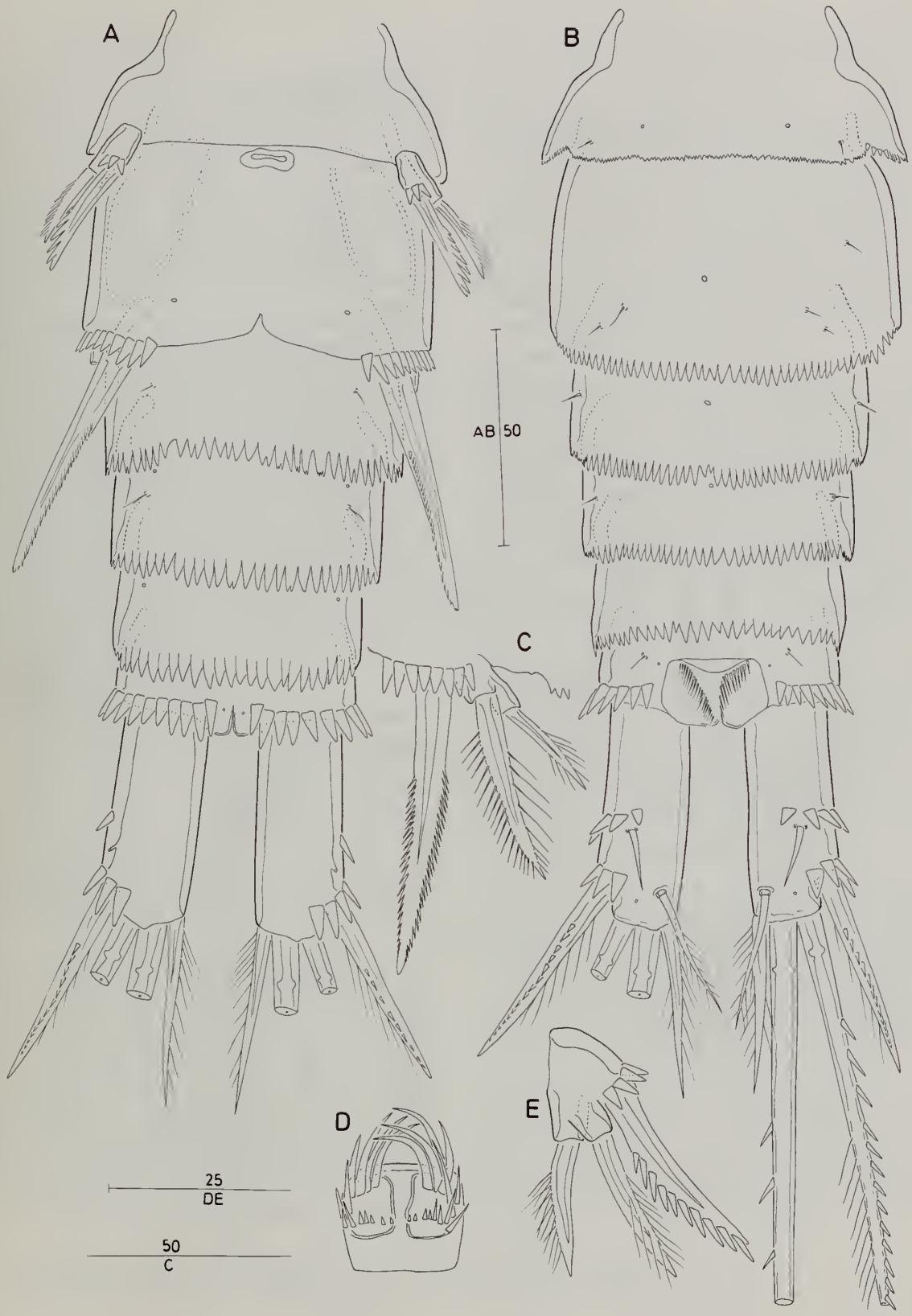

Fig. 19 *P. oligarthrus*. Adult male. A, urosome, ventral; B, urosome, dorsal; C, leg 6, anteroventral; D, intercoxal sclerite of leg 4, posterior; E, leg 5, ventral. Scale bars in μm.

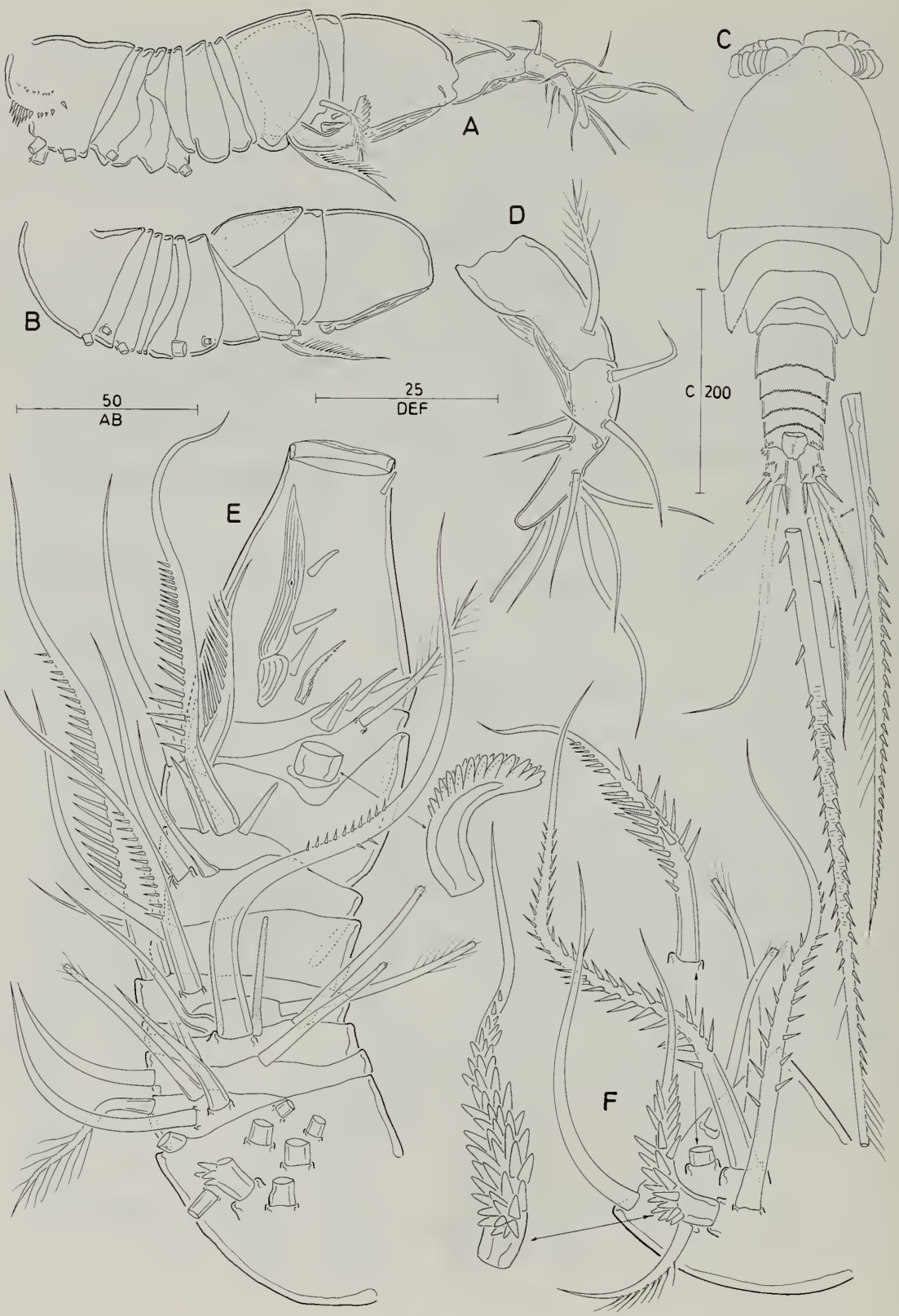

Fig. 20 *P. oligarthrus*. Adult male. A, antennule, ventral showing segmentation; B, dorsal showing segmentation; C, body, dorsal; D, antennule, terminal segments showing setation; E, antennule showing setation, anteroventral; F, first segment showing setation, anteroventral;. Scale bars in µm.

on 1 slide, 1 ♂ dissected and mounted on 1 slide, 2 ♂ ♂ undissected and mounted on 2 slides. Dr H. Yeatman collection. These specimens are deposited in USNM.

REDESCRIPTION OF ADULT FEMALE

Body length and width not including caudal setae given in Table 4. Genital double-somite, second and third abdominal somites with more dorsal surface ridges extending round sides onto ventral surface than *P. affinis* (Figure 21A,B). Seminal receptacle divided into broad anterior and posterior lobes, anterior lobe slightly narrower than posterior (Figure 21B).

Anal cleft with irregularly arranged spinules (Figure 21A,D) and with spinular row extending either side (arrowed in Figure 21D). Caudal rami short about 2 times longer than broad (Figure 21A,B); terminal accessory seta (VI) longer than posterolateral seta (III) (Figure 21A).

Antennule 11-segmented. Segment 6 with spiniform seta. Setal formula 8, 4, 2, 6, 4, 2, 2, 3, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 22C,D) with complex ornamentation on caudal and frontal surfaces as figured; lacking spinular row near base of inner setae on caudal surface (arrowed in Figure 22D).

Basis of maxilliped with one spinular row on anterior surface and 2 groups of spinules on posterior surface (Figure 22B). First endopodal segment with 1 tiny spinule on anterior surface.

Coxae of legs 2–4 with 2 spinular rows on anterior surface (arrowed in Figures 23D, 24A,D) and with inner spine bearing 2 or 3 large spinules posterolaterally (arrowed in Figure 24A); basis without spinular row on anterior surface near inner margin. Coxa of leg 3 with two mid-distal spinules on posterior surface. Intercoxal sclerite of leg 4 with well developed spinular row (stronger than that of *P. affinis*) along free margin and with spinular rows on anterior and posterior surfaces (Figure 24C,D)

Spine and seta formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–1	I–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;0–1;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;0–1;1,II,2

Leg 5 with long inner spine about 4 times as long as segment; outer spinulose seta simple, about half as long as inner spine and without spinules at base (arrowed in Figure 21C).

DESCRIPTION OF ADULT MALE

Differing from adult female as follows: Genital somite with 5 or 6 irregular dorsal surface ridges and 5 incomplete ventral surface ridges; first to third free abdominal somites each with 3 complete dorsal and ventral surface ridges (best seen in Figure 25A,B).

Antennule digeniculate (Figure 25C,D), indistinctly 16-segmented. Segment 1 armed with 8 setae plus an aesthetasc. Segment 10 (= ancestral segment XV) produced on one side into sheath enclosing segment 11 ventrally: armed with 2 setae, one of which pear-shaped and constricted at end in *P. affinis* but simple in *P. canadensis* (arrowed in Figure 25D).

VARIABILITY, FEMALES. Arrangements of spinules in the anal cleft may vary (cf. Figures 21A and 21D).

DIFFERENTIAL DIAGNOSIS. *P. canadensis* is distinguished from other *Paracyclops* species by the combination of 11-segmented antennule, the surface ridges on the urosomal somites, the spinular ornamentation on the anal cleft and by the possession of only 1 seta on the second endopodal segment of leg 4.

P. canadensis and *P. affinis* are very closely related but *P. canadensis* can easily be differentiated from *P. affinis* by the possession of 4 spines on the terminal exopodal segment of leg 3 (Figure 24A), the lack of spinules at the base of the outer seta of leg 5 (Figure 21C); by the presence of more surface ridges on the genital and following 2 free somites (Figure 21A,B); by the extent of the spinular row either side of the anal cleft (Figure 21A,D); by the structure of inner coxal spines of legs 2 to 4 (Figures 23D; 24A,D) and by the absence of spinular rows near the inner margin of the basis of legs 2 to 4 (Figures 23D; 24A,D)

REMARKS

P. canadensis has been reported from North America under the name *P. affinis* by Yeatman (1959), Pennak (1963) and Smith & Fernando (1977, 1978). However, comparison between European and North American specimens of *P. affinis* led to the recognition here of *P. canadensis* as valid species in North America. *P. canadensis* was first recorded from North America in 1934 by Willey as a variety of *P. affinis* (Willey, 1934). According to the rules of zoological nomenclature this taxon when raised to species rank must take Willey's original variety name, becoming *P. canadensis* (Willey, 1934).

DISTRIBUTION. *P. canadensis* occurs in the Eastern parts of Canada and United States.

Paracyclops dilatatus Lindberg, 1952

(Figures 26–27)

Platycyclops dilatatus Sars, 1927a [*nomen nudum*]
Paracyclops dilatatus ivanegai Monchenko, 1977

ORIGINAL DESCRIPTION. *Paracyclops dilatatus* Lindberg, 1952: *Bull. Soc. zool. France*, 77, 1: p.80, fig. 1

TYPE LOCALITY. Caspian Sea.

MATERIAL EXAMINED. Syntypes: Zoologisk Museum, Oslo; 3 slides F6236, F6237a and F6237b contain parts of 1 dissected &. One tube F6237c contains female fragments. F6237a, 6237b and 6237c were separated from one original slide by Dr. P. Frenzel in 1979.

The type specimens of *P. dilatatus* Lindberg, 1952 were obtained on loan from the Zoologisk Museum, Oslo. Unfortunately the 3 slides are not very informative and the available fragments of just one female were insufficient to redescribe *P. dilatatus* in detail.

REDESCRIPTION OF ADULT FEMALE

Body length (Figure 26H) not including caudal setae is 840 µm (given by Lindberg, 1952 as approximately 770µm to 810µm). Genital double-somite, second and third abdominal somites without surface pits on dorsal and ventral surfaces (Figure 26H). Anal somite with spinular row ventrally extending dorsally. Caudal rami (Figure 26K) short, about 2 times longer than broad.

Table 4 Body length (BL) and width (BW) measurements (in µm) of *P. canadensis* (N = number of specimens measured).

Locality	Sex	BL(mean ± SD)	Range	BL(mean ± SD)	Range	N
Canada, Ontario	♀	684 ± 45.2	652–716	257 ± 3.5	254–259	2
U.S.A. (West Virginia)	♀	713 ± 47.6	642–783	251 ± 8.3	242–264	8

Fig. 21 *P. canadensis*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral; D, anal somite, dorsal. Scale bars in μm.

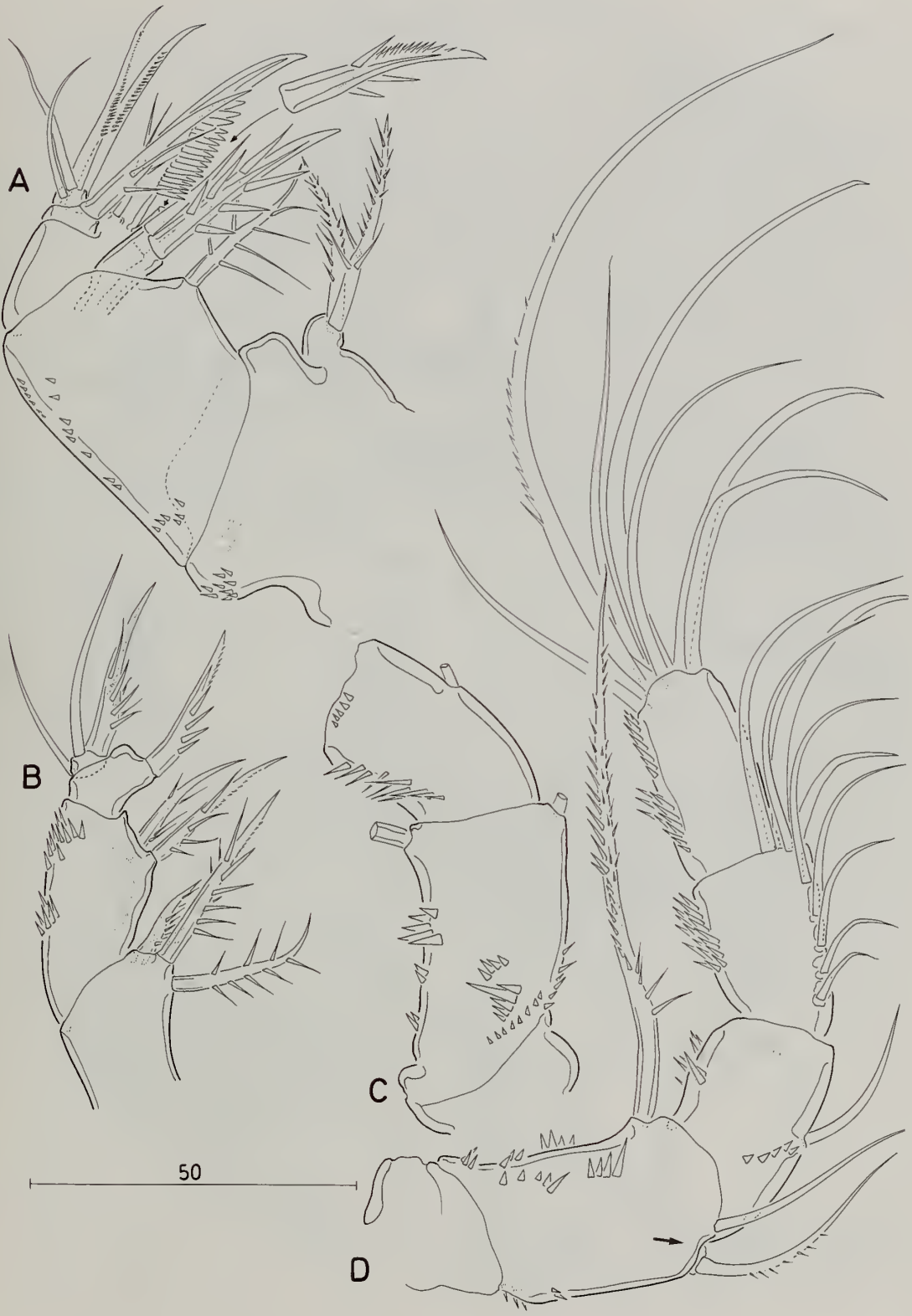

Fig. 22 *P. canadensis*. Adult female. A, maxilla; B, maxilliped; C, antenna, coxobasis, frontal; D, antenna, caudal. Scale bar in μm.

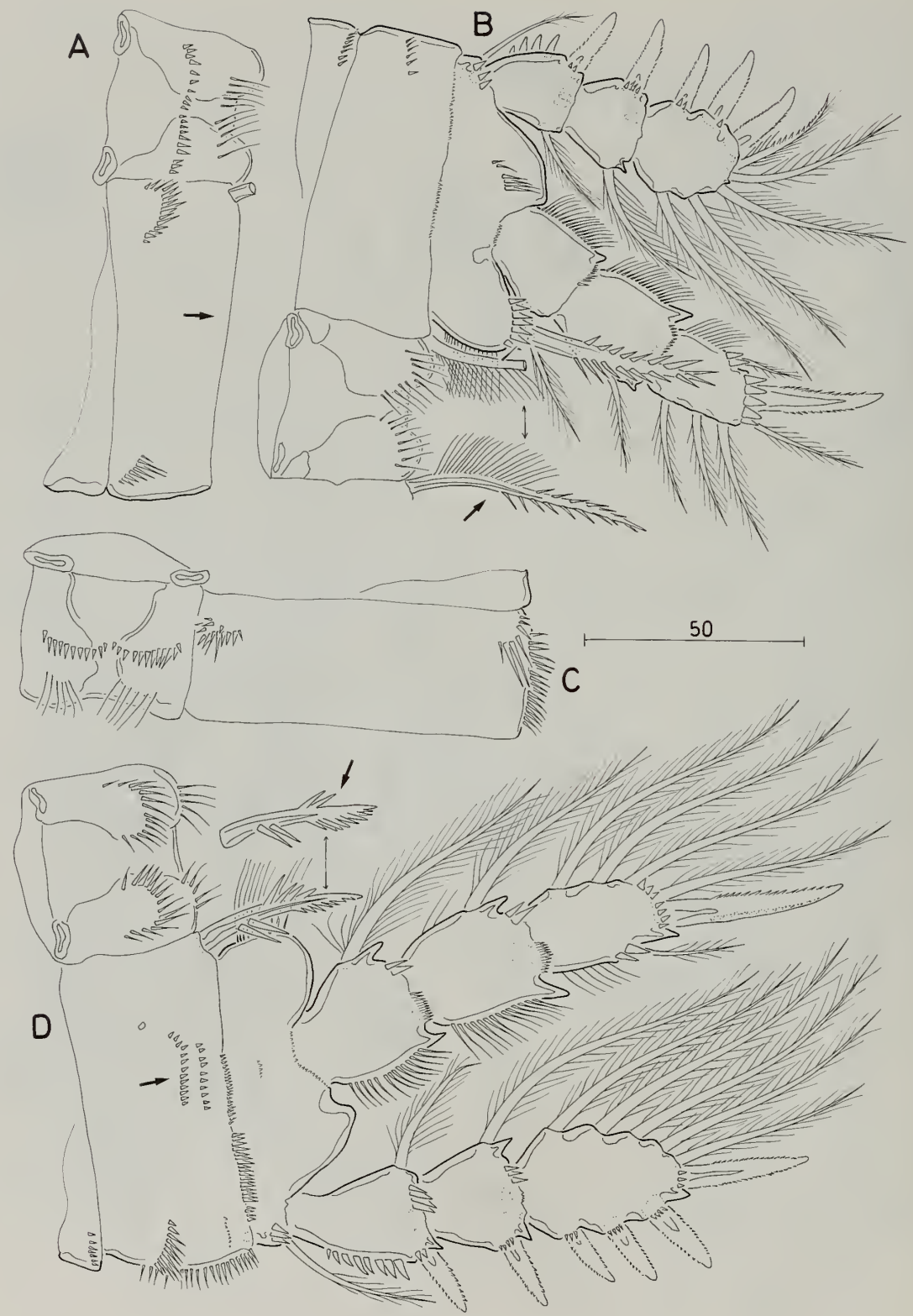

Fig. 23 *P. canadensis*. Adult female. A, intercoxal sclerite and coxa of leg 1, posterior; B, leg 1, anterior; C, intercoxal sclerite and coxa leg 2, posterior; D, leg 2, anterior. Scale bar in µm.

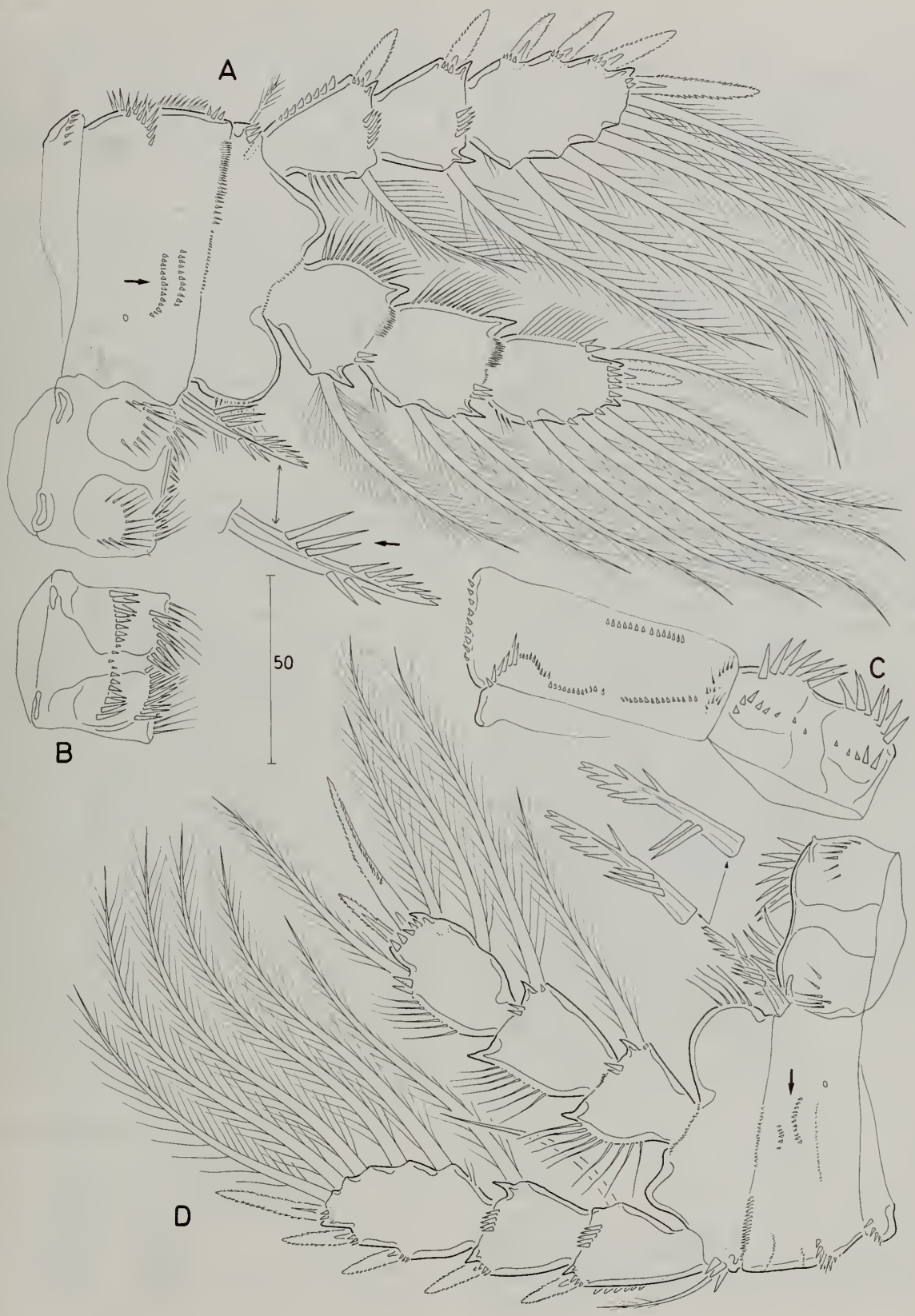

Fig. 24 *P. canadensis*. Adult female. A, leg 3, anterior; B, intercoxal sclerite of leg 3, posterior; C, intercoxal sclerite and coxa of leg 4, posterior; D, leg 4, anterior. Scale bar in μm.

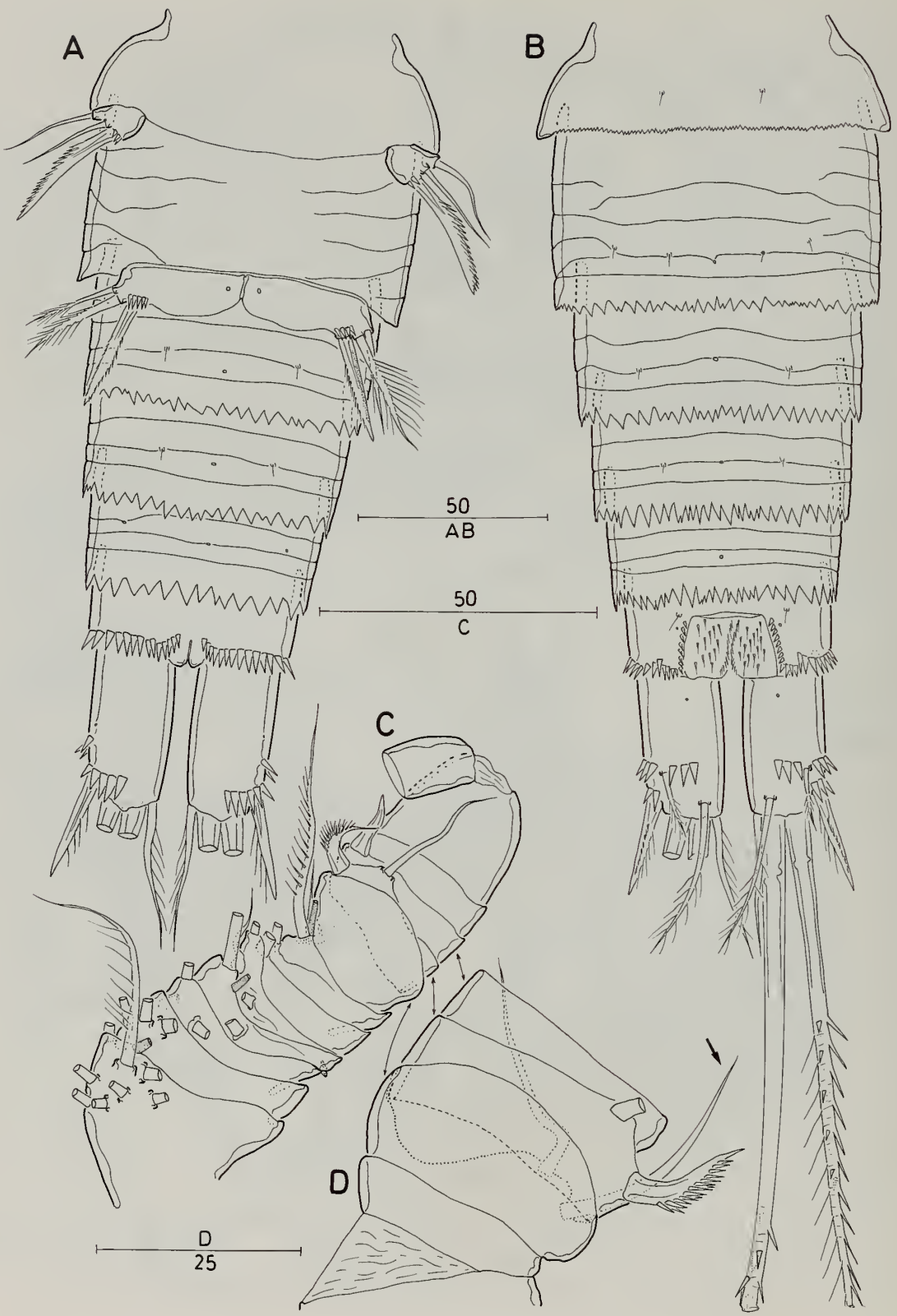

Fig. 25 *P. canadensis*. Adult male. A, urosome, ventral; B, urosome, dorsal; C, antennule showing proximal segmentation, ventral; D, antennule, detail of segments 11 to 14, ventral. Scale bars in µm.

Antennule 8-segmented (Figure 26A,H); third segment with partial suture line. Coxobasis of antenna with spinular row near base of inner setae on caudal surface (arrowed in Figure 26C); second endopodal segment with 9 setae, one seta transformed into massive recurved claw (arrowed in Figure 26C); third endopodal segment armed with 7 setae around apex; 2 of which modified into claw-like setae (arrowed in Figure 26C).

Spine and seta formula of swimming legs (Figure 27A–D) as follows:

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

Leg 5 (Figure 26L) comprising single free segment, armed with 1 long (almost twice as long as inner spine) outer spinulose seta, 1 inner spine surrounded with spinules at base, and 1 plumose seta centrally.

ADULT MALE. Unknown.

DIFFERENTIAL DIAGNOSIS. *P. dilatatus* is remarkable because of the highly transformed seta which forms the massive claw on the second endopodal segment of the antenna (arrowed in Figure 26C). No other *Paracyclops* species possesses such a modified seta on this segment.

REMARKS AND COMPARISONS

Sars (1927a) initially published *Platycyclops dilatatus* as a *nomen nudum* but his death prevented him from describing the new species. In 1952 Lindberg, on the basis of Sars's specimens, described this taxon under the name *Paracyclops dilatatus*. Its incomplete and inaccurate description as *P. dilatatus* (Lindberg, 1952) led Monchenko (1977) to describe a new subspecies from the Black Sea without examining the type specimens. Lindberg's (1952) interpretation of the antennule as 10-segmented is wrong since the examination of type material left no doubt that *P. dilatatus* has an 8-segmented antennule. Lindberg (1952) admitted that that it was difficult to examine and measure the specimens in his original publication on *P. dilatatus*. However, Monchenko (1977) established his new subspecies of *P. dilatatus* on the basis of having an 8-segmented antennule. The other main morphological characters of the caudal rami and its setal elements are so similar to the type that the description of a new subspecies *P. dilatatus ivanegai* Monchenko, 1977 is unjustified. Monchenko's description should be considered to be the first good redescription of *P. dilatatus* Lindberg, 1952.

DISTRIBUTION. *P. dilatatus* is known only from the Caspian Sea and the Black Sea basin in Ukraine.

Paracyclops hardingi nom. nov.

(Figures 28–32)

Paracyclops fimbriatus andinus Lindberg, 1957
non *Paracyclops andinus* Kiefer, 1957

ORIGINAL DESCRIPTION. *Paracyclops fimbriatus andinus* Lindberg, 1957: *Folia Biol. Andina*, 1: 39–52.

TYPE LOCALITY. Lindberg's material (Lindberg, 1957) came from two different sites in Peru, one from Lake Huampucocha and the other from Lake Conococha. Since Lindberg did not specify on which material his description was based, therefore both lakes are type localities.

MATERIAL EXAMINED

Since Lindberg's material of *P. fimbriatus andinus* has not been obtained, some material collected (originally identified under the name *P. finitimus*) during The Percy Sladen Trust Expedition to Lake Titicaca in 1937 under the leadership of Mr H. Cary Gilson was used to describe *P. hardingi*. A series of collections taken during the expedition is stored in The Natural History Museum, London. According to Harding (1955), the localities for the *P. hardingi* examined in this study are as follows: the shores of Taman Bay, Laguna Arapa, Laguna Umayo and the Lagunillas, from springs by the Lagunillas, from the River Ramis and from a ditch by the River Urubamba. These localities are mostly in the Altiplano surrounding Lake Titicaca. The examined material is 2♀ ♀(PFH 227/2), 1♀(G/G 1/93/5), 3♀ ♀(PFH 245), 3♀ ♀and 1♂(PFH 139); BMNH 1946. 11. 26. 216–225.

REDESCRIPTION OF ADULT FEMALE

Body length (μm) not including caudal setae, 894–1129, mean = 975, n = 10. Genital double-somite with surface ridge extending either side of copulatory pore on ventral surface (Figure 28A). Urosomal somites without surface pits (Figure 28A,B). Seminal receptacle divided into small conical anterior and broad posterior lobes as figured (Figure 28A). Anal operculum broad and smooth. Caudal rami parallel and short, about 2.1 times longer than broad; anterolateral seta (II) long; terminal accessory seta plumose (VI) and 1.5 times longer than posterolateral seta (III); outer terminal seta (IV) and inner terminal seta (V) well developed, spinulose and homogeneously ornamented (Figure 28B).

Antennule 8-segmented (Figure 29A); segment 3 with partial suture line reaching nearly to outer margin of segment, and with spiniform seta. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna with complex ornamentation on caudal and frontal surfaces as figured (Fig. 29B,C), and with well-developed spinular row near base of two inner setae (arrowed in Figure 29B).

Intercoxal sclerite of leg 1 ornamented with spinular row on anterior surface (Figure 30B), lacking spinules on posterior surface (Figure 30A). Intercoxal sclerite of leg 2 ornamented with spinular row on both anterior and posterior surfaces (Figure 30D,E).

Intercoxal sclerite of leg 3 without spinular row on anterior surface (Figure 31D) and with 2 spinular rows on posterior surface (Figure 31C). Intercoxal sclerite of leg 4 (Figure 31B) with groups of spinules on posterior surface; first and second exopodal segments without spinular row on posterior surface.

Spine and seta formula as follows:

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

Leg 5 (Figure 28C) comprising single free segment, armed with 1 long (almost 1.5 times longer than inner spine) well-developed outer spinulose seta, 1 inner spine, 1 plumose seta in centre. Leg 6 (Figure 28B) represented by 1 plumose seta and 2 tiny spinules dorsolaterally

DESCRIPTION OF ADULT MALE

Urosomal somites (Figure 32A,B) without ornamentation of surface

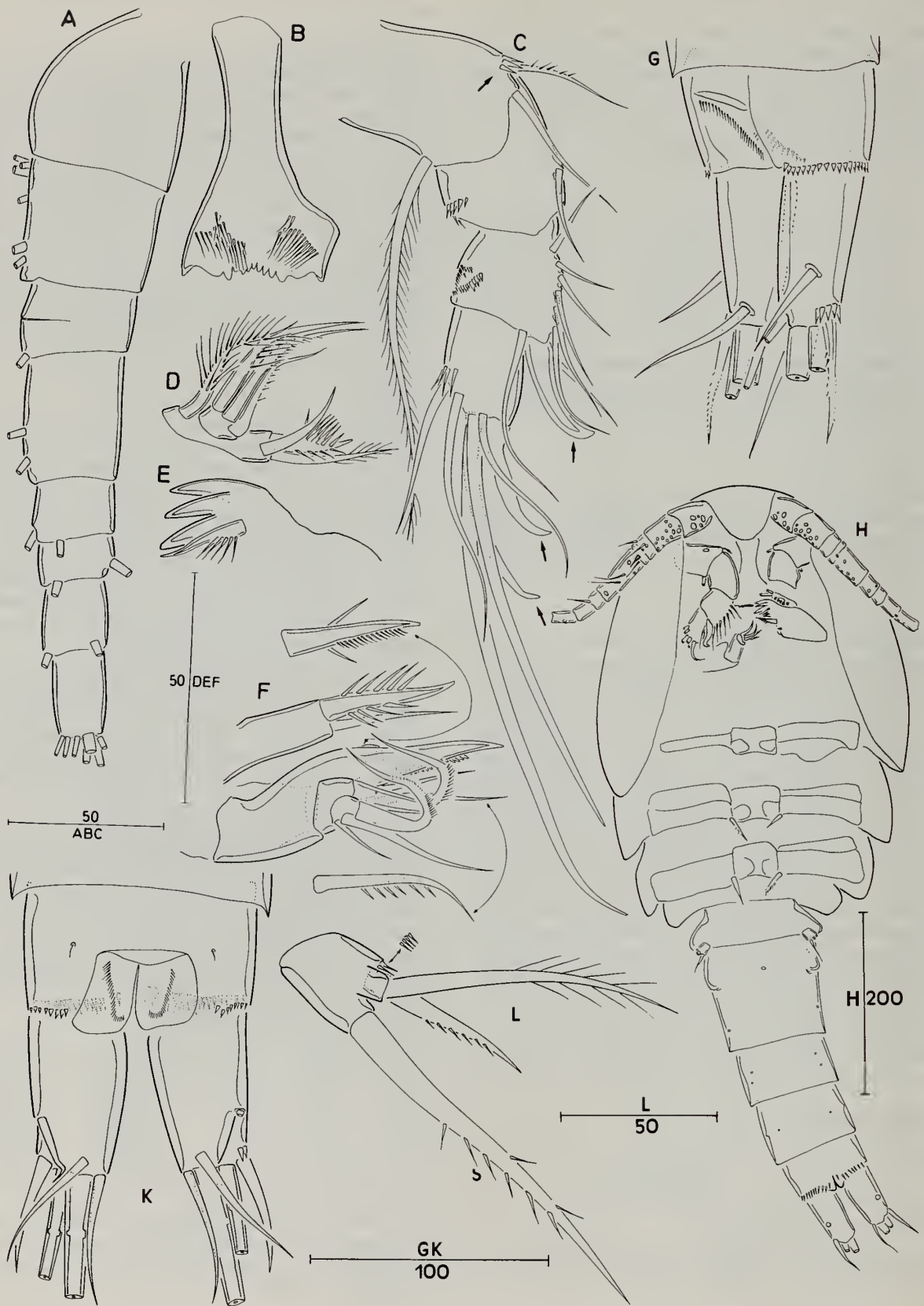

Fig. 26 *P. dilatatus*. Adult female. A, antennule; B, labrum; C, antenna, caudal; D, maxillulary palp; E, maxillule praecoxal armature, distal; F, maxilla, distal part, apical. G, anal somite and caudal rami, lateral; H, body, ventral; K, anal somite and caudal rami, dorsal. L, leg 5, lateral; Scale bars in µm.

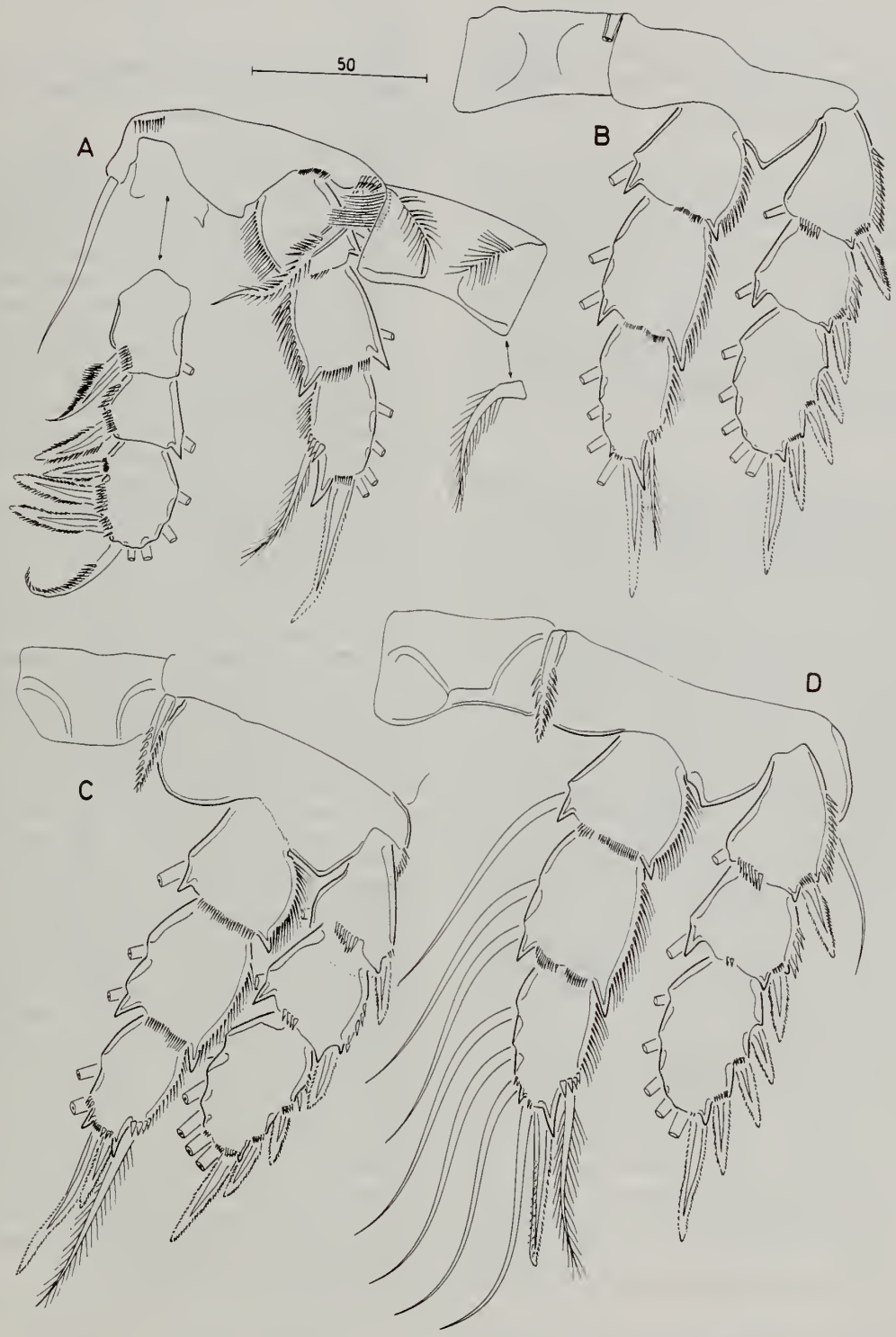

Fig. 27 *P. dilatatus*. Adult female. A, leg 1 with inset showing exopod, anterior; B, leg 2, anterior; C; leg 4, anterior; D; leg 3, anterior. Scale bar in µm.

pits. Caudal rami shorter than female. First antennulary segment armed with 8 setae plus an aesthetasc, 1 seta large (seta A) and modified.

Coxobasis of antenna with spinular row on caudal surface near base of two inner setae (arrowed in Figure 32D); spinules more elongate than those of female. One seta on terminal exopodal segment of leg 1 spinulose (Figure 30C). Outer seta of fifth leg (Figure 32C) plumose and less developed than that of female. Sixth leg (Figure 32B,C) armed with 1 inner spine, longer than second urosomal somite, and 2 outer plumose setae.

DIFFERENTIAL DIAGNOSIS. *P. hardingi* differs from other *Paracyclops* species by the combination of the following characters; the presence of the spinular row on the caudal surface near the base of the 2 inner setae (arrowed in Figures 29B; 32D) of the coxobasis of the antenna in both sexes; by the structure of the seminal receptacle (Figure 28A); by the absence of the spinular rows on the posterior surface of the first and second exopodal segments of leg 4 (Figure 31A); by the wide anal operculum (Figure 28B); by the length of the anterolateral seta (II) on the caudal ramus (Figure 28B); and by the absence of cuticular pits from the urosomal somites in both sexes (Figures 28A,B; 32A,B).

REMARKS

P. hardingi, *P. altissimus* Karaytug, Boxshall & Defaye (in press), *P. longispina* Karaytug, Boxshall & Defaye (in press) and *P. imminutus* Kiefer 1929 are closely related. All four species possess a well-developed spinular row near the base of the two inner setae on the coxobasis of the antenna in both sexes (arrowed in Figures 29B; 32D). *P. hardingi* can easily be differentiated from *P. altissimus* by the length and spinulation of the outer seta of leg 5, the structure of the seminal receptacle (Figure 28A), the presence of the mid-distal spinular rows on the posterior surface of the coxa of legs 1–3, and the relative length of the anterolateral seta (II) on the caudal ramus (Figure 28B). It differs from *P. imminutus* by having a shorter outer seta of leg 5 (Figure 28C), in the structure of seminal receptacle, the position of the mid-distal spinular row on the posterior surface of the coxa of leg 1, the absence of the surface pits on the genital somite and urosomal somites in the male, and the length of the anterolateral seta (II) on the caudal ramus. *P. hardingi* can be differentiated from *P. longispina* by the shorter outer seta of leg 5, the absence of the surface pits on the genital somite and urosomal somites in the male, the presence of the aesthetasc on the first segment of the male antennule, the structure of the seminal receptacle, and the length of the anterolateral seta (II) on the caudal ramus.

P. hardingi was first described by Lindberg (1957) under the name *P. fimbriatus andinus*, but Kiefer used the name *P. andinus* (Kiefer, 1957) earlier in the same year. Therefore, Lindberg's *P. fimbriatus andinus* and Kiefer's *P. andinus* are primary homonyms. According to the priority principle *P. andinus* Kiefer, 1957, published 1 March 1957, takes precedence over *P. fimbriatus andinus* Lindberg, 1957 published on 10 July 1957. The name *P. fimbriatus andinus* is a junior homonym and is invalid (Article 52 (b)). *P. fimbriatus andinus* Lindberg, 1957 must be replaced by a new name (Article 60).

ETYMOLOGY. The new name has been given in honour of the late Dr. J. P. Harding.

DISTRIBUTION. *P. hardingi* was recorded only once, by Löffler (1963), under the name *P. fimbriatus andinus* Lindberg, 1957 from Ecuador, since its original description from Peru.

Paracyclops baicalensis Mazepova, 1961

(Figures 33–37)

ORIGINAL DESCRIPTION. *Paracyclops fimbriatus baicalensis* Mazepova, 1961: *Trud. limnol. Inst. Moscou*, 2, 22: 172–195 (p. 177, fig. 2).

TYPE LOCALITY. Russia, Lake Baikal

TYPE MATERIAL. Mazepova (1961) did not designate any type material.

MATERIAL EXAMINED. The redescription was based on two topotypic females, collected on 19–20 August 1990 from a depth of 200 and 300 m in Lake Baikal.

REDESCRIPTION OF ADULT FEMALE

Body length excluding caudal setae 788–983 μm, mean = 886 μm, n = 2. Fifth pedigerous somite without fringe of elongate setules at posterior margin (arrowed in Figure 34A). Genital double-somite, second and third abdominal somites without surface pits on dorsal and ventral surfaces (Figure 34A,B). Seminal receptacle difficult to observe, anterior lobe apparently small and narrow (Figure 34B). Anal operculum broad and smooth (Figure 34A,D). Caudal rami (Figure 34A,B) very short, about 1.3 times longer than broad. Anterolateral seta (II) long and plumose with spinules at base; posterolateral seta (III) spinulose with spinular row laterally at base extending dorsally; terminal accessory seta spinulose (VI); outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 34B).

Antennule short, compact, 8-segmented (Figure 35A,B): segment 3 with partial suture line and spiniform seta. Segment 5 with characteristic short aesthetasc. Another short aesthetasc located distally on anteroventral margin on segment 7. Apical segment with aesthetasc fused to adjacent seta at base. Most of setal elements highly spinulated. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 35C,D) with complex ornamentation on caudal and frontal surfaces; with spinular row near base of inner setae on caudal surface (arrowed in Figure 35D). Setal elements highly spinulated.

Labrum (Figure 33C) broad posteriorly; posterior margin forming strong teeth and ornamented with 2 patches of spinules on frontal surface; ornamented with paired clusters of long spinules near posterior margin. Mandible (Figure 33D) consisting of well developed coxal gnathobase with 3 lateral spinules distally. Palp represented by 3 spinulose setae, 1 of which very long.

Intercoxal sclerites of legs 1–3 (Figures 36A–D; 37A,B) without spinular rows on anterior and posterior surfaces. Leg 1 with 3 setae on terminal segment of exopod semispinulose; 2 setae on terminal segment of endopod spinulose (arrowed in Figure 36C). Terminal endopodal spine of leg 2 strong, naked and shorter than segment; three setae on terminal segment of exopod and 1 seta on terminal segment of endopod semispinulose (arrowed in Figure 36A). Leg 3 with 3 setae on terminal segment of exopod and 1 seta on terminal segment of endopod semispinulose (arrowed in Figure 37A). Intercoxal sclerite of leg 4 without spinules on anterior surface (Figure 37C) and with spinular row on posterior surface (Figure 37D); second endopodal segment with 3 spinules on posterior surface; 3 setae on terminal segment of exopod (one arrowed in Figure 37C) and 1 seta on terminal segment of endopod semispinulose and 1 seta on terminal segment of endopod spinulose (arrowed in Figure 37C).

Spine and seta formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–I	I–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

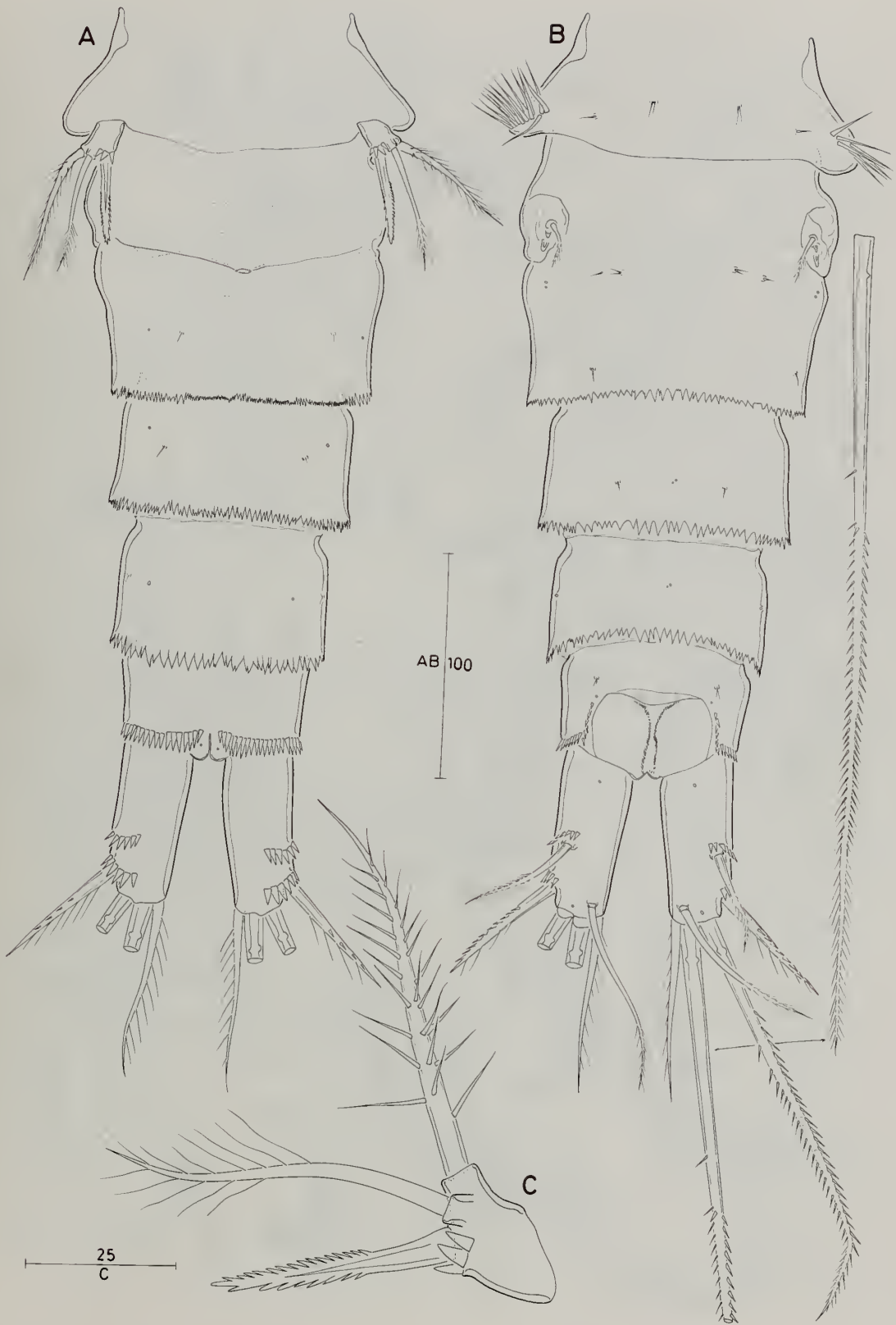

Fig. 28 *P. hardingi*. Adult female. A, urosome, ventral; B, urosome, dorsal; C, leg 5, ventral. Scale bars in μm.

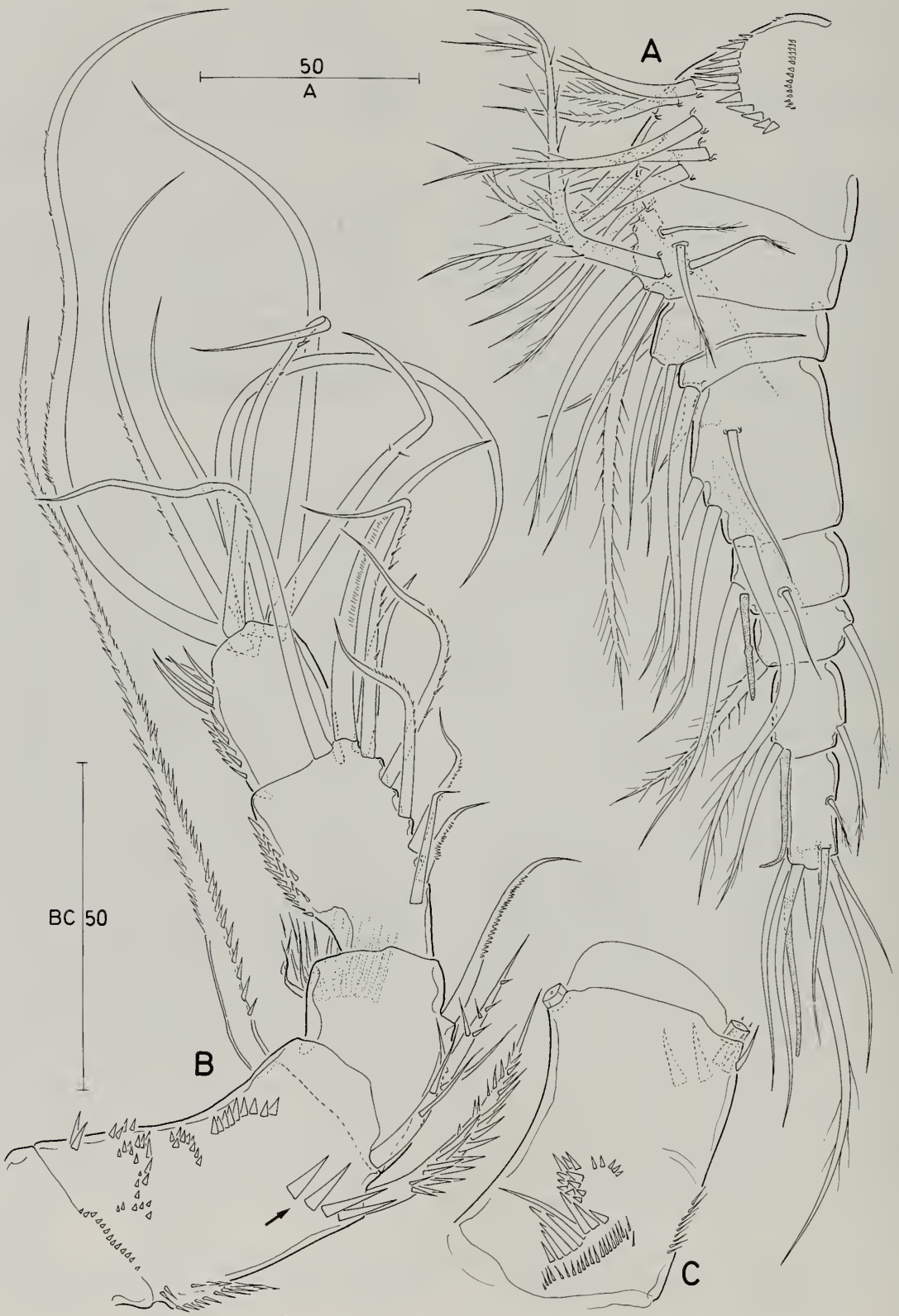

Fig. 29 *P. hardingi*. Adult female. A, antennule; B, antenna, caudal; C, antenna, coxobasis, frontal. Scale bars in μm.

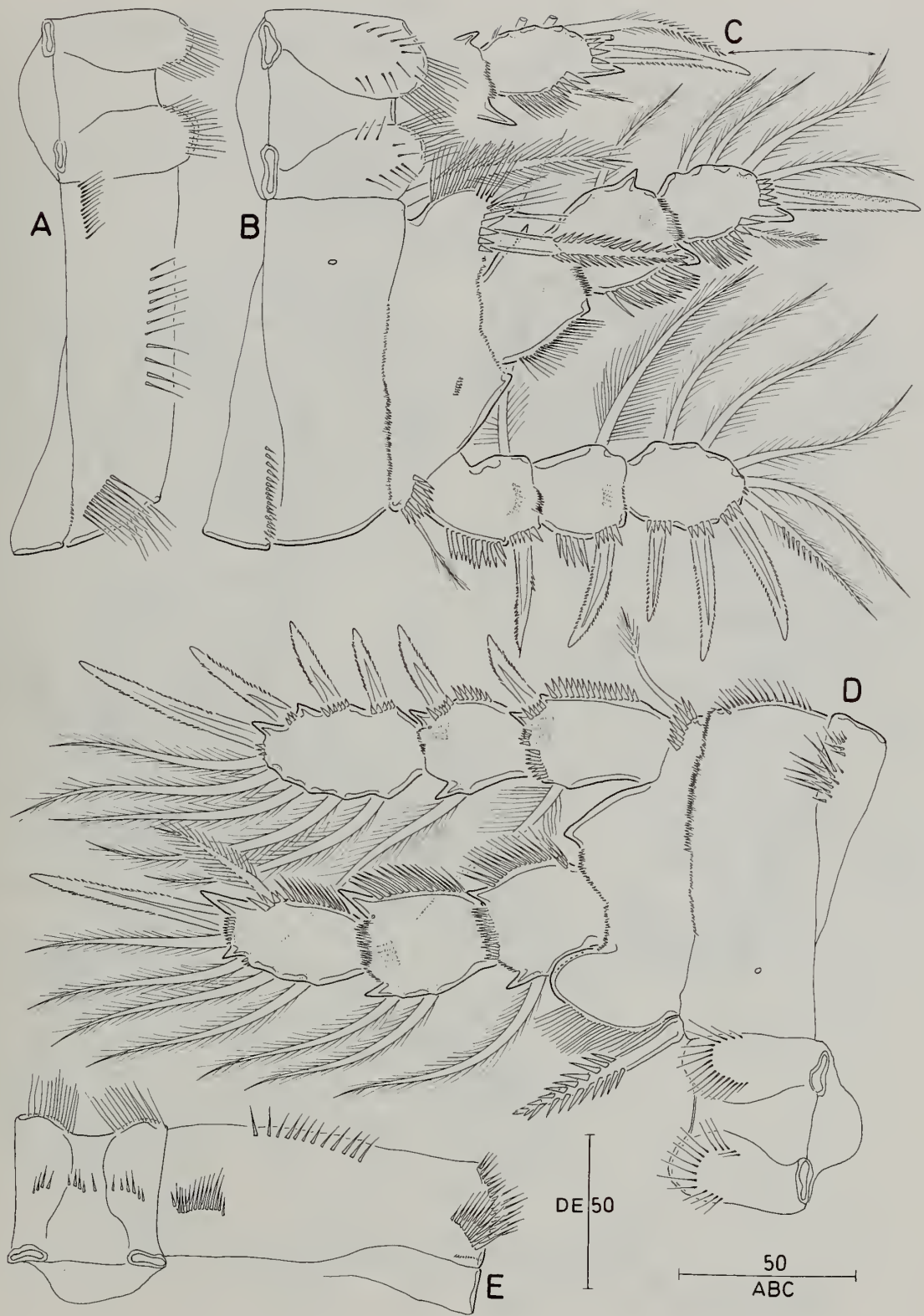

Fig. 30 *P. hardingi*. Adult female. A, intercoxal sclerite and coxa of leg 1, posterior; B, leg 1, anterior; C, adult male, terminal endopodal segment of leg 1; D, leg 2, anterior; E, intercoxal sclerite and coxa of leg 2, posterior. Scale bars in μm.

Fig. 31 *P. hardingi*. Adult female. A, leg 4, anterior; B, intercoxal sclerite and coxa of leg 4, posterior; C, intercoxal sclerite and coxa of leg 3, posterior; D, leg 3, anterior. Scale bar in μm.

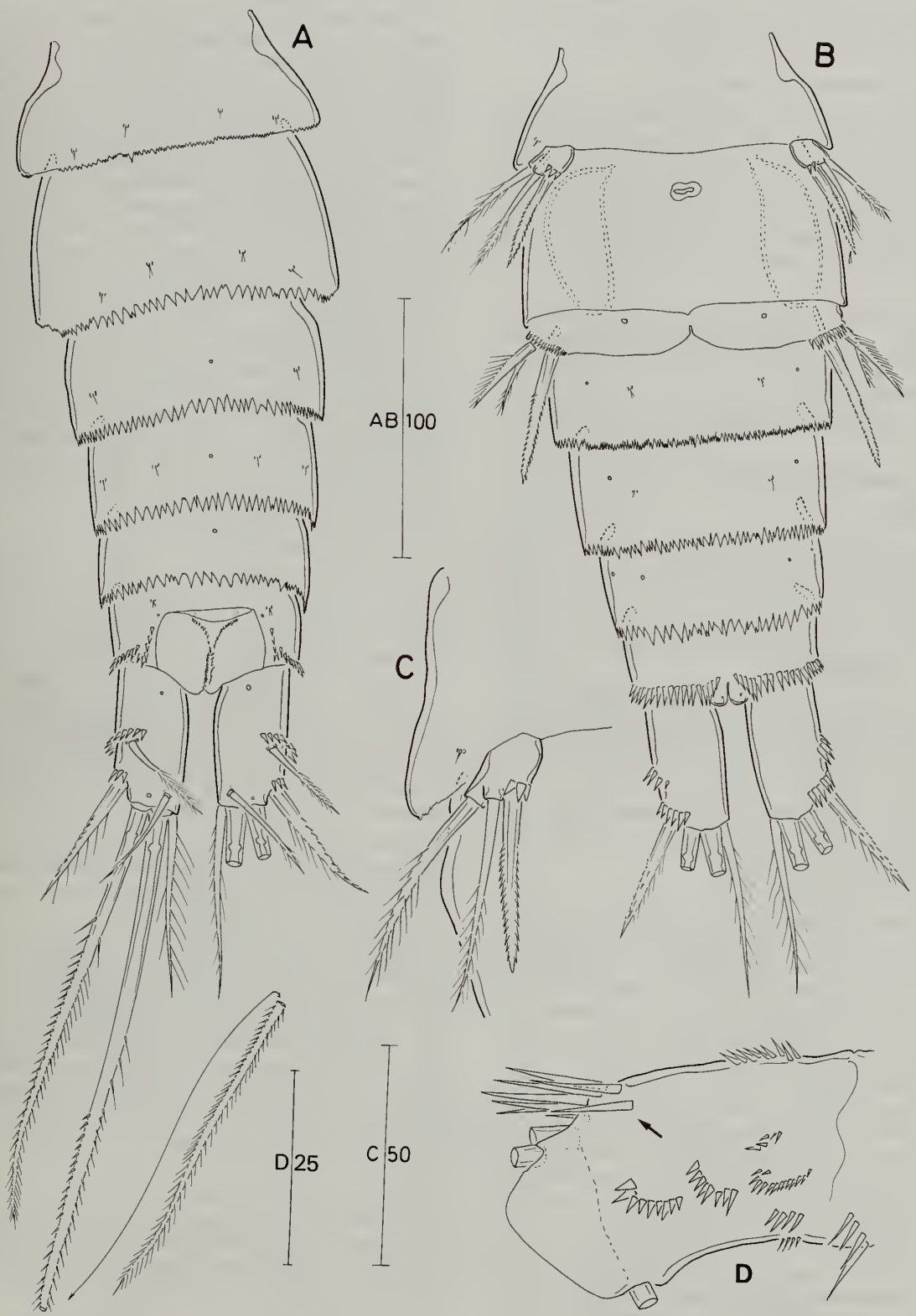

Fig. 32 *P. hardingi*. Adult male. A, urosome, dorsal; B, urosome, ventral; C, detail of leg 5, ventral; D, antenna, coxobasis, caudal. Scale bars in µm.

Leg 5 (Figure 34C) comprising single free segment, armed with 1 long (almost twice as long as inner spine) well developed outer spinulose seta, 1 serrate-like strong inner spine, one spinulose seta in middle (slightly shorter than outer seta). Leg 6 (Figure 34A) represented by 1 plumose seta and 2 tiny spinules dorsolaterally

ADULT MALE. Unavailable for redescription.

DIFFERENTIAL DIAGNOSIS. This endemic Baikalian species can easily be distinguished from other *Paracyclops* species by the absence of the fringe of elongate setules (arrowed in Figure 34A) usually present around the posterior margin of the fifth pedigerous somite in the female; by its very short caudal rami (Figure 34A,B), by the structure of leg 5 (Figure 34C) and by the highly ornamented setal elements on the female antennule (Figure 35A,B).

REMARKS
This species is remarkable by virtue of the highly ornamented setal elements on nearly all the appendages. Mazepova (1961) described this Baikalian endemic as a subspecies but later (Mazepova, 1978) treated it as a distinct species.

DISTRIBUTION. *P. baicalensis* is endemic to Lake Baikal.

Paracyclops yeatmani Daggett & Davis, 1974

(Figures 38–42)

non *Paracyclops yeatmani*: Mahoon & Zia, 1985.

ORIGINAL DESCRIPTION. *Paracyclops yeatmani* Daggett & Davis, 1974: *Can. J. Zool.*, 52, (2) : 301–304.

TYPE LOCALITY. Canada, Newfoundland, Highway 5 between Bay Bulls and Witless Bay.

TYPE MATERIAL. Type material of *P. yeatmani* was obtained from the Canadian Museum of Nature. CMNC1984-1121, paratypes, 2 microscope slides of 2♂♂dissected between prosome-urosome. CMNC1984-1122, paratypes, 1 vial, 4♀♀. 1♀ dissected.

OTHER MATERIAL. 1♀undissected and mounted on one slide; 1♀ dissected and mounted on one slide from the type locality. Dr. H. Yeatman collection, 11 September 1972.

REDESCRIPTION OF ADULT FEMALE
Body length (μm), not including caudal setae, 778–798 (given by Daggett & Davis as 750–860), mean = 785, n = 3. Body width 301–331, mean = 319, n = 3. Prosome (Figure 38C) with cephalothorax longer than 3 free pedigerous somites. Genital double-somite, second and third abdominal somites without surface ornamentation and posterior margins of abdominal somites more conspicuously serrated ventrally than dorsally (Figure 38A,B). Seminal receptacle divided into broad anterior and posterior lobes as figured (Figure 38B). Anal somite with spinular row ventrally extending dorsally midway along either side of anal operculum (Figure 38A,B). Anal operculum smooth; row of spinules present in anal cleft, either side of midline. Caudal rami (Figure 38A,B) about 3.1 times longer than broad; anterolateral seta (II) plumose with spinules originating at base, extending midway along dorsal surface (Figure 38A); terminal accessory seta naked (VI) and about 3 times longer than posterolateral seta (III). Outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 38C).

Antennule 11-segmented (Figure 40A). Segment 3 with partial suture line. Segment 5 with spiniform seta. Segment 8 with short aesthetasc (see inset Figure 40A). Apical segment with aesthetasc fused to adjacent seta at base, and another aesthetasc located distally on anteroventral margin on segment 10. Setal formula 8, 4, 8, 4, 2, 2, 3, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 40D,E) with complex ornamentation on caudal and frontal surfaces as figured.

Proximal segment of maxillulary palp ornamented with 3 minute spinules (arrowed in Figure 39F). Syncoxa of maxilliped (Figure 39A,B) without spinules near setal bases (arrowed in Figure 39B). Basis ornamented with 2 transverse spinular rows near outer distal angle and with 2 irregular spinular rows near bases of medial setae (arrowed in Figure 39A). First endopodal segment with 4 spinules.

Coxa of leg 1 (Figure 41C) with spinular row near outer margin on posterior surface; intercoxal sclerite without spinular rows on anterior and posterior surfaces. Intercoxal sclerite of leg 2 (Figure 42A) ornamented with spinular rows on anterior and posterior surfaces; coxa with spinular row near outer margin on posterior surface; first endopodal segment with spinular row on posterior surface. Intercoxal sclerite of leg 3 (Figure 42B,C) with spinular row on anterior surface and with 3 spinular rows on posterior surface; coxa with spinular row near outer margin on posterior surface; first endopodal segment with spinular row on posterior surface. Intercoxal sclerite of leg 4 with few spinules on anterior surface (Figure 41B) and with 3 long spinular rows on posterior surface (Figure 41A); inner coxal seta with group of setules mainly originating posteriorly; coxa with complex ornamentation on posterior surface as figured (Figure 41A); basis with setules along inner margin.

Spine and seta formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–1	1–I	I–1;I–1;III,5	0–1;0–2;1,I,4
Leg 2	0–1	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	0–1	1–0	I–1;I–1;II.I,5	0–1;0–2;1,II,2

Leg 5 (Figure 38D) comprising single free segment, armed with short outer plumose seta (shorter than inner spine), 1 serrate-like strong inner spine, and 1 plumose seta in middle about twice as long as inner spine. Base of middle seta produced. Leg 6 (Figure 38A) represented by 1 long plumose seta and 2 tiny spinules dorsolaterally.

DESCRIPTION OF ADULT MALE
Antennule (Figure 40C) 16-segmented. The poor condition of the slides and the orientation of the antennule made it impossible to confirm all details of the setation pattern.

DIFFERENTIAL DIAGNOSIS. *P. yeatmani* can easily be differentiated from other *Paracyclops* species by the combination of the following characters: the produced base of the middle seta of leg 5 (Figure 38D), the spinules originating at the base of the anterolateral seta (II), extending midway along the dorsal surface of caudal rami (Figure 38A), the very long, naked terminal accessory seta which is about 3 times longer than the posterolateral seta (Figure 38A), the three rows of long spinules on the posterior surface of intercoxal sclerite of leg 4 (Figure 41A) and its 11-segmented antennule.

REMARKS
Paracyclops yeatmani Mahoon & Zia, 1985 is a junior primary homonym of *P. yeatmani* Dagget & Davis, 1974 and therefore an invalid name (ICZN Article 57 (b)). This species was based on juvenile stages and belongs to a species not related to *P. yeatmani* Dagget & Davis, 1974. It is regarded here as species *incertae sedis* in the Cyclopidae.

There are only three species with 11-segmented antennules in the genus *Paracyclops*; the other two being *P. affinis* and *P. canadensis*. However, the 11-segmented state is not homologous in *P. yeatmani* and in *P. affinis-canadensis* group. Segments 3 and 4 (ancestral

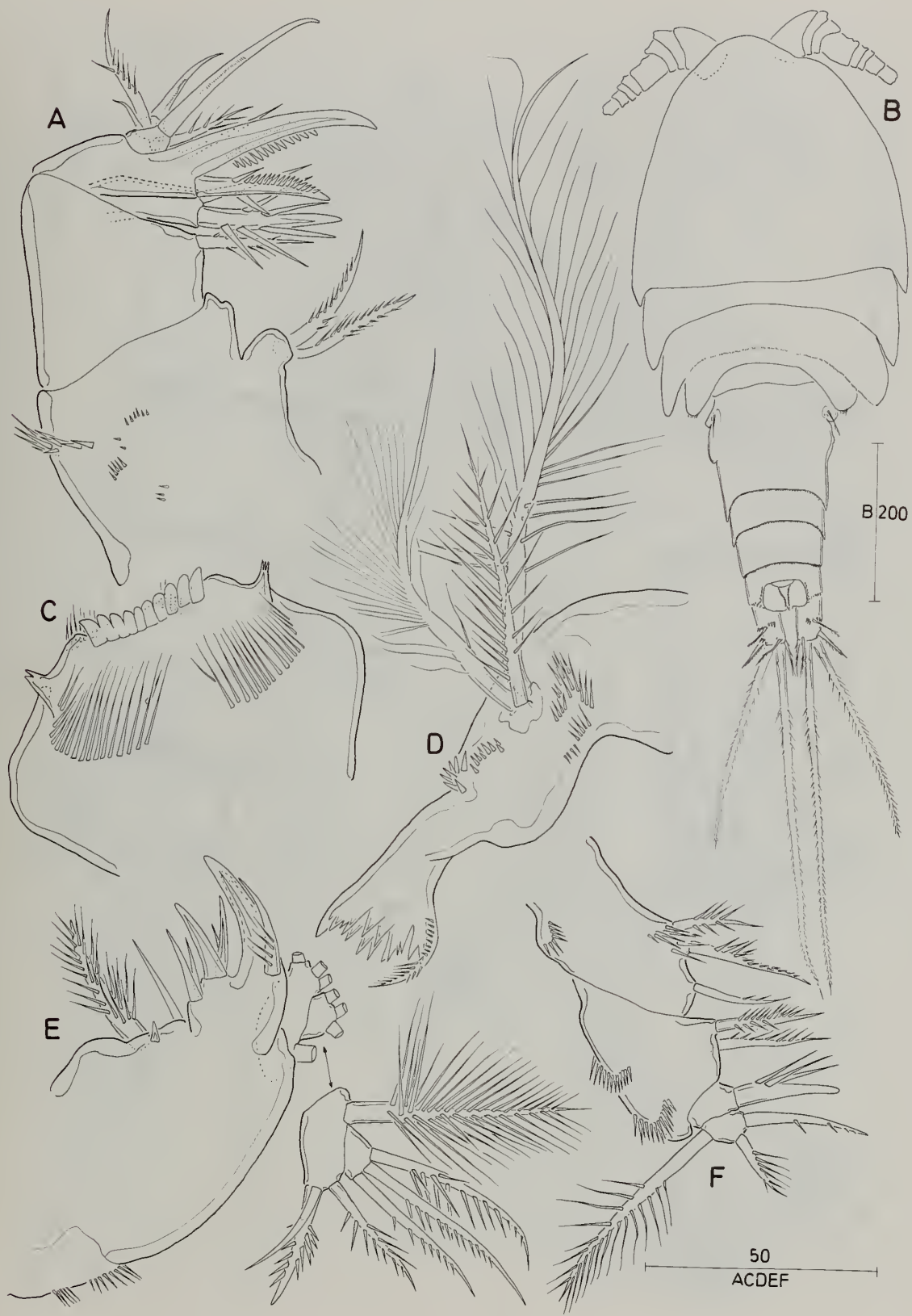

Fig. 33 *P. baicalensis*. Adult female. A, maxilla; B, body, dorsal; C, labrum; D, mandible; E, maxillule; F, maxilliped. Scale bars in µm.

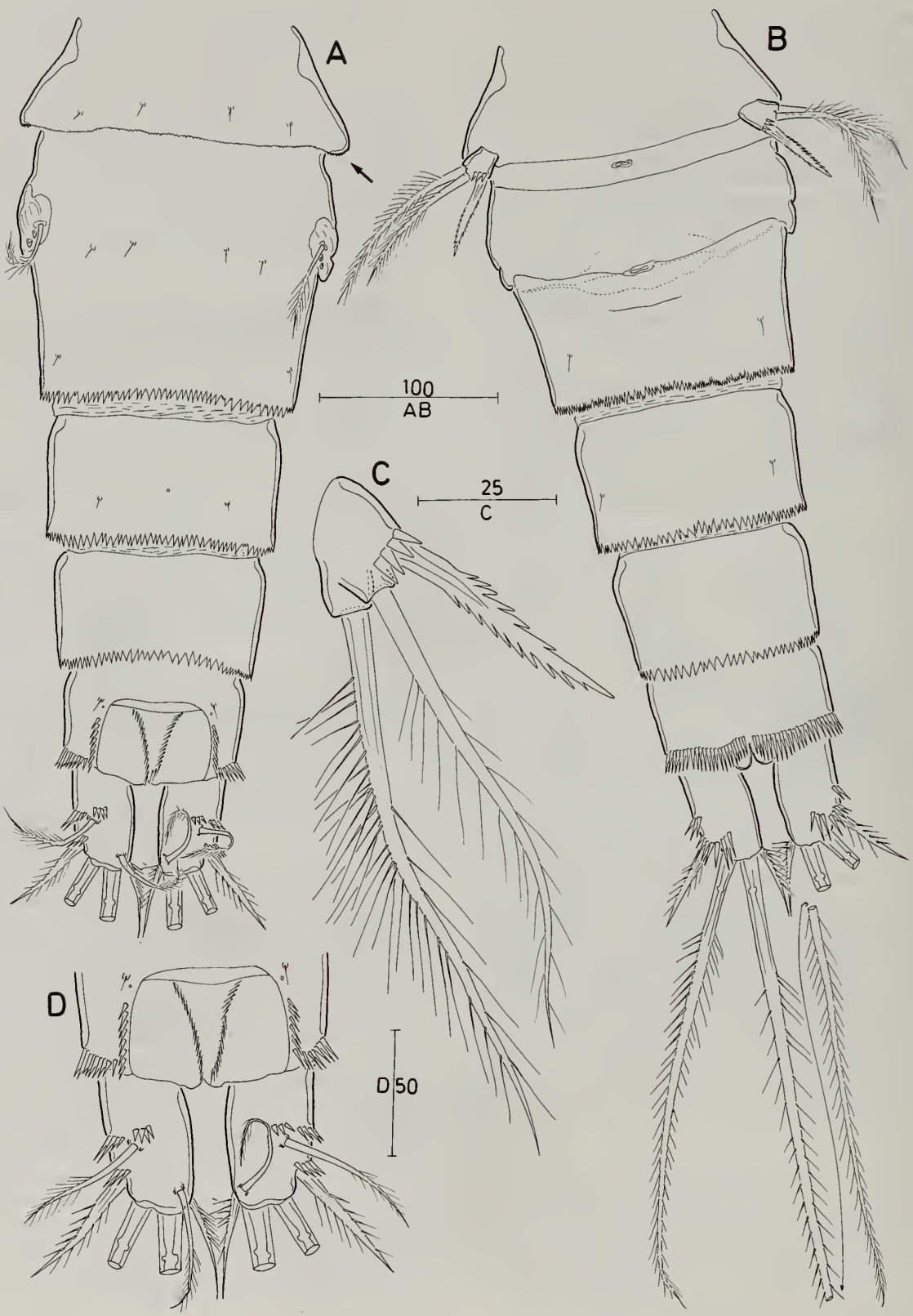

Fig. 34 *P. baicalensis*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral; D, anal somite and caudal rami, dorsal. Scale bars in µm.

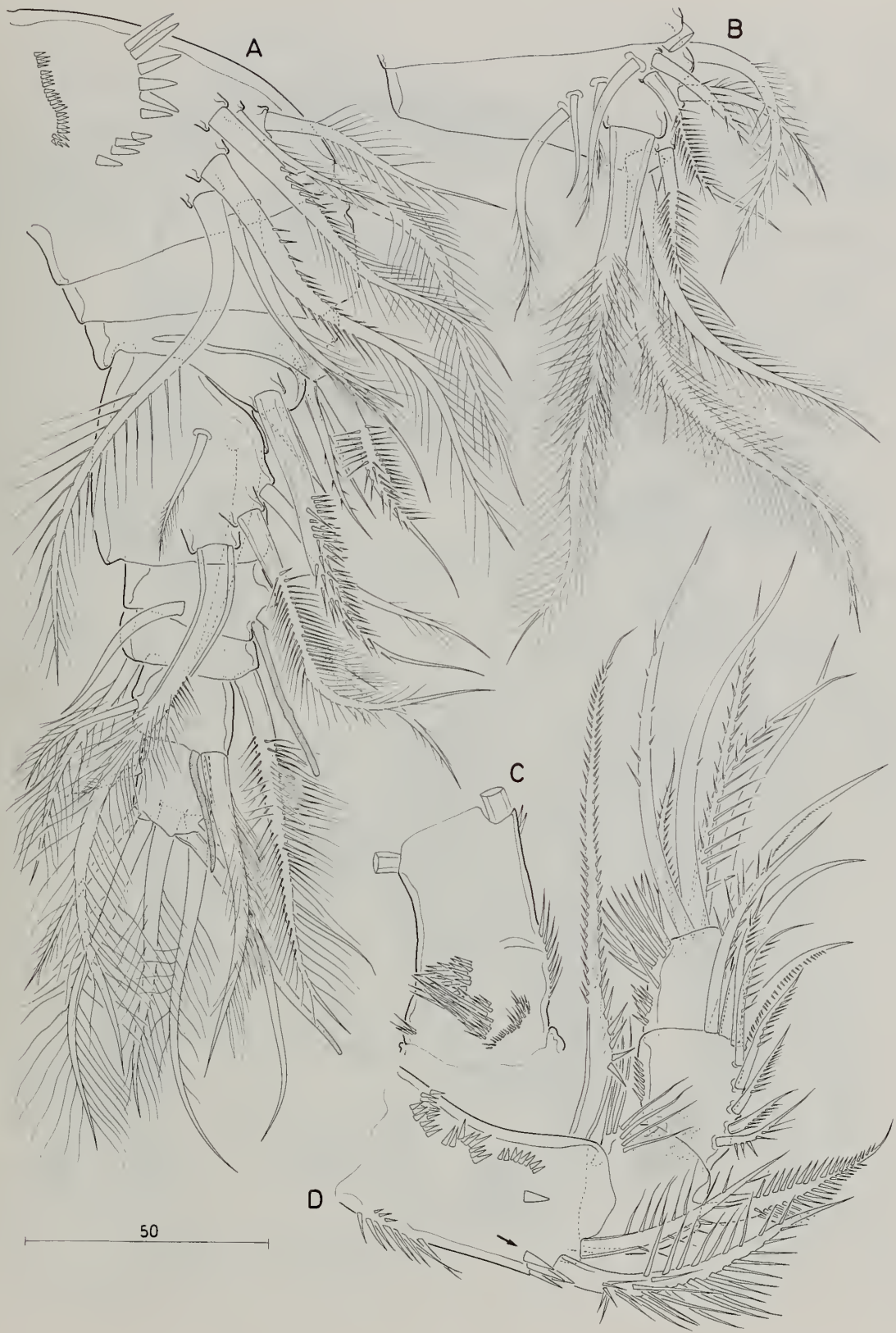

Fig. 35 *P. baicalensis*. Adult female. A, antennule, with setation omitted from segment 2; B, antennule, segment 2 showing setation; C, antenna, coxobasis, frontal; D, antenna, caudal. Scale bar in µm.

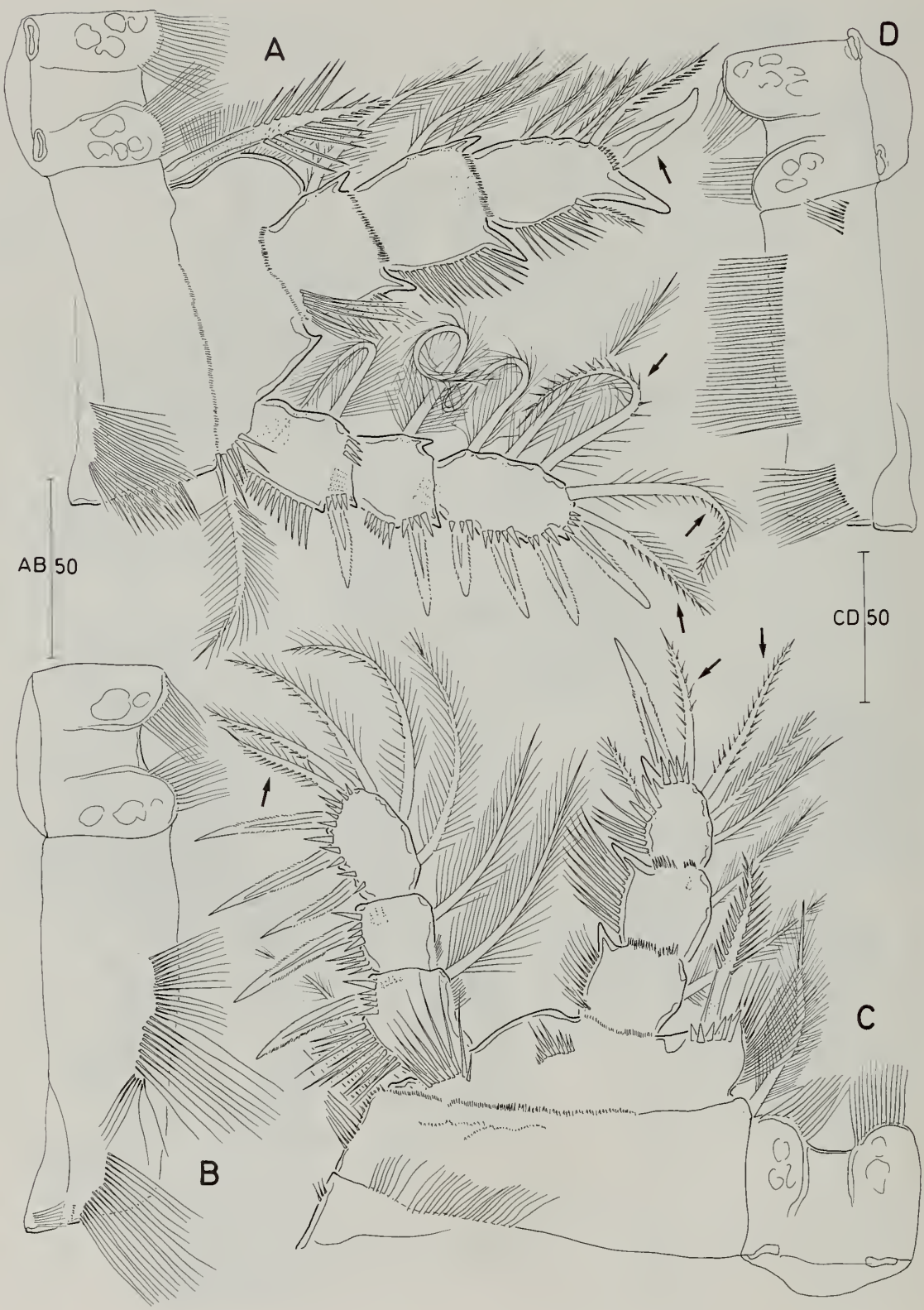

Fig. 36 *P. baicalensis*. Adult female. A, leg 2, anterior; B, intercoxal sclerite and coxa of leg 1, posterior; C, leg 1, anterior; D, intercoxal sclerite and coxa of leg 2, posterior. Scale bars in µm.

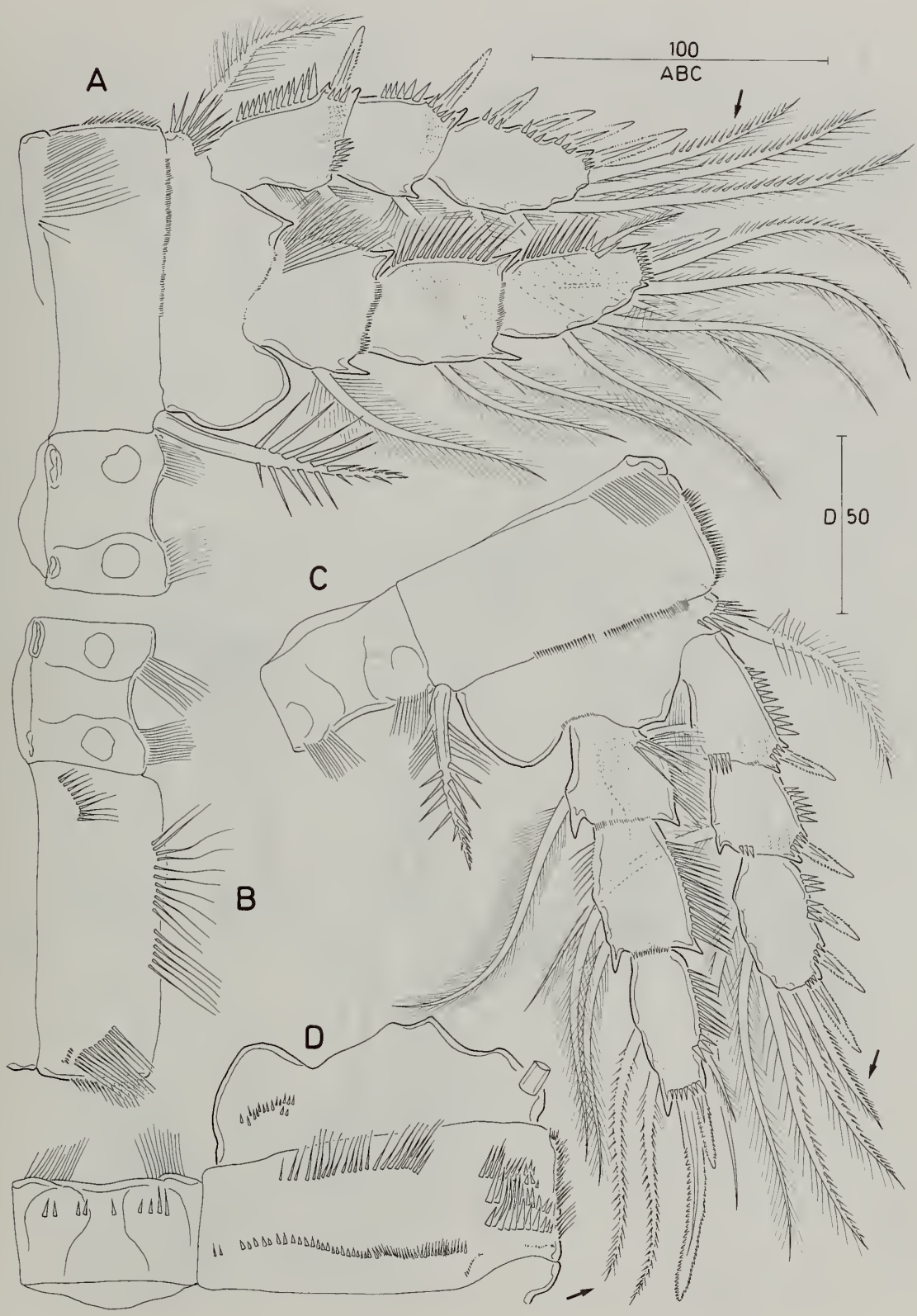

Fig. 37 *P. baicalensis*. Adult female. A, leg 3, anterior; B, intercoxal sclerite and coxa of leg 3, posterior; C, leg 4, anterior; D, intercoxal sclerite and coxa of leg 4. Scale bars in µm.

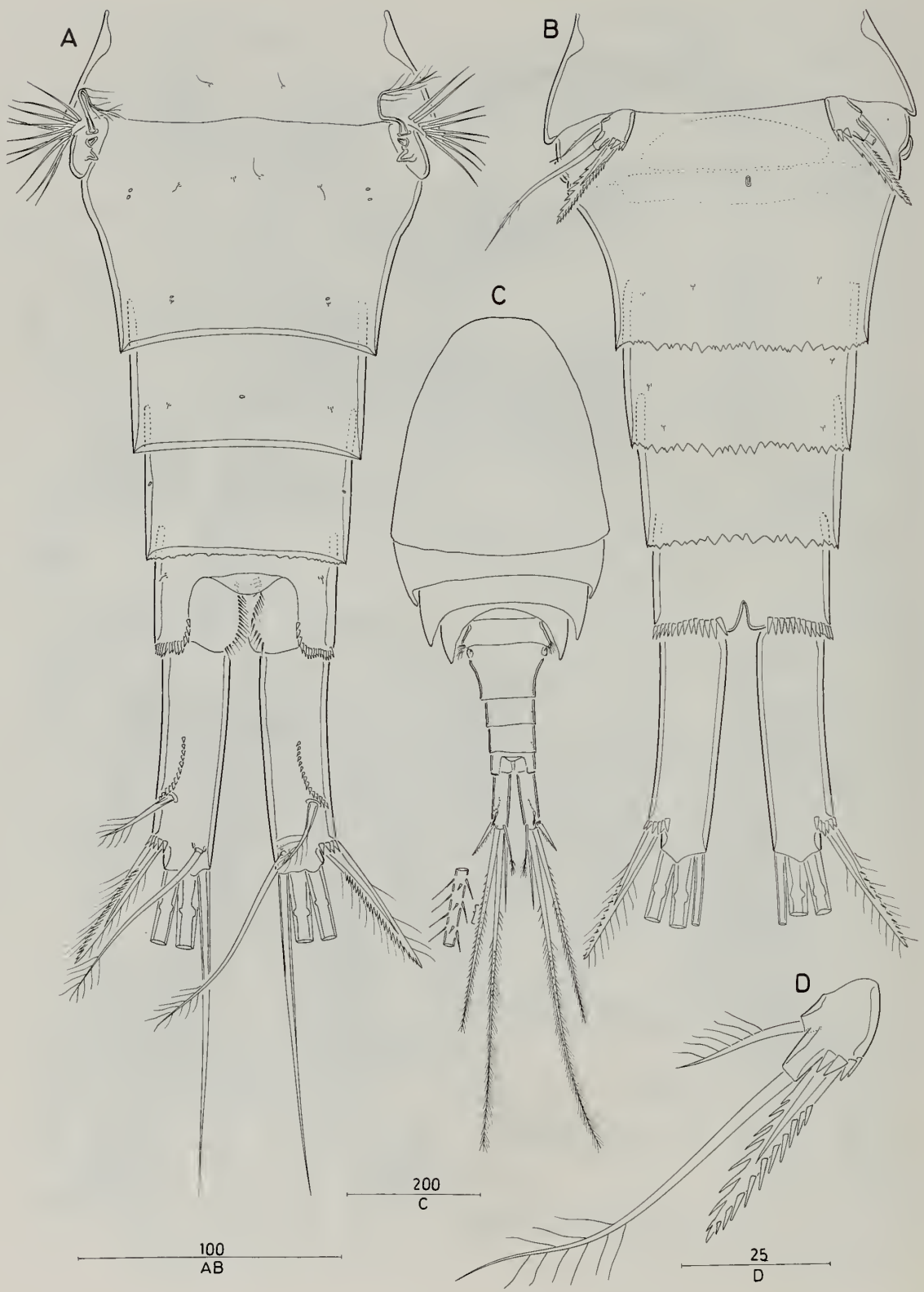

Fig. 38 *P. yeatmani*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, body, dorsal; D, leg 5, ventral. Scale bars in μm.

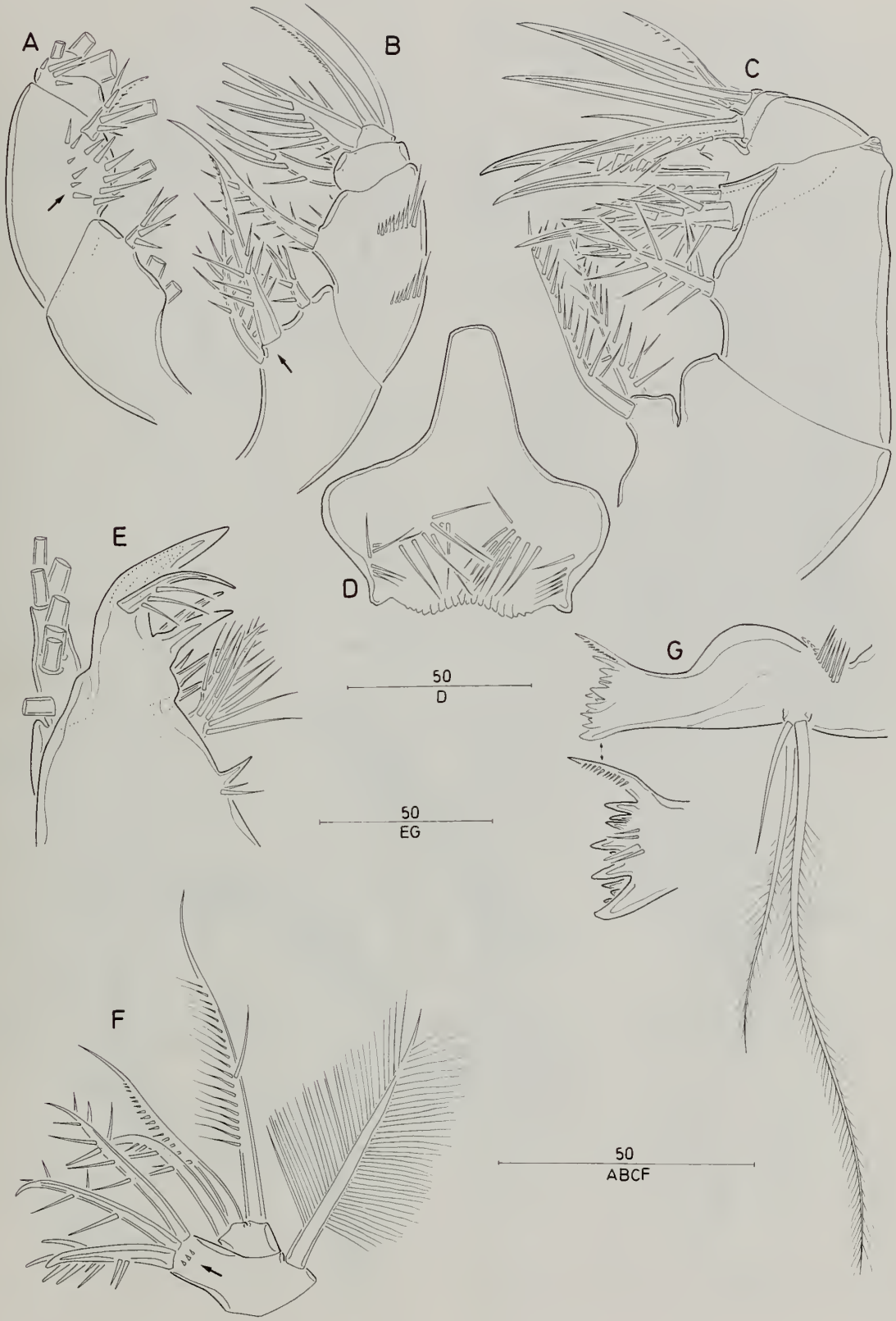

Fig. 39 *P. yeatmani*. Adult female. A, B, maxilliped; C, maxilla; D, labrum; E, maxillule; F, maxillulary palp; G, mandible. Scale bars in μm.

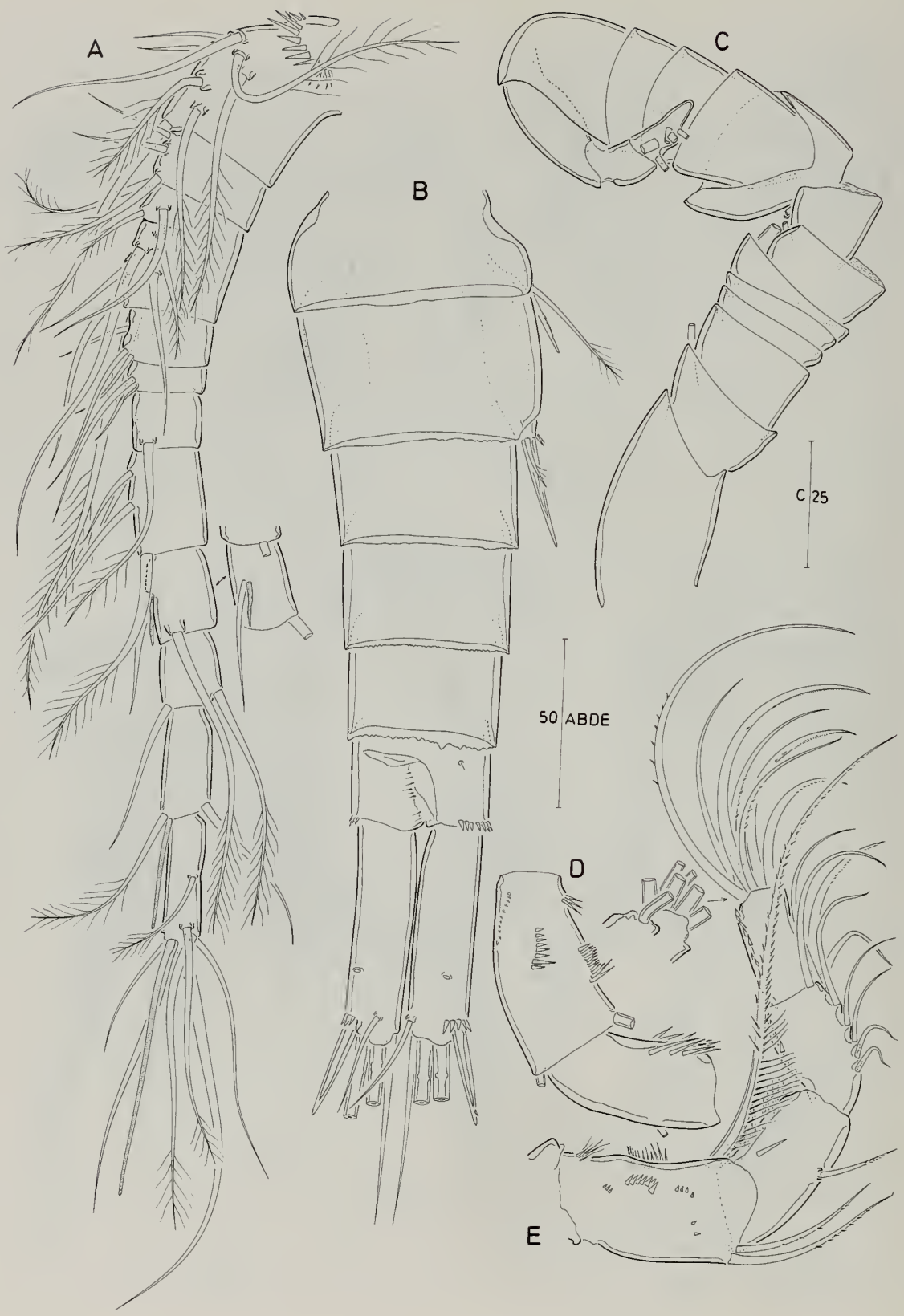

Fig. 40 *P. yeatmani*. A, adult female, antennule; B, adult male, urosome, dorsal; C, adult male, antennule showing segmentation, dorsal; D, adult female, antenna, coxobasis, frontal; E, adult female, antenna, caudal. Scale bars in μm.

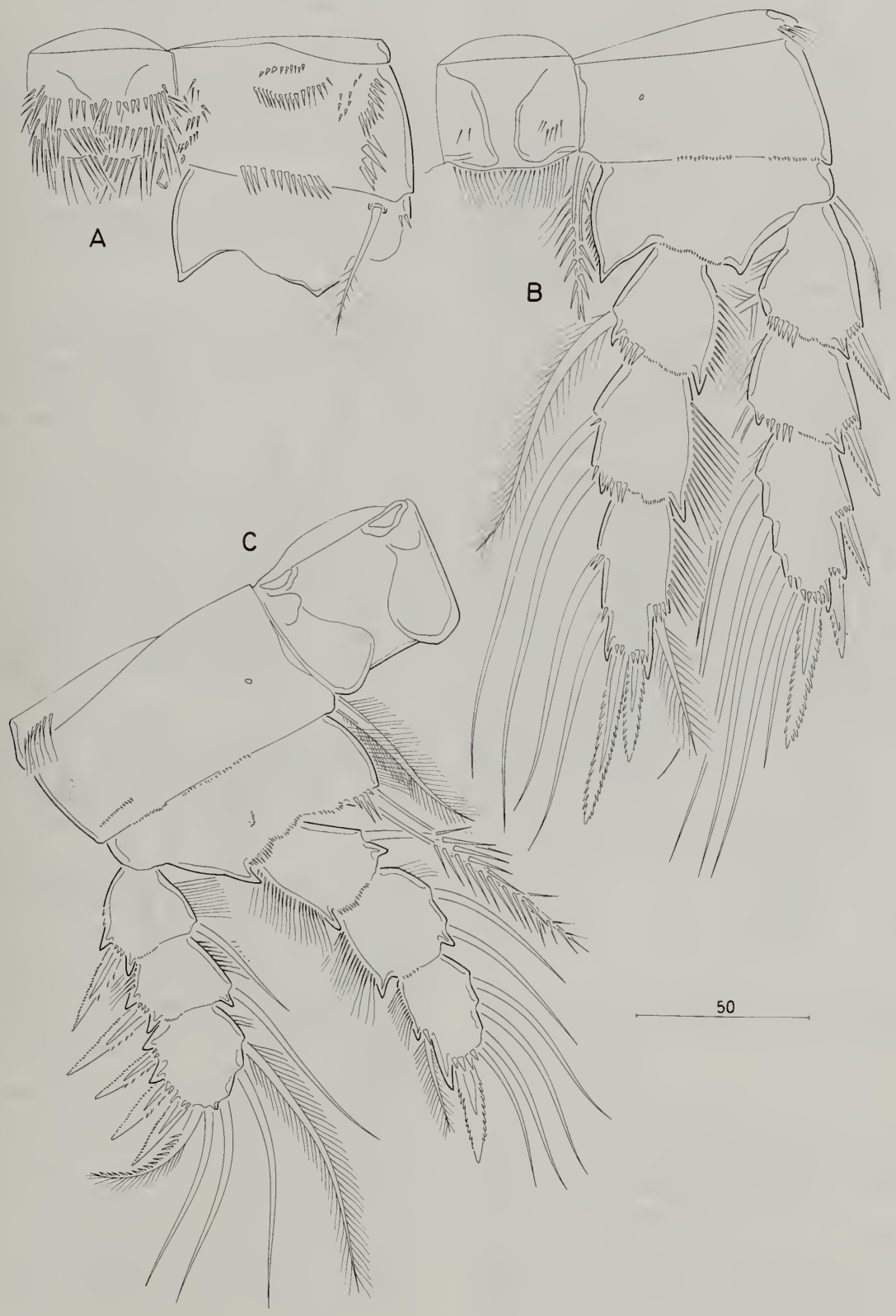

Fig. 41 *P. yeatmani*. Adult female. A, intercoxal sclerite, coxa and basis of leg 4, posterior; B, leg 4, anterior; C, leg 1, anterior. Scale bar in µm.

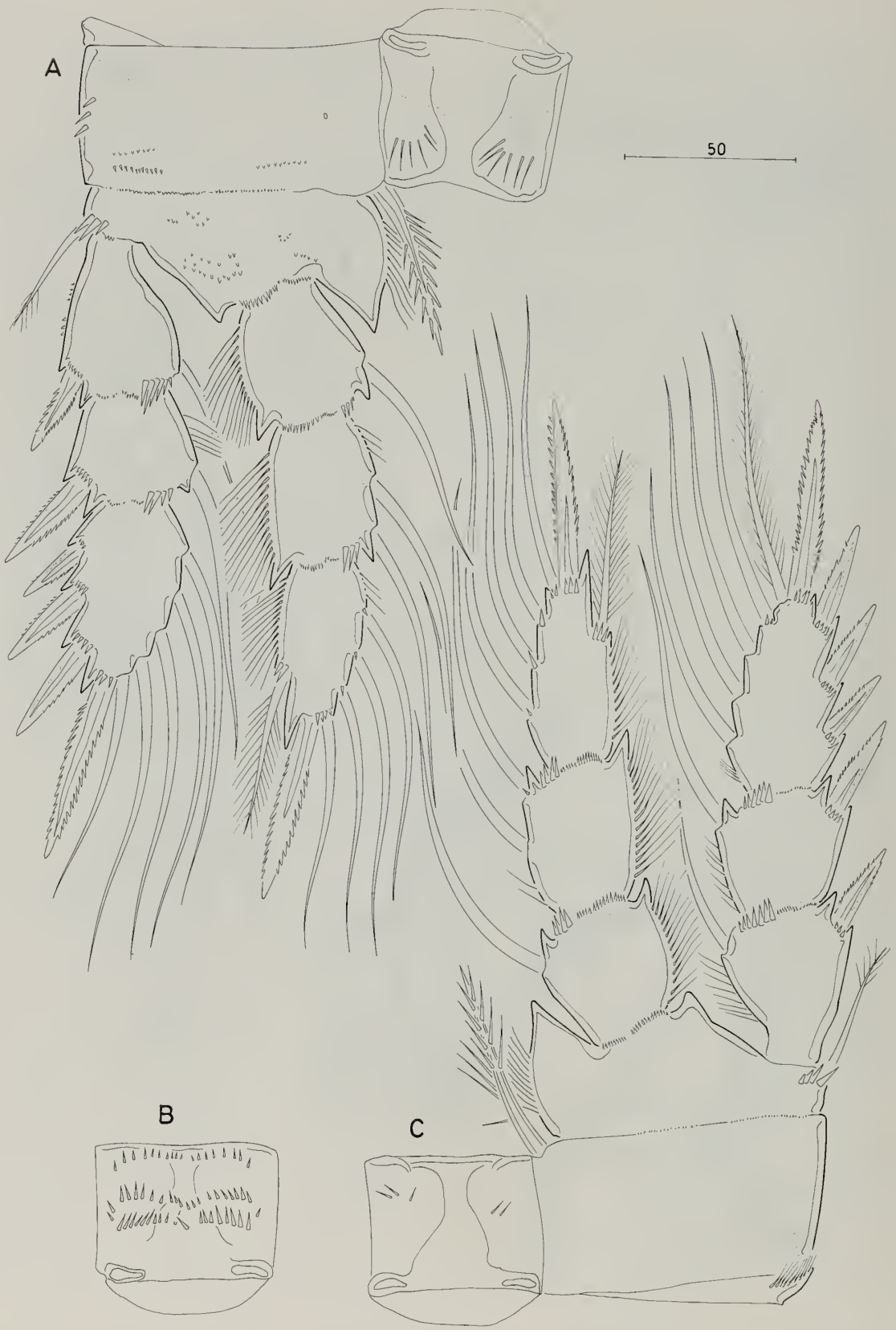

Fig. 42 *P. yeatmani*. Adult female. A, leg 2, anterior; B, intercoxal sclerite of leg 3, posterior; C, leg 3, anterior. Scale bar in µm.

segments VIII and IX–XI) of *P. affinis* have failed to separate in *P. yeatmani* whereas segments 8 and 9 (ancestral segments XXI–XXIII and XXIV) of *P. yeatmani* have failed to separate in *P. affinis* (Karaytug & Boxshall, 1998). The 11-segmented states are, therefore, convergent.

Daggget & Davis (1974) mentioned that there is a seta swollen at its base on the first segment of the antennule of male *P. yeatmani*. It would be remarkable should this seta be homologous with modified seta (A) of the *Paracyclops fimbriatus*-group since modified seta (A) is an important synapomorphy of that group which is only distantly related to *P. yeatmani*.

In the original description only one inner margin seta was reported from the second endopodal segment of leg 1, but 2 setae were observed in all material examined, including the paratypes. It is likely that the presence of this seta was overlooked in the original description

DISTRIBUTION. Canada, Newfoundland, Highway 5 between Bay Bulls and Witless Bay (Daggett & Davis, 1974; Daggett & Davis, 1975). U.S.A: Wisconsin, no locality specified (Torke, 1979).

Paracyclops waiariki Lewis, 1974

(Figures 43–48)

ORIGINAL DESCRIPTION. *Paracyclops waiariki* Lewis, 1974: *New Zealand J. Freshwat. Res.*, 8 (2) : 275–281.

TYPE LOCALITY. New Zealand. Details of the type locality were given by Lewis (1974) as follows: The type specimens were netted in shallow water (up to 50 cm depth) along the roadside edge of Lake Rotowhero, beneath Rainbow Mountain, about 15 miles from Rotorua, just beyond the junction of State Highways 30 and 38, Grid reference: NZMS 1 Sheet N85; 835 817. The water temperature was 27°C.

TYPE MATERIAL. Not available.

MATERIAL EXAMINED. Topotypic specimens including 3 adult ♀♀, 1 cop. 1V ♀ and 1 adult ♂ of *P. waiariki* were obtained on loan from Museum of New Zealand Te Papa Tongarewa. 1 adult male and female dissected. Registration number: MNZ Cr 1928.

REDESCRIPTION OF ADULT FEMALE

Body length, excluding caudal setae 672–938 µm (given by Lewis (1974) as 700–800 µm), mean = 805, n = 2. Body width 229–240, mean = 235, n = 2. Prosome as in Lewis (1974); Rounded appearance of cephalothorax (Figure 43B) due to state of preservation. Genital double-somite, second and third abdominal somites (Figure 44A,B) without ornamentation of pits on dorsal and ventral surfaces. Posterior margins of abdominal somites more conspicuously serrated ventrally than dorsally. Seminal receptacle divided into butterfly-shaped anterior and posterior lobes as figured (Figure 44B). Anal somite with spinular row ventrally, extending dorsally and with 2 small spinules on midsection of ventral surface (Figure 44B). Anal operculum broad and smooth (Figure 44A). Caudal rami (Figure 44A,B) parallel, about 4.2 times longer than broad; ornamented with fine spinules along dorsal and ventral surfaces; anterolateral seta (II) on dorsolateral surface with spinules at base; posterolateral seta (III) unilaterally plumose, surrounded with spinules along dorsal surface and with spinular row around base ventrally, extending dorsally; terminal accessory seta (VI) plumose and slightly longer than posterolateral seta; outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 43B,E).

Antennule 12-segmented (Figure 43A); segment 6 with spiniform seta (arrowed in Figure 43A); segment 9 with short aesthetasc (arrowed in Figure 43A). Setal formula 8, 4, 2, 6, 4, 2, 2, 3, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 43C,D) with complex ornamentation on caudal and frontal surfaces as figured; with spinular row near 2 inner setae on caudal surface (arrowed in Figure 43C); first endopodal segment with transverse spinular row on caudal surface (arrowed in Figure 43C).

Labrum (Figure 45D) narrowing posteriorly; posterior margin with strong teeth; ventral surface ornamented with paired groups of long spinules. Gnathobasic blades of mandible (Figure 45E) mostly simple with 3 spinules laterally; palp represented by 3 setae, 2 of which very long, third short and naked. Proximalmost spine of maxillule (arrowed in Figure 45C) with spinules. Praecoxa of maxilla (Figure 45A) with complex spinular rows on dorsal surface; coxa with group of spinules near base of proximal endite. Syncoxa of maxilliped (Figure 45B) without long spinules near base of endites; basis armed with 2 spinulose setae ornamented with 6 long spinules near base of endites; first endopodal segment with group of long spinules.

Legs 1 to 3 without mid-distal spinular row on posterior surface of coxa. Basis of leg 1 (Figure 46A) with setiform spine on inner margin reaching almost to end of terminal segment; intercoxal sclerite without spinular row on posterior surface; seta next to outermost spine of terminal exopodal segment semispinulose. Intercoxal sclerite of leg 2 (Figure 46B) ornamented with spinular rows on anterior and posterior surfaces. Intercoxal sclerite of leg 3 with spinular row on anterior surface (Figure 46E) and with 2 spinular rows on posterior surface (Figure 46F); first endopodal segment with spinular row on posterior surface.

Intercoxal sclerite of leg 4 (Figure 46D) without spinules on anterior surface and with 2 irregular spinular rows on posterior surface (Figure 46C); inner coxal spine with group of setules mainly originating posteriorly; coxa with complex ornamentation on posterior surface as figured (Figure 46C); basis with setules along inner margin; first endopodal segment with spinular rows on anterior and posterior surfaces (Figure 46D).

Spine and seta formula as follows:

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

Leg 5 (Figure 44C) comprising single free segment, armed with 2 outer setae almost equal in length; strong inner spine shorter than outer setae. Leg 6 (Figure 44A) represented by 1 plumose seta and 1 tiny dorsolateral spinule.

DESCRIPTION OF ADULT MALE

Body length, excluding caudal setae = 568 µm (given by Lewis (1974) as 600–700 µm), body width = 173 (Figure 47B). Urosomal somites without surface ornamentation (Figure 47A,C); genital somite broader than abdominal somites; caudal rami about 3.5 times as long as broad (Figure 47C,D).

Antennule digeniculate (Figure 48A–E), indistinctly 16-segmented. Segment 1 armed with 8 setae plus aesthetasc (arrowed in Figures 48C and E); seta A not modified. Segment 11 bearing small curved seta ornamented with row of strong denticles, plus 1 plumose seta (Figure 48B,C). Segmental fusion pattern as follows: I–V, VI–VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX–XX, XXI–XXIII, XXIV–XXVIII.

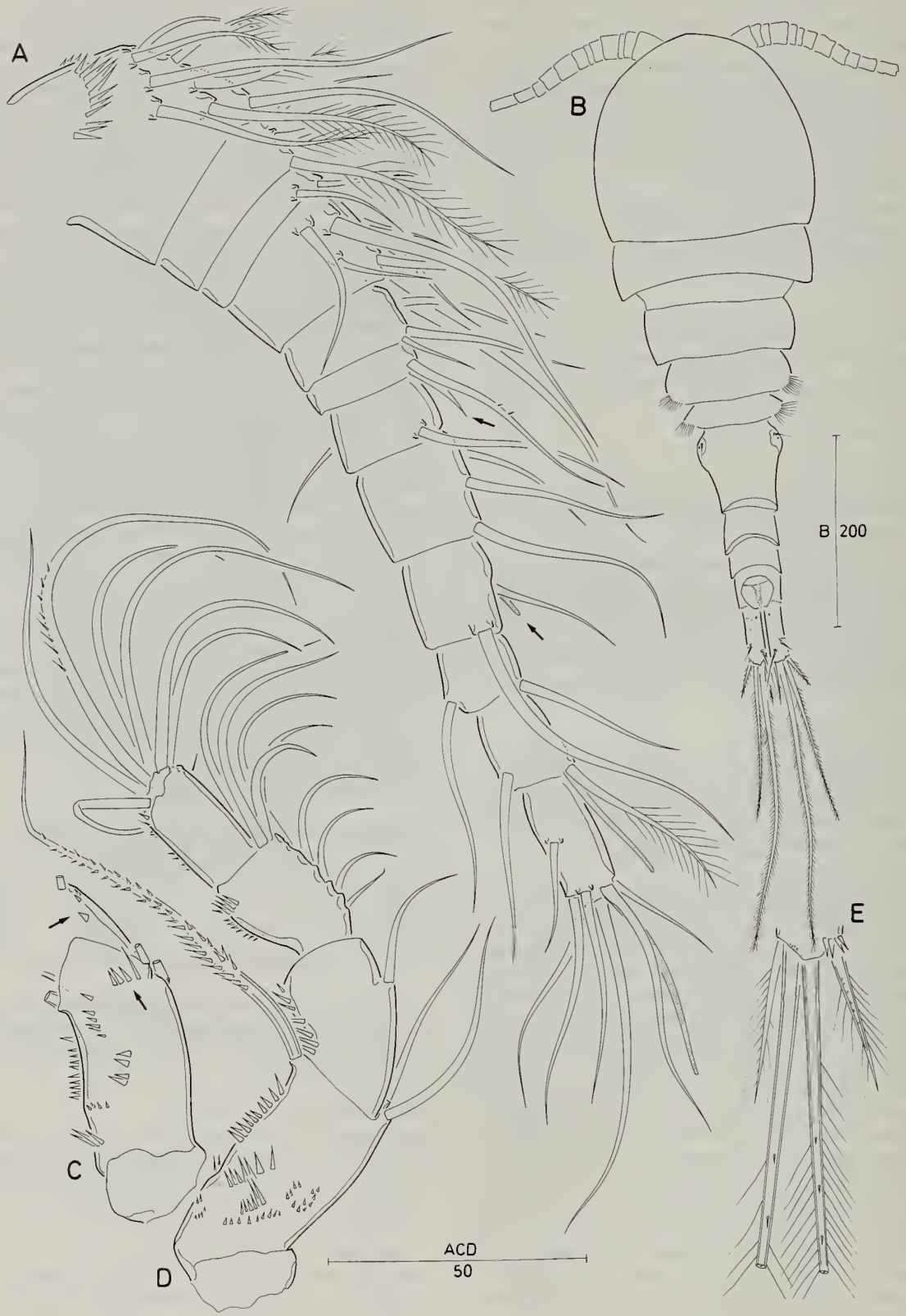

Fig. 43 *P. waiariki*. Adult female. A, antennule; B, body, dorsal; C, antenna, coxobasis, caudal; D, antenna, frontal; E, detail of terminal setal elements of caudal rami, dorsal. Scale bars in μm.

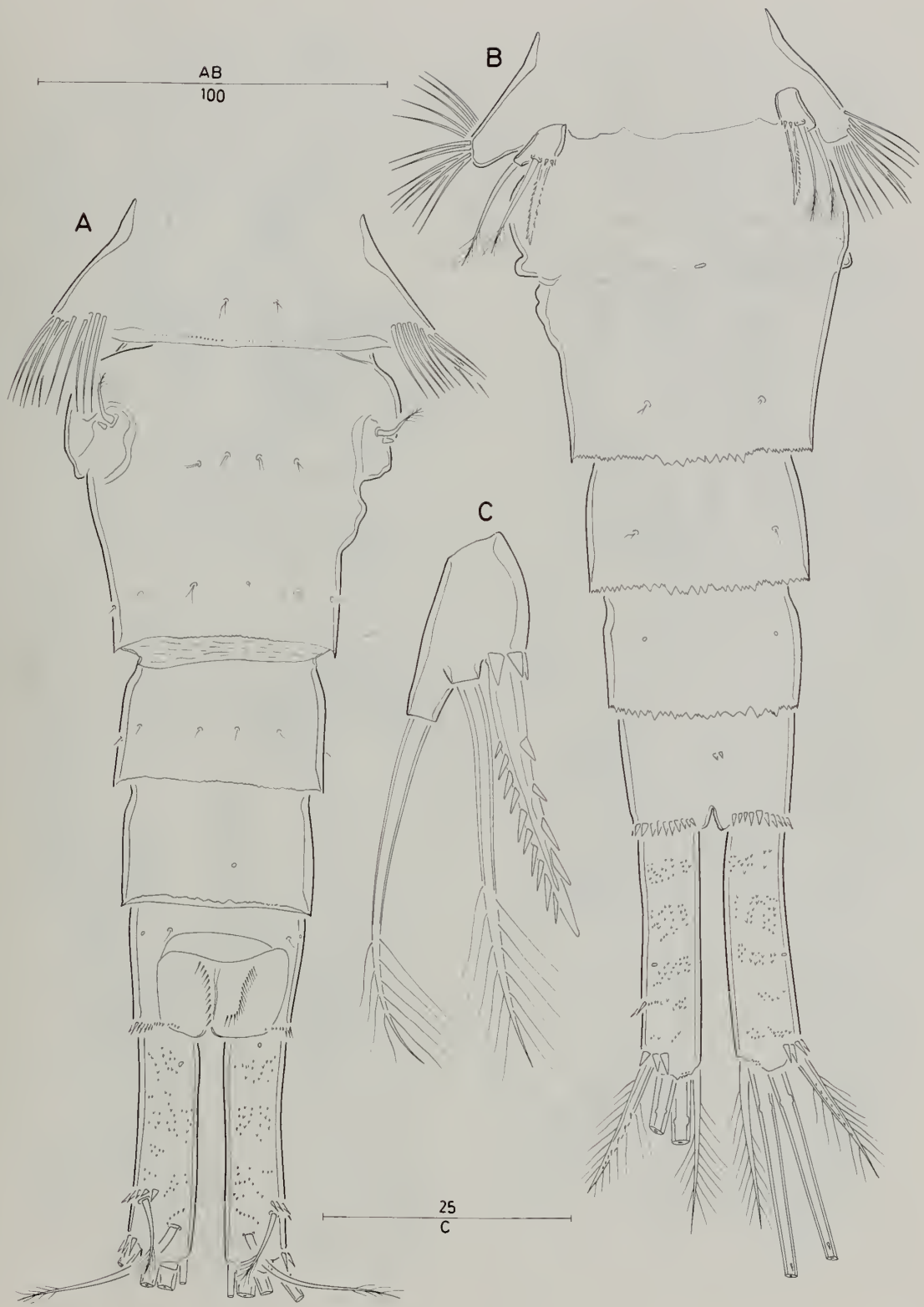

Fig. 44 *P. waiariki*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral. Scale bars in μm.

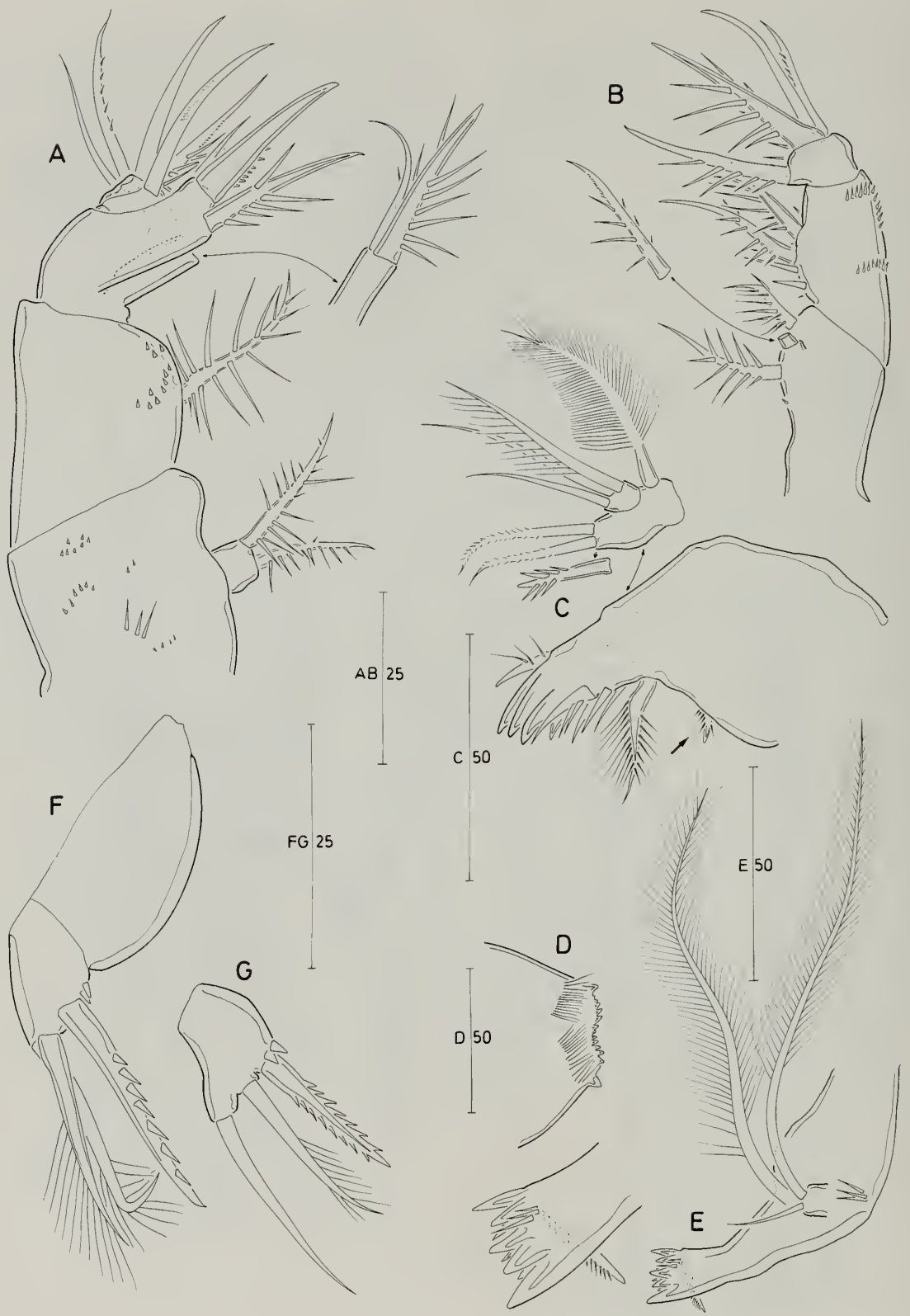

Fig. 45 *P. waiariki*. Adult female. A, maxilla with inset showing accessory armature; B, maxilliped; C, maxillule; D, labrum; E, mandible; F, adult male, leg 6; G, adult male, leg 5. Scale bars in μm.

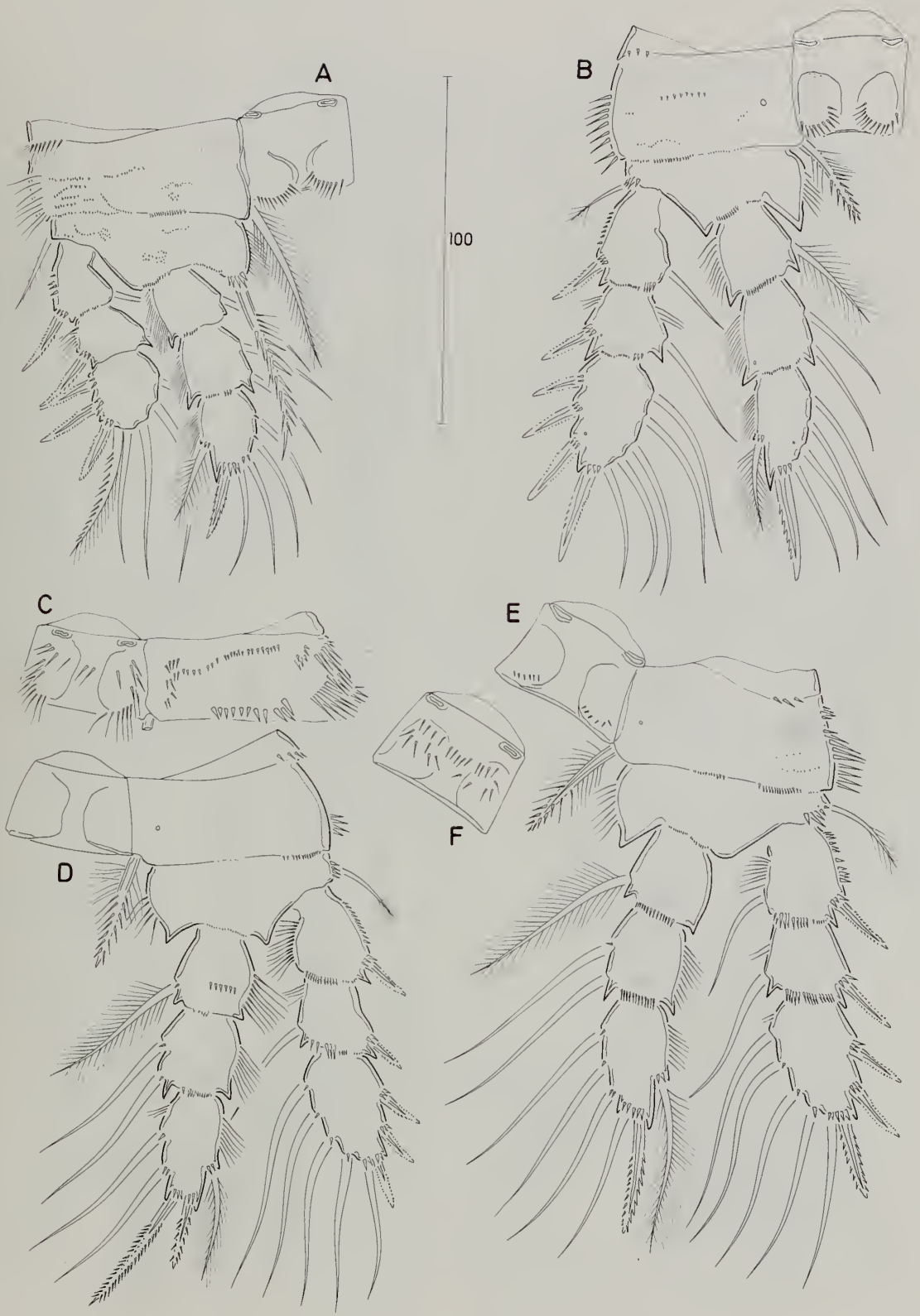

Fig. 46 *P. waiariki*. Adult female. A, leg 1, anterior; B, leg 2, anterior; C, intercoxal sclerite and coxa of leg 4, posterior; D, leg 4, anterior; E, leg 3, anterior; F, intercoxal sclerite of leg 3, posterior. Scale bar in μm.

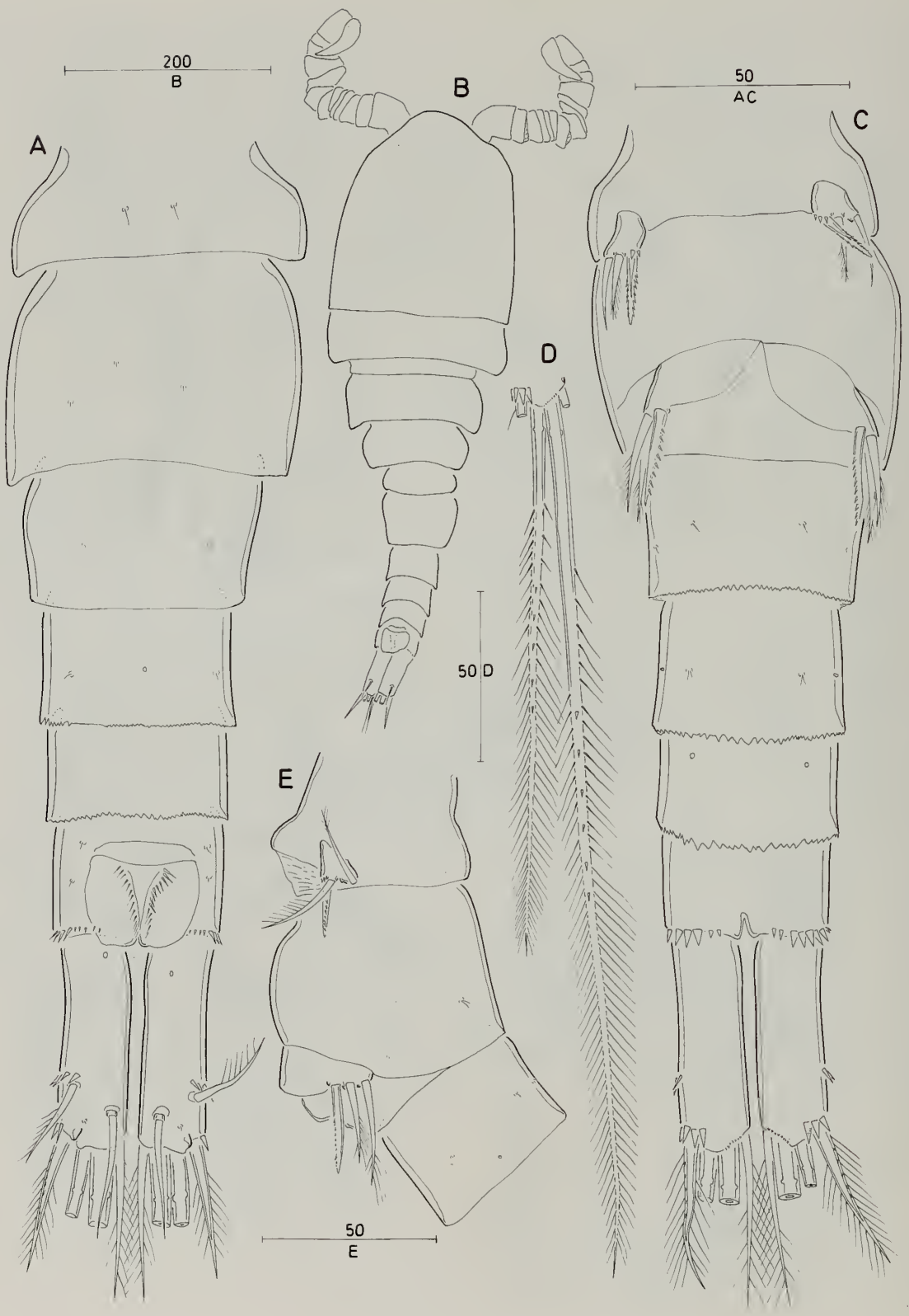

Fig. 47 *P. waiariki*. Adult male. A, urosome, dorsal; B, body, dorsal; C, urosome, ventral; D, caudal rami, detail of the inner and outer terminal setae, dorsal; E, legs 5 and 6, lateral. Scale bars in μm.

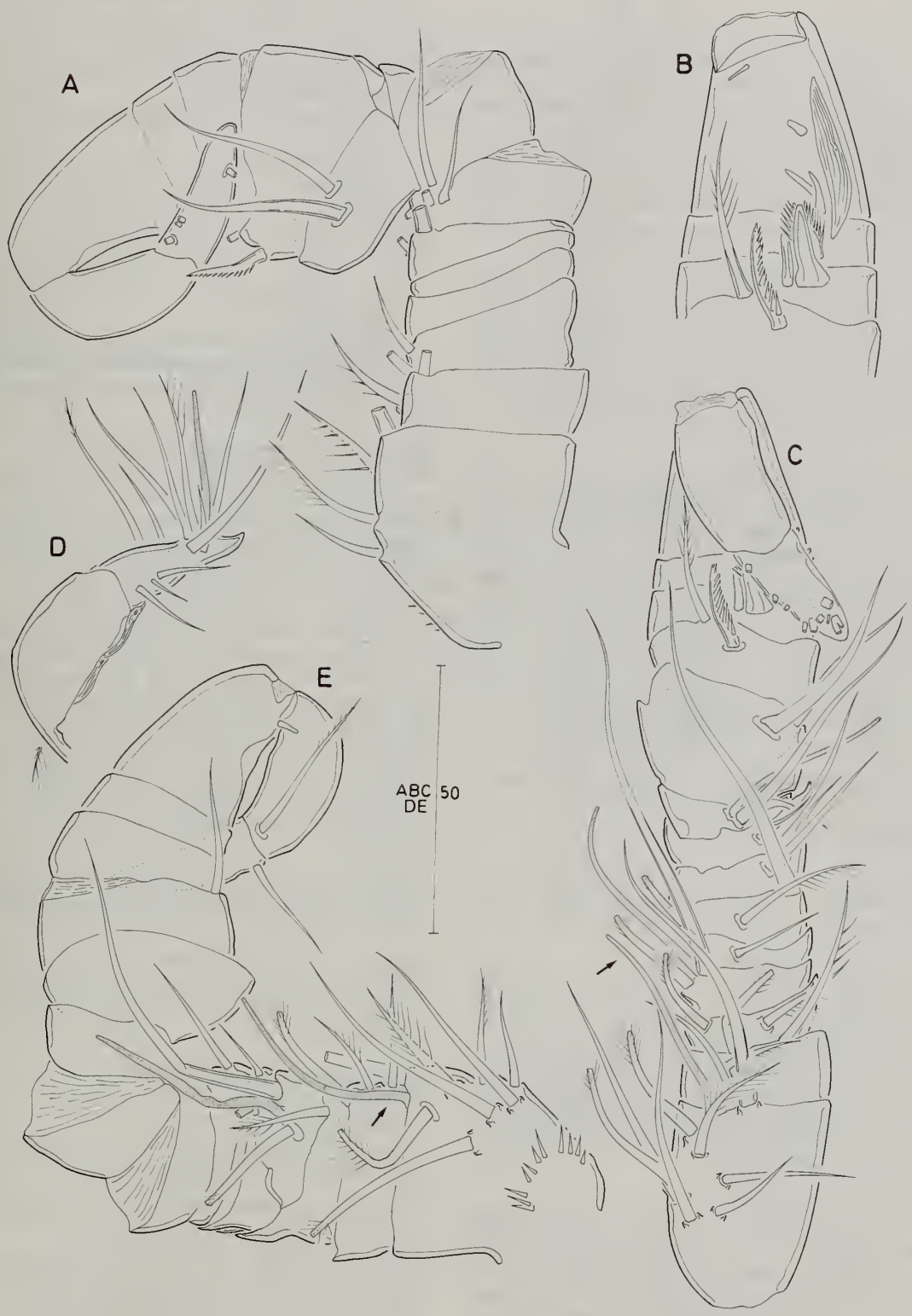

Fig. 48 *P. waiariki*. Adult male. Antennule. A, dorsal showing segmentation; B, detail of segments 12 to 15 showing setation, anteroventral; C, anteroventral showing setation; D, detail of terminal segments showing setation; E, ventral showing segmentation. Scale bar in μm.

Outer setae of fifth leg plumose and about as long as inner spine (Figures 47C,E; 45G); sixth leg (Figures 47C,E; 45F) armed with 1 inner spine (much shorter than second urosomal somite) and 2 outer plumose setae.

DIFFERENTIAL DIAGNOSIS. *P. waiariki* can be differentiated from other *Paracyclops* species by the combination of the following characters; its 12-segmented antennule, the absence of an inner seta on the first exopodal segment of leg 4, the structure of the seminal receptacle, the produced base for the outer seta of leg 5 in the female, the absence of the proximal spine on outer margin of terminal exopodal segment of leg 3, the spinular ornamentation on the frontal surface of coxobasis of the antenna, its wide anal operculum and the ornamentation of the fine spinules along the dorsal and ventral surfaces of caudal rami.

P. waiariki, *P. smileyi* and *P. eucyclopoides* are closely related: however, *P. wairaiki* differs from *P. smileyi* and *P. eucyclopoides* by having 3 spines on the terminal segment of leg 3 rather than 4. In addition, *P. waiariki* can also be separated from *P. eucyclopoides* by the structure of seminal receptacle. *P. waiariki* also differs from *P. smileyi* in the length of outer seta of leg 5, in having a produced base for the outer seta of leg 5 and by the much shorter caudal rami.

REMARKS

Kiefer (1969) originally described *Paracyclops timmsi* from Australia. This species resembles *P. waiariki* in most respects, including the structure of leg 5, the number of segments on the female antennule and in spine and seta formula of swimming legs. As far as Kiefer's description is concerned, the differences between the species are the structure of the seminal receptacle and the body shape. Lewis (1974) does not mention *P. timmsi* in her original description of *P. waiariki* which suggests that she was unaware of Kiefer's work on *P. timmsi*. It is possible that *P. waiariki* may be a synonym of *P. timmsi* but *P. timmsi* needs to be redescribed to modern standards as it is clear that minor details of spinulation can represent significant differences at species level.

DISTRIBUTION. Only known from its type locality in New Zealand.

Paracyclops pilosus Dussart, 1984

(Figures 49–50)

ORIGINAL DESCRIPTION. *Paracyclops pilosus* Dussart, 1984: *Hydrobiologia*, 113: p. 56., fig. 15.

TYPE LOCALITY. Venezuela, Orinoco River.

MATERIAL EXAMINED. This species was originally described from single male and female. Holotype (dissected on 1 slide, MNHN Cp 659) and Allotype (dissected between prosome and urosome on 1 slide, MNHN Cp 669) were obtained on loan from Museum National d'Histoire Naturelle in Paris. Due to the positioning of the female appendages on the slide and to the earlier partial dissection of the male it was not possible to describe every detail of this species but several characters could be clarified.

REDESCRIPTION OF ADULT FEMALE

Genital double-somite, second and third abdominal somites (Figure 49B) ornamented with fine pits on ventral surface (the dorsal surface could not be observed). Seminal receptacle divided into broad anterior and posterior lobes. Caudal rami given as 2.9 times longer than wide in original description (Dussart, 1984). Terminal accessory seta (VI) as long as posterolateral seta (III); posterolateral seta (III) unilaterally plumose, with spinules along dorsal surface; outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 49B).

Antennule 8-segmented (Figure 49D); first and second segments incompletely separated; third segment with two partial suture lines on dorsal surface and with spiniform seta; fifth segment with characteristic short aesthetasc; another aesthetasc located distally on anteroventral margin on segment 7 about 2.5 times longer than terminal segment. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Spinular ornamentation on coxobasis of antenna impossible to observe.

Spine and seta formula of swimming legs as follows:

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

Leg 5 (Figure 49C) comprising single free segment, armed with 1 long (almost 1.5 times longer than inner spine) well developed outer spinulose seta, 1 serrate strong inner spine, plumose seta in centre slightly longer than inner spine.

DESCRIPTION OF ADULT MALE

Genital and 3 free abdominal somites (Figure 49A) without surface pits on ventral surface. Caudal rami short, about 2.5 times longer than broad. First segment of antennule with modified seta. Outer seta of fifth leg plumose, as long as inner spine (Figure 49A); sixth leg (Figure 49A) armed with 1 well-developed inner spine, slightly longer than second urosomal somite.

DIFFERENTIAL DIAGNOSIS. *P. pilosus* is easily distinguishable by the incomplete separation of the first and second segments of the female antennule (Figure 49D), by the presence of 3 setae on the terminal endopodal segment of leg 3 (Figure 50C), by the presence of 4 setae on the terminal exopodal segment of leg 4 (Figure 50D). It can also be separated from closely related species by the combination of the presence of 2 setae on the second endopodal segment of leg 1 (Figure 50A), and the presence of cuticular depressions on the ventral surface of the caudal rami.

REMARKS

The presence of four inner setae on the terminal exopodal segment of leg 4, and of three inner setae on the terminal endopodal segment of leg 3 is remarkable.

DISTRIBUTION. Venezuela: Orinoco River (type locality) (Dussart, 1984). Dussart (1984) also mentioned that this species was found in the littoral zone of flowing waters of the Orinoco at Barrancas at Ciudad Bolivar.

Paracyclops carectum Reid, 1987

(Figures 51–53)

ORIGINAL DESCRIPTION. *Paracyclops carectum* Reid, 1987: *Hydrobiologia*, 153, p. 124. (Figs. 1–12).

TYPE LOCALITY. Vereda Grande Pond, Águas Emendadas Biological Reserve, Federal District, Brazil.

MATERIAL EXAMINED. 4 Paratype ♀ ♀ (USNM Cat. No: 232176) from Brazil, shore of Vereda Grande pond 15°32'30"S; 047°34'57"W: collected by Dr. J. W. Reid (May 1982–1986), 1 ♀ dissected; 1 Paratype ♂ (USNM Cat. No: 232175) from wet campo marsh, Fazenda Agua Limpa, Distrito Federal, Brazil; collected by Dr. J. W. Reid (Apr 1982). 2 ♂ ♂ (USNM 242425) from Brazil; Goias; marsh of Corrego Pocoes; collected by Dr. J. W. Reid (December 1983),

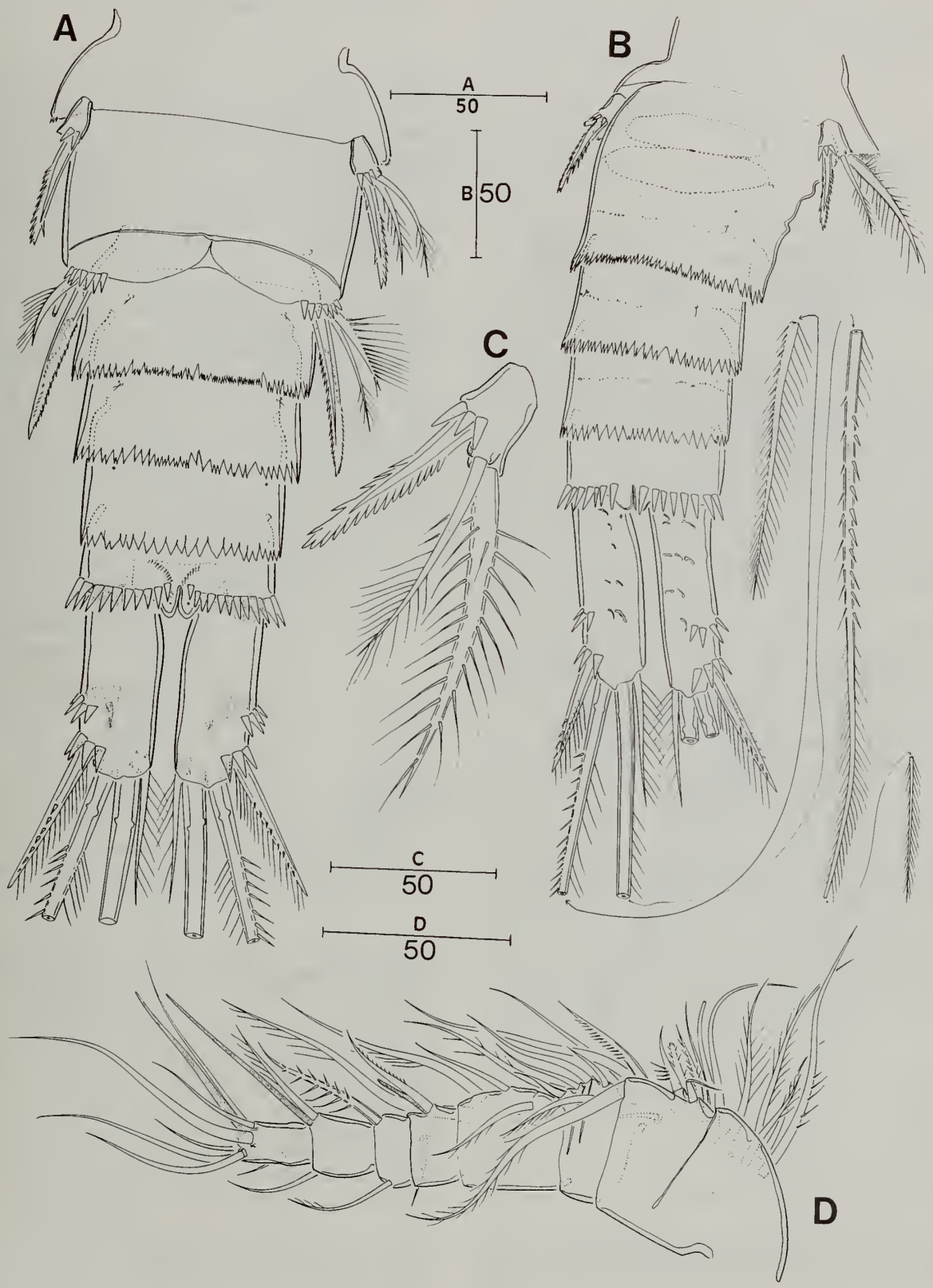

Fig. 49 *P. pilosus*. A, adult male, urosome, ventral; B, adult female, urosome with inset showing the caudal setae (IV) and (V), ventral; C, leg 5, ventral; D, antennule. Scale bars in µm.

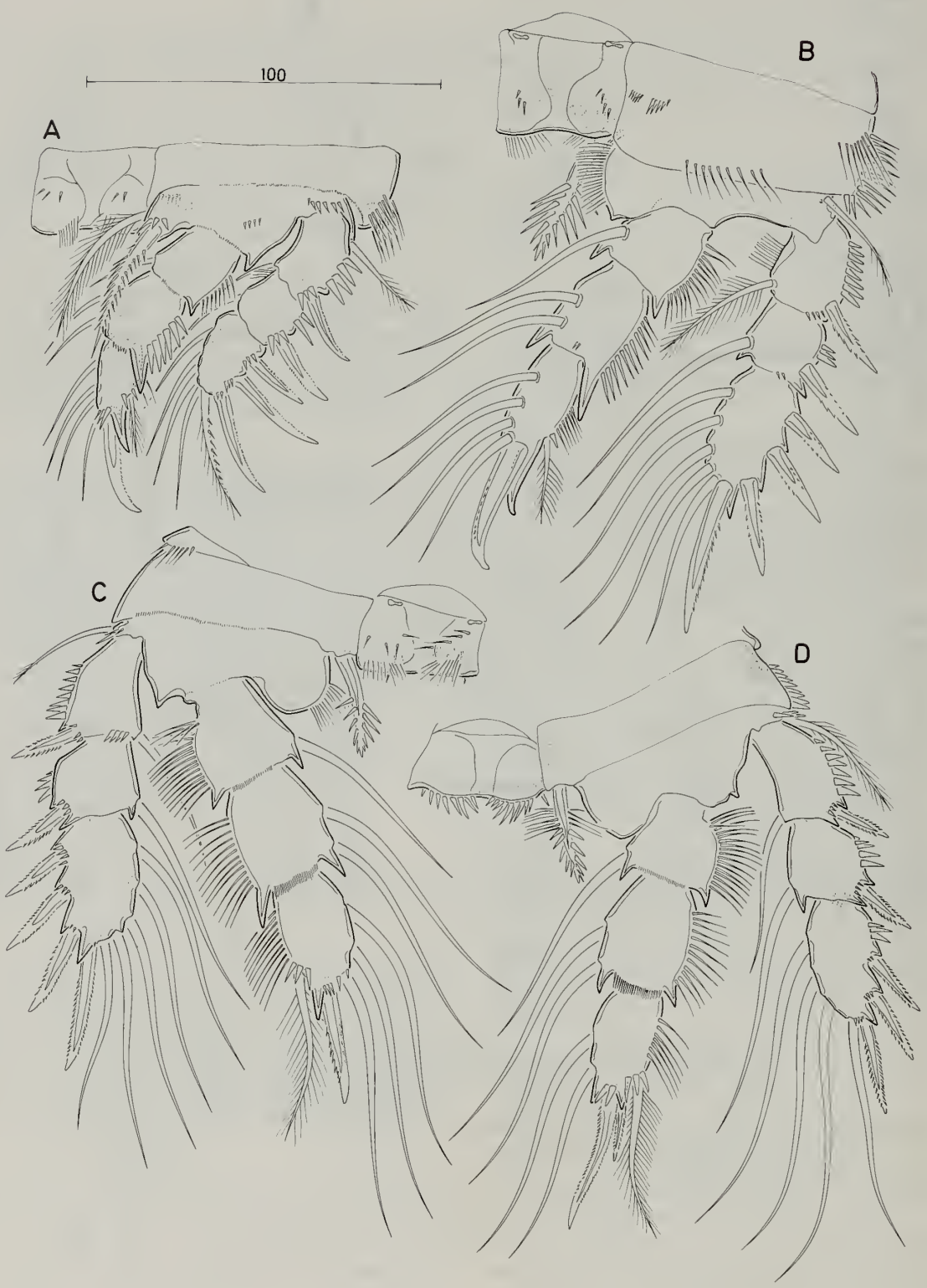

Fig. 50 *P. pilosus*. Adult female. A, leg 1, anterior; B, leg 2, posterior; C, leg 3, anterior; D, leg 4, anterior. Scale bar in μm.

1♂dissected; 1♀(USNM 242423) from Brazil, Federal District; Brasilia Lagoada Peninsula Norte, collected by Dr. J. W. Reid; 1♀(USNM 242424) from Brazil; Federal District; Brasilia, Lagoa Jaburu, collected by Dr. J. W. Reid (Aug 1982).

REDESCRIPTION OF ADULT FEMALE

Body length measured within same range as given in original description (Reid, 1987) as 600–800 µm, mean = 650 µm. Genital double-somite ornamented with fine pits on dorsal surface as figured (Figure 51A,B). Seminal receptacle divided into broad anterior and posterior lobes. Caudal rami (Figure 51A,B) parallel, 3.2 times longer than broad; with groups of spinules and hairs along inner margin (Figure 51A,D); outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 51A).

Antennule 8-segmented; Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 52G,H) with complex ornamentation on caudal and frontal sides as figured; without spinular row on caudal surface near base of two inner setae (arrowed in Figure 52G).

Basis of leg 1 (Figure 52C) with setiform inner spine reaching midway along terminal endopodal segment; intercoxal sclerite ornamented with 2 spinular rows on posterior surface (Figure 52D). Intercoxal sclerite of leg 2 ornamented with spinular rows on anterior and posterior surfaces (Figure 52J,K). Intercoxal sclerite of leg 3 without spinular row on anterior surface and with 2 spinular rows on posterior surface (Figure 52E,F); coxa with complex ornamentation on posterior surface as figured (Figure 52E). Intercoxal sclerite of leg 4 (Figure 52A,B) with 2 spinular rows on posterior surface; inner coxal spine with proximal group of setules mainly originating posteriorly (Figure 52B).

Spine and seta formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–I	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;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 51C) comprising single free segment, armed with 1 long, well developed outer spinulose seta, 1 serrate, strong inner spine, and 1 plumose seta centrally.

DESCRIPTION OF ADULT MALE

Body length measured within same range as original description (Reid, 1987), length of allotype 580 µm, lengths of paratypes 550 and 600 µm. Genital, third, fourth and fifth urosomal somites (Figure 53A,B) ornamented with cuticular pits on dorsal surface. Caudal rami shorter than female, about 2.1 times longer than broad; with complex ornamentation along inner margin as figured (Figure 53A,B,D). First segment of antennule armed with 8 setae plus aesthetasc; 1 seta (A) large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally.

All other appendages as in female except; outer setae of fifth leg plumose (Figure 53C); sixth leg (Figure 53A,C) armed with 1 inner spine as long as second urosomal somite, surrounded by spinules at base; 2 outer setae plumose.

VARIABILITY. The outer margin of inner spine of the female leg 5 may be ornamented with a variable number of spinules (Figure 51C).

DIFFERENTIAL DIAGNOSIS. *P. carectum* is unique within the genus in carrying ornamentation of spinules along the inner margin of the caudal rami (Figure 51A,D).

DISTRIBUTION. Brazil: Vereda Grande Pond, Aguas Emendadas Biological Reserve, Federal District, 15°32'30"S, 47°34'57"W; Wet campo Marsh, Fazenda Agua Limpa, Distrito Federal; Goias, marsh of Corrego Pocoes; Federal district, Brasilia, Lagoada peninsula norte; Federal district, Brasilia, Lagoa Jaburu (Reid, 1987).

Paracyclops novenarius Reid, 1987

(Figures 54–57)

ORIGINAL DESCRIPTION. *Paracyclops novenarius* Reid, 1987: *Proc. Biol. Soc. Wash.* 100(2), p. 262, figs. 1–20.

TYPE LOCALITY. Colombia, Valle, Buenaventura.

MATERIAL EXAMINED. Holotype: 1♀(USNM 231096) collected by Dr. Marco F. Suarez (5 Sept. 1985). Paratypes: 12♀♀and 9♂♂(USNM 231099). 1♂, 1♀, 4 copepodids (USNM 231100); all paratypes collected from the type locality.

REDESCRIPTION OF ADULT FEMALE

Body length measured within same range as in original description (given by Reid (1987) as 570–880 µm, mean = 630). Genital double-somite, second and third abdominal somites ornamented with very fine pits on dorsal and ventral surfaces as figured (Figure 54A,B). Seminal receptacle divided into narrow anterior and broad posterior lobes as figured (Figure 54B). Caudal rami (Figure 54A,B) with fine cuticular depressions on ventral surface. Terminal accessory seta plumose (VI) and 1.5 times longer than posterolateral seta (III); posterolateral seta (III) strong and unilaterally plumose, with spinules along dorsal surface; setae IV and V well developed and heterogeneously ornamented (Figure 54B).

Antennule 8-segmented (Figure 55A). Segment 2 and 3 with complex partial suture lines. Segment 2 may be incompletely separated or with complete separation, best seen in Figure 55A,C,E,F. Segment 3 with partial suture line and spiniform seta. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 55B,D) without spinular row on caudal surface near bases of inner setae (arrowed in Figure 55D).

Coxa of leg 1 lacking spinular row on posterior surface near intercoxal sclerite (Figure 56G). Intercoxal sclerite of leg 2 ornamented with spinular row on anterior surface (Figure 56B); without spinular row on posterior surface (Figure 56A). First and second exopodal segments lacking spinular row on posterior surface (Figure 56B). Intercoxal sclerite of leg 3 with spinular row on anterior surface (Figure 56E) and 2 spinular rows on posterior surface (Figure 56F). Intercoxal sclerite of leg 4 without spinular row on anterior surface (Figure 56D) and with 2 spinular rows on posterior surface (Figure 56C); coxa without mid-distal spinular row on posterior surface (arrowed in Figure 56C).

Spine and seta formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–I	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;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 54C) comprising single free segment, armed with 1 strong outer spinulose seta slightly longer than inner spine, 1 serrate-like strong inner spine with 3 spinules at base, 1 plumose seta in middle.

DESCRIPTION OF ADULT MALE

Body length measured within same range as in original description

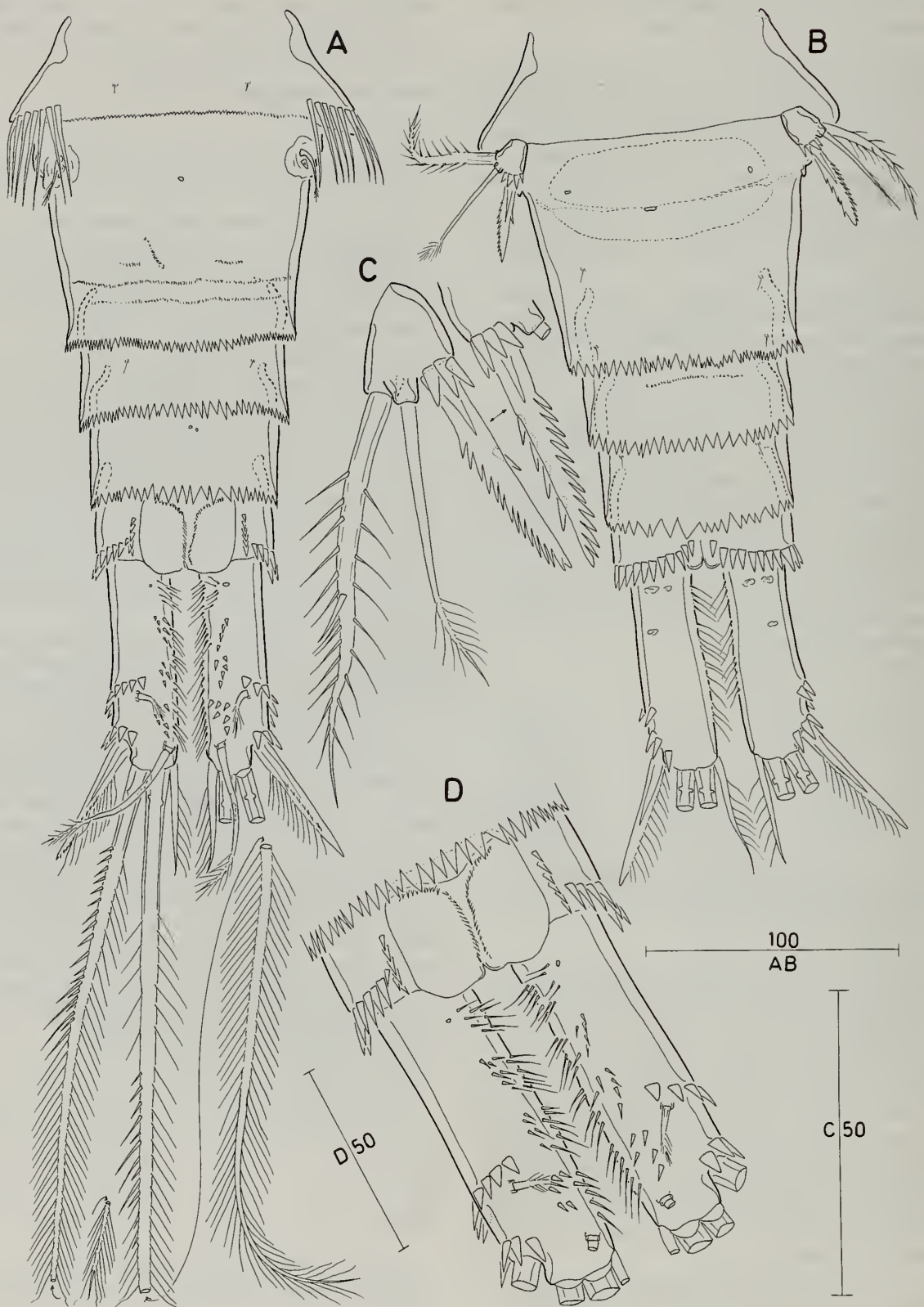

Fig. 51 *P. carectum*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5 with inset showing variant pattern of spinulation on inner spine, ventral; D, anal somite and caudal rami, dorsal. Scale bars in μm.

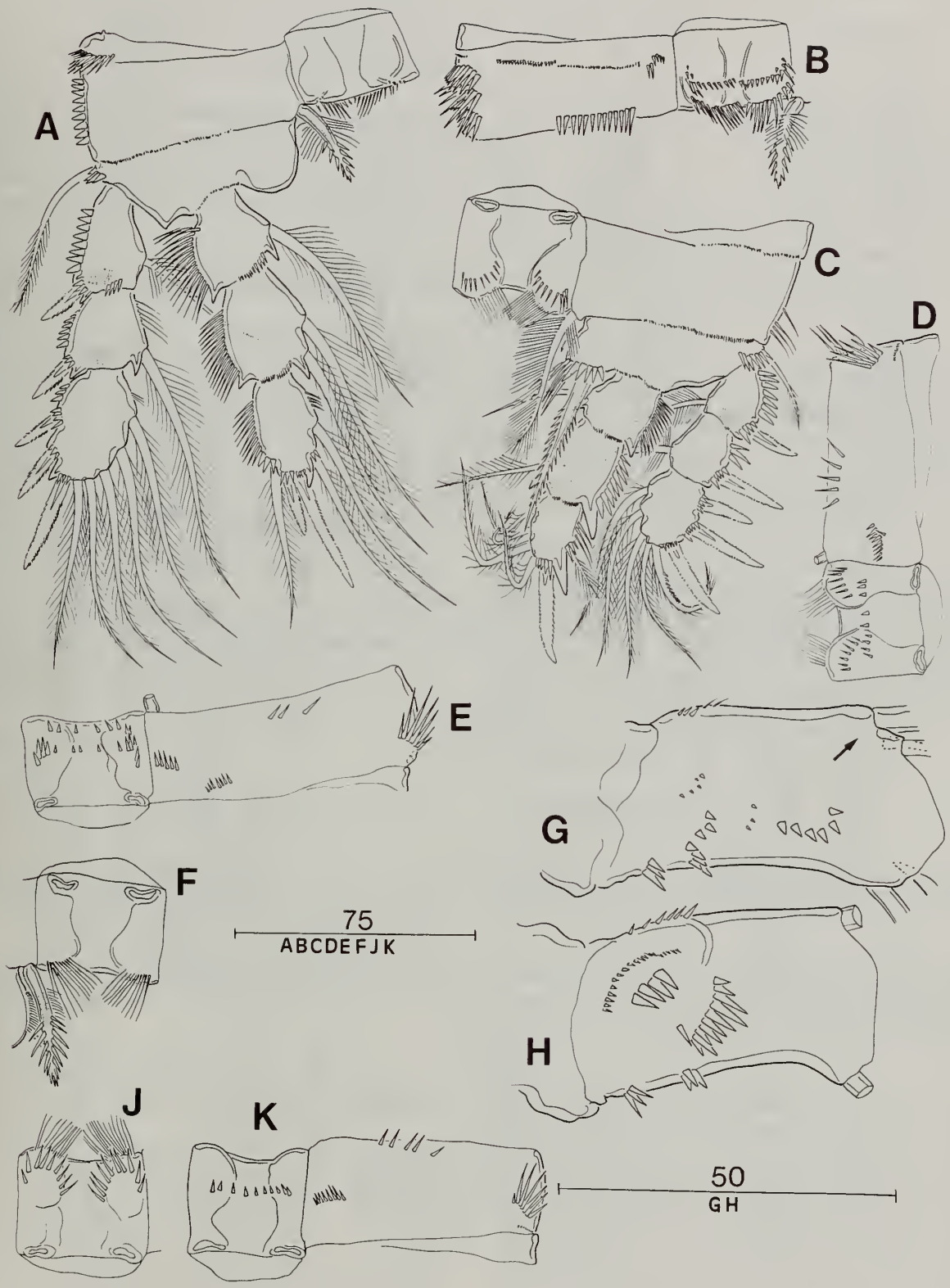

Fig. 52 *P. carectum*. Adult female. A, leg 4, anterior; B, intercoxal sclerite and coxa of leg 4, posterior; C, leg 1, anterior; D, intercoxal sclerite and coxa of leg 1, posterior; E, intercoxal sclerite and coxa of leg 3, posterior; F, intercoxal sclerite of leg 3, anterior; G, antenna, coxobasis, caudal; H, antenna, coxobasis, frontal; J, intercoxal sclerite of leg 2, anterior; K, intercoxal sclerite and coxa of leg 2, posterior. Scale bars in μm.

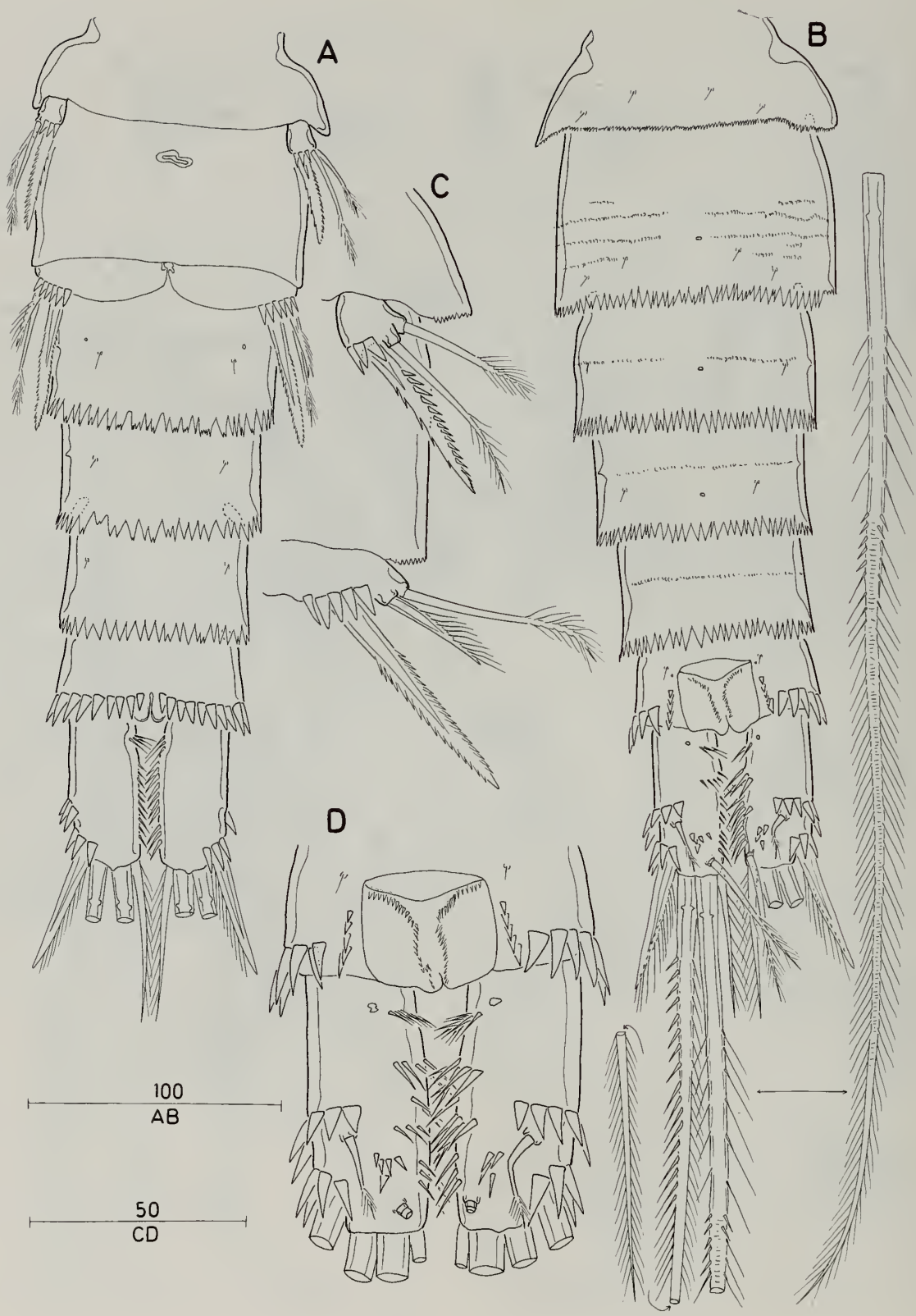

Fig. 53 *P. carectum*. Adult male. A, urosome, ventral; B, urosome, dorsal; C, detail of leg 5 and leg 6, anteroventral; D, anal somite and caudal rami, dorsal. Scale bars in µm.

(given by Reid (1987) as 540–640 µm, mean = 600). Genital, third, fourth and fifth urosomal somites each ornamented with cuticular pits on dorsal surface extending to ventral surface on third, fourth and fifth somites (Figure 57A,B). First segment of antennule armed with 8 setae plus an aesthetasc; one seta (A) large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally.

All other appendages as in female except; one seta on terminal endopodal segment of leg 1 spinulose (Figure 56J). Outer seta of fifth leg plumose and less developed (Figure 57C). Sixth leg (Figure 57D) armed with 1 inner spine, shorter than second urosomal somite, bearing spinules at base; middle seta spiniform, short and stout; outer seta plumose.

DIFFERENTIAL DIAGNOSIS. *P. novenarius* can be differentiated from other *Paracyclops* species by the combination of the following characters:

- the dorsal subdivision of second segment of female antennule, observed in holotype and in one paratype (Figure 55C). Remaining specimens with second segment divided into 2 segments as in Figure 55E, F (partial suture line on second segment indicating boundary between ancestral segments VI–X and XI).
- the structure of the seminal receptacle (Figure 54B), the absence of the mid-distal spinular row on the posterior surface of the coxa of leg 4 (arrowed in Figure 56C), the spinular pattern on the caudal surface of the coxobasis of antenna (Figure 55D), and the absence of spinular rows on the posterior surfaces of the first and second endopodal segments of leg 2 (Figure 56B).

Distribution: Brazil: Vereda Grande Pond, Aguas Emendadas Biological Reserve, Federal District, 15°32'30"S, 47°34'57"W; Wet campo Marsh, Fazenda Agua Limpa, Distrito Federal; Goias, marsh of Corrego Pocoes; Federal district, Brasilia, Lagoada peninsula norte; Federal district, Brasilia, Lagoa Jaburu (Reid, 1987).

Paracyclops smileyi Strayer, 1988

(Figures 58–60)

ORIGINAL DESCRIPTION. *Paracyclops smileyi* Strayer, 1988: *Stygologia* 4 (3): 279–291.

TYPE LOCALITY. Type specimens were collected from the hyporheic zone of Coxing Kill, Town of Gardiner, Ulster County, New York, U.S.A, 17 December 1985 (Strayer, 1988).

MATERIAL EXAMINED. Holotype (USNM Cat. No: 235368, one slide) and Paratype (USNM Cat. No: 235369, one slide) females were obtained on loan from United States National Museum of Natural History.

REDESCRIPTION OF ADULT FEMALE

Due to the positioning of the dissected appendages on the slides and to the poor condition of the slides it was not possible for this species to be redescribed in detail.

Genital double-somite, second and third abdominal somites (Figure 58C) without ornamentation of surface pits dorsally; posterior margins of abdominal somites inconspicuously serrated dorsally. Caudal rami short (Figure 58C,E), length given as 2.5 times longer than broad by Strayer (1988).

Antennule 12-segmented (Figure 59A); segment 6 with spiniform seta (arrowed in Figure 59A); segment 9 with short aesthetasc (arrowed in Figure 59A); apical segment with aesthetasc fused to adjacent seta at base, and another aesthetasc located distally on anteroventral margin of segment 11. Setal formula 8, 4, 2, 6, 4, 2, 2, 3, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna (Figure 59D) with complex ornamentation on caudal and frontal surfaces as figured and without spinular row near base of 2 inner setae on caudal surface.

Spine and seta formula of swimming legs (Figures 60A–E) as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–1	?–I	I–1;I–1;III,5	0–1;0–2;1,I,4
Leg 2	0–I	1–0	I–1;I–1;III,I,5	0–1;0–I(?);I,I,4
Leg 3	0–I	I–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;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 58B) comprising single free segment, armed with 2 outer setae about 3–4 times longer than inner spine, 1 strong inner spine.

ADULT MALE. Unknown

DIFFERENTIAL DIAGNOSIS. *P. smileyi* differs from other *Paracyclops* species except *P. waiariki* Lewis, 1974 and *P. eucyclopoides* Kiefer, 1929 in having a 12-segmented antennule in the female. *P. smileyi* differs from *P. waiariki* and *P. eucyclopoides* in the structure of leg 5 and in having shorter caudal rami (2.5 times longer than broad). *P. smileyi* can also be differentiated from *P. waiariki* by the presence of 4 spines on the terminal exopodal segment of leg 3.

REMARKS

There appears to be only a single inner seta on the second endopodal segment of leg 2 in the available type material. It is probable that the proximal seta (Figure 60C) is broken off in the types but it was difficult to observe any scar indicating the position of such a missing seta because of the poor condition of the slide. The presence or absence of this seta should be confirmed by examination of new material in the future. Similarly setal elements are missing from mouthparts such as the maxillule and maxilla.

DISTRIBUTION. Known only from its type locality.

Paracyclops reidae sp. nov.

(Figures 61–64)

TYPE LOCALITY. Pools in the leaf axils of a terrestrial bromeliad, El Tucuche, Trinidad, W.I.; 24 July 1994, coll. R. Martinez and M. Morton.

TYPE MATERIAL. The type material (11 specimens) is stored in the collection of Smithsonian Institution, Washington D.C., USA, Reg. No: USNM 264163. 1 female and 1 male paratypes are stored in the collection of The Natural History Museum, London, Paratype female, BMNH 1995.I668; paratype male, BMNH 1995.I669.

DESCRIPTION OF ADULT FEMALE

Body length not including caudal setae 778 µm, body width 341 µm. Urosomal somites (Figure 61A,B) without ornamentation on ventral and dorsal surfaces. Seminal receptacle divided into broad anterior and posterior lobes (Figure 61A). Fifth pedigerous somite with fringe of 3–4 elongate setules at posterior margin. Anal somite with spinular row on ventral surface (Figure 61A). Caudal rami (Figure 61A,B) with convex inner margin; about 2.5 times longer than broad. Anterolateral seta (II) longer than rami with 2 spinules near base (Figure 61B); posterolateral seta (III) with spinular row at base on ventral surface; terminal accessory seta (VI) plumose and about 2 times longer than caudal rami; outer terminal seta (IV) and inner terminal seta (V) well developed and plumose; dorsal seta (VII) about 1.5 times longer than ramus (Figure 61B).

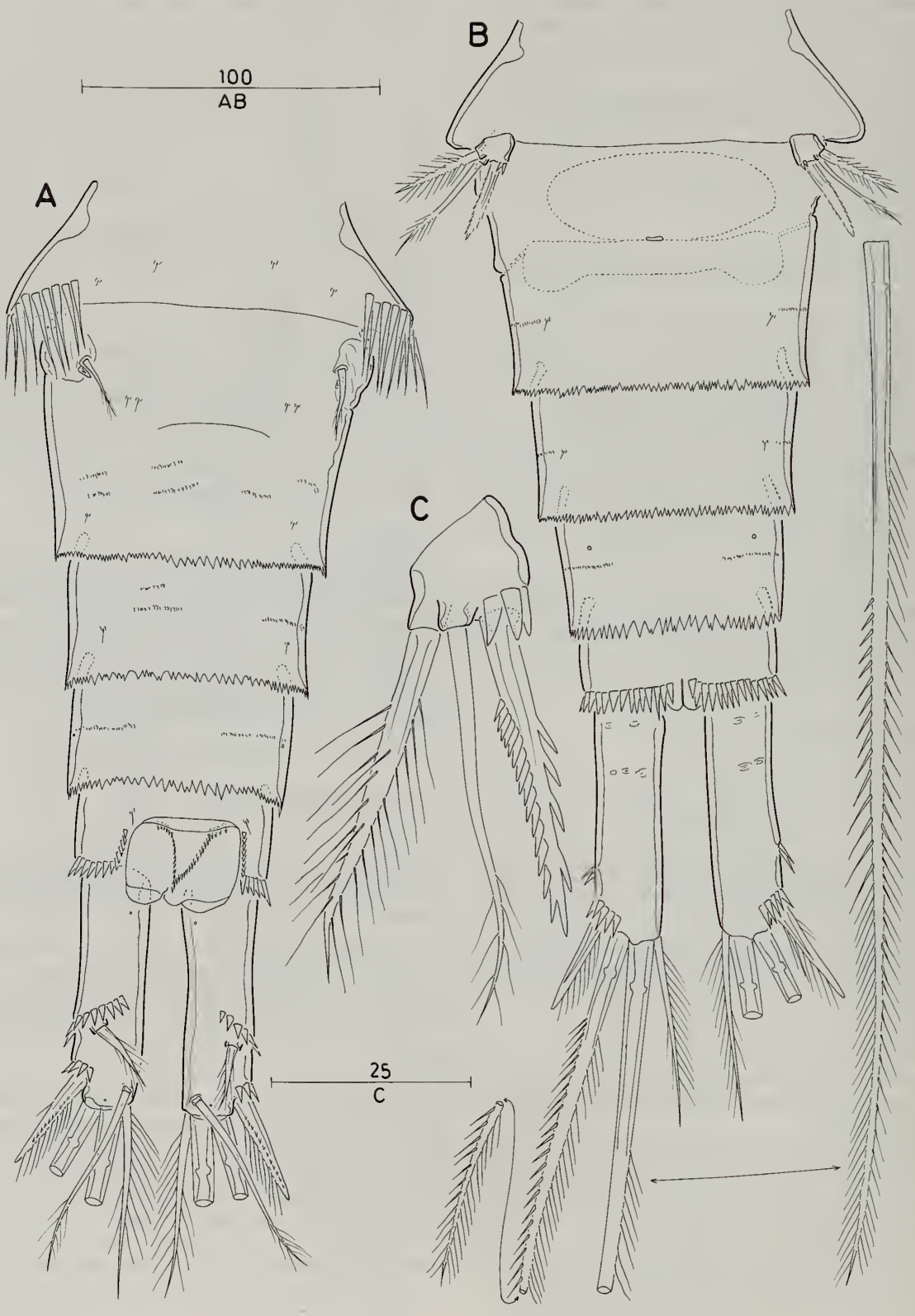

Fig. 54 *P. novenarius*. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral. Scale bars in μm.

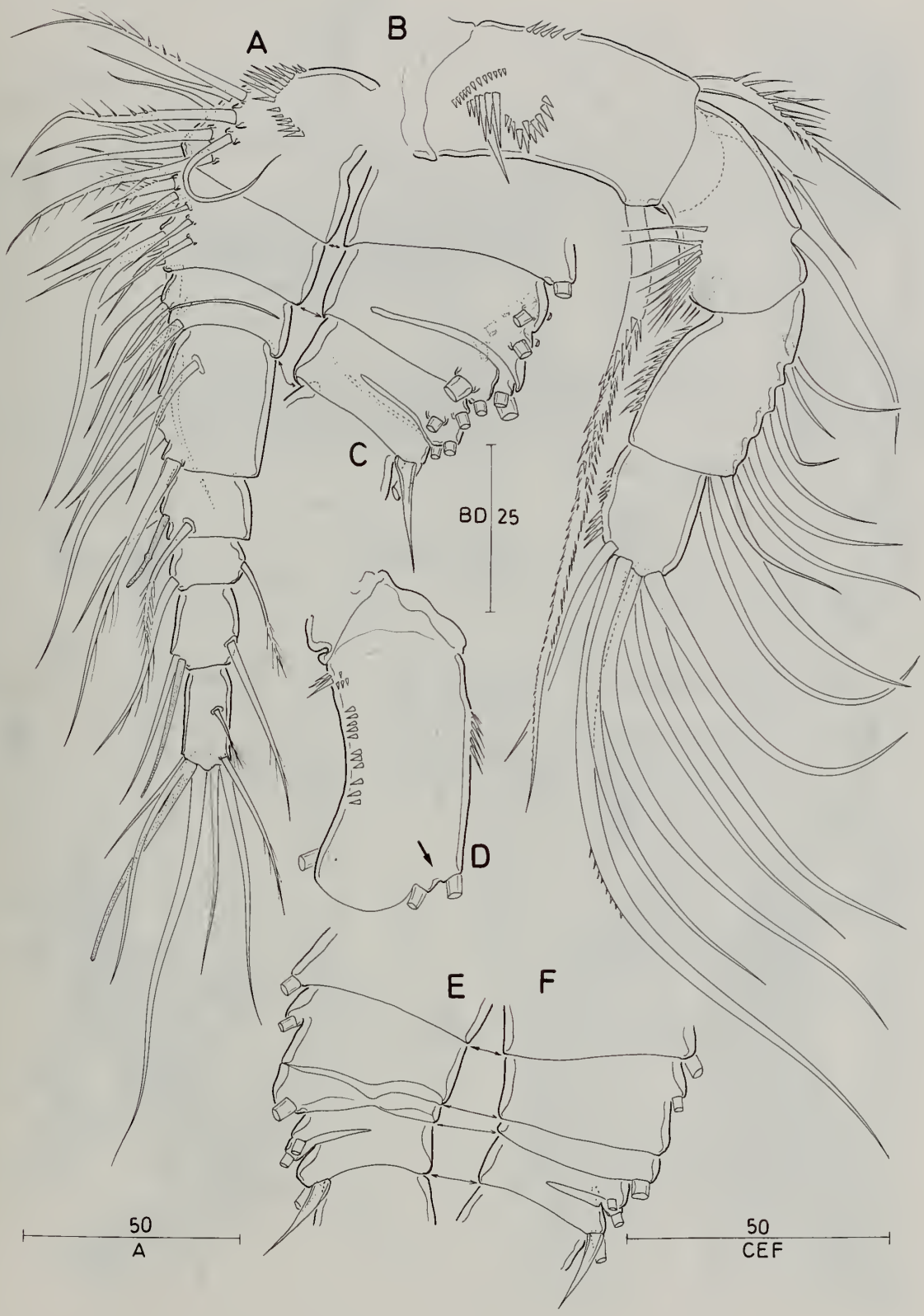

Fig. 55 *P. novenarius.* Adult female. A, antennule ventral; B, antenna, frontal; C, antennule, second and third segments showing pattern of segmentation, dorsal; D, antenna, coxobasis, caudal; E, F, antennule second and third segments showing variant pattern of segmentation. Scale bars in μm.

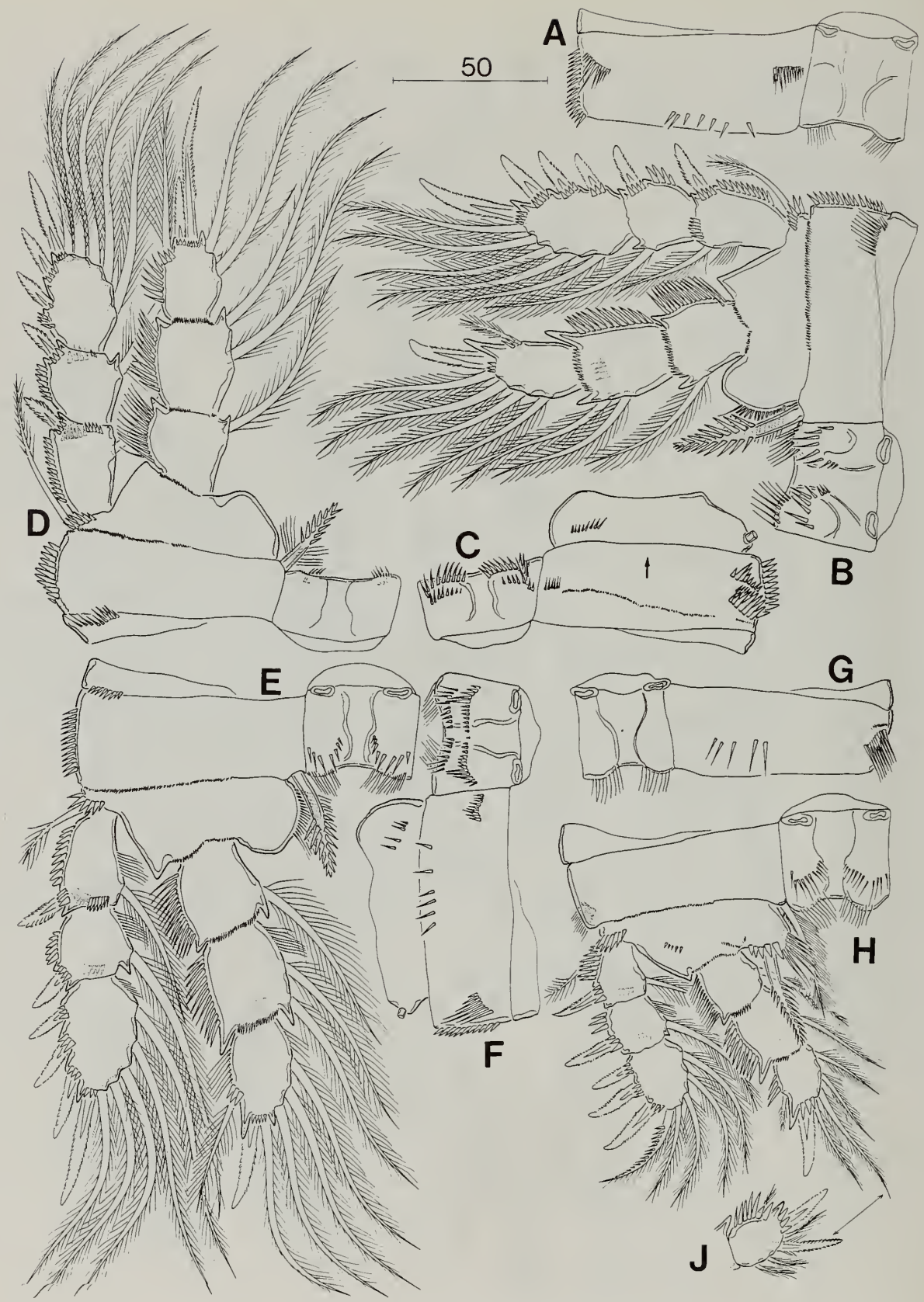

Fig. 56 *P. novenarius*. Adult female. A, intercoxal sclerite and coxa of leg 2, posterior; B, leg 2, anterior; C, intercoxal sclerite and coxa of leg 4, posterior; D, leg 4, anterior; E, leg 3, anterior; F, intercoxal sclerite and coxa of leg 3, posterior; G, intercoxal sclerite and coxa of leg 1, posterior; H, leg 1, anterior; J, adult male, terminal endopodal segment of leg 1 showing the sexually dimorphic seta, anterior. Scale bar in μm.

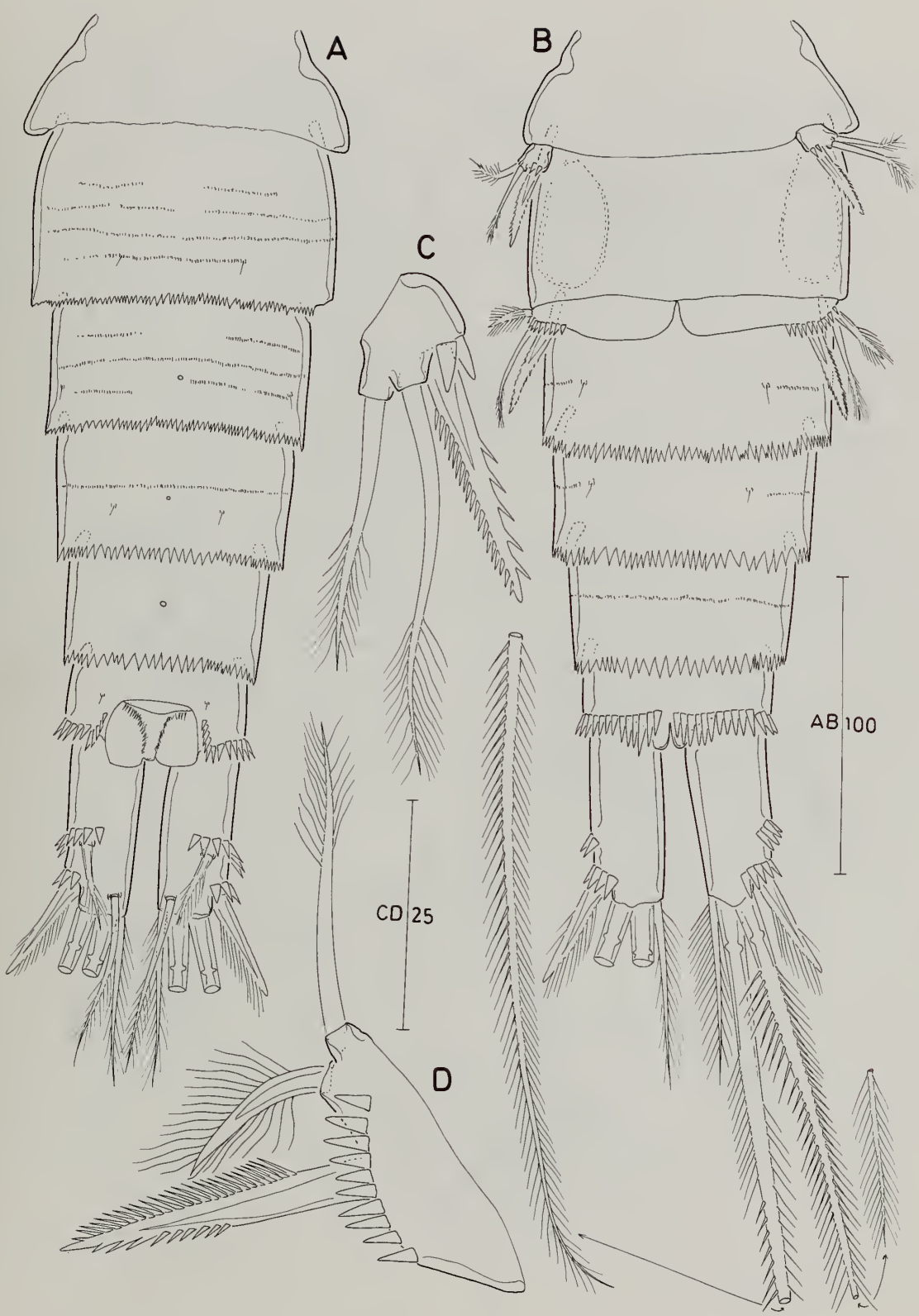

Fig. 57 *P. novenarius*. Adult male. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral; D, leg 6, anteroventral. Scale bars in μm.

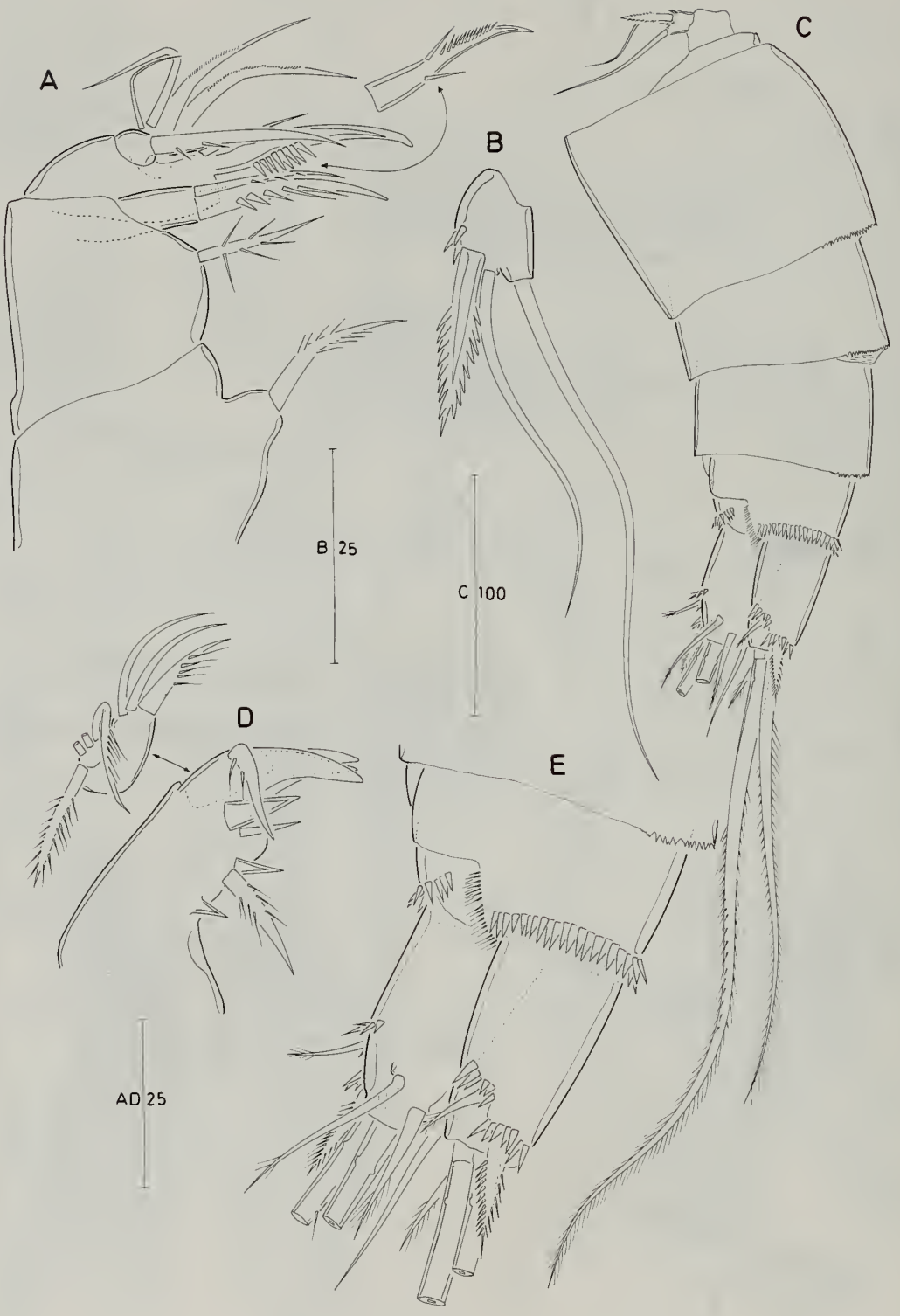

Fig. 58 *P. smileyi*. Adult female. A, maxilla; B, leg 5, dorsal; C, urosome, lateral; D, maxillule with inset showing maxillulary palp; E, anal somite and caudal rami, lateral. Scale bars in μm.

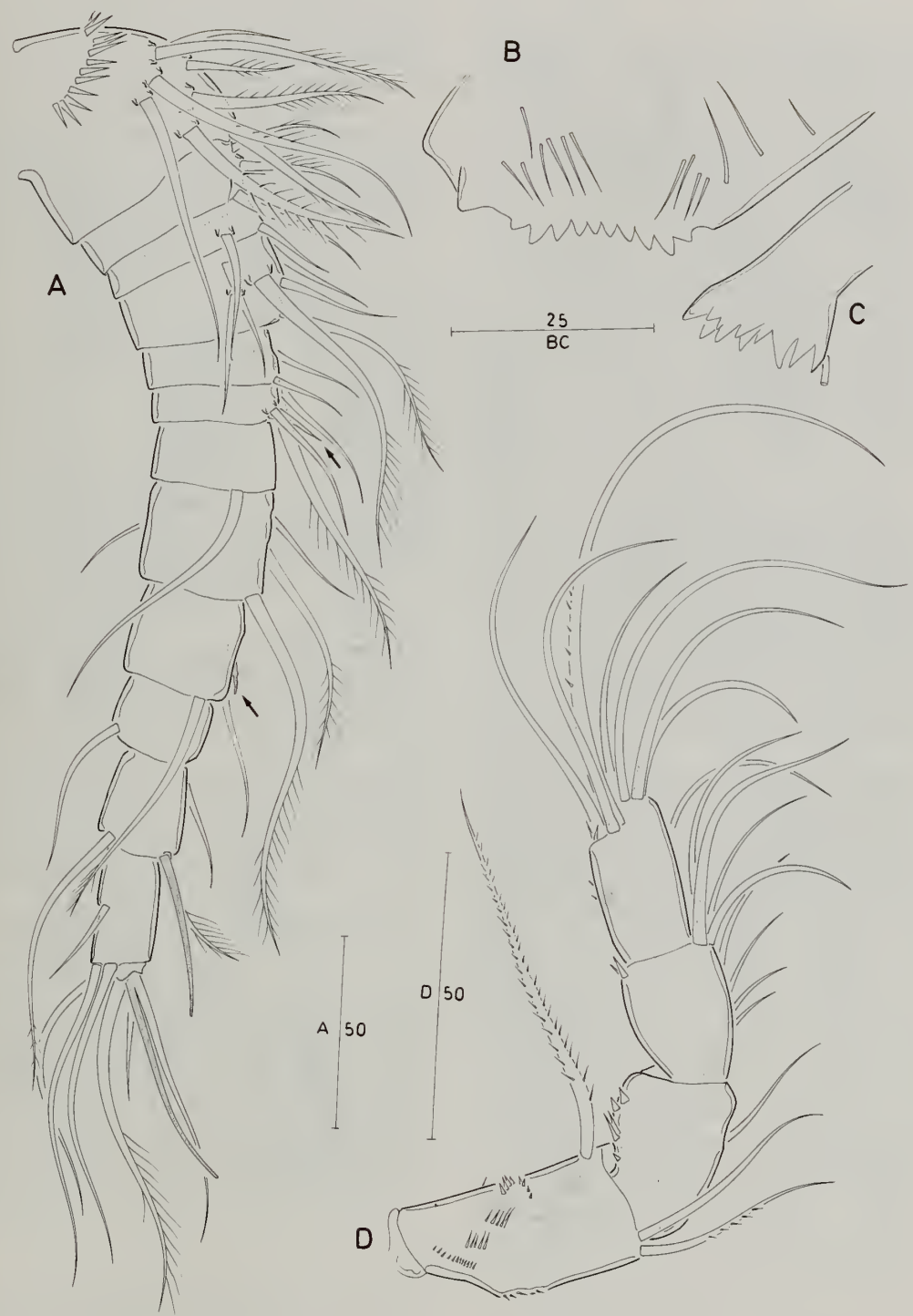

Fig. 59 *P. smileyi*. Adult female. A, antennule; B, labrum; C, gnathobase of mandible; D, antenna, frontal. Scale bars in µm.

Fig. 60 *P. smileyi*. Adult female. A, leg 4, anterior; B, leg 3 with inset showing endopod, posterior; C, leg 2, posterior; D, leg 1, anterior. Scale bar in μm.

Antennule 8-segmented (Figure 62A). 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. Lengths of antennulary segments measured along posterior margin: 32, 42, 27, 59, 30, 20, 32, 35 respectively (length in µm). Coxobasis of antenna with complex ornamentation on caudal (Figure 61D) and frontal surfaces (Figure 61E) and with spinular row on caudal surface, near base of inner setae as figured.

Palp of mandible (Figure 62C) represented by 3 naked setae, 2 of which very long, third seta short.

Legs 1 to 3 each without mid-distal spinular on posterior surface of coxa; without spinular row on anterior surface of intercoxal sclerite (Figure 63A,B,C). Inner coxal spine of leg 4 with group of setules mainly originating posteriorly. Exopodal segments 1 and 2 without spinular row on posterior surface (Figure 63D).

Spine and seta formula as follows:

	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;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 63E) comprising single free segment, armed with 1 strong inner spine with spinules at base and 2 plumose setae about same length; bases of setae produced. Leg 6 (Figure 61B) represented by 1 naked seta and 2 tiny spinules dorsolaterally.

DESCRIPTION OF ADULT MALE

Mean body length 552 µm (n=2), mean body width 250 µm (n=2). Outer lateral seta (III) of caudal rami naked (Figure 3.93B,C). First segment of antennule armed with 8 setae plus aesthetasc; 1 seta (A) large and modified by ornamentation of strong spinules in mid section.

All other appendages as in female except for fifth and sixth legs (Figure 64C). Outer plumose seta of leg 5 shorter than in female. Sixth legs armed with 1 inner spine, 1 outer naked seta and 1 well developed spinulose seta in centre. The inner spine of the left leg 5 of a paratype male was abnormal (Figure 64D).

ETYMOLOGY. The new species is named in honour of Dr. Janet Reid who made the specimens available for study, in recognition of her contributions to cyclopoid systematics.

DIFFERENTIAL DIAGNOSIS. The new species can easily be differentiated from all species in the genus by the structure of leg 5 in both sexes (Figures 63E; 64E), by the absence of a dorsal spinular row either side of anal somite (Figure 61B), by the spinular ornamentation of the coxobasis of the antenna on caudal and frontal surfaces (Figure 61D,E), by the shape of the caudal rami and the structure of its setae in both sexes (Figure 61A,B) and by the lengths of the distal antennulary segments measured along the posterior margin in the female (Figure 62A).

REMARKS

P. reidae, *P. altissimus* (Karaytug et al., in press) and *P. hardingi* nom. nov. are closely related. The three species lack a spinular row on the posterior surface of the first and second exopodal segments of legs 1–3 and possess a spinular row near the base of the two inner setae on the antennary coxobasis in both sexes. However *P. reidae* can easily be differentiated from *P. hardingi* and *P. altissimus* by the relative length of the antennulary segments, the length and spinulation of the outer seta of leg 5, the structure of seminal receptacle and in having the terminal accessory seta (VI) about 2 times longer than the caudal rami.

Paracyclops bromeliacola sp. nov.

(Figures 65–69)

TYPE LOCALITY. Brazil, State of São Paulo, Miracatu. In bromeliads from a farm at Itereí. March 1995. Collected by Léa P. Corrêa.

TYPE MATERIAL. Holotype, female dissected on 5 slides (Museu de Zoologia, São Paulo, Brazil; MZUSP 12788). Paratypes: 1♀, 1♂(BMNH 1997. 1782–1785) from Brazil, State of São Paulo, Miracatu. In bromeliads from a farm at Itereí. March 1995. Collected by Léa P. Corrêa; 2♀♀in Museu de Zoologia, São Paulo, Brazil (MZUSP 12789). Paratypes: 6♀♀, 3♂♂(BMNH 1997. 1786–1802) from Brazil, State of São Paulo, Salesópolis, Boracéia Biological Reserve, 7 August 1986. Carlos E. F. da Rocha col. from pools in soil bromeliads, from the Atlantic rain forest. 5♀♀, 2♂♂in Museu de Zoologia, São Paulo, Brazil (MZUSP 12790). Paratypes: 3♀♀, 5♂♂(BMNH 1997. 1803–1822) from Brazil, State of São Paulo, Juréia Ecological Reserve (24°25'10"S, 47°13'50"W), 2 February 1987, Rubens M. Lopes col. In culture made from leaf litter. 6♀♀, 3♂♂in Museu de Zoologia, São Paulo, Brazil (MZUSP 12791).

DESCRIPTION OF ADULT FEMALE

Body length and width measurements given in Table 5. Urosomal somites without surface pits on dorsal and ventral surfaces except genital double-somite with very fine surface pits on dorsal surface as figured (Figure 65A). Seminal receptacle (Figure 65B) with posterior lobe wider than anterior as figured. Caudal rami (Figure 65A,B) about 2.5 times longer than broad, with inner margin slightly convex distally. Terminal accessory seta (VI) plumose and 1.3 times longer than posterolateral seta (III); outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 65B).

Antennule 8-segmented (Figure 66A). Segment 3 with partial suture line and spiniform seta. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna with complex ornamentation on caudal (Figure 66C) and frontal (Figure 66B) surfaces as figured, and without spinular row on caudal surface near base of two inner setae (arrowed in Figure 66C).

Basis of leg 1 (Figure 67D) with setiform spine on inner margin reaching halfway along terminal endopodal segment; intercoxal sclerite ornamented with spinular rows on anterior and posterior surfaces (Figure 67D). Intercoxal sclerite of leg 2 ornamented with spinular rows on anterior (Figure 67A) and posterior (Figure 67B) surfaces; coxa without mid-distal spinular row on posterior surface (arrowed in Figure 67B). Intercoxal sclerite of leg 3 without spinular row on anterior (Figure 68A) surface and with 2 spinular rows on posterior (Figure 68B) surface; coxa without mid-distal spinular row on posterior surface (arrowed in Figure 68B). Intercoxal sclerite of leg 4 with 2 spinular rows on posterior (Figure 68D) surface, without spinular row anteriorly (Figure 68C).

Spine and seta formula as follows:

	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;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 65C) comprising single free segment, armed with 1

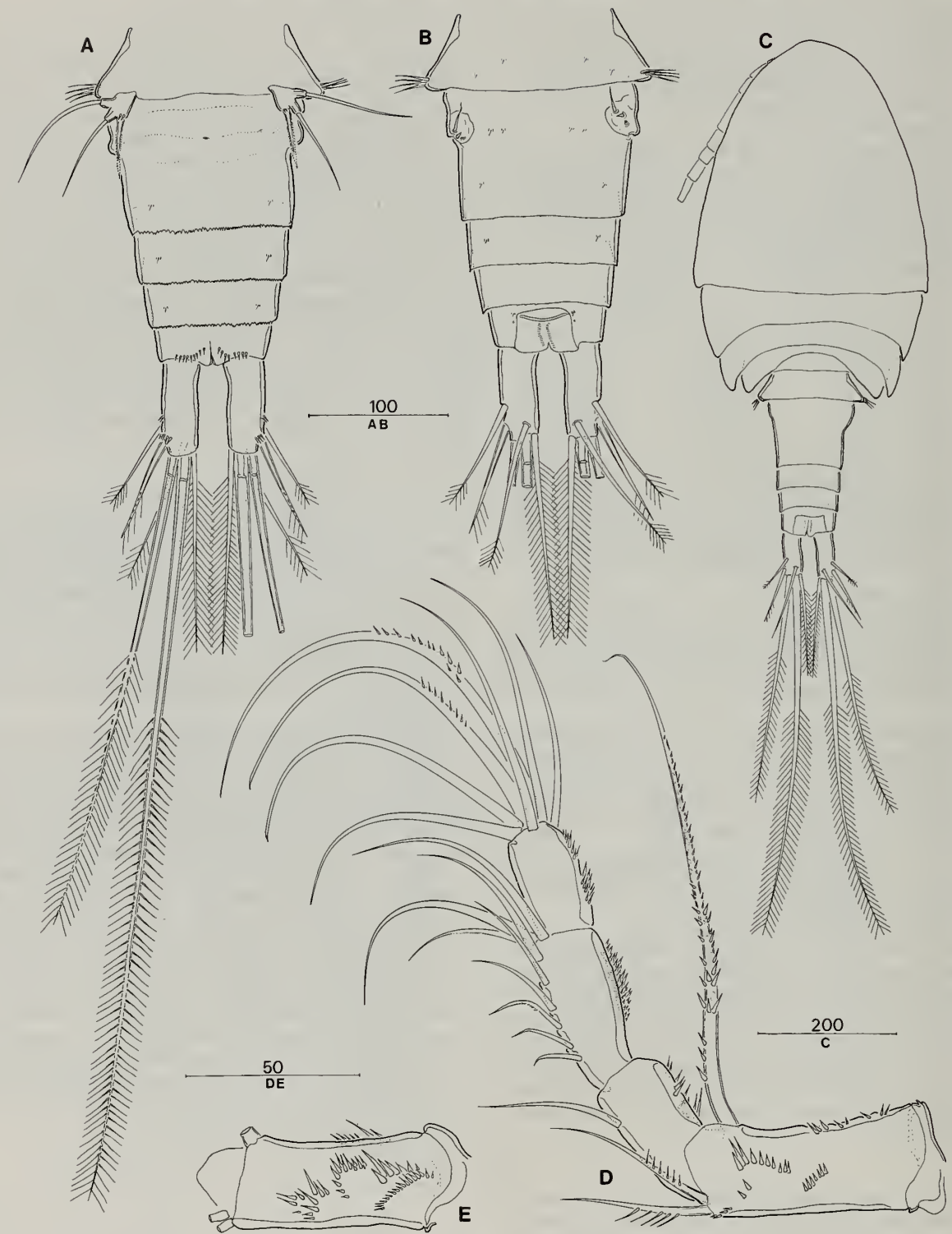

Fig. 61 *P. reidae* sp. nov. Adult female. A, urosome, ventral; B, urosome, dorsal; C, body, dorsal; D, antenna, caudal; E, antenna, coxobasis, frontal. Scale bars in μm.

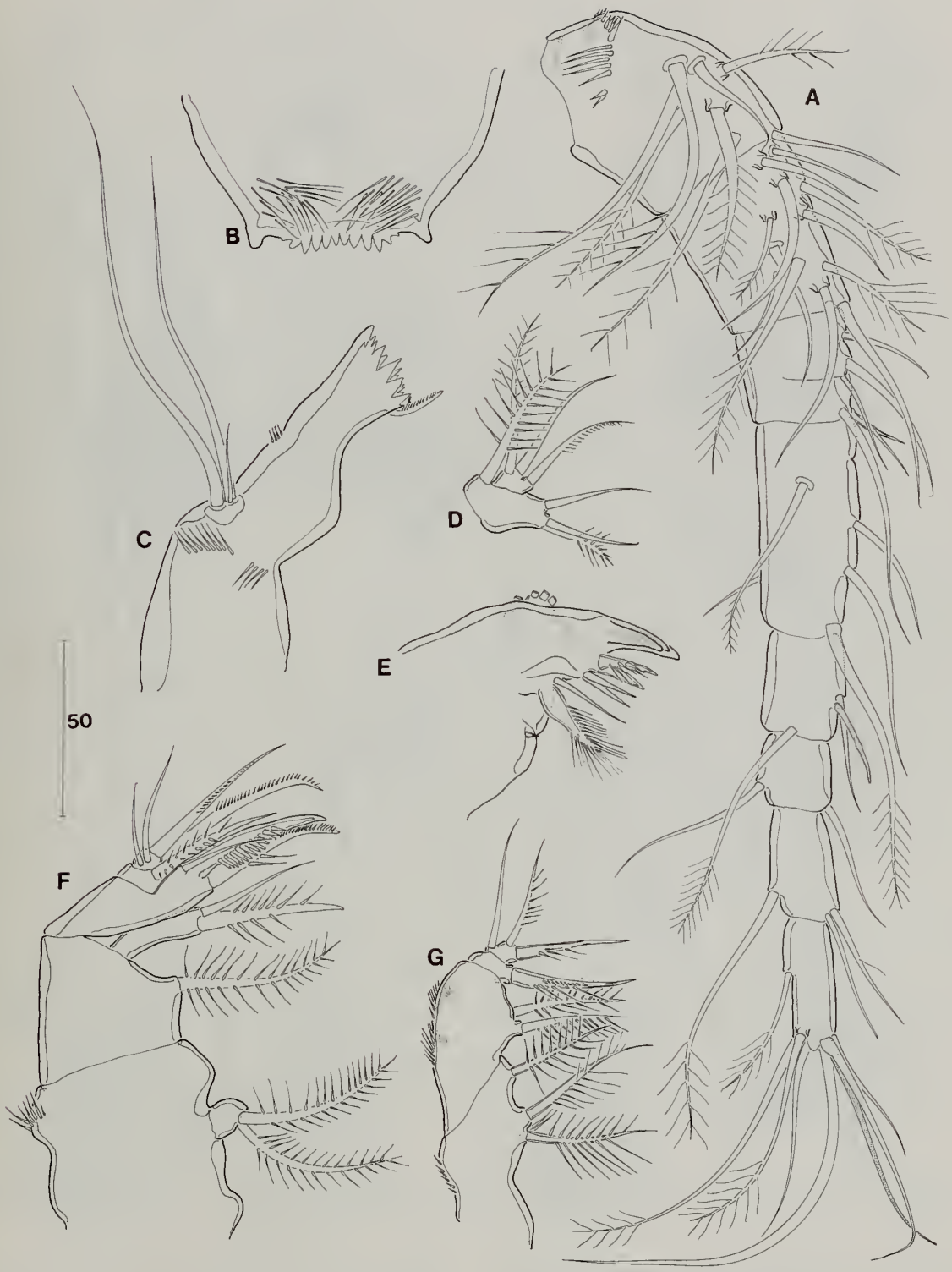

Fig. 62 *P. reidae* sp. nov. Adult female. A, antennule; B, labrum; C, mandible; D, maxillulary palp; E, maxillule; F, maxilla; G, maxilliped. Scale bar in µm.

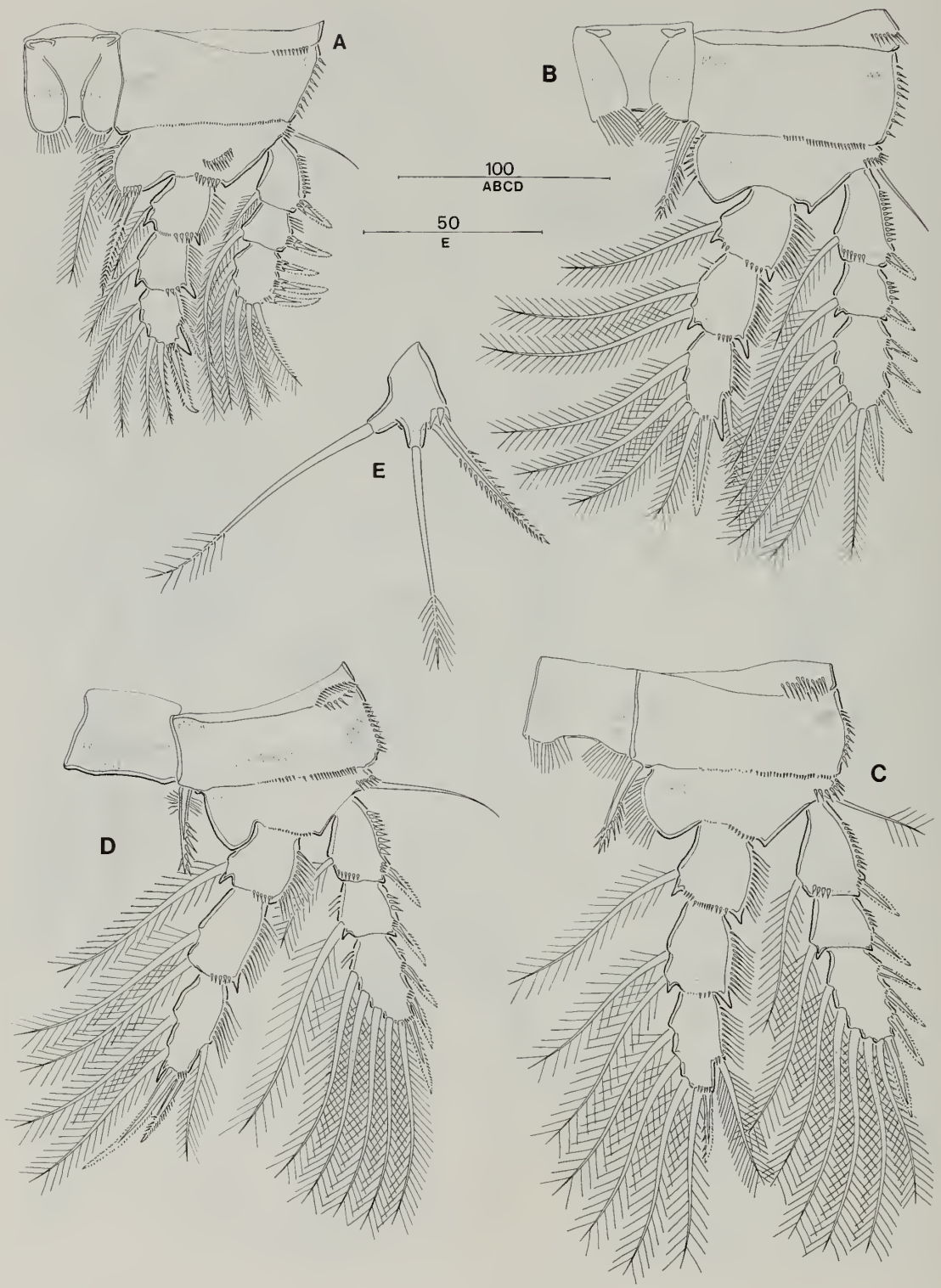

Fig. 63 *P. reidae* sp. nov. Adult female. A, leg 1, anterior; B, leg 2, anterior; C, leg 3, anterior; D, leg 4, anterior; leg 5, ventral. Scale bars in μm.

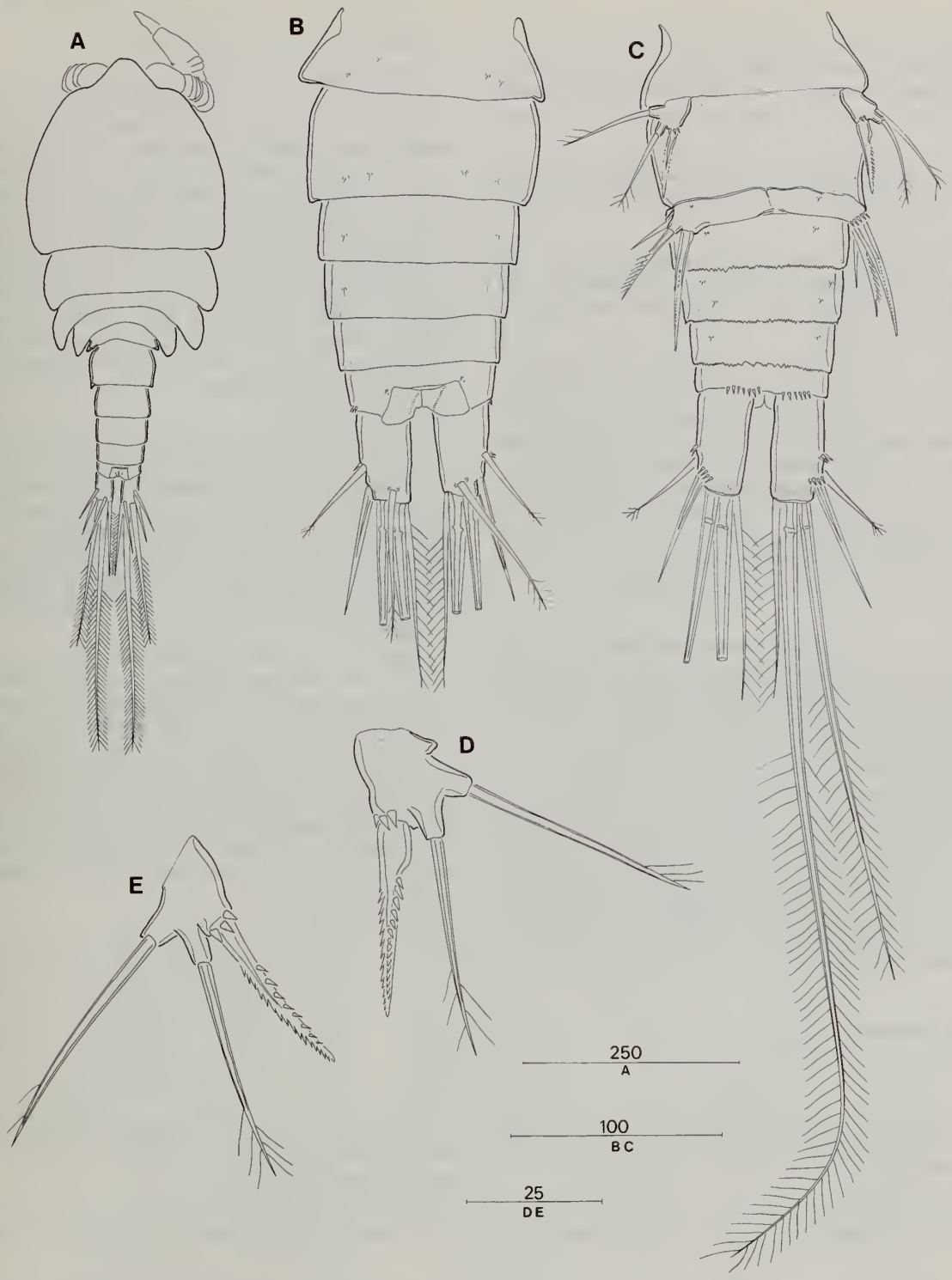

Fig. 64 *P. reidae* sp. nov. Adult male. A, body, dorsal; B, urosome, dorsal; C, urosome, ventral; D, abnormal leg 5 (right), ventral; E, normal leg 5 (left), ventral. Scale bars in µm.

long (almost twice as long as inner spine) well developed outer spinulose seta, 1 inner spine, 1 plumose seta in centre. Leg 6 (Figure 65A) represented by 1 plumose seta and 2 tiny spinules dorsolaterally.

DESCRIPTION OF ADULT MALE

Body length and width measurements given in Table 5. Genital somite with fine surface pits on dorsal surface, other somites without surface pits (Figure 69A,D). Caudal rami, short, only twice as long as broad, with inner margin convex distally (Figure 69A,D). First segment of antennule armed with 8 setae plus aesthetasc; 1 seta (A) large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally.

One seta on terminal endopodal segment of leg 1 spinulose (Figure 67C). Outer seta of fifth leg plumose and less well developed (Figure 69B) than in female; sixth leg (Figure 69C,D) armed with 1 inner spine, about as long as second urosomal somite, bearing spinular row at base, and 2 outer plumose setae, middle seta short and stout.

VARIABILITY. Specimens from Juréia Ecological Reserve and Salesópolis were blackish in colour whilst specimens from Miracatu were pale brown.

ETYMOLOGY. The species name is derived from the *Bromeliaceae*, name of the family of plants providing a microhabitat for this species, and from *colere* meaning to inhabit. It refers to the preferred cryptic habitat of the species.

DIFFERENTIAL DIAGNOSIS. The new species can be differentiated from other *Paracyclops* species by the combination of the following characters: by the long (almost twice as long as inner spine) and well developed outer spinulose seta of leg 5 (Figure 65C), by the structure of the seminal receptacle (Figure 65B), by the absence of a mid-distal spinular row on the posterior surface of leg 2 (arrowed in Figure 67B) and leg 3 (arrowed in Figure 68B) and by the absence of surface pits from the dorsal and ventral surfaces of all urosomal somites except the genital double-somite, which has very fine surface pits on the dorsal surface as figured (Figure 65A,B).

REMARKS

P. bromeliacola is closely related to the other new Brazilian species, *P. rochai* sp. nov. and *P. punctatus* sp. nov. They share the absence of a mid-distal spinular row from the posterior surface of the coxa of leg 2 and leg 3, and they all lack the spinular row near the base of the two inner setae on the coxobasis of the antenna in both sexes (arrowed in Figure 66C). However *P. bromeliacola* differs from *P. rochai* and *P. punctatus* in the long (almost twice as long as inner spine) and well developed outer spinulose seta of leg 5 (Figure 65C) and in the structure of the seminal receptacle (Figure 65B). It also differs from *P. punctatus* in the absence of surface pits from the dorsal and ventral surfaces of the urosomal somites except the genital double-somite of the female and genital somite of the male, both of which have very fine surface pits on the dorsal surface as figured (Figures 65A,B; 69A,D).

Paracyclops punctatus sp. nov.

(FIGURES 70–73)

TYPE LOCALITY. Brazil, State of Sergipe, Riachão do Dantas (11°02'S, 37°45'W), 24 July 1986, Carlos E. F. Rocha col. In leaf pools in soil bromeliads in an Atlantic rain forest remnant.

TYPE MATERIAL. Holotype: (Museu de Zoologia, São Paulo, Brazil. MZUSP 12792) female dissected on 5 slides. Paratypes 2♀♀, 3♂♂(BMNH 1997. 1824–1834). 4♀♀, 4♂♂in Museu de Zoologia, São Paulo, Brazil (MZUSP 12793).

DESCRIPTION OF ADULT FEMALE

Body length (μm) not including caudal setae, 630–711, mean = 681, n = 5; body width 274–309, mean = 292, n = 5. Genital double-somite, second and third abdominal somites ornamented with conspicuous surface pits on dorsal (Figure 70A) and ventral (Figure 70B) surfaces as figured. Genital double-somite widest anteriorly, narrowing posteriorly. Seminal receptacle as figured (Figure 70B). Third and fourth urosomal somites with well-developed hyaline frill dorsally on posterior margin (Figure 70A). Caudal rami 2.8 times longer than broad; with cuticular depressions on ventral surface (Figure 70B); with inner margin convex distally. Terminal accessory seta (VI) plumose and longer than posterolateral seta (III); outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figures 70B; 72B).

Antennule 8-segmented (Figure 71A,B). Segment 3 with two partial suture lines on ventral and dorsal surfaces; with spiniform seta distally. Segment 4 with partial suture line ventrally, extending dorsally (Figure 71A,B). Segment 5 with characteristic short aesthetasc. Setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc. Coxobasis of antenna with complex ornamentation on caudal (Figure 71D) and frontal (Figure 71C) surfaces; without spinular row on caudal surface near base of two inner setae (arrowed in Figure 71D).

Coxa of leg 1 without mid-distal spinular rows on posterior surface (arrowed in Figure 72F); intercoxal sclerite without spinular row on posterior surface; basis with spinular row on anterior surface (arrowed in Figure 72H). Intercoxal sclerite of leg 2 ornamented with spinular row on anterior (Figure 72G) and posterior (Figure 72E) surfaces; coxa without mid-distal spinular row on posterior surface (arrowed in Figure 72E). Intercoxal sclerite of leg 3 with 2 spinular rows on posterior surface (Figure 72D); coxa without mid-distal spinular row on posterior surface (arrowed in Figure 72D). Intercoxal sclerite of leg 4 (Figure 72C) with 2 spinular rows on posterior surface.

Spine and seta formula as follows:

	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;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 70C) comprising single free segment, armed with 1 long (1.6 times longer than inner spine) outer spinulose seta, 1 inner spine, 1 plumose seta in centre.

DESCRIPTION OF ADULT MALE

Body length (μm) not including caudal setae, 657–701, mean = 688,

Table 5 Body length (BL) and width (BW) measurements (in μm) of *Paracyclops bromeliacola* in various localities. (N = number of specimens measured)

Locality	Sex	BL (mean ± SD)	Range	BL (mean ± SD)	Range	N
Brazil (State of São Paulo)	♀	654 ± 62.1	595–741	265 ± 32.8	240–313	4
Miracatu	♂	531		210		1
Brazil (State of São Paulo)	♀	771 ± 38.5	716–847	330 ± 9.3	314–343	9
Juréia Ecological Reserve	♂	636 ± 8.1	617–647	245 ± 11.1	227–262	10
Brazil (State of São Paulo)	♀	705 ± 28.5	657–741	274 ± 14.3	254–296	10
Salesópolis	♂	636 ± 24.2	605–662	238 ± 5.4	230–242	4

Fig. 65 *P. bromeliacola* sp. nov. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral. Scale bars in µm.

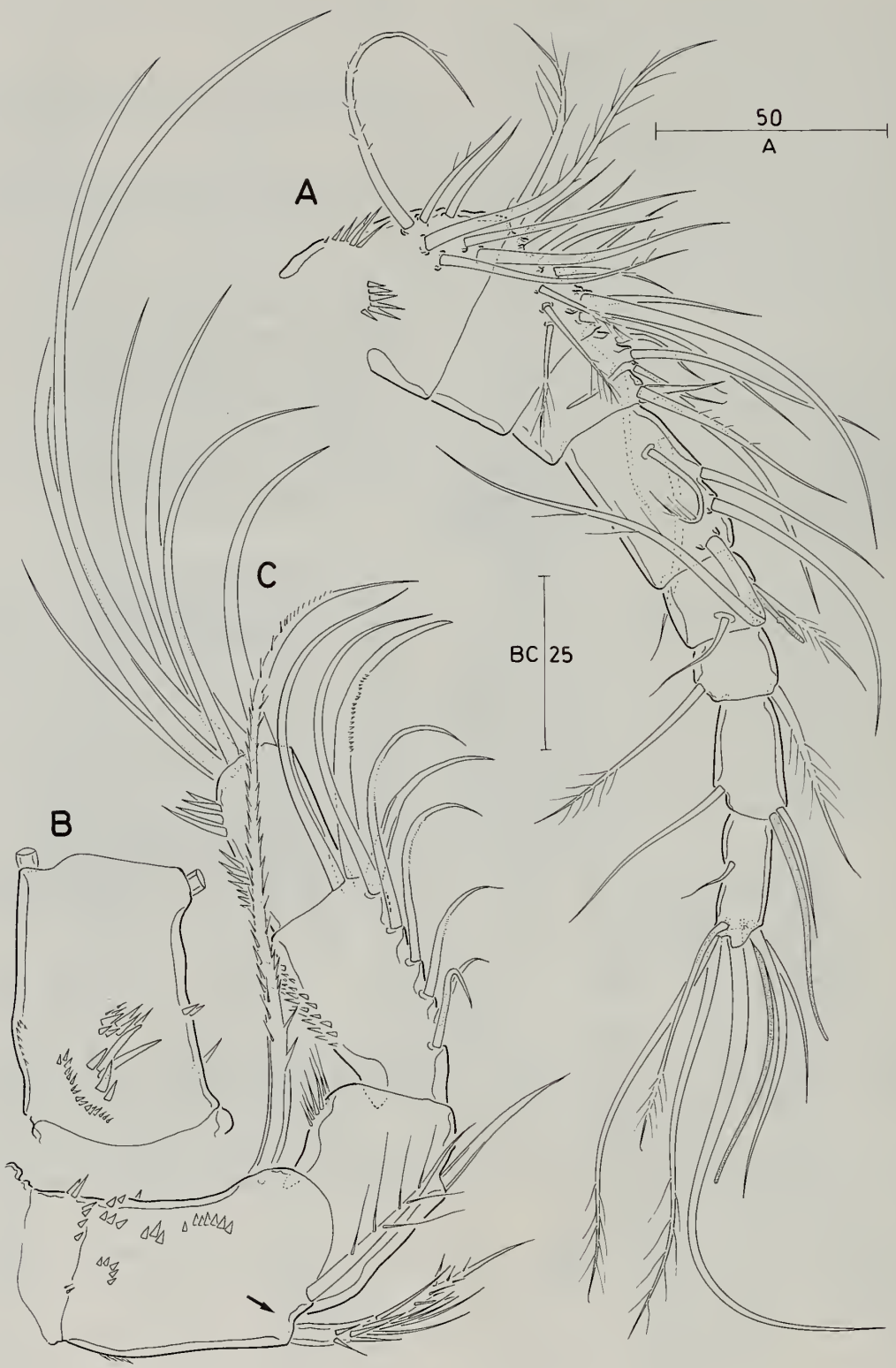

Fig. 66 *P. bromeliacola* sp. nov. Adult female. A, antennule; B, antenna, coxobasis, frontal; C, antenna, caudal. Scale bars in μm.

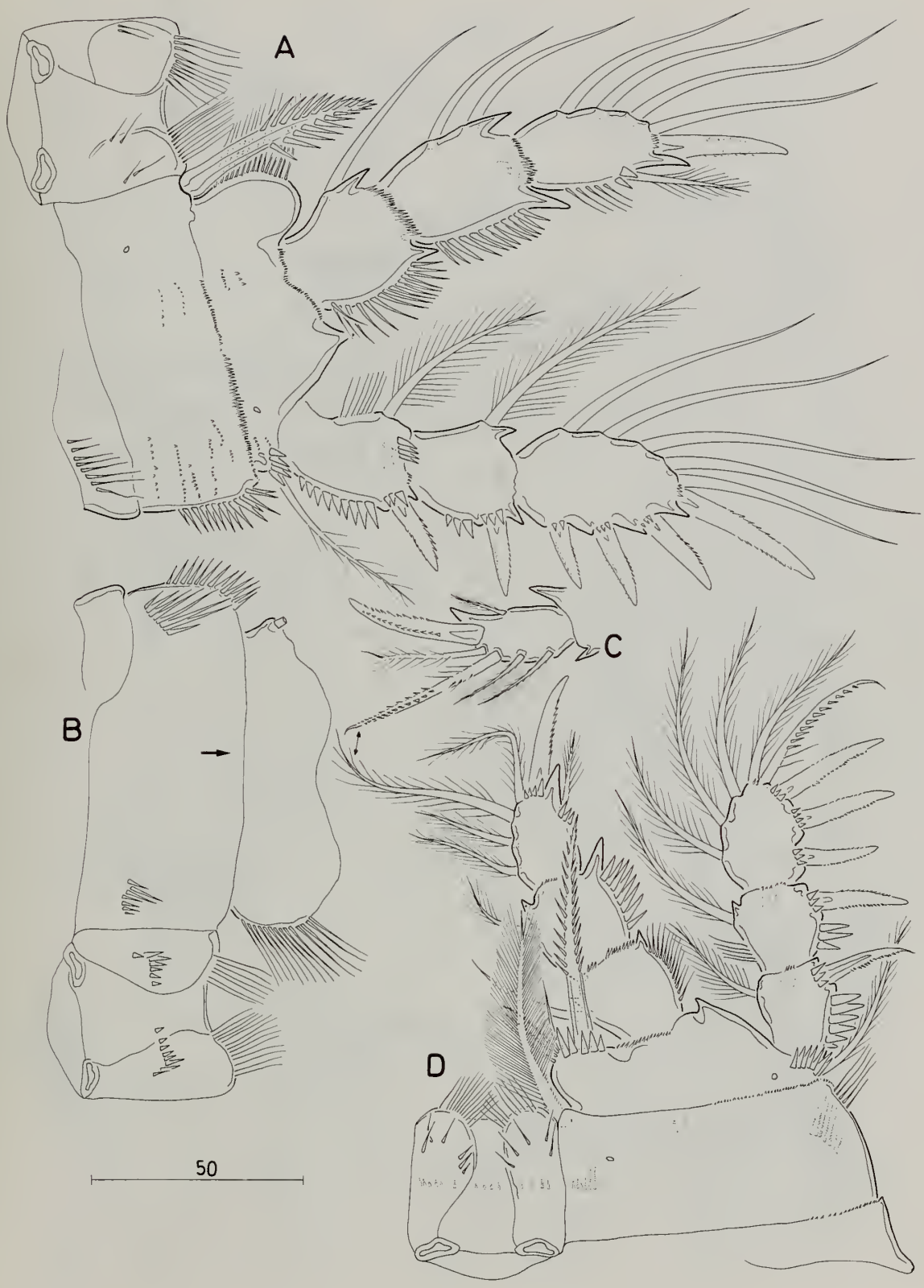

Fig. 67 *P. bromeliacola* sp. nov. Adult female. A, leg 2, anterior; B, intercoxal sclerite, coxa and basis of leg 2, posterior; C, adult male, terminal endopodal segment of leg 1, posterior; D, adult female, leg 1, anterior. Scale bar in μm.

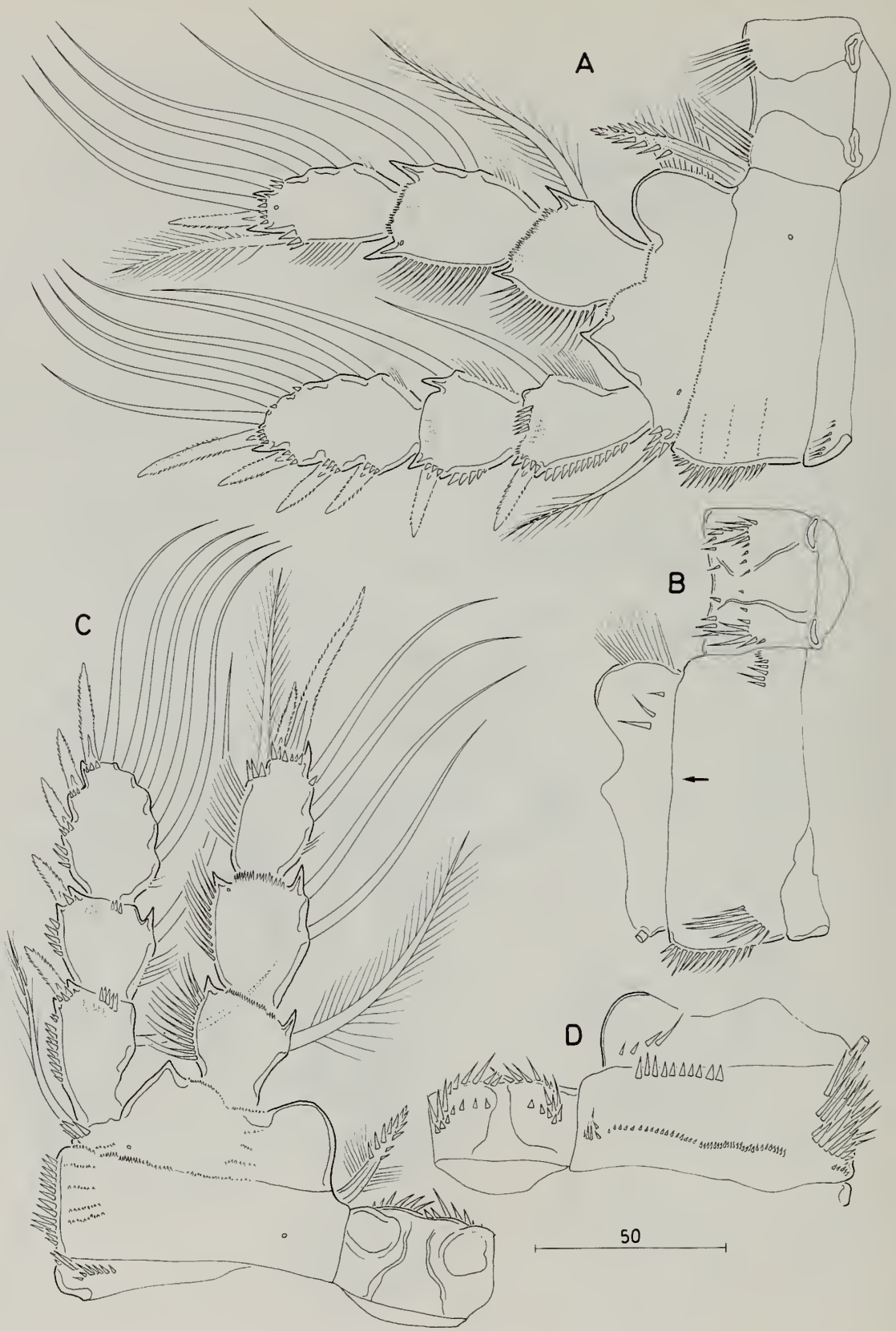

Fig. 68 *P. bromeliacola* sp. nov. Adult female. A, leg 3, anterior; B, intercoxal sclerite, coxa and basis of leg 3, posterior; C, leg 4, anterior; D, intercoxal sclerite, coxa and basis of leg 4. Scale bar in μm.

Fig. 69 *P. bromeliacola* sp. nov. Adult male. A, urosome, dorsal; B, leg 5, ventral; C, leg 6, anteroventral; D, urosome, ventral. Scale bars in µm.

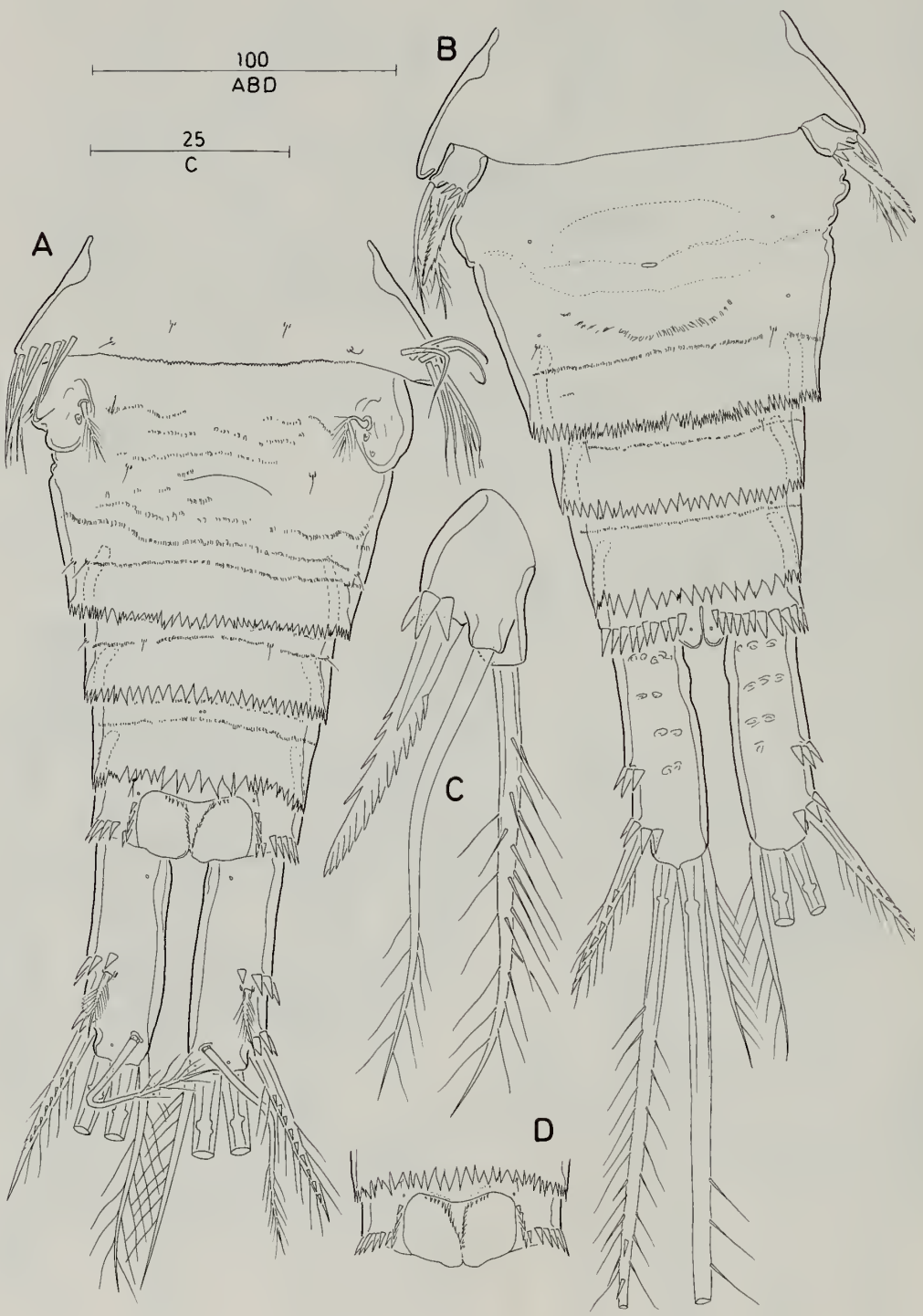

Fig. 70 *P. punctatus* sp. nov. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral; D, anal somite, dorsal. Scale bars in µm.

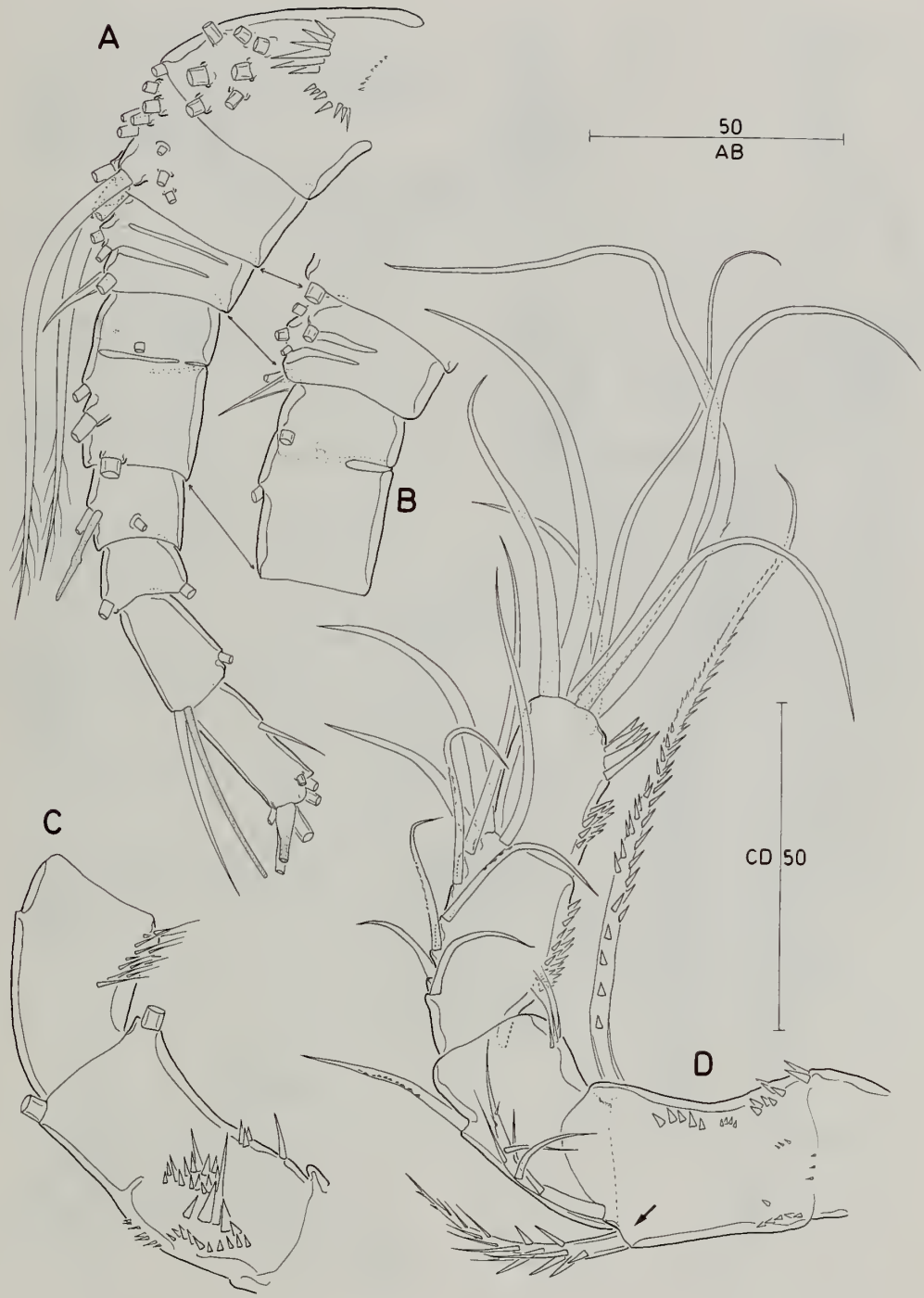

Fig. 71 *P. punctatus* sp. nov. Adult female. A, antennule; B, antennule showing variant pattern of segmentation; C, antenna, coxobasis and first endopodal segment, frontal; D, antenna, caudal. Scale bars in µm.

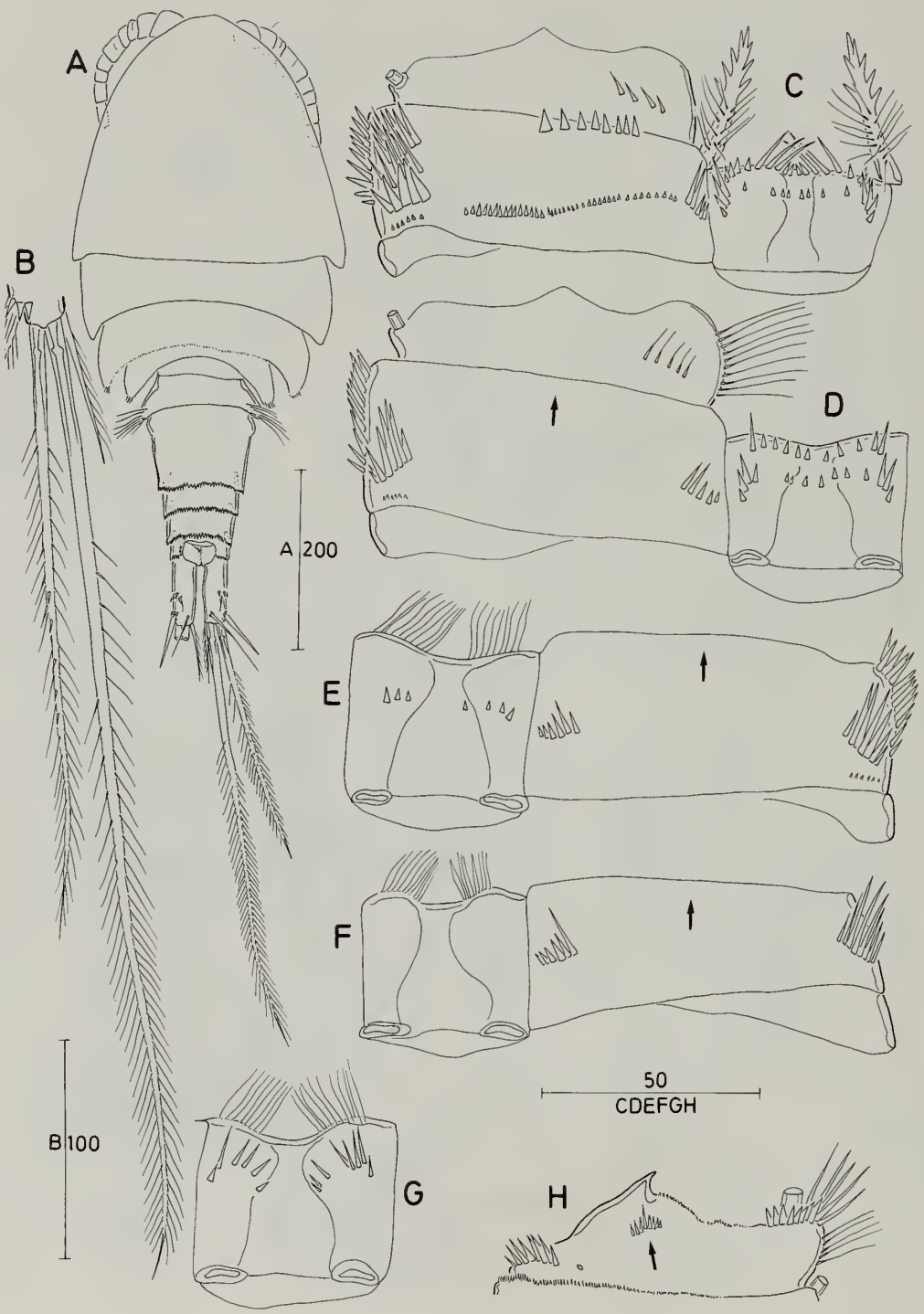

Fig. 72 *P. punctatus* sp. nov. Adult female. A, body, dorsal; B, detail of setal elements of caudal rami, dorsal; C, intercoxal sclerite, coxa and basis of leg 4, posterior; D, intercoxal sclerite, coxa and basis of leg 3, posterior; E, intercoxal sclerite and coxa of leg 2, posterior; F, intercoxal sclerite and coxa of leg 1, posterior; G, intercoxal sclerite of leg 2, anterior; H, basis of leg 1, anterior. Scale bars in µm.

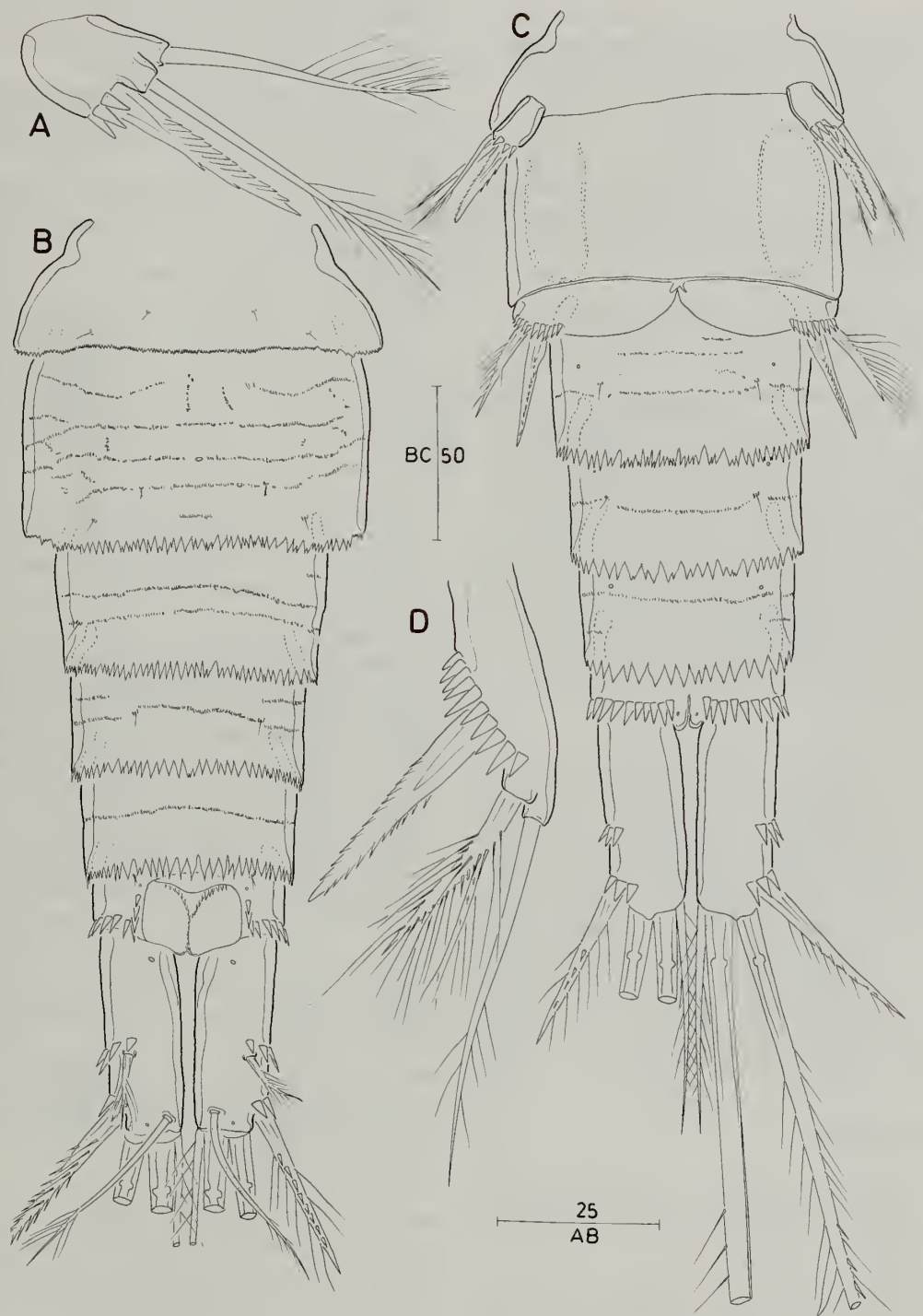

Fig. 73 *P. punctatus* sp. nov. Adult male. A, leg 5, ventral; B, urosome, dorsal; C, urosome, ventral; D, leg 6, ventral. Scale bars in μm.

n = 5; body width 274–291, mean = 279, n = 5. Genital, third, fourth and fifth urosomal somites ornamented with cuticular pits on dorsal surfaces (Figure 73B,C). First segment of antennule armed with 8 setae plus an aesthetasc; 1 seta (A) large and modified by ornamentation of strong spinules in proximal and mid sections, tapering to fine point distally.

Spinular ornamentation of the coxobasis of the antenna as in the female. Outer seta of fifth leg plumose and less well developed than in female (Figure 73A). Sixth leg (Figure 73D) armed with 1 inner spine, shorter than second urosomal somite, and 2 outer plumose setae; middle seta ornamented with long setules.

VARIATION, FEMALE. The extent of the partial suture line on the fourth segment of the antennule varies (Figure 71A,B); it may be shorter than in the figured specimens. The dorsal hyaline frill on the posterior margin of the third urosomal somite may be more or less well developed (cf. Figure 70A and Figure 70D).

ETYMOLOGY. The name of the new species is derived from the Latin *punctum* meaning point. It refers to the ornamentation of cuticular pits on the surface of the urosomal somites.

DIFFERENTIAL DIAGNOSIS. The new species differs from other *Paracyclops* species by the combination of the following characters: the presence of conspicuous surface pits on the dorsal (Figure 70A) and ventral (Figure 70B) surfaces of the genital double-somite, and the second and third abdominal somites of the female, the structure of leg 5, the absence of a mid-distal spinular rows on the posterior surfaces of leg 1 (arrowed in Figure 72F), leg 2 (arrowed in Figure 72E) and leg 3 (arrowed in Figure 72D), the presence of integumental pits on the ventral surface of the caudal rami (Figure 70B), the subdivision of the fourth segment of the female antennule (Figure 71A,B), and the absence of a spinular row on the caudal surface of the antennal coxobasis near the base of the two inner setae in both sexes (arrowed in Figure 71D).

REMARKS

P. punctatus is closely related to the other new Brazilian species, *P. rochai* and *P. bromeliacola*. They share the absence of a mid-distal spinular row from the posterior surface of the coxa of leg 2 and leg 3, and they all lack the spinular row near the base of the two inner setae on the coxobasis of the antenna in both sexes (arrowed in Figure 71D). However *P. punctatus* differs from *P. rochai* and *P. bromeliacola* in the presence of conspicuous surface pits on the dorsal (Figure 70A) surface of the genital double-somite, and the second and third abdominal somites of the female, in the structure of the seminal receptacle (Figure 70A), in the subdivision of the fourth segment of the female antennule (Figure 71A,B) and in the weakly developed outer seta of leg 5 of the female (Figure 70C).

Paracyclops rochai sp. nov.

(Figures 74–76)

TYPE LOCALITY. Brazil, State of Sergipe, Itabaina Mountains, at gruta, near to Areia Branca, 6/11/1993, Carlos E. F. da Rocha collection.

TYPE MATERIAL. Holotype: (Museu de Zoologia, São Paulo, Brazil. MZUSP 12794) female dissected on 4 slides. Paratypes: 8♀♀, and 8♂♂ (BMNH 1997. 1840–1870). 7♀♀, 7♂♂in Museu de Zoologia, São Paulo, Brazil (MZUSP 12795).

DESCRIPTION OF ADULT FEMALE

Body length (μm) not including caudal setae, 506–674, mean = 596, n = 10; body width 204–247, mean = 227, n = 10. Urosomal somites (Figure 74A,B) without surface pits on dorsal and ventral surfaces. Seminal receptacle as figured (Figure 74B). Caudal rami (Figure 74A,B) parallel and about 2.7 times longer than broad; terminal accessory seta (VI) plumose and about as long as posterolateral seta (III); outer terminal seta (IV) and inner terminal seta (V) well developed and heterogeneously ornamented (Figure 74B).

Antennule 8-segmented (Figure 75A); segment 3 with two partial suture lines and spiniform seta. setal formula 8, 12, 6, 5, 2 + aesthetasc, 2, 2 + aesthetasc, 7 + aesthetasc.

Coxobasis of antenna with complex ornamentation on caudal (Figure 75B) and frontal (Figure 75C) surfaces as figured and without spinular row near base of two inner spinulose setae (arrowed in Figure 75B).

Coxa of leg 1 without mid-distal spinular row on posterior surface. Intercoxal sclerite of leg 4 with 2 spinular rows on posterior surface (Figure 75G).

Spine and seta formula as follows:

	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	1–1;I–1;II,I,5	0–1;0–2;1,II,2

Leg 5 (Figure 74C) comprising single free segment, armed with 1 long (almost twice as long as inner spine), well developed outer spinulose seta, 1 strong inner spine with 3 spinules at base. Other appendages as in *P. bromeliacola*.

DESCRIPTION OF ADULT MALE

Body length (μm) not including caudal setae, 459–560, mean = 519, n = 10; body width 185–205, mean = 196, n = 10. Urosomal somites without surface pits on dorsal (Figure 76B) and ventral (Figure 76B) surfaces, except that some fine pits visible on genital somite on dorsal surface. First segment of male antennule armed with 8 setae plus an aesthetasc; 1 seta (A) large and modified by ornamentation of strong spinules in proximal and mid sections.

Spinular rows on posterior surface of intercoxal sclerite of leg 4 well developed (Figure 75F). Outer seta of leg 5 plumose and about as long as inner spine (Figure 76C). Sixth leg (Figure 76C) armed with 1 inner spine, half as long as second urosomal somite.

VARIABILITY, FEMALE. The length of the terminal endopodal segment of leg 4 varied as indicated in Figure 75D,E. One female showed complete subdivision of the third segment of the antennule (Figure 75A).

ETYMOLOGY. The species is named after Prof. Carlos Eduardo Falavigna da Rocha (University of São Paulo), the collector of this material, in recognition of his many contributions to the study of cyclopoid copepods.

DIFFERENTIAL DIAGNOSIS. *P. rochai* can be differentiated from other *Paracyclops* species by the combination of the following characters: the structure of leg 5 in the female (Figure 74C), the absence of surface pits on the dorsal and ventral surfaces of the urosomal somites in the female (Figure 74A,B), and the absence of a spinular row near the base of the two inner spinulose setae in both sexes (arrowed in Figure 75B).

REMARKS

P. rochai is closely related to *P. chiltoni* and *P. punctatus*. However, it differs from *P. chiltoni* in the absence of a spinular row near the base of the two inner spinulose setae in the male (arrowed in Figure

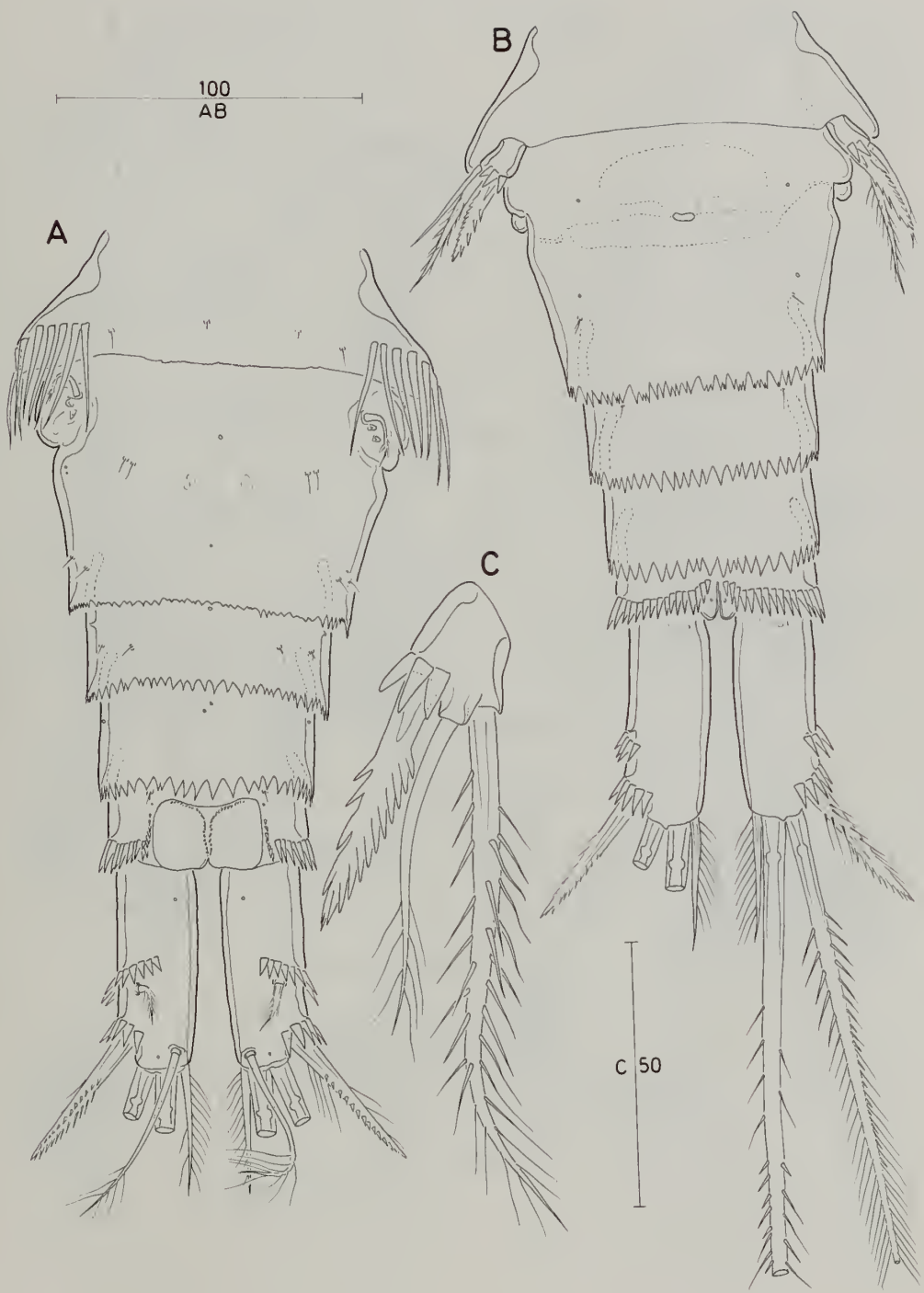

Fig. 74 *P. rochai* sp. nov. Adult female. A, urosome, dorsal; B, urosome, ventral; C, leg 5, ventral. Scale bars in µm.

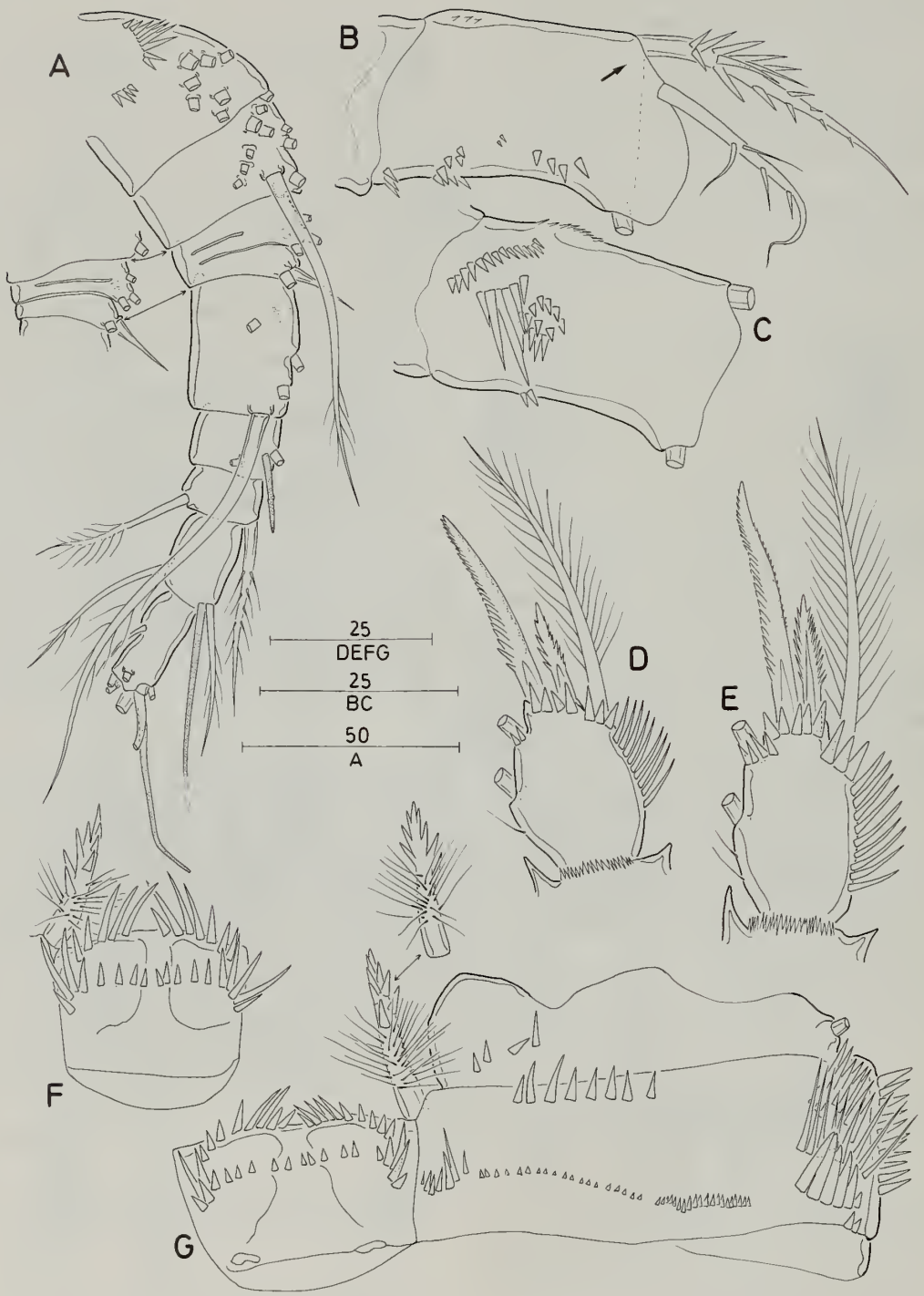

Fig. 75 *P. rochai* sp. nov. Adult female. A, antennule with inset showing variant pattern of segmentation; B, antenna, coxobasis, caudal; C, antenna, coxobasis, frontal; D, terminal endopodal segment of leg 4, anterior; E, same, another specimen; F, adult male, intercoxal sclerite of leg 4, posterior; G, adult female, intercoxal sclerite, coxa and basis of leg 4, posterior. Scale bars in μm.

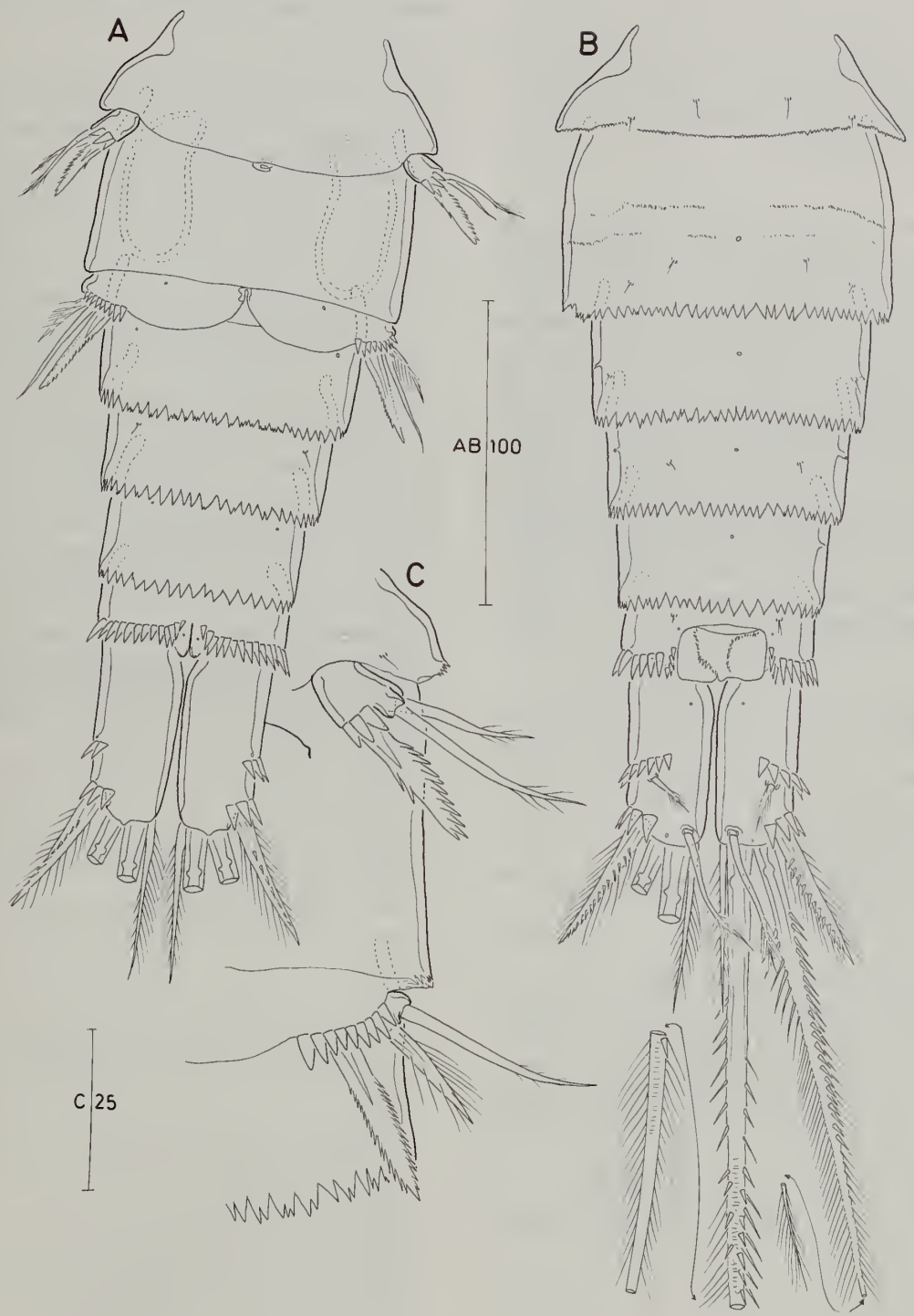

Fig. 76 *P. rochai* sp. nov. Adult male. A, urosome, ventral; B, urosome, dorsal; C, detail of leg 5 and leg 6, ventral. Scale bars in μm.

75B), by the length of the outer seta of leg 5 in the female (Figure 74C), by the absence of surface pits on the dorsal and ventral surfaces of the urosomal somites in the female (Figure 74A,B), and by the absence of integumental pits on the ventral surface of the caudal rami in the female (Figure 74B).

P. rochai differs from *P. punctatus* by the absence of surface pits on the dorsal and ventral surfaces of the urosomal somites in the female (Figure 74A,B), by the absence of integumental pits on the ventral surface of the caudal rami in the female (Figure 74B), by the structure of leg 5 (Figure 74C) and by the ornamentation of the outer terminal seta (IV) and the inner terminal seta (V) of the caudal rami in both sexes (Figure 74B; 76B).

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First records and a new subspecies of *Rhinolophus stheno* (Chiroptera, Rhinolophidae) from Vietnam.

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Synopsis. The recently discovered populations of *Rhinolophus stheno* from North Vietnam, along with specimens previously collected in Thailand, are described as a new subspecies, *Rhinolophus stheno microglobosus*. The median anterior rostral swellings of the new subspecies are notably smaller than those of the nominate subspecies. A morphological and statistical comparison is given between the two subspecies of *R. stheno*, and the closely related *R. malayanus*.

INTRODUCTION

Rhinolophus stheno Andersen, 1905 was originally described from peninsular Malaysia. The known range of the species was later extended to Thailand (Lekagul & McNeely, 1977), Sumatra and Java (Corbet & Hill, 1992; Koopman, 1994) and Tioman Island, off the coast of Malaysia (Csorba et al., 1997). Recent expeditions to Vietnam led by British and Hungarian researchers have discovered the first specimens of *R. stheno* to be recorded from that country. Comparative examination of these specimens with other populations in the collections of The Natural History Museum, London revealed that specimens from Vietnam were most similar to those from Thailand, and that both were sufficiently different from material from Malaysia, Sumatra and Java to represent an undescribed subspecies.

Andersen (1905) considered *R. stheno* to belong to the *borneensis* subgroup of the *simplex*-group of *Rhinolophus*, which Tate & Archbold, 1939 subsequently termed the *ferrumequinum*-group. Andersen distinguished *R. stheno* from other members of the *borneensis* sub-group by the much more projecting anterior nasal swellings of the rostral part of the skull. Lekagul & McNeely (1977) reported that *R. stheno* resembles *R. malayanus* Bonhote, 1903 but that the two are separable by a set of external features (body size, shape of lancet and relative proportions of the first and second phalanges of the third digit). Subsequently, McFarlane & Blood (1986) concluded that, although there are no reliable differences between *R. stheno* and *R. malayanus* in these features, they are instead distinguishable by supraorbital and rostral characters of the cranium. They suggested that the general similarity of the noseleaf and skull of *R. stheno* and *R. malayanus* implied a closer relationship than formerly supposed. This view was accepted by Corbet & Hill (1992), who continued to group both species in the *ferrumequinum* group, and keyed the two species on the basis of the shape and size of the anterior and posterior rostral compartments. Bogdanowicz (1992), in a phenetic analysis of the whole family, proposed different group-level classifications for the two species (*R. malayanus* in the *megaphyllus* group but *R. stheno*, with a question mark indicating uncertainty, in the *euryotis* group).

Specimens of *R. malayanus* and *R. borneensis* Peters, 1861 were also collected during the recent expeditions, confirming the presence of *R. borneensis* in Vietnam (see Hill & Thonglongya, 1972, Corbet & Hill, 1992 and discussion below). In view of the various theories outlined above concerning the relationship between *R. stheno* and *R. malayanus*, morphological comparisons and a Principal ComponentsAnalysis are given below between the two subspecies of *R. stheno* and *R. malayanus*.

MATERIALS AND METHODS

All available specimens were included in the morphological comparisons but for the multivariate analysis, which requires the use of complete sets of measurements, the reduced number of specimens is given in parentheses as follows: 12 (8) specimens of *R. s. microglobosus* described below, 21 (13) specimens of the nominate subspecies of *R. stheno* (from Sumatra, Java and Malaysia) and 14 (11) specimens of *R. malayanus* (from Thailand and Malaysia).

External measurements, to the nearest 0.1 mm, were taken from dry and alcoholic museum specimens using digital calipers. Cranial measurements, to an accuracy of 0.01 mm, were collected using digital calipers and a binocular microscope. Characters for the multivariate analysis included one external and nine cranial measurements, as follows, with the abbreviation in parentheses:

1. forearm length (FA)
2. greatest skull length (GSL) – measured from the anterior of the canine to the posteriormost part of the occiput;
3. maxillary toothrow length (MTL) – the crown length from the anterior of the upper canine (C) to the posterior of the third upper molar (M3);
4. zygomatic width (ZW) – the greatest distance across the zygoma;
5. mastoid width (MW) – the greatest distance across the mastoid region of the braincase;
6. mandible length (ML) – the distance from the most posterior portion of the articular process to the anteriormost edge of the alveolus of the first lower incisor (i1);
7. lower toothrow length (LTL) – the crown length from the anterior of the lower canine (c) to the posterior of the third lower molar (m3);
8. interorbital width (IW) – the least width of the interorbital constriction;

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9. rostral swelling width (RSW) – the greatest width of the nasal swellings;
10. median anterior rostral swelling width (MARW) – greatest width in dorsal view.

To reveal the taxonomic differences and relations between the taxa included in this study the Mann-Whitney U Test and Principal Component Analysis (PCA) were used. For the univariate analysis a non-parametric method was applied since the raw data did not meet the criteria for a normal distribution based on the F-test Both statistical methods were performed by Statistica 5.1, 1984–1995 statistical programme of StatSoft Inc. run on a 486 PC.

Abbreviations used for institutions are: BMNH – The Natural History Museum, London, formerly the British Museum (Natural History); HNHM – Hungarian Natural History Museum, Budapest; MNHN – Muséum National d'Histoire Naturelle, Paris; IEBR – Institute of Ecology and Biological Researches, Hanoi.

RESULTS

Rhinolophus stheno microglobosus ssp. nov.

Figs 1–4, Table 1

HOLOTYPE. BMNH 1997.360 (field number 9601/B11), adult male in alcohol, skull extracted, collected by members of 'Frontier' the Society for Environmental Exploration – Vietnam, between 17 January and 18 March 1996.

TYPE LOCALITY. Na Hang Nature Reserve, Tuyen Quang Province, Vietnam, between 22°16' and 22°31'N, 105°22' and 105°29'E, altitude 100–1082 m. Highly diverse evergreen and semi-evergreen primary limestone rainforest (see Hill & Kemp, 1996).

PARATYPES. The same collection data as the holotype: BMNH 1997.359 (field number 9601/B10) adult female in alcohol, skull extracted; BMNH 1997.361 (field number 9601/B25) adult male in alcohol, skull extracted; BMNH 1997.362 (field number 9601/B28) adult female in alcohol; 2 km SE of Pac Ban, Na Hang Nature Reserve, Tuyen Quang Province, Vietnam, 22°19'N, 105°25'E, altitude 300 m, 3 March 1997, collected by Gábor Csorba and Pham Duc Tien: HNHM 98.1.1. (field number CSOVI 30) adult female, skin, skull and skeleton; HNHM 98.1.2–3. (field number CSOVI 32, 33) adult males, in alcohol, skull extracted; IEBR (not catalogued, field number CSOVI 31) adult female, in alcohol, skull extracted.

Referred material: Tham Tap Tao, Fang, Chiangmai, Thailand, 19°55'N 99°13'E BMNH 1978.974, adult female in alcohol, skull extracted, BMNH 1978.2301, adult skull only; Chanthaburi, Pong Nam Ron, Khao Soi Dao Tai, Thailand, 12°36'N 102°09'E 850 m: BMNH 1978.2298–2300, adult skulls only.

COMPARATIVE MATERIAL. *Rhinolophus stheno stheno* –West Malaysia: Selangor (BMNH 1898.3.13.1 [holotype], 1898.3.13.2–3, 1973.606–607); Gunong Benom, Pahang (BMNH 1967.1492, 1967.1494, 1967.1497, 1967.1533–1534); Batu Pahat, Kangar, Perlis (BMNH 1968.817–818); Tioman Island (HNHM 95.55.2–4); Indonesia: Saekaranda, N. E. Sumatra (BMNH 1907.1.9.2, MNHN 1903.3); Kalipoetjang, Tji-Tandoei River, Java (BMNH 1909.1.5.179–182).

Rhinolophus malayanus – Thailand: Biserat, Jalor (BMNH 1903.2.6.83 [holotype], 1903.2.6.84, 1908.2.5.24–25); Phu Nam Tok, Saraburi (BMNH 1970.1462); Phu Nam Tok Tap Kuang, Khaeng Khoi, Saraburi (BMNH 1978.973); Satun, Muang, Wang Bla Chan (BMNH 1978.2295); Chiangmai, Fang, Tham Tap Tao (BMNH 1978. 2296–2297); West Malaysia: Batu Pahat, Kangar, Perlis (BMNH 1968.812); Kisap Forest Reserve, Pulau Langkawi (BMNH 1968.813–816).

DIAGNOSIS. Anterior median rostral compartments abruptly elevated but narrow and globular in outline; posterior median rostral compartments very small but slightly inflated dorso-laterally. Skull slender, rostral swelling width < 5.1, zygomatic and mastoid width < 9.1.

DESCRIPTION. A medium-sized horseshoe bat belonging to the *ferrumequinum* group (*sensu* Corbet & Hill, 1992), forearm length 43.8–47.2, mean 45.46, SD 1.21, n = 8; head and body length 38.8–45.2, mean 43.39, SD 2.73, n = 8; tail length 17.7–23.0, mean 20.0, SD 1.49, n = 8; hindfoot length 7.8–8.4, mean 8.0, SD 0.18, n = 8; ear length 16.9–18.7, mean 17.89, SD 0.64, n = 8; weight 9–9.5 grams, mean 9.33, SD 0.24, n = 3. Ear medium in length, just reaching the tip of nose when laid forward. Noseleaf with sella almost parallel-sided, only narrowing very slightly, rounded at tip; the connecting process rounded, typical for the *ferrumequinum* group; the lancet long, straight-sided, its tip cuneate; the supplementary noseleaf clearly visible; the lower lip has three groves (Fig. 1). The dorsal pelage is light yellowish-brown at the base of hairs, reddish cinnamon-brown above and c. 8 mm long, that of the venter paler and shorter. The wing membranes are uniformly dark brown. The fifth metacarpal is subequal or slightly longer than the fourth, the third shorter than fourth. Ratio of first to second phalange of third digit 1.56–1.67, mean 1.62, SD 0.04, n = 8.

Skull averaging smaller than in *R. s. stheno;* slender, rostral swelling width less than 5.1 mm, zygomatic and mastoid width subequal, not exceeding 9.1 mm (see Table 1). The anterior median rostral compartments are high and abruptly elevated but narrow and not forming the lateral walls of the rostrum, in profile they are posteriorly concave but less sharply so than in *R. s. stheno*; the posterior median rostral compartments are slightly inflated dorso-laterally so that the anterior region of the supraorbital depression is shallow and narrow, unlike the deep broad depression of *R. s. stheno*; lateral rostral compartments slightly inflated (see Fig. 2). The sagittal crest moderately developed. Palatal bridge less than one-third of the upper toothrow length. Anterior upper premolar well

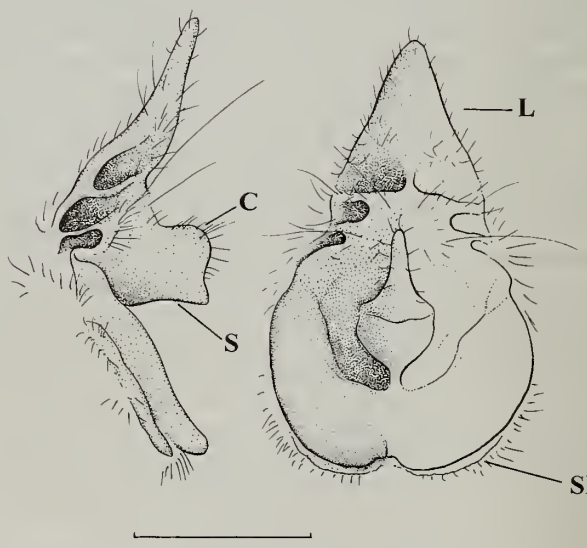

Fig. 1 Lateral (left) and frontal (right) views of noseleaves of *R. s. microglobosus* (HNHM 98.1.2. [paratype]). L = lancet; C = connecting process; S = sella; SN = supplementary noseleaf. Scale = 5 mm.

Table 1 Selected external and craniodental measurements (in mm) of *R. s. microglobosus*, *R. s. stheno* and R. *malayanus* presented as range, mean ± standard deviation and number of specimens in parentheses. Column 1: character. Column 2–4: taxon. Column 5–7: Mann-Whitney U Test p-levels between groups.

Character	Taxon			p-levels between groups		
	R. s. microglobosus	*R. s. stheno*	*R. malayanus*	*R. s. stheno–R. s. microglobosus*	*R. s. stheno–R.malayanus*	*R. s. microglobosus–R. malayanus*
FA	43.8–47.2	43.6–47.2	38.3–42.4			
	45.46± 1.21 (8)	45.55± 1.06 (21)	40.45± 1.18 (14)	0.828	0.000	0.000
GSL	18.22–19.38	18.84–19.92	17.25–17.79			
	18.73± 0.35 (10)	19.37± 0.31 (15)	17.56± 0.22 (11)	0.001	0.000	0.000
MTL	6.74–7.45	7.25–7.78	6.54–7.09			
	7.05± 0.20 (12)	7.49± 0.15 (16)	6.75± 0.16 (11)	0.001	0.000	0.001
ZW	8.81–9.06	9.29–9.75	8.47–8.94			
	8.93± 0.08 (11)	9.56± 0.16 (15)	8.77± 0.13 (11)	0.000	0.000	0.019
MW	8.71–9.07	9.09–9.66	8.14–8.45			
	8.87± 0.11 (12)	9.41± 0.16 (15)	8.23± 0.11 (11)	0.000	0.000	0.000
ML	11.83–12.85	12.59–13.31	11.18–12.08			
	12.23± 0.29 (12)	12.95± 0.21 (16)	11.79± 0.25 (11)	0.000	0.000	0.008
LTL	7.04–7.80	7.68–8.40	6.86–7.36			
	7.45± 0.22 (12)	7.98± 0.17 (16)	7.17± 0.17 (11)	0.000	0.000	0.001
IW	1.49–1.85	1.64 –2.00	2.13–2.67			
	1.66± 0.11 (12)	1.82± 0.13 (15)	2.44± 0.18 (11)	0.033	0.000	0.000
RSW	4.78–5.07	5.01–5.38	4.94–5.37			
	4.91± 0.11 (12)	5.13± 0.10 (15)	5.16± 0.12 (11)	0.001	0.885	0.002
MARW	3.53–4.00	4.13–4.36	3.99–4.41			
	3.82± 0.12 (12)	4.23± 0.07 (15)	4.15± 0.13 (11)	0.000	0.016	0.000

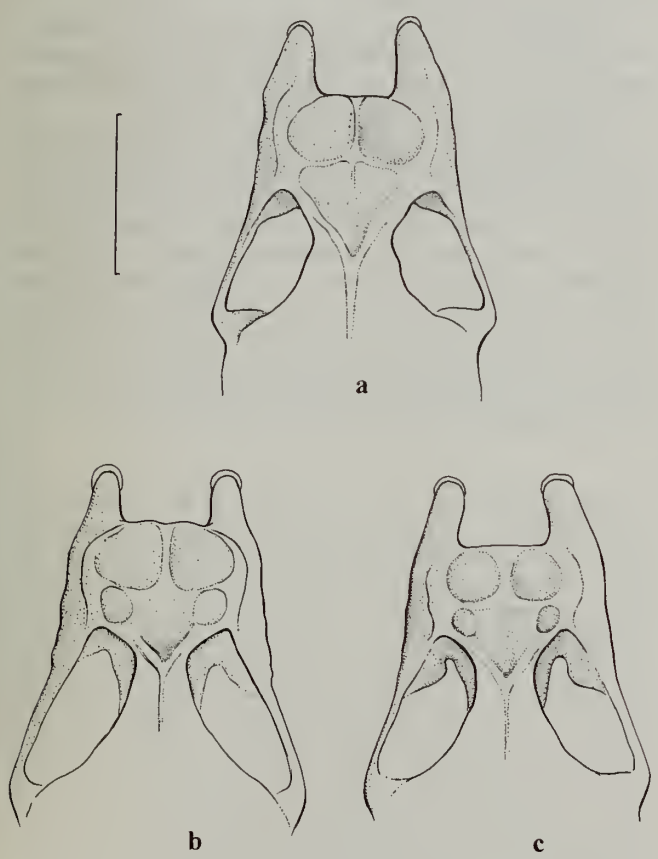

Fig. 2 Dorsal view of rostral part of skulls of a.) *R. malayanus* (BMNH 3.2.6.83 [holotype]), b.) *R. s. stheno* (BMNH 98.3.13.1 [holotype]) and c.) *R. s. microglobosus* (HNHM 98.1.1. [paratype]), Scale = 5 mm.

developed with distinct cusp, included in the toothrow. Lower middle premolar (p3) small and fully extruded from the toothrow; first (p2) and last (p4) lower premolars in contact or nearly so; p2 moderately small and narrow, antero-posterior axis only slightly displaced relative to main axis of toothrow, unlike *R. stheno stheno* in which p2 is slightly larger, overlaps more with the lower canine and p4, and in which the axis is more skewed.

ETYMOLOGY. The Latin word *microglobosus* refers to the size and shape of the median anterior rostral swellings which are considerably smaller than those of the nominate subspecies.

COMPARISONS WITH OTHER TAXA. Besides the classical morphological comparisons of the new subspecies, *R. s. microglobosus* and the nominate subspecies, *R. s. stheno*, the Mann-Whitney U Test was also performed to reveal if statistically significant differences were present in morphological characters. In the course of the analysis highly significant differences (highest $p < 0.01$) were shown in greatest skull length, maxillary toothrow length, zygomatic width, mastoid width, mandible length, lower tooth-row length, rostral swelling width and median anterior rostral swelling width; in all cases the new subspecies was smaller (Table 1).

The same method was used for pair-wise comparisons between *R. malayanus* and *R. s. steno,* and between *R. malayanus* and *R. s. microglobosus* (see Table 1 for p-levels between groups). Significant differences (at $p < 0.01$) were shown for the following variables: forearm length, greatest skull length, lower toothrow length, mastoid width, in which *R. malayanus* was smaller in each parameter, and interorbital width where *R. stheno* was smaller.

To help elucidate the relationships of the three taxa, a Principal Component Analysis (PCA) was performed using the characters recorded in Table 1. The scatterplots of the specimens *against* the factor 1 (F1) and factor 2 (F2) axes showed a *clear* separation of three groups (Fig. 3) supporting the view that *R. s. microglobosus* represents a distinct taxonomic unit. The first two factors represent more than 89% of the total variance where F2 was identified as the 'rostral

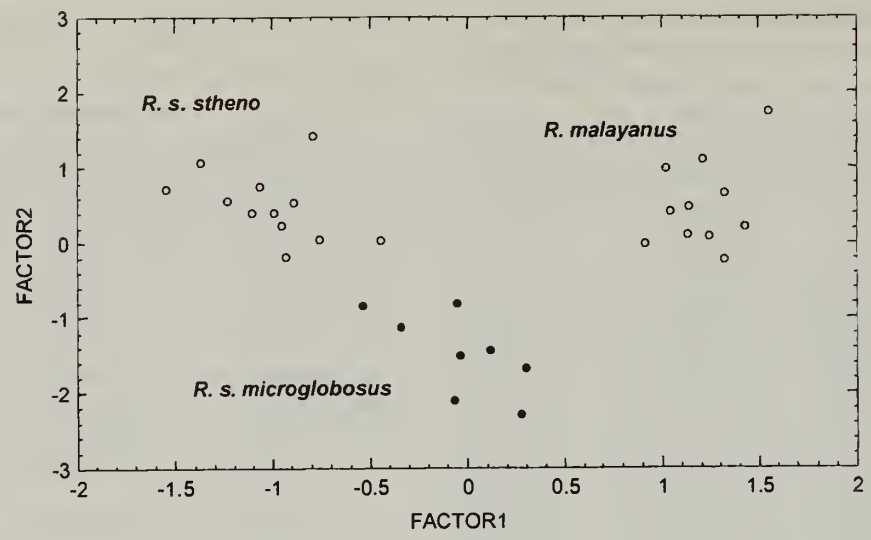

Fig. 3 Principal components analysis of *R. s. microglobosus*, *R. s. stheno* and *R. malayanus* specimens based on 10 external and craniodental characters.

swellings component' in which the two measurements of the rostrum (rostral swelling width and median anterior rostral swelling width) were the most important, and F1 pertained to the other characters (Table 2).

Table 2 Factor loadings of external and craniodental characters obtained by Principal Component Analysis

Character	Factor 1	Factor 2
Forearm length	–0.873	–0.344
Greatest skull length	–0.985	–0.040
Maxillary toothrow length	–0.954	0.075
Zygomatic width	–0.887	0.283
Mastoid width	–0.972	–0.003
Mandible length	–0.943	0.126
Lower toothrow length	–0.955	0.096
Interorbital width	0.740	0.569
Rostral swelling width	–0.050	0.929
Median anterior rostral swelling width	–0.206	0.894
Variance explained	67.67%	22.17%

DISCUSSION

The new records of *R. stheno* extend the known distribution of the species to North Vietnam, and represent a new subspecies which is characterised by its generally smaller, narrower skull and above all, by the small, globular anterior median rostral swellings.

Specimens of *R. stheno* from Thailand in the collection of The Natural History Museum also proved to belong to the new subspecies. It seems possible also, that specimens recorded by Osgood (1932: 219) refer to the same subspecies as described here. His specimens, listed as '*Rhinolophus* sp.', derived from Tonkin (North Vietnam) and Osgood stated that '. . . it is possible that the present [form] is a northern representative of the larger Malayan form *stheno*'. An alternative suggestion, that Osgood's specimens might be referable to *R. borneensis* was, however, made by Hill & Thonglongya (1972). This supposition is equally probable, as affirmed by specimens of *R. borneensis* which were also collected during the recent expeditions to Vietnam. It appears likely that the section on *R. stheno* in Lekagul & McNeely (1977) also refers to the new subspecies; unfortunately, however the accompanying photograph is of a specimen in which the diagnostic characters are not visible on the damaged rostrum.

According to the literature, *R. stheno* and the closely related *R. malayanus* may be distinguished by the shape of the rostral swellings. On the basis of our data set, the width of the interorbital constriction also distinguishes the two species (Table 1).

As regards the external characters, according to Koopman (1994) there is a definite gap between the two species in forearm length (45–48 mm against 40–43 mm) but McFarlane & Blood (1986) concluded 'that there is a probability of overlap between specimens of the two species'. Indeed, during the examination of larger series derived from different geographical regions only very slight differences may be observed between extreme values of forearm length of small *R. stheno* and large *R. malayanus*. Furthermore the ratio of first to second phalange of the third digit in *R. s. microglobossus* shows overlap in size between the smaller *R. malayanus* and the larger *R. s. stheno*, as figured by McFarlane & Blood (1986).

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