

On the synonymy of *Delamarella* Chappuis and *Latiremus* Božić (Copepoda, Harpacticoida, Latiremidae), including the description of *D. obscura* sp. nov. from the Black Sea

RONY HUYS FLS^{1*}, SÜPHAN KARAYTUĞ² and VEZIO COTTARELLI³

¹Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK

²Balıkesir Üniversitesi, Fen-Edebiyat Fakültesi, Biyoloji Bölümü, 10100, Balıkesir, Turkey

³Dipartimento di Scienze Ambientali, Università della Tuscia, Largo dell'Università, 01100 Viterbo, Italy

Received November 2004; accepted for publication March 2005

A new species of *Delamarella* Chappuis, 1954 (Copepoda, Harpacticoida, Latiremidae), *D. obscura* sp. nov., is described from sandy beaches along the western Black Sea coast of Turkey, using both light and scanning electron microscopy. Additional morphological observations of the closely related *D. galateae* Cottarelli, 1971 are presented, based on topotype material from Sardinia and newly collected specimens from mainland Italy. Previous records of *D. karamani* Petkovski, 1957 from the Bulgarian Black Sea coast are based on misidentifications and should be attributed to *D. obscura* sp. nov. All three species are morphologically similar, and criteria based on meristic and ornamentation characters are provided to distinguish them. Examination of copepodid V ♂ intermoult stages provided new insights into the morphology of the highly transformed P4 exopod of the adult male and its homology with reference to the female. A reassessment of the generic distinctiveness of *Delamarella* and the monotypic genus *Latiremus* Božić, 1969 revealed that morphological criteria, traditionally employed to separate both genera, are all essentially unsound and based on erroneous reports in the literature. Consequently, *Latiremus* is relegated to a junior synonym of the type genus, leaving *Delamarella* and *Arbutifera* Huys & Kunz, 1988 as the only remaining valid genera in the family. © 2005 The Linnean Society of London, *Zoological Journal of the Linnean Society*, 2005, 145, 263–281.

ADDITIONAL KEYWORDS: *Delamarella galateae* – homology – Mediterranean – taxonomy – Turkey.

INTRODUCTION

All Latiremidae (Copepoda, Harpacticoida) are genuinely mesopsammic and restricted to sandy beaches, frequently extending into the phreatic zone near river mouths. Their first representative was discovered during the intensive sampling surveys organized by Claude Delamare Deboutteville in the Western Mediterranean. In a series of papers, Chappuis (1954a, b, c), considered *Delamarella arenicola* Chappuis, 1954a a *species incertae sedis* in the Harpacticoida, primarily because of the extraordinary modification of the male P4 exopod. Petkovski (1957) reported a second species from the Croatian coast, *D. karamani*, but this discovery did not shed new light on affinities. Božić (1969), apparently unaware of the existence of the genus

Delamarella Chappuis, described the closely related new genus and species *Latiremus eximius* from La Réunion. The author, who regarded the male P4 exopod as an insurmountable obstacle to inclusion of *Latiremus* in any of the harpacticoid families recognized at that time, proposed with certain reservations the monotypic family Latiremidae. Cottarelli (1971), who in turn had overlooked Božić's (1969) description, added a third mediterranean species to the genus *Delamarella*, *D. galateae*. For some inexplicable reason, Apostolov (1971) listed *Delamarella* under the Ancorabolidae.

It was not until later that various authors (Itô, 1974; Bodin, 1976a, b; Wells, 1976, 1978; Kunz, 1977) almost simultaneously recognized the undeniably close relationship between *Delamarella* and *Latiremus*. Wells (1976) preferred to maintain them as distinct genera pending a thorough re-examination. Conversely, both

*Corresponding author. E-mail: r.huys@nhm.ac.uk

Bodin (1976a, b) and Kunz (1977) considered them congeneric and re-allocated *L. eximius* to the genus *Delamarella*. This course of action was also supported by Božić (1978) who made a careful comparison of the segmental patterns of the antennules, P1 exopod and P4 endopod, the presence/absence of foliaceous spines on the P5, and the ornamentation of the anal operculum. Kunz (1984) further expanded the generic boundaries of *Delamarella* by including the Namibian species *D. phyllosetosa*.

Itô (1974) established a new genus *Protolatiremus* for a single species *P. sakaguchii* Itô, 1974, which he assigned to the Thalestridae. However, Itô's (1974) unfortunate choice of the generic name in conjunction with his dubious supposition of a '... a rough evolutionary line arising from *Protolatiremus* to *Latiremus* and further to *Delamarella*...' led Bodin (1976a, b, 1979, 1988) to cite this genus persistently as a member of the Latiremidae. Any relationship between *Protolatiremus* and the latiremid genera has been refuted by various authors (Božić, 1978; Kunz, 1984; Huys & Kunz, 1988). Huys & Kunz (1988) suggested that *Protolatiremus* could well represent a distinct unrelated family but Bodin (1997) continued to include it in the Latiremidae, this time as *genus incertae sedis*. Recently, Willen (2000) identified *Protolatiremus* as the sistergroup of the Thalestridimorpha, a taxon uniting the Langian families Thalestridae, Diosacidae, Parastenheliidae and Miraciidae.

Huys & Kunz (1988) reviewed the generic distinctiveness of *Delamarella* and *Latiremus*, reinstated the latter and transferred *D. phyllosetosa* to a new genus *Arbutifera*. They recognized a sistergroup relationship between *Latiremus* and *Arbutifera*, and placed this clade in apposition to *Delamarella*. The discovery of new *Delamarella* material from the Turkish Black Sea coast, described herein as a new species, has prompted us to reconsider the generic distinctiveness of *Delamarella* and *Latiremus*.

MATERIAL AND METHODS

Harpacticoids were collected using the Karaman-Chappuis method (Delamare Debutteville, 1954). Specimens were dissected in lactic acid and the parts mounted on slides in lactophenol mounting medium. Glass fibres were added to prevent the animal and appendages from being compressed by the coverslip and to facilitate rotation and manipulation, allowing observation from all angles. Preparations were sealed with transparent nail varnish. All drawings have been prepared using a camera lucida on an Olympus BX-50 differential interference contrast microscope. Measurements were made with an ocular micrometer. Body length was measured from the base of the rostrum to the posterior edge of the caudal rami.

Males and females of *Delamarella obscura* sp. nov. were examined with a Philips XL30 scanning electron microscope. Specimens were prepared by dehydration through graded acetone, critical point dried, mounted on stubs and sputter-coated with gold-palladium alloy. The descriptive terminology is adopted from Huys *et al.* (1996). Abbreviations used in the text are: ae, aesthetasc; P1–P6, first to sixth thoracopod; exp (enp)-1 (2, 3) to denote the proximal (middle, distal) segment of a ramus. Scale bars in illustrations and SEM micrographs are in micrometres. Type and other material is deposited in the collections of the Natural History Museum, London (NHM) and Balıkesir University (BU). Attempts to trace the types of *Latiremus eximius*, *Delamarella arenicola* and *D. karamani* failed (cf. Huys & Kunz, 1988).

RESULTS

FAMILY LATIREMIDAE BOŽIĆ, 1969 GENUS *DELAMARELLA* CHAPPUIS, 1954 *DELAMARELLA OBSCURA* SP. NOV.

Synonym: Delamarella karamani Petkovski, 1957 *sensu* Apostolov (1969).

Type locality: Filyos beach, Hisarönü, Zonguldak province (station 14) (Turkey).

Type material: Holotype adult ♀ dissected on 3 slides (deposited in NHM, reg. no. 2005.167). Paratypes are (1) 1 adult ♂ dissected on 5 slides (deposited in NHM, reg. no. 2005.168), (2) 4 Cop V ♀♀, 1 Cop IV ♀ and 2 Cop V ♂♂ preserved in alcohol; and 1 adult ♀ dissected on 4 slides (deposited in BU). Collected on 7 July 2001 from type locality; leg. S. Karaytuğ and S. Sak.

Other material: (1) From Göbü beach, Hisarönü, Zonguldak province (station 12), Turkey (leg. S. Karaytuğ and S. Sak; 7 July 2001): 4 adult ♀♀ and 1 adult ♂ preserved in alcohol (deposited in NHM, reg. no. 2005.169–173); 3 adult ♀♀, 1 adult ♂, 6 Cop V ♀♀, 2 Cop IV ♀♀, 1 Cop V ♂ all preserved in alcohol, 1 ♂ dissected on 1 slide (deposited in BU); (2) from Türkali beach, Hisarönü, Zonguldak province (station 13), Turkey (leg. S. Karaytuğ and S. Sak; 7 July 2001): 2 adult ♀♀, 1 adult ♂, 3 Cop V ♀♀ and 1 Cop V ♂ preserved in alcohol (deposited in NHM, reg. no. 2005.174–180); (3) from Kapısuğu beach, Kurusacile, Bartın province (station 17), Turkey (leg. S. Karaytuğ and S. Sak; 8 July 2001): 4 ♀♀ preserved in alcohol (deposited in NHM, reg. no. 2005.181–185); (4) from Inebolu beach, Inebolu, Kastamonu province, Turkey (leg. S. Karaytuğ and S. Sak; 8 July 2001): various specimens (deposited in BU).

Description

Female: Total body length: 420–520 µm (mean = 487 µm; $N = 10$). Maximum width measured at cephalothorax. P1-bearing somite completely incorporated in cephalosome forming a cephalothorax (Fig. 1A, B). P2-bearing somite separated from cephalothorax by large intersomitic membranous zone. Posterior margin of cephalothorax and pedigerous somites with plain hyaline frill (Fig. 1A, B); hyaline frill of urosomites with denticulate hyaline frill dorsally and ventrally (Figs 2B, 3A). Rostrum (Fig. 1A) very small, fused to cephalic shield; with 2 delicate sensillae.

Genital somite (Figs 1A, B, 2B) completely free from first abdominal somite. Genital field (Figs 3C, G, 11A) small, positioned far anteriorly on midventral surface of genital somite, flanked by 2 pairs of secretory pores; consisting of 2 closely set crescent-shaped opercula derived from P6 and closing off paired genital apertures, without armature; copulatory pore internal (arrowed in Fig. 3G). All postgenital somites with transverse spinular rows as illustrated in Figure 2B; no distinct ornamentation dorsally. Anal operculum spinulose, with 20–30 small spinules (Figs 3A, 7A); anal frill deeply serrated, setulose, largely covered by anal operculum (Fig. 3A).

Caudal rami (Figs 2B, 3A, 7A) slightly divergent; partly concealed beneath anal operculum; longer than wide; ventral surface with pore near proximal margin and tube-pore subdistally; inner margin with row of fine long setules running on to dorsal surface; dorsal surface with oblique row of strong spinules, increasing in size abaxially; posterior margin smooth dorsally, with strong spinules ventrally. Ramus with 7 setae: seta I relatively well developed; setae II and III spiniform and finely pinnate, with subapical flagellate extension; setae IV and V well developed, bipinnate, with fracture planes; seta VI short and bare; seta VII plumose and tri-articulate at base.

Antennule short (Fig. 1A, B), typically 9-segmented (Fig. 3E) but boundaries between segments 7 and 9 frequently not clearly expressed (Fig. 8A); segment 1 with pinnate seta near anteriolateral corner. Armature formula: 1-[1], 2-[7 + 2 pinnate], 3-[6], 4-[3 + (1 + ae)], 5-[2], 6-[3 + 1 pinnate], 7-[2], 8-[2], 9-[6 + (1 + ae)].

Antenna (Fig. 3F) consisting of coxa, basis, 1-segmented exopod and 2-segmented endopod; basis and proximal endopod segment incompletely separated. Coxa with spinules along distal margin. Basis and proximal endopod segment incompletely fused, original boundary being represented by surface furrow (Fig. 8B) but not by functional articulation; each segment with bipinnate seta. Free endopod with spinules along abexopodal margin; lateral armature consisting of 2 pinnate spines and 1 seta (Fig. 3F: inset); distal armature consisting of 1 simple and 4 geniculate

setae, longest one of which fused basally to long sparsely pinnate seta. Exopod 1-segmented; with 3 curved unipinnate spines laterally and 1 strong pinnate spine apically.

Mandible (Figs 4A, 9A) with well-developed gnathobase provided with series of small, curved teeth and pinnate seta at dorsal corner. Palp uniramous, consisting of basis and endopod. Basis with 1 naked and 2 pinnate setae. Endopod 1-segmented, with 2 lateral and 6 terminal setae.

Labrum well developed, with transverse spinule row along free ventral margin and median tuft of setules on anterior surface (Fig. 8C).

Maxillule (Fig. 4B). Praecoxal arthrite with 2 tube-setae on anterior surface; distal margin with 8 strong spines. Coxal endite with 2 naked setae and 1 geniculate spine. Basis with 2 geniculate, 2 bipinnate and 3 naked setae. Endopod and exopod defined at base, with 3 naked setae each.

Maxilla (Figs 4C–D, 9B). Syncoxa with 3 endites and 2 spinular rows; proximal endite with 4 setae, middle endite with 2 setae and large backwardly directed unipinnate spine, distal endite with 1 naked and 2 pinnate setae; posterior surface with slit-like opening of maxillary gland (arrowed in Fig. 9B). Allobasis with 2 naked setae and 2 serrate spines. Endopod 2-segmented; enp-1 with 2 serrate spines; enp-2 with 1 serrate spine and 3 naked setae.

Maxilliped (Figs 4E, 9C) prehensile, comprising syncoxa, basis and 1-segmented endopod. Syncoxa with 3 spinular rows and 1 pinnate seta. Palmar margin of basis with row of strong spinules anteriorly, row of finer spinules posteriorly and 2 setae (smaller one with tubular extension; arrowed in Fig. 4E). Endopod with small sclerite at base; drawn out into strong, curved claw bearing 3 accessory setae.

P1 (Figs 5A, 9D, 10A, B). Protopod with accessory sclerite positioned dorsally to praecoxa (arrowed in Fig. 9D). Praecoxa represented by a well-developed sclerite with spinular row on anterior surface. Coxa with spinular row anteriorly and posteriorly as figured. Intercoxal sclerite with fine spinular rows anteriorly. Basis with pinnate spine (with subapical flagellate extension) at outer distal corner and inner unipinnate spine; anterior surface with strong spinules around distal margin. Exopod 3-segmented; exp-1 and -2 with outer unipinnate spine and covered with coarse spinules around outer and distal margins; exp-3 small, with 2 unipinnate geniculate spines and 2 long bare setae; boundary between exp-2 and -3 not always clearly defined (Fig. 10B) but more clearly expressed when exp-3 withdrawn into exp-2 (Fig. 10A). Endopod 2-segmented; enp-1 elongate, about twice longer than wide, with serrate inner seta, outer and distal margins spinulose; enp-2 very small, with geniculate claw and very long naked seta apically.

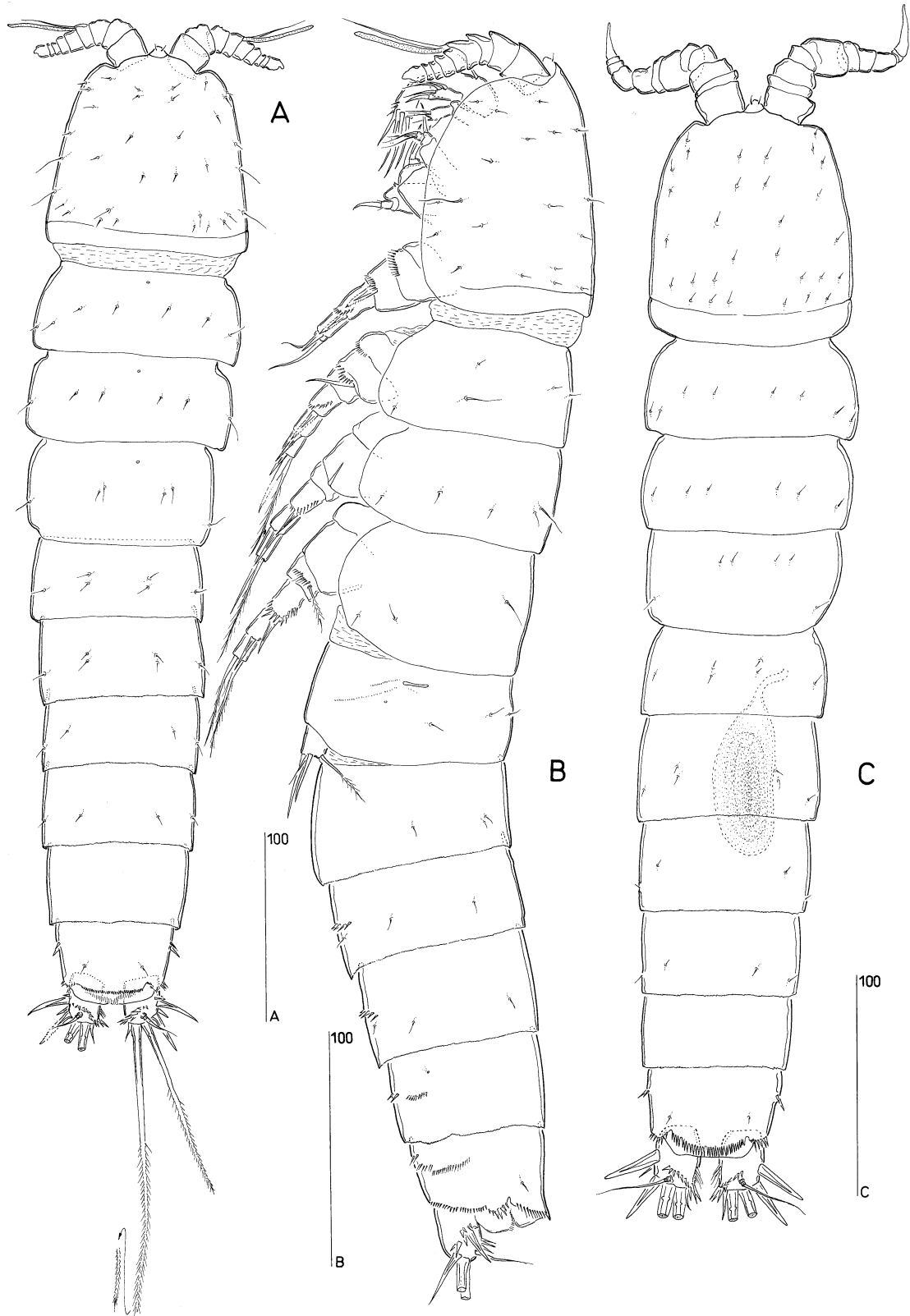


Figure 1. *Delamarella obscura* sp. nov. A, habitus ♀, dorsal; B, habitus ♀, lateral; C, habitus ♂, dorsal.

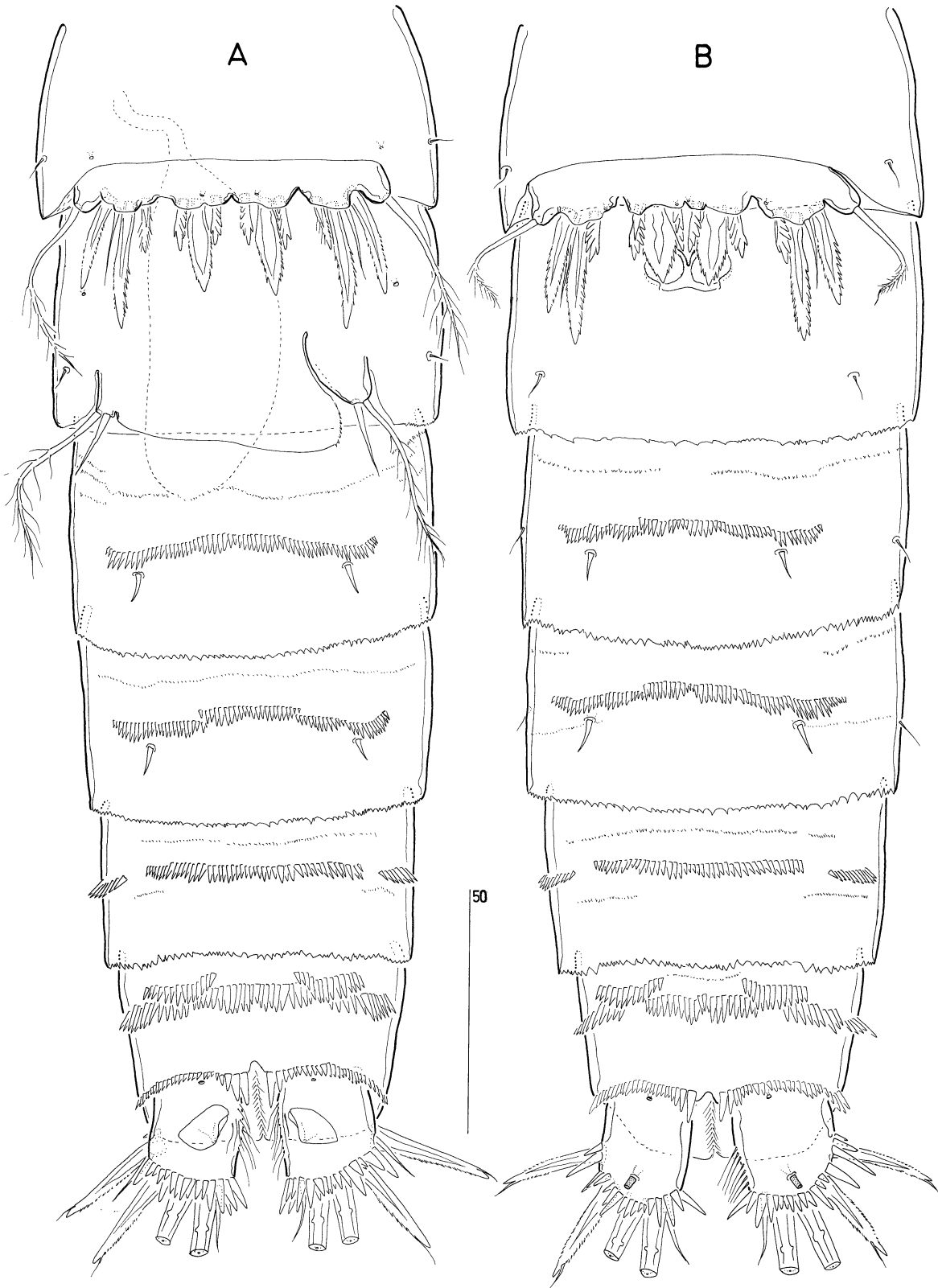


Figure 2. *Delamarella obscura* sp. nov. A, urosome ♂, ventral; B, urosome ♀, ventral.

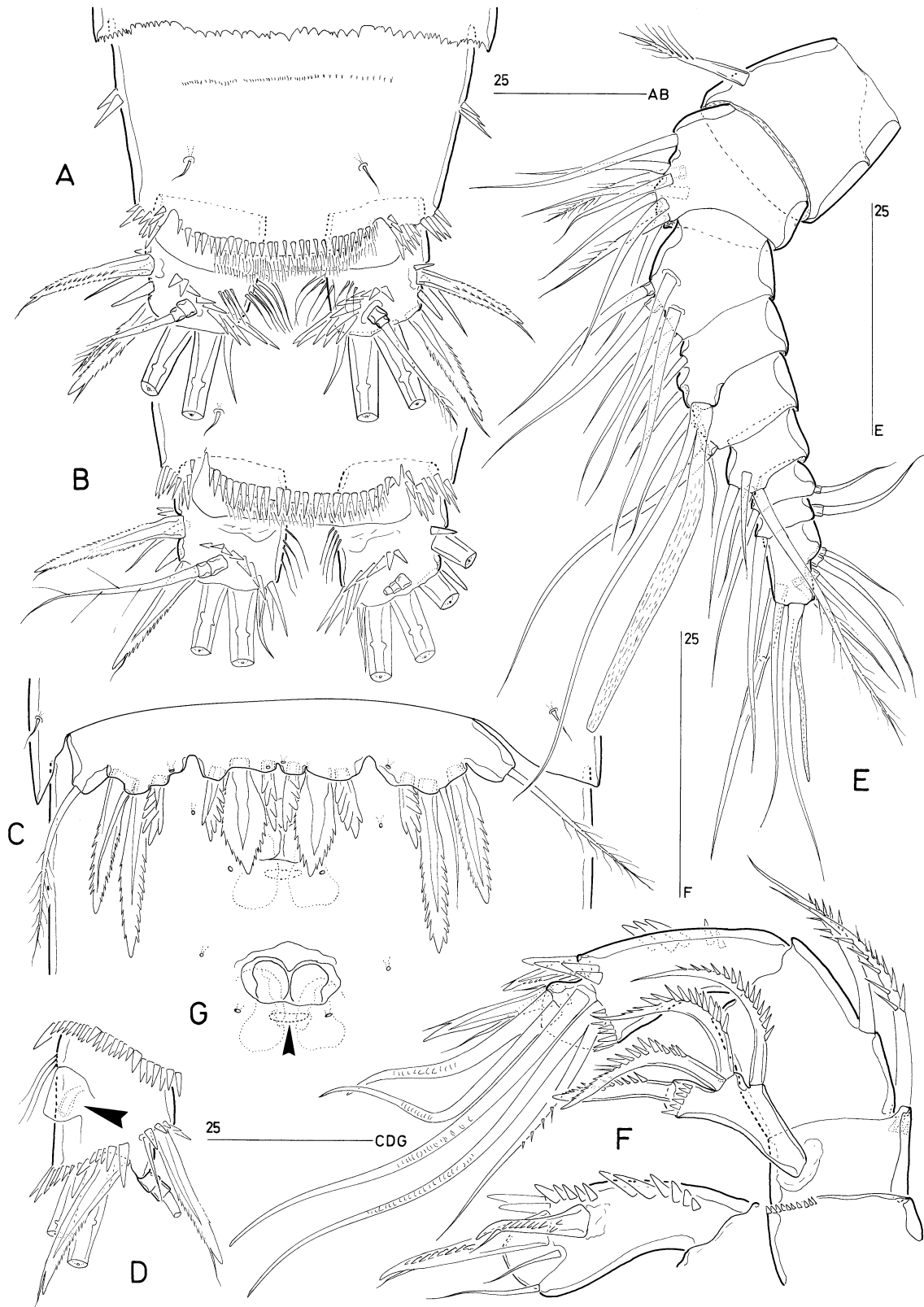


Figure 3. *Delamarella obscura* sp. nov. A, anal somite and caudal rami ♀, dorsal; B, anal operculum and caudal rami ♂, dorsal; C, fifth legs and genital apertures ♀, ventral; D, left caudal ramus ♂, lateral; E, antennule ♀, ventral; F, antenna [inset: medial view of distal endopod segment]; G, genital field ♀.

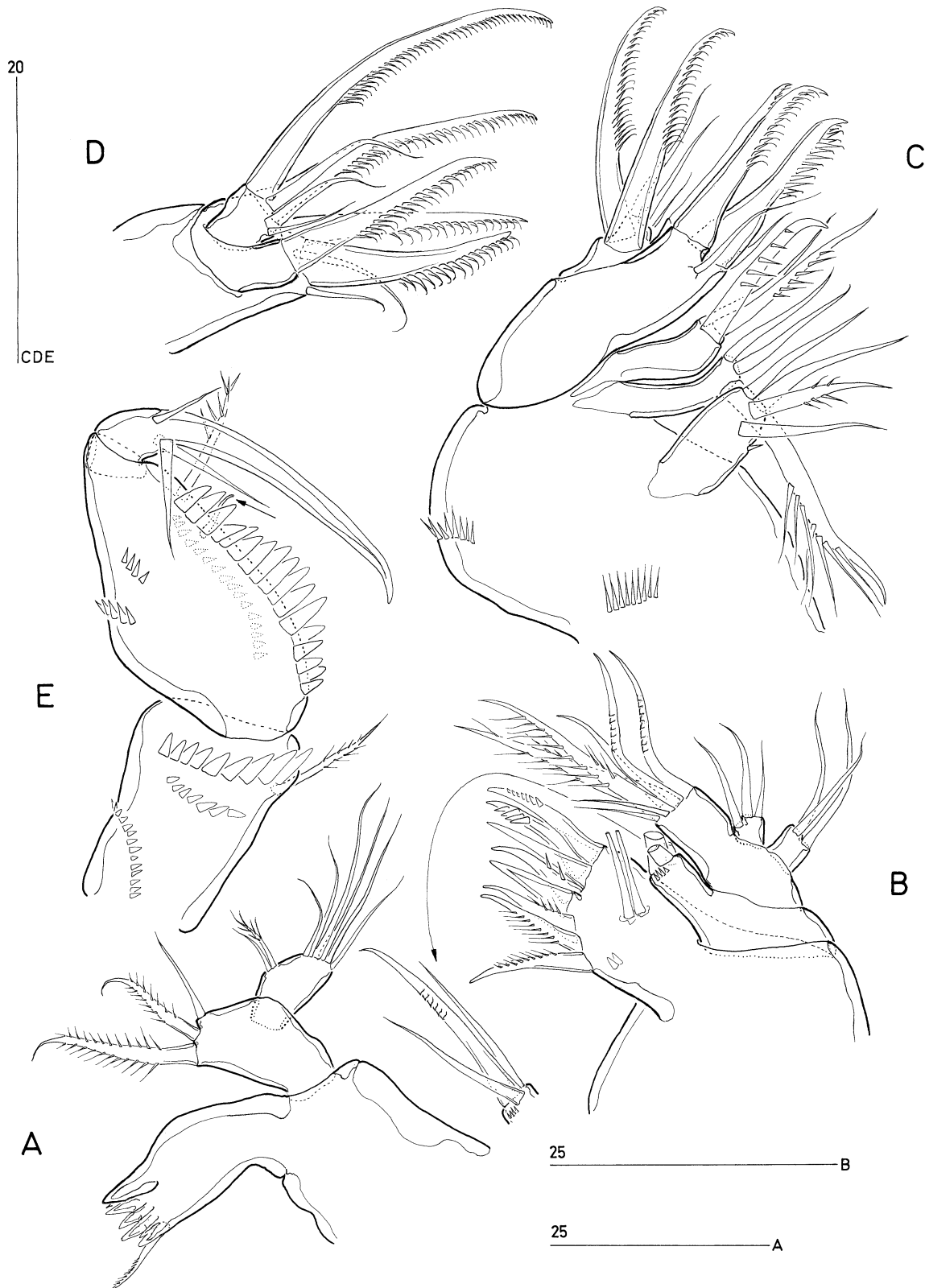


Figure 4. *Delamarella obscura* sp. nov. Female. A, mandible; B, maxillule, anterior [inset: armature of coxal endite]; C, maxilla, anterior; D, maxillary allobasis, posterior; E, maxilliped, anterior [posterior palmar seta on basis arrowed].

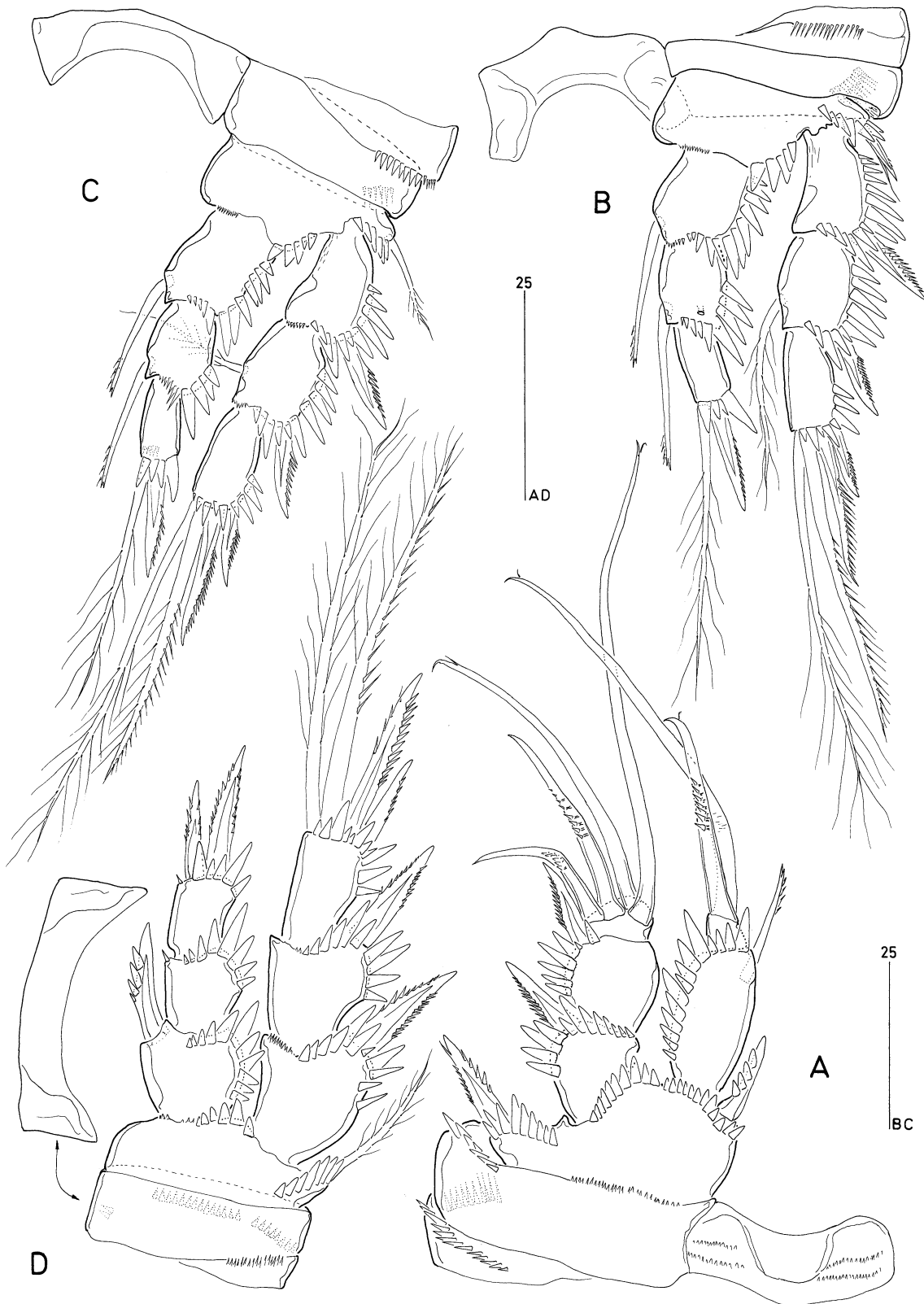


Figure 5. *Delamarella obscura* sp. nov. Female. A, P1, anterior; B, P2, anterior; C, P3, anterior; D, P4, anterior.

P2–P4 (Fig. 5B–D) with 3-segmented exopods and endopods. Intercoxal sclerites with concave ventral margin, without surface ornamentation. Praecoxa represented by well-developed sclerite with anterior spinular row. Coxa with spinular row on posterior surface. Basis with pinnate outer seta (P3–P4) or flagellate outer spine (P2). Exopods longer than endopods. Exopodal segments with coarse spinules along outer and distal margins and without spinules/setules along inner margin. Endopodal segments with coarse spinules along outer (enp-1,2) and distal (enp-1,2,3) margins. P2–P3 (Fig. 5B, C) with serrate inner seta on enp-1 and -2; distal margin of enp-3 with outer pinnate spine and inner plumose seta. P4 enp-1 (Fig. 5D) expanded, with robust unipinnate spine at inner subdistal corner; enp-2 without any spines or setae; enp-3 with 2 pinnate spines apically.

P1–P4 armature formula:

	Exopod	Endopod
P1	0.0.022	1.020
P2	0.1.022	1.1.020
P3	0.1.022	1.1.020
P4	0.0.022 [modified in ♂]	1.0.020

P5 (Figs 2B, 3C). Fifth pair of legs fused medially; baseoendopod and exopod forming a common plate; basal seta plumose, arising from a prominent setophore. Exopodal lobe with 2 long biserrate spines, 1 short spinulose spine and 1 bare seta; endopodal lobe with a strong serrate spine medially and 2 short spinulose spines.

Male: Total body length: 440–500 µm (mean = 471 µm; $N = 4$). Sexual dimorphism in antennule, caudal rami and P4–P6.

Antennule (Figs 6A–C, 8D) haplocer with 5 segments distal to geniculation; indistinctly 13-segmented; boundaries between segments 11 and 13 expressed only dorsally (Fig. 6A), completely fused ventrally (Fig. 8D). Segment 5 small, represented by small U-shaped sclerite. Segment 6 with long aesthetasc fused basally to seta. Segment 8 with denticulate anteriodorsal margin, 1 naked seta, 1 basally fused pinnate seta (with tubular extension) and 1 modified element. Segment 9 with 3 modified elements. Segments 11–13 forming claw-like compound segment with most setae arranged around posterior margin (Fig. 8D). Armature formula 1-[1 pinnate], 2-[1], 3-[8], 4-[6], 5-[1 + 1 pinnate] 6-[4 + 1 pinnate + (1 + ae)], 7-[2], 8-[1 + 1 pinnate + 1 modified], 9-[3 modified], 10-[1], 11-[2], 12-[2], 13-[5 + (2 + ae)]. Modified elements on segments 8 and 9 with longitudinally ribbed surface and fused basally to segment (Fig. 8D).

Caudal rami (Figs 2A, 3D) with large cup-shaped pore ventrally halfway along ramus length (arrowed in Fig. 3D).

P4 (Figs 6D, 10C) with strongly modified exopod; exp-1 and -2 expanded, exp-3 reduced forming claw-like segment. Exp-1 rectangular, about 1.4 times as long as maximum width, with long unipinnate outer spine; distal margin and outer distal corner with strong spinules. Exp-2 forming central socket for exp-3; outer distal corner produced into lobate process (B) and spiniform outgrowth (D); outer spine strongly reduced, represented by small triangular element arising from posterior surface (A). Exp-3 outwardly recurved (C), forming functional grasping device with exp-2; with 3 setiform elements arranged around the inner margin. Endopod relatively longer and more slender than in ♀ enp-1 not expanded as in ♀ and lacking inner spine; outer distal spine on enp-3 comparatively longer than in ♀.

P5 (Figs 2A, 6E, 7D, 10D, 11B) essentially as in ♀ except middle endopodal spine relatively longer and with smaller hyaline flanges.

Sixth pair of legs (Figs 2A, 11B) strongly asymmetrical, with both members fused to genital somite and bearing 1 short bare and 1 long plumose seta; largest member functional one, inner portion rounded and with denticulate free margin. Spermatophore moderately large, about 80 µm.

Etymology. The specific epithet alludes to the small differences between the new species and its mediterranean congeners.

DELAMARELLA GALATEAE COTTARELLI, 1971

Originally described from Sardinia (Cottarelli, 1971), the species has now also been found on mainland Italy (Sorrento area).

Type locality: Italy, Sardinia, north coast, beach near mouth of Rio de li Saldi, 200 m upstream.

Material examined: (1) From type locality: 1 ♀ dissected on slide; leg. V. Cottarelli, 25 February 1999; deposited in NHM, reg. no. 2005.186; (2) south of Salerno, mouth of Torrente Asa, near the village of Pontecagnano Faiano: 2 ♀♀ on slide, 1 ♀ and 1 ♂ on slide, 4 ♂♂ each on 1 slide; all specimens mounted *in toto*; leg. V. Cottarelli, 20 November 1972; deposited in NHM, reg. nos. 2005.187–194; (3) several specimens from rivermouth of Rio Posada, Nuoro Province, western Sardinia; leg. V. Cottarelli.

Additional observations

Female: Anal operculum spinulose, with 7–10 large spinules (Fig. 7B). Caudal ramus with dorsal spinules at inner distal corner and around base of seta VII; the oblique ventral setule row figured by Cottarelli (1971: Tav. I-3, left ramus only) is absent but some fine long

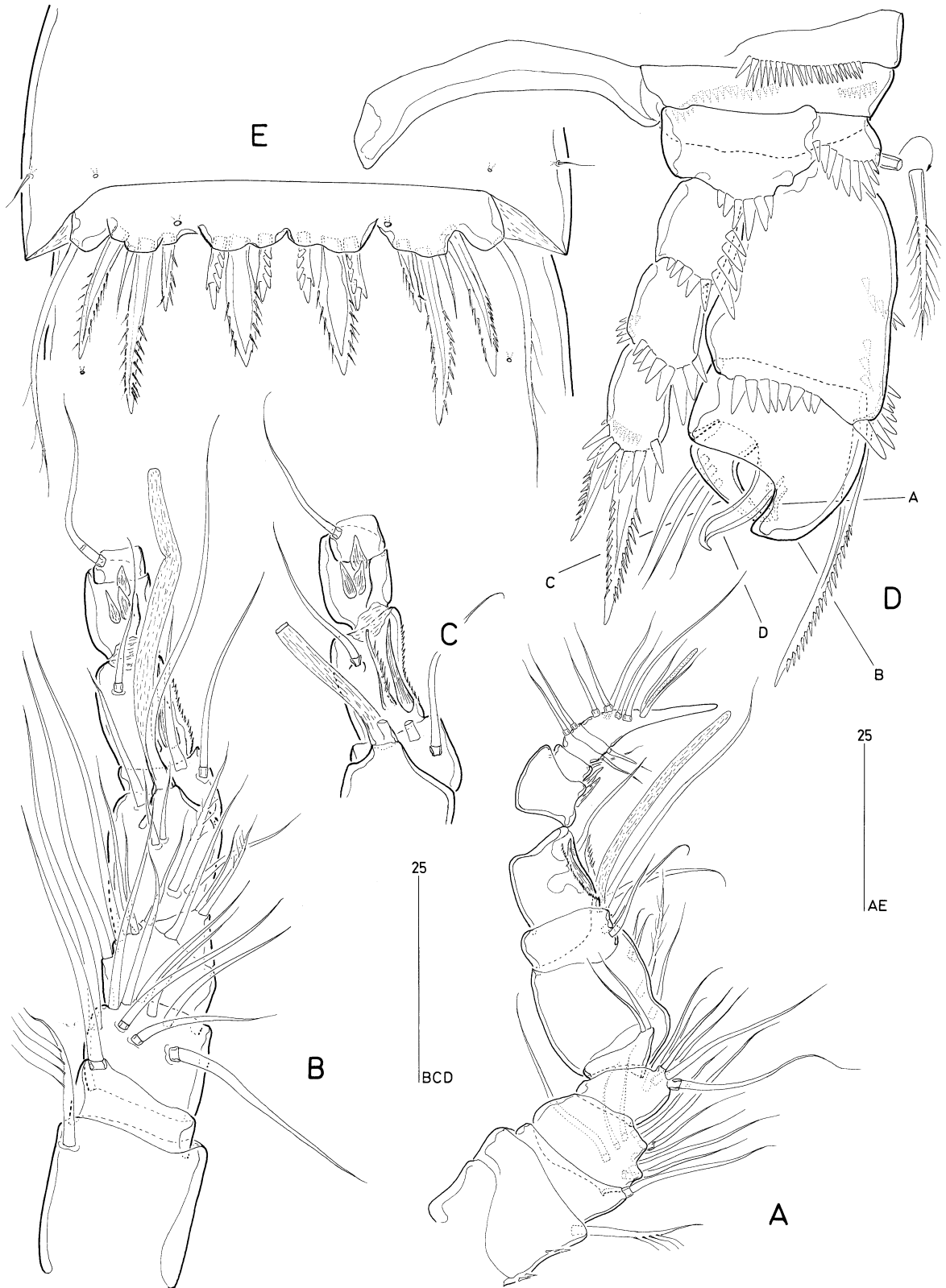


Figure 6. *Delamarella obscura* sp. nov. Male. A, antennule, dorsal [for complete armature pattern see B and C]; B, antennular segments 1–10, anterior; C, antennular segments 7–10, anterior; D, P4, anterior; E, fifth legs, ventral.

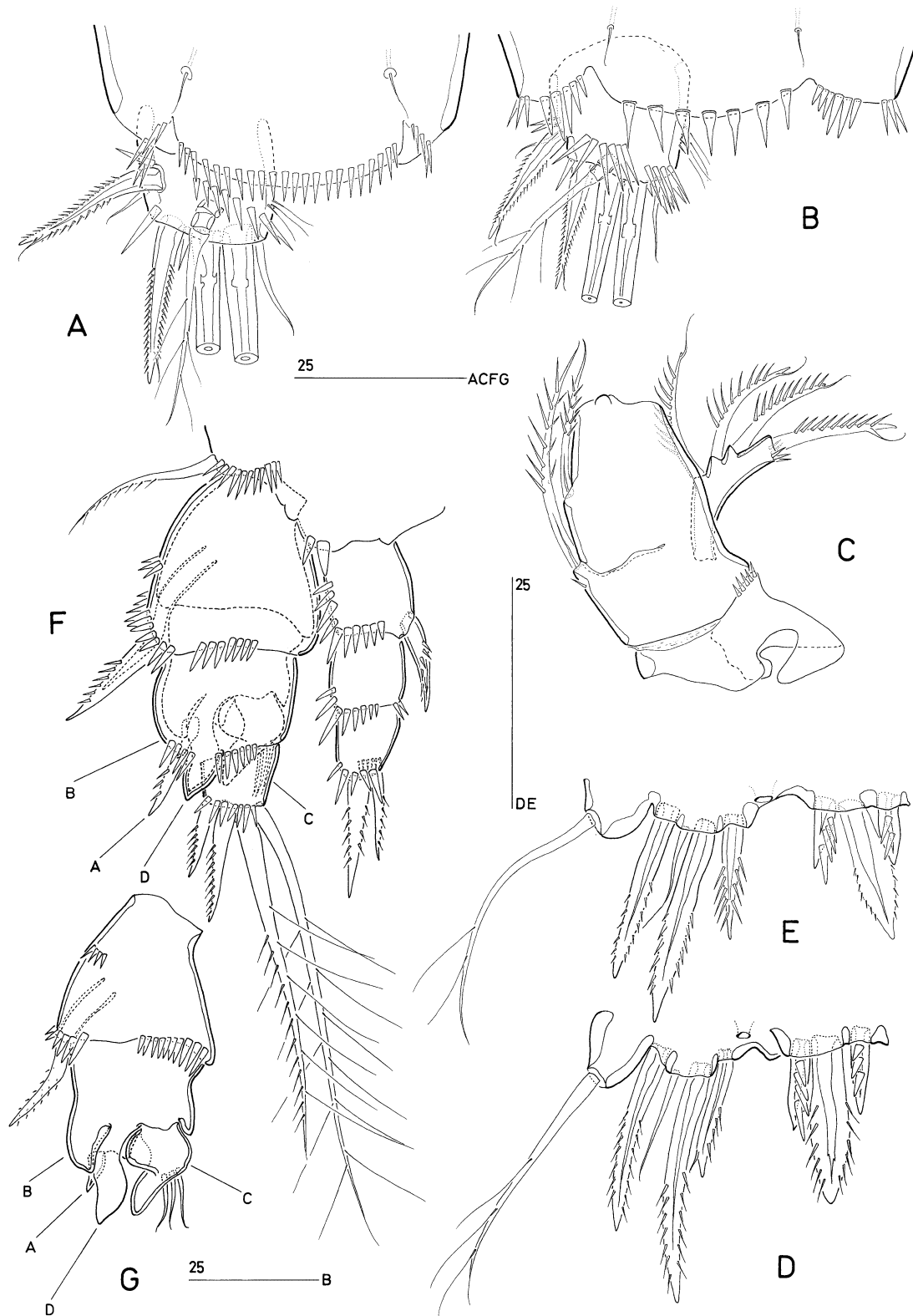


Figure 7. *Delamarella obscura* sp. nov. A, anal operculum and left caudal ramus ♀, dorsal; D, right fifth leg ♂, ventral; F, P4 copepodid V ♂, intermoult stage, anterior; G, P4 exopod ♂, developing inside copepodid V ♀ intermoult stage. *Delamarella galataeae* Cottarelli, 1971; B, anal operculum and left caudal ramus ♀, dorsal; C, antenna (except free endopod) ♀; E, right fifth leg ♂, ventral.

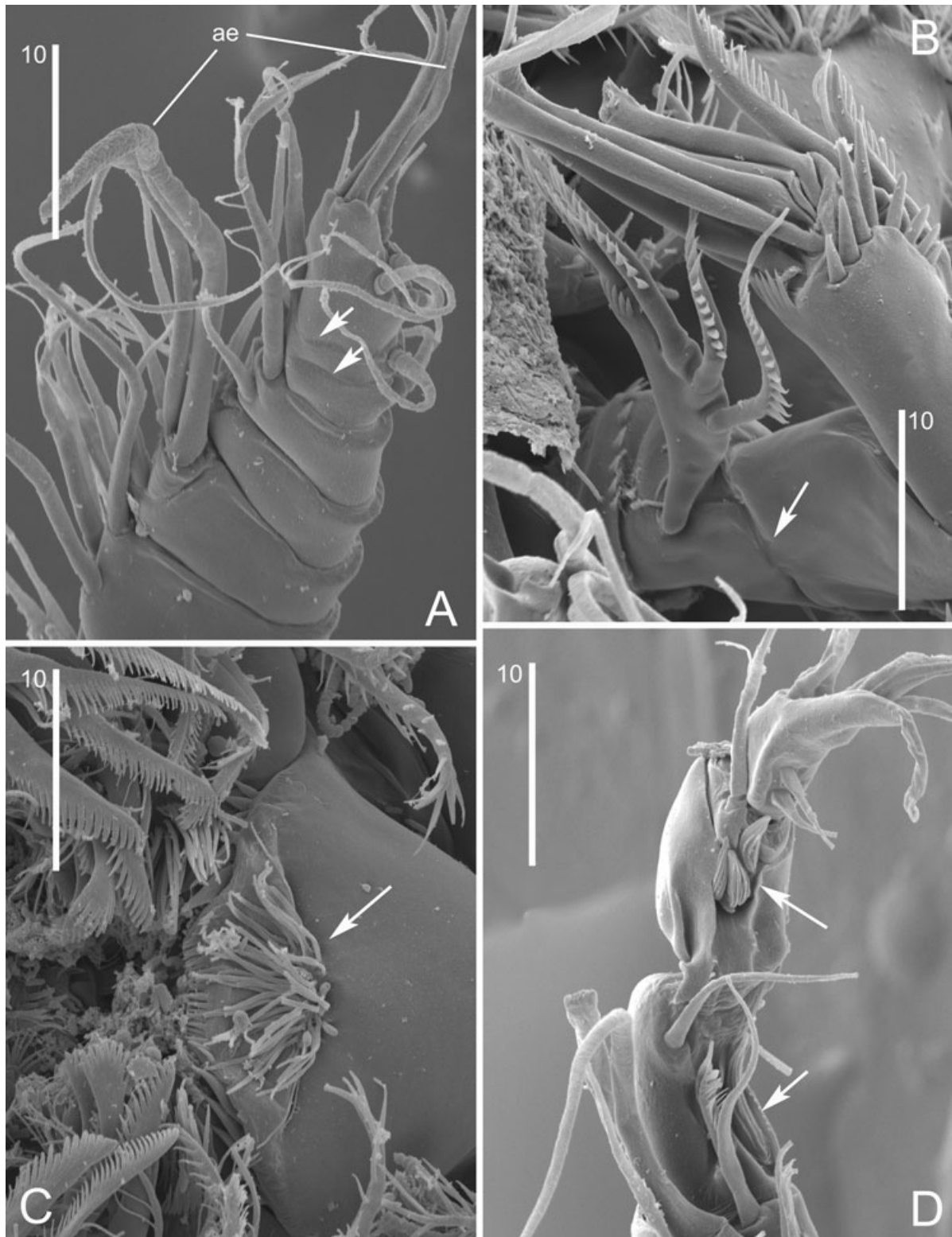


Figure 8. *Delamarella obscura* sp. nov. SEM micrographs. A, distal portion of antennule ♀, ventral [surface sutures separating apical segments arrowed; ae, aesthetasc]; B, antenna ♀ [surface suture separating basis and proximal endopod segment arrowed]; C, labrum [anterior setular tuft arrowed]; D, distal portion of antennule ♂, anterior [modified elements around geniculation arrowed].

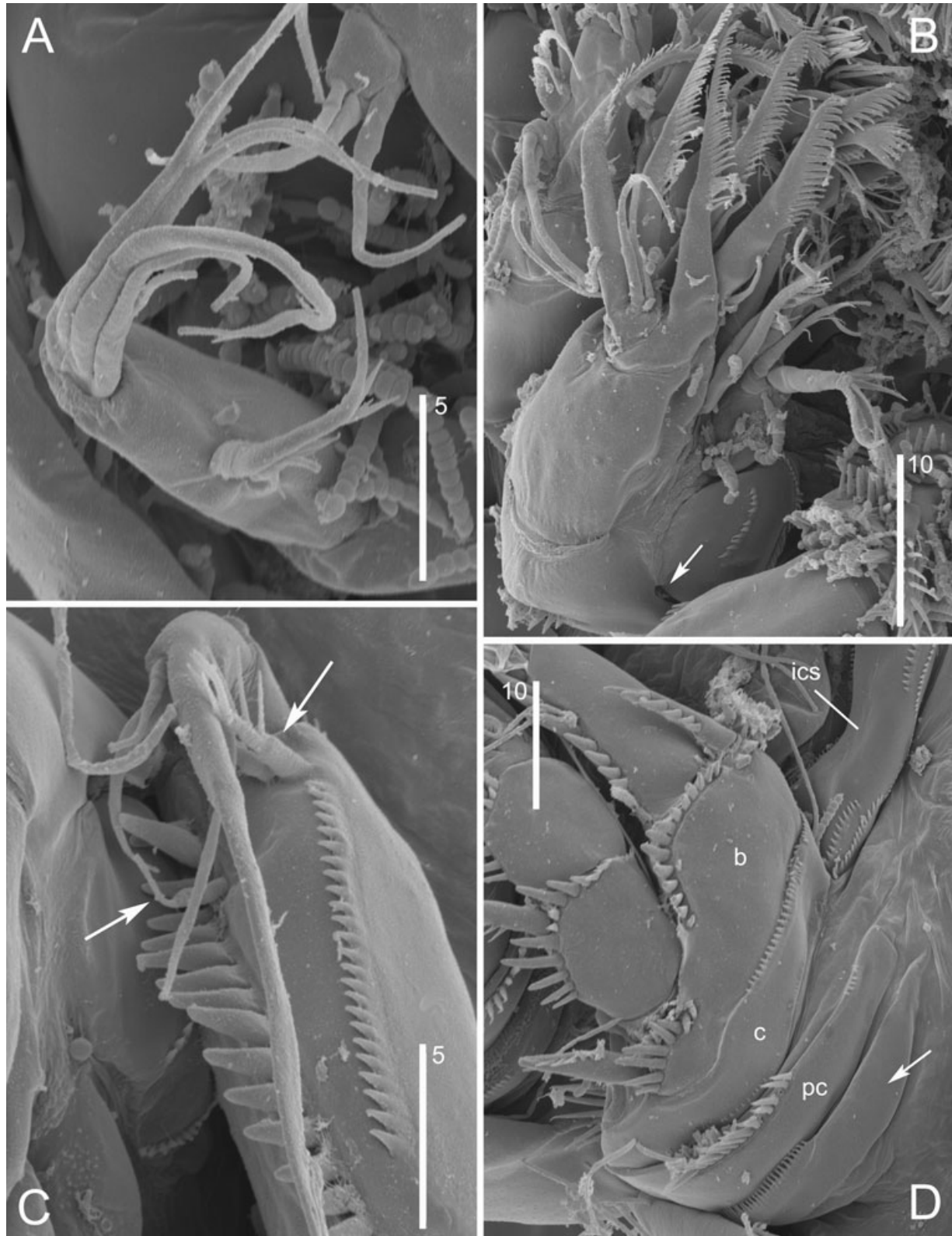


Figure 9. *Delamarella obscura* sp. nov. SEM micrographs. Female. A, mandibular palp; B, maxilla, posterior [opening of maxillary gland arrowed]; C, maxilliped [palmar setae on basis arrowed]; D, P1 protopod, anterior [supplementary sclerite arrowed; b, basis; c, coxa; ics, intercoxal sclerite; pc, praecoxa].

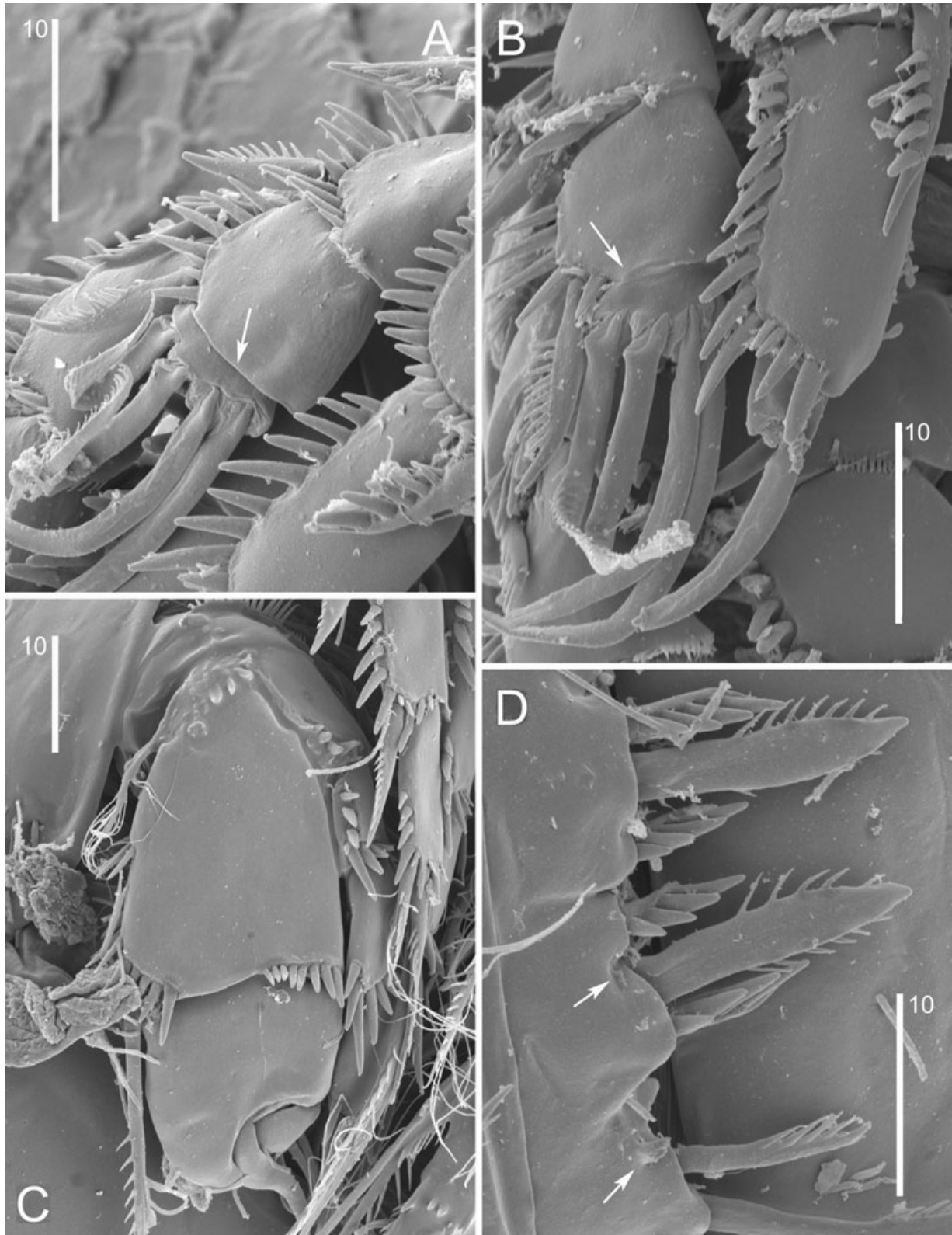


Figure 10. *Delamarella obscura* sp. nov. SEM micrographs. A, P1 exopod, anterior, showing exp-3 partly withdrawn in exp-2 (arrowed); B, P1 exopod, anterior, showing exp-3 fully exposed [surface suture arrowed]; C, P4 exopod ♂, anterior; D, P5 ♂, anterior [secretory tube-pores arrowed].

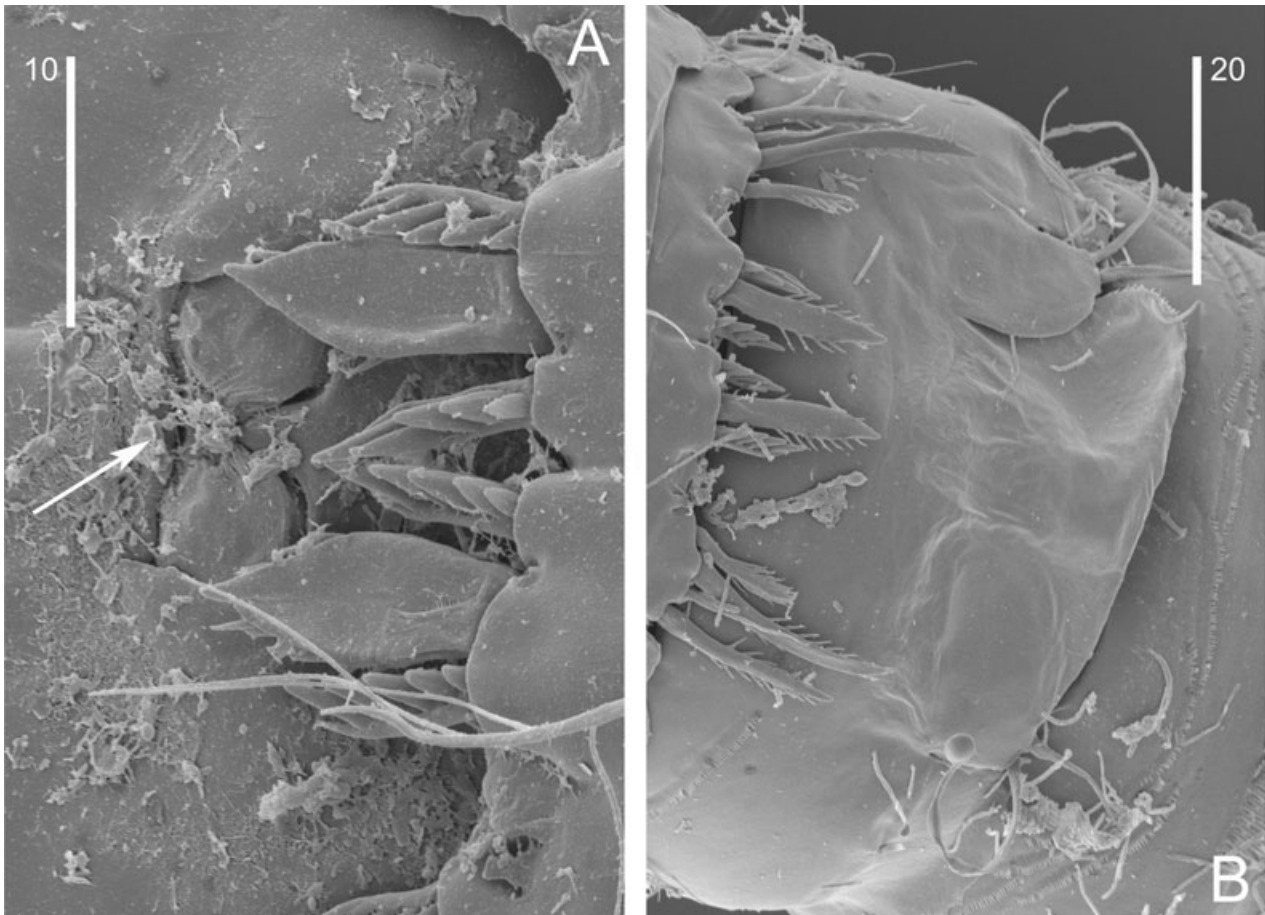


Figure 11. *Delamarella obscura* sp. nov. SEM micrographs. A, endopodal lobes of fifth legs and genital apertures (arrowed) of ♀; B, P5 and genital opercula of ♂.

setules are present along the inner margin; ventral surface with pore near proximal margin and tube-pore subdistally; ramus with 7 setae as in *D. obscura*.

Antennule clearly 9-segmented; armature formula as in *D. obscura*.

Antenna (Fig. 7C). Basis and proximal endopod segment incompletely separated; abexopodal seta of proximal endopod segment much shorter than that on basis; armature of distal endopod segment as in *D. obscura*.

Mandibular endopod with 6 apical setae instead of 5 as figured by Cottarelli (1971: Tav. II-2).

Maxillule and maxilla as in *D. obscura*.

Maxilliped less slender than figured by Cottarelli (1971: Tav. II-8); basis with additional seta on palmar margin and spinule row on posterior surface; endopodal claw more elongate than in original description.

P1 exopod 3-segmented; exp-1 and -2 with outer unipinnate spine and covered with coarse spinules around outer and distal margins; exp-3 small, with 2 unipinnate geniculate spines and 2 long bare setae; boundary

between exp-2 and -3 not always clearly defined. Endopod 2-segmented; enp-1 with serrate inner seta [overlooked in Cottarelli (1971: Tav. III-1,4)].

P2–P3 exp-2 with plumose inner seta [overlooked in Cottarelli (1971: Tav. III-2,6)].

P1–P4 armature formula and detailed morphology of P5 as in *D. obscura*.

Male: Caudal rami with large cup-shaped pore ventrally halfway along ramus length.

Antennule haplocer with 5 segments distal to geniculation; indistinctly 13-segmented; boundaries between segments 11 and 13 expressed only dorsally, completely fused ventrally. Segment 5 small, represented by small U-shaped sclerite. Segment 6 with long aesthetasc fused basally to seta. Armature formula as in *D. obscura*.

P4 closely resembling condition in *D. obscura* but distal seta on exp-3 shorter.

P5 (Fig. 7E) essentially as in *D. obscura* except that exopodal spines are longer and more slender, and mid-

dle endopodal spine has long spinules instead of being denticulate.

Sixth pair of legs strongly asymmetrical, with both members fused to genital somite and bearing 1 short bare and 1 long plumose seta; largest member functional one, inner portion rounded and with denticulate free margin.

DISCUSSION

VALIDITY OF *LATIREMUS* BOŽIĆ, 1969

Chappuis (1954a) established the genus *Delamarella* in a preliminary note, presenting a detailed text description of the type species *D. arenicola*. In a later report, Chappuis (1954b) supplemented this description by providing additional drawings and a discussion of potential relationships; however, having been unable to place the new genus with confidence in any existing family, he preferred to consider it *incertae sedis* (see also Chappuis, 1954c). This uncertain taxonomic position remained unchanged when Petkovski (1957) and Cottarelli (1971) added two more mediterranean species to the genus, *D. karamani* Petkovski, 1957 from Croatia, and *D. galatae* Cottarelli, 1971 from Sardinia.

Božić (1969) described a new genus and species, *Latiremus eximius*, from La Réunion, and considered it the type of a new family Latiremidae. As pointed out by himself (Božić, 1978), he unfortunately overlooked the close affinity between *Delamarella* and *Latiremus*, a relationship first recognized by Itô (1974) and subsequently confirmed by various other authors (Bodin, 1976a, b; Wells, 1976, 1978; Kunz, 1977). Most authorities considered the differences insufficient to maintain generic distinction and relegated *Latiremus* to a junior subjective synonym of the latter (Apostolov & Marinov, 1988; Bodin, 1976a, b; Kunz, 1977, 1984; Božić, 1978). This resulted in the family name being based on an invalid generic name, but as this course of action occurred after 1960, the validity of the family name and the designation of *Delamarella* as the type genus remained unaffected (ICZN: Art. 40). Wells (1976) preferred to treat them as distinct genera, an option also favoured by Huys & Kunz (1988) who redefined the generic boundaries within the Latiremidae. They reinstated *Latiremus* as a valid genus, moved *Delamarella phyllosetosa* Kunz, 1984 to a new genus *Arbutifera*, and restricted *Delamarella* to the three mediterranean species *D. arenicola*, *D. karamani* and *D. galatae*.

Huys & Kunz (1988) justified the separate generic status of *Latiremus* on the basis of the following characters: P1-bearing somite completely incorporated in cephalosome forming cephalothorax; genital and first abdominal somites completely free in ♀; seminal

receptacles clearly separated; anal operculum with setulose frill but without spinules; caudal ramus setae II–III bearing subapical flagella; antennule ♀ 8-segmented; antennary basis and proximal endopod segment not fused; P1-exopod 3-segmented; P1 enp-1 with inner subdistal seta; P4 exopod ♂ with 3 setae and 1 strong spine; P5 without modified setae, exopodal lobe with 3 bipinnate spine plus seta in ♀ and 3 bipinnate spines in ♂. The following character states were used to diagnose *Delamarella*: P1-bearing somite partially incorporated in cephalosome; genital and first abdominal somites fused dorsally in ♀; seminal receptacles closely set; anal operculum with 10–15 spinules; caudal ramus setae II–III without subapical flagella; antennule ♀ 8- or 9-segmented; antennary basis and proximal endopod segment fused forming allobasis; P1-exopod 2-segmented; P1 enp-1 without inner subdistal seta; P4 exopod ♂ with 3 setae and at least 2 strong blunt processes; P5 middle seta of endopodal lobe with strips of serrate membrane, exopodal lobe with 3 bipinnate spine plus seta in both sexes.

Our re-examination of *D. galatae* and description of *D. obscura* revealed that the characters used by Huys & Kunz (1988) to separate *Delamarella* and *Latiremus* are all essentially unsound and based on erroneous reports in the literature. Petkovski (1957) stated that the P1-bearing somite is only partly fused to the cephalosome in *D. karamani* and Cottarelli's (1971) illustration of the male habitus of *D. galatae* appears to substantiate this. It now appears that both authors have wrongly interpreted the extensive intersomatic membrane separating the cephalothorax from the P2-bearing somite. It is conceivable that Kunz (1984) made the same observational error in his description of *Arbutifera phyllosetosa* and that consequently all latiremids possess a genuine cephalothorax. Similarly, Huys & Kunz (1988) extrapolated Petkovski's (1957) observation of a dorsally fused (but ventrally separated) genital double-somite in *D. karamani* to all *Delamarella* species. This is contradicted by our observations of *D. galatae* and *D. obscura*; in these species the genital and first abdominal somites are completely separated as in *Latiremus* and *Arbutifera*. Generic distinction based on seminal receptacle position has also proven unreliable as the structures illustrated by Cottarelli (1971) in reality refer to the crescent-shaped genital apertures (Fig. 11A) and this is probably also the case for Božić's (1969: fig. 4a) figure of the female genital field in *L. eximius*.

The ornamentation of the anal operculum in *D. obscura* is intermediate between the finely serrate condition displayed by *L. eximius* and the more spinulose state found in *D. arenicola* and *D. galatae*, indicating that this character has no significance at generic level. Caudal ramus setae II and III have a subapical flagella in *D. galatae* and *D. obscura*

(Fig. 7A, B), suggesting this structure was not only overlooked in other *Delamarella* species, but is actually a diagnostic character for the family. The level of segmentation expressed in the distal part of the female antennule shows intraspecific variability in *D. obscura* (compare Figs 3E, 8A). Huys & Kunz (1988) remarked that the 8-segmented conditions in *L. eximius* and *D. arenicola* may not be homologous; however, given the generally weakly defined boundaries of the apical segments, this claim requires confirmation before it can be attributed taxonomic significance. A similarly overemphasized character is the presence/absence of an antennary allobasis. All published descriptions of *Delamarella* species invariably state that the basis is fused to the proximal endopod segment, forming an allobasis. Our observations confirmed the presence of a transverse surface suture (Fig. 8B) in both *D. obscura* and *D. galateae* which resembles the faint articulation drawn by Božić (1969) in his description of *L. eximius*.

The 2-segmented P1 exopod reported by Chappuis (1954a, b), Petkovski (1957) and Cottarelli (1971) was considered by Huys & Kunz (1988) as one of six autapomorphies defining the genus *Delamarella*. We observed that in *D. obscura* and *D. galateae* the P1 exopod is in reality 3-segmented although the segment boundary between exp-2 and exp-3 is not always clearly discernible. Unlike the articulation between exp-1 and exp-2, the joint between exp-2 and exp-3 is telescopic in nature and does not display the usual condylar reinforcements. The middle and distal segments are connected by a membranous intersegmental zone (arrowed in Fig. 10B) which enables the latter to be partly withdrawn in the former (Fig. 10B). When exp-3 is fully exposed, the telescopic boundary is hardly discernible, creating the false impression that the ramus is 2-segmented (Fig. 10B). Although the inner seta on P1 enp-1 in *A. phyllosetosa* and *L. eximius* has consistently been claimed to be absent in previous *Delamarella* descriptions, we have shown it to be present in at least *D. galateae* and *D. obscura*. As this element typically arises from the posterior surface of the segment, we suspect that it may have been overlooked in *D. arenicola* and *D. karamani*.

The most striking apomorphy of latiremids is displayed by the complex morphology of the male P4 exopod. The different processes and elements of the distal part of the ramus cannot readily be homologized with their equivalents in the adult female. Prior to the final moult the P4 is essentially the same in both sexes, except that the proximal and middle exopod segments are already expanded in the male (Fig. 7F). Examination of a copepodid V ♂ intermoult of *D. obscura* (Fig. 7F, G) provided new insights into the reorganization and allometric growth of the male exopod. The outer lobate process of exp-2 (B) is the homologue of

the expanded distal outer margin (proximal to the outer spine) of the segment. The outer spine of exp-2 is strongly reduced, being represented by a small spini-form element (A) arising from the posterior surface of the segment. The large attenuated structure on exp-2 (D), opposing the claw-like distal segment, is not a modified setation element but homologous to the outer distal corner of the segment. Exp-3 becomes reshaped into a triangular, curved segment bearing three short setae which are conceivably the homologues of the two distal setae and the distal outer spine in the female. The hook-like extension of exp-3 may be derived from the proximal outer spine, which became incorporated, but no evidence can be found in support of this assumption. The inner spine on enp-1 is expressed as in the female, showing its loss in the adult male is secondary.

The reported difference in the male P4 exopodal ornamentation between *Latiremus* and *Delamarella* is almost completely attributable to observational errors. Chappuis's (1954a, b) illustration of *D. arenicola* shows no setation element on the middle segment but three hook-like spines on the distal segment. Using *D. obscura* as a reference for comparison (Fig. 6D), it is obvious that the inner spine corresponds to the rudimentary distal segment, the middle and outer spines to the attenuated outer distal corners of the middle segment, and that the small outer spine of the middle segment was overlooked. Similarly, Božić (1969) illustrated the P4 of *L. eximius* with no outer spine on exp-2 and three setae plus one spine on exp-3; this atypical pattern results from conflating the reflexed small third segment (three setae) and the spiniform distal outer corner of the middle segment (spine). Petkovski (1957) again presented a different interpretation for *D. karamani*, showing a recurved inner spine on the middle segment (in reality this spine is the reduced distal segment) and two spinous processes (derived from exp-2) plus two setae (derived from exp-3) on the alleged distal segment.

Given the difficulty in observing the serrate flanges of the setae on the fifth legs it is premature to attribute any significance to the absence of this character in *L. eximius*. Finally, we suspect the absence of the smooth seta on the P5 exopodal lobe in female *L. eximius* (but not in the male) is based on an observational error and does not necessarily reflect phylogenetic distinctiveness. No such sexual dimorphism is found in any *Delamarella* species. The explanation for this lack lies in the progenetic development of the P5, resulting in the persistence of the sexually undifferentiated copepodid IV condition in the adults. Because this scenario (early offset) is probably applicable across the family there is little evidence to accept the alternative pattern displayed by *L. eximius*. In conclusion, as there are no conclusive grounds left to main-

tain *Latiremus* as a distinct genus it is formally synonymized with *Delamarella* and, consequently, its type species is transferred as *D. eximia* (Božić, 1969) comb. nov. Based on published records the genus appears to assume a ponto-mediterranean distribution with one outlier in the Western Indian Ocean (Božić, 1969); however, one of us (V.C.) recently discovered another morphologically close congener from the Philippines, suggesting that *Delamarella* is probably Tethyan in distribution. Most mediterranean species are found interstitially in beach sands influenced by freshwater, i.e. at or near the mouth of rivers and streams. This low salinity preference probably enabled the genus to colonize other habitats in the oligohaline Black Sea.

SPECIES DISCRIMINATION IN *DELAMARELLA* CHAPPUIS, 1954

Delamarella species are generally small (about 0.5 mm) and the morphological stasis in the genus makes it extremely difficult to separate congeners unambiguously. Most species belonging to the ponto-mediterranean species complex can only be differentiated by either morphometric characters and/or features related to ornamentation of body and appendages. In addition, characters traditionally applied to separate species are no longer valid. For example, Cottarelli (1971) identified the following characters as diagnostic for *D. galateae*: (1) oblique row of fine spinules on dorsal surface of caudal ramus, (2) caudal ramus sexual dimorphism (with 'tubercle' in ♂) (3) denticulate somitic frills, (4) distinct ventral spinulation of abdominal somites, (5) inner margin of P2–P3 exp-2 [*lapsus calami* in Cottarelli (1971): read exp-2] without seta, and (6) detailed morphology of ♂ P4 exopod. Characters (1)–(4) are also displayed by *D. obscura* and are conceivably present in all *Delamarella* species, being inadequately figured in previous descriptions. Character (5) is based on an observational error given that our re-examination of *D. galateae* revealed the presence of an inner seta on P2–P3 exp-2 as in all other congeners. Finally, given the deficiencies in earlier descriptions (see above) the morphology of the male P4 exopod is of limited usefulness in species discrimination. Cottarelli (1971) remarked that females of both *D. galateae* and *D. karamani* differ from those of the type species *D. arenicola* in the 8-segmented antennule and the P4 endopod which is not only 2-segmented but also distinctly shorter than in its congeners.

The differences between the remaining mediterranean species are less pronounced. *D. obscura* differs from *D. galateae* primarily in the spinulation of the anal operculum (20–30 small spinules vs. 7–10 large spinules; Fig. 7A, B), the length of the distal abexopo-

dal seta on the antenna (much shorter than the proximal one in *D. galateae*; Figs 3F, 7C) and the detailed morphology of the male P5 (exopodal spines longer and ornamentation of middle endopodal spine more pronounced in *D. obscura*; Fig. 7D, E). Despite the conciseness of Petkovski's (1957) description of *D. karamani*, his illustrations provide sufficient information to distinguish this species from *D. obscura*: (1) the anal operculum is less ornate, (2) the P3 endopod is as long as the exopod (distinctly shorter in *D. obscura*; Fig. 5C) and (3) the exopodal spines on the male P5 are markedly longer and more slender.

Apostolov (1969) recorded numerous females and males from coastal groundwater ('Küstengrundwasser') at Cape Galata in the Bay of Varna (Bulgarian Black Sea coast), which he attributed to *D. karamani*. The author claimed his specimens differed from Petkovski's (1957) Croatian type material in the caudal ramus (presence of an oblique dorsal spinule row and two short marginal spinules between setae II and III; the latter form obviously part of the posteroventral spinule row found in other species, e.g. Fig. 2B), the size of the anal somite (reaching halfway along the caudal ramus length) and the anal operculum (with 21–25 spinules). This last character suggests Apostolov's (1969) material and his six females from a sandy beach near the Veleka River (Apostolov, 1971) are conspecific with *D. obscura*, indicating the species has an almost continuous distribution on either side of the Bosphorus, from the Bay of Varna in northern Bulgaria to at least the Kastamonu province in north-western Turkey. It should also be remarked that the illustrations of *D. karamani* in Apostolov & Marinov's (1988) Fauna Bulgarica are based on Petkovski (1957), not on Apostolov (1969).

ACKNOWLEDGEMENTS

This research was funded by the Technical and Scientific Research Council of Turkey (TUBITAK) under project no TBAG-1962(100T120). Our colleague Serdar Sak (University of Balikesir) is gratefully acknowledged for logistic assistance in the field.

REFERENCES

- Apostolov A. 1969.** Harpacticoiden (Crustacea Copepoda) von der bulgarischen Küste. *Zoologischer Anzeiger* **183** (3–4): 260–267.
- Apostolov A. 1971.** Ein Beitrag zur Kenntnis der Harpacticoidenfauna Bulgariens. *Zoologischer Anzeiger* **187** (5–6): 345–356.
- Apostolov AM, Marinov TM. 1988.** Copepoda Harpacticoida (morski kharpaktikoidi). [Copepoda, Harpacticoida (marine harpacticoids)]. *Fauna Bolgarii [Fauna Bulgarica]* **18**: 1–384. Sofia, In Aedibus Academiae Scientiarum Bulgaricae [in Bulgarian].

- Bodin P. 1976a.** Catalogue des nouveaux Copépodes Harpacticoides marins. Additif no. 2. *Téthys* **7**: 265–278.
- Bodin P. 1976b.** *Catalogue des nouveaux Copépodes Harpacticoides marins. Additif no. 3.* Brest: Université de Bretagne occidentale, Laboratoire d'Océanographie biologique, 1–45.
- Bodin P. 1979.** *Catalogue des nouveaux Copépodes Harpacticoides marins. (Nouvelle édition).* Brest: Université de Bretagne occidentale, Laboratoire d'Océanographie biologique, 1–228.
- Bodin P. 1988.** *Catalogue des nouveaux Copépodes Harpacticoides marins. (Édition 1988).* Brest: Université de Bretagne occidentale, Laboratoire d'Océanographie biologique, 1–288.
- Bodin P. 1997.** Catalogue of the new marine Harpacticoid Copepods (1997 Edition). *Studiedocumenten van het K.B.I.N.* **89**: 1–304.
- Božić B. 1969.** *Latiremus eximius*, n. gen., n. sp. à position systématique incertaine (Copépode Harpacticoides): données pour une nouvelle famille. *Bulletin de la Société zoologique de France* **94**: 309–316.
- Božić B. 1978.** Le genre *Delamarella* Chappuis et le problème de son statut systématique (Crustacea, Copepoda, Harpacticoida). *Bulletin du Muséum national d'Histoire Naturelle, Paris* (3)**513** (= *Zoologie* **352**): 153–155.
- Chappuis PA. 1954a.** *Delamarella arenicola* n. g. n. sp. Copépode interstitiel des plages du Roussillon. Note préliminaire. *Vie et Milieu* **4**: 111–113.
- Chappuis PA. 1954b.** IV. Copépodes psammiques des plages du Roussillon. P.A. Chappuis & Cl. Delamare Deboutteville, avec la collaboration de J. Balazuc & S. Ruffo. *Biospeologica* LXXIV. Recherches sur les Crustacés souterrains (première série). *Archives de Zoologie expérimentale et générale* **91**: 35–50.
- Chappuis PA. 1954c.** Harpacticides psammiques récoltés par Cl. Delamare Deboutteville en Méditerranée. *Vie et Milieu* **4**: 254–276.
- Cottarelli V. 1971.** *Delamarella galateae* n. sp., nuovo arpacticoides di acque sotterranee littorali di Sardegna (Crustacea, Copepoda). *Fragmenta Entomologica* **7**: 289–301.
- Delamare Deboutteville C. 1954.** Recherches sur l'écologie et la répartition du mystacocaride *Derocheilocaris remanei* Delamare et Chappuis, en Méditerranée. *Vie et Milieu* **4**: 321–380.
- Huys R, Gee JM, Moore CG, Hamond R. 1996.** Marine and brackish water harpacticoid copepods. Part 1. *Synopses of the British Fauna (New Series)* **51**: i–viii, 1–352.
- Huys R, Kunz H. 1988.** On the generic boundaries within the marine interstitial Latiremidae (Copepoda: Harpacticoida). *Stygologia* **4**: 292–305.
- Itô T. 1974.** Descriptions and records of marine harpacticoid copepods from Hokkaido. V. *Journal of Faculty of Science, Hokkaido University, Zoology* **19**: 546–640.
- Kunz H. 1977.** Zur Kenntnis der Gattungen *Delamarella* Chappuis und *Latiremus* Božić (Copepoda Harpacticoida, Fam. Latiremidae Božić). *Crustaceana* **32**: 210–211.
- Kunz H. 1984.** *Delamarella phyllosetosa* n. sp. (Copepoda, Harpacticoida, Familie Latiremidae Božić) von der Küste Westafrikas. *Mitteilungen aus dem Zoologischen Museum, Kiel* **2** (2): 54–56.
- Petkovski TK. 1957.** VI. Beitrag zur Kenntnis der Grundwasser-Copepoden unserer Meeresküste. *Izdaniya. Zavod za Ribarstvo na N.R. Makedonija* **2**: 1–16.
- Wells JBJ. 1976.** *Keys to aid in the identification of marine harpacticoid copepods*: 1–215, figs 1–41, tabs. Published by the Department of Zoology, University of Aberdeen.
- Wells JBJ. 1978.** Keys to aid in the identification of marine harpacticoid copepods. Amendment Bulletin no. 1. *Zoology Publications Victoria University, Wellington*, **70**: 1–11.
- Willen E. 2000.** *Phylogeny of the Thalestridimorpha Lang, 1944 (Crustacea, Copepoda)*. Göttingen: Cuvillier Verlag, 1–233.