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A new genus of Paramesochridae (Copepoda: Harpacticoida) from amphioxus-sand, Elat, Israel

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A new species of Paramesochridae (Copepoda, Harpacticoida) is described on the basis of a single male collected from intertidal amphioxus-gravel in Elat, Israel. *Singularia ingens* gen. et sp. nov. is the largest paramesochrid discovered to date (> 1 mm) and the first to be recorded from the Gulf of Elat. It belongs to the *Scottopsyllus*-group of genera, and can be differentiated from all known genera on the basis of the structure of the antennary exopod, the male P6, the caudal rami and the segmentation of P2-P4. The modified male P3 exopod is also unique and probably involved in mate guarding. The probable relationships between *S. ingens* and the type species of *Leptopsyllus, L. typicus* T. Scott, are discussed.

KEYWORDS: *Singularia ingens, Leptopsyllus*, Paramesochridae, Harpacticoida, Gulf of Elat.

Introduction

Our knowledge of the interstitial harpacticoid fauna of Israel is restricted to the paper of Masry (1970), reporting on 8 mesopsammic species collected from 9 sandy beaches along the Israeli Mediterranean coast line between Nitzanim in the south and Akhziv in the north. No information is available on the interstitial copepods from the Gulf of Elat though some extensive studies on harpacticoids have been carried out in this area (Por, 1967, 1983; Marcus and Masry, 1971). During a collecting trip to Israel in the summer of 1993, a number of sandy beaches were sampled in Elat. Initial examination of samples taken in the amphioxus-sand in front of the Heinz Steinitz Marine Biology Laboratory revealed high numbers of a new species of *Oniscopsis* Chappuis and a single male of a new genus of Paramesochridae to be described below. Few Paramesochridae are known from the Red Sea, the only records being those of Noodt (1964) who reported *Paramesochra longicaudata* Nicholls and described 3 new species *Kliopsyllus psammophilus* (Noodt), *K. psammobiontus* (Noodt) and *Apodopsyllus schulzi* (Noodt) from coralline sand near Ghardaqa, Egypt. The new genus and species is the first paramesochrid to be described from the Gulf of Elat, and represents only the 3rd record of the family in Israeli waters (Masry, 1970).

Material and methods

The holotype was dissected in lactic acid and the dissected parts were placed in lactophenol mounting medium. Preparations were sealed with glyceel (Gurr™, BDH

Chemicals Ltd, Poole, England). All drawings have been prepared using a camera lucida on a Leitz Diaplan differential interference contrast microscope. The descriptive terminology is adopted from Huys and Boxshall (1991). Abbreviations used in the text are: P1-P6, 1st–6th thoracopod; exp(enp)-1(2, 3) to denote the proximal (middle, distal) segment of a ramus.

Systematics

Family PARAMESOCHRIDAE Lang, 1944
Singularia gen. nov.

Diagnosis. Paramesochridae. Body elongate, cylindrical; no distinct separation between prosome and urosome. Cephalothorax with pattern of chitinous ridges; pedigerous somites with isolated patches of thin cuticle. Penultimate somite with well developed quadrilobate pseudoperculum. Caudal ramus with rounded attenuation at inner distal corner; with 7 setae, seta I well developed, seta VI modified and composite. Rostrum small, rounded, fused to cephalic shield. Antennule 6-segmented in ♂, with aesthetasc on segment 4 and geniculation between segments 4 and 5; aesthetasc-bearing segment not distinctly swollen. Antenna with basis and 1-segmented exopod; exopod with 1 lateral seta and 2 spines plus a spatulate element apically. Mandible with biramous palp comprising unisetose basis, 2-segmented endopod and vestigial exopod represented by single seta. Maxillule with discrete rami; exopod a small bisetose segment, endopod with 5 setae. Maxilla with praecoxal endite largely incorporated into syncoxa; basal endite produced into strong claw accompanied with another claw issuing from partly incorporated endopod; endopod 1-segmented. Maxilliped subchelate; syncoxa with 1 seta; basis elongate; endopod 1-segmented with long, strong claw distally and 4 accessory setae. P1 without outer basal seta; rami 2-segmented, of about equal length; exp-1 with very long outer seta, exp-2 with 4 setae; enp-2 with 2 setae. P2-P4 laterally displaced but coxa and basis not markedly produced laterally; exopods inwardly directed, 3- (P2-P3) or 2-segmented (P4; fusion of exp-2 and -3), with 2 spines on distal segment (3 in P4); endopods absent (P2-P3) or 1-segmented with large pectinate spine (P4). Exopod P3 (presumably) modified in ♂, distinctly larger than other thoracopods, with modified spine on exp-2 and -3. P5 ♂ partly incorporated in somite, baseoendopod and exopod discrete; exopod minute with 3 setae, endopodal lobe rudimentary with 2 setae. P6 symmetrical, with 1 outer seta and 2 small ones at the inner corner.

Type species. *Singularia ingens* gen. et sp. nov.

Etymology. The generic name is derived from the Latin *singularis*, meaning unusual, rare, and refers to the unique combination of character states displayed by the antennary exopod, P3 exopod, P4 exopod, P6 and caudal rami. Gender: feminine.

Singularia ingens sp. nov.

Type material. HOLOTYPE an adult ♂ dissected and mounted on six slides; collected by Karaman-Chappuis method from amphioxus-sand at low-water line in front of Heinz Steinitz Marine Biology Laboratory, Elat, **Israel**; 9 August 1993, leg. R. Huys;

deposited in the collections of The Natural History Museum, London under reg. no. 1994.1229.

Description of male. Body elongate, cylindrical, without distinct separation between prosome and urosome but with clear somite boundaries (Fig. 1A). Thoracic and abdominal somites connected by well developed arthrodial membranes, particularly between cephalothorax and P2-bearing somite (Fig. 1C). Integument pitted. Body length 1100 μm measured from anterior tip of rostrum to rear margin of caudal rami. Largest width 140 μm measured midway along cephalothorax. Penultimate somite longest, about 1·1 × as long as wide (measured in ventral aspect; Fig. 1B).

Cephalothorax with symmetrical pattern of underlying chitinous ridges both dorsally (Fig. 1C) and laterally (Fig. 1D). Thoracic somites bearing P2–P4 with isolated plates of thick cuticle interspersed with membranous areas (Fig. 1A). Penultimate somite with distinct membranous, quadrilobate pseudoperculum covering most of anal somite (Figs 1A, 5C), slightly tapering distally. Inner distal corner with blunt, slightly recurved attenuation (Fig. 5B, C). Each ramus with 7 setae (Fig. 5A–C); seta I well developed, seta III long and plumose; setae IV and V with fracture planes, seta V strongly developed, seta IV relatively short; seta VI modified, composite, consisting of short proximal socle and distal setule; seta VII biarticulate at base.

Rostrum (Fig. 1E) small, rounded anteriorly, fused to cephalothorax, with 2 long sensilla.

Antennule (Figs 1A, D; 2A) short, 6-segmented; geniculation between segments 4 and 5; segments around geniculation not distinctly swollen; aesthetasc on segment 4 (77 μm); segment 1 longest, with 1 pinnate seta; segment 2 and 3 with 8 naked and 2 pinnate setae each; segment 4 with 1 pinnate and 9 naked setae plus 1 aesthetasc; segment 5 with distinct subcylindrical process on ventral surface bearing 1 long plumose seta, anterior margin with 2 setae; segment 6 triangular, with 13 setae.

Antenna (Fig. 3A, a). Coxa small, unarmed. Basis with spinules along abexopodal margin. Exopod 1-segmented, with 1 lateral pinnate seta; apex with spatulate element, 1 pinnate and 1 serrate spine. Endopod 2-segmented; proximal segment with pinnate lateral seta; distal segment with 3 spines laterally, and 1 simple plus 5 geniculate setae distally, the longest one being fused at base with a long bare seta.

Mandible (Fig. 3B). Coxa with well developed gnathobase bearing several teeth and 1 pinnate seta at dorsal corner; ventral corner with spinular row. Palp biramous, consisting of unisetose basis, 2-segmented endopod and rudimentary exopod represented by single seta only. Endopod with 2 setae on proximal segment and 5 basally fused setae on apex of distal segment.

Maxillule (Fig. 3C). Praecoxa with well developed arthrite armed with 2 naked (tube?) setae and a pinnate spine on anterior surface, 1 strong pinnate spine on posterior surface, and 7 spines and 1 seta around distal margin. Coxal endite cylindrical, with 1 pinnate claw and 2 setae. Basis with 5 distal setae. Endopod with 5 setae. Exopod a small segment with 2 pinnate setae.

Maxilla (Fig. 3D). Syncoxa with 3 endites; praecoxal endite largely incorporated into segment, with 2 pinnate setae; middle and distal endites with 2 spines and 1 seta each. Allobasis drawn out into strong pinnate claw; with 1 accessory seta and another articulate, strong claw derived from partly incorporated endopod. Endopod 1-segmented; with 5 setae.

Maxilliped (Fig. 2B). Subchelate. Syncoxa with several spinular rows and 1 pinnate seta. Basis elongate, with 2 spinular rows but no armature. Endopod 1-segmented;

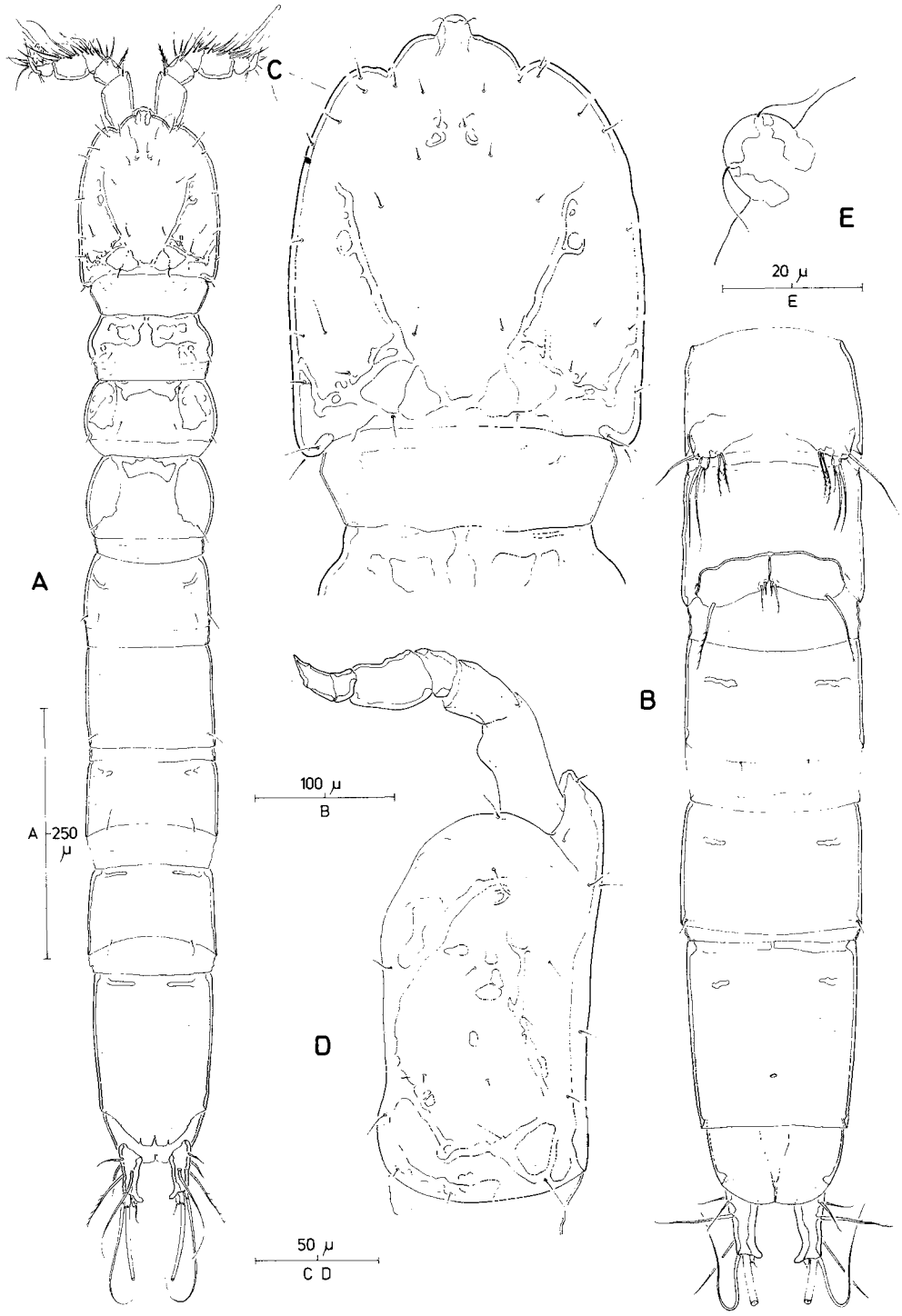

FIG. 1. *Singularia ingens* gen. et sp. nov.: (A) male habitus, dorsal; (B) urosome, ventral; (C) cephalothorax, dorsal; (D) same, lateral; (E) rostrum.

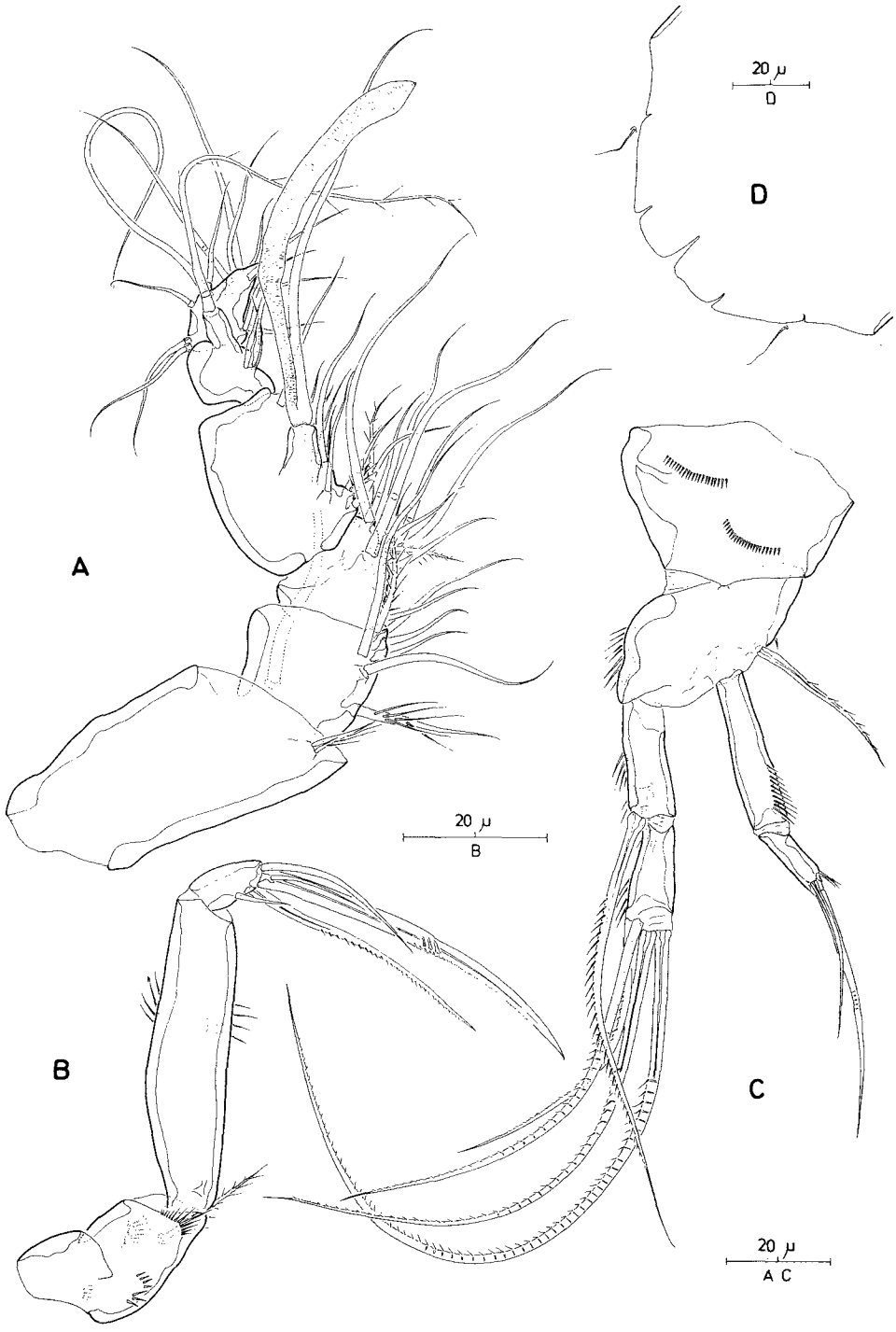

FIG. 2. *Singularia ingens* gen. et sp. nov.: (A) antennule, ventral; (B) maxilliped; (C) P1; (D) pseudoperculum.

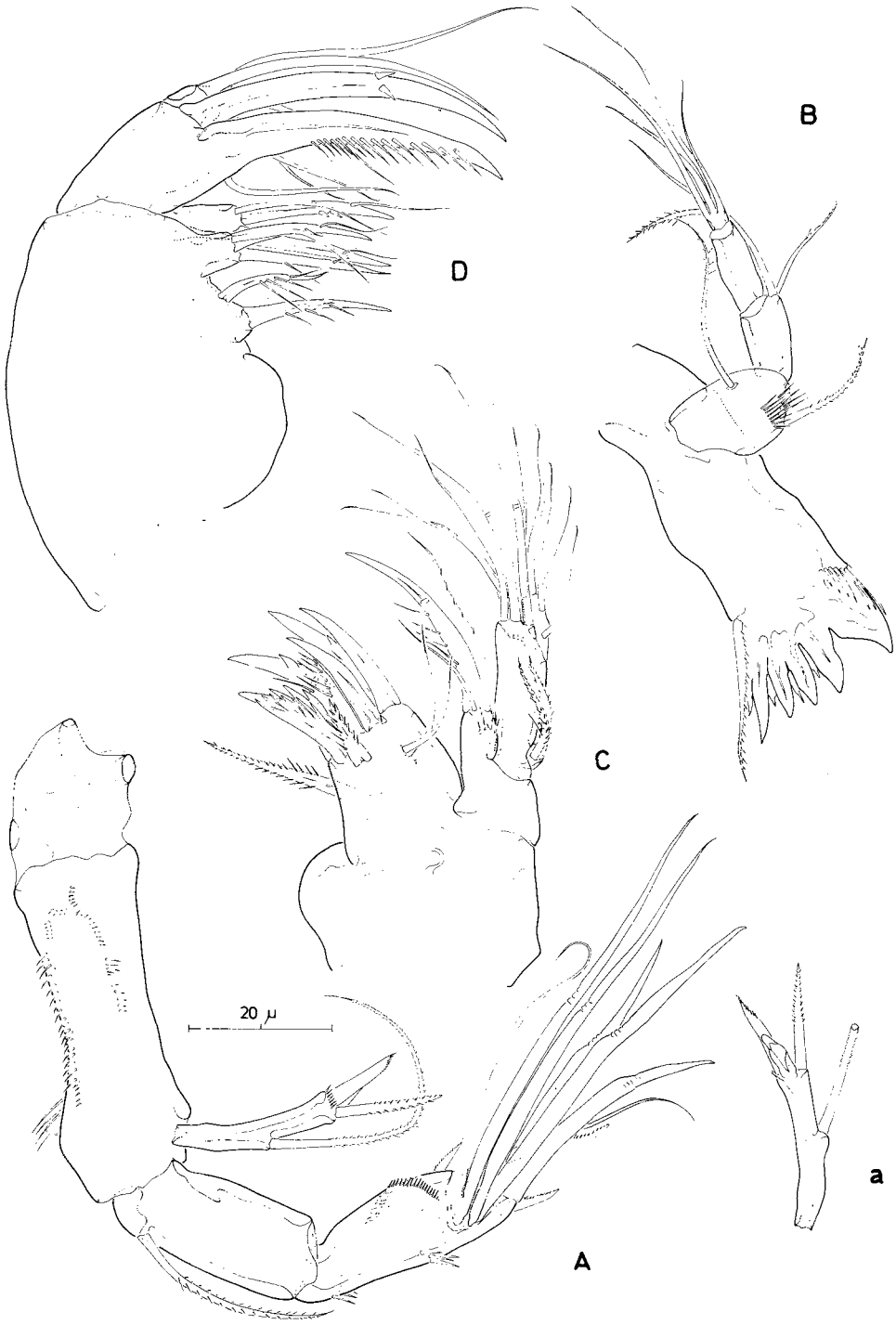

FIG. 3. *Singularia ingens* gen. et sp. nov.: (A) Antenna [a, antennary exopod]; (B) mandible; (C) maxillule; (D) maxilla.

principal element a long, curved pinnate claw; accessory armature consisting of 3 setae issuing from segment and 1 seta implanted on claw.

P1 (Fig. 2C) with large coxa bearing 2 spinular rows. Basis slightly produced abaxially; outer seta absent; inner distal corner with pinnate seta. Rami 2-segmented and of equal length. Exopod with long outer seta on exp-1; exp-2 with 1 simple and 4 long, geniculate setae. Endopod consisting of elongate proximal segment without armature, and short distal segment with 1 geniculate seta distally and 1 shorter seta subdistally.

P2-P4 (Fig. 4). Protopodal segments laterally displaced but not markedly produced abaxially; exopods considerably inwardly directed. Basis with outer plumose (P3–P4) or naked (P2) seta. Endopods absent in P2 and P3; represented by elongate segment with distinct pectinate spine in P4. Exopods 3-segmented in P2 and P3; 2-segmented by fusion of middle and distal segments in P4. P2 with 2 strong spinules on the outer margin of exp-3 (Fig. 4A). P3 (Fig. 4B) modified, distinctly larger than P2 and P4, with specialized joint between exp-2 and -3; exp-1 robust, longer than rest of exopod; exp-2 shortest, modified, with distinct recurved outer spine directed along anterio-posterior axis; exp-3 with blade-like process near outer distal corner, outer spine strongly pectinate. Spine and seta formula as follows:

	Exopod	Endopod
P1	0·022	0·011
P2	0·0·011	–
P3	0·0·011	–
P4	0·012	010

P5 (Figs 1B, 5D). Medial portion partly incorporated into somite. Baseoendopod and exopod discrete. Baseoendopod with 2 large secretory pores on anterior surface, 1 outer (basal) plumose seta and vestigial endopodal lobe represented by 2 pinnate setae. Exopod a small segment with 3 setae, innermost one being minute.

P6 (Figs 1B, 5E). Leg pair symmetrical. Armature consisting of outer plumose seta and 2 small setae near the inner distal corner.

Spermatophore large (220 μm).

Etymology. The specific name is derived from the Latin *ingens*, meaning very large, and alludes to the extreme body size.

Discussion

Singularia can be differentiated from all known paramesochrid genera on the basis of the following combination of characters: antennary exopod with spatulate element, mandible with vestigial exopod, maxilla with 2 claws on allobasis, maxilliped with elongate basis and strong claw exceeding length of basis, segmentation of P2–P4, modification of P3 exopod, P6 with inner setae displaced to inner distal corner, structure and shape of caudal rami.

The presence of only 2 spines on the distal exopod segment of P2–P4 clearly links the new genus to the *Scottopsyllus*-group (Huys, 1987), currently encompassing *Scottopsyllus* Kunz, *Caligopsyllus* Kunz, *Leptopsyllus* T. Scott and *Apodopsyllus* Kunz. [Wells' records (1963, 1967) of 3 spines on P4 exp-3 in *Leptopsyllus harveyi* Wells proved upon re-examination of type material to be erroneous]. The unique segmentation

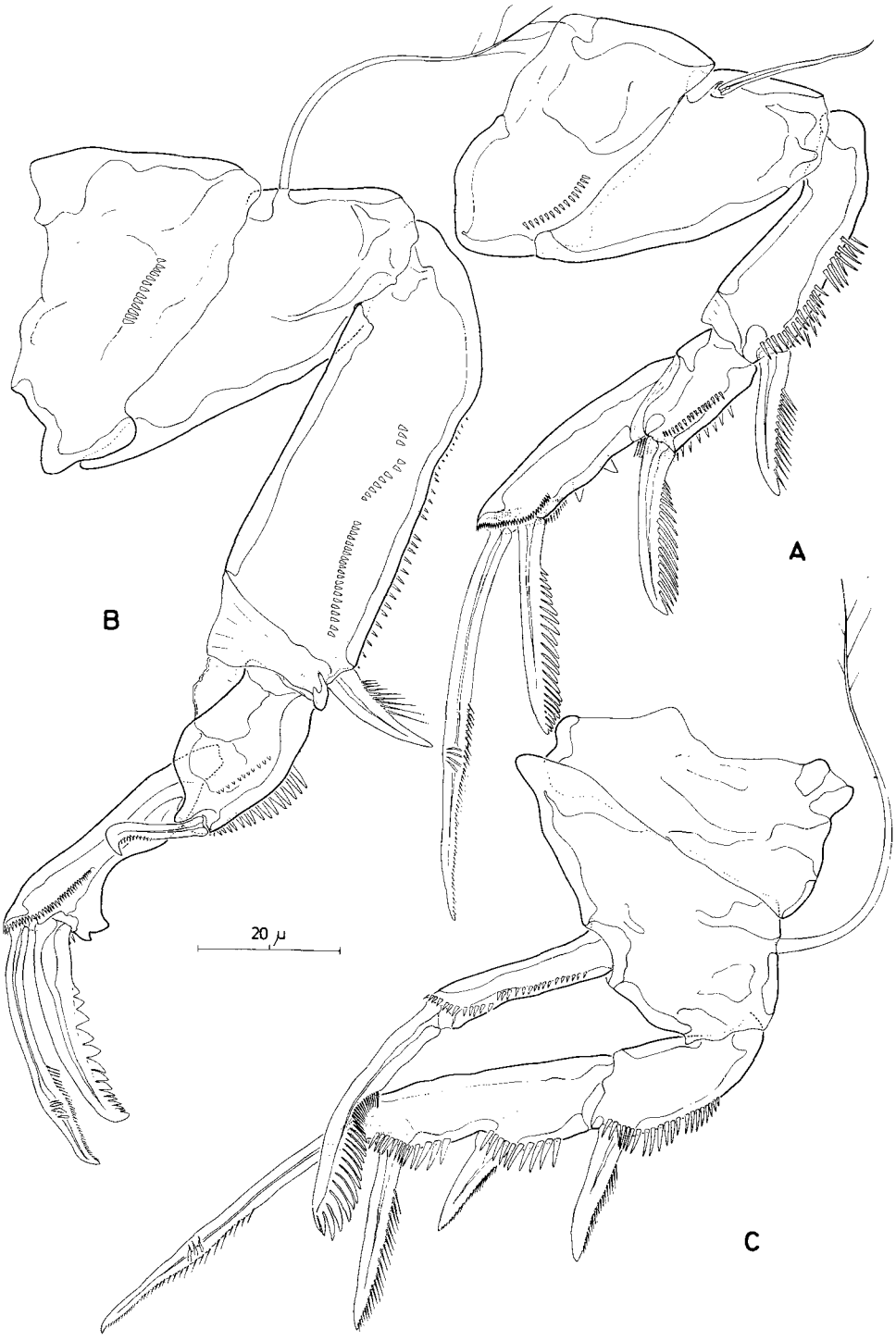

FIG. 4. *Singularia ingens* gen. et sp. nov.: (A) P2; (B) P3; (C) P4.

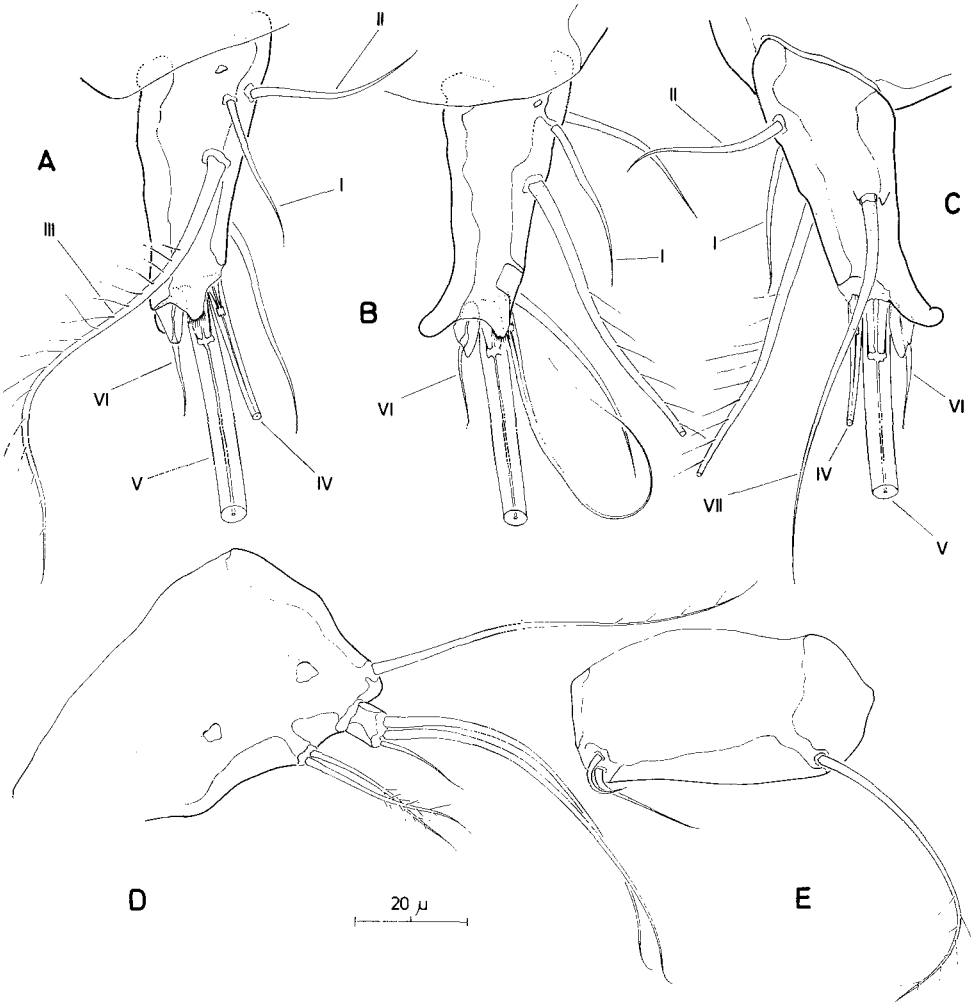

FIG. 5. *Singularia ingens* gen. et sp. nov.: (A) Çaudal ramus, lateral; (B) same, ventral; (C) same, dorsal; (D) P5; (E) P6.

of the swimming legs P2-P4 is the main obstacle to the allocation of *S. ingens* to any of the known paramesochrid genera as diagnosed by Kunz (1981). On the basis of the endopodal segmentation the new species could be placed in *Leptopsyllus* but the 2-segmented exopod of P4 prevents such an allocation. Conversely, the exopodal segmentation of these limbs indicates a superficial relationship with *Intermedopsyllus* Kunz [currently a subgenus of *Scottopsyllus* according to Kunz (1981)] but species of this genus possess a 1-segmented endopod on P2–P4. In addition, the 2-segmented exopod of P4 in species of *Intermedopsyllus* (Kunz, 1938, 1992; Nicholls, 1939) is derived by fusion of the proximal and middle segments, a fusion pattern also found in one species of *Scottopsyllus* (Mielke, 1984a). The condition in *Singularia* is not homologous since it originated through fusion of the middle and distal segments. It is further only found in a single species of *Leptopsyllus* (cf. Becker, 1979) and in *Kliopsyllus laurenticus* (Nicholls), currently regarded *species incertae sedis* by Kunz (1981).

Singularia ingens possesses a well developed pseudoperculum covering most of the anal somite in dorsal aspect. Such a membranous extension of the penultimate somite is typical for most Paramesochridae (e.g. *Paramesochra mielkei* Huys) but since such a structure is highly transparent and only discernible with interference or phase contrast microscopy, it has hardly ever been figured in descriptions. A multilobate pseudoperculum as found in *S. ingens* has also been described for *Leptopsyllus platyspinosus* Mielke and *Apodopsyllus aberrans* Mielke (Mielke, 1984a, b).

Sexual dimorphism on the thoracopods P2-P4 is not common in the Paramesochridae. When present, it usually takes the form of slight modifications such as the small attenuation of the inner distal corner of the distal exopod segment in P2 and P3 of *Kliopsyllus regulextans* Mielke, or the additional presence of spinules on the inner seta of the proximal endopod segment in *Rossopsyllus kerguelenensis quellonensis* Mielke (Mielke, 1984a, 1985). Mielke (1984a) also reported the loss of the inner seta on the distal exopod segment in P4 of males of *Diarthrodella galapagoensis* Mielke. Due to the small size of most species, it is conceivable that differences of this level have passed unnoticed in earlier descriptions of male Paramesochridae. The general facies of the male P3 in *S. ingens* is more distinctive but somewhat difficult to interpret in the absence of the female. The hooked outer spine on the middle exopod segment, directed along an anterio-posterior axis, and the peculiar modifications of the middle and distal segments, are both unique within the family. These features which have never been recorded in females, combined with the large disproportion in size between the P3 and the other thoracopods raise the possibility that this limb performs a function during the precopulatory phase of the mating process, probably assisting in a clasping posture of some kind.

Singularia ingens bears a certain resemblance to *Leptopsyllus typicus* T. Scott, described from west of Queensferry in the Firth of Forth (Scott, 1894). The species is only known from females and has never been recorded again. It was collected by washing of lumps of hardened mud mainly composed of the agglutinated tubes of a *Sabella* species. T. Scott's original description (1894) is deficient in some aspects, but contains sufficient information to reveal several similarities between both species:

Mandible. T. Scott clearly shows an uniramous palp consisting of an elongate endopod and a bisetose basis. In *Singularia* the exopod is rudimentary, being represented by a single seta only, suggesting that it might have been overlooked in *L. typicus*. In all other Paramesochridae—except for *Apodopsyllus aberrans* Mielke and *Leptopsyllus platyspinosus* Mielke whose mouthparts are reduced—the mandibular palp is clearly biramous.

Maxilla. In *Singularia* the distal part of the maxilla shows two strong claws, one arising from the basis, the other one closely adpressed to the former and issuing from the partly incorporated endopod. In T. Scott's drawing these claws can be seen in exactly the same position whereas in all other species the endopodal armature consists only of setae.

Maxilliped. The typical condition in the family is a 2-segmented endopod bearing a sigmoid claw on the proximal and 2 geniculate setae on the distal segment. This armature pattern might be supplemented by 1 or several smaller setae, or might be obscured by partial fusion of the constituent segments, however, it is found in all species except *S. ingens* and *L. typicus*. In both these species the endopod is 1-segmented and the principal armature element is a long curved claw arising from the distal end and exceeding the length of the elongate basis.

Caudal ramus. T. Scott's illustration is no doubt incomplete, but shows an

interesting feature also found in *S. ingens*, referred to in the text (p. 254) as '...the inner distal angle produced into a blunt-pointed tooth-like process'. The distal element ('second joint or appendage to the stylet' as Scott puts it) is either the incomplete seta V, or a seta that is sexually dimorphic in the female as found in females of some *Scottopsyllus* species (e.g. *S. langi*; Mielke, 1984a).

Size. Large, 740 μm.

It is unfortunate that both *S. ingens* and *L. typicus* are known from one sex only since information about the former's female caudal ramus and P5 and the latter's male P3 could have shed more light on their relationships. Both species cannot possibly be congeneric since they have a different segmentation in the rami of P4, and, if correct, a different setation on the P1 exopod. The isolated position of *L. typicus* within *Leptopsyllus* can have potential taxonomic consequences since it represents the type species of a genus currently encompassing 9 species (Bodin and Jackson, 1987). Comparative analysis of the characters within the genus suffers from lack of detail in most descriptions, but nevertheless reveals that it is almost certainly an amalgamate of 3 different genera and only *L. typicus* should be retained in *Leptopsyllus*. The formal establishment of these genera, however, is premature in the absence of detailed descriptions and has to await further revision (Huys, in preparation).

Unlike Cylindropsyllidae and most other interstitial harpacticoids, Paramesochridae have colonized the mesopsammic environment primarily by miniaturization of the body. Most representatives are diminutive, their dimensions ranging between 0·2 and 0·5 mm, and some are the smallest harpacticoids known to date (Wells, 1967). A few species, which presumably only secondarily (re)invaded muddy substrata such as *Wellsopsyllus gigas* (Wells) and *W. abyssalis* (Becker) attained a larger body size (up to 800 μm). *Singularia ingens* is the only species known to exceed 1 mm and this large body size is clearly related to the gravel habitat and its large interstitial lacunae.

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