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SHORT COMMUNICATION

Speleohvarella gamulini gen. et sp. nov., a new copepod (Calanoida, Stephidae) from an anchialine cave in the Adriatic Sea

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A new copepod genus and species, Speleohvarella gamulini, collected from the anchialine cave Živa Voda on Hvar Island (Croatia), is described from both sexes. This is the first record of a calanoid copepod found in an Adriatic anchialine cave. The new genus is distinguished from other Stephidae by a combination of the following features: the cephalosome is separate from the first pedigerous somite, and the fourth and fifth pedigerous somites are fused; the female urosome has 4 segments, the genital double-somite is symmetrical and the caudal rami is asymmetrical with the right longer than the left; antennules of both sexes are symmetrical and 24-segmented, with the fusion of ancestral segments II–IV, X–XI and XXVII–XXVIII; the exopod of antenna is 7-segmented; 2 setae are present on the basal exite of maxillule; in the male the right leg 5 is short and 3-segmented, and the left leg elongate and 5-segmented.

The eastern shore of the Adriatic Sea is a region of Dinaric karst characterized by porous limestone and numerous related geomorphological phenomena, such as anchialine caves. From a biogeographical perspective, the subterranean fauna of the Dinaric coast and islands generally exhibits a paralittoral distribution, the most characteristic element of which is the amphipod *Hadzia fragilis* S. Karaman (Sket, 1994). Sket (Sket, 1996) noted the basic ecological factors of anchialine caves and analysed some of those found along the Croatian Adriatic. A special environmental feature of these caves is the small tidal oscillations to which they are exposed. Salinity varies from ~0 at the surface to 36 psu at 6 m, and temperature is in the range of 14–16°C.

Many researchers have commented on the specific nature of the fauna of marine and anchialine caves, some of which include organisms more typical of the deep sea (e.g. Riedel, 1966). The indigenous calanoid copepods of these caves have remained largely within these ecosystems; in fact, only rather recently have tens of new calanoid species been described from anchialine caves (Bowman, 1976; Yeatman, 1980; Fosshagen and Iliffe, 1989, 1991, 2003; Jaume and Boxshall, 1995; Carola and Razouls, 1996; Ohtsuka *et al.*, 1996; Suárez-Morales and Iliffe, 1996). The Adriatic anchialine cave Šipun, located 25 km from Dubrovnik, was first investigated >50 years ago (Karaman, 1953). It is inhabited by ~60 different species, most of which are endemic, and is the *locus typicus* of dozens of aquatic organisms, including a few species of cyclopoid copepods, e.g. *Metacyclops trisetosus* (Herbst, 1957). Owing to the efforts of the Bio-Speleological Society in Zagreb, preliminary investigations of copepods in anchialine caves have begun, along the Croatian coast and on the islands. A new copepod genus and species has been found in this area, and it is described here.

Material examined was collected during sampling expeditions carried out in April and July 2003 in Živa

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Voda Cave, Bay of Kozja, on Hvar Island (Central Adriatic). Divers from the Croatian Bio-Speleological Society (Zagreb) made collections by vertical, hand-held hauls, from 37 m up to 5 m in western part of cave, with a 20-cm diameter Nansen net. The net was fitted with either a 53-μm mesh or a 125-μm mesh. Ozimec and Polić (Ozimec and Polić, 1998) and Ozimec and Jalžić (Ozimec and Jalžić, 2002) have described the main features of this cave. From the entrance, situated ~30 m above sea level, a steeply descending passage divides into two tunnels after ~30 m. A 27-m deep siphon is located ~60 m along the eastern tunnel, whereas the western tunnel ends in a siphon with 47-m depth. The salinity in water column below 5-m depth was 37–38 and temperature ~15°C. Of particular note, the deep-sea sponge *Oopsacas minuta* Topsent, 1927 was found in deeper section of the cave.

All samples were preserved in a 2.5% formaldehyde–seawater solution neutralized with $CaCO_3$. Specimens were dissected on slides in lactophenol. Drawings were made with the aid of a camera lucida using an Olympus BX51 differential interference contrast microscope. Specimens were measured using an ocular micrometer. The descriptive terminology employed follows to a great Oextent Huys and Boxshall (Huys and Boxshall, 1991).

Order Calanoida Sars, 1903

Family Stephidae Sars, 1902

Genus *Speleohvarella* gen. nov.

Diagnosis: Female. Body oval, prosome 5-segmented; cephalosome separate from first pedigerous somite; fourth and fifth pedigerous somites fused. Urosome with four segments in female. Genital double-somite slightly longer than wide, with genital area symmetrical. Caudal rami asymmetrical, right longer than left, with four long terminal setae and one inner seta on inner border. Antennule symmetrical, 24-segmented, ancestral segments II–IV, X–XI and XXVII–XXVIII fused. Swimming legs 1–4 as described for type species. Third exopodal segment of leg 4 with outer distal spine exceptionally long, about half the length of terminal spine. Antennal exopod 7-segmented, second free segment corresponding to ancestral segments II-IV. Mouthparts identical in both sexes, with maxillule displaying 13 armature elements including 4 posterior setae on praecoxal arthrite and 2 setae on basal exite. Female fifth leg symmetrical, uniramous, 3-segmented, terminal segment with spinules in distal half along their margins. Male body similar in habitus to female, but with 5-segmented urosome; antennule similar in fusion patterns and armature to that of female but with ancestral segments XII and XIII naked. Antenna, mandible, maxillule, maxilla, maxilliped, and legs 1–4 similar to those of female. Fifth legs asymmetrical, uniramous, right leg 5 short, 3-segmented, with coxa incorporating intercoxal sclerite; left leg elongate and 5-segmented. Etymology: The generic name is derived by combining the Greek *spelaion* ('cave') with *hvarella*, the latter formed from the island Hvar.

Type species. *Speleohvarella gamulini* sp. nov., by monotypy.

Speleohvarella gamulini gen. et sp. nov.

Holotype: An adult female (570 μm) recorded in samples from Živa Voda Cave, Bay of Kozja, on Hvar Island, Adriatic Sea, Croatia (43°70′00″ E; 17°03′02″ N), on 11 April, 2003. Type material is deposited at the Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik (Croatia), No. IOR.DU-C15a. Paratypes: 30 adult females and 22 males from the same locality, collected on 25 July, 2003, deposited at the Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik, No. IOR.DU-C15b; Croatian Natural History Museum, Zagreb, No. C1420.

Description: Female: Total length (excluding furcal setae) 520–570 μm (543 ± 17.7 μm, n = 8). Body (Fig. 1A and B) oval in dorsal aspect. Rostral area rounded with a very small protuberance ventrally (Fig. 2C). Cephalosome and first pedigerous somite separate; fourth and fifth pedigerous somite fused. Prosome : urosome ratio = 2.3–2.7 : 1 (n = 8). Prosome 2.24–2.37 times as long as wide. Urosome 4-segmented (Figs. 1C, 2A). Proportional lengths of urosomites and caudal rami: 30:18:15:14:23 = 100. Genital double-somite (Figs. 1D and 2B) slightly longer than wide; genital area symmetrical, located medio-ventrally. Operculi fused, genital apertures and seminal receptacles paired. Row of small spinules on each side of genital double-somite (Fig. 1D). Distal margins of urosomites 1–3 with very fine spinules. Caudal rami asymmetrical, longer than wide, right ramus slightly longer than left and about twice as long as wide. Each ramus with four terminal setae III-VI, small seta VII on inner border of caudal ramus; attachment sites of inner setae asymmetrical developed, with left seta originating anterior to that of right ramus; terminal setae II-VI with fine setules along their lengths (Fig. 1C).

Antennule (Fig. 2D), 24-segmented, reaching almost end of anal segment. Armature and fusion pattern of segments as follows: I-3, fused ancestral segments II–IV-5 + aesthetasc, V-2, VI-2, VII-2 + aesthetasc, VIII-2, IX-2, fused ancestral segments X–XI-4 + aesthetasc, XII-1, XIII-1, XIV-2 + aesthetasc, XV-1, XVI-2 + aesthetasc, XVII-1, XVIII-1, XIX-1, XX-1, XXI-1 + aesthetasc, XXII-1, XXIII-1 , XXIV-2, XXV-2, XXVI-2, fused ancestral segments XXVII–XXVIII-5 + aesthetasc. Posterior margin of segments VII–IX with comb of tiny denticles.

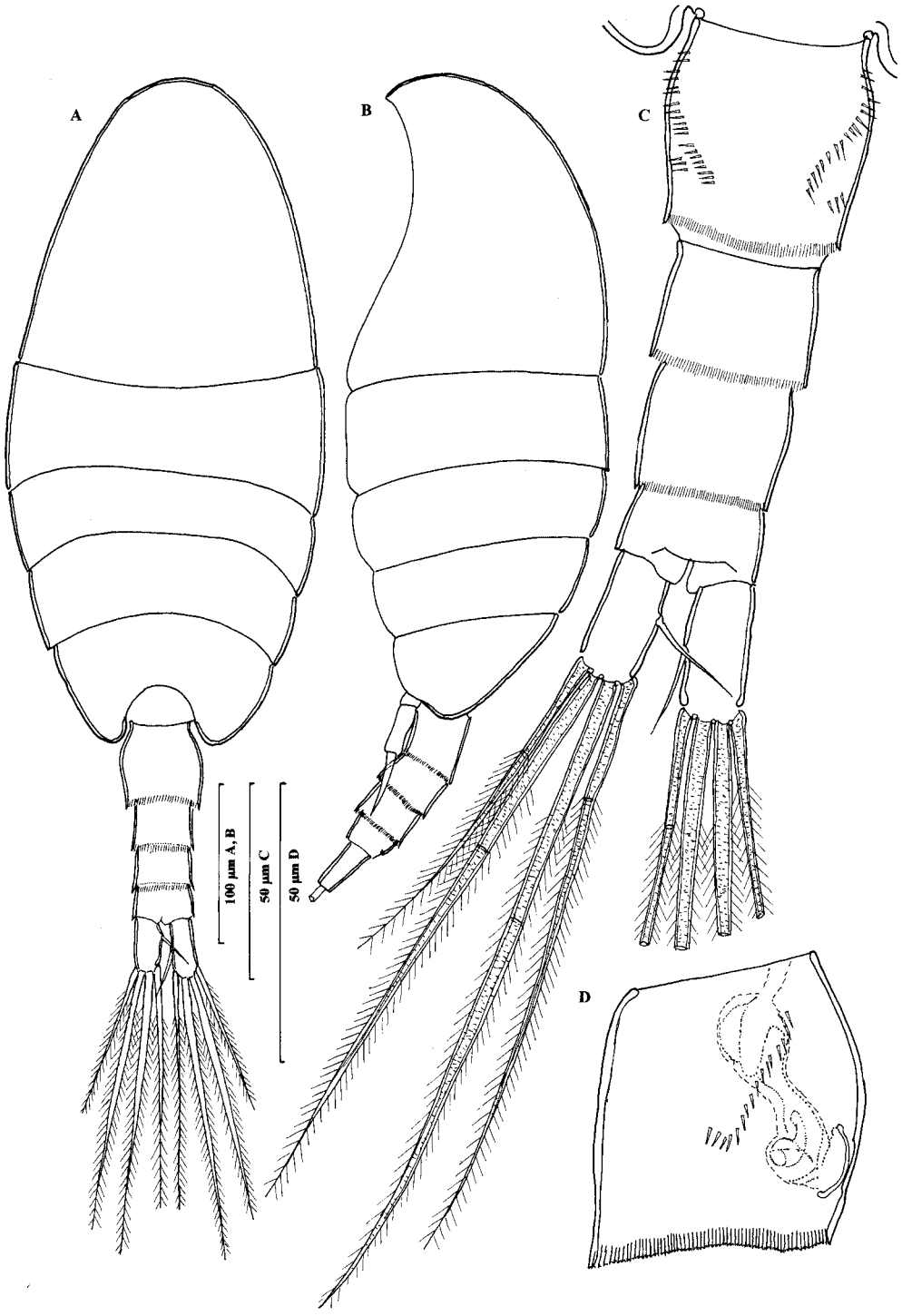

Fig. 1. *Speleohvarella gamulini* gen. et sp. nov. Adult female. (**A**) Habitus, dorsal view; (**B**) habitus, lateral view; (**C**) urosome and caudal rami, dorsal view; (**D**) genital double-somite, lateral view.

Antenna (Fig. 3A), coxa with 1 seta and row of setules; basis with 2 setae at inner angle; exopod 7-segmented, distinctly longer than endopod; armature as follows: 1, 3, 1, 1, 1, 1, 1+ 3 long terminal setae. Endopod 2-segmented, reaching to sixth exopod segment; endopod segment 1 bearing 2 setae on inner and very fine setules on outer margin; second segment bilobate with armature consisting of 8 + 7 setae.

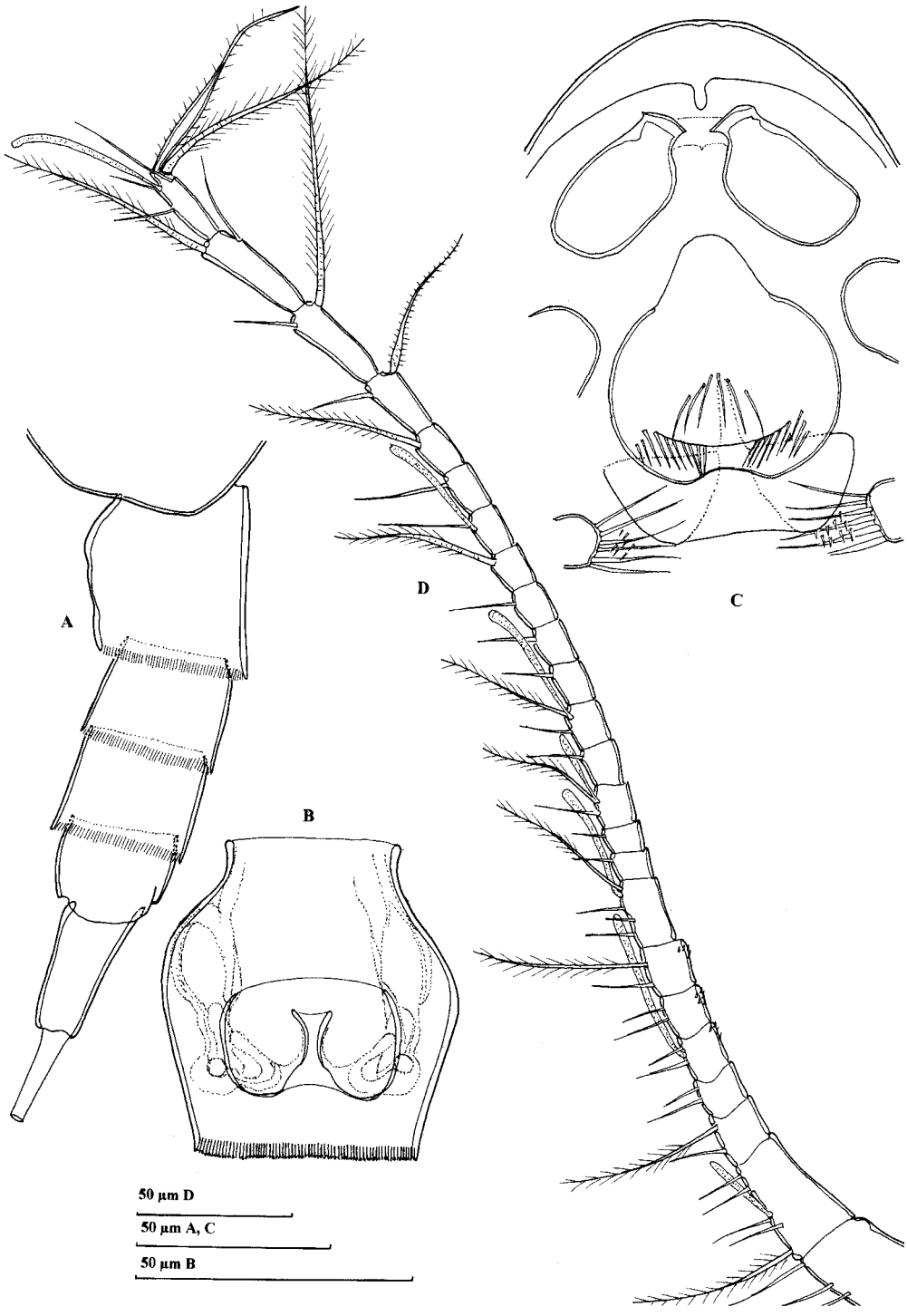

Fig. 2. *Speleohvarella gamulini* gen. et sp. nov. Adult female. (**A**) Urosome, lateral; (**B**) genital double-somite, ventral; (**C**) rostral area ventral with Labrum; (**D**) antennule.

Labrum (Fig. 2C) with 6 secretory pores on anterior surface, distal margin spinulose, and each lateral lobe with spinulose patch.

Mandible (Fig. 3B), gnathobase cutting edge with 11 teeth. Basis with 4 setae. Endopod 2-segmented, first segment with 3 long and 1 smaller setae, truncate terminal

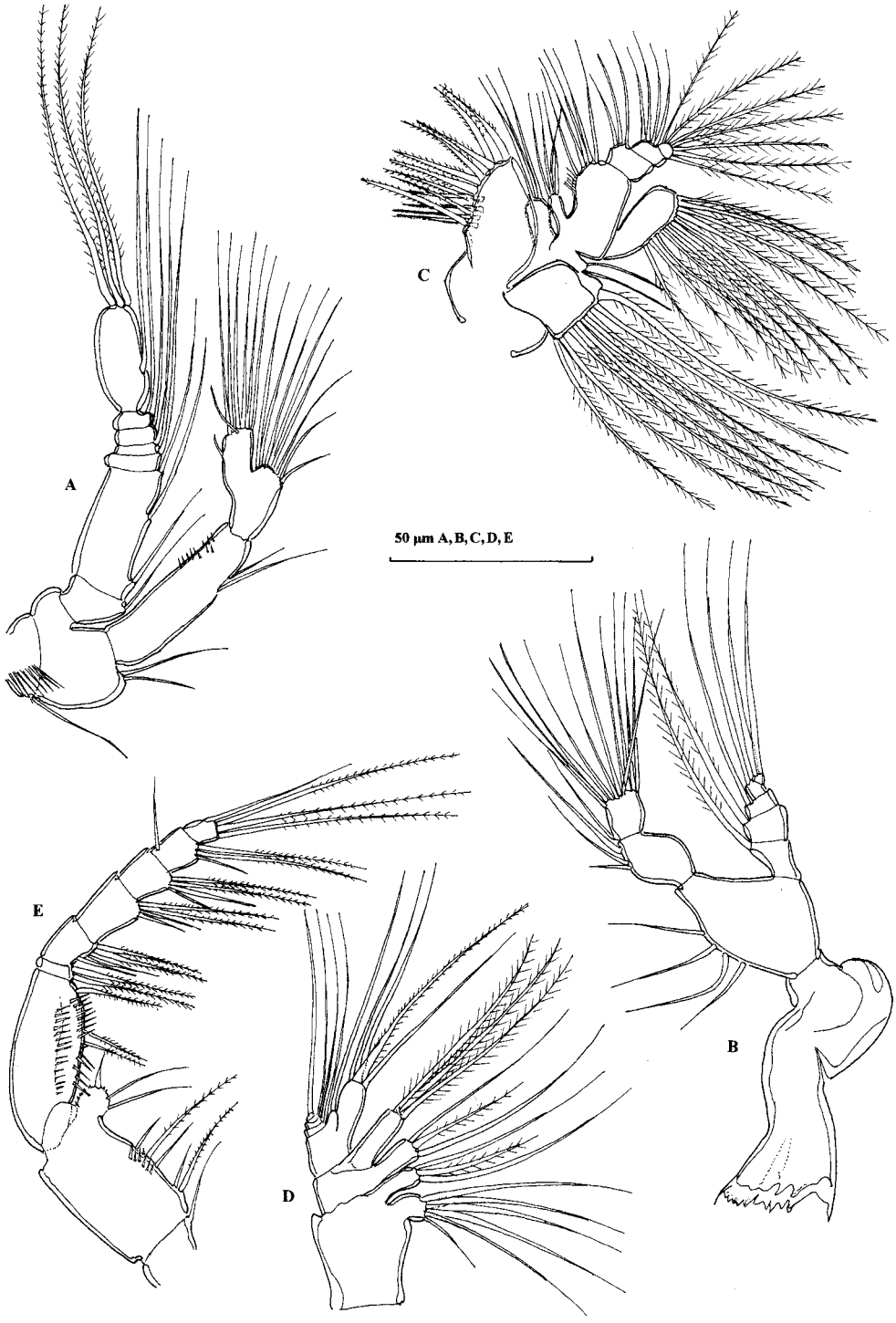

Fig. 3. *Speleohvarella gamulini* gen. et sp. nov. Adult female. (**A**) Antenna; (**B**) mandible; (**C**) maxillule; (**D**) maxilla; (**E**) maxilliped.

segment bearing 11 setae. Exopod 5-segmented, setal formula 1, 1, 1, 1, 2.

Maxillule (Fig. 3C) with praecoxal arthrite bearing 9 + 4 elements posteriorly. Coxal epipodite armed with 8 setae and coxal endite with 3 setae. Proximal basal endite with 4 setae, distal basal endite with 5 and basal exite with 2 setae. Exopod bearing 11 setae. Endopod 3-segmented, setal formula 3, 4, 7.

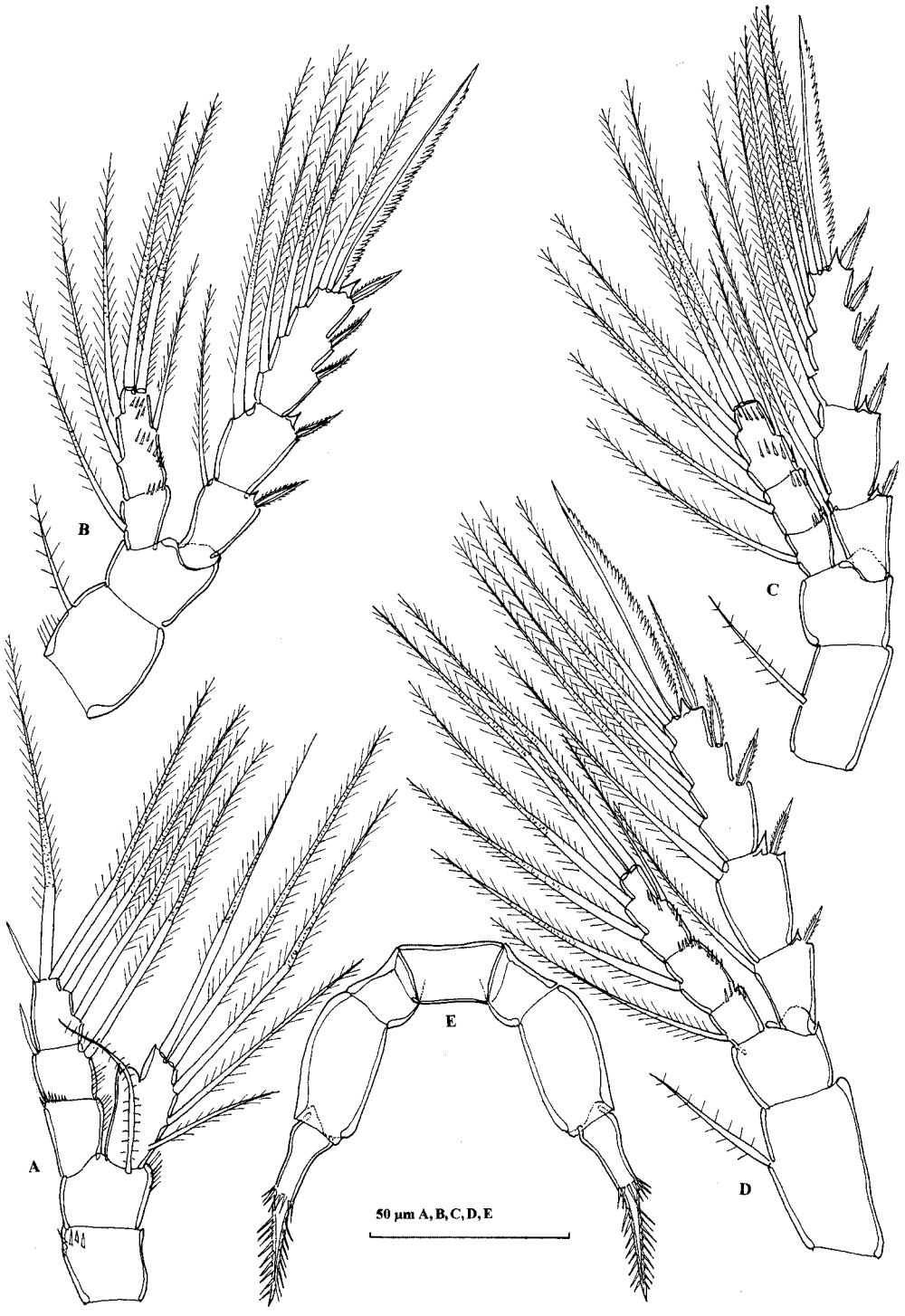

Fig. 4. *Speleohvarella gamulini* gen. et sp. nov. Adult female. (**A**) leg 1; (**B**) leg 2; (**C**) leg 3; (**D**) leg 4; (**E**) leg 5.

Maxilla (Fig. 3D), praecoxal endites with 6 and 3 setae. Coxal endites each with 3 setae. Allobasis with 4 + 1 setae. Free endopod 3-segmented, armed with 5 setae.

Maxilliped (Fig. 3E), praecoxa with 1 seta; coxa as long as basis with 3 endites, first with 2 setae, second with 3 setae and row of spinules and third armed with 3 elements on bulbous part ornamented with fine

spinules. Basis with 3 setae, 2 at midlength, 1 seta distally, and 2 rows of spinules. Endopod 6-segmented, armature formula 2, 4, 4, 3, 3+1, 4.

Swimming legs 1–4 (Figs 4A, B, C, D), armature formula summarized in Table I.

Coxa of leg 1 with spinules anterolaterally; inner lobe of leg 1 endopod with minute spinulose process. Endopod segments of legs 2–4 with spinules anteriorly. Outer distalmost spine of leg 4 exopod distinctly longer than remaining outer spines and extending to midlength of terminal spine (Fig. 4D). Fifth leg (Fig. 4E), uniramous and 3-segmented; second segment elongate; terminal segment furnished with transverse comb of spinules at mid length and rows of spinules along spine-like distal part.

Male: Total length: 530–570 μm (556 ± 11.7 μm, $n = 8$). Prosome 3.1 times longer than wide. Cephalosome and pedigerous somites similar to those of adult female (Fig 5A and B). Rostral area and labrum as in female. Prosome : urosome ratio = 2.5–2.7 : 1 ($n = 8$). Urosome 5-segmented. Proportional lengths of urosomites and caudal rami: 36:15:13:13:10:13 = 100. Genital somite asymmetrical, wider than long, with genital aperture on the left. Posterior margins of urosomites 2–4 fringed with very fine spinules. Caudal rami as in female.

Antennules symmetrical, fusion patterns and armature as in female, except for some segments, as follows: I-2 + aesthetasc, compound segment II–IV-6 + aesthetasc, V-2 + aesthetasc, and segments XII and XIII, both naked.

Antenna, mouthparts and swimming legs 1–4, all identical to female. Fifth legs uniramous, strongly asymmetrical. Left leg elongate (Fig. 5C), 5-segmented; proportional lengths of segments: 18:27:16:33:6 = 100; second segment elongate and robust in distal part; terminal segment with 3 thorn-like spines distally and tuft of fine setules subterminally on outer side plus comparatively large inner lamella proximally, longer than its segment (Fig. 5E). Right leg (Fig. 5D), small, reduced,3-segmented with proximal segment representing coxa and incorporated intercoxal sclerite; terminal segment with small seta on lateral margin and bifid slender spine on tip.

Table I: Swimming legs 1–4, armature formula

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

Etymology. This species is named in honour of Prof. Tomo Gamulin (28 April 1906, Jelsa, Hvar Island to 04 June 1991, Dubrovnik). Dr Gamulin was a prominent Croatian marine biologist and a leading expert on zooplankton, particularly copepods.

Copepods of the family Stephidae generally inhabit the hyperbenthos of neritic regions or marine caves (Mauchline, 1998). Only three genera-comprising ~35 species are known: *Stephos*, T. Scott, 1892; *Parastephos*, Sars, 1902 and *Miostephos*, Bowman, 1976. So far, Stephidae have not been reported from the Adriatic Sea, although records of some stephid species were done in marine caves of the Mediterranean (Riera *et al.*, 1991; Carola and Razouls, 1996). *Speleohvarella gamulini* displays the basic morphological characters of the Stephidae described by Boxshall and Halsey (Boxshall and Halsey, 2004). In *Stephos* and *Parastephos* the female urosome is 4-segmented and the male fifth legs are powerfully developed. The male fifth legs of *Stephos* are ending in an unarmed claw-like or mitten-like segment, in *Parastephos* this segment is armed with spines along its concave margin and also the right endopod of leg 4 is modified. *Speleohvarella gamulini* is similar to the genus *Miostephos* in that the left fifth leg of the male is slender, long and 5-segmented, whereas on the right it is rudimentary and 3-segmented; moreover, the antennulary segments XII and XIII are unarmed. In the new species the left fifth left leg, comparatively short, extends almost to the caudal rami, whereas in *Miostephos* this left ramus attains double length of the urosome if extended. In addition, the outer distalmost spine of the third exopod segment of leg 4 is exceptionally long compared with *Miostephos*. However, the new genus is easily distinguishable from *Miostephos* by the 4-segmented (versus 3-segmented) condition of the female urosome. In *S. gamulini*, the second segment of the female fifth leg is comparatively larger than in the other stephid genera. The segmentation pattern of the antennal exopod of the new genus is similar to that displayed by *Miostephos* and *Parastephos* and *Stephos hastatus* (Bradford-Grieve, 1999), where the 2 free proximal segments correspond to the ancestral I and compound segment II–IV, thus differing from the condition shown in the majority of *Stephos* species, where these segments correspond to the compound I–II and III–V. *Speleohvarella gamulini* displays several primitive features for the family Stephidae, including 13 armature elements on the praecoxal arthrite and 2 setae on the basal exite of the maxillule, contrary to remaining Stephidae which are armed with a single seta on the basal exite.

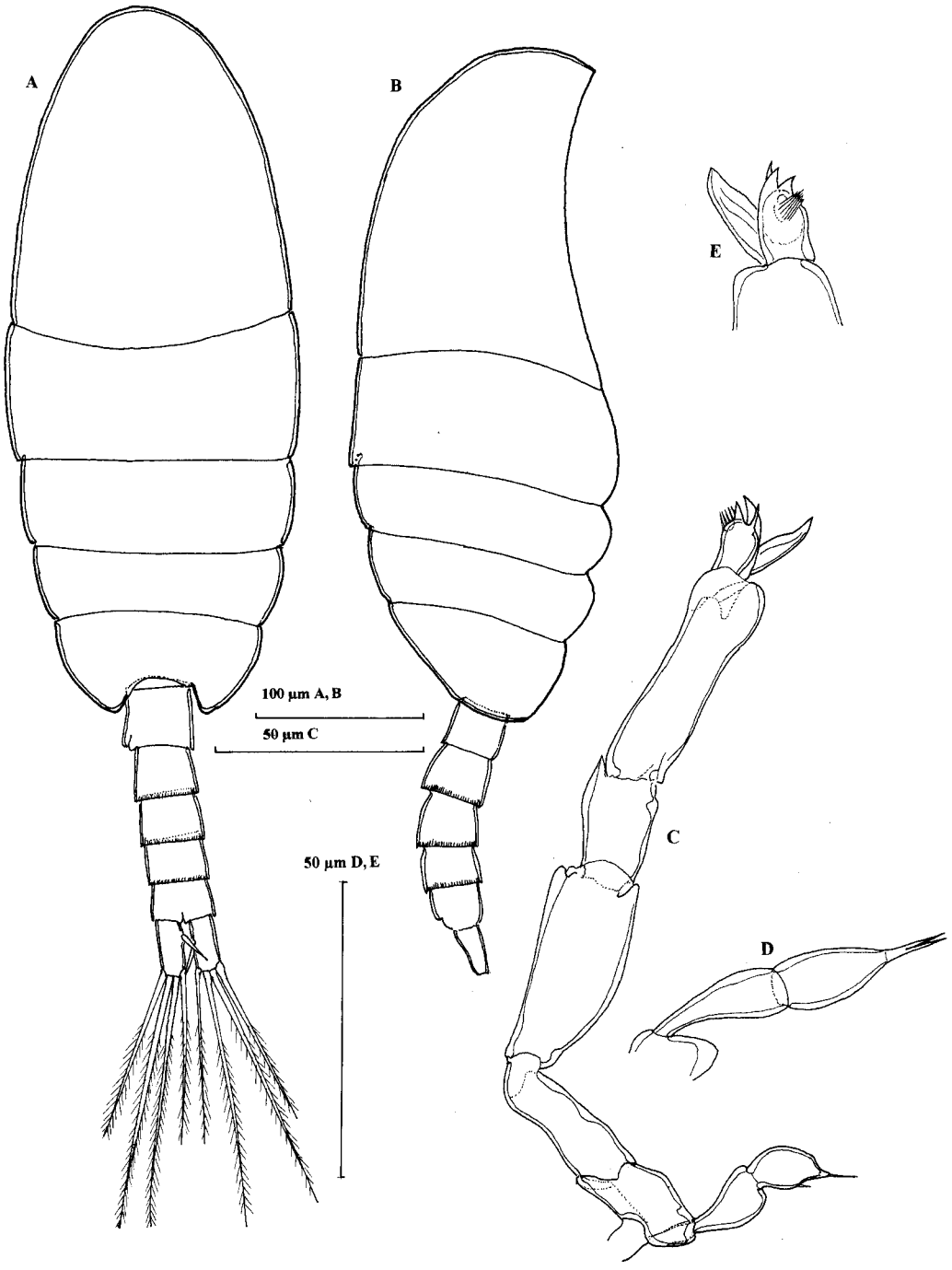

Fig. 5. *Speleohvarella gamulini* gen. et sp. nov. Adult male. (**A**) Habitus, dorsal view; (**B**) habitus, lateral; (**C**) leg 5; (**D**) right part of leg 5, lateral view; (**E**) terminal part of left leg 5.

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