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Mesaiokeras hurei n. sp. (Copepoda, Calanoida, Mesaiokeratidae) from the Adriatic Sea

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A new species of Mesaiokeras is described from the hyperbenthos of Veliko Jezero, a marine lake on the island of Mljet, Croatia. This is the first species of this genus and family (Mesaiokeratidae) reported from the Adriatic and Mediterranean seas. It is characterized by small body length (an average 361 μm for females and 337 μm for males), the low number of free segments (21) and the armature of the antennules, very long spine (a_2) of exopodite I of female right leg 4, the presence of long processes on the ventroposterior area of the female genital double-somite, the form and surface ornamentation of the genital area, the form and ornamentation of male and female leg 5, and the form and armature of caudal rami. This species was found in shallow water with very stable hydrographic conditions and at a population density from 1 to 26 ind. m^{-3}.

INTRODUCTION

The taxonomy, systematics and ecology of hyperbenthic copepods, those that live immediately above the sea bed in the so-called benthic boundary layer, are very poorly known. This may be attributed mainly to problems with standardizing sampling methods that guarantee the exclusive collection of the fauna in this zone.

Matthews (Matthews, 1961) described a new species of hyperbenthic calanoid copepod from bottom hauls taken on a muddy substrate in the Raunefjord (Norway). This is the type of species for the genus *Mesaiokeras* and the family Mesaiokeratidae. Subsequently, six species, collected from shelf to slope depths in the Atlantic have been described (Andronov, 1973, 1995; Fosshagen, 1978).

As part of continuing investigations on the ecology of the marine lakes found on the island of Mljet in the Eastern Adriatic, a new species of the genus *Mesaiokeras* was found, and is described herein. Buljan and Špan (Buljan and Špan, 1976) give a detailed account of the lake's hydrographic and chemical characteristics. Its general ecological conditions have been reported by Benović *et al.* (Benović *et al.*, 2000), and the vertical distribution of the resident zooplankton has been described by Kršinić and Lučić (Kršinić and Lučić, 1994).

METHOD

Material examined in this work was collected in Veliko Jezero, a marine lake on the island of Mljet, Croatia, during a sampling expedition in March 2000.

Two sampling methods were employed: vertical hauls from 45 m to the surface with a 53 μm mesh and 45 cm diameter Nansen net; and a 250 l plankton sampler, type 'Adriatic' (Kršinić, 1990), using a 125 μm mesh netting gauze cylinder at 40 and 45 m.

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 a Jenalumar microscope at a magnification of ×1000. Additional observations of specific details were performed with an Olympus BX51 differential interference contrast microscope. Specimens were measured using an ocular micrometer. The descriptive terminology employed widely follows that of Huys and Boxshall (Huys and Boxshall, 1991).

Taxonomy

Family Mesaiokeratidae Matthews, 1961
Genus *Mesaiokeras* Matthews, 1961
Mesaiokeras hurei Kršinić, n. sp.

Material examined

Holotype
Adult females were taken in samples from Veliko Jezero, a marine lake on the island of Mljet, Croatia (42°46′02″E; 17°22′02″N), on March 23, 2000. Type material was deposited at the Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik (Croatia), No. IOR.DU-C14a.

Paratypes
Adult females and males at the same locality, on different dates, were deposited at the Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik No. IOR.DU-C14b; Croatian Natural History Museum, Zagreb No. C1388, and the Natural History Museum, London (R. Huys collection). Three females and three males dissected on slides, two females and two males undissected on slides.

Etymology
This species is named in honour of Dr Jure Hure, a prominent Croatian copepodologist born on February 9, 1918 in Dubrovnik.

Description

Adult female (Figure 1A,B)
Total length 345–375 μm (361.2 ± 11.5 μm, n = 17). Prosome length 280–310 μm (294.4 ± 10.4 μm, n = 17). Body oval dorsally. Rostral area rounded without filament (Figure 1G). Cephalosome and pedigerous somite 1 fused. Pedigerous somites 4 and 5 fused, asymmetrical in dorsal view, posterior right margin of pedigerous somite 5 longer than left, covering one-half of genital double-somite. Prosome twice as long as wide. Urosome of four free somites. Proportional lengths of urosomites and caudal rami 39:14:16:11:20 = 100. Ratio of length of prosome to length of urosome with caudal rami 3:1. Genital double-somite (Figures 1C and D and 2A and B) longer than wide; the genital area is located medioventrally and symmetrical. The opercula are fused, the genital apertures and seminal receptacles are paired. The spermatophore sac is wrapped round setae of the caudal rami and with a very elongate neck attached directly to the genital aperture (Figure 2B). Ventro-distal margin of genital double-somite armed with four longer processes, some median long, smaller spinules and a tuft of spinules on the left side. Posterior margins of urosomites 3–4 fringed with very fine spines. Caudal rami asymmetrical, longer than wide, right ramus slightly longer than left, on right ramus II seta absent, setae III–VI pinnate and very long, seta VII is the longest and without setules.

Antennule (Figure 1E) symmetrical, reaching almost to end of prosome, comprising 21 free segments. Armature and fusion pattern as follows: I–3, fused ancestral segments II–IV–6 + aesthetasc, V–2 + aesthetasc, VI–2, VII–2 + aesthetasc, VIII–1, fused ancestral segments IX–X–2 + aesthetasc, fused ancestral segments XI–XII–3 + aesthetasc, fused ancestral segments XIII–XIV–2 + aesthetasc, XV–1, XVI–2 + aesthetasc, XVII–1, XVIII–1, XIX–1, XX–1, XXI–1 + aesthetasc, XXII–1, XXIII–1 + aesthetasc, XXIV–2, XXV–2, fused ancestral segments XXVI–XXVIII–6 + aesthetasc.

Antenna (Figure 3A). Coxa with one setule; basis with two setules at inner angle; exopod six-segmented; armature as follows: 1, 4, 1, 1, 1, 1 + 3 long terminal setae. The endopod two-segmented, reaching half-way along second exopod segment; endopod one segment bearing two setules; second segment with three lateral setules, three subterminal and eight terminal setae.

Mandible (Figure 3B). Gnathobase with eight teeth. Basis comprising three curved setae, first seta longer than others. Endopod two-segmented, first segment with two longer and two smaller setae, truncate terminal segment bearing 10 setae. Exopod five-segmented, first to fourth segment bearing one seta and terminal segment two setae. Seta on second segment twice as long as on others.

Maxillule (Figure 3C). Praecoxal arthrite bearing 10 elements. Coxal epipodite armed with seven longer and two smaller setae and coxal endite two spinulose setae, respectively. Basal endite with three setae. Exopod bearing eight longer and three smaller setae. Endopod three-segmented, first bearing two setae, second two setae and third five setae.

Maxilla (Figure 3D). Praecoxa have two endites, each with three setae. Two coxal endites each with two longer spinulose and one shorter seta. Allobasis armed with four setae. Endopodal segments armed with five spinulose setae.

Maxilliped (Figure 3E). Coxa longer than basis; armed with four elements; distally ornamented with spinules. Basis has four setae. Endopod six-segmented; segments 1–5 carrying two setae and segment 6 four setae.

Swimming legs 1–4 (Figure 4A–D). On right leg 4, spine a_2 of exopod segment I much longer than outer spines of all other legs, reaching second exopodal segment. Endopod of leg 1 fused. Ancestral endopodal segments II and III fused. Armature formula is given in Table I.

Fifth leg (Figures 1F and 4E) asymmetrical, left leg two-segmented, right leg represented by short rounded stump. Left leg bifurcate from half length, branched in two unequal processes. Both processes are furnished with setules along their outer margins.

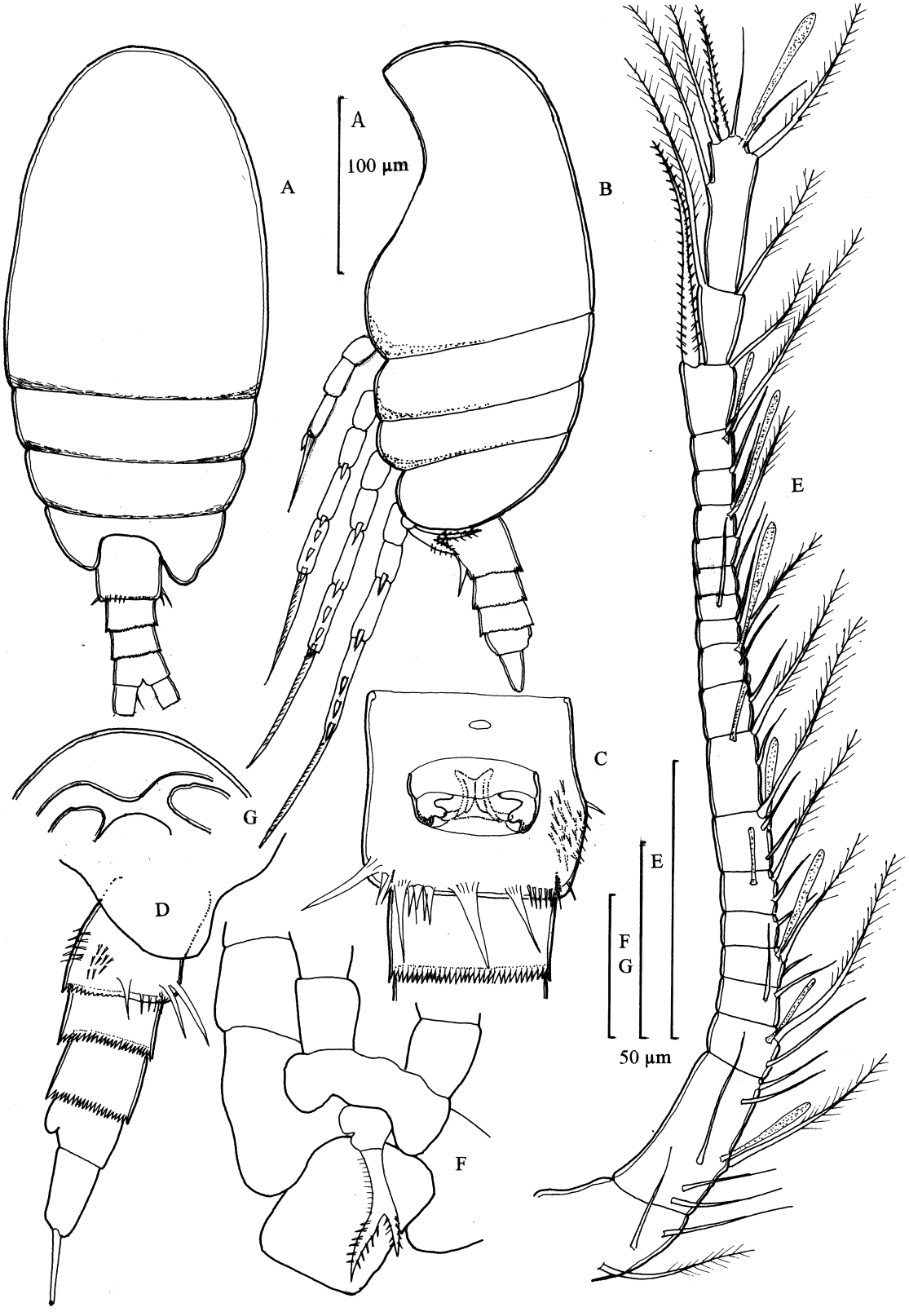

Fig. 1. *Mesaiokeras hurei* n. sp. Adult female. (**A**) Dorsal view, (**B**) lateral view, (**C**) genital double-somite ventral view, (**D**) urosome lateral view, (**E**) antennule, (**F**) position of leg 5, (**G**) rostral area ventral view.

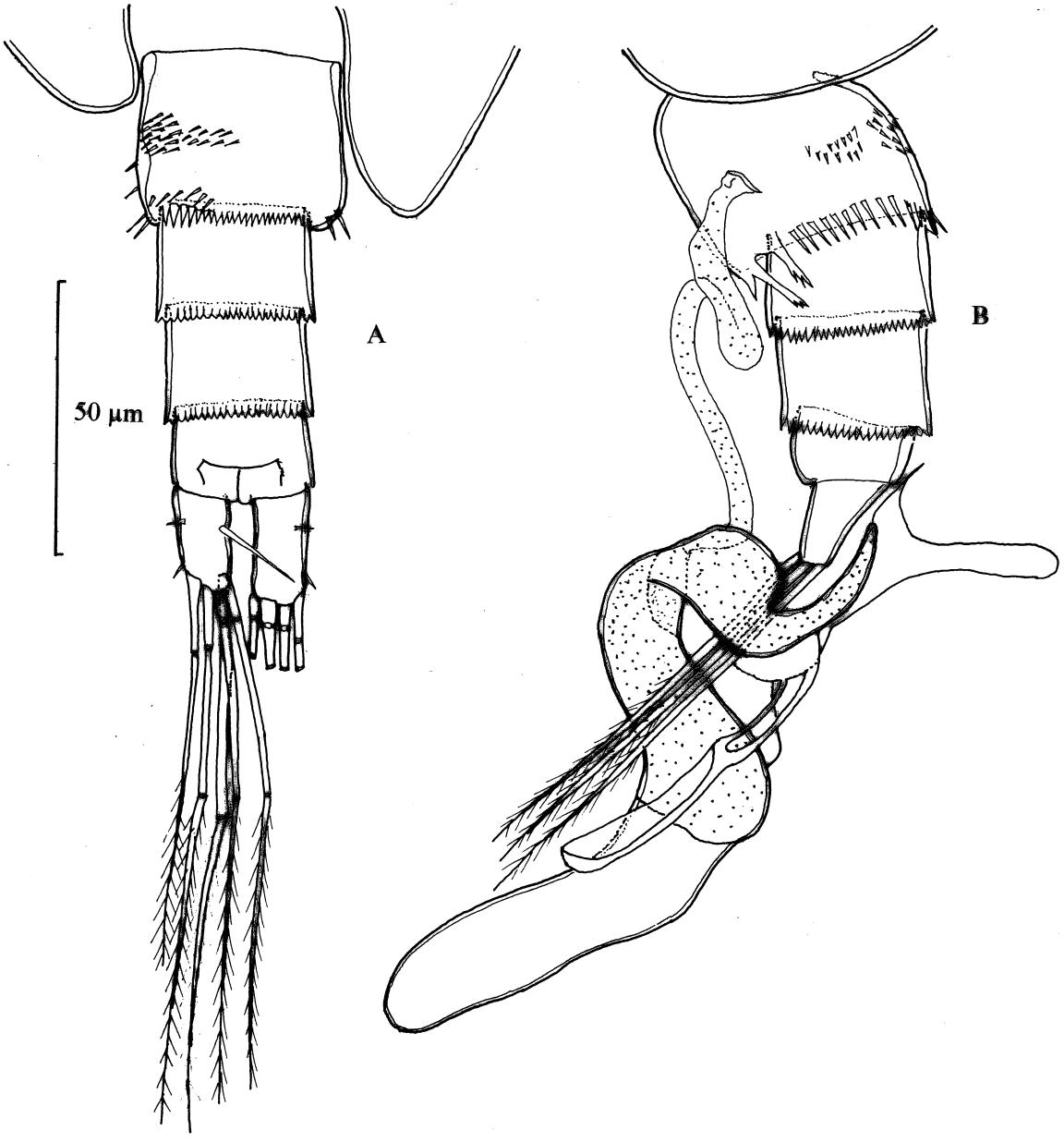

Fig. 2. *Mesaiokeras hurei* n. sp. Adult female. (**A**) Urosome and caudal rami dorsal view, (**B**) urosome with attached spermatophore lateral view.

Table I: Armature formula

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

Adult male (Figure 5A)

Total length 325–350 µm (337.9 ± 10.7 µm, n = 7). Prosome length 260–285 µm (271.4 ± 9.9 µm, n = 7). Cephalosome is 1.9 times longer than it is wide. Cephalosome and pedigerous somites similar to those of adult female. Rostral area rounded without filament (Figure 5B). Prosome twice as long as wide. Urosome of five somites (Figure 5C). Proportional lengths of urosome somites and caudal rami are 36:15:13:13:10:13 = 100.

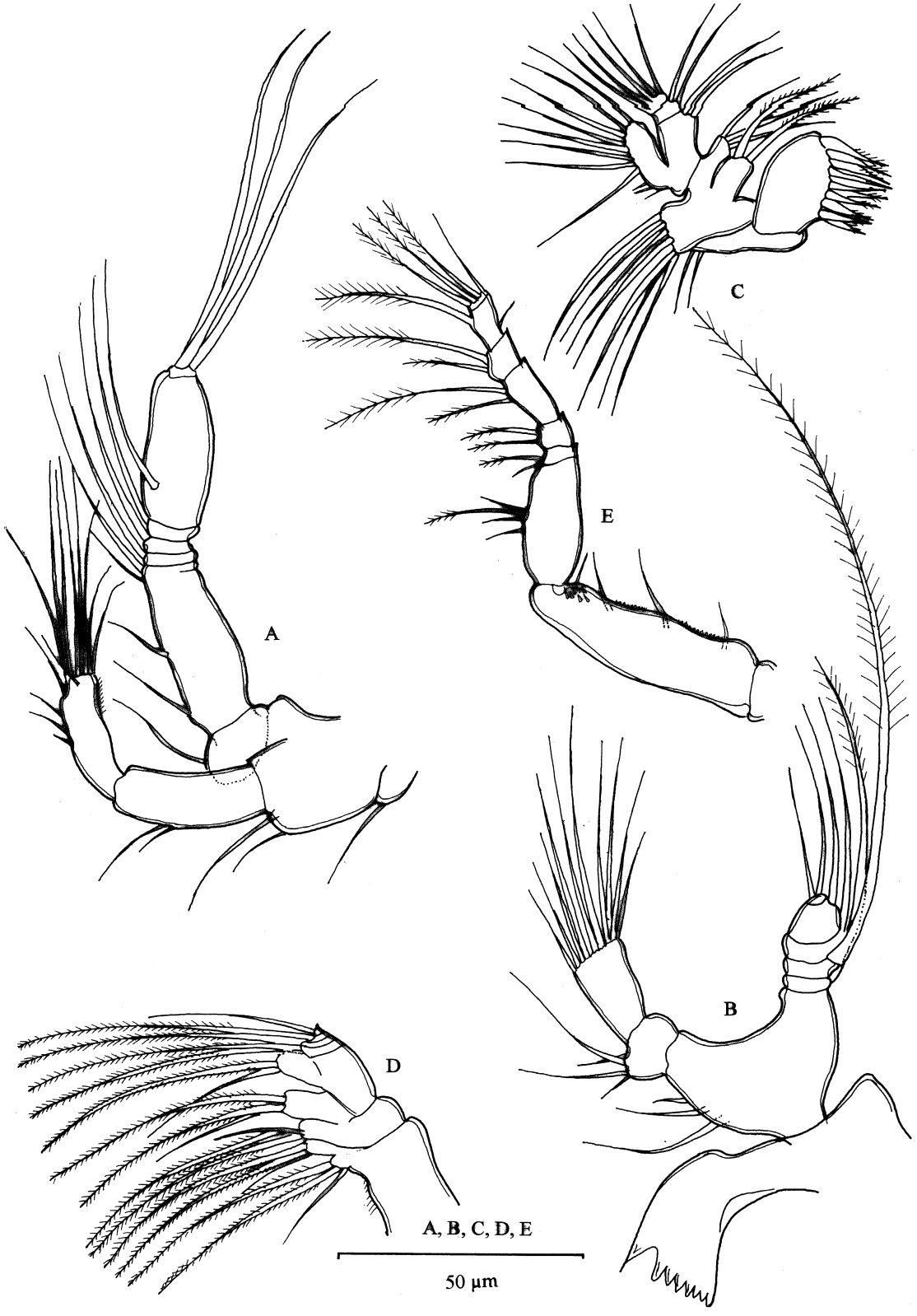

Fig. 3. *Mesaiokeras hurei* n. sp. Adult female. (**A**) Antenna, (**B**) mandible, (**C**) maxillule, (**D**) maxilla, (**E**) maxilliped.

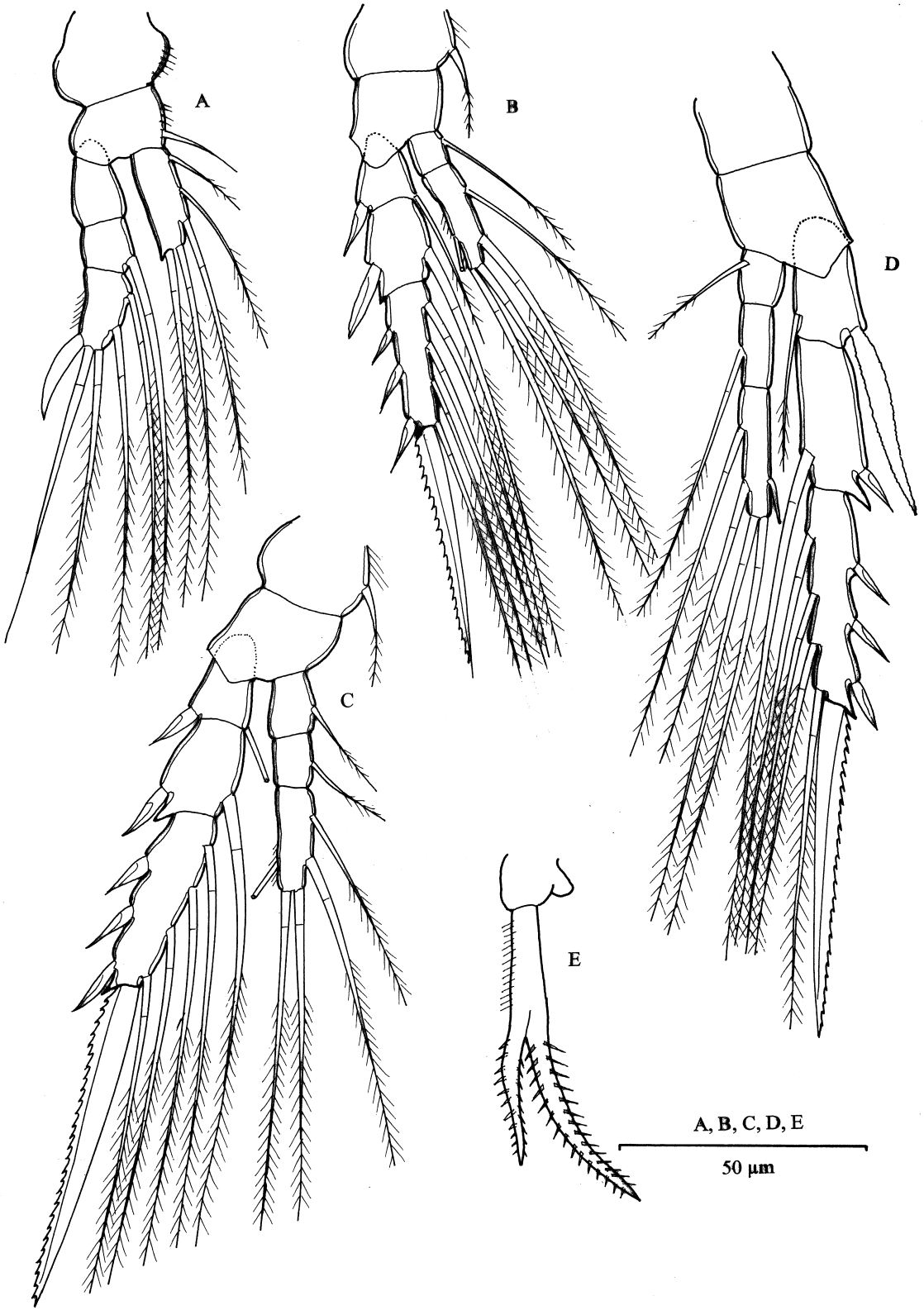

Fig. 4. *Mesaiokeras hurei* n. sp. Adult female. (**A**) Leg 1, (**B**) leg 2, (**C**) leg 3, (**D**) leg 4, (**E**) leg 5.

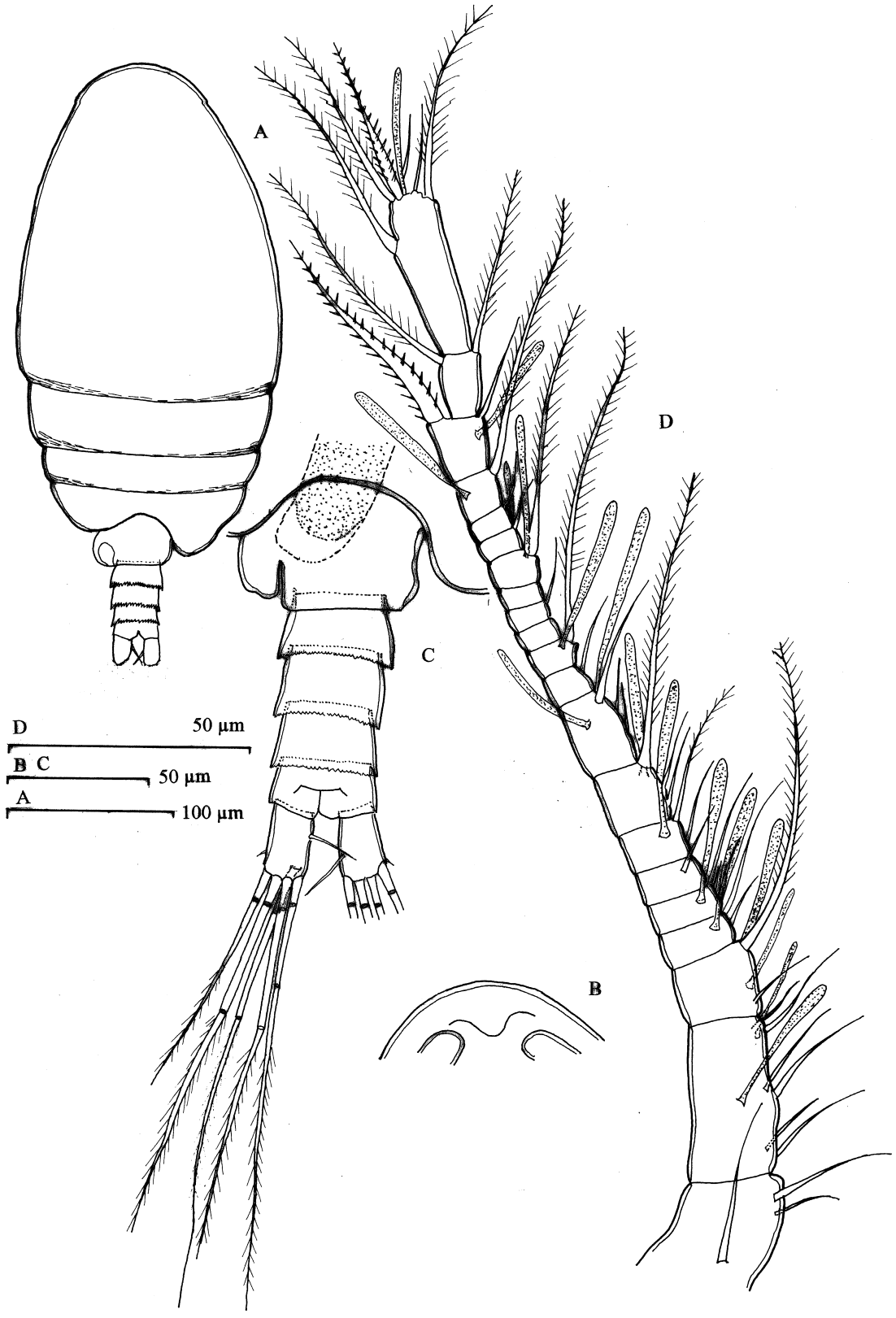

Fig. 5. *Mesaiokeras hurei* n. sp. Adult male. (**A**) Dorsal view, (**B**) rostral area ventral view, (**C**) urosome with caudal rami dorsal view, (**D**) antennule.

Ratio of length of prosome to length of urosome with caudal rami is 3.1:1. Genital somite asymmetrical, wider than long. Posterior margins of urosomites 2–4 fringed with very fine spines. Caudal rami asymmetrical, longer than wide, seta II on right ramus more distal than on left ramus, setae III–VI pinnate and very long, seta VII is the longest and without setules.

Antennule (Figure 5D). Right antennule longer than left, reaching almost to end of prosome, comprising 21 free segments. Armature and fusion patterns as follows: I–3, fused ancestral segments II–IV–6 + 2 aesthetascs, V–2 + 2 aesthetascs, VI–2 + aesthetasc, VII–2 + aesthetasc, VIII–1, fused ancestral segments IX–X–2 + aesthetasc, fused ancestral segments XI–XII–3 + aesthetasc, fused ancestral segments XIII–XIV–3 + 2 aesthetascs, XV–1, XVI–1 + aesthetasc, XVII–1, XVIII–1, XIX–1, XX–1 + aesthetasc, XXI–1 + aesthetasc, XXII–1, XXIII–1 + aesthetasc, XXIV–2 + aesthetasc, XXV–2, fused ancestral segments XXVI–XXVIII–6 + aesthetasc.

Antenna, all of the mouthparts and swimming legs 1–3 identical to those of female (Figure 6A–D). Leg 4 symmetrical, outer spine (a_2) of exopod segment I much smaller than in female. Right leg 5 (Figure 6E) reduced to a short rounded stump; left leg uniramous, elongated, longer than prosome, five-segmented; proportional lengths of segment 10:28:28:19:15 = 100; terminal segment widened distally, like that of a snake jaw; spine like a sickle in the middle.

Remarks

Mesaiokeras hurei is distinguished from other species of the same genus by the following combination of characteristics (Table II): small body length, an average 361 μm in females and 337 μm in males; rostral filament absent; the low number of free segments (21) and the armature of the antennules; same number of antennule free segments in both sexes and sides; very long spine (a_2) of exopodite I of female right leg 4; presence of long processes on ventroposterior area of female genital double-somite; the form and surface ornamentation of the genital area; terminal segment of male leg 5; the form and armature of caudal rami.

Occurrence

Mesaiokeras hurei was found in samples taken from Veliko Jezero, a seawater lake on the island Mljet, located off

Table II: Some comparative characteristics for all species of genus Mesaiokeras

	Occurrence	Total length (mm)	Antennule segment left, right	Legs 1–4	Leg 5	Rostrum
M. nanseni Matthews, 1961	Norway, 35–700 m					
Female		0.480	23, 23	Symm.	Asymm.	Present
Male		0.440	23, 22	Symm.	Asymm.	
M. kaufmanni Fosshagen, 1978	Colombia, 20–27 m					
Male		0.500	22, 20	Symm.	Asymm.	Present
M. heptneri Andronov, 1973	W. Atlantic, 235 m					
Female		0.440	24, 24	Symm.	Symm.	Present
Male		0.420	24, 24	Symm.	Asymm.	
M. semiplenus Andronov, 1973	E. Atlantic, 170 m					
Female		0.500	23, 23	Symm.	Asymm.	Present
Male		0.420	23, 23	Symm.	Asymm.	
M. tantillus Andronov, 1973	E. Atlantic, 170 m					
Female		0.320	23, 23	Symm.	Asymm.	Absent
Male		0.290	23, 23	Symm.	Asymm.	
M. marocanus Andronov, 1995	E. Atlantic, 325 m					
Male		0.480	23, 23	Symm.	Asymm.	Present
M. mikhailini Andronov, 1995	E. Atlantic, 780 m					
Male		0.540	21, 23	Symm.	Asymm.	Absent
M. hurei n. sp.	S. Adriatic, 30–45 m					
Female		0.361	21, 21	Asymm.4	Asymm.	Absent
Male		0.337	21, 21	Symm.	Asymm.	

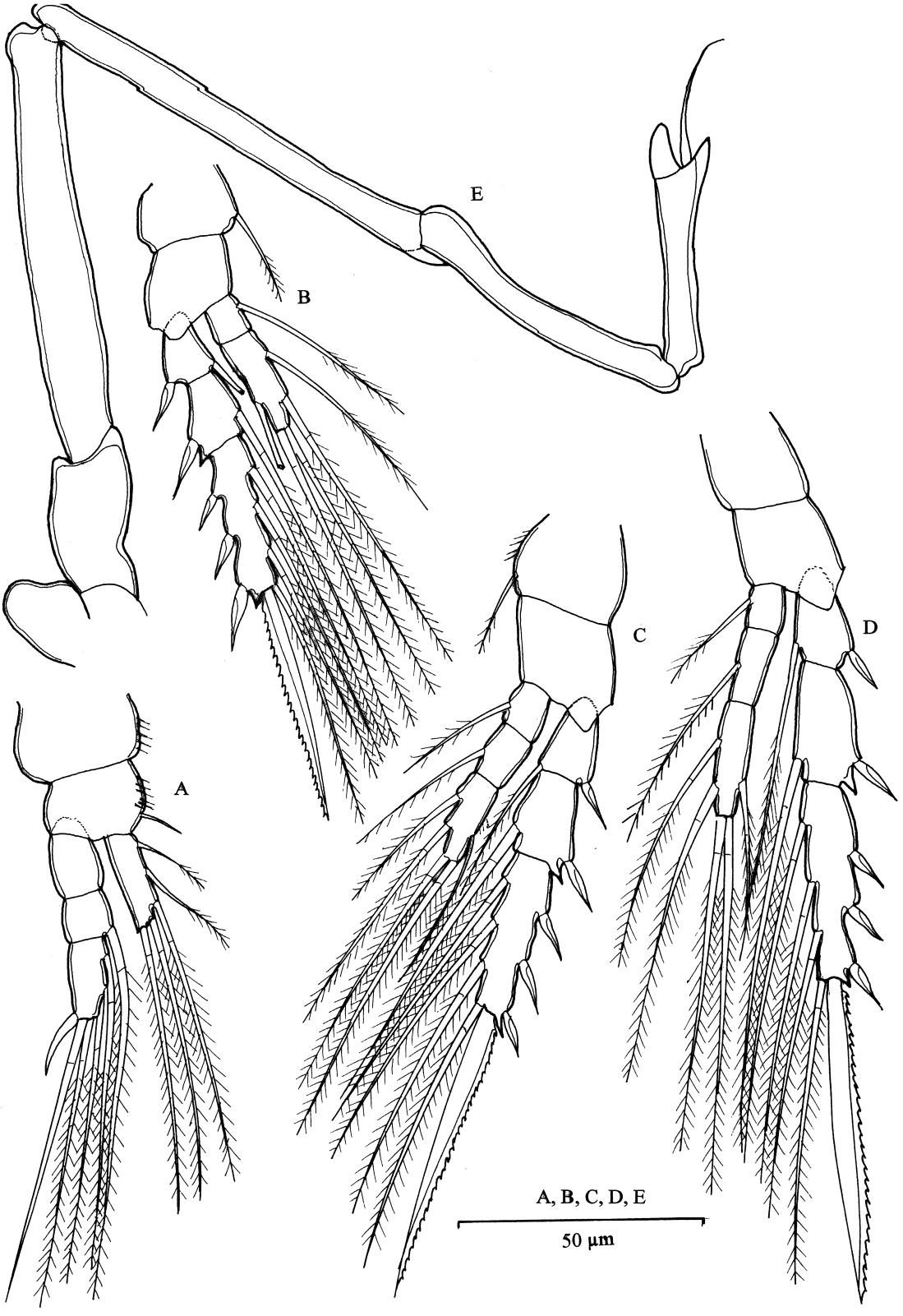

Fig. 6. *Mesaiokeras hurei* n. sp. Adult male. (**A**) Leg 1, (**B**) leg 2, (**C**) leg 3 (**D**) right leg 4, (**E**) leg 5.

Croatia's southern Adriatic coast. The surface area of this oligotrophic lake is 1.45 km^2 and its maximum depth is ~46 m. Veliko Jezero is connected to the open sea by a narrow channel. The channel's maximum depth is 3 m and its minimum width is 10 m.

Investigations conducted over several years show that hydrographic conditions are very stable throughout the year below 30 m. Temperature and salinity varied between 9 and 13°C, and 35.2 and 38.4 p.s.u., respectively. Fine-grained muddy sediments dominate the deeper part of the lake. Vertical turbulence seems to be not very pronounced; thus, a nephaloid layer of very fine, suspended detrital material is found 5–10 m above the seabed. According to our study of the vertical distribution of mesozooplankton (Kršinić and Lučić, 1994), the copepod *M. hurei* was found between 45 and 35 m depth or 1–11 m above the bottom, with a population density from 1 to 26 ind. m^{-3}.

DISCUSSION

Males have been described for all species of the family Mesaiokeratidae, while females for three species thus far remain unknown. Most representatives of these species have been collected in deeper water of the Eastern Atlantic, but *Mesaiokeras nanseni, Mesaiokeras kaufmani* and *M. hurei* have been found in shallow coastal areas from 20 to 50 m depth. Further, *M. hurei* is known to inhabit very restricted and closed areas.

Beyond these very general observations, the only quantitative data on the ecology of the small hyperbenthic and benthopelagic calanoid copepods from this area derive from the plankton trap work of Kršinić (Kršinić, 1990).

Based on the analysis of five species, Fosshagen (Fosshagen, 1978) considered that species such as *M. nanseni* and *Mesaiokeras semiplenus* are easily distinguished. As an example, the left leg 5 of *M. hurei* females is similar to that of *M. semiplenus* and *M. nanseni* females, but other morphological characteristics are clearly different. For example, *M. hurei* females may be distinguished by their asymmetrical genital double-somite with longer processes and asymmetrical leg 4.

Mesaiokeras tantillus and *M. hurei* are the smallest species of this genus. Leg 5 of *M. tantillus* females is very small, almost rudimentary; the outer spines of the exopodite on all segments are of a similar length; the outer margin of the terminal exopod segment leg 1 has a spine; the male terminal segment leg 5 bears two sharp spines, and the first spine near the base of the segment is longer than the same segment.

Females of most species have 23 segmented antennules. *Mesaiokeras heptneri*, however, has 24 segmented antennules and, according to Fosshagen (Fosshagen, 1978), this species is the most primitive representative of the genus *Mesaiokeras*. Both sexes of *M. hurei* have 21 free antennule segments. This suggests that they may be the most advanced representatives of this genus. Differences in the antennulary setation patterns between sexes were noted. Female ancestral segments XIII–XIV and male segments XVI are missing naked setae, in addition female segments VI and XXIV lack aethetascs. Whereas on male ancestral segments II–IV, XIII–XIV and V have double the aesthetascs. The antennules of the male are non-geniculate.

The shape, size and place of attachment of spermatophore may also be important characteristics for distinguishing species of genus *Mesaiokeras*, as has been observed for *Paraeuchaeta* Bradford (Bradford, 1981).

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