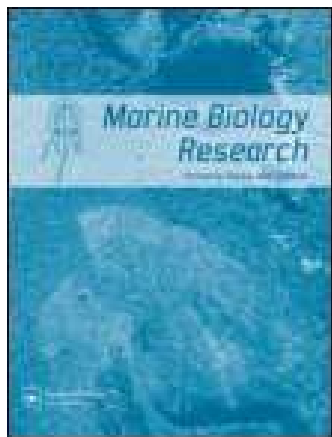


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## Marine Biology Research

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### **Badijella jalzici - a new genus and species of calanoid copepod (Calanoida, Ridgewayiidae) from an anchialine cave on the Croatian Adriatic coast** **Published in collaboration with the University of Bergen and the Institute of Marine Research, Norway, and the Marine Biological Laboratory, University of Copenhagen, Denmark**

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Published online: 18 Feb 2007.

**To cite this article:** Frano Kršinić (2005) Badijella jalzici - a new genus and species of calanoid copepod (Calanoida, Ridgewayiidae) from an anchialine cave on the Croatian Adriatic coast Published in collaboration with the University of Bergen and the Institute of Marine Research, Norway, and the Marine Biological Laboratory, University of Copenhagen, Denmark, Marine Biology Research, 1:4, 281-289, DOI: [10.1080/17451000500262025](https://doi.org/10.1080/17451000500262025)

**To link to this article:** <http://dx.doi.org/10.1080/17451000500262025>

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## ORIGINAL ARTICLE

# ***Badijella jalzici* – a new genus and species of calanoid copepod (Calanoida, Ridgewayiidae) from an anchialine cave on the Croatian Adriatic coast**

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### Abstract

A new genus and species of calanoid copepod belonging to the family of Ridgewayiidae is described from an anchialine cave on the small island of Badija, Croatia. In the new species *Badijella jalzici*, body length varies from 720–870 µm in both sexes. The prosome is 6-segmented, the female urosome is 4-segmented and 5-segmented in the male. The antennules are symmetrical and 26-segmented in the female, and 23-segmented on right side in the male, with two areas of geniculation. The caudal rami are symmetrical and longer than wide. The mouthparts and swimming legs 1–4 are identical in both sexes. The female fifth leg is biramous and symmetrical; the male fifth legs are strongly developed, asymmetrical, biramous on both sides, endopods 2-segmented and exopods 2-segmented and complex in structure.

**Key words:** *Stygofauna, copepoda, calanoid copepods, anchialine caves, Adriatic Sea*

### Introduction

The calanoid copepod family Ridgewayiidae comprises 25 species: 12 in the genus *Ridgewayia* Thompson & A. Scott, 1903; five in *Placocalanus* Ohtsuka, Fosshagen & Soh, 1996 and three in *Exumella* Fosshagen, 1970, while the remaining genera are monotypic: *Brattstromia* Fosshagen & Iliffe, 1991; *Exumellina* Fosshagen & Iliffe, 1998; *Stargatia* Fosshagen & Iliffe, 2003; *Robpalmeria* Fosshagen & Iliffe, 2003 and *Normancavia* Fosshagen & Iliffe, 2003. Most species were described from the Atlantic and Indo-Pacific regions, with only two species and one sub-species from the Mediterranean; *Exumella mediterranea* Jaume & Boxshall, 1995 from an anchialine cave on Mallorca, Balearic Islands (Jaume & Boxshall 1995), *Ridgewayia canalis* from the Suez Canal (Gurney 1927) and *Ridgewayia marki minorcaensis* (Razouls & Carola 1996).

The Croatian Adriatic shores lie in a Dinaric karst zone, rich in anchialine caves. These caves, which are located in a sub-tropical region, exhibit small tidal oscillations, and have a characteristic hydrography in which salinity varies from nearly 0 at the

surface to 36 PSU at 6 m depth, and temperature from 14–16°C (Sket 1996).

With the assistance of the Bio-Speleological Society in Zagreb, investigations of the copepods from anchialine caves have commenced along the Croatian coastline. Material collected in Živa voda Cave, Hvar Island, has been described as a new genus and species *Speleohvarella gamulini* (Kršinić 2005) of the family Stephidae. This paper describes a new genus and species of the calanoid family Ridgewayiidae, based on material gathered from a cave on the small island of Badija, near Korčula, Croatia.

### Materials and methods

The material examined was collected during a sampling expedition in April 2004 in a cave on the island of Badija, Croatia. Members of the Croatian Bio-Speleological Society in Zagreb collected the copepods using SCUBA equipment. Samples were taken with hand-held nets towed from 5 m to the surface using a 20 cm-diameter Nansen net with 125 µm mesh. Samples were preserved in 2.5% formaldehyde-seawater neutralized with CaCO<sub>3</sub>. Speci-

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Published in collaboration with the University of Bergen and the Institute of Marine Research, Norway, and the Marine Biological Laboratory, University of Copenhagen, Denmark

(Accepted 8 July 2005; Printed 12 October 2005)

ISSN 1745-1000 print/ISSN 1745-1019 online © 2005 Taylor & Francis

DOI: 10.1080/17451000500262025

mens were dissected in lactophenol. Drawings were made with the aid of a camera lucida, using an Olympus BX51 with differential interference contrast. Specimens were measured using an ocular micrometer. The descriptive terminology employed, largely follows Huys & Boxshall (1991).

#### Taxonomy

#### **Family Ridgewayiidae M. S. Wilson, 1958**

#### *Badijella* gen. n.

**Diagnosis.** Body oval, prosome 6-segmented with cephalosome separate from first pedigerous somite; posterior corners of prosome symmetrical. Urosome 4-segmented in female and 5-segmented the male. Rostral area with well-developed, paired filaments. Genital double-somite slightly longer than wide, with genital area symmetrical and located mid-ventrally. Caudal rami symmetrical, armed with 1 short subdistal and 5 distal setae. Antennules of female symmetrical, 26-segmented, segments II–III and XXVII–XXVIII fused. Antennules of male asymmetrical, right antennule 23-segmented, with two areas of geniculation, segments II–III, XXI–XXIII, XXIV–XXV and XXVII–XXVIII fused. Swimming legs as described for type species. Legs 3 and 4 each with 3 outer spines on terminal exopodal segments. The endopod segments of legs 2–4 ornamented with spinules. Mouthparts identical in both sexes. Female fifth legs biramous, symmetrical, 3-segmented, third endopod segment with 6 setae. Male fifth legs strongly developed, asymmetrical, both biramous, endopods 2-segmented on both sides, exopods complex and 2-segmented.

**Etymology.** The generic name is derived from Badija Island.

**Type species.** *Badijella jalzici* n. sp. by original designation.

*Badijella jalzici* sp. nov.

**Material examined.** Holotype: adult female (810  $\mu\text{m}$ ) from cave on Badija Island, Adriatic Sea, Croatia, 23 April, 2004. Coordinates: x = 4757,288, y = 6432,341. Type material deposited at Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik (Croatia), No. IOR.DU-C16a.

**Paratypes.** Adult females and males from same locality, taken on April 23, 2004, deposited at the Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik No. IOR.DU-C16b; Croatian Natural History Museum,

Zagreb, No. C1441; Three females and three males dissected on slides, two entire females and two males on slides.

**Etymology.** This species is named in honour of Branko Jalžić, a prominent Croatian biospeleologist.

**Description.** Adult female: (see Figure 1A, B) body length (excluding caudal setae) 760–850  $\mu\text{m}$  ( $810 \pm 28.8$   $\mu\text{m}$ ,  $n = 13$ ). Prosome length: 550–600  $\mu\text{m}$  ( $586 \pm 15.6$   $\mu\text{m}$ ,  $n = 13$ ). Body oval. Rostral area rounded, with well-developed paired filaments and 2 sensille (see Figure 1C). Cephalosome and first pedigerous somite separate; fourth and fifth pedigerous somite separate. Prosome: urosome plus caudal rami ratio = 2.3–2.7: 1 ( $2.52 \pm 0.17$ ,  $n = 11$ ). Prosome 2.4–2.7 as long as wide ( $2.64 \pm 0.01$ ,  $n = 13$ ). Urosome composed of 4 free somites, (see Figure 1D).

Proportional lengths of urosomites: 47:16:24:13 = 100. Genital double-somite (see Figure 2A, 2B) slightly longer than wide; genital area symmetrical, located mid-ventrally, with common genital operculum, internal genital apertures and seminal receptacles paired. On the genital operculum with pair of external processes. Spermatophore, ca. 420  $\mu\text{m}$ , attached ventrally, covering genital double and postgenital somites (Figure 2A). Posterior margins of urosomites fringed with striated hyaline frill. Anal somite with 2 unequal triangular hyaline teeth on distal margin. Caudal rami symmetrical, about 2.5 longer than wide, armed with 1 short sub-distal dorsal seta and 5 distal setae; seta III spiniform, setae IV and V pinnate and long, dorsal distal margin of rami each with 1 triangular tooth.

Antennules (Figure 2C, 2D) symmetrical, 26-segmented, reaching almost to end of prosome. Armature and fusion pattern of segments as follows: I-1 + aesthetasc, fused ancestral segments II–III-4 + aesthetasc, IV-2, V-2 + aesthetasc, VI to XII-2 + aesthetasc each, XIII-1 + aesthetasc, XIV to XVIII-2 + aesthetasc each, XIX and XX-2 each, XXI-2 + aesthetasc, XXII-1 + aesthetasc, XXIII-1, XXIV-2, XXV-2 + aesthetasc, XXVI-2, fused ancestral segments XXVII–XXVIII-5 + aesthetasc.

Antenna (Figure 3A), coxa with 1 seta; basis with 2 small setae at inner angle; exopod 7-segmented; armature as follows: 1, 2, 1, 1, 1, 1, and 4 long terminal setae. Endopod 2-segmented, extending beyond terminal exopod segment; endopod 1 segment bearing 2 small setae; second segment with 3 lateral setae, 4 subterminal and 7 terminal setae.

Mandibular (Figure 3B) gnathobase cutting edge with 11 teeth. Basis with 2 curved inner setae.

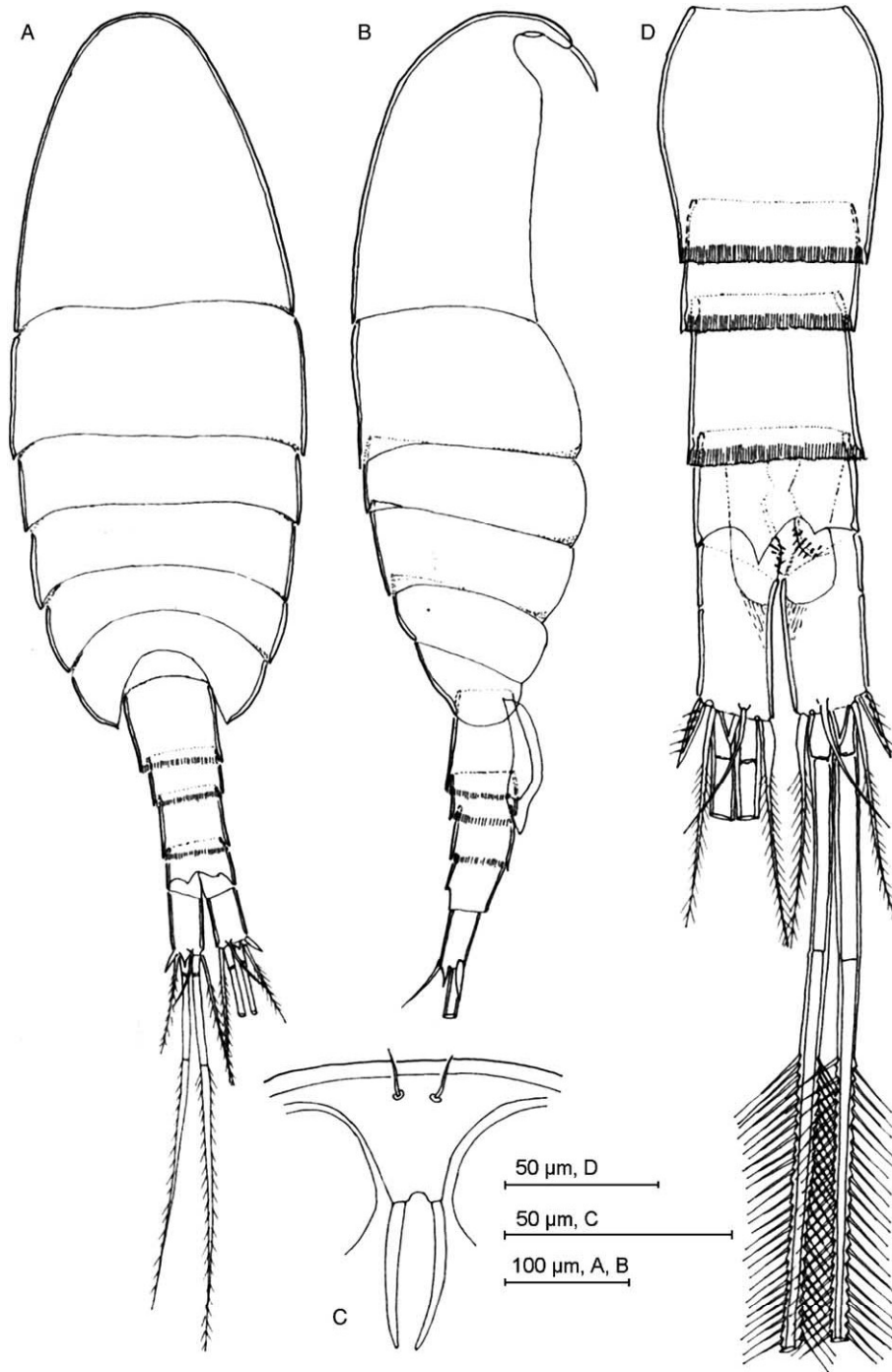


Figure 1. *Badijella jalzici* n. sp., adult female; (A) dorsal view; (B) lateral view; (C) rostrum, frontal; (D) urosome and caudal rami, dorsal.

Endopod well-developed 2-segmented, longer than exopod, first segment with 4 setae, truncate terminal segment with 8 setae. Exopod 5-segmented, setal formula 1, 1, 1, 1, 2.

Maxillule (Figure 3C) with praecoxal arthrite bearing 14 elements, 9 pectinate spines, 4 setae on posterior side and 1 anterior seta. Coxal epipodite with 9 setae and coxal endite with 4 setae. Basal endites with 4 and 5 setae; exopod

bearing 11 marginal setae; endopod 3-segmented bearing 17 elements, probably arranged 5, 5, 7.

Maxilla (Figure 3D) praecoxal with 2 endites, bearing 7 setae and 3 setae, respectively. Coxal endites with 3 setae each. Basal endite armed with 4 setae. Endopodal segments armed with 6 setae.

Maxilliped (Figure 3E) Syncoxa as long as basis; bearing 3 endites, first with 2 setae, second with 1





Figure 2. *Badijella jalzici* n. sp., adult female; (A) urosome with spermatophore attached, lateral view; (B) genital double-somite ventral view; (C, D) antennule.

seta and row of spinules, third with 2 setae. Basis with 3 setae and 2 rows of spinules on medial margin. Endopod reflexed, 6-segmented, setal formula 2, 4, 4, 3, 2 + 1 and 2 + 1 on terminal segment.

Setae on third segment with specialized ornamentation of spinules along one margin.

Swimming legs 1– 5 (Figure 4A–E) armature formula as follows:

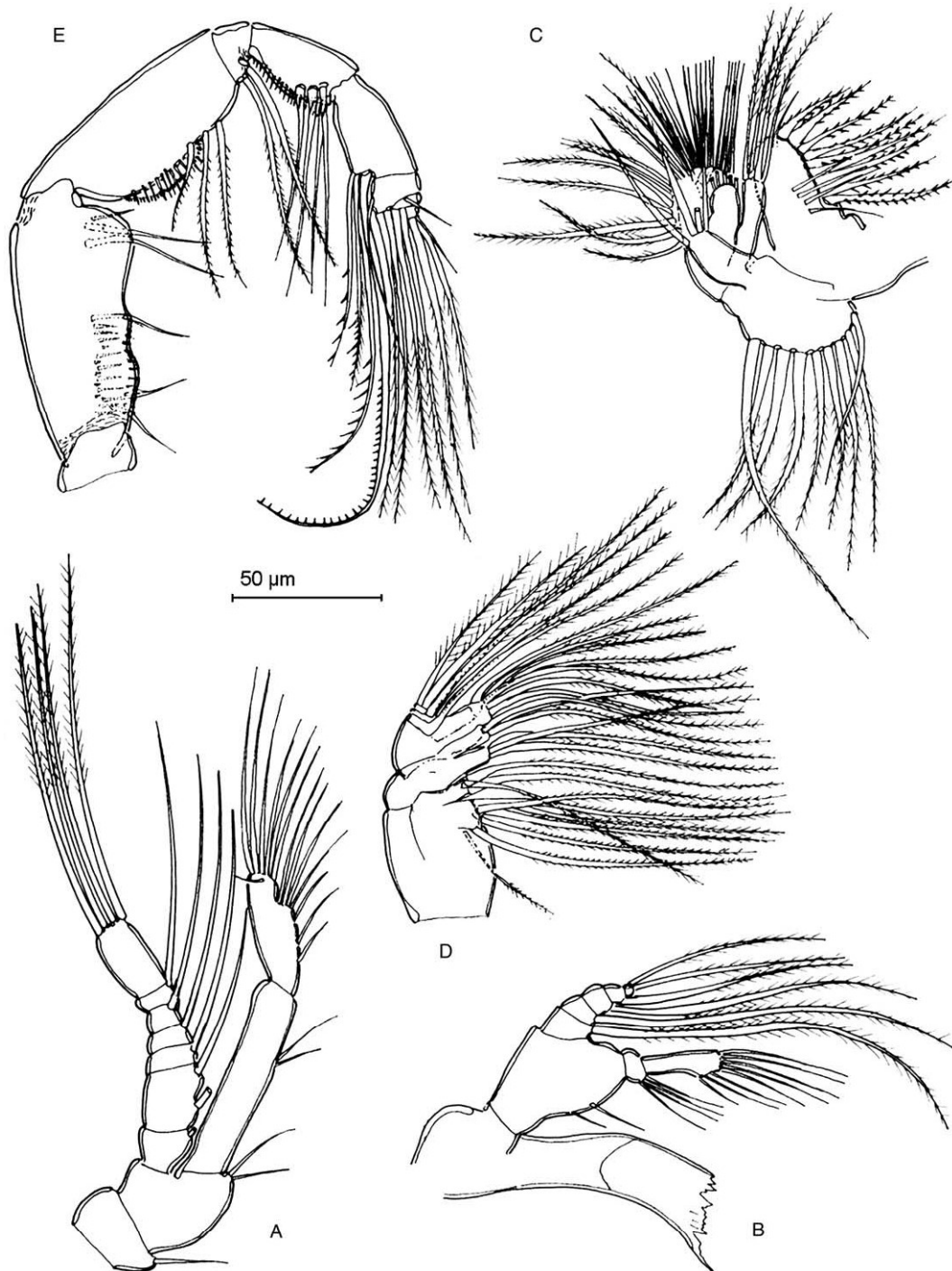


Figure 3. *Badijella jalzici* n. sp., adult female; (a) antenna; (b) mandible; (c) maxillule; (d) maxilla; (e) maxilliped.

	coxa	basis	endopodal segments	exopodal segments
Leg 1	0-1	0-1	0-1; 0-2; 1, 2, 3	I-1; I-1; II, I, 4
Leg 2	0-1	0-0	0-1; 0-2; 2, 2, 4	I-1; I-1; II, I, 5
Leg 3	0-1	0-0	0-1; 0-2; 2, 2, 4	I-1; I-1; III, I, 5
Leg 4	0-1	0-0	0-1; 0-2; 2, 2, 3	I-1; I-1; III, I, 5
Leg 5	0-1	1-0	0-1; 0-1; 2, 2, 2	I-1; I-1; III, I, 3

First leg (Figure 4A) with slender process on posterodistal margin of basis; outer distal corner of second exopodal segment with tuft of setules; first endopodal segment with pointed outer corner. Outer distal margin of first and second endopodal segments of legs 2 and 3 with tuft of long setules.

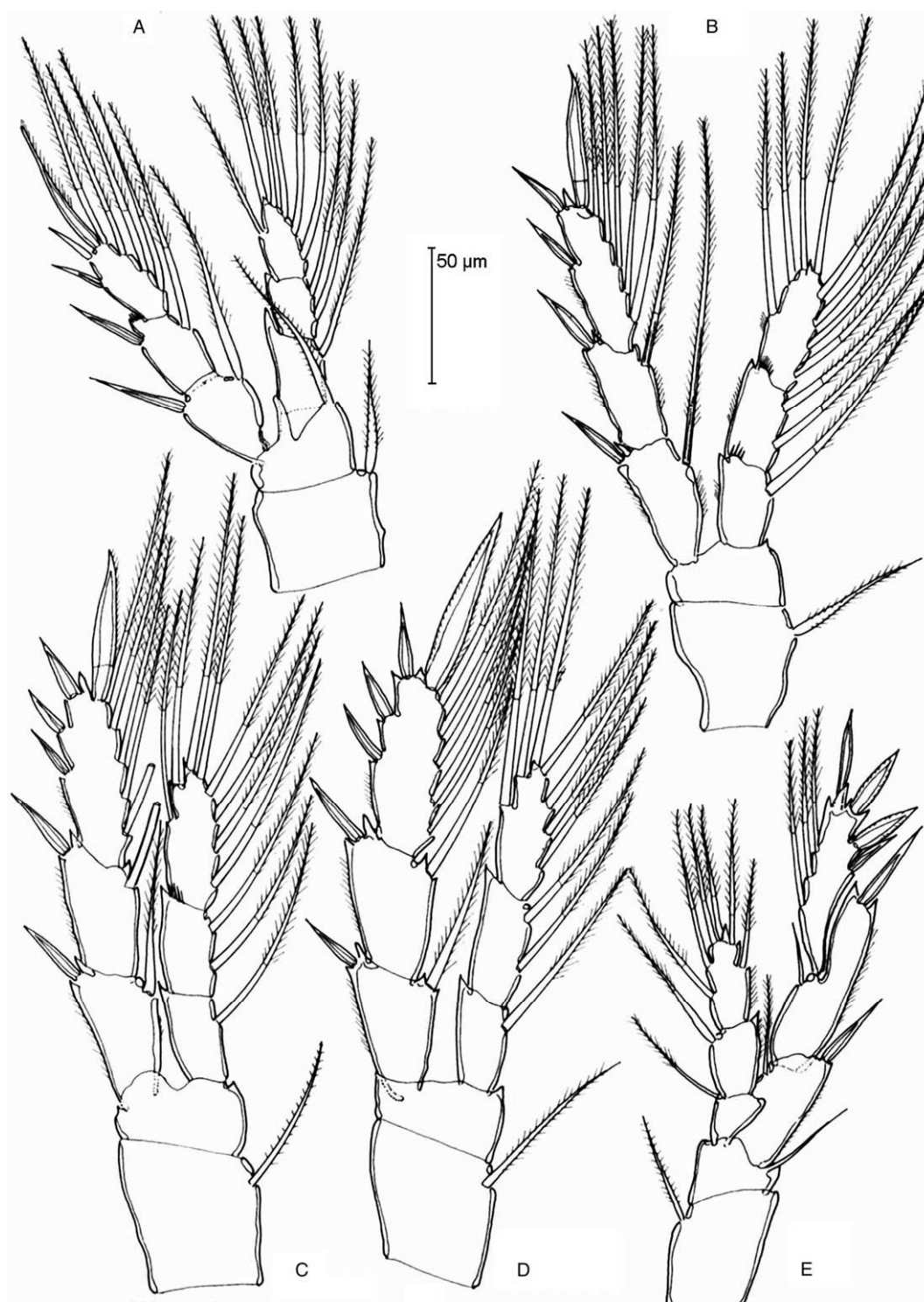


Figure 4. *Badijella jalzici* n. sp., adult female; (a) leg 1; (b) leg 2; (c) leg 3; (d) leg 4; (e) leg 5.

Fifth legs (Figure 4E) third segment of exopod with second and third outer spines and distal spine of equal length, first outer spine shorter than others.

Adult male: Total length: 720–870  $\mu\text{m}$  ( $827 \pm 37.5$   $\mu\text{m}$ ,  $n=15$ ). Prosome length: 560–600  $\mu\text{m}$  ( $575 \pm 11.2$   $\mu\text{m}$ ,  $n=15$ ); prosome 2.6–2.7 times longer than wide. Rostral area, cephalosome, pedi-

gerous somites similar to those of adult female. Prosome: urosome with caudal rami ratio = 1.9–2.5: 1 ( $2.13 \pm 0.18$   $n=15$ ). Urosome of 5 somites; proportional lengths of urosomites: (Figure 5A) 23:19:21:21:16 = 100. Genital somite asymmetrical, long than wide, genital aperture on left side. Anal somite with 2 big triangular hyaline teeth on poster-

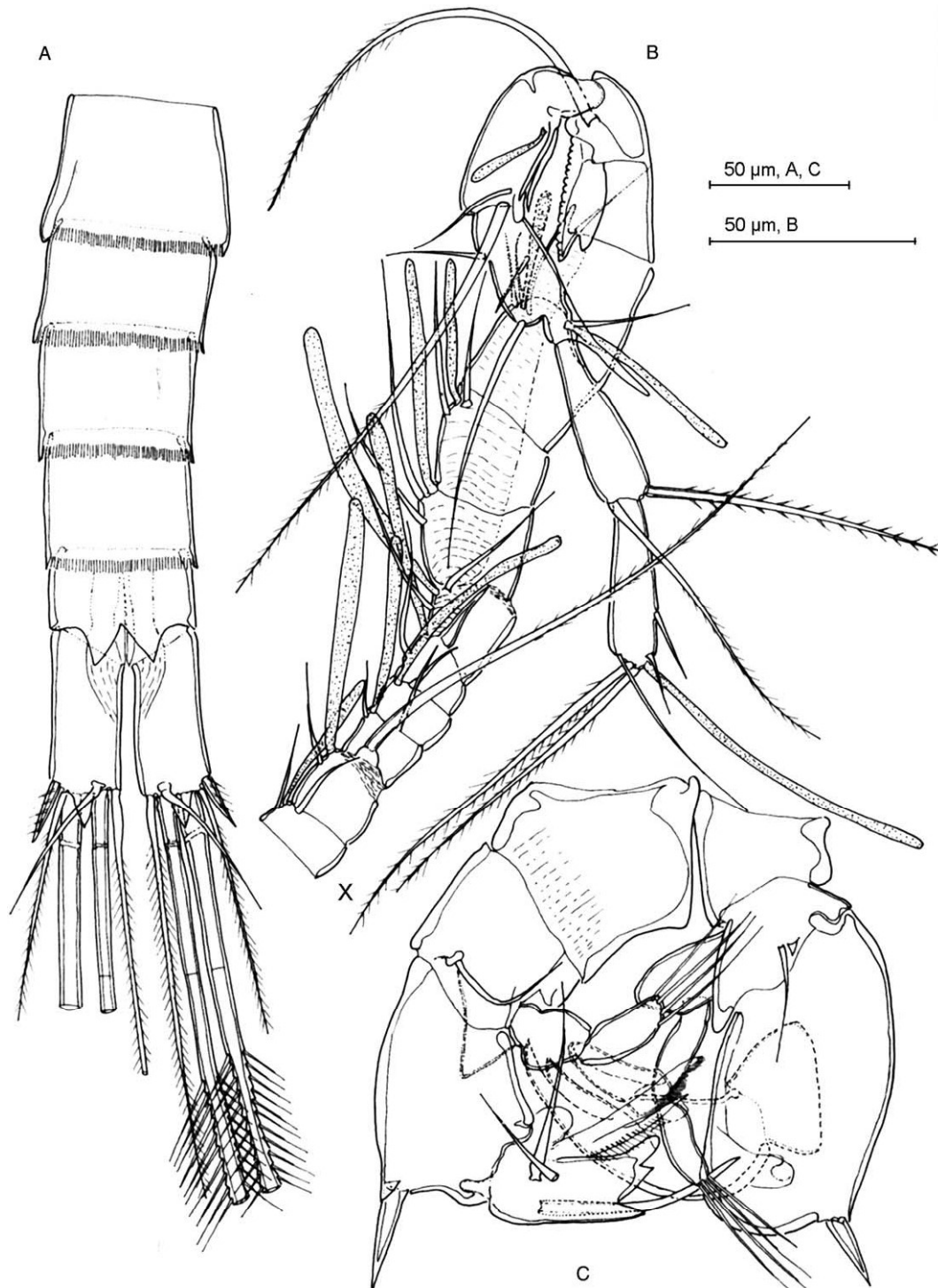


Figure 5. *Badijella jalzici* n. sp., adult male; (A) urosome, dorsal; (B) right antennule, geniculate part from ancestral segment X to tip; (C) leg 5, posterior.

odorsal margin. Posterior margins of urosomites 2–4 fringed with striated hyaline frill. Caudal rami symmetrical, armed as in female.

Antennules (Figure 5B) asymmetrical, reaching almost to end of third urosomite, left antennule as in female, right with 23 free segments and two areas of geniculation, proximal geniculation between seg-

ments XV and XVI, distal geniculation between segment XX and fused ancestral segments XXI to XXIII; distal part of right antennule bent backwards (Figure 5B). Armature and fusion pattern as follows: I to IX as in female; X to XII-2 + aesthetasc each; XIII-1 + aesthetasc, XIV to XVIII-2 + aesthetasc each; XIX-1 + spiniform proces; XX-1 + serrate

plate-like proces; fused ancestral segments XXI-XXIII-2 + aesthetasc + 2 spines + 2 spiniform processes; fused ancestral segments XXIV-XXV-4 + aesthetasc + spiniform process, XXVI-2, fused ancestral segments XXVII to XXVIII-5 + aesthetasc.

Antenna, mouthparts and swimming legs 1–4 identical to those of female (Figure 4A–4D). Fifth legs (Figure 5C) strongly developed, asymmetrical, both biramous; coxae unarmed, bases of different size, each with 1 seta; left basis with anterior extension on anterodistal margin; endopods 2-segmented, each with four setae on distal segment; first segment and terminal setae of right endopod longer than left counterparts. Right leg (Figure 6B) with 2-segmented exopod; proximal segment longer than left counterpart, with rounded anterodistal margin and with 1 spine on outer corner. Distal segment with proximal portion of inner margin expanded into triangular process; 1 seta placed about midway of margin; 2 pointed process distally on segment, plus spoon-like lamella on posterior side (Figure 6B). Left leg (Figure 6A) with 2-segmented exopod, first segment with outer stout spine. Distal segment resembling plant calyx; outer margin of calyx with two triangular and one rounded teeth distally; posterior side with two setae of different size and with stout long spine on anterior side; inner part bearing long tongue-shaped hairy lamella.

**Record.** *Badijella jalzici* n. sp. was first found in samples with more than 100 specimens from a cave on Badija Island. The cave is of small dimensions (11.5 m), with a water layer of approximately 3 m, and placed 15 m inland. The cave bottom is very rich in detritus. Surface salinity was 9.83 PSU, and just above the bottom it was 37.4 PSU (temperature

15.5°C). A few specimens were also found in caves in Živa voda, Hvar Island, April 11, 2003; Gravrnjača Island, Kurba Vela, National park Kornati, September 9, 2003; Lenga, Island, Mljet, April 10, 2004.

## Discussion

Among the eight genera of the family Ridgewayiidae, five are currently monotypic. *Badijella* is compared with all described genera according to Fosshagen and Iliffe (2003) and Boxshall and Halsey (2004) in Table I. For the monotypic genera, the number of endopodal segments in male leg 5, the number of setae on the female third endopodal segment of leg 5 and characteristics of the last prosome somite are given. The new genus is distinguished from genera such as *Ridgewayia*, *Exumella* and *Placocalanus* by morphological characters as well as body dimensions. *Exumella* has a urosome of 3 segments in females and 4 in males. *Ridgewayia* and *Placocalanus* lack rostral filaments and *Placocalanus* has modified proximal antennule segments. The other monotypic genera are geographically very isolated and in addition, *Exumellina* and *Stargatia* have only 2 spines on the third exopodal segments of legs 3 and 4. In *Normancavia* the female fifth leg is uniramous and the body size is very small, with a total length of about 0.5 mm. The genus *Robpalmeria* Fosshagen & Iliffe 2003 from Stargate Blue Hole, South Andros Island, Bahamas, has some characteristics in common with *Badijella*. However, the new genus is easily distinguishable from *Robpalmeria* by the symmetrical last prosome somite, in the female, by the strongly developed tusk-like rostral filaments, the right antennule of the male is double geniculate and is always bent backwards, by the greater number of antennular segments in both sexes, by the specialized terminal segments of the exopods

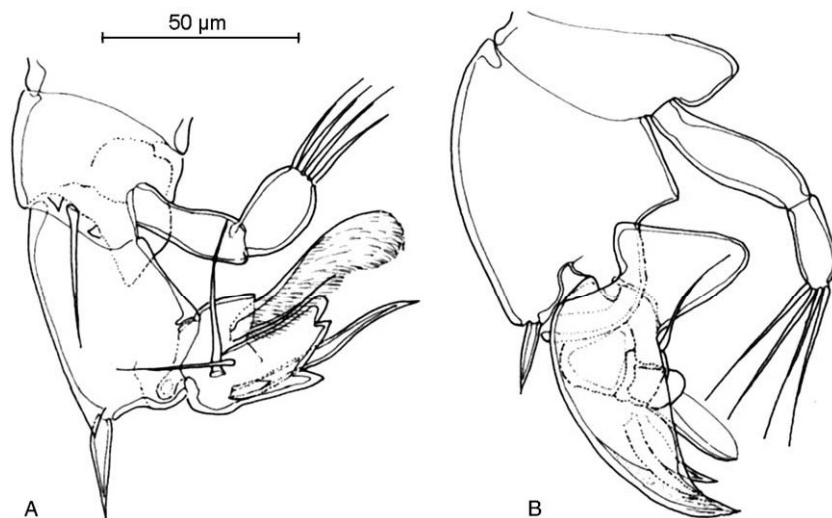


Figure 6. *Badijella jalzici* n. sp., adult male; (A) left leg 5, posterior; (B) right leg 5, anterior.

Table I. Some comparative characteristics for all genera of the family Ridgewayiidae.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>Ridgewayia</i>	0.7–1.0	absent	4/5	no	3	unmod.	biram.	25 or 26	22 or 23	22 or 23	fused				no	2
<i>Exumella</i>	0.8–1.1	present	3/4	yes	3	unmod.	biram.	26 or 27	20 or 24	20 or 24	p.fused				no	1 or 3
<i>Placocalanus</i>	0.4–0.6	absent	4/5	no	3	mod.	biram.	22 or 23	20 or 21	20 or 21	fused				no	2
<i>Bratstromia</i>	1.1–1.2	absent	4/5	no	3	unmod.	biram.	25	23	23	p.fused	bulbous, 3	5	symm.	yes	3
<i>Exumellina</i>	0.7–0.8	present	4/5	no	2	unmod.	biram.	27	22	p.fused		3.2	6	symm.	yes	2
<i>Stargatia</i>	1.5–1.6	absent	4/5	no	2	unmod.	biram.	26	22	fused		3.3	6	symm.	yes	3
<i>Normanacavia</i>	0.5	present	4/5	yes	3	unmod.	uniram.	25	21		fused	1.2	0	symm.	no	1
<i>Robpalmeria</i>	0.9	present	4/5	yes	3	unmod.	biram.	25	21		fused	rudiment	5	asymm.	yes	1
<b><i>Badijella</i></b>	<b>0.7–0.9</b>	<b>present</b>	<b>4/5</b>	<b>yes</b>	<b>3</b>	<b>unmod.</b>	<b>biram.</b>	<b>26</b>	<b>23</b>	<b>fused</b>		<b>2.2</b>	<b>6</b>	<b>symm.</b>	<b>yes</b>	<b>3</b>

1. Female length mm; 2. Rostral filament; 3. Urosome female/male somites; 4. Maxilliped reflexed; 5. Outer spines on third exopodal segments legs 3 and 4; 6. Antennule proximal segment; 7. Female fifth leg; 8. Female antennule segments; 9. Male right antennule segments; fused or partially fused, 10. II–III; 11. II–IV; 12. Male leg 5 endopod segments (left, right); 13. Female leg 5 endopod third segment with setae; 14. Female last prosome somite; 15. Mandible distal endopodal segment elongate; 16. Maxillule endopodal segments.

on both sides and the well-developed 2-segmented endopods of the male leg 5. *Badijella* is also distinguished from other genera by a combination of the following features; antenna with elongate endopod and 7-segmented exopod; mandibular gnathobase with 11 teeth of unequal size and well developed endopod; maxillule endopod 3-segmented with setation formula 5,5,7 but different from that of *Exumellina* and *Stargatia* (see Fosshagen & Iliffe 1998, 2003); reflexed maxilliped, and only the third segment has setae with specialized ornamentation including a uniserrate tip.

## Acknowledgements

I would like to thank Branko Jalžić and the Croatian Bio-Speleological Society in Zagreb for collecting the material on which this work was based. I would like to thank the anonymous reviewers for their suggestions on the improvement of this paper. This paper is supported by the Croatian Ministry of Science, Education and Sport.

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