



Research article

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**Taxonomic status of the family Biokoviellidae Mršić, 1992
(Diplopoda, Chordeumatida): reconsideration,
with a description of one new species**

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Abstract. A new troglobitic species of the previously monotypic genus *Biokoviella* Mršić, 1992, *B. mosorensis* Antić & Dražina sp. nov., is described from caves on Mt. Mosor, Croatia. In addition to this, *B. mauriesi* Mršić, 1992, is partially re-described, and the taxonomic status of the family Biokoviellidae is re-considered. The genus *Biokoviella* is placed in the subfamily Biokoviellinae Mršić, 1992 stat. nov. within the family Anthogonidae Ribaut, 1913. The relationship of the genus *Biokoviella* with other anthogonids is briefly discussed, and a distribution map of the genus is presented. Notes on ecology and coinhabitants of the genus *Biokoviella*, and new data on some Balkan anthogonids are also included in the paper.

Keywords. *Biokoviella*, new species, caves, Croatia, Balkan Peninsula.

Antić D.Ž., Dražina T., Rađa T., Lučić L.R. & Makarov S.E. 2016. Taxonomic status of the family Biokoviellidae Mršić, 1992 (Diplopoda, Chordeumatida): reconsideration, with a description of one new species. *European Journal of Taxonomy* 205: 1–23. <http://dx.doi.org/10.5852/ejt.2016.205>

Introduction

A little more than two decades ago, Mršić (1992) described the new monotypic genus *Biokoviella* Mršić, 1992 from caves on Mt. Biokovo in Croatia. For this taxon, he established the new monotypic family Biokoviellidae, indicated similarities with representatives of the families Chamaesomatidae and Anthogonidae, and placed the new family in the superfamily Cleidogonoidea *sensu* Mauriès (1982). He retained this opinion in his paper from 1994 (Mršić 1994: 249). After that, in Shear's paper from 2000 on the higher classification of Chordeumatida, the family Biokoviellidae was not assigned to any superfamily, not being mentioned at all; however, it was included by Shelley *et al.* (2000) and Shelley (2002) in the superfamily Cleidogonoidea *sensu* Shear (2000), a somewhat extended superfamily concept based on Hoffman's classification from 1980, but significantly different from that of Mauriès (1982). The indicated classification of Cleidogonoidea as given by Shelley (2002) was followed by Shear (2011). In Chapter 16 of a recently published taxonomic overview of Diplopoda by Enghoff *et al.* (2015), the family Biokoviellidae is likewise placed in the superfamily Cleidogonoidea *sensu* Shear (2000) and Shelley (2002).

In our opinion, great similarities exist between some of the representatives of the family Anthogonidae *sensu* Antić *et al.* (2015) and the family Biokoviellidae (see Discussion). After examining a topotype male of *B. mauriesi* Mršić, 1992, as well as a new *Biokoviella* species, we conclude that the family Biokoviellidae deserves subfamily level only, and at the family level we synonymize this taxon with the family Anthogonidae. In this rearrangement, the family Anthogonidae should be placed in the superfamily Anthroleucosomatoidea, together with Anthroleucosomatidae and Vandeuleumatidae according to Enghoff *et al.* (2015). These authors included the family Acherosomatidae, together with Anthroleucosomatidae and Vandeuleumatidae, in Anthroleucosomatoidea. This chapter was probably prepared before publication of the paper by Antić *et al.* (2015), where we included the subfamily Acherosomatinae in the family Anthogonidae. In the present paper, we describe one new *Biokoviella* species from Mt. Mosor in Croatia.

Materials and methods

Specimens preserved in 70% ethanol were examined under a Carl Zeiss Jena Technival 2 binocular stereo microscope and a Carl Zeiss Stemi 2000-c binocular stereo microscope with an AxioCamMRc camera. All taxonomically important structures were dissected and mounted in glycerin for temporary microscope preparations and observed under a Carl Zeiss Axioscope 40 microscope. Drawings of gonopods were executed using a computer monitor and pictures made with a Canon PowerShot A80 digital camera connected to an Axioscope 40 microscope. Some relevant structures were investigated with a JEOL JSM-6460LV scanning electron microscope (University Center for Electron Microscopy, Department of Biology and Ecology, University of Novi Sad, Serbia).

The distribution map was created using QGIS version 2.12.0 and Adobe Photoshop CS6. The final images were processed with Adobe Photoshop CS6. The coordinates given in the location data are based on WGS84.

Descriptions of the new species follow a pattern proposed for Chordeumatida by Spelda (2001). The terminology used to denote the different parts of gonopods follows the pattern proposed by Mršić (1992), with some modifications.

Abbreviations for morphological terms used in descriptions

- a = anterior coxal process
- a1, a2 = branches of anterior coxal process
- b = bristle apparatus

bu	=	bursa
CIX	=	(macrochaetal index) distance between exterior and median macrochaetae/distance between interior and median macrochaetae
f	=	pseudoflagellum
l	=	rounded lobe
lv	=	lateral valve
m	=	medial process
MA	=	(macrochaetal angle) angle between the arm created by the median and exterior macrochaetae and the arm formed by the median and interior macrochaetae
MIX	=	(median index) distance between interior macrochaetae and axial suture/distance between interior and median macrochaetae
mv	=	mesal valve
op	=	operculum
p	=	posterior coxal process
PIX	=	(paratergal index) (width of metazonite - width of prozonite)/(2 × length of paratergum)
s	=	sternal plate
sp	=	lateral sternal process
ss	=	shield-like structure of lateral valve
t	=	telopodal remnant
ts	=	tooth-like structure of lateral valve
v	=	syncoxal vesicle

Other abbreviations used

CBSS	=	Croatian Biospeleological Society, Zagreb, Croatia
IZB	=	Institute of Zoology, University of Belgrade - Faculty of Biology, Belgrade, Serbia
NHMSC	=	Natural History Museum, Split, Croatia
SEM	=	scanning electron microscope

Results

Taxonomy

Class Diplopoda Blainville-Gervais, 1844
Order Chordeumatida Pocock, 1894

Family **Anthogonidae** Ribaut, 1913

Anthroleucosomatidae Verhoeff, 1899: 130. (pro parte)

Acherosomatinae Verhoeff, 1930: 4.

Haasiinae Hoffman, 1980: 137.

Biokoviellidae Mršić, 1992: 53. **syn. nov.**

Subfamily **Biokoviellinae** stat. nov.

Nomen translatum ex family Biokoviellidae Mršić, 1992

Genus ***Biokoviella*** Mršić, 1992

This genus was established by Mršić (1992) for the type and until now only species, *B. mauriesi* (from caves and pits on Mt. Biokovo, Dalmatia, Croatia). The name is regarded as a feminine noun.

Type species

Biokoviella mauriesi Mršić, 1992, by monotypy.

Diagnosis

This genus clearly differs from all other anthogonids in the presence of one pair of bristle apparatuses in combination with one pair of bristle-clad pseudoflagella on the anterior gonopods, while the posterior gonopods consist of coxal vesicles fused in the form of a medial process and telopodal remnants; without lateral coxal processes.

Etymology

The genus is named after its type locality, Mt. Biokovo.

Included species

Biokoviella mauriesi Mršić, 1992

Biokoviella mosorensis Antić & Dražina sp. nov.

Biokoviella mauriesi Mršić, 1992

Figs 1–3, 9A, 10A

Diagnosis

Differs from *B. mosorensis* sp. nov. in larger body size, anterior gonopods that are more robust and several other details of their structure. Lateral valve of vulva with tooth-like subtriangular structures posteriorly.

Etymology

The species was named in honor of the well-known world expert in diplopodology Dr. Jean-Paul Mauriès.

Material examined (total: 13 ♂♂, 7 ♀♀, 9 juveniles)

Topotype

CROATIA: ♂, Stara Ledenica Cave, 43.318° N, 17.050° E, 1350 m a.s.l., Biokovo Mountain, Dalmatia, 16 Jun. 2002, leg. R. Ozimec (IZB).

Other material

 (total: 12 ♂♂, 7 ♀♀, 9 juveniles)

CROATIA, Dalmatia, Mt. Biokovo: 4 ♂♂, Jama kraj Stare Škole Pit, Lokva, 12. Jul. 1989, leg. B. Jalžić (CBSS); 2 ♂♂, Jama Čavlenovača Pit, 18 Jun. 2002, leg. R. Ozimec (CBSS); 2 ♂♂, 2 ♀♀, 2 juveniles, Jama pod Sv. Jurom Pit, below Sv. Jure Peak, 20 Jun. 2002, leg. R. Ozimec (CBSS); 1 ♀, Kašogijeva Jama Pit, below Sv. Jure Peak, 21 Jul. 2002, leg. M. Lukić (CBSS); 1 ♀, 1 juvenile, Lovricia Jama 2 Pit, 26 Jul. 2002, leg. J. Bedek (CBSS); 1 ♂, 1 juvenile, Jezero Ledenica Cave, Stražbenica, Kaoci, 20 Jul. 2003, leg. R. Ozimec (CBSS); 1 juvenile, Led 1 Pit, below Sv. Jure Peak, 21 Jul. 2003, leg. J. Bedek (CBSS); 1 ♂, Crna Ledenica Cave, below Sv. Jure Peak, 24 Oct. 2006, leg. M. Lukić (CBSS); 1 ♀, same data except 18. Jun. 2011, leg. A. Kirin (CBSS); 1 ♂, 1 ♀, 3 juveniles, Velika Mačka Pit, Velika Mačka, 22 Jun. 2008, leg. M. Lukić (CBSS); 1 juvenile, same data except leg. S. Nižetić (CBSS); 1 ♂, 1 ♀, Lovricia 3 Pit, Lipi Dočić, 30 May 2015, leg. T. Delić (IZB).

Type locality

Stara Ledenica Cave, Mt. Biokovo, Dalmatia, Croatia.

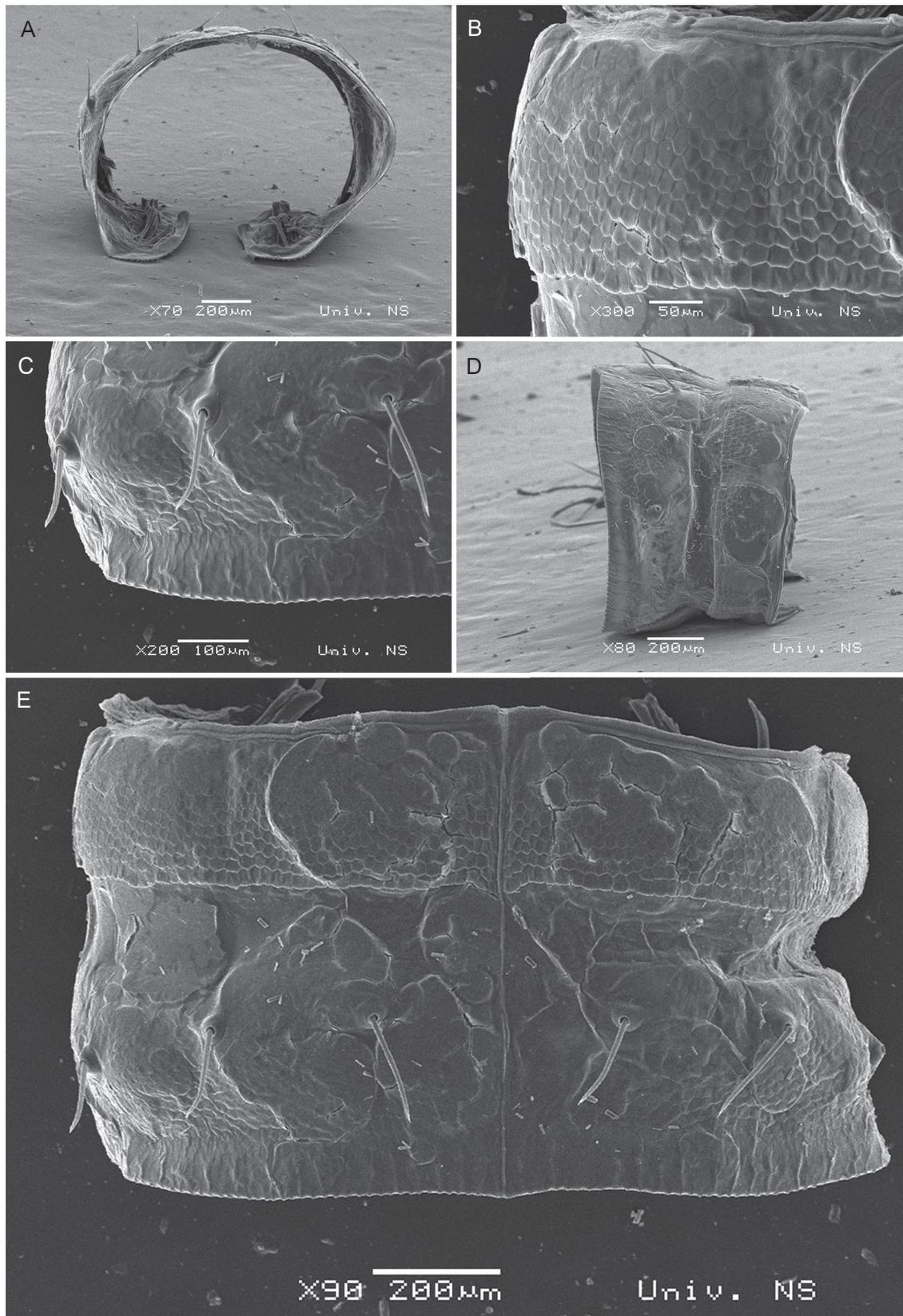


Fig. 1. *Biokoviella mauriesi* Mršić, 1992, ♂, topotype, pleurotergite 15. **A.** Posterior view. **B.** Prozonite, dorsal view. **C.** Metazonite, dorsal view. **D.** Lateral view. **E.** Dorsal view.

Redescription

Body indices

PLEUROTERGITE 15 (Fig. 1). CIX ~ 0.8; MIX ~ 0.8; PIX = 0.25; MA ~ 160°.

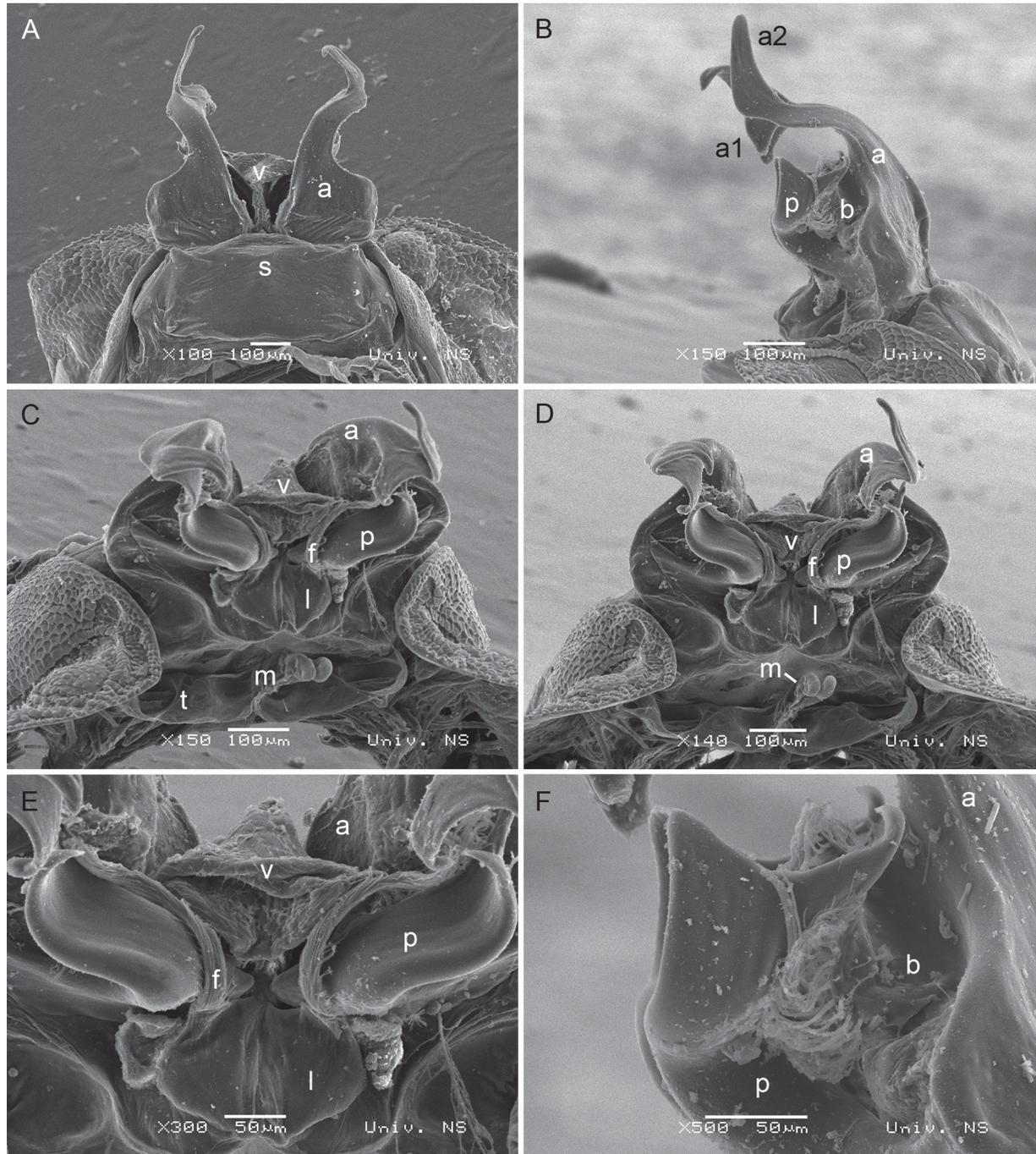


Fig. 2. *Biokoviella mauriesi* Mršić, 1992, ♂, topotype, gonopods. **A.** Anterior gonopods, anterior view. **B.** Anterior gonopods, lateral view. **C–D.** Anterior and posterior gonopods, postero-distal view. **E.** Anterior gonopods, postero-distal view of the medial part. **F.** Anterior gonopods, lateral view of the posterior process and bristle apparatus. Abbreviations: see Material and methods.

Redescription of male sexual characters

MALE SEXUAL CHARACTERS. Leg pairs 3–7 are somewhat larger than the rest of the legs, leg pairs 3 and 4 the most robust; without any peculiarities (see Discussion).

ANTERIOR GONOPODS (Fig. 2). Anterior coxal processes (a) [= angiocoxites *sensu* Mršić (1992)] completely separated from each other, rising from the wide subquadrangular sternal plate (s); first $\frac{1}{3}$ (base) very broad, remaining $\frac{2}{3}$ very slender and long, curved caudad, apically with two branches (a1 and a2)

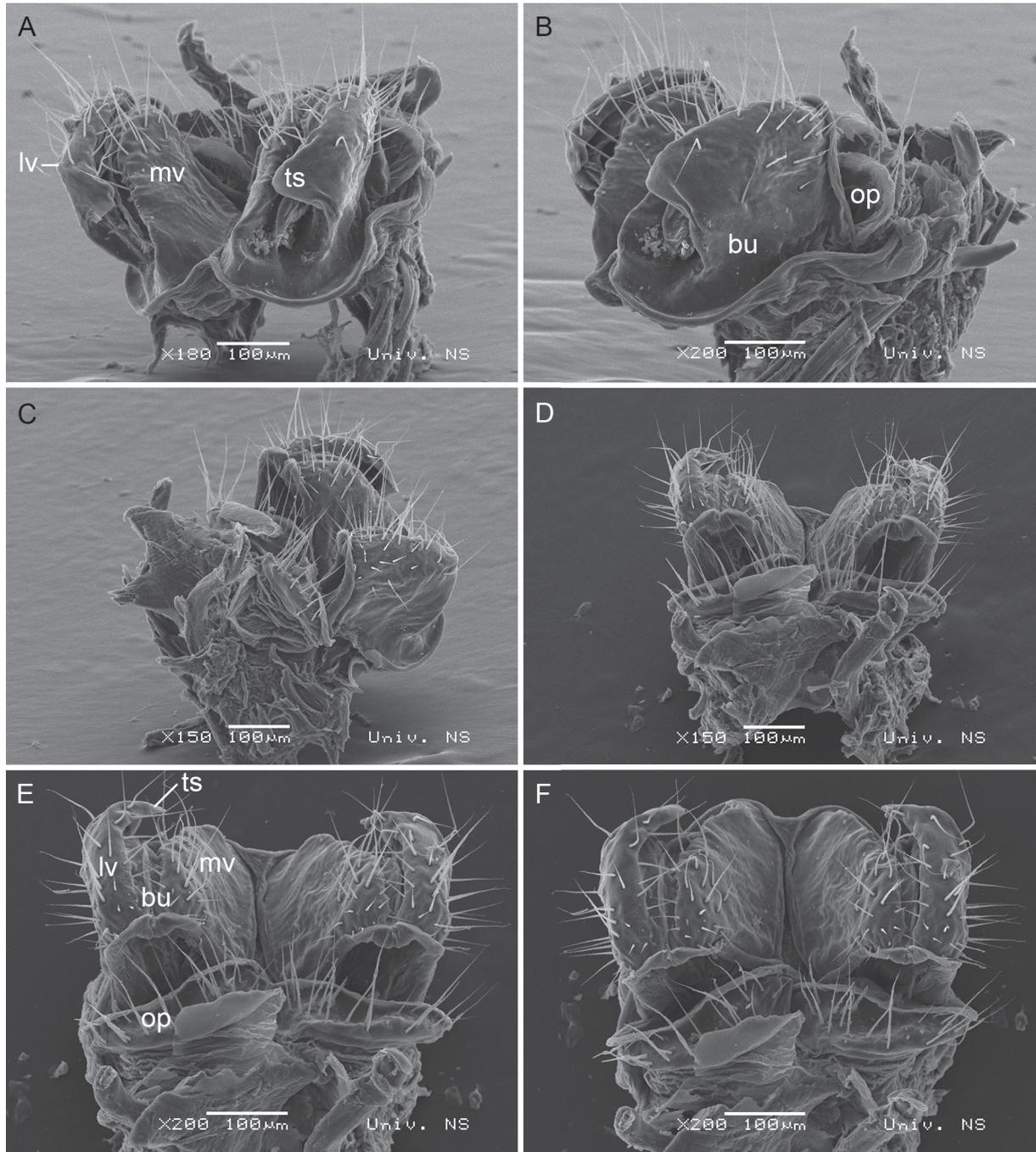


Fig. 3. *Biokoviella mauriesi* Mršić, 1992, ♀ from the Lovricia 3 Pit, vulvae. **A.** Posterior view. **B.** Lateral view. **C.** Latero-distal view. **D.** Anterior view. **E.** Antero-distal view. **F.** Distal view. Abbreviations: see Material and methods.

opposite to each other. Posteriorly, anterior coxal processes equipped with bristle apparatuses (b) [= oval coxal intermediate process with bristles *sensu* Mršić (1992)]. Posterior coxal processes (p) [= syncoxal processes *sensu* Mršić (1992)] well-developed, broad at the base, “C”-curved in posterior view, apically divided into two parts, very wide in lateral view. The most posterior parts of the anterior gonopods are a pair of pseudoflagella (f) covered by bristles over almost their whole length, with tassels at the top (see Discussion). These pseudoflagella starting from the well-developed, rounded lobes (l). The only unpaired part of the anterior gonopods, apart from the sternum, is the rounded syncoxal vesicle (v) [= a small intermediate (medial) bridge *sensu* Mršić (1992)] situated between the coxal processes (deflated on the SEM photos). There are no traces of telopodites.

POSTERIOR GONOPODS (Figs 2C–D, 9A). Very reduced in both size and structure. Consist of coxal vesicles fused in the form of a medial process (m) apically divided. Laterally with telopodal remnants (t). Lateral sternal processes (sp) high and subtriangular.

Descriptions of vulvae

VULVAE (Fig. 3). Somewhat elongated from lateral view. Mesal (mv) and lateral (lv) valves of bursae (bu) distally with long setae. Several setae are present on the lateral side of the lateral valvae. Lateral valvae posteriorly with tooth-like subtriangular structures (ts), which only partly cover the mesal valvae, so the bursa apertures can be seen from posterior view. Operculum (op) with long setae.

Distribution

Croatia: known only from several caves on Mt. Biokovo (Fig. 11, red triangles).

Habitat

Biokoviella mauriesi is limited to deep and cold caves on Mt. Biokovo with temperatures ranging from 0 to 7°C. The entrances of these caves are situated on an elevated plateau stretching from above 1300 m a.s.l. to the highest parts of Biokovo.

Biokoviella mosorensis Antić & Dražina sp. nov.

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Figs 4–8, 9B, 10B

Diagnosis

The new species can be clearly separated from *B. mauriesi* on the basis of the smaller body size, the presence of anterior gonopods that are much more gracile and differences in several other details of their structure. Lateral valve of vulva with shield-like structures posteriorly.

Etymology

The new species is named after Mt. Mosor (Middle Dalmatia, Croatia), its *terra typica*.

Material studied (total: 14 ♂♂, 17 ♀♀, 4 juveniles)

Holotype

CROATIA: ♂, Balića Špilja Cave (= Kraljeva Peć Cave), 43.573° N, 16.570° E, 404 m a.s.l., Balići, village of Dugopolje, Mt. Mosor, Middle Dalmatia, Croatia, 7 Sep. 2015, leg. D. Antić & T. Rada (NHMSC).

Paratypes

 (total: 10 ♂♂, 10 ♀♀, 4 juveniles)

CROATIA: 9 ♂♂, 7 ♀♀, 2 juveniles (IZB, NHMSC), same data as holotype; 1 ♂, 3 ♀♀, 2 juveniles, same data except 28 Apr. 2012, leg. M. Pavlek (CBSS).

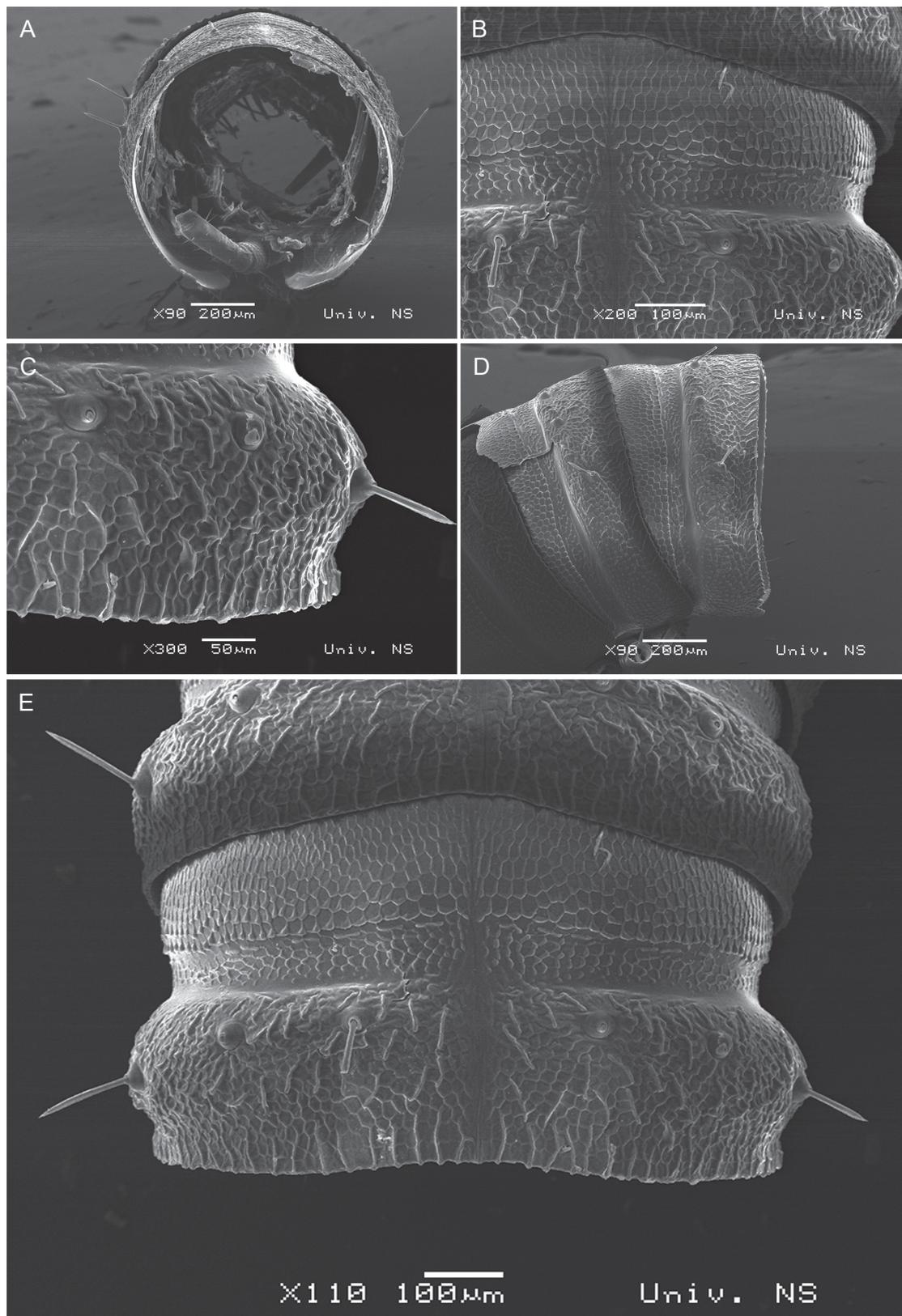


Fig. 4. *Biokoviella mosorensis* Antić & Dražina sp. nov., ♂, paratype. **A.** Pleurotergite 15, posterior view. **B.** Pleurotergite 15, prozonite and metazonite, dorsal view. **C.** Pleurotergite 15, metazonite, dorsal view. **D.** Pleurotergites 14 and 15, lateral view. **E.** Pleurotergites 14 and 15, dorsal view.

Other material (total: 3 ♂♂, 7 ♀♀)

CROATIA, Mt. Mosor: 1 ♀, Ledenica pod Jabukovcem Pit, Jabukovac, 23 Jun. 2011, leg. P. Bregović (CBSS); 1 ♀, Maklutača Špilja Cave, Čevrljin Klen, Kute, 24 Jun. 2011, leg. R. Baković (CBSS); 1 ♂, Velika Gajna Pit, Gornje Sitno, 5 May 2012, leg. R. Cvitanić (CBSS); 2 ♂♂, 5 ♀♀, same data except 7 Jun. 2015, leg. B. Jalžić (CBSS).

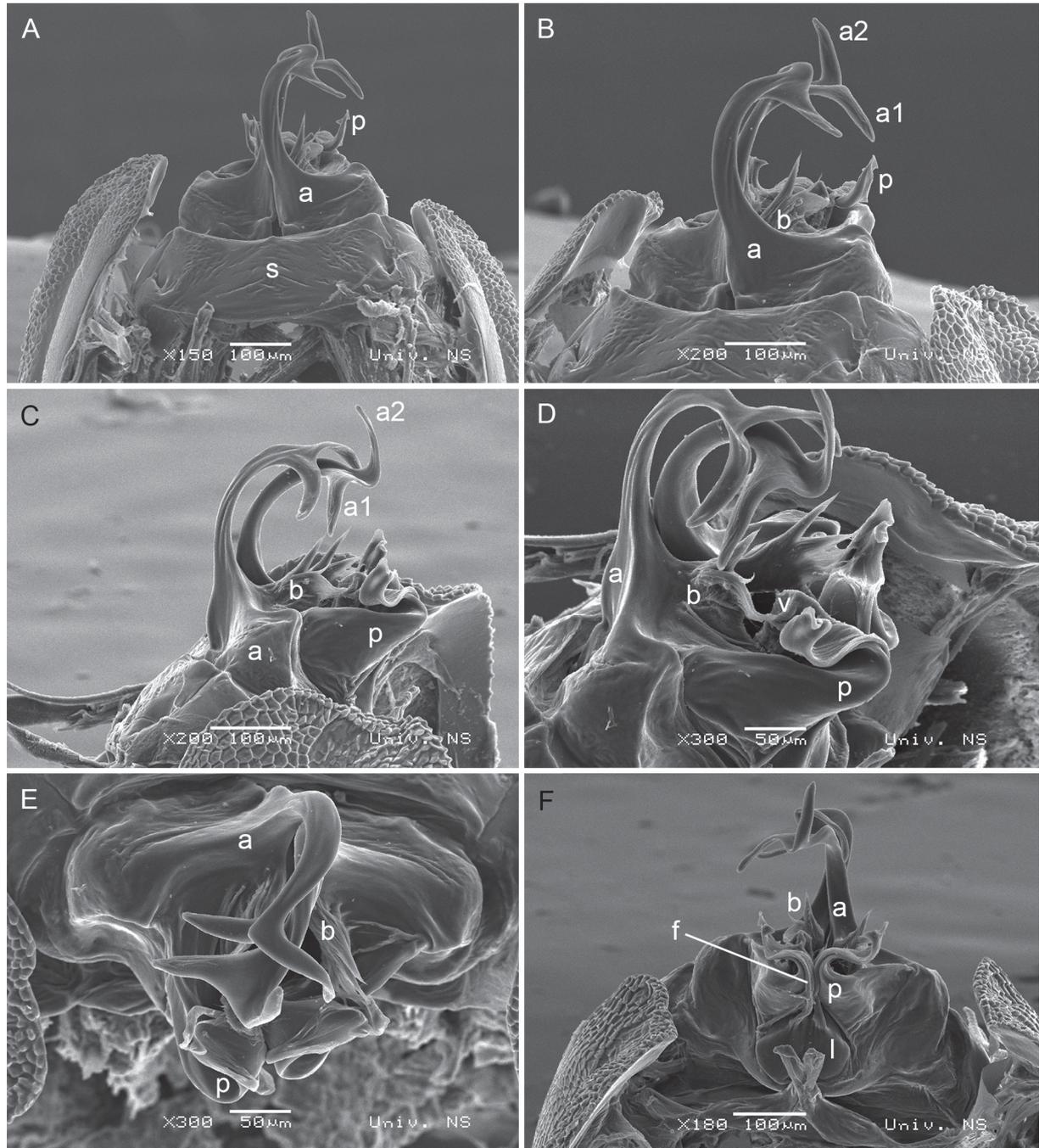


Fig. 5. *Biokoviella mosorensis* Antić & Dražina sp. nov., ♂, paratype, gonopods. **A.** Anterior gonopods, anterior view. **B.** Anterior gonopods, antero-lateral view. **C.** Anterior gonopods, lateral view. **D.** Anterior gonopods, latero-distal view. **E.** Anterior gonopods, distal view. **F.** Anterior and posterior gonopods, posterior view. Abbreviations: see Material and methods.

Type locality

CROATIA: Balića Špilja Cave (= Kraljeva Peć Cave), Balići, village of Dugopolje, Mt. Mosor, Middle Dalmatia.

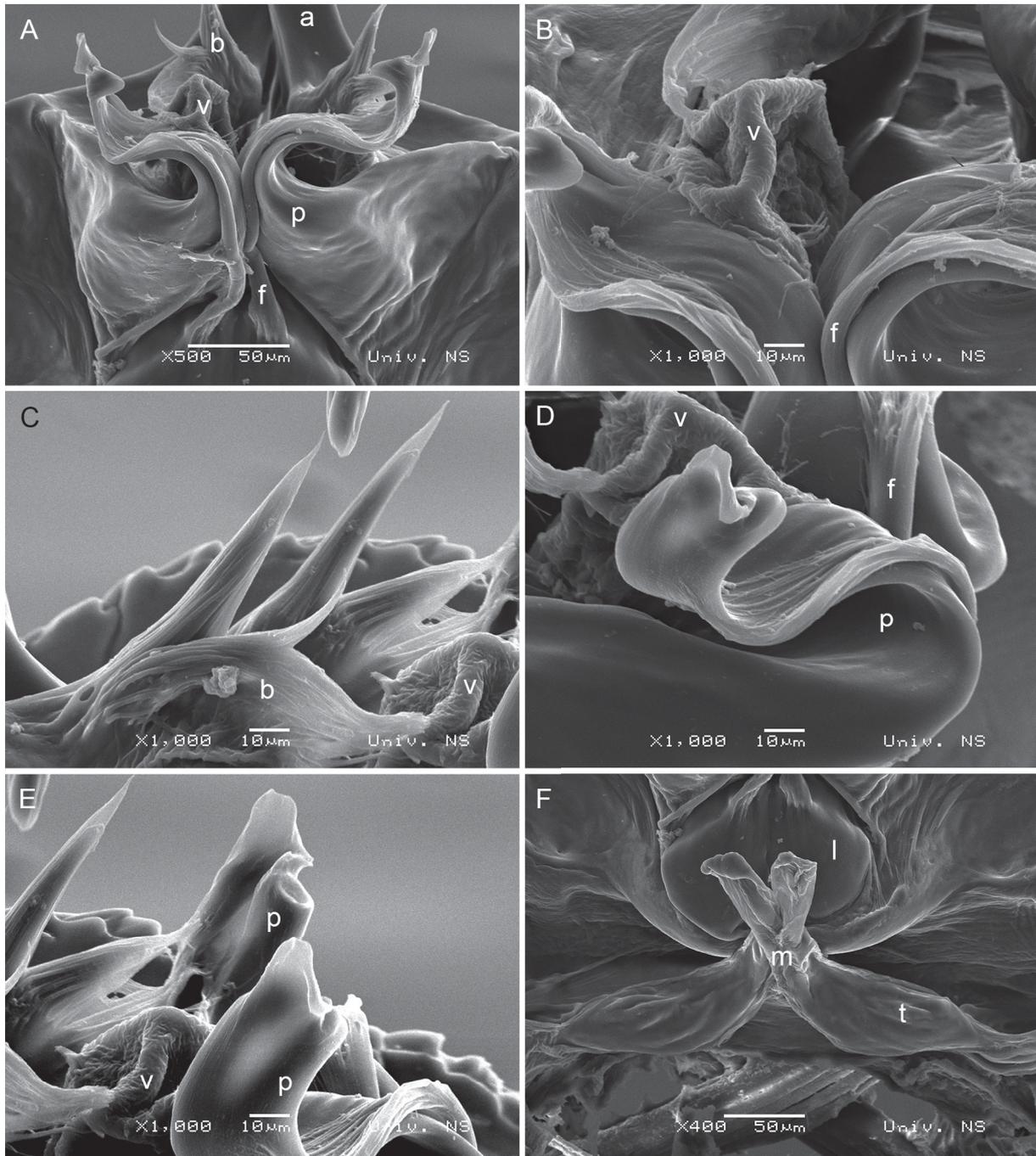


Fig. 6. *Biokoviella mosorensis* Antić & Dražina sp. nov., ♂, paratype, gonopods. **A.** Anterior gonopods, posterior view. **B.** Anterior gonopods, postero-distal view of vesicle. **C.** Anterior gonopods, lateral view of bristle apparatus. **D.** Anterior gonopods, latero-distal view of posterior coxal process and vesicle. **E.** Anterior gonopods, lateral view of the apex of posterior coxal processes. **F.** Posterior gonopods, postero-distal view. Abbreviations: see Material and methods.

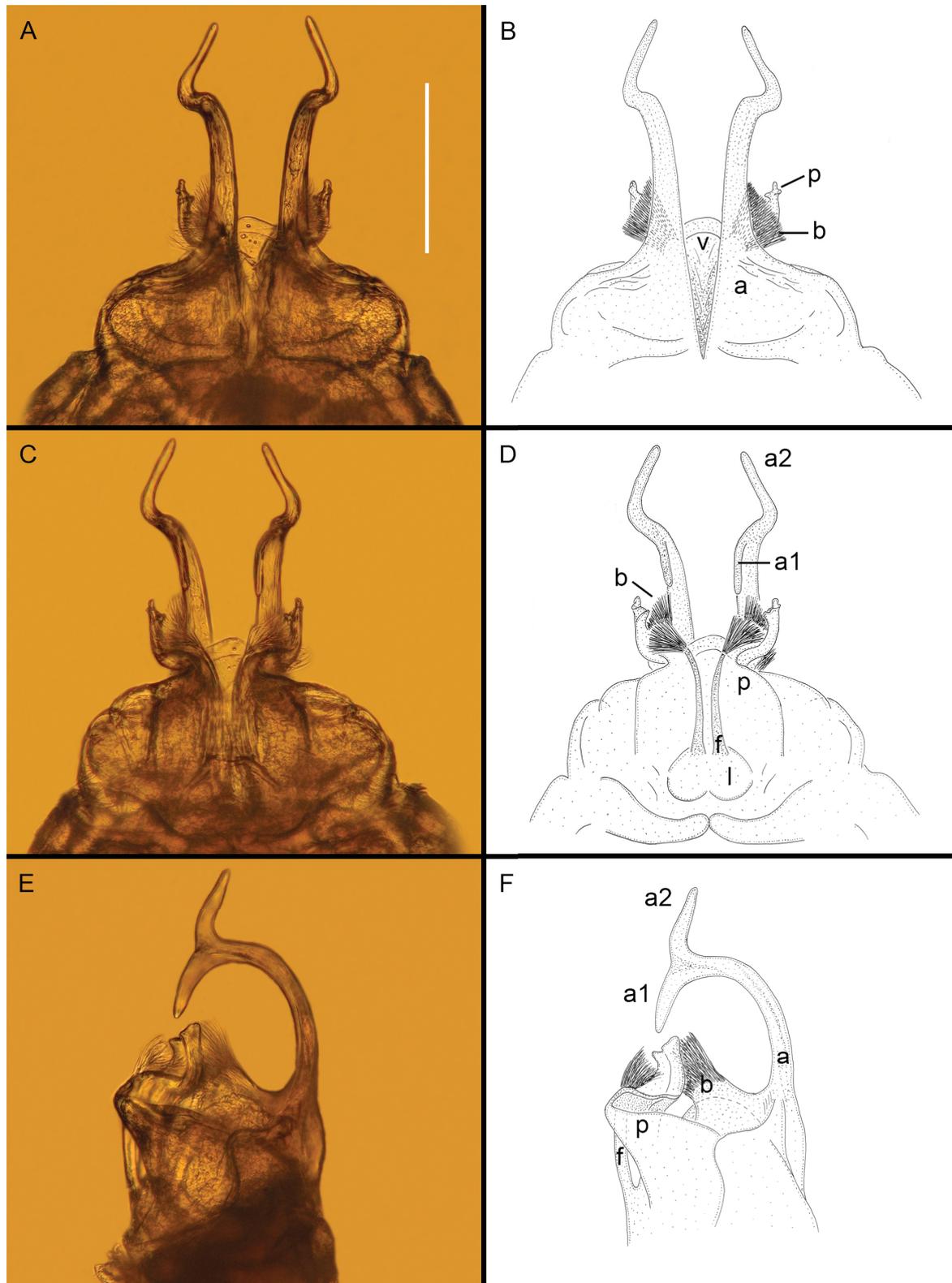


Fig. 7. *Biokoviella mosorensis* Antić & Dražina sp. nov., ♂, holotype, anterior gonopods. **A–B.** Anterior view. **C–D.** Posterior view. **E–F.** Lateral view. Abbreviations: see Material and methods. Scale line = 0.2 mm.

Description

SEGMENTS. Body with 30 segments (including telson) in adults. Juveniles with 28 and 26 segments (including telson), respectively.

MEASUREMENTS. Males 9–12 mm long, vertical diameter of the largest pleurotergite 0.9–1 mm. Females 10.5–13 mm long, vertical diameter of the largest pleurotergite 1–1.05 mm. Holotype male 10.5 mm long, vertical diameter of its largest pleurotergite 1 mm.

COLORATION. Pigmentless, whitish (Fig. 10B).

HEAD. Setose. Labrum with three medial labral teeth and with 4+4 labral and 1+1 supralabral setae. Gnathochilarium normal. Antennae elongated, 2.4 mm long in holotype male. Length of antennomeres (in mm): I (0.1), II (0.27), III (0.58), IV (0.3), V (0.7), VI (0.22), VII (0.2) and VIII (0.03). Length/breadth ratios of antennomeres I–VII: I (1), II (2.1), III (5.3), IV (2.7), V (5.4), VI (1.5) and VII (2). Antennomeres II, IV, V, VI and VII with one, three, one, four and one macrochaetae, respectively. Blind.

COLLUM. Narrower than head, with six macrochaetae.

BODY SEGMENTS (Fig. 4). Without lateral keels, metazonites with only small lateral swellings. Macrochaetae short, trichoid. CIX (pleurotergite 15) ~ 0.9; MIX (pleurotergite 15) ~ 1; PIX (pleurotergite 15) = 0.6; MA (pleurotergite 15) ~ 140°.

TELSON. Epiproct with a pair of spinnerets and six trichoid setae arranged in two rows (2+2 marginal and 1+1 paramedial setae). Hypoproct with two trichoid setae. Paraprocts with 3+3 marginal trichoid setae.

WALKING LEGS. Elongated. Leg pairs 1 and 2 with tarsal combs in both sexes.

MALE SEXUAL CHARACTERS. Leg pairs 3–7 somewhat larger than the rest of the legs, leg pairs 3 and 4 the most robust; without any peculiarities. Leg pairs 10 and 11 with coxal glands; leg pair 11 with posteriorly directed coxal horn.

ANTERIOR GONOPODS (Figs 5, 6A–E, 7). Anterior coxal processes (a) [= angiocoxites *sensu* Mršić (1992)] completely separated from each other, rising from the very wide sternal plate (s); first $\frac{1}{3}$ (base) very broad, remaining $\frac{2}{3}$ very gracile, long, thin and curved caudad, apically with two branches (a1 and a2) opposite to each other. Posteriorly anterior coxal processes with bristle apparatuses (b) [= oval coxal intermediate process with bristles *sensu* Mršić (1992)]. Posterior coxal processes (p) [= syncoxal processes *sensu* Mršić (1992)] well-developed, broad at the base, “S”-curved from posterior view, with only a small apical notch. The most posterior parts of the anterior gonopods are a pair of pseudoflagella (f), naked over their whole length, with tassels at the top. These pseudoflagella starting from the well-developed, rounded lobes (l). The only unpaired part of the anterior gonopods, apart from the sternum, is the rounded syncoxal vesicle (v) [= small intermediate (medial) bridge *sensu* Mršić (1992)] situated between the coxal processes (deflated on the SEM photos). There are no traces of telopodites.

POSTERIOR GONOPODS (Figs 6F, 9B). Very reduced in both size and structure. Consisting of coxal vesicles fused in the form of a medial process (m) divided halfway. Laterally with telopodal remnants (t). Lateral sternal processes (sp) low and rounded.

VULVAE (Fig. 8). Subquadrangular from lateral view. Mesal (mv) and lateral (lv) valvae of bursae (bu) distally with long setae. Lateral valvae posteriorly with shield-like structures (ss) which almost completely cover the mesal valvae, so that bursa apertures can't be seen from posterior view. Operculum (op) with long setae.

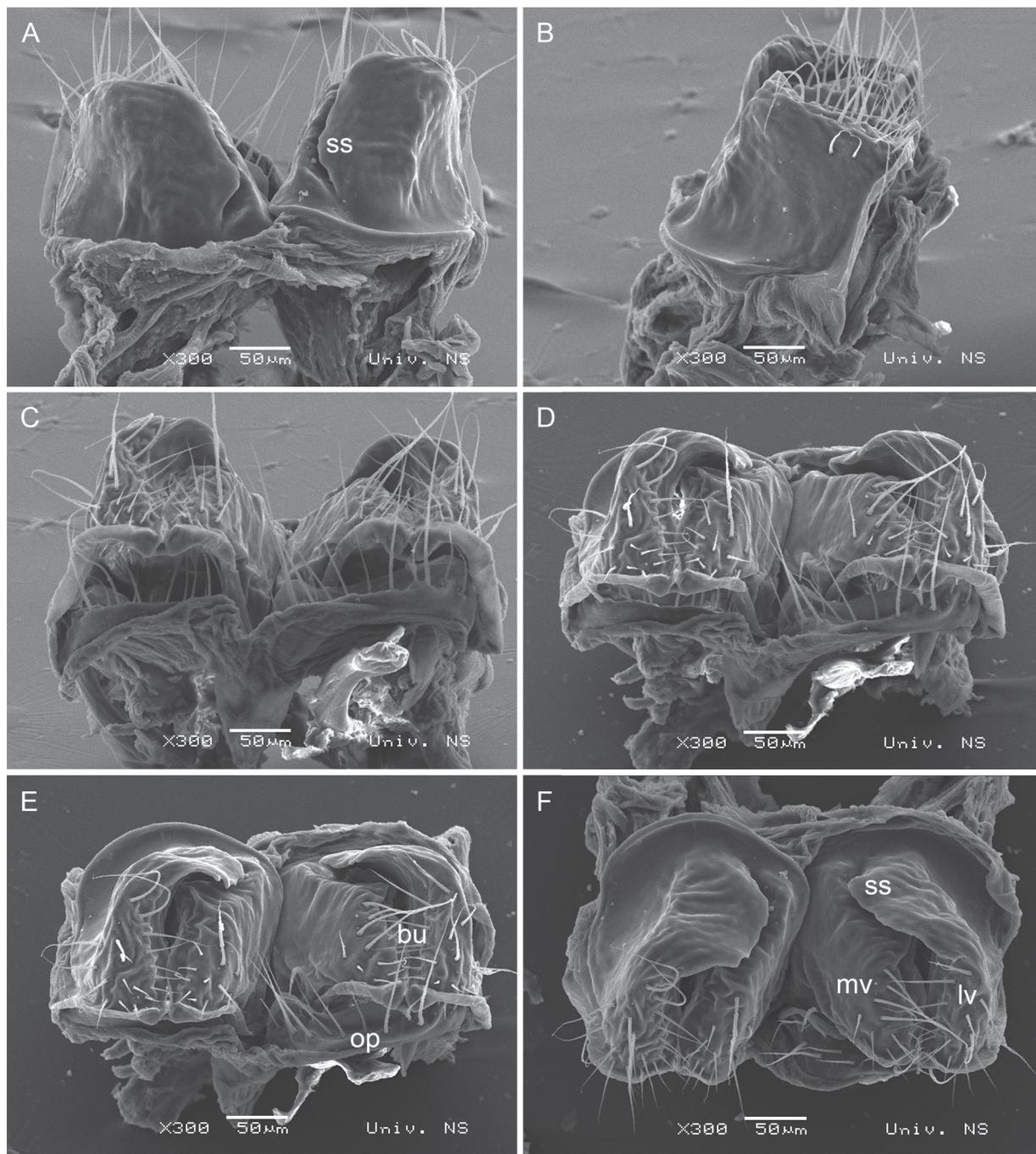


Fig. 8. *Biokoviella mosorensis* Antić & Dražina sp. nov., ♀, paratype, vulvae. **A.** Posterior view. **B.** Lateral view. **C.** Anterior view. **D.** Antero-distal view. **E.** Distal view. **F.** Postero-distal view. Abbreviations: see Material and methods.

Distribution

Croatia, known only from several caves on Mt. Mosor (Fig. 11, blue circles).

Habitat

Balića Špilja is a cave with a huge entrance enabling light to penetrate through almost the whole cave. Only the innermost part is in complete darkness and with various speleothems. Mean air temperature in the cave is 6.3°C and humidity is high (99.6%). Altogether, the cave is 194 m long and 50 m deep. Balića

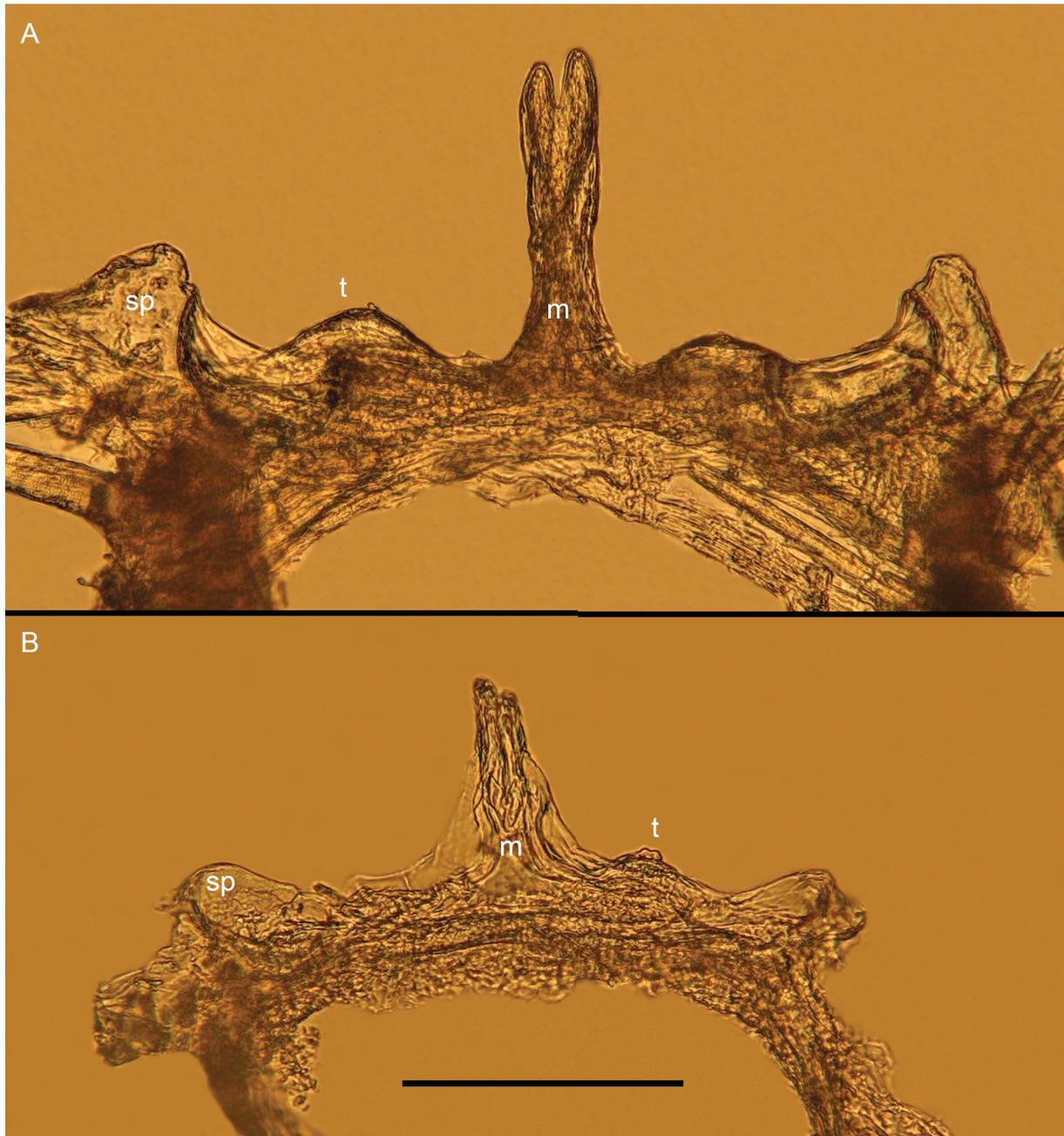


Fig. 9. Posterior gonopods. **A.** *Biokoviella mauriesi* Mršić, 1992, ♂ from the Lovricia 3 Pit. **B.** *Biokoviella mosorensis* Antić & Dražina sp. nov., ♂, holotype. Abbreviations: see Material and methods. Scale line = 0.2 mm.



Fig. 10. Habitus. **A.** *Biokoviella mauriesi* Mršić, 1992, ♀, topotype (photo by H. Bilandžija). **B.** *Biokoviella mosorensis* Antić & Dražina sp. nov., ♂ and ♀ from the type serie (photo by D.A.). Without scale.

Špilja is a very important biospeleological locality, being *locus typicus* for eight different taxa (Bedek *et al.* 2006; Makarov *et al.* 2011): *Folkia boudewijni* Deeleman-Reinhold, 1993, *Troglohyphantes giromettai* (Kulczyński, 1914) and *Troglohyphantes strandi* Absolon & Kratochvíl, 1932 (all Araneae); *Neobisium dalmatinum* Beier, 1938 (Pseudoscorpiones); *Massarilatzeria dugopoljica* Makarov & Rada, 2011 (Diplopoda); and *Neotrechus ganglbaueri bluehweissi* (Hoffmann, 1913), *Haplotropidius taxi subinflatus* (Apfelbeck, 1907) and *Spelaites grabowskii* Apfelbeck, 1907 (all Coleoptera). Apart from the aforementioned taxa, the cave is also inhabited by another interesting troglobiont or trogophile fauna, including such species as: *Oroniscus dalmaticus* Strouhal, 1937, *Alpioniscus balthasari* (Frankenberger, 1937) and *Armadillidium* sp. (all Isopoda, Bedek *et al.* 2011 and CBSS); *Apfelbeckia insculpta* (L. Koch, 1867) and *Brachydesmus subterraneus* Heller, 1858 (both Diplopoda, present study); *Nesticus eremita* Simon, 1879, *Rhode* sp., *Stygopholcus absoloni* (Kulczyński, 1914) and *Barusia maheni* (Kratochvíl & Miller, 1939) (all Aranea, CBSS); and *Duvalius novaki* (Müller, 1911) (Coleoptera, Pretner 1973). *Biokoviella mosorensis* sp. nov. is found in the middle part of the cave, walking on rocks or large stones on surfaces facing the dark.

With a depth of 176 m, Velika Gajna Pit is one of the deepest pits on Mt. Mosor. *Biokoviella mosorensis* sp. nov. was collected near the bottom of this pit, where measured air temperature was 7°C and humidity 90%. Other notable collected species of the pit's fauna were: *Alpioniscus* sp. (Isopoda); *Brachydesmus subterraneus* Heller, 1858 (Diplopoda); and *Duvalius erichsonii* (Schaufuss, 1864), *Haplotropidius taxi* (Müller, 1903), *Laemostenus cavicola* (Schaum, 1858), *S. grabowskii* and *Speoplanes giganteus* (J. Müller, 1911) (all Coleoptera) (Jalžić *et al.* 1990 and CBSS).

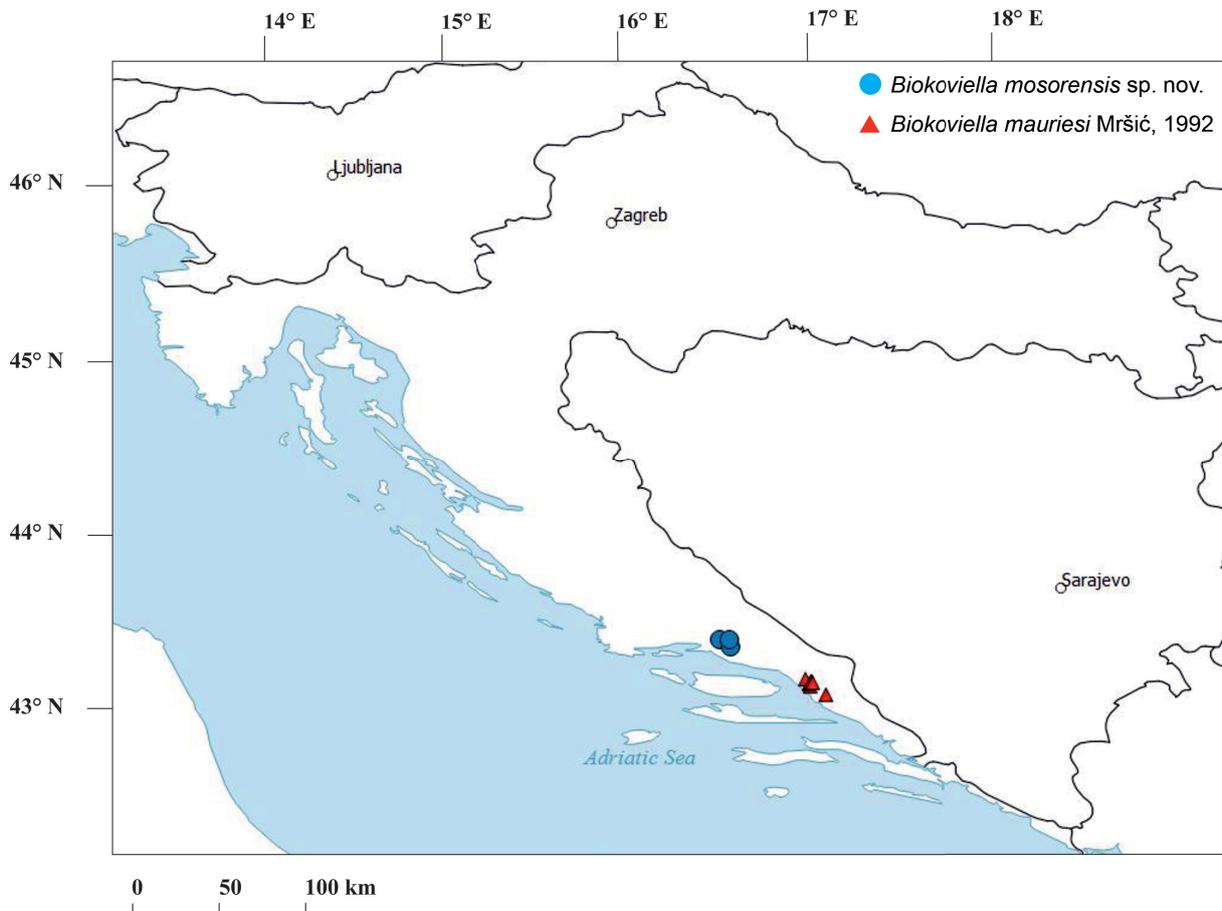


Fig. 11. Distribution of the subfamily Biokoviellinae stat. nov.

Maklutača is a cave almost 150 m long and 39 deep (Jalžić *et al.* 2013). Similar to Balića Špilja, Maklutača has a huge entrance, with light penetrating through the first half of the cave. Measured air temperature was 6.7°C. This cave is the type locality of *Nicoletiella absoloni absoloni* Willmann, 1940, a subspecies of small troglobitic mite (Acari). The following troglobitic or troglophilic forms were also recorded from this locality: *T. giromettai* and *T. strandi* (both Aranea); *A. balthasari* (Isopoda, Bedek *et al.* 2011); Onychiuridae indet., *Heteromurus (Verhoeffiella)* sp. and *Pseudosinella* sp. (all Collembola, CBSS); and *Neotrechus ganglbaueri* (Padewieth, 1891) and *H. taxi* (Pretner 1973 and CBSS). Furthermore, another diplopod species, *Massarilatzelia dugopoljica* Makarov & Rađa, 2011, was collected in Maklutača cave, which is the second known locality for this Mt. Mosor endemic species (present study).

The Ledenica pod Jabukovcem Cave is situated in a deep dolina, and its specific position enables it to retain snow and ice up to the summer months. For that reason air temperature is extremely low, on average around 3.6° C. The cave has a total length of 105 m and depth of 34 m (Jalžić *et al.* 2013). This speleological locality is an important *locus typicus*, with three described taxa: *Neobisium maderi* Beier, 1938 (Pseudoscorpiones), *Traegardhia dalmatina gigantea* Willmann, 1941 (Acari) and *Speoplanes giganteus giganteus* (J. Müller, 1911) (Coleoptera). Pretner (1973) mentioned two additional species of Coleoptera for this cave: *H. taxi* and *S. grabowskii*.

Notes on the ecology and distribution of *Biokoviella*

Biokoviella mosorensis sp. nov. inhabits cold caves on Mt. Mosor, those in which the air temperature does not exceed 7° C and humidity ranges from 95 to 100%. A similar ecological preference is also characteristic of *B. mauriesi*. Chordeumatidans are known to tolerate low temperature, and they can be active in the soil and in rocky crevices below the snow cover (Mauriès 1986, 1988). Thus, this group of diplopods is well adapted for colonization of cold underground habitats.

The subterranean habitats of Mts Biokovo and Mosor have diverse and endemic troglobiotic faunas. Turbulent geological history and the role of the Dinaric area as a refuge during glacial periods promoted continuous colonization of suitable underground habitats. A high rate of endemism is present throughout the entire Dinarides, and Mosor is no exception – even after more than 100 years of speleological and biospeleological research (Girometta 1914), new species are still being discovered.

New data for some Balkan anthogonids

New data for *Egonpretneria vudutschajldi* Antić & Dražina, 2015

CROATIA: 2 ♂♂, 1 ♀, Pećina Čakovec Cave, Javorinske Drage, Mlakva, Perušić, 2 Aug. 2015, leg. B. Jalžić (CBSS); 2 ♂♂, 1 ♀, Kalvarija Cave, Bužin, Gospić, 1 Sep. 2015, leg. H. Cvitanović (CBSS).

New data for *Haasia cornuata* (Strasser, 1940)

SLOVENIA: 1 ♂, 1 juvenile, Veliki Mižuk Pit, Mokri Potok, 15 Dec. 2015, leg. T. Delić & S. Polak (IZB).

New data for *Haasia stenopodium* (Strasser, 1966)

CROATIA: 1 ♂, 2 ♀♀, Pepelarica Pit, Middle Velebit, 4 Jul. 2015, leg. G. Rnjak (CBSS); 1 ♂, 3 ♀♀, Meduza Pit, Crikvena, North Velebit National Park, 4 Aug. 2015, leg. B. Jalžić (CBSS).

SLOVENIA: 1 ♀, Velika Ledenica u Paradani Pit, Lokve, Batuje, Nova Gorica, 6 Apr. 2014, leg. T. Delić & Š. Borko (IZB); 1 ♂, same data except Jun. 2014, leg. Š. Borko (IZB); 2 ♂♂, 1 juvenile, Brezno Treh Src, Cifre, Snežnik, 12 Sep. 2015, leg. T. Delić (IZB); 1 ♂, 2 ♀♀, 2 juveniles, Brajnica Pit, Dobec, Bezuljak, 14 Nov. 2015, leg. T. Delić (IZB).

New data for *Macrochaetosoma bertisceae* Antić & Makarov, 2015

MONTENEGRO: 2 juveniles, Trzy Kopce Pit, Prokletije Mountains, 17 Jul. 2015, leg. M. Petković (IZB).

New data for *Macrochaetosoma troglomontanum* Absolon & Lang, 1933

CROATIA: 1 ♂, 4 juveniles, Jama pod Gažnovcem Pit, Stilja, Vrgorac, 3 Aug. 2014, leg. T. Rađa (IZB); 3 juveniles, Martina Jama Pit, Stilja, Vrgorac, 9 Aug. 2015, leg. T. Rađa (IZB).

MONTENEGRO: 1 ♀, Jama u Dubokomdolu Pit, Njeguši, no dates or leg. (IZB); 2 ♀♀, Ericova Jama Pit, Krivošije Mt., Crkvice, 20 Sep, 2006, leg. M. Perreau (IZB); 1 ♀, Opasna Jama Pit, Kučka Korita, 21 Jun. 2015, leg. M. Petković (IZB).

Notes on the distribution of the *Macrochaetosomatinae*

In a recent review of the family Anthogonidae, Antić *et al.* (2015) in their key to the anthogonid genera stated that the genus *Macrochaetosoma* Absolon & Lang, 1933 is distributed in Croatia, Bosnia and Herzegovina, Montenegro and Serbia (?). In writing that review, we unfortunately overlooked a paper mentioning *M. troglomontanum* from caves in Albania (Stoev 2001).

Discussion

In their review of the family Anthogonidae Antić *et al.* (2015) recognized three subfamilies viz., Anthogoninae, Acherosomatinae and Macrochaetosomatinae, with 30 species. To the family Anthogonidae, we now add one more subfamily, Biokoviellinae, with two species.

As stated earlier, Mršić established a new monotypic family, Biokoviellidae, based on specimens from caves on Mt. Biokovo, even though he acknowledged some similarities with the families Anthogonidae and Chamaesomatidae. After examining the topotype male of *B. mauriesi* and specimens of *B. mosorensis* sp. nov., we recognized some mistakes in the descriptions of *Biokoviella* and found enough evidence to support inclusion of this genus in the family Anthogonidae and consequently synonymization of the family Biokoviellidae with the family Anthogonidae. On the other hand, new observation on the posterior gonopods show clear differences of the genus *Biokoviella* from all other anthogonid genera and supports recognition of the Biokoviellinae as a fourth subfamily within the family Anthogonidae.

According to Antić *et al.* (2015), the main taxonomic character of the family Anthogonidae is the presence of bristle apparatuses, a bristle-clad pseudoflagellum and several pseudoflagella on coxites of the anterior gonopods. These characters (bristle apparatuses and bristle-clad pseudoflagellum) can be seen in the genus *Biokoviella*. In his paper from 1992, Mršić mentioned the presence of bristled oval inner processes at the base of the posterior part of the anterior coxal processes and listed these structures as one of the similarities with the subfamily Acherosomatinae (Haasiinae *sensu* Mršić 1992). Such structures indeed exist in both *Biokoviella* species and are much hairier than in Mršić's drawing (see Mršić 1992: 57, fig. 2), especially in the new species (Fig. 7). These structures are very similar to, and definitely homologous with bristle apparatuses in the subfamily Macrochaetosomatinae, being placed in both taxa in the base of the posterior part of the anterior coxal processes (see Antić *et al.* 2015: figs 56–66, 76, 79, 84). Also, well-developed and high anterior coxal processes are present in some representatives of the subfamily Anthogoninae and especially the subfamily Acherosomatinae.

According to Mršić (1992), the presence of bristle-clad pseudoflagella in *Biokoviella* links it with the subfamily Scutogoninae (fam. Chamaesomatidae). One of the main characters of Scutogoninae is the presence of a single pair of flagella on the posterior side of the anterior gonopods. Such

flagella in Scutogoninae are very different from the bristle-clad pseudoflagella in *Biokoviella*. It is therefore unnecessary to comment on the possibility of including the genus *Biokoviella* in the family Chamaesomatidae. Thus, *Biokoviella* cannot be linked with scutogonins. On the other hand, more similar, but still different, bristle-clad pseudoflagella are present in some Anthogoninae [*Escualdosoma gorbaultae* (Mauriès, 1965) and *Vascanthogona vicenteae* Mauriès & Barraqueta, 1985]. After examining the topotype male of *B. mauriesi* and a male from another locality, we found some differences compared to the drawing by Mršić (1992), who presented these pseudoflagella as mascara brush (see Mršić 1992: 57, fig. 2), i.e., one rod with a bristle on the top. Our examination shows that these pseudoflagella are indeed equipped with bristles on the top, in the form of a tassel not a brush, but also with hairs over their entire length (Fig. 2E). On the other hand, in the new species, pseudoflagella are equipped with an apical tassel only.

The only unpaired structure on the anterior gonopods actually is not a bridge between the posterior coxal processes, but a rounded syncoxal vesicle, cited by Mršić (1992) as a “small intermediate bridge or little intermediate (medial) bridge (brace)”. This vesicle starts from the base of the anterior gonopods, between the coxal processes. Clear evidence that this structure represents a vesicular structure is presented on the SEM photographs, where the vesicle in question is obviously deflated (Figs 2A, C–E, 6B–C, 6E) in contrast to anterior gonopods *in situ*, where the structure has globular shape (Fig. 7A–D, or see Mršić 1992: 57, fig. 2G). Such structures are also present in some other anthogonids and are especially developed in both species of *Egonpretneria* Strasser, 1966 (see Antić *et al.* 2015: 156, figs 12 and 16, sco; and Mršić 1992: 72, figs 2 and 7B). This structure probably represents fused coxal vesicles. On the other hand, in Macrochaetosomatinae coxal vesicles on the anterior gonopods are not fused but paired, and they are situated on the posterior part of those gonopods (see Antić *et al.* 2015: 167, fig. 60, cv; 172, figs 79 and 84, cv).

The similarity between the genus *Biokoviella* and Anthogonidae that Mršić (1992) saw also applied to the posterior gonopods. It is probable that he had in mind similarity of the medial process on the posterior gonopods. He stated that the posterior gonopods “[...] are merely sternite remnants, with no coxal part at all” and that “In the middle the medial sternite process is situated”. The medial process of the posterior gonopods in the subfamilies Acherosomatinae and Macrochaetosomatinae is indeed of sternal origin (see Antić *et al.* 2015). As a result of examining the posterior gonopods of both *Biokoviella* species under a scanning electron microscope, we think that Mršić was wrong when he wrote that the medial process of the posterior gonopods is of sternal origin. To judge from the SEM and light microscope photos (Figs 2C–D, 5F, 6F, 9), it seems that this medial process is actually of coxal rather than sternal origin and probably represents partly fused coxal vesicles, but completely without the lateral coxal processes seen in other anthogonids. Also, one more point about structure of the posterior gonopods was omitted by Mršić. These are telopodal remnants located lateral to the medial process in both species (Fig. 9, *t*). Within the Anthogonidae, telopodal remnants are present in only two representatives of the Macrochaetosomatinae, and they are situated on the very robust lateral coxal processes (see Antić *et al.* 2015: 172, figs 77–78, 82–83). Generally, the posterior gonopods of biokoviellines are very reduced in size in comparison to the anterior gonopods or posterior gonopods of other anthogonids.

All the above-mentioned similarities between the genus *Biokoviella* and some representatives of Anthogonidae with respect to structure of the anterior gonopods argue in favor of including it in the indicated family, but on the other hand, structure of the posterior gonopods clearly separates the genus from all other anthogonids. We therefore think that inclusion of the subfamily Biokoviellinae as a member of Anthogonidae is justified.

Apart from features of the anterior and posterior gonopods, one more sexual character should be discussed. This character relates to the structure of leg pairs 3–7 in males. Mršić (1992: 54) stated that

these pairs of legs “[...] are equipped with tarsal papillae”. He probably had in mind the tarsal papillae present in some chordeumatidans. In examining these pairs of legs in our specimens of both *B. mauriesi* and *B. mosorensis* sp. nov., we could not find any traces of tarsal papillae. Inasmuch as Mršić (1992) in the same paper dealt with the family Heterolatzeliidae, a small Dinaric group with tarsal papillae on leg pairs 3–7 in males, it seems likely that he may have accidentally mixed up the legs from specimens of these two groups. The absence of tarsal papillae in *Biokoviella* is one more reason for inclusion of this genus in the family Anthogonidae.

The family Anthogonidae now includes four subfamilies: Anthogoninae, Acherosomatinae, Biokoviellinae and Macrochaetosomatinae. All of these subfamilies are characterized by the presence of bristle apparatuses and/or bristle-clad pseudoflagella as parts of the anterior gonopods. On the other hand, they all possess some apomorphies that separate them from each other, and they would surely be recognized as separate families by some diplopodologist, a viewpoint to which we do not have any major objections. But in our opinion, it is better for now to leave four subfamilies within Anthogonidae and gradually reduce, if possible, the number of families within the extremely chaotic order Chordeumatida.

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References

- Antić D., Dražina T., Rađa T., Tomić V.T. & Makarov S.E. 2015. Review of the family Anthogonidae (Diplopoda, Chordeumatida), with descriptions of three new species from the Balkan Peninsula. *Zootaxa* 3948 (2): 151–181. <http://dx.doi.org/10.11646/zootaxa.3948.2.1>
- Bedek J., Gottstein Matočec S., Jalžić B., Ozimec R. & Štamol V. 2006. Type locality catalogue of subterranean fauna in Croatia. *Natura Croatica* 15 (S1): 1–154.
- Bedek J., Taiti S. & Gottstein S. 2011. Catalogue and atlas of cave-dwelling terrestrial isopods (Crustacea: Oniscidea) from Croatia. *Natura Croatica* 20 (2): 237–354.
- Enghoff H., Golovatch S., Short M., Stoev P. & Wesener T. 2015. Diplopoda – Taxonomic overview. In: Minelli A. (ed.) *The Myriapoda. Vol. 2. Treatise on Zoology – Anatomy, Taxonomy, Biology*: 363–447. Brill, Leiden. http://dx.doi.org/10.1163/9789004188273_017

- Girometta U. 1914. Prilog poznavanju troglobijske i troglofilne faune Dalmacije uz geomorfološke bilješke o istraženim špiljama i jamama. Fauna Cavernarum Dalmatiae. *Program Velike gimnazije u Spljetu za školsku godinu 1913/1914*: 3–16.
- Hoffman R.L. 1980. *Classification of the Diplopoda*. Muséum d'Histoire Naturelle, Genève.
- Jalžić B., Bedek J., Bilandžija H., Bregović P., Čuković T., Čukušić A., Cvitanović H., Dražina T., Đud L., Gottstein S., Hmura D., Kljaković Gašpić F., Komerički A., Kutleša P., Lukić M., Malenica M., Miculinić K., Ozimec R., Pavlek M., Raguž N., Slapnik R. & Štamol V. 2013. *The Cave Type Localities Atlas of Croatian Fauna*. Volume 2. Croatian Biospeleological Society, Zagreb.
- Jalžić B., Pavićević D., Nonveiller G. & Rađa T. 1990. Novi podaci o špiljskim kornjašima (Insecta, Coleoptera) planine Mosor (Hrvatska). *Speleologia Croatica* 1: 31–34.
- Makarov S.E., Čurčić B.P.M., Tomić V.T., Rađa T., Rađa B., Čurčić S.B., Mitić B.M. & Lučić L.R. 2011. Revision of the family Heterolatzeliidae (Diplopoda, Chordeumatida). *Zootaxa* 2994: 33–44.
- Mauriès J.-P. 1982. Une famille nouvelle et deux genres nouveaux de Cleidogonoidea, avec notes sur la classification de la superfamille (Diplopoda, Craspedosomida). *Steenstrupia* 8 (6): 165–176.
- Mauriès J.-P. 1986. Un diplopode cavernicole relictuel des Alpes calcaires suisses: *Niphatrogleuma wildbergeri* n.g., n.sp. (Craspedosomida, Cleidogonoidea). *Revue Suisse de Zoologie* 93 (1): 249–256. Available from <http://biodiversitylibrary.org/page/41278560> [accessed on 12 May 2016]
- Mauriès J.-P. 1988. Un diplopode cavernicole cryophile relictuel du karst d'altitude des Pyrénées Centrales: *Marboreuma brouquissei* n.g., n.sp. (Craspedosomida, Cleidogonoidea). *Bulletin de la Société d'Histoire naturelle de Toulouse* 124: 29–34.
- Mršić N. 1992. *Biokoviella mauriesi* gen. nov., sp. nov. (Biokoviellidae fam. nov.), Macrochaetosomatinae subf. nov. (Anthogonidae) and superfamily Cleidogonoidea of the western Balkans (Craspedosomidea, Diplopoda). *Razprave IV. Razreda SAZU* 33 (3): 51–91.
- Mršić N. 1994. The Diplopoda (Myriapoda) of Croatia. Dvojnoge (Diplopoda: Myriapoda) Hrvatske. *Razprave IV. Razreda SAZU* 35 (12): 219–296.
- Pretner E. 1973. Koleopterološka fauna pećina i jama Hrvatske. *Krš Jugoslavije* 8: 101–239.
- Shear W.A. 2000. On the milliped family Heterochordeumatidae, with comments on the higher classification of the order Chordeumatida (Diplopoda). *Invertebrate Taxonomy* 14 (3): 363–376. <http://dx.doi.org/10.1071/IT99016>
- Shear W.A. 2011. Class Diplopoda de Blainville in Gervais, 1844. In: Zhang Z.-Q. (ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa* 3148: 159–164.
- Shelley R.M. 2002. A revised, annotated, family-level classification of the Diplopoda. *Arthropoda Selecta* 11: 187–207.
- Shelley R.M., Sierwald P., Kiser S.B. & Golovatch S.I. 2000. *Nomenclator generum et familiarum Diplopodorum II. A list of the genus and family-group names in the class Diplopoda from 1958 through 1999*. Pensoft Publishers, Sofia.
- Spelda J. 2001. Review of the millipede genus *Pterygophorosoma* Verhoeff, 1897 (Diplopoda, Chordeumatida, Craspedosomatidae). *Andrias* 15: 29–48.
- Stoev P. 2001. On two myriapods (Chilopoda, Diplopoda) new to the fauna of Albania. *Historia naturalis bulgarica* 13: 109–110. Available from <http://biodiversitylibrary.org/page/31191306> [accessed on 12 May 2016]

Verhoeff K. 1899. Beiträge zur Kenntniss paläarktischer Myriopoden. VIII. *Archiv für Naturgeschichte* 65: 95–154. Available from <http://biodiversitylibrary.org/page/15114916> [accessed 8 Jun. 2016]

Verhoeff K. 1930. Arthropoden aus südostalpinen Höhlen gesammelt von Karl Strasser. 3. Aufsatz: *Atherosoma* und seine verwandtschaftlichen Beziehungen. *Mitteilungen über Höhlen- und Karstforschung* 1: 1–12.

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