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Original paper

Cornogonopus – a new monotypic cave-dwelling genus of the family Anthroleucosomatidae (Diplopoda, Chordeumatida) from Serbia, Balkan Peninsula

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Summary. This paper presents a description of a new monotypic genus of the family Anthroleucosomatidae – *Cornogonopus pavicevici* gen. nov., sp. nov. – from a cave in eastern Serbia. This new genus is the tenth of the *"Bulgarosoma"* complex of genera. The new species is illustrated with micrographs, SEM photographs, drawings, as well as *in situ* photographs. Further, an identification key to all 10 genera of this complex is provided and the structure of the posterior and anterior gonopods is briefly discussed. The geographical distribution of all genera is presented, with a distribution map attached.

Key words: *"Bulgarosoma"* complex, endemic, identification key, millipedes, troglomorphic.

INTRODUCTION

In recent years, it has been noted that the family Anthroleucosomatidae is one of the most heterogeneous families in the very chaotic order Chordeumatida (Shear and Leonard 2004; Ćurčić et al. 2007, 2008; Makarov et al. 2012; Antić et al. 2014). From the moment it was established until today, the family has had a turbulent history marked by additions, evictions and overflowing taxa. Based on previous treatments of this group (see Ćurčić et al. 2007, 2008; Makarov et al. 2012; Antić and Makarov 2016), Antić (2017) and Antić and Makarov (2017) made the latest attempts to reorganize genera within this family. According to these authors, today the family Anthroleucosomatidae includes 84 species and 35 genera, grouped in 12 complexes of genera, of which almost half consist of only one genus. The genera *Bulgardicus* Strasser, 1960, *Camptogona* Brolemann, 1935 and *Ghilarovia* Gulička, 1972 were excluded from Anthroleucosomatidae and now represent "floating" genera without family assignment (Antić 2017; Antić and Makarov 2017). Considering the current classification, the family Anthroleucosomatidae presents a disjunct Holarctic distribution, with the largest number of representatives in the Palearctic, especially in the Western Palearctic, whereas only one suspicious representative – *Leschius mcallisteri* Shear & Leonard, 2004 – is known from the Nearctic region. In terms of the number of taxa, it is clear that the Balkan Peninsula and the Caucasus *sensu lato* are centers of diversity for this family (Makarov et al. 2012; Antić and Makarov 2016). According to Antić (2017), eight of the 12 recognized complexes of genera are endemic to the Caucasus region (see also Antić and Makarov 2016), two are endemic to the Balkan Peninsula, and one monotypic

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complex is native to North America, while the predominantly northern Mediterranean "*Anamastigona*" complex has a somewhat wider distribution, with one representative anthropogenically widespread in the western parts of Europe.

As far as the Balkan Peninsula is concerned, in addition to the "*Anamastigona*" complex, this region is inhabited by two endemic complexes of genera, viz., the "*Anthroleucosoma*" complex (three genera) and the "*Bulgarosoma*" complex (nine genera) (Antić 2017; Antić and Makarov 2017). Of special interest is the "*Bulgarosoma*" complex, whose representatives are characterized by a strongly developed and posteriorly placed medial syncolpocoxite (mentioned as syncoxite in previous papers) of the anterior gonopods, an apomorphic character within the family Anthroleucosomatidae. Because of this unique structure, it has been repeated several times that these genera deserve a suprageneric rank within Chordeumatida (Ćurčić et al. 2007, 2008; Makarov et al. 2012). However, no new family has ever been formally established, nor will be in this paper, until a combination of morphology and molecular analyses show us whether this is true or not. The genera of this complex can be biogeographically divided into two groups, the Carpatho-Balkan and the Rhodopian elements.

In the present study, we describe a new monotypic genus *Cornogonopus* gen. nov., the tenth of the "*Bulgarosoma*" complex. The new genus nicely fits the distribution pattern of the "*Bulgarosoma*" complex in the Carpatho-Balkanids.

MATERIAL AND METHODS

Specimens preserved in 70% and 96% ethanol were examined with a Nikon SMZ 745T binocular stereo microscope. All taxonomically important structures were dissected and mounted in glycerine as temporary microscope preparations and observed with a Carl Zeiss Axioscope 40 microscope. Pictures of the specimens and legs were taken using a Nikon DS-Fi2 camera with a Nikon DS-L3 camera controller attached to a Nikon SMZ 1270 binocular stereo microscope and stacked with a Zerene Stacker. Line drawings of the gonopods and vulva were obtained using tracing paper placed on a computer monitor displaying pictures of those structures made with a Canon PowerShot A80 digital camera connected to a Carl Zeiss Axioscope 40 microscope and stacked with a Zerene Stacker. Pictures of specimens *in situ* and the type locality were made using a Canon PowerShot SX530 HS digital camera. Some relevant structures were investigated with a JEOL JSM-6460LV scanning electron microscope (SEM) using Secondary Electron Imaging (SEI) and Backscattered Electron Imaging (BEI) (University Center for Electron Microscopy, Department of Biology and Ecology, University of Novi Sad, Serbia). The distribution map was created using Google Earth Pro (version 7.3.0.3832) and Adobe Photoshop CS6. The final images were processed with Adobe Photoshop CS6.

The type material is deposited in the Institute of Zoology, University of Belgrade – Faculty of Biology (IZB).

The terminology used in the present study mainly follows Antić et al. (2014) with some modifications. For the lateral parts of the anterior gonopods, we use the term angiocoxite, as we are of the opinion of Shear (2000) that in most chordeumatidans the anterior gonopods are of coxal or even partly of sternal origin. The term syncoxite, which is quite often used in previous reports (e.g. Antić et al. 2014; Ćurčić et al. 2008; Makarov et al. 2012), is replaced here by the term syncolpocoxite as stated in Bachvarova et al. (2017).

Abbreviations used to denote particular structures of the gonopods are explained directly in the description and figure legends. Abbreviations on the map are as follows: BG – Bulgaria, RO – Romania, RS – Serbia.

RESULTS

Taxonomy

Class Diplopoda Blainville-Gervais, 1844
Order Chordeumatida Koch, 1847
Suborder Craspedosomatidea Cook, 1895
Superfamily Anthroleucosomatoidea Verhoeff, 1899
Family Anthroleucosomatidae Verhoeff, 1899

Genus *Cornogonopus* Antić, gen. nov.

Diagnosis. A member of the "*Bulgarosoma*" complex (complex characterized by the presence of strongly developed, posterior, medial syncolpocoxite of the anterior gonopods). The new genus differs from all other genera of this complex by the shape of the syncolpocoxite of the anterior gonopods characterized by a medial, lanceolate process with spine-like outgrows and two lateral, lamellar processes strongly curved anteriad, and by the presence of well-developed posterior horns on the angiocoxites of the posterior gonopods (vs. the absence of such horns in all other genera of the "*Bulgarosoma*" complex).

Etymology. The new genus is named to emphasize the presence of well-developed posterior horns (cornu=horn) on the angiocoxites of the posterior gonopods, as a unique character in the "*Bulgarosoma*" complex. The name is a masculine noun.

Description. See below.

Type species. *Cornogonopus pavicevici* gen. et sp. nov., by present designation and monotypy.

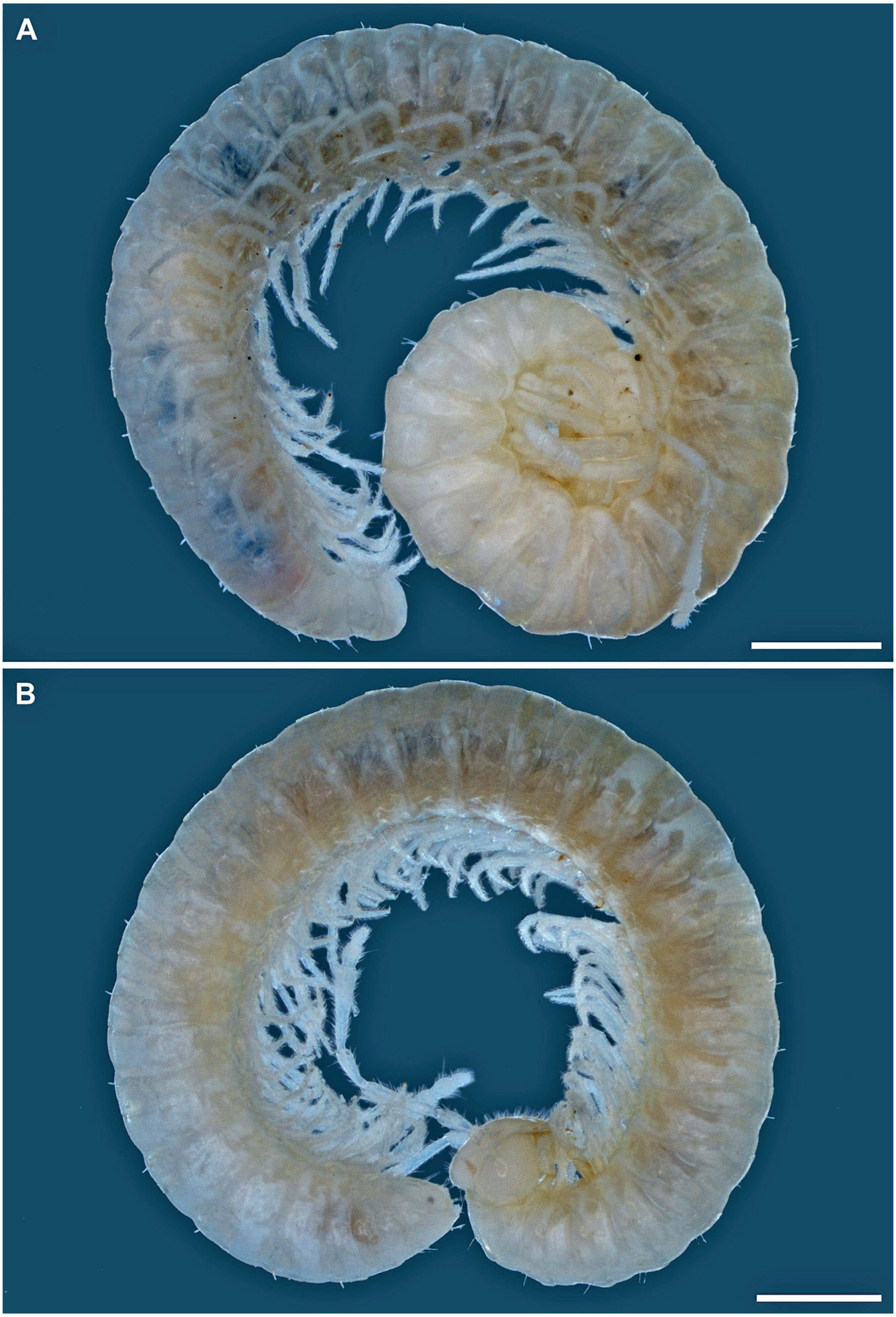

Fig. 1. *Cornogonopus pavicevici* gen. nov., sp. nov., habitus, lateral view. **A,** holotype male; **B,** paratype female. (Scale bars: 1 mm.)

Cornogonopus pavicevici **Antić, gen. et sp. nov.**

Figs 1–9

Diagnosis. As for the genus.

Etymology. The new species is named in honour of colleague and friend Dragan Pavićević (Belgrade), a well-known Serbian coleopterologist and biospeleologist, who was the first to discover this taxon in Ceremošnja cave. In addition to this, Dragan discovered numerous other interesting or new taxa of millipedes throughout the Balkans. Noun in the genitive case.

Material examined

Holotype ♂ (IZB) – Serbia, Ceremošnja Cave (44.38° N, 21.63° E), village of Ceremošnja, near Kučevo, Homoljske Planine Mts., 29.05.2019, leg. D. Antić.

Paratypes (IZB): 1 ♀, 1 juvenile, same data as for holotype; 2 ♂♂, 8 juveniles, same locality, 11.04.2019, leg. D. Antić & D. Stojanović; 1 ♀, same locality, 15.08.1998, leg. D. Pavićević.

Description. Body in adults with 30 segments (including telson).

Measurements. Holotype male 15.5 mm long, vertical diameter of the largest pleurotergite 1.1 mm. Paratype males 15 and 15.5 mm long, vertical diameter of the largest pleurotergite 1 and 1.1 mm, respectively. Paratype females 12 and 14 mm long, vertical diameter of the largest pleurotergite 0.9 and 1.1 mm, respectively.

Coloration (Figs 1, 8B–C). Depigmented, live animals yellowish-white.

Head (Fig. 2A–D). Setose, frontal side slightly concave in males, with a transverse supralabral ridge and longitudinal, dorsal bulge; convex in females. Labrum with three medial teeth in paratype male, with 5+5 labral and 2+2 supralabral setae (Fig. 2C). Promentum triangular, with one seta in paratype male. Lingual plates (paratype male) with 5+4 setae arranged in one row. Stipites each with 15 setae. Antennae elongated, slender, 2.5 mm long in holotype male. Length of antennomeres (in mm): I (0.16), II (0.29), III (0.65), IV (0.32), V (0.69), VI (0.19), VII (0.17) and VIII (0.03). Length/breadth ratios of antennomeres I–VII: I (1.5), II (2), III (6), IV (2.5), V (4.3), VI (1.3) and VII (1.5). Antennomeres II, IV, V, VI and VII with one, three, one, four and one sensillum trichodea, respectively. Lateral to antennal sockets a group of papilla-like outgrowths present. Number of light-brown ommatidia 15 in paratype male, arranged in an elongated group (Fig. 2B, D).

Collum. Narrower than head, with six macrochaetae. Anterior edge semi-circular, posterior margin gently concave.

Body segments (Figs 2E–F, 8B–C). Paraterga more developed in males than in females; pronounced on the first third of the body, after that gradually becoming smaller. Prozonites with hexagonal tiles. Metazonites with scale-like structures. Dorso-medial and dorso-mediolateral areas of metazonites smooth. Macrochaetae longer and trichoid on the anterior pleurotergites and telson, rest of pleurotergites with rather short and bacilliform macrochaetae. CIX (macrochaetal index) (pleurotergite 15) i.e., (distance between exterior and median macrochaetae)/(distance between interior and median macrochaetae) = 0.7; MIX (median index) (pleurotergite 15) i.e., (distance between interior macrochaetae and axial suture)/(distance between interior and median macrochaetae) ~ 1.3; PIX (paratergal index) (pleurotergite 15) i.e., (width of metazonite - width of prozonite)/(2 x length of paratergum) = 0.6; MA (macrochaetal angle) (pleurotergite 15) i.e., (angle between the arm created by the median and exterior macrochaetae and the arm formed by the median and interior macrochaetae) ~ 100°.

Telson. Epiproct with a pair of spinnerets and 3+3 setae (1+1 paramedian, 2+2 marginal). Hypoproct semicircular with 1+1 apical setae. Paraprocts with 3+3 marginal setae.

Leg-pairs 1 and 2 (Figs 3A–B, 6A). In both sexes with tarsal combs; prefemora with several long and robust setae; femora and postfemora each with several long and robust setae arranged in a group.

Male sexual characters (Figs 2G–K, 3). Leg-pair 2 with genital openings on coxae (Fig. 3B). Leg-pairs 3–7 strongly incrassate. Leg-pairs 3 and 4 each with a basal, exterior protrusion on prefemur and femur (Fig. 3C–D). Leg-pair 4 with a small posteroventral protrusion on postfemur, tibia and tarsus (Fig. 3D). Leg-pair 5 with a well-developed anterobasal protrusion on prefemur and a small ventral protrusion on tibia and tarsus; tarsus curved, almost C-shaped with a rounded apex (Fig. 3E–F). Leg-pair 6 with C-shaped tarsus with extended apex (Fig. 3G). Leg-pair 7 with a posteromesal protrusion on coxa covered by several setae; lateral to protrusion one long seta present; tarsus elongated, with extended distal half (Fig. 3H). Leg-pair 10 and 11 both with a coxal sac (Fig. 3I–J); additionally leg-pair 11 with a prominent, posterior coxal horn (Fig. 3J). Leg-pair 13 with enlarged coxa, with ventral concavity; trochanter pronounced (Fig. 2I–K). Leg-pair 15 with a similar coxa, but smaller compared to leg-pair 13. Until midbody, each odd-numbered coxa slightly enlarged compared to the preceding even-numbered one; this difference becomes insignificant or absent towards the end of the body. From sternum 12, this structure is characterized by the presence of an anteromedial, laterally flattened bulge (Fig. 2G–J, white arrows).

Anterior gonopods (Figs 4A–E, 5A–F). Sternum (st) wide, anteriorly with a pair of sternal lobes (sl). Syncolpocoxite (s) more or less bottle-shaped; posterodistally with a me-

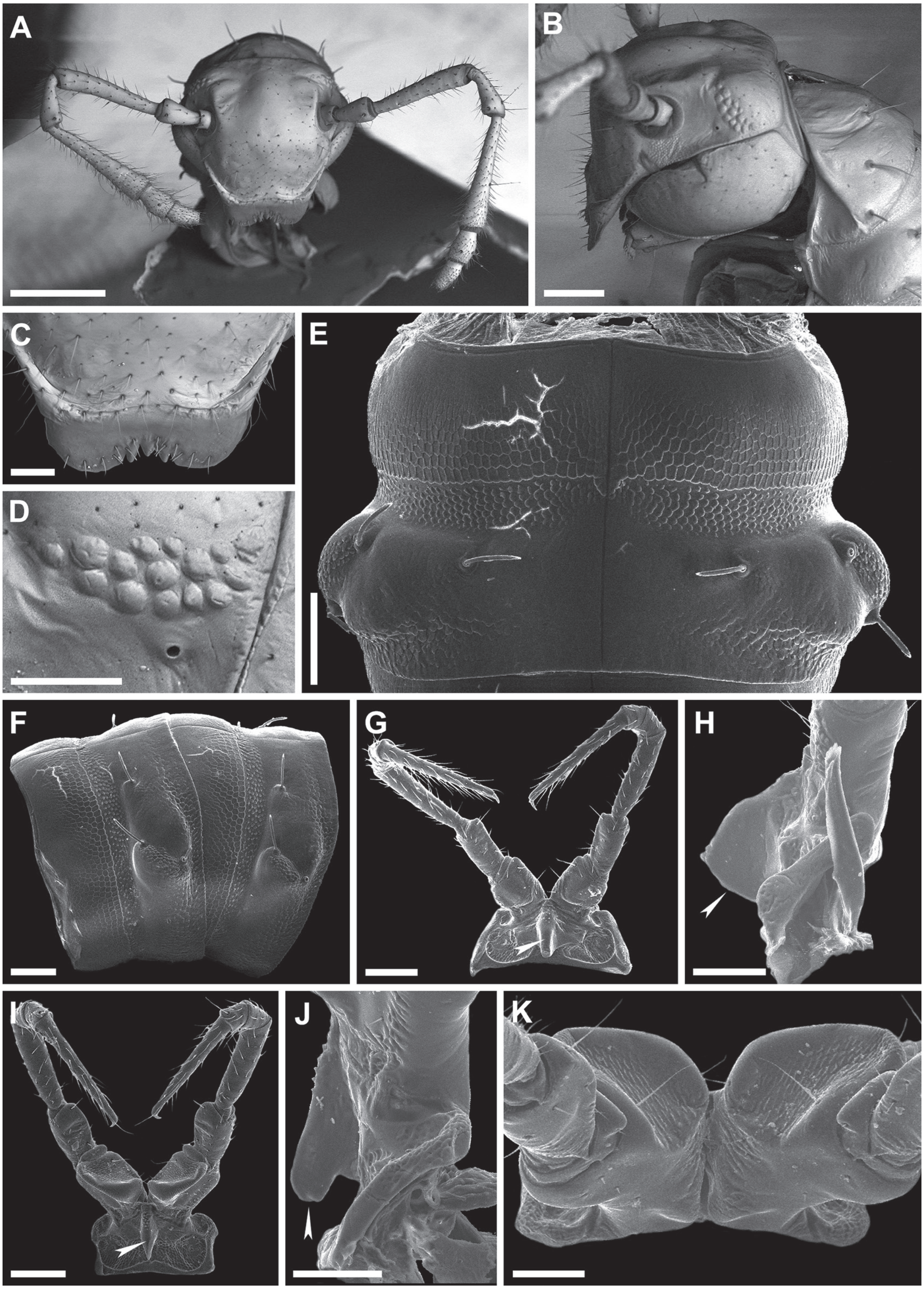

Fig. 2. *Cornogonopus pavicevici* gen. nov., sp. nov., paratype male. **A,** head, anterior view; **B,** head, lateral view; **C,** labrum, anterior view; **D,** ommatidia, lateral view; **E,** pleurotergite 15, dorsal view; **F,** pleurotergites 15 and 16, lateral view; **G,** leg-pair 12, anterior view; **H,** sternum 12, lateral view; **I**, leg-pair 13, anterior view; **J,** sternum 13, lateral view; **K,** leg-pair 13, coxa, trochanter and prefemur, distal view. White arrows indicate the anteromedial, sternal bulge on sterna 12 and 13. (Scale bars: A = 0.5 mm; B, E, F, I = 0.2 mm; C, D, H, J = 0.1 mm.)

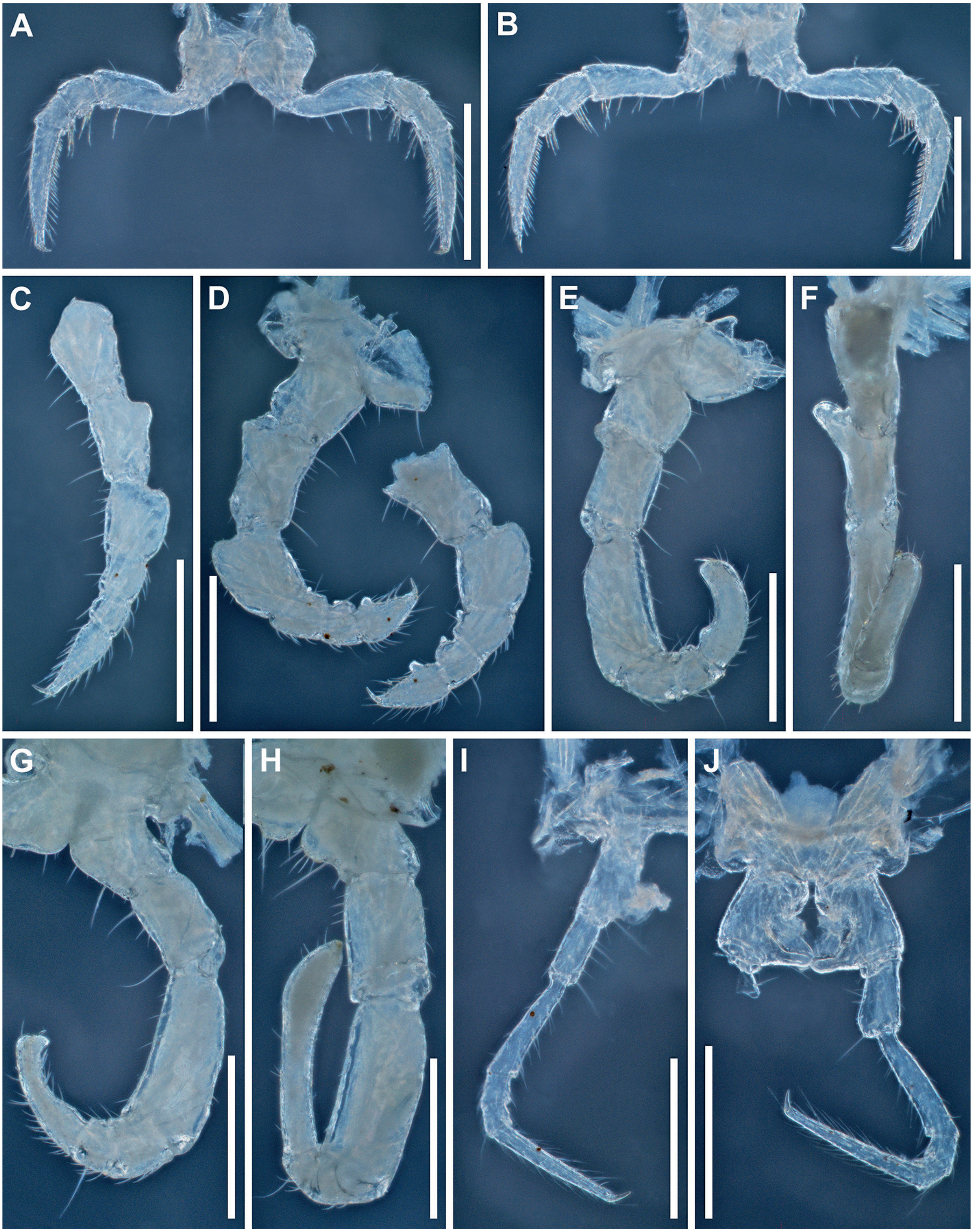

Fig. 3. *Cornogonopus pavicevici* gen. nov., sp. nov., paratype male legs. **A,** leg-pair 1, anterior view; **B,** leg-pair 2, posterior view; **C,** left leg 3, anterior view; **D,** leg-pair 4, anterior view; **E,** right leg 5, anterior view; **F,** right leg 5, mesal view; **G,** left leg 6, anterior view; **H,** right leg 7, posterior view; **I,** right leg 10, anterior view; **J,** leg-pair 11, posterior view (left telopodite broken). (Scale bars: 0.5 mm.)

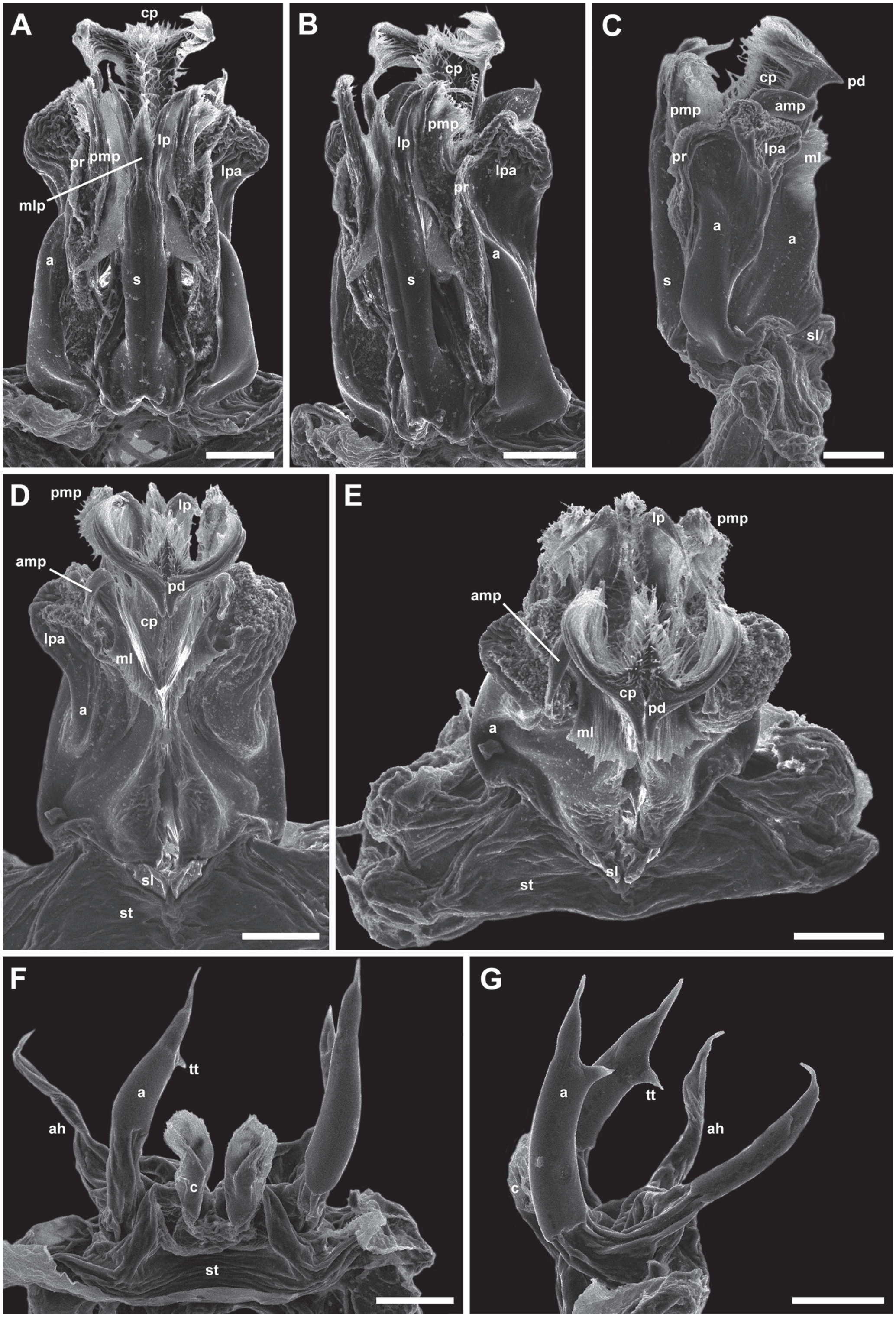

Fig. 4. *Cornogonopus pavicevici* gen. nov., sp. nov., paratype male, gonopods (partially deformed during SEM preparation). **A–E,** anterior gonopods; **F–G,** posterior gonopods. **A,** posterior view; **B,** posterolateral view; **C,** lateral view; **D,** anterior view; **E,** anterodistal view; **F,** anterior view; **G,** lateral view. Abbreviations: a: angiocoxite; ah: angiocoxal posterior horn; amp: anteromesal process; c: colpocoxite; cp: unpaired central process; lp: lateral lamellar process; lpa: lateral part of angiocoxite; ml: mesal lamella; mlp: medial lanceolate process; pd: paramedial denticles; pmp: posteromesal process; pr: posterior ridge; sl: sternal lobe; st: sternum; tt: triangular posterior tooth. (Scale bars: 0.1 mm.)

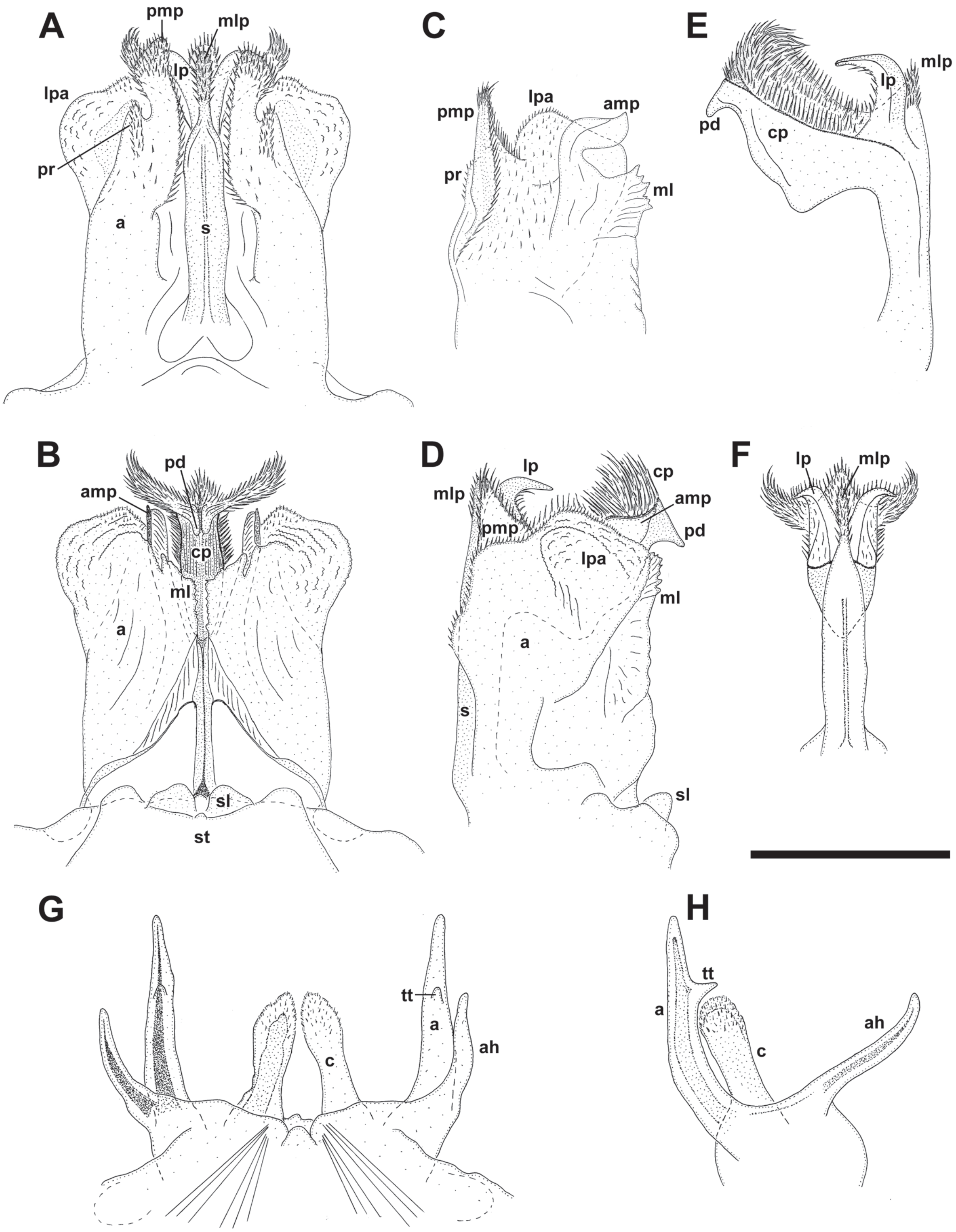

Fig. 5. *Cornogonopus pavicevici* gen. nov., sp. nov., paratype male, gonopods. **A–F**, anterior gonopods; **G–H**, posterior gonopods. **A,** posterior view; **B,** anterior view; **C,** angiocoxite, mesal view; **D,** lateral view; **E,** syncolpocoxite, lateral view; **F,** syncolpocoxite, posterior view; **G,** posterior view; **H,** lateral view. Abbreviations: a: angiocoxite; ah: angiocoxal posterior horn; amp: anteromesal process; c: colpocoxite; cp: unpaired central process; lp: lateral lamellar process; lpa: lateral part of angiocoxite; ml: mesal lamella; mlp: medial lanceolate process; pd: paramedial denticles; pmp: posteromesal process; pr: posterior ridge; sl: sternal lobe; st: sternum; tt: triangular posterior tooth. (Scale bars: 0.3 mm.)

dial, lanceolate process (mlp) covered by spine-like outgrows; laterally to medial process, lamellar processes (lp) present, both strongly bent anteriad, with a hair-like outgrowth on anterior margin. Anteriorly, syncolpocoxite with an unpaired central process (cp) with three horns (medial and two lateral) directed posterodistad and densely covered with hair-like outgrowths. The most anterior parts of the central process with paramedial denticles (pd), directed proximad, as mesal parts of lateral horns. The proximal part of the central process subtriangular in anterior view and with a strong, proximal bugle in lateral view. Medial anterior horn of central process and medial posterior process connected longitudinally with a ridge covered by hair-like outgrows. Lateral to syncolpocoxite, symmetrical angiocoxites (a) present. The last-mentioned structures robust, complex and lamellar. The most lateral parts (lpa) of angiocoxites swollen, laterodistally finely den-

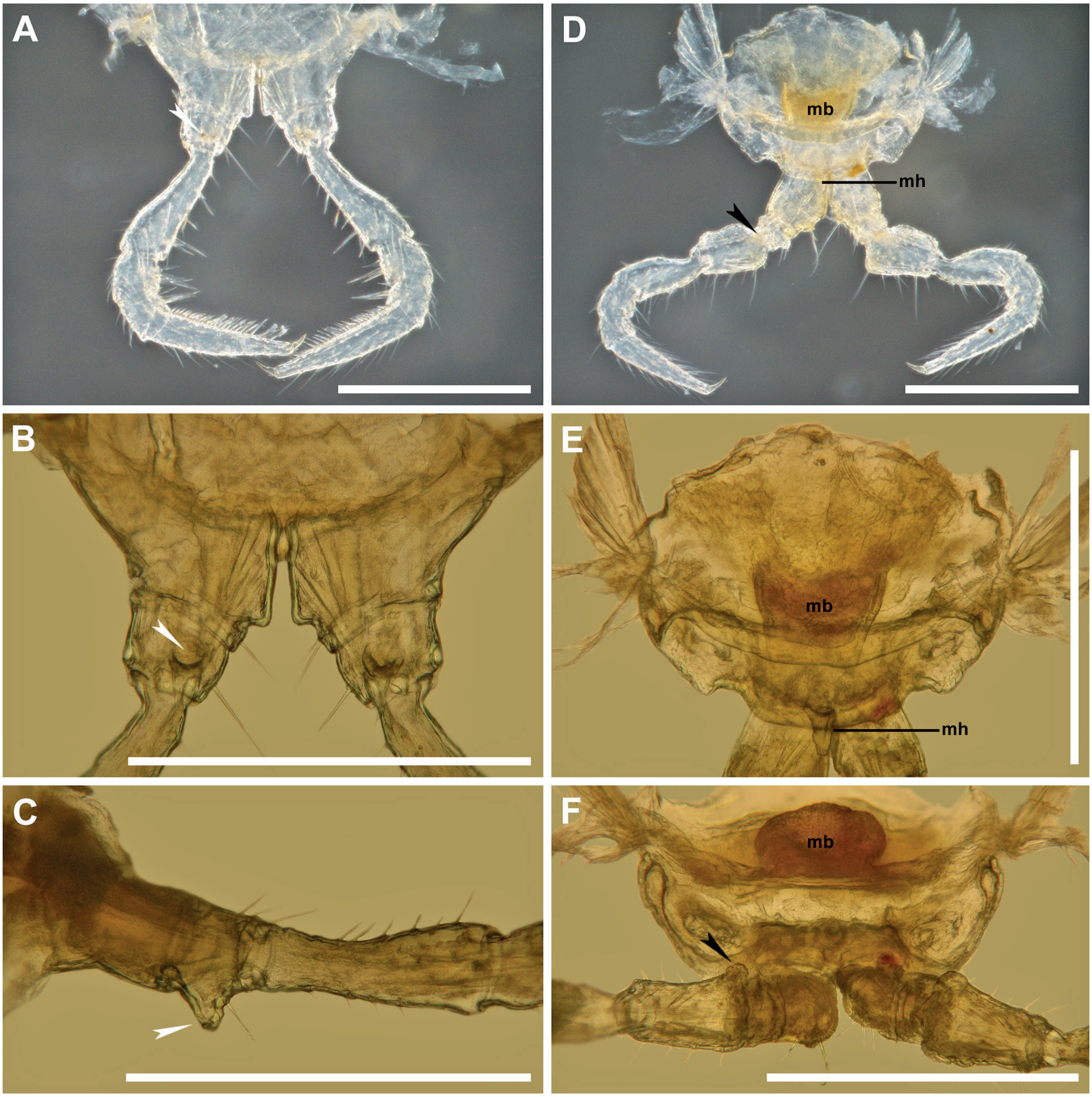

Fig. 6. *Cornogonopus pavicevici* gen. nov., sp. nov., paratype female. **A,** leg-pair 2, posterior view; **B,** leg-pair 2, sternum, coxa, trochanter and prefemur, posterior view; **C,** right leg 2, lateral view; **D,** leg-pair 3, anterior view; **E,** sternum 3 with wide anterior structure, anterior view; **F,** leg-pair 3 and wide anterior structure, distal view. Abbreviation: mb: medial bulge, mh: medial sternal horn. White arrows indicate the posterior protrusion on prefemur 2; black arrows indicate the tuberculate protrusion on prefemur 3. (Scale bars: 0.5 mm.)

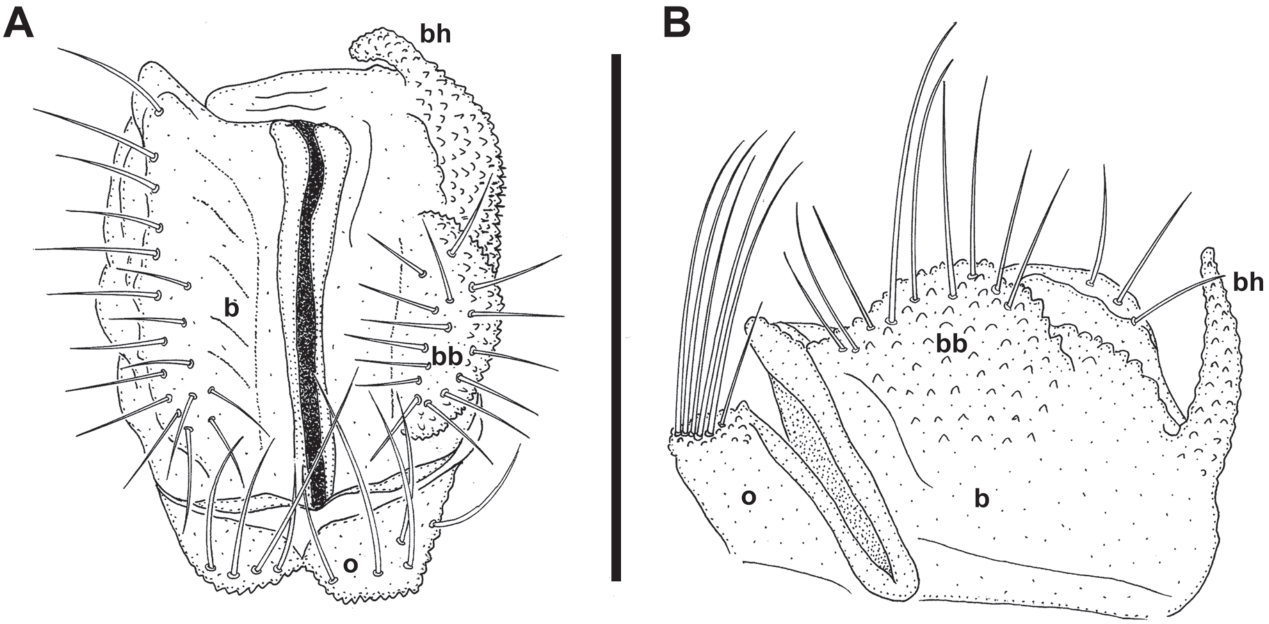

Fig. 7. *Cornogonopus pavicevici* gen. nov., sp. nov., paratype female, right vulva. **A,** distal view; **B,** lateral view. Abbreviation: b: bursa; bb: lateral bulge; bh: tuberculate horn; o: operculum. (Scale bar: 0.3 mm.)

ticulate, distally pilose, with finely serrated posterior ridge (pr). Anterior side of angiocoxite with mesal lamella (ml) completely fused with strongly curved anteromesal process (amp). Posterior side of angiocoxite with posteromesal process (pmp) densely covered by hair-like outgrowths on posteromesal and distal parts. Posterior mesal process triangular in lateral and mesal views and with an extended distal part in posterior view; fused with finely serrated posterior ridge.

Posterior gonopods (Figs 4F–G, 5G–H). Sternum (st) wide. Colpocoxites (c) lanceolate, apically pilose and hyaline. Angiocoxites (a) straight, parallel to each other; distal half with a short, triangular, posterior tooth (tt). Additionally, angiocoxites with a strongly developed horn (ah) directed posteriad, *in situ* these horns are placed on the lateral sides of coxae 10.

Female sexual characters (Fig. 6). Leg-pair 2 with the posterior protrusion on prefemur (Fig. 6A–C, white arrows). Leg-pair 3 with enlarged prefemur characterized by the presence of anterobasal, tuberculate protrusion (Fig. 6D, F, black arrow). Sternum 3 with a medial horn (mh). Anteriorly sternum 3 merged by a membrane with a wide structure characterized by a well-developed, medial bulge (mb) covered with papillae (Fig. 6D–F). From sternum 4, this structure is characterized by the presence of an anteriomedial, laterally flattened bulge.

Vulvae (Fig. 7). Operculum (o) bilobed, denticulate, with a few long setae on both lobes. Bursa (b) somewhat longer then wide; mesally with several ridges covered by long setae; laterally denticulate, with well-developed bulge (bb) covered by long setae; additionally lateral half with long, tuberculate, posterior horn (bh).

Type locality. The Ceremošnja cave (Fig. 8A) is a cave that is popular for tourists, which is located in the northwestern foothills of the Homoljske Planine Mts., in eastern Serbia, with 775 m of explored channels. This cave is an inflow type, characterized by three groups of galleries: dry, inflow and periodical. One of the most spectacular parts of the cave is its amphitheater hall, which is rich in various and beautiful speleotherms (Đurović 1998).

Type specimens of the new genus were collected by hand in the dark parts of the cave. During two fieldtrips to the cave in 2019, a total of three males and one female were collected, as well as nine juveniles, of which four were juvenile males. Although only four adult specimens were collected, a large number of juveniles were registered in almost all examined parts of the cave, which indicates that it there is a very stable and large population of this species in the Ceremošnja cave.

In addition to this new troglobiontic genus, a troglobiontic trechine ground beetle has recently been described from this cave – *Duvalius (Paraduvalius) ceremosnjensis* Pavićević and Ćurčić in Pavićević et al. (2018), which,

Figure 8. A, Entrance to the Ceremošnja cave; **B–C,** *Cornogonopus pavicevici* gen. nov., sp. nov. **B,** paratype male, dorsal view; **C,** holotype male, dorsal view. (photos: D. Antić).

like the new genus, is currently a stenoendemic of the Ceremošnja cave. During the first fieldtrip in 2019 D.A. and D.S. found one specimen of the cave-dwelling centipede *Lithobius lakatnicensis* Verhoeff, 1926, which is the northernmost record of this species.

Key to the genera of the "*Bulgarosoma*" complex based on male characters

(*Bulgarosoma superficiei* Strasser, 1975 is not included in the key under any genus, see below)

1. The frontal side of the head with a strongly developed process .... ***Bulgarosoma***
- The frontal side of the head without such a process, sometimes with a well-developed bulge **2**
2. Head with ommatidia **3**
- Head without ommatidia **7**
3. Angiocoxites of the posterior gonopods with numerous distal nipples **4**
- Angiocoxites of the posterior gonopods without nipples **5**
4. The frontal side of the head in the form of an enlarged bulge .... ***Banatosoma***
- The frontal side of the head not in the form of an enlarged bulge ....***Dazbogosoma***
5. Angiocoxites of the posterior gonopods sigmoid, without posterior subdistal teeth .... ***Belbogosoma***
- Angiocoxites of the posterior gonopods not sigmoid, with posterior subdistal teeth **6**
6. Angiocoxites of the posterior gonopods with strongly developed posterior horns. ***Cornogonopus* gen. nov.**
- Angiocoxites of the posterior gonopods without posterior horns .... ***Rhodoposoma***
7. Angiocoxites of the posterior gonopods without distal nipples .... ***Svarogosoma***
- Angiocoxites of the posterior gonopods with distal nipples **8**
8. Posterodistal part of syncolpocoxite branched **9**
- Posterodistal part of syncolpocoxite simple .... ***Troglodicus***
9. Posterodistal part of syncolpocoxite with hammer- or anchor-like tip, with two subapical lamellar processes .... ***Serbosoma***
- Posterodistal part of syncolpocoxite with a medial, finely serrated process and two long laterall processes .... ***Perunosoma***

DISCUSSION

Notes on the structures of the posterior and anterior gonopods of the "*Bulgarosoma*" complex

Based on the global anthroleucosomatid fauna, Ćurčić et al. (2008) recognized six complexes of genera within the family. Later, in a monographic study on Caucasian antroleucosomatids, Antić and Makarov (2016) listed eight endemic complexes of genera for this territory, including a rearrangement of some genera compared to Ćurčić et al. (2008). A year later, in his doctoral dissertation, Antić (2017) compiled all genera and identified a total of 12 complexes within Anthroleucosomatidae, as mentioned above. Of these 12 complexes, only four, including the "*Bulgarosoma*" complex, have representatives characterized by the absence of telopodites on the posterior gonopods. In addition to the "*Bulgarosoma*" complex, the complete absence of telopodites on the posterior gonopods characterizes the North American monotypic "*Leschius*" complex, the Caucasian monotypic "*Ratcheuma*" complex, as well as a few species of the "*Anamastigona*" complex.

The posterior gonopods of the "*Bulgarosoma*" complex appear very characteristic within the Anthroleucosomatidae. The ground plan of these structures in all genera of this complex is the same, but their appearance differs between them. The gonopods consist of laterally placed angiocoxites and mesally placed colpocoxites, without telopodites. However, for the species *Rhodoposoma rhodopinum* (Strasser, 1966), Strasser (1966: 21, fig. 20, te) cited the presence of pigmented granules on the posterior gonopods, as the last step in the reduction of telopodites. The same author stated the presence of reduced telopodites on posterior gonopods in the species *Bulgarosoma bureschi* Verhoeff, 1926 (Strasser 1962: 450, fig. 19, h) but Ćurčić et al. (2008) could not confirm this when they studied topotype males. However, Strasser (1962, 1966) could have been right in both cases. In fact, Antić and Makarov (2016: 54, fig. 41B, t; 95: fig. 77C, t) demonstrated the presence of a pigmented mass in some individuals of *Caucaseuma variabile* Antić and Makarov, 2016 and *Paranotosoma subrotundatum* Antić and Makarov, 2016, as a possible remnant of a telopodite, even on the anterior gonopods. Also, it was observed that in some species of Caucasian anthroleucosomatids, which are characterized by clearly visible telopodites on the posterior gonopods, these structures may be developed to varying degrees in individuals of the same population. Furthermore, in one topotype adult male of the Balkan *Dazbogosoma naissi* Makarov and Ćurčić in Makarov et al. (2012), from the "*Bulgarosoma*" complex, the posterior gonopods take the shape of normal, but smaller, walking legs, while the anterior gonopods are fully developed (Antić, personal observation). These isolated cases are most likely a consequence of atavism. This is illustrated here by the presence of remnants of telopodites in some individuals of a population in species, where these structures do not occur, indicating an ancestral state of that character. However, representatives of the "*Bulgarosoma*" complex should be treated as anthroleucosomatids lacking telopodites on the posterior gonopods, as an apomorphy. It is worth mentioning that four species of the genus *Anamastigona* Silvestri, 1898 (the "*Anamastigona*" complex), which were previously included in *Antrodicus* Gulička, 1967 and *Balkandicus* Strasser, 1960 have similarly built posterior gonopods. However, the lateral and mesal extensions are very slender and close to each other (especially the mesal processes) compared to the "*Bulgarosoma*" complex. Because of this, we have come to disagree with the opinion reported in Mauriès et al. (1997) that these four species belong to the genus *Anamastigona*. Instead, we propose that they actually belong to a separate genus (or two genera), but this will be considered in a separate paper.

Posterior gonopods can be of exceptional taxonomic value within the "*Bulgarosoma*" complex, both in recognizing genera and species within it. These differences are reflected mainly in the shape and structure of the angiocoxites. These structures may be straight, slightly curved mesad or laterad, strongly curved or sigmoid, with or without numerous outgrowths distally in the form of nipples. As far as the latter character is concerned, *Cornogonopus* gen. nov. belongs to the group characterized by the absence of distal nipples on the angioxocites. Such a condition can be also seen in *Belbogosoma* Ćurčić and Makarov in Ćurčić et al. (2008), *Rhodoposoma* Ćurčić and Makarov, 2000 and *Svarogosoma* Makarov in Makarov et al. (2003). The rest of the genera, viz., *Banatosoma* Ćurčić and Makarov, 2000, *Bulgarosoma* Verhoeff, 1926, *Dazbogosoma*, *Perunosoma* Ćurčić and Makarov in Ćurčić et al. (2007), *Serbosoma* Ćurčić and Makarov, 2000 and *Troglodicus* Gulička, 1967 are all characterized by the presence of such outgrows in the distal part of the angioxocites. However, the new genus clearly differs from all other genera of this complex by the presence of strongly developed

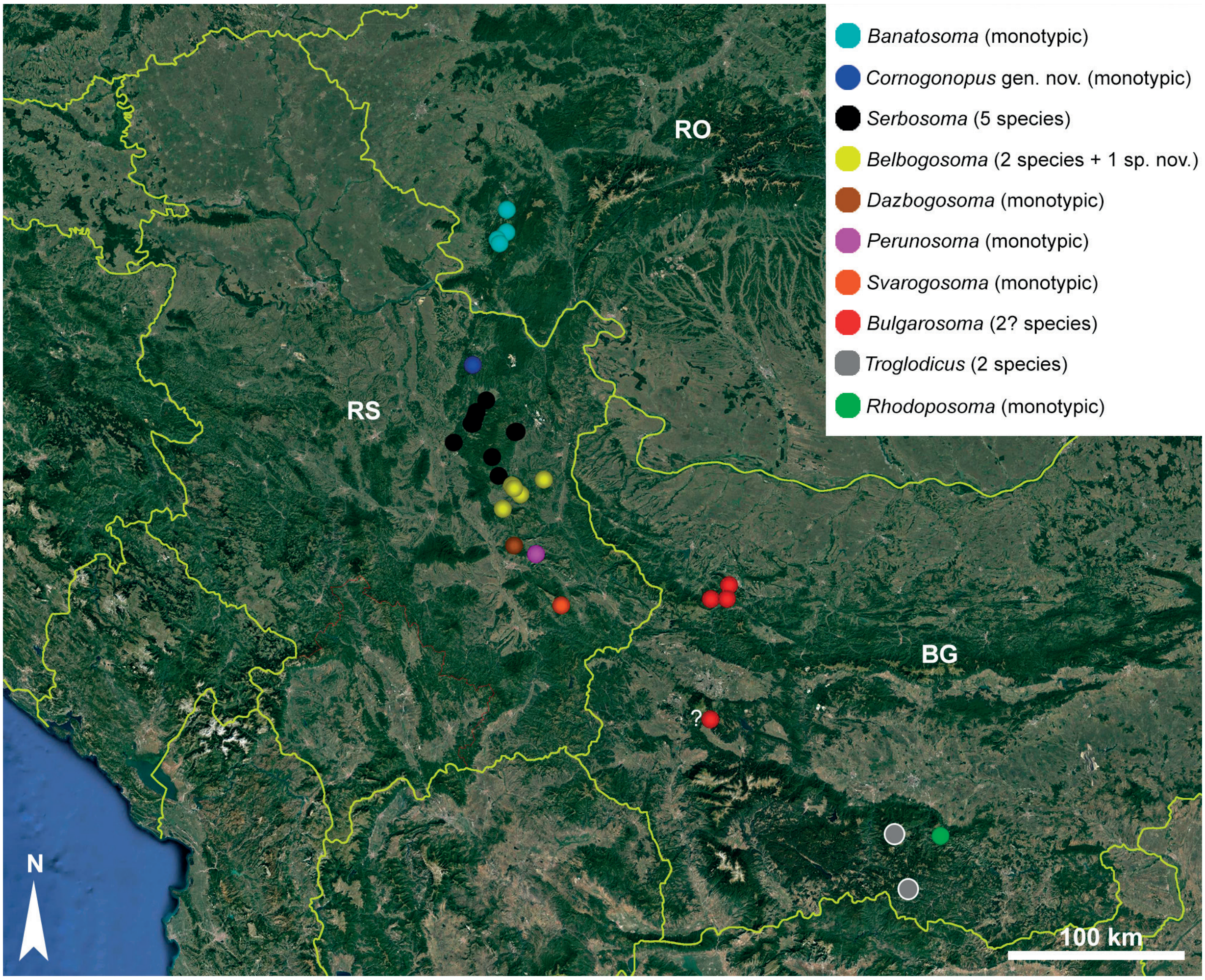

Fig. 9. Distribution map of the "*Bulgarosoma*" complex.

posterior horns on the angiocoxites. Structures that can be homologous to these horns can be seen in *Rhodoposoma rhodopinum* (Strasser, 1966) in Strasser's (1966: 21, fig. 20) drawing, but they are far less noticeable compared to the new genus. Also, the genera *Cornogonopus* gen. nov. and *Rhodoposoma* are characterized by the presence of a small posterior tooth in the subdistal part of the angiocoxites. However, the general appearance of posterior gonopods in these two genera is clearly different, including strongly developed colpocoxites and straight and shorter angiocoxites in *Cornogonopus* gen. nov. On the other hand, colpocoxites in *Rhopodosoma* are far less developed, while angiocoxites are longer and distally curved.

As for the anterior gonopods of the "*Bulgarosoma*" complex, their structure appears to be unique within the family Anthroleucosomatidae. One of the most remarkable structures of the anterior gonopods is the posterior, strongly developed syncolpocoxite with anteriad directed and robust unpaired central process, characterized by hair-like outgrows. Such a structure is absent in all other complexes within anthroleucosomatids and represents an autapomorphic state within the family. The syncolpocoxite with an unpaired central process is certainly the main taxonomic character in the "*Bulgarosoma*" complex, not only for the genus level but also the species level. The shape and complexity of the posterodistal part of syncolpocoxite vary from relatively simple to branched. The new genus belongs to a group with more complex and branched posterodistal part, characterized by the presence of medial, lanceolate process covered by spine-like outgrows and lateral, lamellar processes both strongly bent anteriad, with a hair-like outgrows on anterior margin. Such a structure of the posterodistal part of syncolpocoxite is unique within the "*Bulgarosoma*" complex. In addition, the anterior gonopods of this complex are also characterized by well-developed, lateral and symmetrical angiocoxites. These structures are also more or less complex and are characterized by numerous processes that are mostly lamellar and covered by numerous serrated, hair- or spine-like outgrows. In the new genus, angiocoxites of the anterior gonopods are also very complex, and their most lateral parts give the impression of being inflated. It is likely that only the superficially similar inflated lateral parts can be seen in the genera *Banatosoma* and *Rhodoposoma*. Given the great complexity of the anterior gonopods, as well as the insufficient level of knowledge concerning its structures, it currently appears to be nearly impossible to draw any conclusions with respect to the relationships within this complex.

Notes on the distribution of the "*Bulgarosoma*" complex

The "*Bulgarosoma*" complex now includes 10 genera and 17 species, with as many as six monotypic genera, viz., *Banatosoma*, *Cornogonopus* gen. nov., *Dazbogosoma*, *Perunosoma*, *Rhodoposoma* and *Svarogosoma*. The four remaining genera, viz., *Belbogosoma*, *Bulgarosoma*, *Serbosoma* and *Troglodicus* have two, two, five and two species, respectively. This complex is very limited by the fact that its distribution mainly encompasses the karst areas of the Carpathian-Balkan arc and the Rhodopian massif (Fig. 9). Also, it is interesting to note that each genus of this complex is restricted to one or a few mountain systems. In the north, the distribution of this group is limited by the Tamiš and Cerna river valleys, which separate the Banat Mountains from the Transylvanian Alps (Southern Carpathians) in Romania. The Banat Mountains in Romania represent the northernmost range of this group, and are inhabited by the monotypic genus *Banatosoma*: the sole member of this group in Romania (Fig. 9, light blue dots). The distribution of this group stretches further to the south, across the Danube River, on the territory of the karst area of eastern Serbia. Toward the north, the first genus in relation to *Banatosoma* on the other side of the Danube River is *Cornogonopus* gen. nov., which is known from the Homolje Mountains (Fig. 9, dark blue dot) and represents the northernmost finding of the "*Bulgarosoma*" complex in Serbia. However, Serbia is inhabited by five more genera toward the south. The genus *Serbosoma*, with 5 species, inhabits Beljanica Mountain and the Kučaj Mountains (Fig. 9, black dots). The genus *Belbogosoma*, with its two described species, is confined to the mountains of Rtanj, Slemen and Tupižnica. Recently, a third, still undescribed species of this genus was found on Ozren Mountain (Fig. 9, yellow dots). The remaining three genera in Serbia, viz., *Dazbogosoma*, *Perunosoma* and *Svarogosoma*, are all monotypic, and are only known from Kalafat Mountain (Fig. 9, brown dot), Svrljig Mountains (Fig. 9, violet dot) and Suva Planina Mountain (Fig. 9, orange dot), respectively. It is clear that the western border of the entire complex is delimited by the Great Morava and South Morava river valleys in Serbia, while the southern border could hypothetically be the Vlasina river valley, also in Serbia. In addition, based on presently known distributions and our own efforts toward collecting cave millipede fauna, it seems that the eastern distribution of this group in Serbia is limited by the White Timok and Trgoviški Timok river valleys. From the southernmost findings of this complex on the territory of Serbia (Suva Planina Mountain), the distribution continues toward the east to Stara Planina Mountain and southeast to Vitosha Mountain and the Rhodope Mountains in Bulgaria. The genus *Bulgarosoma*, with two species (see below), is known from the northern foothills of the western part of Stara Planina Mountain and from Vitosha Mountain (Fig. 9, red dots), while the genera *Troglodicus*, with two species (Fig. 9, grey dots), and the monotypic genus *Rhodoposoma* (Fig. 9, green dot) are known from the

Rhodope Mountains. Based on this, we can hypothesize that the western and southwestern boundaries of the distribution of the entire complex would be defined by the beginning of the Central Stara Planina Mountain, as well as Marica river valley and the southwestern parts of the Rhodope Mountains.

This complex includes almost exclusively troglobiontic species, each known from one or a few caves of a particular mountain system. All of these troglobionts are characterized by a depigmented, pale-yellowish white body and varying degrees of elongated antennae. Some of these taxa, viz., *Banatosoma*, *Belbogosoma*, *Cornogonopus* gen. nov., *Dazbogosoma* and *Rhodoposoma*, are still characterized by the presence of ommatidia, which indicate that these taxa have colonized underground habitats relatively recently. On the other hand, the genera *Serbosoma*, *Perunosoma*, *Svarogosoma* and *Troglodicus*, as well as *Bulgarosoma bureschi*, are characterized by the complete absence of ommatidia.

Only one representative of this complex is known from outside of a cave habitat – *Bulgarosoma superficiei* Strasser, 1975. This species was described from a high mountain site on Vitosha Mountain (Fig. 9, red dot with a question mark). However, in the original description, Strasser (1975) stated that he was not able to analyze one of the most important taxonomic characters of the "*Bulgarosoma*" complex – the syncolpocoxite. We assume that this structure, in the only male that Strasser had, was broken. During this period, almost all taxa of this group were included in the genus *Bulgarosoma*. Interestingly, a second male representative of this taxon was found only recently and in the immediate vicinity of a type locality (Bachvarova et al. 2017). However, based on SEM pictures reported by Bachvarova et al. (2017: 512, Figs 5, 6, sc), it is clear that the syncolpocoxite is also coincidentally broken. Based on the rest of the anterior gonopods and picture of the posterior gonopods, we suspect that this species does not belongs to the genus *Bulgarosoma*. Only a male with whole anterior gonopods would provide us with more information.

In conclusion, the "*Bulgarosoma*" complex includes interesting forms that are endemic mainly to the underground habitats of the Carpatho-Balkanids and the Rhodope Massif. Also, although it appears that this group has too many monotypic genera, this is not such a rare situation within the order Chordeumatida. However, past experience has shown that many previously monotypic genera, or higher categories, were subsequently supplemented with additional members. One example here is the genus *Belbogosoma*, which recently acquired a second member (Antić et al. 2014), and as mentioned earlier, a third species has recently been discovered. Many caves on the territory of Serbia and Bulgaria are still unexplored, and we should certainly expect more new taxa from this group to be reported in the future.

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REFERENCES

Antić DŽ. 2017. Filogenija, biogeografija i postembrionalno razviće predstavnika holarktičke porodice Anthroleucosomatidae Verhoeff, 1899 (Myriapoda, Diplopoda, Chordeumatida) [Phylogeny, biogeography and post-embryonic development of representatives of the Holarctic family Anthroleucosomatidae Verhoeff, 1899 (Myriapoda, Diplopoda, Chordeumatida)]. [Doctoral Thesis]. Belgrade, Serbia: University of Belgrade—Faculty of Biology. 119 pp. [in Serbian, English summary].

Antić DŽ, Tomić VT, Ćurčić BPM, Ćurčić SB, Stamenković SP, Lučić LR, Makarov SE. 2014. Genus *Belbogosoma* Ćurčić & Makarov, 2008, with descriptions of new troglobitic species from east Serbia, Balkan Peninsula (Diplopoda: Chordeumatida: Anthroleucosomatidae). Archives of Biological Sciences. 66(2):907–918.

Antić DŽ, Makarov SE. 2016. The Caucasus as a major hotspot of biodiversity: Evidence from the millipede family Anthroleucosomatidae (Diplopoda, Chordeumatida). Zootaxa. 4211(1):001–205.

Antić DŽ, Makarov SE. 2017. Review of the Holarctic family Anthroleucosomatidae (Diplopoda, Chordeumatida). Tropical Natural History. Supplement 5:10 (published abstract, 17th International Congress of Myriapodology).

Bachvarova D, Vagalinski B, Doichinov A, Stoev P. 2017. New records of millipedes and centipedes from Bulgaria, with an annotated checklist of the Bulgarian myriapods. Zootaxa. 4263(3):507–526.

Ćurčić BPM, Makarov SE, Tomić VT, Mitić BM. 2007. Global review of some Anthroleucosomatidae (Diplopoda: Chordeumatida) with a description of a new millipede genus from the Balkan Peninsula. Canadian Entomologist. 139:478–588.

Ćurčić BPM, Makarov SE, Tomić VT, Mitić BM, Ćurčić SB, Dudić BD, Lučić LR, Jasnić N. 2008. On a new genus of endemic millipedes (Diplopoda: Chordeumatida: Anthroleucosomatidae) from the Balkan Peninsula. Zootaxa. 1743(1):1–16.

Đurović P, editor. 1998. Speleological Atlas of Serbia. Special Issues No. 52. Serbian Academy of Sciences and Arts, Geographical Institute "Jovan Cvijić", Institute for Protection of Nature of Serbia, Faculty of Geography - University of Belgrade & Faculty of Biology - University of Belgrade, Belgrade.

Makarov SE, Mitić BM, Ćurčić SB. 2003. *Svarogosoma bozidarcurcici* n. g., n. sp., (Diplopoda, Anthroleucosomatidae) from the Balkan Peninsula, with notes on its phylogeny. Periodicum Biologorum. 105(4):465–472.

Makarov SE, Ćurčić BPM, Milinčić M, Pecelj MM, Antić DŽ, Mitić BM. 2012. A new genus and species of the family Anthroleucosomatidae from Serbia (Myriapoda, Diplopoda, Chordeumatida). Archives of Biological Sciences. 64(2):793–798.

Mauriès JP, Golovatch SI, Stoev PE. 1997. The millipedes of Albania: recent data, new taxa; systematical, nomenclatural and faunistical review (Myriapoda, Diplopoda). Zoosystema. 19(2-3):255–292.

Pavićević D, Vesović N, Popović M, Ćurčić S. 2018. A new troglobitic ground beetle (Carabidae: Trechinae) from eastern Serbia. Zaštita Prirode. 68(1-2):61–66.

Shear WA. 2000. On the millipede family Heterochordeumatidae, with comments on the higher classification of the order Chordeumatida (Diplopoda). Invertebrate Taxonomy. 14(3): 363–376.

Shear WA, Leonard WP. 2004. The milliped family Anthroleucosomatidae new to North America: *Leschius mcallisteri*, n. gen., n. sp. (Diplopoda: Chordeumatida: Anthroleucosomatoidea). Zootaxa. 609(1):1–7.

Strasser K. 1962. Diplopoden aus Bulgarien und Jugoslawien. Senckenbergiana Biologica. 43(6):437–470.

Strasser K. 1966. Über Diplopoden Bulgariens. Annales Zoologici, Warszawa. 23(12):1–61.

Strasser K. 1975. Weiterer Beitrag zur Kenntnis der bulgarischen Diplopoden. Acta Zoologica Bulgarica. 3:70–77.