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Playing hard to get: two new species of subterranean Trechini beetles (Coleoptera, Carabidae, Trechinae) from the Dinaric Karst

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Abstract

Almost 200 years of continuous and systematic research in subterranean habitats of the Dinaric Karst and adjoining areas have resulted in the discovery of more than 400 specialized subterranean beetles. Among these, a special place belongs to the morphologically well distinguished and elusive, so called aphaenopsoid trechine beetles, which are characterized by a prolonged head, pronotum and appendages, and widened, ovoid-shaped elytra. Two new species of aphaenopsoid trechines – *Derossiella lukici* **sp. n.** from two deep pits on Mt Biokovo, Croatia, and *Adriaphaenops petrimaris* **sp. n.** from Pištet 4 Cave, Kameno more, Montenegro – are described, illustrated, and compared with closely related congeners. Identification keys for both genera and an annotated catalogue for all *Adriaphaenops* species, as well as data on the distribution and the ecology of these remarkable species, are provided and discussed.

Introduction

Following the description of the first cave animal, a subterranean beetle *Leptodirus hochenwartii* Schmidt, 1832 (Polak 2005, Moldovan 2012), the western Balkan's Dinaric Karst became a theater of ceaseless discoveries of highly specialized, cave adapted fauna. The so called troglobionts. Here, the richness of subterranean biodiversity exceeds that of similar areas throughout the world; thus, it is considered the world's primary subterranean biodiversity hotspot (Sket et al. 2004, Culver et al. 2006, Sket 2012). Moreover, it is only here that caves (locally called jama, pećina or špilja) having more than 100 troglobiotic species are known to exist (Ozimec and Lučić 2009, Zagmajster et al. in prep). Much of this exceptional richness consists of beetles specialized for living in these (Bregović and Zagmajster 2016) resource-scarce habitats (Gibert and Deharveng 2002, Culver and Pipan 2009). To date, more than 400 species of troglobiotic beetles have been recognized in the Dinaric Karst and adjoining areas (Bregović and Zagmajster 2016, Zagmajster, personal communication). The vast majority are classified in two subfamilies: Cholevinae (family Leiodidae) and Trechinae (family Carabidae). Even though their natural histories and ecology differ, the two groups show similar distribution patterns, which might suggest that the same mechanisms triggered the emergence of the two species richness peaks in the Dinaric Karst: one in the northwest and the other in the southeast (Zagmajster et al. 2008, Bregović and Zagmajster 2016).

Among the Trechini, a group of morphologically derived and predatory "aphaenopsoid" beetles, characterized by a

prolonged head, pronotum, and appendages, can be easily distinguished (Jeannel 1928, Casale and Laneyrie 1982, Luo et al. 2018). By the beginning of the 20th century, the genus *Aphaenopsis* Müller, 1913 was the only aphaenopsoid trechine genus recorded from the Dinaric Karst. Only two additional genera, *Scotoplanetes* Absolon, 1913 and *Adriaphaenops* Noesske, 1928, were discovered until the employment of vertical caving techniques, which enabled karst researchers to explore deeper sections of the caves. This also offered the possibility to sample new and hardly accessible habitats, i.e. the cave hygropetric (Sket 2004). During the following decades, discoveries of peculiar, yet unrecognized aphaenopsoid beetles were reported from all over the Dinaric Karst. Overall, nine new genera were described (*Dalmataphaenops* Monguzzi, 1993 [junior synonym *Biokovoaphaenopsis radici* Jalžić, 1993]; *Albanotrechus* Casale & Guéorguiev, 1994; *Croatotrechus* Casale & Jalžić, 1999; *Minosaphaenops* Quéinnec, 2008; *Derossiella* Quéinnec, 2008; *Jalzicaphaenops* Lohaj & Lakota, 2010; *Acheroniotes* Lohaj & Lakota, 2010; *Velebitaphaenops* Casale & Jalžić, 2012; and *Velesaphaenops* Ćurčić & Pavićević, 2018) (Quéinnec 2008, Casale et al. 2012, Ćurćić et al. 2018). The newly recognized genera encompassed an entire range of body sizes, from the 4.4 mm long *Croatotrechus* to the gigantic, 14 mm long *Velebitaphaenops* (Casale and Jalžić 1999, Casale et al. 2012). Most of the newly discovered genera remained monotypic, with the exception of the genera *Minosaphaenops* (2 species) and *Acheroniotes* (3 species) (Lohaj and Jalžić 2009, Ćurćić et al. 2018), and seem to represent geographically isolated and morphologically well-defined lineages. Moreover, most of the Dinaric aphaenopsoid trechine genera seem to be ecologically specialized predators and are rarely found. In many cases, species or even genera are single-site endemics known by one or several specimens only, with the only exceptions being the genera *Acheroniotes* and *Dalmataphaenops* (Noesske 1928, Scheibel 1935, Pretner 1959, Pavićević 1990, Monguzzi 1993, Casale and Guéorguiev 1994, Casale and Jalžić 1999, Pavićević 2000, Quéinnec 2008, Quéinnec and Pavićević 2008, Quéinnec et al. 2008, Lohaj and Jalžić 2009, Lakota et al. 2010, Casale et al. 2012, Lohaj and Lakota 2010, Lohaj and Mlejnek 2012, Lohaj et al. 2016, Ćurćić et al. 2018). To date, including the most recently described genus *Velesaphaenops*, the Dinaric aphaenopsoid trechines are classified into twelve genera comprising 28 species.

Herein we describe two recently discovered species of the Dinaric Karst aphaenopsoid trechines. They are representatives of genera with apparently differing or even opposing distribution patterns. One species belongs to the formerly monotypic and narrowly distributed *Derossiella* and the other to the relatively widely distributed and species-rich genus *Adriaphaenops*.

The genus *Derossiella* with its type species, *Derossiella nonveilleri* Quéinnec, 2008, was described based on a single female collected in April 1999 in a nameless pit about 15 m deep, situated ca 500 m south-southeast from the Balićeva špilja (Kraljeva jama), Balići, Mt Mosor, Croatia (Quéinnec, 2008). The locality was later identified as Mala jama, Jelinac, Džakići, Dugopolje, Croatia (Jalžić et al. 2013). The second specimen of *D. nonveilleri*, a male, was collected in the Drinovčuša jama, Kotlenice, Mt Mosor, Croatia in August 2007 by the Croatian speleobiologist Branko Jalžić (Lohaj and Jalžić 2009). Subsequently, both localities were visited multiple times by B. Jalžić or the second author (T.D.), but without success in finding additional specimens.

An immature female of a new species was first found during speleobiological research in the cave Biokovka, Golubinjak, Mt Biokovo, Croatia in September 2007, by the Croatian speleobiologist Marko Lukić. This specimen was examined by the first author (R.L.) and provisionally placed in the genus *Derossiella*. Further intensive research of the deep subterranean habitats of Mt Biokovo was executed from 2015 to 2017 by members of the Croatian Biospeleological Society, DZRJ Ljubljana, and members of the SubBioLab (Bregović et al. 2015). During one of the visits to the Pretnerova jama, Lokva, Mt Biokovo, Croatia in 2015, biology student Ester Premate found a second immature female at an approximate depth of 120 m. Finally, in June 2017, a male was collected by the second author (T.D.), again in Biokovka, at a depth of ca 300 m. Subsequent examination of all three specimens, including male genitalia, confirmed that they belong to an undescribed species of the genus *Derossiella*, whose description is provided below.

Whereas representatives of the genus *Derossiella* seem to be rare and exceptionally hard to find, almost half of the Dinaric Karst aphaenopsoid trechines, 12 out of 28 described species, are classified within the Southern Dinaric genus *Adriaphaenops*. The first species of the genus, *Adriaphaenops antroherponomimus* (Noesske, 1928), was found during the summer of 1927 in a small cave named Snježnica u Tišovom kršu (synonym = Čatol jama), Mt Bjelašnica, Gacko, Bosnia and Herzegovina by Leo Weirather, a famous Austro-Hungarian speleobiologist and an early explorer of the Dinaric Karst. Just before the Second World War, Oskar Scheibel, an entomologist from Zagreb, Croatia, described two additional species, each based on a single female specimen found in two famous caves. He described *A. pretneri* Scheibel, 1935 from Vjetrenica, Zavala, Popovo polje, Bosnia and Herzegovina, and *A. staudacheri* Scheibel, 1939 from Grbočica, Virpazar, Rijeka Crnojevića in south-eastern Montenegro. The fourth species, *A. stirni* Pretner, 1959, was discovered during the autumn of 1956 by a Slovenian entomologist, Jože Štirn, in Velja peć, a small cave located near Nikšić in Montenegro (Pretner 1959). By the end of the 20th century, speleobiological investigations made on Mt Durmitor, Montenegro led to the discovery of a new species with two subspecies, *A. zupcense zupcense* and *A. zupcense tartariensis* (Pavićević 1990, 2001). Intensive speleobiological investigations in Eastern Hercegovina, in the beginning of the 21st century, resulted in the discovery of two new species, *A. perreaui* Quéinnec & Pavićević, 2008 from Pećina u Mravinjac, Mt Bjelašnica, Trebinje, Bos-

nia and Herzegovina, and *A. kevser* Quéinnec, Pavićević & Ollivier, 2008 from Vilina pećina, Mt Lebršnik, Gacko, Bosnia and Herzegovina. Finally, five new species, *A. albanicus*, *A. jasminkoi*, *A. mlejneki*, *A. njegosiensis*, and *A. rumijaensis*, were found during speleological and speleobiological survey in the central and southern Dinarides (Bosnia and Hercegovina, Montenegro, and Albania) and were described in 2016 (Lohaj et al. 2016).

Recently, during speleobiological research performed by SubBioLab members and cavers from DZRJ Ljubljana in Pištet 4 cave (synonym = PT4), Velji Pištet, Kameno more, Risan, Montenegro in spring 2018, two specimens of the genus *Adriaphaenops* were found by the second author (T.D.). Subsequent examination confirmed that they belong to a new species described below.

Material and methods

Geomorphological framework and locality descriptions

Plate tectonics during Eocene and Miocene triggered uplift of the so called Adriatic carbonate platform, resulting in the formation of the Dinaric Karst, a 650 km long mountain range stretching along the eastern Adriatic Sea coast (Vlahović et al. 2005, Korbar 2009) from the border with the Southern Calcareous Alps to the Albanian coast (Gams 2004). Along the Dinaric Karst, protruding mountain ridges like Mt Biokovo and Orjen (and associated Kameno more) are recognized and accompanied by numerous karstic poljes. Both ridges are predominantly formed by Jurassic and Cretaceous limestones and subordinate dolomites (Adamson et al. 2014, Velić et al. 2017), and are characterized by high levels of yearly precipitation (Ranković 1961). Moreover, as a part of the Orjen foothills, Kameno more is considered to be the area receiving the highest amount of precipitation in Europe (Ducić et al. 2012). In addition, both areas are highly karstified and characterized by a lack of surface waters. Another common factor in both areas is the existence of many karst springs with outlets below sea level, so called "vrulje" (Bellafiore et al. 2011, Kuhta et al. 2012), whose origins are connected to oscillations of the sea level during the Miocene and Pleistocene (Bonacci 2015). The rise and fall of glaciers during the Pleistocene largely shaped the surface morphologies of both areas (Hughes et al. 2011, Žebre et al. 2013). Both areas include extensive karstic landscapes with numerous phenomena such as dolines, sinkholes, and a large number of caves. As a result of glacial melt water ingressing deeply into the vadose zone, deep caves were formed. On Mt Biokovo alone, more than 400 caves are known (Vedran Sudar personal communication), and 11 of them have depths exceeding 250 m. Most renowned are the caves of Mokre noge (831 m deep), discovered in 2009, and Amfora (788 m deep). No similar data on the number of caves exists for the areas of Orjen or Kameno more, but some of the deepest caves are of similar depths to those found on Mt Biokovo (e.g. Kozi Dira, 654 m deep, and PT4, 455 m deep). However, due to the thickness of the limestone beds, the large extent of yet unexplored terrain, and hydrological connections with the extensive karstic springs and vruljes in the coastal area, the potential for deep caves in both areas is likely to surpass the depth of 1 km.

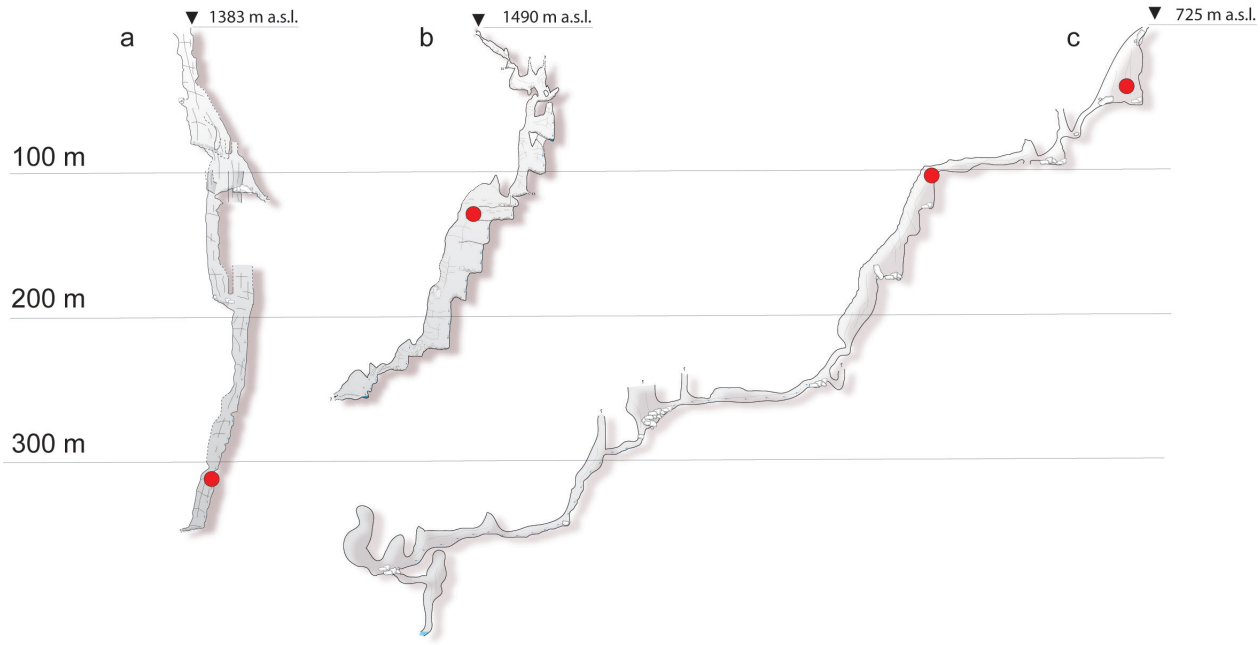

Figure 1. Cross sections of the caves from which the newly described species were collected: **a)** Biokovka, Golubinjak, Mt Biokovo, Croatia; **b)** Pretnerova jama, Lokva, Mt Biokovo, Croatia; **c)** Pištet 4 cave (PT4), Velji Pištet, Kameno more, Risan, Montenegro. Approximate finding localities are presented with red points. The original cave surveys of Biokovka and PT4 were made by Ivan Glavaš and the University of Bristol Spelaeological Society, respectively.

Due to the high endemicity of Biokovo's subterranean fauna, several speleobiological excursions were organized in recent years, culminating with the "1st Biospeleological expedition – Biokovo 2017" (Sudar et al. 2017). The main goal of the expedition was to gather additional distributional data on the poorly known taxa and to execute speleological surveys of some of the deep caves. During four visits in 2017, from April to October, 26 caves were visited, including eight caves exceeding 250 m in depth. Some of the deep caves were visited due to the existence of pre-expedition data on ambiguous trechine belonging to a yet undescribed species of *Derossiella*. These caves include Biokovka, Golubinjak, Vošac, Mt Biokovo, Croatia (43.322197°N, 17.050591°E; 363 m deep) (Fig. 1a) and Pretnerova jama, Lokva, Mt Biokovo, Croatia (43.33945°N, 17.03836°E; 254 m deep) (Fig. 1b) (Bregović et al. 2015). Both caves are characterized by a series of vertical pits ingressing deeply into the vadose zone. Deeper parts of both caves, starting from the approximate depth of 75 m in Pretnerova jama and 200 m in Biokovka, are characterized by films of percolating water flowing over vertical walls; the cave hygropetric. Also, the temperature span was similar in both caves, ranging from about 4 °C in the entrance parts without direct sun influence to 5 °C in the lower parts. Subterranean fauna in both caves was sampled by using baited pitfall traps, hand collecting or by mean of an aspirator. No preserving media was used in the pitfall traps; therefore, the trapped fauna was alive and mainly released upon collecting the traps.

Similarly, the Kameno more area was visited due to the speleobiological potential, the existence of already known and peculiar troglobiotic species such as *Hadesia* cf. *weiratheri* (Perreau and Pavićević 2008), and the existence of caves with the deep vadose pits. Such is also the second deepest cave in the area, Pištet 4 cave (synonym = PT4), Velji Pištet, Kameno more, Risan (42.55183°N, 18.73864°E) (Fig. 1c), whose entrance opens beneath a boulder in the bottom of a collapsed doline. Like the described caves of Mt Biokovo, PT4 is also characterized by the existence of a series of vertical pits interconnected with a stream running through the limestone beds, reaching the phreatic waters at the maximum depth of 455 m. Deeper portions of the cave, starting already at a depth of 60 m, are characterized by the existence of the cave hygropetric. The temperature in the cave was measured only once, at an approximate depth of 200 m, and was 7.4 °C. Detailed descriptions of the cave, including morphology, hydrology, and detailed speleological maps can be found in Binding (2010, 2011). Due to a time constraint, the cave was sampled using hand collecting only.

Laboratory work and morphology

The morphological structures of the beetles were examined using Olympus SZ 60 (Olympus, Tokyo, Japan) and Leica S8 APO (Leica, Wetzlar, Germany) stereoscopic microscopes. Macrophotographs were taken using a Canon 5D Mark II camera. Male and female genitalia were dissected, cleaned, and mounted in Euparal or Dimethyl-Hydantoin formaldehyde (DMHF) on transparent slides, which were later pinned under the specimens. Fine structures of male and female genitalia were studied at magnifications up to 600× by using a Leica DM1000 light microscope (Leica, Wetzlar, Germany). Drawings were made using an attached drawing tube.

Measurements

TL total body length (measured from the anterior margin of clypeus to the apex of elytra).
L overall length, from apex of mandibles to apex of elytra, measured along the suture.
HL head length (measured from the anterior margin of the clypeus to the neck constriction).
HW maximum width of head.
AL antennal length (measured from the base of antennal scape to the apex of terminal antennal segment).
PL Pronotal length (measured along the median line).
PW Maximum width of pronotum, as greatest transverse distance.
EL Elytral length (as linear distance measured along the suture from the elytral base to the apex).
EW Maximum width of elytra.
HL/HW Ratio head length/maximum width of head.
PL/PW Ratio length of pronotum/maximum width of pronotum.
EL/EW Ratio length of elytra/maximum width of elytra.

Forward slash indicates separate labels.

Acronyms

CNHM Collection of Croatian Natural History Museum, Zagreb, Croatia
PMSL Collection of Slovenian Natural History Museum, Ljubljana, Slovenia
CRL Private collection of Roman Lohaj, Slovakia.

Higher classification of the Trechini used here follows Belousov (2017).

Results

Genus *Derossiella* Quéinnec, 2008

Figs 2–5

Derossiella Quéinnec, 2008: 164, by monotypy; type species: *Derossiella nonveilleri* Quéinnec, 2008.

Material examined. Male labelled: Croatia, Split, Mt Mosor, Kotlenice, Tukići, Bradarića staje, Drinovčuša jama, 01.08.2007 B. Jalžić lgt. (white label, printed) / *Derossiella nonveilleri* Quéinnec, 2008, R. Lohaj det. 2008 (white label, printed), CNHM.

***Derossiella lukici* sp. n.**

http://zoobank.org/BCB33301-A988-465D-A0F5-82060EAD16B0
Figs 2–5

Type series. Holotype male labelled: "Croatia, Mt Biokovo, Golubinjak, Biokovka, -300 m, 24.6.2017, T. Delić lgt." (white label, printed) / "DNA extraction RL–07" (orange label, printed) / "HOLOTYPUS *Derossiella lukici* sp. n. Lohaj & Delić des. 2018" (red label, printed), (CNHM, voucher code 600: ZAG; ZEC2, 4194 Coll. Jalžić). Paratypes: one female (right posterior tarsus missing) labelled: "Croatia, Mt Biokovo, Golubinjak, Biokovka, 2.9.2007, M. Lukić lgt." (white label, printed) / "PARATYPUS *Derossiella lukici* sp. n. Lohaj & Delić des. 2018" (red label, printed), (CNHM, voucher code 600: ZAG; ZEC2, 4195 Coll. Jalžić)., one female (last three antennomeres of right antenna missing) labelled: "Croatia, Mt Biokovo, Lokva, Pretnerova, -120 m, 19.05.2015, E. Premate lgt." (white label, printed) / "PARATYPUS *Derossiella lukici* sp. n. Lohaj & Delić des. 2018" (red label, printed), (CRL).

Diagnosis. Medium-sized aphaenopsoid trechine with morphological features fully matching generic description proposed by Quéinnec (2008). Head long, parallel-sided, with complete, deep frontal furrows reaching neck constriction and two pairs of supraorbital setae, posterior setae doubled. Eyes absent, mentum with simple tooth. Aphaenopsoid habitus with very narrow head and pronotum; elytra oblong-oval, 2.6 times wider than head and pronotum. Hind angles of pronotum without setae. Surface completely glabrous, striae absent, elytral chaetotaxy with macrochetae and microchetae. Cuticle depigmented, reddish-yellow, body strongly flattened dorso-ventrally, with very long and slender legs and antennae (Figs 3, 4). Closely related to the type species of the genus, *Derossiella nonveilleri*, from which it differs by paired posterior supraorbital setiferous punctures, differently shaped elytra with higher number of macro- and microchetae, narrower pronotum, as well as by the differently shaped aedeagus.

Description. L: 5.5 mm (PT)–6.0 mm (HT), TL: 4.8 mm (PT)–5.4 mm (HT). Head relatively large, nearly parallel-sided, with maximum width behind middle, distinctly longer than wide (index HL/HW 1.35 (PT)–1.42 (HT), slightly wider than pronotum, sparsely pubescent. Frontal furrows deep, complete, reaching neck constriction, slightly divergent posteriorly. Anterior pair of supraorbital setae situated before middle of head length, posterior supraorbital setae paired, two setae on each side of head situated close to neck constriction. Neck constriction distinct; genae gently convex. Clypeus and labrum with three pairs of setae, outer pairs longer. Antennae length 4.9 mm (HT)–4.3 mm (PT), scape as long as pedicel, almost as long as terminal antennomere.

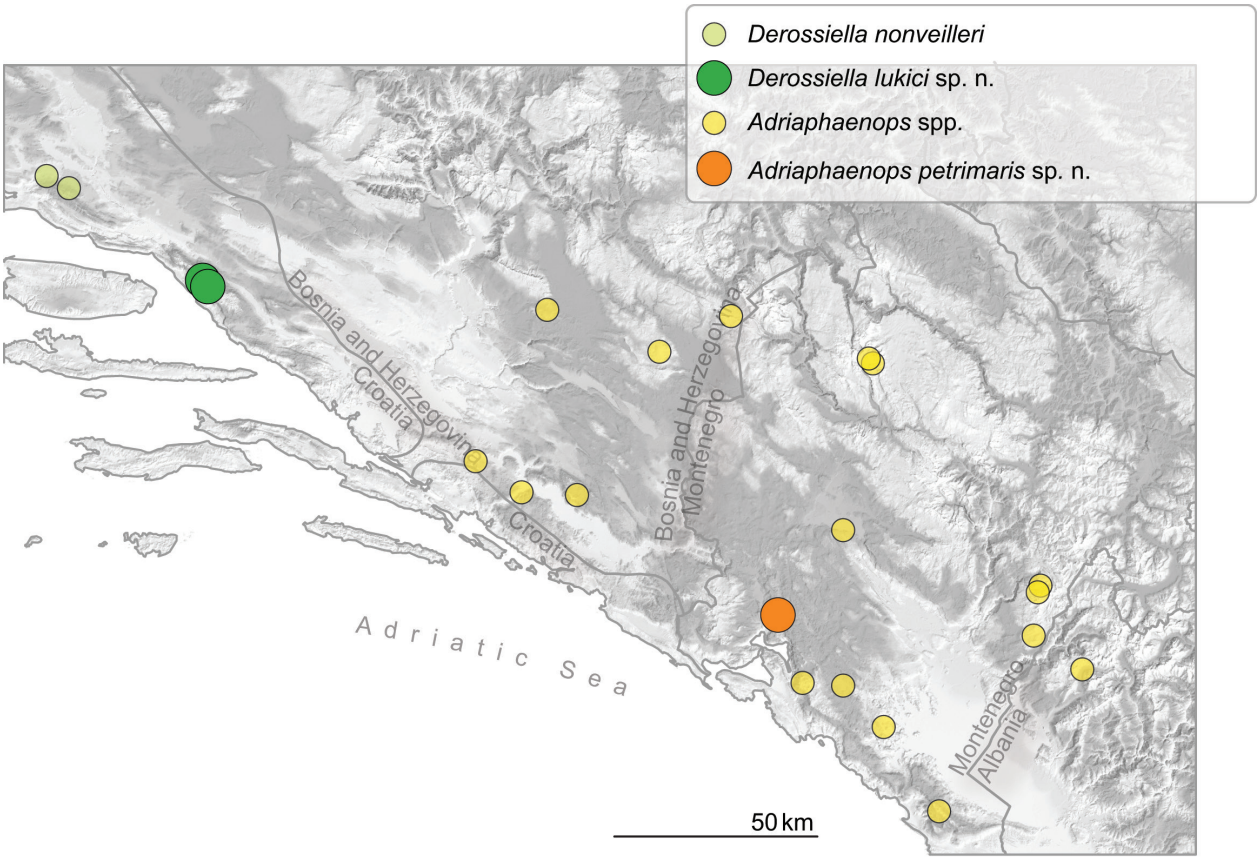

Figure 2. Geographical distribution of the Dinaric aphaenopsoid trechines of the genera *Derossiella* and *Adriaphenops*. Source of data: http://subbio.net/db/

Figure 3. *Derossiella lukici* sp. n. in its habitat in the cave Biokovka, Golubinjak, Mt Biokovo (Photo courtesy of P. Bregović).

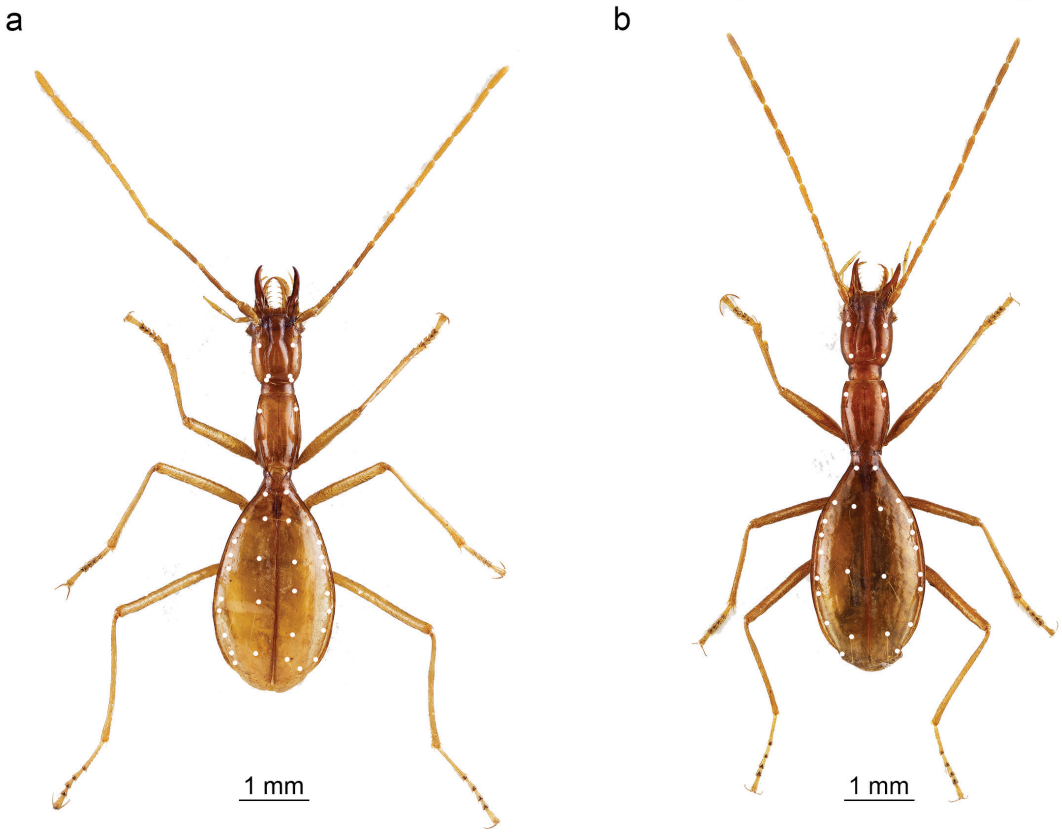

Figure 4. Habitus of *Derosiella* species. *Derossiella lukici* sp. n. **(a)** and *Derossiella nonveilleri* **(b)**. Chetotaxy is presented as white points (photo courtesy of Dušan Beňo).

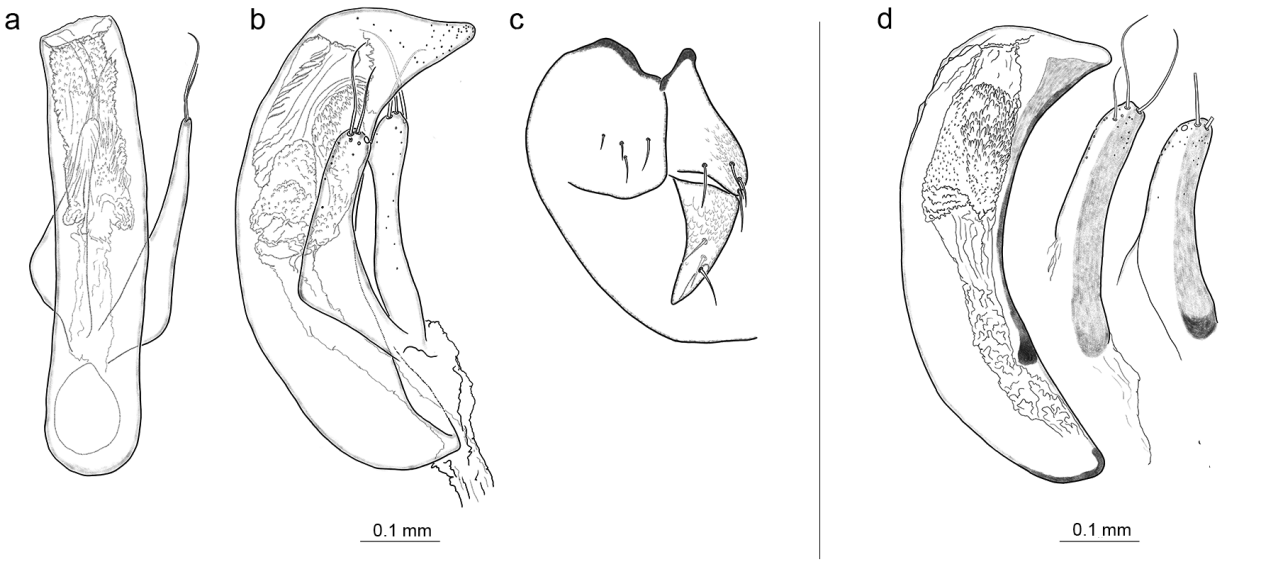

Figure 5. Male and female genitalia of *Derossiella* representatives: aedeagus of *D. lukici* sp. n., dorsal view **(a)**; and lateral view **(b)**; female genitalia gonocoxite 1 and 2 (basal and apical segments of gonostylus) copulatory piece of *D. lukici* sp. n. **(c)**; and *D. nonveilleri*, lateral view of male aedeagus with parameres detached **(d)** (illustration by Fedor Čiampor).

Pronotum elongated, slightly longer and narrower than head, with maximum width in anterior third, index PL/PW 1.75 (PT)–1.83 (HT), only slightly narrowed anteriorly, posterior part distinctly narrower than anterior. Surface glabrous, median furrow distinct, visible in whole pronotal length. Propleura visible from dorsal aspect in basal two-thirds. Anterior angles of pronotum not protruding, posterior angles obtuse. Lateral furrows well developed, deep, with one pair of anterolateral setae, situated in the apical fifth of pronotal length.

Elytra subovate elongate, distinctly longer than wide, index EL/EW 1.74 (PT)–1.85 (HT), with maximum width in posterior third; elytral surface glabrous, without pubescence; striae absent. Stria 3 with 4–5 (3–4 discal and one preapical) macrochetae and 3 or 4 microchetae situated between macrochetae, stria 5 with 4 or 5 microchetae (Fig. 4). Humeral group of umbilicate pores not aggregated, first anterior pore of humeral group isolated and situated at level of the first discal seta.

Legs long, slender, densely pubescent. First two tarsomeres of male protarsi distinctly dilated and protracted at their internal margins. Tarsal claws very long and slender, without traces of denticulation on their internal sides.

Male genitalia. Aedeagus (Fig. 5) 0.58 mm long, relatively robust, regularly wide, lacking apical constriction, laterally flattened. Parameres relatively long and slender, longer than half of the length of aedeagus. Apex very short, tip obtuse. Each paramere at apex with three setae, two long, and one short.

Female genitalia as in Figure 5.

Etymology. Patronymic, dedicated to our dear friend Marko Lukić (Zagreb, Croatia), enthusiastic speleologist and speleobiologist, taxonomic specialist on subterranean Collembola, and collector of the first specimen of the new species.

Differential diagnosis. *Derossiella lukici* sp. n. is closely related to the type species of the genus, *Derossiella nonveilleri*. However, these two species can be easily recognized using the following key:

1(2) Head with 2 posterior supraorbital setiferous punctures on each side, which are very close to each other. Elytra with maximum width in the posterior third. Putative stria 3 with 4 or 5 macrochetae and 4–6 microchetae, putative stria 5 with 3 or 4 microchetae (Fig. 4). Pronotum narrower, index PL/PW: 1.75–1.83, anterior angles not protruding. Aedeagus (Fig. 5) shorter, more robust. L: 5.5–6.0 mm. Croatia, Mt Biokovo ..... *Derossiella lukici* sp. n.

2(1) Head with only 2 posterior supraorbital setiferous puncture on each side. Elytra with maximum width in middle. Putative stria 3 with 3 macrochetae and 2 microchetae between each macrochetae, putative stria 5 with 1 microcheta in basal fourth (see Fig. 4). Pronotum wider, index PL/PW: 1.43–1.44, anterior angles slightly protruding. Aedeagus (Fig. 5) longer and slenderer. L: 5.4–5.8 mm. Croatia, Mt Mosor ..... *Derossiella nonveilleri* Quéinnec, 2008

Distribution. So far this species is known from the two pits on Mt Biokovo, the type locality, Biokovka, Golubinjak and Pretnerova jama, Lokva. All three specimens were found in deeper parts of the caves, attaining depths of 120 to 300 m. They were all found walking on the "moonmilk", a white, pastelite material consisting of microbiologically transformed microcrystalline calcites with high water content (60–90%), and near the cave hygropetric.

Associated subterranean coleopteran fauna observed in the pits:

1 Biokovka, Golubinjak, Biokovo, Croatia:
Carabidae: Trechinae
Neotrechus dalmatinus (Miller, 1861)
Leiodidae: Cholevinae
Leptomeson biokovensis Giachino, Bregović & Jalžić, 2012
Radziella styx Casale & Jalžić, 1988
Speoplanes giganteus biocovensis Müller, 1934

2 Pretnerova jama, Lokva, Biokovo, Croatia:
Carabidae: Trechinae
Dalmataphaenops chiarae Monguzzi, 1993
Carabidae: Sphodrini
Laemostenus cavicola (Schaum, 1858)
Leiodidae: Cholevinae
Leptomeson biokovensis Giachino, Bregović & Jalžić, 2012
Radziella styx Casale & Jalžić, 1988
Speoplanes giganteus biocovensis Müller, 1934
Staphylinidae: Pselaphinae
Pselaphinae gen.

Genus *Adriaphaenops* Noesske, 1928

Adriaphaenops Noesske, 1928: 5, type species: *Trechus antroherponomimus* Noesske, 1928 by monotypy, type locality: Čatol jama des Bjelasica-Gebirges (weitere Umgebung von Gacko) im nord-ostherzegowinischen Karstlande.

Aphaenopsis (sg. *Adriaphaenops*) Jeannel, 1928: 793, Pretner 1959: 79, Casale and Laneyrie 1982: 159, Vigna Taglianti and Sciaky 1988: 166, Pavićević 1990: 365.

Aphaenops (sg. *Adriaphaenops*) Scheibel, 1935: 34, Pavićević 2001: 33.

Adriaphaenops Sciaky & Vigna Taglianti, 1990: 171, Monguzzi 1993: 238, Casale and Guéorguiev 1994: 421, Drovenik and Peks 1994: 43, Moravec et al. 2003: 289, Quéinnec 2008: 157, Quéinnec and Pavićević 2008: 144, Quéinnec et al. 2008: 154, Lakota et al. 2010: 100, Lohaj and Lakota 2010: 78.

Revision. Lohaj et al. 2016.

Adriaphaenops petrimaris sp. n.

http://zoobank.org/7C58EE0D-541B-4C5A-9937-CCDE8AAF01C5
Figs 2, 6, 7, 8, 9

Type series. Holotype male labelled: "MONTENEGRO, Risan, Velji Pištet, Kameno more, cave Pištet 4 (PT4), (18.73864°E, 42.55183°N), - 40 m, 3.5.2018, T. Delić lgt." (white label, printed) / "DNA extraction XA475" (white

Figure 6. *Adriaphaenops petrimaris* sp. n. in its natural habitat in Pištet 4 cave, Velji Pištet, Kameno more, Risan.

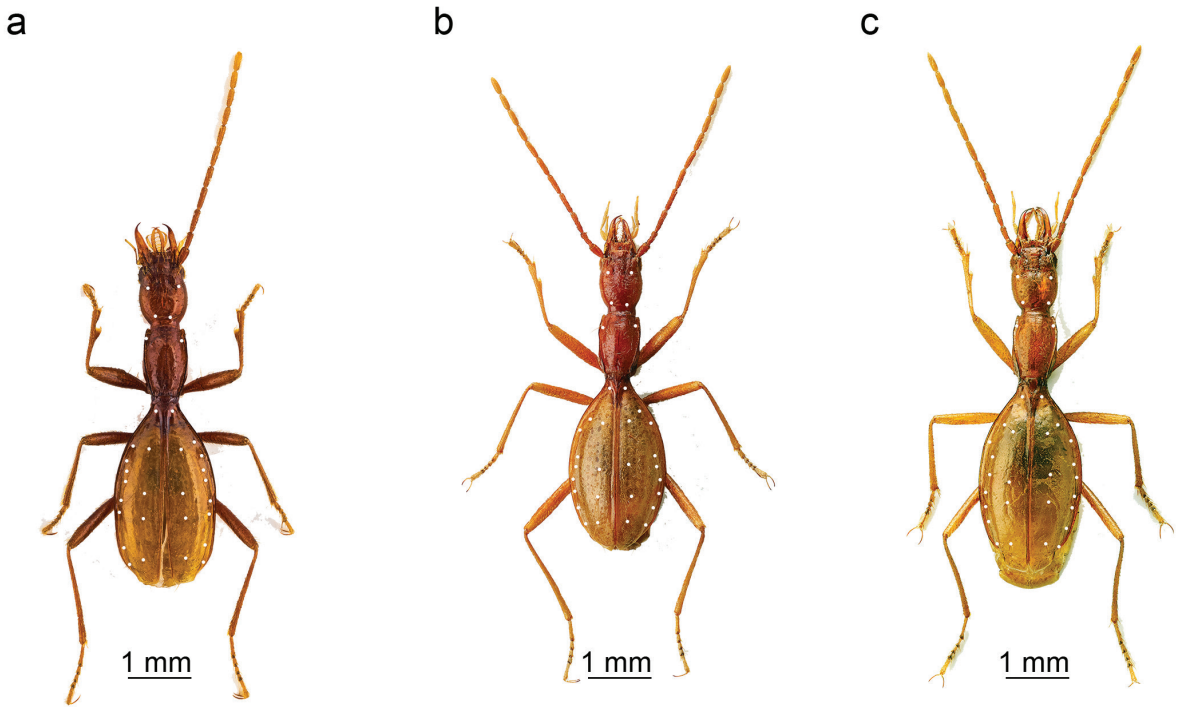

Figure 7. Habitus of morphologically similar *Adriaphaenops* species. *Adriaphaenops petrimaris* sp. n. **(a)**, *Adriaphaenops rumijaensis* **(b)** and *Adriaphenops kevser* **(c)**. Chetotaxy is presented as white points (photo courtesy of Dušan Beňo).

label, printed) / "HOLOTYPUS *Adriaphaenops petrimaris* sp. n. Lohaj & Delić des. 2018" (red label, printed) (PMSL, voucher code Coleoptera–11519). Paratype one female (left antenna missing), labelled: MONTENEGRO, Risan, Velji Pištet, Kameno more, cave Pištet 4 (PT4), (18.73864°E, 42.55183°N), - 100 m, 2.5.2018, T. Delić lgt." (white label, printed) / "PARATYPUS *Adriaphaenops petrimaris* sp. n. Lohaj & Delić des. 2018" (red label, printed) (CRL).

Diagnosis. A medium-sized trechine beetle with aphaenopsoid features: head and pronotum elongate; elytra ovoid, strongly narrowed at the base, obviously wider than head and pronotum; body depigmented, strongly flattened, covered with sparse pubescence (Figs 6, 7). This new species is mainly characterized by the presence of four pairs of dorsal setae (three discal and one preapical) on elytra. This character is so far present only in presumably closely related species, *A. kevser* and *A. rumijaensis*; see identification key below.

Description. L: 5.0 mm (HT)–5.4 mm (PT), TL: 4.7 mm (HT)–5.1 mm (PT). Head relatively large, rounded, with maximum width behind middle, distinctly longer than wide (index HL/HW 1.23 (HT)–1.33 (PT), slightly wider than pronotum, sparsely pubescent. Frontal furrows weakly impressed, short, ending in the front half of head. Two pairs of long supraorbital setae present; neck constriction distinct; genae gently convex. Clypeus and labrum with three pairs of setae, outer pairs longer. Antennae length 3.3 mm (HT)–3.4 mm (PT), scape as long as pedicel, almost as long as terminal antennomere.

Pronotum elongate, slightly longer and wider than head, with maximum width in middle, only very slightly narrowed anteriorly, basal part distinctly narrower than anterior (index PL/PW 1.66 (HT)–1.57 (PT)), sparsely pubescent, setae long, suberect; median furrow weakly marked, visible in the middle part of pronotum. Propleura visible from dorsal aspect only in basal half. Anterior angles of pronotum distinctly protruding, obtuse, posterior angles obtuse. Lateral furrows developed, deep, with one pair of anterolateral setae, situated in apical fourth of pronotal length.

Elytra subovate elongate, distinctly longer than wide (index EL/EW 1.74 (HT)–1.78 (PT)), with maximum width in middle; elytral surface covered with very sparse, long and erect pubescence; striae absent. Site of stria 3 with four (three discal and one preapical) setae, humeral group of umbilicate pores not aggregated, first anterior pore of humeral group isolated and situated before the level of the first discal seta. Pore 5 located nearer to pore 6 than to pore 4.

Legs long, slender, densely pubescent. First two tarsomeres of male protarsi distinctly dilated and protracted at their internal margins. Tarsal claws very long and slender, without traces of denticulation on their internal sides.

Male genitalia (Fig. 8): aedeagus very long and slender, gradually narrowed towards apex in lateral aspect, sagittal aileron large, endophallus without distinct copulatory piece. Parameres long and slender, with two long setae at apex. Female genitalia as in Figure 9.

Etymology. Topotypic, referring to the toponym where the Pišet 4 cave is situated, Kameno more (in English, Sea of stone and in Latin, Mare petris).

Differential diagnosis. Genus *Adriaphaenops* currently comprises 13 described species, including *A. petrimaris* sp. n.

This species, *A. kevser*, and *A. rumijaensis* form a group of species with four discal setae (three dorsal and one preapical) on elytra, with elytral pubescence in all three species sparser in comparison to the other species (Fig. 7). *A. petrimaris* morphologically resembles *A. kevser*, described from Mt Lebršnik, Bosnia & Hercegovina. These two species can be easily recognized by the shape of head, pronotum, and aedeagus (Figs 7, 8) (see identification key below).

Distribution. So far this species is known only from the type locality, Pištet 4 cave (synonym = PT4), Kameno more, Risan, Montenegro. Both specimens, HT and PT, were found walking on the wet and damp vertical cave walls at the depth of 40 and 100 m.

Associated subterranean fauna observed in the pit:

Carabidae: Trechinae:

Neotrechus suturalis ssp. (Schaufuss, 1864)

Neotrechus paganettii ssp. (Ganglbauer, 1896)

Leiodidae: Cholevinae:

Blattochaeta sp.

Anthroherpon sp.

Hadesia cf. *weiratheri* Zariquiey, 1927

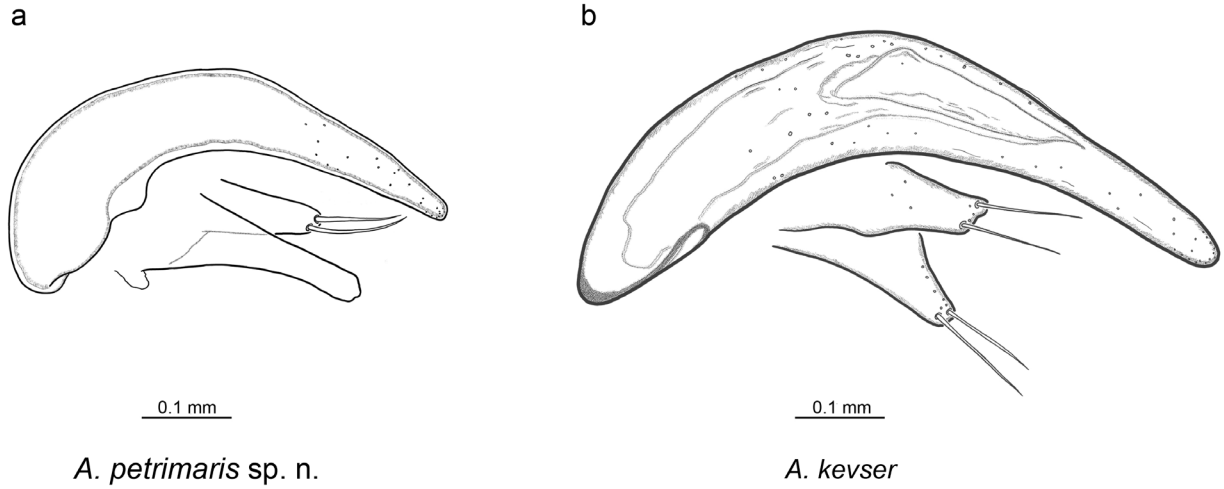

Figure 8. Male genitalia of *Adriaphaenops petrimaris* sp. n. **(a)** and similarly looking *A. kevser* **(b)** (illustrations by Fedor Čiampor).

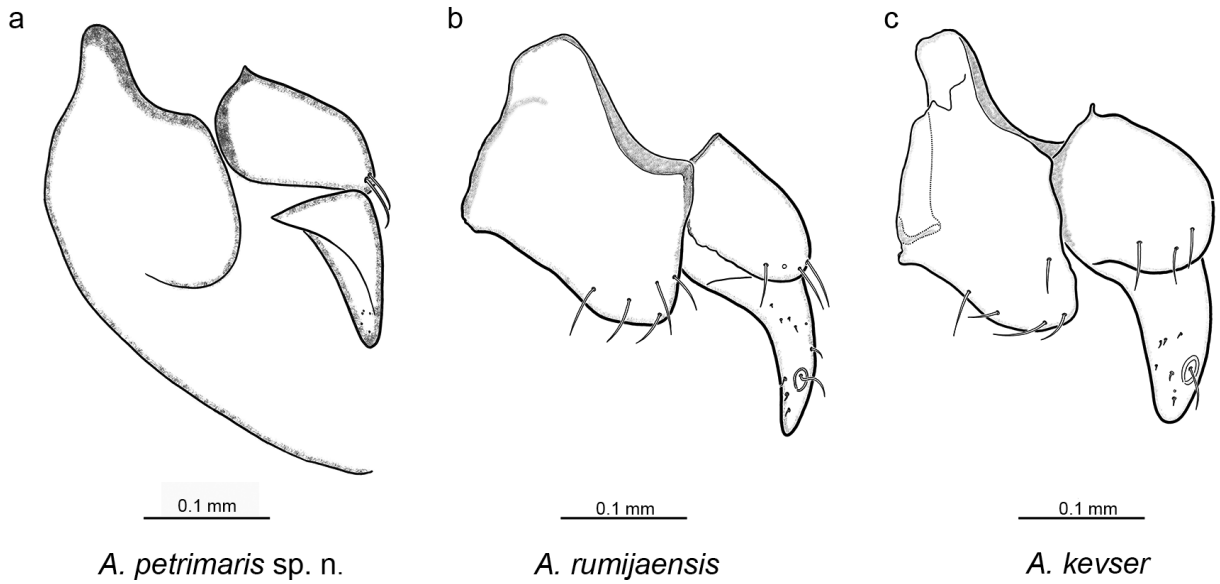

Figure 9. Female genitalia; gonocoxite 1 and 2 (basal and apical segments of gonostylus) of *Adriaphaenops petrimaris* sp. n. **(a)**, *A. rumijaensis* **(b)**, and *A. kevser* **(c)** (illustrations by Fedor Čiampor).

Identification key to the species of the genus *Adriaphaenops* Noesske (for the drawings and details, see Lohaj et al. 2016)

1(6) Head almost rounded, wider 2
2(5) Head with 2 pairs of supraorbital setae 3
3(4) Clypeus with 4 pairs of setae, pronotum wider, index PL/PW 1.21, base of pronotum as wide as anterior part L: 4.65–5 mm. BiH, Hercegovina, Popovo polje ..... 9. *A. pretneri* Scheibel, 1935
4(3) Clypeus with 3 pairs of setae, pronotum narrower, index PL/PW 1.42, base of pronotum narrower than anterior part. L: 5.5 mm. BiH, Hercegovina, Nevesinje ..... 3. *A. jasminkoi* Lohaj et al., 2016
5(2) Head without supraorbital setae or these setae are indistinguishable from head pubescence L: 4.6 mm. BiH, Hercegovina, Turica, Mt Bjelašnica ..... 7. *A. perreaui* Quéinnec & Pavićević, 2008
6(1) Head elongate or parallel-sided, distinctly narrower 7
7(12) Elytra with 4 pairs of discal setae (3 dorsal and 1 preapical), only very sparsely pubescent 8
8(11) Pronotum widest in anterior third/middle. Ultimate segment of maxillar palpi distinctly shorter than penultimate 9
9(10) Pronotum widest in anterior third, distinctly narrowed anteriorly, head narrower. Aedeagus wider in lateral view, apex widely rounded (Fig. 8) L: 4.8–5.7 mm. BiH, Hercegovina, Mt Lebršnik ..... 4. *A. kevser* Quéinnec, Pavićević & Ollivier, 2008
10(9) Pronotum widest in middle, only very slightly narrowed anteriorly, head more rounded. Aedeagus narrower in lateral view, apex pointed (Fig. 7). L: 5.0–5.4 mm. Montenegro, Risan, Kameno more ..... 8. *A. petrimaris*, sp. n.
11(8) Pronotum widest in anterior fourth. Ultimate segment of maxillar palpi as long as penultimate. L: 5.05–5.4 mm. Montenegro, Mt Rumija ..... 10. *A. rumijaensis* Lohaj et al., 2016
12(7) Elytra with 3 pairs of discal setae (two dorsal and one preapical), densely pubescent 13
13(16) Head without supraorbital setae or these setae are very short, indistinguishable from head pubescence 14
14(15) Clypeus with 4 pairs of setae. Smaller species, L: 3.8 mm. Montenegro, Virpazar, Trnovo ..... 11. *A. staudacheri* Scheibel, 1939
15(14) Clypeus with three pairs of setae. Larger species L: 4.9 mm. Montenegro, Cetinje. 6. *A. njegosiensis* Lohaj et al., 2016
16(13) Head with one or two pairs of long supraorbital setae 17
17(20) Head with only posterior pair of supraorbital setae, anterior pair absent 18
18(19) Clypeus with four pairs of setae, frontal furrows longer, exceeding half length of head, anterior angles of pronotum rounded. L: 4.7–5.75 mm. Montenegro, Kučke planine Mts ..... 5. *A. mlejneki* Lohaj et al., 2016
19(18) Clypeus with three pairs of setae, frontal furrows distinctly shorter than half length of head, anterior angles of pronotum pointed. L: 4.65 mm. Albania, Shkodër, Boga ..... 1. *A. albanicus* Lohaj et al., 2016
20(17) Head with both anterior and posterior pairs of supraorbital setae 21
21(22) Clypeus with 3 pairs of setae, head wider, index HL/HW 1.10–1.15, posterior angles of pronotum protruding, acute. L: 3.5–5.1 mm. Montenegro, Mt Durmitor ..... 13. *A. zupcense* Pavićević, 1990
22(21) Clypeus with 4 pairs of setae, head narrower, index HL/HW 1.33–1.36, posterior angles of pronotum not protruding, obtuse 23
23(24) Head parallel-sided, pronotum narrower, index PL/PW 1.5, with maximum width in anterior fourth. L:4.7–4.85 mm. BiH, Hercegovina, Gacko, Mt Bjelašnica ..... 2. *A. antroherponomimus* (Noesske, 1928)
24(23) Head slightly rounded, pronotum wider, index PL/PW 1.35, with maximum width in anterior third. L: 5–5.35 mm. Montenegro, Nikšić ..... 12. *A. stirni* (Pretner, 1959)

Annotated catalogue of the genus *Adriaphaenops* Noesske

1 ***albanicus*** Lohaj, Lakota, Quéinnec, Pavićević & Čeplík, 2016: 518 (*Adriaphaenops*). Type locality: Albania, District Shkodër, V. Boga, Mts Thatë, Grotte No. 25.
Distribution: Albania, Prokletije Mts.

2 ***antroherponomimus*** Noesske, 1928: 7 (*Trechus*). Type locality: Čatol jama des Bjelasica-Gebirges (weitere Umgebung von Gacko) im nordostherzegowinischen Karstlande [= Sniježnica, Tišov krš]). Distribution: Bosnia and Hercegovina, Mt Bjelašnica near Gacko.

3 ***jasminkoi*** Lohaj, Lakota, Quéinnec, Pavićević & Čeplík, 2016: 520 (*Adriaphaenops*). Type locality: Bosnia and Hercegovina, Nevesinje, Bišina village, Novakuša (Novakova) pećina.
Distribution: Bosnia and Hercegovina, Nevesinje.

4 ***kevser*** Quéinnec, Pavićević & Ollivier, 2008: 154 (*Adriaphaenops*). Type locality: Vilina pećina, alt. 1840 m a.s.l., Lebršnik planina, eastern Hercegovina, Bosnia and Hercegovina)
Distribution: Bosnia & Hercegovina, Mt Lebršnik.

5 ***mlejneki*** Lohaj, Lakota, Quéinnec, Pavićević & Čeplík, 2016: 524 (*Adriaphaenops*). Type locality: Montenegro, Žijovo Mts, Šila Mt env., Gornje Stravče, Katun Guzovalja, 1690 m a.s.l.,

Prometheus abyss (−130 m). Other localities: Montenegro, Žijovo, Borova jama 1, Borova jama 2, Snježna jama, Milići-Miliči snježnica.
Distribution: Montenegro, Kučke planine Mts (=Žijovo Mts).

6 ***njegosiensis*** Lohaj, Lakota, Quéinnec, Pavićević & Čeplík, 2016: 526 (*Adriaphaenops*). Type locality: Cetinjska pećina, Cetinje, Montenegro. Other localities: Lovćen Mts, Štirovnik, Dvogrla jama (synonym = Kétlyukú-barlang), −130 m (T. Delić lgt., new locality).
Distribution: Montenegro, Mt Lovćen.

7 ***perreaui*** Quéinnec & Pavićević, 2008: 144 (*Adriaphaenops*) Type locality: Pećina u Mravinjac, alt. 1000 m a.s.l., Turica, Motka, Bjelašnica planina, Bosnia and Hercegovina.
Distribution: Bosnia and Hercegovina, Mt Bjelašnica near Turica, above Popovo polje.

8 ***petrimaris*** sp. n. (*Adriaphaenops*). Type locality: Montenegro, Risan, Kameno more, Velji Pištet, Pištet 4 cave (synonym = PT4) (42.55183°N, 18.73864°E).
Distribution: Montenegro, Risan, Kameno more.

9 ***pretneri*** Scheibel, 1935b: 35 (*Adriaphaenops*). Type locality: Windhohle bei Zavala, Herzegowina [= Vjetrenica pećina]. Another locality: Popovo polje, Turkovići, Žira jama (Lohaj et al. 2017).
Distribution: Bosnia and Hercegovina, Popovo polje.

10 ***rumijaensis*** Lohaj, Lakota, Quéinnec, Pavićević & Čeplík, 2016: 522 (*Adriaphaenops*). Type locality: Montenegro, Virpazar, Mt Rumija, ca 1100 m a.s.l. Phoenix (cave) (−70 m).
Distribution: Montenegro, Mt Rumija.

11 ***staudacheri*** Scheibel, 1939: 372 (*Adriaphaenops*). Type locality: in der "Grbovica", etwa 500 Meter langen Höhle am Rande des Polje von Trnovo, bei Virpazar in Montenegro [= Grbočica pećina]
Distribution: Montenegro, Virpazar.

12 ***stirni*** Pretner, 1959: 83 (*Aphaenopsis*). Type locality: Velja Peć appelatur apud Carev most in margine meridiano regionis Nikšićko polje (Respublica Montenegro)
Distribution: Montenegro, Nikšić.

13 ***zupcense zupcense*** Pavićević, 1990: 365 (*Aphaenopsis*). Type locality: Durmitor: pećina u Zupcima (Sedleni do, 1900–2000 m a.s.l.)

14 ***zupcense tartariensis*** Pavićević, 2001: 35 (*Aphaenops*). Type locality: Montenegro, Mt Durmitor, Jama na Vjetrenim Brdima ("Pit on the Windy Hills"), 2196 m a.s.l. (entrance).
Distribution: Montenegro, Mt Durmitor.

Discussion

The vast landscape of the Dinaric Karst is characterized by the existence of numerous karstic fields and mountain ridges reaching well above 2000 m a.s.l. While most of the lowland areas, including most of the karstic fields, were intensively sampled already in the early days of speleobiology, high mountainous areas received far less attention, mostly due to their physical remoteness and the challenging logistical demands intrinsic to their exploration. However, in the last 25 years many new beetle species and even genera have been found and described from such areas (Monguzzi 1993, Casale et al. 2012, Lohaj et al. 2016). Their discovery was largely dependent on the improvements of caving techniques, which enabled speleological surveys and speleobiological sampling in the deep vadose caves of the Dinaric Karst that reach a maximum depth of 1471 m (Lukina jama–Trojama system, Nothern Velebit, Croatia) (Bakšić et al. 2013).

Sixteen of 30 Dinaric aphaenopsoid trechines, including those described here, were discovered in vertical pits. Moreover, if we consider only those species discovered after 1980, 16 of 23 species (70%) were discovered in caves where vertical caving equipment is needed. The rest were predominantly discovered in remote and hardly accessible karstic areas, while only a few of them were found after systematic sampling of already known caves. Along with the aphaenopsoid trechine beetles discovered throughout the Dinaric Karst, new species and genera of Cholevinae were also discovered. Some genera include morphologically and ecologically specialized hygropetricolous Cholevinae: *Radziella* Casale & Jalžić, 1988; *Tartariella* Nonveiller & Pavićević, 1999; *Croatodirus* Casale, Giachino & Jalžić, 2000; *Nauticiella* Moravec & Mlejnek, 2002; *Velebitodromus* Casale, Giachino & Jalžić, 2004 and *Kircheria* Giachino & Vailati, 2006. All of these filter-feeding genera are dependent on the constant influx of percolating waters in the vadose zone, which enables functioning of the cave hygropetric (Sket 2004, Giachino and Vailati 2006).

Genera morphologically similar to the Dinaric aphaenopsoid trechines are also found among subterranean trechines distributed in the Alps or Pyrenees (Faille et al. 2013). Common morphology of these genera is characterized by elongated appendages, head, and a pronotum, with ovoid and basally strongly narrowed elytra, which are wider than the head or pronotum. Such morphological characteristics are present also in other groups of Balkan, American, and Asian specialized Carabidae (Gómez et al. 2016, Luo et al. 2018, Vrbica et al. 2018) and are probably a consequence of directional selection driving the convergent evolution of elaborated traits in the subterranean fauna. However, such morphological derivations still lack a proper evolutionary or functional explanation (but see Luo et al. 2018).

Representatives of the Dinaric aphaenopsoid trechines are generally hard to find, inaccessible, and mostly known from a few individuals caught by hand or, as in several cases, "accidentally" by long-term pitfall trapping. The only exceptions to this rule are representatives of the genera *Acheroniotes* (Lohaj and Lakota 2012) and *Dalmataphaenops* (our own unpublished data). The lat-

ter genera are known to locally form large populations. Although the Dinaric aphaenopsoid trechines are often considered to be specialized predators (Quéinnec 2008), little is known about their biology or their role in the subterranean communities. Moreover, as they are not prone to pit-fall trapping, most of our knowledge on their biology and behavior is based on scarce field observations. At present, we are not aware of their phylogenetic relations and biogeography or evolutionary trends, as only several samples of Dinaric taxa were included into phylogenetic analyses on the continental scale (Faille et al. 2013). Some of the genera, like *Scotoplanetes* (Lakota et al. 2010), and the species of *Derossiella* described above, have elongate legs and claws. Also, when compared to other aphaenopsoid genera in the Dinaric Karst, these genera are characterized by thin integument (Quéinnec 2008). These characters can to some extent be connected with specialization to the habitat these animals most probably live in. Most representatives of these genera, including the specimens described here as *D. lukici* sp. n., were collected directly from 'moonmilk' or the cave hygropetric (Lakota et al. 2010, our data). Such morphological adaptations offer possibilities to hypothesize the adaptive value of these characters to predation on specialized taxa found in the cave hygropetric (hygropetricolous beetles, springtails, leeches, and crustaceans). Unfortunately, such hypotheses remain untested as most of the specimens were preserved in low concentration ethanol or even vinegar, causing degradation of DNA material and minimizing the possibilities for later DNA isolation of the gut content.

Another interesting hypothesis to be tested is the adaptive value of divergent morphological characters, as *Derossiella* and *Adriaphaenops* are known to exist in sympatry with other specialized aphaenopsoid trechines, *Dalmataphaenops* and *Scotoplanetes*, respectively. This raises the question of niche differentiation among the specialized subterranean beetles, similarly to what was already shown in other subterranean taxa (Trontelj et al. 2012, Vergnon et al. 2013). However, with the extremely low number of specimens and the already mentioned lack of a phylogenetic context for the Dinaric aphaenopsoid trechines we are unable to place such hypotheses in their proper evolutionary context. Although data on the Dinaric aphaenopsoid trechines are lacking, only the publication of all known data will enable recognition of the distributional patterns of the group, the mechanisms underlying these patterns, general biology of the taxa, and the potential need to employ suitable conservation policies.

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References

Adamson KR, Woodward JC, Hughes PD (2014) Glaciers and rivers: Pleistocene uncoupling in a Mediterranean mountain karst. Quaternary Science Reviews 94: 28–43. https://doi.org/10.1016/j.quascirev.2014.04.016

Bakšić D, Paar D, Stroj A, Lacković D (2013) Northern Velebit Deep Caves. 16th International Congress of Speeleology, Proceedings. Czech Speleological Society and UIS, Brno, 24–29. http://digre.pmf.unizg.hr/960/

Bellafiore D, Guarnieri A, Grill F, Penna P, Bortoluzzi G, Giglio F, Pinardi N (2011) Study of the hydrodynamical processes in the Boka Kotorska Bay with a finite element model. Dynamics of Atmospheres and Oceans 52: 298–321. https://doi.org/10.1016/j.dynatmoce.2011.03.005

Belousov IA (2017) Trechini. In: Löbl I, Löbl D (Eds) Catalogue of Palearctic Coleoptera, Vol. 1, Archostemata–Myxophaga–Adephaga. Revised and Updated Edition. Brill, Leiden/Boston, 357–455.

Binding CJ (2010) Expedition to the Kameno more region, Montenegro, 2009: the exploration of cave Pištet 4. Proceedings of the University of Bristol Spelaeological Society 25(1): 35–46. http://www.ubss.org.uk/resources/proceedings/vol25/UBSS_Proc_25_1_35-46.pdf

Binding CJ (2011) 2010 expedition to the Kameno more region, Montenegro_ Further exploration in the cave Pištet 4. Proceedings of the University of Bristol Spelaeological Society 25(2): 125–131. http://www.ubss.org.uk/resources/proceedings/vol25/UBSS_Proc_25_2_125-131.pdf

Bonacci O (2015) Karst hydrogeology/hydrology of Dinaric chain and isles. Environmental Earth Sciences 74: 37–55. https://doi.org/10.1007/s12665-014-3677-8

Bregović P, Delić T, Jalžić B (2015) Doprinos poznavanju rasprostranjenosti rijetke faune podzemnih kornjaša Biokova i ponovno istraživanje Pretnerove jame. Subterranea Croatica 19: 40–49.

Bregović P, Zagmajster M (2016) Understanding hotspots within a global hotspot – identifying the drivers of regional species richness patterns in terrestrial subterranean habitats. Insect Conservation and Diversity 9: 268–281. https://doi.org/10.1111/icad.12164

Casale A, Guéorguiev VB (1994) *Albanotrechus beroni*, nuovo genere, nuova specie di Trechini cavernicoli di Albania (Coleoptera, Carabidae). Bolletino del Museo regionale di Scienze naturali di Torino 12(2): 413–423. https://eurekamag.com/research/029/951/029951274.php

Casale A, Jalžić B (1999) *Croatotrechus* (new genus) *tvrtkovici* n. sp., a new species of eyeless trechine beetle from Gorski Kotar (Coleoptera, Carabidae, Trechini). Natura Croatica 8(2): 137–145. https://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=89031

Casale A, Jalžić B, Lohaj R, Mlejnek R (2012) Two new highly specialised subterranean beetles from the Velebit massif (Croatia): *Velebitaphaenops* (new genus) *giganteus* Casale & Jažić, new species (Coleoptera: Carabidae: Trechini) and *Velebitodromus ozrenlukici* Lohaj, Mlejnek & Jalžić, new species. Natura Croatica 21: 129–153. https://hrcak.srce.hr/index.php?id_clanak_jezik=123957&show=clanak

Casale A, Laneyrie R (1982) Trechodinae et Trechinae du monde. Tableau des sous-familles, tribus, series phyllétiques, génrés et catalogue general des espèces. Mémoires de Biospéologie 9: 1–228.

Culver DC, Deharveng L, Bedos A, Lewis JJ, Madden M, Reddell JR, Sket B, Trontelj P, White D (2006) The mid-latitude biodiversity ridge in terrestrial cave fauna. Ecography 29: 120–128. https://doi.org/10.1111/j.2005.0906-7590.04435.x

Culver DC, Pipan T (2009) The Biology of Caves and Other Subterranean habitats. Oxford University Press, New York, 272 pp.

Ćurćić S, Pavićević D, Vesović N, Marković Đ, Petković M, Bosco F, Kuraica M, Nešić D (2018) First report of aphaenopsoid trechines (Coleoptera: Carabidae: Trechini) from Serbia, with descriptions of new taxa. Zootaxa 4425(2): 311–326. https://doi.org/10.11646/zootaxa.4425.2.7

Ducić V, Luković J, Burić D, Stanojević G, Mustafić S (2012) Precipitation extremes in the wettest Mediterranean region (Krivošije) and associated atmospheric circulation types. Natural Hazards and Earth System Science 12: 687–697. https://doi.org/10.5194/nhess-12-687-2012

Faille A, Casale A, Balke M, Ribera I (2013) A molecular phylogeny of Alpine subterranean Trechini (Coleoptera: Carabidae). BMC Evolutionary Biology 13: 248. https://doi.org/10.1186/1471-2148-13-248

Gams I (2004) Kras v Sloveniji v prostoru in času. Inštitut za raziskovanje Krasa, Postojna, 515 pp.

Giachino PM, Vailati D (2006) *Kircheria beroni*, a new genus and new species of subterranean hygropetricolous Leptodirinae from Albania (Coleoptera, Cholevidae). Subterranean Biology 4: 103–116. https://eurekamag.com/research/022/891/022891268.php

Gibert J, Deharveng L (2002) Subterranean ecosystems: a truncated functional biodiversity. BioScience 52: 473–481. https://doi.org/10.1641/0006-3568(2002)052[0473:SEATFB]2.0.CO;2

Gómez RA, Reddell J, Will K, Moore W (2016) Up high and down low: molecular systematics and insight into the diversification of the ground beetle genus *Rhadine* LeConte. Molecular Phylogenetics and Evolution 98: 161–175. https://doi.org/10.1016/j.ympev.2016.01.018

Hughes PD, Woodward JC, van Calsteren PC, Thomas LE (2011) The glacial history of the Dinaric Alps, Montenegro. Quaternary Science Reviews 30: 3393–3412. https://doi.org/10.1016/j.quascirev.2011.08.016

Jalžić B (1993) *Biokovoaphaenopsis* (new genus) *radici* n. sp. A new troglobiotic trechinae (Coleoptera, Carabidae) from Dinaric karst region of Croatia (Dalmatia). Spelaeologia Croatica 4: 73–78.

Jalžić B, Bedek J, Bilandžija H, Bregović P, Cvitanović H, Čuković T, Ćukušić A, 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 II. Croatian Biospeleological Society, Zagreb, 238 pp.

Jeannel R (1928) Monographie des Trechinae (troisième livraison). Société entomologique de France, Paris, 808 pp.

Korbar T (2009) Orogenic evolution of the External Dinarides in the NE Adriatic region: a model constrained by tectonostratigraphy of Upper Cretaceous to Paleogene carbonates. Earth-Science Reviews 96: 296–312. https://doi.org/10.1016/j.earscirev.2009.07.004

Kuhta M, Brkić Ž, Stroj A (2012) Hydrodynamic characteristics of Mt. Biokovo foothill springs in Croatia. Geologia Croatica 65: 41–51. https://doi.org/10.4154/gc.2012.03

Lakota J, Lohaj R, Dunay G (2010) Taxonomical and ecological notes on the genus *Scotoplanetes* Absolon, with the description of a new species from Montenegro (Coleoptera: Carabidae: Trechini). Natura Croatica 19: 99–110. ttps://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=82796

Lohaj R, Jalžić B (2009) *Minosaphaenops croaticus*, a new species of the cave dwelling Trechinae beetle from Croatia, with description of the male specimen of *Derossiella nonveilleri* Quéinnec (Coleoptera: Carabidae: Trechinae). Natura Croatica 18(2): 229–242. https://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=70102

Lohaj R, Lakota J (2010) Two new genera and species of aphaenopsoid cave-dwelling Trechini beetles from Croatia and Montenegro (Coleoptera: Carabidae: Trechinae). Natura Croatica 19(1): 77–97. https://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=82812

Lohaj R, Lakota J, Quéinnec E, Pavićević D, Čeplík D (2016) Study on *Adriaphaenops* Noesske with the description of five new species from the Dinarides (Coleoptera:Carabidae: Trechini). Zootaxa 4205(6): 501–531. https://doi.org/10.11646/zootaxa.4205.6.1

Lohaj R, Mlejnek R (2012) A new species of the genus *Acheroniotes* Lohaj & Lakota, 2010 from Ljubišnja Mts., Bosnia & Herzegovina (Coleoptera: Carabidae: Trechinae). Natura Croatica 21(1): 155–163. https://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=124037

Luo XZ, Wipfler B, Ribera I, Liang HB, Tian MY, Ge SQ, Beutel RG (2018) The cephalic morphology of free-living and cave-dwelling species of trechine ground beetles from China (Coleoptera, Carabidae). Organisms Diversity & Evolution 18: 125–142. https://doi.org/10.1007/s13127-017-0351-5

Moldovan O (2012) Beetles. In: White WB, Culver DC (Eds) Encyclopedia of Caves. Academic Press, Amsterdam, 54–62. https://doi.org/10.1016/B978-0-12-383832-2.00008-6

Monguzzi R (1993) *Dalmataphaenops* (n. gen.) *chiarae* (n. sp.) nuovo eccezionale Trechino troglobio della regione Dinarica e considerazioni sul genere *Aphaenopsis* G. Müller, 1913. Natura Bresciana, Annali del Museo civile di Scienze naturali di Brescia 28: 231–242. http://sito.comune.brescia.it/servizi/arteculturaeturismo/museoscienze/Documents/1992_28_231-242_Monguzzi.pdf

Noesske O (1928) *Adriaphaenops* nov. subg. *antroherponomimus* nov. spec., eine neue Form der blinden Trechen aus der Herzegowina. (Anhang: Systematisch-phylogenetische und morphologische Studien and den cavernicolen Trechen.). Coleopterologisches Centralblatt 3: 4–19.

Ozimec R, Lučić I (2009) The Vjetrenica cave (Bosnia & Herzegovina) – one of the world's most prominent biodiversity hotspots for cave-dwelling fauna. Subterranean Niology 7: 17–23.

Pavićević D (1990) *Aphaenopsis* (*Adriaphaenops*) *zupcense* sp.nov. (Coleoptera, Carabidae, Trechinae). In: Nonveiller G (Ed.) Fauna of Durmitor, Vol. 3. The Montenegrin Academy of Sciences and Arts, Titograd, 355–362.

Pavićević D (2001) A new subspecies of *Aphaenopsis* (*Adriaphaenops*) *zupcense* Pavićević, 1990 from Durmitor, Montenegro. (Coleoptera, Carabidae, Trechinae). Acta Entomologica Serbica 6(1/2): 33–36.

Perreau M, Pavićević D (2008) The genus *Hadesia* Müller, 1911 and the phylogeny of Anthroherponina (Coleoptera, Leiodidae, Cholevinae, Leptodirini). In: Pavićević D, Perreau M (Eds) Advances in the Studies of the Fauna of the Balkan Peninsula. Institute for Nature Conservation of Serbia, Belgrade, 215–239.

Polak S (2005) Importance of discovery of the first cave beetle *Leptodirus hochenwartii* Schmidt, 1832. Endins: publicació d'espeleologia 28: 71–80. https://www.raco.cat/index.php/Endins/article/view/122550/169676

Pretner E (1959) Doneski k poznavanju rodu *Aphaenopsis* J. Müller (Coleoptera, Trechinae). Poročila – Acta carsologica 2: 79–95.

Quéinnec E (2008) Two new genera and species of 'aphaenopsid' cave beetles from the Balkan Peninsula and considerations about the evolutionary trends of the so-called "hyper-specialised" trechines. In: Pavićević D, Perreau M (Eds) Advances in the Studies of the Fauna of the Balkan Peninsula. Institute for Nature Conservation of Serbia, Belgrade, 157–176.

Quéinnec E, Pavićević D (2008) A new species of cave-dwelling trechine from the eastern Hercegovina karst (Coleoptera, Carabidae, Trechinae). In: Pavićević D, Perreau M (Eds) Advances in the Studies of the Fauna of the Balkan Peninsula. Institute for Nature Conservation of Serbia, Belgrade, 143–151.

Quéinnec E, Pavićević D, Ollivier E (2008) Preliminary description of a new *Adriaphaenops* from Lebršnik Mountain (Hercegovina, BiH) (Coleoptera, Carabidae, Trechinae). In: Pavićević D, Perreau M (Eds) Advances in the Studies of the Fauna of the Balkan Peninsula. Institute for Nature Conservation of Serbia, Belgrade, 154–156.

Ranković S (1961) Srednja količina padavina za godinu, period 1931–1960. Zbirka Atlas klime Jugoslavije. Hidrometeorološka služba SFR Jugoslavije, Beograd.

Scheibel O (1935) Ein neuer *Adriaphaenops* und ein neuer *Pterostichus* aus Jugoslawien. Coleopterologische Rundschau 21: 34–38.

Sket B (2004) The cave hygropetric – a little known habitat and its inhabitants. Archiv für Hydrobiologie 160: 413–425. https://doi.org/10.1127/0003-9136/2004/0160-0413

Sket B, Paragamian K, Trontelj P (2004) A census of the obligate subterranean fauna of the Balkan Peninsula. In: Griffiths HI, Kryštufek B, Reed JM (Eds) Balkan Biodiversity: Pattern and Process in the European Hotspot. Kluwer Academic Publishers, Dordrecht, 309–322. ttps://doi.org/10.1007/978-1-4020-2854-0_18

Sket B (2012) Diversity patterns in the Dinaric karst. In: White WB, Culver DC (Eds) Encyclopedia of Caves. Academic press, Amsterdam, 228–238. https://doi.org/10.1016/B978-0-12-383832-2.00031-1

Sudar V, Kuharić N, Bregović P, Kirin A (2017) Prva biospeleološka ekspedicija – Biokovo 2017. Subterranea Croatica 23: 2–20. https://hrcak.srce.hr/197109

Trontelj P, Blejec A, Fišer C (2012) Ecomorphological convergence of cave communities. Evolution 66: 3852–3865. https://doi.org/10.1111/j.1558-5646.2012.01734.x

Velić J, Velić I, Kljajo D, Protrka K, Škrabić H, Špoljar Z (2017) A geological overview of glacial accumulation and erosional occurrences at the Velebit and the Biokovo Mts., Croatia. Rudarsko-geološko-naftni zbornik 32: 77–96. https://doi.org/10.17794/rgn.2017.4.8

Vergnon R, Leijs R, van Nes EH, Scheffer M (2013) Repeated parallel evolution reveals limiting similarity in subterranean diving beetles. The American Naturalist 182: 67–75. https://doi.org/10.1086/670589

Vlahović I, Tišljar J, Velić I, Matičec D (2005) Evolution of the Adriatic Carbonate Platform. Palaeogeography, Palaeoclimatology, Palaeoecology 220: 333–360. https://doi.org/10.1016/j.palaeo.2005.01.011

Vrbica M, Petrović A, Pantelić A, Krmpot A, Rabasović M, Pavlović D, Jovanić S, Guéorguiev B, Goranov S, Vesović N, Antić D, Marković Đ, Petković M, Stanisavljević Lj, Ćurčić S (2018) The genus *Pheggomisetes* Knirsch, 1923 (Coleoptera: Carabidae: Trechinae) in Serbia: taxonomy, morphology and molecular phylogeny. Zoological Journal of the Linnean Society 183(2): 347–371. https://doi.org/10.1093/zoolinnean/zlx078

Zagmajster M, Culver DC, Sket B (2008) Species richness patterns of obligate subterranean beetles (Insecta: Coleoptera) in a global biodiversity hotspot – effect of scale and sampling intensity. Diversity and Distributions 14: 95–105. https://doi.org/10.1111/j.1472-4642.2007.00423.x

Žebre M, Stepišnik U, Fabekovič G, Grlj A, Koblar S, Kodelja B, Pajk V, Štefanić K (2013) Pleistocenska poledenitev Biokova. Dela 39: 141–155. https://doi.org/10.4312/dela.39.8.141-155