New subterranean freshwater gastropod species from Montenegro (Mollusca, Gastropoda, Moitessieriidae, and Hydrobiidae)

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Abstract
During the field trips to Bosnia & Herzegovina and Montenegro in the years 2015 - 2018 we investigated the subterranean freshwater gastropod fauna in several karst springs. Five subterranean gastropod species new to science had been recorded within the collected material. Three of the new species are assigned to the family Moitessieriidae: *Paladilhiopsis cattaroensis* n. sp., *Paladilhiopsis matejkoi* n. sp., *Bosnidilhia vitojaensis* n. sp. and two to the family Hydrobiidae: *Plagigeyeria feheri* n. sp. and *Stygobium hercegnoviensis* n. sp., the latter in the new genus *Stygobium*.

Key words: stygobiont, spring, interstitial, *Paladilhiopsis*, *Bosnidilhia*, *Plagigeyeria*.

Introduction
The subterranean (hypogean) freshwater (stygobiont or phreatic) molluscan fauna of the Dinaride Alps represents the most rich subterranean species assemblages hitherto known in Europe (Radoman 1983, Bole and Velkovrh 1986, Kabat and Hershler 1993, Sket 2008) but worldwide (Culver 2012). The territory hosts more than 130 recorded underground freshwater gastropod taxa, which is almost half of the worldwide fauna (Sket 2012). The presence of three underground bivalve species of the relictual genus *Congeria* is also noteworthy (Bilandžija et al. 2013). The extremely high underground biodiversity is not surprising, as the Dinaric Alps have a somewhat isolated natural history (Sket 2012). This mountain chain, also called the Dinarides, extends from the foot of the Julian Alps in Slovenia 645 km southeast to the Valley of White Drin River, north of the Šarplanina-Korab massif at the border of Albania and Kosovo. Most of the range consists of well-karstified Mesozoic and Cenozoic carbonate formations with extraordinarily developed and isolated aquifers with hypogean water circulation. Rainwater disappears into many sinkholes (dolines) and swallow holes (ponors) in the foothills and at elevated enclosed mountain basins (poljes) with their own springs and swallow holes and with occasional flooding episodes. The concentrated underground water streams form
Numerous large, mainly unexplored cave systems and emerge on the surface in a remarkable number of large and impressive karst river outlets such as the Soča, Slunjčica, Krušnica, Klokot, Ostrožica, Bastaša, Sana, Sanica, Krka, Zrmanja, Pliva, Una, Dabar, Livno, Sturba, Bosna, Buna, Bunicia, Jadro, Cetina, Grab, Rumin, Ruda, Zaton, Trebišnjica, Čepelica, Sušica, Bregava, Tihajlina, Vrioštica, Studenćica, Lištica, Ombla, Zaton, Plat, Ljuta, Risan, Obod, Zeta, Karuč, Vitoja, Shegan, Shoshan, Vrukut, Vau i Dejes, Prekal, Krumč, Drin i Bardhit, and Istok along the entire range. The remarkable variability of the underground habitats and microhabitats host an extraordinary level of stygobiont invertebrate biodiversity (Bernasconi and Riedel 1994, Sket 2008, Pešić et al. 2018), including the highest recorded biodiversity of stygobiont molluscan species worldwide (Sket 2012). This exciting and hidden biodiversity has been the focus of researchers within the past and recent decades yielding an ever-increasing number of species (Schütt 1959, 1960, 1961, 1972, Reischütz and Reischütz 2008; Pešić and Glöer 2012, 2013a and 2013b; Boeters et al. 2013, 2014; Glöer and Pešić 2014a, b, Glöer and Grego 2015; Glöer et al. 2015; Reischütz et al. 2013, 2014 and 2016; Beran et al. 2014, 2016; Grego et al. 2016, 2018; Rysiewska et al. 2017; Osikowski 2017)

Material and Methods

The studied material was collected during field trips in Hercegovina and Montenegro in the years 2015 - 2018 (Fig. 1). Various spring outflows and karstic springs were sampled (Fig. 2). Microhabitat preference and sampling methods were employed as described by Grego et al. (2017). Samples of fine sand were screened while wet under a stereomicroscope for live animals. Then the samples were dried and screened again for dry shells that might have been overlooked. Frontal and lateral view images were taken with a Nikon SMZ25 microscope with Nikon D200 camera and an AF-S Micro NIKKOR 60 mm lens, and ImageJ scientific image analysing software was used to take measurements. Measurements were also obtained using an eyepiece micrometer.

DNA was extracted from foot tissue using a Sherlock extraction kit (A&A Biotechnology) and dissolved in 20 ml of tris-EDTA buffer. We used two molecular markers: mitochondrial cytochrome oxidase subunit 1 (COI) and nuclear histone 3 (H3). Details of PCR conditions, primers used, and sequencing were given in Szarowska et al. (2016). Sequences were initially aligned in the MUSCLE (Edgar 2004) program in MEGA 6 (Tamura et al. 2013) and then checked in Bioedit 7.1.3.0 (Hall 1999). The saturation test (Xia et al. 2003) was performed using DAMBE (Xia 2013). In a phylogenetic analysis additional sequences from GenBank were used as a reference (Table 1). The data were analysed using approaches based on Bayesian inference (BI) and maximum likelihood (ML). We applied the GTR model, parameters of which were estimated by the RaxML (Stamatakis 2014). The Bayesian analyses were run using MrBayes v. 3.2.3 (Ronquist et al. 2012) with default priors. Two simultaneous analyses were performed, each with 10,000,000 generations, with one cold chain and three heated chains, starting from random trees and sampling the trees every 1,000 generations. The first 25% of the trees were discarded as burn-in. The analyses were summarized as a 50% majority-rule tree. The ML approach was applied with RAxML v. 8.0.24 (Stamatakis 2014). One thousand searches were started with initial trees obtained using the randomised stepwise addition maximum parsimony method. Bootstrap support was calculated with 1,000 replicates and summarized on the best ML tree. RAxML analyses were performed using the free computational resource CIPRES Science Gateway (Miller et al. 2010).

Abbreviations

NHMUK Natural History Museum London, UK
HNHM Hungarian Natural History Museum, Budapest, Hungary
NHMW Naturhistorisches Museum Wien, Austria
OSUM Ohio State University Museum of Biological Diversity, Columbus, Ohio, USA
CNHM Croatian Natural History Museum, Zagreb, Croatia
SMF Senckenberg Museum, Frankfurt, Germany
NMBE Naturhistorisches Museum, Bern, Switzerland
FMNH Field Museum, Chicago, USA
FLMNH Florida Museum of Natural History, Gainesville, USA
MZUSP Museum de Zoologia da Universidade de São Paulo, Brazil
RHMN Naturalis Biodiversity Center, Leiden
Figure 1. Type localities (LT) of the new species (red dots) and faunistical records mentioned in this paper (blue dots): 1. Herceg Novi, Nemila (LT of Paladilhiopsis matejkoi n. sp.); 2. Herceg Novi- Meljine Hospital (LT of Stygobium hercegnoviensis n. sp. and Plagigeyeria feheri n. sp.); 3. Herceg Novi, Zelenika - Kuti (S. hercegnoviensis n. sp. and LT of Paladilhiopsis cattaroensis n. sp.); 4. Herceg Novi, Trebesinj (S. hercegnoviensis n. sp.); 5. Herceg Novi, Suščepan (S. hercegnoviensis n. sp.); 6. Vitoja (LT of Bosnidilhia vijoaensis n. sp.); 7: Bileća, Trebinjčica, (LT of Saxurinator montenegrinus); 8. Risan, Velika Špilja (Paladilhiopsis cf. matejkoi and LT of Plagigeyeria pageti forma minor).
Tab. 1. Taxa used for phylogenetic analyses with their GenBank accession numbers and references.

| Species | COI/H3 GB numbers | References |
|---------|------------------|------------|
| Agrafia wiktori Szarowska & Falniowski, 2011 | JF906762/MG543158 | Szarowska & Falniowski (2011)/Grego et al. (2017a) |
| Alzoniella finalina Giusti & Bodon, 1984 | AF367650 | Wilke et al. (2001) |
| Anagnostina zetaavlis (Radoman, 1973) | EF070616 | Szarowska (2006) |
| Avenitia brevis berengueri (Draparnaud, 1805) | AF367638 | Wilke et al.(2001) |
| Belgrandiella cf. kusceri (Wagner, 1914) | KT218511/MG551366 | Falniowski & Beran (2015)/Oskowski et al. (2018) |
| Bithynia tentaculata (Linnaeus, 1758) | AF367643 | Wilke et al. (2001) |
| Bythinia austriaca (von Frauenfeld, 1857) | JQ639858 | Falniowski et al. (2012b) |
| Bythinia micherdzinskii Falniowski, 1980 | JQ639854 | Falniowski et al. (2012b) |
| Bythospium acicula (Hartmann, 1821) | KU341350/xxxxxx | Richling et al. (2017)/Falniowski et al. (in press) |
| Dalmatinella flaviatilis Radoman, 1973 | KC344541 | Falniowski & Szarowska (2013) |
| Daphniola louisi Falniowski & Szarowska, 2000 | KM887915 | Szarowska et al. (2014a) |
| Emmericia expansilabris Bourguignat, 1880 | KC810060 | Szarowska & Falniowski (2013a) |
| Fissuria boui Boeters, 1981 | AF367654 | Wilke et al. (2001) |
| Graziana alpestris (Frauenfeld, 1863) | AF367641 | Wilke et al. (2001) |
| Grossuana codreamnui (Grossu, 1946) | EF061919 | Szarowska et al. (2007) |
| Hauffenia michleri Kuščer, 1932 | -/KY087878 | Rysiewska et al. (2017) |
| Heleobia maltzani (Westerlund, 1886) | KM213723/xxxxxx | Szarowska et al. (2014b)/Falniowski et al. in press |
| Horatia klecakiana Bourguignat, 1887 | KJ159128 | Falniowski & Szarowska (2014) |
| Iglica cf. gracilis (Clessin, 1882) | MH720989/MH721004 | Hofman et al. (2018) |
| Iglica cf. hauffeni (Brusina, 1886) | -/MH720995 | Hofman et al. (2018) |
| Iglica cf. forumjuliana (Pollonera, 1887) | -/MH721006 | Hofman et al. (2018) |
| Iglica helenica Falniowski & Sarbu, 2015 | KT825581/MH721007 | Falniowski & Sarbu (2015)/Hofman et al. (2018) |
| Islamia zermanica (Radoman, 1973) | KU662362/MG551320 | Beran et al. (2016)/Grego et al. (2017a) |
| Lithoglyphus prasinus (Küster, 1852) | JX073651 | Falniowski & Szarowska (2012) |
| Littorina littorea (Linnaeus, 1758) | KF644330/KP113574 | Layton et al. (2014)/Neretina (2014), unpublished |
| Marstoniopsis insubrica (Küster, 1853) | AF322408 | Falniowski & Wilke (2001) |
| Moitessieria cf. puteana (Coutagne, 1883) | AF367635/MH721012 | Wilke et al. (2001)/Hofman et al. (2018) |
| Montenegroesperum bogici (Pešić & Glöer, 2012) | KM875510/MG880218 | Falniowski et al. (2014)/Grego et al. (2018) |
| Paladiophis bosniaca (Clessin, 1910) | -/MH721020 | Hofman et al. (2018) |
| Paladiophis bosnica Bole, 1970 | -/MH721021 | Hofman et al. (2018) |
| Paladiophis grobbeni Kušcer, 1928 | MH720991/- | Hofman et al. (2018) |
| Paladiophis turrita (Kuščer, 1933) | MH720992/MH721015 | Hofman et al. (2018) |
| Paladiophis gittenbergeri (A. Reischütz & P. L. Reischütz, 2008) | MH720993/MH721025 | Hofman et al. (2018) |
| Pontobelgrandiella sp. | KU497024/MG551321 | Rysiewska et al. (2016)/Grego et al. (2017a) |
| Pseudamnicola sp. | -/KT710579 | Szarowska et al. (2016) |
| Radomaniola curta (Küster, 1853) | KC011814 | Falniowski et al. (2012a) |
| Sadleriana fluminensis (Küster, 1853) | KF193067 | Szarowska & Falniowski (2013b) |
| Tanousia zrmaniae (Brusina, 1866) | KU041812 | Beran et al. (2015) |
| Ecrobia maritima (Milaschewitsch, 1916) | -/MG551322 | Grego et al. (2017a) |
Figure 2. Photographs of studied localities: A. Montenegro: Herceg Novi, Meljine Hospital (*Stygobium hercegnowiensis* n. sp., *Plagigeyeria feheri* n. sp); B. Montenegro: Herceg Novi, Trebesinj (*S. hercegnowiensis* n. sp.); C. Montenegro: Herceg Novi, Sušćepan, Izvor Vostanj (*S. hercegnowiensis* n. sp.); D. Montenegro: Kotor Bay with Risan, arrow. Velika Špilja (*Plagigeyeria pageti forma minor*, Schütt, 1961); E. Montenegro, Herceg Novi, Nemila (*S. hercegnowiensis* n. sp., *Paladilhiospis matejkoi* n. sp.); F. Montenegro: Izvor Vitoja (*Bosnidilhia vitojaensis* n. sp.). (photo’s: Jozef Grego and Maroš Grego).
Results

Superfamily Truncatelloidea Gray, 1840

Family Moitessieriidae Bourguignat, 1863

Genus Paladilhiopsis Pavlović, 1913
Type species: Paladilhia robiciana Clessin, 1882

Figures 3-8. Discussed species of the genus Paladilhiopsis, Bosnidilhia, and Stygobium: 3-4 Paladilhiopsis cattaroensis n. sp. (Holotype HNHM 103039); 5 Bosnidilhia vreloana (Holotype ZMH 79663); 6 Bosnidilhia vitojaensis n. sp. (Holotype HNHM 103041); 7-8 Stygobium hercegnoviensis n. sp. (Holotype HNHM 103037) (photo's: Peter Glöer, Jozef Grego)

Paladilhiopsis cattaroensis Grego and Glöer, n. sp.
(Figs 3-4)

Type locality
Montenegro: Herceg Novi, Zelenika - Kuti, side rivulet of Opaćica, spring from well behind last house, 42.462747°N, 18.587347°E, (Fig. 2E).

Type material
Holotype, Type locality, J. Grego and Z. P. Erőss leg., 25.07.2016 (HNHM 103039).

Measurements
Holotype: H 2.0 mm; W 0.83 mm; BH 1.13 mm; BW 0.73 mm; AH 0.63 mm; AW 0.49 mm.

Etymology
Named after its type locality situated in the northern part of Kotor (Cattaro) Bay.

Description
Two mm high fragile shell, yellowish corneous, translucent with five convex whorls separated by deep suture. The surface smooth and shiny. Shell elongate, oval-conical, slightly tapering towards semi-blunt apex. Umbilicus closed. Aperture asymmetric, tear shaped, attached to the body whorl at its upper columellar side. Peristome margin blunt, equally thick and not reflected. Outer lip not protruding beyond body whorl and frontal shell profile. Lateral profile of outer lip straight.
Differentiating features
The new species is distinguished from *Paladilhiopsis gittenbergeri* (Reischütz and Reischütz, 2008) (Vau i Dejës, Albania) by its smaller more slender shell shape with a blunter apex and proportionally much smaller aperture. *Paladilhiopsis falniowskii* (Grego et al., 2017) (Krumë, Albania) has a larger shell with proportionally larger body whorl and a larger, differently positioned aperture. It differs from syntopic *Stygobium hercegnoviensis* n. sp. by its larger, more inflated, more conical shell with a proportionally smaller apex, proportionally larger and more elongated aperture, and more tumid whorls.

Habitat
The type locality is an outlet from the stony well build some centuries ago to supply the water to adjacent gardens and houses.

Distribution
Known only from the type locality, where it was found together with the *Stygobium hercegnoviensis* n. sp. The species likely inhabits the adjacent stygobiont habitats around Zelenika basin.

Remarks
The assignment of the new species to the genus *Paladilhiopsis* is only provisional, until the molecular data become available.

Paladilhiopsis (Lanzaia) matejkoi Grego and Glöer, n. sp.
(Figs. 19–21)

Type locality
Montenegro, Herceg Novi, left side spring of Nemila rivulet, on turn of Spasića i Masare street, 42.456214°N; 18.538386°E, (Fig. 1E).

Type material
Holotype: Type locality, J. Grego leg., 26.07.2016 (HNHM 103043). Paratypes: same data (NHMW 111666/2, OSUM 42390/2, NHMUK 20180025/2, SMF 349440/2, CNHM 11480/2; FMNH 384780/2, NMBE 554115/2, MNHN-IM-2014-6894/2. FLMNH UF510442/2, RMNH.MOL.290816/2, MUZSP 138303/2, coll. Glöer/1, coll. Grego/59,); same data, Z. P. Erőss and Z. Fehér leg., 17.07.2017 (HNHM 103044/64, col. ZPE/60, coll. Grego/19); 714 JG/24 HNHM 76.

Other material
A similar but smaller and smoother form had been reported by Schütt 1960 from Risan Velika Špilja cave at NE Bank of Kotor Bay (SMF 194006), erroneously assigned to *Saxurinator montenegrinus*, and could possibly represent the subspecies of *P. matejkoi* n. sp.

Measurements
Holotype: H 2.31 mm; W 1.01 mm; BH 1.17 mm; BW 0.61 mm; AH 0.75 mm; AW 0.65 mm.

Etymology
Named after Matej Grego, who participated on the discovery of new species and is the younger son of the first author.

Description
Solid elongate milky-yellowish conical shell (2.31 mm) with blunt apex and six convex whorls separated by a deep suture. Shell surface smooth and shiny with faint axial ribs. Umbilicus open, slit-like and obscured by reflected columellar margin. Aperture ovoid, attached to body whorl at its upper columellar part. Peristome blunt, reflected at columellar part. Outer lip profile weakly sinuous in lateral view and parallel to the columellar axis. In frontal view labral margin protrudes from body whorl.
Differentiating features
The morphologically and geographically closest species to *Paladilhiopsis matejkoi* n. sp. is the *Saxurinator montenegrinus* Schütt, 1959 (Hercegovina, Bileća), from which it differs by its more oval aperture, much less sinuous labral margin, more open umbilicus, and different lateral profile of anterior body whorl (Tab. 2).

The geographically close *Lanzaia edlaueri* Schütt, 1961 (Figs. 25-27) and *Lanzaia vjetrenicae* Kuščer, 1933 have more elongate shells with sinuous axial ribs and differently shaped expanded apertures.

Tab. 2 Shell morphometry comparison of *Paladilhiopsis matejkoi* n. sp. with related species and forms:

| *Paladilhiopsis* (Lanzaia) | H/W | AH/AW | W/BW | H/BH | H/AH | W/AW |
|---------------------------|-----|-------|------|------|------|------|
| Holotyp *matejkoi* n. sp. | 2.31| 1.01  | 1.17 | 0.61 | 0.75 | 0.65 |
| Genus species             |     |       |      |      |      |      |
| *Paladilhiopsis* montenegrinus | 2.30| 0.98  | 1.08 | 0.82 | 0.74 | 0.67 |
| Holotyp *montenegrinus*    |     |       |      |      |      |      |
| spring Čepo SMF 194006     | 3.06| 1.12  | 1.19 | 0.93 | 0.82 | 0.65 |
| Holotyp *matejkoi* cf. montenegrinus |     |       |      |      |      |      |
| cave Risan SMF 194006       | 1.90| 0.84  | 0.94 | 0.58 | 0.64 | 0.48 |
| Holotyp schlickumi          | 1.85| 0.91  | 0.94 | 0.70 | 0.65 | 0.55 |
| *Paladilhiopsis* cattaroensis |     |       |      |      |      |      |
| Holotyp HNHM 103039         | 2.00| 0.86  | 1.13 | 0.73 | 0.63 | 0.49 |
| Holotyp *Stygobium* herecegnoviensis |     |       |      |      |      |      |
| Holotyp HNHM 103037         | 1.65| 0.68  | 0.87 | 0.61 | 0.45 | 0.44 |

Anatomy
The penis (Fig. 9) straight, without surface protrusions, with a broad base and long and slender filament, vas deferens easily visible inside. The female reproductive organs typical of the *Paladilhiopsis* (Hofman et al. 2018), not illustrated since the specimen was not well fixed.

Molecular data
*Paladilhiopsis matejkoi* clearly belongs to the *Paladilhiopsis* clade based on COI as well as for H3 loci (Figs. 10, 11), but it is different from all the other species of *Paladilhiopsis*. It differs from other *Paladilhiopsis* species at 9.9 – 12.5% for COI and 1.6 – 6.2% for H3.

Distribution
Known only from the type locality and a spring 300 m E of type locality, where it occurs syntopically with more scarce *S. hercegnoviensis* n. sp.

The type locality is a small spring on the right bank of the Nemila rivulet. The no longer-used stony water reservoir indicates its historical importance, but even now the active well is used as a water supply to
the adjacent houses. The spring zone is covered by dense vegetation and is inhabited by *Lithhabiella chilodia* (Westerlund, 1886). The new stygobiont species was also found in another spring situated near the left bank of Nemila about 300 m downstream from the type locality and likely inhabits the groundwater aquifers of the whole Nemila tributary upstream to the large seasonal springs at the northern end of its valley.

**Discussion**

The shell morphology of the new species corresponds well with all members of the genus *Saxurinator* Schütt, 1972 (type species: *Paladilhiopsis buresi* Wagner, 1928), especially to the *Saxurinator montenegrinus* Schütt, 1959. However, the H3 (Fig. 10) and COI (Fig. 11) data recovered from the two specimens found alive (Fig. 10) proved the close relationships of the new species with the members of the genus *Paladilhiopsis* Pavlovic, 1913, with its position between *Paladilhiopsis* (Costellina) turrita (Kuščer, 1933), and *Paladilhiopsis gittenbergeri* (Reischütz & Reischütz, 2008) and close to *Paladilhiopsis* (Lanzaia) bosnica (Bole, 1970). Thus, the position of new species within the family Moitessieriidae and genus *Paladilhiopsis* is confirmed. We assume, that all the other West Balkan species assigned to *Saxurinator* (*S. montenegrinus* Schütt, 1959; *S. schlickumi* Schütt, 1960; *S. brandti* Schütt, 1968; *S. copiosus* (Angelov, 1972); *S. hadzi* (Bole, 1961), *S. labiatus* (Schütt, 1963); *S. microbeliscus* Schütt, 1968; *S. orthodoxus* Schütt, 1960; *S. sketi* (Bole, 1960)) will also fall within the genus *Paladilhiopsis*. For the time being we refrain from treating the genus *Saxurinator* as a junior synonym of *Paladilhiopsis*, until the status of the type species of the genus *Saxurinator*, *S. buresi* A. J. Wagner, 1928 from Bulgaria, is clarified. It is likely that the geographically isolated type species could represent an independent evolutionary lineage. Nevertheless the distinct shell morphology of *Lanzaia* Brusina, 1906, with its ribbed whorls and conspicuously sinuous labral and columellar aperture margins, would distinguish the taxa treated above from the other members of *Paladilhiopsis* at the subgenus level. The proposed subordination to subgenus would unite members of *Lanzaia* and the above-mentioned former West Balkan members of the genus *Saxurinator* under *Paladilhiopsis*. The molecular data certainly support this proposal.

![Figure 10. Maximum likelihood tree of the selected Hydrobiidae and Moitessieriidae compared to *P. matejkoi* n. sp. and *Stygobium hercegoviensis* n. sp., computed for H3; bootstrap supports given if >50% and Bayesian probabilities if >50](image-url)
NEW SUBTERRANEAN FRESHWATER GASTROPOD SPECIES FROM MONTENEGRO

Figure 11. Maximum likelihood tree of the selected Hydrobiidae and Moitessieriidae compared to *P. matejkoi* n., computed for COI; bootstrap supports given if >50% and Bayesian probabilities if >50.

**Bosnidilhia Boeters, Glöer and Pešić, 2013**
Type species: *Bosnidilhia vreloana* Boeters, Glöer & Pešić, 2013 (Fig. 5)

**Bosnidilhia vitojaensis Grego and Glöer n. sp.**
*Bosnidilhia cf. vreloana* Glöer, Grego, Erőss and Fehér, 2016 (Fig. 6)

**Type locality**
Montenegro: Podgorica municipality, Hasanoj, Izvor Vitoja, near Skadar Lake close to Albanian border pass Božaj, 10 m a.s.l., 42.325400° N; 19.362888° E.

**Type material**
Holotype: Type locality, leg. Erőss, Fehér, Grego 05.07.2015 (HNHM 103041). Paratypes: (HNHM 103041/1, coll. Glöer/1, coll. Grego/6, ZPE/3).

**Measurements**
Holotype: H 1.40 mm; W 0.59 mm; BH 0.76 mm; BW 0.48 mm; AH 0.45 mm; AW 0.42 mm.

**Etymology**
Named after type locality, the Vitoja spring in Podgorica municipality on the NE shore of Skadar Lake.

**Description**
Small (1.4 mm) fragile milky yellowish shell with four almost flat whorls with a weak suture and very blunt rounded apex. Shell surface smooth and silky. Umbilicus closed. Aperture irregular ovoid, separated from the body whorl by a tiny furrow along all the columellar side. Peristome margin blunt and very slightly reflected. Outer lip sinuous-straight and protruded from the body whorl in frontal view.
Figures 12–24. Discussed species of the genus Saxurinator (= Paladilhiopsis) and Lanzaia: 12-15 Saxurinator montenegrinus Schütt, 1959 = Paladilhiopsis (Lanzaia) montenegrinus comb. nov. (SMF 162035); 16–18 Paladilhiopsis (Lanzaia) cf. matejki n. sp. from cave Velika Špilja, Risan (SMF 194006); 19–21 Paladilhiopsis (Lanzaia) matejki n. sp. (Holotype HNHM 103043); 22–24 Holotype of Saxurinator schlickumi Schütt, 1960 = Paladilhiopsis schlickumi comb. nov. (SMF 163504); 26–28 Lazaia edlaueri Schütt, 1961 = Paladilhiopsis (Lanzaia) edlaueri comb. nov. (Holotype SMF 164353); 28-30 Paladilhiopsis (Lanzaia) cf. montenegrinus from spring Čepo in Bileća (SMF 194005); (photos: Sigrid Hof, Peter Glöer, Jozef Grego).
Differentiating features
This species can be distinguished from *Bosnidilhia vreloana* Boeters, Glöer & Pešić, 2013 (Fig. 5, Bosnia, Banja Luka) by its smaller shell (1.4 mm vs 1.9 mm), more cylindrical shell shape with blunter apex, proportionally smaller body whorl, and the different shape of the aperture, which is more expanded on its columellar aspect (Tab. 2).

### Tab. 2 Shell morphometry comparison of *B. vreloana* and *Bosnidilhia vitojaensis* n. sp.:

| Genus          | Species            | H mm | W mm | BH mm | BW mm | AH mm | AW mm | CA deg | H/W  | AH / AW | W / BW | H/BH  | H/AH  | W / AW |
|----------------|--------------------|------|------|-------|-------|-------|-------|--------|------|---------|--------|-------|-------|--------|
| *Bosnidilhia*  | *vreloana* n. sp.  | 1.90 | 0.64 | 0.89  | 0.58  | 0.51  | 0.42  | 30     | 2.97 | 1.21    | 1.10   | 2.13  | 3.73  | 1.52   |
| Holotyp        | ZMH 79663           |      |      |       |       |       |       |        |      |         |        |       |       |        |
| *Bosnidilhia*  | *vitojaensis*      | 1.40 | 0.59 | 0.76  | 0.48  | 0.45  | 0.42  | 36     | 2.37 | 1.07    | 1.23   | 1.84  | 3.11  | 1.40   |
| Holotyp        | HNHM 103041         |      |      |       |       |       |       |        |      |         |        |       |       |        |

Habitat
Vitoja Spring is located on the northeastern shore of the Skadar Lake in Montenegro, near the settlement Hasanjoj and close to the Albanian border pass Božaj on E762 Rd. It is a large karstic spring zone adjacent to the shore and consists of one main spring flowing into two joined small spring lakes with several additional sublacustrine spring zones at their bottom. In addition, five side springs of variable outflows are located within 150 m west of the main spring. During high-water conditions the whole spring zone is absorbed by the elevated level of Skadar Lake, while during the summer dry season, some of the side springs are very small or intermittent. All springs emerge at the border of the limestone massif and the alluvium of Skadar Lake and are most likely supplied from sinkholes of Skorač Polje at Kučke Planine and perhaps from ponors in the Cjievna River valley as well.

Distribution
Only known from the type locality, where it is found together with *Plagigeyeria zetaprotogona* Schütt, 1960, *Vinodolia matjasic* (Bole, 1961), *Vinodolia scutarica* (Radoman, 1973), *Lanzaia pesici* Glöer, Grego, Eröss & Fehér, 2017, *Pyrgula annulata* (Linnaeus, 1767), *Islamia montenegrina* Glöer, Grego, Eröss & Fehér, 2017 and *Bracenica vitojaensis* Glöer, Grego, Eröss & Fehér, 2017.

Remarks
The assignment of the new species to the genus *Bosnidilhia* is based only on similarities in shell morphology, and it remains provisional until the molecular data become available.

Family Hydrobiidae Stimpson, 1865

**Genus Stygobium** Grego and Glöer n. gen.
Type species *Stygobium hercegnoviensis* Grego and Glöer n. sp

**Diagnosis**
The diagnostic features of the new genus are the same as those of the type species, *Stygobium hercegnoviensis* n. sp. The main distinction vs other hydrobiid genera is in molecular H3 data, where the new genus forms a very distinct clade.

**Etymology**
Named after its stygobiont habitat.

**Stygobium hercegnoviensis** Grego and Glöer n. sp.
(Figs. 7–9)

**Type locality**
Montenegro: Herceg Novi, Savina, below Savina Monastery under Braće Grakalić street at Melinje Hospital, behind the neonatal pavilion, 42.451656°N; 18.555225°E, 16 m a.s.l. (Fig. 2A).
**Type material**
Holotype: Type locality, J. Grego leg., 26.07.2016 (HNHM 103037). Paratypes: same data (HMUK 20180026/2, SMF 349441/2, CNHM 11479/2, NMBE 554116/2, coll. Glöer/1, coll. Grego/22); same data, Z. P. Erőss and Z. Fehér leg., 16.07.2017 (HNHM 103038/73, NHMW 111665/2, Grego/6); same data, Z. P. Erőss and Z. Fehér leg., 16.07.2018 coll HNHM 115, ZPE/55 coll. Grego/55 Montenegro: Herceg Novi, right bank spring of Nemila rivulet, on turn of Spasića i Masare street, 42.456214°N; 18.538386°E, (Fig.2E), Jozef Grego leg., 26.07.2016 (coll Grego/1); same locality Z. P. Erőss and Z. Fehér leg., 16.07.2017(coll. Grego/4); 714 HNHM /4; Montenegro: Herceg Novi: Sušćepan, Izvor Vostonj above the village, 42.468768°N; 18.513022°E, (Fig.2C), Jozef Grego leg., 28.7.2016 (coll. Grego/34); Montenegro: Herceg Novi, Trebesinj, springs above the village behind Crkva St. Tome, 42.472886°N, 18.524117°E, (Fig.2B), Jozef Grego leg., 28.7.2016 (coll. Grego/20); Montenegro: Herceg Novi, Zelenika - Kuti, side rivulet of Opačica, spring behind last house, 42.462747°N, 18.587347°E, J. Grego and Z. P. Erőss leg., 25.07.2016 (coll. Grego/6).

**Measurements**
Holotype: H 1.65 mm; W 0.68 mm; BH 0.87 mm; BW 0.61 mm; AH 0.45 mm; AW 0.44 mm.

**Etymology**
Named after the type locality situated inside Herceg Novi town at north shore of Kotor Bay, Montenegro.

**Description**
Fragile milky yellowish, silky, translucent shell with 4½ convex whorls with a deep suture and a blunt apex. Shell surface smooth with very weak axial growth lines. Shell small (1.65mm), elongate, subconical, slightly tapering towards the blunt apex. Umbilicus tiny, slit like. Aperture ear-shaped, proportionally smaller than body whorl, from which separated by a weak furrow. Peristome margin sharp and not reflexed reflected. Outer lip straight in lateral view and slightly scooped backward at its anterior end. In frontal profile lip aligned with the tapering shell outline.

**Differentiating features**
According to molecular data (only H3), the new genus forms a distinct Hydrobiid clade among the Agrafia Szarowska & Falniowski, 2011, Hauffenia Pollonera, 1898, Belgranniella Wagner, 1928 and Montenegrosean Pešić & Glöer, 2013 group, with a p-distance 0.039 to 0.062. The small elongate shell of the new genus can be compared with two Albanian species provisionally treated in the family Moitessieriidae: Paladilhiopsis szerkensesi Grego et al., 2017 (Albania, Tamare) and Paladilhiopsis prekalesis Grego et al., 2017 (Albania, Prekal). From both it differs by its more slender elongated conical shell, less blunt apex, and smaller aperture, which is situated expanded more on the columnella side (Tab. 1). The availability of molecular data from the above two Paladilhiopsis species could possibly confirm their affiliation with the new genus Stygobium.

**Habitat**
The type locality is a small spring captured in a cistern with one central outlet and one leak near the neonatal building of Meljine Hospital. Few live specimens and empty shells were found in sandy sediment of the drainage channel collecting the leaked water. All the other known localities along NW coast of Kotor Bay have a similar stony cisterns with roughly-carved stone outlets collecting spring water, and the specimens were found in sediments near these outlets. Most likely, the species inhabits the underground water channels and stony water reservoirs, and only the occasionally washed-out specimens are trapped in sand beyond the water outlet.

**Distribution**
Aside from the type locality on the grounds of Meljine Hospital, the species is known in the greater vicinity of Herceg Novi on the N shore of Kotor Bay: at Sušćepan, Trebesinj, Zelenika-Kuti and two springs near the right bank of Nemila rivulet Rivulet at 18 - 320 m altitude. In the locality near Zelenika the species is found with Paladilhiopsis cattaroensis n. sp., and at Nemila with Saxurinator matejkoi n. sp. while at the type locality its syntopic with Plagigeyerta feheri n. sp.
Genus *Plagigeyeria* Tomlin, 1930  
Type species: *Geyeria plagiostoma* Wagner, 1914

**Figures 31–39.** Discussed species of the genus *Plagigeyeria*: 31–34 *Plagigeyeria pageti* forma *minor* Schütt, 1961 from cave Velika Špilja, Risan (Paratype SMF 221256); 35–38 *Plagigeyeria feheri* n. sp. (Holotype HNHM 103046); 39 *Plagigeyeria feheri* n. sp. (Paratype 1 coll. Glöer).

*Plagigeyeria feheri* Grego and Glöer n. sp.  
(Figs. 35–39)

**Type locality**  
Montenegro: Herceg Novi, Savina, below Savina Monastery under Braće Grakalić street at Meljine Hospital, behind neonatal pavilion, 42.451656°N; 18.555225°E, (Fig. 2A).

**Type material**  
Holotype: Type locality, J. Grego leg., 26.07.2016 (HNHM 103046). Paratypes: same data (col. Gloer 1, coll. Grego/8); same data, Z. P. Erőss and Z. Fehér leg., 16.07.2018 (HNHM 104183/17, coll. Grego/10, collection Erőss/10).

**Measurements**  
Holotype: H 1.50 mm; W 0.78 mm; BH 0.88 mm; BW 0.66 mm; AH 0.56 mm; AW 0.51 mm.
Etymology
Named after Hungarian malacologist and friend Zoltán Fehér, curator of the malacological collection of Hungarian Natural History Museum, Budapest to acknowledge his substantive work on the gastropod fauna of the Balkans.

Description
Shell small, 1.5 mm high, with four convex whorls separated by a deep suture, oval-elongated in shape, with blunt apex and corneous-yellowish color. Surface shiny, very finely axially ribbed, covered by small incrustation spots from precipitated calcium carbonate. Umbilicus closed. Proportionately large oval aperture with conspicuously reflected margins. Outer lip weakly sinuated sinuous at columellar margin in lateral view. Expanded labral margin protrudes from body whorl in frontal (apertural) view.

Differentiating features
This is the smallest known *Plagigeyeria* species (1.50 mm). Compared to the geographically close *Plagigeyeria zetaprotogona pageti* forma *minor* Schütt, 1961 (Montenegro, Risan) (Figs. 31–31), the new species differs by its much smaller, more slender elongated subcylindrical shape with less conspicuous axial ribbing, by the more closed umbilicus as well as by the different shape of the aperture and the weakly sinuated labral margin (Tab. 4). The overall shell shape of the new species resembles *Plagigeyeria plagiostoma* (A.J. Wagner, 1914) from Vrelo Bosne near Ilidža, but the new species differs by more small, oval and slender shell with its hidden umbilicus.

Table 4. Shell morphometry comparison of *Plagigeyeria feheri* n. sp. and *P. zetaprotogona pageti* forma *minor*:

| Plagigeyeria        | Genus species | H  | W  | BH | BW | AH | AW | CA deg. | H/W  | AH / AW | W / BW | H/BH | H/AH | W / AW |
|---------------------|---------------|----|----|----|----|----|----|---------|------|---------|--------|------|------|-------|
| Holotyp             | *feheri* n. sp. | 1.50 | 0.78 | 0.88 | 0.66 | 0.56 | 0.51 | 40      | 1.92 | 1.10     | 1.18   | 1.70 | 2.68 | 1.53  |
| Paratyp             | *z. pageti* f. *minor* | 1.90 | 1.20 | 1.11 | 0.95 | 0.89 | 0.75 | 32      | 1.58 | 1.19     | 1.26   | 1.71 | 2.13 | 1.60  |

Habitat
See *Stygobium hercegnoviensis* n. sp.

Distribution
Known only from the type locality, where it was found with the *Stygobium hercegnoviensis* n. sp.

Discussion
The majority of the new stygobiont gastropod records are still based only on empty shells washed out to epigean habitat or found in alluvial deposits (Pešić et al., 2018). Despite the increased effort and improved sampling methods during recent decades, live-collected specimens remain very scarce, and thus the understanding of their phylogeny based on molecular data has made only very slow progress (Szawrowska 2006, Falniowski et al. 2008, Beran et al. 2014 and 2016, Grego et al. 2018, Rysiewska et al. 2018, Hofman et al. 2018). The stygobiont species inhabit mostly inaccessible epigean habitats, only seldom combined with a short seasonal availability. Only few of the karst springs are associated with an accessible cave system where the stygobiont samples could be taken directly on their habitat, and frequently also such cave localities yield only empty shells indicating more hidden and remote microhabitats of the stygobiont populations. Obtaining sufficient amounts of live specimens (enough for molecular and anatomical studies of male and female reproductive organs, as well as other soft parts morphology) is still more dependent on luck than on a systematic approach. We can confirm that the chance to get live specimens in spring outlets is higher with sampling shortly after large water discharges, mainly during early spring. We are also aware that shell morphology alone does not reflect all the characters important to properly assigning the new species systematically. Therefore some of the assigned genera within this study have to be treated as provisional, based mostly on the shell character resemblance to already distinguished genera and likelihood of fit within its most probable zoogeographic distribution pattern and the estimated species variability. The assigned genera will remain provisional until they are confirmed by anatomical and molecular data. Regarding to
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scarcity of even empty shells and rarity of live collected specimens, in combination with vanishing or anthropogenic altering of spring habitats (water reservoirs, dams, waterworks, fishponds, drought, draining channels, groundwater pollution), it is even possible that live specimens of many stygobiont species will never be found. We are convinced it is important to describe the new stygobiont species based on the available shell morphology in order to put their presence and zoogeographic occurrence to the focus of future researchers and ecologists. Additionally, in many cases it is likely the last chance to obtain any study material in the locality due to dynamic environmental alterations and climatic changes.

We are fully aware of the possible high variability in shell morphology among the localities of some stygobiont species as was demonstrated for the genus *Bythiospeum*, Bourguignat, 1882 (Richling et al. 2017). However, the close molecular relationship among the studied *Bythiospeum* populations within this study can be most likely explained by relatively recent post glacial colonization and population disparsal to the ex-permafrost localities from only few refugia situated at the foot of the Northern Alps. The likely path of this colonization was through the continuous stygobiont habitats within the alluvial (sand and gravel) hyporheic sediments of river valleys and basins. Compared to the areas north of the Alps, the Dinarides had a very different natural history during the glacial, interglacial, and post-glacial epochs (Grabowski et al., 2018) with much stronger development of the underground, with more robust cave systems, which provided much more favorable stabilized refugia. This process was associated with a reduced area of post glacial alluvial hyporheic gravel beds (a likely conduit for stygobiont species migration). Additionally the Dinarides alluvial gravel beds are very fragmented, or in most cases represented by very narrow stripes around the rivers penetrating through the karst by gorges. Accumulations of alluvium gravel suitable for eventual stygobiont species dispersal can be presently be found only at the periphery of Dinaride Alps, around the rivers Sana, Bosnia, and Sava, or along the lower Neretva River. Thus, the Balkan stygobiont species had very favorable and longer, stable time of isolation with minimum migration routes available for the species radiation compared to their relatives from the Central Europe (tributaries of Rein, Main and Danube). As the two geographically very close but genetically different *Paladilhiopsis* species occurring in the Mecsek Mountains in south Hungary (Angyal et al. 2018) suggests, areas such as the Mecsek or Dinarides, located further south of the main glaciation influence, could foster a more genetic diversity compared to the areas N of Alps and Carpathian.

Conclusions

The current study contributes to the knowledge of stygobiont gastropod species of Montenegro as a biodiversity hotspot with worldwide importance. It confirms our earlier observations, that even very small springs or overlooked water outlets could host interesting, hitherto unrecognized, species. The recognizing of the hydrobiid genus *Stygobia* n. gen. indicates, that the shell morphology of stygobiont Hydrobiidae and Moitessieriidae inhabiting similar habitats displays extraordinarily high similarity. Thus shell morphology alone provides an insufficient basis for correctly assigning species to their superordinate taxa – even at the family level. The genera and family associations of the new stygobiont gastropod species described solely by shell morphology should always be considered provisional until their position is confirmed by molecular and/or anatomical data.

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