

# Revealing the stygobiotic and crenobiotic molluscan biodiversity hotspot in Caucasus: Part I. The phylogeny of stygobiotic Sadlerianinae Szarowska, 2006 (Mollusca, Gastropoda, Hydrobiidae) from Georgia with descriptions of five new genera and twenty-one new species

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## Abstract

The position of the southwestern Caucasus as a stygobiotic Mollusca hotspot is confirmed. Molecular data of stygobiotic gastropods revealed the diversity of subfamily Sadlerianinae Szarowska, 2006, inhabiting the subterranean environment of Georgia. In addition to the well-known endemic genera *Pontohoratia* Vinarski, Palatov & Glöer, 2014 and *Motsametia* Vinarski, Palatov & Glöer, 2014, five more genera were identified in northwestern Georgia as new to the science: *Kartvelobia* gen. nov., *Imeretiopsis* gen. nov., *Caucasogeyeria* gen. nov., and *Hausdorfenia* gen. nov. Additionally, 21 new species were found to inhabit the studied area (Samegrelo, Imereti, Racha regions in Georgia).

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## Keywords

cave, biodiversity, freshwater, interstitial, mtDNA, molecular taxonomy, spring, subterranean

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## Introduction

The southwestern Great Caucasus hosts a remarkable biodiversity of stygobiont and crenobiont molluscan species. The stygobiont fauna of the region was brought to the attention of the scientific community by Shadin (1932) from Rion Cave (= Iazoni = Tskal-Tsitela Cave) near Kutaisi with the description of Horatia borutzkii (= Motsametia borutzkii (Shadin, 1932)) and Pisidium subterraneum (= Euglesa subterranea (Shadin, 1932)). Later Shadin (1952) described the Pisidum cavaticum (= Euglesa cavatica (Shadin, 1952)) from Uschelna Cave at the upper Khosta River in Abkhazia. Tzvetkov (1940) had highlighted the presumably high stygobiont diversity of the region. Based on the field collection of Birstein (1959–1960) and Lyovuschkin (1961), 14 new stygobiont taxa were described by Starobogatov (1962) from western Great Caucasus: Horatia birsteini (= Pontohoratia birsteini); Horatia sokolovi (= Pontohoratia birsteini); Horatia ljovuschkini (= Pontohoratia birsteini); Paladilhiopsis shadini; Paldilhiopsis subovata; Paladilhiopsis pulcherrima; Paladilhiopsis orientalis; Paladilhiopsis schakuranica; Paladilhopsis aculeus; Belgrandiella caucasica (= Tschernomorica caucasica); Belgrandiella abchasica (= Tschernomorica caucasica); "Geyeria" (= Plagigeyeria) valvataeformis; "Geyeria" (= Plagigeyeria) horatieformis; Pisidum ljovuschkini (= Euglesa ljovuschkini (Starobogatov, 1962)). Type specimens of Yaroslav Igorevich Starobogatov with his species from the southwestern Caucasus deposited in ZIN St. Petersburg were figured by Sitnikova et al. in 2017. The figured "Paladilhiopsis" subovata and "P." orientalis holotypes are represented only by fragments of broken shells, while the original descriptions depict drawings of complete shells. It is likely the fragile subfossil shells could have been damaged later, after the descriptions. For decades the stygobiont Mollusca of the Caucasus were not in the focus of malacologists. Only Schütt and Şeşen (1993) described a new species of Belgrandiella nemethi (= Tschernomorica caucasica (Starobogatov, 1962)), based on dry material collected by Lázló Németh near the village of Rostsvet in the Khosta valley. Vinarski et al. (2014) revised the species assigned to Horatia. Statistical conchological analysis revealed that three of the Starobogatov "Horatia" species were conspecific, and anatomical investigations supported the erection of the new genus Pontohoratia Vinarski, Palatov & Glöer, 2014. Shadin's Horatia borutzkii species was transferred to the new genus Motsametia Vinarski, Palatov & Glöer, 2014, and a new species, Pontohoratia smyri Vinarski, Palatov & Glöer, 2014, was described from Novoafonskaya Cave. The Caucasian

stygobiont species were included by Bole and Velkovrh (1986) in their "Mollusca from Continental Subterranean Aquatic Habitats", listed by Kantor et al. (2010), by Barjadze et al. (2015), and by Vinarski and Kantor (2016). Chertoprud et al. (2016) summarised the species detected during their research in the southeast Caucasus. Nevertheless, it was clear from the above works and from recent studies of the Balkan fauna (Szarowska 2006; Falniowski at al. 2008; Beran et al. 2015, 2016; Rysiewska et al. 2017; Grego et al. 2018; Hofman et al. 2018; Osikowski et al. 2018; Grego et al. 2019), that the Caucasian species were assigned to respective Balkan genera (Belgrandiella, Paladilhiopsis, Plagigeyeria) based only on the few morphological features of the shell, and it is not likely that they are closely related to the geographically distant morphotypes. Molecular investigations of genus Belgrandiella from Georgia (Grego et al. 2017) revealed its close relationship to the genus Agrafia Szarowska & Falniowski, 2011 from Greece. Later Vinarski and Palatov (2019) transferred the Caucasus and Crimean members of Belgrandiella to a new genus, Tschernomorica Vinarski & Palatov, 2019, based on their anatomical differences from Belgrandiella Wagner, 1927 and Agrafia. Two new species of Tschernomorica from Caucasus were established: T. inconspicua (Vinarski & Palatov, 2019) and T. lindholmi Vinarski & Palatov, 2019.

In the present work we provide the results of our recent field work in the karst massifs of the southwestern Great Caucasus which revealed a remarkable diversity of the subterranean mollusc fauna. Based on morphological and genetic investigations, we here describe 21 new species in five new genera belonging to subfamily Sadlerianinae Szarowska, 2006 (Gastropoda, Hydrobiidae) and provide diagnostic features and distribution data.

## Materials and methods

The studied material was collected during field trips to the Samegrelo, Imereti, and Racha provinces of Georgia in 2018 and 2019 (Fig. 1). Different caves, spring outflows and karstic springs were sampled (Figs 1–4). Microhabitat preference and sampling methods were used as described by Grego et al. (2017). Samples of fine sand were freshly wet screened under a stereomicroscope to retrieve live animals. Then the samples were dried and screened again for shells that might have been overlooked during the wet screening. Frontal, ventral, and lateral view images of the shells were made by a Nikon SMZ25 microscope equipped with a Nikon D200 camera and an AF-S Micro NIKKOR 60 mm lens at the Vienna Natural History Museum (NHMW), Austria. ImageJ image analysis software was used to measure the specimens (Rueden et al. 2017). The shell morphology features were followed after Davis et al. (1992) and Hershler and Ponder (1998).

Snails for molecular analysis were fixed in 80% ethanol, changed twice, and later stored in 80% ethanol. DNA was extracted from whole specimens; tissues were hydrated in TE buffer ( $3 \times 10$  min); then total genomic DNA was extracted with the



Figure 1. Map of stygobiotic Sadlerianinae distribution in the southwestern Caucasus: historical localities (blue dots) and new studied localities (red dots) **0** Krasnoalexandrovskaya Cave **1** New Athos Cave **2** Tsebedinska Cave **3** Srednaya Sakuranskaya Cave **4** Nizhnaya Sakuranskaya Cave **5** Abrskila Cave **6** Tskhal-Tsiteli Cave **7** Prometheus Cave **8** Nakerala Spring **9** small spring near Gorgoleti **3 10** Tsivtskala 2 Spring near power station **11** Kidobana Cave **12** Cholaba Spring **13** Shakishore Cave **14** Dolabistavi Cave **15** Krikhula Spring **16** Kinchkha Cave and Spring and Kinchkha Waterfall **17** Kinchkhaperdi Spring **18** Upskhero Spring **19** Nakhriduri Spring **1** and 2 **20** Turchu Gamosadivari Cave **21** Turchusmtha Spring **22** Motena Cave **23** Pirveli Balda Spring **24** Nazodelavo Cave **25** Kachara Cave **26** Shisha Spring **27** Mapeli Cave **28** Shurubumu Springs **29** Kanti, Mapeli Spring **30** Letsurtsume Cave **31** Garakha, Savekuo Cavern.

Sherlock extraction kit (A&A Biotechnology), and the final product was dissolved in 20  $\mu$ l of tris-EDTA (TE) buffer. The extracted DNA was stored at -80 °C at the Department of Malacology, Institute of Zoology and Biomedical Research, Jagiellonian University in Kraków (Poland).

Mitochondrial cytochrome oxidase subunit I (COI) and nuclear histone 3 (H3) loci were sequenced. Details of PCR conditions, primers used, and sequencing were given in Szarowska et al. (2016). Sequences were initially aligned in the MUSCLE (Edgar 2004) Programme in MEGA 7 (Kumar et al. 2016) and then checked in Bioedit 7.1.3.0 (Hall 1999). Uncorrected p-distances were calculated in MEGA 7. The estimation of the proportion of invariant sites and the saturation test for entire data sets (Xia 2000; Xia et al. 2003) were performed using DAMBE (Xia 2013). In the phylogenetic analysis, additional sequences from GenBank were used as reference (Table 1). The data were analysed using approaches based on Bayesian Inference (BI) and Maximum Likelihood (ML). In the BI analysis, the GTR + I +  $\Gamma$  model of nucleotide substitution was applied. Model was selected using MrModelTest 2.3 (Nylander 2004). The analyses were run using MrBayes v. 3.2.3 (Ronquist et al. 2012) with default of most priors. Two simultaneous analyses were performed, each with 10,000,000 generations,



**Figure 2.** Photographs of studied localities in Georgia **A** Imereti, Kutaisi, Iazoni (Tskhal-Tsiteli) Cave, entrance **B** Tskalsithela Cave, cave stream **C** Racha, Nikorsminda, Shareula River Spring from Shareula Cave **D** Racha, Tsivtskala 2 Spring at left side of the Shareula River near power station **E** Imereti, Satsiskvilo, spring near Turchusmtha **F** Imereti, Zeda Gordi, Upskhero Spring at Turchu Gamosadivari Basin near Nakhriduri. Photograph M. Olšavský.

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 summarised as a 50% majority-rule tree. Convergence was checked in Tracer v. 1.5 (Rambaut and Drummond 2009). The Maximum Likelihood analysis was conducted in RAxML v. 8.2.12 (Stamatakis 2014) using the 'RAxML-HPC v.8



**Figure 3.** Photographs of studied localities in Georgia **A** Imereti, Zeda Gordi, Turchu Gamosadivari Cave spring **B** Imereti, Zeda Gordi, spring in Nakhriduri **C** Racha, Skhartali, Shakishore Cave **D** Racha, Shua Skhava, Krikhula Spring **E** Samegrelo, Pirveli Balda, spring in village **F** Samegrelo, Mukhuri, Shurubumu 1, spring at left bank of Khobistskali River. Photograph M. Olšavský.

on XSEDE (8.2.12) tool via the CIPRES Science Gateway (Miller et al. 2010). We applied the GTR model which is the only nucleotide substitution model implemented in RaxML, whose parameters were estimated by RaxML (Stamatakis 2014). Two species delimitation methods were performed: Poisson Tree Processes (PTP) (Zhang et al. 2013) and Automatic Barcode Gap Discovery (ABGD). The PTP approach was run



Figure 4. Photographs of studied localities in Georgia A Samegrelo, Chkhorotsku, Letsurtrume, Lesurtsume Cave entrance B Lesurtsume Cave stream C Samegrelo, Mukhuri, Shisha Spring D Samegrelo, Chkhorotsku, Kachara Cave E Samegrelo, Chkhorotsku, Nazodelavo Cave F Samegrelo, Pirveli Balda, Motena Cave. Photograph M. Olšavský.

using the web server https://species.h-its.org/ptp/, with 100,000 MCMC generations, 100 thinning and 0.1 burn-in. We used RAxML output phylogenetic tree. The ABGD approach using the web server (https://bioinfo.mnhn.fr/abi/public/abgd/abgdweb. html) and the default parameters.

Species	COI/H3 GB numbers	References
Agrafia wiktori Szarowska & Falniowski, 2011	JF906762/MG543158	Szarowska and Glöer 2011/Grego et al. 2017
Belgrandiella kusceri (Wagner, 1914)	KT218511/MG551366	Falniowski and Beran 2015/Osikowski et al. 2018
Bithynia tentaculata (Linnaeus, 1758)	AF367643/-	Wilke et al. 2001
Bythinella austriaca (von Frauenfeld, 1857)	JQ639858/-	Falniowski et al. 2012b
Bythiospeum acicula (Hartmann, 1821)	KU341350/ MK609536	Richling et al. 2016/ Falniowski et al. 2019
Ecrobia maritima (Milaschewitsch, 1916)	KX355830/MG551322	Osikowski et al. 2016/Grego et al. 2017
Emmericia expansilabris Bourguignat, 1880	KC810060/-	Szarowska and Falniowski 2013
Hauffenia michleri Kuščer, 1932	KY087865/KY087878	Rysiewska et al. 2017
Heleobia maltzani (Westerlund, 1886)	KM213723/ MK609534	Szarowska et al. 2014/ Falniowski et al. 2019
Iglica cf. gracilis (Clessin, 1882)	MH720988/MH721003	Hofman et al. 2018
<i>Iglica hellenica</i> Falniowski & Sarbu, 2015	KT825581/MH721007	Falniowski and Sarbu 2015/ Hofman et al. 2018
Islamia zermanica (Radoman, 1973)	KU662362/MG551320	Beran et al. 2016/Grego et al. 2017
Littorina littorea (Linnaeus, 1758)	KF644330/KP113574	Layton et al. 2014/ Neretina 2014, unpublished
Marstoniopsis insubrica (Küster, 1853)	AF322408/-	Falniowski and Wilke 2001
Moitessieria cf. puteana Coutagne, 1883	AF367635/MH721012	Wilke et al. 2001/Hofman et al. 2018
Montenegrospeum bogici (Pešić & Glöer, 2012)	KM875510/MG880218	Falniowski et al. 2014/Grego et al. 2018
Paladilhiopsis grobbeni Kuscer, 1928	MH720991/MH721014	Hofman et al. 2018
Paladilhiopsis turrita (Kuščer, 1933)	MH720992/MH721015	Hofman et al. 2018
Pontobelgrandiella sp. Radoman, 1978	KU497024/MG551321	Rysiewska et al. 2016/Grego et al. 2017

Table 1. Taxa used for phylogenetic analyses with their GenBank accession numbers and references.

The conservation status evaluation of each newly described species is based on the categories and criteria of IUCN and recommendations provided by Cardoso et al. (2011). Abbreviations:

AH	Aperture height;
AOO	Area of occupancy;
AW	Aperture width;
BH	Height of the body whorl;
BW	Width of the body whorl;
CA	Aperture declination angle: Angle of aperture-elongation axis vs. the columella;
EOO	Extent of occurrence;
Н	Shell height;
HNHM	Hungarian Natural History Museum, Budapest, Hungary;
ISU	Ilia State University, Tbilisi, Georgia;
LT	Type locality;
MNHN	Muséum national d'Histoire naturelle, Paris, France;
NHMW	Naturhistorisches Museum Wien, Austria;
NHMUK	Natural History Museum London, UK;
NMBE	Naturhistorisches Museum Bern, Switzerland;
SBMNH	Santa Barbara Museum of Natural History, California, USA;
SMF	Senckenberg Museum, Frankfurt, Germany;
W	Shell width;
ZIN	Zoological Institute of Russian Academy of Science, St Petersburg, Russia;
ZMH	Zoological Museum University Hamburg.



**Figure 5.** Maximum Likelihood tree inferred from mitochondrial COI. Bootstrap supports and Bayesian probabilities are given. Newly obtained sequences in bold.

## Results

## Molecular phylogeny

We obtained 21 new sequences of COI (409 bp, GenBank Accession Numbers MT406082–MT406102) (Fig. 5), and 21 new sequences of H3 (309 bp, GenBank Accession Numbers MT410508–MT410528) (Fig. 6). The tests by Xia et al. (2003) for COI and H3 revealed no saturation. Phylograms were constructed for COI, H3 and for combined COI+H3 dataset. In all analyses, the topologies of the resulting phylograms were identical in both the ML and BI.

In all three cases (COI, H3, and COI+H3), the newly obtained sequences formed well-supported distinct lineage, with closest relation to the subfamily Sadlerianinae. For COI most phylogeny relationships were unresolved, since the low bootstrap supports are typical for deep nodes inferred with COI. Fortunately, the tree for COI+H3



**Figure 6.** Maximum Likelihood tree inferred from nuclear H3. Bootstrap supports and Bayesian probabilities are given. Newly obtained sequences in bold.

gave a clear phylogeny of the new species. This 'georgian' clade consisted of six subclades (Figs 5–7), representing most probably six distinct genera. The inter-genus pdistances for COI and H3, and intra-genus for COI are given in Table 2. Intra-genus p-distances for H3 are not shown due to very low or lack of variation. For both studied loci, clades A (*Pontohoratia*) and B (*Caucasopsis*) were most similar (p-distance 0.074 and 0.014 for COI and H3, respectively: Table 2). The other subclades also formed distinct lineages, but the relationships among them are not clear due to low bootstrap and BP supports. The p-distances among these four clades (C – *Caucasogeyeria*,



**Figure 7.** Maximum Likelihood tree inferred from COI + H3. Bootstrap supports and Bayesian probabilities are given. Red and green bars indicate results from the ABGD and PTP methods, respectively. Newly obtained sequences in bold.

**Table 2.** P-distances between main clades for COI (below diagonal) and H3 (above diagonal); intragenus p-distances for COI are also shown if present (in bold).

	Pontohoratia	Caucasopsis	Caucasogeyeria	Imeretiopsis	Kartvelobia	Hausdorfenia
Pontohoratia	0.055	0.014	0.027	0.025	0.027	0.024
Caucasopsis	0.074	0.005	0.020	0.018	0.020	0.017
Caucasogeyeria	0.130	0.107	0.035	0.018	0.020	0.017
Imeretiopsis	0.119	0.113	0.099	0.014	0.018	0.014
Kartvelobia	0.130	0.117	0.113	0.098	_	0.017
Hausdorfenia	0.148	0.137	0.132	0.121	0.112	-

D – *Imeretiopsis*, E – *Kartvelobia*, and F – *Hausdorfenia*) varied from 0.098 to 0.132 (for COI) and from 0.014 to 0.020 (for H3).

Both species delimitation methods (PTP and ABGD; Fig. 7) distinguished twelve new species described below, including four within *Caucasogeyeria*, three within *Pontohoratia*, and two within *Imeretiopsis*.

## **Taxonomic accounts**

Class: Gastropoda Cuvier, 1795

Clade Littorinimorpha Golikov & Starobogatov, 1975 Superfamily Truncatelloidea Gray, 1840 Family Hydrobiidae Stimpson, 1865 Subfamily Sadlerianinae Szarowska, 2006

Genus Kartvelobia Grego & Mumladze, gen. nov. http://zoobank.org/21F0C1AB-8EA0-49BF-A84F-592032DD2D85

#### Type species. Kartvelobia sinuata Grego & Mumladze, sp. nov.

**Species assigned to the genus.** *Kartvelobia sinuata* Grego & Mumladze, sp. nov., *K. kinchkha* Grego & Mumladze, sp. nov., *K. shishaensis* Grego & Mumladze, sp. nov.

**Diagnosis.** The new genus differs from all known stygobiotic Hydrobiidae and Moitessieriidae by general shell shape with characteristically deeply sinuated labral margin; however, the smaller representatives of the genus can possess only very weak labral sinuation while still having elongate-oval shells with inflated whorls and aperture slightly detached from the body whorl.

Etymology. Name derived from the name of Georgia in local language Sakartevelo (საქართველო), which is frequently used in its short vocative form as Kartvelo (ქართველო). Its gender is feminine.

**Distribution.** The new genus is known from western Imereti region, where it can be found in springs and caves in the Turchu Gamosadivari basin and around the karstic Pakhe Plateau. In the Samegrelo region it is distributed in springs and caves on the eastern slope of Pakhe Plateau and from the springs around Mukhuri village (Fig. 8).

#### Kartvelobia sinuata Grego & Mumladze, sp. nov.

http://zoobank.org/86E484BD-58E7-45E4-84FC-DB969532B845 Plates 1(1-3); 2(1-15); 3(1-4); 4(5-7); 5(3); Fig. 9A–E

**Type locality.** Georgia • Imereti, Satsiskvilo, Turchusmtha (თურჩუსმთა, სოფელი საწისქვილო); 42°29'49"N, 42°32'49"E; 980 m a.s.l.; Small spring at left side of path to the plateau.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T020-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T020-P1/500 dry specimens, SBMNH 633041/7 dry, NHMW 113374/10 dry, HNHM 104683/10 dry, NHMUK 20191339/10 dry, NHMB 563971/10 dry, SMF 358930/10 dry, ZMH 140635/10 dry, MNHN-IM-2016-7894, ZIN 1/511-2020/10 dry, coll. JG F0989/500 dry, coll. Glöer/2 dry; *Other material*: Georgia • Imereti, Nakhriduri, Turchu Gamosadivari Cave; 42°29'13"N, 42°31'20"E; 951 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg., JG/3 dry.



Figure 8. Distribution map of *Kartvelobia* gen. nov. 16 *K. kinchkha* sp. nov. (blue dot) 17–21 *K. sinuata* sp. nov. (magenta dots) 22, 23 *K.* cf. *sinuata* (purple dots) 26, 27 *K. shishaensis* sp. nov. (red dots).



**Plate 1. 1–3** *Kartvelobia sinuata* sp. nov. Imereti, Satsiskvilo, Turchusmtha, specimens used for molecular and anatomical study. Measurement of aperture declination angle (CA): aperture-elongation axis vs. the columella is depicted in green. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph A. Falniowski.

Imereti, Nakhriduri 3 spring at Turchu Gamosadivari Basin left side; 42°28'41"N, 42°30'45"E; 860 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. JG/5 dry.
Imereti, Nakhriduri 2, Turchu Gamosadivari Basin left side spring above small ford; 42°28'39"N, 42°30 43"E; 860 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg., JG/6 dry.
Imereti, Kinchkhaperdi (305βb390%00), spring right along the road to Askhi Plateau; 42°30'7"N, 42°33'34"E; 880 m a.s.l.; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg., L. Mumladze and M. Olšavský leg., JG/6 dry.



**Figure 9.** *Kartvelobia sinuata* sp. nov., Imereti, Satsiskvilo, Turchusmtha, morphology of the reproductive organs **A–D** morphology of the penis **E** female renal and pallial section of reproductive organs. Bc – bursa copulatrix; cbc – duct of bursa copulatrix; ga – albuminoid gland; gn – nidamental gland; gp – go-noporus; ov – oviduct; ovl – loop of oviduct; rs – receptaculum seminis; vc – ventral channel. Photograph and drawing A. Falniowski.

42°30'3"E; 890 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. JG/6 dry. • Imereti, Turchusmtha, spring of Okatse above Kinchkha waterfall; 42°29'49"N, 42°32'49"E; 1050 m a.s.l.; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. JG/5 dry.

#### K. cf. sinuata

Other material. Georgia • Imereti, Samegrelo, Pirveli Balda, Motena Cave (მოტენას მღვიმე), sandy sediment at terminal sump lake; 42°28'36"N, 42°23'29"E; 485 m a.s.l.; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. • Samegrelo, Pirveli Balda (პირველი ბალდა), spring at village; 42°29'2"N, 42°23'53"E; 295 m a.s.l.; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. • same as preceding; 13 October 2019; J. Grego leg.



Plate 2. 1–5 Kartvelobia sinuata sp. nov., Imereti, Satsiskvilo, Turchusmtha I holotype 2–5 paratypes 6 K. sinuata sp. nov., Imereti, Turchusmtha, spring of Okatse above Kinchkha waterfall 7,8 K. cf. sinuata, Samegrelo, Pirveli Balda, Motena Cave 9–11 K. cf. sinuata, Samegrelo, Pirveli Balda, spring in village 12 K. sinuata sp. nov., Imereti, Nakhriduri, spring cave Turchu Gamosadivari 13 K. sinuata sp. nov., Imereti, Nakhriduri Basin 14, 15 K. sinuata sp. nov., Imereti, Nakhriduri spring at Turchu Gamosadivari Basin. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.



Plate 3. *Kartvelobia sinuata* sp. nov. I Imereti, Turchu Gamosadivari Basin, Nakiduri spring, paratype SBMNH 633100 2 *K. sinuata* sp. nov., Imereti, Turchu Gamosadivari Basin, Nakhriduri 5, paratype SBMNH 633103 3 *K. sinuata* sp. nov., Samegrelo, Pirveli Balda, Motena Cave, paratype SBMNH 633043 4 *K. sinuata* sp. nov., Samegrelo, Pirveli Balda, spring in village, paratype SBMNH 633070. SEM SBMNH Vanessa Delnavaz. Scale bars: 1 mm.

Genus species	Η	W	BH	BW	AH	AW	CA	H/W	AH /	W/	H/	H/	W/	H/(W-
-	mm	mm	mm	mm	mm	mm	deg.	1	AW	BW	BH	AH	AW	BW)
Kartvelobia sinuata sp. nov.	1.67	0.96	1.16	0.81	0.76	0.61	38	1.74	1.25	1.19	1.43	2.20	1.58	11.00
Holotype LT														
Kartvelobia sinuata sp. nov.	1.62	0.91	1.16	0.76	0.68	0.61	36	1.78	1.13	1.20	1.39	2.37	1.50	10.67
<b>Paratype</b> LT	1.77	0.96	1.16	0.86	0.71	0.56	35	1.84	1.27	1.12	1.52	2.50	1.73	17.50
	1.72	1.01	1.11	0.81	0.76	0.61	36	1.70	1.25	1.25	1.55	2.27	1.67	8.50
	1.82	1.06	1.16	0.91	0.81	0.71	43	1.71	1.14	1.17	1.57	2.25	1.50	12.00
Kartvelobia sinuata sp. nov.	2.07	1.11	1.26	0.86	0.81	0.66	38	1.86	1.23	1.29	1.64	2.56	1.69	8.20
Okatse Spring														
Kartvelobia cf. sinuata sp. nov.	1.87	1.06	1.31	0.86	0.76	0.76	44	1.76	1.00	1.24	1.42	2.47	1.40	9.25
Motena Cave	1.77	0.96	1.21	0.83	0.73	0.63	40	1.84	1.16	1.15	1.46	2.41	1.52	14.00
Kartvelobia cf. sinuata sp. nov.	1.79	1.16	1.09	0.86	0.76	0.66	42	1.54	1.15	1.35	1.65	2.37	1.77	5.92
Priveli Balda spring	1.87	1.01	1.26	0.83	0.81	0.66	45	1.85	1.23	1.21	1.48	2.31	1.54	10.57
Kartvelobia sinuata sp. nov.	1.62	0.91	1.11	0.81	0.71	0.58	43	1.78	1.22	1.13	1.45	2.29	1.57	16.00
Turchu Gamosadivari														
Kartvelobia sinuata sp. nov.	1.62	0.86	1.06	0.78	0.71	0.58	38	1.88	1.22	1.10	1.52	2.29	1.48	21.33
Nakriduri 1 spring														
Kartvelobia sinuata sp. nov.	1.46	0.78	0.98	0.71	0.66	0.48	35	1.87	1.37	1.11	1.49	2.23	1.63	19.33
Nakriduri 2 spring														
Kartvelobia sinuata sp. nov.	1.36	0.96	0.91	0.81	0.71	0.66	23	1.42	1.08	1.19	1.50	1.93	1.46	9.00
Nakriduri 2 spring														

Table 3. Measurement comparisons of Kartvelobia sinuata sp. nov. from different localities.

**Diagnosis.** The new species differs from all known stygobiotic gastropods by the characteristically and deeply sinuated labral margin with two to three large tooth-like folds. The two most closely related species, *Kartvelobia kinchkha* sp. nov. and *Kartvelobia shishaensis* sp. nov., have only weakly sinuated labral margin and generally smaller shell. Compared to *K. kinchkha* sp. nov. the protoconch is smoother and to *K. shishaensis* sp. nov. it is more conspicuously pitted. Both of the latter species generally have smaller shells.

**Description.** *Shell:* shape is ovate-conical, 1.36–2.07 mm high with four whorls separated by a deep suture, a blunt protoconch, and a closed umbilicus. Shell surface whitish, translucent, smooth to glossy, with very faint growth lines. The aperture ovate-ellipsoid with its axis declined from columella by 38° and separated from the body whorl by a gap or groove. Its labral margin characteristically sinuated with a deeply cut broad round shaped adapical sinulus, continuing with a triangular tooth-like structure curved inward, and smoothly followed by two more, similar tooth-like structures down to lower extremity of the shell. The wavy labral margin varies significantly within the species. The lateral profile of the columellar margin more-or-less straight. The protoconch surface very weakly pitted.

**Operculum:** yellowish, translucent, elongate ellipsoid, paucispiral with an excentric nucleus.

*Animal body*: milky whitish coloured, eyeless.

*Holotype measurements:* H-1.67 mm; W-0.96 mm; BH-1.16 mm; BW-0.81 mm; AH-0.76 mm; AW-0.61 mm; CA: 38°.

**Anatomy:** the penis (Fig. 9A–D) simple, broad and massive, proximally bent, with a small outgrowth in the middle of its left side, the vas deferens running straight. The female reproductive organs (Fig. 9E) with a short and broad oviduct loop, small distal receptaculum seminis (at the position of  $rs_1$  of Radoman: see Szarowska (2006)) and big spherical bursa copulatrix with a long duct.

Etymology. Named after the conspicuously sinuated labral margin.

**Habitat.** The empty shells of the new stygobiotic species were found in the sandy sediments of several cave streams or karst spring heads. Few live individuals were found in a small concrete basin built on a small permanent spring emerging from a fissure in the thick limestone beds. The individuals of this hypogean species were washed out from its stygobiont habitat and accumulated in the small artificial basin.

**Distribution.** This species is known from the Pakhe karstic plateau NW of Kinchkhaperdi and Satsiskvilo (south of the Askhi Plateau) in the caves and springs emerging from cliffs at its foot and slopes, as well from the springs and caves at Turchu Gamosadivari Basin situated at the top of the plateau the Turchu Gamosadivari River sink at the western edge of the basin, and appearing again in First Toba Cave and in Arsen Okrojanashvili Cave. A more conical form of the new species with slightly different labral margin (*K. cf. sinuata* is known from the southernmost tip of the Pakhe Plateau massif, from the springs in village Pirveli Balda and from Motena Cave. A local form with minute shell, inflated whorls is found around Kinchkhaperdi below the NW foot of the plateau. The taxonomic status of both forms should be clarified.

**Conservation status.** The number of known locations is 11 and EOO is ca. 70 km<sup>2</sup>. The AOO is represented by only several underground karst conduits with much smaller total area compared to EOO. Each karst conduit is supplied by surface water through swallow holes, where stochastic events, as human driven pollution or habitat destruction, could lead to rapid species decline or extinction. Therefore, it is assessed as Vulnerable (VU) D2.

**Remarks.** The labral sinuation intensity can vary by specimen, especially juvenile individuals have only weakly developed sinuation.

#### Kartvelobia kinchkha Grego & Mumladze, sp. nov.

http://zoobank.org/25A99522-9ACE-4F14-B78C-01E73755595D Plates 4(3, 4); 5(1)

**Type locality.** Georgia • Imereti, Kinchkhaperdi, Kinchkha; 42°29'42"N, 42°33'01"E; 855 m a.s.l.; a small spring above right edge of the lower waterfall.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T018-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T018-P1/1 dry, SBMNH 633106/1 dry, coll. JG F0987/1 dry.

**Diagnosis.** The new species differs from *Kartvelobia sinuata* sp. nov. by its less weakly-sinuated labral margin without tooth-like folds, by smaller shell size, smooth protoconch surface and the different shape of the aperture. From the similar sized *K. shishaensis* sp. nov. it differs by its more smoothly sinuated labral margin, by proportionally larger body whorl, by smoother protoconch surface and by more inflated whorls.

**Description.** *Shell:* the minute shell (1.29–1.32 mm high) with 3<sup>1</sup>/<sub>2</sub> whorls and a blunt apex, with elongate-oval shape, inflated whorls, weak suture and closed umbilicus. Shell surface smooth to glossy, whitish translucent. The aperture of an irregular tear-shaped with pronounced upper-right tip and separated from the body whorl by a



Plate 4. 1–4 *Kartvelobia shishaensis* sp. nov., Georgia, Samegrelo, Mukhuri, Shisha Spring 1 holotype 2 paratype **3**, **4** *K. kinchkha* sp. nov., Imereti, Kinchkha, small travertine waterfall at right bank of Okatse below the large waterfall: **3** holotype **4** paratype **5**, **6** *K. sinuata* sp. nov., Imereti, Kinchkhaperdi, spring along road to Askhi Plateau, dwarf population **7** *K. sinuata* sp. nov., Imereti, Satsiskvilo, Turchusmtha, paratype – typical form **8**, **9** *K.* cf. *shishaensis* sp. nov., Georgia, Samegrelo, Mukhuri, Mapeli Cave. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.



Plate 5. I Kartvelobia kinchkha sp. nov., Georgia, Imereti, Kinschkhaperdi, paratype SBMNH 633106
2 K. shishaensis sp. nov., Samegrelo, Mukhuri, Shisha Spring, paratype SBMNH 633084 3 K. sinuata sp. nov., Imereti, Satsiskvilo, Turchusmtha Spring, SBMNH 633041 4 K. shishaensis sp. nov., Samegrelo, Mukhuri, Mapeli Cave, SBMNH 635905. Scale bars: 1 mm. SEM SBMNH Vanessa Delnavaz.

deep groove. The lateral profile of labral margin characteristically weakly sinuated and anteriorly elongated. The labral columellar profile almost straight, only slightly curved. Protoconch with a smooth surface.

Operculum: not known.

Animal body: not known.

*Holotype measurements:* H-1.32 mm; W-0.71 mm; BH-0.95 mm; BW-0.62 mm; AH-0.58 mm; AW-0.52 mm; CA: 45°.

Anatomy: not known.

Etymology. Name derived from the tallest Georgian waterfall Kinchkha (კინჩხას ჩანჩქერი) near Kinchkhaperdi. Type locality is situated between the two lower cascades of the waterfall.

**Habitat.** Stygobiotic species. The habitat represents small permanent water springs, where the water leaks out from fissures in the large limestone beds. The water emerging from fissures could be supplied from the springs and water-episaturated zones above the Kinchkha waterfall. The very narrow fissures likely lead to evolution of the more minute shell shape of the species. Some of the small springs are captured as tap water for the nearby cabins.

Distribution. Only known from the type locality.

**Conservation status.** Number of known locations (1) fewer than 5 and AOO smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining or extremely fluctuating. However, due to very small AOO it is assessed as Vulnerable (VU) D2.

#### Kartvelobia shishaensis Grego & Mumladze, sp. nov.

http://zoobank.org/A96A5432-AC26-460A-BA9F-AF01A8B63BDF Plates 4(1, 2, 8, 9); 5(2, 4)

**Type locality.** Georgia • Samegrelo, Mukhuri, Shisha Spring; 42°37'47"N, 42°11'26"E; 250 m a.s.l.; sediment from the spring lake bottom.

Material. *Holotype:* Georgia • 1 adult, dry; type locality; 42°37'47"N, 42°11'26"E; 250 m a.s.l.; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T019-H. *Paratypes:* Georgia • same as for holotype; ISU FM-T019-P1/3 dry, SBMNH 633084/2 dry, coll. JG F1043/3 dry; • same as for holotype; 12 October; 2019; J. Grego, L. Mumladze and G. Bananashvili leg.; NHMW 113373 ISU-T019-P2/4 dry, coll JG F1056/4 dry; Georgia • Samegrelo, Mukhuri, Mapeli Cave (dsJgcob dc30cd); 42°38'22"N, 42°11'39"E; 330 m a.s.l.; 12 October 2019; J. Grego, L. Mumladze and G. Bananashvili leg.

**Diagnosis.** The new species differs from the *Kartvelobia sinuata* sp. nov. by its very weakly sinuated almost straight labral margin, minute shell size, more pitted protoconch and different shape of the aperture. From the similar sized *K. kinchkha* sp. nov. differs by its less sinuated labral margin, by less inflated whorls and by the pitted protoconch surface. Measurement comparison of *Kartvelobia* species is given in Table 4.

Genus species	H	W	BH	BW	AH	AW	CA	H/W	AH /	W /	H/	H/	W /	H/(W-
	mm	mm	mm	mm	mm	mm	deg.	]	AW	BW	BH	AH	AW	BW)
Kartvelobia shishaenis sp. nov.	1.45	0.74	1.02	0.62	0.55	0.58	51	1.96	0.95	1.20	1.42	2.61	1.26	11.75
Holotype LT														
Kartvelobia shishaenis sp. nov.	1.32	0.68	0.95	0.62	0.54	0.52	48	1.95	1.03	1.10	1.39	2.46	1.29	21.50
Paratype LT														
Kartvelobia kinchkha sp. nov.	1.32	0.71	0.95	0.62	0.58	0.52	45	1.87	1.12	1.15	1.39	2.26	1.35	14.33
Holotype LT														
Kartvelobia kinchkha sp. nov.	1.29	0.77	0.92	0.65	0.58	0.49	46	1.68	1.19	1.19	1.40	2.21	1.56	10.48
Paratype LT														
Kartvelobia sinuata sp. nov.	1.51	0.95	0.95	0.71	0.62	0.55	25	1.58	1.11	1.35	1.58	2.45	1.72	6.13
dwarf Kinchkaperdi	1.60	0.98	0.98	0.71	0.66	0.55	31	1.63	1.19	1.39	1.63	2.42	1.78	5.78
Kartvelobia sinuata sp. nov.	1.91	1.17	1.29	0.92	0.80	0.65	27	1.63	1.23	1.27	1.48	2.38	1.80	7.75
Paratype LT														
Kartvelobia shishaenis sp. nov.	1.51	0.77	0.95	0.66	0.55	0.46	42	1.96	1.20	1.16	1.58	2.72	1.67	14.00
Mapeli Cave	1.48	0.74	0.92	0.62	0.58	0.42	34	2.00	1.41	1.20	1.60	2.53	1.78	12.00

Table 4. Measurement comparison of species from genus Kartvelobia gen. nov.

**Description.** *Shell:* minute, 1.32–1.45 mm high, elongated-oval shell with four whorls, semi-blunt apex and smooth whitish glossy surface; slightly inflated whorls separated by weak suture. Aperture irregularly tear-shaped, slightly expanded and detached from the body whorls by a distant grove or gap. Lateral profile of labral margin almost straight with very inconspicuous sinuation; columellar labral profile straight. Protoconch surface pitted.

**Operculum:** not known.

Animal body: not known.

*Holotype measurements:* H-1.45 mm; W-0.74 mm; BH-1.02 mm; BW-0.62 mm; AH-0.55 mm; AW-0.58 mm; CA: 51°.

Anatomy: not known.

**Etymology.** Name after the type locality: the karst spring Shisha at southeast end of village Mukhuri.

**Habitat.** Stygobiotic species. The empty shells of the species were washed out through the small spring lake after large water flow induced by heavy rains in May 2018. The deep spring Lake Shisha drains karstic waters from the nearby limestone massif, but likely gets a portion of its water directly from the surface through a nearby sinkhole (more opalescent water observed shortly after the heavy rain). The condition of the shells (few worn shells and many fragments) suggests its stygobiont habitat deeper than the spring head.

**Distribution.** Only known from the type locality and from nearby Mapeli Cave in Mukhuri.

**Conservation status.** The number of known locations (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The second population from Mapeli Cave generally has a more elongate and conical shell with more inflated whorls. Its taxonomic position needs to be further investigated.

## Genus Imeretiopsis Grego & Mumladze, gen. nov. http://zoobank.org/6DA03D4C-31F4-412B-8D68-30E9EAC228E4

Type species. Imeretiopsis prometheus Grego & Palatov, sp. nov.

**Species assigned to the genus.** *I. prometheus* Grego & Palatov, sp. nov., *I. gorgoleti* Grego & Mumladze, sp. nov., *I. nakeralaensis* Grego & Mumladze, sp. nov., *I. cameroni* Grego & Mumladze, sp. nov., *I. iazoni* Grego & Mumladze, sp. nov.

**Diagnosis.** The general shell morphology of the new genus is similar to some stygobiotic genera from the Balkans (*Paladilhiopsis* Pavlović, 1913; *Iglica* A. J. Wagner, 1910), Middle Europe (*Bythiospeum* Bourguignat, 1882) and Southeast Asia (*Pseudoiglica* Grego, 2018). The main conchological difference distinguishing the new genus from *Caucasopsis* gen. nov., is the sinuated labral profile. The penis long, without the filament characteristic of *Caucasopsis*, but with two broad outgrowths on its left side.

Etymology. Name is derived from the Imereti (იმერეთი) region, where the type locality and the known distribution of the genus are located. The suffix *—iopsis* refers to the resemblance to the shells of the Balkan genus *Paladilhiopsis* Pavlović, 1913. Its gender is feminine.

**Distribution.** The genus *Imeretiopsis* gen. nov. is known from the Imereti and West Racha regions of Georgia (Fig. 10).



Figure 10. Distribution map of *Imeretiopsis* gen. nov.: (magenta dots) and *Caucasopsis* gen. nov. (blue dots) 6 *I. cameroni* sp. nov. and *I. iazoni* sp. nov. 7 *Imeretiopsis prometheus* sp. nov. 8 *I. nakeralaensis* sp. nov. 9 *I. gorgoleti* sp. nov. 0 *Caucasopsis orientalis* (Starobogatov, 1962), *C. subovata* (Starobogatov, 1962) and *C. pulcherrima* (Starobogatov, 1962) 3 *C. shadini* (Starobogatov, 1962) 4 *C. aculeus* (Starobogatov, 1962) and *C. schakuranica* (Starobogatov, 1962) 22, 23 *C. egrisi* sp. nov. 24 *C. olsavskyi* sp. nov. 25, 30, 31 *C. letsurtsume* sp. nov.

## Imeretiopsis prometheus Grego & Palatov, sp. nov.

http://zoobank.org/70A971CF-7229-4C46-93CC-8D31DDC65E07 Plates 6(1–6); 7(1); 9(7)

**Type locality.** Georgia • Imereti, Kumistavi, Prometheus Cave (პრომეთეს მღვიმე); 42°22'33"N, 42°36'2"E; 175 m a.s.l.; bottom of cave stream.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 01 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T017-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T017-P1/21 dry, SBMNH 633098/4 dry, NHMW 113372/1 dry, HNHM 104682/1 dry, NHMUK 20191338/1 dry, NHMB 563970/1 dry, SMF 358929/1 dry, ZMH140634/1 dry, NHMW 113372/1 dry, ZIN 1/508-2020/1 dry, coll. JG F/21 dry and 2 wet, coll. Glöer/1 dry.



**Plate 6. 1–6** *Imeretiopsis prometheus* sp. nov., Imereti, Kumistavi, Prometheus Cave, specimens used for molecular and anatomical studies. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph A. Falniowski.



Plate 7. 1 *Imeretiopsis prometheus* sp. nov., Imereti, Kumistavi, Prometheus Cave, paratype SBMNH 633098 2 *I. nakeralaensis* sp. nov., Imereti, Tikbuli, spring below Nakerala Pass, paratype SBMNH 633110 3 *I. gorgoleti* sp. nov., Racha, Gorgoleti, above road to Tsakhi, paratype SBMNH 635910 4 *Caucasopsis egrisi* sp. nov., Pirveli Blada, spring in village, paratype SBMNH 639559. Scale bars: 1 mm. SEM SBMNH Vanessa Delnavaz.



Figure 11. Morphology of the penis **A**, **B** *Caucasopsis letsurtsume* sp. nov., Samegrelo: **A** ventrally **B** dorsally **C** *Imeretiopsis gorgoleti* sp. nov. Photograph A. Falniowski and A. Rysiewska.

**Diagnosis.** The species differs from all the related morphotypes from the Caucasus by the more conical-elongate shell with typical triangular shell shape, by the more oval aperture situated more right of the columellar axis (to viewer; shell in apertural pose, apex up). *I. cameroni* sp. nov. has a much narrower elongated shell shape with a more elongated aperture and less inflated whorls with closed umbilicus, and *I. nakeralaensis* sp. nov. has more robust, oval shell with proportionally smaller aperture and narrower umbilicus.

**Description.** *Shell:* elongate-conical, 1.42–1.66 mm high with five whorls, blunt protoconch, inflated whorls, deep suture and proportionally larger body whorl. Umbilicus narrow, slit like. Shell surface glossy, translucent with horny-yellowish periostracum, occasionally covered by rusty-brown inorganic incrustations. Aperture irregularly ovate, slightly expanded, separated from body whorl by a grove and by broadening adapical apertural gap. Lateral labral profile weakly sinuated, columellar profile straight. Protoconch strongly pitted.

**Operculum:** yellowish, translucent, elongate ellipsoid, paucispiral with excentric nucleus.

Animal body: eyeless, milky whitish coloured with light brown pellets.

*Holotype measurements:* H-1.66 mm; W-0.53 mm; BH-0.87 mm; BW-0.72 mm; AH-0.60 mm; AW-0.47 mm; CA: 33°.

Etymology. Name is derived from the type locality inside Prometheus Cave (პრომეთეს მღვიმე). The cave was named after Prometheus, the Titan of Greek mythology, who created mankind from clay, stealing the fire from gods and providing it to humanity. As punishment, he was eternally bound to a rock at Caucasus Mountains, where each day an eagle was sent to feed on his liver. **Habitat.** Stygobiotic species. Empty shells of the new species were found among the sandy sediments inside the cave stream of Prometheus Cave. Live individuals were found attached at the slimy surface of boulders and gravel at the bottom of underground streambed. The rock surface was covered by dark brown- black slimy microbial mats likely serving as a food substrate. More specimens were found in flowing stream than semi-stagnant water.

**Distribution.** Only known from the type locality.

**Conservation status.** The number of known localities (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

#### Imeretiopsis gorgoleti Grego & Mumladze, sp. nov.

http://zoobank.org/9326015A-DFD6-4CE8-BFE4-4A35FBFC981C Plates 7(3); 8(1–4, 9–14); Fig. 11C

**Type locality.** Georgia • Racha, Gorgoleti; 42°31′03″N, 42°54′59″E; 620 m a.s.l.; small cave spring on the right bank of the Shareula River between Gorgoleti and Tsakhi villages.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 13 October 2019; J. Grego, L. Mumladze and G. Bananashvili; ISU FM-T013-H. *Paratypes*: same as for



Figure 12. A, B *Caucasopsis letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave, specimens used for molecular studies. Photograph A. Falniowski.



Plate 8. 1–4 Imeretiopsis gorgoleti sp. nov., Racha, Gorgoleti, small spring above the road to Tsakhi:
I holotype 2 paratype NHMW113279 3, 4 paratypes 5, 6 I. iazoni sp. nov., Imereti, Kutaisi, Iazoni Cave:
5 holotype 6 paratype 7, 8 I. cameroni sp. nov., Imereti, Kutaisi, Iazoni Cave, paratypes 9–13 I. gorgoleti sp. nov., specimens used for molecular and anatomical studies 14 I. gorgoleti sp. nov., operculum. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph Sara Schnedl, NHMW, and A. Rysiewska.

holotype; ISU FM-T013-P1/49 dry and 83 wet, SBMNH 635910/7 dry, NHMW 113279/2 dry, HNHM 104681/2 dry, NHMUK 20191337/2 dry, NHMB 563968/2 dry, SMF 358928/2 dry, ZMH 140633/2 dry, MNHN-IM-2016-7897, ZIN 1/509-2020/2 dry, coll. JG F1430/49 dry and 84 wet.

**Diagnosis.** The new species differs from all the related species of the region by its more robust shape, more open umbilicus and more expanded rounded aperture. The most similar shell morphology can be seen in *I. iazoni* sp. nov., however, *I. gorgoleti* sp. nov. has a much larger and robust shell with a more open umbilicus and more expanded aperture. From the members of the genus *Caucasopsis* gen. nov. as the *C. tsurtsume* sp. nov. it differs by its less sinuated labral margin and by a more regular apertural form.

**Description.** *Shell:* height ranges from 1.52 to 2.18 mm, conical to ovate-conical shell, with 4½ whorls, blunt protoconch, rather inflated whorls and deep suture. Umbilicus widely open. Shell surface glossy, milky-translucent with very faint almost invisible axial growth lines. Aperture subcircular and expanded. Lateral labral profile weakly sinuated adapically toward the body whorl; columellar labrum has a weak sinuation near columella. Protoconch surface densely covered by large regular weak pits.

Operculum: translucent, milky whitish, paucispiral with excentric nucleus.

*Animal body*: animal white, eyeless with light brown pellets and randomly spread dark grey diffused fibre-like streaked blotches on mantle visible through the translucent shell from body whorl up to the early whorls.

*Holotype measurements:* H-2.18 mm; W-1.44 mm; BH-1.35 mm; BW-1.15 mm; AH-0.94 mm; AW-0.82 mm; CA: 38°.

*Anatomy*: the penis (Fig. 11C) bent, cylindrical, distally with no filament but broadly conical, in its median part a characteristically shaped double outgrowth, proximally broad and distally blunt.

**Etymology.** Name derived from Gorgoleti village (Racha region) (სოფელი გორგოლეთ), which is the closest village to the type locality.

**Habitat.** Stygobiotic species. Many live specimens were found on tree roots submerged in small cave ponds. The phreatic rhizosphere habitat provides enough food either directly through root exudation (Canarini et al. 2019), by direct feeding on root tissue or feeding on microbial slime covering the submerged roots, as well as on the decaying roots.

Distribution. Only known from the type locality.

**Conservation status.** The number of known localities (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The phreatic rhizosphere habitat for gastropods was known to us from Central and South-eastern Europe. There it hosts mostly valvatiform shelled stygobiotic gastropods; however, the rich food source it provides can attract various gastropod species. We suppose the slightly sinuated aperture (labral and columellar margin) of *Imeretiopsis* could help the animals in attaching to cylindrical shape of the fine roots.

## *Imeretiopsis nakeralaensis* Grego & Mumladze, sp. nov. http://zoobank.org/38835E75-8986-46B0-9040-F427F5E12A57 Plate 9(9)

**Type locality.** Georgia • Imereti, Tkibuli, Tkibuli-Nikortsminda road to Nakerala Pass (ნაქერალას უღელტეხილი); 42°23'00"N, 42°00'45"E; 980 m a.s.l.; spring above left side of road with small travertine waterfall and a small spring cavern entrance.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 04 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T015-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T015-P1/10 dry, SBMNH 633110/2 dry, NHMW 113371/1 dry, NHMB 563969/2 dry, coll. JG F1009/10 dry, coll. Glöer/1 dry.

**Diagnosis.** The new species differs from all the morphotypes with related shell shape in the region by its more robust oval shape, by the position of the aperture more right of the columella (to viewer; shell in apertural pose, apex up), and by the more open umbilicus. *Caucasogeyeria shakuranica* (Starobogatov, 1962) from Abkhazia has similar but narrower shell shape with less inflated whorls and a proportionally smaller body whorl. *Caucasogeyeria letsurtsume* sp. nov. has a smaller shell with more inflated whorls and more open umbilicus.

**Description.** *Shell:* 2 mm high, elongate ovate-conical with pronounced protoconch, five tumid whorls and moderately deep suture. Shell surface whitish, translucent-glossy, covered by faint axial growth lines. Umbilicus open. Proportionally small aperture irregular, almost round, not expanded, with straight lateral and columellar labral profiles lacking sinuation. Protoconch surface densely and coarsely pitted.

## **Operculum:** not known.

#### Animal body: not known.

*Holotype measurements:* H-2.00 mm; W-1.09 mm; BH-1.02 mm; BW-0.85 mm; AH-0.64 mm; AW-0.53 mm; CA: 29°.

#### Anatomy: not known.

**Etymology.** Name after the Nakerala Pass 1218 m alt. situated above the type locality north of Tikbuli along the road to Ambrolauri.

**Habitat.** Stygobiotic species. The empty shells of the species were found at the foot of small travertine cascade formed by a small stream emerging from the very narrow cave spring (small entrance covered by moss and ivy). Only a few shells were found in sparse sediments accumulated near the cave walls. The shells were washed out from its subterranean habitat by the very small permanent stream.

Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The assignment of the new species to the genus *Imeretiopsis* gen. nov. is only provisional, based on the resemblance if its shell to that of the type species. However, molecular data will be essential to confirm generic placement.



Plate 9. 1 *Caucasopsis olsavskyi* sp. nov., Samegrelo, Chkhorotsku, Nazodelavo Cave, holotype 2 *C. let-surtsume* sp. nov., Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave, holotype 3 *C. letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Kachara Cave 4 *C. egrisi* sp. nov., Samegrelo, Pirveli Balda, Motena Cave form 5, 6 *C. egrisi* sp. nov., Samegrelo, Pirveli Balda, spring in village: 5 holotype 6 paratype 7 *Imeretiopsis prometheus* sp. nov., Imereti, Kumistavi, Prometheus Cave, holotype 8 *I. cameroni* sp. nov., Imereti, Kutaisi, Iazoni (Tskhal-Tsiteli) Cave Spring, holotype 9 *I. nakeralaensis* sp. nov., Imereti, Tikibuli, spring above Tikibuli-Nikortsminda road to Nakerala pass, holotype 10 *C. letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Letsurtsume Cave, robust morphotype. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.

## Imeretiopsis cameroni Grego & Mumladze, sp. nov.

http://zoobank.org/0E981A62-FAEF-4440-9B5F-636EA97EFBAB Plates 8(7, 8); 9(8)

**Type locality.** Georgia • Imereti, Kutaisi, Iazoni (Tskhal-Tsiteli) Cave spring (იაზონის იგივე წყალ-წითელას მღვიმე), right bank of Tskalsitela River; 146 m alt., 42°16'18"N, 42°44'2"E; 145 m a.s.l.; sandy sediment inside the cave.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 01 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T016-H. *Paratypes*: Georgia • same as for holotype; 12 October 2019; J. Grego, L. Mumladze and G. Bananashvili leg.; 4 ISU FM-T016-P1/1 dry, JG F1406/1 dry, ZIN 1dry.

**Diagnosis.** The new species differs conspicuously from all the similar species of the region by its more slender shell with more conspicuous axial growth lines, closed umbilicus and narrower aperture. *Caucasogeyeria orientalis* (Starobogatov, 1962) has a similar, but more robust, oval shell shape with a different shape of the aperture.

**Description.** *Shell:* elongate narrow-turreted, 2.00–2.29 mm high shell with 5½ tumid whorls, weak suture and flat blunt apex. The early whorls rather inflated, and the inflation of whorls regularly decreasing abapically, apex almost flat. Shell surface glossy, whitish translucent with faint regularly spaced distant rib-like growth lines. Umbilicus closed. Aperture not expanded, elongate-oval with weakly sinuated labral profile and flat columellar profile. Protoconch pitted.

*Operculum:* light yellow, horny, elongate ellipsoid, paucispiral with excentric nucleus. *Animal body:* not known.

*Holotype measurements:* H-2.00 mm; W-0.81 mm; BH-0.96 mm; BW-0.72 mm; AH-0.62 mm; AW-0.49 mm; CA: 35°

Anatomy: not known.

**Etymology.** Named after Robert A. D. Cameron from Sheffield University, who significantly contributed to the malacological knowledge of Eurasia including Caucasus region.

**Habitat.** Stygobiotic species. The fresh empty shells, some with opercula, were found in the sandy sediment of the cave stream. The condition of the shells indicates its habitat in the deep cave zone.

**Distribution.** Only known from the type locality.

**Conservation status.** The species is known from a single location and EOO is smaller than 10 km<sup>2</sup>. There is also indication of stochastic human driven habitat pollution and a very scare occurrence of dead mature individuals indicating a very weak surviving population. Therefore, it is assessed as Critically endangered (EN) B2.

**Remarks.** The assignment of the new species to the genus *Imeretiopsis* gen. nov. is only provisional, based on the shell habitus, e.g., the similarly sinuated lateral labral profile. Molecular data will be necessary to confirm the taxonomic position of the species. The type locality, Iazoni Cave was formed in Cretaceous limestone with a high content of quartz sand grains. The sand accumulated in thick sedimentary layers after the carbonate dissolution inside the cave. A few kilograms of the cave sand had to be screened to find a single specimen. The cave drains water from a populated area SE of Kutaisi, and the sediments indicated a contamination by micro plastic and perhaps occasionally by chemicals

from municipal waste. This can pose a direct danger to the important cave fauna including *Motsametia borutzkii* (Shadin, 1932), *Euglesa subterranea* (Shadin, 1932) and cave shrimps *Xiphocaridinella kutaissiana* Sadowski, 1930, *Niphargus borutzkyi* Birstein, 1933 and *Asellus monticola fontinalis* Birstein, 1936 reported from the type locality.

#### Imeretiopsis iazoni Grego & Mumladze, sp. nov.

http://zoobank.org/39F50FD0-D0AC-4DD5-9298-90CFE998515F Plate 8(5–6)

**Type locality.** Georgia • Imereti, Kuatisi, Iazoni (Tskhal-Tsiteli) Cave Spring (იაზონის იგივე წყალ-წითელას მღვიმე), right bank of Tskalsitela River Canyon; 42°16'18"N, 42°44'02"E; 145 m a.s.l.; sandy sediment inside the cave.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; J. Grego, L. Mumladze and G. Bananashvili leg.; ISU FM-T014-H. *Paratypes*: same as for holotype, ISU FM-T014-P1/1 dry, coll. JG F1409/1dry.

**Diagnosis.** The species differs from the most closely related *Imeretiopsis gorgoleti* sp. nov. by its much smaller, less inflated shells with proportionally smaller and less expanded aperture and by the smaller umbilicus. From the other stygobiotic gastropods of the region with similar shell shape it differs by its smaller shell with the sinuated lateral labral profile. From the sympatric *I. cameroni* sp. nov. it differs by the much smaller shell, more inflated whorls, flatter apex and more open umbilicus. Measurement comparison *Imeretiopsis* species is given in Table 5.

<u> </u>	**	3377	DII	DW		43377	<b>C A</b>	TTOW	A T T /	NYC /			NY7 /	TTION
Genus species	н	w	вн	BW	AH	AW	CA	H/W	AH /	w/	H/	H/	w/	H/(W-
	mm	mm	mm	mm	mm	mm	deg.		AW	BW	BH	AH	AW	BW)
Imeretiopsis gorgoleti sp. nov.	2.18	1.44	1.35	1.15	0.9 4	0.82	38	1.51	1.15	1.25	1.61	2.32	1.76	7.52
Holotype LT														
Imeretiopsis gorgoleti sp. nov.	1.64	1.03	1.09	0.85	0.71	0.62	35	1.59	1.15	1.21	1.50	2.31	1.66	9.11
<b>Paratype</b> LT	1.85	1.02	1.18	0.94	0.76	0.62	30	1.82	1.23	1.08	1.57	2.43	1.64	23.72
Imeretiopsis iazoni sp. nov.	1.47	0.74	0.85	0.68	0.50	0.47	35	1.99	1.06	1.09	1.73	2.94	1.57	24.50
Holotype LT														
Imeretiopsis iazoni sp. nov.	1.35	0.88	0.82	0.68	0.50	0.41	32	1.53	1.22	1.29	1.65	2.70	2.15	6.75
<b>Paratype</b> LT														
Imeretiopsis cameroni sp. nov.	2.29	0.94	1.15	0.79	0.71	0.53	34	2.44	1.34	1.19	1.99	3.23	1.77	15.27
Paratype LT	2.12	0.85	1.06	0.71	0.62	0.50	32	2.49	1.24	1.20	2.00	3.42	1.70	15.14
Imeretiopsis cameroni sp. nov.	2.00	0.81	0.96	0.72	0.62	0.49	35	2.47	1.26	1.12	2.09	3.24	1.65	23.50
Holotype LT														
Imeretiopsis prometheus sp. nov.	1.66	0.53	0.87	0.72	0.60	0.47	33	3.12	1.27	0.74	1.90	2.79	1.14	-8.67
Holotype LT														
Imeretiopsis prometheus sp. nov.	1.63	0.85	0.88	0.75	0.55	0.48	32	1.91	1.16	1.13	1.86	2.95	1.79	16.25
Topotype LT	1.55	1.63	0.90	0.70	0.53	0.45	31	0.95	1.17	2.32	1.72	2.95	3.61	1.68
	1.43	0.75	0.75	0.63	0.48	0.38	32	1.90	1.27	1.20	1.90	3.00	2.00	11.40
	1.48	0.88	0.85	0.70	0.58	0.45	30	1.69	1.28	1.25	1.74	2.57	1.94	8.43
	1.70	0.88	0.88	0.73	0.53	0.46	34	1.94	1.14	1.21	1.94	3.24	1.89	11.33
Imeretiopsis nakeralaensis sp. nov.	2.00	1.09	1.02	0.85	0.64	0.53	29	1.84	1.20	1.28	1.96	3.13	2.04	8.55
Holotype LT														

Table 5. Measurement comparison of species from genus Imeretiopsis gen. nov.

**Description.** *Shell:* rather small, 1.38–1.47 mm high, elongate-conical with four whorls, blunt and flat apex, inflated whorls and deep suture. Umbilicus narrow, almost closed. Shell surface glossy, milky white with irregular growth lines, randomly forming faint, rib-like structures. Aperture irregularly oval, slightly depressed from columel-lar side and slightly expanded. Lateral labral profile very weakly sinuated, columellar profile rather straight.

**Operculum:** not known.

Animal body: not known.

*Holotype measurements:* H-1.47 mm; W-0.74 mm; BH-0.85 mm; BW-0.68 mm; AH-0.50 mm; AW-0.47 mm; CA: 35°.

Anatomy: not known.

**Etymology.** Named after the type locality, Iazoni Cave (იაზონის მღვიმე) (= Tskal-Tsiteli = Rioni Cave (= წყალწითელას = რიონის მღვიმე)) in Kutaisi.

Habitat. Stygobiotic species. See habitat of Imeretiopsis cameroni sp. nov.

Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The assignment to the genus *Imeretiopsis* gen. nov. is only provisional due to sinuated aperture margins and resemblance to *I. gorgoleti*. sp. nov.; molecular data will be needed to determine its true taxonomic status. The type locality has indications of occasional pollution, and most of the stygobiotic Mollusca endemic to the cave (*M. borutzkii* (Shadin, 1932), *Euglesa subterranean* (Shadin, 1932) and *Imeretiopsis cameroni* sp. nov.) have shown declining populations. The new species is scarcer than all of the sympatric species.

#### Genus Caucasopsis Grego & Mumladze, gen. nov.

http://zoobank.org/7FAE27A6-16B9-4946-A5E8-4CAD2DCF6C33

#### Type species. Caucasopsis letsurtsume Grego & Mumladze, sp. nov.

Species assigned to the genus. Paladilhiopsis shadini Starobogatov, 1962, Paldilhiopsis subovata Starobogatov, 1962; Paladilhiopsis pulcherrima Starobogatov, 1962; Paladilhiopsis orientalis Starobogatov, 1962 Paladilhiopsis schakuranica Starobogatov, 1962; Paladilhopsis aculeus Starobogatov, 1962; Caucasopsis letsurtsume Grego & Mumladze, sp. nov., Caucasopsis olsavskyi Grego & Mumladze, sp. nov., Caucasopsis egrisi Grego & Mumladze, sp. nov.

**Diagnosis.** The new genus has a shell shape similar to members of the genus *Imeretiopsis* gen. nov. from more eastern localities of the Imereti region, which have, in contrast, a sinuated labral lateral profile. However, both genera can be clearly distinguished by their penes (Fig. 11A, B): the penis is long, with the filament (lacking in *Imeretiopsis*) and, below the filament, delicately marked outgrowth on the left side (in *Imeretiopsis* there are two broad outgrowths).

**Etymology.** The name derived from the prefix *Caucas*- referring to the distribution range in the Caucasus Mountains and suffix *–opsis* reminiscent of the previously applied genus *Paladilhiopsis Pavlović*, 1913, adopted by Starobogatov (1962) for the similar shelled species from Abkhazia and from the Sochi region (Russia). Its gender is feminine.

**Distribution.** The new genus *Caucasopsis* is known from the Samegrelo region, and likely from the Abkhazia and Sochi regions in the Russian Federation (Fig. 10).

#### Caucasopsis letsurtsume Grego & Mumladze, sp. nov.

http://zoobank.org/06134CEA-7B68-4E06-939E-D47A2B991109 Plates 9(2, 3, 10); 10(1, 2, 4); 11(1–4); Figs 11A, B, 12A, B

**Type locality.** Georgia • Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave (ლეწურწუმეს მღვიმე); 42°32'21"N, 42°06'48"E; 180 m a.s.l.; sandy sediment in cave stream.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T010-H *Paratypes*: same as for holotype; ISU FM-T010-P1/80 dry, SBMNH 633077/5 dry, NHMW 113368/2 dry, HNHM 104679/2 dry, NHMUK 0191335/2 dry, NHMB 563966/2 dry, SMF 358926/2 dry, ZMH 140631/2 dry, MNHN-IM-2016-7896, ZIN 1/510-2020/2 dry, coll. JG F1045/80 dry, coll. Glöer/1 dry. *Other material*: Georgia • Samegrelo, Chkhorotsku, Kachara Cave (ქაჩარას მღვიმე); 42°31'47"N, 42°10'39"E; 205 m a.s.l.; sandy sediment at cave stream; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM/6 dry and 7 wet, SBMNH 633080, coll. JG F1051/6 dry and 8 wet. Georgia • Samegrelo, Chkhorotsku, Garakha, Savekuo Cavern; 42°30'23"N, 42°08'46"E; 240 m a.s.l.; mud sediments in the spring pond; 12 June 2019; H. Reip leg.; coll. F. Walther/58, coll. J. Grego/3 dry.

**Diagnosis.** *Caucasopsis letsurtsume* sp. nov. differs from its closest relatives by its elongate-oval shell with inflated whorls and open umbilicus with aperture situated more right of the columellar axis (to viewer; shell in apertural pose, apex up). *Caucasopsis letsurtsume* sp. nov. has a more robust shell with proportionally larger body whorl, smaller umbilicus and with different protoconch surface. *Caucasopsis olsavskyi* sp. nov. can be differentiated by its different shell shape, closed umbilicus and proportionally smaller aperture situated adjacent to the columellar axis. The shell of *C. egrisi* sp. nov. is more slender with less inflated whorls and more closed umbilicus. Its shell morphology also resembles *Imeretiopsis nakeralaensis* sp. nov., which has a more elongate shell, more open umbilicus, less inflated whorls and a proportionally smaller rounded aperture situated more left of the columella (to viewer; shell in apertural pose, apex up).

**Description.** *Shell:* elongate-oval, 1.64 mm high with blunt apex, inflated, 4½ whorls and deep suture. Shell surface smooth, glossy with very faint growth lines. Umbilicus narrow, slit-like. Aperture ovoid in shape, attached to the body whorl only shortly by an indistinct groove. Lateral and columellar profiles of the aperture straight. Lateral profile of the body whorl slightly expanding. Protoconch densely pitted.


Plate 10. I *Caucasopsis letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Letsurtsume Cave, paratype SBM-NH 633079 2 *C. letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave, morphotype SBMNH 633078 3 *C. olsavskyi* sp. nov., Samegrelo, Chkhorotsku, Nazodelavo Cave, paratype SBMNH 633081 4 *C. letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Kachara Cave, SBMNH 633080. Scale bars: 1 mm. SEM SBMNH Vanessa Delnavaz.



**Plate 11. 1–4** *Caucasopsis letsurtsume* sp. nov., Samegrelo, Chkhorotsku, Kachara Cave, specimens used for molecular and anatomical study. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph A. Falniowski.

*Operculum:* paucispiral yellowish, horny elongate ellipsoid with excentric nucleus. *Animal body:* not known.

*Holotype measurements:* H-1.64 mm; W-0.94 mm; BH-0.89 mm; BW-0.72 mm; AH-0.60 mm; AW-0.47 mm; CA: 34°.

**Anatomy:** the penis (Fig. 11A, B) simple, straight, proximally and medially broad, distally with a moderately long, narrow filament; below the filament a delicately marked outgrowth on the left side.

**Etymology.** Name derived from the name of Letsurtsume Cave, the type locality of the species.

**Habitat.** Stygobiotic species. Empty shells of the new species were found in the sandy sediments of a cave stream penetrating through Miocene conglomerate deposits. Live individuals were found on a blackish microbial slime covered surface of rocks and gravel at the bottom of cave stream.

Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (3) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The shell shape of the species varies considerably in the only known locality. A second morphotype occurs in the type locality and differs significantly in shell morphology from the typical form. It is characterised by a more inflated-conical shell with 4½ whorls, by proportionally larger body whorl and open umbilicus (Morphotype B, Plates 9(10); 10(2), Fig. 12A). Shell morphology is similar to the genus *Motsametia* Vinarski, Palatov & Glöer, 2014. However, the DNA sequences (COI and H3) of both morphotypes are almost identical (see 1Z82 and 1Z80 on molecular trees in Figs 5–7); we consider them for the time being as one species with extraordinary morphological variability. The occurrence of the robust morphotype in much lower ratio, and the few available anatomical data do not suggest a sexual dimorphism. No parasites explaining the malformation found.

The population of *C. letsurtsume* sp. nov. from Kachara Cave differs from the type series by less inflated whorls and more closed umbilicus. The molecular distance within Clade B (Fig. 7) is 0.007 for COI, which indicates, that very closely situated hypogean habitats could host typical populations as a result of early allopatric evolution without any recent communication among the two populations.

#### Caucasopsis olsavskyi Mumladze & Grego, sp. nov.

http://zoobank.org/F220AA48-63FE-4C96-A2CB-05D7AFEEF821 Plates 9(1); 10(3)

**Type locality.** Georgia • Samegrelo, Chkhorotsku, Nazodelavo Cave (ნაზოდელავოს მღვიმე); 42°30'18"N, 42°13'15"E; 275 m a.s.l.; sandy sediment in cave stream.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 11 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T009-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T009-P1/ dry, NHMW 113369/1 dry, coll. JG F1053/2 dry, coll. Glöer/1 dry.

**Diagnosis.** The new species differs from its closest relatives by its oval shell shape, proportionally smaller aperture more close-set to the columella and closed umbilicus. There is some similarity to the shell shape of *C. subovata* (Starobogatov, 1962) from Abkhazia, however, the broken subfossil type does not allow more detailed comparison, and the drawing of the author within the description was likely just a reconstruction of the broken holotype.

**Description.** *Shell:* is 1.50–1.96 mm high, elongate ovate-conical with rounded whorls and blunt apex. Surface smooth, whitish, occasionally with inorganic incrustations. Aperture proportionally small, flat-ovoid shaped, situated below larger body whorl. Lateral profile of labral margin straight, columellar margin very weakly sinuated. Umbilicus closed.

**Operculum:** not known.

Animal body: not known.

*Holotype measurements:* H-1.87 mm; W-0.85 mm; BH-0.94 mm; BW-0.77 mm; AH-0.60 mm; AW-0.45 mm; CA: 26°.

Anatomy: not known.

**Etymology.** Named for our friend Mário Olšavský, geologist and speleologist from Banská Bystrica, Slovakia, who actively participated in the field trip to Georgia.

**Habitat.** Stygobiotic species. Empty shells were found at the sandy bottom of the cave stream inside a conglomerate cave. The empty shells were very scarce, as an undetermined *Tschernomorica* sp. was more abundant in the type locality.

Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

# Caucasopsis egrisi Grego & Mumladze, sp. nov.

http://zoobank.org/746702F9-8F03-425B-89C4-BFD55834BFC6 Plate 9(4–6)

Type locality. Georgia • Samegrelo, Pirveli Balda (პირველი ბალდა), spring in village above road; 42°29'2"N, 42°23'53"E; 300 m a.s.l.

Material. *Holotype*: Georgia • 1. Adult, dry; type locality; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T007-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T007-P1/1 dry, coll. JG F1031/2 dry. • same as for holotype; 13 October 2019; J. Grego leg.; ISU FM- T007-P2/2 dry, coll. JG F1436/22 dry SBMNH 639553, HNMB 563965/1 dry, NHMW 113367/1 dry.

### Caucasopsis cf. egrisi

**Other material.** Georgia • Samegrelo, Pirveli Balda, Motena Cave; 42°28'36"N, 42°23'29"E; 480 m a.s.l.; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. ISU FM-HYD1/2 dry and JG/3 dry.

**Diagnosis.** The new species shows some similarity to the geographically isolated *C. olsavskyi* sp. nov. from Nazodelavo Cave near Chkhorotsku, but it differs by its by its more oval, elongate shells shape with proportionally larger body whorl, by larger and differently positioned aperture situated more left of the columella (to viewer; shell in apertural pose, apex up) and by the more closed umbilicus. Measurement comparison of *Caucasopsis* species is given in Table 6.

**Description.** *Shell:* narrow elongate-oval, 1.66–2.00 mm high with 4½ slightly tumid whorls, blunt protoconch, and weak suture. Shell surface whitish and smooth with faint axial growth lines, covered by milky white periostracum and by inorganic incrustations. Aperture proportionally smaller vs. the body whorl and more close-set to the columellar axis. The peristome attached to the body whorl by a weak sulcus over approximately a quarter of its outline. Lateral and columellar labral profiles smooth-straight with no traces of any sinuation. Umbilicus closed.

**Operculum:** not known.

Animal body: not known.

*Holotype measurements:* H-2.00 mm; W-0.91 mm; BH-1.19 mm; BW-0.81 mm; AH-0.64 mm; AW-0.51 mm; CA: 34°.

Anatomy: not known.

**Etymology.** Named after Egrisi (ეგრοსο), the historical name of the Colchis Kingdom established in the region from the 13<sup>th</sup> to the 1<sup>st</sup> century BC (disestablished in 164 BC).

**Habitat.** Stygobiotic species. The secondary position where the empty shells of the new species were found is the spring head of small springs in village Pirveli Balda emerging from the stone debris at foot of the limestone plateau. The primary subterranean habitat is inaccessible and unknown.

Genus species	Н	W	BH	BW	AH	AW	CA	H/W	AH /	W/	H/	H/	W /	H/(W-
-	mm	mm	mm	mm	mm	mm	deg.	1	AW	BW	BH	AH	AW	BW)
Caucasopsis letsurtsume sp. nov.	1.83	1.00	1.11	0.89	0.64	0.53	33	1.83	1.20	1.12	1.65	2.87	1.88	17.20
Kachara Cave	1.81	0.92	0.96	0.77	0.62	0.50	30	1.96	1.23	1.20	1.88	2.94	1.85	11.75
	1.96	1.00	1.06	0.81	0.65	0.54	32	1.96	1.21	1.24	1.85	3.00	1.86	10.20
	1.50	0.81	0.96	0.71	0.58	0.42	32	1.86	1.36	1.14	1.56	2.60	1.91	15.60
Caucasopsis letsurtsume sp. nov.	1.64	0.94	0.89	0.72	0.60	0.47	34	1.75	1.27	1.29	1.83	2.75	2.00	7.70
Holotype LT (form A)														
Caucasopsis letsurtsume sp. nov.	1.72	1.23	1.19	1.00	0.72	0.58	2	1.40	1.24	1.23	1.45	2.39	2.12	7.48
Paratype LT (form B)														
Caucasopsis olsavskyi sp. nov.	1.87	0.85	0.94	0.77	0.60	0.45	26	2.20	1.33	1.11	2.00	3.14	1.90	22.00
Holotype LT														
Caucasopsis egrisi sp. nov.	1.66	0.87	0.89	0.68	0.57	0.47	30	1.90	1.23	1.28	1.86	2.89	1.86	8.67
Motena Cave														
Caucasopsis egrisi sp. nov.	2.00	0.91	1.19	0.81	0.64	0.51	34	2.19	1.25	1.13	1.68	3.13	1.79	18.80
Holotype LT														
Caucasopsis egrisi sp. nov.	1.74	0.77	0.98	0.72	0.57	0.43	30	2.28	1.35	1.06	1.78	3.04	1.80	41.00
Paratype LT														

Table 6. Measurement comparison of species from genus Caucasopsis gen. nov.

**Distribution.** Only known from the type locality; the similar shells can be found in a nearby Motena Cave.

**Conservation status.** The number of known locations (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The assignment of the new species to the genus *Caucasopsis* gen. nov. is only provisional, based on the sinuated lateral labral profile and on the locality, situated close to the distribution range of *Imeretiopsis* gen. nov. The molecular data will be essential to assign the species to the correct genus. The population in Motena Cave has slightly different shell morphology, and, despite their close localities, both represent different hydrological systems (perched water tables) separated by horizontal impermeable sandstone beds with more than 100 m difference in altitude. It is possible both populations could show separation at the species level; however, we prefer provisionally to treat them as one species until molecular data become available.

### Genus Caucasogeyeria Grego & Mumladze, gen. nov.

http://zoobank.org/AC1C48F4-F8E2-455B-AA9D-630CA818AAF5

#### Type species. Caucasogeyeria gloeri Grego & Mumladze, sp. nov.

**Species assigned to the genus.** "*Geyeria*" valvataeformis Starobogatov, 1962, "*Geyeria*" horatieformis Starobogatov, 1962, *C. gloeri* Grego & Mumladze, sp. nov., *Caucasogeyeria ignidona* Grego & Palatov, sp. nov., *C. colchis* Grego & Mumladze, sp. nov., *C. pseudocolchis* Grego & Mumladze, sp. nov., *C. chrysomallos* Grego & Mumladze, sp. nov.

**Diagnosis.** The genus is well-separable from all other genera of the region by its conspicuously and deeply sinuated labral and columellar margins. The genus *Imeretiopsis* gen. nov., has much weaker and morphologically different labral sinuation, and the type species of the genus *Kartvelobia* gen. nov. has a very differently curled labral margin. The penis simple, long and narrow, different than in the genera mentioned above.

**Etymology.** The prefix of the new species *Caucaso-* is derived from the distribution range of genus in the Caucasus Mountains, and the suffix *–geyeria* indicating the invalid genus "Geyeria", previously applied for the genus by Starobogatov (1962). The genus name "Geyeria" was originally dedicated to the famous German malacologist David Geyer (6 November 1855–6 November 1932), who contributed greatly to the documentation of the German malacofauna. It was introduced by A. J. Wagner (1914) for the species "*Geyeria" plagiostoma* from the Bosna River springs near Sarajevo. However, the genus name proved permanently invalid due to junior homonymy, as it had been previously used by Buchecker in 1876 to name a moth in the family Castniidae Boisduval, 1828, Buckman 1899 for a cephalopod, Carapezzae and Schopen 1899 for a brachiopod, and Fucini 1901 for a cephalopod. Based on the homonymy, Tomlin in 1930 renamed the genus to *Plagigeyeria*. Later Starobogatov (1962) erroneously applied the invalid genus name to two stygobiotic species from the southwestern Caucasus ("*Geyeria" valvataeformis* and "*G." horatieformis*). The gender is feminine.

**Distribution.** The genus is distributed on the Pakhe Plateau (situated S of Askhi Plateau) and in springs emerging around its slopes as well as at spring emerging from limestone massif north of Mukhuri settlement (Fig. 13).

#### Caucasogeyeria gloeri Grego & Mumladze, sp. nov.

http://zoobank.org/2899DC4B-27E1-4ABF-AECD-74A7048A53C5 Plates 13(1–7); 14(1–4); 16(9); 18(3)

**Type locality.** Georgia • Imereti, Satsiskvilo, Turchusmtha (სოფელი საწისქვილი), small spring on the left side of path ascending the plateau; 42°29'25"N, 42°32'50"E; 980 m a.s.l.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T003-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T003-P1/170 dry, SBMNH 633095/11 dry, NHMW 113363/2 dry, HNHM 104677/2 dry, NHMUK 20191333/2 dry, NHMB 563963 /2 dry, SMF 358924/2 dry, ZMH 140629/2 dry, MNHN-IM-2016-7894, ZIN 1/506-2020/2 dry, coll. JG F0990/170 dry, coll. Glöer/1 dry. *Other material*: Georgia • Imereti, Nakhriduri 2 left tributary spring at Turchu Gamosadivari Basin; 42°28'39"N, 42°30'43"E; 870 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/12 dry. • Imereti, Turchusmtha, Okatse Spring above Kinchkha waterfall; 42°29'49"N, 42°32'49"E; 1050 m a.s.l.; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/19 dry. • Imereti, Nakhriduri, Turchu Gamosadivari Cave Spring; 42°29'13"N, 42°31'20"E; 954 m a.s.l.; 03 May 2018; E J. Grego, L.

Mumladze and M. Olšavský leg.; coll. JG/4 dry. • Imereti, Nakhriduri left side tributary spring at Turchu Gamosadiyari Basin above small ford; 42°28'39"N, 42°30'43"E; 875 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/27 dry. • Imereti, Upskhero (უფსკერო) Spring Lake at Turchu Gamosadivari Basin; 42°27'47"N, 42°30'3"E; 960 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/3 dry. • Imereti, Nakhriduri 1 at bottom of Turchu Gamosadivari Basin near farm house; 42°28'27"N, 42°30'13"E; 860 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/2 dry. • Imereti, Nakhriduri 3 spring at Turchu Gamosadivari Basin left tributary spring; 42°28'40"N, 42°30'46"E; 875 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/23 dry.• Imereti, Nakhiduri 2 left side spring above small ford; 42°28'39"N, 42°30'43"E; 870 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/ dry. Georgia • Samegrelo, Pirveli Balda (პირველი ბალდა), spring in village above road; 42°29'2"N, 42°23'53"E; 300 m a.s.l. • Samegrelo, Pirveli Balda, Motena Cave; 42°28'36"N, 42°23'29"E; 480 m a.s.l.; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. ISU FM-HYD2/2 dry and JG/3 dry.

### Caucasogeyeria cf. gloeri

Other material. Georgia • Samegrelo, Shurubumu Spring (შურუბუმუს წყარო) on the left bank of Khobistskali River; 42°39'0"N, 42°12'21"E; 310 m a.s.l.; 10 May



Figure 13. Distribution map of *Caucasogeyeria* gen. nov. 0 *C. valvataeformis* (Starobogatov, 1962) (magenta dot) 4. *C. horatiaeformis* (Starobogatov, 1962) (turquoise dot) 16–22 *C. gloeri* sp. nov. (blue dots)
27, 28 *C. cf. gloeri* (light blue dots) 7 *C. ignidona* sp. nov. (purple dot) 20, 22, 23 *C. colchis* sp. nov. (red dots) 26, 28 *C. pseudocolchis* sp. nov. (black dots) 27, 29 *C. chrysomallos* sp. nov. (green dots).



Plate 12. *Caucasogeyeria* specimens used for molecular and anatomical studies 1 *C. chrysomallos* sp. nov. 2-4 *C. ignidona* sp. nov. 5-8 *C. colchis* sp. nov., live specimens Pirveli Balda, spring in the village 9-12 *C. chrysomallos* sp. nov. The numbers correspond to individuals. Photograph A. Falniowski, J. Grego, A. Rysiewska.



Plate 13. 1–7 *Caucasogeyeria gloeri* sp. nov. 1, 2 Imereti, Satsiskvilo, Turchusmtha I holotype 2 paratype 4 Imereti, Nakhriduri, Spring at Turchu Gamosadivari Basin 5 Imereti, Turchusmtha, spring of Okatse and cave above Kinchkha waterfall 6 Imereti, Nakhriduri, Turchu Gamosadivari Cave Spring 7 Imereti, Nakhriduri, left tributary spring in Turchu Gamosadivari Basin 3 *Caucasogeyeria* cf. *gloeri* 2, Samegrelo, Shurubumu, spring on left bank of Khobistskali River. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.

2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-HYD2/5 dry, SBMNH 633085/1, NHMW 113364/1 dry, coll. JG F0988/4 dry. • Samegrelo, Mapeli Cave (053000b 00300), Mukhuri, water catchment (above cemetery); 42°38'22"N, 42°11'39"E; 325 m a.s.l.; 12 October 2019; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-HYD3/4 dry, coll. JG F1411/5 dry.

**Diagnosis.** The new species differs from the other representatives of the genus by the aperture with a characteristic positive labral and negative columellar sinuations and pyramidal-triangular shell shape. From *C. ignidona* sp. nov. it can be distinguished by the different form of the aperture and its larger, more robust shell shape. *Caucasogeyeria colchis* sp. nov. has a more deeply cut labral sinuation at its junction with the body whorl (posterior canal), more inward reflexed mid-labral section and more elevated conical spire. *Caucasogeyeria chrysomallos* sp. nov. has a similar lateral labral profile, but the shell is significantly smaller with a more narrow-elongate conical shape with a sharper apex. The two species from Abkhazia (*C. valvataeformis* and *C. horatiaeformis*) differ in shell shape and lack sinuated labral and columellar margins.

**Description.** *Shell:* conically shaped with 3½ inflated whorls and blunt apex, height 1.40–2.08 mm. The body whorl proportionally large and expands slightly towards the aperture. The shell surface milky whitish with dense faint regular axial growth lines, frequently covered by rusty-brown inorganic incrustations. The expanding irregular shaped aperture with a characteristic pronounced sinuation at its labral margin best seen in lateral profile. The sinuation slightly curved inward the aperture. The columellar margin with an inward sinuation. Umbilicus widely open. Protoconch surface smooth with almost invisible smooth pitting.

**Operculum:** translucent glass-whitish, circular, paucispiral with excentric nucleus.

Animal body: not pigmented, white coloured, eyeless with proportionally long tentacles.

*Holotype measurements:* H-1.40 mm; W-1.29 mm; BH-1.06 mm; BW-1.00 mm; AH-0.80 mm; AW-0.70 mm; CA: 26°.

#### Anatomy: not known.

**Etymology.** Named after the renowned German malacologist Peter Glöer from Hetlingen (Germany), who contributed much to the study of Eurasian freshwater Mollusca as well as the knowledge of Ponto-Caspian freshwater biodiversity.

**Habitat.** Stygobiotic species. Most of the empty shells of the new species were found in the sandy sediments of karst springs of all types, from large spring lakes down to very small water outlets emerging from tiny fissures among limestone slabs. The great number of empty shells in some localities with no live individuals suggest its habitat is deeper in underground fissures and caves with very limited survival at epigean habitats. The few live shells were obtained from a spring emerging from stone debris, after removing the larger stones from the spring head and digging ca. 60–80 cm inside the spring head.

**Distribution.** *Caucasogeyeria gloeri* sp. nov. is known from the eastern range of limestone Pakhe Plateau from Kinchkhaperdi to Satsiskvilo and in all springs of the Turchu Gamosadivari Basin in Imereti region. The isolated population from Shurubumu Spring and Mapeli Cave at Mukhuri (*C. cf. gloeri*), Samegrelo region (Plates 13(3), 14(4) and 16(9)) could represent a geographical subspecies or a distinct species.



Plate 14. *Caucasogeyeria gloeri* sp. nov. I Imereti, Satsiskvilo, Turchusmtha, paratype SBMNH 633095
2 Imereti, Nakhriduri, 1 paratype SBMNH 633102
3 Imereti, Nakhriduri, spring at Turchu Gamosadivari Basin paratype SBMNH 633095
4 *Caucasogeyeria* cf. *gloeri*, Samegrelo, Mukhuri, Shurubumu spring, paratype SBMNH 633085. Scale bars: 1 mm (SEM SBMNH Vanessa Delnavaz).

Genus species	Н	W	BH	BW	AH	AW	CA	H/W	AH /	W/	H/	H/	W/	H/(W-
	mm	mm	mm	mm	mm	mm	deg.	1	AW	BW	BH	AH	AW	BW)
Caucasogeyeria gloeri sp. nov.	1.40	1.29	1.06	1.00	0.80	0.70	26	1.09	1.14	1.29	1.32	1.75	1.84	4.83
Holotype LT														
Caucasogeyeria gloeri sp. nov.	1.46	1.21	1.03	1.00	0.80	0.71	24	1.21	1.13	1.21	1.42	1.83	1.70	6.95
Paratype LT														
Caucasogeyeria gloeri sp. nov.	1.97	1.71	1.37	1.31	0.97	0.94	45	1.15	1.03	1.31	1.44	2.03	1.82	4.93
Nakriduri 1 spring														
Caucasogeyeria gloeri sp. nov.	2.08	1.69	1.34	1.37	1.09	0.88	45	1.23	1.24	1.23	1.55	1.91	1.92	6.50
Okatse Spring														
Caucasogeyeria gloeri sp. nov.	1.67	1.54	1.31	1.20	0.97	0.80	45	1.08	1.21	1.28	1.27	1.72	1.93	4.91
Turchu Gamosadivari														
Caucasogeyeria gloeri sp. nov.	1.81	1.54	1.31	1.20	0.97	0.80	46	1.18	1.21	1.28	1.38	1.87	1.93	5.32
Nakriduri 4														
Caucasogeyeria gloeri sp. nov.	1.69	1.48	1.37	1.11	1.00	0.86	45	1.14	1.16	1.33	1.23	1.69	1.72	4.57
Shurubumu														
Caucasogeyeria gloeri sp. nov.	1.81	1.53	1.30	1.21	0.93	0.84	22	1.18	1.11	1.27	1.39	1.95	1.83	5.57
Mapeli Cave														

Table 7. Measurement comparison of *Caucasogeyeria gloeri* sp. nov. from different localities.

**Conservation status.** The number of known locations is 13 and EOO is ca. 70 km<sup>2</sup>. The AOO is represented by only several underground karst conduits with much smaller total area compared to EOO. Each karst conduit is supplied by surface water through swallow holes, where stochastic events, as human driven pollution or habitat destruction, could lead to rapid species decline or extinction. Therefore, it is assessed as Vulnerable (VU) D2.

**Remarks.** The shell shape of the new species is quite variable over its range, but the typical features, such as the apertural sinuation seem to be more-or-less constant. A more intensive search in areas between the two main distribution points would be necessary to understand the phylogenetic relations of different populations. The population from Shurubumu Spring and Mapeli Cave is conchiologically very similar, however differs significantly by more coarsely pitted protoconch surface, molecular data are needed to confirm its specific or sub-specific status. Measurement comparison of different *C. gloeri* populations is given in Table 7.

#### Caucasogeyeria ignidona Grego & Palatov, sp. nov.

http://zoobank.org/6DE56E85-4B3D-431D-AE7F-2CB087B421CD Plate 15(1); Fig. 14A–C

**Type locality.** Georgia • Imereti, Kumistavi, Prometheus Cave (პრომეთეს მღვიმე); 42°22'33"N, 42°36'2"E; 175 m a.s.l.; bottom of cave stream.

Material. *Holotype*: Georgia • adult, dry; type locality; 01 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T005-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T005-P1/1 dry and 1 wet, coll. JG F0969/1 dry and 2 wet.

**Diagnosis.** The new species can be distinguished from other members of the genus by the typical shell aperture. *Caucasogeyeria gloeri* sp. nov. has a larger, more robust

shell with different aperture, *C. colchis* sp. nov. has more sinuated and more deeply cut labral margin at its columellar side, and *C. chrysomallos* sp. nov. has smaller, more conical and elongate shell with a greater number of whorls and proportionally smaller, differently shaped aperture.

**Description.** *Shell:* conical with blunt protoconch and with 3½ inflated whorls separated by semi-deep suture. Height 1.4–1.7 mm. Shell surface milky white, glossy with occasional rusty brown incrustations. Aperture expanded, proportionally larger, rhomboidal with a weak negative sinuation at labral junction with the body whorl and a weak positive sinuation at columellar margin. Umbilicus slit-like.

**Operculum:** paucispiral, glass-like translucent.

Animal body: white, without eye spots.

*Holotype measurements:* H-1.60 mm; W-1.10 mm; BH-1.15 mm; BW-0.9 mm; AH-0.85 mm; AW-0.70 mm; CA: 28°.

**Anatomy:** the penis (Fig. 14A–C) bent, simple, narrow, gradually narrowing towards its distal end, vas deferens inside running straight.

**Etymology.** Name derived from Latin word *ignidona* meaning of "donating fire", referring to the gift of Prometheus to the mankind, indirectly indicating the name of type locality in the Prometheus Cave near Kutaisi.

Habitat. Stygobiotic species. Live individuals of the new species were found in the cave stream on submerged stones and gravel, covered by a layer of dark brown-black layer of bacterial mats. Empty shells were found in sandy sediment of the cave stream.

**Distribution.** Only known from the type locality.

**Conservation status.** The number of known locations (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The sympatric *Imeretiopsis prometheus* sp. nov. has more numerous populations throughout the cave stream. It is not clear whether both species share the micro-habitats within the same cave stream.

#### Caucasogeyeria colchis Grego & Mumladze, sp. nov.

http://zoobank.org/740D6F25-3482-4F15-B21B-784B7C0319BE Plates 15(2–4); 17(1, 2)

**Type locality.** Georgia • Samegrelo, Pirveli Balda, Motena Cave; 42°28'36"N, 42°23'29"E; 480 m a.s.l.; sediment in terminal lake.

Material. *Holotype*: Georgia • 1 adult dry; Type locality; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T002-H. *Paratypes*: Georgia • same as for holotype; coll. JG T1036/1 dry; • Samegrelo, Pirveli Balda (პირველი ბალდა), spring in village above road; 42°29'2"N, 42°23'53"E; 295 m a.s.l.; 09 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T002-P1/12 dry, SBMNH 633068/4 dry, NHMW 113362/1 dry, coll. JG F1034/12 dry. • same as preceding;



Plate 15. I *Caucasogeyeria ignidona* sp. nov., Imereti, Kumistavi, Prometheus Cave, holotype 2 *Caucasogeyeria colchis* sp. nov., Samegrelo, Pirveli Balda, Motena Cave, holotype 3 *Caucasogeyeria colchis* sp. nov., Samegrelo, Pirveli Balda, spring in village, holotype 4 *Caucasogeyeria colchis* sp. nov., Imereti, Nakhriduri 2 left side spring in Turchu Gamosadivari Basin above small ford, paratype 5–8 *Caucasogeyeria pseudocolchis* sp. nov., Samegrelo, Mukhuri, Shisha Spring 5 holotype 6–8 paratypes. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.



Figure 14. A–C *Caucasogeyeria ignidona* sp. nov., Imereti, Kumistavi, Prometheus Cave D *C. chrysomallos* sp. nov., Kanti, Mapeli Spring, morphology of the penis. Photograph A. Falniowski and A. Rysiewska.

same as preceding; 12 October 2019; J. Grego leg.; ISU FM-T002 P2/5 dry, HNHM 104676/1 dry, NHMB 563962 /1 dry, SMF 358923/1 dry, coll JG F1434/37 dry. *Other material:* Georgia • Imereti, Nakhriduri 6, left tributary rivulet under travertine waterfall; 42°29'7"N, 42°31'22"E; 960 m a.s.l.; 03 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG/4 dry.

**Diagnosis.** The *C. colchis* sp. nov. differs from all the members of the genus by its more deeply cut sinuation at the junction of the labral margin with the body whorl. The sinulus-like deep grove and the characteristically inward bent labral fold clearly distinguish the species from its congeners. From *C. pseudocolchis* sp. nov. it can be distinguished mainly by shallower and narrower sinulus-like cut at the posterior canal, by the differently curved columellar peristome, different sinuation of the labral margin and by proportionally larger body whorl.

**Description.** *Shell:* conical, elevated 1.35–1.80 mm high shell with 4½ inflated whorls and a deeply cut suture. Shell colour milky white with frequent reddish-brown inorganic encrustations. Umbilicus widely open. The expanded, rhomboidal aperture with a characteristic deep and broad sinus-like cut at the adapical labral junction with the body whorl. The protruded labral fold characteristically curved inward, continuing to a negative sinuation at the lower extremity of the aperture. Columellar margin just slightly positively sinuated. Protoconch surface regularly pitted.

**Operculum:** white, glassy translucent, circular and paucispiral with excentric nucleus.

Animal body: entirely white, without eyes and bears, very long tiny tentacles (Plate 12(5-8)).

*Holotype measurements:* H-1.80 mm; W-1.40 mm; BH-1.15 mm; BW-1.10 mm; AH-0.85 mm; AW-0.65 mm; CA: 37°.

Anatomy: not known.

Etymology. Named after the ancient kingdom Colchis (3mmbgomo) established in the territory of the southwestern Caucasus and the Colchis lowland from the  $13^{th}$  century BC to 164 BC.

**Habitat.** Stygobiotic species. The scarce empty shells were found in the terminal sump lake of Motena Cave, and a few live individuals with some empty shells in the head of Pirveli Balda spring as it emerges from stone debris.

**Distribution.** Except the type locality and the Motena Cave, the species is known from one locality in the Turchu Gamosadivari basin.

**Conservation status.** The number of known locations (3) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The species is sympatric with the *C. gloeri* sp. nov. in Nakhriduri 2 spring in the Turchu Gamosadivari Basin, Imereti and in Motena Cave and Piveli Balda spring in Samegrelo. Both species can be clearly separated by shell morphology without intermediates, indicating their separate specific position. Separation is confirmed by a p-distance = 0.034 in the H3 gene.

### Caucasogeyeria pseudocolchis Grego & Mumladze, sp. nov.

http://zoobank.org/36879DBA-9FA7-47B7-8AFC-9590900986DA Plates 15(5–8); 17(4); 18(2)

**Type locality.** Georgia • Samegrelo, Mukhuri, Shisha Spring (სოფელი მუხური, შიშა წყარო); 42°37'47"N, 42°11'26"E; 255 m a.s.l.

Material. *Holotype:* Georgia • 1 adult, dry; type locality; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T006-H. *Paratypes:* Georgia • same as for holotype; coll. JG F1057/2 dry. • same as preceding; 10 October 2019; J. Grego, L. Mumladze and G. Bananashvili leg.; ISU FM-T006-P1/5 dry, SBMNH 635902/1 dry, coll. JG F1420/9 dry. • Samegrelo, Mukhuri, Shurubumu 1 Spring on left bank of Khobistskali River; 42°39'0"N, 42°12'21"E; 310 m a.s.l.; sediment at outlet; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG F1057/2 dry.

**Diagnosis.** *Caucasogeyeria pseudocolchis* sp. nov. differs from all the members of the genus by its more deeply cut and broader sinuation at the posterior canal, at the junction of the labral margin with the body whorl. The larger sinulus-like deep grove and the characteristically unbent labral fold with a different aperture shape clearly distinguish the species from the closely related *C. colchis* sp. nov.

**Description.** *Shell:* pyramidal with four inflated whorls, deeply cut suture and proportionally larger body whorl. Height 1.32–1.55 mm. The milky white shell with occasionally reddish brown inorganic encrustation. Umbilicus widely open. The expanded, rhomboidal aperture framed by a very deep and very broad cut at the posterior canal. The protruded labral fold straight, not curved inward. Labrum continues smoothly toward the lower extremity. Columellar margin is more or less straight. Protoconch surface with large regular deep pits.

**Operculum:** not known.

#### Animal body: not known.

*Holotype measurements:* H-1.45 mm; W-1.15 mm; BH-1.25 mm; BW-0.95 mm; AH-0.70 mm; AW-0.60 mm; CA: 28°.

Anatomy: not known.

**Etymology.** Named after the very similar shell shape to the *C. colchis* sp. nov. known from the Pakhe Plateau near Pirveli Balda and Nakhriduri.

**Habitat.** Stygobiotic species. Very worn and fragmented empty shells with only a few intact specimens were found in Shisha Spring, and a single live individual was found in a spring Shurubumu near Mukhuri. The condition of the material indicates a deep stygobiotic habitat far from the springhead with its accumulated recent thanatocoenoses.

**Distribution.** Known only from the type locality at Shurubumu Spring and from Shisha Spring in the vicinity of Mukhuri.

**Remarks.** The new species is sympatric with the *C*. cf. *gloeri* at Shurubumu Spring. **Conservation status.** The number of known locations (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

### Caucasogeyeria chrysomallos Grego & Mumladze, sp. nov.

http://zoobank.org/5837CAA1-020A-46D1-9168-E1881C232D9F Plates 16(1–8); 17(3); 18(1); Fig. 14D

**Type locality.** Georgia • Samegrelo, Kanti Village near Mukhuri, Mapeli Spring (სოფელი კანტი, მაპელის წყარო); 42°38'23"N, 42°10'08"E; 290 m a.s.l.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 12 October 2019; J. Grego, L. Mumladze and G. Bananashvili leg.; ISU FM-T001-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T001-P1/12 dry and 24 wet, SBMNH 633099/2 dry, NHMW 113365/1 dry, HNHM 104678/1 dry, NHMUK 20191334/2 dry, NHMB 563964/1 dry, SMF 358925/1 dry, NHMW 113365, ZMH 140630/1 dry, MNHN-IM-2016-7895, ZIN 1/507-2020/1 dry, coll. JG F1414/15 dry and 24 wet, coll. Glöer/1 dry. • same as for holotype; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG F1041/2 dry. *Other material*: Georgia • Samegrelo, Mapeli Cave, Mukhuri, water catchment (above cemetery); 42°38'22"N, 42°11'39"E; 325 m a.s.l.; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; coll. JG Frego, L. Mumladze and M. Olšavský leg.; coll. JG 7404.

**Diagnosis.** The new species differs from all congeners by its smaller more elongateconical shell with more numerous whorls combined with a smaller umbilicus. The aperture sinuation shows similarity with *C. gloeri* sp. nov., however, the latter has a larger, more robust and less elevated shell shape with the columellar sinuation. *Caucasogeyeria colchis* sp. nov. differs from new species by its larger size and more deeply sinuated labral margin. Measurement comparison of *Caucasogeyeria* species is given in Table 8.

**Description.** *Shell*: elongate conical with five tumid whorls, a semi-deep suture, a blunt apex and a narrow umbilicus. Height 1.40–1.93 mm. Shell surface smooth,



Plate 16. 1-6 Caucasogeyeria chrysomallos sp. nov., Samegrelo, Mukhuri, Kanti, Mapeli Spring I holotype 2-6 paratypes 7, 8 Caucasogeyeria chrysomallos sp. nov., Samegrelo, Mukhuri, Kanti, Mapeli Spring 9 Caucasogeyeria cf. gloeri, Samegrelo, Mukhuri, Mapeli Cave, paratype. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.



Plate 17. 1 *Caucasogeyeria colchis* sp. nov., Samegrelo, Pirveli Balda, Motena Cave, paratype SBMNH 633072 2 *Caucasogeyeria colchis* sp. nov., Samegrelo, Pirveli Balda, spring in village, paratype SBMNH 633068 3 *Caucasogeyeria chrysomallos* sp. nov., Samegrelo, Mukhuri, Kanti, Mapeli Spring, paratype SBMNH 633099 4 *Caucasogeyeria pseudocolchis* sp. nov., Samegrelo, Mukhuri, Shisha Spring, paratype SBMNH 633082. Scale bars: 1 mm. SEM SBMNH Vanessa Delnavaz.

covered by a milky white periostracum, frequently overlaid by thick dark brown-black inorganic precipitate. The expanded aperture irregularly pear shaped. Labral margin with a weak but broad negative sinuation near the body whorl junction, followed by a characteristic inward curved but shallow labral fold. Columellar margin is straight, not sinuated. Protoconch surface regularly pitted, pitting fading out at the nucleus.

**Operculum:** light yellow, paucispiral with central nucleus.

Animal body: without eye spots, not pigmented, whitish translucent.

*Holotype measurements:* H-1.93 mm; W-1.21 mm; BH-1.21 mm; BW-1.07 mm; AH-0.84 mm; AW-0.65 mm; CA: 30°.

Anatomy: penis (Fig. 14D) straight, simple, without any outgrowth.

**Etymology.** Name derived from the Greek name *Chrysomallos*, meaning Golden Fleece (symbol of authority and monarchy), which, according to Greek mythology, was held in Colchis. Jason and his crew of Argonauts were sent out on a quest for the Golden Fleece by order of King Pelias.

**Habitat.** Stygobiotic species. Live individuals as well as empty shells were washed out from its subterranean habitat through a small spring in Mapeli emerging near the road in village Kanti. The dense brown-black deposits on most of individuals indicates a subterranean habitat with chemolithotrophic bacteria. The second known population was found in the sediments of a subterranean cave stream inside Mapeli Cave, ca. 30 m from its entrance

Distribution. Only known from the type locality and from Mapeli Cave.

**Conservation status.** The number of known locations (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO,

Genus species	Н	w	BH	BW	AH	AW	CA	H/W	AH /	W/	H/	H/	W/	H/(W-
Genne operate	mm	mm	mm	mm	mm	mm	deg.		AW	BW	BH	AH	AW	BW)
Caucasogeyeria ignidona sp. nov. Holotype LT	1.60	1.10	1.15	0.90	0.85	0.70	28	1.45	1.21	1.22	1.39	1.88	1.57	8.00
Caucasogeyeria colchis sp. nov. Holotype LT	1.80	1.40	1.15	1.10	0.85	0.65	37	1.29	1.31	1.27	1.57	2.12	2.15	6.00
<i>Caucasogeyeria colchis</i> sp. nov. <b>Paratype</b> Priveli Balda	1.35	1.30	0.95	0.90	0.75	0.55	31	1.04	1.36	1.44	1.42	1.80	2.36	3.38
<i>Caucasogeyeria colchis</i> sp. nov. <b>Paratype</b> Nakriduri 2 spring	1.60	1.20	1.05	0.90	0.75	0.60	30	1.33	1.25	1.33	1.52	2.13	2.00	5.33
Caucasogeyeria pseudocolchis sp. nov. Holotype Shisha Spring	1.45	1.15	1.25	0.95	0.70	0.60	28	1.26	1.17	1.21	1.16	2.07	1.92	7.25
<i>Caucasogeyeria pseudocolchis</i> sp. nov. <b>Paratype</b> Shisha Spring	1.55	1.20	1.10	0.95	0.76	0.57	24	1.29	1.33	1.26	1.41	2.04	2.11	6.20
Caucasogeyeria chrysomallos sp. nov. Holotype LT	1.93	1.21	1.21	1.07	0.84	0.65	30	1.60	1.29	1.13	1.60	2.31	1.86	13.83
Caucasogeyeria chrysomallos sp. nov.	1.86	1.21	1.16	0.98	0.79	0.65	28	1.54	1.21	1.24	1.60	2.35	1.86	8.00
Paratype LT	1.77	1.23	0.98	0.95	0.74	0.63	33	1.43	1.19	1.29	1.81	2.38	1.96	6.33
	1.77	1.16	1.07	0.93	0.74	0.60	29	1.52	1.23	1.25	1.65	2.38	1.92	7.60
	1.67	1.16	1.05	0.93	0.72	0.60	33	1.44	1.19	1.25	1.60	2.32	1.92	7.20
	1.77	1.14	0.98	0.88	0.79	0.60	28	1.55	1.31	1.29	1.81	2.24	1.88	6.91
	1.40	1.23	0.98	0.98	0.70	0.65	30	1.13	1.07	1.26	1.43	2.00	1.89	5.45
	1.58	1.14	1.02	0.93	0.74	0.56	28	1.39	1.33	1.23	1.55	2.13	2.04	7.56

Table 8. Measurement comparison of species from genus Caucasogeyeria gen. nov.



Plate 18. 1 *Caucasogeyeria chrysomallos* sp. nov., Samegrelo, Mukhuri, Kanti, Mapeli Spring, paratype SBMNH 635903 2 *Caucasogeyeria pseudocolchis* sp. nov., Samegrelo, Mukhuri, Shisha Spring, paratype SBMNH 635902 3 *Caucasogeyeria* cf. *gloeri*, Samegrelo, Mukhuri, Mapeli Cave, paratype SBMNH 635901. Scale bars: 1 mm. SEM SBMNH Vanessa Delnavaz.

number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The population in Mapeli Cave is typical but has a lower spire and fewer whorls. Its taxonomic position will be clarified after the collection of live individuals.

#### Genus Pontohoratia Vinarski, Palatov & Glöer, 2014

Type species. Horatia birsteini Starobogatov, 1962

Species assigned to the genus. Pontohoratia birsteini (Starobogatov, 1962), P. smyri Vinarski, Palatov & Glöer, 2014, P. vinarskii Grego & Mumladze, sp. nov., P. pichkhaiai Grego & Mumladze, sp. nov., P. mapeli Grego & Mumladze, sp. nov.

**Distribution.** The genus is known from Samegrelo region around Mukhuri and from Abkhazia in the vicinity of Sukhumi (Fig. 15).

#### Pontohoratia vinarskii Grego & Mumladze, sp. nov.

http://zoobank.org/785C454A-73B0-4C37-AAB4-A9989B268236 Plates 19(1–5); 20(1, 2, 8, 9); Fig. 16A, B

**Type locality.** Georgia • Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave (ლეწურწუმეს მღვიმე); 42°32'21"N, 42°06'48"E; 180 m a.s.l; sandy sediment in the cave stream bottom.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 02 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T023-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T023-P1/350 dry and 18 wet, P2/10 dry, SBMNH 633077/5 dry, NHMW 113377/3 dry, HNHM 104686/3 dry, NHMUK 20191341/3 dry, NHMB 563974/3 dry, SMF 358934/3 dry, ZMH 140638/3 dry, MNHN-IM-2016-7902, ZIN 1/505-2020/3 dry, coll. JG F1046/350 dry and 18 wet, JG F1047/10 dry, coll. Glöer/1 dry. *Other material*: Georgia • Samegrelo, Chkhorotsku, Garakha, Savekuo Cavern, mud sediments in the spring pond; 42°30'23"N, 42°08'46"E; 240 m a.s.l.; 12 June 2019; H. Reip leg.; coll. F. Walther/243 dry, coll. JG/20 dry.

**Diagnosis.** The new species differs from *P. smyri* Vinarski, Palatov & Glöer, 2014 by its more elevated spire and by a proportionally smaller and more ovate aperture. The geographically close *C. pichkhaiai* sp. nov. and *C. mapeli* sp. nov. have similar shells, but both are flatter and have much smaller rounded apertures.

**Description.** *Shell:* flat, discoid with elevated spire and flat apex. Diameter 1.31– 1.58 mm. Umbilicus widely opened. The 2<sup>3</sup>/<sub>4</sub> whorls are separated by a deeply cut sulcus. Shell transparent whitish colour with smooth surface and almost invisible growth lines. Oval aperture with axis declined towards columella. Peristome smooth without any folds. Lateral profile of the labrum is slightly angled towards the body whorl at its upper side, where attached by a narrow furrow. Protoconch surface regularly weakly pitted on the nuclear portion and abapically smooth.

**Operculum:** orange coloured circular, translucent, with central nucleus, thickened at its centre, but without peg on its inner side.

Animal body: whitish, not pigmented, eyeless.

*Holotype measurements:* H-1.08 mm; W-1.47 mm; BH-0.87 mm; BW-1.00 mm; AH-0.63 mm; AW-0.55 mm; CA: -20°.



Figure 15. Distribution map of genera *Pontohoratia* Vinarski, Palatov & Glöer, 2014; *Motsametia* Vinarski, Palatov & Glöer, 2014 and *Hausdorfenia* gen. nov. I *P. smyri* Vinarski, Palatov & Glöer, 2014 (black dot) **2–4** *P. birsteini* (Starobogatov, 1962) (grey dots) **6** *M. borutzkii* (Shadin, 1932) (purple dot) **10** *H. shareula* sp. nov. (dark red dot) **12–15** *H. hauffeniaformis* sp. nov. (red dots) **27** *P. pichkhaiai* sp. nov. (light blue dot) **28** *P. mapeli* sp. nov. (medium blue dot) **30–31** *P. vinarskii* sp. nov. (dark blue dot).

*Anatomy*: the penis (Fig. 16A, B) simple, broad and blunt, without any outgrowth. **Etymology.** Named after renowned Russian malacologist Maxim V. Vinarski, Saint-Petersburg State University, Russia, who contributed significantly to Eurasian freshwater Mollusca studies as well as to the study of southwestern Caucasus freshwater Mollusca.

Habitat. Stygobiotic species. See habitat of Caucasopsis letsurtsume sp. nov.

Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The shell morphology of the new species within the type locality varies considerably from almost flat shells to specimens with elevated spired and a more conical shell shape. Similar variability in the shell shape had been observed in the sympatric *Caucasopsis letsurtsume* sp. nov. It is curious whether both extreme variabilities could have the same environmental driver in the locality or if it could be a result of a parasitism. Many individuals are densely covered by calcareous inorganic precipitates, and some of them resemble a grain of sand without a recognisable shell shape. The operculum may also be densely covered by inorganic incrustations (Plate 20(9)).



**Plate 19. 1–5** *Pontohoratia vinarskii* sp. nov.: Samegrelo, Chkhorotsku, Letsurtsume Cave, specimens used for molecular and anatomical study. The numbers correspond to individuals. Photograph A. Falniowski.

#### Pontohoratia pichkhaiai Grego & Mumladze, sp. nov.

http://zoobank.org/CC9EB289-9412-41F5-A761-EE76E6AD276D Plates 20(3); 21(2); 22(5–8); Fig. 16C, D

Type locality. Georgia • Samegrelo, Mukhuri, Shisha Spring (შიშა წყარო, სოფელი მუხური); 42°37'47"N, 42°11'26"E; 255 m a.s.l.; sediment at bottom of spring zone.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 10 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T022-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T022-P1/9 dry, coll. JG F1044/9 dry; • same as for holotype; J. Grego, L. Mumladze and G. Bananashvili leg.; ISU FM-T022-P2/13 dry SBMNH 633083/1 dry, NHMW 113376/1 dry, HNHM 104685/1 dry, NHMB 563973/1 dry, SMF 358933/1 dry, ZMH 140637/1 dry, MNHN-IM-2016-7901, ZIN 1/504-2020/1 dry, coll. JG F1419/14 fry, coll. Glöer/1 dry.

**Diagnosis.** The new species differs from the geographically close *P. vinarskii* sp. nov. by its flatter shell and smaller, more rounded aperture. *P. mapeli* has a flatter shell with smaller, more rounded aperture.

**Description.** *Shell:* planispiral small, discoid, the spire only a slightly pronounced and early whorls flat, umbilicus widely opened and protoconch surface pitted. Diameter 1.36–1.68 mm. The descending whorls separated by a deep suture. The shell wall is translucent, the surface whitish and smooth. The aperture proportionally small and circular with the labral peristome angled vs. the columellar axis. The aperture in a short distance joining the body whorl. Protoconch surface weakly pitted in its nuclear portion and abapically gradually changing into a smooth slightly malleated surface.

**Operculum:** reddish, circular, paucispiral, with central nucleus and smooth central callosity without forming a peg at its attachment.



**Figure 16. A, B** *Pontohoratia vinarskii* sp. nov.: Samegrelo, Chkhorotsku, Nazodelavo Cave, morphology of penis **C, D** *P. pichkhaiai* sp. nov.: Samegrelo, Chkhorotsku, Shisha Spring, morphology of penis **E, F** *P. mapeli.* sp.: Samegrelo, Kanti, Mapeli Spring, morphology of penis. Photograph A. Falniowski and A. Rysiewska; drawing A. Falniowski.



Plate 20. 1, 2 Pontohoratia vinarskii sp. nov., Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave: I holotype 2 paratype 3 *P. pichkhaiai* sp. nov., Samegrelo, Mukhuri, Shisha Spring, holotype 4 Hausdorfenia pseudohauffenia sp. nov., Racha, Zemo Krikhi, Krikhula Spring, holotype 5 *H. shareula* sp. nov., Racha, Nikortsmintha, Tsivtskala 2 Spring near power station in the Shareula valley, holotype 6 *P. mapeli* sp. nov., Samegrelo, Mukhuri, Kanti, Mapeli Spring, holotype 7 *H. pseudohauffenia* sp. nov., Racha, Zemo Krikhi, Krikhula Spring; aberrant specimen 8,9 *P. vinarskii* sp. nov., Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave: 8 morphotype 9 live specimen with marked carbonate incrustations. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph J. Grego.

*Holotype measurements:* H-0.87 mm; W-1.42 mm; BH-0.66 mm; BW-1.00 mm; AH-0.50 mm; AW-0.5 mm; CA: -45°.

**Anatomy:** the penis (Fig. 16C, D) simple, without any outgrowths, broad, slowly narrowing to its distal end.

Etymology. Named after the avid speleologist Igor Pichkhaia (იგორ ფიჩხაია) from Chkhorotsku, who supported our research in the region of Samegrelo (Mingrelia).

**Habitat.** Stygobiotic species. Empty shells and a few live individuals were found washed out from primary habitat at the bottom sediments of the spring lake of Shisha spring near Mukhuri. See the habitat of *Kartvelobia shishaensis* sp. nov.

Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

# Pontohoratia mapeli Grego & Mumladze, sp. nov.

http://zoobank.org/B4E27364-8825-4C7F-8E4F-B60648230AF3 Fig. 16E, F; Plates 20(6); 21(4); 22(1–4)

**Type locality.** Georgia • Samegrelo, Kanti Village near Mukhuri, Mapeli Spring (მაპელის წყარო, სოფელი კანტი); 42°38'23"N, 42°10'08"E; 290 m a.s.l.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 06 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T021-H. *Paratypes*: Georgia • same as for holotype; col. JG F1060/5 dry; • same as preceding; 12 October 2019; J. Grego, L. Mumladze and G. Bananashvili leg.; ISU FM-T021-P1/ 40 dry and 69 wet, SBMNH 635896/6 dry, NHMW 113375/2 dry, HNHM 104684/2 dry, NHMUK 20191340/2 dry, NHMB 563972/2 dry, SMF 358931/2 dry, ZMH 140636/2 dry, MNHN-IM-2016-7900, ZIN 1/503-2020/2 dry, coll. JG F1413/40 dry and 69 wet, coll Glöer/1 dry.

**Diagnosis.** The shell of the new species is more flat-discoid with a more open umbilicus, more rounded and proportionally smaller aperture vs. the geographically closest relatives: *P. vinarskii* sp. nov. and *P. pichkhaiai* sp. nov. The shell shape is somewhat similar to *H. pseudohauffenia*, but it can be differentiated by less pronounced protoconch, lower shell height to width ratio the proportionally smaller, more rounded aperture as well by its operculum lacking the knobby sculpture.

**Description.** *Shell:* small, paucispiral, discoid with flat, only slightly pronounced spire and widely opened umbilicus. Diameter 1.37–1.51 mm. The inflated whorls are separated by a deeply cut sulcus. Protoconch surface covered by dense shallow pits. The shell surface whitish and translucent with smooth surface. The aperture round with labral peristome oblique to the columellar axis. The aperture barely attached at its upper columellar side to the body whorl. Protoconch surface covered by raised malleations gradually changing to a regular pitting towards the nucleus.

**Operculum:** reddish, circular, paucispiral with central nucleus, centrally thickened and elevated inward without peg.

*Holotype measurements:* H-0.57 mm; W-1.38 mm; BH-0.55 mm; BW-0.95 mm; AH-0.42 mm; AW-0.45 mm; CA: -40°.

*Anatomy*: the penis (Fig. 16E, F) proximally broad, with a broad, slightly marked outgrowth on its left side in the median part, and thin filament distally.

**Etymology.** Name derived from the name of Mapeli (მაპელი) Spring in Kanti (კანტი) Village, the type locality of the species.

Habitat. Stygobiotic species. See the habitat of *Caucasogeyeria chrysomallos* sp. nov. Distribution. Only known from the type locality.

**Conservation status.** The number of known locations (1) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

## Genus Hausdorfenia Grego & Mumladze, gen. nov.

http://zoobank.org/45FEE38A-2C15-465F-A411-F21DDE5A522A

Type species. Hausdorfenia pseudohauffenia Grego & Mumladze, sp. nov.

Species assigned to the genus. Hausdorfenia shareula Grego & Mumladze, sp. nov. Diagnosis. The new genus differs from Pontohoratia Vinarski, Palatov & Glöer, 2014 by its flatter shell shape, more coarsely pitted protoconch and by its operculum with a distinct peg on its inner side. The molecular data support the closest relationship is to the genus Kartvelobia gen. nov.; however, its valviform shell shape is substantially different from the elongate oval shape and aperture morphology of its relative.

**Etymology.** Name derived from Bernhard Hausdorf, Hamburg University (Germany), who contributed much to the study of Mollusca from whole Caucasus region.

**Distribution.** Known from the karstic plateau of Shaori (ປັດກາດປະຊາດ 3 ແລະ ອັດການ ອາຍັນ ອາຍັນ

# Hausdorfenia pseudohauffenia Grego & Mumladze, sp. nov.

http://zoobank.org/B6B96400-015F-4FFA-8B11-79A1DD25AE38 Plates 20(4, 7); 21(1)

**Type locality.** Georgia, • Racha, Shua Skhvava, Zemo Krikhi, Krikhula Spring (მდინარე კრიხულა); 42°30'04"N, 43°12'27"E; 707 m a.s.l.

Material. *Holotype*: Georgia • 1 adult, dry; type locality. 07 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T011-H. *Paratypes*: Georgia • same as for holotype; ISU FM-T011-P1/41 dry, SBMNH 633086/5 dry, NHMW 113370/1 dry, HNHM 104680/1 dry, NHMUK 20191336/1 dry, NHMB 563967/2 dry, SMF 358927/1 dry, ZMH140632/1 dry, MNHN-IM-2016-7897, ZIN 1/512-2020/1 dry, coll. JG F1025/41 dry, Glöer/1 dry; • same as preceding; 13 October 2019; J. Grego, L. Mumladze and G. Bananashvili leg.; ISU FM-T011-P2/19 dry, coll. JG F1426/19 dry. *Other material*: Georgia • Racha, Kveda Tlughi, Kidobana Cave (კიდობანას მღვიმე); 42°26'1"N, 43°8'45"E; 1190 m a.s.l.; 07 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. • Racha, Kveda Tlughi, Cholaburi karst spring; 42°26'8"N, 43°08'58"E; 1175 m a.s.l.; 07 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. • Racha, Skhartali, Sakishore Cave (საკიშორეს მღვიმე); 42°26'32"N, 43°09'30"E; 1160 m a.s.l.; 07 May 2018; J. Grego, L. Mumladze and M. Olšavský leg. • Racha, Velevi, Dolabistavi Cave (დოლაბისთავის მღვიმე); 42°27'05"N, 43°10'39"E; 1170 m a.s.l.; 07 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.

**Diagnosis.** *Hausdorfenia pseudohauffenia* sp. nov. differs from most of the congeners by its flatter shell with elevated embryonal whorls and more backward protruding lower aperture vs. the columellar axis. Only *P. shareula* sp. nov. has a flatter shell, but its spire is sunken. The reddish operculum with an elevated peg-like structure differentiates the species from all relatives.

**Description.** *Shell:* very flat paucispiral, 1.46–1.73 mm in diameter, discoid with flat or only very slightly elevated apex and widely expanded umbilicus. Descending 3¼ whorls separated by deeply depressed sulcus. Shell pale translucent, whitish surface, smooth with very faint axial growth lines. Aperture ovoid and in basal view declined left towards the body whorl, from which separated by a narrow gap. Lateral profile of the aperture is strongly sloped towards the apex. Protoconch with coarsely pitted surface converting adapically into a raised malleated surface.

**Operculum:** circular, with central nucleus, thickening at its central part. Inner side smooth centrally raising to a distinct internal peg at point of attachment to the retractor muscle (Fig. 17).

*Animal body*: without eye spots, milky white coloured with irregular small dispersed dark grey blotches visible through translucent shell.

*Holotype measurements:* H-0.82 mm; W-1.68 mm; BH-0.74 mm; BW-1.11 mm; AH-0.53 mm; AW-0.58 mm; CA: -48°.

Anatomy: not known.

**Etymology.** Name derived from the shell morphology resemblance of the new taxon to the Middle European stygobiotic genus *Hauffenia* Pollonera, 1899.

**Habitat.** Stygobiotic species. The studied material was found directly at the spring outlet among the larger debris. A few live individuals washed out from its stygobiotic habitat were attached to the undersides of boulders in the spring zone.

**Distribution.** Aside from the type locality similar shells or fragments, likely belonging to the same species, were found in the following localities: Kidobana Cave, Cholaba Spring, Shakishore Cave and Dolabistavi Cave in the Shaori Basin.

**Conservation status.** The number of known locations is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** The sample from type locality yielded a few aberrant solute shells (scalarity) (Plate 20(7)).



Plate 21. I Hausdorfenia pseudohauffenia sp. nov., Racha, Shua Skhvava, Krikhula Spring, paratype SBMNH 633086 2 Pontohoratia pichkhaiai sp. nov., Samegrelo, Mukhuri, Shisha Spring, paratype SBMNH 633083 3 P. vinarskii sp. nov., Samegrelo, Chkhorotsku, Letsurtsume, Letsurtsume Cave, paratype SBMNH 633077 4 P. mapeli sp. nov., Samegrelo. Mukhuri, Kanti, Mapeli Spring, paratype SBMNH 635896. Scale bars: 1 mm. SEM SBMNH Vanessa Delnavaz.



**Plate 22.** Specimens used for molecular and anatomical study **I-4** *Pontohoratia mapeli* sp. nov., Samegrelo, Mukhuri, Mapeli Cave **5–8** *P. pichkhaiai* sp. nov., Samegrelo, Mukhuri, Sisha Spring. The numbers correspond to individuals, and the letters represent the different views of the same individual. Photograph A. Rysiewska.



Figure 17. *Hausdorfenia pseudohauffenia* sp. nov. **A, B** operculum, SBMNH 633086. SEM SBMNH Vanessa Delnavaz.

#### Hausdorfenia shareula Grego & Mumladze, sp. nov.

http://zoobank.org/29BDD264-C578-49D8-945E-F4835070D996 Plate 20(5)

**Type locality.** Georgia • Racha, Nikortsminda, Tsivtskala 2 Spring on left bank of the Shareula River near the power station; 42°28'18"N, 43°03'54"E; 1084 m a.s.l.

Material. *Holotype*: Georgia • 1 adult, dry; type locality; 06 May 2018; J. Grego, L. Mumladze and M. Olšavský leg.; ISU FM-T012-H. *Other material*: Georgia • Fragmented shells; Racha, Nikorsminda, Shareula River Head (Shareula Cave); 42°28'12"N, 43°04'4"E; 1105 m a.s.l.; date; 20.08.2017, J. Grego leg.

**Diagnosis.** The new taxon significantly differs from all congeners by its flat shape with spire hidden in apertural profile and its planorboid coiling, a unique feature within the southwestern Caucasus stygobiotic Gastropoda. Measurement comparison of *Pontohoratia* and *Hausdorfenia* species is given in Table 9.

**Description.** *Shell:* planispiral, discoid with planorboid (slightly hyperstrophic) coiling and 1.34 mm in diameter. Descending 2<sup>1</sup>/<sub>4</sub> whorls separated by a deep suture. Umbilicus very widely expanding. Shell colour milky white, surface smooth with very faint axial growth lines. Aperture circular, and its labral periphery is oblique to the columellar axis. It attached to the whole length of the adjacent body whorl by a narrow suture. Protoconch pitted over whole surface.

**Operculum:** not known.

#### Animal body: not known.

*Holotype measurements:* H-0.53 mm; W-1.34 mm; BH-0.50 mm; BW-0.82 mm; AH-0.48 mm; AW-0.42 mm; CA: -57°.

Anatomy: not known.

Etymology. Name derived from the name of the Shareula River (მდინარე შარეულა), left tributary of the Rioni River, in which valley and a nearby tributary the new taxon was found.

**Habitat.** The intact empty shell was found in sandy sediment at the spring head in a small cave. The supposed habitat is stygobiotic.

Genus species	H	W	BH	BW	AH	AW	CA	H/W	AH /	W/	H/	H/	W /	H/(W-
	mm	mm	mm	mm	mm	mm	deg.	1	AW	BW	BH	AH	AW	BW)
Pontohoratia vinarskii sp. nov.	1.08	1.47	0.87	1.00	0.63	0.55	-20	0.73	1.15	1.47	1.24	1.71	2.67	2.30
Holotype LT														
Pontohoratia vinarskii sp. nov.	1.11	1.42	0.95	1.00	0.66	0.53	-24	0.78	1.25	1.42	1.17	1.68	2.68	2.64
Paratype LT	1.46	1.50	1.13	1.08	0.75	0.63	30	0.97	1.19	1.39	1.29	1.95	2.38	3.48
Pontohoratia mapeli sp. nov.	0.57	1.38	0.55	0.95	0.42	0.45	-40	0.41	0.93	1.45	1.04	1.36	3.07	1.33
Holotype LT														
Pontohoratia pichkhaiai sp. nov.	0.87	1.42	0.66	1.00	0.50	0.50	-45	0.61	1.00	1.42	1.32	1.74	2.84	2.07
Holotype LT														
Hausdorfenia pseudohauffenia sp. nov.	0.82	1.68	0.74	1.11	0.53	0.58	-48	0.49	0.91	1.51	1.11	1.55	2.90	1.44
Holotype LT														
Husdorfenia shareula sp. nov.	0.53	1.34	0.50	0.82	0.48	0.42	-57	0.40	1.14	1.63	1.06	1.10	3.19	1.02
Paratype LT														

**Table 9.** Measurement comparison of species in genera *Pontohoratia* Vinarski, Palatov & Glöer, 2014 and *Hausdorfenia* gen. nov.

**Distribution.** Except the type locality few similar fragments were found at the Shareula River Head (entrance of Shareula Cave).

**Conservation status.** The number of known locations (2) is no more than 5 and EOO is smaller than 20 km<sup>2</sup>. There is no reason to suppose that AOO, EOO, number of locations, number of subpopulations or the number or mature individuals are declining however due to its extremely small EOO we assessed as Vulnerable (VU) D2.

**Remarks.** *Hausdorfenia pseudohauffenia* sp. nov. and *P. shareula* sp. nov. display shell features different from other members of the genus, as well as a characteristic operculum with a peg (at least in the former taxon). Both represent a new genus different from *Pontohoratia*.

# Genus Motsametia Vinarski, Palatov & Glöer, 2014

# Motsametia borutzkii (Shadin, 1932)

Fig. 18

Motsametia borutzkii M. V. Vinarski, D. M. Palatov & P. Glöer, 2014 – J. Nat. Hist., 48: 2241 fig. 2B, 2244 fig. 5A, and 2249 fig. 7E
Horatia borutzkii A. V. Shadin, 1932 – Arch. Molluskenkd. 64: tab. 1, fig. 1.

**Conservation status.** The species is known from a single location and AOO is smaller than 10 km<sup>2</sup>. There is also indication of stochastic human driven habitat pollution and introduction of possibly competing invasive species (*Ferrissia californica*) (Vinarski and Palatov 2018) leading to severe population decline since 2009 with scarce occurrence of live individuals. Therefore, it is assessed as Critically endangered (EN) B2.

**Remarks.** Since the field work of Dimitry Palatov in 2009–2012 (Vinarski et al. 2014), we have recorded a continuous population decrease of *M. borutzkii* at the only known locality, with live individuals becoming scarce. It is possible that pollution of groundwater from settlements just above the cave could influence the groundwater quality. The pollution of the cave stream can be traced by increased micro-plastic par-



Figure 18. *Motsametia borutzkii* (Shadin, 1932) **A–D** Imereti, Kutaisi, Iazoni (Tskal-Tsiteli) Cave. Photograph J. Grego.

ticles present in the cave sediments. The population of *Ferrissia* cf. *californica* (Rowell, 1863) in the cave does not seem to have an invasive character, but could lead to a food competition with *M. borutzkii* (Vinarski and Palatov 2018). The presence of *Ferrissia* seem to be an incidental migrant via sinking surface water.

# Discussion

The molecular data confirmed the presence of the representatives of the subfamily Sadlerianinae Szarowska, 2006 in hypogean habitats of the southwestern Caucasus. The extraordinary high diversity suggests a longer isolation of populations presumably in isolated cave systems and their allopatric development. Some of the species (e.g. within the genera Caucasopsis gen. nov. or Imeretiopsis gen. nov.) in relatively close but isolated cave streams show molecular differences, while others (e.g., Kartvelobia sinuata sp. nov. or Caucasogeveria gloeri sp. nov.) have a distribution pattern over a larger aquifer under a single isolated limestone plateau Pakhe. The isolated aquifers of the Samegelo, Imereti and Racha regions have typical features of episaturation or Perched water table (Vepraskas and Lindbo 2012), which means isolated water tables (aquifers) elevated above the aquifers of the lowlands. Bedded Mesozoic limestones in the studied Georgian regions are characterised by mostly thick subhorizontal beds occasionally separated by less permeable or impermeable sandstones or dolomite beds. Such a hydrological separation of beds over a large area results in a large number of karst springs situated high on the hillslopes or near the middle of cliffs, emerging frequently as waterfalls directly from a cave spring or spring zone (e.g., waterfalls at Toba, Oniore, Kinchkha and caves in Motena, Mapeli, Dolabistavi). The perched water tables at a highly elevated places allowed a development of another perched water table (or sometimes tables) situated under the limestone beds below the impermeable rocks of the higher water table comprises a system of Multiple Levels Episaturation. This can result in several floors (or altitude levels) of perched water tables, where the aquifers are situated one above the other, separated by impermeable beds. Such a vertical isolation (Fig. 19) could also lead to isolated development of their stygobiont fauna, and could explain the high diversity over the relatively small area. As an example, we can use the



**Figure 19.** Multiple Level Episaturation: Formation of multiple levels (floors) of perched aquifers on permeable carbonates with subhorizontal beds and with periodical inclusion of impermeable beds. The levels of episaturation can have no or just minimal water communication, which can lead in a development of isolated stygobiont ecosystems in each level. Similar geology can be found in carbonates framing the southwestern Caucasus. Springs are frequently emerging high on hillslopes or near the middle of the cliff through caves and waterfalls.

distribution pattern of K. sinuata sp. nov. found in the springs of the highest level of perched aquifer of the Pakhe Plateau emerging in its slopes or at the middle of its cliffs. In contrast, the springs emerging from the lower-positioned perched aquifer of the same plateau around its base host different species or maybe subspecies of the same genus (e.g., morphologically different minute inflated population of K. cf. sinuata and K. kinchkha sp. nov. at N foots of the plateau and a K. cf. kinchkha from southern foot of the same plateau). More molecular data from both perched aquifers could confirm their phylogenetic separation. Most of the sampled localities host approximately three or four sympatric stygobiotic species of different genera, usually Caucasogeyeria, Kartvelobia and Pontohoratia or Hausdorfenia, with one species of the following three genera by region: Caucasopsis in Samegrelo, Imeretiopsis in Imereti and a new belgrandinellinid genus in Racha. Additionally, many of the springs host a *Tschernomorica* species which occasionally also inhabited the stygobiont habitats including caves (e.g., Nazodelavo, or Sataplia Caves). In majority of localities we found only one representative of each genus, only very seldom two species of the genus Caucasogeyeria could be found as sympatric (e.g., C. colchis and C. gloeri in Nakhriduri Spring, C. pseudocolchis and C. cf. gloeri. in Shurubumu or C. chrysomallos and C. cf. gloeri in Mapeli Cave.

The finding of two new species with many individuals living on slime covering tree roots inside a cave pond confirmed the phreatic rhizospere (Jasinska et al. 1996) as a preferred habitat also for gastropods (Grego et al. 2017). The tree roots secret a variety of reach nutrients by a process called *Root Exudation* (Canarini et al. 2019) and support the growth of symbiotic bacteria and fungi. The secretion can be massive, representing 20–40% of the carbon fixed by photosynthesis (Badri and Vivanco 2009). It seems that some of the hypogean gastropods found in the phreatic rhizosphere feed on microbial mats associated with the plant roots, or maybe directly on the root material, as we had seen in a small cave spring at the middle Shareula River valley.

Knowing the hydrogeological preconditions and rich geological history of the area, we believe a much larger stygobiont diversity exists than presented in this study. During our studies we sampled only a very small portion of suitable habitats (springs and caves) over the studied area, and large karstic expanses of the southwestern Caucasus remain unexplored.

The new genera we established in consideration of the shell morphology supported by the anatomical and molecular data we got from the type species. However, due to lack of live collected material, some species had to be described solely based on shell morphology characters and placed into provisional genera until the molecular data can be obtained. Many of the species are scarce and live specimens were never found. We believe that it is important to bring attention to such species and, due to the absence of live material, treat their description as in the case fossil taxa and use only available shell characters for species characterisation. Especially considering the rapidly changing environment and increasing pollution, the recognition of stygobiont species has ecological importance. While waiting decades for molecular data to be generated, some species could become extinct. It seems more expedient to treat them as provisional genera now and to correct their generic position in the case a live specimen is ever found. Additionally, the species established by their shell morphology can inspire and provide a taxonomic framework for future researchers to perform more extensive field work needed to recover complementary living material and new taxa in the future.

# Conclusions

With the present study we confirm the extraordinarily high stygobiotic gastropod diversity of the southwestern Caucasus. The high diversity on the generic level was supported by molecular and anatomical data. The taxonomic position of the genera "*Geyeria*" and "*Paladilhiopsis*" sensu Starobogatov, 1962 and *Pontohoratia* Vinarski, Palatov & Glöer, 2014 were solved, as well the assignment of five new genera in the subfamily Sadlerianinae Szarowska, 2006. The stygobiotic gastropod species radiation of Caucasus was more than doubled from previously known 16 species-level taxa (placed in five genera) to up to 40 taxa within eight genera. This further corroborates the "biodiversity hotspot" status of the western Great Caucasus karst region. It is very likely that future intensive field research could reveal even higher hypogean biodiversity not only
in the class Gastropoda, but also for other subterranean freshwater invertebrates. The results of the study of Belgrandiellinae Radoman, 1983 from the region will be subject of the next report, which is in preparation.

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RESEARCH ARTICLE



# A history of study and new records of terrestrial enchytraeids (Annelida, Clitellata, Enchytraeidae) from the Russian Far East

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#### Abstract

A list of terrestrial enchytraeids of the Russian Far East is compiled based on literature and extensive field data collected by the authors in 2019. A database has been created consisting of geographic coordinates, habitat type, species, and data source. For some species collected by the authors, barcoding using COI, 16s, and 12s rRNA genes has been performed. In total, there are at least 62 species of enchytraeids belonging to 12 genera. Seven species (*Achaeta macroampullacea, Cognettia sphagnetorum, Enchytraeus dichaetus, Fridericia cusanica, Globulidrilus riparius, Marionina southerni, Mesenchytraeus gigachaetus*) are reported in the Russian Far East for the first time. *Cognettia sphagnetorum* and *F. cusanica* are most probably introduced. Taxonomic and biogeographical remarks on some of the species found and differences from the original descriptions are provided. Some of the specimens may be undescribed species, but this requires a more in-depth examination. The Russian Far East, especially its southeastern part, is of great interest as a possible location for new species of enchytraeids.

#### Keywords

biodiversity, COI, potworms, soil fauna, 12S rRNA, 16S rRNA

# Introduction

The Russian Far East (hereafter referred to as RFE) ranges in climate, from arctic deserts in the north to dry steppes and broadleaf forests in the south. In this paper, RFE is equated with the Far Eastern Federal District of Russia, which includes the Republic of Buryatia, Sakha Republic (Yakutia), Kamchatka, Khabarovsky, Primorsky, and Zabaykalsky Krais, Amur, Magadan and Sakhalin Oblasts, Chukotka Autonomous Okrug, and Jewish Autonomous Oblast. This region occupies 40.6% of the territory of Russia (Rosstat 2019). On the Pacific coast, the climate is monsoon, which is most pronounced in the south and weakens to the northeast. Summer here is moderately warm and rainy, and winter, although not very snowy, is cold, due to the spread of cold air from the interior of Siberia. More inland, the climate becomes more continental, with warm summers and very cold winters. The northern regions of the RFE, adjacent to the Arctic Ocean, are characterized by cold summers and cold winters. Landscapes also vary from mountain ranges in the northeast to the plains along the Amur River in the south. Part of the territory is represented by islands and archipelagos, such as Sakhalin, the Kuril Islands, the New Siberian Islands, and Wrangel Island (Krestov 2003). The large area of the RFE contributes to the diversity of biomes. Arctic desert and tundra are replaced to the south by a wide strip of coniferous forests and then by forest-steppes and steppes. In the southeast of the RFE, in Primorsky Krai, broadleaf and mixed forests are represented. Diversity of biomes leads to great diversity of flora and fauna, especially that of invertebrates (Storozhenko et al. 2002; Ryabinin 2015). However, general knowledge about the soil biodiversity of this area is rather poor and fragmentary.

The Enchytraeidae are a family of terrestrial oligochaetes consisting mainly of small unpigmented annelid worms. Enchytraeids inhabit all continents and are perhaps the most widespread representatives of the Clitellata (Erséus 2005). An ecologically plastic group, enchytraeids are found in a wide range of habitats. Various species of the family are broadly represented in soil and in the splash zone on seacoasts; they are also found in freshwater and marine sediments (Erséus and Rota 2003; Erséus 2005). Twenty of the 35 valid genera of enchytraeids are found in soil (Coleman et al. 2018; Timm and Erséus 2020), where they are important in the decomposition of organic matter (Römbke et al. 2005).

At the same time, the RFE, as well as the territory of Russia as a whole, the enchytraeid fauna has been poorly studied, and this situation has persisted since the 1980s (Nurminen 1982). Thus, researching enchytraeid diversity of the RFE has both inventory and biogeographic significance.

In the last decade, many studies have been conducted on the fauna of enchytraeids of the territories geographically close to the RFE: Manchuria (Chen and Xie 2015), South Korea (Dózsa-Farkas and Hong 2010; Dózsa-Farkas et al. 2015), and Japan (Torii 2012). In contrast, there is a knowledge gap for enchytraeids in the RFE itself, some studies have been conducted. Some species were described from materials collected by Russian polar expeditions at the beginning of the 20<sup>th</sup> century (Michaelsen 1901, 1916; Cejka 1910, 1912, 1914). After many years, Piper et al. (1982) reported the enchytraeid fauna at several points on the coast of northeastern Russia. Nurminen (1980) found several new species of enchytraeids in samples sent from Primorsky Krai.

Ganin (1984) suggested the possibility of finding even more new species in the RFE. In 1994, a Swedish-Russian expedition took samples, including for enchytraeid extraction, in the Palaearctic tundra. Some of their sampling sites were located in the RFE (Christensen and Dózsa-Farkas 1999).

In the summer of 2019, we have collected much material from across the RFE, between the city of Magadan (northern coast of the Okhotsk Sea) and the southernmost areas of Primorsky Krai. The identity of some species was confirmed with the help of molecular analysis of the genes COI, 12S rRNA, and 16S rRNA.

In this study we summarize currently available data on the fauna of terrestrial enchytraeids of the RFE, both from the literature and our own new data.

### Materials and methods

To estimate terrestrial enchytraeid diversity of the RFE, a database has been created. It includes the following attributes: geographic coordinates of sampling sites, habitat type, species, and data source. Data on enchytraeids from marine and freshwater environments were not included.

**Data from literature.** We included data collected by other researchers. These data are mostly from tundra and taiga habitats (see below). Although there are numerous reports of enchytraeids in soil samples in the soil-zoological literature, we only included those studies where enchytraeid species were identified.

**Our data.** We collected our material during July and August 2019 in Khabarovsky, Primorsky, and Zabaykalsky krais, as well as Amur, Magadan, and Sakhalin oblasts (Fig. 1). The investigations were carried out in steppes, broadleaf and coniferous forests, and azonal habitats like floodplains and meadows. Within each locality (see Fig. 1), five samples each 5 cm in diameter were collected and brought to the laboratory in Moscow. They were stored at 4 °C until the extraction. Enchytraeids were extracted from soil using the wet funnel method (Römbke 1995), identified *in vivo*, and then preserved in 96% alcohol.

Species were identified according to Schmelz and Collado (2010) or, for species not found in Europe, by comparison with the original descriptions. Taxonomy follows Schmelz and Collado (2012, 2015), excluding genera and species described after 2015.

Some samples were selected for genetic analysis. The DNA extraction was performed using "ExtractDNA blood" kits (Evrogen, Russia). In each sample the entire enchytraeid body was used for DNA extraction. We amplified one or two of three mitochondrial regions: 12S rRNA, 16S rRNA, and cytochrome oxidase I (COI) genes. The COI fragment is the standard DNA barcode for animals (Hebert et al. 2003). The PCR mixture contained 1–3 ng of the DNA matrix, 0.1  $\mu$ M of each primer, and the precast PCR mixture from Evrogen (Russia) according to the manufacturer's instructions. The primers were synthesized by Evrogen (Russia) as well. For the COI gene the primers were LCO1490 (Folmer et al. 1994) (5'-GGTCAACAAATCATAAAGATATTGG-3') and COI-E (Bely and Wray 2004) (5'-TATACTTCTGGGTGTCCCGAAGAATCA-3') and the amplification program was: 95 °C for 5 min, 35 cycles of 95 °C for 40 sec, 45 °C for 45 sec, 72 °C for 60 sec, and finally, 72 °C for 8 min, resulting in a fragment of about 608 bp. For the 12S rRNA gene the primers were 12S-E1 (5'-AAAACATG-GATTAGATACCCRYCTAT-3') and 12SH (5'-ACCTACTTTGTTACGACT-TATCT-3') (Jamieson et al. 2002), and the amplification program was: 94 °C for 2 min; 35 cycles of 94 °C for 15 sec, 50 °C for 15 sec, 72 °C for 90 sec, and finally 72 °C for 5 min, resulting in a fragment of about 322 bp. For the 16S rRNA gene the primers were 16SAR-L (5'-CGCCTGTTTATCAAAAACAT-3') and 16SBRH (5'-CCG-GTCTGAACTCAGATCACGT-3') (Palumbi et al. 2002), and the amplification program was: 95 °C for 5 min, 35 cycles each of 95 °C for 30 sec, 50 °C for 30 sec, 72 °C for 60 sec, and finally, 72 °C for 8 min resulting in a fragment of about 423 bp.

The phylogenetic analysis for species of *Fridericia* Michaelsen, 1889 was conducted using the maximum likelihood (ML) method. *Enchytraeus albidus* Henle, 1837 was chosen as an outgroup. Phylogenetic analysis involved 25 16S rRNA nucleotide sequences; 20 of them were obtained from NCBI GenBank. The sequences were aligned using Clustal Omega (Sievers et al. 2011). There was a total of 409 positions in the final alignment. GTR model of nucleotide substitution with Gamma distribution and invariable sites was chosen using the BIC criterion (Nei and Kumar 2000). The initial tree was obtained automatically by applying NJ and BioNJ algorithms and then the topology with superior log likelihood value was selected. All positions containing gaps and missing data were eliminated. Bootstrap replications value was set to 10000. The ML analysis was performed in MEGA X (Kumar et al. 2018).

The phylogenetic analysis for species of *Bryodrilus* Ude, 1892 was conducted using the Bayesian inference (BI) method. *Henlea perpusilla* Friend, 1911 was chosen as an outgroup. Phylogenetic analysis involved 10 COI mDNA nucleotide sequences; nine of them were obtained from NCBI GenBank. The sequences were aligned using Clustal Omega (Sievers et al. 2011). There was a total of 528 positions in the final alignment. GTR model of nucleotide substitution with Gamma distribution was chosen in TOPALi v. 2 (Milne et al. 2009) using the AIC criterion (Akaike 1974). The analysis was run with 4 chains for 20,000,000 generations, sampling each 1000 generations and burning in 25%. The BI analysis was performed using MrBayes v. 3.2 software package (Ronquist et al. 2012). A list of all DNA sequences originally obtained in this study is provided (Table 1).

#### List of localities with confirmed enchytraeid data

The habitats are described and the geographical coordinates (WGS 84) are provided with varying degree of precision depending on the information given in the original source. For the sites based on literature data, the respective references are given. The absence of a literature reference presumes that enchytraeids from this site were identified by us. In the absence of an accurate geographical reference (literature from the beginning of the 20<sup>th</sup> century), a point on the map (Fig. 1) shows only approximate place of origin of the sample. In the commented list of terrestrial enchytraeids of the RFE, the localities are given for each species, in accordance with description of the sampling sites.

Species	Locality	GenBank accession numbers		
		12\$	165	COI
Bryodrilus sp. A	6 km north-east of Terney, Primorsky Krai, Russia. <i>Quercus-Betula</i> forest. Cambisol soil. 45°02'29N, 136°40'56E.	MT241728	N/A	MT237714
<i>Fridericia bulboides</i> type 'a'	Near Serebryanka river, Primorsky Krai, Russia. Sparse <i>Betula</i> forest. Cambisol soil. 45°06'42N, 136°31'51E.	MT241729	MT232978	N/A
Fridericia bulboides type 'c'	same	MT241730	MT232979	N/A
Fridericia bulboides type 'c'	same	MT241731	MT232980	N/A
Fridericia bulboides type 'd'	same	N/A	MT232981	N/A
Mesenchytraeus gigachaetus	6 km north-east of Terney, Primorsky Krai, Russia. <i>Quercus-Betula</i> forest. Cambisol soil. 45°02'29N, 136°40'56E.	MT214330	N/A	MT160424

**Table 1.** DNA sequences of enchytraeid species originally obtained in this study. Species, localities and GenBank accession numbers are given in columns.



**Figure 1.** Map of enchytraeid record locations in the Russian Far East. Black dots represent own data sampled in July-August 2019. Red dots are data from the literature. Purple line depicts the administrative border of the Far Eastern Federal District. JAO – Jewish Autonomous Oblast.

#### Sites for which data were available from the literature:

- [1] New Siberian Islands. Between 74°30'–76°N, 137–150°E (Cejka 1910).
- [2] Kotelny Island. Between 74°30'–76°N, 137–144°E (Cejka 1912).
- [3] New Siberian Islands. Between 74°30'-76°N, 137-150°E (Cejka 1914).
- [4] New Siberian Islands. Between 74°30′–76°N, 137–150°E (Michaelsen 1901).
- [5] Primorsky Krai, Upper Ussuri station ca 35 km NE of Chuguyevka. Litter of Ulmus wood in a mountain stream valley. Ca 44°23'N, 134°12'E (Nurminen 1980).
- [6] Primorsky Krai, Upper Ussuri station. Litter of *Picea* and *Abies* forest with *Dry-opteris* and *Pleuzorium*. Ca 44°04'N, 133°56'E (Nurminen 1980).
- [7] Taiga forests near Magadan (with azonal habitats: stream bank and riparian birch forest). Ca 59°30'N, 151°50'E (Piper et al. 1982).
- [8] Tundra at the Chaun Bay research station (including mesic heath, mountain area and wet meadow). Ca 68°44'N, 170°36'E (Piper et al. 1982).
- [9] Kotelny Island. 75°03'30"N, 140°11'24"E (Christensen and Dózsa-Farkas 1999).
- [10] Faddeyevsky Island. 75°29'36"N, 143°44'30"E (Christensen and Dózsa-Farkas 1999).
- [11] Lopatka Peninsula. 72°11'06"N, 148°26'18"E (Christensen and Dózsa-Farkas 1999).
- [12] NE Kolyma Delta. 69°21'18"N, 163°34'48"E (Christensen and Dózsa-Farkas 1999).
- [13] Wrangel Island. 70°57'24"N, 179°33'24"E (Christensen and Dózsa-Farkas 1999).
- [30] Khabarovsky Krai, oak forest, Khekhtsir mountain range, 20 km south of Khabarovsk. Ca 48°11'N, 134°51'E (Ganin 1984).

## Sites where material was collected by the authors:

- [14] Near Ust-Imalka, Daurian Nature Reserve, Zabaykalsky Krai. Dry steppe with *Stipa* and *Leymus*. Kastanozem soil. 50°11'02"N, 115°26'09"E. 27.07.2019.
- [15] South of Kulusutay, Daurian Nature Reserve, Zabaykalsky Krai. Dry steppe with *Stipa* and *Leymus*. Kastanozem soil. 50°08'36"N, 115°41'36"E. 28.07.2019.
- [16] Borzya river bank, Zabaykalsky Krai. Periodically flooded meadow with *Carex*. Fluvisol soil. 50°31'23"N, 116°45'20"E. 25.07.2019.
- [17] Adun-Chulun mountains, Daurian Nature Reserve, Zabaykalsky Krai. Mountain steppe with *Leymus* and *Carex*. Kastanozem soil. 50°28'14"N, 116°03'16"E. 29.07.2019.
- [18] Near Pogibi, Sakhalin Oblast. Larix forest with Pinus pumila. Podzol soil. 52°11'47"N, 141°42'47"E. 11.07.2019.
- [19] Pogibi, Sakhalin Oblast. Disturbed coniferous forest with *Pinus pumila* in suburban area. Podzol soil. 52°13'27"N, 141°39'19"E. 11.07.2019.
- [20] Lazarev, Khabarovsky Krai. Typical taiga forest with *Larix gmelinii* predominance. Podzol soil. 52°11'18"N, 141°30'31"E. 12.07.2019.

- [21] Near Lyublino, Primorsky Krai. Meadow/shrubland with Carex. Fluvisol soil. 44°54'15"N, 132°01'50"E. 07.08.2019.
- [22] Lebedinoye, Primorsky Krai. Periodically flooded meadow with *Carex*. Fluvisol soil. 44°48'14"N, 132°45'23"E. 08.08.2019.
- [23] 6 km north-east of Terney, Primorsky Krai. *Quercus-Betula* forest. Cambisol soil. 45°02'29"N, 136°40'56"E. 13.08.2019.
- [24] Near Serebryanka river, Primorsky Krai. Sparse *Betula* forest. Cambisol soil. 45°06'42"N, 136°31'51"E. 14.08.2019.
- [25] 10 km south of Terney, Primorsky Krai. Quercus-Betula forest. Cambisol soil. 44°57'19"N, 136°32'38"E. 15.08.2019.
- [26] Gamova peninsula, Primorsky Krai. Sparse Quercus forest. Alfisol soil. 42°35'39"N, 131°11'44"E. 19.08.2019.
- [27] Urup island, Sakhalin Oblast. Coniferous shrubland and meadow with *Sasa kurilensis*. Andosol soil. 45°53'32"N, 150°06'10"E. 09.08.2019.
- [28] Eastern part of Staritskogo peninsula, Magadan Oblast. *Alnus* forest with high grass. Podzol soil. 59°30'08"N, 150°53'49"E. 28.07.2019.
- [29] Suburban area near river Amur, Blagoveshchensk, Amur Oblast. Meadow/ deciduous forest with *Prunus padus* and *Acer*. Cambisol soil. 50°17'18"N, 127°23'14"E. 05.08.2019.
- [31] Near Kasatka Bay, Iturup island, Sakhalin Oblast. *Abies* forest and *Picea* forest with broadleaf undergrowth. Andosol soil. 45°00'10"N, 147°43'59"E. 20.08.2019.

## Results

We have found at least 12 genera and not fewer than 62 species in the RFE. No enchytraeids were found in sites [14] and [15], possibly due to the aridity of steppe habitats. The enchytraeid fauna consisted mostly of species from genera *Mesenchytraeus* Eisen, 1878 (15 species), *Henlea* Michaelsen, 1889 (10 species), *Fridericia*, and *Marionina* Michaelsen in Pfeffer, 1890 (nine species each), and *Bryodrilus* (seven species). *Cognettia* Nielsen & Christensen, 1959 is represented by four species, *Enchytraeus* Henle, 1837 by three species, *Achaeta* Vejdovský, 1878, *Euenchytraeus* Bretscher, 1906, and *Hemifridericia* Nielsen & Christensen, 1959 each by two species, and *Globulidrilus* Christensen & Dózsa-Farkas, 2012 and *Hemienchytraeus* Cernosvitov, 1934 each by a single species. The list of all the species, including those found in this study as well as those from the literature, with their localities is given in the Suppl. material 1: Table S1.

In addition to the species listed below, we also found several unidentified juvenile *Bryodrilus* at sites [27] and [28], *Fridericia* at [24, 26, 31], *Hemienchytraeus* at [29], *Hemifridericia* at [27], and *Mesenchytraeus* at [20, 23, 24, 26, 27, 28, 31]. For single records of species without a clear geographical reference, the approximate location is indicated directly in the list. Remarks on some species are also given below.

## A commented list of terrestrial Enchytraeidae of the Russian Far East

Genus Achaeta Vejdovský, 1878

1. Achaeta macroampullacea Dózsa-Farkas, Felföldi, Nagy & Hong, 2018 – 29, 31.

Specimens are fully consistent with the original description. Described from Jeju Island, Korea (Dózsa-Farkas et al. 2018), this is the first find of the species outside the original description.

2. Achaeta macrocyta Christensen & Dózsa-Farkas, 1999 – 8, 11, 12.

Genus Bryodrilus Ude, 1892

3. Bryodrilus arcticus (Bell, 1962) – 7, 8, 9, 10, 11, 12, 13.

- 4. Bryodrilus borealis Cejka, 1912 2, 13, 16.
- 5. Bryodrilus cejkai Nurminen, 1980 5.
- 6. Bryodrilus diverticulatus Cernosvitov, 1929 13, 23, 25, 26.

Enchytraeids from sites [23], [25], and [26] are not typical *B. diverticulatus*, but similar worms were already described from both Greenland and the Canadian Arctic Archipelago as a variety of *B. diverticulatus* with smaller male organs (Christensen and Dózsa-Farkas 2006).

- 7. *Bryodrilus ehlersi* Ude, 1892 7, 24.
- 8. Bryodrilus librus (Nielsen & Christensen, 1959) 9, 10, 13.
- 9. Bryodrilus sp. A 23.

The resulting tree of BI phylogenetic analysis is shown in Figure 2. While the phylogenetic analysis gives support to *Bryodrilus* sp. A as a separate species of the genus, this inference may not be completely correct due to incomplete set of COI sequences available for the species of the genus. Taxonomic status of this species will be clarified in the near future.

Genus Cognettia Nielsen & Christensen, 1959

10. Cognettia glandulosa (Michaelsen, 1888) s.l. – 8, 11, 16.

This species was recently separated into two, *C. glandulosa s.s.* and *C. varisetosa* (Martinsson, Erséus & Rota, 2015) (Martinsson et al. 2015b). The specimen from [16] morphologically corresponds to *C. glandulosa s.s.*, but we cannot be sure of the specimens from the literature ([8, 11]).

11. Cognettia lapponica Nurminen, 1965 – 7, 8, 11, 12, 13, 18, 19, 20, 28.

12. Cognettia quadrosetosa Christensen & Dózsa-Farkas, 1999 – 13.

13. Cognettia sphagnetorum (Vejdovský, 1878) s.l. – 27, 31.

As this species is predominantly European and even in Europe it has large genetic variation (Martinsson et al. 2015a), we use the *sensu lato* approach. Found only in the Kuril Islands, it is most probably an introduced species.

#### Genus Enchytraeus Henle, 1837

- 14. Enchytraeus buchholzi Vejdovský, 1879 6, 7, 16, 23, 24, 26, 29, 31.
- 15. Enchytraeus christenseni Dózsa-Farkas, 1992 6.



**Figure 2.** Phylogenetic tree of *Bryodrilus* species based on mtDNA COI obtained using Bayesian inference (BI). Numbers represent the posterior probabilities of the BI. Sequences obtained from NCBI Gen-Bank are given with their accession numbers.

16. Enchytraeus dichaetus Schmelz & Collado, 2010 - 16, 17, 21, 22, 24, 27.

Specimens are fully consistent with the original description. Some specimens at [16] have a short ectal duct. Some specimens at [21] have refractile vesicles in the coelomocytes. This is the first report of this species in the Asian part of Russia. Possibly, it is a Holarctic species with a range extending from North Africa (Rota and Healy 1994) to East Asia (Dózsa-Farkas et al. 2015) and Canada (Schmelz and Collado 2010).

Genus Euenchytraeus Bretscher, 1906

17. Euenchytraeus bisetosus Bretscher, 1906 – 11, 13.

18. *Euenchytraeus piperi* (Christensen & Dózsa-Farkas, 1999) – 8, 11, 12, 13, 23, 25, 28.

Genus Fridericia Michaelsen, 1889

19. Fridericia bisetosa (Levinsen, 1884) – 3, 24.

20. Fridericia bulboides Nielsen & Christensen, 1959 – 7, 8, 16, 21, 22, 24, 26, 27, 29.

Four morphological types were discovered in our material (Fig. 3): type a – typical *F. bulboides* ([7, 8, 16, 21, 22, 24 (partly), 26, 27]), type b – *F. bulboides* with large spermathecal ectal gland ([29]), type c – *F. bulboides* with big floppy sperm funnels, large male bulbs, and a compact glandular field near the spermathecal ectal gland ([24 (partly)]), and type d – *F. bulboides* with medium-sized male bulbs and a compact glandular field near the spermathecal ectal gland ([24 (partly)]). East-Asian *F. bulboides* with unusually large ectal gland are mentioned by Schmelz (2003). Those with the sperm funnel considerably larger and with the male copulatory organ and glandular structure at the orifice of the spermathecal ectal duct are found in Hungary (Cech and Dózsa-Farkas 2005). Our original phylogenetic analysis indicates that *F. bulboides* (types c, d) cannot be considered as separate species (Fig. 4). Although the final dendrogram has several events of unresolved phylogeny, there is relatively strong support for no division



**Figure 3.** Morphological characteristics of four different types of *Fridericia bulboides*. For indexes **1a-3d** each numeral indicates a specific organ (**I** sperm funnel **2** male gland (only outline shown) **3** end of spermathecal ectal duct and spermathecal ectal gland), letter corresponds to morphological type (**a** "classical" *F. bulboides* **b** *F. bulboides* with large spermathecal ectal gland **c** *F. bulboides* with big floppy sperm funnels, large male bulbs and compact glandular field near spermathecal ectal gland **d** *F. bulboides* with medium-sized male bulbs and compact glandular field near spermathecal ectal gland) **4** coelomocytes of *F. bulboides* with refractile vesicles at coelomo-mucocyte periphery (types a, b) **5** coelomocytes of *F. bulboides* without refractile vesicles at coelomo-mucocyte periphery (types c, d).



**Figure 4.** Phylogenetic tree of *Fridericia* species based on rRNA 16s obtained using Maximum likelihood (ML) method. Numbers represent bootstrap support values of ML analysis. Values lower than 65 are hidden. Sequences obtained from NCBI GenBank are given with their accession numbers.

into separate species. On the other hand, *F. bulboides* (type a) from [24] is likely to be a new species of *Fridericia*, even with full morphological similarity with European specimens. However, such a claim demands further analysis with other molecular markers.

21. Fridericia callosa (Eisen, 1878) – 9, 10, 11, 13.

22. Fridericia cusanica Schmelz, 2003 – 27.

This species was described from Germany (Schmelz 2003) and is known from southern Europe (Schmelz and Collado 2010), but recently it was also recorded in Tibet (Lu et al. 2018). We found it from one of Kuril Islands. Thus, it is possibly a Holarctic species. This is the first report of *F. cusanica* in Russia.

23. Fridericia cf. cusanicaformis Dózsa-Farkas, Feldföldi & Hong, 2015 – 26, 29.

Differences from the original description (Dózsa-Farkas et al. 2015) are the absence of the spermathecal ectal gland and only one chaeta in ventral post-clitellar bundles. Our specimens were not fully mature, so these differences cannot be considered taxonomically significant. This is the first finding outside of Korea.

24. Fridericia cf. schmelzi Cech & Dózsa-Farkas, 2005 - 26.

The specimens from Primorsky Krai differed from the original description in the number of preclitellar nephridia (four). They had mostly three chaetae in lateral preclitellar bundles. The great distance to previously recorded localities (Hungary, Canada; Schmelz and Collado 2010) also raise doubts about the species' identity.

25. *Fridericia* sp. A – 29.

This is a new species. It will be described in an upcoming article.

26. *Fridericia* sp. B – 25.

This species does not fit the descriptions of the other species of *Fridericia* found in the RFE. This is a rare species, and more specimens needed for proper determination.

Genus Globulidrilus Christensen & Dózsa-Farkas, 2012

27. Globulidrilus riparius (Bretscher, 1899) s.l. - 16.

The specimens possess up to three chaetae in the ventral preclitellar bundles. This is the first find of this species and the genus in a terrestrial habitat in Russia. *Globulidrilus riparius* is possibly a trans-Palaearctic species having a range from Europe (Schmelz and Collado 2010) to Japan (Torii 2012). It was recently discovered than *G. riparius* is a complex of several species (Martinsson and Erséus 2018), but these are still undescribed.

Genus Hemienchytraeus Cernosvitov, 1934

28. Hemienchytraeus sp. A – 26.

This is the first find of the genus in Russia. The taxonomic status was not determined due to the poor condition of the extracted specimens.

Genus Hemifridericia Nielsen & Christensen, 1959

29. Hemifridericia parva Nielsen & Christensen, 1959 - 30.

30. *Hemifridericia* sp. A – 24.

This is probably a new species. More material is needed for a proper description, as it differs morphologically from the other three currently known *Hemifridericia* species (Christensen and Dózsa-Farkas 2006).

Genus Henlea Michaelsen, 1889

- 31. Henlea adiverticulata Christensen & Dózsa-Farkas, 1999 13.
- 32. Henlea conchifera Christensen & Dózsa-Farkas, 1999 10, 13.

33. Henlea diverticulata Cejka, 1912 – 2, 8, 10, 11.

34. Henlea glandulifera Nurminen, 1970 – 13, 27.

35. Henlea heleotropha Stephenson, 1922 – 13.

36. Henlea nasuta (Eisen, 1878) - 3, 5.

37. Henlea ochracea (Eisen, 1878) - 1, 5, 9.

38. *Henlea perpusilla* Friend, 1911 – 5, 7, 8, 10, 13, 14, 16, 22, 23, 25, 26, 29, 30, 31.

Specimens from [29] and [31] had only four pairs of fully developed preclitellar nephridia (6/7 - 9/10), whereas nephridia in 10/11 were rudimentary or (in some specimens from [31]) completely absent.

39. Henlea tolli Michaelsen, 1903 – 2, 4, 11, 13.

40. Henlea ventriculosa (d'Udekem, 1854) - 3, 5, 7, 8, 13, 16, 22, 23, 29.

Genus Marionina Michaelsen in Pfeffer, 1890

41. Marionina aporus (Stephenson, 1925) – 13.

This species has an uncertain status and was not mentioned by Schmelz and Collado (2012, 2015).

42. Marionina argentea (Michaelsen, 1889) s.l. – 9.

Christensen and Dózsa-Farkas (1999) wrote that the morphology of their specimens from the RFE is consistent with that accepted by Nielsen and Christensen (1959) before the separation of *M. argentea* into four species (Rota 2013). Thus, we use *sensu lato* approach here.

43. Marionina communis Nielsen & Christensen, 1959 – 30.

44. Marionina macrobulbi Christensen & Dózsa-Farkas, 1999 – 10.

45. Marionina minutissima Healy, 1975 – 12.

46. Marionina nordica Christensen & Dózsa-Farkas, 1999 – 13.

47. Marionina cf. nordica Christensen & Dózsa-Farkas, 1999 – 17.

Specimens are 5 mm long, always with 37 segments, and with spermathecal ectal glands absent; the chaetal formula is 3 - 2 : 3, 2 - 2. The shape of the spermatheca generally fits the original description, but the chaetal pattern is unlike the original (2 - 2 : 3 - 3). This is most probably a new species.

48. Marionina southerni (Cernosvitov, 1937) - 31.

Genus Mesenchytraeus Eisen, 1878

49. Mesenchytraeus affinis Michaelsen, 1901 – 4.

50. *Mesenchytraeus arcticus* Bell, 1962 – vicinity of Kolyma (Christensen and Dózsa-Farkas 1999).

51. Mesenchytraeus asiaticus Eisen, 1904 – Chukotka (Eisen 1905).

52. Mesenchytraeus cejkai Cernosvitov, 1937 – 3.

53. Mesenchytraeus chaunus Piper, Maclean & Christensen, 1982 – 8, 12.

54. Mesenchytraeus diverticulatus Piper, Maclean & Christensen, 1982 – 7.

55. Mesenchytraeus gigachaetus Xie, 2012 – 23.

Our specimens generally fit the original description, differing only in the shape of the sperm funnels (collar wide, open, wider than sperm funnel body). This is the first find of *M. gigachaetus* outside China.

- 56. Mesenchytraeus kontrimavichusi Piper, Maclean & Christensen, 1982 8.
- 57. Mesenchytraeus konyamensis Michaelsen, 1916 Chukotka (Michaelsen 1916).
- 58. Mesenchytraeus melanocephalus Christensen & Dózsa-Farkas, 1999 9, 12, 13.
- 59. Mesenchytraeus mirabilis Eisen, 1878 10.
- 60. Mesenchytraeus svetae Piper, Maclean & Christensen, 1982 8.
- 61. Mesenchytraeus torbeni Christensen & Dózsa-Farkas, 1999 9, 13.
- 62. Mesenchytraeus tundrus Piper, Maclean & Christensen, 1982 8.
- 63. Mesenchytraeus variabilis Cejka, 1914 3.

## Discussion

Representatives of *Mesenchytraeus* were found only in taiga forests and tundra. Thus, the biogeographic border between coniferous and deciduous forests, which runs across the RFE (Ryabinin et al. 2018), can also be the southern border of the unique Beringian fauna of enchytraeids, characterized by the dominance of large *Mesenchytraeus* (Piper et al. 1982). The RFE is apparently located at the contact area of three large enchytraeid faunas: (i) the Beringian fauna, (ii) the Euro-Siberian fauna, characterized by a great variety of *Fridericia* and *Henlea* spp. and the presence of small *Enchytraeus* spp., part of the *Enchytraeus buchholzi*-group (Nurminen 1973; Schmelz and Collado 2010), and (iii) the East-Asian fauna, characterized by a large number of endemic species (especially *Hemienchytraeus* spp.) (Dózsa-Farkas and Hong 2010) and possibly a few representatives of the BrE should be studied not as single fauna of the whole region, but as a combination of several, partially overlapping faunas.

A list of enchytraeids of the RFE is prepared for the first time and consists of at least 62 species. This number is about half the number of species in Germany (Römbke et al. 2013), mainly because of the lack of knowledge of the RFE. Thus, this article is just a first step, with some unaddressed questions on the enchytraeid fauna for future studies. Some species, especially those that were described in the 1900–1910s, need taxonomic revision because their descriptions are very poor and inconsistent with modern science. Based on our molecular results, we suggest two potentially new species. Undeniably, the Russian Far East, especially its southeastern part, is of great interest as a possible location for new species of enchytraeids.

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### Supplementary material I

#### Table S1

Authors: Maksim I. Degtyarev, Iurii M. Lebedev, Ksenia G. Kuznetsova, Konstantin B. Gongalsky

Data type: species data

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RESEARCH ARTICLE



# Contributions to Chinese fauna of Torrenticolidae Piersig, 1902 (Acari, Hydrachnidia), with the description of three new species

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### Abstract

Five species of torrenticolid mites (Acari, Hydrachnidia), collected in the Anzihe and Qingliangfeng national nature reserves, R. P. China, are identified. Three species are described as new to science: *Torrenticola pseudosiamis* Gu & Guo, **sp. nov.**, *T. anziensis* Gu & Guo, **sp. nov.**, and *Monatractides sichuanensis* Gu & Guo, **sp. nov.** The other two species, *M. macrocorpis* Gu & Guo, 2019, *M. xiaoxiensis* Gu & Guo, 2019, are newly reported from Zhejiang Province. Descriptions and illustrations of these species are included.

### Keywords

China, morphology, running waters, taxonomy, torrenticolid mites, water mites

# Introduction

China is rich in ecological diversity and types of water bodies, which suggests that a rich species diversity of water mites is expected in the Chinese fauna. In the number of species, the family Torrenticolidae is one of the largest groups of water mites. Until now, the total number of torrenticolid mites is about 600 worldwide, but only 38 species are known from China, including the three new species added in this paper (Gu et al. 2019a, 2020a, b, c; Gu and Guo 2019). This means that the Chinese torrenticolid

mites fauna is largely unknown, and the identification of Chinese torrenticolid species will be a focus in the near future.

In this paper, five species of Torrenticolidae are identified from two national nature reserves in China, Anzihe National Nature Reserve in Sichuan Province and Qingliangfeng National Nature Reserve in Zhejiang Province. Three of these species are new to science: *Torrenticola pseudosiamis* Gu & Guo, sp. nov., *T. anziensis* Gu & Guo, sp. nov., and *Monatractides sichuanensis* Gu & Guo, sp. nov. The other two are newly reported from Zhejiang Province: *M. macrocorpis* Gu & Guo, 2019 and *M. xiaoxiensis* Gu & Guo, 2019. These five species are described and illustrated here.

### Material and methods

Water mites were collected, preserved, cleaned, and mounted following the usual methods (Jin 1997; Ding et al. 2019).

The following abbreviations are used (Jin 1997; Wiles 1997; Goldschmidt 2007; Zhang 2018): aL = apical length; Ap = anal pore; bs = basal segment of chelicera; Cx-I–Cx-IV = coxae I–IV; dL = dorsal length; I-L-1–6, etc. = first leg's segment 1–6, etc.; L = length; mL = medial length; Gf = genital field; GUGC = Institute of Entomology, Guizhou University, Guiyang, China; P-1–5 = palp segment 1–5; vL = ventral length; W = width. The chaetotaxy used follows Jin (1997):  $A_2$  = postantennal glandularia;  $D_1$ – $D_4$  = dorsoglandularia 1–4;  $E_2$ ,  $E_4$  = epimeroglandularia 2, 4;  $L_1$ – $L_4$  = lateroglandularia 1–4;  $O_2$  = postocularia;  $V_1$ – $V_4$  = ventroglandularia 1–4; 4+1 = five plates: four anterior platelets and a single large dorsal plate.

All measurements of palp and legs are of the dorsal margin, given in micrometers ( $\mu$ m) and following Goldschmidt (2007). All the specimens examined are kept in GUGC (no. ZJ-TO-20180701–ZJ-TO-20180709, SC-TO-20160701–SC-TO-20160704).

#### Taxonomy

Class Arachnida Lamarck, 1801 Order Trombidiformes Reuter, 1909 Family Torrenticolidae Piersig, 1902 Subfamily Torrenticolinae Piersig, 1902 Genus *Torrenticola* Piersig, 1896

*Torrenticola pseudosiamis* Gu & Guo, sp. nov. http://zoobank.org/C8F4222B-E74D-4A0E-BE01-80751961123F Figures 1, 2

**Material examined.** *Holotype*:  $\bigcirc$  (ZJ-TO-20180701), Qingliangfeng National Nature Reserve, Lin'an, Zhejiang Province, P. R. China (30°6'44"N, 118°53'36"E,



**Figure 1.** *Torrenticola pseudosiamis* Gu & Guo, sp. nov., female **A** dorsal view **B** ventral view **C** palp, lateral view **D** infracapitulum and chelicera. Scale bars: 100 μm.

940 m a.s.l.), collected by Xinyao Gu, 31-VII-2018. *Paratype*: 2 ♀♀ (ZJ-TO-20180702, ZJ-TO-20180703), same data as holotype.

**Diagnosis.** Idiosoma elliptical; dorsal plate 4+1; infracapitular bay U-shaped;  $E_4$  at the same level as the 6<sup>th</sup> pair of acetabula; gnathosoma with a short rostrum, the lateral view of gnathosoma regular triangle-like.

**Description. Female** (n = 3): Idiosoma elliptical, L 847 (774–887), W 586 (586–648), L/W ratio 1.4 (1.3–1.4). Dorsal plate 4+1 (Fig. 1A), dorsal shield L 755 (682–770), W 530 (530–585), dorsal plate L 694 (620–709), frontal platelets L 158 (152–170), W 83 (69–90), shoulder platelets L 169 (169–196), W 99 (81–99). Infracapitular bay U-shaped, depth 126 (126–150); only the tip of Cx-I exceeding to the anterior margin of idiosoma; Cx-I L 270 (230–273), mL 123 (102–123), Cx-



**Figure 2.** *Torrenticola pseudosiamis* Gu & Guo, sp. nov., female **A** leg-I **B** leg-II **C** leg-III **D** leg-IV-1–4 **E** leg-IV-5–6. Scale bar: 100 μm.

II+III mL 33 (19–33); Gf pentagonal, L 220 (180–220), W 168 (168–192), L/W ratio 1.3 (1.1–1.3), distance between Gf and Ap 220 (156–220);  $E_4$  at the same level as the 6<sup>th</sup> pair of acetabula; Ap away from the line of primary sclerotization, on the same level of  $V_1$  and anterior to  $V_2$  (Fig. 1B). Gnathosoma (Fig. 1D): the lateral view of gnathosoma regular triangle-like; vL 231 (200–242), dL 151 (128–159), chelicera bs L 214 (202–251), claw L 41 (41–43). P-1 with one dorsal seta; P-2 with one dorsal and one ventral setae at the base of the ventral extension; P-3 with three dorsal seta in proximal half,

two mediodistal setae and two ventral setae at the slight ventral extension (Fig. 1C). dL of palp segments: P-1, 27 (26–30); P-2, 68 (65–68); P-3, 41 (37–48); P-4, 62 (59–72); P-5, 20 (19–25). Legs (Fig. 2): dL of leg segments: I-L-1–6: 64 (64–74), 86 (86–87), 84 (82–92), 109 (105–123), 124 (116–124), 125 (115–125); II-L-1–6: 51 (44–51), 92 (89–116), 78 (76–86), 110 (110–132), 129 (129–149), 132 (127–142); III-L-1–6: 73 (54–73), 80 (80–108), 82 (72–86), 123 (105–123), 139 (107–139), 146 (121–146); IV-L-1–6: 126 (115–134), 119 (111–123), 118 (112–133), 169 (157–185), 169 (165–192), 167 (148–174).

Male. Unknown.

Habitat. Streamlet.

**Remarks.** Due to the characteristic shape of gnathosoma and dorsal shield (i.e., gnathosoma with a short rostrum, the lateral view of gnathosoma regular triangle-like), this new species is similar to *Torrenticola siamis* Pešić & Smit, 2009 (Pešić and Smit 2009). However, there are obvious differences between them: (1) only the tip of Cx-I exceeding to the anterior margin of idiosoma in this new species, but the tip of Cx-I and Cx-II exceeding in *T. siamis*; (2)  $E_4$  at the same level as the 6<sup>th</sup> pair of acetabula in the new species, but the 4<sup>th</sup> pair in *T. siamis*; (3)  $D_2$  on the same level with muscle scars in the new species, but  $D_3$  anterior to muscle scars in *T. siamis*.

**Etymology.** The specific name is from Latin affix: "*pseudo-*", which means fake or simulated; this new species is named after its similar species, *T. siamis*.

Distribution. China (Zhejiang).

#### Torrenticola anziensis Gu & Guo, sp. nov.

http://zoobank.org/2BB83E40-0117-4BD6-8205-AF3A754EBD6B Figures 3, 4

**Material examined.** *Holotype*:  $\bigcirc$  (SC-TO-20160701), Anzihe, Chongzhou, Sichuan Province, P. R. China (30°47'43"N, 103°12'36"E, 1690 m a.s.l.), collected by Zhuhui Ding, 29-VII-2016. *Paratype*:  $1 \bigcirc$  (SC-TO-20160702), same data as holotype.

**Diagnosis.** Dorsal plate 4+1; infracapitular bay U-shaped and wide; genital flaps with six pairs of setae at the margins;  $E_4$  at the same level as the 3<sup>rd</sup> pair of acetabula;  $V_1$  fused with the line of primary sclerotization; gnathosoma: rostrum long, dorsal apodemes short and sharp, ventral apodemes slender and sharp, claw short.

**Description. Female** (*n* = 2): Idiosoma elliptical, L 840 (836), W 583 (576), L/W ratio 1.4 (1.5). Dorsal plate 4+1 (Fig. 3A), dorsal shield L 680 (668), W 520 (505), dorsal plate L 617 (602), frontal platelets L 162 (158), W 78 (76), shoulder platelets L 220 (218), W 87 (89). Infracapitular bay U-shaped and wide, depth 175 (162); Cx-I L 317 (315), mL 83 (81), Cx-II+III mL 99 (89); Gf L 200 (208), W 140 (144), L/W ratio 1.4 (1.4), genital flaps with six pairs of setae at the margins; distance between Gf and Ap 123 (134);  $E_4$  at the same level as the 3<sup>rd</sup> pair of acetabula; Ap on the same line with  $V_2$ ,  $V_1$  fused with the line of primary sclerotization, and  $V_1$  anterior to  $V_2$  (Fig. 3B). Gnathosoma (Fig. 3D): rostrum long, dorsal apodemes short and sharp,



**Figure 3.** *Torrenticola anziensis* Gu & Guo, sp. nov., female **A** dorsal view **B** ventral view **C** palp, lateral view **D** infracapitulum and chelicera. Scale bars: 100 µm.

ventral apodemes slender and sharp, claw short; vL 355 (336), dL 256 (242); chelicera bs L 378 (369), claw L 63 (58). P-1 with one long dorsal seta; P-2 with three dorsal setae and one ventral seta at the base of the ventral extension; P-3 with two dorsal setae and one long seta at the base of the ventral extension; P-4 with one mediodistal seta and two ventral setae at two ventral extensions (Fig. 3C). dL of palp segments: P-1, 42 (39); P-2, 113 (109); P-3, 67 (66); P-4, 93 (95); P-5, 18 (16). Legs (Fig. 4): dL of leg segments: I-L-1–6: 44 (39), 95 (102), 88 (85), 102 (108), 110 (116), 96 (101); II-L-1–6: 43 (45), 98 (102), 93 (94), 121 (118), 136 (129), 149 (139); III-L-1–6: 43 (45), 98 (102), 81 (85), 101 (108), 117 (115), 114 (121); IV-L-1–6: 107 (102), 118 (115), 125 (119), 161 (158), 179 (183), 166 (171). **Male.** Unknown. **Habitat.** Streamlet.

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**Figure 4.** *Torrenticola anziensis* Gu & Guo, sp. nov., female **A** leg-I **B** leg-II **C** leg-III **D** leg-IV-1–4 **E** leg-IV-5, 6. Scale bar: 100 μm.

**Remarks.** Due to the characteristic shape of gnathosoma and dorsal shield (i.e., gnathosoma with a long rostrum, dorsal and ventral apodemes sharp), this new species is similar to *Torrenticola haliki* Pešić & Smit, 2010 (Pešić and Smit 2010). However, there are obvious differences between them: (1) ventral projection of P-2 nose-shaped in *T. haliki*, but normally shaped in this new species; (2) P-4 with one long and three short setae at the base of ventral extensions and one thick mediodistal seta in *T. haliki*, but only with two ventral setae and one fine mediodistal seta in this new species; (3) ratio Cx-I mL/Cx-II+III mL 1.2 (male), 1.7–2.3 (female) in *T. haliki*, but 0.8 (female) in this new species.

**Etymology.** This new species is named after Anzi (Anzi River), where the new species was collected.

Distribution. China (Sichuan).

#### Genus Monatractides (K. Viets, 1926)

*Monatractides sichuanensis* Gu & Guo, sp. nov. http://zoobank.org/8EFE370B-7D4D-46B4-9D87-2608AE618101 Figures 5, 6

Material examined. *Holotype*: ♀ (SC-TO-20160703), Anzihe National Nature Reserve, Chongzhou, Sichuan Province, P. R. China (30°47'43"N, 103°12'36"E,



**Figure 5.** *Monatractides sichuanensis* Gu & Guo, sp. nov., female **A** dorsal view **B** ventral view **C** palp, lateral view **D** infracapitulum and chelicera. Scale bars: 100 μm.

1690 m a.s.l.), collected by Zhuhui Ding, 29-VII-2016. *Paratype*: 1  $\bigcirc$  (SC-TO-20160704), same data as holotype.

**Diagnosis.** Infracapitular bay U-shaped and wide; the tip of Cx-I with a papillary cuticular extension,  $E_4$  at the same level as the posterior margins of Gf;  $V_1$  fused with the line of primary sclerotization;  $D_2$  on the same level with muscle scars; dorsal and ventral apodemes of gnathosoma slender and sharp; dorsal seta on P-1 long.

**Description. Female** (n = 2)**:** Idiosoma elliptical, L 749 (715), W 497 (469), L/W ratio 1.5 (1.5). Dorsal plate 4+1 (Fig. 5A), dorsal shield L 628 (586), W 438 (536), dorsal plate L 584 (423), frontal platelets L 118 (120), W 57 (68), shoulder platelets



**Figure 6.** Monatractides sichuanensis Gu & Guo, sp. nov., female **A** leg-I **B** leg-II **C** leg-III **D** leg-IV-1–4 **E** leg-IV-5, 6. Scale bar: 100 μm.

L 174 (157), W 80 (75). Infracapitular bay U-shaped and wide, depth 171 (163); the margins of Cx-II and Cx-III blunt and flat, the tip of Cx-I with a papillary cuticular extension, Cx-I L 292 (266), mL 123 (102), Cx-II+III mL 46 (31); Gf pentagonal, L 156 (159), W 122 (109), L/W ratio 1.3 (1.5), genital flaps with six pairs of setae at the margins; distance between Gf and Ap 222 (181);  $E_4$  at the same level as the posterior margins of Gf;  $V_1$  fused with the line of primary sclerotization, Ap at the same line with  $V_2$  (Fig. 5B). Gnathosoma (Fig. 5D) vL 182 (177), dL 177 (116); dorsal and ventral apodemes slender and sharp; claw short, chelicera bs L 159 (162), claw L 27 (22). P-1

with one long dorsal seta; P-2 with three dorsal and one ventral setae; P-3 with two long dorsal setae and one short ventral seta; P-4 with one short dorsal seta and two mediodistal setae (Fig. 5C). dL of palp segments: P-1, 21 (25); P-2, 52 (48); P-3, 34 (32); P-4, 34 (39); P-5, 17 (14). Legs (Fig. 6): dL of leg segments: I-L-1–6: 57 (46), 70 (71), 59 (62), 67 (80), 58 (72), 79 (83); II-L-1–6: 55 (61), 92 (85), 56 (60), 86 (75), 84 (92), 108 (96); III-L-1–6: 63 (51), 99 (92), 71 (69), 94 (95), 118 (112), 120 (115); IV-L-1–6: 113 (115), 97 (87), 115 (111), 138 (140), 151 (126), 144 (142).

Male. Unknown.

Habitat. Streamlet.

**Remarks.** This new species is similar to *Monatractides harveyi* Pešić & Smit, 2012 (Pešić and Smit 2012) in the general shape of gnathosoma, but differs in: (1) P-4 with small denticles near the insertion of the ventral setae in *M. harveyi*, but smooth in the new species; (2) the margins of Cx-II and Cx-III sharp in *M. harveyi*, but blunt and flat in the new species; (3)  $D_2$  anterior to muscle scars in *M. harveyi*, but  $D_2$  on the same level with muscle scars in the new species.

**Etymology.** This new species is named after Sichuan Province, where it was collected. **Distribution.** China (Sichuan).

#### Monatractides macrocorpis Gu & Guo, 2019

Figures 7, 8

**Material examined.** Qingliangfeng National Nature Reserve, Lin'an, Zhejiang Province, P. R. China (30°6'44"N, 118°53'36"E, 940 m a.s.l.), collected by Xinyao Gu, 31-VII-2018, 1  $\Im$ (ZJ-TO-20180704), 2  $\Im$  (ZJ-TO-20180705, ZJ-TO-20180706).

**Morphology. Male (n = 1):** Idiosoma L 1083, W 833, L/W ratio 1.3. Dorsal plate 4+1 (Fig. 7A) with a red colour patterns, dorsal shield L 898, W 749, dorsal plate L 804, frontal platelets L 181, W 103, shoulder platelets L 254, W 115. Infracapitular bay U-shaped, depth 206; Cx-I L 376, mL 177, Cx-II+III mL 65; Gf elongated and oval, L 246, W 188, L/W ratio 1.3; distance between Gf and Ap 206. Gnathosoma (Fig. 7D) vL 231, dL 158; dorsal apodeme blunted and ventral apodeme sharp; chelicera bs L 284, claw L 27. P-1 with one dorsal seta; P-2 with three dorsal and one ventral setae; P-3 with two dorsal and one long ventral setae; P-4 with one ventral seta on the slight ventral extension (Fig. 7C). dL of palp segments: P-1, 34; P-2, 80; P-3, 54; P-4, 74; P-5, 30. Legs: dL of leg segments: I-L-1–6: 70, 129, 114, 147, 144, 125; II-L-1–6: 70, 116, 107, 151, 188, 164; III-L-1–6: 86, 146, 108, 169, 216, 192; IV-L-1–6: 152, 159, 176, 220, 241, 224. Ejaculatory complex: L 326, aL 221.

**Female (***n* = 2). Body features same as the male except: Idiosoma L 1212 (1213), W 945 (949), L/W ratio 1.2 (1.3). Dorsal plate (Fig. 8A), dorsal shield L 959 (989), W 871 (845), dorsal plate L 918 (928), frontal platelets L 195 (173), W 109 (96), shoulder platelets L 269 (295), W 123 (117). Infracapitular bay depth 220 (222); Cx-I L 369 (402), mL 145 (176), Cx-II+III mL 68 (38); Gf L 256 (267), W 253 (236), L/W ratio 1.0 (1.1); distance between Gf and Ap 292 (248). Gnathosoma (Fig. 8B) vL



**Figure 7.** *Monatractides macrocorpis* Gu & Guo, 2019, male **A** dorsal view **B** ventral view **C** palp, lateral view **D** infracapitulum and chelicera. Scale bars: 100 μm.

257 (259), dL 246 (262), claw short L 32 (29), chelicera bs L 246 (262). dL of palp segments: P-1, 32 (34); P-2, 90 (91); P-3, 51 (58); P-4, 77 (83); P-5, 21 (32). Legs: dL of leg segments: I-L-1–6: 100 (77), 114 (137), 121 (120), 153 (157), 147 (149), 127 (123); II-L-1–6: 90 (78), 134 (148), 99 (98), 154 (175), 195 (203), 168 (176); III-L-1–6: 101 (-), 161 (170), 119 (120), 177 (193), 214 (228), 217 (203); IV-L-1–6: 144 (159), 181 (160), 188 (192), 235 (243), 245 (261), 230 (220).

## Habitat. Streamlet.

**Remarks.** The populations from Zhejiang Province fit the definition of *Monatractides macrocorpis* Gu & Guo, 2019 (Gu et al. 2019b). Differences with the original description are: (1) the ventral apodeme of gnathosoma, sharp in Zhejiang specimens,



**Figure 8.** *Monatractides macrocorpis* Gu & Guo, 2019, female **A** dorsal view **B** infracapitulum and chelicera. Scale bars: 100 µm.

but blunt in Hunan specimens; (2) with a red colour pattern in Zhejiang specimens, but purple in Hunan specimens.

Distribution. China (Hunan, Zhejiang).

#### Monatractides xiaoxiensis Gu & Guo, 2019

Figure 9

**Material examined.** Qingliangfeng National Nature Reserve, Lin'an, Zhejiang Province, P. R. China (30°6'12"N, 118°55'12"E, 440 m a.s.l.), female, collected by Xinyao Gu, 31-VII-2018, 3 QQ (ZJ-TO-20180707 – ZJ-TO-20180709).

**Morphology. Female (***n* **= 3):** Idiosoma elliptical, L 741 (722–762), W 473 (472–491), L/W ratio 1.6 (1.5–1.6). Dorsal plate 4+1 (Fig. 9A), dorsal shield L 631 (595–656), W 428 (413–441), dorsal plate L 567 (541–579), frontal platelets trapezoidal, L 131 (120–138), W 62 (62–74), shoulder platelets triangular, L 155 (142–155), W 76 (72–79). Infracapitular bay depth 134 (134–150); Cx-I L 269 (244–269), mL 133 (92–133), Cx-II+III mL 37 (37–42); Gf L 132 (132–151), W 116 (115–118), L/W ratio 1.1 (1.1–1.3), distance between Gf and Ap 197 (197–217); Ap away from the line of primary sclerotization, on the same line with  $V_1$  and anterior to  $V_2$  (Fig. 9B). Gnathosoma (Fig. 9C) vL 152 (152–173), dL 117 (113–121); claw short L 23 (19–23), chelicera bs L 159 (159–172). dL of palp segments: P-1, 23 (20–23); P-2, 52 (43–52); P-3, 34 (34–38); P-4, 44 (43–44); P-5, 15 (15–19). dL of leg segments: I-L-1–6: 66 (60–66), 71 (71–81), 76 (67–76), 97 (90–98), 97 (94–97), 92 (88–94); II-L-1–6: 63 (58–63), 80 (72–85), 68 (60–76), 93 (88–93), 107 (96–107), 109 (107–115); III-L-1–6: 54 (54–58), 93 (87–93), 71 (71–74), 99 (97–109), 127 (114–127), 117


**Figure 9.** *Monatractides xiaoxiensis* Gu & Guo, 2019, female **A** dorsal view **B** ventral view **C** infracapitulum and chelicera. Scale bars: 100 µm.

(112–127); IV-L-1–6: 102 (99–114), 94 (88–108), 115 (109–118), 145 (133–154), 154 (151–156), 147 (135–149).

Male. Unknown.

Habitat. Streamlet.

**Remarks.** The specimens match the general morphology of *Monatractides xiaoxiensis* Gu & Guo, 2019, a species from China (Gu et al. 2019b). *Monatractides xiaoxiensis* is characterized by: frontal platelets trapezoidal, shoulder platelets triangular; only the tip of Cx-I and Cx-II exceeding to the anterior margin of idiosoma; tips of Cx-I with an elongated cuticle extension; gnathosoma dorsal apodeme long with a blunt end, ventral apodeme pointed and bent towards dorsum; bs curved heavily towards ventrum (Gu et al. 2019b). According to these characters, we believe our specimens from Zhejiang Province are *M. xiaoxiensis*. The only differences are found in  $V_4$ , which is away from the line of primary sclerotization in Zhejiang specimens, but close to the line in Hunan specimens.

Distribution. China (Hunan, Zhejiang).

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RESEARCH ARTICLE



# Moss inhabiting flea beetles of the West Indies III: Erinaceialtica, a new genus from Hispaniola (Coleoptera, Chrysomelidae, Galerucinae, Alticini)

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### Abstract

*Erinaceialtica* Konstantinov & Linzmeier, a new genus of moss inhabiting flea beetles, containing seven species from the Dominican Republic and Haiti is described and illustrated. Five species are new (*E. gabbysalazarae, E. janestanleyae, E. rickstanleyi* (the type species), *E. rileyi*, and *E. thomasi*) and two species are transferred from *Aedmon: A. albicincta* (Blake) and *A. hugonis* (Blake) **comb. nov.** The new genus is compared to *Aedmon* Clark, *Apleuraltica* Bechyne, *Andersonaltica* Linzmeier & Konstantinov, *Distigmoptera* Blake, and *Ulrica* Scherer. Keys to *Erinaceialtica* and related genera and to *Erinaceialtica* species are provided.

#### Keywords

bryophyte, Monoplatina, moss cushions, new genus, new species, West Indies

# Introduction

Moss cushions in the West Indies, and in Hispaniola in particular, continue to reveal previously unknown flea beetles and allow proper classification of already described ones. Specimens that form a foundation of this paper were collected on the island of Hispaniola. The ones that we have collected in 2005, 2006, and 2014 were extracted from moss cushions the same way as the other moss-inhabiting flea beetles were (for methods see Linzmeier and Konstantinov 2020). However, it remains unknown if Erinaceialtica albicincta (Blake, 1945) and E. hugonis (Blake, 1943a) collected by Darlington in Haiti and the Dominican Republic, respectively, came from moss cushions, although they both were found at significant altitude where moss is generally available. In addition, it seems that E. rileyi and E. thomasi did not come from moss cushions as well. There is a chance that they were sifted out of leaf litter as their collectors (C. O'Brien and M. Thomas) sifted leaf litter regularly. Species of a number of flea beetle genera which occur in moss are also known to live in leaf litter [e.g. Andersonaltica Linzmeier & Konstantinov (Konstantinov et al. in press), Benedictus Scherer (Sprecher-Uebersax et al. 2009, Ulrica Scherer (Konstantinov and Konstantinova 2011)]. Even if beetles were picked up in sweep net, that would not be the first example of catching moss living flea beetles with a net [e.g. Menudos chamorrae (Konstantinov and Konstantinova 2011)].

The three species, for which association with moss is established, are the very rare examples of flea beetles that live in moss cushions but have fully developed wings and elytra that are free with fully developed humeral calli. Another example is *Distigmoptera borealis* Blake, 1943b (Konstantinov et al. 2019). However, ability of *Erinaceialtica* species to fly have not been verified. As has been noticed previously, having fully developed wings, but shortened metasternites (e.g. *Nicaltica* Konstantinov et al. 2009) may be an indication that the flight muscles are reduced. *Erinaceialtica rickstanleyi* has such a metasternite (Fig. 32). Although these beetles have wings (Fig. 2), they probably cannot fly, as in the case of some Neotropical cicindelines (Zerm and Adis 2002).

# Material and methods

Dissecting techniques and terminology for most internal and external structures follow Konstantinov (1998). In addition, terminology for adult thoracic structures and ridges follows Lawrence and Slipinski (2013), Lingafelter and Konstantinov (2000), and McHugh et al. (1997). Specimen labels are sited verbatim, according to the format justified previously (Konstantinov 1998, Konstantinov and Lingafelter 2002, and Konstantinov et al. 2011). Specimen observations were made with a Zeiss Stemi SV11 Apo microscope. Digital photographs of morphological structures were taken with Axio Zoom V16 microscope and AxioCam HRC digital camera attached to it and with AxioCam HRC Zeiss attached to Leitz Diaplan compound microscope. Additional images were taken with Macropod Pro photomacrography system (Macroscopic Solutions, LLC, Tolland, CT). The beetles are deposited in the following collections: National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM); E. Riley collection (ERPC); and Museo Nacional de Historia Natural, Santo Domingo, Dominican Republic (MHND).

### Taxonomy

#### Erinaceialtica gen. nov.

http://zoobank.org/D8DC4FAF-5A12-454D-B8B5-11E29E5FE557 Figs 1–54, Map 1

**Description.** Body length 2.1–2.81 mm, width (widest point of elytra) 1.19–1.35 mm, height 0.97–1.13. Elytron metallic green, blue, black, or coppery, light metallic green; some parts of elytra yellow to brown. Color of pronotum almost same as elytron: metallic blue, green, or dark brown, in some species pronotum greenish when elytra blueish.

Head. Orbit as wide as transverse diameter of antennal socket with punctures dense, large, their diameter greater than distance between them. Inner margins of eye straight, nearly parallel with each other. Distance between eyes (above antennal sockets) in frontal view much greater than transverse diameter of eye (2.4 times). Supraorbital pore only slightly larger than other punctures, but different color (mostly vellowish). Vertex densely and evenly covered with round, setose punctures placed close together. Antennal sockets situated below middle of eye. Frontal ridge (from dorsal side to frontoclypeal suture) 1.58–1.87 times longer than longitudinal diameter of antennal socket; straight in lateral view; extends to level of antennal calli, does not enter in between them. Sides of frontal ridge between antennal sockets and below straight, parallel to each other. Dorsal side of frontal ridge truncate. Frontal ridge and vertex separated by antennal calli. Frontal ridge dorsally as wide as ventrally. Anterofrontal ridge tall, slopes abruptly towards clypeus. Dorsal side of anterofrontal ridge laterally of frontal ridge even, without visible convexity. Frontal ridge and anterofrontal ridge in frontal view form nearly straight angle with each other. Length (thickness) of anterofrontal ridge less than that of frontal ridge. Sides of head below eyes converging ventrally. Shape of clypeus band like. Anterior margin of labrum emarginate. Labrum with 3 pairs of setae, distributed evenly on both sides.

Head sulci and antennal calli. Midcranial suture absent. Supraorbital, orbital, supracallinal, frontolateral and suprafrontal sulci absent. Midfrontal sulcus well developed, long. Antennal calli and top of frontal ridge meet, not separated from each other. Antennal callus not entering interantennal space. Surface of antennal callus on same level as surface of vertex and frontal ridge. Length of antennal callus about as great or shorter than its width. Antennal grooves between eye and frontal ridge present.

Antenna with 11 antennomeres, apical antennomeres much wider than basal. Color of antennomeres (not counting basal antennomeres being a bit lighter than rest) different. Antennomere 5 white. Antenna not reaching half of elytron. Antennomere 1 shorter than next two antennomeres combined. Antennomere 2 globular, shorter than 3, longer than half of it, about as wide as 1, wider than 3. Antennomere 3 longer than 4. Antennomere 5 as long as 4, longer than or as long as 6. Antennomere 7 much wider than antennomeres 4 and 5 separately. Distal antennomeres robust.

Prothorax. Pronotal surface hairy. Anterolateral callosity ovoid or otherwise rounded. Anterolateral callosity: expansion beyond lateral margin slight, facing anterolaterally. Anterior setiferous pore situated about middle callosity. Anterolateral corners of pronotum projected at about same level as middle of pronotum. Sides of pronotum nearly straight with a slight lobe anterior to middle. Pronotal margins even. Base of pronotum straight, without lateral longitudinal impressions. Antebasal transverse impression on pronotum wide, shallow, poorly differentiated from rest of pronotal surface or absent. Longitudinal impressions anteriorly present in middle. Two bumps with groove between present. Lateral margin of pronotum complete. Numerous setae on lateral margin of pronotum present. Posterolateral callosity situated on corner of posterior and lateral margins. Procoxal cavities closed. Intercoxal prosternal process in lateral view more or less straight or slightly convex, in ventral view generally wide, surface concave, posteriorly much wider than in middle. Sides of intercoxal prosternal process concave, posterior end straight, extends beyond procoxae posteriorly.

Mesothorax. Scutellum present. Mesothoracic prefragma very short. Mesoventral process about as wide as long. Mesocoxal cavities transverse. Mesosternum without elevated projection in middle.

Elytra with sides nearly straight, sometimes parallel to each other. Humeral calli well developed. Elytron with basal callus. Transverse impression of elytron posteriad to humeral or basal callus deep. Oblique impression on elytron between humeral and basal calli present. Elytron with punctures arranged in striae, not in grooves. Dorsal surface covered with sparse erect and dense hairs arranged in different directions. Elytra at base wider than base of pronotum. Ridges on elytra absent. Epipleura about as wide as front femur, abruptly narrowing before apex, oblique, directed outwardly, reaches end of side of elytron, but not apex.

Metathorax. Metasternum short, about twice as long as mesosternum, anteriorly projecting forward, but not covering mesosternum, without elevated projection in middle. Posterior end of metasternum slightly swollen. Metathoracic discrimen extends a bit more than half of metasternum length. Metatergite about twice as wide as long, with full set of ridges in middle. Metendosternite with relatively short stem, slightly narrower than arms near base. Arm tendon slightly closer to middle than to arm end. Arm ends lightly sclerotized, simple.

Abdomen. Abdominal ventrites 1 and 2 not fused. Abdominal ventrite 1 slightly longer than ventrites 2 and 3 together. Abdominal ventrite 5 slightly shorter than ventrites 4 and 3 together. First abdominal ventrite between coxae without longitudinal ridges. Apex of first abdominal sternite in female evenly and narrowly rounded. Last visible tergite of female without longitudinal groove in middle.

Legs. Pro- and mesotibiae and femora not sexually dimorphic. Profemur generally cylindrical. Pro- and mesotibial spurs absent. Pro- and mesotibiae without longitudinal ridges. Apical part of middle tibia without obtuse tooth beyond middle, followed by excavation. Metafemur enlarged. Posterior edge of metafemur in males as in females. Metafemoral spring present. Metatibia in dorsal and lateral views straight. Metatibia in cross section around middle more or less cylindrical, dorsally convex. Metatibial apex flattened. Sharp edge present on dorsal side of metatibia laterally, absent medially. Metatibia with transverse ridge above insertion of tarsus. Metatibial spur situated laterally, single, simple, narrow, ending in one tooth, shorter than greatest width of metatibial apex. Metatibia ventrally at apex makes lobe on side of spine. Metatarsomere 1 attached anteriorly of apex. First protarsomere of males about as wide and long as in females. Protarsomere 3 wide, with round sides. Metatarsomere 3 longer than wide, elongate, incision absent. Metatarsomere 4 globose. Claw bifid or appendiculate.

Genitalia. Spermatheca with receptacle and pump without distinct border in between. Receptacle curved, three dimensional, longer than wide or as wide as long. Receptacle about as wide as pump. Pump with flattened end. Duct of spermatheca with coils longer than receptacle or as long as receptacle. Vaginal palpi many times longer than wide. Posterior sclerotization of vaginal palpi elongate, rounded at apex. Tignum narrow anteriorly, widens posteriorly. Median lobe of male genitalia elongate. Median lobe of male genitalia in cross section (about middle) oval or flattened.

Type species. Erinaceialtica rickstanleyi sp. nov. by present designation.

**Etymology.** The name of this genus is a combination of two words. First is a Latin word for hedgehog – Erinacei (genitive, singular, masculine, II declension) as a reference to beetles having highly unusual setae that remind needles of a hedgehog. The second word is Altica, the name of the type genus of the Alticini.

**Comparative diagnosis.** The first known species of *Erinaceialtica* have been described in the genus *Hadropoda* (Blake 1943a, 1945). However, while describing *E. hugonis*, Blake (1943a) noticed that this species is substantially different from West Indian congeners "and may eventually be placed in a different genus ..." (page 440). She made similar observations two years later describing *E. albicincta* (Blake, 1945) suggesting that "... together they form a group that stands a little apart in the genus [*Hadropoda*] and resembles in many ways the species of the North American genus *Distigmoptera*. *H. albicincta* closely resembles *hugonis* but differs in having raised sutural margins and three warts as well as an apical tumidity on each elytron. Its elytral punctation is a little finer and the whole beetle slightly more slender" (page 89).

Classification of monoplatine genera presents significant difficulties, moss and leaf litter inhabiting and associated morphological transformations contribute to it. Nevertheless, we were able to circumscribe some distinct species groups among West Indian species that include already described genera (*Aedmon* Clark, *Andersonaltica* Linzmeier & Konstantinov, *Apleuraltica* Bechyne, *Distigmoptera* Blake, *Menudos* Linzmeier & Konstantinov, and *Ulrica* Scherer) and the one described in this paper. To facilitate their identification, we provide a key below.

Some features of *Erinaceialtica* that cannot be included in the key, but still worth mentioning are: 1) presence of subtle sexual dimorphism in the general

color of the body (small difference in size of dark spots is noticed in *E. gabbysalazarae*) and width of the head (sexual dimorphism among *Menudos* species exceeds one that generally occurs in flea beetles); 2) median lobe of the aedeagus differs dramatically between species (in most genera, particularly those occurring in leaf litter or moss, median lobes are very similar and differ only in very subtle features e.g. *Andersonaltica*); 3) species are very colorful (more so than flea beetles in general), dramatically different in color of the body and appendages as well as in color and direction of the setae on pronotum and elytra; this makes species identification relatively easy based on external characters and makes it possible to identify *E. albicincta* and *E. hugonis* based on images of the types (see MCZ citations in the reference section).

# Key for Monoplatina genera of the West Indies related to Erinaceialtica

1	Head and pronotum almost smooth with small and shallow punctures; pro-
	notum and elytra lack hairs or with sparse hairs; pronotum without ridges
_	Head and pronotum densely and deeply punctuated; pronotum and elytra
	covered with hairs; pronotum with ridges
2	Body oblong-oval, elongate, subparallel
_	Body elliptical to rounded
3	Pro- and mesotibiae bicolored with wide yellowish band in middle (band
	may be very vivid (Fig. 1), or subtle (Fig. 14); antennomere 5 always white;
	pronotum and elytra with different metallic tint Erinaceialtica gen.nov.
_	Pro- and mesotibiae without wide yellowish band in middle; antennomere 5
	similar in color to other antennomeres; pronotum and elytra not metallic4
4	Elytra with impression near the suture before the middle
	Distigmoptera Blake (Fig. 59)
_	Elytra without impression or with a very faint one near the suture before the
	middle Aedmon Clark (Fig. 56)
5	Basal callus poorly developed, antennae filiform with all antennomeres longer
	than wide; pygidium exposed Menudos Linzmeier & Konstantinov (Fig. 60)
-	Basal calli well developed; antennae with some distal antennomeres wider
	than long; pygidium not exposed6
6	Antennal calli widely separated anteriorly; antennae clavate, antennomeres 7
	to 11 forming tight club; elytra uneven, highly convex in lateral view; metati-
	bia without transverse ridge above insertion of tarsus
	Andersonaltica Linzmeier & Konstantinov (Fig. 57)
-	Antennal calli longitudinal, not widely separated anteriorly; antennomeres 7
	to 11 more robust forming almost a clave, with antennomeres 8 to 10 wider
	than long; elytra even, slightly convex in lateral view; metatibia with trans-
	verse ridge above insertion of tarsus forming a preapical dorsal projection, in
	lateral view

http://zoobank.org/A55E8C8F-B188-42FF-8A1D-DF10875B09C1 Figs 1–13, Map 1

**Description.** Body length 2.27–2.64 mm, width 1.29–1.51 mm. Vertex dark brown, part of head below vertex mostly antennal calli and frons yellowish. Antennomere 11 slightly lighter than 9. Base of pronotum yellowish, apex dark. Sides of pronotum dark. Antebasal pronotal impression shallow, poorly defined. Elytral disc broadly yellow, except triangular spot on side and below scutellum, sides and slope of elytron, two spots at beginning of elytral slope in male and larger spot in female. Elytral apex yellowish, slightly darker than elytral disc. Ventral side of body orange. Base of pro- and mesofemora and middle of pro- and mesotibiae white. Apex of pro- and mesofemora dark, apical lighter. Setae on orbit bright yellow, directed ventrally. Setae on middle of vertex directed towards middle, forming a small "mohawk". Pronotal setae directed posteriorly starting from about middle. Median lobe of aedeagus flattened, nearly straight in lateral view, complex ventrally with deep longitudinal impression from base to apex between two sharp ridges and a lobe in middle of impression; narrow before apex, widening towards it, apex itself ogival in shape.

**Diagnosis.** *Erinaceialtica gabbysalazarae* has a uniquely shaped median lobe of the aedeagus and unique color and can be easily identified using the key at the end of the paper.

**Habitat.** *Erinaceialtica gabbysalazarae* was collected at El Cachote forest on a rainy day in moss that was hanging from branches and growing trunks of the trees (Figs 12, 13). Altogether about 5 gallons (= 19 L) of moss was collected in a single pillowcase. Some of it was processed directly with Berlese extraction and some was sifted and then processed with Berlese.



Map 1. Distribution of *Erinaceialtica* species on the island of Hispaniola.



**Figure 1.** *Erinaceialtica gabbysalazarae* sp. nov., dorsal habitus (illustration by Katie Sayers, USNM and SEL scientific illustrator internship program, summer 2019).



Figures 2–4. Adult *Erinaceialtica gabbysalazarae*, male 2 habitus, dorsal view 3 habitus, lateral view 4 habitus, three quarter view.



**Figures 5–7.** Adult *Erinaceialtica gabbysalazarae*, male **5** habitus, frontal view **6** median lobe of aedeagus, ventral and lateral views **7** metatibia, dorsal view.



Figures 8–11. Adult *Erinaceialtica gabbysalazarae*, female 8 habitus, dorsal view 9 habitus, lateral view 10 hind leg, lateral views 11 head, frontal view.



Figures 12, 13. El Cachote, habitat of *Erinaceialtica gabbysalazarae*.

**Etymology.** The species epithet, gabbysalazarae, is a matronym in honor of Gabby Salazar of Bethesda, Maryland in appreciation for comradery and companionship during collecting trips to the Dominican Republic, which she documented in numerous photos.

**Type material examined.** Holotype male: 1) Dominican Republic, Barahona Pr., El Cachote 8.XII 2014, 961m 18°03.295'N, 71°09.778'W WP-189 Leg. A. S. Konstantinov; 2) 2014.12.08 0633 (code for molecular voucher) (USNM). Paratypes with the same labels as holotype (2 USNM).

#### Erinaceialtica janestanleyae sp. nov.

http://zoobank.org/FD44BB79-692A-410A-A886-CBF9A6143946 Figs 14–21, Map 1

Description. Body length 2.92–2.97 mm, width 1.45–1.51 mm. Vertex and part of head below vertex with antennal calli and frons same bright metallic green. Antennomere 11 slightly lighter than 9. Base and sides of pronotum same color as apex, bright metallic green. Antebasal pronotal impression absent. Elytral disc bright metallic green. Some spots on elytron appear black in part because elytral surface darker, in part because it is covered with dark setae. In dorsal view dark spots are: below basal margin lateral to scutellum, on lateral slope near middle, and another spot directly below it towards posterior. Elytra towards apex also appear darker. Ventral side of body dark brown, except last abdominal segment being lighter in color. Base of pro- and mesofemora white. Apex of pro- and mesofemora and most of pro- and mesotibiae dark brown, except small lighter ring around middle tibiae. Metafemora dark, with bronzy shine. Metatibia dark yellow. Setae on orbit and vertex yellow, directed laterally. Setae on middle of vertex short, directed towards middle, not forming a small "mohawk". Pronotal setae directed posteriorly starting from about middle. Second row on punctures on elytral slope longitudinally impressed with setae directed laterally and ventrally from it.

**Diagnosis.** *Erinaceialtica janestanleyae* has unique color and can be easily identified using the key at the end of the paper.

**Habitat.** *Erinaceialtica janestanleyae* was collected in Zapoten forest (northern slopes of Sierra de Baoruco) in moss that was abundant on the sides of the road, tree trunks and branches (Figs 20, 21). Altogether about 30 gallons (= 114 L) of moss was collected in five pillowcases. Small portion of it was processed directly with Berlese extraction and the rest was sifted and then processed with Berlese. This moss collecting event revealed the largest diversity of flea beetles that included one species of *Erinaceialtica*, one species of *Kiskeya* Konstantinov & Chamorro and a species of *Andersonaltica* (Konstantinov et al. in press).

**Etymology.** The species epithet, janestanleyae, is a matronym in honor of Jane Stanley of Bethesda, Maryland. We greatly appreciate Jane and her family's friendship and generosity in providing access and encouragement at the Punta Cana Resort, including use of their beautiful home, Casa de los Sueños, near the Ecological Reserve.



**Figure 14.** *Erinaceialtica janestanleyae* sp. nov., dorsal habitus (illustration by Linden Pederson, USNM and SEL scientific illustrator internship program, summer 2019).



Figures 15–19. Adult *Erinaceialtica janestanleyae*, female 15 habitus, dorsal view 16 habitus, lateral view 17 habitus, three quarter view 18 hind tibia, three quarter view 19 habitus, frontal view.



Figures 20, 21. Zapoten, habitat of *Erinaceialtica janestanleyae*.

**Type material examined.** Holotype female: 1) Dominican Republic, Zapoten, 15.XII 2014, highest Pls, 1705 m, WP-522, 18°18.496'N, 71°41.994'W, Leg. A, Konstantinov; 2) 2014.12.15 2324 (code for molecular voucher) (USNM). Paratype female: 1) Dominican Republic, Independencia, Sierra de Baoruco, Zapoten h-1705m 15.XII.2014 WP-522, 18.19.655N, 71.41.994W, thick moss cushion on rocks trees, leg. A. Konstantinov; 2) 2014.12.15 0636 (code for molecular voucher) (USNM).

### Erinaceialtica rickstanleyi sp. nov.

http://zoobank.org/26EF38BD-5F0C-4054-806B-2E06BFCE4EAF Figs 22–45, Map 1

Description. Body length 2.59–2.86 mm, width 1.45–1.78 mm. Vertex and part of head below vertex including frons same metallic blue. Antennal calli with a greenish shine. Antennomere 11 slightly lighter than 9. Base and sides of pronotum same color as apex, metallic blue and purple (some specimens have pronotum with greenish tint). Antebasal pronotal impression absent. Elytral disc metallic blue and purple. Some spots on elytron appear black in part because elytral surface darker, in part because it is covered with dark setae, these places also slightly impressed compared to rest of elytron surface. In dorsal view dark spots are: on lateral slope near middle and another spot directly below it towards posterior and one on posterior end. Elytra towards apex also appear darker. Triangular spot lateral to scutellum dark yellow. Ventral side of body dark brown, except last abdominal segment being lighter in color. Base of pro- and mesofemora light yellow. Apex of pro- and mesofemora and most of pro- and mesotibiae dark brown, except lighter poorly defined ring around middle tibiae. Metafemora dark, with bronzy shine. Metatibia dark yellow at base, brown near apex. Setae on orbit and vertex whitish, directed laterally. Setae on middle of vertex short, directed towards middle, not forming a small "mohawk". Pronotal setae directed posteriorly starting from about middle. Second row on punctures on elytral slope longitudinally impressed with setae directed laterally and ventrally from it. Median lobe of aedeagus narrows substantially from middle to apex in ventral view, apex rounded.

**Diagnosis.** *Erinaceialtica rickstanleyi* has unique color and can be easily identified using the key at the end of the paper.

**Habitat.** *Erinaceialtica rickstanleyi* was collected on the southern slopes of Sierra de Baoruco in the area called Las Abejas. The site is a deep ravine situated at about 1200 m, which descends abruptly from pine forest (Figs 44, 45). Fisher-Meerow and Judd (1989) classified the area as premontane wet forest, rich in epiphytes. Moss was sampled three times in this area, in July of 2004, late June of 2005 and mid July of 2006. No moss inhabiting flea beetles were collected in 2004. In addition to *E. rickstanleyi, Kiskeya baorucae* Konstantinov & Chamorro-Lacayo 2006 was found in that place in 2005 and 2006.

**Etymology.** The species epithet, rickstanleyi, is a patronym in honor of Rick Stanley of Bethesda, Maryland. We greatly appreciate Rick and his family friendship and



**Figure 22.** *Erinaceialtica rickstanleyi* sp. nov., dorsal habitus (illustration by Katie Sayers, USNM and SEL scientific illustrator internship program, summer 2019).



**Figures 23–27.** Adult *Erinaceialtica rickstanleyi* **23** habitus, dorsal view **24** habitus, lateral view **25** habitus, three quarter view **26** median lobe of aedeagus, ventral and lateral views **27** habitus, frontal view.



**Figures 28–33.** Adult *Erinaceialtica rickstanleyi*, morphological structures **28** middle part of head, ventral view **29** labrum **30** antenna **31** mesotergite **32** meso- and metasternites **33** metatergite.



Figures 34–40. Adult *Erinaceialtica rickstanleyi*, morphological structures 34 metendosternite 35 hind tarsus 36 right elytron 37 hind leg 38 middle leg 39 abdominal ventrites, female 40 last abdominal tergite, female.



Figures 41-43. Adult Erinaceialtica rickstanleyi, female genitalia 41 spermatheca 42 vaginal palpi 43 tignum.

generosity in providing access at the Punta Cana Resort, including use of their home, Casa de los Sueños. Rick took part in our numerous collecting trips over the years in Bolivia, Costa Rica, Dominican Republic, and Nicaragua documenting local landscapes, avian- and insect faunas with numerous photos, some of which were used in publications (e.g. Konstantinov et al. 2009).

**Type material examined.** Holotype, male: 1) DOMINICAN REPUBLIC: Pedernales Prov., PN Sierra de Baoruco, Las Abejas 1270 m, 18°09.008'N, 71°37.338'W, 18.VI.2005, moss sifting A. Konstantinov (USNM). Paratype females 3, with the same labels as holotype (2 USNM), (1 MHND). Paratype male: DOMINICAN REPUB-LIC: Pedernales Province Sierra de Baoruco, Las Abejas forest 1230 m. 17.VII.2006 18°09.132'N, 71°37.430'W leg. A.Konstantinov (USNM).



Figures 44, 45. Las Abejas, habitat of *Erinaceialtica rickstanleyi*.

#### Erinaceialtica rileyi sp. nov.

http://zoobank.org/0ADEC145-16A8-44DD-8AEC-67C3AA2A3930 Figs 46–51, Map 1

Description. Body length 2.10–2.54 mm, width 1.18–1.40 mm. Vertex and part of head below vertex including frons and antennal calli black with dark greenish to blueish tint. Antennomere 11 slightly lighter than 9. Base of pronotum dark yellow, slightly lighter in color than apex. Antebasal pronotal impression absent. Elytral disc black to dark brown with dark greenish to blueish tint. Some spots on elytron appear black in part because elytral surface darker, in part because it is covered with dark setae. In dorsal view dark spots are: one spot lateral to scutellum, two spots down posteriorly near suture, and two more on posterior slope; one spot on humeral callus, two spots behind each other on lateral slope near middle, and another spot directly below it towards posterior. Elytra laterally and towards apex also appear darker. Ventral side of body dark brown, except last abdominal segment being lighter in color. Pro- and mesofemora and pro- and mesotibiae brown, with slightly lighter area on tibiae. Metafemora dark, with bronzy shine. Metatibia uniformly brown to dark amber in color. Setae on orbit and vertex whitish, denser and more vivid on orbit, directed ventrally. Setae on middle of vertex short, directed towards middle, not forming a small "mohawk". Pronotal setae more erect, directed laterally and posteriorly. Second row on punctures on elytral slope not impressed with setae directed laterally and ventrally from it. Median lobe of aedeagus narrows gradually from middle to apex in ventral view with wide apex.

**Diagnosis.** *Erinaceialtica rileyi* has unique color and can be easily identified using the key at the end of the paper.

Habitat. Unknown.

**Etymology.** The species epithet, rileyi, is a patronym in honor of Ed Riley, who contributed greatly to our knowledge of diversity and taxonomy of Chrysomelidae in the United States and the New World in general.

**Type material examined.** Holotype, male: 1) Dom. Rep.: LaVega 19 km E El Rio Aug 3, 1979, C.W.O'Brien (USNM). Paratype, female, with the same labels as holotype (ERPC).

Paratype, male: DOMINICAN REPUBLIC, La Vega, Estacion Cabanito 20 July 1996, R. Turnbow; 2) Reserva Científica Ebano Verde (ERPC).

#### Erinaceialtica thomasi sp. nov.

http://zoobank.org/D4F0C9CE-880C-4942-90D4-5F4559046D85 Figs 52–55

**Description.** Body length 2.37 mm, width 1.24 mm. Vertex and part of head below vertex including frons and antennal calli black without apparent greenish or blueish tint. Antennomere 11 as dark as 9. Pronotum dark brown with base slightly lighter in color than apex. Antebasal pronotal impression very shallow and poorly defined.



**Figures 46, 47.** Adult *Erinaceialtica rileyi* sp. nov. **46** habitus, dorsal view, male **47** habitus, dorsal view, female.



Figures 48–51. Adult *Erinaceialtica rileyi* 48 habitus, three quarter view, male 49 median lobe of aedeagus, ventral and lateral views 50 habitus, frontal view, male 51 habitus, frontal view, female.

50

51



**Figures 52–55.** Adult *Erinaceialtica thomasi* sp. nov. **52** habitus, dorsal view **53** median lobe of aedeagus, ventral and lateral views **54** habitus, three quarter view **55** habitus, frontal view.



Figures 56-61. Habitus drawing of moss inhabiting Monoplatina.

Two bumps on pronotum short with even shorter one in between them close to posterior margin. Elytral disc with two long, triangular, dark greenish to blueish metallic tint along suture. Rest of disc posteriorly dark yellow. Elytra laterally and towards apex appear darker. Ventral side of body dark brown to black, except last abdominal segment being lighter in color. Pro- and mesofemora yellow at base, dark brown for rest of its length. Pro- and mesotibiae brown, with slightly lighter area around middle. Metafemora dark, with bronzy shine. Metatibia bicolored, darker at apex, lighter at base. Setae on orbit and vertex as sparse and same color. Setae on middle of vertex short, directed towards middle, not forming a small "mohawk". Pronotal setae directed laterally and posteriorly. Second row on punctures on elytral slope not impressed with setae directed laterally and ventrally from it. Median lobe of aedeagus narrows extensively from middle to apex, apex more or less cylindrical in ventral view. In lateral view, median lobe bends abruptly ventrally.

**Diagnosis.** *Erinaceialtica rileyi* has unique color and can be easily identified using the key at the end of the paper.

Habitat. Unknown.

**Etymology.** The species epithet, thomasi, is a patronym in honor of late Mike Thomas, who contributed greatly to our knowledge of beetle diversity, taxonomy, and identification in the United States.

**Type material examined.** Holotype, male; 1) Haiti Dept. Sud-Oueste, Parc National La Visite 2040–2150m, 23-V-1984 Coll. M.C. Thomas (USNM).

### Erinaceialtica albicincta (Blake, 1945), comb. nov.

*albicincta* Blake 1945: 89 (Type locality. Morne La Hotte, elevation 5,000–7,800 feet, Haiti, holotype, female, MCZ); as *Hadropoda*. Scherer 1962: 512 as *Aedmon* Clark.

**Notes.** For images see MCZ type data-base (accessed April 16, 2020): https://mczbase. mcz.harvard.edu/MediaSearch.cfm?action=search&media\_id=314649,314650,31465 1,314652,314653

56 Aedmon sericellum Clark (illustration by Rebecca Jabs, National Museum of Natural History and Systematic Entomology Laboratory scientific illustrator internship program, summer 2016) 57 Andersonaltica villabarrancoli Konstantinov & Linzmeier (illustration by Linden Pederson, National Museum of Natural History and Systematic Entomology Laboratory scientific illustrator internship program, summer 2019)
58 Apleuraltica curculionoides Bechyne (illustration by Taina Litwak Systematic Entomology Laboratory)
59 Distigmoptera borealis Blake (illustration by Abby Williams, National Museum of Natural History and Systematic Entomology Laboratory scientific illustrator internship program, summer 2016)
60 Menudos maricao Linzmeier & Konstantinov (illustration by Katie Sayers, National Museum of Natural History and Systematic Entomology Laboratory scientific illustrator internship program, summer 2019)
61 Ulrica eltoro Konstantinov & Konstantinova (illustration by Jessica Hsiung, National Museum of Natural History and Systematic Entomology Laboratory scientific illustrator internship program, summer 2019)
61 Ulrica eltoro Konstantinov & Konstantinova (illustration by Jessica Hsiung, National Museum of Natural History and Systematic Entomology Laboratory scientific illustrator internship program, summer 2019)

# Erinaceialtica hugonis (Blake, 1943a), comb. nov.

*hugonis* Blake 1943a: 439 (type locality: Cloud forest, vicinity of Valle Nuevo, circa 6000 ft., Dominican Republic; holotype, male, MCZ); *Hadropoda*. Scherer 1962: 512 as *Aedmon* Clark.

**Notes.** For images see MCZ type data-base (accessed April 16, 2020) https://mczbase. mcz.harvard.edu/MediaSearch.cfm?action=search&media\_id=314502,314636,31463 7,314638,314639,314640,314641,314642,314643

# Key to Erinaceialtica species

1	Antennomere 6 whitish Erinaceialtica albicincta (Blake)
_	Antennomere 6 dark (Fig. 2)2
2(1)	Elytron bicolorous, with broad, yellow to brown oblique stripe starting
	from around humeral calli and extending towards suture and below (Figs 4,
	46)
_	Elytron unicolorous, without broad, brownish oblique stripe starting from
	around humeral calli and extending towards suture and below (Fig. 15)5
3(2)	Elytron with broad yellowish stripe. Dark colored part of elytron with bright
	metallic green lustre (Fig. 4). Median lobe of aedeagus with apical part wider
	than middle (Fig. 6) Erinaceialtica gabbysalazarae sp. nov.
_	Elytron with broad brownish stripe. Dark-colored part of elytron with dull
	metallic greenish and blueish lustre (Fig. 54). Median lobe of aedeagus with
	apical part as wide or narrower than middle (Figs 46, 53)4
4(3)	Median lobe of aedeagus narrows extensively from middle to apex, apex more
	or less cylindrical in ventral view. In lateral view, median lobe bends abruptly
	ventrally (Fig. 53) Erinaceialtica thomasi sp. nov.
_	Median lobe of aedeagus more or less parallel sided from middle to apex, apex
	flat in ventral view. In lateral view, median lobe bends slightly dorsally
	Erinaceialtica hugonis (Blake)
5(2)	Head, pronotum, and elytron bright metallic green (Fig. 17)
	Erinaceialtica janestanleyae sp. nov.
_	Head, pronotum, and elytron mostly black or dark metallic blue or green
	with a few light-green spots (Fig. 25)
6(5)	Base of elytron with dark-yellow spot lateral to scutellum (Fig. 23). Median
	lobe of aedeagus narrows substantially from middle to apex in ventral view
	(Fig. 26) Erinaceialtica rickstanleyi sp. nov.
_	Base of elytron without dark-yellow spot lateral to scutellum (Figs 46, 47).
	Median lobe of aedeagus narrows gradually from middle to apex in ventral
	view (Fig. 49) Erinaceialtica rileyi sp. nov.

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RESEARCH ARTICLE



# Two new West Palaearctic species of Atelestus Walker (Diptera, Atelestidae) and new distributional records of the family

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## Abstract

Atelestus turcicus Barták, **sp. nov.** (Turkey) and Atelestus ibericus Barták, **sp. nov.** (Spain) are described and illustrated. A key to all known Palaearctic species of Atelestus is provided and the main diagnostic characters are discussed. The female of Nemedina acutiformis Carles-Tolrá, 2008 is described for the first time. New distributional records are presented: Atelestus dissonans Collin, 1961 – first records from Spain and Bulgaria, A. pulicarius (Fallén, 1816) – first record from Turkey, Nemedina alamirabilis Chandler, 1981 – first record from Bulgaria and N. acutiformis Carles-Tolrá, 2008 – first record from Turkey.

#### Keywords

Atelestidae, Atelestus, descriptions, Diptera, Europe, Nemedina, taxonomy

# Introduction

In the light of the unprecedented reduction in biodiversity and the possible further mass extinction of biota we should save species at least in collections for further studies (Barták 2019).

The family Atelestidae is a very small family of Diptera Brachycera, often assigned to the large superfamily Empidoidea. Numerous works have tried to elucidate phyloge-

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netic relationships within Empidoidea including placement of the family Atelestidae. A comprehensive summary of empidoid morphology and relationships was provided by Sinclair and Cumming (2006). This key work was preceded or followed by a number of other important works. The above-mentioned classification was primarily proposed by Chvála (1983), but later molecular studies have clarified relationships further. The contribution by Wiegmann et al. (1993) was the first modern computer-generated analysis based on morphological characters to investigate the origins of the Cyclorrhapha. However, the first molecular study was provided by Collins and Wiegmann (2002), followed by Moulton and Wiegmann (2004, 2007). Recently, Wahlberg and Johanson (2018) studied phylogenetic relationships within Empidoidea based on mitochondrial and nuclear genes. All these molecular studies found the family Atelestidae to be sister group to the remaining Empidoidea. In addition, newly described amber fossil species have helped to clarify empidoid relationships (Grimaldi and Cumming 1999), in particular the work by Sinclair and Kirk-Spriggs (2010), which provides two new species for the family Atelestidae. The manuscripts from Chandler (1981), Sinclair and Arnaud (2001), Sinclair and Shamshev (2003), Sinclair and Papp (2004) and Carles-Tolrá (2008) significantly contributed to the knowledge of the genus Nemedina. These works above were complemented by relatively recent atelestid catalogs, checklists and faunistic records. For example, the work by Chvála (1983) provided an overview of all Nordic empidoid species. The same author created an atelestid checklist of Czech Republic and Slovakia (Chvála 2009), but his most important works are a Catalogue of Palaearctic Diptera, including family Atelestidae (Chvála 1989) and a list of valid European atelestid species on the "Fauna Europaea" website (Chvála 2013). Further information about Afrotropical Atelestidae was submited by Sinclair (2017) in Manual of Afrotropical Diptera. Faunistic records of Atelestidae have also been published by country, e.g., from Germany with a contribution by Franzen (1996), from Bulgaria by Dzhambazov and Beschovski (2000), from French Corsica by Grootaert and Shamshev (2003), from Finland by Kahanpää (2014); from Hungary by Papp (2009), from Portugal by Andrade and Chandler (2016), and from Russia by Shamshev (2016) and Kustov et al. (2016).

The following species of extant Atelestidae are known from the West Palaearctic: three species of *Nemedina* Chandler (*N. alamirabilis* Chandler, 1981; *N. acutiformis* Carles-Tolrá, 2008 and *N. zaitsevi* Sinclair & Shamshev, 2003), two species of *Atelestus* Walker (*A. dissonans* Collin, 1961 and *A. pulicarius* (Fallén, 1816)) and one species of *Meghyperus* Loew (*M. sudeticus* Loew, 1850). Two additional species of *Atelestus* are added herein. The first assignment of the genus *Nemedina* to the family Atelestidae was proposed by Barták (2000) and this proposal was further supported and confirmed by later studies – Sinclair and Shamshev (2003), Sinclair and Papp (2004) and Sinclair and Cumming (2006).

## Material and methods

The material studied originated from recent collections of authors MB and ŠK in Spain and Turkey and it is deposited in the collection of the Czech University of Life Sciences, Prague (CULSP). The material was collected by means of mass trapping methods (sweeping vegetation, yellow and white water pan traps) and stored in ethyl alcohol. Voucher specimens were selected and dried using method described by Barták (1997).

Genitalia preparations and drawings: genitalia, together with the preceding 2 or 3 abdominal segments were removed from the rest of the body using small scissors and macerated in potassium hydroxide solution (approx. 10%) in small vials submerged in hot water for 1–2 hours. After neutralizing with 8% acetic acid (5 minutes), the genitalia were dissected in glycerine and photographed. The photos were produced using a Nikon SMZ 1500 stereomicroscope equipped with a Canon EOS 700D digital camera and were aligned and stacked using Adobe Photoshop. Images served as model for hand drawings, details were added directly observing objects.

The morphological terms used here follow Cumming et al. (1995), Merz and Haenni (2000), Sinclair (2000) and Sinclair and Cumming (2006). All body measurements (including body and setae length) were taken from dry specimens (therefore the actual length may differ from that of fresh or wet-preserved material) by means of an ocular micrometer mounted on Nikon SMZ 1500 binocular microscope. Male body length was measured from antennal base to the tip of genitalia and female body length from base of antennae to the tip of cerci. Thoracic setae are counted on one side of body.

# Taxonomy

Descriptions of new species

#### Atelestus turcicus Barták, sp. nov.

http://zoobank.org/FB1FCE1B-D431-477F-A6F1-F7C2ECCC1B6 Figs 1, 2

**Type material.** *Holotype*  $\Diamond$ , Turkey: Muğla, University campus, MT, 720 m, 37°09'42"N, 28°22'13"E, H. Kavak, 26.v.–26.vi.2015 (CULSP). *Paratypes:* 7  $\Diamond$ , 1  $\heartsuit$ , same data as holotype; 1  $\heartsuit$ , Turkey: 13 km NE of Muğla, pasture/pine wood, 1200 m, 37°14'50"N, 28°30'E, Barták, Kubík, 23.–27.vi.2015; 1  $\Diamond$ , Turkey: Muğla, University campus, YPWT, 720 m, 37°09'42"N, 28°22'13"E, Barták, Kubík, 26.–27.vi.2015; 3  $\Diamond$ , Turkey: Muğla, University campus, SW [= sweeping]+PT, 700 m, 37°09'42"N, 28°22'21"E, Barták, Kubík, 17.–22.v.2011; 2  $\Diamond$ , same locality, O. Dursun, May 2013; 21  $\Diamond$ , 4  $\heartsuit$ , Turkey: Muğla, University campus, MT, 720 m, 37°09'42"N, 28°22'13"E, H. Kavak, May 2015; 3  $\Diamond$ , same locality, H. Pala, June 2016; 2  $\Diamond$ , same locality, H. Pala, July 2016 – (CULSP).

**Diagnosis.** Small brownish black, pale (white to yellow) setose species of *Atelestus*. Male genitalia: anterior part of gonocoxal apodeme short (at most 0.10 mm long), postgonites serrate, and hypandrium in ventral view nearly square-shaped, with long posterior lobes pointed upwards. Female frons shiny.

Etymology. The species is named after country of origin (Turkey).

**Description.** *Male head* black, holoptic, entirely rather light grey microtrichose, white setose (except several dark setulae on labellum). Eye large, ventral third with

smaller facets sharply divided with horizontal line from dorsal part with much larger facets. Occiput in dorsal part with row of short postocular setae (setae about as long as ocellar triangle), in lower part more densely short setose. Frons (very small triangle above antennae) without setae. Face including clypeus and gena microtrichose, without setae, postgena with several longer setae (about as long as ocellars). Ocellar setae short (about 0.15 mm). Palpus brown, slightly clavate, with several short setulae; labrum very short (about 0.08 mm), postmentum microtrichose, with several setae, labellum broad, covered with brownish setulae. Antenna black, pedicel with circlet of very short setulae (0.03 mm); postpedicel broadly pear-shaped; length of antennal segments (scape: pedicel: postpedicel: 1<sup>st</sup> segment of stylus: stylus, in 0.01 mm scale) = 3: 4: 7-10: 1-2: 23-26. Thorax brownish black, sparsely grey microtrichose, without stripes, whitish to yellowish setose. Chaetotaxy: antepronotum with 1-3 rather long setulae, propleura with 1-2 similar setulae, proepisternum and prosternum without setae; postpronotum with 1 long seta and several additional much shorter setae; acrostichals biserial, setae about as long as distance between acrostichals and dorsocentrals (about 7-9 setae in one row); dorsocentrals irregularly biserial as long as acrostichals, inner row ending in 2 long prescutellars, outer row diverging and curved towards postpronotal lobe anteriorly; 1 presutural and 2 postsutural intraalars, 1 presutural supraalar; notopleuron with 3-4 strong and long setae; 1 postalar seta, 2 pairs of long scutellars, outer pair shorter. Laterotergite bare. Legs including coxae brownish black, microtrichose, all knees and bases of tibiae vellow to various extent (in darkest specimens basal third to fourth of fore and mid tibiae and basal fifth of hind tibiae pale and in lighter specimens up to half of fore and mid tibiae yellow and basitarsi partly yellowish brown), most setae and setulae pale, tarsi partly dark setulose. Fore femur short setulose, posteroventral row of setae nearly as long as femur depth, anteroventrals much shorter. Fore tibia narrow and without conspicuous setae, fore basitarsus with several elongate setulae ventrally. Mid femur short setose, with long preapical anteroventral seta and several posteroventrals on apical part. Mid tibia narrow, short setulose, with single rather long dark preapical ventral seta. Hind femur slightly widened, with rows of dorsal and anteroventral setae nearly as long as femur depth (longest dorsals situated on basal half and longest anteroventrals on apical third). Hind tibia "club-shaped", uniformly short setulose, hind basitarsus very slightly dilated. *Wing* clear, covered with microtrichia, Sc incomplete, stigma brown, radial veins brown, remaining veins yellowish, anal vein complete and depigmented, axillary angle slightly acute, C terminating at M<sub>1.2</sub>, basal costal seta pale and relatively short. Halter brownish black, calypter pale with short yellow fringes. Abdomen blackish brown, microtrichose, pale (yellow to white) setose. Lateral marginal setae on tergites nearly as long as segments; discal setae short, forming almost regular row, tergites 7 and 8 desclerotized and without setae. Hind marginal setae on segment 8 short; sternites with 5-8 pairs of pale setae, sternite 1 setose. Tergite 8 L-shaped as in other Atelestus spp., vertical narrow part bare, horizontal lower part broader and armed with 1-3 short setae, sternite 8 divided into two separate sclerites, each with 2-4 short setae. Genitalia as in Figs 1, 2: generally very similar to remaining three Atelestus spp., hypandrium short, roughly rectangular (lateral margins nearly parallel), desclerotized in middle part, with posterior hypandrial



**Figures 1, 2.** *Atelestus turcicus* sp. nov., male genitalia **I** ventral view **2** dorsal view. GAP = gonocoxal apodeme, PGN = postgonites.

lobes directed upwards (similarly as in Fig. 9); epandrium ovoid, in posterior view ending with blunt tip. *Length:* body 2.0–2.8 mm, wing 1.5–2.1 mm.

**Female.** Similar to male except the following: frons broad, entirely shiny including vertex, ocellar triangle and occiput microtrichose. Frons with submedian pair of setae subequally long and strong as verticals and pair of ocellars, ocellar triangle with additional two pairs of smaller setulae. Abdomen very short setose. Legs somewhat paler than in male, often also apex of coxae yellowish; hind tibia less distinctly clavate. Cercus long and slender. *Length:* body 1.8–2.3 mm, wing 2.4–2.9 mm.

**Remarks.** The new species described above may be easily recognized by the entirely pale (white to yellow) setose body. It is rather similar to *A. ibericus* sp. nov. in having a small body and wing size, and a short setulose hind tibia. The shiny female frons is similar to *A. dissonans*, but this character remains unknown in female of *A. ibericus* sp. nov. There are several small differences in genitalia between three similar small species: *A. ibericus* sp. nov. has a long anterior part of the gonocoxal apodeme (about 0.20 mm long; Figs 3, 4) and unserrated postgonites. In both *A. turcicus* sp. nov. and *A. dissonans* the anterior part of the gonocoxal apodeme is short (at most 0.10 mm long) and the postgonites are serrated. The hypandrium in *A. dissonans* forms almost an equilateral triangle in ventral view with posterior lobes pointed upwards; in *A. turcicus* sp. nov. the hypandrium is short triangle-shaped, without posterior lobes. Additionally, in *A. pulicarius* the hypandrium forms an elongated (isosceles) triangle with posterior lobes pointed posteriorly.

#### Atelestus ibericus Barták, sp. nov.

http://zoobank.org/65A38384-DB02-4865-97B6-9B345AE2B8FF Figs 3, 4

**Type material.** *Holotype*  $\Diamond$ , Spain, Embalse de Barbate, SW [= sweeping], pasture nr. river, 37 m, 36°25'51"N, 5°44'38"E, Barták, Kubík, 6.–8.v.2017 (CULSP). *Paratypes:* 3  $\Diamond$ , Embalse de Barbate, SW, meadow + cork oak, 55 m, 36°24'10"N, 5°44'16"E, Barták, Kubík, 5.–9.v.2017; 1  $\Diamond$ , 8 km NE from Alcalá de los Gazules, SW, oak forest, 335 m, 36°30'50"N, 5°39'50"E, Barták, Kubík, 7.–8.v.2017 – (CULSP).

**Diagnosis.** Small brownish black species of *Atelestus* with most setae black but abdomen partly pale setose. Male with long anterior part of gonocoxal apodeme, postgonites not serrate, and hypandrium short triangle-shaped, without posterior lobes. Female remains unknow.

Etymology. The species is named after the region of origin (Iberian Peninsula).

Description. Male head black, holoptic, entirely rather dark grey microtrichose, black setose. Eye large, ventral third with smaller facets sharply divided with horizontal line from dorsal part with larger facets. Occiput in dorsal part with row of medium long inclinate postocular setae (setae about as long as postpedicel), in lower part more densely medium moderately long setose, setae mostly black. Frons (very small triangle just above antennae) without setae. Face including clypeus and gena microtrichose, without setae, postgena with several longer pale setae (about as long as ocellars). Ocellar setae medium moderately long (about 0.20 mm), black, ocellar triangle with one pair of additional small posterior setae. Palpus brown, slightly clavate, with several short setulae; labrum very short (about 0.10 mm), postmentum microtrichose, with several setae, labellum broad, covered with black setulae. Antenna black, pedicel with circlet of short setulae (up to 0.09 mm); postpedicel broadly pear-shaped; length of antennal segments (scape: pedicel: postpedicel: 1<sup>st</sup> segment of stylus: stylus, in 0.01 mm scale) = 3-4: 5-6: 8-9: 1-2: 25-29. Thorax brownish black, sparsely grey microtrichose, without stripes, mostly black setose. Chaetotaxy: antepronotum with 1 rather long pale lateral seta and row of 6–10 short pale setulae, propleura with 1 seta, proepisternum with 0–1 setae, prosternum without setae; postpronotum with 1 long seta and several additional much shorter setae; acrostichals biserial, setae slightly longer than distance between acrostichals and dorsocentrals (about 8-10 setae in one row); dorsocentrals irregularly 2-3-serial, as long as acrostichals, inner row ending in 2 long prescutellars, outer row slightly diverging outwards; 1 presutural and 2 postsutural intra-alars, 1 presutural supra-alar; notopleuron with 3 long setae; 1 postalar seta, 2 pairs of long scutellars, outer pair shorter. Laterotergite bare. Legs including coxae brownish black, microtrichose, all "knees" and bases of tibiae yellow to various extent (in darkest specimens only "knees" yellowish, and in lighter specimens up to third of fore and mid tibiae brownish yellow and hind basitarsus partly yellowish), most setae and setulae black, largest setae (all setae on coxae, posteroventrals on fore femur and both antero- and posteroventrals on hind femur partly or entirely pale – variable). Fore femur short setulose, posteroventral row of setae as long as femur depth or slightly longer, posterodorsals slightly shorter than femur depth, anteroventrals much shorter. Fore tibia narrow, without conspicu-



Figures 3, 4. Atelestus ibericus sp. nov., male genitalia 3 ventral view 4 dorsal view.

ous setae; fore basitarsus with two subbasal and slightly elongate setulae ventrally. Mid femur short setose, with long preapical anteroventral seta and row of posteroventrals. Mid tibia narrow, short setulose, with single rather long dark preapical ventral seta. Hind femur slightly widened, with rows of dorsal and anteroventral setae nearly as long as femur depth (longest dorsals situated on basal half and longest anteroventrals on apical third). Hind tibia clavate (slightly wider than hind femur), uniformly short setulose; hind basitarsus very slightly dilated. *Wing* with slight brownish tinge, covered with microtrichia, Sc incomplete, stigma brown, radial veins yellowish brown, remaining veins brownish yellow, anal vein complete and depigmented, axillary angle slightly obtuse, C terminating at M<sub>1,2</sub>, basal costal seta black and long. Halter brownish black, calypter whitish with short pale fringes. Abdomen blackish brown, microtrichose, most setae pale (yellow to white), those on dorsal part of tergites, posterior three segments and sometimes posterior sternites black (variable). Lateral marginal setae on tergites nearly as long as corresponding segments; discal setae short, forming almost regular row. Hind marginal setae on segment 8 long; sternites with 5-8 pairs of pale long setae, sternite 1 setose. Genitalia as in Figs 3, 4: generally very similar to other Atelestus spp., hypandrium short, triangular, without processes; epandrium ovoid, in posterior view ending with small process. Length: body 2.0-2.7 mm, wing 2.0-2.2 mm.

Female. unknown.

**Remarks.** The new species described above is rather similar to *A. turcicus* sp. nov. in having a partly pale setose body, small body and wing size, and short setulose hind tibia. The main difference is the black setose thorax in *A. ibericus* sp. nov., but pale setose in *A. turcicus* sp. nov. See also remarks under *A. turcicus* sp. nov.

#### Additions to described species

#### Nemedina acutiformis Carles-Tolrá, 2008

**Description. Female** (first description). Only characters different from description of the female of *Nemedina alamirabilis* as described by Chandler (1981) and Sinclair and Papp (2004) or not specified in those papers are mentioned here.

Eye with sparse and very short ommatrichia about as long as diameter of single facet. Frons broad, 0.14–0.15 mm at level of anterior ocellus, occupying 34–37% of head width, very sparsely microtrichose (best visible in dorsal view, frons almost subshiny in anterior view), covered with very short setulae (0.02–0.03 mm long) arranged in 3 irregular rows on each side (5–6 setulae in each row, outer rows continuing along eye margin up to vertex), leaving only narrow central area bare. Occiput and ocellar triangle covered with setulae about as long as those on frons. Gena medium wide (0.03 mm), lustrous. Thorax uniformly covered with short setulae and sparse microtrichiae. No apparent bare area between acrostichals and dorsocentrals. Notopleuron with 2–3 setae stronger, only slightly longer than surrounding setulae, postalar callus with 1 short seta, scutellum with 2–3 pairs of setae. Wing with anal vein almost complete and depigmented apically. Legs including coxae with very short setulae. Femora not compressed, fore tibia equally narrow. Hind tibia wider than hind femur. Abdomen microtrichose, only tergite 8 partly lustrous. Sternite 8 fully developed, hypoproct (sternite 10) present (Figs 5–7). Length of wing 1.3–1.5 mm.

**Remarks.** Carles-Tolrá (2008) indicated two characters (beside genitalia) that distinguish males of *N. acutiformis* from *N. alamirabilis*: postpedicel ovate-conical and



Figures 5–7. *Nemedina acutiformis* Carles-Tolrá, 2008, female abdomen 5 in lateral view 6 dorsal view 7 ventral view.

anal vein reaching wing margin. In fact both these characters are rather variable between our specimens of both species (males and females) and cannot be used as differentiating characters.

## Key to Palaearctic species of Atelestus

1 \_ 2(1)3(2)Female frons microtrichose. Male mid tibia usually with several elongate dorsal setae; apex of epandrial lamella broadly ovate and microtrichose, hypandrium longer than wide in ventral view, with posterior lobes pointed posteriorly (L- to C- shaped in lateral view; Fig. 8); wing usually longer than Female frons shiny. Male mid tibia with all setae subequally long; apex of epandrial lamella narrowly ovate and shiny, hypandrium short (about as long as wide in ventral view), with posterior lobes pointed dorsally (U-shaped in 

## Faunistic records

# Atelestus dissonans Collin, 1961

**Material examined.** 3 ♂, Spain: Fragas Do Eume NP, MT, along brook, 60 m, 43°24'46"N, 8°03'50"E, Garcia and Ševčík, 20.vi.–19.vii.2019; 2 ♂, Bulgaria: Slanchev Brjag envir., PT, deciduous wood, 10 m, 42°45'03"N, 27°53'09"E, Barták, Kubík, 18.–20.vi.2019.

**Remarks.** First records from Spain and Bulgaria. This species was reported from Portugal by Andrade and Chandler (2016).

## Atelestus pulicarius (Fallén, 1816)

Material examined. 4 ♂, 4 ♀, Turkey: 13km NE of Muğla, pine wood + pasture, 1100–1300 m, 37°15'N, 28°30'E, Barták, Kubík, 2.–3.v.2016. Remarks. First record from Turkey.

## Nemedina alamirabilis Chandler, 1981

**Material examined.** 2 ♂, Bulgaria: 2 km NE of Hristo Danovo, SW [= sweeping], forest path, 1160 m, 42°44'09"N, 24°37'15"E, Barták, Kubík, 15.vi.2017 (CULSP).

Remarks. First record from Bulgaria.



**Figures 8, 9.** *Atelestus* species **8** *A. pulicarius* (Fallén, 1816), hypandrium, lateral view **9** *A. dissonans* Collin, 1961, hypandrium, lateral view. PL = posterior lobes.

#### Nemedina acutiformis Carles-Tolrá, 2008

**Material examined.** 11  $\Diamond$ , 3  $\bigcirc$ , Turkey: Toparlar, lowland forest, SW, 36°58'39"N, 28°39'30"E, Barták, Kubík, 5.–7.v.2013; 1  $\Diamond$ , Spain: Embalse de Barbate, SW, meadow + cork oak, 55 m, 36°24'10"N, 5°44'16"E, Barták, Kubík, 5.–9.v.2017 (CULSP).

Remarks. First record from Turkey.

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