

TWO NEW SUBTERRANEAN FRESHWATER GASTROPOD SPECIES (GASTROPODA: TRUNCATELLOIDEA) FROM THE RUDNICA VI CAVE IN CROATIA

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Two new subterranean freshwater gastropod species from the superfamily Truncatelloidea were found during a field trip in the cave Rudnica VI located in central Croatia, near the town of Ogulin. They have been described based on their conchological characteristics and therefore only preliminary assigned to *Plagigygeria* and *Paladilhioopsis* genera. These two species represent a new addition to the already unique freshwater fauna of Rudnica VI.

Keywords: cave, spring, hydrology, isolation, stygobiont, shell, *Paladilhioopsis*, *Plagigygeria*, Truncatelloidea

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Tijekom terenskog istraživanja u špilji Rudnica VI, smještenoj u središnjoj Hrvatskoj blizu grada Ogulina, pronađene su dvije nove vrste slatkovodnih puževa iz natporodice Truncatelloidea. Opisane su na temelju njihovih kućica i stoga tek preliminarno svrstane u rodove *Plagigygeria* i *Paladilhioopsis*. Ove dvije vrste predstavljaju novi dodatak već sada jedinstvenoj slatkovodnoj fauni špilje Rudnica VI.

Ključne riječi: špilja, izvor, hidrologija, izolacija, stigobiont, kućica, *Paladilhioopsis*, *Plagigygeria*, Truncatelloidea

INTRODUCTION

Ogulin and its surrounding area represent an area of high diversity for subterranean freshwater gastropods (BOLE, 1961, 1972, 1992; SLAPNIK, 2018). Located in central Croatia, the area is a part of the Dinaric Alps and with its caves, springs, sinkholes, rivers and karst poljes forms a complex hydrogeological web (BAHUN, 1968). Several species have a very narrow distribution range and are endemic for this area (OZIMEC *et al.*, 2009). These narrow distributional patterns are probably explicable by the insular characteristics of cave habitats (FALNIOWSKI *et al.*, 2008), which stimulate non-adaptive allopatric speciation in truncatelloid gastropods (WILKE *et al.*, 2010).

Rudnica VI is a well known locality for its unique subterranean freshwater fauna. Two freshwater subterranean gastropods: *Lanzaia rudnicae* Bole, 1992 and *Hadziella rudnicae* Bole, 1992 are described from and found only in this cave (OZIMEC *et al.*, 2009). *Eunapius subterraneus mollisparspanis* Sket & Velikonja, 1984 a

freshwater subterranean sponge from the family Spongillidae has a distribution also limited to Rudnica VI (BILANDŽIJA *et al.*, 2007).

In this paper we describe two new species of subterranean freshwater gastropods found in the outflows of the spring cave Rudnica VI.

MATERIALS AND METHODS

The studied material was collected during a field trip in June 2016 from the stream Rudnica. This stream has its main outflow from the spring cave Rudnica VI, located in central Croatia (Fig. 1). The stream is fed not only from the spring cave Rudnica VI but also from a few outflows located 50 m downstream from the main outflow. All the outflows belong to the same hydrologic system (BAHUN, 1968). During the dry season, only the downstream outflows are active and they were used as sampling sites for this study. Sampling was carried out by a metal sieve of cca 0.5 mm mesh size. The material was stored in plastic 150 ml cups and fixed using 96% ethanol. Wet samples were isolated using a Zeiss 2000-C stereomicroscope.

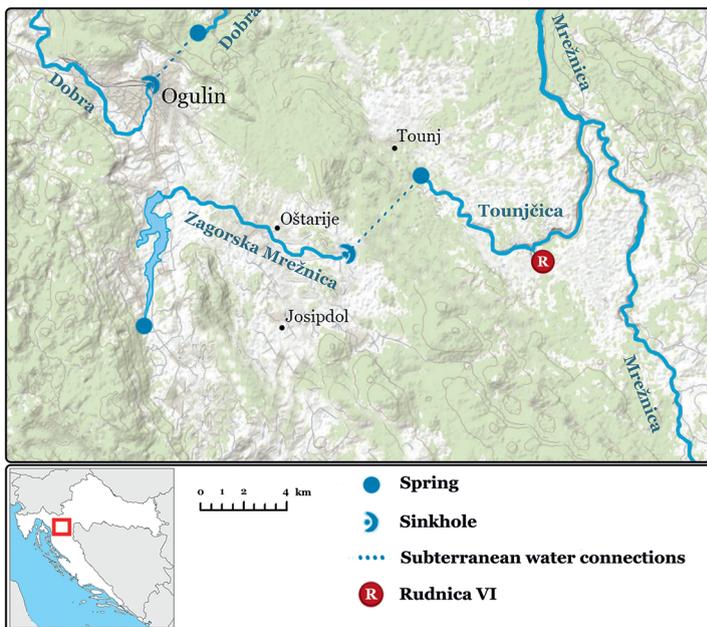


Fig. 1. Location of the Rudnica VI sampling site (R) and known hydrological connections of the area.

Frontal and lateral images of each snail shell specimen were taken using a Canon EOS 80D digital camera mounted on a Zeiss 2000-C loupe. Measurements were made using ImageJ software. In addition to standard measurements of shell height, shell width, whorl width, aperture height and aperture width, an additional measurement of shell angle was made. Shell angle was determined using the method of ANGYAL *et al.*, 2018, measuring the angle between two tangents each touching the second and fourth whorl in the frontal view.

RESULTS

Only empty shells were collected, despite numerous field trips made during 2017 and 2018 and careful examinations of the locality.

As mentioned by GREGO *et al.*, 2017 shells of the genus *Bythiospeum* and *Paladilhiopsis* are indistinguishable and because of that there is an ongoing debate as to whether *Bythiospeum* and *Paladilhiopsis* are synonymous (see BOETERS, 1998) and if all *Bythiospeum* species from the Balkans in fact belong to the genus *Paladilhiopsis* (SZAROWSKA, 2006; FALNIOWSKI & SARBU, 2015; ANGYAL *et al.*, 2018.) However, recent molecular studies (HOFMAN *et al.*, 2018) have concluded that there is no *Bythiospeum* in the Balkans, only *Paladilhiopsis* and because of that we decided to assign *Paladilhiopsis* as the generic position of *Paladilhiopsis insularis* sp. n.

Comparing the shells of *Plagigeyeria jalzici* sp. nov. with shells from many other different genera found in the Balkans from coll. Slapnik we concluded that the shell shape mostly looks like a *Plagigeyeria* shell type and thus this generic position was given to *Plagigeyeria jalzici* sp. nov.

Superfamily Truncatelloidea J. E. Gray, 1840

Family Moitessieriidae Bourguignat, 1863

Genus *Paladilhiopsis* Pavlović, 1913

Paladilhiopsis insularis sp. nov.

Diagnosis. – New species similar to *Paladilhiopsis grobbeni* Kuščer, 1928 from the cave Vranja peč, Sevnica, Slovenia from which it differs by the number of whorls, shell size, a slightly extended mouth and the almost not corrugated outer edge of the mouth, and from *Paladilhiopsis illustris* (Schütt, 1970) from spring near Gjurić, eastern Obrovac, Croatia by its bigger shell, the number of the whorls, a more prominent apex, less convex whorls, with a smooth surface, and the shape of the aperture.

Type locality. – Croatia, Karlovac County, Ogulin, Kamenica Skradnička, Špilja Rudnica VI (Rudnica VI Cave) 45° 12' 49" N, 15° 23' 31" E (WGS 84).

Type material. – Holotype, leg. K. Cindrić, B. Jalžić, 3.VI.2017 (GAST60, Croatian biospeleological society). Paratypes, same data (GAST75 24 specimens and coll. Slapnik 2 specimens).

Measurements. – Holotype, H 4.55 mm; W 2.36 mm; WB 1.97 mm; HA 1.55 mm; WA 1.37 mm; A 32.18°. Paratypes. H 3.32-5.05 mm; W 1.71-2.56 mm; WB 1.48-2.21 mm; HA 1.17-1.84 mm; WA 0.96-1.44 mm; A 26.13°-42.70°.

Etymology. – Derived from the Latin word for island because of the island-like isolated characteristic of the type locality.

Description. – A whitish smooth shell with four and a half convex, slightly flattened whorls with a semi-deep suture. The shell is big (H 3.32-5.05 mm), elongated, slightly conical, and almost subcylindrical. The aperture is almost round with the margins slightly attached to the body whorl and very slightly reflexed. The umbilicus is slit-like. Peristome margin sharp, and not reflexed outwards (Fig. 2).

Habitat. – The stream Rudnica flows through limestones from the Early Cretaceous and has a short course after which it flows into the Tounjčica River. During higher groundwater levels, the main outflow of the stream comes



Fig. 2. *Paladilhiopsis insularis* sp. nov.

from inside the cave Rudnica VI. However, during late spring and summer the outflow appears about 50 m downstream and the stream is formed from numerous discharge points in the stream bed (BAHUN, 1968). This new species was collected from one of these outflow points. Even during the driest seasons of the year a stream can be heard in Rudnica VI flowing a few meters underground (BAHUN, 1968) which suggests that these outflows downstream are a part of the main stream. Having that in mind we can conclude that this species is a true subterranean freshwater gastropod.

Distribution. – Only known from the type locality.

Family Hydrobiidae Stimpson, 1865

Genus *Plagigeyeria* Tomlin, 1930

Plagigeyeria jalzici sp. n.

Diagnosis. – The shells of *Plagigeyeria jalzici* sp. n. are most similar to the shells of *P. edlaueri* Schütt, 1961 from a spring in Metkovići, Dalmatia. The shell is more conical with fewer whorls, which are more extended and rapidly expanding. The suture is deeper. The aperture is smaller and more oval. The umbilicus is more open and deeper.

Type locality. – Croatia, Karlovac County, Ogulin, Kamenica Skradnička, Špilja Rudnica VI (Rudnica VI Cave) 45° 12' 49" N, 15° 23' 31" E.

Type material. – Holotype, Type locality: leg. K. Cindrić, B. Jalžić, 3.6.2017. (GAST55, Croatian biospeleological society). Paratypes, same data (GAST76 53 specimens and coll. Slapnik 3 specimens).

Measurements. – Holotype. H 3.76 mm; W 2.46 mm; WB 1.92 mm; HA 1.54 mm; WA 1.45 mm; A 39.80°. Paratypes. H 2.22-3.64 mm; W 1.41-2.51 mm; WB 1.18-1.90 mm; HA 0.87-1.66 mm; WA 0.73-1.37 mm; A 35.80°-51.68°.

Etymology. – Named after Branko Jalžić a renowned cave biologist, mentor and a dear friend who helped during the field work when this species was found.

Description. – Shell evenly conical with a pointed apex and strong extended whorls (Fig. 3). The regularly developed four and a half whorls are convex with a deep suture. Shell surface smooth. The large aperture is round in the lower edge and angular in the upper edge. The edge of the mouth is sharp. The umbilicus is half open and deep.

Habitat. – see habitat of *Paladilhiopsis insularis* sp. nov.

Distribution. – Only known from the type locality.



Fig. 3. *Plagigeyeria jalzici* sp. nov.

DISCUSSION

Relationships between endemic species and their distributional patterns can give insights into the hydrological histories of research areas (MAURICE, 2012). Based on previous data (OZIMEC *et al.*, 2009) and recent thorough research (unpublished data) it is known that the freshwater gastropod species *Lanzaia rudnicae*, *Hadziela rudnicae*, *Plagigeyeria jalzici* sp. nov. and *Paladilhiopsis insularis* sp. nov. occur only in Rudnica VI. Other taxa like *Eunapius subterraneus mollisparspanis* show the same isolated distributional pattern.

The biogeographic data of freshwater fauna and hydrological studies previously discussed (BAHUN, 1968) suggest that Rudnica VI is hydrologically isolated from the surrounding area with its own drainage basin. Additional research into Rudnica VI and the wider area could give new insights into diversification patterns of freshwater gastropods and other freshwater fauna and the unique role of Rudnica VI in this process.

As recent studies show, conchological characteristics are often not enough for precise generic placements. Additional anatomical and molecular data sometimes lead to revisions of species to different genera or to the description of new, sometimes monotypic, genera (see HAASE, 2008). Because of that, the generic positions of these two new species are tentative. Further investigation of both

new species is needed, with the goal of finding live specimens for a thorough phylogenetic research based on molecular data so that the taxonomic questions could be resolved.

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