

RELIC LAND SNAILS IN THE CAUCASIAN GLACIAL REFUGIUM: A FIRST NON-FOSSIL RECORD OF *VALLONIA TENUILABRIS* FROM WESTERN EURASIA

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Abstract In the upper part of the Sophia River Valley near Arkhyz village (Northern Caucasus, Russia) at an altitude of 2000–3000m an unusual species composition of land snails was observed. The species composition herewith reported is similar to that known from the Pleistocene of the East European Plain and consists of 14 species, including 3 extremely rare and with fragmented distributions: *Vallonia tenuilabris*, *Zoogenetes harpa* and *Pupilla sterrii*. Most of other species are common and widespread and only 2 of the 14 are Caucasian endemics. It suggests that this species composition originates from the Pleistocene malacofauna of the Ciscaucasia and adjacent territories of the East European Plain and the Sophia River Valley is a glacial refugium. The 56 collected specimens of *P. sterrii* are not quite usual -- all their shells have no white callus that is normally present in this species and several specimens are toothless or have 3 teeth (normally 2 teeth are present).

Key words Pleistocene, relics, terrestrial molluscs, Caucasus

INTRODUCTION

As shown in the fossil record certain land snail species were widely distributed in Europe during the Pleistocene and Early Holocene but declined during the Holocene. Thus, these species are traditionally referred to as relicts from these periods in temperate Europe (Ložek, 1964; Alexandrowicz, 1987; Hausdorf & Hennig, 2003; Kunitsa, 2007; Horsák *et al.*, 2010, 2015) and include some species of Valloniidae, Vertiginidae and Pupillidae, but also a few other families of stylommatophoran molluscs. Such species are often used as a tool for paleoecological reconstructions in the Quaternary (Ložek, 1964; Alexandrowicz, 1987; Kunitsa, 2007; Horsák *et al.*, 2015). Several of these relic land snails have were thought extinct, but almost all of them were later found to survive in Siberia, Central Asia and/or in the isolated refugia in Europe. These refugial populations were found mainly in the most northern regions or highest mountains (e.g. Schenková & Horsák 2013). Several of the Pleistocene relicts survived in the refugiums of Caucasus (Schileyko, 1984; Pokryszko *et al.*, 2011; Tarkhnishvili *et al.*, 2012; Walther *et al.*, 2014a).

One of such Pleistocene relic species is *Vallonia tenuilabris* (Braun 1843) (Stylommatophora, Valloniidae), a minute land snail that was described from the loess of Germany and for

some time was considered extinct, known only from the Pleistocene deposits of Europe and as one of the most common mollusc species here. Later living snails were found in Siberia and Central Asia, mainly in the large mountain systems – Altai, Tian Shan, Pamir and Himalayas (Schileyko, 1984; Gerber, 1996; Meng & Hoffmann, 2009; Sysoev & Schileyko, 2009; Horsák *et al.*, 2010). This species is important in paleoecological reconstructions: it is associated with a cold climate and often used as an indicator of cold conditions (Ložek, 1964; Alexandrowicz, 1987; Kunitsa, 2007). Most western non-fossil records of this species before now were from the Central Asia (Gerber, 1996) more than 1500km from the Caucasus and 2000km from our new finding of this species.

MATERIAL AND METHODS

Material was collected in July 1989 by Dr. Alexander Baidashnikov (I.I. Schmalhausen Institute of Zoology, retired) to the south of Arkhyz village (Karachay–Cherkessia, Northern Caucasus, Russia) in the upper Sophia River Valley and on the ridges above it. Main plots with *Vallonia tenuilabris* and other relicts: 1) slopes above the confluence of the Sophia and Ak-Airy rivers in the sparse forests of birch, mountain ash, pine and sycamore maple, alt 2000–2500m (43°27'00"N 41°15'00"E); 2) Irkiz

pass above the Sophia lakes, rocky grassland, alt 3000m (43°26'55"N 41°13'55"E). Several *Pupilla sterrii* specimens were also collected southwest of Arkhyz village near Arkasara (Dukka) pass and the Semitsvetnoe Lake, on the meadows, alt 2200m (43°29'33"N 41°03'45"E). Material was deposited in the Collection of terrestrial molluscs of I.I. Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine (Kiev). Several specimens of *Vallonia tenuilabris* and *Pupilla sterrii* were sent to Dr. Michal Horsák (Masaryk University, Brno, Czech Republic).

Specimens of *Pupilla sterrii* from the Sofia River Valley were compared with snails of this species from the North-Western Caucasus that were collected on the Lagonaki plateau (Republic of Adygea, Russia) and Yatirgvarta mountain (Krasnodar Krai, Russia) (collection of the Zoological Institute of the Russian Academy of Sciences, Saint Petersburg, No 39/510–2008, No 40–45/522–2015).

Specimens of *Vallonia tenuilabris* were compared with shells of *V. tenuilabris* and *V. ladacensis* (Nevill 1878) from Altai that were kindly given to us by Dr. Michal Horsák.

RESULTS

The 34 specimens of *Vallonia tenuilabris* (Fig. 1) were collected from the 2 closest sites. Description: shell depressed, moderately thin, translucent, colourless (whitish), of 3.25–3.5 whorls. Surface densely, strongly ribbed. Suture moderately deep. Spire relatively high, 1/3–1/4 of shell high. Walls of aperture are not closely placed on the wall of penultimate whorl. Margins of aperture slightly reflected, without lip (most specimens

are adult). Umbilicus is large, 1/3 of shell's width. Height 1.4–1.6mm, width 2.8–3.0mm. Most of the shells are with solidified mucus in aperture (Fig. 1), which proves that snails were alive during collecting.

This description corresponds well to the last revision of *Vallonia tenuilabris* by Gerber (1996). One of the most important characteristics of this species is absence of the lip in adult shells. It is also larger than other species of *Vallonia* in the region. From the common *Vallonia costata* (Müller 1774) it differs also by not so closely placed margins of aperture on the wall of the penultimate whorl and by the denser and finer ribs.

Special mention should be made regarding a similar species from Central Asia and India, *Vallonia ladacensis*. It commonly differs from *V. tenuilabris* by very closely placed walls of the last whorl on the penultimate whorl (Gerber, 1996; Sysoev & Schileyko, 2009). But in some populations it is similar to *V. tenuilabris* and conditions in the Sophia Valley may be rather suitable for the habitat preferences in Central Asia of *V. ladacensis* than of *V. tenuilabris* (Horsák *et al.*, 2010). But snails from the Sophia Valley are still very far in morphology from the typical *V. ladacensis* and there are not even fossil records of this species in Western Eurasia, in contrast to numerous fossil records of *V. tenuilabris*. Therefore in our opinion there is no serious reason to suspect that populations of *V. ladacensis* would occur in the Sophia Valley.

Together with *V. tenuilabris* the 14 species of molluscs collected were: *Zoogenetes harpa* (Say 1824) (17 specimens), *Pupilla sterrii* (Forster 1840) (52), *Vertigo nitidula* (Mousson 1876) [syn. *V. sieversi* (Boettger 1879) (Walther *et al.*, 2014b)]



Figure 1 Shell of *Vallonia tenuilabris* from the Sophia River Valley. Scale bar 1mm.

(25), *Truncatellina cylindrica* (Férussac 1807) (4), *Columella edentula* (Draparnaud 1805) (8), *Cochlicopa lubrica* (Müller 1774) (5), *Punctum pygmaeum* (Draparnaud 1801) (14), *Discus rud-eratus* (Hartmann 1821) (11), *Euconulus fulvus* (Müller 1774) (32), *Aegopinella pura* (Alder 1830) (4), *Perpolita petronella* (Pfeiffer 1853) (15), *Vitrina pellucida* (Müller 1774) (6), *Phenacolimax annularis* (Studer 1820) (5) and *Teberdinia flavolimbata* (Boettger 1883) (36). 4 additional specimens of *P. sterrii* were collected on the Arkasara pass together with some of the listed species and *Quadriplicata aggesta* (Boettger 1878). Most of the listed species are widely distributed, only three of them are Caucasian endemics: *V. nitidula*, *Q. aggesta* and *T. flavolimbata* (Sysoev & Schileyko, 2009) and only two of these endemics occur in the main location in the Sophia Valley together with *V. tenuilabris* and *Z. harpa*.

Some of the species, such as *Zoogenetes harpa* (Fig. 2) and *Pupilla sterrii* (Fig. 3), have wide but fragmented ranges. *Z. harpa* occurs in the polar and high mountain regions across whole Northern Hemisphere with isolated locations in Alps, Caucasus and Rocky Mountains (Schileyko, 1984; Sysoev & Schileyko, 2009; Welter-Schultes, 2012). *P. sterrii* is common in Pleistocene deposits in most parts of Europe but its current range is much narrower, related mainly to the mountains of Central and Southern Europe (Welter-Schultes, 2012). In southern parts of the East European Plain this species is common and widely occurs in the Pleistocene deposits (Kunitsa, 2007), but now there is only one confirmed population that still exists: in the rocky steppes of Medobory Reserve



Figure 2 Shell of *Zoogenetes harpa* from the Sophia River Valley. Scale bar 1mm.

on the Podolian Upland in Western Ukraine (Balashov & Gural-Sverlova, 2012). It was previously considered that *P. sterrii* occurs in Central Asia and Siberia, however a recent revision based on the DNA-sequence has shown that if we consider *Pupilla turcmenica* (Boettger 1889) as a separate species then the eastern border of the *P. sterrii* range is located in the Ural Mountains (Nekola *et al.*, 2015). In the Caucasus only nine locations of *P. sterrii* were known before now: two of them are located on the Baksan gorge (Walther & Hausdorf, 2014); six – on the Lagonaki plateau; and one on the Yatirgvarta mountain (specimens from the last seven locations are stored in the Zoological Institute in Saint Petersburg).

The 56 collected specimens of *P. sterrii* are not typical and their description is notable. The shell is cylindrical (almost perfectly in most specimens), moderately translucent, moderately



Figure 3 Shells of *Pupilla sterrii* from the Sophia River Valley. Scale bar 1mm.

thin-walled, brown, of 5.5–6 whorls. Surface densely and strongly striated. Suture very deep. Callus is absent (most specimens) or very weak and not white (Fig. 3, left). Aperture is round, its margins reflected. In aperture 0–3 teeth (palatal, parietal and sometimes columellar), weak or moderate, most specimens have 2 weak teeth (palatal and parietal). Height of shell 2.6–3.1mm, width of shell 1.5–1.6mm. The shells from the Arkasara pass are all edentulous (including 3 adults with reflected margins of aperture). From the main locality most of the shells have 2 teeth, but others have 0, 1 or 3. There is overlap of other character similarities in those shells with different numbers of teeth. Many of the shells, with all variants of the teeth number, have solidified mucus in aperture (Fig. 3), which proves that snails were alive during collecting.

Non-fossil specimens of *P. sterrii* from Ukraine that we have to compare differ by the presence of a well developed white callus and less cylindrical shell. In the most of the *P. sterrii* descriptions it is stated that a white callus is present (Schileyko, 1984; Welter-Schultes, 2012). However, in the last revision of *P. sterrii* it is pointed that callus is sometimes absent (Nekola *et al.*, 2015). It is notable that the callus is absent in the whole population of the Sophia River Valley. Moreover, *P. sterrii* normally has 1–2 teeth (Schileyko, 1984; Welter-Schultes, 2012; Nekola *et al.*, 2015). It is not common that there are several specimens without teeth or with 3 teeth. The specimens from the Sophia River Valley with 3 teeth (or lamellae and folds) look similar to *Pupilla kyrostriata* Walther & Hausdorf 2014, recently described from the Transcaucasia (Walther & Hausdorf, 2014) and toothless specimens look similar to *Pupilla loessica* Ložek 1954. However *P. kyrostriata* is slightly smaller and its teeth are more developed, especially the long parietal lamella. *P. loessica* was described from the Pleistocene deposits of Central Europe (Ložek 1954), known from the Pleistocene of the East European Plain (Kunitsa, 2007), and as *V. tenuilabris* it was considered extinct before living specimens were found in the Central Asia (Meng & Hoffmann, 2009; Nekola *et al.*, 2015). However, *P. loessica* has a deeper suture and different microsculpture. Another similar species is *Pupilla turcmenica* (Boettger, 1889) from Asia but it differs morphologically from *P. sterrii* (Nekola *et al.*, 2015) mainly by small differences in microsculpture. In the last revision of *P. turcmenica*

using DNA sequencing (Nekola *et al.*, 2015) it was separated from *P. sterrii* by a different distribution of these two forms rather than by large differences in morphology or DNA. In our opinion such data seems to be more supportive for conception of “European” and “Asian” subspecies of *P. sterrii* rather than two separate species.

DISCUSSION

The reported species composition of land snails in the Sophia River Valley clearly has a relic nature. Three of species collected, *Vallonia tenuilabris*, *Pupilla sterrii* and *Zoogenetes harpa*, have wide and very fragmented ranges. These species are extremely rare in the Caucasus and absent in the adjacent regions. Currently most of the other reported species are widely distributed and common, but it is surmised that this distribution took place in the Pleistocene at the same time with wide distribution of *V. tenuilabris* and *P. sterrii* that declined later during late Pleistocene and early Holocene (Kunitsa, 2007). Only two of the land snails species reported from the Sophia River Valley are Caucasian endemics from more than 200 terrestrial molluscs endemic to Caucasus (Walther *et al.*, 2014a). Therefore influence of the indigenous Caucasian molluscan fauna on this area was minimal and it was instead inhabited from the north, probably during the middle or late Pleistocene.

Species composition of molluscs consisted by *V. tenuilabris*, *P. sterrii* and some common species, mainly *Columella edentula*, *Cochlicopa lubrica*, *Punctum pygmaeum*, *Discus ruderratus*, *Euconulus fulvus* and *Perpolita petronella* was typical for the East European Plain north and northwest to the Caucasus during most of the Pleistocene (Kunitsa, 2007), but differs greatly to this in the Neogene (Steklov, 1966). Therefore current snail species composition in the Sophia River Valley is very similar to that in the cold landscapes of East European Plain during some the middle and late Pleistocene.

Perhaps *Zoogenetes harpa* (subfamily Acanthinulinae of Valloniidae) is also a representative of the same Pleistocene fauna, or maybe even earlier, but there are no fossil records of this species to clarify its origin.

Confirmed records of *P. sterrii* from the Caucasus, same as *Z. harpa*, are also related to the most north-western part of this mountain system

only. It suggests that this fauna originated from the plains north of Caucasus. Similar situations occur with more common Pleistocene relic land snails known from the Crimean Mountains (Cameron *et al.*, 2013; Balashov, 2013; Balashov & Baidashnikov, 2013) and several insular plots on the uplands of the East European Plain (Balashov *et al.*, 2013; Balashov & Kryvokhyzha, 2015).

These relics survived in the Sophia River Valley due to the cold conditions in the high mountains and some other unknown peculiarities, which is probably why this area is not favourable for the Caucasian endemics.

Consequently, the upper part of the Sophia River Valley can be considered as a glacial refugium of the Pleistocene malacofauna and this territory should be of special conservation attention.

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