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Land snail communities of Cheile Vârghişului Nature Reserve (the Perşani Mountains, Romania)

Voichița Gheoca[1,✉]

SUMMARY. This paper analyses the land snail communities of Cheile Vârghişului Nature Reserve located at the limit between Covasna and Harghita Counties (the Perşani Mountains), one of the most spectacular karst area of the southern part of the eastern Carpathians. In total 43 species of terrestrial gastropods were identified during this study and from the literature. The most abundant species were *Truncatellina cylindrica, Laciniaria plicata, Carychium tridentatum, Ruthenica filograna, Faustina faustina* and *Alopia bogatensis*. The highest diversity was found in the forest habitat with limestone outcrops, while the limestone cliffs located in the forest sheltered large populations of typical limestone species, as well as typical forest species. The restrictive environmental conditions of the exposed limestone cliffs are favourable only for a limited number of species developing large populations.

Keywords: biodiversity, community ecology, Gastropoda, limestone.

Introduction

The Cheile Vârgişului Nature Reserve represents one of the most interesting karst areas of the eastern Carpathians. The 800 ha of the reserve cover about 95% of the Cheile Vârghişului Natura 2000 site (ROSCI0036). Located at the limit between Harghita and the Perşani Mountains, the gorge, cut by the Vârghiş river into Jurassic and Cretacic limestone, is about 3.5 km long, limited by limestone cliffs of up to 200 m high (Grigore, 1989). The gorge with its 125 caves is a habitat/species management area (Category IV IUCN) and shelters valuable flora and fauna elements.

Several relatively recent studies concentrate on the vegetation (Vojtkó *et al.*, 2012) or different fauna groups (Tăbăcaru and Giurgincă, 2013; Jére *et al*., 2007; Nitzu *et al*., 2007).

[1] *Faculty of Sciences, "Lucian Blaga" University of Sibiu, Dr. Ioan Raţiu Street, 5-7, Sibiu, Romania*
✉ ***Corresponding author: Voichița Gheoca*** *Faculty of Sciences, "Lucian Blaga" University of Sibiu, Dr. Ioan Raţiu Street, 5-7, Sibiu, Romania,*
E-mail:vgheoca@yahoo.com

As usually in karst areas, land snails are one of the most important invertebrate taxa (Necola, 1999). During the second half of the 20th century Cheile Vârghişului area was the object of some faunistic studies concerning especially cavernicolous snail species. The most comprehensive work was published by A. Negrea (1994) - a list of the aquatic and terrestrial snail species known from the caves and adjacent areas in karst habitats of Romania, a synthesis of her previous studies and the data of Grossu (1981, 1983, 1987).

The aim of the present work is to analyse the land snail communities of Cheile Vârghişului Nature Reserve (Fig. 1).

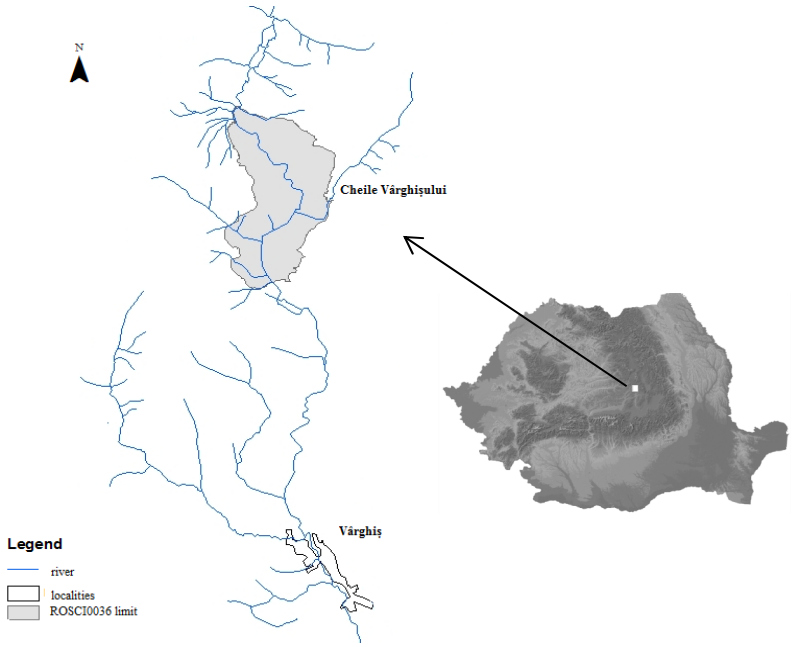

Figure 1. Location of the sampling area

Materials and methods

Three habitat types were sampled in June 2015: two of them located in an old beech forest - a rocky habitat in the forest (ST1, ST4), limestone cliffs in the forest (ST2, ST3) and exposed limestone cliffs (ST5). In the sampling point ST1 and ST4, the limestone outcrops had different sizes, smaller in ST1 and larger in ST4. The size of the limestone outcrops influences the habitat humidity. Habitats with larger outcrops have less vegetation and store more heat. We expected that species with high humidity demands are mostly found in habitats with small outcrops. Also the larger the outcrops, the more complex habitats are, providing a variety of shelters for snails.

At each site, snails from an area of approximately 200m^2 were collected by hand (two person hours by site). Additional about 20 l of leaf litter was sieved in each sampling point (Pokryszko and Cameron, 2005), and the material was sorted and identified in the laboratory. The works of Grossu (1981; 1983; 1987) and Welter-Schultes (2012) were used for species identification. The taxonomic list follows Fauna Europaea (Bank, 2013).

The list of species was registered. The number of living individuals and fresh empty shells were used to estimate snail abundance. The community structure was assessed using the relative abundance of each species. The presence/absence of snail species was used to build the Jaccard similarity diagram of the sampling stations (single linkage method, Euclidean distance). The variation of snail assemblages was analysed using Canoco 4.5 software (Ter Braak and Smilauer, 2002). An indirect gradient analysis detrended by segments (DCA) was first performed to establish the length of the gradients. Because the first gradient was 2.7 we used the linear ordination method (Leps and Smilauer, 2003). The relationships between species were investigated by means of the principal component analysis (PCA). The samples were plotted in the ordination space considering the first two axes. Species variables (the number of collected individuals) were log-transformed by the relation $y' = \log(y+1)$, and they were analysed based on inter-species correlation, divided by standard deviation, the data being centred by species. The analysis was performed on the entire snail community as well as on Hygromiidae and Helicidae species, because the representatives of the two families are gravimetrically dominant in this community. In the diagram illustrating the snail community, only the species with the best fit were represented.

Results and discussion

The systematic list is presented below. Since the only previous work referring specifically to the snail fauna of Cheile Vârghișului is that of A. Negrea (1994), the list contains also the results presented in her paper (Table 1). In total, 43 land snail species were found in the area. This number is similar to that found in the Iron Gates, for a much larger area (Gheoca, 2014). Among the identified species, 21 are listed for the first time. Also, five of the species listed by Negrea were not found during this study. Some of the differences could be due to the nature of the sampling, as a result of the fact that in the previous work were sampled the caves and the adjacent area, with some permanently wet patches. Others could be the result of errors in identification as is the most probable the case of *Cattania trizona*. Most probably its citation by A. Negrea is the result of a confusion with *Faustina faustina*, since the distribution of *C. trizona* in our country is limited to the south-western part (Banat). It is unlikely that *C. trizona* was found in Cheile Vârgișului.

The most abundant species were *Truncatellina cylindrica, Laciniaria plicata, Carychium tridentatum, Ruthenica filograna, Faustina faustina* and *Alopia bogatensis*. The highest number of specimens were found on limestone cliffs located in forest, 1634 specimens of 31 snail species, while on small rocks the diversity was higher (38 species) but with a lower abundance (834 specimens).

Among the snail species found only on small rocks scattered in the forest, were *Vertigo pygmaea, Pupilla muscorum, Ena montana, Oxychilus draparnaudi.* Due to restrictive environmental conditions of the open habitat only 9 species were found here. *Cepaea vindobonensis* was the only species found exclusively in this type of habitat.

Table 1.

The systematic list of land snail species of Cheile Vârghișului. The historical record (Negrea, 1994), the present study, and the land snail species habitat preferences (for the species found in 2015) are presented. The codes for habitats are: 1 - rocky habitat in the forest; 2 - limestone cliffs in the forest; 3 - exposed limestone cliffs.

Family/Species	Negrea 1994	Present study	Habitat type
Aciculidae			
Platyla polita polita (W. Hartmann, 1840)	-	+	1,2
Acicula parcelineata Clessin 1911	-	+	2,
Carychiidae			
Carychium tridentatum (Risso, 1826)	-	+	1,2
Carychium minimum O.F. Müller,	+	-	
Cochlicopidae			
Cochlicopa lubrica (O.F. Müller, 1774)	+	+	1
Cochlicopa lubricella (Rossmässler, 1834)	-	+	1,2,3
Orculidae			
Sphyradium doliolum (Bruguière, 1792)	+	+	1,2
Argnidae			
Agardhiella parreyssii parreyssii (L. Pfeiffer, 1848)	+	-	
Valloniidae			
Vallonia costata (O.F. Müller, 1774)	+	+	1,2,3
Vallonia excentrica Sterki 1893	-	+	2,3
Acanthinula aculeata (O.F. Müller 1774)	+	+	1,2
Pupillidae			
Pupilla muscorum (Linnaeus, 1758)	-	+	1
Pyramidulidae			
Pyramidula pusilla (Vallot, 1801)	-	+	1,2
Chondrinidae			
Granaria frumentum (Draparnaud, 1801)	+	+	1,2,3
Chondrina arcadica clienta (Westerlund, 1883)	+	+	1,2,3
Vertiginidae			
Truncatellina cylindrica (A. Férussac, 1807)	+	+	1,2
Vertigo pusilla Müller, 1774	-	+	1,2,3
Vertigo pygmaea (Draparnaud, 1801)	-	+	

Table 1 continued

Enidae			
Ena montana (Draparnaud, 1801)	-	+	1
Merdigera obscura (O.F. Müller, 1774)	-	+	1,2
Clausiliidae			
Alopia bogatensis bogatensis (E.A. Bielz, 1856)	+	+	1,2,3,
Cochlodina laminata (Montagu, 1803)	+	+	1,2
Cochlodina orthostoma (Menke, 1828)	+	+	1,2,3
Ruthenica filograna (Rossmässler, 1836)	+	+	1,2
Clausilia dubia Draparnaud, 1805	-	+	1,2,3
Laciniaria plicata (Draparnaud, 1801)	+	+	1,2,3
Vestia elata (Rossmassler 1836)	+	-	
Bulgarica cana (Held, 1836)	-	+	1,2,3
Punctidae			
Punctum pygmaeum (Draparnaud, 1801)	-	+	1,2
Patulidae			
Discus perspectivus (Megerle von Mühlfeld, 1816)	+	+	1,2
Pristilomatidae			
Vitrea diaphana (S. Studer, 1820)	+	+	1
Vitrea transsylvanica (Clessin, 1877)	+	+	1,2
Vitrea crystallina (O.F. Müller, 1774)	+	+	2
Euconulidae			
Euconulus fulvus (O.F. Müller, 1774	+	+	1,2
Gastrodontidae			
Zonitoides nitidus (O.F. Müller, 1774)	+	-	
Oxychilidae			
Oxychilus draparnaudi (Beck, 1837)	-	+	2
Cellariopsis deubeli (A.J. Wagner, 1914)	-	+	1
Morlina glabra (Rossmässler, 1835)	+	-	
Aegopinella epipedostoma Fagot, 1879	-	+	1,2
Aegopinella pura (Alder, 1830)	+	+	1
Bradybaenidae			
Fruticicola fruticum (O.F. Müller, 1774)	-	+	1
Hygromiidae			
Euomphalia strigella (Draparnaud, 1801)	-	+	1,3
Petasina bielzi (E.A. Bielz, 1859)	-	+	1,2
Perforatella bidentata (Gmelin, 1791)	+	+	1
Urticicola umbrosus (C. Pfeiffer, 1828)	+	-	
Helicidae			
Cattania trizona (Rossmässler, 1835)	+	-	
Faustina faustina (Rossmässler, 1835)	+	+	1,2
Isognomostoma isognomostomos (Schröter, 1784)	+	+	1,2
Cepaea vindobonensis (Pfeiffer, 1828)	+	+	3
Helix pomatia Linnaeus, 1758	-	+	1,2,3

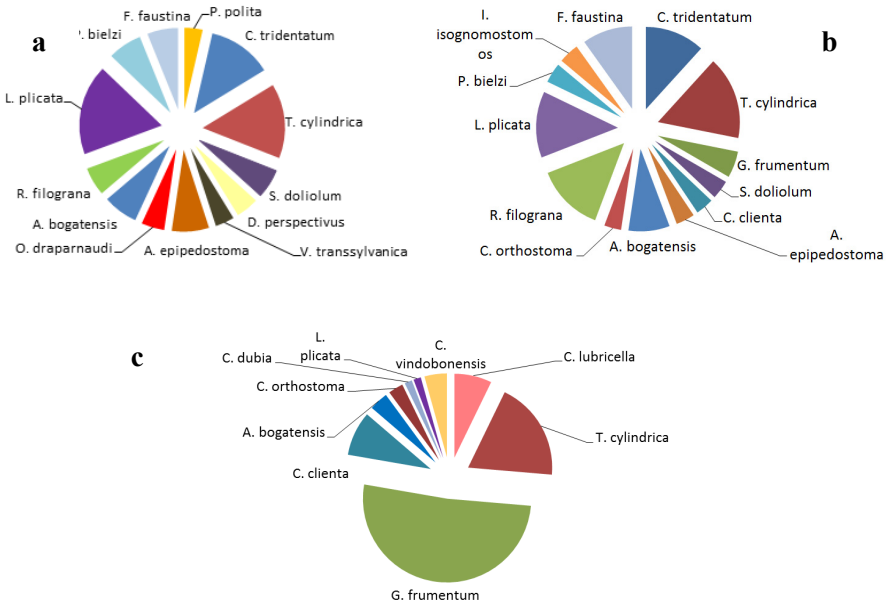

Figure 2. The relative abundance of the most common land snail species in the three habitat types a - rocks in the forest, b - limestone cliffs in the forest, c - exposed limestone cliffs . Only the species with over 2% abundance in each of the three habitat types were selected.

The relative abundance of land snail species considering the three types of habitats is represented in Figure 2. The forest habitat with scattered rocks is dominated by *L. plicata* and minute species like *T. cylindrica* and *C. tridentatum*. The limestone cliffs located in the forest offer shelter for typical forest species as *R. filograna, L. plicata, F. faustina, I. isognomostomos*, minute species as *T. cylindrica* and *C. tridentatum* and characteristic limestone species as *A. bogatensis, G. frumentum* and *C. clienta,* with large populations for most of the species. The exposed rocks are populated by typical limestone species as *G. frumentum,* which represents half of the community in this type of habitat, *T. cylindrica* and *C. clienta.* Most of the species found in the area are common land snail species, more or less confined to limestone. One of the most important exceptions is *Alopia bogatensis,* an endemic species for the Perşani Mountains. *A. bogatensis* develops large populations on limestone cliffs, being among the most abundant species in this type of habitat.

The tree diagram built on Jaccard similarity index (Figure 3), displays a cluster of the sampling points with limestone cliffs (ST2, ST3), which includes ST4, the forest habitat with large limestone outcrops. The exposed habitat is the most distinct (ST5).

Figure 4 exhibits a PCA biplot based on the abundance of land snail species. The two axes extract 72.9% of the species variation. Axis 1 displays the sampling points according to the homogeneity of the habitat.

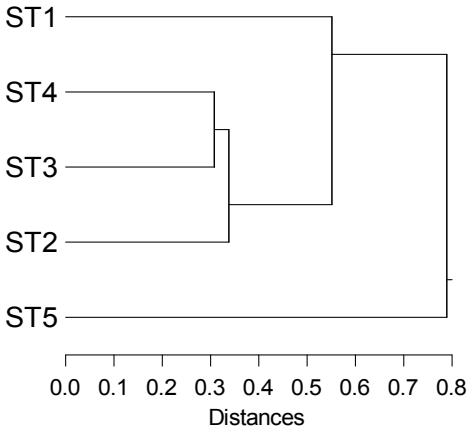

Figure 3. Hierarchical cluster analysis of sampling points based on the Jaccard similarity index between the ST1-ST5 sampling stations (Vârghișului Gorge, the Perșani Mountains, Romania).

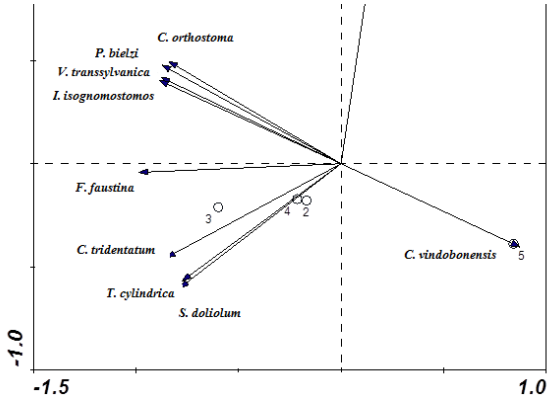

Figure 4. Result of the principal component analysis (PCA) of the land snail species from Vârghișului Gorge, the Perșani Mountains. The five sampling stations, 1-5, and the species with the best fit were represented.

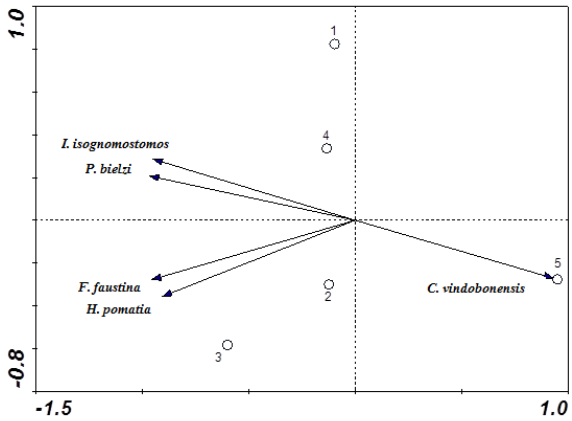

Figure 5. Result of the principal component analysis (PCA) of species Hygromiidae and Helicidae. The numbers represent the five sampling stations.

The presence of limestone blocks in the forest, combine the typical forest habitat with the diversity of microhabitats offered by these structures. Along the first axis, most of the species are associated with complex habitats. *C. vindobonensis* is the single species placed at the other extreme, being found only on exposed limestone walls.

The sampling points are displayed on Axis 2 according to their humidity. The most humid is the sampling point 1, the most typical forest habitat, while sampling point 5 is the most arid. The species' cluster display their water demands, with hygrophilous and typical forest species like *C. orthostoma, P. bielzi, I. isognomostomos,* having positive loadings on this axis, and limestone and xerophylous species (*T. cylindrica, S. doliolum, C. vindobonensis*) with negative loadings.

The PCA conducted on species of Hygromiidae and Helicidae families (Fig. 5), exhibits the discrimination among species regarding the type of the habitat. The first two axes extract 97.5% of the species variation. The first axis is given by humidity, separating the xerophylous *C. vindobonensis* from all the other species. The species' position along Axis 2 is correlated with the size of the limestone structures. *I. isognomostomos* and *P. bielzi* prefer forest habitat with small limestone outcrops, while *F. faustina* inhabit mostly cliffs. The affinity of *F. faustina* for cliffs in limestone habitat was confirmed before (Sólymos et al., 2009; Juřičková and Kučera, 2005). *H. pomatia* was found in this type of habitat together with *F. faustina*, although, the species has wide ecological amplitude.

Conclusions

The Cheile Vârghișului Nature Reserve is one of the most important karst areas of the eastern Carpathians. As usually in limestone habitats, the land snail species are developing large populations, especially the micro snails like T*runcatellina cylindrica*, and other species confined to limestone, like *Granaria frumentum*. However, the land snail communities in forest habitats, regardless the size of limestone outcrops, are dominated by clausiliids. Almost a third of the collected individuals belong to three species, *L. plicata*, *R. filograna* and *Alopia bogatensis,* the only species of the *Alopia* genus inhabiting the Perșani Mountains. The conservation of these endemic species depends on how well these limestone habitats are preserved. The diversity of the limestone habitat combined with the presence of a running water and the vegetation cover increase the species richness. Although a supplementary sampling would expand the number of taxa, we consider that our data capture an accurate image of the land snail community of this protected area.

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