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Diversity of Terrestrial Gastropods (Mollusca, Gastropoda) in the Mariovo Region, Republic of North Macedonia

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Abstract: The Mariovo Region is an area of rich biodiversity in the southern part of the Republic of North Macedonia. In connection with expected hydro-power projects, baseline information on terrestrial was accumulated. Several collecting trips 2010–2022 in the Mariovo Region provided data on the distribution of 46 terrestrial gastropod species-group taxa. The data collected during the expeditions provides the first information on terrestrial gastropods in this region of North Macedonia. The recorded species include the North-Macedonian endemics *Carinigera drenovoensis*, *Euxinella radikae*, *Monacha dofleini* and *Vitrea* cf. *mikuskai* and the Balkan endemics *Candidula rhabdotoides*, *Chondrula macedonica*, *Helix philibinensis* and *Truncatellina rothi*. In addition, *Vertigo angustior*, a species of high conservation importance according to the IUCN Red List, has also been recorded.

Key words: fauna, distribution, Western Balkans, remote area

Introduction

Mariovo is a large area area in the southern parts of the Republic of North Macedonia, which is surrounded by the mountains Selechka Planina in the west, Nidzhe (=Kajmakchalan) in the south, Kozjak in the east and the mountains Dren and Garvan in the north. It is a large hilly plateau divided by the valley of the river Crna Reka into two parts. Average altitude is c. 750 m. The silicate bedrock is represented by gneisses, granites, mica and amphibolite; however, there is also a large marble Precambrian formation in the central part of the region. It is an area that has been almost entirely abandoned for many decades. The total area of the region is 430.50 km^2 (Melovski et al. 2013).

The gastropod fauna of the Mariovo Region is completely unknown (no previous records). In 2017, a prefeasibility study was conducted with the aim to consider the possibilities for constructing new hydropower plants (HPPs) upstream from the HPP Tikveš on the Crna Reka River. The highest ranked option was the combination of the Čebren Pumped Storage Plant (PSP) with the Orlov Kamen HPP and the corresponding dams. Our survey was related to the baseline biodiversity risk screening in connection with the Čebren Power Project.

Materials and Methods

The survey of terrestrial gastropods was based on samples in the context of the project “Design and

Implementation of Biodiversity Surveys in the Framework of the Environmental and Social Impact Assessment (ESIA) for the Čebren Power Project" (2021–2022). A few earlier collections from the area (2010–2017) were also studied. All basic types of habitats typical for terrestrial snails and slugs were examined: carbonate and silicate terrains, open rocks, meadows, forests, ecotones, wetlands near marshes and rivers banks (Table 1, Fig. 1). The gastropods were collected by hand as well as by following the soil-sampling procedure described by Dedov & Antonova (2015). The studied specimens are preserved in the malacological collection of the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia.

Results

We found 46 terrestrial gastropod taxa, all of them recorded for the fist time for the region (Table 2). Four species are North-Macedonian endemics: *Carinigera drenovoensis* (R. A. Brandt, 1961), *Euxinella radikae* H. Nordsieck, 1973, *Monacha dofleini* (Hesse, 1928) and *Vitrea* cf. *mikuskai* Pintér, 1977. Other four species are Balkan endemics: *Candidula rhabdotoides* (A. J. Wagner, 1928), *Chondrula macedonica* A. J. Wagner, 1914, *Helix philibinensis* Rossmassler, 1839 and *Truncatellina rothi* (Reinhardt, 1916).

Among the recorded taxa, there are also species of economic and conversational importance. *Helix lucorum* L., 1758 is an edible snail used by the local people for food. *Vertigo angustior* Jeffreys, 1830 is included in Annex II of EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992).

During the collecting trips, new localities of the North-Macedonian endemic species *Carinigera drenovoensis* (R.A. Brandt, 1961) were found in the Melniška Skrka area: one at the road from Melniška Skrka area to Gola Skrka peak and another at the road to the village Manastir (for more details, see Table 1).

For the locally-rare species *Vertigo pusilla* O. F. Müller, 1774, the second locality in the Republic of North Macedonia was registered (near the village Budimirtsi).

Nine species were found in limestone areas only, including the Macedonian endemic *C. drenovoensis.* Further 16 taxa were found in both limestone and granite (or silicate) localities. In granite and silicate localities only, 21 species were recorded. According to the main habitat preferences, 16 species occur in semi-open and open wet habitats, 16 species in moderately-wet forest and semi-open habitats, 11 species in open dry habitats, two species in semi-open and forests dry habitats and one species only is eurybiont (Table 2).

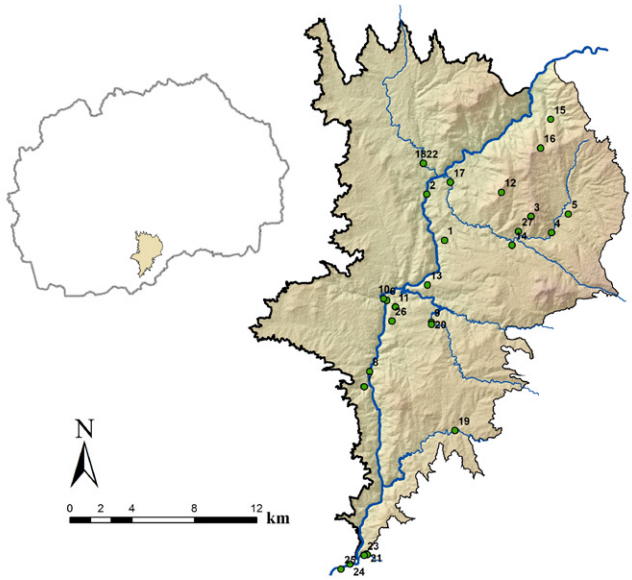

Fig. 1. Map of the Republic of North Macedonia with indication of the Mariovo Region (left). Scheme of the Mariovo Region showing the studied localities of terrestrial gastropods (right).

Discussion

The Mariovo Region is an area of high biodiversity value, especially because of its vulture colonies (Melovski et al. 2013). However, its invertebrate fauna has remained understudied for a long time. Especially for terrestrial gastropods, almost no data have been published before the present survey. The only exception is the record of *Vertigo angustior* Jeffreys, 1830, which has been reported (Dedov et al. 2023) as a pilot result of the present study. The reasons for the limited knowledge on the gastropod fauna of Mariovo are complex. The region has been nearly abandoned for many decades (Melovski et al. 2013) and the roads to many parts in this area impassable during the rainy season (when the gastropods are active). For a long period of the year, the weather is very hot and dry (Lazarevski 1993), a period when the gastropod species are not active. This is the reason why some of the taxa in our survey were found as shells or (and) juveniles only and therefore, identified at the genus level only. Nevertheless, the number of taxa found has demonstrated a rich gastropod diversity, including species with high value in terms of their endemic status on rarity (Table 2).

Table 1. Sampling sites of terrestrial gastropods in Mariovo, Republic of North Macedonia.

№	Locality and habitats	Coordinates	Date	Coll. №
1	Manastir Village, in the village	N41.167 E021.728	2010 10 VII 2012	**10853** **10748**
2	Rasimbegov Most (bridge) on the river Crna Reka	N41.1951 E021.7143 N41.19435 E021.71424 N41.19441 E021.71447	06 VII 2012 29 VII 2021 22 X 2021	**10742** **10915** **10921**
3	Road from Melniška Sk'rka area to Gola Sk'rka Peak on, under limestone rocks, in crevices	N41.180639 E021.796028	06 VII 2012	10743
4	Road from St. Ilija Monastery to Vitolište Village, right bank of the Buturica River	N41.171 E021.812	10 VII 2012	**10744** **10745**
5	Vitolište Village, bank of the Buturica River	N41.18 E021.82 N41.18189 E021.82540	10 VII 2012 07 V 2022	**10746** **observ.**
6	Mariovo, Čebren, temperate meadows	N41.25642 E021.58794 N41.131661 E021.682284	12 VII 2017 29 VII 2021	**observ.**
7	Brnički Potok (Stream)	N41.08060 E021.66407	28 VII 2021	**10910**
8	Rapeški Most (Bridge) on the Crna Reka (river)	N41.08960 E021.66849 N41.09007 E021.66930	28 VII 2021 23 X 2021	**10911,** **10927**
9	Bridge on Gradeška Reka river, in vill. Zovič	N41.11858 E021.71734	29 VII 2021	**10912**
10	Čebrenski Monastery, banks of Crna Reka river, deciduous forest	N41.13280 E021.67995 N41.13124 E021.67930	29 VII 2021 06 V 2022	**10913** **10936**
11	Road to Čebrenski Monastery, wet meadows, reeds	N41.12777 E021.68903	29 VII 2021	**10914**
12	Road to Manastir Village	N41.170170 E021.74208 N41.1951825 E021.77294	29 VII 2021 22 X 2021 22 X 2021	**10917** **10923** **10928**
13	Čebren Village	N41.140754 E021.714280	29 VII 2021	**10918**
14	St. Prorok Ilija Monastery	N41.16370 E021.78102	30 VII 2021	**observ.**
15	Vill. Vrpsko, backyard, under waste and in yard, fountain	N41.23813 E021.81227	30 VII 2021	**observ.**
16	Road to Vrpsko Village (from Jivovo Village)	N41.22454 E021.80612 N41.22120 E021.80404	30 VII 2021	**10919** **10920**
17	Buturica River	N41.20142 E021.73304	22 X 2021	**10922**
18	Dunjska Reka (River), open terrain and bushes near the river, sandy sediments near the river, riparian vegetation	N41.21276 E021.71170 from N41.21926 E021.71149 to N41.21531 E021.71082	22 X 2021 06 V 2022	**10924** **10938**
19	Budimirci Village, Bela Reka (River)	N41.05422 E021.73491	23 X 2021	**10925**
20	Zovič Village, backyard, meadows	N41.11731 E021.717313 N41.11728 E021.71305	23 X 2021 06 V 2022	**10926** **observ.**
21	Skočivir Village, confluence of the rivers Crna Reka and Konjarka, above the Recreational Park "Konjarka", on the border between fir-tree and oak forest	N40.981121 E021.665556	13 II 2022	**10929**
22	Confluence of the rivers Crna and Dunjska, bank vegetation	N41.212706 E021.711850	13 II 2022	**10930**
23	Konjarka River, deciduous forests, *Q. petraea* and *Fraxinus ornus*	N40.98065 E021.66310	05 V 2022	**10933**
24	After Skočivir Village, road to Konjarka River, deciduous trees near the road	N40.97562 E021.65193	05 V 2022	**observ.**
25	Skočivir Village, beginning of Skočivirska Klisura (gorge)	N40. 97258 E021.64497	05 V 2022	**10934**
26	Riad Čebrenski Manastir – Zovič Village, meadows with silicate base	N41.11947 E021.68615	06 V 2022	**10937**
27	Melniška Skurka, limestone rocks, *Juniperus* and a single *Quercus macedonicus*	N41.17194 E021.78614	07 V 2022	**10941**

An important result of our study is the discovery of new localities of the Macedonian endemic species *C. drenovoensis*. This species (Fig. 2) was recently known from a very small area in the southwestern part of the country, i.e. Drenovo Gorge, Raec and Mariovo area. *Carinigera drenovoensis* is known as an inhabitant of limestone rocks (in crevices, under stones or among rock vegetation) (Brandt 1961). However, in Mariovo, the species uses also sparse limestone-based oak forests as shelter and could be found under stones and among leaf litter (Dedov 2017; present study). A new road was recently built in the region of the Drenovo Gorge, which led to a significant decline of the species population. Under the IUCN criteria, the species has been assessed as Critically Endan-

Table 2. Terrestrial gastropods from the area of Mariovo, Republic of North Macedonia (RNM). MKE – RNM endemic species; BLE – Balkan endemic species; RS – resource species; HD, ann. II – Habitats Directive, Annex II. Ground: GR – granite; LM – limestone. Habitat types: OD – open dry habitats, SOD/FD – semi-open and forests dry habitats, MW – moderately wet forest and semi-open habitats, SOW/OW – semi-open and open wet habitats. The main habitat type is underlined. 0 – collected between 2010 and 2017. 1 – collected in July 2021. 2 – collected in October 2021. 3 – collected in February 2022. 4 – collected in May 2022.

No	Species	Importance	Ground	Habitats types (summarized)	Distribution / Specimens	0	1	2	3	4
1	*Acanthinula aculeata* (O. F. Müller, 1774)	--	GR	Deciduous trees and bushes not far from the rivers; river's bank with bushes, reeds and reed-makes; open rocky terrains and wet meadows near the rivers; **MW, SOW/OW**	10912/3; 10914/3; 10921/3; 10922/7; 10924/9; 10925/15; 10929/5; 10933/11; 10934/1; 10936/14; 10938/7		+	+	+	+
2	*Candidula rhabdotoides* (A. J. Wagner, 1928)	BLE	LM	Rocks and rocky meadows; deciduous forest and its ecotone; **OD, MW, SOD/FD**	10743/16; 10917/3; 10918/10; 10919/10; 10923/4	+	+	+		
3	*Carinigera drenovoensis* (R. A. Brandt, 1961)	MKE	LM	Rocks and rocky meadows; deciduous forest and its ecotone; **OD, SOD/FD**	10743/2; 10917/25; 10923/5; 10941/1	+	+	+		+
4	*Carychium minimum* O. F. Müller, 1774	--	LM; GR	River's bank with bushes, reeds and reed-makes; open terrains and wet meadows near the rivers; deciduous forest; **SOW/OW, MW**	10914/21; 10917/1; 10922/17; 10924/4; 10938/10		+	+		+
5	*Cecilioides* sp.	--	LM; GR	River's bank with bushes and reed-makes; **SOW/OW**	10853/2; 10922/1	+		+		
6	*Cernuella virgata* (Da Costa, 1778)	--	LM	Temperate meadows; **OD**	10746/1	+				
7	*Chondrula macedonica* A. J. Wagner, 1914	BLE	LM	Rocks and rocky meadows; deciduous forest and its ecotone; **OD, SOD/FD**	10743/many; 10744/3; 10745/11; 10917/4; 10918/2; 10919/25; 10923/7; 10937/1	+	+	+		+
8	*Chondrula microtragus* (Rossmässler, 1839)	BLE	GR	Rocks; **OD**	10915/1		+			
9	*Cochlicopa lubrica* O. F. Müller, 1774	--	GR	Wet meadows and reeds near the rivers; **SOW/OW**	10914/4; 10934/1		+			+
10	*Cochlicopa lubricella* (Rossmässler, 1835)	--	GR	Rocks, soil in the crevices; bushes and reed-makes on the river's bank; **MW, SOW/OW**	10921/1; 10924/16; 10938/12			+		+
11	*Cochlodina laminata* (Montagu, 1803)	--	LM; LM mix with silicates	Deciduous forests and its ecotone; **MW**	10744/1; 10920/2	+	+			
12	*Daudebardia brevipes* (Draparnaud, 1805)	--	GR	Bushes and reed-makes on the river's bank; **SOW/OW**	10912/1; 10922/2			+		
13	*Daudebardia rufa* (Draparnaud, 1805)	--	GR	Deciduous trees and bushes not far from the river; **MW**	10919/1		+			
14	*Deroceras* cf. *turcicum* (Simroth, 1894)	BLE	GR	Deciduous forests and its ecotone; **MW**	10927/1; WP663/observed; WP672/1 observed			+		+
15	*Euconulus* sp.	--	GR	Deciduous trees and bushes not far from the river; open rocky terrains near the rivers; **MW**	10925/1			+		

Table 2. Continuation.

No	Species	Importance	Ground	Habitats types (summarized)	Distribution / Specimens	0	1	2	3	4
16	*Euomphalia strigella* (Draparnaud, 1801)	--	LM; LM mix with silicates	Deciduous forests and its ecotone; **MW**	10920/1		+			
17	*Euxinella radikae* cf. *radikae* H. Nordsieck, 1973	MKE	GR (?)	Rocks, soil in the crevices; **OD**	10915/11; 10921/28; 10929/3		+	+	+	
18	*Granopupa granum* (Draparnaud, 1801)	--	LM	Deciduous forests and its ecotone; **MW**	10917/5		+			
19	*Helix lucorum* Linnaeus, 1758	RS	LM; GR	Temperate meadows and open terrains; river's bank, reed-make; bushes; deciduous forests' ecotone; single deciduous trees and deciduous forests; single deciduous trees and deciduous forests; **Eurybiont; MW, OD, SOD/FD, SOW/OW**	10742/observe; 10748/2; WP173/ observed; 10911/1; 10913/1; 10921/1; 10924/1; 10925/3; 10929/1; 10933/1; WP667/4 observed; WP673/1 observed	+	+	+	+	+
20	*Helix philibinensis* Rossmassler, 1839	BLE	LM; GR	Temperate meadows and open terrains; rocks; bushes; **OD**	10743/5; 10745/4; 10748/6; 10913/1; 10917/1; 10921/2; 10925/2;10933/1; 10941/1	+	+	+		+
21	*Laciniaria plicata* (Draparnaud, 1801)	--	LM; GR	Deciduous forests and its ecotone; single deciduous trees and bushes; rocks; **MW**	10744/6; 10745/11; 10912/22; 10915/1	+	+			+
22	*Limax* cf. *maximus* Linnaeus, 1758	--	GR	Backyards; **MW**	Photo/1; 10936/1 observed; 10938/2		+			+
23	*Merdigera obscura* (O. F. Müller, 1774)	--	LM; GR	Single deciduous trees and bushes; rocks; **SOD/FD**	10748/1; 10912/3	+	+			
24	*Mediterranea inopinata* (Uličný, 1887)	--	LM; GR	Deciduous forests and its ecotone; bushes; **MW**	10748/1 10927/4	+		+		
25	*Monacha* cf. *claustralis* (Rossmässler, 1834)	--	LM; GR	Temperate meadows; wet meadows; rocky meadows; river banks with reeds, backyards; bushes; deciduous forest ecotone; deciduous forest; **OD, SOD/FD, MW, SOW/OW**	10911/1; 10916/1; 10917/5; 10928/1	+	+	+		
26	*Monacha dofleini* (Hesse, 1928)	MKE	GR	Meadows; backyards; deciduous forest ecotone; **MW**	10911/1; 10919/1; 10926/1		+	+		
27	*Oligolimax annularis* (S. Studer, 1820)	--	LM	Deciduous forests and rocks; **MW**	10743/11; 10745/1	+				
28	Orculidae, cf. *Sphyradium doliolum* (Bruguière, 1792)	--	GR	Open terrain and bushes near the rivers; **SOW/OW**	10924/1			+		
29	*Punctum pygmaeum* (Draparnaud, 1801)	--	LM; GR	Deciduous forests; deciduous trees and bushes not far from the rivers; river's bank with bushes and reed-makes; open rocky terrains and wet meadows near the rivers; **MW, SOW/OW, SOD/FD, OD**	10912/3; 10917/134; 10921/4; 10922/10; 10924/9; 10925/15; 10929/1; 10933/1; 10936/6; 10938/8		+	+	+	+
30	*Pupilla triplicata* (Studer, 1820)	--	LM	Rocks; **OD**	10743/15	+				
31	Succineidae sp.	--	GR	Bushes and reed-makes at the river's bank; **SOW/OW**	10930/1				+	

Table 2. Continuation.

No	Species	Importance	Ground	Habitats types (summarized)	Distribution / Specimens	0	1	2	3	4
32	*Truncatellina claustralis* (Gredler, 1856)	--	LM; GR	Deciduous forests; deciduous trees and bushes not far from the rivers; river's bank with bushes and reed-makes; open rocky terrains and wet meadows near the rivers; **MW, SOW/OW, SOD/FD, OD**	10912/many; 10917/many; 10922/4; 10924/9; 10925/50; 10929/10; 10933/6; 10936/mix		+	+	+	+
33	*Truncatellina cylindrica* (A. Ferussac, 1807)	--	LM; GR	Deciduous trees and bushes not far from the rivers; river's bank with bushes and reed-makes; rocks, in crevices; open terrains and rocky meadows near the rivers; **MW, SOW/OW, SOD/FD, OD**	10743/up to 50 spm.; 10853/up to 50 spm.; 10912/up to 50 spm.; 10917/ up to 50 spm.; 10921/47; 10922/4; 10924/up to 50; 10925/2; 10934/1; 10936/up to 50 spm.; 10938/up to 50 spm.	+	+	+		+
34	*Truncatellina rothi* (Reinhardt, 1916)	BLE	LM; GR	Bushes and reed-makes at the river's bank; **SOW/OW**	10917/up to 50 spm.; 10922/3; 10938/ up to 50 spm.		+	+		
35	*Vallonia costata* (O. F. Müller, 1774)	--	LM; GR	Single trees, bushes and reed-makes at the river's bank, open terrain and rocky meadows near the rivers; **SOD/FD, SOW/OW, MW**	10748/1; 10921/24; 10922/6; 10924/38; 10925/2; 10930/1; 10936/17; 10938/24	+		+	+	+
36	*Vallonia enniensis* Gredler, 1856	--	GR	Bushes and reed-makes at the river's bank, open terrain near the rivers; **SOW/OW**	10922/7; 10924/5; 10938/6			+		
37	*Vallonia pulchella* (O. F. Müller, 1774)	--	GR	Bushes and reed-makes at the river's bank; **SOW/OW**	10922/1			+		
38	*Vertigo angustio*r Jeffreys, 1830	HD, ann. II	GR	Open terrain and bushes near the river; **SOW/OW**	10924/4; 10938/2			+		+
39	*Vertigo* cf. *antivertigo* (Draparnaud, 1801)	--	GR	Single trees, bushes and reed-makes at the river's bank; rocky meadows with granite rocks; open terrain near the river; **SOW/OW**	10922/2; 10924/2; 10925/1; 10938/2			+		+
40	*Vertigo pusilla* O. F. Müller, 1774		GR	Rocky meadows, bushes and single trees near the river; **SOW/OW**	10925/5			+		
41	*Vertigo pygmaea* (Draparnaud, 1801)	--	GR	Bushes and reed-make at the river's bank; open terrain near the river, **SOW/OW**	10922/3; 10924/3; 10930/1; 10938/5			+	+	+
42	*Vitrea* cf. *mikuskai* Pintér, 1977	MKE	GR	Wet meadows, reeds **SOW/OW**	10914/6		+			
43	*Vitrina pellucida* (O. F. Müller, 1774)	--	LM; GR	Deciduous trees; bushes; river's bank with bushes and reed-makes; open terrains; **SOW/OW, MW**	10744/1; 10922/1; 10924/2; 10929/7	+		+	+	
44	*Xerolenta obvia* (Menke, 1828)	--	LM	Rocks; **OD**	10743/9	+				
45	*Zebrina detrita* (O.F. Müller, 1774)	--	LM	Temperate rocky meadows; rocks; deciduous forests and its ecotone; **OD, SOD/FD**	10743/9; 10917/1; 10918/4; 10923/1; 10941/many	+	+	+		+
46	*Zonitoides nitidus* O. F. Müller, 1774	--	GR	Single trees, bushes and reed-makes at the river's bank; rocky meadows; **SOW/OW**	10922/2; 10925/1			+		
	Total number of taxa – 46		**Species according to the habitat types:** SOW/OW – 16; MW – 16; OD – 11; SOD/FD – 2; Euribiont – 1 **Species according to the ground types:** GR – 21, LM – 9, LM and GR or LM mix with silicates – 16			**19**	**25**	**31**	**9**	**19**

Fig. 2. *Carinigera drenovoensis* (Brandt, 1961) and its locality near the road to the Manastir Village.

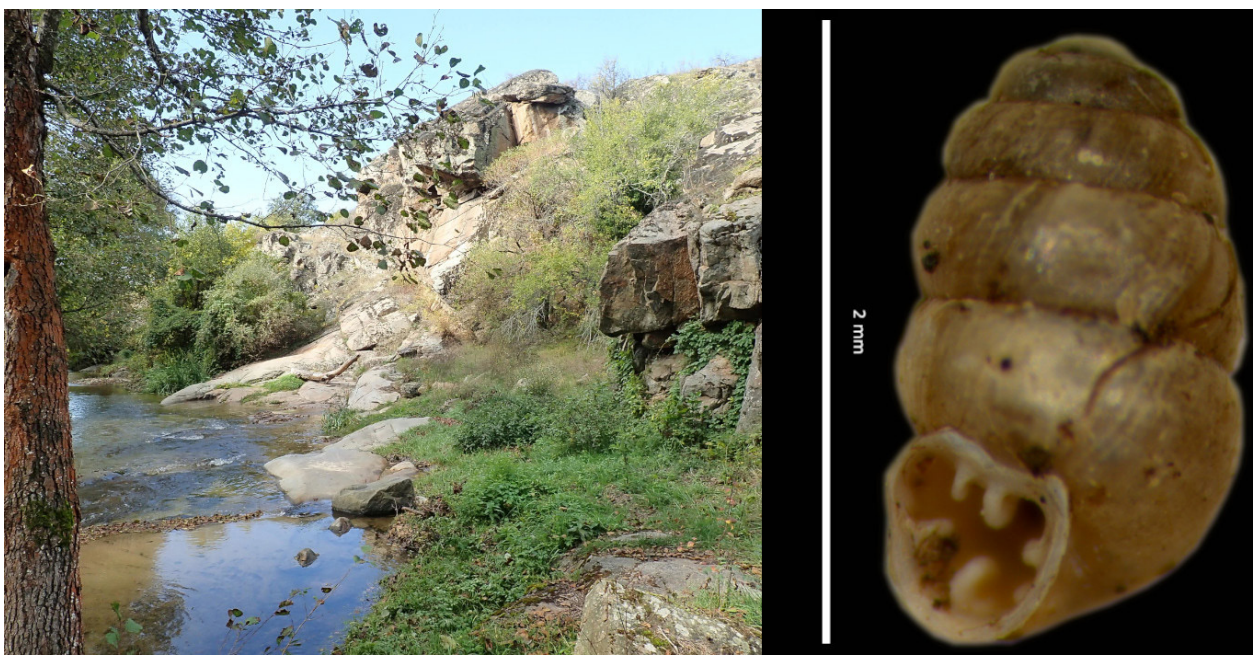

Fig. 3. *Vertigo pusilla* O. F. Müller, 1774 and its locality near the river Bela, Budimirci Village.

gered (CR) at the global and European levels (Dedov 2017).

During the research carried out in the Mariovo Region, another important species, *Vertigo angustior* Jeffreys, 1830, was found in the valley of the river Dunjska Reka. This is the only recent locality of the species from the Republic of North Macedonia (Dedov et al. 2023). The species is included in Annex II of the EU Habitats Directive (Council Directive 92/43/EEC, 21 May 1992). The conservation status of this species, according to IUCN Red List, is Vulnerable (Moorkens et al. 2012).

The fist record of *Vertigo pusilla* in the Republic of North Macedonia was from Jakupica Mountains near the Patishka River by (Stankovic et al. 2006). The second record is provided by the present study by finding the species near the village Budimirci. The specimens found in Mariovo have the typical size (about 2 mm) and teeth number (6 teeth – 2 parietal, 2 columellar and 2 palatal) (Welter-Schultes 2012); however, its aperture is less heart-shaped, more rounded and the indentation of the aperture edge is almost invisible (Fig. 3). We are not sure if this is a stable character for the Mariovo population because only two adult shells have been collected. Stankovic et al. (2006) published only the name and locality of *V. pusilla*, without any morphological data. We assume that the isolation of this remote area might be a reason for the formation of specific population characters that may deserved to be recognised at the subspecies level when more specimens are available.

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