

BAT FAUNA FROM THE LIMESTONE MINES OF THE CRICOVA-GOIAN AREA OF THE ICHEL RIVER BASIN, REPUBLIC OF MOLDOVA

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Abstract. The studies were performed in 2013-2022 in limestone mines of the Cricova-Goian area. The bat fauna was represented by 10 species, 9 of which were registered in the Cricova I mines, 4 species in the Cricova II mines, 10 species in the Goianul Nou mines and 2 species in the Goian mines. The Cricova II and Goian mines are new bat sites, found in 2021-2022. In the Cricova I mines, 489 individuals from 9 species were registered during the hibernation period and *Myotis daubentonii* represented more than half of the bat community. The analysis of multiannual dynamics shows a stable trend of chiropteran species populations. The *M. species bechsteinii* and *Rhinolophus hipposideros* with about 10% each. In the Cricova II mines, 4 bat species were registered; the dominant one was *M. daubentonii* with about 85% and other species had an abundance of less than 8%. In the Goianul Nou mines, 10 species from 4 genera were recorded, but the community structure was different at the end of hibernation period, when 3 species were dominant (over 80%), and in September, when 2 species dominated (about 77%). The Goian mines have a very low depth and only two species with single individuals were registered. The diversity was the highest in Goianul Nou mines, followed by Cricova I mines, being much lower in the Cricova II and Goian mines. All the registered bat species are protected at the national and international level and the Cricova-Goian area is of great importance in animal diversity conservation in the central part of the Republic of Moldova.

Keywords: limestone mines, bats, community, abundance, diversity, protected species.

Rezumat. Fauna de lilieci din minele de piatră din aria Cricova-Goian a bazinului râului Ichel, Republica Moldova.

Studiile au fost efectuate în anii 2013-2022 în minele de calcar din zona Cricova-Goian. Fauna de lilieci a fost reprezentată de 10 specii, dintre care 9 specii au fost înregistrate în minele Cricova I, 4 specii în minele Cricova II, 10 specii în minele Goianul Nou și 2 specii în minele Goian. Minele Cricova II și Goian sunt situri noi ale liliecilor, găsite în 2021-2022. În minele Cricova I au fost înregistrați 489 de indivizi din 9 specii în perioada de hibernare, iar *Myotis daubentonii* a constituit mai mult de jumătate din comunitatea de lilieci. Specia *M. dasycneme* a înregistrat 13,5%, urmată de *M. bechsteinii* și *Rhinolophus hipposideros* cu aproximativ 10% fiecare. Analiza dinamicii multianuale arată o tendință stabilă a populațiilor speciilor de chiroptere. În minele Cricova II au fost înregistrate 4 specii de lilieci, dominantă a fost *M. daubentonii* cu aproximativ 85%, iar alte specii au avut abundența sub 8%. În minele Goianul Nou au fost înregistrate 10 specii din 4 genuri, dar structura comunității a fost diferită la sfârșitul perioadei de hibernare, când dominau 3 specii (peste 80%), și în septembrie, când dominau 2 specii (circa 77%). Minele Goian au o adâncime foarte mică și au fost înregistrate doar două specii cu câte un individ. Diversitatea a fost cea mai mare în minele de la Goianul Nou, urmate de minele Cricova I, fiind mult mai scăzută în minele Cricova II și Goian. Toate speciile de lilieci semnalate pe parcursul cercetărilor sunt protejate la nivel național și internațional, iar zona Cricova-Goian are o mare importanță în conservarea diversității animalelor din zona centrală a Republicii Moldova.

Cuvinte cheie: minele de calcar, lilieci, comunitate, abundență, diversitate, specii protejate.

INTRODUCTION

In the Republic of Moldova, the main underground shelters for bat hibernation and resting are the abandoned lime stone mines. Various bat species find favorable conditions in such habitats due to low anthropogenic disturbances, large surfaces and the presence of a high number of suitable shelters.

The Ichel River is a right tributary of the Dniester River of the Republic of Moldova. Between the Cricova and Goian localities, the riverbed of the Ichel river is characterized by ravines and deep valleys, often even in the shape of canyons (Fig. 1). Its high slopes are formed mostly of Sarmatian limestone rock. The activities of limestone extraction started in the middle of the past century and there are many abandoned mines that serve as appropriate underground roost for bats. The area includes the Goian Outcrop that is a paleontological monument of high scientific importance (DAVID et al., 2016). The building of dams and the use of river waters for irrigation and aquaculture purposes disturbed the natural course of the Ichel river and has affected the natural components of the area. Nevertheless, the mammal fauna of the Cricova-Goian area from the lower Ichel basin is rather rich and 33 species were registered until 2016 (CÎRLIG & CÎRLIG, 2015), of which 10 bat species (NISTREANU et al., 2016), while in subsequent studies 47 mammal species, including 12 bat species have been recorded (LARION et al., 2021).

The studies on bat fauna in stone mines near Cricova started in the 1950s and data on bat species can be found in several papers (SAENKO, 1959; DOROSHENCO, 1975). After the 1970s, the studies on bat fauna in the Cricova mines practically ceased and continued in the 1990s as part of a project on bat diversity conservation, when some entrances to the abandoned mines were closed with iron bars, but no data were published. Starting from 2013, intensive monitoring of bat wintering in the abandoned Cricova mines was resumed and several papers were published (DIBOLSCAIA, 2016; NISTREANU 2014, 2016, 2018; LARION et al., 2021).

The aim of the study was to reveal the diversity of bat fauna in limestone mines of the Cricova - Goian area, the species distribution and trends, as well as to emphasize the importance of the area in bat diversity conservation in the central part of the Republic of Moldova.



Figure 1. Ichel River near Cricova I limestone mines (original).

MATERIALS AND METHODS

The studies were performed during 2013-2021 in various abandoned limestone mines from the Cricova – Goian area of the Ichel river basin. Besides the oldest Cricova mines, some new ones were studied: those situated near the Cricova wine cellars, the Goianul Nou mines and the Goian mines.

The Cricova mines (Cricova I), situated in the north-western part of the town, have the coordinates 47.153 N 28.855 E, altitude 99 m. The mines were excavated manually and have two levels. The lower level has 5 entrances, of which 2 are blocked by fallen stones and 3 are accessible for entering inside the mines. The upper level has one entrance of about 1 m wide and 1 m height. The ceiling height is between 0.5-2.5 m, in some places it is knocked down. The depth of the mines is about 300 m and the underground passages are chaotic. Downstream of the Ichel river, at about 100 m, there is another wide entrance (3x2.5 m), the mine is machine-made, has a depth of about 400 m, the ceiling between 1.8-3 m height and consists of longitudinal cracks of 7-10 cm width.

The mines located near the wine cellars (Cricova II) have the coordinates 47.150 N 28.863 E, altitude 90 m, are machine made, have 5 entrances, of which 2 are blocked, the ceiling is between 2 m and 2.5 m height and consists of longitudinal cracks of 7-15 cm width.

The Goianul Nou mines have the coordinates 47.121 N 28.921 E, altitude 67 m; they have 4 entrances that are 2.5-4 m wide and up to 3 m high. The depth is over 300 m, the corridors are 2-5 m wide, mechanically cut and connected to each other by side passages. The Goian mines with the coordinates 47.139 N 28.911 E, altitude 76 m, have only 2 entrances that are very short. One entrance is rather large, with the depth of about 50 m and a ceiling height of 2 m, with many cracks of 5-12 cm width. The second entrance is very narrow, almost entirely hidden by vegetation. The depth is of 30 m, the height of ceiling – up to 1 m. The bats were studied directly by visual observation, all individuals were identified, and some of them were extracted from the ceiling holes in order to determine their sex, age, weight and morphological peculiarities.

RESULTS

In the limestone mines from the Cricova-Goian area the bat fauna is represented by 10 species, of which 9 species were registered in the Cricova I limestone mines, 4 species in the Cricova II mines, 10 species in the Goianul Nou mines and 2 species in the Goian mines (Table 1).

Table 1. Bat species registered in the limestone mines of Cricova-Goian area in the hibernation period.

No	Species	Cricova I	Cricova II	Goianul Nou	Goian
1.	<i>Rhinolophus hipposideros</i> – Lesser horseshoe bat	+	-	+	-
2.	<i>Myotis myotis</i> – Greater mouse-eared bat	-	-	+	-
3.	<i>Myotis blythii</i> – Lesser mouse-eared bat	+	-	+	-
4.	<i>Myotis daubentonii</i> – Daubenton's bat	+	+	+	-
5.	<i>Myotis dasycneme</i> – Pond bat	+	-	+	-
6.	<i>Myotis mystacinus</i> – Whiskered bat	+	+	+	+
7.	<i>Myotis bechsteinii</i> – Bechstein's bat	+	-	+	-
8.	<i>Plecotus austriacus</i> – Grey long-eared bat	+	+	+	+
9.	<i>Plecotus auritus</i> – Brown long-eared bat	+	+	+	-
10.	<i>Eptesicus serotinus</i> – Serotine bat	+	-	+	-
Total species		9	4	10	2

The monitoring of bat hibernation communities in Cricova I mines started in 2013 and allow to establish the bat community structure and its changes during the last 10 years. The temperature at 30 m from the entrance was +9.3°C, at 100 m was of +13°C. A total number of 489 individuals from 9 species were registered in the study period.

The most abundant during the whole period was *M. daubentonii*, which constituted more than half of the bat community. The second most abundant species was *M. dasycneme* with 13.5%, followed by *M. bechsteinii* and *Rh. hipposideros* with about 10% each. Other species had less than 4% (Fig. 2). Since the Daubenton’s bat and the pond bat prefer aquatic biotopes, their high proportion in Cricova mines is explained by the proximity of the Ichel river.

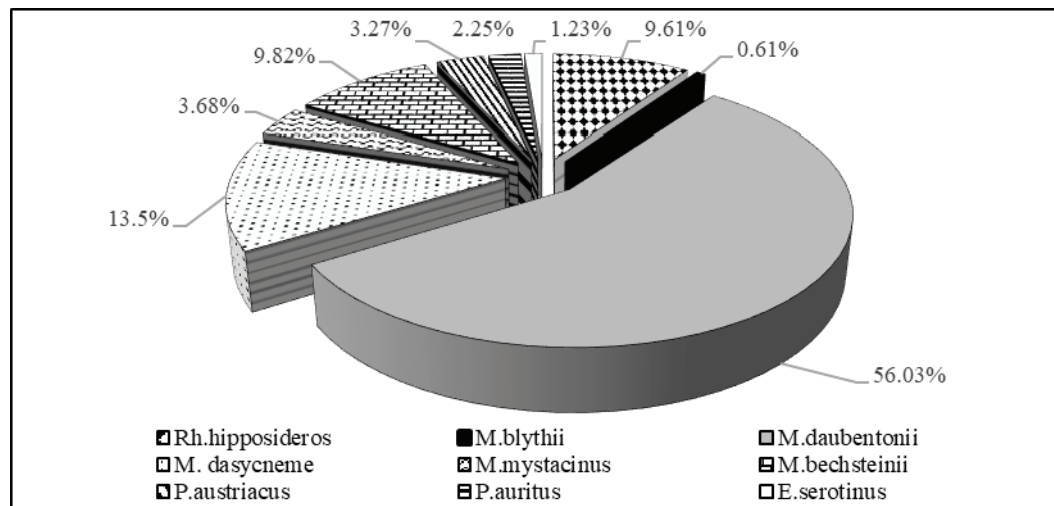


Figure 2. Structure of bat community hibernating in abandoned stone mines Cricova I.

In the studied years, the relative abundance of *M. daubentonii* varied between 42% - 71% of the bat community. The *M. dasycneme* species was rather abundant (10-30%) in 2013, December 2015, 2016, 2017, in 2018 and 2022, while in 2014, 2019 and 2021 it registered less than 10%. The lesser horseshoe bat was not found in the winter of 2013-2014, while in March 2014 and February 2018 it was recorded in rather large number (22-30%) and in other years its abundance did not exceed 10%. The whiskered bat (*M. mystacinus*) had a high abundance in January 2014 only, in 2019 and 2021 it was not recorded, while in most years its share ranged from 1.4% to 8.7%. The Bechstein’s bat had a high abundance in 2014, 2015, 2018, 2019 and 2022 (9-20%), while in other periods it was registered in small amount. The number of the grey long-eared bat was the highest in February 2013, wasn’t registered in March 2014, December 2015, 2016, 2018, 2019 and in other years the species had a low abundance The brown long-eared bat abundance did not exceed 7%, and was not found in 2013 and 2017. *M. blythii* and *E. serotinus* were represented by single individuals in some study periods (Table 2).

Table 2. Dynamics of the bat community structure (%) in Cricova I mines in the hibernation period of 2013-2022.

No	Species	2013	2014		2015		2016	2017	2018	2019	2021	2022
		Febr.	Jan.	March	Febr.	Dec.	March	March	Febr.	March	March	Febr.
1.	<i>Rhinolophus hipposideros</i>	-	-	30,43	8,97	6,52	5,77	10	22.54	9.09	3.33	6.67
2.	<i>Myotis blythii</i>	-	-	-	-	-	-	2	1.41	3.03	-	-
3.	<i>Myotis daubentonii</i>	51.22	43,75	39,12	62,68	69,57	71.15	50	45.07	63.64	60	51.1
4.	<i>Myotis dasycneme</i>	29.27	6,25	4,35	10,45	15,22	13.47	22	14.08	9.09	6.67	11.1
5.	<i>Myotis mystacinus</i>	2.44	21,87	8,70	1,49	4,35	3.85	2	1.41	-	-	2.22
6.	<i>Myotis bechsteinii</i>	2.44	9,38	17,40	13,43	2,17	1.92	12	9.86	12.12	20	13.33
7.	<i>Plecotus austriacus</i>	14.63	9,38	-	1,49	-	-	2	-	-	6.67	6.67
8.	<i>Plecotus aurtus</i>	-	6,25	-	1,49	2,17	1.92	-	1.41	3.03	3.33	6.67
9.	<i>Eptesicus serotinus</i>	-	3,12	-	-	-	1.92	-	4.23	-	-	2.22
	Total individuals	41	32	23	67	46	51	50	71	33	30	45

The first individuals were found at a distance of 4-5 m from the entrance, these were long-eared bats, which prefer to winter near the entrances and the lesser horseshoe bat, which was found both near the entrances, as well as in the depth of the mines at 200-250 m. In general, the lesser horseshoe bat (*Rh. hipposideros*) prefers quiet places, without air flow and temperature fluctuations, with warm and stable conditions.

Single individuals of *M. blythii* and *E. serotinus* were found 10-15 m from the entrance. All species were found solitarily, except for the Daubenton’s and pond bats, in which small groups of 2-8 individuals were found.

The highest species number was found in February 2018 (8 species). The highest number of bats was registered in February and the lowest in March, at the end of hibernation period, when some individuals become active and can live the winter roost. In general, the bat number and diversity varied between years, depending on the study

month and on the abundance of each species. Nevertheless, in the last 10 years, the trend of species population dynamics can be evaluated as stable, which is particularly important for the conservation of critically endangered and endangered species.

The Cricova II mines is a new site and was studied for the first time in February 2022. 26 individuals from 4 bat species were registered and the dominant was *M. daubentonii* with about 85%. The whiskered bat had the abundance of 8%, both long-eared bat species *P. austriacus* and *P. auritus* had similar low abundances of less than 4%.

The studies in the Goianul Nou mines were carried out at the end of hibernation period and at the beginning of the autumn. The total number of individuals was rather low (38 individuals in March and 35 individuals in September), due to the small surface of the mines, but the bat diversity was high, being registered 10 species from 4 genera. At the end of hibernation period, 7 bat species were recorded and in September – 6 species (Fig. 3).

The community structure showed significant seasonal differences: at the end of hibernation period the dominant species were *M. daubentonii*, *M. bechsteinii* and *M. myotis* that constituted more than 80% of the bat community, while other species registered less than 6% each. The species *M. dasycneme*, *P. auritus* and *E. serotinus*, recorded in autumn, were not found at the beginning of spring. In September, the dominant was the serotine bat with 40%, followed by *M. daubentonii* with over 37%, *M. bechsteinii* had almost 9%, other species having the abundance of less than 6%. The species *Rh. hipposideros*, *M. blythii*, *M. mystacinus* and *P. austriacus* were not registered in September (Fig. 3).

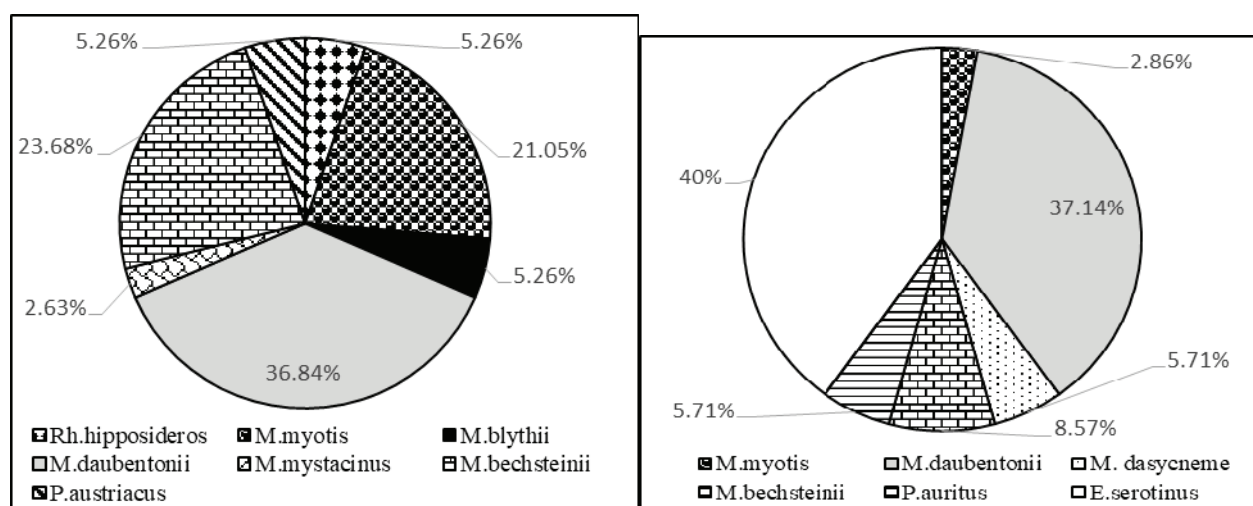


Figure 3. Structure of bat community at the end of hibernation (left) and in September (right) in Goianul Nou stone mines.

The mines near Goian represent a new study site, have a very low depth and only two species, each with one individual, were recorded: *M. mystacinus* and *P. austriacus*.

The Shannon diversity index was the highest in the Goianul Nou site (0.789) and in the Cricova I site (0.619), while in Cricova II and Goian it was much lower (0.263 and 0.184, respectively). The species richness evaluated using Margalef's index showed the highest diversity in Goianul Nou mines (5.988), a lower diversity in the Cricova I mines (3.986) and the lowest one in the Cricova II and Goian mines. The Berger-Parker index that expresses the proportional importance of the most abundant type, was the highest in the Cricova II mines (2.896) due to the very high dominance (up to 85%) of one species, followed by the Cricova I (1.797) and Goianul Nou mines (1.437).

DISCUSSIONS

In the studied limestone mines, the protection status of bat species was analysed for the Republic of Moldova in comparison with neighbouring countries and with the main international biodiversity conventions. In the Red Book of Moldova (RBM), 9 out of 10 species are listed, the serotine bat is considered a common species, especially in the anthropogenic landscape (Red Book of R. Moldova, 2015). The presence of the critically endangered species *M. myotis* and *M. bechsteinii* with a rather high abundance (about 20%) within bat communities is of particular interest and emphasizes the importance of the Cricova I and Goianul Nou sites in bat diversity conservation in the central area of the republic (LARION et al., 2021).

In the Red Book of Vertebrates from Romania (RBVR) all 10 species are listed, of which *M. daubentonii* and *M. dasycneme* are critically endangered (BOTNARIUC & TATOLE, 2005). In the Red Book of Ukraine, the species belong to the categories vulnerable, rare – corresponding to endangered, and disappearing – corresponding to critically endangered (<https://redbook-ua.org/>). All 10 species are listed, of which *M. dasycneme* is critically endangered (Table 3).

At the international level, all 10 species are included in Appendix II (strictly protected fauna species) of the Bern Convention on the Conservation of European Wildlife and Natural Habitats and in Appendix II (species which have an unfavourable conservation status) of CMS (Convention on the Conservation of Migratory Species of Wild Animals) (<https://rm.coe.int/1680304355>; <https://www.cms.int>). In the IUCN Red List (<https://www.iucnredlist.org>) the *M. dasyncneme* species has the status of vulnerable, the species *Rh. hipposideros*, *M. blythii*, *M. dasyncneme* and *P. austriacus* are near threatened and other 5 species are of least concern. The EU Directive on the conservation of natural habitats and of wild fauna and flora, known as Habitat Directive, includes several annexes, of which Annex II (Animal and plant species of community interest whose conservation requires the designation of special areas of conservation) are listed 5 bat species found in the studied area, and Annex IV (Animal and plant species of community interest in need of strict protection) are listed all Microchiroptera species (Table 3).

Table 3. Rarity status of bat species registered in the stone mines of the Cricova-Goian area.

No	Species	RBM	RBVR	RBU	Bern convention	CMS	IUCN	Habitat Directive	
1.	<i>Rhinolophus hipposideros</i>	EN	VU	VU	App.II	App.II	NT	Ann.II	Ann.IV
2.	<i>Myotis myotis</i>	CR	EN	VU	App.II	App.II	LC	Ann.II	Ann.IV
3.	<i>Myotis blythii</i>	VU	EN	VU	App.II	App.II	NT	Ann.II	Ann.IV
4.	<i>Myotis daubentonii</i>	VU	CR	VU	App.II	App.II	LC	-	Ann.IV
5.	<i>Myotis dasyncneme</i>	EN	CR	CR	App.II	App.II	NT	Ann.II	Ann.IV
6.	<i>Myotis mystacinus</i>	VU	EN	VU	App.II	App.II	LC	-	Ann.IV
7.	<i>Myotis bechsteinii</i>	CR	EN	VU	App.II	App.II	VU	Ann.II	Ann.IV
8.	<i>Plecotus austriacus</i>	VU	EN	EN	App.II	App.II	NT	-	Ann.IV
9.	<i>Plecotus auritus</i>	EN	VU	VU	App.II	App.II	LC	-	Ann.IV
10.	<i>Eptesicus serotinus</i>	-	VU	VU	App.II	App.II	LC	-	Ann.IV

Note: VU-vulnerable, EN-endangered, CR-critically endangered

Since the Cricova II, Goianul Nou and Goian limestone mines are new sites, there are no literature data on bats from these locations. For the Cricova I mines the first mention of the presence of bats is dated from the 1950s, where 2 individuals of *P. austriacus*, 2 individuals of *E. serotinus* and 5 individuals of *Barbastella barbastellus* were found (SAENCO, 1959). In the period 1956-1974, during hibernation, 11 species of bats were recorded in the Cricova I mines, of which *Myotis nattereri*, *M. myotis* and *B. barbastellus* were not found in 2013-2022 (DOROSHENCO, 1975). The number of bats in the last century was lower than at present, in some years single individuals were recorded, and the maximum number of individuals was 51 in 1957. Whereas in our studies, the minimum number of individuals was 23 at the end of hibernation and more than 70 in February. The number of *Rh. hipposideros* was higher and the species was even dominant in 1957, 1958, 1962, 1966 and 1970 (DOROSHENCO, 1975).

The limestone mines from the Cricova-Goian area of the Ichel river provide favourable conditions for a high number of bat species, of which 9 are listed in the Red Book of the Republic of Moldova, despite strong anthropic disturbances, and is of huge importance in biodiversity conservation in the central part of the Republic of Moldova. The monitoring of the bat sites will continue in order to reveal the changes and trends in bat species populations.

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CONCLUSIONS

In the Cricova-Goian area the bat fauna is represented by 10 species, of which 9 species were registered in the Cricova I limestone mines, 4 species in the Cricova II mines, 10 species in the Goianul Nou mines and 2 species in the Goian mines. The Cricova II and Goian mines are new bat sites, found in 2021-2022.

In the Cricova I mines, 489 individuals from 9 species were registered during hibernation and the most abundant during the whole period was *M. daubentonii*, which constituted more than half of the bat community. The second most abundant species was *M. dasyncneme* with 13.5%, followed by *M. bechsteinii* and *Rh. hipposideros* with about 10% each, while other species had less than 4%. In general, in the last 10 years the trend of species population dynamics can be evaluated as stable. In the Cricova II mines, 4 bat species were registered and the dominant was *M. daubentonii* with about 85% other species had the abundance of less than 8%.

In the Goianul Nou mines, 10 species from 4 genera were recorded, but the community structure was different at the end of hibernation period (7species) and in September (6 species). In March, the dominant species were *M. daubentonii*, *M. bechsteinii* and *M. myotis* that constituted more than 80% of the bat community. In September, *E. serotinus* and *M. daubentonii* were dominant (about 77%) and *M. bechsteinii* had almost 9%. The new site – Goian mines have a very low depth and only two species with single individuals were registered.

The diversity was the highest in the Goianul Nou mines, followed by the Cricova I mines, being much lower in the Cricova II and Goian mines.

All the registered bat species are protected at national and international level and the Cricova-Goian area is of great importance in animal diversity conservation in the central part of the Republic of Moldova.

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