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THE PARCANI LIMESTONE MINE—A NEW BAT (MAMMALIA: CHIROPTERA) ROOSTING SITE OF MAJOR IMPORTANCE IN THE REPUBLIC OF MOLDOVA

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Abstract

Limestone mines are the most important underground roosts for bat species in the Republic of Moldova. The aim of the paper was to first study the bat fauna of a newly registered roosting site—the limestone mine near Parcani, Soldanesti district, in the north of Moldova, in order to elucidate the diversity of bats in various phenological periods and to highlight the importance of this roost in preserving chiropteran diversity. Field studies were carried out in 2023–2024 in different seasons, according to standard methods of bat monitoring in underground roosts, in order to reveal the changes in the bat community structure thorough the year. The species diversity was relatively high, with 10 bat species recorded during the study period: *Rhinolophus hipposideros*, *Myotis blythii*, *M. nattereri*, *M. daubentonii*, *M. dasycneme*, *M. bechsteinii*, *M. mystacinus*, *Barbastella barbastellus*, *Plecotus auritus*, and *Plecotus austriacus*. The structure of the bat community was different depending on the season. The highest diversity and largest number of individuals were recorded in the hibernation period, when *Myotis blythii* was the dominant species representing over 80% of the whole bat community. During the summer season, the diversity and number were the lowest, the dominant species was again *M. blythii* (55.1%), followed by *M. daubentonii* (20.4%) and *M. dasycneme* (14.3%). During the breeding season, the diversity and number increased significantly; *M. daubentonii* and *M. blythii* were dominant representing more than 90% of the bat community. The Parcani mine is an important roosting site for many bat species, especially in the breeding and hibernation periods. The registered hibernating colony of *M. blythii* was the largest among all the known colonies in underground roosts of Moldova. The critically endangered species in Moldova—*M. nattereri*, *M. bechsteinii*, and *B. barbastellus*—were registered in the cold period. For *M. nattereri* and *B. barbastellus*, it is the second record locality in the territory of the republic. All species recorded in the Parcani mine are protected at national level in Moldova and in neighbouring countries, while the species *Myotis blythii*, *M. dasycneme*, *M. bechsteinii*, *Barbastella barbastellus*, and *Plecotus austriacus* are protected at a European level.

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Вапнякова копальня Паркані — нове важливе місце скупчення кажанів (Mammalia: Chiroptera) в Республіці Молдова

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Резюме. Вапнякові копальні є найважливішими підземними місцями скупчення кажанів у Республіці Молдова. Метою статті було дослідити фауну кажанів у новому місці їх скупчення — вапняковій копальні поблизу Паркані, район Солданешті, що у північній частині Молдови, оцінити різноманіття кажанів у різні фенологічні періоди та підкреслити важливість цього місцезнаходження для збереження різноманіття хіроптерофауни. Польові дослідження проводили в 2023–2024 роках у різні пори року відповідно до стандартних методів моніторингу кажанів у підземних сховищах з метою виявлення змін у структурі угруповання кажанів протягом року. Видове різноманіття було порівняно високим, і протягом періоду дослідження було зареєстровано 10 видів кажанів: *Rhinolophus hipposideros*, *Myotis blythii*, *M. nattereri*, *M. daubentonii*, *M. dasycneme*, *M. bechsteinii*, *M. mystacinus*, *Barbastella barbastellus*, *Plecotus auritus* та *P. auritus*. Структура угруповання кажанів змінювалася залежно від пори року. Найвище видове різноманіття і найбільша кількість особин зафіксовані в період зимівлі, коли домінантним видом був *Myotis blythii*, що становив понад 80 % від усього угруповання кажанів. У літній сезон видове різноманіття і кількість особин були найнижчими, домінуючим видом також був *M. blythii* (55,1 %), за ним слідували *M. daubentonii* (20,4 %) і *M. dasycneme* (14,3 %). Під час сезону розмноження видове різноманіття і кількість особин значно зросли; *M. daubentonii* і *M. blythii* були домінуючими, складаючи понад 90 % від усього угруповання. Шахта Паркані є важливим місцем скупчення для багатьох видів кажанів, особливо в період розмноження та зимівлі. Зареєстрована зимівельна колонія *M. blythii* є найбільшою серед усіх відомих у підземних сховищах Молдови. Критично загрожені види в Молдові — *M. nattereri*, *M. bechsteinii* та *B. barbastellus* — були зареєстровані в холодний період. Для *M. nattereri* та *B. barbastellus* це друге місце реєстрації на території республіки. Усі види, що були зареєстровані в копальні Паркані, охороняються на національному рівні в Молдові та в сусідніх країнах, а види *Myotis blythii*, *M. dasycneme*, *M. bechsteinii*, *Barbastella barbastellus* та *Plecotus austriacus* охороняються на європейському рівні.

Ключові слова: кажани, різноманітність, сплячка, чисельність, Паркані, вапнякова копальня, рідкісні види, охорона природи.

Introduction

Underground sites serve as important year-round roosts for bats. The abandoned mines and other man-made subterranean structures are critical to the survival of many European bat species, since they often provide shelter for most of cave-dwelling bat fauna [Furey & Racey 2016; Mitchell-Jones *et al.* 2007; Pocora *et al.* 2008; Siivonen & Wermundsen 2008; Vintulis & Pētersons 2014 etc.]. Many bat species, mostly representatives of the genera *Myotis* and *Barbastella*, hibernate in mines, cellars, and bunkers [Baagøe 2001; Baranauskas 2006; Daan & Wichers 1968; Hoffmann *et al.* 2016; Ruczynski *et al.* 2005]. In the Republic of Moldova, limestone mines are the most important underground roosts for bat species, in which the conditions are similar to those of cave environments with a relatively constant microclimate.

Studies of bat fauna in anthropogenic underground sites in Moldova started in the 1960s–1970s, mainly in the central and northern parts, where most of the limestone mines are located [Averin & Lozan 1965; Doroshenko 1975; Kuchuk & Lozan 1970; Lozan & Skvortsov 1965; Lozan 1969]. As a result, 11 bat species were registered, most of them in the hibernation period, and some data regarding their ecology during hibernation were presented. For about 20 years, the study of bats was practically abandoned, and in the mid-1990s some investigations continued in underground shelters of the Nistru River basin [Andreev & Vasilev 1997; Vasilev & Andreev 1998].

Since 2013, in-depth studies of bat species have been conducted in previously known underground roosts, as well as in some new sites found in the last 10 years [Caldari *et al.* 2018; Larion *et al.* 2024; Nistreanu *et al.* 2020, 2022 *a–b*]. In the studied sites, a high diversity and number of bats

was found, most of which were represented by rare species. The study and long-term monitoring of bats in abandoned limestone mines is of enormous importance for bat conservation in Moldova, as they represent the only roosts for cave species. The bats use the mines for hibernation, rearing the young in summer, mating, and as temporary shelter in the warm period as their microclimatic conditions are similar to those in natural caves.

The aim of the paper was to first study the bat fauna of a new underground site—the Parcani limestone mine (Soldanesti district) in the Republic of Moldova in order to elucidate the diversity of bats in various phenological periods and to highlight the importance of this roost in preserving chiropteran diversity.

Material and Methods

In the winter of 2023, a new bat underground site was found, located between the town of Şoldănești and the village of Parcani, in the rocky slopes of the Ciorna River (47.821 N, 28.822 E) in the Nistru River basin, at 120–130 m a.s.l. The fieldwork was carried out in 2023–2024 in different phenological periods: hibernation—January and February 2023, November and December 2024; breeding—middle of September 2023; and summer—end of May 2024.

The mine is about 700 m long and has several reachable entrances located along the right slope of the Ciorna River in the Nistru River basin (Fig. 1).

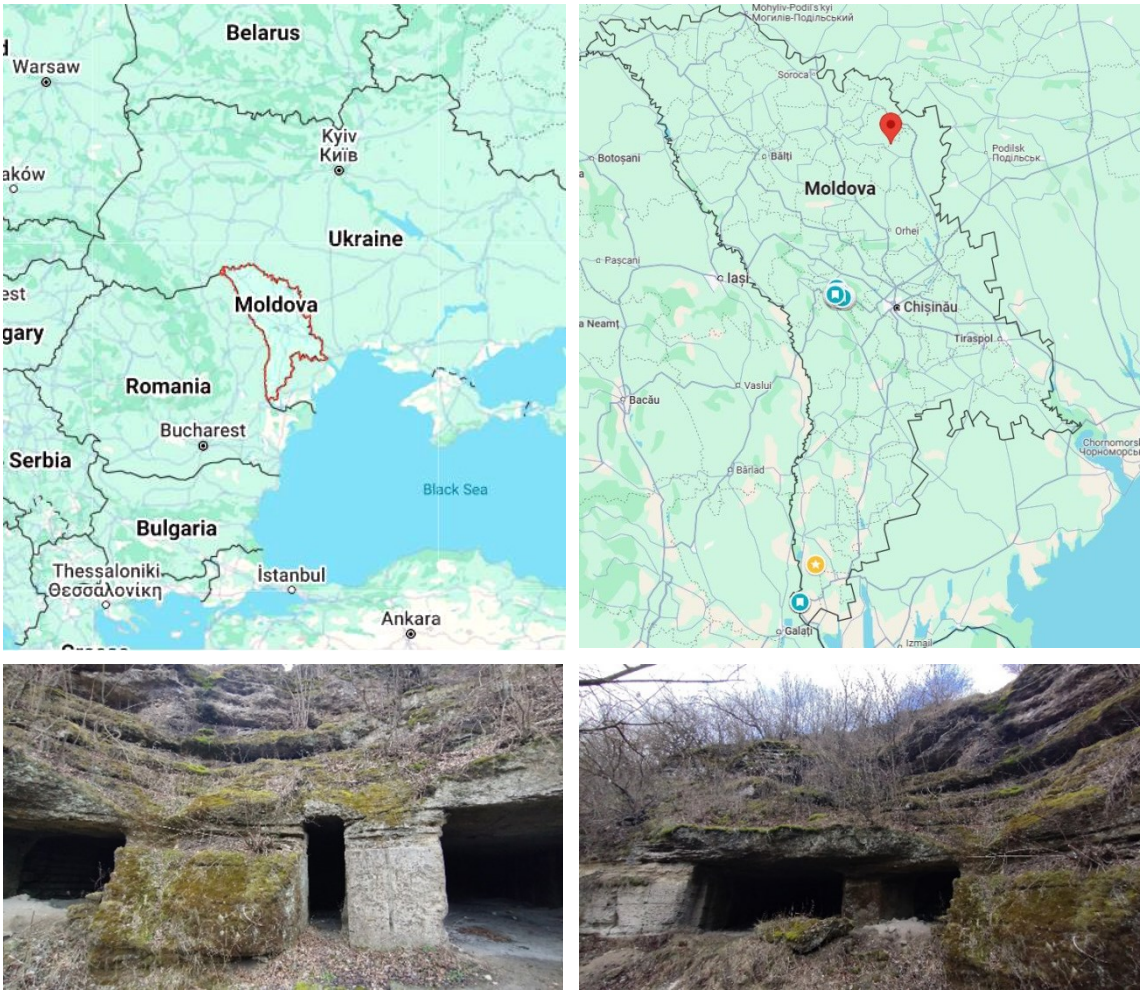

Fig. 1. Location of the Parcani mine and its entrances; 22 February 2023, Parcani, Photo by V. Nistreanu.

Рис. 1. Розташування шахти Паркані та входи до шахти; 22.02.2023, Паркані, Фото В. Ністреану.

The mine is machine excavated, the walls and the ceiling consists of multiple cracks, left over from stone extraction activities, and has a height of 1.5–2 m. The microclimate is relatively cool and constant—the air temperature in April–October varies form +8°C to +14°C, in winter varies from +2.4°C to +8°C depending on the depth, the humidity is 60% to 80%, being higher in the cold season. There are several parallel tunnels of 400–800 m long, connected to each other by shorter side tunnels. Along some tunnels, there are many stone debris and rubble, occupying approximately half of the space, sometimes even blocking the tunnels.

The monitoring of bat species was performed according to the methodology developed for monitoring bat species in Europe [Buttersby 2010]. The number of counts was limited to two per hibernation period, carried out at 1–1.5 months apart.

Bat species were identified by visual observations; all individuals were counted. In few cases, some difficult to identify individuals were extracted and additional biometric measurements were taken, such as tail length, ear and tragus length and width, forearm length, and identification keys were used [Decu *et al.* 2003; Dietz & Halversen 2004; Murariu *et al.* 2016]. In the case of compact clusters of individuals, an effective estimate per surface unit was made on site, and the exact count was carried out using pictures taken.

Results and Discussion

During the study period, 10 bat species were recorded in Parcani mine, 1 species of the family Rhinolophidae—*Rhinolophus hipposideros* (Bechstein, 1800) and 9 species of the family Vespertilionidae—*Myotis blythii* (Tomes, 1857), *M. nattereri* (Kuhl, 1818), *M. daubentonii* (Kuhl, 1819), *M. dasycneme* (Boie, 1825), *M. bechsteinii* (Kuhl, 1818), *M. mystacinus* (Kuhl, 1819), *Barbastella barbastellus* (Schreber, 1774), *Plecotus auritus* (Linnaeus, 1758), and *P. austriacus* (Fischer, 1829). The largest number of individuals and the greatest diversity was registered during the hibernation period, when all 10 species were found (Table 1).

In early January 2023, eight species were registered with a total number of 722 individuals: *R. hipposideros*, *M. blythii*, *M. nattereri*, *M. daubentonii*, *M. dasycneme*, *M. mystacinus*, *B. barbastellus*, and *P. auritus*. The dominant species was *M. blythii* (ca. 88%), while other species had much lower abundance.

In late February 2023, 945 individuals of 6 species were recorded: *R. hipposideros*, *M. blythii*, *M. daubentonii*, *M. dasycneme*, *M. mystacinus*, and *P. auritus*. The dominant species was *M. blythii* (ca. 84%), while other species had much lower abundance. The western barbastelle and Natterer's bat, found in very low number in January, were not recorded.

Table 1. Diversity and relative abundance of bats in the study period

Таблиця 1. Різноманіття та відносна чисельність кажанів у період дослідження

Species	04.01.2023	22.02.2023	19.09.2023	23.05.2024	14.11.2024	10.12.2024
R. hipposideros	3.74	2.54	0.75	2.04	22.29	0.37
M. blythii	87.81	84.34	42.54	55.10	62.23	87.59
M. nattereri	0.14	–	–	–	–	0.37
M. daubentonii	3.05	7.50	49.25	20.41	11.15	5.71
M. dasycneme	1.11	1.80	2.24	14.29	1.86	1.86
M. bechsteinii	–	–	–	–	–	0.25
M. mystacinus	2.63	2.43	2.24	8.16	1.24	1.12
B. barbastellus	0.28	–	–	–	–	0.37
P. auritus	1.25	1.39	1.50	–	1.24	2.11
P. austriacus	–	–	1.50	–	–	0.25
Total species	8	7	7	5	6	10
Total individuals	722	945	134	49	323	806

At the beginning of the hibernation (middle of November 2024), 323 individuals of 6 species were found, while the number and species diversity in the first half of December 2024 were much higher with 806 individuals of 10 species registered: *R. hipposideros*, *M. blythii*, *M. nattereri*, *M. daubentonii*, *M. dasycneme*, *M. bechsteinii*, *M. mystacinus*, *B. barbastellus*, *P. auritus*, and *P. austriacus*. The dominant species in both periods was *M. blythii*, the abundance of *M. daubentonii* decreased twice and that of *R. hipposideros* decreased drastically form 22.3% in mid-November to 0.4% in mid-December. The share of other species was up to 2%. The species *M. bechsteinii* was recorded for the first time during the two years of monitoring (see: Table 1).

The lowest number of bats was recorded in late May—only 49 individuals of the species *Rhinolophus hipposideros*, *Myotis blythii*, *M. daubentonii*, *M. dasycneme*, and *M. mystacinus*. The dominant species was *M. blythii*, followed by other *Myotis* species, and *R. hipposideros* had the smallest share (2.04%).

In late September, 134 individuals of 7 species were registered; the dominant species were *M. daubentonii* and *M. blythii*, which constituted more than 90% of the bat community. Many individuals were observed mating, the Parcani mine is therefore an important mating site for at least two species. Other species had a share of 0.75%–2.24% (Table 1).

The number and diversity of bats were different depending on the season, the lowest being registered in summer due to the absence or very low number of forest-dwelling species, such as *M. nattereri*, *M. bechsteinii*, *B. barbastellus*, and *Plecotus* species in underground roosts. Also, there were no maternity colonies in the mine, and therefore even the number of cave-dwelling species (*Rh. hipposideros*, *M. blythii*, and *M. daubentonii*) was low.

The most abundant species during the study period was *M. blythii*, especially during hibernation. It was found in mine ceiling cracks, seldom found solitary and frequently in small groups or large clusters from dozens to a few hundred individuals (Fig. 2). The number of registered individuals reached about 800, being the largest hibernating colony of the species among all known in underground roosts of Moldova. Another large colony of the lesser mouse-eared bat is known from the Gordinești mine, where about 200 individuals hibernate, and a large maternity colony of about 700 individuals roost in summer [Nistreanu *et al.* 2021].

The species *M. daubentonii* was the dominant species in autumn and quite numerous in the summer period. In the Republic of Moldova, Daubenton's bat was registered as one of the dominant species in many abandoned mines, since most of them are located near the rivers [Caldari *et al.* 2018; Nistreanu *et al.* 2020; 2022 *a–b*; Dibolscaia 2023]. The species *M. nattereri* was previously registered only in the Cocieri (Molovata Noua) mine and *B. barbastellus* only in the Saharna mine [Nistreanu *et al.* 2022 *b*]. The species *M. bechsteinii* was recorded in several mines from the central part of Moldova, such as Cricova, Goianul Nou, Trebujeni, Măşcăuţi, and Cocieri (Molovata Nouă) [Nistreanu *et al.* 2020, 2021, 2022 *a*]. The Parcani site is the northernmost record locality of the species in Moldova. All three species are very rare in the fauna of the country.

Fig. 2. Clusters of hibernating *Myotis blythii*; 22 February 2023, Parcani, Photo by V. Nistreanu.

Рис. 2. Групи зимуючих *Myotis blythii*; 22.02.2023, Паркані, Фото В. Ністреану.

Table 2. National and international conservation statuses of bat species form the Parcani site

Таблиця 2. Національний та міжнародний статус охорони видів кажанів з території Паркані

Species	RBM	RBVR	RBU	BC, App.II	CSM, App.II	IUCN
Rhinolophus hipposideros	EN	VU	VU	+	+	LC
Myotis blythii	VU	EN	VU	+	+	VU
Myotis nattereri	CR	EN	VU	+	+	LC
Myotis daubentoni	VU	CR	VU	+	+	LC
Myotis dasycneme	EN	CR	CR	+	+	VU
Myotis bechsteini	CR	EN	VU	+	+	VU
Myotis mystacinus	EN	EN	VU	+	+	LC
Barbastella barbastellus	CR	VU	CR	+	+	VU
Plecotus auritus	EN	VU	VU	+	+	LC
Plecotus austriacus	VU	EN	EN	+	+	NT

Note: RBM—Red Book of the Republic of Moldova; RBVR—Red Book of Vertebrates from Romania; RBU—Red Book of Ukraine; BC—Bern Convention; CSM—Convention on the Conservation of Migratory Species; VU—Vulnerable; EN—Endangered; CR—Critically Endangered; NT—Near Threatened; and LC—Least Concern.

High bat species diversity in mines was constantly recorded all over Europe [Mcaney 2009; Furey & Racey 2016; Rydell *et al.* 2018]. The dominant species in the mines were *Myotis myotis/blythii*, *Myotis daubentonii*, *Miniopterus schreibersii*, and *Barbastella barbastellus*, their hibernating colonies ranging from several hundred to several thousand [Hoffmann *et al.* 2008; Godlevska *et al.* 2011; Drebet 2024]

All the species registered in Parcani are listed in the Red Book of the Republic of Moldova and in red lists of neighbouring countries with different conservation status [Murariu 2005; Akimov 2009] (Table 2).

All of the recorded species are listed in Appendix II of the Bern Convention (strictly protected fauna species) (URL), in Appendix II of the Convention on the Conservation of Migratory Species (URL) and in the Agreement on the Conservation of Populations of Bats in Europe—EUROBATS (URL). In the IUCN Red List, the species *Myotis blythii*, *Myotis dasycneme*, *Myotis bechsteinii*, and *Barbastella barbastellus* are listed as vulnerable in Europe, *Plecotus austriacus* is listed as near threatened (NT) globally, and the other species are being of least concern (URL) (Table 2).

Six bat species, namely *Rhinolophus hipposideros*, *Barbastella barbastellus*, *Myotis bechsteinii*, *M. blythii*, and *M. dasycneme* are of the highest conservation interest within the Natura 2000 and Emerald networks, requiring special conservation measures (Resolution no. 6 of Bern Convention).

The Parcani mine is an important underground roost for many bat species, including rare ones. It is the most important hibernation roost for *Myotis blythii* in the Republic of Moldova, and the monitoring of bat fauna in the Parcani site will continue. The Ciorna River valley between the city of Soldanesti up to its confluence with the Nistru River has a picturesque landscape and includes natural forest ecosystems, rocky and grassland ecosystems, four waterfalls, and many tourist attractions. This area was proposed to be included in the Emerald network and, subsequently, in the Natura 2000 network.

Conclusions

In the Parcani mine, 10 bat species were registered: *Rhinolophus hipposideros*, *Myotis blythii*, *Myotis nattereri*, *Myotis daubentonii*, *Myotis dasycneme*, *Myotis bechsteini*, *Myotis mystacinus*, *Barbastella barbastellus*, *Plecotus auritus*, and *Plecotus austriacus*.

The structure of the bat community was different depending on the season. The highest diversity and largest number of individuals were recorded in the hibernation period, when *Myotis blythii* was the dominant species representing over 80% of the whole bat community. The species has the largest hibernation colony among all the known underground roosts of Moldova.

The rare species *Barbastella barbastellus*, *M. nattereri*, and *M. bechsteinii* were recorded only during hibernation. For *M. nattereri* and *B. barbastellus*, it is the second known record locality in the territory of the republic.

All species recorded in the Parcani mine are protected at national level and in neighbouring countries, while the species *Myotis blythii*, *M. dasycneme*, *M. bechsteinii*, *Barbastella barbastellus*, and *Plecotus austriacus* are protected at a European level. Six bat species (*Rhinolophus hipposideros*, *Barbastella barbastellus*, *Myotis bechsteinii*, *M. blythii*, and *M. dasycneme*) are of the highest conservation interest within the Natura 2000 and Emerald networks.

The valley of the Ciorna River between the city of Soldanesti and its confluence with the Nistru river, including the Parcani mine, was proposed to be included in the Emerald network and, subsequently, in the Natura 2000 network.

Declarations

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Conflict of interests. The authors have no conflicts of interest to declare that are relevant to the content of this article.

Handling of materials. The studied specimens were handled according to the current legislation of the Republic of Moldova.

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