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SEASONAL DISTRIBUTION OF CAVE-DWELLING BATS AND CONSERVATION STATUS OF UNDERGROUND HABITATS IN MOLDOVA AND DOBROGEA (ROMANIA)

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Key words: *cave-dwelling bats, microclimate, conservation, Romania*

INTRODUCTION

Bats use caves for hibernation, reproduction, rearing of young and other social events (Kunz 1982). Bats hibernate only in places providing suitable microclimatic conditions and safety from predation and disturbance (Kryštufek 2007). Both of these requirements are met in caves, where the world's largest aggregations of bats are found (Hutson et al. 2001). Caves, however, are scarce in many parts of the world and their availability influences the distribution and abundance of bats (Kryštufek 2007). Bat species differ in their thermopreferenda and therefore choose different shelters (Nagel & Nagel 1991).

Pieces of information referring to the ecology of the bats from the caves in Moldavian Carpathians are few. Valenciuc et al. (1964, 1966), starting from 1963, has studied the dynamics and the microclimate conditions from 2 caves: Bats Cave from Rarău (Suceava) and Toşorog Cave from the county of Neamț. In the last decade, a number of authors published new data of various undergrounds (Baltag et al. 2009, Chachula et al. 2008, Done 2007, Ifrim & Valenciuc 2006, Nagy & Postawa 2010, Pocora et al. 2008, 2010 in press).

In Dobrogea, are few researches about the bats fauna, those being mainly focused on the underground shelters (Cerveny 1982, Dumitrescu et al. 1962-1963, Răduleț 1994, Răduleț & Stănescu 1966, Valenciuc & Ion 1971). Lately few publications have emerged to deal with the chiropterofauna from Dobrogea karsts (Răduleț 2005, Ifrim & Pocora 2007, Murariu et al. 2009, Nagy & Postawa 2010).

Nagy and Postawa (2010), evaluated the degree of conservation of the underground shelters from Romania, based on the observations from 2003, they gave conservation value between 1 and 4 to the caves in Romania (Mitchell-Jones et al. 2000).

From the study area, they gave the highest level of conservation - 2 for Bats Cave from Rarău Mountain.

The focus of this study was on cave utilization by bats in Moldova and Dobrogea areas, the microclimate preference for hibernaculas by 15 bat species, and the degree of conservation of the undergrounds from Moldova and Dobrogea.

MATERIAL AND METHODS

There were investigated 5 caves from Moldova region (at least three times): Bats Cave from Rarău (SV), Mine nr. 1 from Rarău (SV), Munticelu Cave (NT), Toşorog Cave (NT) and Grota Mare from Repedea Hill (IS) and 4 caves from Dobrogea area, Constanța county: Limanu Cave, Hagieni Tunnel, Bats Cave from Gura Dobrogei and Casian Cave. To these we add a single visit at two other underground shelters: Mina lui Mantz (SV) and Avenul Mare from Ceahlău (NT). Caves from Moldova are found at altitudes between 322 (Grota Mare) and 1638 m (Avenul Mare), having length between 120 (Munticelu Cave) and 955 m (Mina nr. 1). Two of the undergrounds show the pit entrance, at Bats Cave from Rarău is about 12 m and in Avenul Mare is of 95 m. The caves from Dobrogea lies at altitudes between 11 and 50 m, and the length is between 58 and 3200 m (Limanu Cave).

Caves were thoroughly searched for roosting bats during daylight hours in all months of the year but most intensively during the hibernation period (September/October–March/April). The number of visits per cave ranged between one and 40 (Grota Mare).

Larger clusters were photographed using a digital camera and the bats were counted from photos. Bat species were identified without handling, using only the external morphological features described in Decu et al. 2003, Dietz &

Helversen 2004, Schober & Grimmberger 1996, Valenciuc 2002.

Our evaluation of the relative importance of the sites was based on the method of Mitchell-Jones et al. (2000). Priority level 1 refers to the most important underground roosts, which support the largest populations of most bat species and have the scores of 10 000 or more; level 2 refers to important underground sites, in which there are large populations and many bat species (1000< score<10 000); level 3 includes sites of lower priority used by few species in small number (100<score<1000); while level 4 are sites used by few bats (score<100). Contribution of a particular species in the roost was calculated as a product of its highest count (Ai), if the cave was visited twice, and its specific multiplier (Mi). Mi was 4 for vulnerable and 2 for lower risk or threatened species (Mitchell-Jones et al. 2000). The score (S) assigned to a site is the sum of contributions from all species (n) found there (Furman & Özgul 2004).

$$S = \sum_{i=1}^{n} (A_i M_i)$$

In the case of multiple observations from the same site, only the largest recorded number of bats was considered in subsequent analyses (table 1).

The very similar species *Myotis myotis/Myotis oxygnathus, Myotis mystacinus/Myotis brandtii* were distinguished only during several controls, by external features. If this was not possible, both species were classified together as *Myotis myotis/Myotis oxygnathus, Myotis mystacinus/Myotis brandtii.*

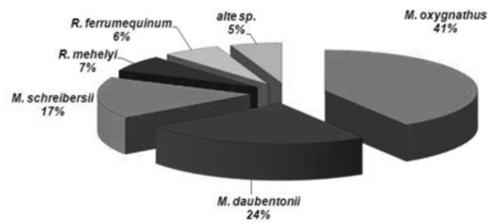
Mist nets were placed at the cave entrance of caves: Bats Cave from Rarău, Bats Cave from Gura Dobrogei, Casian Cave, Limanu Cave and Hagieni Tunnel, from May until October. The nets were anchored after sunset until 2 AM.

The equipment: for catching bats we used mist nets of 3, 7 and 12 m length. The captured bats were measured with the caliper (0.5 mm), weighed on a Pesola scale of 60g, the teeth were observed with a magnifier glass of 10x. Data on the microclimate were recorded with the help of a digital termohigrometer.

RESULTS AND DISCUSSIONS

In Romania, the bats are unequally distributed between regions, both in abundance and in species composition. Environmental characteristics as latitude, area and temperature are the main predictors of bat species richness in Europe (Ulrich et al. 2007). The Eastern Carpathians, with cold caves at a high elevation, host small numbers of bats in both seasons, and the Dobrogea region with small caves characterized by dynamic temperatures host exclusively maternity colonies (Nagy and Postawa 2010). The same authors state that regions with the lowest number of species and the smallest colonies of bats are the karst from Dobrogea, followed by the one from Eastern Carpathians.

In our study, at the caves from Moldova and Dobrogea, were identified 20 species of bats: *Barbastella barbastellus, Eptesicus nilssonii, Eptesicus serotinus, Myotis aurascens, Myotis bechsteinii, Myotis brandtii, Myotis dasycneme, Myotis daubentonii, Myotis emarginatus, Myotis myotis, Myotis mystacinus, Myotis nattereri, Myotis oxygnathus, Plecotus auritus, Plecotus austriacus, Vespertilio murinus, Miniopterus schreibersii, Rhinolophus ferrumequinum, Rhinolophus hipposideros, Rhinolophus mehelyi*. In the karst from Dobrogea region, were identified 13 bat species, and in the undergrounds from Moldova area, 15 species. The dominant species from the undergrounds in Moldova are *Myotis myotis/Myotis oxygnathus* (71,5%), and from the ones from Dobrogea are: *Myotis oxygnathus* (41,1%), *Myotis daubentonii* (24,1%), and *Miniopterus schreibersii* (16,7%) (fig. 1).



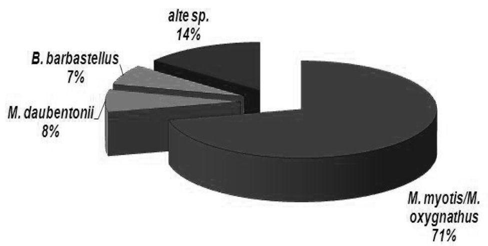


Fig. 1 The composition of bats species in undergrounds from Dobrogea (up) and from Moldova area (down)

The karst from Moldova

In the undergrounds shelters from Moldova we found 15 species of bats: *Barbastella barbastellus, Eptesicus nilssonii, Eptesicus serotinus, Myotis bechsteinii, Myotis brandtii,* *Myotis dasycneme, Myotis daubentonii, Myotis myotis, Myotis mystacinus, Myotis nattereri, Myotis oxygnathus, Plecotus auritus, Plecotus austriacus, Rhinolophus ferrumequinum* and *Rhinolophus hipposideros*. The dominant and most common species are: *Myotis myotis/Myotis oxygnathus* (71,5%), with *Myotis daubentonii* are characteristic species for the undergrounds in Moldova. *Barbastella barbastellus, Myotis bechsteinii, Myotis mystacinus/Myotis brandtii, Rhinolophus hipposideros, Plecotus sp., Eptesicus nilssonii* and *Myotis nattereri* were recorded quite often. The other species have been observed in the study area accidentally: *Eptesicus serotinus, Rhinolophus ferrumequinum* and *Myotis dasycneme* (tabel 2). *Rhinolophus ferrumequinum* was first identified in Moldova on 15 April 2007, as a specimen found dead in Tosorog Cave (Baltag et al. 2009).

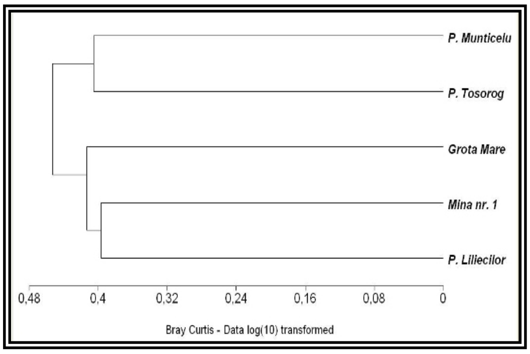
Table 2. Percentage values and class of ecological indices: dominance (D), frequency (F) and ecological significance index (W), based on observations in karst in Moldova (Varvara et al. 2001)

Species	Dominance		Frequency		W	
	%		%		%	
B. barbastellus	6,7	D4	42,9	C2	2,9	W3
E. nilssonii	2,5	D3	28,6	C2	0,7	W2
E. serotinus	<0,1	D1	14,3	C1	<0,1	W1
M. bechsteinii	3,3	D3	42,9	C2	1,4	W3
M. dasycneme	<0,1	D1	14,3	C1	<0,1	W1
M. daubentonii	7,5	D4	71,4	C3	5,4	W4
M. myotis/M. oxygnathus	**71,5**	**D5**	**100**	**C4**	**71,5**	**W5**
M.mystacinus/ M. brandtii	3	D3	57,1	C3	1,7	W3
M. nattereri	1	D1	28,6	C2	0,3	W2
Plecotus sp.	2,5	D3	71,4	C3	1,8	W3
R. ferrumequinum	<0,1	D1	14,3	C1	<0,1	W1
R. hipposideros	1	D1	42,9	C2	0,4	W2

Fig. 3 renders the degree of affinity between the undergrounds from Moldova and the bat species, based on similarity index analysis, Bray-Curtis method. The tightest affinity is between Bats Cave and Mina nr. 1, affinity is given by similar habitat and species, both undergrounds stand in Rarău Mountains. Affinity is also between Munticelu Cave and Toşorog Cave; both undergrounds are in the same type of habitat and with similar bat species.

Regarding different species of bats, found in underground shelters from Moldova, the highest affinity is between the species: *Myotis daubentonii, Myotis mystacinus/Myotis brandtii* and *Plecotus auritus/Plecotus austriacus*, all are medium-sized species, which hibernate in cracks, are characteristic or accessories species of Moldova caves. High affinity was observed between *Eptesicus nilssonii* and *Barbastella barbastellus* species, both are boreal species, characteristics for coniferous habitats, with the highest percentage of abundance in Rarău Mountains. *Eptesicus serotinus* and *Myotis dasycneme* also present affinity; both species were found accidentally, being observed in one underground shelter.

The caves from Moldova, being cold undergrounds, do not host birth colonies, but hibernating colonies. In August-October period these caves are swarming places for the following species of bats: *Barbastella barbastellus, Eptesicus nilssonii, Myotis bechsteinii, Myotis brandtii, Myotis daubentonii, Myotis myotis, Myotis mystacinus, Myotis nattereri, Myotis oxygnathus, Plecotus auritus* and *Plecotus austriacus.*



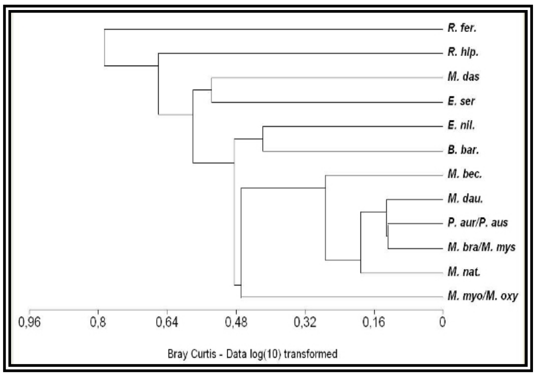


Fig. 3 The similarity dendogram between the undergrounds (up) and the identified bat species from Molova (down)

The karst from Dobrogea

In the undergrounds from Dobrogea, were indentified the following species of bats: *Eptesicus serotinus, Myotis aurascens, Myotis bechsteinii, Myotis daubentonii, Myotis emarginatus, Myotis oxygnathus, Plecotus auritus, Plecotus austriacus, Vespertilio murinus, Miniopterus schreibersii, Rhinolophus ferrumequinum, Rhinolophus hipposideros, Rhinolophus mehelyi*.

From those, we found in hibernation: *Myotis daubentonii, Myotis oxygnathus, Plecotus auritus, Miniopterus schreibersii, Rhinolophus ferrumequinum, Rhinolophus hipposideros* and *Rhinolophus mehelyi*.

The species that forms birth colonies are: *Eptesicus serotinus, Myotis aurascens, Myotis bechsteinii, Myotis daubentonii, Myotis emarginatus, Myotis oxygnathus, Plecotus austriacus, Vespertilio murinus, Miniopterus schreibersii, Rhinolophus mehelyi.* In the swarming period, the caves from Dobrogea are visited by the species: *Eptesicus serotinus, Myotis daubentonii, Myotis oxygnathus, Plecotus austriacus, Miniopterus schreibersii, Rhinolophus ferrumequinum, Rhinolophus mehelyi*.

The dominant species in the karst of Dobrogea are: *Myotis oxygnathus, Myotis daubentonii* and *Miniopterus schreibersii*, and are characteristics for this type of habitat. *Eptesicus serotinus, Plecotus austriacus, Rhinolophus mehelyi* and *Rhinolophus ferrumequinum* are accessories species for the undergrounds in Dobrogea. The other identified species are rare in the studied region, being accidentally observed/caught: *Rhinolophus hipposideros, Myotis aurascens, Myotis bechsteinii, Myotis emarginatus, Plecotus auritus* and *Vespertilio murinus* (table 3).

Tabel 3. Percentage values and class of ecological indices: dominance (D), frequency (F) and ecological significance index (W), based on observations in karst in Dobrogea (Varvara et al. 2001)

Species	No. ex.	Dominance		Frecquency			W
		%		%		%	
E. serotinus	16	2,1	D3	50	C2	1,1	W3
M. aurascens	1	<0,4	D1	25	C1	0,1	W1
M. bechsteinii	1	<0,4	D1	25	C1	0,1	W1
M. daubentonii	185	24,1	D5	100	C4	24,1	W5
M. oxygnathus	**315**	**41,1**	**D5**	**50**	**C2**	**21**	**W5**
P. auritus	3	<0,4	D1	50	C2	0,2	W2
P. austriacus	11	1,4	D2	75	C3	1,1	W3
V. murinus	2	<0,4	D1	25	C1	0,1	W1
M. schreibersii	128	16,7	D5	75	C3	12,5	W5
R. ferrumequinum	47	6,1	D4	50	C2	3,1	W3
R. hipposideros	2	<0,4	D1	50	C2	0,2	W2
R. mehelyi	50	6,5	D4	25	C1	1,6	W3

The affinity between the Bats Cave from Gura Dobrogei and Casian Cave is tight, these is due to the presence of approximately the same species and similar habitats, were can be founded both caves (fig. 4).

In terms of the species, the tightest activity is between the *Myotis bechsteinii* and *Myotis aurascens*, both species were met accidentally in the karst of Dobrogea. R*hinolophus ferrumequinum* and *Eptesicus serotinus* species were identified only at two of the studied undergrounds (Bats Cave from Gura Dobrogei and Casian Cave). *Rhinolophus hipposideros* and *Myotis emarginatus* also present affinity; both are accidental, being identified only in Hagieni Tunnel. Based on the affinity, the species are grouped in 2 clusters: characteristics and accessories (in terms of ecological significance index), with tightest affinity and another group made up of accidental species for Dobrogea karst (tabel 3).

In the 60's, *Rhinolophus mehelyi* was a characteristic species for Dobrogea karst. Now, in Romania, the species is critically threatened and prone to extinction. The remnant population forms maternity and hibernation colonies in a single location (Limanu Cave) situated in southern Dobrogea (Dragu & Borissov 2011). The same authors confirm for the first time the low genetic diversity of this species in Romania.

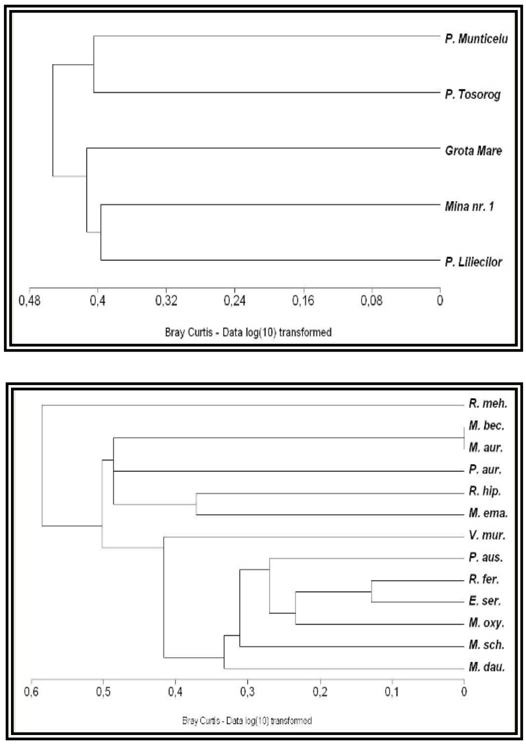


Fig. 4 The similarity dendogram between the undergrounds (up) and the identified bat species from Dobrogea (down)

The microclimate of undergrounds in Moldova and Dobrogea, in the hibernation period

Because the insectivorous bats are heterothermic, the microclimate of their roosts plays an important role in their energy expenditure, both in winter and in summer (Nagy and Postawa 2010). Bats that are hibernating at lower temperatures benefit energetically and are therefore able to hibernate up to 6.8 months in a row.

Such behavior is common to sedentary bats living in northeastern Europe (Masing et al 2009). Temperatures measured at bat hibernation sites are different for the same bat species hibernating in the same type of underground shelters in different parts of Europe.

At the studied underground shelters from Moldova and Dobrogea (Bats Cave and Mina nr. 1 from Rarău - SV, Toşorog Cave and Munticelu Cave – NT, Avenul Mare from Ceahlău - NT, Grota Mare – IS, Bats Cave from Gura Dobrogei, Casian Cave, Limanu Cave and Hagieni Tunnel - CT), the temperature and humidity were recorded in places chosen by different species of bats, for hibernation. Thus, graphics were made with the minimum, maximum and average temperature, preferred by different species of bats in hibernation (fig. 5). The same type of graph has been made on humidity (fig. 6).

Table 4. Temperatures and humidity values recorded in underground shelter from Moldova and Dobrogea, for different species of bats, in hibernation

Species	Min. T. ºC	Max. T. ºC	Aver. T. ºC	Min. H. %	Max. H. %	Aver. H. %
B. barbastellus	-2	6.7	4.8	37	91	77.7
E. nilssonii	-5	7.4	3.6	37	93	74.3
E. serotinus	0.7	2.5	1.6	62	79	70.5
M. bechsteinii	4.3	12.8	8.8	53	94	74.5
M. dasycneme	5.3	5.9	5.6	72	94.2	83.2
M. daubentonii	3	18.2	11.1	46	99	80.5
M. nattereri	4.3	13.7	8.6	54	99	73.9
M. myotis/ M. oxygnathus	-2	17.5	8.5	43	99	73.9
M. mystacinus/ M. brandtii	3	12.9	7.1	43	99	77.9
P. auritus	3	16.9	11.1	43	99	75.7
P. austriacus	-5	5.6	4.9	53	93	70.4
M. schreibersii	9.4	17.5	11.2	45	90	70
R. ferrumequinum	9.5	17.7	12.8	58	95	75.3
R. hipposideros	8.5	16	11.2	55	80	69
R. mehelyi	15	18.2	16.7	75	90	82.3

The preference for certain temperatures in the hibernacula is very different, from species to species, and depends on the cave type. New data values are indicative. Microclimate data were recorded during the cold season (October-April), in different wintry seasons.

Depending on the optimum of temperature, bats can be divided into three categories: bats which often tolerate low and oscillating temperatures, beneath 0ºC (*Barbastella barbastellus, Eptesicus nilssonii, Plecotus austriacus*); hibernating bats that choose hibernacula with average temperatures between 5.5 and 12ºC (*Myotis* sp., *Plecotus auritus*) and bats of warm caves (*Rhinolophus* sp., *Miniopterus schreibersii*), where the minimum temperature do not decrease under 8ºC (table 4). Thus, the species that bear the lowest temperature, often negative are: *Barbastella barbastellus* (Mine nr. 1 from Rarău and Toşorog Cave), *Eptesicus nilssonii* (Mine nr. 1 from Rarău and Avenul Mare from Ceahlău) and *Plecotus austriacus* (Avenul Mare from Ceahlău and Mina nr. 1 from Rarău); the opposite is *Rhinolophus mehelyi* (Limanu Cave).

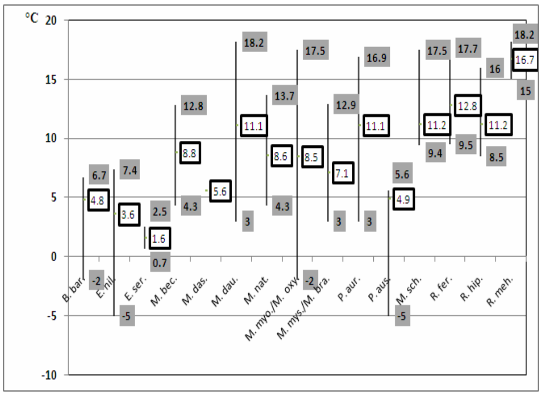


Fig. 5. Temperature range recorded in various undergrounds from Moldova and Dobrogea, by different species of bats, in hibernation

The first category of species was found in hibernation only in the karst of Moldova, these are boreal species. *Barbastella barbastellus, Eptesicus nilssonii* and *Plecotus austriacus* were met at Mine nr. 1 from Rarău, in the galleries which are opened at the end, marked by low temperature during winter (T = -2 and 5ºC and U = 53 – 80%), with temperature oscillations and cold wind (Pocora et al. 2008). The best conditions as underground hibernacula for *Barbastella barbastellus* are temperature of 1.6 – 4.8ºC and humidity of 70 – 90% (Boye & Dietz 2005). *Eptesicus nilssonii*, which often chooses less protected hibernation sites such as caves, tunnels, bunkers and abandoned cellars with open entrances, and tolerates temperatures down to -5.5°C (Masing & Lutsar 2007). The lowest temperature at which the species was met is – 5ºC (Avenul Mare from Ceahlău). In the same underground, *Plecotus austriacus* was found at -5ºC, the species can cope with air temperatures of -7ºC (Boye & Dietz 2005). During winter, in the main gallery of Mine nr. 1 and in Avenul Mare appear ice formations.

The same species are present in undergrounds with the lowest average temperature (table 4).

The average low temperature recorded for *Eptesicus serotinus* and *Myotis dasycneme* species is not conclusive, because were recorded twice only in a single hibernacula.

Rhinolophus mehelyi is a Mediterranean species, uses warm caves with small temperature fluctuation (Paksuz et al. 2007). The eastern part of the Danubian Lowland in Bulgaria and the karstic region of Romanian Dobrogea represent the northern margin of the known distribution of these species in the Balkans (Benda et al. 2003). Average temperatures recorded from hibernation at Limanu Cave, in areas were the species was found, was 16.7ºC.

For *Myotis oxygnathus, Myotis daubentonii* and *Plecotus auritus* we registered the largest temperature ranges, between maximum and minimum temperature, these species were found in hibernation, both in the karst of Moldova and Dobrogea, from sea level to 1504 m altitude. In the study area, these species seem to be the most adaptable in various caves microclimate.

Of these species, the widest range of temperatures was recorded for *Myotis oxygnathus* species, which was meet until 1638 m altitude, minimum temperature recorded for the species was -2ºC (Avenul Mare). For *Rhinolopus mehelyi* species the range of the values of temperature recorded is most tight, the species was identified only in Limanu Cave, being more sensitive to the microclimate of the cave, among the bat species from caves.

For some species of bats, the big difference between minimum and maximum temperatures is given by the type of hibernacula.

Thus, in the caves from mountain areas (Bats Cave from Rarău, Mina nr. 1 from Rarău, Avenul Mare from Ceahlău), temperatures often showed negative values, these are cold caves. However, in the karst from Dobrogea, even during deep hibernation (December-February), temperatures were raised (over 8ºC), the warmer cave is Limanu Cave, were the average temperature, in hibernation period was 16.1ºC (table 5).

The microenvironment of the hibernacula's from Dobrogea is conditioned, first by geographical position, temperate steppe region with Mediterranean influences (Dumitrescu 1969). Because de values of minimum, maximum and average temperature are very diverse from one cave to another, average temperature preferred by distinct species of bats in the study area, was much higher than in other studies (Benda et al. 2003, Boye & Dietz 2005, Masing & Lutsar 2007, Nagy & Postawa 2010, Schoeber & Grimmberger 1996), the average of temperatures from various hibernacula's are influenced by the comparatively small number of the searched undergrounds.

The other underground shelters from Moldova exhibit average temperatures between 5.2ºC (Mina nr. 1) and 10.1ºC (Toşorog Cave) (table 5).

Temperature decreases with increasing altitude, in hibernacula located above 1500 m elevation, temperatures tend to be negative.

Table 5. Values of temperature and humidity prevailing in undergrounds in the area of study, during hibernation

Micro climate	1	2	3	4	5	6	7	8	9
Min. T.	3	-2	5,6	-	3,5	8,7	11,6	15	9,4
Max. T.	0,3	8,6	14,2	-	14	17,7	15,5	18,2	16
Aver. T.	5,8	5,2	10,1	9,3	9,3	12,8	14,1	16,1	12,2
Min. H.	64	37	55	-	53	43	48	75	45
Max. H.	92	99	80	-	99	96	80	90	76
Aver.H.	76,7	74	69,8	74,5	75,8	87,7	61,7	85,4	65,3

1 – Bats cave from Rarău, 2 – Mine nr. 1, 3 –Toşorog Cave, 4 –Munticelu Cave, 5 – Grota Mare, 6 – Bats Cave from Gura Dobrogei, 7 – Casian Cave, 8 – Limanu Cave, 9 – Hagieni Tunnel

It is known that troglophile bats are not uniform, but on contrary, it varies not only according to the geographical situation of the caves, size and their topography, especially depending on their internal microclimate (Valenciuc 1972). The microclimate inside the shelter is influenced by: the type of cave, its size and topography, the altitude at which the cave is located, type of rock the cave is dug, the depth at which the cave is located.

Between the average temperature and the altitude of the cave is a negative correlation (-0.9), as altitude increases the average temperature from cave lowers, thus at high altitude are cold caves and warm caves are at low altitudes. Between the length of the cave and average temperature is a low positive correlation (0.4), so the length of the cave does not influence the temperate from inside. Instead, the humidity is not influenced by altitude but by the length of the cave (0.6), thereby the shortest underground shows the lowest values of humidity (Casian Cave and Toşorog Cave), and in the longest caves the values of humidity are highest (Limanu Cave and Bats Cave from Gura Dobrogei) (table 5). The only exception is figured by Mine nr. 1, here humidity values are lower in the main gallery, caused by harsh air currents and low temperature, often around 0ºC.

Between the temperature off hibernacula and the number of species is a negative correlation (-0.7), the lower is the average temperature from the shelter, in hibernation; the number of species is even higher. Likewise is a negative correlation between temperature and the number of bats (-0.5), so in cold caves hibernate more bats and many species, and in warm caves (the ones from Dobrogea), only few species and individuals of bats, these caves shelters birth colonies. Our results contradict observation from other regions, were bats that seem to prefer longer and deeper caves situated at lower elevations (Kryštufek 2007). Thermal regimes through the winter are major determinants of hibernation use by bats; size of underground is perhaps just a surrogate for a greater diversity of micro ecological conditions. Although the structure of a cave may compensate for its size, in effectively extending the ambient range available to bats (Ransome 1990).

All bat species require high humidity this prevent dehydration. The air in the undergrounds is often saturated with water vapor, so bats, in some shelters, are covered with dew drops.

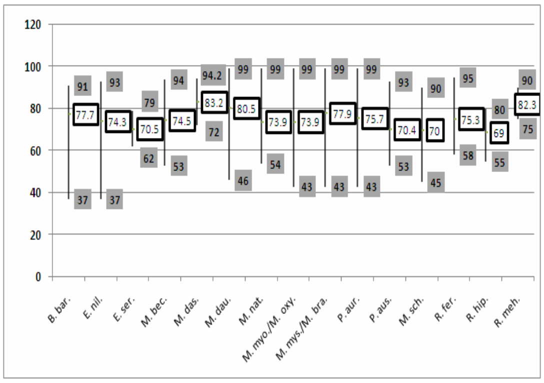


Fig. 6. Humidity range recorded in various undergrounds from Moldova and Dobrogea, for different species of bats, in hibernation

In terms of humidity, preferred values of various species of bats are closer, the optimum ranging from 69% (*Rhinolophus hipposideros*), 70% (*Miniopterus schreibersii*) to 82.3% (*Rhinolophus mehelyi*). The high average humidity at the shelter for *Myotis dasycneme* species is not conclusive because only two values were recorded in a single shelter (table 4).

Depending on the places elected by bats during hibernation, the bats are divided into three categories:

- species that are freely hung from the ceiling (*Rhinolophus ferrumequinum* and *Rhinolophus hipposideros*);
- species that can be found freely hanging from de ceiling but often seek cracks and crevices, niches, with more favorable microclimate (*Barbastella barbastellus, Eptesicus nilssonii*, *Myotis bechsteinii*, *Myotis dasycneme*, *Myotis myotis/Myotis oxygnathus, Plecotus* sp., *Miniopterus schreibersii, Rhinolophus mehelyi*);
- species that prefers narrow cracks, the body is in contact with the wall on all sides (*Eptesicus serotinus*, *Myotis daubentonii, Myotis mystacinus/Myotis brandtii, Myotis nattereri*).

The level of conservation of undergrounds from Moldova and Dobrogea

In Romania, the largest aggregations of bats were situated in caves in the Apuseni Mountains and the Southern Carpathians. Aggregations from 500 to 5000 individuals occurred in 13.6% caves from Romania (Nagy & Postawa 2010). Among the 4961 bats identified in this study, a percentage of 81% was recorded in the Bats Cave from Rarău, where a big winter colony (about 3700 individuals) of *Myotis oxygnathus/Myotis myotis* species can be found.

S score was calculated for the studied caves, so the Bats Cave from Rarău shows the highest score having the highest level of conservation of caves from the studied area (level 2). Level 3 of conservation was assent to Bats Cave from Gura Dobrogei, Limanu Cave and Mina nr. 1 from Rarău (fig. 7). From these, the highest score it holds the first cave, score given by the largest birth colony from the caves studied (200 individuals).

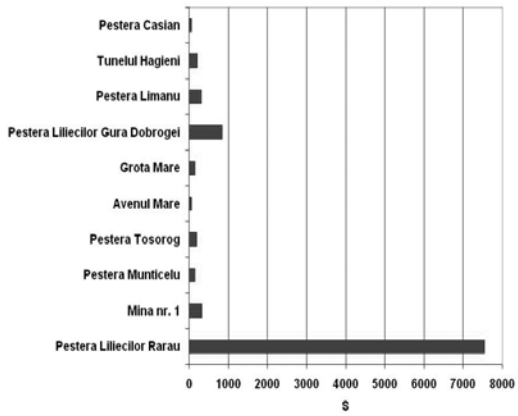


Fig. 7. S score calculated for the undergrounds from Moldova and Dobrogea

Unlike the 60s-80s, the conservation level (table 1) and S score of some caves fell dramatically (fig. 8).

In the karst of Moldova, of the caves study by us, only at Bats Cave from Rarău and Toşorog Cave, studies have been done in 60s-70s. Thereby, the number of specimens of *Myotis oxygnathus/Myotis myotis* species from the first cave fell to 50%.

The level of conservation of the cave has been preserved like in the past, which are 2 (table 1). At Toşorog Cave, the number of individuals and the number of bat species was kept.In the last five years, at caves from Moldova (except Bats Cave from Rarău), we noticed a decrease in the number of specimens of the following species: *Rhinolophus hipposideros* (50%), *Myotis myotis/Myotis oxynathus* (40,5%), *Barbastella barbastellus* (29,6%), *Eptesicus nilssonii* (25%). The only species that grew in number of specimens is *Myotis daubentonii* (32%). In the karst of Dobrogea since the 60s-80s, bat populations have declined dramatically. In the 60s -70s Bats Cave from Gura Dobrogei sheltered a birth colony of about 5000 exemplars of bats (Dumitrescu et al. 1962-1963, Valenciuc & Ion 1972), in 1974 sheltered a birth colony of about 7000 individuals (Cerveny 1982), currently the colony counts maximum 250-260 exemplars in the summer and 120-130 exemplars in winter (table 1). But in the recent winter seasons (2008-2009), winter colony fell to 20-30 individuals. The colony from the 60s-70s, of 5000 exemplars, consisted almost entirely of *Rhinolophus mehelyi*, which formed here the largest birth colony from Europe. In the 70s (Cerveny 1982) the birth colony of about 7000 individuals identified was composed of species: *Myotis oxygnathus, Miniopterus schreibersii, Rhinolophus ferrumequinum* and *Rhinolophus mehelyi*. Currently we have not seen any specimen of *Rhinolophus mehelyi* in the cave. Thus, in recent decades, the cave has fallen from level 1 to level 3 of conservation (fig. 8).

Same thing happened with Limanu Cave, which in the 60s sheltered a winter colony of about 5000 exemplars of *Rhinolophus mehelyi* (Dumitrescu et al. 1962-1963), the cave now houses a birth colony of about 150 exemplars of *Rhinolophus mehelyi* and *Myotis daubentonii*, in the winter there are few exemplars of the mentioned species. The cave has decrease from level 2 at level 3 of conservation (fig. 8).

Hagieni Tunnel did not have a high level of conservation (3), but here was identified for the first time in Dobrogea *Myotis capaccinii* (Răduleț 1994); one of the most rare species of Europe. Once forming here a birth colony, now the species disappeared. The current level of conservation is 4 (fig. 8).

Bat species that have declined drastically in the last decades, in the karst of Dobrogea, are: *Myotis capaccinii* (100%), *Rhinolophus mehelyi* (99%), *Miniopterus schreibersii* (96,5%), *Myotis oxygnathus* (95,6%) and *Rhinolophus ferrumequinum* (86,7%). The only species whose numbers increased, being seen in all the caves from Dobrogea is *Myotis daubentonii* (98,5%). Several temperate bat species have undergone rapid population decline in western and central Europe since the middle of the 20th century. Only in several species, notably in *Myotis daubentonii*, stable or increasing population numbers have been reported from the whole period of the second half of the 20th century until now (Řehak 1997, Uhrin et al. 2010). In the last five years, at Bats Cave from Gura Dobrogei, the winter colony of *Myotis oxygnathus* has decrease with 95,7% and *Rhinolophus ferrumequinum* species with 43,2%. At Tunelul Hagieni, the winter colony of *Miniopterus schreibersii* has disappeared (2009).

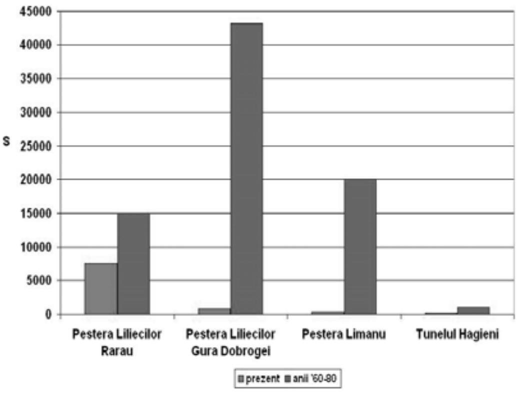


Fig. 8. S score calculated for four caves, now compared to 60s-80s.

Factors underlying the abundance variations and anthropogenic impact.

The Bats Cave from Rarău Mountain is the most important hibernacula from Eastern Romania, and the second from Romania, for the sibling species *Myotis myotis* and *Myotis oxygnathus* (Pocora et al. 2010, in press). Unlike other hibernation colonies, that disappeared almost completely (Limanu Cave, Bats Cave from Gura Dobrogei – Constanța county) (Ifrim & Pocora 2007), the colony from Bats Cave from Rarău Mountain has decreased to half. In the 60's, there was present a hibernation colony of about 7500 exemplars of *Myotis oxygnathus/Myotis myotis* (Valenciuc & Ion

1964). Arlettaz et al. (2000), specifies that, in the 80's the European populations of bats have decreased at half, possibly the main cause being the pesticides.In the 60s-70s, at Bats Cave from Gura Dobrogei there was a birth colony of about 5000-7000 exemplars. Now the colony counts 250-260 exemplars in the summer and 120-130 exemplars in winter (table 1).

In the last decades (2008-2009), the winter colony has decreased to 20-30 exemplars. In the 60s, *Rhinolophus mehelyi* formed in Bats Cave from Gura Dobrogei a birth colony of about 4000-5000 exemplars; number of individuals in the colony fell to 500, in 1974 and to 100-150, in 1979 (Cerveny 1982). In 2006-2008, at Bats Cave from Gura Dobrogei we did not met any specimen of *Rhinolophus mehelyi*.

Tourism generates a wide range of impacts upon such caves and the accompanying disturbances are known to pose a threat to hibernating bats (Kryštufek 2007). Rhinolophids and *Miniopterus schreibersii* often roost in very visible locations, making them even more vulnerable to disturbance by human visitors (Hutson *et al*., 2001). The changes in cave microclimate induced by frequent visiting by humans making fire and affecting bat shelters are proposed as the main factor of bat emigration (Smirnov et al 2007). The caves from Dobrogea are accessible, with no need for special equipment or training. Here, the speoturism affected the most bat communities (Bats Cave from Gura Dobrogei), followed by vandalism (Limanu Cave), lighting fires (Bats Cave from Gura Dobrogei, Hagieni Tunnel), waste disposal (in all the caves) or the deliberate killing of bats (Hagieni Tunnel). The changes were sometimes explained also by global climatic or environmental oscillations seeing that the development of bat numbers in hibernacula conspicuously correlated with annual variation of global temperature (Uhrin et al. 2010). Another cause of the disappearance of wintering colonies could be caused by changes in the microclimate of the caves. In Bats Cave from Rarău, unlike in the '60, the microclimate of the cave has changed a lot, from 2-2.4ºC (Valenciuc & Ion 1969) to 4.4-6ºC in the hibernation period 2005-2009, with some variations depending to the season. This also happened to the humidity which changed from 95-100%, in the 60's to 71-83% in 2005-2009 (Pocora et al. 2010, in press). In the past, at Toşorog Cave, in the area inhabited by bats, average temperature was 7.4ºC.

The humidity was generally higher, as it swings between 95% and 100% (Valenciuc 1972). Currently, the average temperature recorded in cave was of 10.1ºC and the humidity of 69.8% (table 4). At Bats Cave from Gura Dobrogei, seasonal variation in temperature occurs with highlights values only in spaces near entrances, while the temperature remains nearly constant at the end of the galleries, maintaining through the year between 9.5 and 11.5ºC, that is equal to the average annual air temperature in the region, humidity varies between 80 and 95% (Dumitrescu 1969). Currently in hibernation, temperatures extend between 8.7 and 17.7ºC, and humidity between 43 and 96% (table 4).

Our results suggest that there might be only one cave suitable for large bat aggregations in the Moldova area (Bats Cave from Rarău). In terms of undergrounds from Dobrogea, the only cave that in the past sheltered thousands of bats in summer (Bats Cave from Gura Dobrogei) does not have adequate protection, being the most affected cave by the tourism. Maybe if the cave will be closed, in time would restore the old colony of birth.

ABSTRACT

We investigated the distribution and abundance of the bats from the undergrounds in Moldavia and Dobrogea. Data was collected during 2002-2010. There were identified 20 species of bats (3-12 species/cave). In the undergrounds from Moldova area the dominating species are *Myotis myotis/Myotis oxygnathus* (71,5%), and in Dobrogea, *Myotis oxygnathus* (41,1%), *Myotis daubentonii* (24,1%), and *Miniopterus schreibersii* (16,7%).

The most important underground shelter is the Bats Cave from Rarău Mountains, which hosts a wintering colony of 3500-3700 individuals of *Myotis myotis/Myotis oxygnathus*, and in the warm season shelters 10 species of bats. We analyzed the microclimate preferences (for temperature and humidity), during hibernation, at 15 species of bats. Nowadays, from the undergrounds studied, only the Bats Cave from Rarău has an adequate protection and some populations of bats are seriously threatened or have disappeared.

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ANNEX

Table 1. Cave characteriscs and occurence of bat species observed during the study

Cons. level	Cave name	Altitude	Length	Date	*R.f.*	*R.h.*	*M.be.*	*M.m /M.o.*	*M.b/M.my*	*M.dau.*	*E.s.*	*E.n.*	*B.b.*	*P.aus*	*P.aur*	M.s.	Nr. sp.	Other species
2	Bats Cave from Rarău	1492	340	16.03.08 02.09.08	- -	- 2	- 1	3758 43	4 6	- 3	- -	- 1	- -	- -	- 5	- -	10	6 *M.na*
3	Mina No. 1 from Rarău	1504	955	04.01.07	-	-	1 -	53	5	3	3	12	47	-	3	-	10	
-	Mina lui Mantz	917	80	02.12.04	-	-	-	17	1	2	-	-	-	-	-	-	3	
4	Munticelu	934	120	26.02.08	-	3	-	65	-	2	-	-	-	-	2	-	5	
4	Toşorog	965	155	23.12.07	1*	9	-	61	-	-	-	-	7	-	-	-	5	
-	Avenul Mare	1638	208	28.03.03	-	-	-	40*+15	-	-	-	2	-	2	-	-	3	
4	Big Cave	322	120	15.03.05	-	-	18	14	9	28	1	-	1	1	4	-	12	5 *M.na* 1*M.das*
3	Bats Cave from Gura Dobrogei	45	480	14.12.06 17.06.07	37 5	- -	- 1	100 200	- -	6 22	- 9	- -	- -	- 5	1 1	3 65	9	1 *M.a.*, 1 *M.be*
-	Casian	50	58	09.02.07 25.09.08	2 1	- -	- -	2 13	- -	- 3	- 3	- -	- -	- 4	- -	- 2	7	2 *V.m.*
3	Limanu	26	3200	08.03.08 19.05.08	1 -	1 -	- -	- -	- -	2 100	- -	- -	- -	- -	- 1	- -	5	3 *R.m.* 50 *R.m.*
4	Hagieni Tunnel	11	131.5	08.03.08 14.05.07	- -	1 -	- -	- -	- -	- 10	- -	- -	- -	- 1	2 -	18 40	5	6 *M.e.*

Note: * exemplars found dead

(*Barbastella barbastellus – B.b., Eptesicus nilssonii – E.n., Eptesicus serotinus – E.n., Myotis aurascens – M.a., Myotis bechsteinii – M.be., Myotis brandtii – M.b., Myotis dasycneme – M.das., Myotis daubentonii – M.dau., Myotis emarginatus – M.e., Myotis myotis – M.m., Myotis mystacinus – M.my., Myotis nattereri – M.n., Myotis oxygnathus – M.o., Plecotus auritus – P.aur., Plecotus austriacus – P.aus., Vespertilio murinus – V.m., Miniopterus schreibersii – M.s., Rhinolophus ferrumequinum – R.f., Rhinolophus hipposideros – R.h., Rhinolophus mehelyi – R.m.*)

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