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Species structure of the bat community hibernating in Muierilor Cave (Southern Carpathians, Romania)

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Abstract. The winter community structure of bats visiting Muierilor Cave, Romania, was studied between 2004 and 2008. Field observations revealed the presence in the hibernacula of the following species: *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros*, *Myotis myotis/oxygnathus*, *Myotis emarginatus*, *Myotis daubentonii* and *Miniopterus schreibersii*. The hibernating bat assemblages were characterized by a significant dominance of *R. ferrumequinum* and *M. schreibersii*. During the eight visits conducted at Muierilor Cave in the winter months the maximum number of bats recorded was 2830. Our observations indicate that in spite of frequent disturbance arising from speleotourism, Muierilor Cave is one of the biggest and most important bat hibernacula in Southern Carpathians.

Key words: bats, winter community structure, Muierilor Cave.

Introduction

Caves all over the world are subject to major pressures which threaten bat populations. Main threats include: hydrological threats, land development (highways and buildings), vandalism (killing, over-collecting), chemical pollution (Elliott 2000, Elliott 2005), alteration of cave entrances and passages that change the cave microclimate. Because they consume night-flying insects, some of which are pests, bats have important economical and ecological value (Elliott 2005). Regarding most of the bat species occurring in Romania, it is very hard to establish population trends because of insufficient or incomplete data from past surveys (Jére et al. 2007). Thus, for long-term bat population monitoring, winter checks of bats inhabiting underground shelters are important (Řehák & Gaisler 2005).

The first written mention of the Muierilor Cave was made by Al. Odobescu in 1870. At the same time, the archaeological remains discovered there suggest that the cave was known to human populations starting with the Neolithic Age (Bleahu et al. 1976). The first observations of bats inhabiting Muierilor Cave were made in 1930 by Chappuis and Winkler (Chappuis & Jeannel 1951, Borda et al. 2006) (P. Muierilor (GJ) 1930.05.25., one male leg. Chappuis & Winkler, in ISERC no. 1380) and in 1951 by Dumitrescu et al. (1962-1963b). The cave was repeatedly visited over the next seven years, but observations regarding the bat fauna were made only during spring and summer seasons. For this period, the authors recorded the presence of four bat species: *Rhinolophus ferrumequinum*, *R. hipposideros*, *Myotis myotis/oxygnathus* and *Miniopterus schreibersii*. After that, the cave

came to bat researcher's attention only in 1974, when Bazilescu started a systematical research of the bat fauna from Oltenia (Bazilescu 1974). Unfortunately, these data cannot be used for quantitative comparisons as they are incomplete.

Muierilor Cave was included on the list of the *National bat monitoring program* starting with the year 2000 and the observations performed by Romanian Bat Protection Association have shown that this site has the largest aggregation of greater horseshoe bats in Romania, the population reaching up to 1,600 individuals in 2002 (Nagy et al. 2005; Szodoray-Parádi, pers. comm. 2005). The purpose of this study was to evaluate the species diversity and abundance and to analyze the pattern of spatial distribution of different bat species during hibernation in Muierilor Cave.

Materials and methods

Muierilor Cave (45°10'N, 23°46'E) is situated in the Getic Depression of Oltenia on the right slope of the Galben Gorges, 2 km North from Baia de Fier village at the relative altitude of 40 m (above the valley bottom) (Southern Carpathians, Romania). Muierilor Cave has 3,600 meters of galleries disposed on four levels. The upper level has a length of more than 1,200 m, the main gallery (573 m in length) being electrified and opened for the public since 1963. In the past, the access to the cave was possible by all three entrances, orientated North, East and South (Fig. 1). However, the Eastern entrance, which leads directly to the Altarului Hall, is obturated. Both remaining entrances have gates that prevent passage of bats.

Regarding the presence of the bats, the most important sectors of the upper level of the cave are the Altarului Hall, the Turcului Hall and the Guano Hall. Thus, the air temperature in the cave was recorded at these sites, and also in the Electrified Gallery, using a digital thermometer (type Cole Parmer; ± 0.1°C). The surveys at Muierilor Cave were conducted during eight visits which took place in three winter seasons. The cave was visited four times in the winter season 2004/2005 (in November 2004, and January, February and April 2005), once in 2006 (February) and three times in the winter season 2007/2008 (November 2007, and December and February 2008). During the count/estimation visits in Muierilor Cave bats were not handled, being identified to species based on their specific external morphological characters taking care to minimize disturbance. Isolated individuals and small clusters of individuals were counted directly. As for the larger aggregations, the number of individuals was estimated by multiplying the number of bats counted in an area of a certain dimension by the total area covered by the aggregation (Furman & Özgül 2004) or at home by counting the bats directly on the photographs that were taken. The latter method proved to be more accurate and also has the advantage that it greatly reduces observation time, while diminishing bat disturbance caused by prolonged exposure to light. Location of the bats within the cave was recorded in order to document the rooms and places along the Electrified Gallery that are used more often. In all sections of the cave it was possible to establish the species composition, the number and spatial distribution of bats, since Muierilor Cave is not abundant in crevices, hollows or niches.

Results

The air temperature in Muierilor Cave during the winter seasons of 2004/05 and 2007/08 and in February 2006 is presented in Figure 2. During the mentioned periods, the measured air temperature inside the cave ranged from 4.3°C in the Electrified Gallery to 8.9°C in Turcului Hall.

During the eight visits conducted at Muierilor Cave between 2004 and 2008 we found six bat species (Table 1): greater horseshoe bat (*Rhinolophus ferrumequinum)*, lesser horseshoe bat (*R. hipposideros)*, greater mouse eared bat/lesser mouse eared bat (*Myotis myotis/oxygnathus)*, Geoffroy's bat (*Myotis emarginatus)*, Daubenton's bat (*Myotis daubentonii)* and Schreiber's bat (*Miniopterus schreibersii)*.

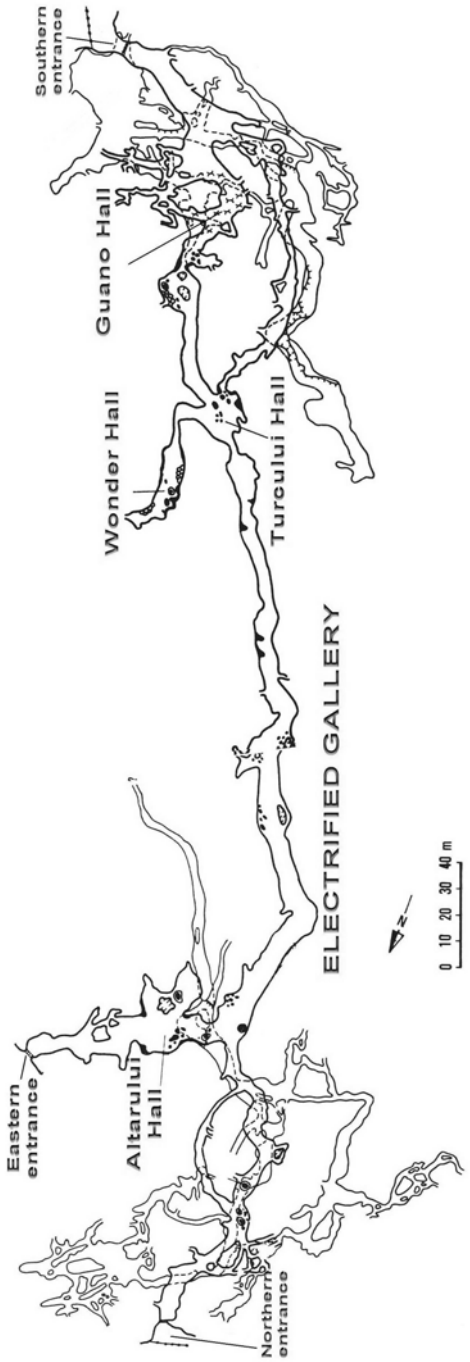

Figure 1. Map of Muierilor Cave (after Diaconu, Povară and Goran, Bleahu et al. 1976).

Rhinolophus ferrumequinum was the most numerous species hibernating in Muierilor Cave, with the maximum number of individuals concentrated in the Altarului Hall in February 2008. The distribution of *R. ferrumequinum* inside the cave is presented in Figure 3. Most hibernating greater horseshoe bats were present in aggregations of hundreds of individuals, and they were observed in the same site, the eastern wall of Altarului Hall in November 2004 and January 2005. Since February 2005, the colony moved on the north-eastern wall of the same hall. In 2006, most bats were gathered in a big aggregation occupying the north-eastern wall and only few individuals were hanging free in other parts of the hall. In November 2007 most of the bats were found hibernating in clusters of about 200 and respectively 400 individuals in the Electrified Gallery, at the entrance of the Turcului Hall and in the Guano Hall. Small clusters were also found in the Altarului Hall. In December 2007, three major aggregations, summing approximately 1,100 bats were found resting in the Turcului Hall, while in February most of the bats (95%) were occupying the southern wall of Altarului Hall. In all the recent data the smallest number of bats was recorded on the Electrified Gallery, possibly due to the low ceiling of the gallery or to the intense tourist activity.

Together with the greater horseshoe bat, *M. schreibersii* dominated the winter aggregations in Muierilor Cave during all our monitoring visits. Maximum number of Schreiber's bat was recorded in November 2007. The distribution of *M. schreibersii* inside the cave is presented in Figure 4. During the winter season 2004/2005 and in February 2006, all the bats were observed in the same location – Altarului Hall, either in

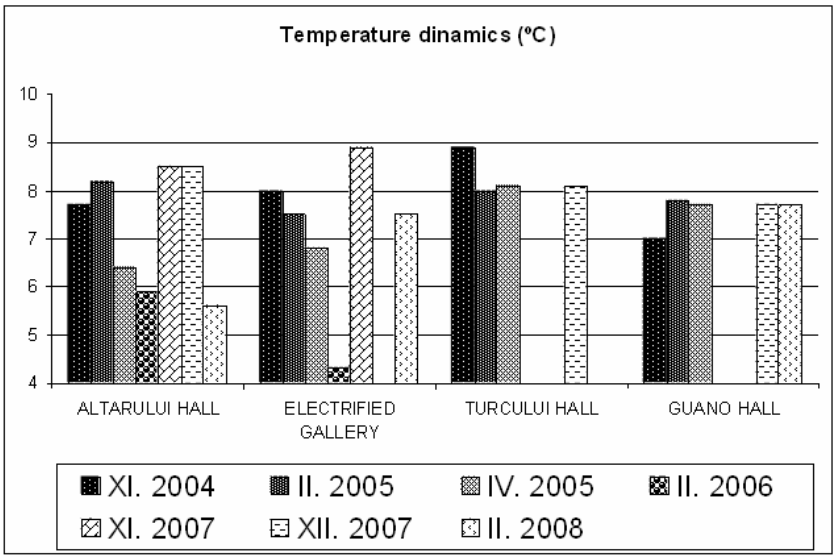

Figure 2. Temperature dynamics (°C) in different sections of the Muierilor Cave during bat hibernation seasons in 2004/2005, 2006 and 2007/2008.

Table 1. Species composition and abundance of bats hibernating in Muierilor Cave in the winter season 2004/2005, February 2006 and in the winter season 2007/2008
[Rh.f.= *Rhinolophus ferrumequinum*; Rh.h.= *Rhinolophus hipposideros*; My.m.= *Myotis myotis/oxygnathus*; My.d.= *Myotis daubentonii*; My.e.= *Myotis emarginatus*; Mi.s.= *Miniopterus schreibersii*].

Date	Rh.f.	Rh.h.	My.m.	My.d.	My.e.	Mi.s.	Total
30.11.2004	774	46	5	-	-	45	870
08.01.2005	791	39	6	-	-	50	886
19.02.2005	715	31	10	-	-	88	844
02.04.2005	685	16	4	-	-	417	1122
13.02.2006	1100	31	11	-	-	400	1542
10.11.2007	776	12	4	-	1	2038	2830
30.12.2007	1280	36	10	1	-	489	1815
16.02.2008	1639	43	4	-	1	402	2088

monospecific clusters or forming mixed aggregations with *R. ferrumequinum*. In November 2007, 91% of all Schreiber's bats were found in the Guano Hall, particularly occupying the southern wall of the 20 meters chimney. The rest of the Schreiber's bats were found in the Turcului and the Altarului Hall in monospecific clusters. With the following visits, beside the dramatic decrease in the number of *M. schreibersii,* a gradual movement of the bats inside the cave and towards Altarului Hall was also observed. In December 2007, 67% of all bats were found in the Turcului Hall and 32% in the Electrified Gallery not very far from the Turcului Hall. By the time of our last visit in February 2008, practically 99% of all Schreiber's bats had moved into the Altarului Hall.

The third most numerous species was the lesser horseshoe bat, with maximum number of individuals in November 2004. *R. ferrumequinum*, *M. emarginatus* and *M. daubentonii* were less abundant. Only few, solitary, greater mouse eared bats were found during our surveys dispersed from the Altarului Hall to the Turcului Hall. *M. emarginatus* and *M. daubentonii* were represented by single individuals and, since their frequency was less than 1%, they were excluded from further discussions.

Discussion

Muierilor Cave is one of the most important hibernacula in the Southern Carpathians, hosting the largest aggregation of *R. ferrumequinum* from Romania. Outside hibernation period the number of bats is very small and the cave is used rather as a day roost by solitary males than as a nursery shelter.

The temperature records for the caves used as hibernacula by *R. ferrumequinum* and *M. schreibersii* have demonstrated that these species prefer warmer places to spend the cold season (Ransome 1968, Borda et al. 2004). In the caves from the North-Western Romania, the greater horseshoe bat was found hibernating at temperatures varying between 8.5°C and 9.6°C and sometimes

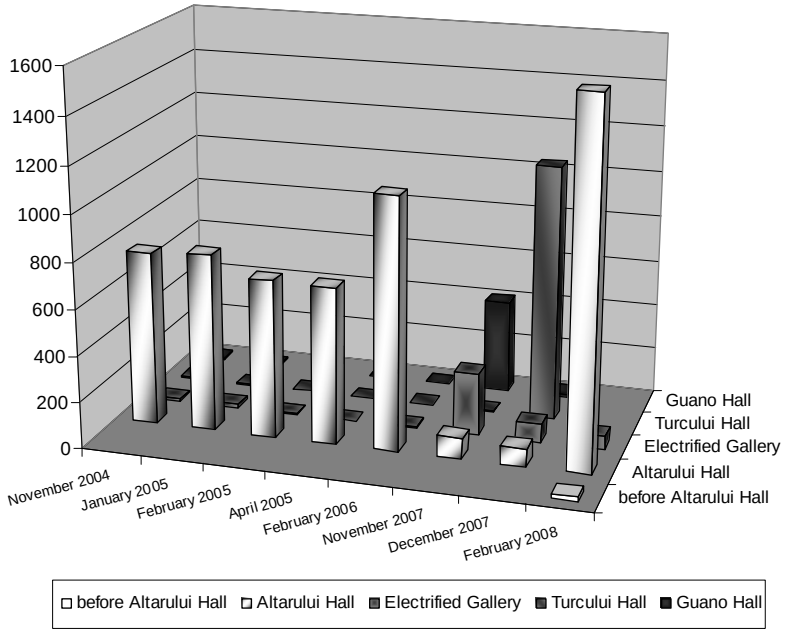

Figure 2. Distribution of *Rhinolophus ferrumequinum* inside Muierilor Cave during hibernation.

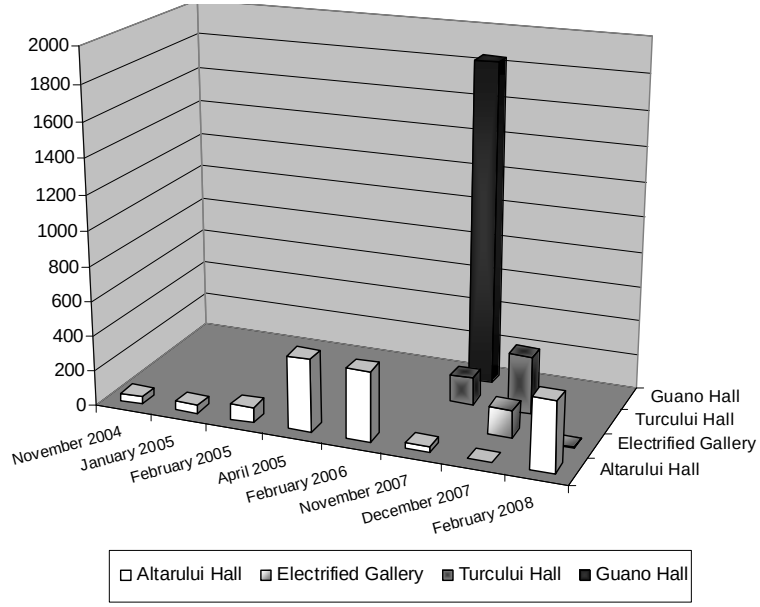

Figure 4. Distribution of *Miniopterus schreibersii* inside the Muierilor Cave during hibernation.

even at 3.6ºC (Szodoray-Parádi & Szántó 1998). According to Zukal et al. (2005), *R. hipposideros* prefers portions of the caves with very stable microclimatic conditions, the optimum temperature oscillating from 2°C to 14°C (Roer & Schober 2001). Instead, *M. myotis/oxygnathus* shows a great tolerance for variable temperatures inside the hibernation shelter (Borda et al. 2004). The study of some Romanian caves show that *M. myotis/oxygnathus* can hibernate at temperatures ranging from –2ºC to 9.5ºC (Dumitrescu et al. 1962-1963a, Borda et al 2004).

According to Ransome (Ransome 1968, 1971, Park et al. 2000), *R. ferrumequinum* selects those positions in the roost with fluctuating ambient temperature that will allow it to synchronise arousals with dusk and take advantage of foraging opportunities in mild weather. During wintertime, in Muierilor Cave, the most stable number of *R. ferrumequinum* was recorded in Altarului Hall. The temperature regime within this section of the cave, which is situated at a distance of 130 metres from the northern entrance, was similar to the optimal hibernation conditions of the greater horseshoe bats: 6-8ºC (Ransome & Hutson 2000).

As for *R. hipposideros*, the common roosting sites of this species in Central Italy are the narrow galleries and low vaults of natural or artificial caves where bats hang individually (Crucitti 1985; Crucitti & Cavalletti 2002). In all our research campaigns, the lesser horseshoe bat was found hanging freely mainly in the middle part of the upper level of the cave from Altarului to the Turcului Hall, especially on the lateral sides of the gallery in places where the ceiling went very low (70-80 cm).

Miniopterus schreibersii was the second most common species encountered during our study in Muierilor Cave. Before our investigations, the presence of *M. schreibersii* in Muierilor Cave was mentioned only for the maternity period. One of the main factors contributing to the increasing abundance of hibernating Schreiber's bat can be the gradual colonization of Muierilor Cave by the species. Other factors to be considered are the destruction or changes of the microclimatic conditions of other shelters used by *M. schreibersii*. The maximum number of *M. schreibersii* was recorded in November 2007, very close to the southern entrance, in the Guano hall. The sudden decrease in the following months (departure of over 75 % of all Schreiber's bats) suggests that Muierilor Cave was used by the majority of the bats recorded in this month as a temporary resting place during autumn dispersal.

Regarding the occupancy of the cave by the dominant species (Figs 3-4), in the winter of 2004/2005, bats mostly occupied the Altarului Hall, while in the first months of the hibernation period of 2007, the Guano and the Turcului Halls were preferentially occupied. These observations lead us to conclude that the access in the cave might be made through the southern entrance and as the winter months go by bats gradually move towards the Altarului Hall.

Bats have only a few natural enemies and although they may fall victim to natural factors such as flooding or rock falls, the greatest threat comes from human activities (McAney 1999). There are many publications pointing towards the anthropogenic factor responsible for trends in the significant decrease of bats abundance and range in past decades in Europe and in the rest of the world (Baranauskas 2001). Bats are very sensitive not only to the changes in

the microclimate of the hibernation sites but also to strong stimuli, such as light and noise. Rhinolophids and *M. schreibersii* often roost in very visible locations, making them even more vulnerable to disturbance by human visitors (Hutson et al. 2001, Kryštufek 2007).

As a result of our visits conducted between 2004 and 2008 at Muierilor Cave we have observed that the number of hibernating *R. ferrumequinum* and *M. schreibersii* has increased. Therefore, one can assert that the anthropogenic impact during winter to the bat fauna in past decades in Muierilor Cave is minimal. Presently, tourists visit the cave all year and the lighting system does not seem to greatly influence size of the bat population. One explanation might be that some species simply got used to the presence of tourists. Nevertheless, today there is little sign of the large nursery colony mentioned in the literature from the 1950's and 70's. It is plausible that the disappearance of this colony was caused by human disturbance during the visits that are more frequent in the summer and, therefore, the anthropogenic impact cannot be ignored in terms of noise, heat and light.

Muierilor Cave plays an important role as a hibernating site for the nationally vulnerable bat species *R. ferrumequinum*, *R. hipposideros* and *M. schreibersii*. It is also used by small numbers of the nationally endangered species *M. myotis/oxygnathus*, *M. daubentonii* and *M. emarginatus* (Murariu 2005). *Rhinolophus ferrumequinum*, *R. hipposideros, M. myotis/oxygnathus, M. schreibersii* and *M. emarginatus* are species of European importance being listed on the Annex II of the EU Habitats Directive (Council Directive 92/43/EEC). Moreover Muierilor Cave is part of the "Nordul Gorjului de Est" Natura 2000 site. Taking all this into consideration, it appears essential that special protection measures are applicable to future preservation of the bat community hibernating in Muierilor Cave. Restriction of the visitor's access and organizing visits outside the hibernation period should be considered as a future management priority.

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