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Assemblages of bats in deposits of the Dobšinská Ice Cave, Slovenský raj National Park, Slovakia

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Abstract. Skeletal remains of hibernating bats were collected in several parts of the Dobšinská Ice Cave, Slovenský raj National Park, Slovakia. In most samples, the composition of bat species is similar to the results of winter censuses held in the cave since the 1960s. *Myotis mystacinus* (40.3%) and *M. brandtii* (34.2%) are most abundant in the samples. *Barbastella barbastellus* (68.6%) is dominant in four samples of deposits from the Suchý dóm section. It can be assumed that in the period when a numerous winter colony of the latter species was present in non-glaciated lower parts of the cave, the place served as a food reserve of *Martes martes*. Bat assemblages in deposits of the neighbouring warmer caves of Duča and Stratenská jaskyňa are dominated by *Myotis myotis* (76.7%).

Cave asseblages, bat communities, thanatoceonoses

Introduction

In caves with high numbers of hibernating bats there are places with accumulated skeletal remains of bats, known as bat cemeteries or thanatocoenoses. Those found in the surface layer of cave sediments are supposed to be of recent to subfossil, i.e. Holocene age. The relative proportion of particular bat species in skeletal remains reflects the proportion of species hibernating in the cave in a certain period of time, depending on climatic conditions in the cave and its wider surroundings, where the bats spend the growing season. Some types of cave thanatocoenoses were described by Obuch (1994, 1995), presuming that they were *Martes martes* which caused accumulation of skeletal remains in the caves.

The Dobšinská Ice Cave ranks among the most important bat hibernacula in Slovakia with the highest numbers of wintering *Myotis mystacinus* and *M. brandtii* in Central Europe (Uhrin 1998). The material from this cave was very important in definition of the species *Myotis brandtii* (Hanák 1971). Analysis of osteological material from different parts of the cave confirmed slight prevalence of the numbers of *M. mystacinus* over *M. brandtii* (Horáček 1976), as indicated by captures of hibernating bats carried out in the beginning. Since that, the two bat species have not been distinguished during the regular winter censuses and total numbers of *M. mystacinus / M. brandtii* have been recorded (Bobáková 2002). Other collections of skeletal remains gathered in 1995–1997 confirmed the two species to be dominant in non-glaciated parts of the cave. In January 2006, the cavers broke through the ice to the Suchý dóm dome and a sample of bones was collected by P. Holúbek. Other samples were taken in December, some of them showing *Barbastella barbastellus* to be a dominant species.

Material and Methods

List of older collections (Fig. 1, Table 1):

Ho76: Horáček (1976), samples taken from 10 places in non-glaciated parts in 1971–1975;

Ob95: sample taken near the walls of the Vstupná chodba ["Entrance Corridor"] corridor, 14 February 1995 (Obuch 1995);

Ob96: samples taken from 3 places near the walls of the cave Part C, 29 January 1996;

Ob97: sample taken in the Kvapľová sieň ["Dripstone Dome"] dome, 26 January 1997;

R96: sample taken in the Pivnica ["Cellar"] corridor, 29 January 1996, leg. A. Reiter;

L95/6: collections of frozen bats near the corridor in the lower part of the tour route, 14 February 1995 and 29 January 1996.

Collections from the Suchý dóm ["Dry Dome"] dome (Table 2):

1: November 2006, coll. P. Holúbek, sample taken from the corridor 1.5m above the bottom;

2: 14 December 2006, sample taken in an elevated corridor along the right wall, 2 m in length, layer 0–10 cm;

3: 14 December 2006, sample taken in an elevated corridor along the left wall, 2 m in length, layer 0–10 cm;

4: 14 December 2006, on the bottom of the dome, left from the elevated corridor along the wall, 1 m in length, layer 0–5 cm;

5: 14 December 2006, on the bottom of the dome, 3m from the elevated corridor under the boulders;

6: 14 December 2006, on the bottom of the dome along the right wall with deposited soil, 2 m in length, layer 0–2 cm;

7: 14 December 2006, scattered recent skeletons of bats found on the bottom of the dome.

Duča cave: samples taken along the back wall of the main hall, 14 February 1995 (Obuch 1995) and 29 January 1996.

Stratenská jaskyňa cave: samples taken near the entrance door on 15 February 1995 (Obuch 1995) and about 20 m from the entrance on 28 August 2001. A part of this sample was analysed by Ižoldová (2003) and it is not included in Table 3.

Clean osteological material was obtained by rinsing the samples in water. Mammal skulls and mandibles, bird beaks, humerus, metacarpus and tarsometatarsus, amphibian os ilium and reptile jaw bones were sorted out for further analysis. Numbers of species were determined based on the most numerous bone. Calculation of values significantly deviated from the mean (+, –) in Tables 1–3 follows Obuch (2001).

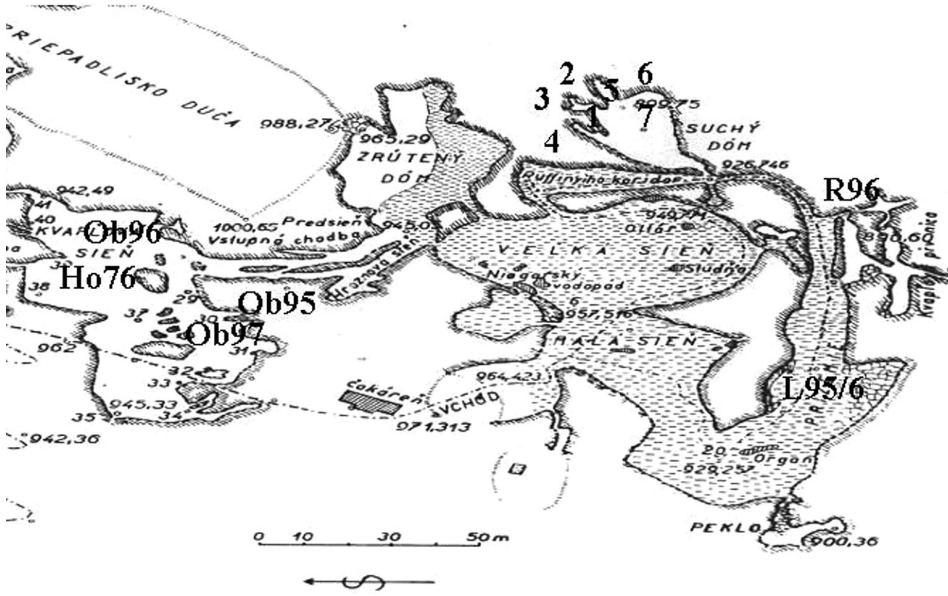

Fig. 1. Sites of collections of osteological deposits in the Dobšinská Ice Cave, see Material and Methods for explanations. Dashed areas – parts covered and/or filled by ice.

Table 1. Dobšinská Ice Cave, composition of previously collected samples from cave deposits. Legend: cave parts: KVS – Kvapľová sieň dome, VSC – Vstupná chodba corridor, ICE – glaciated parts of cave, PIV – Pivnica corridor; samples: o1996 – 29 January 1996, leg. J. Obuch, o1997 – 26 January 1997, leg. J. Obuch, o1995/1996 – findings in the ice in 1995 and 1996, r1996 – 29 January 1996, leg. A. Reiter

cave part species \ sampling	KVS Horáček (1976)	VSC Obuch (1995)	KVS o1996	KVS o1997	ICE o1995 /1996	PIV r1996	total	%
Talpa europaea			4	1			5	0.45
Sorex araneus			5				5	0.45
Sorex minutus			1				1	0.09
Sorex alpinus			1				1	0.09
Neomys fodiens			1				1	0.09
Rhinolophus hipposideros	1		1				2	0.18
Myotis mystacinus	215	1+ 108	1– 76	1+ 17	7	27	450	40.32
Myotis brandtii	200	81	83	2– 0	2	16	382	34.23
Myotis nattereri	4	3	6				13	1.16
Myotis bechsteinii	18	3	11				32	2.87
Myotis myotis	1+ 52	1– 3	1– 3	2			60	5.38
Myotis blythii	12	1	4				17	1.52
Myotis daubentonii	1			1			2	0.18
Myotis dasycneme	13		2				15	1.34
Eptesicus nilssonii	1		2		1	2	6	0.54
Barbastella barbastellus	1– 1	1	1+ 12	1		5	20	1.79
Plecotus auritus	40	1– 6	16	2	1	3	68	6.09
Sciurus vulgaris			1			1	2	0.18
Muscardinus avellanarius		1	1				2	0.18
Sicista betulina			1				1	0.09
Apodemus flavicollis			2	1			3	0.27
Clethrionomys glareolus	2– 0	1	1+ 16				17	1.52
Microtus subterraneus			4				4	0.36
Microtus agrestis		1	1				2	0.18
Martes martes		1	1				2	0.18
Mammalia	558	210	255	25	11	54	1113	99.73
Tetrastes bonasia			1				1	0.09
Turdus philomelos			1				1	0.09
Rana temporaria			1				1	0.09
Aves, Amphibia	0	0	3	0	0	0	3	0.27
total	558	210	258	25	11	54	1116	100.00
H’	1.51	1.15	2.13	1.18	1.03	1.28	1.70	

Results and Discussion

Horáček (1976) identified 59 individuals of *Myotis mystacinus* and 53 individuals of *M. brandtii*. In the remaining 303 individuals he could not distinguish between the two species. Therefore we divided the undistinguished individuals in the 59 : 53 ratio and in Table 1 we mention 215 ind. of *M. mystacinus* and 200 ind. of *M. brandtii* (415 ind. in total). *M. mystacinus* slightly prevails in the sample from Vstupná chodba collected in 1995, while *M. brandtii* is more abundant in that from the Kvapľová sieň dome from 1996. When all samples from different parts of the cave given in Table 1 are pooled, the overall dominance of *M. mystacinus* and *M. brandtii* is 40.3% and 34.2%, respectively. Horáček (1976) mentioned a relatively high proportion of *Myotis myotis*. The latter species was found only sporadically in the other osteological collections, but it has been abundant

Table 2. Dobšinská Ice Cave, composition of new samples from the Suchý dóm dome. See Material and Methods and Fig. 1 for definition of samples

species \ samples	1	2	3	4	5	6	7	total	%
Talpa europaea		1	1					2	0.06
Sorex alpinus		1						1	0.03
Myotis mystacinus	80	2– 60	1– 83	1+ 124	1+ 77	2+ 36	1+ 8	468	15.08
Myotis brandtii	1– 62	1– 80	1– 65	2+ 264	1– 23	1– 3		497	16.01
Myotis nattereri	3	1	2					6	0.19
Myotis bechsteinii	3	9	1+ 12	2	1			27	0.87
Myotis myotis			1					1	0.03
Myotis blythii				1				1	0.03
Myotis dasycneme	1							1	0.03
Eptesicus serotinus					1			1	0.03
Eptesicus nilssonii	2	15	10	2		1		30	0.97
Nyctalus noctula					1			1	0.03
Barbastella barbastellus	378	1+ 778	511	3– 36	1– 89	2– 10	1– 0	1802	58.05
Plecotus auritus	46	67	65	43	13	1+ 10	2	246	7.93
Muscardinus avellanarius						1		1	0.03
Clethrionomys glareolus		2	1	1	2			6	0.19
Martes martes	1	3	1					5	0.16
Mammalia	576	1017	752	473	207	61	10	3096	99.74
Turdus philomelos					2			2	0.06
Parus major					1			1	0.03
Loxia curvirostra		1						1	0.03
Passeriformes sp.				1				1	0.03
Bufo bufo						1		1	0.03
Rana temporaria					1			1	0.03
Lacerta vivipara		1						1	0.03
Aves, Amphibia, Reptilia	0	2	0	1	4	1	0	8	0.26
total	576	1019	752	474	211	62	10	3104	100.00
H’	1.09	0.92	1.10	1.18	1.36	1.25	0.50	1.26	

during winter censuses carried out since the 1960s (Bobáková 2002). We thus assume that there is a more common recent occurrence of the species in the cave and the samples collected by Obuch in 1995–1997 comprise osteological remains from the older subrecent period. *Plecotus auritus* (6.1%) and *Myotis bechsteinii* (2.9%) are relatively abundant species with even representation in all samples. During winter censuses especially in the non-glaciated parts of the cave, *Eptesicus nilssonii* was rather common. Findings of skulls of the pine marten suggest that the accumulated bat bones are non-consumed remains of their food reserves (Obuch 1995). This is also evidenced by occurrence of other species of mammals, birds and frogs which were brought to the cave by pine martens from outside. During winter censuses, altogether 10 bat species were recorded, and additional two species were found sporadically in cave deposits: *Rhinolophus hipposideros* and *Myotis daubentonii*. In 2006, cavers from the Nicolaus caving club cut through the 1 m thick layer of ice to get to Suchý dóm, and they took out remains of wooden construction and sawdust coming from the year 1871, when the cave was made accessible to the public for the first time. During the event of the Carpathian club in October 1925, a large number of bats was recorded in the lower non-glaciated part (Lalkovič 1994). In December 2006, *M. mystacinus*, *M. brandtii* and *Eptesicus nilssonii* were found hibernating in the Suchý dóm section. On the bottom of the dome, skeletons of *M. mystacinus* and *P. auritus* (sample no. 7 in Table 2), which died in previous years, were found. This suggests

that the bats can access these spaces even after the upper opening got glaciated. The dominant species *B. barbastellus* is abundant in samples nos. 1, 2 and 3 from the elevated side corridor and in no. 5 which was collected on the bottom of the dome under this corridor. Skeletal remains of the pine martens were also found in the corridor. The martens caused accumulation of the bones in the period when a numerous colony of *B. barbastellus* hibernated in the lower parts of the Dobšinská Ice Cave. Bones in samples nos. 4 and 6 were deposited by water towards the lower margin of rock walls of the bottom of the Suchý dóm section. *M. brandtii* is the most abundant species in sample no. 4, while *M. mystacinus* in sample no. 6. The latter two samples correspond with the proportion of bat species in deposits from the other parts of the cave, given in Table 1. Sample no. 5 includes *Nyctalus noctula* and *Eptesicus serotinus*, which have not been recorded in the Dobšinská Ice Cave so far. Samples nos. 4, 6 and 7 from Suchý dóm and older osteological collections from other parts of the Dobšinská Ice Cave are characterised by dominance of *M. mystacinus* and *M. brandtii*. The relative proportion of species in these thanatocoenoses resembles recent results of winter censuses of bats. Samples nos. 1–3 and 5 from Suchý dóm document occurrence of an abundant hibernating colony of *B. barbastellus* in the lower parts of the Dobšinská Ice Cave in the past. Similar findings of bat thanatocoenoses are available from some parts of the Demänovská Ice Cave (Obuch 2000, 2009), where *B. barbastellus* dominates along with *P. pipistrellus*, while none of these two species hibernates there at present. A common recent hibernaculum of the two species was found in the Dielik tunnel in the Muránska planina Mts. in the 1990s (Uhrin et al. 2002), however, the roost was suddenly abandoned by the bats in 1999 due to numerous visits of the tunnel. A similar thing might happen if the Dobšinská and Demänovská Ice Caves were made accessible to the public.

In the vicinity of the Dobšinská Ice Cave, there are two caves with a warmer climate, Duča and Stratenská jaskyňa. During winter censuses, *M. myotis* dominates in both caves and numbers of *R.*

Table 3. Dobšinská Cave System, comparison of three deposite sites. Legend: SD – Suchý dóm dome, samples nos. 1, 2, 3 and 5, DIC – Dobšinská Ice Cave, the samples from Tables 1 and 2 other than under SD, Duča – Duča cave, Stratenská – Stratenská jaskyňa cave; for details see also Material and Methods

species \ site	SD		DIC		Duča		Stratenská		total	%
Barbastella barbastellus	1+	1756	3–	66	5–	1	6–	0	1823	37.59
Myotis mystacinus	1–	300	1+	618		48	3–	9	975	20.10
Myotis brandtii	1–	230	1+	649	2–	15	3–	4	898	18.52
Myotis blythii	2–	0	1+	18		1		4	23	0.47
Clethrionomys glareolus	1–	5	1+	18				4	27	0.56
Myotis dasycneme	1–	1	1+	15				3	19	0.39
Rhinolophus hipposideros	1–	0		2	1+	7		4	13	0.27
Myotis myotis	6–	1	2–	60	3+	191	3+	292	544	11.22
Myotis bechsteinii	1–	25		34		1	1+	14	74	1.53
Myotis nattereri	1–	6		13		3		1	23	0.47
Plecotus auritus		191		123	2–	4	1–	10	328	6.76
Eptesicus nilssonii		27		9		1			37	0.76
Sorex araneus	1–	0		5				4	9	0.19
Talpa europaea		2		5				1	8	0.16
Martes martes		5		2					7	0.14
Microtus subterraneus				4				2	6	0.12
Mammalia		2552		1657		272		355	4836	99.71
Aves		4		3		0		1	8	0.16
Amphibia, Reptilia		2		2		0		2	6	0.12
total		2558		1662		272		358	4850	100.00
H’		1.09		1.61		1.00		0.93	1.75	

hipposideros have been increasing. Composition of bat species in the thanatocoenosis from the Duča cave corresponds with the results of winter censuses, suggesting its recent age. In the Stratenská jaskyňa cave, remains from a fresh pine marten food reserve were collected in 1995 (Obuch 1995), but the sample from 2001 comes from the period before discovery of the cave in 1972, when the abundance of hibernating *R. hipposideros* was lower than recently recorded during winter censuses (Hájek et al. 2002). The tawny owl (*Strix aluco*) also hunted bats near the entrances to both caves. In owl pellets found at the entrance to the Duča cave, dominance of bats reached 22%, while even 89% in older bones from a rock window above the current entrance to the Stratenská jaskyňa cave (Obuch 1998).

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