



NOTEWORTHY HIGH-SITUATED BAT BONY ASSEMBLAGE (CHIROPTERA) IN THE ALPS (LEOGANG STEINBERGE MASSIF, AUSTRIA)

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Noteworthy high-situated bat bony assemblage (Chiroptera) in the Alps (Leogang Steinberge Massif, Austria). The authors described bat thanatocenosis found in CL-3 cave which entrance is situated at 2346 m a.s.l. (Leogang Steinberge Massif, Austrian Alps). It is one of the highest-situated bat thanatocenoses in Europe. In the collected material two bat species from Vespertilionidae family were identified: *Myotis bechsteinii* (7 individuals) and *Myotis mystacinus* (27 individuals). Remains of *Plecotus* sp. were found, either. The age of this bat bony assemblage is discussed.

Key words: bat thanatocenoses, altitudinal distribution, *Myotis bechsteinii*, *Myotis mystacinus*, *Plecotus* sp.

1. Introduction

In the literature describing bat thanatocenoses from caves in the Alps there is little information on the occurrence of chiropteran remains in the alpine belt (e.g. JORDI 1978, AMELIO & BONZANO 1986, DÖPPES *et al.* 1997). The majority of information on the Austrian Alps from the very rich literature concerning chiropteran thanatocenoses refers to caves situated up to 1800 m a.s.l. (timberline in Northern Alps) (e.g. BAUER 1973, BAUER & MAYER 1983). In cave sediments at higher altitudes, remains of just single bat specimens were found (e.g. BAUER 1995, CECH *et al.* 1997, DÖPPES *et al.* 1997, RABEDER 1997).

2. Materials and Study Site

CL-3 cave is located in Leoganger Steinberge, a small mountain massif in Northern Calcareous Alps, ca. 40 km south-west of Salzburg (Fig. 1.). It was discovered by Polish cavers in 1996. Its entrance is situated at 2346 m a.s.l., 60 m above the Lamprechtsofen

System – the third deepest cave in the world (1632 m of vertical range). CL-3 is a typical alpine-type cave, with spacious vertical pitches, and horizontal passages or galleries. The length of discovered corridors is ca. 7000 m and denivelation 748 m (CISZEWSKI 2001, CISZEWSKI & KLAPPACHER 2007). In this cave, in the beginning of horizontal sections situated 170 m below entrance (2176 m a.s.l.), in “In a Wrong Direction Gallery” and in “Bat Room” (320 m below opening) deposits containing bat remains were found. In late July and early August 2000 during several surveys two samples were collected. Bones were taken from the surface of the cave floor or from under a clastic sediments, unfortunately they are of no stratigraphic value. Both samples were collected under low stiles and their nearest vicinity. The majority of bone material was well preserved and did not bear any trace of water transposition and corrosion. The osseous remains were exceptionally fragile (even at small pressure the hardest parts of cranial skeleton, e.g. the canines, went to pieces), some bones were covered with calcite.



Fig. 1. Location of the study site in Austria.

3. Results

In the collected osteological material 44 cranial parts of bat skeleton belonging to at least 35 individuals were found (Minimum Number of Individuals – MNI=35). Two bat species from the Vespertilionidae family were represented: the whiskered bat, *M. mystacinus* (Kuhl, 1817) and the Bechstein’s bat, *M. bechsteinii* (Kuhl, 1817). Also remains belonging to genus *Plecotus* were collected.

M. bechsteinii – well preserved two crania, four rostra, two fragments of rostrum, and fragment of left mandible were identified in the deposit (MNI = 7).

M. mystacinus – well preserved 9 crania, 26 rostra and rostral fragments, and 9 mandible and mandibular fragments were recovered (MNI = 27).

Plecotus species indeterminate – this taxon is represented in the fauna of CL-3 by a single specimen: fragment of left mandible containing canine, M_2 plus alveoli for P_1 - M_1 . Lack of cranial distinguishing features do not allow us for more precise identification of this specimen (see also discussion).

First sample collected in „In a Wrong Direction Gallery” includes remains of four individuals of *M. mystacinus* and one specimen of *M. bechsteinii*, the second sample – bones of the remaining bats.

4. Discussion

The characteristic feature of this chiropteran assemblage is the high number of remains of *M. mystacinus* – species, which in the thanatocenoses of mountain caves in Central Europe and the Alps is often recorded (e.g. RABEDER 1973, RYBÁŘ 1979, MOREL 1989, PIKSA & WOŁOSZYN 2001). However, only in the highest-situated objects it is the most numerous species (JORDI 1978, MOREL 1989, OBUCH 1985, 1995, PIKSA & WOŁOSZYN 2001). For example, in seven high-situated caves (above 1580 m a.s.l.) in the Swiss Alps this species accounts for over 42% of all the recorded bats, and in one cave it reaches as much as 74,3% (MOREL 1989). Similarly, in the highest-situated caves in the Polish part of the Tatras (above 1770 m altitude) it is the most numerous – approximately 67% of all bats (PIKSA & WOŁOSZYN 2001). In the deposits of high-situated caves of the Austrian Alps *M. mystacinus* is recorded often, yet less numerous. Its share does not exceed 25% (e.g. BAUER 1973, BAUER & MAYER 1983).

Among European bats, the whiskered bat is distinguished by a very wide spectrum of altitudinal range (TUPINIER 2001). Its remains were found in cave deposits in the Austrian Alps at an altitude of 2250 m (RABEDER 1997), in the Ligurian Alps at 2435 m a.s.l. (AMELIO & BONZANO 1986) and in Swiss Alpine cave Rottalhöhle at an altitude of 2480 m (JORDI 1978).

The assemblage of CL-3 cave was probably formed in the post-glacial period. This assumption is based on numerous occurrence of remains of the whiskered bat which, according to HANÁK (1970) and WOŁOSZYN (1970), settled Europe in the post-glacial period.

Noteworthy is a relatively large number of *M. bechsteinii* remains in the collected sample. Its presence presumably indicate Atlantic, Subboreal or later age of the assemblage. *M. bechsteinii* was widely distributed in the eastern Alps from Older Atlantic to Younger Subatlantic periods, the oldest records are from Bölling-Alleröd (SPITZENBERGER & BAUER 2001). Similarly in other mountain ranges, the Bechstein's bat reached its largest number during so-called “forest optimum” in the Tatra caves in Poland (PIKSA & WOŁOSZYN 2001) and in caves in various regions of Slovakia (OBUCH 1994). In this period on a given area there was an old growth of broad-leaved woodland, which this tree-dwelling bat is mostly dependent on.

It appears that the most probable and significant reasons for the decline of the Bechstein's bat in Europe are not only climatic changes, as WOŁOSZYN (1970) supposed, but also, or perhaps mainly, anthropogenic changes: deforestation and alteration of forest

stands (e.g. BAUER 1987, STEBBINGS 1988, OBUCH 1994, HORAČEK 1995, PIKSA & WOŁOSZYN 2001). This hypothesis is confirmed e.g. by the data from the Dinaric Alps (KRYŠTUFEK & ČERVENY 1997). Nowadays, despite climate cooling (in relation to climatic optimum of the Holocene), in undisturbed forests of that south-eastern European region *M. bechsteinii* is one of the most numerous bat species.

Thus during its optimal development in the Holocene *M. bechsteinii* reached much higher than today. Nowadays, in European caves *M. bechsteinii* was captured in pre-hibernal period at an altitude of 1800 m (MAGNIN 1991). The highest in Europe in winter it was observed in the Polish Tatra Mountains at 1410 m a.s.l. (PIKSA & NOWAK 2002). In the Austrian caves in winter it reaches up to an altitude of 1160 m (SPITZENBERGER & BAUER 2001).

CL-3 cave is the highest-situated site of this species in Austrian caves and one of the several highest-situated in Europe. To date in the Austrian Alps the species was often recorded in cave deposits up to 1800 m a.s.l. (e.g. BAUER 1973, BAUER & MAYER 1983), it was also found at an altitude of 2160 m (SPITZENBERGER & BAUER 2001). In caves of the Swiss Alps its remains were found at 2000 m a.s.l. (MAGNIN 1989). The highest-situated cave in Europe with deposits containing bones of this species is Abisso dei Caproschi cave at an altitude of 2435 m in the Ligurian Alps (AMELIO & BONZANO 1986).

It was surprising to find that remains of *Plecotus* were so sparsely represented. So far in thanatocenoses from the highest-situated caves in the Alps the brown long-eared bat *P. auritus* (Linnaeus 1758) was almost as numerous as whiskered bat, and sometimes even more numerous. Its share in some high-lying thanatocenoses of caves in the Swiss Alps exceeds 35% (MAGNIN 1991), and occasionally reaches 43% (MAGNIN 1989). In the deposits of high-situated caves in the Ligurian Alps *P. auritus* is the most numerous species and its number exceeds even 70% (AMELIO & BONZANO 1986). As in the case of the other two species, its remains were found in cave deposits situated very high: in the Ligurian Alps at an altitude of 2435 m (AMELIO & BONZANO 1986) and in the Swiss Alps at 2480 m a.s.l. (JORDI 1978).

CL-3 cave is one of the highest-situated chiropteran thanatocenoses which have already been discovered in European caves. The highest in caves of Europe, bat bones were found e.g. in Abisso dei Caproschi cave at 2435 m a.s.l. (AMELIO & BONZANO 1986) and in Rottalhöhle in Jungfrau Massif at an altitude of 2480 m (JORDI 1978). However, the numbers of bat remains found in these two objects are much lower: 8 and 6 individuals, respectively.

Small amount of data concerning the past and present occurrence of bats in the highest-situated caves in Europe results mostly from lack of investigations in these objects or their limited scale. For most chiropterologists penetration of caves (many of which are vertical systems of vacua) is especially difficult as it requires using of specialistic spelaeon techniques and equipment. Moreover, probability of discovering deposits containing chiropteran remains is very low. Factors such as: (i) intensive water corrosion, (ii) high intensity of denudation processes, (iii) fast accumulation and deposition of sediments as well as (iv) the type of rock vacua and their huge size cause that bat remains, which are organogenic allochthonous deposits, are quickly damaged or difficult to find.

The fact that high-situated caves have been and still are used by bats is confirmed by the above data as well as by accidental observations of the recent fauna. For example,

in caves of the Slovenian Alps *P. austriacus* (FISCHER, 1829) was recorded in the ice cave: Ivačičeva Jama at an altitude of 2450 m (KRYŠTUFEK 1989). It seems that penetration of this kind of the highest-lying objects would result in further discoveries; however, it requires great expenditure of work.

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