



Upward Trends in Some Bat Populations from Central Poland between 2000 and 2023 Revealed in Small Hibernacula

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Abstract: Results of a long-term study conducted in large bat hibernacula of central Europe showed upward trends in populations of many species over the last three decades. This study was aimed to check if similar changes in numbers could be observed in smaller underground winter roosts of bats. Surveys were made in three military shelters near Warsaw between 2000 and 2023 (once a year in February). These roosts hosted relatively small number of hibernating individuals (up to 38). Six bat species were recorded: *Myotis nattereri*, *Myotis daubentonii*, *Eptesicus serotinus*, *Plecotus auritus*, *P. austriacus* and *Barbastella barbastellus*. The species preferring cold sites for hibernation (*P. auritus* and *B. barbastellus*) predominated in the studied roosts, representing together over 86% of the recorded individuals. The numbers of the two most abundant species and of all bats showed statistically significant upward trends.

Key words: Chiroptera, hibernation, changes in numbers, military shelters

Introduction

Several studies on bat abundance in large winter roosts showed that many populations of central European bats have increased in numbers over the last three decades (LESIŃSKI et al. 2005, FUSZARA et al. 2010, HORÁČEK 2010, LESIŃSKI 2010, UHRIN et al. 2010, LESIŃSKI et al. 2011, SPITZENBERGER & ENGELBERGER 2013, KOKUREWICZ et al. 2019, BATOR-KOŁO & CICHOCKI 2020, WĘGIEL et al. 2021). *Rhinolophus hipposideros*, *Myotis myotis*, *M. nattereri* and *Barbastella barbastellus* were the species characterised by clear upward trends.

Small underground hibernacula were rarely used to track population trends in bats. In some

parts of Europe, especially the cooler ones, countryside cellars are common and abundant winter roosts (MASING 1983, RYDELL 1989, LESIŃSKI et al. 2004). Eight bat species were found to hibernate in small cellars of NE Poland (LESIŃSKI et al. 2004). Bats use also small underground roosts in military shelters.

The aim of this study was to test predictions that recovery processes in central European bat populations over the last decades could be observed also in relatively small hibernacula.

Materials and Methods

The study was conducted in three military shelters situated at site of Natura 2000 PLH140034 “Poligon

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Rembertów” close to the eastern outskirts of Warsaw agglomeration (central Poland). The area was covered mostly by coniferous forests with dunes and small marshes (Rembertów-Okuniew Forest). The selected bat roosts comprised several rooms, which were built of bricks. They were underground structures covered by a soil layer (Fig. 1) and localised on the area of ca. 1 ha. Shelters I and II were very similar, each consisting of eight rooms and small entrance corridors (total floor area ca. 150 m²). Shelter III was smaller, i.e. a large room with a small



Fig. 1. The entrance to the military shelter under study.

entrance corridor (total floor area ca. 50 m²). The height of all rooms was ca. 2.5 m. Hibernacula under study were abandoned by people in late 1970s.

Surveys were performed once in the hibernation period of bats, in the first half of February in the years 2000–2023 (except 2010–2012, 2014 and 2016). Bats were counted and were identified to the species level without removing from the walls and crevices. Regression analysis was used to estimate significance of trends in the number of hibernating individuals in subsequent years. Statistica ver. 13.3 was used for calculations; the adopted significance level was $p = 0.05$.

Results

Six bat species hibernated in roosts under study with clear domination of *Plecotus auritus* and *B. barbastellus* (together over 86%). The contribution of species from the genus *Myotis* (*M. nattereri* and *M. daubentonii*) was relatively low (10.3%). Remaining species (*Eptesicus serotinus* and *Plecotus austriacus*) were least frequent and both constituted 3.5% of all bats (Table 1). Moreover, three individuals whose species was not determined were observed.

Bats showed upward trends over the study period covering 24 years. It was proved for all species and for the two most abundant ones. Slightly stronger relationship was recorded for *P. auritus* compared to *B. barbastellus* (Fig. 2). For two species of the genus *Myotis*, which were analysed together, significant but weak relationship was found ($R^2 = 0.22$, $F = 10.8$, $p = 0.002$).

Discussion

Bats, which prefer to hibernate at low temperatures (*E. serotinus*, *P. auritus*, *P. austriacus* and *B. barbastellus*), clearly dominated in roosts under study (near 90%). *Barbastella barbastellus* is frequently noted in places with air temperatures below 0°C

Table 1. Species composition of bats hibernating in military shelters (I–III) under study (results of all surveys were combined).

Species	I	II	III	Total	%
<i>Myotis nattereri</i> (Kuhl, 1817)	7	10	0	17	6.5
<i>Myotis daubentonii</i> (Kuhl, 1817)	3	7	0	10	3.8
<i>Eptesicus serotinus</i> (Schreber, 1774)	0	2	0	2	0.8
<i>Plecotus auritus</i> (Linnaeus, 1758)	83	54	6	143	54.8
<i>Plecotus austriacus</i> (Fischer, 1829)	3	4	0	7	2.7
<i>Barbastella barbastellus</i> (Schreber, 1774)	47	35	0	82	31.4
Total	143	112	6	261	100.0

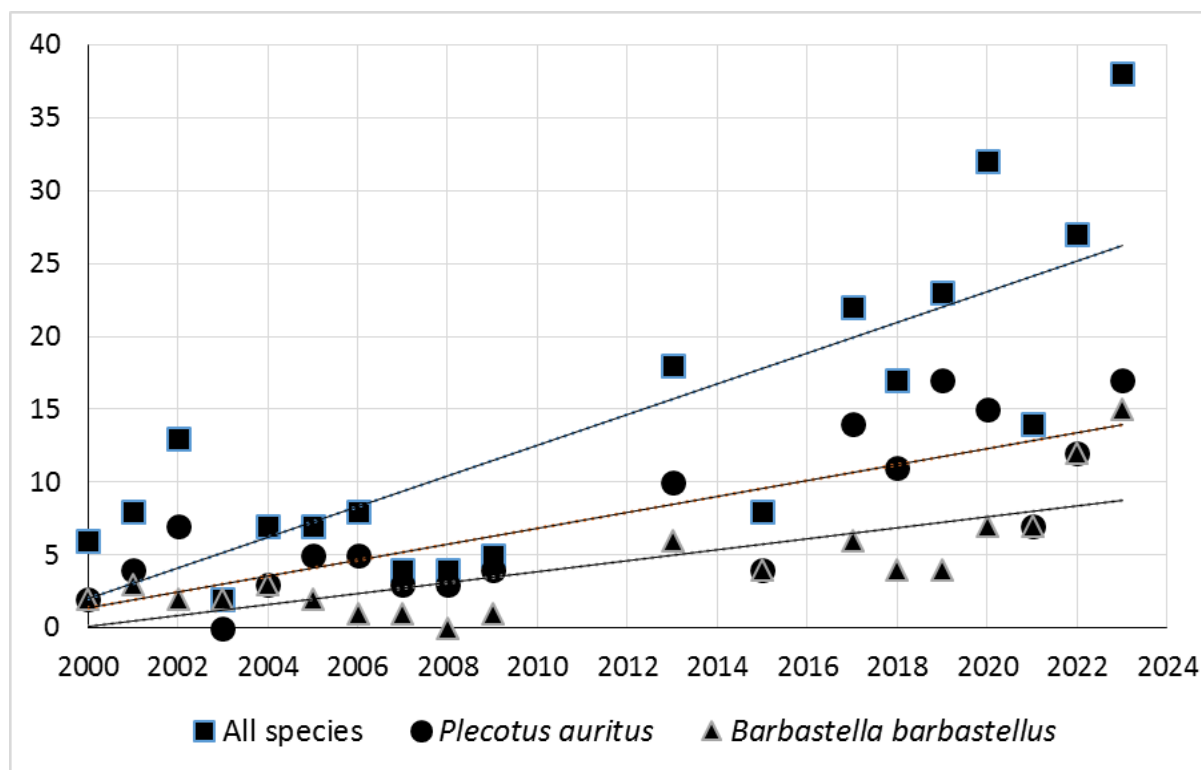


Fig. 2. Trends in abundance of all species and two bat species in sites under study between 2000 and 2023. $N = 19$. All species: $R^2 = 0.59$, $F = 49.8$, $p < 0.001$; *Plecotus auritus*: $R^2 = 0.60$, $F = 52.0$, $p < 0.001$; *Barbastella barbastellus*: $R^2 = 0.54$, $F = 41.1$, $p < 0.001$

(LESIŃSKI 1986, URBĄCZYK 1991, RYDELL & BOGDANOWICZ 1997). In addition, bats of the genus *Plecotus* are known to select relatively cool roosts for hibernation (HORÁČEK 1975, LESIŃSKI 1986, SIIVONEN & WERMUNDSEN 2008).

Upward trends observed in the last decades in central Europe (HORÁČEK 2010, UHRIN et al. 2010, LESIŃSKI et al. 2011, SPITZENBERGER & ENGELBERGER 2013, BATOR-KOŁO & CICHOCKI 2020) were confirmed in small underground roosts in the present study. *Plecotus auritus* was also reported to increase in numbers in the Szachownica Cave in Poland (LESIŃSKI et al. 2011). Similarly, *B. barbastellus* had increasing numbers in several Polish roosts (LESIŃSKI et al. 2005). The latter species showed a similar pattern in winter roosts of Czechia (HORÁČEK 2010).

Plecotus auritus is known to hibernate in small winter roosts, mostly cellars (MASING 1983, LESIŃSKI et al. 2004). Therefore, long-term changes in the number of individuals of this species in hibernacula are rarely recorded. Our study is a unique example of monitoring of this species conducted in small roosts over a period lasting 24 years.

It is difficult to interpret unambiguously the increasing numbers of bats in winter roosts described in the recent decades mainly in central Europe. One

of the reasons recognised in the studies on the restoration of bat populations is the abandonment (or substantial limitation) of the use of very toxic plant protection chemicals (LESIŃSKI et al. 2011, WĘGIEL et al. 2021). A positive effect of climate warming on bats associated with the increasing food resources (small invertebrates) cannot be excluded. However, it is noteworthy to mention that milder climate affects the microclimatic conditions in wintering grounds and makes them less attractive to bats, which prefer colder sites for hibernation. In the latter cases, the changes in the number of bats observed in some winter roosts may not fully reflect population trends in a given area (GOTTFRIED et al. 2020, DE BRUYN et al. 2021). It is also possible that some species have already completed the restoration of their populations after the drastic decline in the last decades (DZIĘCIOŁOWSKI et al. 2022).

Conclusion

The observed upward trends in bats wintering in the study area should be interpreted carefully because they could be caused by many reasons. Bat monitoring in the future will be able to show when the restoration processes in local populations will end due to limited resources.

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