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HIDING BEHAVIOUR OF BATS IN SANDSTONE MINES OF NORTH-EASTERN UKRAINE

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Abstract.

*Winter counting of bats in hibernacula is one of the main methods of estimating their population trends in Europe. However, it is not always possible for humans to identify and count all bats in the maze of big karstic caves or abandoned mines. Previously we notice a significant fluctuation in the numbers of bat species and individuals in sandstone mines located in the Kharkiv region (NE Ukraine), and hypothesized that a significant undercount happened due to the hiding of bats in deep crevices of sandstone. Here using a camera trap placed inside a mine (September 17-19, 2017) we tested this hypothesis. Firstly, we identified significant levels of bat flight activity where no roosting bats had been observed through conventional visual survey methods. The proportion of identified bats (*Myotis *group and* Plecotus auritus*) on footage was similar to that obtained by usual winter counts. Finally, we filmed and documented cases of crawling bats inside the deep crevices in the wall depths. We ventured to make an extrapolation of bat numbers in a mine on the basis of autumn-spring mist-netting data, and our evidence that they do hide in crevices. Our observations clearly demonstrate that hiding bat behaviour in mines might result in an underestimation of the real number of hibernating bats in sandstone mines.*

Key Words: *bats, winter aggregation*, Plecotus auritus, Myotis daubentonii, Myotis brandtii, Myotis dasycneme, *photo-trap*

Introduction

Bat winter censuses in hibernacula are a key part of national bat monitoring programs in most countries of Western and Central Europe (Battersby 2010). These censuses have run for decades, covering thousands of hibernacula and involving hundreds of bat researchers and have become one of the main methods of gathering data about bat population trends in Europe (e.g. Van der Meij et al. 2015; Węgiel et al. 2021). However, little is known about hiding bat behaviour in hibernacula which may lead to a significant underestimation of bat winter aggregation numbers.

The area of our survey is the North-Eastern part of Ukraine which is karst-less region with only a few mines suitable for bat hibernation for hundreds of square kilometres (Vlaschenko & Naglov 2006; Vlaschenko et al. 2016; Vlaschenko & Naglov 2018). Previous reports show a gradual disproportion in summer bat numbers (about hundreds of thousands) and the number of bats censused in hibernacula (several tens of individuals) for the vast area the NE Ukraine and further north (Strelkov 1958). The hibernacula of NE Ukraine were discovered between 1999 and 2004, most of them were in the Kharkiv region (Oblast') (Vlaschenko & Naglov 2006). When census surveys were undertaken just a few individuals were identified in old cellars and abandoned mines. However, late, we noticed that in sandstone mines there were significant fluctuations in bat individual and species numbers, not only multi-years but between different months in winter (Vlaschenko & Naglov 2018). First, we formulated the hypothesis that bats hide in the deep crevices in the wall depths of sandstone and the real number of bats is much higher than we censused. We confirmed this hypothesis indirectly on the basis of late-summer (autumn) and spring mist-netting near mines' entrances (Vlaschenko & Naglov 2018). However, evidence was required to confirm bats really get inside the crevices. Finally, we tested our hypothesis using a camera trap set exactly in front of sandstone wall in a mine. Here we presented our results of two days of filming of bat activity in a mine during a period of active swarming (September). Additionally, we ventured to make an extrapolation of a number of bat winter aggregation in a mine that is the most well-studied in our region.

Materials and methods

On September 17-19, 2017 the infrared camera trap Bushnell Trophy CAM HD Aggressor was placed in "Pobyeda" mine, one of the sandstone mines in the Tetlega mines system (Kharkiv region, Ukraine, 49°54' N, 36°43' E) (detailed description see: Vlaschenko et al., 2016). The camera trap was placed in the deepest adit near the dead-end of the "Pobyeda" mine opposite the sandstone wall with cracks (four meters in front of the wall).

The camera trap recorded short movies in 720 HD quality, with intervals of 1 second, the sensor works at a distance of up to 24.4 meters. The records started at 12:00 AM on September 17th and finished at 12:00 AM on September 19th. The photo trap recorded video and took pictures in the dark with infrared flash, each record shows: the date, time, and temperature (^{o}C).

Before setting the camera trap inside the mine standard bat counts were performed; all chambers and adits we carefully inspected (methods see: Vlaschenko & Naglov 2018).

All the video material was analyzed by a person. On the basis of morphological features of bats, the species identification was made by such categories: i) all species from *Myotis* group, ii) *Plecotus auritus* and iii) unidentified Vespertilionidae. Three species of bats (*Myotis daubentonii*, *M. brandtii*, *Pl. auritus*) were known as overwintering in this mine system (Vlaschenko et al. 2016).

For extrapolation of bat winter aggregation number, we used data of mist-netting near entrances of Liptsy 1 mine as a model. It is a mine from the Liptsy mines system (Kharkiv region, Ukraine, 50°12' N, 36°22' E, detailed description see: Vlaschenko & Naglov 2018). The index of bat activity - bats per hour (b/h) was calculated for each mist-netting night in the period August-September and March-May on the basis of mist-netting success. The total number of captured bats (N) of each species ($_i$) was divided by the time (hours) (H) of mist-netting ($b/h = N_i/H$). The b/h index values were used for extrapolation of the number of flights into and departure bats. The extrapolation was conducted for 10- and 30-day periods, with taken into the account the time of darkness hour for each month.

Results

Any bat was observed inside the "Pobyeda" mine on September 17 and 19, 2017; when the camera trap was set up and set down.

For two days of video shooting, a totally of 783 footages were made. Among them, 293 footages were with bats. Totally 679 bats were identified, followed by categories: *Myotis* group – 611 counted individuals, *Pl. auritus* – 18 counted individuals, and 50 unidentified Vespertilionidae. Most of the footages were shot in the evening-night time, between 5:30 PM and 4:30 AM, with a few cases in day- and late-morning time. The ratio of different bat species was similar for two days, 4% and 2% for *Pl. auritus* and the other *Myotis* group.

Video recording made possible direct observation of moments when a bat landed on the wall and crawled inside the deep crevices of the sandstone (Fig. 1). There were shot tens of cases of going in and out of crevices by bats in the mine's wall.

The results and calculation of the extrapolation are presented in Table S1. We estimated similar number of flying-into in late summer and autumn, and flying-out in spring *M. daubentonii* from about 300 to 800 individuals (Table S1). For *Myotis dasycneme* we got estimation from about 25 to 75 individuals both for entering and departure. The estimation for *P. auritus* was different in autumn (from about 130 to 400 individuals) and spring (80 – 180 individuals, respectively). The total number of bats hibernating in Liptsy 1 mine could be estimated as 500 – 1000 individuals.

Discussion

Here we present a case of camera trap documenting a mass presence of hiding bats in a visually empty mine. Further, we filmed exact moments of bats passing into sand-stone crevices. These pieces of evidence clearly support our hypothesis that most of the bats hide in deep crevices and the real number of them in sand-stone mines is much higher than humans may estimate. As a further step, we have ventured to extrapolate the number of bat winter aggregation on the results of mist-netting near a mine's entrances in autumn and spring. Summarising, abandoned sandstone (possibly other rocks as well) mines in karst-less plain areas may harbour considerably more numerous bat aggregations than was previously thought.

It is not a new idea that most of the bats that are occupying natural hibernacula remain unaccounted by humans, or their number understudied. There are many examples when the number of bats counted by people in hibernacula was ten times less than the real number of bats that were wintered there (e.g. Strelkov 1971; Ilyin 1994; Gaisler & Chytil 2002). The recently published paper that applied advanced technologies in the automatic counting of bats proves the human-understudied of bats in hibernacula (Krivek et al. 2023). Here, combining two methods we prove that the sandstone mines of Eastern Ukraine provide the hibernacula for hundreds and thousands of bats and not for a couple of dozen as previously thought (Strelkov, 1958; Vlaschenko & Naglov, 2006). Our results suggest reconsidering the status of the sand-stone mines in the Kharkiv region as hibernacula with high conservation priorities, in analogy to the "hibernation sites of national importance" in the UK (Guidelines for the implementation of Resolution … 2000). Future monitoring and research activities have to be implemented not only in these mines in the Kharkiv region but for other sand-stone underground sites where previously only a few bats were counted.

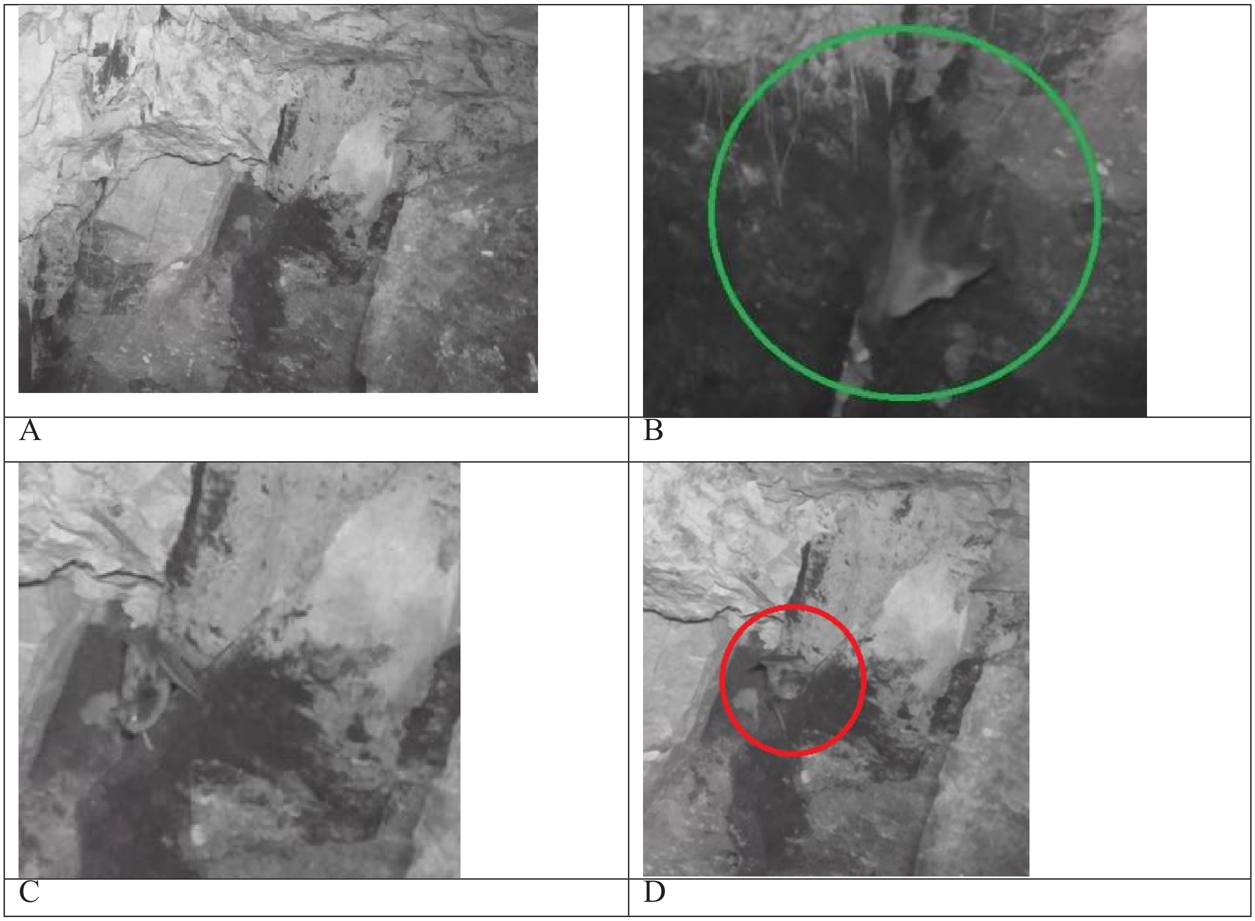

Figure 1: General view of a wall with crevices from camera trap (A), *Pl. auritus* landing on the wall (B), *Myotis* species landing (C) on the wall and crawling inside (D).

The architectonics of mines in the Kharkiv region specifically the narrow borrow-like entrances and low-height adits (0.5-3 m) form a particular space where bats hibernated openly and have high risks of being eaten by predators (Vlaschenko and Naglov, 2018). We noted the periodic presence of badgers, foxes, rodents and stray dogs in these mines (Vlaschenko et al. 2016; Vlaschenko & Naglov 2018). At the same time, a lot of deep crevices in the sandstone walls allow bats to hide there and utilize this space. This hiding behaviour is also challenging for bat researchers who count bats in hibernacula.

Integrating advanced technologies like thermo-cameras, camera traps, and acoustic recordings in bat hibernacula studies brings light to aspects of bat behaviour and predation often unseen (Haarsma & Kaal 2016; Blazek et al. 2019; Whiting et al. 2022). The ecological relevance of these studies is multifold. They reveal vital insights into long-term population dynamics of bat winter aggregations (e.g. Piksa & Nowak, 2013; Van der Meij et al. 2015). Advanced counting technologies also allow the monitoring of predation patterns, that form significant pressure on hibernating bats (e.g. Tryjanowski, 1997; Haarsma & Kaal 2016). Therefore, the ongoing use of such research techniques is crucial for enhancing our understanding of these complex ecological interactions and informing more effective conservation policies. In light of rapidly changing ecosystems and increasing anthropogenic pressures, it is more vital than ever to utilise and refine these techniques for proactive bat conservation management.

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Conflict of interest statement

The authors declare that they have no competing interests.

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Table S1.
Mean b/h index (±SD) and extrapolation of bat activity level for Liptsy 1 mine in summer-autumn and spring periods. VIII-V – number of months, IXs – summer period of September (01-11[th]), IXa – autumn period of September (after 12[th]). n – number of mist-netting nights for each period with each particular species (details see Vlaschenko & Naglov, 2018).

Periods / Species	VIII-IXs	Extrapolation for 9 h night-long	IXa	Extrapolation for 10 h night-long	III	Extrapolation for 10 h night-long	IV	Extrapolation for 9 h night-long	V
M. daubentonii	**2.69**±1.968 max-6.4 min-0.33 n=7	For 10 days - ~240 bats For 30 days - ~725 bats	**0.309**±0.095 max-0.37 min-0.2 n=3	For 10 days - ~30 bats For 30 days - ~90 bats	**1.402**±0.98 max-3.16 min-0.16 n=10	For 10 days - ~140 bats For 30 days - ~420 bats	**1.828**±2.246 max-5.77 min-0.57 n=5	For 10 days - ~164 bats For 30 days - ~490 bats	**2.833**±1.283 max-4.25 min-1.75 n=3
M. dasycneme	**0.28**±0.092 max-0.285 min-0.105 n=3	For 10 days - ~25 bats For 30 days - ~75 bats	-	-	**0.256**±0.068 max-0.333 min-0.2 n=3	For 10 days - ~25 bats For 30 days - ~75 bats	**0.222** n=1	-	-
P. auritus	**0.885**±0.993 max-2.76 min-0.111 n=6	For 10 days - ~80 bats For 30 days - ~240 bats	**0.517**±0.399 max-0.8 min-0.235 n=2	For 10 days - ~50 bats For 30 days - ~150 bats	**0.4**±0.19 max-0.705 min-0.166 n=7	For 10 days - ~40 bats For 30 days - ~120 bats	**0.222** max-0.222 min-0.222 n=2	For 10 days - ~20 bats For 30 days - ~60 bats	**0,5** n=1