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Extremely high mortality of newborn juveniles in the nursery colony of *Myotis myotis* at Žihobce, SW Bohemia, Czech Republic (Chiroptera: Vespertilionidae)

Extrémně vysoký úhyn čerstvě narozených mláďat v mateřské kolonii netopýra velkého (*Myotis myotis*) v Žihobcích v jihozápadních Čechách (Chiroptera: Vespertilionidae)

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Abstract. In 2020, an extremely high mortality of juveniles was recorded in a nursery colony of *Myotis myotis* at Žihobce (Klatovy Dist.), reaching 50.6% of the potential growth. Most juveniles died within two weeks of age (67.4%). The cause of this phenomenon is not known. The results of chemical analyses carried out in five dead juveniles showed neither the presence of heavy metals nor pesticides in the bodies. The dissection of cadavers revealed a good nutrition state. In all dissected individuals, intestinal inflammation was recorded. Most juveniles in the colony were significantly parasitised. In the period of parturition, it was cold and very rainy for several days, the mortality thus may have been caused by chilling of the juveniles. The effort of females to nurse even the dying juveniles which fell down from the colony was observed. The mortality of juveniles was checked in further 28 control colonies in different parts of the Czech Republic in 2020. At eight sites, making up 27.6% of all studied sites, the mortality of 10.1–20.0% was recorded. At the remaining twenty sites (69% of the studied sites), the mortality reached 0–10%. High mortality of juveniles of *M. myotis* (18.7–39.2%) was also recorded at Vyšší Brod (Český Krumlov Dist.) in the years 1988–1991. In that case, the probable cause was the application of Lastanox (tributyltin oxide), a toxic chemical used for timber treatment in the colony roost.

Key words. *Myotis myotis*, nursery colonies, juvenile mortality, Czech Republic.

INTRODUCTION

The greater mouse-eared bat, *Myotis myotis* (Borkhausen, 1797), is generally considered as an originally cave-dwelling species which uses different man-made structures as daily roosts in the northern part of its distribution range. This applies mainly to the roosts of maternity colonies which are found in the attics of large buildings and churches. In these anthropogenic roosts, environmental conditions are not as constant as in caves, various short-term changes in the character of occurrence can thus occur there more often (see e.g., Audet 1990, Zahn 1999, Rodrigues et al. 2003, Postawa & Gas 2009). They include mainly changes in the size of the nursery colony, different timing of parturitions, abandonment of the roost in case of adverse

microclimatic conditions, but also a variable mortality of juveniles. In 2020, during the check of the *Myotis myotis* nursery colony at Žihobce, situated at the foothills of the Šumava Mts., we recorded an unusually high mortality of juveniles at the beginning of the existence of the colony. For that reason, we monitored the colony regularly and tried to reveal the causes of this high mortality, which was quite extraordinary during the whole season.

MATERIAL AND METHODS

Study sites

In 2020, the nursery colony of *Myotis myotis* at Žihobce (Plzeň Region) was studied in detail. In addition, data from further 28 colonies in different parts of the Czech Republic were assessed as a control. The list of these sites in geographical order is as follows:

1 **Žihobce** (Klatovy Dist.), castle tower attic, 49.2144°N, 13.6320°E, 555 m a. s. l., checks: 8 June 2020, 23 June 2020, 25 June 2020, 5 July 2020, 14 July 2020, 24 July 2020, 4 August 2020 (leg. L. Bufka, J. Červený & R. Zachová);
2 **Dolany** (Klatovy Dist.), church tower attic, 49.4425°N, 13.2491°E, 375 m a. s. l., checks: 8 June 2020, 8 July 2020 (leg. V. Hanzal & V. Spurný);
3 **Předslav** (Klatovy Dist.), church tower attic, 49.4480°N, 13.3547°E, 420 m a. s. l., checks: 8 June 2020, 8 July 2020 (leg. V. Hanzal & V. Spurný);
4 **Kladruby** (Tachov Dist.), a monastery room, 49.7122°N, 12.9955°E, 405 m a. s. l., checks: 31 July 2020 (leg. P. Tájek & P. Tájková);
5 **Všeruby** (Plzeň-sever Dist.), church attic, 49.8419°N, 13.2280°E, 425 m a. s. l., checks: 8 June 2020, 8 July 2020 (leg. V. Hanzal & V. Spurný);
6 **Manětín** (Plzeň-sever Dist.), church attic, 49.9914°N, 13.2310°E, 415 m a. s. l., checks: 8 June 2020, 8 July 2020 (leg. V. Hanzal & V. Spurný);
7 **Radnice** (Rokycany Dist.), church tower attic, 49.8576°N, 13.6075°E, 380 m a. s. l., checks: 8 June 2020, 8. 7. 2020 (leg. V. Hanzal & V. Spurný);
8 **Točník** (Beroun Dist.), spaces around staircase, 49.8907°N, 13.8877°E, 440 m a. s. l., check: 9 July 2020 (leg. J. Červený, I. Horáček & D. Weinfurtová);
9 **Beroun** (Beroun Dist.), school attic, 49.9622°N, 14.0686°E, 230 m a. s. l., check: 3–JUly 2020 (leg. D. Weinfurtová);
10 **Dobříš** (Příbram Dist.), castle attic, 49.7819°N, 14.1793°E, 370 m a. s. l., check: 2 July 2020 (leg. J. Červený & I. Horáček);
11 **Voznice** (Příbram Dist.), highway bridge body, 49.8174°N, 14.2216°E, 375 m a. s. l., check: 9 July 2020 (leg. I. Horáček);
12 **Kyselka** (Karlovy Vary Dist.), house attic, 50.2646°N, 12.9944°E, 360 m a. s. l., check: 7 July 2020 (leg. J. Matějů);
13 **Chřibská** (Děčín Dist.), church tower attic, 50.8640°N, 14.4826°E, 350 m a. s. l., check: 9 July 2020 (leg. J. Červený, D. Horáček, J. Kučera & Z. Kučerová);
14 **Cvikov** (Česká Lípa dist.), house attic, 50.7766°N, 14.6330°E, 355 m a. s. l., check: 9 July 2020 (leg. J. Červený, D. Horáček, J. Kučera & Z. Kučerová);
15 **Kvítkov** (Česká Lípa Dist.), house attic, 50.6544°N, 14.4858°E, 300 m a. s. l., check: 9 July 2020 (leg. J. Červený, D. Horáček, J. Kučera & Z. Kučerová);
16 **Dubá** (Česká Lípa Dist.), house attic, 50.5406°N, 14.5423°E, 265 m a. s. l., check: 9 July 2020 (leg. J. Červený, D. Horáček, J. Kučera & Z. Kučerová);
17 **Ledce** (Mladá Boleslav Dist.), house attic, 50.3548°N, 15.0783°E, 255 m a. s. l., checks: 4 June 2020, 2 July 2020, 26 July 2020 (leg. J. Červený, V. Hanzal & M. Průcha);
18 **Opočno** (Rychnov nad Kněžnou Dist.), castle attic, 50.2649°N, 16.1154°E, 310 m a. s. l., check: 14 July 2020 (leg. V. Lemberk);

19 **Doudleby** (Rychnov nad Kněžnou Dist.), castle attic, 50.1085°N, 16.2637°E, 290 m a. s. l., check: 14 July 2020 (leg. V. Lemberk);
20 **Sruby** (Ústí nad Orlicí Dist.), church tower attic, 50.0017°N, 16.1744°E, 285 m a. s. l., check: 17 July 2020 (leg. V. Lemberk);
21 **Vranová Lhota** (Svitavy Dist.), church tower attic, 49.7103°N, 16.8267°E, 290 m a. s. l., check: 28 June 2020 (leg. V. Lemberk);
22 **Zvíkovské Podhradí** (Písek Dist.), bridge body, 49.4255°N, 14.1951°E, 400 m a. s. l., check: 7 July 2020 (leg. R. Lučan);
23 **Kratochvíle** (Prachatice Dist.), castle attic, 49.0590°N, 14.1682°E, 435 m a. s. l., check: 3 July 2020 (leg. L. Bufka & J. Červený);
24 **Chvalšiny** (Český Krumlov Dist.), church attic, 48.8541°N, 14.2115°E, 570 m a. s. l., check: 3 July 2020 (leg. L. Bufka & J. Červený);
25 **Zlatá Koruna** (Český Krumlov Dist.), monastery attic, 48.8554°N, 14.3712°E, 465 m a. s. l., check: 3 July 2020 (leg. L. Bufka & J. Červený);
26 **Lesonice** (Třebíč Dist.), castle attic, 49.1081°N, 15.7557°E, 520 m a. s. l., check: 1 July 2020 (leg. A. Reiter, Z. Mačát & A. Toman);
27 **Bítov** (Znojmo Dist.), castle attic, 48.9435°N, 15.7012°E, 405 m a. s. l., check: 1 July 2020 (leg. A. Reiter, Z. Mačát & A. Toman);
28 **Jevišovice** (Znojmo Dist.), castle attic, 48.9912°N, 15.9887°E, 345 m a. s. l., check: 1 July 2020 (leg. A. Reiter, Z. Mačát & A. Toman);
29 **Znojmo** (Znojmo Dist.), church attic, 48.8564°N, 16.0511°E, 255 m a. s. l., check: 3 July 2020 (leg. A. Reiter).

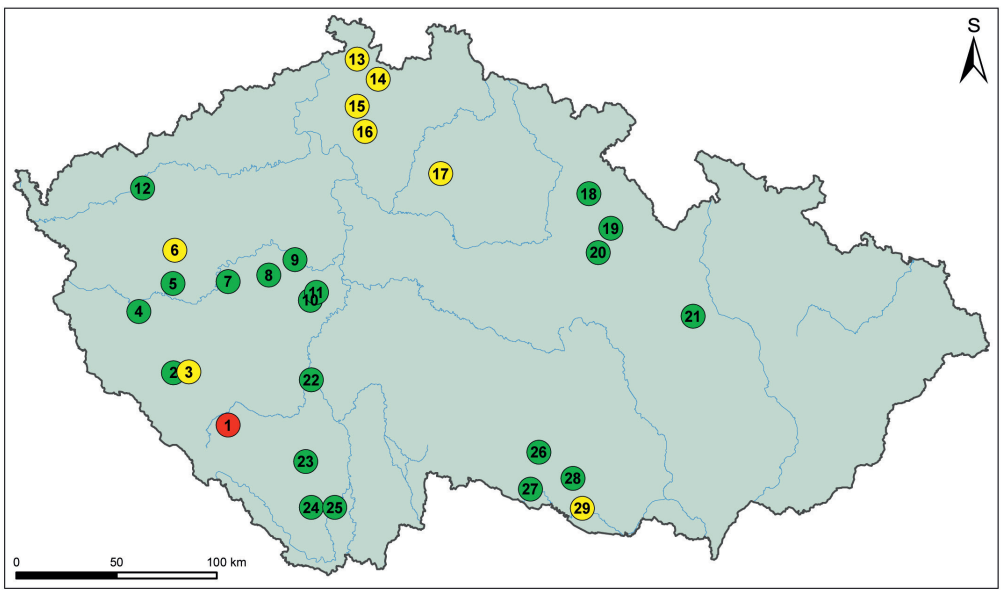

Fig. 1. Map of the sites studied in 2020; green – juvenile mortality reaching 0–10%, yellow – 10.1–20%, red – over 20%.
Obr. 1. Mapa lokalit sledovaných v roce 2020; zeleně – mortalita mláďat 0–10 %, žlutě – 10.1–20 %, červeně – více než 20 %.

Table 1. Numbers of *Myotis myotis* individuals and the rate of juvenile mortality in the particular colonies (* – data on the number of individuals in the colony are qualified estimates with the accuracy of tens of individuals; ? – only visible individuals were counted from a hidden colony; % – % of the aduls)
Tab. 1. Počty jedinců *Myotis myotis* a výše úhynu mláďat v jednotlivých koloniích (* – údaje o počtu jedinců v kolonii jsou kvalifikované odhady s přesností na desítky kusů; ? – spočítáni pouze viditelní jedinci z ukryté kolonie; % – % z počtu dospělých)

site / lokalita	colony size / velikost kolonie (n)		dead juveniles / mrtvá mláďata (n)			%
	adult ♀♀ dospělé ♀♀	juveniles mláďata	newborns novorozená	others ostatní	total úhrnem	
Žihobce*	660	380	225	109	334	50.6
Dolany*	270	310			17	6.3
Předslav	14?	15?			2	14.3
Kladruby*	580	550	0	0	0	0
Všeruby*	60	60			4	6.7
Manětín*	1,060	1,000	143	8	151	14.2
Radnice	230	120			20	8.7
Točník*	500	300	15	62	21	4.2
Beroun*	180?	200			20	11.1
Dobříš	41	31	1	0	1	2.4
Voznice*	120	40			2	1.6
Kyselka	83	28			3	3.6
Chřibská*	180	140	26	3	30	16.6
Cvikov*	380	300	31	39	69	18.2
Kvítkov*	180	150	13	4	19	10.6
Dubá*	490	380	59	35	95	19.5
Ledce*	2,380	1,450	247	21	269	11.3
Opočno*	180	100	3	1	4	2.2
Doudleby*	70	50	0	0	0	0
Sruby*	350	220	5	2	7	2.0
Vranová Lhota*	400	200	0	4	4	1.0
Zvíkovské Podhradí*	290	130	0	0	0	0.0
Kratochvíle*	210	190	2	1	3	1.4
Chvalšiny*	90	70	2	0	2	2.2
Zlatá Koruna	62	36	0	0	0	0
Lesonice*	220				3	1.4
Bítov	45	23			2	4.5
Jevišovice*	450	300			3	0.7
Znojmo*	100	?			13	13.0
total / úhrnem	9,875	6,773	772	289	1,098	11.1

Methods

At all sites, the numbers of adult females and juveniles were recorded. Dead juveniles were registered in two age categories (sensu Sklenář 1962): newborn up to the age of approx. 10 days, and older. For each site, the proportion of live juveniles in the colony and especially the percentage of dead juveniles from the potential growth were recorded. Based on the assumption that each female in the colony has one juvenile (e.g. Horáček 1985, Rogee & Lehmann 1994, Zahn 1998), this proportion is defined as a ratio

between the number of dead juveniles and the number of adult females. The numbers of individuals in the colonies were determined using photos; in large colonies or in clusters of a complicated distribution, the total number was estimated with the accuracy of tens of individuals.

At the Žihobce site with an enormously high mortality, altogether seven checks were carried out. During each visit, the dead juveniles were removed. On 25 June 2020, five cadavers of juveniles, which died approximately at the age of one week, were taken. Dissection of these cadavers was carried out in the State Veterinary Institute Prague and later on, toxicological analyses aimed at the presence of heavy metals and pesticide residues were performed there too.

RESULTS AND DISCUSSION

Overall situation

The map of all 29 studied sites in the Czech Republic is given in Fig. 1. Results from the particular sites are provided in Table 1. The absolutely highest proportion of dead juveniles from the potential growth was recorded at Žihobce (50.6%), which is 3.4% of all studied sites. Most juveniles died within two weeks of age there (67.4%), the other later. At eight sites, making up 27.6% of all studied sites, the mortality of 10.1–20.0% was recorded. At the remaining twenty sites (69% of the studied sites), the mortality reached 0–10%. These mortality values are in accordance with previously published data (Horáček 1985). This author mentioned the mortality of 5–10% at long-term studied sites in central Bohemia.

Fig. 2. The Žihobce site (location of the colony roost is indicated by an arrow). Photo by J. Červený.
Obr. 2. Lokalita Žihobce (šipkou znázorněné umístění kolonie). Foto J. Červený.

Fig. 3. A female by a dying juvenile on the attic floor under the colony roost, Žihobce, 23 June 2020. Photo by L. Bufka.
Obr. 3. Samice u hynoucího mláděte na podlaze půdy pod mateřskou kolonií, Žihobce, 23. 6. 2020. Foto L. Bufka.

In general, the following factors are considered to affect the rate of juvenile mortality in bat nursery colonies:

(a) climatic conditions at the site during the period of parturitions and insufficient termoregulation of the juveniles (e.g. Heidinger et al. 1989, Audet 1990, Zahn 1999, Zahn et al. 2007, Postawa & Gas 2009);
(b) lack of available food for lactating females (e.g. Audet 1990, Zahn et al. 2006, 2007);
(c) intoxication of the environment including food sources (e.g. Correo et al. 2009, Kunz et al. 1977, Zukal et al. 2015);
(d) the level of infestation of bats by ecto- or endoparasites (e.g. Christie et al. 2000, Zahn & Rupp 2004, Frank et al. 2015);
(e) predation by owls, martens, and/or domestic cats (Bauer 1956, Petržílková et al. 2004, Ancillotto et al. 2013, Spitzenberger et al. 2014)
(f) infection situation in the population, mainly concerning viral diseases (e.g. Amengual et al. 2008, Drexler et al. 2011, He et al. 2014).

Ž i h o b c e

This site (Fig. 2) situated at the foothills of the Šumava Mts. has been regularly monitored already since the year 1971, when a *Myotis myotis* colony of 100–150 adult females was found there. The nursery colony then gradually declined and disappeared completely after the year 1986. No increased mortality of juveniles was recorded at that time, however. In the meantime, the site started to serve as a late summer roost for several male harems. In 2019, a nursery colony

of an unknown origin, with the abundance of about 600 adult females and mortality of 15 juveniles (2.5%), appeared at the site again. In 2020, the first visit on 8 June showed the presence of 120 females and the first 9 dead juveniles. During the second check on 23 June, the colony size was estimated at 600 females and 60 dead or dying juveniles were recorded, most of them fallen down to the attic floor (Fig. 4). Females approached these juveniles, trying to feed them and encourage them to stay alive (Fig. 3). Two days later, on 25 June, further 155 dead juveniles appeared. During another visit on 5 July, 79 dead juveniles were found, while the number of present adult females increased to 660 individuals. During the fifth check on 14 July, there were further 31 newly dead juveniles. First during the visit on 24 July, no new dead juveniles were recorded. Similarly, the last check of the year carried out on 4 August did not show any new mortality. Because of the cold weather, the whole colony held together and its abundance was determined as 850 adult females and 250 juveniles. In total, at least 334 juveniles died at the site during the breeding season of 2020, making up 50.6% of the potential growth. The cause of this phenomenon is not clear. Results of chemical analyses excluded the presence of heavy metals as well as pesticides in the bodies of dead juveniles. The dissection of cadavers proved a good nutrition state. However, intestinal inflammation was recorded in all dissected individuals. The origin of the inflammation (whether it was an infectious colitis) was not studied. Neither the level of infestation by parasites was investigated, but it was significant according to the documentation (see Fig. 5). The effect of a long period of heavy rains at the time of parturitions and consequent lack of milk in the females due to food shortage, or chilling of the juveniles during long absence of the females cannot be excluded either.

The same attic of the castle is currently used also by colonies of other bat species. In the year 1986, a small colony of three individuals of *Rhinolophus hipposideros* was recorded there for the first time. This colony gradually grew in numbers, reaching almost 200 females in 2020. Until 2018, the colony used the part of the attic which was occupied by the *M. myotis* colony in 2019. The *R. hipposideros* colony thus moved to a more distant part of the attic in that year. In

Fig. 4. Dead juveniles, Žihobce, 25 June 2020. Photo by L. Bufka.
Obr. 4. Uhynulá mláďata, Žihobce, 25. 6. 2020. Foto L. Bufka.

Fig. 5. A juvenile highly infested by parasites, Žihobce, 25 June 2020. Photo by L. Bufka.
Obr. 5. Mládě vysoce napadené parazity, Žihobce, 25. 6. 2020. Foto L. Bufka.

both 2019 and 2020, only a minumum mortality was registered in the *R. hipposideros* colony. *Myotis nattereri* is another species occurring at the site, its colony inhabits different cavities in beam joints. These cavities are also sometimes used by *M. myotis* individuals, eight inds. of undetermined sex were found in one of them in 2020.

The recorded mortality of *M. myotis* at Žihobce in the year 2020 is quite unusual. In 2020, extremely high mortality of young of this species was found also in locality Benátky nad Jizerou, which was, however, not the subject of our monitoring. Approximately 32% of the young died here. In May, the colony had 250 females, beginning July, however, the bats disappeared from the site. During the subsequent inspection, 80 corpses of young of various ages were found (leg. D. Weinfurtová & E. Cepáková). Somewhat higher mortality was recorded in 2020 in two West Bohemian colonies: Předslav (14.3%), Manětín (14.2%), one Central Bohemian colony Ledce (11.3%) and one South Moravian colony (Znojmo 13.0%). Of particular interest was the finding of higher mortality of young in four nearby North Bohemian colonies: Chřibská (16.6%), Cvikov (18.2%), Kvítkov (10.6%), and Dubá (19.5%). Mortality higher than 10% was recorded also at the Beroun locality (see Fig. 1, Table 1). Here, however, due to the late control on 3 August, a part of the females was probably already missing and besides that, for this colony also predation of bats by the beech marten (*Martes foina*) is known; so the given value probably does not correspond to reality and is lower (D. Weinfurtová, ad verb.). High mortality (Červený, unpubl. data) was also recorded in the years 1988–1991 at another site in the Šumava foothills, in the attic of the monastery at Vyšší Brod (Český Krumlov Dist.). In 1987, the nowadays forbidden toxic chemical Lastanox (tributyltin oxide) was used there for timber treatment in the colony roost. This resulted not only in serious and persisting health problems in the females (fur loss, bruises, broken veins in auricles and wing membranes, festering inflammations of mammary

glands), but also in repeatedly high mortality of the juveniles, which reached 39.2% in the year 1988, 19% in 1990 and 18.7% in 1991.

SOUHRN

V mateřské kolonii netopýrů velkých (*Myotis myotis*) Žihobce (okr. Klatovy) byla v roce 2020 zaznamenána mimořádně vysoká mortalita mláďat, dosahující hodnoty 50,6 % potencionálního přírůstku (tab. 1). Většina mláďat uhynula do věku dvou týdnů (67,4 %), ostatní později. Příčina této skutečnosti není známa. Výsledky chemických analýz u pěti uhynulých mláďat vyloučily přítomnost jak těžkých kovů, tak i pesticidů v jejich těle. Pitva kadáverů prokázala dobrý výživný stav, u všech pitvaných jedinců však byly zjištěny záněty střev. Většina mláďat v kolonii byla značně parazitována. V době porodů bylo několik dní chladno a silně deštivo, takže příčinou úhynů mohlo být i prochlazení mláďat. Pozorována byla snaha samic kojit i umírající mláďata vypadlá z kolonie. Mortalita mláďat byla v roce 2020 sledována na dalších 28 kontrolních koloniích v různých částech České republiky (obr. 1). Na osmi lokalitách byl zjištěn úhyn 10,1–20 %, to představuje 27,6 % ze sledovaných lokalit. Na zbylých dvaceti lokalitách byl zjištěn úhyn 0–10 %, což představuje 69 % ze všech sledovaných lokalit. Vysoká mortalita mláďat *M. myotis* (18,7–39,2 %) byla zjištěna i v letech 1988 až 1991 na lokalitě Vyšší Brod (okr. Český Krumlov). Zde však bylo příčinou použití jedovaté látky Lastanox (tributylcínoxid) na asanaci dřevěných krovů půdy v místě kolonie.

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