Vestnik Zoologii, **52**(5): 395–416, 2018
DOI 10.2478/vzoo-2018-0042

UDC 599.4:047.36(477.54)

RESULTS OF THE 10-YEAR MONITORING OF BAT (CHIROPTERA, VESPERTILIONIDAE) WINTER AGGREGATION FROM THE NORTH-EASTERN UKRAINE (LIPTSY MINES, KHARKIV REGION)

A. Vlaschenko[1,2], A. Naglov[3]

[1]*Interdepartmental research laboratory "Study of biodiversity and development of nature reserve management", P.O. Box 2385, Kharkiv, 61001 Ukraine*
[2]*Bat Rehabilitation Center of Feldman Ecopark, Kharkiv Region, Dergachevsky District, vil. Lesnoye, Kyiv Highway st., 12, Ukraine*
E-mail: anton.vlaschenko@gmail.com
[3]*Department of Biology, V. N. Karazin Kharkiv National University, sq. Svobody, 4, Kharkiv, 61077 Ukraine*
E-mail: zzzmmt@ukr.net

Results of the 10-Year Monitoring of Bat (Chiroptera, Vespertilionidae) Winter Aggregation from the North-Eastern Ukraine (Liptsy Mines, Kharkiv Region). Vlaschenko, A., Naglov, A. — Monitoring of bats in hibernacula is a key element for the estimation of long-term population trends in Northern hemisphere bats. However, there is currently limited winter bat monitoring data from Ukraine, making long-term population estimates difficult. We present data on bat population monitoring in the largest bat hibernacula in North-Eastern Ukraine (Liptsy mines). Between 1999–2010 we conducted 115 censuses inside the three mines and counted 1150 specimens of *M. daubentonii*, *M. dasycneme* and *P. auritus*. 385 individuals of the same species were captured by mist-nets (39 nights). The yearly average temperature in the Liptsy 1 mine is close to the mean of annual temperature in the Kharkiv Region (about +7 °C); the humidity ranged from 85–100 %. The mean number of bats counted in a visit ranged from 1.4 to 4.9 bats, and 28 in one case. Great fluctuations in bat number were noted in Liptsy 1 and Liptsy 3–4 mines. There were high bat numbers (up to one hundred individuals on average) in the winters 2000–2001 and 2007–2008, and low bat number in winters 2002–2003 and 2003–2004. The species relative abundance for *M. daubentonii*was — 75–90 %, *P. auritus* — 7–20 %, *M. dasycneme* — 1–10 % respectively.
Key words: *Myotis daubentonii*, *Myotis dasycneme*, *Plecotus auritus*, bat hibernacula, mine microclimate, swarming, spring departure, Kharkiv Region, Ukraine.

Census and monitoring of bats in underground sites has a long history in western and central European countries (e.g. Eisentraut, 1957; Stebbings, 1988; Battersby, 2010). The results of winter censuses have been the main method for estimation of bat population trends both at the regional scale (e. g. Lesiński et al., 2011; Gaisler, Chytil, 2002; Kervyn et al., 2009; Spitzenberger, Engelberger, 2013) and broader geographical scales (e. g. Lesiński et al., 2005; Van der Meij et al., 2014; Ingersoll et al., 2013) across the northern hemisphere. In most countries of Western and the Central Europe, bat winter censuses are an important part of national monitoring programs (Battersby, 2010). Every year hundreds of hibernacula are surveyed by bat-researchers, and this activity has run for decades. But there are several countries in Eastern Europe where bat winter censuses are less common, one such country is Ukraine.

Ukraine has a vast and heterogeneous territory. In the west part of the country there are karstic areas with multiple underground sites suitable for bats. In the east part of the country there are vast regions without any karstic caves and rock denudations with only few mines for hundreds of square kilometers. The data on bat wintering in Ukraine's underground areas has been limited to a few publications of the middle 20th century (Abelentsev et al., 1956; Strelkov, 1958; Volansky, 1967), and these considered mainly the West of the country. An inventory of underground sites suitable for bat hibernation was started in Ukraine at the end of 1990's (Pokynchereda, 1998; Godlevskaya, 2003; Godlevska et al., 2005) and has been continued until the present (Godlevskaya et al., 2011 a; Godlevska et al., 2016). However, total winter censuses were only carried out in few hibernacula (Godlevskaya, 2007; Godlevskaya et al., 2011 b; Dykyy et al., 2008). In the beginning of 21st century tens of caves and mines with many thousands of hibernating bats were found in the mountain and karstic areas in the southern (Godlevskaya et al., 2008, 2009) and western (Godlevska et al., 2010) parts of Ukraine. In contrast, in the plain areas of north-eastern Ukraine there are only few underground hibernacula with more than ten bats (Vlaschenko, Naglov, 2006; Godlevskaya, Ghazali, 2009; Godlevska et al., 2016). One of them is a mine system named Liptsy mines in Kharkiv Region (Vlaschenko, Naglov 2006; Godlevska et al., 2016). This site was discovered as a bat hibernaculum in 1999 and was later included in the List of International Important Underground Sites for Bats in Europe by the EUROBATS Agreement (Conservation…, 2014).

To gain further knowledge about bat hibernation in the Kharkiv Region of Ukraine, four research objectives were considered in the Liptsy mines: 1) the microclimatic conditions of the mines; 2) the bat species composition, including seasonal and long-term changes; 3) the sex ratio of the local population; 4) the timing of bat autumn swarming and spring departure. Additionally, the tracks and signs of other animals in the mines (mainly mammals), and the frequency of visits by people were recorded. In this paper we estimate the threats to the bat winter aggregation in Liptsy mines and outline an Action Plan for future conservation of the mines.

Material and methods

Study area and study site

Kharkiv Region is an administrative territory on the North-Eastern Ukraine on the border with the Russian Federation (31.4 thousands km²). The Region is located on the border of forest-steppe and steppe nature zones. It is characterized by undulating plains with a maximal elevation above sea level 236 m in the North of the Region, and minimum of 90 m above sea level in the south-east. The branches of the Central Russian Upland penetrate into the northern and north-eastern part of the Region. The mean annual temperature is 8.1 °C, the mean January and July temperatures are −7 °C and +21 °C respectively. Annual precipitation does not exceed 540 mm. The Region has forest coverage of 12 % (Golikov et al., 2011).

For different parts of the analysis we considered different parts of the yearly cycle. We divided the year using three approaches: 1) phenological periods, 2) calendar months and 3) bat life cycle periods. Phenological winter (the period at which daily average temperatures fall below 0 °C) starts on average on the 15th of November and finishes on the 20th of March. Spring finishes on average on the 18th of May, and summer continues till the 11th of September when autumn begins (the period after the date of stable fall of daily average temperature below +15 °C) (Boot, 1971; Golikov et al., 2011).

The Liptsy mines (50°12' N, 36°22' E) are located in the north of the Kharkiv Region near Liptsy village, not far (10 km) from the border with Russia. The mines were excavated in a bed of sandstone on the bank of a deep valley on a branch of Central Russian Upland. The mines were established sometime between the late 18th and 19th century and were caved in at the beginning of 20th century. In the 1970s the undergrounds were dug up, by members of local speleological club, at first there were four mine galleries named "Liptsy" 1 to 4, but galleries Liptsy 3 and Liptsy 4 were later connected by dig adit (Kovalev, 2014). From the moment of our first visit in 1999 there were three mine galleries (Appendix, figs 1–3). We use toponyms and maps of the mines from the database of Kharkiv Speleological Club "Variant".

Liptsy 1 — the total length of galleries is about 230 m, the line length from entrance to the distant chamberis 50 m. The height of adits ranges from 0.5 to 3 m. The mine has two entrances (0.9 x 1 and 0.9 x 0.4 m) (Appendix, fig. 1).

Liptsy 2 — the total length of galleries is about 600 m, the line length from entrance to the distant chamber is 110 m. The height of adits ranges from 0.4 to 2 m. The mine has only one man-accessible both bat-accessible entrance, tight vertical tunnel (0.8 x 0.4m) (Appendix, fig. 2).

Liptsy 3–4 — the total length of galleries is about 400 m, the line length from entrance to the distant chamber is 35 m. The height of adits ranges from 0.4 to 2 m. The mine has two entrances (1 x 0.6 and 1.1 x 0.7 m) (Appendix, fig. 3).

There are a lot of deep crevices in walls, bays and ceiling of all three mines. There are two types of crevices in the mines. The first one is not deep crevices in clay mostly in ceiling of mines. The second one is deep cracks in beds of sandstone. The second type is located in walls and can reach for some meters deep.

The mines do not have any protection gates and are usually visited by people (speleologists or tourists) three or five times in winter annually.

Microclimate characteristics

The temperature inside the mines was measured by mercury thermometers with an accuracy of 0.2 °C (before 2002) and by digital thermometer (TFA 301020, manufactured in China) with an accuracy of 0.1 °C (after 2002 till now). The temperature was mainly recorded 20–30 centimeters above the mine floor. Thermometers were left for 5–10 minutes to minimize the influence of human body temperature on thermometer readings. Results of temperature measurements were noted on the scheme of a mine. At total about 300 measurements were made, but some of them we did in chance points. We selected four points where temperature were measured in Liptsy 1 (Appendix, fig. 1) and three locations in Liptsy 2 (Appendix, fig. 2) that were used to determine temperature year round temperature dynamics. Data of temperature in Liptsy 3–4 was not considered because of the low sample size. 35 locations for temperature measurement from Liptsy 1 and 9 locations for Liptsy 2 were selected for comparison of winter temperatures (from December to February). For this comparison only points outside the freezing zone were chosen. The borders of the freezing zone were mapped on 21 January 2006 during a period of extreme cold weather (the day maximum temperature was –19 °C, and the day minimum temperature was –24 °C). Temperatures were below freezing throughout all of January 2006, with an absolute minimum of –27.7 °C (22 January). Temperatures were below –10 °C between the 17th and 28th of January. The air humidity was measured by a digital thermo-hygrometer to an accuracy of 1 %.

Bat census inside the mines

The mines were visited 115 times in total (Liptsy 1 — 48 censuses, Liptsy 2 — 35, and Liptsy 3–4 — 32 censuses respectively) between December 1999 and June 2010. Observations in the mines started in the end of August and finished in the June of the next year. During each visit a full inspection of the mines was performed. During the early years (1999–2002) of our research work we handled bats at winter censuses for specific identification of bat species and sex, and we measured forearm length. After 2005, we have carried censuses without disturbance of the bats in winter months; only active bats (flying inside a mine) were handled and measured during winter, as well as in August–October and the second half of March. We recorded locations of individuals on schematic maps of the mines and noted the wall or ceiling position, whether roosting openly or inside a crevice, and the number of bats in a cluster. The full list of recorded bats is presented in Appendix, List 1. In total we caught and recorded more than 1150 specimens of three species: *Myotis daubentonii* Kuhl, 1817, *Myotis dasycneme* Boie, 1825 and *Plecotus auritus* Linnaeus, 1758.

Bat mist-netting near the mines' entrances

Bats were caught using Chinese ultrathin and normal nylon mist-nets (7 × 3.5 m and 4 × 3.5 m; mesh size 15 mm) from 2003 to 2010. The mist-nets were set in front of the entrances of Liptsy 1 and Liptsy 2 mines and opened from sunset for between 4 hours and all night long. The total time of mist-netting was 233 h. 39 mist-nets captures were carried out from the end of August to October and from March to June in total, of which 33 caught bats (Appendix, List 2). Species, sex and age of captured bats was recorded, and forearm length and weight was also measured. Bats were ringed using special batrings (Aranea, Poland) (Vlaschenko, 2012). 385 individuals of three species (*M. daubentonii*, *M. dasycneme* and *P. auritus*) were captured by mist-nets (recaptured bats with rings included in total amount).

The index of bats per hour (b/h) was calculated on the basis of mist-netting success. The total number of captured bats (N) of each species ($_i$) was divided by time (hours) (H) of mist-netting ($b/h = N_i/H$). The index is calculated for each case of mist-netting.

All animals were immediately released after biometrical processing in the mines during the cold season or the next evening during the warm season. All methods of bat capture and handling were carried out under consideration of the international ethical rules of animal welfare and conservation of protected species (Gannon et al., 2007).

Statistical analysis

Mann-Whitney U tests were used to calculate significance of differences between non-parametric numeric samples (values of temperature inside the mines and numbers of bats). We applied Spearman rank R test (nonparametric) to calculate correlation between ranks of data (dynamic of bat numbers). χ^2tests were used to test differences in the sex ratio (in samples more than 10 specimens) and bat relative abundance. Statistical analyses were conducted with Statistica 7.0 (StatSoft) and Excel 2003.

Others notes

We recorded (observed) the tracks and signs of others animals in the mines and near the entrances, mainly mammals, and also the frequency of visits by people.

Results

Microclimate characteristic of the mines

The annual dynamics of temperatures in both Liptsy 1 and Liptsy 2 mines is presented in figs 1–2. In deep parts of Liptsy 1 mine (points 3 and 4, Appendix, fig. 1) the temperature

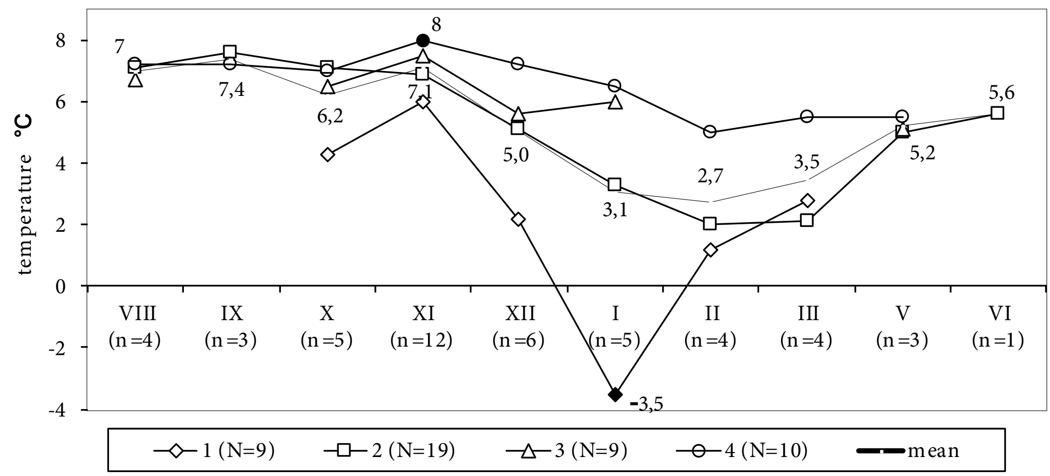


Fig. 1. Annual temperature (°C) fluctuations in Liptsy 1 mine: 1–4 — main temperature measurement points (marked on Appendix, fig. 1); VIII–VI — months, August to June (except April); N — number of measurements at each point; n — number of measurements for each month, thick line shows mean temperature for each month.

fluctuated over 3 °C during autumn and winter (fig. 1). The minimum temperature for the Liptsy 1mine was below zero, recorded near the mine entrance (point 1, figs 1, 4). The temperature in Liptsy 1 mine was stable (about +7 °C) from August to November, but started to fall down in December with minimum temperatures in February (+2.7 °C, fig. 1). The maximum temperature in Liptsy 1 mine was +9.5 °C. The temperature in the Liptsy 1 mine is close to the mean of annual air temperature for Kharkiv Region.

Winter temperatures were higher in Liptsy 2 mine compared with Liptsy 1 ($U = 83$, $p \leq 0.05$) (Appendix, fig. 3). There was no the freezing zone in Liptsy 2 mine (Appendix, fig. 2) and we did not record temperatures below +8 °C inside the mine. The year round dynamic of temperature in Liptsy 2 is stable (Appendix, fig. 2). The maximum temperature for Liptsy 2 was higher than in Liptsy 1 (figs 1, 2). The mean temperature in the Liptsy 2 mine was also little higher than the mean annual temperature in the Kharkiv Region.

The widest freezing zone was marked for Liptsy 3–4 mine (Appendix, fig. 3). Our preliminary data on temperature in this mine shows that it is similar to temperature condi-

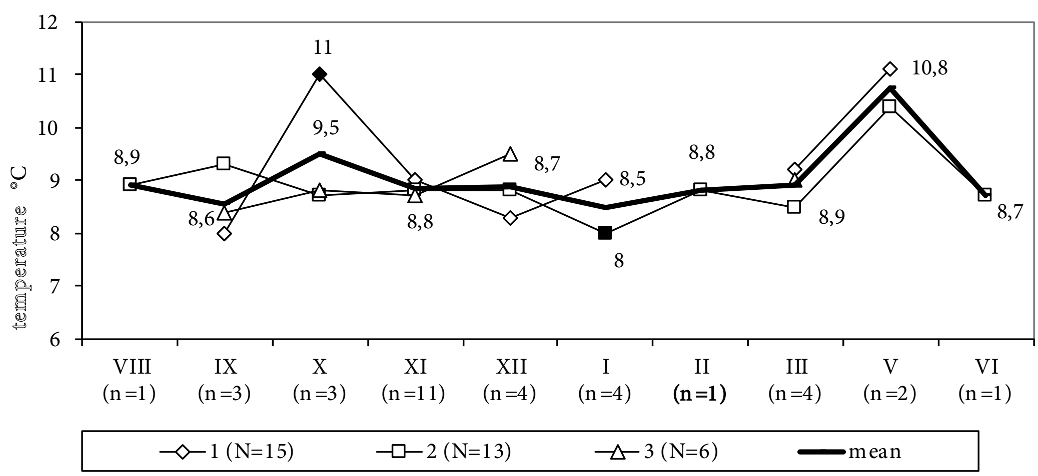


Fig. 2. Annual temperature (°C) fluctuations in Liptsy 2 mine: 1–3 — main temperature measurement points (marked on Appendix, fig. 2); VIII–VI — months, August to June: N — number of measurements at each point; n — number of measurements for each month. Thick line with valuesshows the mean temperature for each month.

tions in Liptsy 1. Humidity in Liptsy 2 mine fluctuated from 90 % to 100 %, humidity in the other two mines was from 85 % to 100 %.

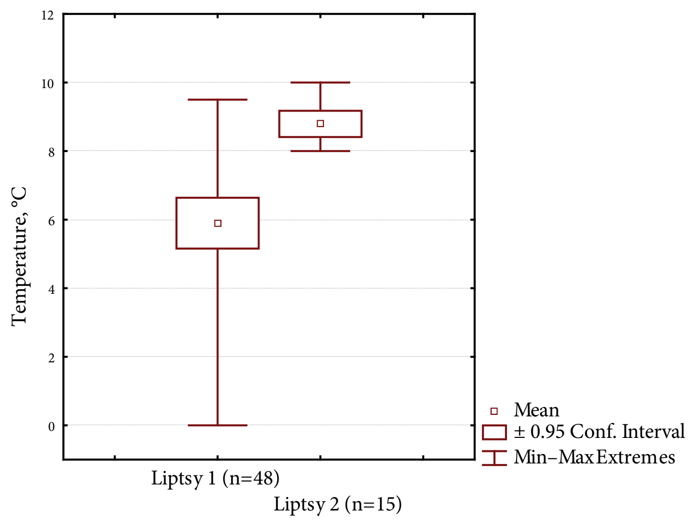


Fig. 3. Winter temperatures (December–February) in Liptsy 1 and Liptsy 2 mines (data from points outside the freezing zone, see Appendix, figs 1 and 2); n — number of measurements.

Bat census inside the mines

In most cases few bats were noted in each mine (fig. 4, Appendix, List 1), with the exception of the Liptsy 1 mine where many *M. daubentonii* were recorded. Mean bat numbers per a count fluctuated between 1.4 to 4.9 bats per a count. 28 specimens in mean of *M. daubentonii* were recorded in Liptsy 1 mine (fig. 4). A pairwise comparison (Mann-Whitney U test) showed no significant differences between the mean number per a count of *P. auritus* ($U = 37.5$, $p = p \geq 0.05$) and *M. daubentonii* ($U = 144.5$, $p \geq 0.05$) in Liptsy 2 compared to Liptsy 3–4. There were statistically significant differences of *P. auritus* between Liptsy 1 and Liptsy 2 ($U = 49$,

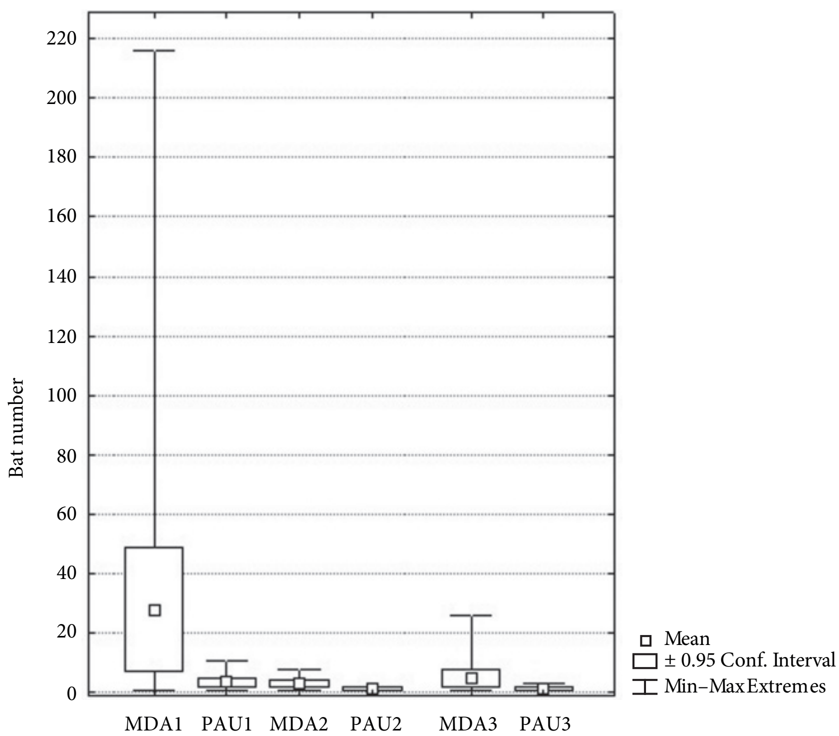


Fig. 4. Cumulative number of *M. daubentonii* (MDA) and *P. auritus* (PAU) in three Liptsy mines (1, 2 and 3–4), for 10 winter seasons (1999–2009) in period of phenological winter: MDA1 (23 counts); PAU1 (17 counts); MDA2 (16 counts); PAU2 (11 counts); MDA3–4 (19 counts); PAU3–4 (7 counts).

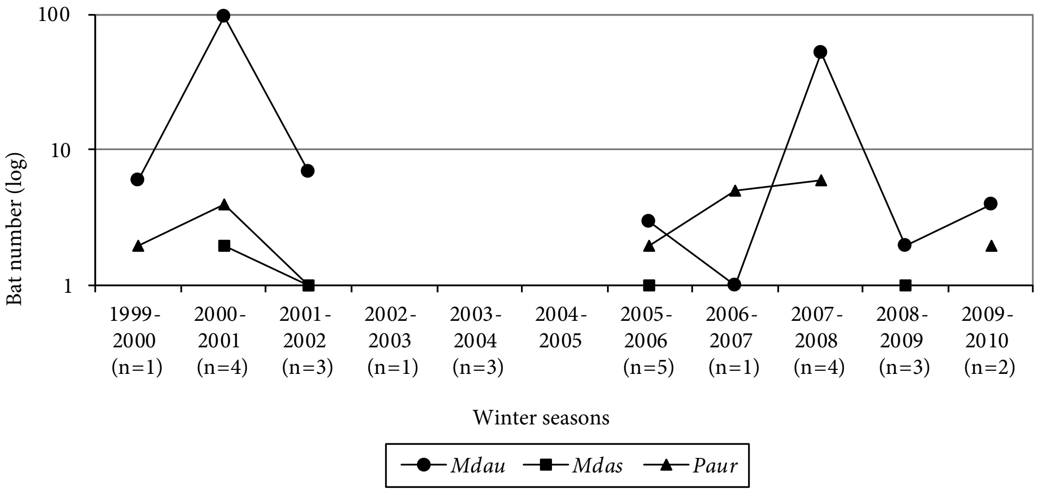


Fig. 5. Fluctuations in the number of hibernating batsin Liptsy 1: n— number of counts; *Mdau — M. daubentonii; Mdas — M. dasycneme; Paur — P. auritus*. In winters 2002–2003 and 2003–2004 there was censured any bats; in winter 2004–2005 censuses were not conducted.

p = p ≤ 0.05), Liptsy 1 — Liptsy 3–4 (U = 31, p = p ≤ 0.05) and *M. daubentonii* between Liptsy 1 and Liptsy 2 (U = 97.5, p ≤ 0.01) mines, and Liptsy 1 and Liptsy 3–4 (U = 131.5, p ≤ 0.05). In all cases mean bat number were higher in Liptsy 1 mine.

The fluctuations in bat numbers across all three mines (mean for different winters) are presented on figs 5–6. We noted great differences in the mean number of *M. daubentonii* in Liptsy 1 mine from one hundred individuals in the winter 2000–2001 to no sightings in the two winters between 2003 and 2004 (fig. 5). In the two other mines we did not find such significant difference in bat numbers between winters. In Liptsy 2 and Liptsy 3–4 there were no cases of “empty winters” without any hibernating bats observed (figs 6–7).

There were two clear peaks in bat numbers during the winters of 2000–2001 and 2007–2008, which were observed in both Liptsy 1 and Liptsy 3–4 mines. The correlation between total number of all bat species between Liptsy 1 and Liptsy 2 was low R = 0.46 and statistically not significant (S = 88.90, p ≤ 0.05). There was also no statistically significant correla-

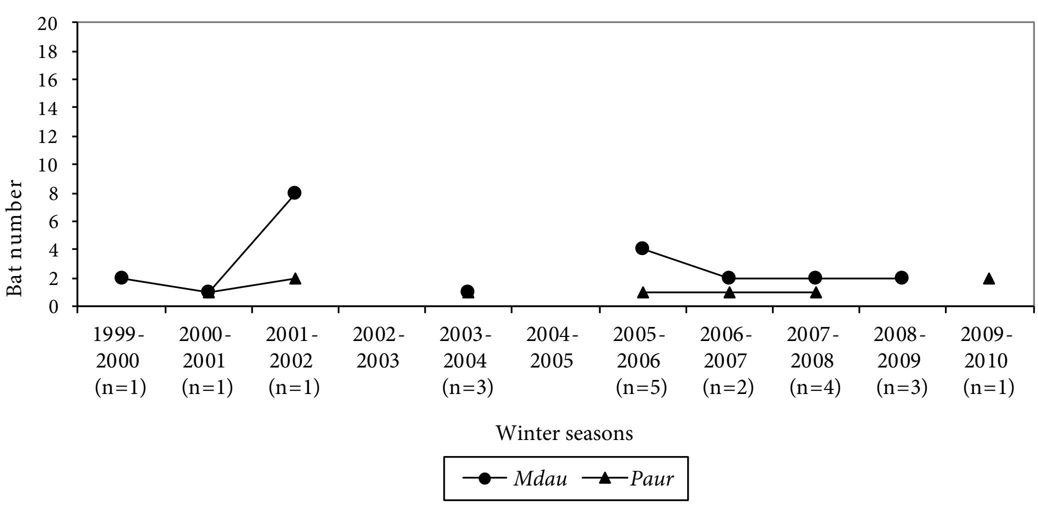


Fig. 6. Fluctuations in the number of hibernating bats in Liptsy 2: n — number of counts; *Mdau — M. daubentonii; Mdas — M. dasycneme; Paur — P. auritus*. In winters 2002–2003 and 2004–2005 censuses were not conducted.

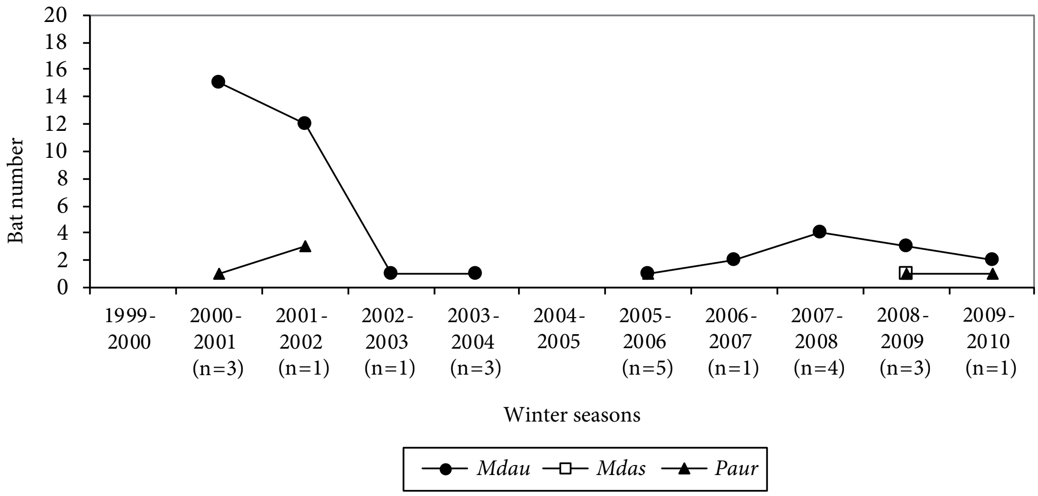


Fig. 7. Fluctuations in the number of hibernating bats in Liptsy 3–4: n — number of counts; *Mdau* — *M. daubentonii; Mdas — M. dasycneme; Paur — P. auritus*. In winter 2004–2005 censuses were not conducted.

tion between bat numbers in Liptsy 1 and Liptsy 3–4 ($R = 0.56$, $S = 71.00$, $p \le 0.05$), and Liptsy 2 and Liptsy 3–4 ($R = 0.34$, $S = 107.38$, $p \le 0.05$) respectively.

Relative abundance of the three observed bat species during winter is presented in fig. 8. *M. daubentonii* was the dominant bat species in all three mines, *P. auritus* was common and *M. dasycneme* was rare. Bat species relative abundance in winter aggregations in Liptsy 1 and Liptsy 3–4 mines were more similar in comparison with Liptsy 2 mine. But the similarity between Liptsy 1 and Liptsy 3–4 mines was not statistically significant ($\chi^2 = 0.981$, d. f. = 2, $p \ge 0.05$). *M. dasycneme* was not recorded in Liptsy 2 mine during winter, but it was recorded in autumn (13.10.2007 see Appendix, List 1).

The bat species composition was unstable during the autumn–winter–spring period (seen in the example of Liptsy 1 mine; fig. 9). *M. dasycneme* was recorded in Liptsy 1 from the end of August to December. In one case, in the beginning of November, only two individuals of this species were counted. Some individuals of *M. dasycneme* were also noted in March. *P. auritus* started to occur in the mine from the end of November, and was recorded regularly till the end of March. *M. daubentonii* was irregularly sighted from August to No-

	L1 (n=698)	L2 (n=64)	L3-4 (n=104)
Paur	7.0	23.4	9.6
Mdas	0.7		0.9
Mdau	92.3	76.6	89.4

Fig. 8. Bat relative abundance in Liptsy mines in winter: n — total number of bat counts for all years; *Mdau* — *M. daubentonii; Mdas — M. dasycneme; Paur — P. auritus*.

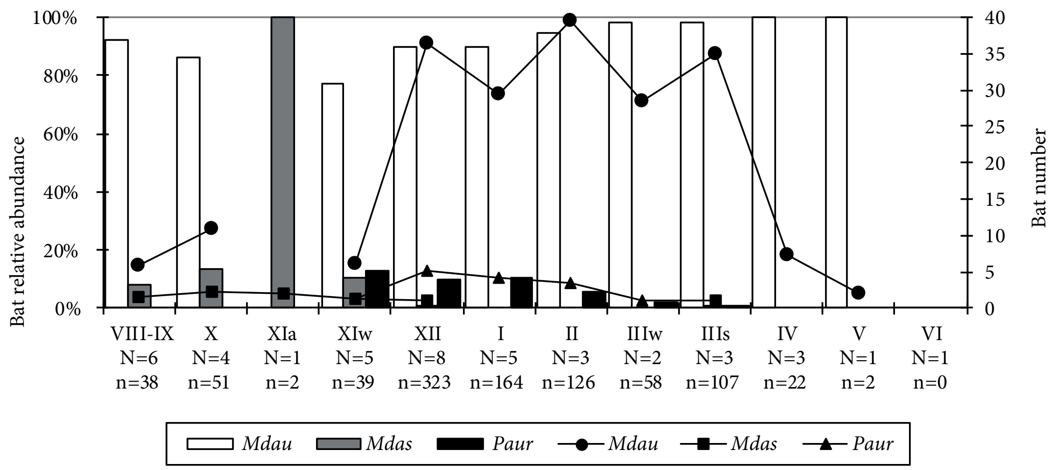


Fig. 9. Annual fluctuations of bat numbers (shown by lines) and relative abundance (shown by bars) in Liptsy 1: VIII–VI — number of months, August to June; XIa — autumn period in November; XIw — winter period in November; IIIw — winter period in March; IIIs — spring period in March; N — number of counts with bats in each period; n — total number of bats in each period; *Mdau — M. daubentoni; Mdas — M. dasycneme; Paur — P. auritus*.

vember and from December the species had stable numbers till the May. *M. daubentonii* was the only species which remained in the mine until late spring (fig. 9). All three bat species were recorded in short period — second part of November beginning of December.

We analyzed allocation of *M. daubentonii* and *P. auritus* inside the Liptsy 1 mine (figs 10, 11). Bats of these two species preferred to hibernate in higher parts of the mine. There was a statistically significant difference between observed (fig. 10) allocation in height for *M. daubentonii* ($\chi^2 = 68.1$, d. f. = 3, $p \leq 0.05$) and *P. auritus* ($\chi^2 = 49.2$, d. f. = 3, $p \leq 0.05$) in comparison to uniform allocation. *M. daubentonii* and *P. auritus* were found at different heights. This difference was statistically significant ($\chi^2 = 8.2$, d. f. = 3, $p \leq 0.05$) (fig. 10).

All observed *P. auritus* hibernated in open position in the galleries. A quarter of *M. daubentonii* hibernated in crevices (fig. 11). There was a statistically significant difference between observed position of *M. daubentonii* ($\chi^2 = 10.8$, d. f. = 1, $p \leq 0.05$) (fig. 14) compared to uniform allocation. Both examined species (*M. daubentonii*: $\chi^2 = 48$, d. f. = 1, $p \leq 0.05$; *P. auritus*: $\chi^2 = 45.3$, d. f. = 1, $p \leq 0.05$) showed a statistically significant preference for roosting on ceilings than on walls (fig. 11).

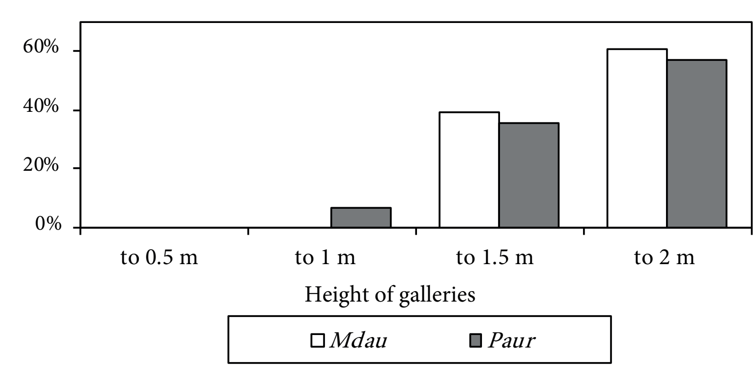


Fig. 10. Bat distribution in galleries of different height. An example from Liptsy 1: *Mdau — M. daubentonii; Paur — P. auritus*.

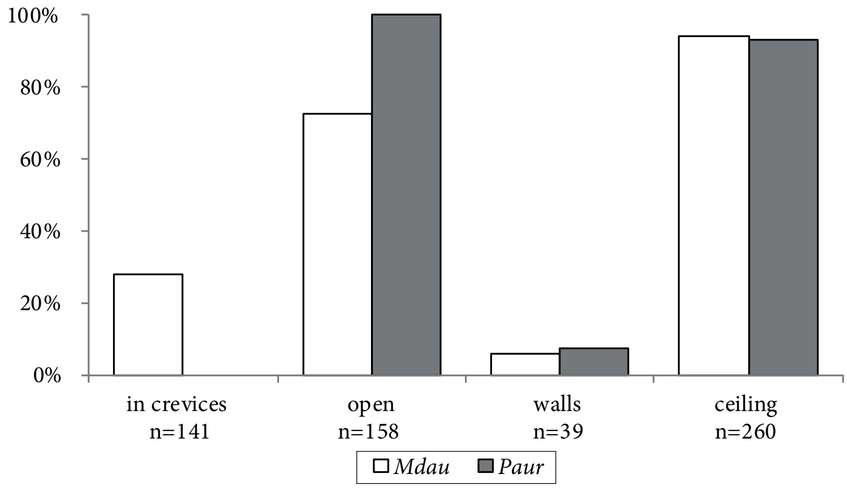


Fig. 11. Bat distribution in crevices or in the open; and on walls or ceilings. An example from Liptsy 1 mine: n — bat number included in each category; *Mdau — M. daubentonii; Paur — P. auritus*.

Bat mist-netting in autumn swarming and spring departure seasons

The number of *M. daubentonii* caught flying into Liptsy 1 mine in one night was several times more than counted the next day (fig. 12). *P. auritus* began to enter the hibernation site at the same time as *M. daubentonii* (fig. 12), but *P. auritus* was not recorded roosting inside the mine until three months after (fig. 9). A similar pattern was observed in Liptsy 2 mine (fig. 13, cases 3 and 4): *M. daubentonii* entered and roosted in the mine earlier than *P. auritus*. The number of departing bats in March over one night was a little less or equal to the number of bats counted inside the day before (fig. 12, cases 8 and 9). In April–May we caught more bats than counted inside while *P. auritus* was caught on a day where the species was not recorded inside (fig. 12, cases 10 and 11).

During the period of autumn swarming the highest bat activity was between the end of August and beginning of September (fig. 13). The level of *P. auritus* activity gradually declined from that period to October. For *M. daubentonii,* we noted rapid declines in activity from late summer to the beginning of autumn. The level of spring activity gradually increased from the end of March to May for both *M. daubentonii* and *P. auritus*; and the highest level of activity was in May (fig. 13). The species relative abundance in mist-nets during late summer (late summer, fig. 13, case VIII–IXs) and in the first half of spring departure (March, fig. 13, case III) were similar ($\chi^2 = 1.2$, d. f. = 2, $p \geq 0.05$). But in the second half (April, fig. 13, case IV) the species relative abundance were not similar to the fly-into one (August–September, fig. 13, case VIII–IXs) ($\chi^2=7.3$, d. f. =2, $p \leq 0.05$) respectively. The percentage of species caught in late summer (fig. 13, case VIII–IXs) was close to the species ratio from counted bats inside the mines in late November–December (fig. 9, case XIw). There was no significant difference between these two proportions ($\chi^2 = 5.2$, d. f. = 2, $p \geq 0.05$).

Sex ratio in bats of local population

Sex ratio of *M. daubentonii* was not significantly different to even in Liptsy 1 during the winter season ($\chi^2 = 0.1$, d. f. = 1, $p \geq 0.05$) and Liptsy 3–4 ($\chi^2 = 0.5$, d. f. = 1, $p \geq 0.05$) (fig. 14) and there was no difference in *P. auritus* ($\chi^2 = 1.6$, d. f. = 1, $p \geq 0.05$) in Liptsy 1 (fig. 14). There was no statistically significant difference in the sex ratio of *M. daubentonii* between Liptsy 1 and Liptsy 3–4 mines ($\chi^2 = 0.6$, d. f. = 1, $p \geq 0.05$).The ratio of *M. daubentonii* females increased from late summer to November and decreased in January. In May only males were observed in Liptsy 1 mine (fig. 15). However, there was no statistically significant difference

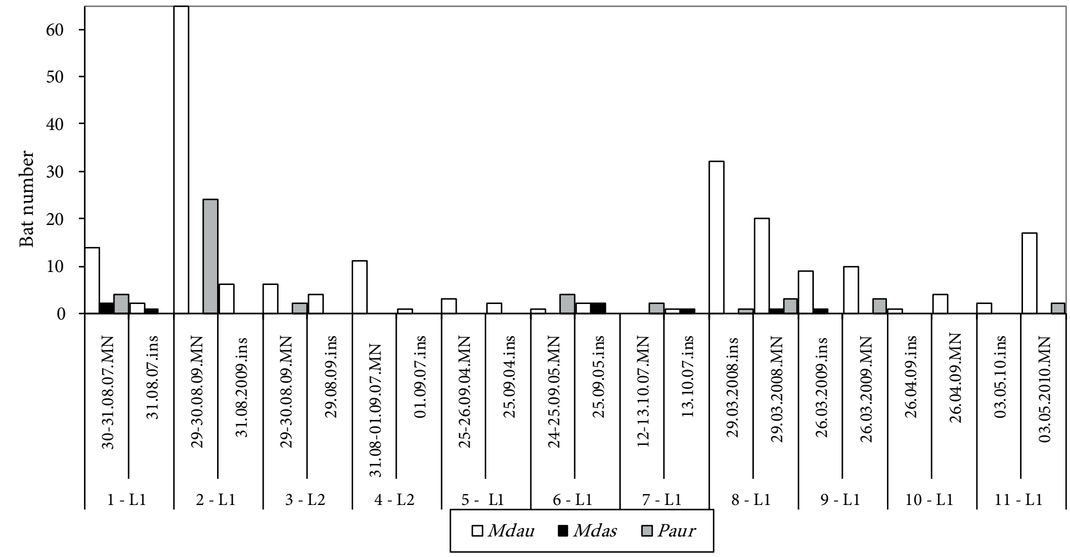


Fig. 12. Numbers of bats recorded inside and outside Liptsy 1 and 2 on 11 separate visits. Inside numbers are from visual counts (ins.) and outside numbers from mist netting (MN): L1 — Liptsy 1 and L2 — Liptsy 2. In the summer and autumn period (visits 1 to 7) mist netting and inside counts sometimes took place on different days: *Mdau — M. daubentonii*; *Mdas — M. dasycneme*; *Paur — P. auritus*.

between the sex ratio of *M. daubentonii* between seasons to 1 : 1 (August–September — $\chi^2 = 0.3$, October — $\chi^2 = 0.3$, November (winter) — $\chi^2 = 1.5$, December — $\chi^2 = 0.2$, January — $\chi^2 = 1.7$, February — $\chi^2 = 0.03$, March — $\chi^2 = 0.7$, April — $\chi^2 = 0.02$).

Sex ratios in mist nets were male biased in both *M. daubentonii* and *P. auritus* in late summer and September (fig. 16). In cases of *M. daubentonii* sex ratio there was a statistically significant difference compared to 1 : 1 ($\chi^2 = 8.2$, d. f. = 1, $p \le 0.05$), while in the case of *P. auritus* there was not ($\chi^2 = 1.6$, d. f. = 1, $p \ge 0.05$). In contrast, in March there was a statistically significant difference to 1 : 1 in the case of *P. auritus* ($\chi^2 = 6.8$, d. f. = 1, $p \le 0.05$) but not for *M. daubentonii* ($\chi^2 = 3.6$, d. f. = 1, $p \le 0.05$). In April the sex ratio for

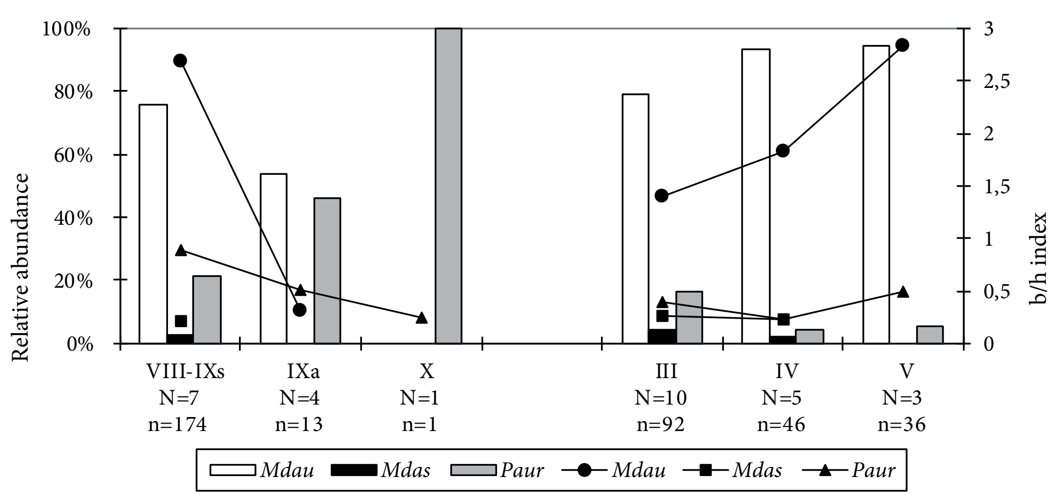


Fig. 13. Bat activity (shown by lines) and relative abundance (shown by bars) during autumn swarming and spring departure periods — an example from Liptsy 1: VIII–V = number of months, August to May; IXs — summer period in September; IXa — autumn period in September; N — number of mist-netting nights; n — total number of bats in each period; *Mdau — M. daubentonii; Mdas — M. dasycneme; Paur — P. auritus.*

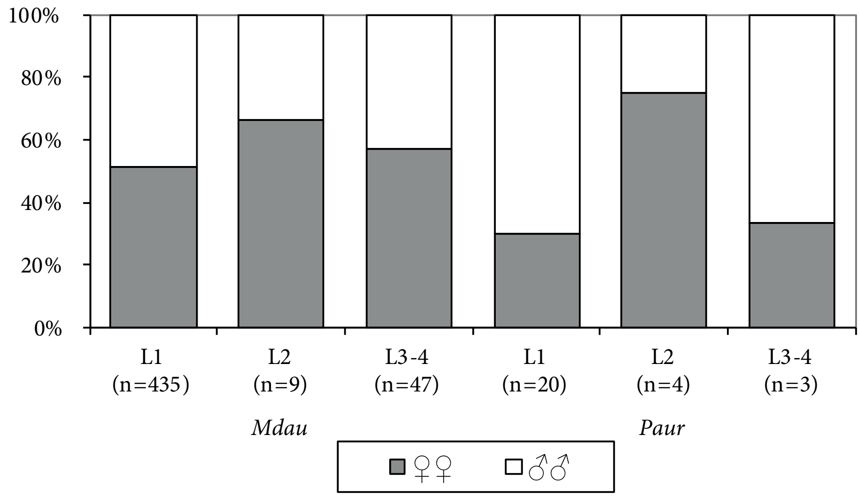


Fig. 14. Sex ratio in *M. daubentonii* and *P. auritus* in winter in three Liptsy mines (L1, L2 and 3–4): n — number of bats; *Mdau — M. daubentonii; Paur — P. auritus.*

M. daubentonii ($\chi^2 = 0.01$, d. f. = 1, $p \geq 0.05$) was no different to equal. We observed an equal sex ratio in *M. daubentonii* in autumn swarming (August–September) and spring departure (March). The number of females increased in April but in May only males were observed in Liptsy 1 mine (fig. 16). There was no equality in proportion of females to males of *P. auritus* in spring and in late summer and September.

Presence of other animals and frequency of people visiting

Other mammal species noted in the mines were mainly common field mouse (*Apodemus* sp.) and carnivores (foxes, badgers and semi-wild domestic dogs). In winter 2002–2003, we noted the presence of badgers in Liptsy mines. They lived in adits unsuitable for humans, and used near-entrance parts of the mines like toilet-rooms. The local population of badgers was killed by illegal hunters in late autumn 2003. Foxes and semi-wild dogs visited the mines in winter we recorded the tracks on snow and droppings inside the mines. However, we never registered any signs of breeding for these two species. Several times during autumn 2000–2003 we found the remains (bit off forearms) of *M. daubentonii*

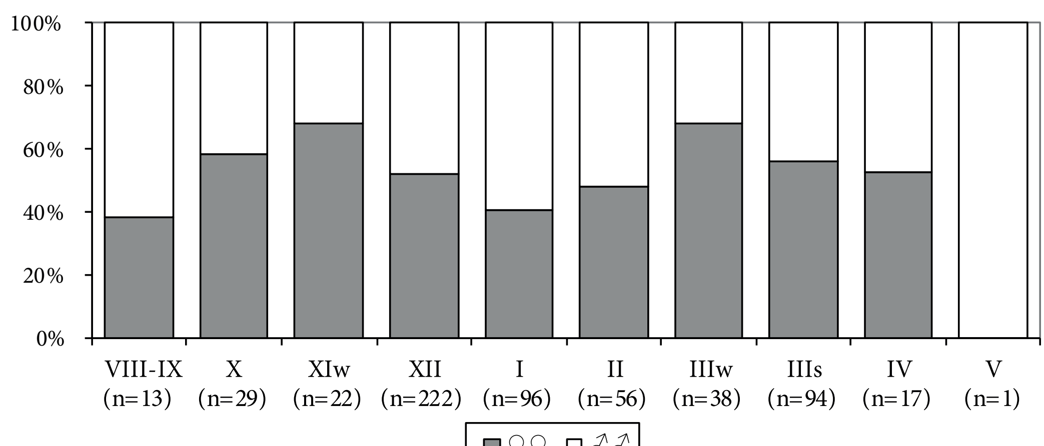


Fig. 15. Sex ratio in *M. daubentonii* throughout the year from bats recorded inside Liptsy 1: VIII–V — number of months August to June; n — number of bats.

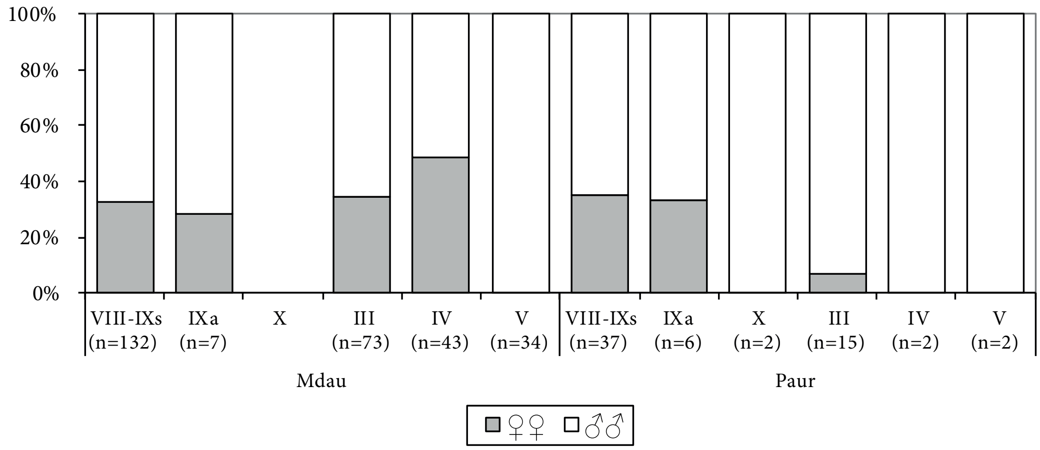


Fig. 16. Sex ratioin *M. daubentonii* and *P. auritus* during autumn swarming and spring departure periods — an example from Liptsy 1 mine: VIII–V — number of months, August to May; n — number of bats; *Mdau — M. daubentonii; Paur — P. auritus.*

near the second entrance to Liptsy 1 mine. People visited these mines approximately once a month. The Liptsy mines are the only underground site within easy access of Kharkiv City. This site is well known for local Touristic and Speleological clubs, and the maps of each mine are accessible online. The most frequently visited mines are Liptsy 3–4. There were only several cases (known for us) when bats were killed by people directly (children's from the local school in 2000 and 2001). In most cases visitors know about bat conservation status and usually do not disturb them.

Discussion

In this study we presented large-scale information on bat winter aggregation in the Liptsy mines of North-eastern Ukraine. Reporting of bat wintering was common in Central Europe at the end of the 20th century (e. g., Bárta et al., 1981; Bagrowska-Urbańczyk, Urbańczyk, 1983; Lesiński, 1986; Řenák et al., 1994; Furmankiewicz, Górniak, 2002) but has not been regularly conducted since. Currently, most bat observations in winter consist of bat counting without disturbance, mainly once a winter (e. g. Battersby, 2010; Van der Meij et al., 2014). For the territory of North-Eastern Ukraine this study is the first detailed report on the structure of bat winter hibernation aggregation and dynamics. In contrast to Western and Central Europe, where bat hibernacula have been inspected since the 19th century (Spitzenberger, Engelberger, 2013), the first inventory of bat hibernation in underground sites of North-Eastern Ukraine and the Central Black Earth Region of Russia was only carried out in the middle of 20th century by Strelkov (1958). In that survey, only one underground site in the Sumy Region (distance from Kharkiv — 230 km to the NW) was inspected (Strelkov, 1958). During the 20th century the summer bat fauna of the Kharkiv Region has been studied sufficiently, but all winter records have been limited to Kharkiv City (Vlaschenko, 2011). There were no data on bat hibernation in underground sites of the Kharkiv Region before 1999, but after 2000 information on bat wintering in underground sites of Eastern and the North-Eastern Ukraine has increased rapidly. Currently seven bat species (*M. daubentonii*, *M. dasycneme*, *Myotis brandtii* (Eversmann, 1845), *Myotis nattereri* (Kuhl, 1817), *Eptesicus serotinus* Schreber, 1774, *P. auritus* and the other species: current name *Myotis davidii* (Peters, 1869) (Benda et al., 2016) previous name *Myotis aurascens* Kuzyakin, 1935 (Benda, Tsytsulina 2000) have been recorded hibernating in underground sites and in rock crevices within this Region (Vlaschenko, Naglov, 2005; Vlaschenko, Naglov, 2006; Godlevskaya, Ghazali, 2009; Zagorodniuk, Korobchenko, 2008; Vlaschenko et al., 2014; Vlaschenko et al., 2016).

The bat winter fauna of this part of Ukraine is much poorer than on the South and the Western parts (Godlevska et al., 2016). This is likely a result of the common decline of bat species number to the East from the Dnipro River (Strelkov, Il'in, 1990; Vlaschenko, 2006). Three species (*M. daubentonii*, *M. dasycneme* and *P. auritus*) found in the Liptsy mine are more common in underground sites of northern and eastern Ukraine and the neighboring part of Russia according to our previous data (Strelkov, 1958; Vlaschenko, Naglov, 2006; Vlaschenko et al., 2012). In a more recent review (Godlevska et al., 2016) *E. serotinus* was noted as a fourth common bat species in hibernacula of northern Ukraine. The only known hibernaculum of *M. brandtii* in the whole of the Left-bank Ukraine (the part from the East from the Dnipro River) is located just in 40 km to the South-East (Vlaschenko et al., 2016) from Liptsy mines. *M. aurascens* and *M. nattereri* were found in underground sites further south from Kharkiv, in the Donetsk Region (Godlevskaya, Ghazali, 2009).

Mine microclimate and bat species composition

Is the observed bat species composition in Liptsy mines a result of the mines' microclimatic conditions or is it a reflection of the surrounding summer bat assemblage? We recognized differences in abiotic conditions of these mines. The Liptsy 2 mine has a higher temperature conditions and higher humidity, and a stable annual regime (Appendix, fig. 2). The two others mines have a variable gradient of temperature conditions (Appendix, fig. 1). These differences seem to reflect the number and size of entrances into the mines (Appendix, figs 1–3). The one narrow burrow used as an entrance to Liptsy 2 might also impact the structure of bat assemblages. It is not clear which factor has a more significant impact on bat assemblage: the difficulty of entry for bats (due to entrance size) or warm temperature conditions. The available information on microclimate conditions in underground sites from North-Eastern Ukraine and the Central Black Earth Region of Russia demonstrated the following regularities. Underground sites less than 50 meters with narrow or big entrances have low temperature near 0 °C or even lower, where only *P. auritus* are seen to hibernate (Strelkov, 1958; Vlaschenko, Naglov, 2006; Vlaschenko et al., 2012). Longer (more than 50 meters) underground sites have temperatures from +6 °C — +8.5 ° C up to 9 ° C and they are inhabited by *M. daubentonii*, *M. dasycneme*, *M. brandtii* and *P. auritus* (Strelkov, 1958; Vlaschenko, Naglov, 2006; Vlaschenko et al., 2014; 2016). Kokurewicz (2004) proposed the optimal hibernation temperature for *M. daubentonii* as being between +6.9 °C +6.3 °C. Smirnov et al. (2008) estimated this species as a psychrophilic species — +1.7 °C +2.8 °C. For others species, described temperature ranges vary: *M. dasycneme* — +2 °C +4.5 °C, *M. brandtii* — +1 °C +4 °C, *P. auritus* — –3.5 °C +5.3 °C (Smirnov et al., 2008). Therefore the temperature conditions recorded in all Liptsy mines are suitable for a range of these bat species.

Eleven bat species have been observed in the Kharkiv Region until now (Vlaschenko, 2011). Some of these breed in the Region and migrate to the South for hibernation; the others hibernate in urban areas (including *E. serotinus*). In summer time *M. brandtii* is not rare in bat assemblages of the Kharkiv Region. (Vlaschenko, Gukasova, 2009, 2010) compared to *M. nattereri*. *M. nattereri* is rare and known only from one bat swarming locality in Kharkiv Region (120 km to the South from the Liptsy mines) (Vlaschenko, Naglov, 2005). It is unclear why we did not record any *M. brandtii* in the Liptsy mine, this species might travel several hundred kilometers during seasonal migration (Hutterer et al., 2005). The absence of *M. brandtii* (and may be others species) in Liptsy mines reflects the structure of bat assemblages in the surrounding area rather than unsuitable underground microclimatic conditions.

Bat species composition and number dynamics

It is worth noting that the relative abundance of the three species hibernating in Liptsy 1 and 3–4 mines (fig. 8) is very similar to their relative abundance in breeding habitats.

Mist-netting data in July 2008 in "Homilsha Forest" National Nature Park (oak forest on 65 km to the South) found the following relative abundances: *M. daubentonii* — 92.9 %, *M. dasycneme* — 1.7 %, *P. auritus* — 5.3 % (n = 57) (Vlaschenko, Gukasova, 2009). In another location, Yaremivka Nature Reserve (oak forest on 140 km to the South), abundances of these three species were 87.7 %, 6.1 %, 6.1 % (n = 131) respectively (Vlaschenko, Gukasova, 2010). Similarity of winter and summer relative abundances could show the real ratio of these species in this part of Ukraine.

The first three winters of monitoring in Liptsy mines brought us extraordinary results in the light of the usual dynamics of bat winter aggregation. In 1999 we recorded low bat density, it was our first visit and there was no information about disturbance of bats in these mines before. In winter 2000–2001 we identified a peakin bat numbers but the following winter the bat numbers were back to their previous level (fig. 5). This fluctuation was not typical for bat winter aggregation under human disturbance impact or monitoring. Typically bats show rapid declines after disturbance or gradual increase after years of protection (e. g. Řenák et al., 1994; Gaisler, Chytil, 2002; Mitchell-Jones et al., 2007; Uhrin et al., 2010; Lesinski et al., 2011; Spitzenberger, Engelberger, 2013). The extraordinary fluctuation of bat number in Liptsy mines (figs 5, 7) could be explained by two hypotheses: 1 — the Liptsy mines are a peripheral hibernation site and bat winter aggregations form here only occasionally; 2 — the bats stay in the mines all winter time, but they hide or emerge according to disturbance, temperature fluctuation etc. In 2003–2004 we inventoried all known underground sites suitable for bat hibernation in Kharkiv and Sumy Regions and confirmed that the Liptsy mines are the only mine system with numerous bat winter aggregations in NE Ukraine (Vlaschenko, Naglov, 2006). The next five years (2004–2009) of bat aggregation monitoring in the Liptsy mines and mist-netting outside, convinced us to reject hypothesis 1. The Liptsy mines are not a peripheral hibernation site for local bats. Instead, we support hypothesis 2 that bats hide or emerge depending on current conditions.

We have data on two parts of bat winter aggregation: 1) available for visual census and 2) unavailable for the visual census. The first group is situated on the walls, ceiling and in shallow clay crevices. The second group hides in deep cracks in sandstone beds. We consider that in the harsh continental climate of Kharkiv Region, bats have little chance to move in winter for long distance from one hibernaculum to another. Therefore, in winters with low bat densities (1999–2000, 2001–2002 and 2005–2006, figs 5, 7) or even absence of bats (2002–2003, 2003–2004, fig. 5) we are not recording a population decrease, but rather a change in the allocation between available or unavailable crevices. There are plenty of examples where bat numbers counted by people in hibernacula are ten times less than real number (e. g. Strelkov, 1971; Il'in, 1994; Gaisler, Chytil, 2002).

Nevertheless the causes of bat emergence in one winter and disappearance in another inside the mines are not clear. On the one hand, bats could disappear after disturbance by researchers. The study of bat hibernation in Liptsy mine was started with unfriendly methods to bats, with handling. On the other hand after the season when we stopped handling bats and bat numbers did not increase. Soon we had a new peak of bat number (2007–2008, figs 5, 7) after two years of monitoring, and a further decrease (2008–2009 and 2009–2010, figs 5, 7). The great fluctuation of bat numbers is possible to be estimated as a stochastic event. But both the peaks (2000–2001 and 2007–2008, figs 5, 7) coincide in Liptsy 1 and Liptsy 3–4. Consequently we predict that there are some factors that impact bat emergence from deep crevices. One of such factor could be predators. There are many examples where bats in winter torpor are easy prey for different kinds of mammals from shrews to foxes (Il'in, 1988). We hypothesized that badgers could hunt on hibernating bats also, and decrease of bat number in 2002–2003 could be related to badger predation. Allocation of bats inside the mine could be an example of protection from ground predators. The bat allocation on ceilings (fig. 11) and in adits higher than 1.5 m from the floor (fig. 10) might be explained as protection from predators. Il'in (1988) noted that bats that allocated less than 1m high on walls were killed by mammals at the first stage.

The fluctuation of bat number inside mines from August to May (on example of Liptsy 1 mine, fig. 9) is more easily explained than long-term fluctuations. There are many papers that demonstrated fluctuation in bat number during hibernation time (e. g. Bagrowska-Urbańczyk, Urbańczyk, 1983; Lesiński, 1986; Řenák et al., 1994; Furmankiewicz, Górniak, 2002). The emergence or disappearance of different bat species in hibernacula reflects the mating activity of species and different requirements in microclimatic conditions (Strelkov, 1971). For example, *M. dasycneme* was recorded inside Liptsy 1 mine from August to December and in March only. In the autumn and at the beginning of winter *M. dasycneme* use open spaces of the mines for mating (Vlaschenko, Naglov, 2006), while later it may enter hibernation torpor in deep crevices. *M. dasycneme* emerged from the crevices again during the period of spring departure (fig. 9). However, Strelkov (1971) noted the mating activity of the species up until March, and the ratio of fertilized females in December–January was only 60 %. Two other species (*M. daubentonii* and *P. auritus*) have winter dynamics that could be explained by the necessity to store fat in autumn, and mating activity in winter. During winter the species' relative abundance changes significantly such that conducting the censuses in different periods of winter could give crucial differences in relative abundance. In Liptsy 1 mine we could see that the species relative abundance is closer to cumulative (fig. 8) in the beginning of winter (fig. 9). As it is mentioned above, the cumulative relative abundance is close to the species ratio at autumn swarming and spring departure (fig. 13). Consequently the species relative abundances where *M. daubentonii* keeps 75–90 %, *P. auritus* keeps 7–20 % and the rarest *M. dasycneme* has not more 1–10 % may be taken as objective species ratios for these mines. Therefore, the end of November and the beginning of December is the time where the species relative abundance is more similar to the objective one. It could be the best time for bat censuses and monitoring. But across Europe there are different recommendations and practices for the time of bat winter censuses and monitoring. For example in countries of central Europe, the season of bat censuses is mainly February (e. g. Grzywiński et al., 2012; Lesinski et al., 2005; Mitchell-Jones et al., 2007). The single case of total bat censuses in underground in Western Ukraine was carried out in February too (Godlevska et al., 2011 b). At the same time in the European part of Russia in the Middle Volga province bat winter censuses were conducted in late November (Smirnov et al., 2007). For future monitoring in Liptsy mines we recommended a minimum of two censuses in the beginning of December and in February. Because of the large fluctuation of bat numbers in Liptsy mines presented in this study it is difficult to estimate long-term trends in local bat populations. Furthermore, it is difficult to add these results to a European wide picture of bat population trends. On the one hand more winter monitoring is needed. On the other hand we need to manage bat winter monitoring in the other bat hibernacula in North-Eastern Ukraine.

S e x r a t i o i n l o c a l b a t p o p u l a t i o n

The sex ratio in local bat populations and the particularities of both sexes' over time and space is one of the key parameters which can tell us about bat habitat suitability (e. g. Strelkov, 1999; Rakhmatulina, 2000; Russo, 2002; Snit'ko, 2007; Estók, 2007; Vlaschenko, 2008; Ibáñez et al., 2009). In winter parts of bat ranges in temperate latitudes, females stay a shorter time than males (Snit'ko, 2007). To the contrary males could live in winter part of ranges or even in hibernaculas all year long (Snit'ko, 2007; Estók, 2007), or migrate out in short periods of mid-summer only (Snit'ko, 2007). It was hypothesized that in new winter roosts males are dominant in samples because this sex group started wintering in a new location or region for species (Snit'ko, 2007). The sex ratio of *M. daubentonii* in Liptsy 1 and 3–4 mines is equal to 1 : 1. In Liptsy 2 mine the females are dominant, but in this case there is insufficient sample size. The seasonal change in sex ratio in *M. daubentonii* in Liptsy 1 mine demonstrates that in the end of summer males predominate both inside (fig. 15) and among mist-netting bats (fig. 16). Population structure with males dominant in sex ratio is typical for autumn swarming (Snit'ko, 2007; van Schaik et al., 2015). Inside the mines, females are dominant in the beginning of the hibernation period. It is possible that the decrease of females in the mid-winter and increase again in spring reflects their mating activity. Female *M. daubentonii* leave the mines earlier than males (fig. 16). Contrary to *M. daubentonii*, *P. auritus* sex ratio is not equal in autumn swarming and spring departure (fig. 16). It is possible that females of *P. auritus* leave the mines earlier than when we begin our mist-netting (Appendix, List 2) — in mid-March. As the result the particularities of sex structure in bat populations of Liptsy mines are similar to other known hibernation cites.

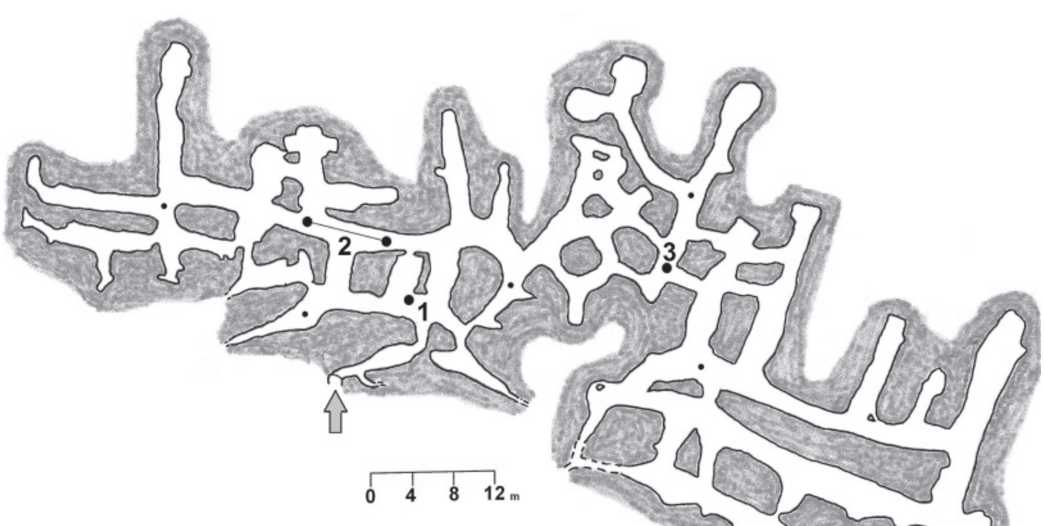
Conclusions and conservation strategy

The results of this study support that the Liptsy mines are important underground sites for bats (Vlaschenko, Naglov, 2006; Godlevska et al., 2016) and are winter habitats to several hundred individuals each winter. The results of local recaptures of ringed bats confirm that the same individuals are wintering in the mines from year to year (Vlaschenko, 2012; Vlaschenko et al., 2014). However, in spite of the high importance of the mines for conservation of local bat populations, Liptsy mines have no official protection status. To get the legal protection status for the mines all documents were completed and sent to the Ministry of Ecology and Natural Resources of Ukraine in 2013. However, no answer has yet been given. The management of Liptsy mines and the creation of a conservation strategy (as one of the most important bat hibernation site in the Region) is the key element of all European bat conservation strategies (Mitchell-Jones et al., 2007).The Liptsy mines urgently need an Action Plan for future conservation. In the first years of survey we did not note backfilled of celling inside the mines. But for all long-term periods of observations and looking forward we recognize that without human operation the mines entrances will likely collapse in ten or fifteen years. We think that local Nature Protection and Speleological Non-Governmental Organizations have to be initiators and drivers of future conservation of these mines. We need a big effort in the coming years to finish the protection progress (legal protection status, separation of touristic and strictly protected parts, setting grates, etc.) of the mines, in accordance with EUROBATS recommendations (Mitchell-Jones et al., 2007).

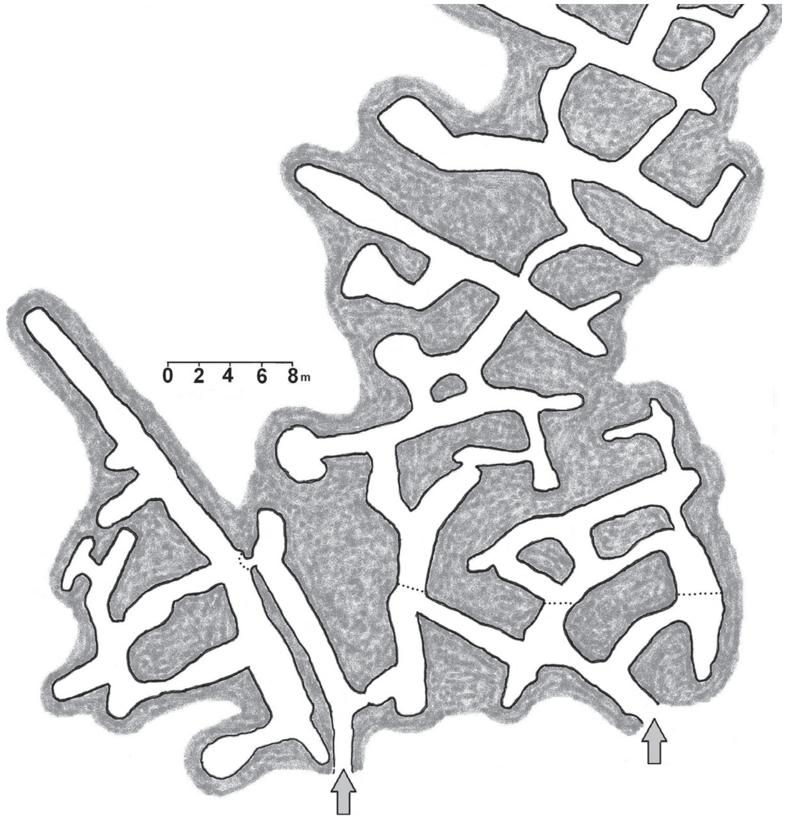
We recognized that bats prefer mines with bigger entrances and gradual temperature regime. Do we need to dig out and expand the entrance in the Liptsy 2 mine? The Liptsy mines are man-made caves and it could be easy to change the entrance in Liptsy 2 mine. On the other hand, two close mines with different temperature regimes could be important research sites for bat research as well as underground mycobiota (Kravchenko et al., 2015) or other underground living organisms. The other important subjects that need to be tested in future are 1) what are the real bat number in Liptsy 1 mine?; 2) do the carnivores visiting the mines hunt local bats and what is the number of individuals eaten? We need an estimation of real pressure of predators on winter bat aggregation in the mines and how to protect bats from them; 3) to be sure we will continue the monitoring of winter aggregations and searching of ringed bats in summer time.

We thank Pavel Vlaschenko, Anton Biatov, Dr. Yegor Yatsuk, Roman Krasovsky, Sergey Chernykh, Victoria Kornienko, Sergey Saprykin, Marina Kharyakova, Natalya Ovcharenko, Maryna Krivoshyzha, Alexey Barsukov, Oleg Prylutsky, Daria Yelagina and Maria Sudakova for the field assistance in different periods of the long-time research. Our special thanks to Kseniia Kravchenko, Dr. Yulia Kuznetsova and Dr. Alona Prilutskaya as for field assistance and for discussions of the results, important help and recommendations on data analyzing. We are very grateful to Simon Mickleburgh and Dr. Liam Bailey for correction of the English language and two anonymous referees for important comments. In 2004–2005 the bat winter monitoring were conducted under support of Fauna & Flora International, Flagship Species Fund Small Grants Program (UK) the project N 02/28/12 FLAG "The study of hibernation sites of threatened species of bats in territory of North-East of Ukraine". conducted under support of Fauna & Flora International, Flagship Species Fund Small Grants Program (UK) the project N 02/28/12 FLAG "The study of hibernation sites of threatened species of bats in territory of North-East of Ukraine".

Appendix. Fig. 1. Map of Liptsy 1 mine. Large numbered dots — main temperature measurement points (see fig. 1), small dots — additional temperature measurement points. Entrances (numbered I and II) are shown by arrows. The dashed line is the border of the freezing zone.



Appendix. Fig. 2. Map of Liptsy 2 mine. Large numbered dots – main temperature measurement points (see fig. 2), small dots — additional temperature measurement points. Entrance shown by arrow.



Appendix. Fig. 3. Map of Liptsy 3–4 mine. Entrances shown by arrows. Dashed line is the border of the freezing zone.

Appendix. List 1. Records of bats inside the Liptsy mines (included only that visits when bats were recorded).Abbreviations: 18–12–99 — dd–mm–yy; L1 — Liptsy 1 mine, L2 — Liptsy 2 mine and L3–4 — Liptsy 3–4 mine; *Mdau* — *Myotis daubentonii*; *Mdas* — *Myotis dasycneme*; *Paur* — *Plecotus auritus*.

18–12–99 L1 — *Mdau* 3 ♀, 3 ♂; *Paur* 2 ♂. 18–12–99 L2 — *Mdau* 2 ♂. 08–04–00 L1 — *Mdau* 8 ♀, 6 ♂. 08–04–00 L2 — *Mdau* ♀, 3 ♂; 1. 08–04–00 L3–4 — *Mdau* 3 ♀, *Paur* — ♂. 02–09–00 L1 — *Mdau* ♀, 4 ♂, 8. 07–10–00 L1 — *Mdau* 14 ♀, 11 ♂. 07–10–00 L2 — *Mdau* ♀, ♂. 07–10–00 L3–4 — *Mdau* 6 ♀, 2. 18–11–00 L1 — *Mdau* 7 ♀, 3 ♂, 4; *Mdas* ♀, ♂; *Paur* 2 ♂. 18–11–00 L2 — *Mdau* ♀; *Paur* ♀. 18–11–00 L3–4 — *Mdau* 6 ♀, 2 ♂; *Paur* ♀, ♂. 29–12–00 L1 — *Mdau* 113 ♀, 103 ♂; *Paur* 2 ♀, 6 ♂. 21–12–01L1 — *Mdau* 39 ♀, 55 ♂; *Paur* 2 ♀, 2 ♂. 05–02–01 L3–4 — *Mdau* 14 ♀, 12 ♂. 26–02–01 L1 — *Mdau* 26 ♀, 29 ♂; *Paur* ♂. 16–03–01 L3–4 — *Mdau* 5 ♀, 6 ♂; *Paur* ♂. 23–03–01 L1 — *Mdau* 34 ♀, 30 ♂. 21–04–01 L1 — *Mdau* 1 ♀, 2 ♂, 4. 22–04–01 L3–4 — *Mdau* 4. 07–10–01 L1 — *Mdau* 2 ♀, ♂, 12. 24–11–01 L1 — *Mdau* 6 ♀, 2 ♂; *Mdas* ♀; *Paur* ♀. 25–11–01 L1 — *Mdau* 2 ♀, 2 ♂; *Paur* ♂. 22–12–01 L1 — *Mdau* 8. 25–01–02 L2 — *Mdau* 8; *Paur* ♂, 1. 25–01–02 L3–4 *Mdau*12; *Paur* 3. 01–03–03 L3–4 — *Mdau* ♀. 01–11–03 L3–4 — *Mdau* ♀. 29–11–03 L2 — *Mdau* ♂; *Paur* ♀. 29–11–03 L3–4 — *Mdau* ♀. 22–01–04 L3–4 — *Mdau* 1. 03–03–04 L3–4 — *Mdau* 1. 25–09–04 L1 — *Mdau* ♀, ♂. 25–09–04 L2 — *Mdau* ♀, ♂. 25–09–05 L1 — *Mdau* ♀, ♂; *Mdas* ♀, ♂. 21–10–05 L1 — *Mdas* 5 ♀. 22–10–05 L2 — *Mdas* ♀. 10–12–05 L1 — *Mdau* 2; *Paur* 3. 10–12–05 L2 — *Mdau* 2 ♀, 2; *Paur* 2. 10–12–05 L3–4 — *Mdau* 2; *Paur* 1. 24–12–05 L1 — *Mdau* 5; *Mdas* 1; *Paur* 4. 24–12–05 L2 *Mdau* 2; *Paur* 1. 21–01–06 L1 — *Mdau* 4; *Paur* 1. 21–01–06 L2 — *Mdau* 5; *Paur* 1. 10–02–06 L1 — *Mdau* ♀, 3. 10–02–06 L2 — *Mdau* 5; *Paur* 1. 10–02–06 L3–4 — *Mdau* 1. 11–03–06 L1 — *Mdau* 2; *Paur* 1. 11–03–06 L2 — *Mdau* 5. 12–01–07 L1 — *Mdau* 1; *Paur* 1 ♀, 4. 12–01–07 L2 — *Mdau* 2; *Paur* 1. 12–01–07 L3–4 — *Mdau* 2. 31–08–07 L1 — *Mdau* ♀, ♂; *Mdas* ♀. 01–09–07 L2 — *Mdau* ♂. 01–09–07 L3–4 — *Mdau* 2 ♀, ♂. 13–10–07 L1 — *Mdau* ♀; *Mdas* ♀. 13–10–07 L2 — *Mdas* ♀. 13–10–07 L3–4 — *Mdau* ♀. 30–12–07 L1 — *Mdau* ♂, 47; *Paur* 11. 30–12–07 L2 — *Mdau* 1. 30–12–07 L3–4 — *Mdau* 3. 20–01–08 L1 — *Mdau* 45; *Paur* 7. 20–01–08 L2 — *Mdau* 1; *Paur* 1. 20–01–08 L3–4 — *Mdau* 4. 23–02–08 L1 — *Mdau* 60; *Paur* 6. 23–02–08 L2 — *Mdau* 3; *Paur* 1. 23–02–08 L3–4 — *Mdau* 4. 15–03–08 L1 — *Mdau* 26 ♀, 12 ♂, 17. 15–03–08 L2 — *Mdau* 3. 15–03–08 L3–4 — *Mdau* 3. 29–03–08 L1 — *Mdau* 17 ♀, 9 ♂, 6; *Paur* ♂. 29–03–08 L2 — *Mdau* 2.

30–03–08 L3–4 — *Mdau* 2. 26–04–08 L1 — *Mdau* 1. 19–10–08 L1 — *Mdau* 3; *Mdas* 1. 19–10–08 L2 — *Mdau* 2. 19–10–08 L3–4 — *Mdau* 2. 05–11–08 L1 — *Mdas* 2. 05–11–08 L2 — *Mdau* 2. 29–11–08 L1 — *Mdau* 1; *Mdas* 1. 29–11–08 L3–4 — *Mdau* 2; *Mdas* 1. 30–12–08 L1 — *Mdau* 1. 30–12–08 L2 — *Mdau* ♀, 2. 30–12–08 L3–4 — *Mdau* 3; *Paur* 1. 22–01–09 L1 — *Mdau* 2 ♂, 1. 22–01–09 L2 — *Mdau* 2 ♀, 1. 22–01–09 L3–4 — *Mdau* 4; *Paur* 1. 26–03–09 L1 — *Mdau* 2 ♀, 2 ♂, 5; *Mdas* ♂. 29–08–09 L2 — *Mdau* 4. 31–08–09 L1 — *Mdau* ♀, ♂, 4. 28–11–09 L1 — *Mdau* 3; *Paur* 1. 28–11–09 L2 — *Paur* 2. 28–11–09 L3–4 — *Mdau* 2; *Paur* 1. 18–12–09 L1 — *Mdau* 5; *Paur* 3. 03–05–10 L1 — *Mdau* ♂, 1. 04–05–10 L2 — *Mdau* 1. 15–08–10 L1 — *Mdau* 10.15–08–10 L2 — *Mdau* 2.

Appendix. List 2. Bats captured by mist-nets near entrances at Liptsy mines (recaptured ringed bats are included). Abbreviations: 25/26–09–04 — dd/dd–mm–yy; L1/1 — Liptsy 1 mine, entrance 1; L1/2 — Liptsy 1 mine, entrance 2; L2 — Liptsy 2 mine; *Mdau— Myotis daubentonii*; *Mdas — Myotis dasycneme*; *Paur — Plecotus auritus*.

25/26–09–04 L1/1 — *Mdau* 3 ♂. 23/24–09–05 L1/1 — *Mdau* ♀, 2 ♂; *Paur* 2 ♂. 24/25–09–05 L1/1 — *Paur* 2 ♀, 2 ♂. 24/25–09–05 L1/2 — *Mdau* ♀. 30/31–08–07 L1/1 — *Mdau* 5 ♀, 9 ♂; *Mdas* 2 ♂; *Paur* ♀, 4 ♂. 31/01–08/09-07 L1/2 — *Mdau* 3 ♂; *Paur* ♂. 31/01–08/09–07 L2 — *Mdau* 4 ♀, 7 ♂. 01/02–09–07 L1/1 — *Mdau* 6 ♀, 8 ♂; *Mdas* ♀; *Paur* ♀, 2 ♂. 12/13–10–07 L1/1 — *Paur* 2 ♂. 28–03–08 L1/1 — *Mdau* ♂. 28–03–08 L1/2 — *Mdau* ♀, ♂. 29–03–08 L1/1 — *Mdau* 5 ♀, 4 ♂; 29–03–08 L1/2 — *Mdau* 2 ♀, 9 ♂; *Mdas* ♀; *Paur* 2 ♂. 25/26–04–08 L1/1 — *Mdau* 4 ♂. 26/27–03–09 L1/1 — *Mdau* ♂; *Paur* ♂. 26/27–03–09 L1/2 — *Mdau* 2 ♀, 7 ♂; *Paur* 2 ♂. 27/28–03–09 L1/1 — *Mdau* 2 ♀, 3 ♂; *Mdas* 2 ♀; *Paur* 3 ♂. 27/28–03–09 L1/2 — *Mdau* 5 ♀, 14 ♂; *Paur* ♀, 2 ♂. 28–03–09 L1/1 — *Mdau* 4 ♀, 4 ♂; *Mdas* ♀; *Paur* 3 ♂. 28–03–09 L1/2 — *Mdau* 4 ♀, 4 ♂. 04–04–09 L1/2 — *Mdau*15 ♀, 11 ♂; *Paur* ♂. 11–04–09 L1/2 — *Mdau* 6 ♀, ♂; *Mdas* ♂. 12–04–09 L1/1 — *Mdau* 3 ♂; *Paur* ♂. 12–04–09 L1/2 — *Mdau*3 ♂. 29/30–08–09 L1/1 — *Mdau* 12 ♀, 28 ♂; *Paur* ♀, 5 ♂. 29/30–08–09 L1/2 — *Mdau* 10 ♀, 15 ♂ *Paur* 8 ♀, 10 ♂ 29/30–08–09 L2 — *Mdau* 3 ♀, 3 ♂; *Paur* ♀, ♂ 31/01–08/09–09 L1/1 — *Mdau* 5 ♀, 13 ♂ 31/01–08/09–09 L1/2 — *Mdau* 5 ♀, 13 ♂; *Mdas* 2 ♂; *Paur* 2 ♀, 2 ♂. 03–05–10 L1/1 — *Mdau* 7 ♂; *Paur* 2 ♂. 03–05–10 L1/2 — *Mdau* 10 ♂ 04–05–10 L2 — *Mdau* 2 ♂ *Paur* ♂ 05–05–10 L1/1 — *Mdau* 17 ♂.

References

Abelentsev, V., Pidoplichko, I., Popov, B. 1956. Order bats. Chiroptera. *In*: Bilanovsky, I., ed. *Fauna of Ukraine. Vol. 1. Mammals. Is. 1. Basic characteristic of Mammals. Insectivores, Bats.* Vydavnyctvo Akademii nauk Ukrainskoj RSR, Kiev, 229–446 [In Ukrainian].

Bagrowska-Urbańczyk, E., Urbańczyk, Z. 1983. Structure and Dynamics of a Winter Colony of Bats. *Acta Theriologica*, **28**, 183–196.

Bárta, Z., Čerený, J., Gaisler, J., Hanák, P., Hanák, V., Horáček, I., Hurka, L., Miles, P., Hevrlý, M., Rumler, Z., Sklenář, J., Žalman, J. 1981. Results of winter census of bats in Czechoslovakia: 1969–1979. *Sborn. OM Most, prír.*, **3**, 71–116 [In Czech with English summary].

Battersby, J. (comp.) 2010. *Guidelines for surveillance and monitoring of European bats*. EUROBATS Publication Series No 5. UNEP / EUROBATS Secretariat, Bonn 1–95.

Benda, P., Gazaryan, S., Vallo, P. 2016. On the distribution and taxonomy of bats of the *Myotis mystacinus* morphogroup from the Caucasus region (Chiroptera: Vespertilionidae). *Turkish Journal of Zoology*, 40, 842–863.

Benda, P., Tsytsulina, K. 2000. Taxonomic revision of *Myotis mystacinus* group (Mammalia: Chiroptera) in the western Palearctic. *Acta Societatis Zoologicae Bohemicae*, 64, 331–398.

Boot, V. 1971. Periodical natural phenomena in Kharkov region and conducting of phenological observations. *Materials of Kharkov department of Ukrainian geographical society*. *Is. 8.* Kharkov region nature and economy, Kharkov, 90–96 [In Russian].

Conservation of Key Underground sites 2014: the database http://www.eurobats.org/activities/intersessional_working_groups/underground_sites

Dykyy, I., Kus'nezh, O., Mysiuk, V. 2008. Fauna of bats of Medova Cave (Lviv region) and prospects of its protection. *In*: Zagorodniuk, I., ed. *Rare Mammal Fauna and Its Conservation*. *Proceedings of the Theriological School*, *Is. 9.* Lugansk, 214–218 [In Ukrainian with English summary].

Eisentraut, M. 1957. *Ausdem Lebender Fledermäuseund Flughunde*. Gustav Fischer Vlg., Jena, 1–175.

Estók, P. 2007. Seasonal changes in the sex ratio of *Nyctalus* species in North-East Hungary. *Acta Zoologica Academiae Scientiarum Hungaricae*, **53**, 89–95.

Furmankiewicz, J., Górniak, J. 2002. Seasonal changes in number and diversity of bat species (Chiropeta) in the Stolec mine (SW Poland). *Przyroda Sudetów Zachodnich Sup.*, **2**, 49–70.

Gaisler, J., Chytil, J. 2002. Mark-recapture results and changes in bat abundance at the cave of Na Turoldu, Czech Republic. *Folia Zoologica*, **51**, 1–10.

Gannon, W., Sikes, R. 2007. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *Journal of Mammology*, **88**, 809–823.

Godlevskaya, E. 2003. Data on bats of Kerch peninsula (Crimea). *Plecotus et al.*, **6**, 29–36 [In Russian with English summary].

Godlevska, O., Petrushenko, Ya., Tyschenko, V., Zagorodniuk, I. 2005. Bats' winter aggregations in caves of Central Podillya. *Vestnik Zoologii*, **39** (2), 37–45 [In Ukrainian with English summary].

Godlevskaya, E. 2007. Use of Kiev caves by bats (Chiroptera): hibernation and swarming. *Vestnik Zoologii*, **41** (5), 438–449.

Godlevskaya, E., Panchenko, P., Formanjuk, O. 2008. New data on cave-dwelling bats of Odessa City vicinities. *In*: Zagorodniuk, I., ed. *Rare Mammal Fauna and Its Conservation. Proceedings of the Theriological School, Is.* 9. Lugansk, 93–101 [In Russian with English summary].

Godlevskaya, E. V., Ghazali, M. A. 2009. New Records of Bats (Chiroptera) at the Territory of Donetsk Region (Ukraine). *Vestnik Zoologii*, **43** (5), 470 [In Russian].

Godlevskaya, E. V., Ghazali, M. A., Postawa, T. 2009. A current state of cave dwelling bat species (Mammalia, Chiroptera) of the Crimea. *Vestnik Zoologii*, **43** (3), 253–265 [In Russian with English summary].

Godlevska, O. V., Tyshchenko, V. M., Ghazali, M. A. 2010. A current status of cave-dwelling bats of Podillya and Middle Dniester River region (Ukraine). *Nature reserves in Ukraine*, **16** (1), 53–64 [In Ukrainian with English summary].

Godlevskaya, E. V., Ghazali, M. A., Tyshchenko, V. M. 2011 a. Results of the first full-scaled bat census in underground sites of the Continental Black Sea Region of Ukraine. *Nature reserves in Ukraine*, **17** (1–2), 34–41 [In Russian with English summary].

Godlevska, O. V., Ghazali, M. A., Tyshchenko, V. M., Drebet, M. V., Martynjuk, V. Ju. 2011 b. Results of the winter bat census in two sites of the Central Podolia (Ukraine). *Vestnik Zoologii,* **45** (1), 81–84.

Godlevska,L., Buzunko, P., Rebrov, S., Ghazali, M. 2016. Underground bat sites of "not-cave" region of Ukraine on results of 2002–2015. *Visnyk of Lviv University. Biology series*, **71**, 178–189 [In Ukrainian].

Golikov, A. P., Kazakova, N. A., Shuba, M. B. 2011. *Kharkov region: regional development, current and perspectives.* V. N. Karazin Kharkiv National University Press, Kharkiv, 1–329 [In Russian].

Grzywiński, W., Boratyński, J. S., Górecki, J., Jaros, R., Ignaczak, M., Karwowska, B., Kmiecik, A., Kmiecik, P., Łochyński, M., Malak, K., Polowy, K., Wieczorek, M., Wojtaszyn, G. 2012. Bats hibernating in stand-alone bunkers of the Międzyrzecki Fortified Front in the years 2005–2012. *Vespertilio*, **16,** 149–157.

Hutterer, R., Ivanova, T., Meyer-Cords, C., Rodrigues, L. 2005. Bat migration in Europe. A review of banding data and literature. *Naturschutz und Biologische Vielfalt,* **28.** Federal Agency of Nature Conservation, Bonn, 1–162.

Ibáňez, C., Guillén, A., Agirre-Mandi, P. N., Juste, J., Schreur, G., Cordero, A. I., Popa-Lisseanu, A. G. 2009. Sexual segregation in Iberian Noctule Bats. *Journal of Mammology*, **90** (1), 235–243.

Il'in, V. Yu. 1988. Natural predators of bats in Penza region. *In*: Topachevsky, V. A., Kovtun, M. F. eds., *Bats.* Naukova Dumka, Kiev, 152–156 [In Russian].

Il'in, V. Yu. 1994. Bat wintering on the South of Forest-steppe natural zone of Right-bank Volga region. *In*: Il'in, V. Yu., ed. *Inter-Universities book of scientific works. "Fauna and ecology of animals".* Penza State Pedagogical University, Penza, 3–21 [In Russian].

Ingersoll, T. E., Sewall, B. J., Amelon, S. K. 2013. Improved Analysis of Long-Term Monitoring Data Demonstrates Marked Regional Declines of Bat Populations in the Eastern United States. *PLoS ONE,* **8** (6), e65907. doi:10.1371/journal.pone.0065907

Kervyn, T., Lamotte, S., Nyssen, P., Verschuren, J. 2009. Major decline of bat abundance and diversity during the last 50 years in southern Belgium. *Belgian Journal of Zoology,* **139**, 124–132.

Kokurewicz, *T*. 2004. Sex and age related habitat selection and mass dynamics of Daubenton's bats *Myotis daubentonii* (Kuhl, 1817) hibernating in natural conditions. *Acta Chiropterologica*, **6**, 121–144.

Kovalev, A. G. 2014. Caves of Kharkov region (on the base of a cadaster). *In*: Kovalev, A. G., ed. *Exploration of undergrounds of Kharkiv region: Proceedings of V research and practice conference.* Avantazh, Kharkiv, 27–46 [In Russian].

Kravchenko, K. A., Vlaschenko, A. S., Prilutskii, O. V., Prilutskaya, A. S. 2015. A Search of *Geomyces destructans*, a Dangerous Pathogen of Bats in Caves of Eastern Europe. *Russian Journal of Ecology*, **46** (5), 490–493.

Lesiński, G. 1986. Ecology of Bats Hibernating Underground in Central Poland. *Acta theriologica*, **31** (37), 507–521.

Lesiński, G., Fuszara, E., Fuszara, M., Jurczyszyn, M., Urbańczyk, Z. 2005. Long-term changes in the numbers of the Barbastelle *Barbastella barbastellus* in Poland. *Folia Zoologica*, **54** (4), 351–358.

Lesiński, G., Ignaczak, M., Kowalski, M. 2011. Increasing bat abundance in a major winter roost in central Poland over 30 years. *Mammalia*, **75**, 163–167.

Mitchell-Jones, A. J., Bihari, Z., Masing, M., Rodrigues, L. 2007. Protecting and managing underground sites for bats. *EUROBATS Publication Series No. 2* (English version). UNEP EUROBATS Secretariat, Bonn, 1–38.

Pokynchereda, V. 1998. Cadaster of underground bat hibernate roosts on the territory of the Carpathian biosphere reserve. *In*: Zagorodniuk, I., ed. *European bat night '98 in Ukraine*. *Proceedings of the Theriological School*, Is. 1, Kiev, 166–172 [In Ukrainian with English summary].

Rakhmatulina, I. K. 2000. Sex ratio in bat populations in the Eastern Transcaucasus. *Plecotus et al.*, **3**, 50–76 [In Russian with English summary].
Řenák, Z., Zukal, J., Kovařik, M. 1994. Long- and short-term changes in the bat community of the Kateřinská cave (Moravian Karst) — a fundamental assessment. *Folia Zoologica*, **43** (4), 425–436.
Russo, D. 2002. Elevation affects the distribution of the sexes in Daubenton's bats *Myotis daubentonii* (Chiroptera: Vespertilionidae) from Italy. *Mammalia*, **66**, 543–551.
Smirnov, D. G., Vekhnik, V. P., Kurmaeva, N. M., Shepelev, A. A., Il'in, V. Yu. 2008. Spatial Structure of the Community of Bats (Chiroptera: Vespertilionidae) Hibernating in Artificial Caves of Samarskaya Luka. *Biology Bulletin*, **35** (2), 211–218.
Smirnov, D. G., Vekhnik, V. P., Kurmaeva, N. M., Shepelev, A. A., Il'in, V. Yu. 2007. Spatial Structure and Dynamics of the Bat Community (Chiroptera: Vespertilionidae), Hibernating in Artificial Caves of Samarskaya Luka. *Izvestia Rossiyskoy Akademii Nauk, Seria Biologicheskay,* **5**, 608–618 [In Russian with English summary].
Snit'ko, V. P. 2007. Seasonal Spatial Differentiation of Sex Groups in Populations of Resident Bat Species (Chiroptera, Vespertilionidae) in the Southern Urals. *Russian Journal of Ecology*, **38** (5), 334–340.
Spitzenberger, F., Engelberger, S. 2013. Negative trend reversal after 16 years of constant growth: The case of *Rhinolophus hipposiderosin* an Austrian mass hibernaculum (Chiroptera: Rhinolophidae). *Lynx, n. s.*, **44**, 149–156.
Stebbings, R. E. 1988. *Conservation of European Bats*. Christopher Helm, London, 1–264.
Strelkov, P. P. Ilin, V. Yu. 1990. The bats (Chiroptera, Vespertionidae) of the south Middle Volga and Lower Volga provinces. *Annals of the Zoological Institute of Academy of Science of USSR*, **225**, 42–167 [In Russian].
Strelkov, P. P. 1958. Contribution to bat hibernations in European part of USSR. *Trudy Zoologicheskogo Instituta AN SSSR*, **25**, 255–303 [In Russian].
Strelkov, P. P. 1971. Ecological attendance for bat hibernation (Chiroptera, Vespertilionidae) in Leningrad region. *Annals of the Zoological Institute of Academy of Science of USSR*, **48**, 251–302 [In Russian].
Strelkov, P. P. 1999. Sex ration in breeding season in adult individuals of long-distant migrant bats (Chiroptera, Vespertilionidae) of Eastern Europe and adjacent territories. *Zoologicheskiĭ zhurnal*, **78** (12), 1441–1454 [In Russian with English summary].
Uhrin, M., Benda, P., Obuch, J., Urban, P. 2010. Changes in abundance of hibernating bat s in central Slovakia (1992–2009). *Biologia*, **65**, 349–361.
Van der Meij, T., Van Strien, A. J., Haysom, K. A., Dekker, J., Russ, J., Biala, K., Bihari, Z., Jansen, E., Langton, S., Kurali, A., Limpens, H., Meschede, A., Petersons, G., Presetnik, P., Pruger, J., Reiter, G., Rodrigues, L., Schorcht, W., Uhrin, M., Vintulis, V. 2014. Return of the bats? A prototype indicator of trends in European bat populations in underground hibernacula. *Mammalian Biology*, **80**, 170–177.
van Schaik, J., Janssen, R., Bosch, T., Haarsma, A-J., Dekker, J. J. A., Kranstauber, B. 2015. Bats Swarm Where They Hibernate: Compositional Similarity between Autumn Swarming and Winter Hibernation Assemblages at Five Underground Sites. *PLoS ONE*, **10** (7), e0130850. doi:10.1371/journal.pone.0130850
Vlaschenko, A. S., Naglov, A. V. 2005. A Marl Open Pit as a Unique Place of Bats (Chiroptera) Inhabiting. *Vestnik Zoologii*, **39** (2), 94.
Vlaschenko, A. S., Naglov, A. V. 2006. Bats (Chiroptera: Vespertilionidae) hibernation in artificial caves of north-eastern Ukraine. *Journal of V. N. Karazin National University. Series: biology*, **3** (729), 122–133 [In Russian with English summary].
Vlaschenko, A. S. 2006. Biogeocenological role of bats (Mammalia, Chiroptera) on the South part of forest-steppe zone. Ph. D. thesis, V. N. Karazin Kharkiv National University, Kharkov, 1–234 [In Russian].
Vlaschenko, A. S. 2008. Sex ratio in four bats species in North-Eastern Ukraine. *Journal of V. N. Karazin National University. Series: biology*, **7** (814), 65–73 [In Russian with English summary].
Vlaschenko, A. S., Gukasova, A. S. 2009. Development of method for the inventory of species composition and population structure of Chiroptera. *Nature reserves in Ukraine*, **15** (1), 49–57 [In Russian].
Vlaschenko, A. S., Gukasova, A. S. 2010. Bat (Chiroptera) fauna and structure of assemblage of projecting protected area "Yaremovskoe" (Kharkov region). *Nature reserves in Ukraine*, **16** (2), 44–50 [In Russian with English summary].
Vlaschenko, A. S. 2011. Research history and list of records of bats (Chiroptera) in the Kharkov Region in the XIX and XX centuries. *Plecotus et al.*, **14**, 26–54 [In Russian with English summary].
Vlaschenko, A. S. 2012. Results of Bat (Chiroptera) Ringing on the Territory of Kharkov Region (2002–2012). *Proceedings of the National Museum of Natural History (Kyiv)*, **10**, 31-41 [In Russian with English summary].
Vlaschenko, A. S., Gukasova, A. S., Shapovalov, A. S. 2012. Contribution to bat (Chiroptera) fauna and ecology of Belgorod region. *Vestnik St. Petersburg University. Ser. 3*, **3**, 3–11 [In Russian].
Vlaschenko, A. S., Gukov, V. S., Kravchenko, K. A., Naglov, A. V., Rodenko, O. E., Suvorova, A. D. 2014. Microclimate and biological studies in mines of Kharkov region. *In*: Kovalev, A. G., ed. *Exploration of undergrounds of Kharkiv region: Proceedings of V research and practice conference.* Avantazh, Kharkiv, 47–50 [In Russian].

Vlaschenko, A., Hukov, V., Naglov, A., Prylutska, A., Kravchenko, K., Rodenko, O. 2016. Contribution to ecology of Brandt's Bat *Myotis brandtii* (Chiroptera, Vespertilionidae), in the North-eastern Ukraine: comparison of local summer and winter bat assemblages. *Vestnik Zoologii*, **50** (3), 231–240.

Volansky, Yu. E. 1967. Bat hibernation in the vicinity of Odessa. *Vestnik Zoologii*, **1** (1), 77–78 [In Russian with English summary].

Zagorodniuk, I., Korobchenko, M. 2008. Rare fauna of Eastern Ukraine: its composition and distribution of rare species. *In*: Zagorodniuk, I., ed. *Rare Mammal Fauna and Its Conservation. Proceedings of the Theriological School, Is. 9*, Lugansk, 107–156 [In Ukrainian with English summary].

Received 14 November 2017
Accepted 25 October 2018