Hibernacula of *Barbastella barbastellus* in Ukraine: distribution and some ecological aspects

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**Abstract.** The paper presents a study regarding the winter aggregations of the barbastelle bat (*Barbastella barbastellus*) in western Ukraine, based on data collected in natural underground spaces and artificial structures (abandoned mines, ancient monuments, military fortifications, etc.). Some parameters including the size and dynamics of winter aggregations, as well as microclimate conditions of hibernacula were investigated. The most numerous barbastelle hibernaculum has been found in the Tarakaniv fortress (Rivne region); the largest aggregation of the species consisted of ca. 950 individuals. The numbers of barbastelles in Ukraine seem stable or even increasing. In Central Europe the species is not threatened as seriously as it is in Western Europe.

**Distribution, hibernation, winter aggregations, conservation**

**Introduction**

The barbastelle bat, *Barbastella barbastellus* (Schreber, 1774), is a Palearctic bat species. Its range stretches from the northern Morocco to Iran and from southern Scandinavia and Latvia to Greece (Wołoszyn & Bashta 2009). In Ukraine, the barbastelle is found from the western borders to the Dnieper river. The majority of records come from the western part of Ukraine and the Crimean Mts. (Kovalyova & Taraborkin 2001, Bashta & Potish 2007, Bashta 2009).

The last assessment of the barbastelle status and distribution in Ukraine, including a review of its records was made in 2001 (Kovalyova & Taraborkin 2001). Since then, a lot of new records and observations have appeared. Therefore the aim of this paper is to summarize and evaluate the information, including the new data on distribution and localization of roosts, and to determine population trends of the species in the eastern part of its range within the borders of Ukraine with a special attention to the Tarakaniv fortress as the largest hibernaculum of the species in Ukraine.

**Study Area and Methods**

The western part of Ukraine, where the study was conducted, includes very different type of landscapes. It covers several physiographic regions, including Polissâ and the Volynska upland (northern part), Podillâ (central part) and the Carpathian region (southern part). Broadleaved forests (incl. beech stands) of Central Europe, forests (incl. oak woods) of the forest-steppe areas of eastern Europe, mixed coniferous-broadleaved forests of northern Europe and meadow-steppe vegetation of southern areas as well as agricultural areas are represented here. The study area includes the Ukrainian Carpathians, which make up about 10% of the whole Carpathian Mts. The mountains are characterized by very varied landscape, limestone areas rich in caves and a temperate continental climate. Karst areas are most evident in the southern part of the Ukrainian Carpathians. The altitude of the investigated area ranges between 105 and about 2000 m a. s. l. (Marynych & Shyshchenko 2005).

The presence of large hibernacula of the barbastelle in underground fortifications of the neighbouring Central-European countries has stimulated us to search for such hibernacula in the territory of Ukraine. Inspection of potential hibernation roosts, mainly large cellars and other underground spaces was carried out in winter season, mainly during the second half of January and February. The checks were sometimes conducted also in late November, December and March. Monitoring of
barbastelle numbers in Western Ukraine has been carried out since 1996, but many important roosts have been discovered only recently. The sites varied in respect of the years in which hibernating bats were counted.

Since the identification of the barbastelle in winter roosts is easy, based on its specific external morphological characters, the specimens were not handled (except for several individuals), taking care to minimize disturbance, so the information on sex is mostly not available. Individuals and small clusters of individuals were counted directly. Number of individuals in the larger aggregations was estimated by multiplying the number of bats counted in a unit area of a certain dimension by the total area covered by the aggregation, or mainly at home by counting the bats directly on the photographs that were taken. The latter method was preferable and proved to be more accurate and also has the advantage that it greatly reduces observation time, while diminishing bat disturbance caused by prolonged exposure to light.

All known museum collections of the main museums of Ukraine were analysed. The majority of barbastelle records are from the Zoological Museum of the Užgorod National University (ZMUzNU), as well as the State Museum of Natural History in Kyiv (NNPM) and the State Natural History Museum in Lviv (DPM) (Bashta & Shydlovsky 2001, Shevchenko & Zolotukhina 2005, Bashta 2007).

**Results and Discussion**

**Current distribution**

The barbastelle bat is distributed mainly in the forest and forest-steppe zones, in the mountains and foothills of the Crimean and Carpathian Mts. in Ukraine (Bashta 2009). Kovalyova & Taraborkin (2001) reported on about 20 winter observation records of the species in Ukraine. Nowadays we have more than 40 localities of the barbastelle winter roosts. The records are distributed unevenly, depending on the intensity of research effort in different parts of the country.

The first record of the species in western Ukraine was described by Pietruski (1853), who noted that the barbastelle had settled mostly in towers and old churches of cities. This author caught two specimens in the attic of a house in Lviv in 1832. This is probably the first published observation of the barbastelle in Ukraine.

Large hibernacula of the barbastelle are known from underground fortifications of several Central-European countries (e.g. Modlinski forts, forts near Torun, Osoviec in Poland, Brest fortress in Belarus or Kaunas forts in Lithuania – Fuszara & Fuszara 2002, Kasprzyk et al. 2002, Lesiński 2001, Demianchik & Demianchik 2002, Pauža & Paužiene 2002) and other countries and they are key sites for hibernation of many other bat species. It is characteristic that underground cavities of anthropogenic origin, in particular fortifications, are the most important wintering places for this species (Table 1).

Some parts of the country (e.g., the Polissâ and Volynska upland) are characterised by the absence of large underground cavities of natural origin. Therefore different artificial underground spaces became important shelters for bats there. During the study, in 2006, we found the country’s largest hibernaculum of the barbastelle bat which is situated in an abandoned fortification (so called Tarakaniv fort) in the Rivne region (western part of the country).

**Polissâ and the Volynska Upland**


The barbastelle bat was observed only in the western and central parts of the Polissâ area (because its area of distribution is restricted eastwards by the Dniepro river in central Ukraine). The first
record of this species (from the Poliskyi Dist., Žytomyr Region) was made by Abelentsev et al. (1956). The Polissâ area is characterized mainly by the absence of large underground cavities which are usually used by the barbastelle. However, probability of barbastelle wintering in this area is confirmed by the finding of one specimen in the Šac’k settlement in late October (DPM).

Relatively more winter records of the barbastelle come from the V olynska upland. Majority of them were found in the underground parts of big old buildings. Thus, a large number of hibernacula is located in the cellars of old castles, houses and fortifications, such as the castle in the Olyka (Kiverci Dist., V olyn’ Region), castles in Dubno, castle in Novomalyn (Ostrih Dist.), fort near the Tarakaniv village (Dubno Dist.), etc., in the Rivne Region.

Podillâ


Despite the fact that the Podillâ area is characterized by numerous underground spaces of natural and artificial origin, the number of recent winter observations is not so high as expected. The main number of winter records comes from the caves of the southern part of the region. In particular, barbastelles were found in the Kryvčan’ska cave in the Ternopil Region (Tatarynov 1962), limestone mines near the Gumenci in the Hmelnyckyj Region (Tyshchenko et al. 2005, Matveev et al. 2010). We suppose that because of a large number of different underground spaces, the barbastelle, which often prefers small crevices, remained outside researchers’ attention.

Carpathians


The Carpathian region is represented by probably the largest number of barbastelle records. In the Transcarpathian part of this region the barbastelles were found both in the plains, foothills
and mountain areas which is a result of the existence of a large number of different underground spaces. The pre-Carpathian part (lower north-eastern part of the Carpathian region) is characterized by a much smaller number of the barbastelle records.

**Prydniprovska Upland**

**Records.** **Kyiv Region:** **Kyiv, Golosieve**, 16 March 1938: 1 ind.; 11 November 1939: caves of Lavra, hydrostructures; 30 November 1939: Golosieve, 13 inds.; January 1940: Kytaeve; February 1940: Kytaeve; 24 March 1940: Golosieve, 1♂, 4♀♀ (Abelentsev et al. 1956); January 1941: 1♂; 12 January 1941: Cerkivšyna hamlet, 2♀♀ (Likhotop et al. 1980); 24 February 1948 (Abelentsev et al. 1956); 24 November 1948: Kytaeve, 2 inds. (1♀); 28 November 1948: Kytaivska cave, 2♀♀ (NNPM); 12 April 1949: Kytaivska cave, 5♂♂, 5♀♀ (Abelentsev et al. 1956); **Lisnyky** (Kyevo-Sviatošyns’kyj Dist.), 2 April 1983: 1♂ (Likhotop...

Majority of the records were related to the city of Kyiv and to the Kanivskyj Nature Reserve which probably reflects rather the concentration of scientists in the area than the real spatial distribution of the barbastelle population.

Crimea


The earliest information about the observation of barbastelle bats in Crimea was mentioned by Nordman (1840). The author noted that the species is “quite common” at the southern coast of Crimea. Nikolskiy (1891) noted that the species is distributed throughout the mountain part of Crimea. Data on the species were also found in the publication by Sharleman (1920).

Roost preference in winter period

The roosts of barbastelle bats are associated mainly with underground cavities in winter period. They are mainly underground spaces, cellars, tunnels etc. as well as cracks in rocks. The species often hibernates in large underground shelters in Central and Eastern Europe (Bogdanowicz 1983, Lesiński 1986, Richarz 1989, Urbańczyk 1989, Uhrin 1995, Fuszara et al. 1996, Matveev et al. 2010, Demianchik & Demianchik 2002, Bashta & Ivashkiv in press). Numerous suitable hibernation roosts (mostly military structures or mines) are known in Ukraine.

Mainly records of isolated barbastelle bats are known from the winter roosts of the Carpathian region. They are situated mainly in the Ugolsko-Šyrokolužanskyj massif of the Carpathian Biosphere Reserve (Krochko 1992, Pokynchereda & Pokynchereda 1997, Vargovich 2000, Zhdanovych 2000), but also in other parts of the region. Mainly isolated individuals were found there, but in some cases there were clusters of 4–7 inds. like in the mines near the Hlyboke vill. in the Transcarpathian region, where the numbers have reached several individuals both in the past (Abelentsev et al. 1956, Tkach 1987, Krochko 1992) and nowadays (Basha & Potish 2007). The most numerous barbastelle hibernaculum located in a mine in the Ukrainian Carpathians numbered no more than 25 inds. (V. Pokynchereda, pers. comm.). The largest number of barbastelles in the Prydniprovska upland area was found in the Kytaiivska cave (Kyiv region; Abelentsev et al. 1956). Relatively large winter aggregations of barbastelles were noted in large mines, mostly limestone ones, located in the Podillâ area. In particular, 35 individuals were counted in the Gumenecki mines (Hmelnyckyj region; Matveev et al. 2010). The largest number (350–400 inds.) was found in the Ivankovecki mines in 2008–2009 (Drebet & Martyniuk 2009). Number of this species was significantly smaller in the natural underground spaces – caves and grottoes. The largest known number of barbastelles was counted in the Stradčanska cave (Lviv region) – 10 inds., Medova cave (Lviv region) – 20 inds. (Tatarynov 1952), cave in Holodnyj Âr (Čerkasy region) – ca. 50 inds. (Golub 1996).
The Tarakaniv fortress is situated in the Volynska upland and it seems to be the largest hibernaculum of barbastelles in Ukraine and one of the largest in Central and Eastern Europe. Winter aggregations ranged here from 300 to 950 individuals in different seasons (2008–2009 – ca. 740 inds., 2009–2010 – ca. 300 inds., 2010–2011 – ca. 730 inds., 2011–2012 – ca. 950 inds.; indicated the highest number of bats found during certain seasons). Such large fluctuations in the number of winter aggregations during a relatively short time interval of 2009–2012 impede deeper interpretation of their dynamics and analysis of population trends. A significant increase in the number of wintering individuals was noted in the winter 2011/2012. The reasons of such fluctuation are still unknown. Actually, the total amount of aggregations could increase. However, it may be caused by redistribution of wintering individuals within the fort, so that more individuals were observable. It is also possible that this phenomenon was a result of bat immigration from other wintering sites. The main reason for such movements may be changes of microclimatic conditions due to frequent visits of the roosts by people (Kowalski & Lesiński 1991, Řehák 1997, etc.).

The lowest number of bats in this hibernaculum was found in November 2010 with ca. 300 individuals only. One of the possible reasons of such low number could be a relatively high temperature in the roost (mean t=8.7 °C) in this period. Moreover, it could have been caused by disturbance due to tourists visiting the fortress during the period of formation of winter aggregations and a subsequent movement of some individuals into inaccessible cavities.

Spatial distribution and microclimatic characteristics of hibernation roosts

The barbastelle is a rather cold-resistant species and it uses relatively cold part of the shelters, where the temperatures are close to 0 °C, to spend the winter season (Rydell & Bogdanowicz 1997). Cavities in the Tarakaniv fortress are characterized mainly by rather cold microclimatic conditions, which is confirmed by the presence of the barbastelle and other relatively cold-resistant bat species (*E. serotinus*, *P. auritus*). Other fortifications may have a much wider amplitude of microclimatic conditions that attract species with different ecological preferences. In this case a wider range of bat species can use the roosts, which provide favourable conditions for hibernation. For example, in the Miedzyrzecki forts (Poland), *Myotis myotis* and *Myotis daubentonii* were the most numerous species (Urbańczyk & Gólski 1994), indicating a relatively warmer temperatures than in the Tarakaniv fortress. The winter temperatures in the Tarakaniv fortress varied between −0.9 and +3.0 °C and depended on outside temperatures, while the relative humidity varied between 65 and 100%.

In warmer underground spaces, barbastelles usually occupied parts close to the entrance, where the temperature is relatively low. In the Gumenecki mines they have been found only at sites with the temperature of +3 to +5 °C (Matveev et al. 2010). In the winter of 2009/2010 with the outside temperature of −25 °C, the temperature in corridors of underground bunkers near the city of Lviv was −3.3 °C, but it was +0.3 °C in the cleft with wintering barbastelles.

Wintering barbastelles in the Tarakaniv fortress can be divided into three spatial groups: (a) isolated individuals or small groups distributed freely on walls, ceilings or in small cracks, (b) individuals situated in long narrow cracks at the ceilings of corridors, (c) large aggregations in ventilation ducts. In addition, the fourth group of individuals can be identified, hiding in inaccessible cavities. Individuals belonging to the first group could be placed open (on walls or ceilings) or occupy very different microshelters, such as different cracks or fissures. The minimum height from the floor was 1.5 m. Generally a few percent of bats were found at the height of up to 3.5 m and they occupied mainly deep fissures and cavities in the walls. It was caused by disturbance from visitors. The proportion of bats belonging to the first group was 5–10% only. Location of wintering barbastelles in the narrow cracks of corridor ceilings (second group) was evidently
caused by the necessity to minimize energy costs during the winter. Crack width allowed fitting of one or two individuals, while the length of these cracks was up to 20 meters and, accordingly, such aggregations of bats had a “linear” structure. The third group of barbastelles showed clear tendency to create aggregations, which were situated in vertical ventilation ducts located in the ceiling of the underground casemates and included 76–82% of the wintering bats. Some of these ducts were blocked up with stones or concrete pieces and the bats grouped by attaching to them. Some bats were situated on inner walls of the ventilation ducts, creating groups of various sizes (from 6 to over 250 inds.). Supposedly, those ducts were blocked up too (although it was not visible), because the test did not detect air movement inside them.

Generally two or three bat aggregations were noted in different ventilation ducts with the mean number of 203 inds. They were usually located at the bottom of the ducts, near their entrance in the ceiling. During the winter of 2011/2012, the bats created 12 such aggregations, which, however, consisted mainly of a relatively small number of individuals, on average 38.6 (n=12; S\textsubscript{max}=140) and were dispersed along the vertical length of the ducts. The aggregations are probably formed in order to reduce energy expenses during hibernation. In mines in the Podillâ area, particularly in the Gumenecki mines, the barbastelles were found to hang mostly alone (71.1%) and very rarely in groups of up to 10 inds. (Matveev et al. 2010). Temperature in those mines reached 3–5 °C, allowing the bats to avoid creation of such aggregations.

Large aggregations of barbastelles were usually monospecific. However, formation of multispecies groups (\textit{B. barbastellus} + \textit{E. serotinus}) were noted rarely, where the number of individuals did not exceed 2–5 (1+1; 3+1; 2+3) and only one aggregation included 17 \textit{B. barbastellus} and 5 \textit{E. serotinus} individuals.

The large number of barbastelles in the Tarakaniv fortress caused its absolute dominance in this underground space. Dominance rates fluctuated within 93.3–97.6% (mean 96.1%) in different years. A similar percentage of barbastelles was discovered in the forts of Eastern Poland (Kowalski & Lesiński 1997 etc.). Taking into consideration that underground spaces in the Tarakaniv fortress are not well isolated from external influences, fluctuations in barbastelle numbers may be significantly affected by climatic conditions of the region. Such fluctuations are also known from other studies (see Fuszara & Fuszara 2002, Fuszara et al. 2002).

Most of our surveyed underground roosts may be significantly affected by human disturbance. It may be also able to reduce the individual movements and changes of their shelters, particularly to the inaccessible ones, which may have caused underestimation of the bats during censuses. February is the best period for winter counts of barbastelles, when the greatest number of individuals was detected. It can be caused by two factors. Firstly, winter aggregations are relatively stable already and, secondly, the mean number of wintering bats increased during the winter.

Population status and its changes in Ukraine

The barbastelle is considered as one of the most threatened species of bats in Europe. This species was assigned a relatively high conservation category: it is included in the IUCN Red List in the category NT "near threatened" (Hutson et al. 2008), in the Bern Convention (Appendix II), Bonn Convention (Annex II), Eurobats (Appendix I), Annexes II and IV of the Habitats Directive as well as in the Red Data Book of Ukraine (2009) as "disappearing".

Based on fragmentary data from previous years, we may outline some population trends in the western part of Ukraine. Negative dynamics of the barbastelle were noted for the Stradčans’ka and Medova caves (Lviv region) since the middle of the 20th century (Abelentsev et al. 1956, Tatarynov 1974, Dyky et al. 2008, Bashta 2010) (Table 2). Negative trends in both caves were
caused by direct human impact. Some authors suggest that the number of the Crimean population used to be larger (Dulitsky 2001).

Our studies suggest that the barbastelle population is at least stable in Ukraine today. In general, its size and number of records have been increasing. However, it may be caused most likely by increasing research intensity and surveying new areas and roosts. In the countries of Northern, Central and Eastern Europe, populations are stable or increasing (Slovakia, Uhrin et al. 2010; Austria, Spitzenberger & Mayer 2003; and Germany, Rudolph et al. 2003, Schober 2003 etc.). Positive trends were observed in some hibernacula of Central Europe (Poland, Lesiński et al. 2005; Lithuania, Pauža & Paužiene 2002; Czech Republic, Řehák & Gaisler 1999, Horáček et al. 2005). In contrast, the barbastelle populations from the Western and Southern European countries indicate decline in numbers, particularly in Belgium (Fairon & Busch 2003), Switzerland (Theiler 2003) and the Balkan Peninsula (Paunović et al. 2003), and even disappearance from the Netherlands (Hutson et al. 2008). Significant decline of the barbastelle population took place in Slovakia in the 1970s (Gaisler 1975, Gaisler et al. 1981) as well as in some hibernacula in the 1990s (Uhrin et al. 2002).

Threats affecting barbastelle populations are largely unknown. However, due to some species peculiarities, namely trophic specialization (feeding on nocturnal butterflies) and usually the use cavities or dead bark of old deciduous trees, this species is probably especially vulnerable to intensive forest activities (Sierro & Arlettaz 1997, Russo et al. 2004), which often consist of removing dead and damaged trees. Bats have only few natural enemies. However, human activity is the greatest danger for them. Bats are very sensitive not only to changes in the microclimate in hibernacula, but also to some disturbance factors such as light or noise. The major threat for barbastelle could be destruction of roosts, which may include changes of wall structure in the corridors, making fire in the corridors and storage of toxic waste there. In extreme cases the underground spaces may be exploded by special devices. Small roosts can be destroyed or devastated, or even filled up with garbage. Like all bat species, the barbastelle is very vulnerable to disturbance during hibernation. Threats in this period include frightening, and rarely even killing of animals. Frequent awakening of bats causes depletion of their fat reserves. We assume that the barbastelle population in Ukraine, like in almost all Central and Eastern European countries is not as decreasing as in the Western European countries. More detailed studies have resulted in the change of conservation status of this species in the IUCN Red List from vulnerable (1996) to near threatened (2008; Hutson et al. 2008).

Importance of anthropogenic underground cavities for barbastelle conservation in Ukraine

Our results show that large underground cavities of anthropogenic origin may be important for the survival of barbastelle populations not only in Ukraine, but throughout Central and Eastern Europe. These structures are used in different seasons and seem to be vital places to maintain the population of this species with disjunctive distribution range. The role of these cavities for the
species outside the hibernation season is as important as in winter. They are the places of formation of so called coupling-migratory colonies and aggregations during the autumn accumulation of fat reserves. Preliminary studies suggested that the species composition in these sites in late summer and the first half of autumn is no smaller than in winter.

Therefore, such places that attract large numbers of bats from the surrounding areas should be protected by law. This is particularly important for the bat species like the barbastelle, which has a high level of philopatry. Bats generally show a very high degree of connection to concrete wintering sites (Glover & Altringham 2008). In recent years, tourism and recreation development has caused deterioration of the conditions for bats in different fortresses. Regular and uncontrolled visits by tourists affect directly the bat fauna (a factor of disturbance) and change substantially the microclimate conditions in the roosts. Such influence is a significant negative factor for bats, because it can lead to premature determination of hibernation. Strong anthropogenic influence may cause a significant reduction of the size of bat winter aggregations. Therefore, these hibernacula must be secured by active protection; first of all by closing the entrances to underground spaces or other restrictions of unauthorised access, especially during the period from November to April.

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