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Structure and dynamics of the bat assemblage inhabiting military bunkers

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With 4 Figures

Introduction

Abandoned military objects are frequently used by bats as transition and hibernation roosts.

However, the state of knowledge of the bat distribution and abundance in such shelters in Poland is still not adequate to their expected importance. The wide range of fortification types built in Poland during last centuries includes from small concrete bunkers, lacking an underground parts and practically inappropriate for hibernating bats, to large systems of underground corridors maintaining suitable microclimate and attracting thousands of animals, like the biggest Polish hibernaculum – Nietoperek Reserve (URBAŃCZYK 1990).

In the north-eastern Poland, fortifications and cellars were recognised as the most valuable winter roosts for bats. Among them, relevant data regarding the species composition and assemblage structure are available only for forts of Biebrza valley (LESIŃSKI 2001), military bunkers of Masurian Lakeland (FUSZARA et al. 2003), as well as for small cellars (LESIŃSKI et al. 2004).

Distribution of bats in their winter roosts has been surveyed in the area of Siemiatycze and Drohiczyn since 1992. It was revealed, that among different roost types (bunkers, cellars and village wells) only several cellars and better preserved military bunkers supported significant number of hibernating individuals, with *B. barbastellus* appearing the most numerous and most frequently recorded species (SACHANOWICZ 2003). These fortifications also maintained the highest species diversity with the presence of bats rarely recorded in Poland: *M. dasycneme* and *E. nilssonii*. The relationship between external temperature and seasonal changes in the number of *B. barbastellus* as well as its spatial distribution within bunkers was also studied (SACHANOWICZ & ZUB 2002).

In this paper, I describe the structure and dynamics of the bat assemblage inhabiting Siemiatycze military bunkers during the transition and hibernation period.

Study area, material and methods

The military bunkers, that were surveyed, are located on the edge of the Bug river valley near Siemiatycze town (52° 25' N, 22° 51' E), Wysoczyzna Drohiczyńska, central part of the Podlasie Lowland, north-eastern Poland. Farmland is a dominating type of landscape in that part of the region, where forests – mainly coniferous plantations – covered only ca 24% of the area. The temperature of winter months in the Podlasie Lowland is among the lowest over the entire lowland part of Poland. The mean January temperature amounted to -4°C and the snow cover lasted 80-100 days (KONDRACKI 2001).

The bunkers, constructed in 1940/1941 by the Soviet army, formed Anusin resistance point, which was a local section of the fortification system informally known as Molotov Line. The goal of those fortifications was to secure the Second World War time (after Ribbentrop – Molotov agreement) border between the Soviet Union and Germany. During the war-time military activity and after it most of bunkers were heavily destroyed and no more used for military purpose (WESOŁOWSKI 2001).

The Anusin resistance point was formed of 14 different bunkers (WESOŁOWSKI 2001). Of them, four well preserved objects of similar construction, numbered SM 3, SM 5, SM 7 and

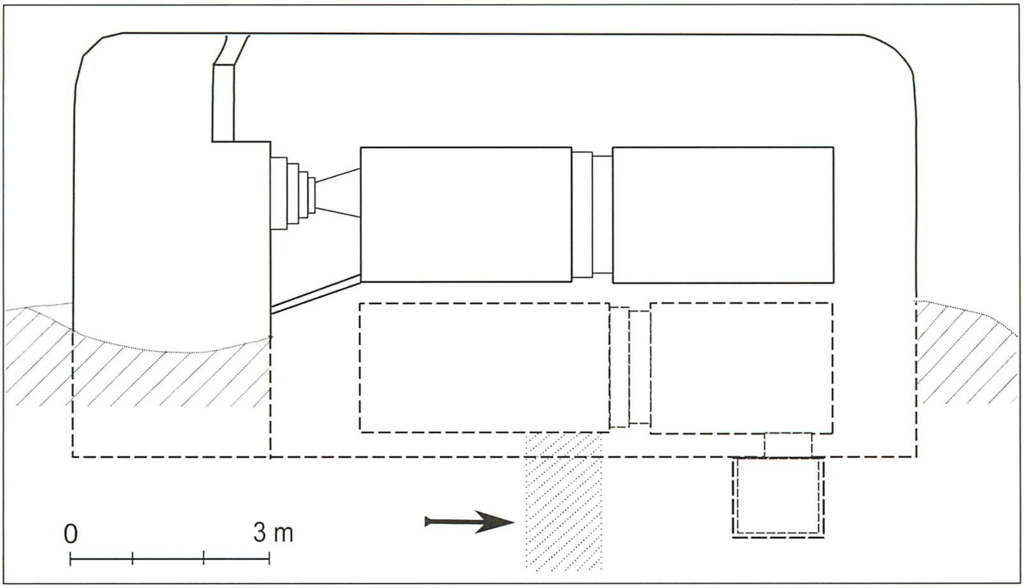

Figure 1. Plan of a military bunker near Siemiatycze, from WESOŁOWSKI (2001), changed. An arrow points localisation of a water well.

SM 13 (SACHANOWICZ & ZUB 2002) or 9, 8, 2 and 14, respectively (WESOŁOWSKI 2001), were selected for this study. These are middle-sized reinforced concrete bunkers, each containing several small rooms on two levels and a water well (3-6 m in depth) below the bottom level – the only truly underground part of a bunker (Fig. 1). The wells, used by a crew as a drinking water source and built of concrete rings (ca 120 cm in diameter), were the most important roosts for hibernating bats (SACHANOWICZ & ZUB 2002). The bunkers, surrounded by farmland habitat and young pine *Pinus sylvestris* plantations, are located between Anusin and Mackowicze villages and there is ca 1,5 km between the two most distant objects. Since the bunkers are not an underground constructions (Fig. 2), usually having several entrances causing intensive air circulation, thermal conditions inside of them largely depend on weather. The objects are poorly insulated of frost in winter, except of their wells, where mean temperature (1.3°C, SD=2.60) was significantly higher and more stable than measured in the upper floor (-2.7°C, SD=3.34), (range 7°C and 9°C, respectively), (SACHANOWICZ & ZUB 2002). Those and other fortifications in the area, together with small cellars and village wells provided winter roosts available for bats. However, the remaining bunkers were too small or strongly devastated to be used by more than single bats, therefore were not controlled subsequently (SACHANOWICZ 2003).

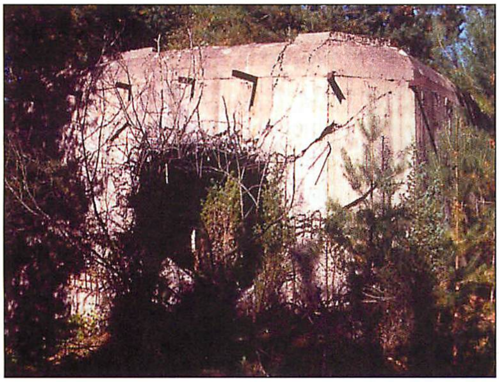

Figure 2. The bunker SM 13. Photo: K. SACHANOWICZ

Initially, in the season 1994/1995 bats were counted only in bunkers SM 3, SM 5 and SM 7, while in next seasons 1995/1996 and 1996/1997 (after finding SM 13 bunker), four these objects were visited regularly, usually once per each consecutive month since September – October till April. In total, bats were counted on 21 controls between 1994 and 1997 (7 controls in 1994/1995, 8 – in 1995/1996

Table 1. The number and percentage of bat records in four bunkers near Siemiatycze. Total number of controls – 21, autumn: end of IX – 2 XII (7 controls), winter: 3 XII – II (8 controls), spring: III – middle of IV (6 controls).

species	autumn		winter		spring		total	
	n	%	n	%	n	%	n	%
M. nattereri	12	10.5	7	0.8	6	1.8	25	1.9
M. brandtii	1	0.9	-	0.0	-	0.0	1	>0.1
M. dasycneme	2	1.8	1	0.1	-	0.0	3	0.2
M. daubentonii	14	12.3	15	1.7	6	1.8	35	2.6
E. nilssonii	-	0.0	2	0.2	2	0.6	4	0.3
E. serotinus	4	3.5	17	1.9	12	3.7	33	2.5
P. auritus	2	1.8	1	0.1	2	0.6	5	0.4
B. barbastellus	79	69.3	836	95.1	295	91.3	1210	91.9
total	114	100.0	879	100.0	323	100.0	1316	100.0
species number	7		7		6		8	

and 6 – in 1996/1997). Exceptions: two counts conducted in December 1995 and no control performed in January 1997. All available bat shelters were checked using a head and a hand torches. Bats hid typically in crevices of internal walls and ceilings as well as in deep spaces among the wells' internal rings. Individuals free hanging on walls or in unsheltered places were saw sporadically. Bats hibernating within wells were counted separately using climbing techniques. However, the unknown number of animals could remain uncounted, hiding in inaccessible places – cavities surrounding internal rings. The individual of *M. brandtii* was handled to examine its dental characters allowing correct identification. The unidentified bats were not included for calculations. To describe seasonal changes in the number of bats, the transition and hibernation period was divided into three parts: autumn (the end of September – 2nd of December), winter (3rd December – February) and spring (March – middle of April).

Results

In total, 8 species of bats (1316 individual records) were observed in military bunkers during transition and hibernation period: *Myotis nattereri* (Kuhl, 1817), *M. brandtii* (Eversmann, 1845), *M. dasycneme* (Boie, 1825), *M. daubentonii* (Kuhl, 1817), *Eptesicus nilssonii* (Keyserling et Blasius, 1839) (Fig.3), *E. serotinus* (Schreber, 1774), *Plecotus auritus* (Linnaeus, 1758) and *Barbastella barbastellus* (Schreber, 1774). The number of species was almost equal in autumn, winter and in spring (Tab. 1), but it ranged from 3 to 7 (mean=5.5, SD=1.73, n=4) in particular objects (Tab. 3). In contrast, the abundance of animals peaked in winter and differences among bunkers were noticeable (mean=329, SD=192.8, n=4). The maximal number of

Figure 3. *E. nilssonii* observed in one of the Siemiatycze bunkers. Photo: A. TABOR

Table 2. The frequency of species records in four bunkers near Siemiatycze. Total number of controls – 21, autumn: end of IX – 2 XII (7 controls), winter: 3 XII – II (8 controls), spring: III – middle of IV (6 controls).

species	autumn		winter		spring		total	
	n	%	n	%	n	%	n	%
M. nattereri	5	71.4	5	62.5	4	66.7	14	66.7
M. brandtii	1	14.3	-	0.0	-	0.0	1	4.8
M. dasycneme	2	28.6	1	12.5	-	0.0	3	14.3
M. daubentonii	7	100.0	5	62.5	4	66.7	16	76.2
E. nilssonii	-	0.0	2	25.0	2	33.3	4	19.0
E. serotinus	2	28.6	6	75.0	4	66.7	12	57.1
P. auritus	1	14.3	1	12.5	2	33.3	4	19.0
B. barbastellus	4	57.1	8	100.0	6	100.0	18	85.7

bats, counted during one control in 4 objects (216 individuals of 6 species), was recorded on 9.03.1996.

B. barbastellus predominated during the consecutive periods in all bunkers (Tab. 1). The remaining species may be divided into two groups. The first including sporadic (1–5%) species: *M. daubentonii*, *E. serotinus* and *M. nattereri* recorded in consecutive periods and in all objects – except of *M. daubentonii* in SM 5 (Tab. 3). In autumn, *M. daubentonii* and *M. nattereri* belonged even to accessory species (5–15%). The second group covers random species altogether making 1.0% of the assemblage: *M. brandtii* (1 ♀ 26.11.1994: SM 7), *M. dasycneme* (single on 29.10.1994, 28.12.1995, 26.10.1996: SM 7 and SM 13), *E. nilssonii* (single since 13.01 till 06.04.1996: SM 3 and SM 13, Fig. 3) and *P. auritus* (single on 26.11.1994, 13.04.1995, 09.03.1996, 08.02.1997: SM 3 and SM 7).

Although the structure of the bat assemblage was rather stable, the share of individual species changed during the season (Tab. 1). Differences in species distribution were also noticeable (Tab. 3). The proportion of *M. nattereri* was the highest in autumn and decreased more than 10 times in winter, while its number declined only about 50%. Almost all individuals concentrated in bunkers SM 7 and SM 3. Similarly, the share of *M. daubentonii* dropped down ca 6 times between autumn and winter, although its abundance was almost the same in both these periods. The species inhabited 3 objects in similar numbers. *E. serotinus* was the most numerous during winter, but the highest values of its proportion occurred in autumn and in spring. More than 50% of its records concentrated in SM 3 bunker. The abundance of *B. barbastellus* increased during winter with 66% of records concentrated in objects SM 3 and SM 13. The peak of its number in spring resulted of prolonged freezing period of the season 1995/1996 (Fig. 4).

Table 3. The number and percentage of bat records in four bunkers near Siemiatycze.

species	SM 3		SM 5		SM 7		SM 13	
	n	%	n	%	n	%	n	%
M. nattereri	7	1.2	1	1.0	16	5.7	1	0.3
M. brandtii	-	0.0	-	0.0	1	0.3	-	0.0
M. dasycneme	-	0.0	-	0.0	1	0.3	2	0.5
M. daubentonii	13	2.3	-	0.0	10	3.5	12	3.2
E. nilssonii	1	0.2	-	0.0	-	0.0	3	0.8
E. serotinus	19	3.4	5	5.1	5	1.8	4	1.0
P. auritus	1	0.2	-	0.0	4	1.4	-	0.0
B. barbastellus	519	92.7	92	93.9	243	86.8	356	94.2
total	560	100.0	98	100.0	280	100.0	378	100.0
species number	6		3		7		6	

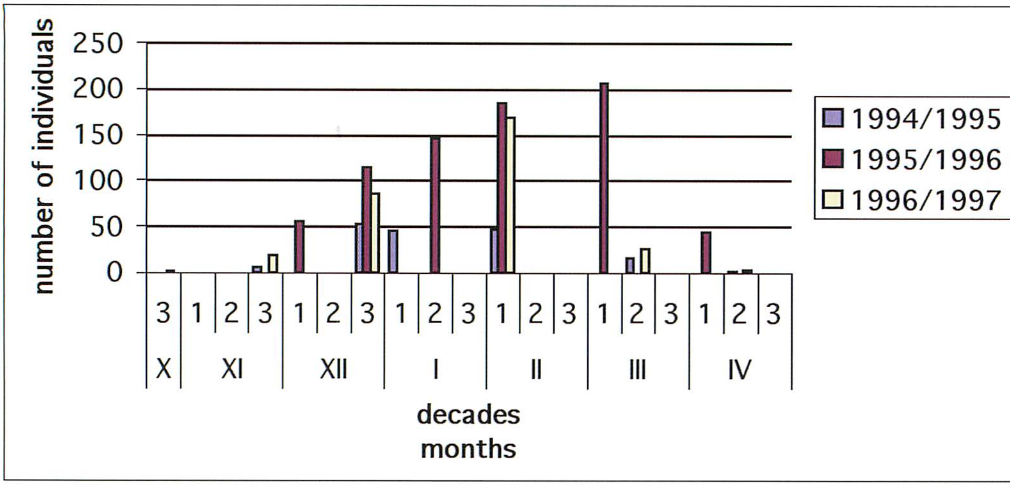

Figure 4. Seasonal dynamics of the number of *B. barbastellus* in Siemiatycze bunkers during three winter seasons.

The frequency of species records also changed through the season. *M. daubentonii* was recorded during all controls in autumn, followed by *M. nattereri* and *B. barbastellus*. Contrastingly, in winter the most constant were: *B. barbastellus* and *E. serotinus* followed by *M. daubentonii* and *M. nattereri*. The latter 3 species were equally frequent also in spring (Tab. 2).

Discussion

The species composition and structure of the bat assemblage using military bunkers near Siemiatycze is very similar to those reported from other fortifications located in north-eastern Poland: forts of Biebrza basin (LESIŃSKI 2001) and bunkers in Mamerki, Masurian Lakeland (FUSZARA et al. 2003), (Tab. 4).

The species composition of surveyed assemblages seems to be affected by the large-scale distribution patterns and the regional variation in abundance of several species. *M. myotis* – observed only in one fort of Biebrza basin – occurred there on the north-eastern limit of its European distribution (GÜTTINGER et al. 2001). Only single individuals of that species were recorded at several sites in north-eastern Poland (SACHANOWICZ & CIECHANOWSKI 2005). Similarly, most of that part of Poland is outside of the distribution range of *P. austriacus* (KOWALSKI et al. 1997, SACHANOWICZ & CIECHANOWSKI 2005), which was not observed neither during this study nor in other fortifications or cellars (Tab. 4). Interestingly, several

Table 4. The comparison of bat assemblages (D%) using fortifications and small cellars in north-eastern Poland, * identified only as *M. brandtii* or *M. mystacinus*.

species	Biebrza forts (LESIŃSKI 2001)	Mamerki bunkers (FUSZARA et al. 2003)	Small cellars (LESIŃSKI et al. 2004)	Siemiatycze bunkers (this article)
M. myotis	>0.1	-	-	-
M. nattereri	0.5	0.7	12.4	1.9
M. brandtii	>0.1	>0.1*	>0.1	>0.1
M. dasycneme	5.0	-	0.4	0.2
M. daubentonii	11.4	0.9	47.1	2.6
E. nilssonii	-	0.7	0.7	0.3
E. serotinus	2.6	>0.1	0.1	2.5
P. auritus	0.6	2.5	37.6	0.4
B. barbastellus	79.6	95.0	1.7	91.9
Records number	2975	2262	433	1316

grey long-eared bats regularly hibernated in basements and a cellar of Korczew village, in the vicinity of Siemiatycze (SACHANOWICZ 2003). In some parts of western Poland, *M. bechsteinii* is frequently recorded in military bunkers (e.g. SZKUDLAREK et al. 2001), but its geographical range apparently does not cover the north-eastern part of the country (SACHANOWICZ & CIECHANOWSKI 2005). The single individuals of *Pipistrellus pipistrellus* sensu lato were found recently hibernating in several military objects in north-western Poland (WOJTASZYN et al. 2004). No such observations are available from the rest of the country suggesting the local character of that phenomenon, probably related to milder climatic conditions in winter, better for the species in mentioned region than in the rest of Poland.

Of the two sibling *M. mystacinus* and *M. brandtii*, only the second occurred randomly (not exceeding 0.1% of the bat assemblage) in fortifications and cellars (Tab. 4). Contrastingly, summer bat surveys in forests of the Podlasie Lowland revealed, that *M. brandtii* is not a rare species in the region (SACHANOWICZ & RUCZYŃSKI 2001). Its very low numbers in studied anthropogenic shelters may suggest the main species winter roosts still remain unknown. Rather astonishing absence of *M. mystacinus*, convergent with the lack of records from most of the north-eastern Poland, seems difficult to explain unlike referring to undiscovered factors affecting its distribution. However, the status of the whiskered bat over most of Poland remains completely unknown. The fort Osowiec in Biebrza valley is one of the most important winter sites of *M. dasycneme* (assumed globally vulnerable species – HUTSON et al. 2001) in Poland, used by up to 34 bats LESIŃSKI 2001), what explains unusually high proportion of the species in the local assemblage. The pond bat was not recorded in bunkers of Masurian Lakeland, while its share was very small both in Siemiatycze bunkers and in cellars (Tab. 4). The share of *E. nilssonii* was marginal in fortification and in cellars (Tab. 4), however the species was the second dominant (10.1% but in 4 times smaller record sample n=485) in Gierłoż bunkers of Masurian Lakeland (FUSZARA et al. 2003). The northern bat belonged to dominants also among bats wintering in small cellars within woodland of the Romincka Forest, north-eastern Poland (MARZEC 2003).

In general, the most striking feature of described assemblages is a disproportionate predomination of *B. barbastellus*, as well as related marginal number of other species altogether amounting to less than 10% of the sample in Mamerki and Siemiatycze objects (Tab. 4). Such a structure results of particular thermal conditions of bunkers favouring cold resistant species, like the barbastelle preferring hibernacula maintaining low temperatures (0–3.0°C) and relatively dry air (BOGDANOWICZ & URBAŃCZYK 1983). The species is characterised by the shortest duration of hibernation and the highest activity among bats within winter roosts (RYBÁŘ 1975). Thermal conditions inside of Siemiatycze bunkers, dependent on the external air temperature, were the crucial factor affecting the dynamics, spatial distribution and seasonal movements of *B. barbastellus* between upper floors and wells (SACHANOWICZ & ZUB 2002). The abundance of *E. serotinus* was almost the same as that of *M. daubentonii* – the second most numerous species in Siemiatycze bunkers. Such a situation seems to be unique among compared fortifications (Tab. 4). The serotine was also among the rarest bats in cellars, indicating that none of those types of shelter match its requirements, although its preference for temperature and humidity seems to be similar to that of *B. barbastellus* (LESIŃSKI 1986). *E. serotinus* winters mainly in buildings (BAAGØE 2001), but its hibernal ecology still remains largely unknown. Microclimate conditions within bunkers due to their larger parts situated above the ground level, may resemble these observed in abandoned buildings rather than in typical underground objects.

Although the species composition of bats in fortifications and cellars appears the same, there are obvious differences in structure of assemblages (Tab. 4). The latter shelters were used by the barbastelle only in small number. The share of *P. auritus* in fortifications (0.4–

2.5%) appears unusually low comparing with its value in cellars of the same region, where it was the second dominant – 37.6% (Tab. 4). The possible explanation may be related to specific thermal requirements of the brown long-eared bat, which seems a stenothermic species, usually hibernating in sites, where the temperature is relatively stable (HORÁČEK 1975). Contrary to destroyed and not protected of freezing military bunkers, small cellars – in most cases used by their owners in winter – could maintain optimal thermal conditions to *P. auritus*. The same factors may partly explain the marginal share of *M. nattereri* and *M. daubentonii* in fortifications, while they belonged to dominants in cellars (Tab. 4). Both these species dominated also in large and warm (due to enlarged, partly flooded underground parts) bunkers of western Poland (SZKUDLAREK et al. 2001, WOJTASZYN et al. 2003), supporting the hypothesis of a winter roost selection on the basis of its microclimate conditions. The Natterer's and Daubenton's bats prefer shelters maintaining higher temperatures (2.0–7.0°C) and 85–100%, but the most often over 90% humidity (BOGDANOWICZ & URBAŃCZYK 1983, JURCZYSZYN 1998).

The phenology of *B. barbastellus* revealed in the present study and described elsewhere (SACHANOWICZ & ZUB 2002), is similar to that reported for other fortifications. The species usually appears in hibernacula during late autumn or in winter and departs from in late winter or during early spring, with a peak of its number recorded during winter months (e.g. RYBÁŘ 1975, URBAŃCZYK 1991). The same pattern of dynamics, with winter abundance several-times higher than in autumn, may be observed also in *E. serotinus*, but the number of records was much smaller. The seasonal variations in the abundance of *M. nattereri* (between autumn and winter) and *M. daubentonii* (between winter and spring) could be an artefact, most likely resulted of internal movements of several bats within bunkers e.g. hiding in inaccessible shelters, rather than reflected the real dynamics of the bat number (JURCZYSZYN 1998).

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Zusammenfassung

Struktur und Dynamik von Fledermausgesellschaften in Militärbunkern

In sowjetischen Militärbunkern (1940/1941 gebaut) bei Siematycze in nordöstlich Polen wurden die Struktur und die Dynamik von Fledermausgemeinschaften in der Übergangs- und Hibernationsperiode untersucht. Die Objekte wurden im und nach dem II. Weltkrieg stark zerstört, verlassen und seitdem nicht mehr für militärische Zwecke genutzt. Insgesamt wurden acht Arten gefunden: *Myotis nattereri*, *M. brandtii*, *M. dasycneme* (vermutlich selten und in Europa gefährdet), *M. daubentonii*, *Eptesicus nilssonii* (selten in Polen), *E. serotinus*, *Plecotus auritus* und *Barbastella barbastellus* (selten und gefährdet in Europa). Artenzahlen waren im Herbst, Winter und Frühling nahezu identisch und schwankten in den einzelnen Bunkern von drei bis sieben (Mittel=5.5, SD=1.73, n=4). Die maximale Gesamtzahl aller Fledermäuse während eines Kontrollgangs durch alle Bunker war 216 Individuen aus sechs Arten (09.03.1996). *B. barbastellus* dominierte (91.9% der Nachweise) gefolgt von *M. daubentonii* (2.6%), *E. serotinus* (2.5%) und *M. nattereri* (1.9%). Die Anzahl von *M. nattereri* war im Herbst am höchsten und fiel im Winter um etwa 50%. *M. daubentonii* kam in beiden Perioden etwa gleich häufig vor, *E. serotinus* war im Winter am zahlreichsten, ihr Anteil an der Gesamtzahl aller Fledermäuse war jedoch im Herbst und Frühling am höchsten. *B. barbastellus* dominierte im Winter aber auch im Frühling der Saison 1995/1996.

Abstract

The structure and dynamics of bat assemblages during transition and hibernation period were investigated in military bunkers, built by the Soviets in 1940/1941, near Siematycze, north-eastern Poland. The objects were heavily destroyed during and after the Second World War, then abandoned and no more used for military purposes. In total, 8 species of bats were recorded: *Myotis nattereri*, *M. brandtii*, *M. dasycneme* (assumed to be rare and vulnerable in Europe), *M. daubentonii*, *Eptesicus nilssonii* (rare in Poland), *E. serotinus*, *Plecotus auritus* and *Barbastella barbastellus* (rare and vulnerable in Europe). The number of species registered in autumn, winter and in spring was almost equal, and it ranged from 3 to 7 (mean=5.5, SD=1.73, n=4) in particular bunkers. The maximal number of bats in all bunkers during one control (216 individuals of 6 species) was recorded on 9.03.1996.

B. barbastellus predominated during the consecutive periods in all bunkers (91.9%), followed by: *M. daubentonii* (2.6%), *E. serotinus* (2.5%) and *M. nattereri* (1.9%) recorded in all periods and in all bunkers. The number of *M. nattereri* was the highest in autumn and decreased

about 50% in winter. The number of *M. daubentonii* records was almost the same in both of these periods. *E. serotinus* was the most numerous during winter, but the highest values of its proportion occurred in autumn and in spring. The number of *B. barbastellus* was highest in winter and during the season 1995/1996 also in spring.

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