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Seasonal changes in number and diversity of bat species (*Chiroptera*) in the Stolec mine (SW Poland)

Sezonowe zmiany liczebności i zróżnicowania gatunkowego nietoperzy w sztolni w Stolcu

Abstract

Winter community structure and autumn-spring activity of bats visiting an old mining shaft in limestone rocks in the „Stolec Rocks" reserve (Ząbkowice Śląskie district, SW Poland) were studied in years 2000-2002. In two winter seasons the following bat species were recorded: *Barbastella barbastellus, Myotis nattereri, M. daubentonii, M. myotis, M. bechsteinii, M. mystacinus/brandtii, Plecotus auritus, P. austriacus* and *Eptesicus serotinus*. *M. nattereri* (39.2%, max. 81 ind.) and *B. barbastellus* (44.4%, max. 87 ind.) were dominant. During non-winter seasons 12 bats species were netted. In addition to the wintering bat species two rarely seen species, *Pipistrellus pipistrellus* and *Eptesicus nilssonii,* were recorded. During netting *B. barbastellus* (42.2%), *P. auritus* (19.2%), *M. nattereri* (12.9%) and *M. daubentonii* (12.0%) were most common. Most individuals were caught in March - April and in August – October and the majority were males. The observation indicated that the mine in the reserve is one of the biggest and most important hibernacula in the Polish side of the Sudetes and an important autumn - spring swarming site for several bat species. Swarming behaviour of the most numerous species at underground sites could play an important role during their reproductive period and bats from an extensive area and different colonies or populations probably meet in such places to avoid inbreeding. The spring and autumn migrations and searching for good hibernating places could partly explain this behaviour, too.

Key words: *Chiroptera*, diversity of bats, hibernaculum, swarming

1.Introduction

The first winter records of bats in the Stolec Rocks mine were in 1926 by Seidel (1927). The author found four species: greater mouse-eared bat *Myotis myotis* (10-15 individuals), brown long-eared bat *Plecotus auritus* (2 ind.), barbastelle *Barbastella barbastellus* (about 100 ind.) and whiskered bat *Myotis mystacinus*. The next investigations were in the 1960s and 1970s and confirmed the same species as before (Wołoszyn 1968, Haitlinger 1976). Observations performed in the 1990s by the Group for Research and Protection of Bats working by Polish Society of Wildlife Friends "pro Natura" and preliminary observation of authors have shown that the mine in the Stolec Rocks reserve is one of the greatest and most important hibernacula in Lower Silesia and in the Polish part of Sudetes (Szkudlarek and Paszkiewicz 1999, Górniak and Furmankiewicz 2001).

In spring and autumn seasons intensive activity of bats was observed, too. This activity, called swarming (Fenton 1969), was described for several bat species (e.g. Davis and Hitchckock 1965, Horáček and

Zima 1978, Řehák et al. 1994, Degn et al. 1995, Parsons et al., in press). The function of bat swarming is not well investigated and explained. It is suggested that the bats often visit underground sites at this time because of greater possibility of meeting other individuals of both sexes and mating (Fenton 1969, Horáček and Zima 1978, Thomas et al. 1979). It could be connected with autumn and spring migrations. The bats can visit such places in order to check potential wintering places (Horáček and Zima 1978, Řehák 1995) or to show the young (by adult females) the location of hibernacula (Fenton 1969).

The main aims of this study were to describe seasonal changes in number and diversity of bat species visiting the Stolec Rocks mine from early spring to late autumn in comparison to species composition in winter. The obtained data will be useful in planning effective ways of protecting bats in this reserve and in other underground sites.

2. Materials and methods

2.1. Study area

"Stolec Rocks" reserve is situated about 500 m west from Stolec village, near Ząbkowice Śląskie, on the Niemczańsko-Strzelińskie Upland (Fig. 1A). It was established in 1965 on the Wapienna Hill (398 m a.s.l.), surrounded by agricultural fields. The 2.03 ha reserve is composed of rocks of the old, abandoned limestone quarry (0.9 ha, working between 1780 and 1912), a partly afforested area around this quarry (1.13 ha) and a 30 m long cavern in the rocks and a system of mines left after the limestone excavation. The main mine is strongly ramified into several corridors and high halls, which together have a length of about 600 m. In the lower part of this mine there are two small water reservoirs (Fig. 1B, Organiściak et al., 1997). The average temperature inside the mine in winter seasons (2000/01 and 2001/02) was +2.7 °C in the entrance hall, +3,3°C near the water reservoirs and +4.8°C in the end hall. Additionally there is a small (about 12 m long) mine near the main one (Fig. 1B, Organiściak et al. 1997).

Average temperature of this region in January is –2°C, in April +7°C, in July +17°C and in October +7.5°C. Annual precipitation is approximately 600 mm with a maximum in July (about 100 mm) and minimum in February (about 30 mm). The snow cover remains for about 60 days of the year. The early spring begins between 25th January and 1st March. The early winter begins between 5th – 10th November (Piasecki 1997). The south aspect of the quarry rocks and protection to the north causes a specific microclimate on reserve area. Temperatures are higher here during the day and lower in the morning than in the surrounding area. Additionally the air humidity is lower.

The main aim of establishing the reserve was to protect the most northern locality of rare xerophilous insect species, which are now extinct. Therefore the object of the protection should be changed. Because the mines at the reserve are very important winter and autumn-spring locality for several bat species, the new protection plan includes, beyond the reconstruction of the former microclimatic conditions, protection activities for bats (Furmankiewicz et al. 2000).

2.2. Winter census

The winter surveys of bats hibernating in the Stolec mines were carried out during two winter seasons 2000/01 and 2001/02. The bats were identified to species on the basis of the external characters without touching them. The undetermined individuals

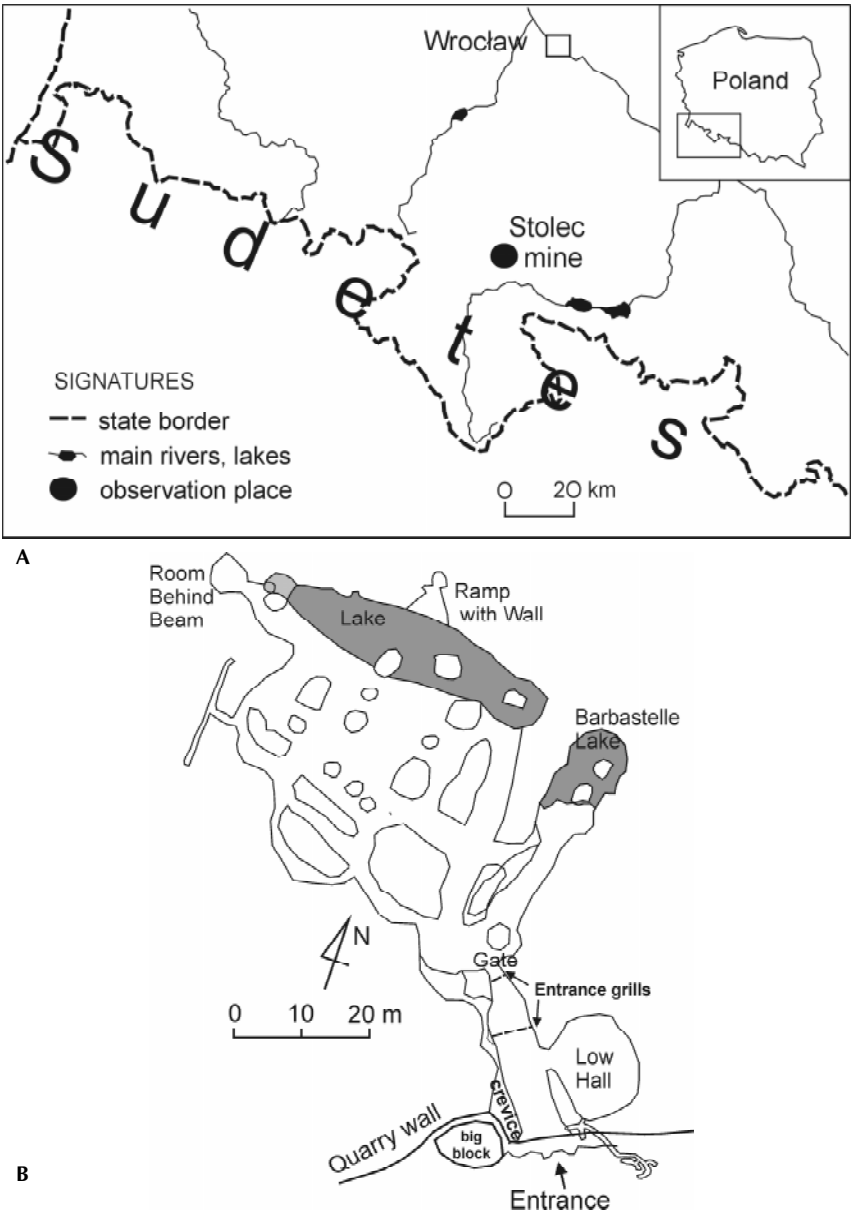

Fig. 1. Study area. A– the location of the "Stolec Rocks" reserve in the Sudetes, B – schematic plan of main mine adapted from Pawełczyk in Organiściak (1997).

Ryc. 1. Obszar badań. A – położenie rezerwatu „Skałki Stoleckie" w Sudetach, B - schematyczny plan głównej sztolni wg Pawełczyka (w: Organiściak 1997, uzupełnione).

were classified as "Ind" (*Indeterminata*). The two sibling species whiskered bat and Brandts' bat were not distinguished. Accurate identification of these two species is often possible only after disturbing them to study the teeth pattern and the shape of the penis (HANÁK 1970, 1971), therefore they were classified together as *Myotis mystacinus / brandtii.*

Two surveys were performed in the winter season 2000/01 and six surveys during the following winter (Tab. 4). The area around the water reservoirs was not checked during every survey, therefore only data from the area without the water reservoirs were used in analysis.

The position of bats in the mine and the degree of shelters preferred (protected or open hibernating site) were noted. Selection of shelters is shown only for two most numerous bat species: Natterer's bat and barbastelle, because the sample size was too small for the other species.

The air temperature in the mine was measured electronically by thermometer (± 0.1˚C) in the entrance hall, near the water reservoirs and at the end of mine (the end hall).

2.3. Bat census in non-hibernating seasons

In 2000 and 2001 bats were netted in non-hibernating seasons at the main mine, using three or four mist-nets (2.5 x 10 m; 2.5 x 7 m, 4 x 7 m, 3 x 3 m). One or two nets were placed 10 m in front of the mine entrance and two partly covered the mine entrance. Nettings were carried out from sunset to sunrise each week between March and April and between September and mid November and once or twice per month between May and August (Tab. 5 and 6). Time of capture and species and sex of each individual were noted. The bats were weighed with a 30 g Pesola balance (accurate to 0.25 g) and forearm length was measured using calipers (accurate to 0.1 mm). In 2001 age of bats (juvenile, subadult, adult) was determined on the basis of the epiphyseal-diaphyseal fusion in the finger bones (ANTHONY 1988), but in spring and late autumn it was very difficult or impossible, because of complete ossification of the epiphyseal joints.

2.4. Data analysis

The following ecological indices were used to describe the species composition of bats:

– proportion of bat species (P %) calculated from the number of individuals of *i* species (N_i) and the total number of individuals of all identified species (N):
$P = (N_i / N) \cdot 100\ \%$
– frequency (F %) was calculated from the number of surveys with *i* species (l_i) and the total number of surveys (surveys with no bats were counted) (L):
$F = (l_i / L) \cdot 100\%$
χ^2 – test was used to test for differences in sex ratio.

3. Results

3.1. Number and species composition of bats hibernating in the mine and visiting the mine from spring to autumn

During two winter seasons at least 10 hibernating bat species were found: great mouse-eared bat *Myotis myotis*, Bechstein's bat *M. bechsteinii*, Natterer's bat *M. nattereri*, whiskered bat / Brandt's bat *M. mystacinus* / *brandtii*, Daubenton's bat *M. daubentonii*, brown long-eared bat *Plecotus auritus*, grey long-eared bat *P. austriacus*, barbastelle *Barbastella barbastellus* and serotine *Eptesicus serotinus*. The maximal number of hibernating bats and bat species were observed in January, and then gradually decreased to April. Number of bats was correlated with number of species (Fig. 2). The details of winter species composition are shown in Tab. 4.

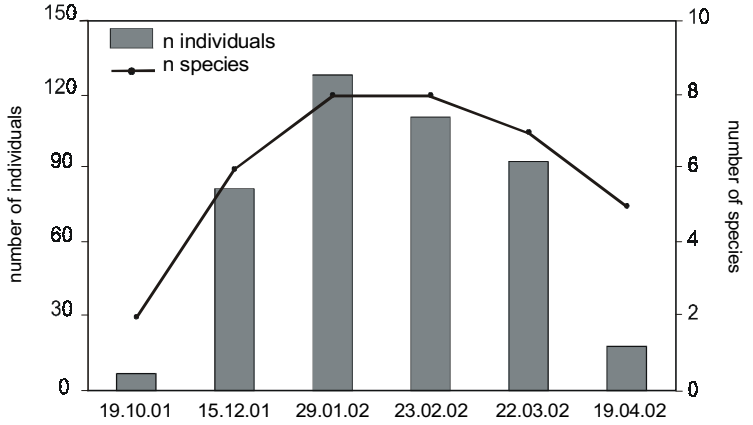

Fig. 2. Changes in number of bat species and individuals hibernating in the Stolec mine in winter season 2001/2002.

Ryc. 2. Zmiany liczby gatunków i liczebności wszystkich nietoperzy zimujących w sztolni w Stolcu w sezonie zimowym 2001/2002.

The species composition of bats visiting the mine from spring to autumn was similar to that found in winter, but additionally two new species were recorded: northern bat *Eptesicus nilssonii* and common pipistrelle *Pipistrellus pipistrellus*, but they were netted as single individuals once and three times, respectively (Tab. 5-6). During 53 netting nights at the mine 1314 bats of 12 species were caught. The greatest number of individuals and bat species were noted in March and April and in August and September. The fewest bats and species were caught in July (0-2 species) (Fig. 3).

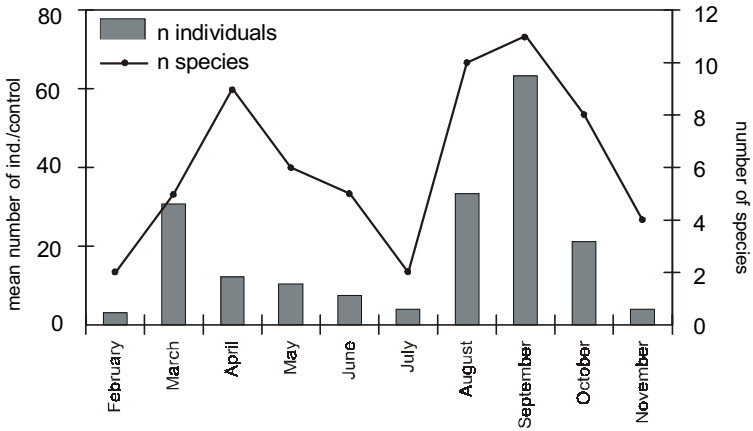

Fig. 3. Changes in number of bat species and individuals visiting the Stolec mine from spring to late autumn (data combined from two years 2000 and 2001).

Ryc. 3. Zmiany liczby gatunków i liczebności wszystkich nietoperzy odłowionych przy sztolni w Stolcu w okresie od wiosny do późnej jesieni, w latach 2000-2001.

Tab. 1. **Total number (N_i), proportion (P%) and frequency (F%) of different bat species hibernating in the Stolec Rocks mine during winter seasons (data combined from two winters: 2000/01 – 2 surveys, 2001/02 – 6 surveys) and visiting the mine during non-hibernating seasons (data combined from 2000-2001 and 53 nettings).**

Tab.1. Całkowita liczebność (N_i), proporcja (P%) i frekwencja (F%) poszczególnych gatunków nietoperzy zimujących w sztolni w Stolcu (w sezonach zimowych 2000/2001 – 2 kontrole i 2001/02 – 6 kontroli) i odłowionych w okresie pozahibernacyjnym w latach 2000-2001 (53 noce z odłowami).

Species	Hibernating seasons			Non-hibernating seasons		
	N_i	P%	F%	N_i	P%	F%
M. myotis	39	5.8	100	27	2.1	28.3
M. bechsteinii	4	0.6	50	22	1.7	28.3
M. nattereri	266	39.2	87.5	169	12.9	52.8
M. mystacinus	-	-	-	28	2.1	20.8
M. brandtii	-	-	-	17	1.3	13.2
M. mystacinus / brandtii	24	3.5	87.5	-	-	-
M. daubentonii	26	3.8	100	158	12.0	56.6
E. serotinus	1	0.1	12.5	78	5.9	41.5
E. nilssonii	0	-	-	1	0.1	1.2
P. pipistrellus	0	-	-	4	0.3	5.7
P. auritus	17	2.5	62.5	253	19.2	67.9
P. austriacus	1	0.1	12.5	3	0.2	3.4
B. barbastellus	302	44.4	77.8	554	42.2	89.5
Indeterminata	17	-	-	-	-	-
Total	**697**			**1314**		

Barbastella barbastellus

B. barbastellus was the most numerous species in both winter seasons (44.4% of all bats) (Tab. 1). 77.1 % of barbastelle bats hibernated in open sites and 22.9 % in crevices (Tab. 2). Most of the bats (about 50-75%) hibernated in clusters consisting of several to tens of individuals and many were observed in the same sites each year. The maximal number of hibernating bats was noted in January (N=87, Tab. 4). They were observed in the mine only from December to March, but in March only one individual was found (F=77.8%) (Tab. 1 and 4, Fig. 4). In this month the high number of active bats were caught at the mine entrance (Tab. 5-6, Fig. 4).

Barbastelles dominated in non-hibernating seasons, too (42.2%, Tab. 1) and two peaks of their flight activity were noted: in March and in September (Fig. 4). The first bats were caught in February and the last in November. In April and July no barbastelles were netted (Tab. 5-6, Fig. 4).

Plecotus auritus

This species was observed in the mine from December to February (F=62.5%), but only several (2.5%) wintering brown long-eared bats were noted each winter (Tab. 1 and 4, Fig. 4). Three times single individuals were found hibernating in the middle small mine (Tab. 4). Beyond the hibernating period it was the second numerous bat species visiting the mine and caught very often (19.2% of all bats, F=67.9%). Its numbers peaked in March and in September. Spring activity was observed from the beginning of March to the end of April. In autumn the number of bats visiting the mine increased from August to September and then decreased in October (Tab. 5-6, Fig. 4).

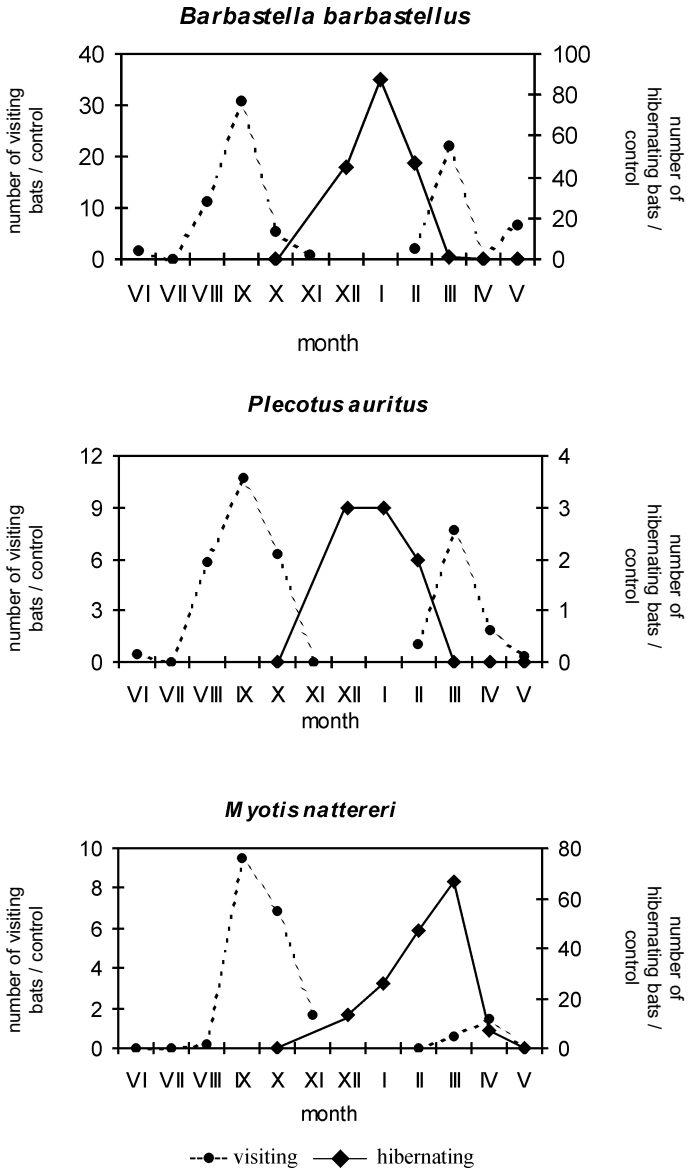

Fig. 4. Seasonal changes in mean number of different bat species visiting the Stolec mine and hibernating in this mine (data for hibernating bats from winter season 2001/02, for bats visiting the mine combined from the years 2000-2001).

Ryc. 4. Sezonowe zmiany średniej liczebności poszczególnych gatunków nietoperzy odłowionych przy sztolni w Stolcu w latach 2000-2001 i zimujących w tej sztolni w sezonie zimowym 2001/02.

Myotis nattereri

This species dominated together with barbastelle in winter seasons (39.2% of all bats). It was observed during nearly every month of the winter census in 2001/02 (F=87.5%, Tab. 5). The number of hibernating bats increased from December to March, when the greatest number was noted (N=81). In April bats left the mine and only a few hibernating individuals were found (Tab. 4, Fig. 4). In total about 70 % of bats hibernated in crevices, and the remaining individuals in open sites (Tab. 2). On 10th February 2001 one individual was found by chance hibernating in rubble.

In non-hibernating seasons Natterer's bat was the third most common species (12.9% of all bats) and caught during half of all netting nights (F=52.8%) (Tab. 1). The highest number of active individuals was netted in September and in October. In spring it was observed for only a short duration and in very low numbers (Fig. 4). From the end of April to the end of August it was absent in the nettings (Tab. 5-6, Fig. 4).

Myotis daubentonii

A maximum of eight hibernating individuals of this species were noted in the mine (3.8%) between October and the end of April (F=100%) (Tab. 1 and 4, Fig. 5). One individual was found in the middle small mine in October (Tab. 4). Despite the small sample size, the number of hibernating bats changed. It declined from December to February and then increased two-fold in March (Tab. 4, Fig. 5). On 10th February 2001 one individual was found by chance hibernating in rubble.

Daubenton's bat was often netted at the mine entrance in non-hibernating seasons (12.0% of all bats, F=56.6%) and the highest number of individuals was noted in April, August and October (Tab. 1 and 5-6, Fig. 5).

Myotis mystacinus / Myotis brandtii

Only a few hibernating bats of these two sibling species were found during each winter (3.5%, N_{max}=9), but their frequency of occurrence was high (F=87.5%) (Tab. 1).

Tab. 2. **Shelter preferences (open and protected sites) of *M. nattereri* and *B. barbastellus* hibernating in the Stolec Rocks mine in two winter seasons 2000/01 and 2001/02.**

Tab. 2. Preferecje w wyborze miejsca zimowania (odkryte i osłonięte) *M. nattereri* i *B. barbastellus* w sztolni w Stolcu w dwóch sezonach zimowych 2000/01 i 2001/02.

Date	*Myotis nattereri*				*Barbastella barbastellus*			
	open sites		protected sites		open sites		protected sites	
	N	%	N	%	N	%	N	%
12.01.01	20	45.4	24	54.6	72	84.7	13	15.3
10.02.01	19	23.7	61	76.3	30	69.8	13	30.2
15.12.01	4	30.8	9	69.2	40	88.9	5	11.1
29.01.02	10	38.5	16	61.5	66	75.9	21	24.1
23.02.02	18	25.7	52	74.3	30	61.2	19	38.8
22.03.02	26	32.1	55	67.9	1	100	0	0
19.04.02	0	0	6	100	0	–	0	–
Total	**97**	**30.3**	**223**	**69.7**	**239**	**77.1**	**71**	**22.9**

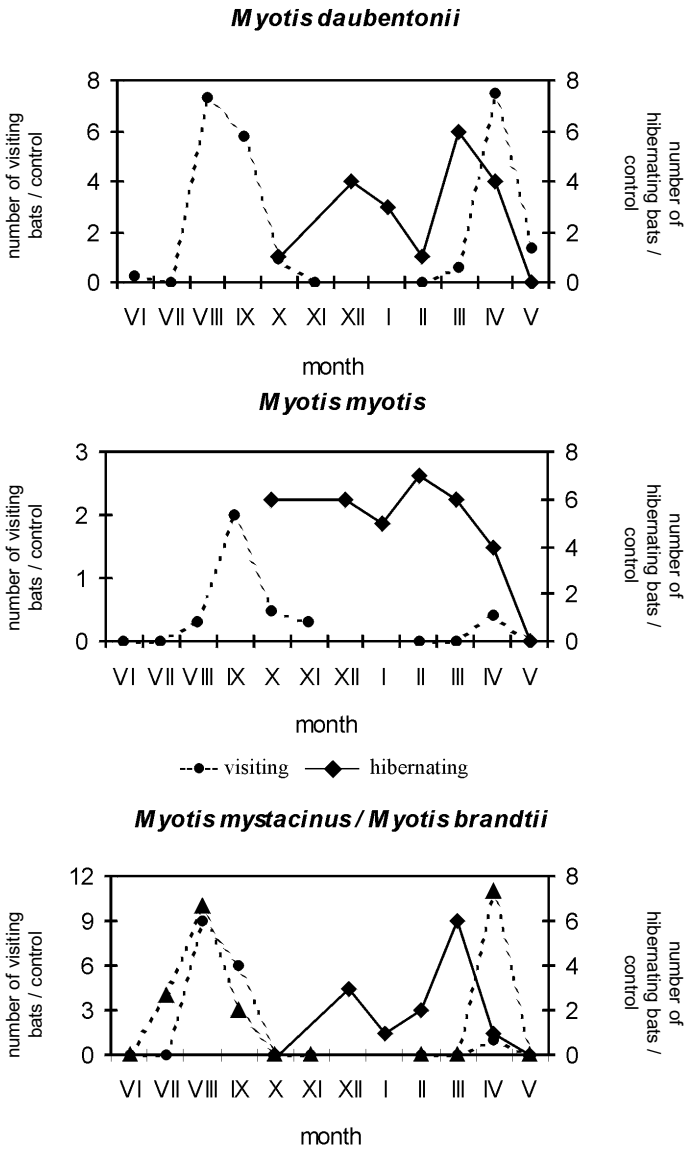

Fig. 5. Seasonal changes in mean number of different bat species visiting the Stolec mine and hibernating in this mine (data for hibernating bats from winter season 2001/02, for bats visiting the mine combined from years 2000-2001).

Fig. 5. Sezonowe zmiany średniej liczebności poszczególnych gatunków nietoperzy odłowionych przy sztolni w Stolcu w latach 2000-2001 i zimujących w tej sztolni w sezonie zimowym 2001/02.

The smallest number of bats were observed in January and the largest in March (Tab. 4, Fig. 5). In the non-hibernating season two peaks were observed for both species, in April and in August. In May, June and October no bats of these two species were caught (Tab. 5-6, Fig. 5). Brandt's bat was less numerous than whiskered bat (1.3% of all bats, F=13.2% and 2.1% of all bats, F=20.8%, respectively).

Myotis myotis

Greater mouse-eared bat was the third most common species wintering in the mine (5.8 % of all bats), although during each winter only several (N_{max}=9) hibernating individuals were found. It was present in the mine from October to April (F=100%). The number of bats found during the whole hibernating period did not change significantly, perhaps an artefact of the small sample size (Tab. 1 and 4, Fig. 5). The highest number of *M. myotis* at the mine was noted in September. The last active individual was caught in November, when several bats were already observed hibernating (Tab. 4-6, Fig. 5).

Myotis bechsteinii

One hibernating individual was observed at the end of the mine on 6th April 2001. One individual was noted on each of four surveys from the end of January to the end of April in winter 2001/02, (Tab. 4). Bechstein's bat was observed more often and more regularly (but only one or two individuals in several nettings) in spring and autumn, with a maximum in September (Tab. 5-6, Fig. 6).

Eptesicus serotinus

One serotine was found hibernating in the dry rock crevices outside the mine, near the entrance, at the end of January 2002 (Tab. 1 and 4). This species often visited the mine in non-hibernating seasons, but at different times to other species. Between May and August, when most individuals were observed, only males were seen and this sex ratio was significantly different from the unity (χ^2 = 20, d.f. = 1, $p < 0.001$) (Tab. 6). Outside these months only single individuals were caught (Tab. 5-6, Fig. 6).

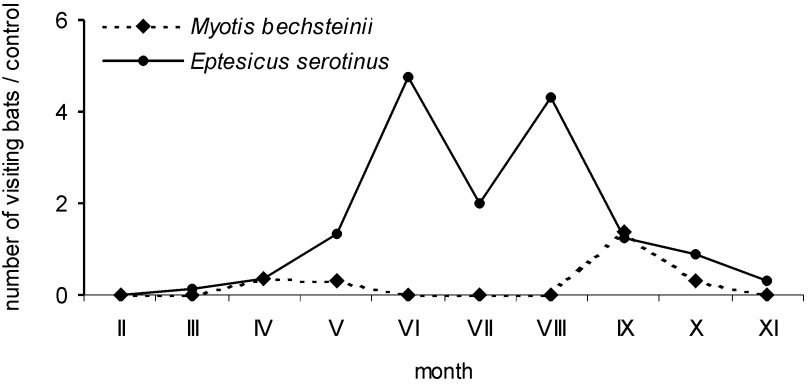

Fig. 6. Seasonal changes in mean number of *Myotis bechsteinii* and *Eptesicus serotinus* visiting the Stolec mine (data combined from two years 2000-2001).

Ryc. 6. Sezonowe zmiany średniej liczebności *Myotis bechsteinii* i *Eptesicus serotinus* odłowionych przy sztolni w Stolcu w latach 2000-2001.

Plecotus austriacus*, *Eptesicus nilssoni and ***Pipistrellus pipistrellus***

Single individuals of these species were sporadically caught and, with the exception of one winter record of *P. austriacus,* were never observed during hibernation in the mine (Tab. 1 and 4-6).

3.2. Sex composition

Overall more males than females were caught of *P. auritus, M. nattereri, M. daubentonii, E. serotinus, B. barbastellus*. Sex ratio was not significantly different from unity for *M. myotis*, *M. bechsteinii*, *M. mystacinus* and *M. brandtii* (Tab. 3). The sex ratio changed for several species through the season. In spring (III-IV) sex ratio was highly significantly different from unity in *Plecotus auritus* and *Barbastella barbastellus*. At this time only a few females of these species were caught. Sex ratio for *M. nattereri* and *M. mystacinus* was not significantly different from the unity in spring. For other species the sample was too small to identify differences (Tab. 3). Between May and July only one female (of *P. austriacus*) was noted, and in all other species only males were recorded. In autumn (VIII –XI) the number of females increased, but there were still significantly more males than females in *P. auritus, B. barbastellus, M. nattereri* and *M. daubentonii* (Tab. 3).

Tab. 3. **Sex ratio (proportion of males to females) of different bat species visiting the Stolec mine from March to November in two non-hibernating seasons 2000-2001 (53 nettings). Significance level of differences between numbers of males and females caught: NS – not significant, * = P<0.05; ** = P<0.01; *** = P<0.001 (calculated with the χ^2 – test, when more than 10 individuals were netted).**

Tab. 3. Proporcja płci (samców do samic) poszczególnych gatunków nietoperzy odłowionych przy sztolni w Stolcu w dwóch sezonach pozahibernacyjnych 2000-2001 (53 noce z odłowami). Różnice pomiędzy liczbą odłowionych samców i samic testowano przy użyciu testu χ^2, wówczas gdy próba wynosiła powyżej 10 osobników. Podano następujące poziomy istotności statystycznej: NS - nieistotny statystycznie, * = P<0.05; ** = P<0.01; *** = P<0.001.

Species	March – April	May – July	August - November	Total
M. myotis	0.33	-	0.46 ^{NS}	0.44 ^{NS}
M. bechsteinii	0.33	1.00	0.61 ^{NS}	0.59 ^{NS}
M. nattereri	0.63 ^{NS}	-	0.71 ***	0.70 ***
M. mystacinus	0.55 ^{NS}	1.00	0.54 ^{NS}	0.61 ^{NS}
M. brandtii	1.00	1.00	0.73 ^{NS}	0.76 ^{NS}
M. daubentonii	0.54	1.00	0.60 *	0.59 *
E. serotinus	0.60	1.00 ***	0.56	0.72 ***
E. nilssonii	0.00	-	-	0.00
P. pipistrellus	-	-	0.75	0.75
P. auritus	0.90 ***	1.00	0.67 ***	0.74 ***
P. austriacus	-	0.00	0.50	0.33
B. barbastellus	0.86 ***	1.00 ***	0.57 *	0.67 ***
Total	0.77	0.99	0.62	0.67

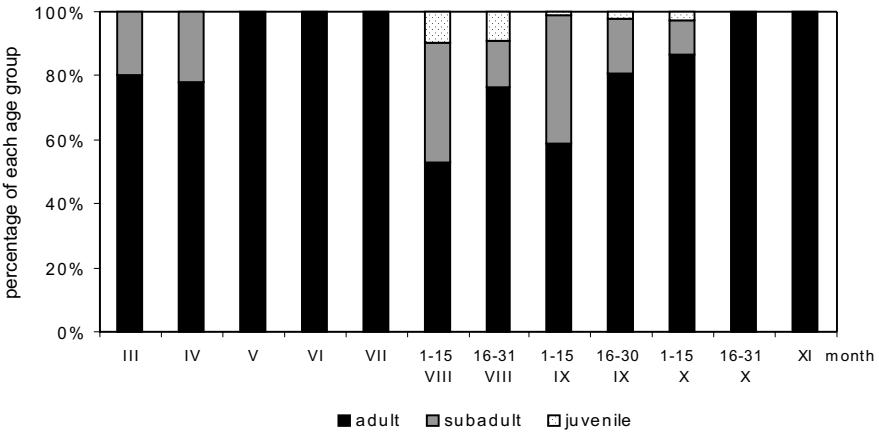

Fig. 7. Dynamics of particular age groups of bats netted at the Stolec mine in the season 2001.

Ryc. 7. Dynamika występowania poszczególnych grup wiekowych nietoperzy odławianych przy sztolni w Stolcu w sezonie 2001.

3.3. Age composition

The bats were aged only in 2001. During netting adult bats were most numerous (Fig. 7). In March and April the adults comprised about 80%, and subadults about 20%. Between May and July only adults were netted. From the first half of August to the first half of October all three age groups were recorded. Subadults and juveniles comprised between 15 and 50% of all caught individuals, but juveniles were not very numerous (mostly a few individuals per month). In the second half of October and in November only adults were noted (Fig. 7), but this could have resulted from difficulties in distinguishing the young, because of the complete ossification of the epiphyseal joints by this time (see Methods).

4. Discussion

4.1. Winter species composition

The mine in the "Stolec Rocks" reserve is the most numerous wintering site for Natterer's bat and one of the most numerous hibernacula for barbastelle in Lower Silesia (GÓRNIAK 2000). By comparison, the greatest hibernacula for barbastelles in Lower Silesia are the old cellar in Cieszków near Milicz (65 km NE from Wrocław), which has more than 200 individuals, the cellars in the Lubiąż monastery and the mine in Młoty (Bystrzyckie Mountains) which has approximately 100 individuals (GÓRNIAK 2000, BUŘIČ et al. 2001, WOŁOSZYN 2002). Barbastelle was the dominant bat species during our surveys and in previous investigations (SEIDEL 1927, WOŁOSZYN 1968, HAITLINGER 1976). Low mean temperature in the mine (average +3.6 °C) could explain its prevalence in winter, because barbastelle prefers low temperatures during hibernation (BOGDANOWICZ 1983). The winter dynamics of barbastelle with the peak number in January is similar to that observed in other underground sites, where this species arrives in the hibernacula late in the winter and leaves earlier than other species (BAGROWSKA-URBAŃCZYK and URBAŃCZYK 1983, KOWALSKI and LESIŃSKI

1991). In November and March, when temperatures underground are too warm (or during warmer weather in winter), barbastelle probably uses weaker shelters outside the mine that are less thermally isolated from the environment. Similar winter dynamics are observed for the brown long-eared bat (Bagrowska-Urbańczyk and Urbańczyk 1983, Kowalski and Lesiński 1991), which is characterised by similar thermal preference (Bogdanowicz 1983, Bogdanowicz and Urbańczyk 1983). Radiotelemetry data collected on *P. auritus* at the Stolec Rocks mine in March-April and October showed that bats roost in tree holes or buildings outside the mine at this time.

The second most common species in our study was Natterer's bat, which was not observed during winter in previous studies (Seidel 1927, Wołoszyn 1968, Haitlinger 1976). Perhaps the number of bats has increased during the 1990s and in 2000 and 2001. Increasing numbers of *M. nattereri* were observed e.g. on Częstochowa Upland (Postawa and Zygmunt 2000) and in the caves in Połom (NW Sudetes) (Kliś et al. 2001) also. Alternatively, it could be the result of bat migration from other areas, as suggested for the population of this species on Częstochowa Upland (Postawa and Zygmunt 2000).

During hibernation Natterer's bat prefers protected sites, which give good protection against climatic conditions inside and outside the hibernaculum (Bogdanowicz 1983, Bogdanowicz and Urbańczyk 1983, Jurczyszyn 1998). The increase in number of bats in February and March could result from a change in the frequency of bats hibernating in deep crevices. Hibernation site selection is probably affected by outdoor and ambient temperature. Movement of bats into crevices where they cannot be seen is a major source of error in analysing the dynamics of bat populations (Jurczyszyn 1998). This could explain the opposite result seen in Poznań forts, where Natterer's bats reached maximum number at the end of November and at the beginning of December, after which the number of individuals slightly decreased (Jurczyszyn 1998). This problem has great implications for the interpretation of winter bat surveys and needs more investigation.

4.2. Spring – autumn species composition and swarming behaviour

Spring – autumn species composition did not differ from that in winter. *P. pipistrellus* and *E. nilssonii* were recorded in spring – autumn but not in winter. The absence of common pipistrelle in winter probably results from their preference for different hibernation shelters. They mainly use big churches, crevices in buildings, cellars, deep rock crevices, tree holes and sometimes old mines or caves (Schober and Grimmberger 1998). The single bats that visited the mine probably came from the nearest village, Stolec. A maternity roost of this species was found (about 30 individuals) in the village church and in several places vocalisation was heard. Swarming behaviour at the underground sites was not observed in this species. Because swarming is often connected with mating (Fenton 1969, Thomas et al. 1979, Parsons et al., in press), the common pipistrelle is not expected to visit underground sites in late summer and spring, because territorial males establish harems of females near the maternity roosts (Gerrell and Lundberg 1985, Lundberg and Gerell 1986). However swarming (in underground site) and "invasion" (in buildings) of *P. pipistrellus* in Germany, in summer and in autumn was described and discussed in relation to the mating behaviour

Fig. 8. The winter colony of barbastelles *Barbastella barbastellus* and Natterer's bats *Myotis nattereri* in the Stolec mine. Phot. J. Furmankiewicz.

Ryc. 8. Zimowa kolonia mopków i nocków Natterera w sztolni w Stolcu. Fot. J. Furmankiewicz.

Fig. 9. The barbastelles *Barbastella barbastellus* in crevice in the Stolec mine. Phot. J. Furmankiewicz.
Ryc. 9. Mopki w szczelinie skalnej w sztolni w Stolcu. Fot. J. Furmankiewicz.

(Kretzschmar and Heinz 1995, Sachteleben 1991).

Single records of a female of northern bat *Eptesicus nilssonii* and females of *P. austriacus* in non-hibernating seasons, suggest that there are maternity roosts of these two species in the vicinity, as they are not long-range migrants (Schober and Grimmberger 1998). Other authors noted small numbers of *Plecotus austriacus* also (Horáček and Zima 1978, Bauerová and Zima 1988, Řehák 1995). This could be because they lack swarming behaviour, or because the population inhabiting this region is small or they preference other wintering and swarming sites.

The activity of most species of bats in spring is probably associated with departure from the hibernaculum, as observed by several authors (Horáček and Zima 1978, Ehlers 1983, Degn et al. 1995, Jurczyszyn 2001). The first bats to leave the mine were the barbastelle and brown long-eared bats. Barbastelle probably left the mine quickly, before the end of March. Brown long-eared bats were present for longer, in March and April. The radiotelemetry and ringing data showed that bats probably visited the mine only for one night (once or several times in season), and normally roosted in the vicinity (tree holes and buildings). This behaviour is likely connected with mating behaviour of the brown long-eared bat; because at this time there is much vocal activity and males are present which have cauda epididymides distended with sperm. It is evidence that at least for one species, swarming occurs in early spring (Bauerová and Zima 1988). The *Myotis* species depart from the mine in April. *M. nattereri* was noted seldom in spring nettings, although found in high number while hibernating. It may leave the hibernaculum very quickly in a short period of time (Ehlers 1983).

There may be several reasons for autumn swarming behaviour. It could be a possibility for checking different and appropriate hibernating sites (Řehák 1995) and showing young of the year the hibernacula (Fenton 1969). Autumn migration of bats is also one of explanation of the swarming (roaming) behaviour at caves and mines (Hall and Brenner 1965, 1968; Horáček and Zima 1978). Such behaviour could also give the bats a possibility to meet more individuals of both sexes in one place (Horáček and Zima 1978) and therefore is the opportunity for mating and gene flow between different colonies or populations from extensive area (Fenton 1969, Thomas et al. 1979). Often the behaviours interpreted as mating activities (vocalisation, chasing, copulations) were observed in such places (Moffat 1922, Fenton 1969, Thomas et al. 1979). It seems that the population (or community) size of different species visiting the mine is very large, because during swarming in spring or in autumn, a small number of recaptures have been noted (for *P. auritus* about 20%, our unpublished data). Bauerová and Zima (1988) estimated the community size of some of the more frequent species visiting a cave at 600-2000 bats. On the other hand the bats often returned to the mine in the next year (next season), which shows fidelity of bats to this place. Therefore such swarming sites seem to be very important for bat populations in autumn and for some species in spring. Additionally, many observations suggest, that different sites are important for different bat species (Horáček and Zima 1978, Ehlers 1983, Bauerová and Zima 1988, Řehák 1995, Degn et al. 1995, Hanzal and Průcha 1996, Parsons et al., in press).

From May to July activity of bats was low near the mine, similar to observations of other authors (Horáček and Zima 1978,

Bauerová and Zima 1988, Řehák 1995, Hanzal and Průcha 1996). Only serotine showed peak visitation at that time. The activity pattern of this species is opposite to other swarming bat species. Perhaps the bats were coming to the reserve for feeding, and when the opportunity occurred they visited the mine. The area of the reserve could be commuting route to the foraging sites and the bats could be caught by chance. According to Gaisler (1975), high numbers of insects accumulated at underground entrances and on the open spaces nearby, which might be the reason for intense bat activity at the underground sites in the non-hibernating period. But the negative correlation between bats visiting and the number and species composition of insects obtained by Mumford and Whitaker (1975) showed, that this factor has little or no significance and needs more investigation.

4.3. Bat protection and monitoring

The Stolec Rocks mine plays an important role as a hibernating and breeding site for several bat species. The nationally rare and vulnerable species: *M. bechsteinii, M. emarginatus, E. nilssonii* (Głowaciński 2001), and species of European importance: *M. myotis* and *B. barbastellus* were recorded here (Stebbings 1988, Hutson et al. 2001). The new protection plan for the reserve includes protection activities for bats (Furmankiewicz et al. 2000). To date the mine has suffered from strong people pressure, because of its location near urban areas and the tourist trail. Therefore it was grilled in June 2002 through cooperation between the European Nature Heritage Fund EURONATUR and the Polish Society of Wildlife Friends "pro Natura", within the project "Bats on the border area of Germany, Poland and Czech Republic" (EURONATUR 2001). Additionally this site was included as nature mainstay in the European network protected areas (Natura 2000) in 2002. Continuation of monitoring of the bat community which hibernates and swarms in the mine, and further research projects to explain the swarming behaviour are required. Landscape elements, such as tree and bush corridors, are important for bats when commuting. They give bats protection against wind and/or predators (Limpens and Kapteyn 1991). Therefore it is important to preserve existing corridors or to reconstruct landscape tree cover elements in agricultural areas near swarming and hibernation sites to provide commuting lines to such sites.

The winter censuses should be adjusted to changes in bat species composition. In January the greatest number of hibernating bats and species were observed. However, for some species, like *Myotis nattereri* the highest number was noted in March. Therefore the winter surveys should be done twice, once in January for *P. auritus* and *B. barbastellus* and once in March for *M. nattereri*.

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Fig. 10. The two grills in the main entrance to the Stolec mine. Phot. M.Furmankiewicz.
Fig. 10. Dwie kraty zabezpieczające główne wejście do sztolni w Stolcu. Fot. M. Furmankiewicz.

Grzegorz Gołębniak, Maria Roszkowska, Aleksandra Mąkolska, Dominika Mielcarek, Krzysztof Zając, Roman and Wojciech Wieczorek, Marcin Wójcik, Katarzyna Zgrzebna, Łukasz Iwaniuk, Anna Iwaniuk, Anna Bawolska, Magda Łochyńska, Mateusz Tarnowski, Biały, Katarzyna Duma, Katarzyna Mielcarek. This study was performed within three projects: master thesis of J. Górniak (2002), Ph.D. thesis of J. Furmankiewicz (in preparation) and part of the master thesis of T. Gottfried. The collected data were used in the new conservation plan of the "Stolec Rocks" reserve (Furmankiewicz et al. 2001). Bats were caught under licenses from Environmental Ministry and Voivodship Nature Conservancy Manager.

Tab. 4. **Number of bats hibernating in the Stolec mines in two winter seasons 2000/01 and 2001/02** (bold type – number of all bats including the individuals hibernating on the water reservoir, cursive type – number of hibernating bats excluding the individuals on the water reservoirs, when the part with water wasn't checked only one number is given). The following acronyms were used: MYM – *Myotis myotis*, MBE – *M. bechsteinii*, MYN – *M. nattereri*, MMB – *M. mystacinus/brandtii*, MDA – *M. daubentonii*, PAR – *Plecotus auritus*, PAS – *P. austriacus*, ESE – *Eptesicus serotinus*, BAR – *Barbastella barbastellus*, IND – *Chiroptera indeterminata*.

Tab. 4. Liczebność nietoperzy zimujących w sztolni w Stolcu podczas dwóch sezonów zimowych 2000/01 i 2001/02 (pogrubioną czcionką oznaczono wszystkie nietoperze łącznie z osobnikami zimującymi nad wodą, kursywą – liczbę nietoperzy zimujących poza zbiornikami wodnymi; przy kontrolach nie obejmujących części sztolni z wodą, podano tylko jedną liczbę). Akronimy użyte w tabeli podano powyżej.

a) main mine

Date	MYM	MBE	MYN	MMB	MDA	PAR	PAS	BAR	ESE	IND	Total	Authors
9.03.00	*4*		*42*		*4*			*7*		*6*	*63*	J.Furmankiewicz, T.Gottfried, S.Telatyński
12.01.01	**9** *5*		**44** *38*	2 *2*	**6** *5*	**5** *4*		**85** *81*			**151** *135*	J. i M. Furmankiewicz, S.Telatyński
10.02.01	**7** *5*		**80** *68*	9 *9*	**4** *2*	**7** *5*	1 *1*	**43** *41*		**1** *1*	**152** *132*	J. i M. Furmankiewicz, T.Gottfried, B.Smyk
19.10.01	*6*				*1*						*7*	T.Gottfried, J.Górniak
15.12.01	*6*		*13*	*3*	*4*	*3*		*45*		*7*	*81*	T.Gottfried, R.Urban, A. Zieja, M.Furmankiewicz
29.01.02	*5*	*1*	*26*	*1*	*3*	*3*		*87*	*1*		*127*	J.Furmankiewicz, R.Urban, J.Ziemińska, A. Zieja
23.02.02	**9** *7*	1 *1*	**70** *47*	**3** *2*	**2** *1*	2 *2*		**49** *47*		3 *3*	**139** *110*	J.i M.Furmankiewicz, J.Karcz, T. Śnieżek, P. Szuszkiewicz
22.03.02	**8** *6*	1 *1*	**81** *67*	6 *6*	**8** *6*			1 *1*		5 *5*	**110** *92*	J.i M.Furmankiewicz, M.Biegański, M. Wiklik
19.04.02	*4*	*1*	*7*	*1*	*4*					*1*	*18*	J.Furmankiewicz, S. Bryła J.Górniak, R.Pielech,

b) middle small mine

Date	MDA	PAR	Total	Authors
12.01.01	1		1	M.Furmankiewicz
15.12.01		1	1	M.Furmankiewicz
29.01.02		1	1	J.Furmankiewicz
23.02.02		1	1	M.Furmankiewicz

Tab. 5. Species and number of bats netted at Stolec mine entrance in 2000. The following acronyms were used: MYM – *Myotis myotis*, MBE – *M. bechsteinii*, MYN – *M. nattereri*, MYS – *M. mystacinus*, MYB – *M. brandtii*, MDA – *M. daubentonii*, ENI – *Eptesicus nilsonii*, ESE – *E. serotinus*, PPP – *Pipistrellus pipistrellus*, PAR – *Plecotus auritus*, PAS – *Plecotus austriacus*, BAR – *Barbastella barbastellus*, Sum – total.

Tab. 5. Gatunki i liczebności nietoperzy odłowionych przy otworze sztolni w Stolcu w roku 2000. Akronimy użyte w tabeli podano powyżej.

Date	MYM	MBE	MYN	MYS	MYB	MDA	ENI	ESE	PPP	PAR	PAS	BAR	Sum	Main authors
13.03.00								1		17		63	81	J.Furmankiewicz, S.Telatyński
27.03.00			1							6			7	J.Furmankiewicz, S.Telatyński
04.04.00			2			10				2			14	J.Furmankiewicz, S.Telatyński
06.04.00			3			8							11	J.Furmankiewicz, S.Telatyński
10.04.00	1	1	2			7		1		7			19	J.Furmankiewicz, T.Gottfried
17.04.00		1				5		1		2			9	J.Furmankiewicz J.Struzik, M.Szerszeń
15.05.00		1			1	2		4		1		17	26	J.Furmankiewicz, T.Gottfried
28.05.00												3	3	J.Furmankiewicz
10.06.00						1		14		2	1	7	25	J.Furmankiewicz
28.06.00								1					1	J.Furmankiewicz, J. Struzik
09.07.00													0	J.Furmankiewicz, T. Gottfried
01.08.00				1	5	5		5				3	19	S.Telatyński, D. Łupicki
21.08.00	1				2	17		6		14		26	66	J.Furmankiewicz, T. Gottfried
02.09.00	1	2	5		5	8		4	2	12		28	67	J. i M. Furmankiewicz T.Gottfried
15.09.00	6	1	6			2		1		32		13	61	J.Furmankiewicz, T. Gottfried
27.09.00	1		11			2		3		14		41	72	J.Furmankiewicz, K.Zając T.Gottfried, S. Telatyński
29.09.00		2	14	1		2		2		15	2	49	87	J.Furmankiewicz T.Gottfried, K.Zając
06.10.00	1		1			1				3		6	12	J.Furmankiewicz, T.Gottfried
13.10.00			4					8		11		3	26	J.Furmankiewicz, T. Gottfried
19.10.00			6							5		1	12	J.Furmankiewicz, K.Zając
27.10.00			1							1			2	J.Furmankiewicz, M.Biegański, R.Urban
03.11.00			2										2	J. i M. Furmankiewicz T.Gottfried
15.11.00								1				2	3	J.Furmankiewicz, T.Gottfried
Total	**11**	**8**	**58**	**2**	**13**	**70**	**0**	**52**	**2**	**144**	**3**	**262**	**625**	

Tab. 6. **Species and number of bats netted at Stolec mine entrance in 2001. For the acronyms see the table 5.**

Tab. 6. Gatunki i liczebność nietoperzy odłowionych przy otworze sztolni w Stolcu w roku 2001. Wyjaśnienia akronimów podano w tab. 5.

Date	MYM	MBE	MYN	MYS	MYB	MDA	ENI	ESE	PPP	PAR	PAS	BAR	Sum	Main authors
10.02.01										1		2	3	J. i M. Furmankiewicz
02.03.01												1	1	J.Furmankiewicz, J. Struzik
08.03.01										6		57	63	J. Furmankiewicz, S.Telatyński
15.03.01										5		11	16	J. Furmankiewicz, J. Górniak
22.03.01			1							5		17	23	J. Furmankiewicz T. Gottfried
31.03.01			2			4		1		11		6	24	J. i M. Furmankiewicz
06.04.01		1	1			6				3			11	J. Furmankiewicz, J. Górniak
12.04.01	2		3	3		11	1	1		1			22	J. Furmankiewicz, J. Górniak
20.04.01			1	5		3							9	J. Furmankiewicz, J. Górniak
27.04.01				3	1								4	J. Furmankiewicz, J. Górniak
19.05.01						2							2	J. Furmankiewicz T. Gottfried, M. Wójcik
09.06.01								4					4	J. Furmankiewicz, J. Górniak, Ł. Iwaniuk
25.06.01													0	J. Furmankiewicz, J. Górniak, Ł. Iwaniuk
09.07.01													0	J. Furmankiewicz
23.07.01				4				4					8	J. Górniak, T. Gottfried, Ł. Iwaniuk
06.08.01		2				4		6		1			13	J. Furmankiewicz, T. Gottfried, J. Górniak
14.08.01	1			5		12		5		5		14	42	J. Furmankiewicz, J. Górniak
21.08.01		2		4	2	5		4	1	4		16	38	M. Biegański, T. Górniak, T. Gottfried
28.08.01			1			1				11		9	22	J. Furmankiewicz, J. Górniak, Ł. Iwaniuk
04.09.01	1	1				18				5		11	36	J. Furmankiewicz, J. Górniak, Ł. Iwaniuk
11.09.01	5	2	4	1		10				5		23	50	J. Furmankiewicz, J. Górniak
19.09.01	2	2	19		1	2				2		39	67	J. Furmankiewicz, J. Górniak, R. Urban
26.09.01		1	17	1		2				1		43	65	J. i M. Furmankiewicz, J. Górniak
02.10.01	2		2			1				5		30	40	J. Furmankiewicz M. Biegański, Ł. Iwaniuk
06.10.01	1	1	8			2				13		6	31	J. i M. Furmankiewicz, Ł. Iwaniuk
09.10.01	1	2	13			2		1		11		5	35	J. Furmankiewicz, J. Górniak, Ł. Iwaniuk
12.10.01			15			3				8		2	28	J. i M. Furmankiewicz, A. Nowakowski
19.10.01			11							6			17	J. Furmankiewicz, J. Górniak, T. Gottfried
25.10.01			8										8	J. Furmankiewicz, J. Górniak
05.11.01	1		5						1				7	J. Furmankiewicz, T. Gottfried
Total	**16**	**14**	**111**	**26**	**4**	**88**	**1**	**26**	**2**	**109**	**0**	**292**	**689**	

References

ANTHONY E. L. P. 1988. Age determination in bats. In: KUNZ T. H. (Eds.): Ecological and behavioural methods for the study of bats. Smithsonian Institution Press, Washington: 47-58.

BAGROWSKA-URBAŃCZYK E., URBAŃCZYK Z. 1983. Structure and dynamics of a winter colony of bats. Acta theriologica, 28, 11: 183-196.

BAUEROVÁ Z., ZIMA J. 1988. Seasonal changes in visits to a cave by bats. Folia Zoologica, 37(2): 97-111.

BOGDANOWICZ W. 1983. Community structure and interspecific interactions in bats hibernating in Poznań. Acta theriologica, 28, 23: 357-370.

BOGDANOWICZ W., URBAŃCZYK Z. 1983. Some ecological aspects of bats hibernating in city of Poznań. Acta theriologica, 28, 24: 371-385.

BUŘIČ Z., FURMANKIEWICZ J., FURMANKIEWICZ M., KLODEK R., KOKUREWICZ T., TELATYŃSKI S. 2001. Zimowe stanowiska nietoperzy na ziemi kłodzkiej. Szczeliniec, 5: 149-168.

DAVIS W. H., HITCHCOCK H. B. 1965. Biology and migration of the bat *Myotis lucifugus* in New England. Journal of Mammalogy, 46 (2): 296-313.

DEGN H. J., ANDERSEN B.B., BAAGØE H. 1995. Automatic registration of bat activity through the year at Mønsted Limestone Mine, Denmark. Zeitschrift für Säugetierkunde, 60: 129-135.

EURONATUR, 2001. Projekt: Fledermäuse. Stiftung Europäisches Naturerbe (EURONATUR). Radolfzell (information folder).

EHLERS J. 1983. Untersuchungen an Fledremäusen in einer Winterquartier im Deister unter besonderer Berücksichtigung der Flugaktivität in Abhängigkeit von exogenen Faktoren. Inaugural-Dissertation zur Erlangung des Grades eines Doctor Medicinae veterinariae durch die Tierärztliche Hochschule Hannover. Hannover, pp. 85.

FENTON M.B. 1969. Summer activity of *Myotis lucifugus* (*Chiroptera: Vespertilionidae*) at hibernacula in Ontario and Quebec. Canadian Journal of Zoology, 47: 597-602.

FURMANKIEWICZ J., POMORSKI R.J., SZCZĘŚNIAK E. 2000. Plan ochrony faunistycznego rezerwatu przyrody „Skałki Stoleckie" na lata 2000 – 2020. Archiwum Wojewódzkiego Konserwator Przyrody. Wrocław (mrsc).

GAISLER J., 1975. A quantative study of some populations of bats in Czechoslovakia *(Mammalia: Chiroptera).* Acta scientiarium naturalium Academiae scientiarium bohemoslovacae, 9(5): 1-44.

GERELL R., LUNDBERG K. 1985. Social organisation in the bat *Pipistrellus pipistrellus.* Behavioral Ecology and Sociobiology, 16: 177-184.

GŁOWACIŃSKI Z. (Ed.) 2001. Polska Czerwona Księga Zwierząt. Kręgowce. Państwowe Wydawnictwo Rolnicze i Leśne. Warszawa.

GÓRNIAK J. 2000. Zimowe stanowiska nietoperzy na Dolnym Śląsku. Unpublished B. Sc. thesis, Institute of Zoology, University of Wrocław, Poland. [In Polish].

GÓRNIAK J. 2002. Sezonowe zmiany liczebności i różnorodności gatunkowej nietoperzy (*Chiroptera*) w rezerwacie przyrody „Skałki Stoleckie" (Przedgórze Sudeckie). Unpublished M. Sc. thesis, University of Wrocław, Poland. [In Polish].

GÓRNIAK J., FURMANKIEWICZ M. 2001. Nowe obserwacje nocka Bechsteina *Myotis bechsteinii* w Sudetach. Studia Chiropterologica, 2: 87-89.

HAITLINGER R. 1976. Nietoperze Dolnego Śląska. Przegląd Zoologiczny 20, (1): 124-134.

HALL J.S., BRENNER F.J. 1965. A behaviour of bats, not related to roosting, in the use of caves in summer. American Zoologist, 5: 225.

HALL J.S., BRENNER F.J. 1968. Summer netting of bats at a cave in Pensylvania. Journal of Mammalogy, 49(4): 779-781.

HANÁK V. 1970. Notes on the distribution and systematics of *Myotis mystacinus* Kuhl, 1819. Bijdragen tot de Dierkunde, 40: 40-44.

HANÁK V., 1971. *Myotis brandtii* (Eversmann 1845) in der Tschechoslowakei. Věstník Československé zoologické společnosti w Praze, 35: 175-185.

HANZAL V., PRŮCHA M. 1996. Annual course of cave visitation by bats (*Mammalia: Chiroptera*) in the Bohemian Karst (Czech Republic). Acta societatis zoologicae bohemosloveniae, 60: 25-30.

HORÁČEK I., ZIMA J. 1978. Net-revealed cave visitation and cave-dwelling in European bats. Folia Zoologica, 27(2): 135-148.

JURCZYSZYN M. 1998. The dynamics of *Myotis nattereri* and *Myotis daubentonii* (*Chiroptera*) observed during hibernation season as an artefact in some type of hibernacula. Myotis, 36: 85-91.

JURCZYSZYN M. 2001. Departure dynamics of *Myotis daubentonii* (Kühl, 1817) (*Mammalia, Chiroptera*) from their hibernaculum. Mammalia, 65(2): 121-130.

KLIŚ T., FURMANKIEWICZ J., KOKUREWICZ T. 2001. Zmiany liczebności i składu gatunkowego nietoperzy hibernujących w jaskiniach góry Połom (Góry Kaczawskie, Sudety Zachodnie) w latach 1964 – 2001, Studia Chiropterologica, 2: 47-66.

KOWALSKI M., LESIŃSKI G., 1991. Changes in number of bats in Szachownica cave (central Poland) during 10 years. Myotis, 29: 35-38.

KRETZSCHMAR F., HEINZ B. 1995. Social behaviour and hibernation of a large population of *Pipistrellus pipistrellus* (Schreber, 1774) (*Chiroptera: Vespertilionidae*) and some other bat species in the mining-system of a limestone quarry near Heidelberg (South West Germany). Myotis, 32-33: 221-229.

LIMPENS H.J.G.A., KAPTEYN K. 1991. Bats, their behaviour and linear landscape elements. Myotis, 29: 39-48.

LUNDBERG K., GERELL R. 1986. Territorial advertisement and mate attraction in the bat *Pipistrellus pipistrellus*. Ethology, 71: 115-124.
MOFFAT C. B. 1922. The habits of the Long-eared bat. The Irish Naturalist 31: 105-111.
MUMFORD R.E., WHITAKER J.O. 1975. Seasonal activity of bats at an Indiana Cave. Proceedings of Indiana Academic Scientist, 84: 500-507.
ORGANIŚCIAK J., DUDZIAK T., DZIEDZIC M., 1997. Ząbkowickie opowieści. Część III: Okolice Ząbkowic Śląskich. Monografia krajoznawcza. Ząbkowice Śląskie.
PARSONS K.N., JONES G., DAVIDSON-WATTS I., GREENAWAY F. Swarming of bats at underground sites in Britain – implications for conservation. Biological Conservation (in press).
PIASECKI J. 1997. Termiczne pory roku (1951–80). Mapa nr 48. In: Atlas Śląska Dolnego i Opolskiego. Uniwersytet Wrocławski, Polska Akademia Nauk, Oddział we Wrocławiu, Wrocław.
POSTAWA T., ZYGMUNT J. 2000. Zmiany liczebności nietoperzy (*Chiroptera*) w jaskiniach Wyżyny Częstochowskiej w latach 1975-1999. Studia Chiropterologica, 1: 83-114.
ŘEHÁK Z. 1995. Letová aktivita netopýrů v Moravském Krasu. Autoreferát dizertační práce.
ŘEHÁK Z., ZUKAL J., KOVAŘÍK 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.
SACHTELEBEN VON J. 1991. Zum „Invasions" verhalten der Zwergfledermaus (*Pipistrellus pipistrellus*). Nyctalus, 4: 51-66.
SCHOBER W., GRIMMBERGER E. 1998. Die Fledermäuse Europas. Kennen, Bestimmen, Schützen. Franckh-Kosmos Verlags-GmbH and Co, Stuttgart.
SEIDEL J. 1927. Zur Kenntnis schlesiescher Fledermäuse. Abhandlungen der naturforschenden Gesellschaft Görlitz, 30(1): 1-39.
STEBBINGS R., E. 1988: The conservation of European bats. Christopher Helm. London.
SZKUDLAREK R., PASZKIEWICZ R. 1999. Zimowe stanowiska rzadkich gatunków nietoperzy w Sudetach Zachodnich. Przyroda Sudetów Zachodnich, 2: 83-88.
THOMAS D. W., FENTON M. B., BARCLAY R.M.R. 1979. Social behaviour of the Little Brown Bat, *Myotis lucifugus*. I. Mating behaviour. Behavioral Ecology and Sociobiology, 6: 129-136.
WOŁOSZYN B. W. 1968. Badania nietoperzy Dolnego Śląska. Przegląd Zoologiczny, 22(2): 108-119.
WOŁOSZYN B. W. 2002. Polish National Report on the Implementation of the Agreement on the Conservation of the Populations of European Bats (EUROBATS) 2001, EUROBATS (http://www.eurobats.org).

Sezonowe zmiany liczebności i zróżnicowania gatunkowego nietoperzy w sztolni w Stolcu

W latach 2000-2002 prowadzono obserwacje sezonowych zmian liczebności i składu gatunkowego nietoperzy w sztolni w rezerwacie „Skałki Stoleckie" koło Ząbkowic Śląskich (płd.-zach. Polska). W trakcie dwóch sezonów zimowych stwierdzono następujące gatunki: *Barbastella barbastellus, Myotis nattereri, M. daubentonii, M. myotis, M. bechsteinii, M. mystacinus/brandtii, Plecotus auritus, P. austriacus* i *Eptesicus serotinus*. Dominującymi gatunkami były *M. nattereri* (39.2%, maks. 81 osobników.) i *B. barbastellus* (44.4%, maks. 87 osobników). W sezonach pozahibernacyjnych najwyższą aktywność nietoperzy obserwowano w marcu i kwietniu oraz we wrześniu i październiku. W okresie od marca do listopada odłowiono 12 gatunków, w tym dwa nowe, nie obserwowane zimą, *Pipistrellus pipistrellus* i *Eptesicus nilssonii*. *B. barbastellus* (42.2%), *P. auritus* (19.2%), *M. nattereri* (12.9%) i *M. daubentonii* (12.0%) były najczęściej odławianymi gatunkami. Dominowały wśród nich samce. Sztolnia w Skałkach Stoleckich jest jednym z największych i najważniejszych zimowisk nietoperzy po polskiej stronie Sudetów. Jest to również ważne miejsce jesienno-wiosennego swarmingu dla kilku gatunków nietoperzy. W trakcie swarmingu przy obiektach podziemnych spotykają się prawdopodobnie osobniki z różnych kolonii lub populacji, co najpewniej związane jest z okresem godowym i sprzyja wymianie genów. Wiosenne i jesienne migracje oraz wyszukiwanie schronień zimowych może także częściowo wyjaśnić wysoką aktywność nietoperzy przy podziemiach poza okresem hibernacji.

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