LOW ABUNDANCE OF THE WHISKERED BAT *MYOTIS MYSTACINUS* (KUHL, 1817) IN POLAND – CONSEQUENCE OF COMPETITION WITH PIPISTRELLE BATS?

KUREK, K.[1] – TOŁKACZ, K.[2] – MYSŁAJEK, R. W.[3*]

[1]*Association for Nature „Wolf"*
Twardorzeczka 229, 34-324 Lipowa, Poland

[2]*University of Warsaw, Faculty of Biology, Institute of Zoology, Department of Parasitology*
Miecznikowa 1, 02-096 Warszawa, Poland

[3]*University of Warsaw, Faculty of Biology, Institute of Genetics and Biotechnology*
Pawińskiego 5a, 02-106 Warszawa, Poland

**Corresponding author*
e-mail: robert.myslajek@gmail.com

(Received 19th Mar 2017; accepted 5th Jul 2017)

Abstract. Interspecific competition is an important factor influencing the distribution of animals, including bats. In this study we tested if the presence of pipistrelles *Pipistrellus* sp. affects the distribution of the whiskered bat *Myotis mystacinus* using information about the species structure of bat communities obtained by capturing with mist nets in whole Poland. Abundance of the whiskered bat is low (on average 3.1%), and it only occurs frequently in the western part of the Carpathian Mountains (24.5%). The negative correlation between the abundance of the whiskered bat and pipistrelles (especially *P. nathusii* and *P. pipistrellus*) in bat communities across Poland seems to support the hypothesis that its occurrence is shaped by competitive interactions.
Keywords: *bat distribution, species range, mountains, sympatric bats, species coexistence*

Introduction

The whiskered bat *Myotis mystacinus* (Kuhl, 1817) has an extensive range in Europe that covers almost the entire continent (Dietz et al., 2009; Benda et al., 2016; Sachanowicz et al., 2016). However, there is no certainty about the eastern boundary of its occurrence due to the difficulty in distinguishing it from the steppe whiskered bat *Myotis aurascens* Kuzyakin, 1935 (Hutson et al., 2008). In Poland, the whiskered bat is widespread throughout the country (Sachanowicz et al., 2006). However its abudance seems to be unequal, with some areas lacking the species (Sachanowicz et al., 2006a) and other regions dominated by them (Piksa, 2011).

Presence of the whiskered bat can be affected by interspecific competition with pipistrelles *Pipistrellus* sp. (Baagøe, 1973). Such processes are key factors shaping the distribution patterns of organisms, as ecologically analogous species sharing a niche cannot occur in the same area (Gause, 1934). This results in the exclusion of one of the competing species (Hardin, 1960), which influences the structure of communities. Interspecific competition is an important factor influencing the distribution of mammals (Ylönen, 1990; Letchter et al., 1994; Eccard and Ylönen, 2003; Bonesi et al., 2006); however it has rarely been considered during the assessment of bat ranges (Arlettaz et al., 2000; Delaval et al., 2005; Santos et al., 2014; Zeus et al., 2017).

In this paper, we attempted to validate the predictions of Baagøe (1973) by comparing the distribution of the whiskered bat with that of pipistrelle species in

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_241248

Poland. Our null hypothesis was that the whiskered bat is more abundant in areas where pipistrells are rare or absent.

Material and Methods

To assess the current occurrence of the whiskered bat in Poland we used information on the species structure of bat communities obtained by capturing with mist nets. We analysed both data published since 1997 and our unpublished data from studies conducted since 2000. Initially, we obtained data from 42 locations distributed across the whole of Poland (*Table 1*), and for further analysis we divided these locations into three groups: locations where (1) whiskered bats were not caught, (2) the total contribution of the species accounted for less than 10%, and (3) locations where the whiskered bat accounted for over 10% of all caught individuals. Statistical analyses were performed in R (R Development Core Team, 2009).

Results

The whiskered bat was the most abundant bat species found in southern Poland, and it was most common in the western part of the Carpathian Mountains (*Fig. 1*, *Table 1*) where its average share in bat communities was 24.5% (SE±7.0). In the remaining areas it was rather rare (Welch t-test, $t=-3.0315$, $df=5.059$, $p<0.05$), with its average share in bat communities only 3.1% (SE±0.5).

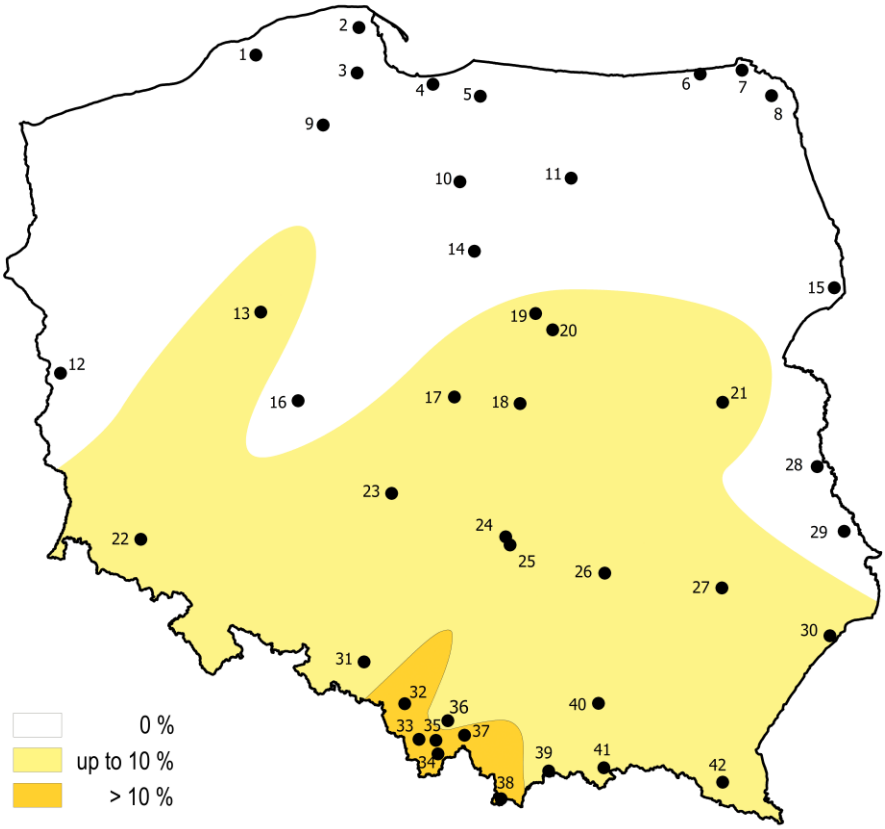

Figure 1. *Percentage of whiskered bats in catches in Poland, 1997–2012 (see Table 1 for details)*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_241248

Table 1. *Percentage of whiskered bat (MYS), Nathusius's pipistrelle (PIN), common pipistrelle sensu stricte (PIP s.s.), soprano pipistrelle (PPY), not distinguished common pipistrelle and soprano pipistrelle (PIP s.l.), all pipistrelles in total (PIPS), and total number of captured bats (N) in various parts of Poland, 1997–2012.*

Area ID	MYS	PIPS	PIN	PIP s.l.	PIP s.s.	PPY	N	source
1	0	13.0	2.0	11.0	8.0	3.0	99	Ciechanowski et al., 2006a
2	0	15.1	10.6	4.5	–	–	132	Ciechanowski, 2002
2	0	16.2	9.3	6.9	–	–	216	Ciechanowski, 2003
3	0	83.9	64.5	19.4	–	–	31	Jarzembowski et al., 1997
4	0	44.5	22.6	–	0.8	21.1	133	Ciechanowski et al., 2008
5	0	15.4	–	–	–	–	87	Authors unpublished data
6	0	3.7	3.7	0	0	0	27	Sachanowicz et al., 2001
7	0	30.3	20.1	2.2	0	8.0	139	Kmiecik et al., 2010
8	0	0	0	0	0	0	146	Postawa and Gas, 2003
9	0	5.0	4.2	0.8	0.8	0	120	Ciechanowski et al., 2006b
10	0	17.6	11.9	0.5	5.2	–	194	Ciechanowski et al., 2002
11	0	6.4	6.4	0	0	0	31	Ciechanowski and Duriasz, 2005
12	0	+	+	–	+	+	?	Cichocki and Łupicki, 2006
13	1.0	3.1	2.4	0.7	0.7	0	289	Łochyński and Grzywiński, 2009
14	0	7.0	6.0	1.0	–	–	84	Kowalski et al., 2001
15	0	13.8	8.5	5.3	–	–	452	Rachwald et al., 2001
16	0	7.4	7.4	0	0	0	27	Łochyński, 2001
17	4.2	5.2	3.1	–	1.0	1.0	96	Hejduk et al., 2008
18	1.7	?	–	–	–	–	231	Hejduk et al., 2004
19	1.5	0.2	–	–	–	–	396	Lesiński et al., 2007
20	1.5	0.3	0.3	0	0	0	400	Lesiński et al. 2006
21	0.8	1.6	0	1.6	–	–	125	Sachanowicz and Krasnodębski, 2003
22	6.8	?	?	?	–	–	44	Dudek et al., 2001
23	3.8	10.0	5	5.0	–	–	131	Ignaczak et al., 2001
24	3.0	?	–	–	–	–	79	Hejduk et al., 2001
25	6.4	16.1	6.4	9.7	–	–	62	Ignaczak, 2003
26	2.3	+	0	0	+	0	2711	Piksa et al,. 2011
27	1.5	0	0	0	0	0	65	Piskorski and Urban, 2003
28	0	5.9	3.4	2.5	1.7	0.8	116	Piskorski, 2008
29	0	5.1	0	5.14	5.14	0	214	Piskorski et al., 2009
30	7.3	4.8	2.4	2.4	0	2.4	82	Piskorski, 2007
31	2.5	16.6	5.1	4.9	1.2	5.4	721	Mysłajek et al., 2002, 2005, 2014
32	18.7	3.3	3.3	0	0	0	91	Authors unpublished data
33	15.9	0	0	0	0	0	1795	Mysłajek et al., 2007 and authors unpublished data
34	21.6	0	0	0	0	0	306	Mysłajek et al., 2010
35	17.9	0.6	0.6	0	0	0	526	Mysłajek et al., 2004 and authors unpublished data
36	8.1	0	0	0	0	0	365	Mysłajek et al., 2013

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_241248

37	13.8	0	0	0	0	0	290	Piksa and Gubała, 2011
38	59.3	0	0	0	0	0	3464	Piksa et al., 2011
39	0.8	14.6	0	14.6	−	−	130	Paszkiewicz et al., 1998
40	1.2	0.3	0	0.3	0	0.3	348	Bator et al., 2008
41	2.2	0	0	0	0	0	899	Węgiel et al., 2004
42	3.1	1.2	0	1.2	1.2	0	159	Sachanowicz and Wower, 2013

The abundance of the whiskered bat in Poland was negatively correlated with abudance of pipistrelle species, especially *P. nathusii* and *P. pipistrellus* (*Table 2*).

Table 2. *Spearman's correlation coefficient (Rho) for the percentage of whiskered bats (Myotis mystacinus) in combination with pipistrelles (considered collectively by each species or group of species) in the cohorts of trapped bats in Poland. The table shows the value of the test statistic (S), statistically significant correlation (p-value), and sample size (N).*

Myotis mystacinus in combination with:	Rho	S	p-value	N
Pipistrellus sp.	− 0.589	14519.28	p<0.001	38
P. nathusii	− 0.551	12055.46	p<0.001	36
P. pipistrellus s.l.	− 0.396	9135.34	p<0.05	34
P. pipistrellus s.s.	−0.408	4613.76	p<0.05	27
P. pygmaeus	−0.263	3694.32	ns	26

Disccussion

The observed pattern of whiskered bat abundances in Poland could be explained by their selection for mountainous habitats or intraspecific competition. A factor that may limit the occurrence of the whiskered bat in Poland is the wintering ecology of the species. Whiskered bats hibernate in a fairly broad spectrum of caves; however, they prefers caves located between 1,000 and 1,930 m above sea level (Piksa et al., 2013). Thus, the main wintering grounds of this species can be found at higher altitudes on mountains, where in a study by Piksa et al. (2013), bats from *M. mystacinus* complex group (species are usually impossible to distinguish during winter counts, although the community is probably dominated by the whiskered bat) accounted for 88.5%. The whiskered bat is a species that does not migrate and only undertakes relatively short flights up to a distance of 165 km (Hutterer et al., 2005). Thus, limited abilities for long-distance migration may also limit the distribution and abundance of the species to around the most suitable hibernaculas.

Nethertheless, the presence of mountains alone does not seem to be the most important factor shaping their distribution. Reproducing females were recorded in the lowlands, and the species roosts mainly in anthropogenic shelters and utilizes feeding grounds located primarily in woodlands scattered across agricultural lands (Buckley et al., 2012; Kurek, 2014), which are common in the lowlands. Furthermore, the wide range of the whiskered bat in Europe, which reaches the northern edges of the continent (Hutson et al., 2008), shows that this is a not thermophilic species restricted to the southern and central, i.e. warmer, parts of the continent.

Antagonistic interactions between species most likely explain the observed pattern of whiskered bat distribution in Poland. Gerell (1987), by analysing the density of

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_241248

distribution of Brandt's and whiskered bats in northern Europe, suggested that the distribution of these two species is the result of competitive interactions with the common pipistrelle *Pipistrellus pipistrellus* (Schreber, 1774). Our analyses confirmed the constraining effects of at least two pipistrelle species (Nathusius's and common pipistrelle) on whiskered bats. In areas where whiskered bats were captured in large numbers, pipistrelles were not observed at all or were scarce. In addition, pipistrelles were found in these regions beyond the reproductive period (Piksa et al., 2011; Kurek, 2014), which suggests that they were migrating individuals. In other areas, pipistrelle bats are a stable part of the bat fauna (Sachanowicz et al., 2006). Both the whiskered bat and pipistrelles show a preference for similar foraging areas and shelters of anthropogenic origin (Dietz et al., 2009; Buckley et al., 2012; Kurek, 2014), and competition for such resources could be a major factor for the push-out of a significant part of the whiskered bat population to more hostile mountainous areas.

We are aware that the analysis of bat communities based solely on the results of mist-netting could be biased due to a number of factors, including the size and placement of nets, and the frequency at which investigators check the nets (Kunz et al., 2009). Nonetheless, we believe that the potential bias was minimized by using data from numerous studies conducted across the whole country, which includes the repeated sampling of targeted regions, utilization of a variety of netting sites, and use of variable net-sets as suggested by Larsen et al. (2007). Another source of bias may be the use of data obtained during swarming. Places where this phenomenon occurs are called 'hot spots', and during mist-netting researchers capture bats that are not necessarily resident in that given area (Fenton, 1969; Kerth et al., 2003; Bogdanowicz et al., 2012). However, taking into account only catches made in potential feeding grounds, the share of whiskered bats in the southern regions of the country is still estimated to be over 10% (*Table 1*), which supports our findings that the western Carpathians are the main area in Poland where whiskered bats occur.

Acknowledgements. The study was financed by the statutory budget of the Association for Nature "Wolf". We thank Tomasz Diserens for linguistic advice.

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http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_241248