

## Activity of male-dominated bat communities above streams in the forests of the Western Carpathians (Poland)

Korneliusz KUREK<sup>1</sup>, Robert W. MYŚLAJEK<sup>2</sup>, Piotr ORYSIAK<sup>2</sup>,  
Sabina NOWAK<sup>2</sup> & Michał KOZAKIEWICZ<sup>1</sup>

<sup>1</sup>Department of Ecology, Institute of Zoology, Warsaw University, Banacha 2,  
PL–02-571 Warsaw, Poland; kornel.kurek@chello.pl

<sup>2</sup>Association for Nature "Wolf", Twardorzeczka 229, PL–34-324 Lipowa, Poland; rwm@autograf.pl

**Abstract.** Significantly higher bat activity, measured by duration of echolocation calls per hour during the second hour after sunset, was found above streams flowing through an open habitat compared to the more cluttered site. Similar numbers of bats were captured with mist nets in both the open and cluttered habitats, but species diversity was higher in the open habitats (Simpson's index of diversity, 0.696 vs. 0.412). Bats of the *Nyctalus/Eptesicus/Vespertilio* group had stronger representation in the open habitat. Males dominated at both study sites (73.6% for cluttered and 86.2% for open). The volume of insects assessed with the help of a UV-light trap was significantly larger within the cluttered habitat (3652 mm<sup>3</sup> for one hour) than within the open habitat (2264 mm<sup>3</sup> for one hour), but there was no significant difference between the number of insects caught in the cluttered and open habitats (66 and 55 insects for one hour, respectively). It seems that above streams in the Western Carpathians, the ability to hunt and maneuver in a given habitat is more important for bats than the availability of food.

**Chiroptera, activity, riparian habitats, mountains**

### Introduction

A decline in bat populations (Hutson et al. 2001) has made biologists define and quantify factors influencing their diversity and survival. As bats often forage or roost in forests (Meschede et al. 2000, Lacki et al. 2007), most attention is directed at developing friendly forestry practices that would best meet the needs of bats. This is especially important in the case of forests surrounding water bodies, which serve as drinking and foraging places, as well as flying trails (Bell 1980, Furlonger et al. 1987, Racey 1998, Lesiński et al. 2000).

There are many factors influencing activity and species composition of bats above watercourses, for example; dimensions, surrounding plant cover, water movement, level of water eutrophication, and availability of insects (Vaughan et al. 1996, Racey 1998, Seidman & Zabel 2001). It is disputable which factor is more important for bat activity, whether habitat structure or availability of food. There are examples showing that bats can change their behaviour to utilize different resources and habitats (Barclay 1991, Norberg 1994), but they are limited by their echolocation calls and morphology – primarily, the shape and size of wings, which determine flight speed and maneuverability (Bogdanowicz et al. 1999, Fenton & Bogdanowicz 2002).

At upper elevations, a male-biased sex ratio of bats was frequently observed (Cryan et al. 2000, Russo 2002). It has been suggested that this bias is a result of the minimization of thermoregulatory costs and increase of foraging efficiency by females (Cryan et al. 2000, Brack et al. 2002).

Thomas (1988) suggested that males are better adapted for living in areas characterized by poorer weather conditions and scarcity of food.

We were interested in the diversity and activity of male-dominated bat communities above mountain streams flowing through forests with different structure. We hypothesize that, despite male domination, bats tend to avoid more cluttered habitats in montane forests, even if a greater availability of food exists within these habitats.

## Study Area

Both study sites were situated at the Leśna stream in the westernmost part of the Polish Carpathians, southern Poland (19° 04' 34" N; 49° 39' 56" E). The altitude within the study area is around 520 m a. s. l. The mean July temperature is 16 °C, decreasing to -3 °C in January. Snow cover persists for 80 days. For more details see Mysłajek et al. (2007).

The area was formerly covered by rich forests dominated by oak (*Quercus* sp.) and lime (*Tilia* sp.), but it is nowadays covered mainly with planted spruce monocultures with a high proportion of farmland and villages (Wilczek 2006). Sixteen species of bats have been recorded in the regions surrounding the study area in recent years (Mysłajek et al. 2004, 2007, Kurek et al. 2007).

For our study we chose two sites, each within a different habitat type: (A) cluttered habitat, in which the stream is covered by tree canopy, and (B) open space, where the stream is not covered by tree canopy. The sites were situated 500 m apart in the Lipowa village.

## Methods

Data were collected in two separate time series: from June 13 to July 5 and from July 27 to August 31, 2005. Each series included 7 nights of recording and 7 nights of catching bats at each study site.

To estimate the level of bat activity, we recorded echolocation calls of all bat species using a D220 heterodyne ultrasound detector (Pettersson Elektronik AB, Sweden), fixed at the frequency of 40 kHz. Data collection started one hour after sunset in each habitat. Bat activity was estimated by measuring the total duration of echolocation during 60 minutes of recording. All echolocation calls of bats were counted together, without distinguishing between species.

While recording at one study site, bats were captured at the other site to avoid affecting bat activity at the recorded site. To determine species composition, sex and age structure of the population, bats were captured in mist nets installed across the stream during the period of the highest foraging activity from sunset to midnight. Between sites, we compared the proportion of bats from two ecological groups: (1) *Nyctalus*, *Eptesicus*, and *Vespertilio* (N/E/V) – species foraging mostly in open habitats, and (2) *Myotis*, *Pipistrellus*, and *Plecotus* (M/P) – species foraging mostly in cluttered habitats (Neuweiler 1989, Rachwald et al. 2001, Ciechanowski 2002). We also measured species diversity at both study sites using the Simpson's index of diversity.

During bat capture sessions, nocturnal insects were also captured with UV-light traps to assess food supply (approximate volume and number of insects). All insects were divided into the three conventional size classes: small (<7 mm length), medium (7–20), and large (>20). The captured insects were identified to order level. Light traps used for estimating the availability of food attract nocturnal insects, particularly moths. Thus, their numbers may be inflated (Ausden & Drake 2006). On the other hand, small, light, and maneuverable insects could avoid the trap, and therefore their number may be underestimated. These errors are similar for both study sites, and therefore comparisons of the data between the sites are reliable. We also measured air temperature and humidity during bat capture sessions to ascertain whether there are microclimate factors affecting bat activity.

## Results

Significantly higher bat activity was found within the open habitat ( $H=19.864$ ;  $df=1$ ;  $p<0.001$ ) (Fig. 1). There were no significant differences between the first and second series of data collection in the two habitats: cluttered (Kruskal-Wallis test:  $H=0.0167$ ;  $df=1$ ; n.s.) and open (Kruskal-Wallis test:  $H=0.0167$ ;  $df=1$ ; n.s.).

Altogether 72 bats were caught in the cluttered habitat and 80 bats were caught in the open habitat (Tables 1, 2). The Daubenton's bat (*Myotis daubentonii*) dominated at both study sites. Bats

Table 1. The number of bats caught in cluttered habitat (site A) in first (from June 13, 2005 to July 05, 2005) and second (from July 27, 2005 to August 31, 2005) series of captures

Tab. 1. Liczba nietoperzy odłowionych w środowisku typu zamkniętego (stanowisko A) w trakcie pierwszej (od 13. czerwca do 5. lipca 2005 roku) i drugiej (od 27. lipca do 31. sierpnia 2005 roku) serii odłowów

species / gatunek	series I / seria I		series II / seria II		total / razem	
	n	%	n	%	n	%
<i>Myotis daubentonii</i>	1	11.1	53	84.1	54	75.0
<i>Myotis mystacinus</i>	1	11.1	4	6.3	5	6.9
<i>Myotis brandtii</i>	5	55.6	5	7.9	10	13.9
<i>Myotis bechsteinii</i>	1	11.1	0	0.0	1	1.4
<i>Plecotus auritus</i>	0	0.0	0	0.0	0	0.0
<i>Nyctalus leisleri</i>	1	11.1	0	0.0	1	1.4
<i>Eptesicus nilssonii</i>	0	0.0	0	0.0	0	0.0
<i>Vespertilio murinus</i>	1	11.1	1	1.6	2	2.8
total	9	100.0	63	100.0	72	100.0

of the N/E/V group were caught in both habitats. However, this group had significantly stronger representation in the open habitat than in the cluttered habitat (23% vs. 3%). Species diversity, measured by the Simpson's index, was higher in the open habitat (0.696) than in the cluttered habitat (0.412). Males dominated at both study sites (73.6% for cluttered and 86.2% for open). There was no significant difference in sex ratio between the two habitats ( $\chi^2=3.8212$ ;  $df=1$ ; n.s.). There was also no significant difference in age structure between the two habitats – 43% of juvenile bats in the cluttered habitat vs. 32% in the open habitat (Chi-square test:  $\chi^2=0.0047$ ;  $df=1$ ; n.s.).

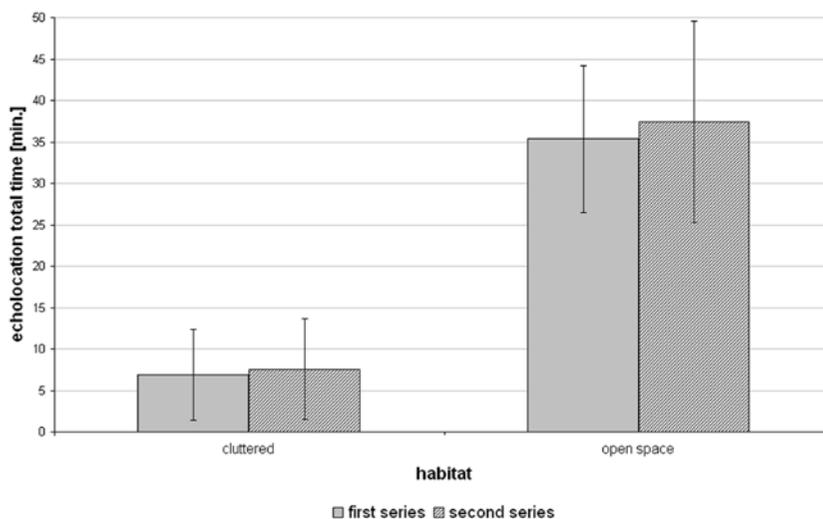


Fig. 1. Bat activity within cluttered and open space habitat in first (from June 13, 2005 to July 05, 2005) and second (from July 27, 2005 to August 31, 2005) series of recording echolocation calls.

Rys. 1. Aktywność nietoperzy na stanowisku typu zamkniętego (cluttered) i otwartego (open space) w trakcie pierwszej (od 13. czerwca do 5. lipca 2005 roku) i drugiej (od 27. lipca do 31. sierpnia 2005 roku) serii nagrań sygnałów echolokacyjnych.

Table 2. The number of bats caught in open space habitat (site B) in first (from June 13, 2005 to July 05, 2005) and second (from July 27, 2005 to August 31, 2005) series of captures

Tab. 2. Liczba nietoperzy odłowionych w środowisku typu otwartego (stanowisko B) w trakcie pierwszej (od 13. czerwca do 5. lipca 2005 roku) i drugiej (od 27. lipca do 31. sierpnia 2005 roku) serii odłowów

species / gatunek	series I / seria I		series II / seria II		total / razem	
	n	%	n	%	n	%
<i>Myotis daubentonii</i>	4	20.0	35	58.3	39	48.8
<i>Myotis mystacinus</i>	3	15.0	10	16.7	13	16.3
<i>Myotis brandtii</i>	1	5.0	8	13.3	9	11.3
<i>Myotis bechsteinii</i>	0	0.0	0	0.0	0	0.0
<i>Plecotus auritus</i>	1	5.0	0	0.0	1	1.3
<i>Nyctalus leisleri</i>	0	0.0	0	0.0	0	0.0
<i>Eptesicus nilssonii</i>	5	25.0	2	3.3	7	8.8
<i>Vespertilio murinus</i>	6	30.0	5	8.3	11	13.8
total	20	100.0	60	100.0	80	100.0

The volume of insects caught within the cluttered habitat (3652 mm<sup>3</sup> in one hour) was significantly larger than that recorded within the open habitat (2264 mm<sup>3</sup>) ( $Z=17.0025$ ;  $df=5825$ ;  $p<0.01$ ), but there was no significant difference between the number of insects caught in the two habitats, 66 vs. 55 insects in one hour, respectively ( $Z=0.9211$ ;  $df=121$ ; n.s.). We found no correlation between food supply and the number of bats captured.

## Discussion

Strong differences exist in the ability to detect mist nets between species or even individuals (Kunz & Kurta 1990, Rachwald et al. 2001). Results of capture efforts are strongly dependent on the siting of the nets. These sources of uncertainty suggest that the capture of bats cannot be used as an accurate method of estimating bat activity. Efforts focussing on the recording of echolocation calls seem to be much more reliable. Many studies show that bat activity is highest in the first three hours after sunset (Kunz 1974, Jones et al. 1996, Zielinski & Gellman 1999). Thus, data gathered in the first half of the night are sufficient to assess habitat exploitation by bats. Records from the second hour after sunset allow estimation of activity during feeding.

Availability of food was not the major factor determining habitat preferences of bats in the Western Carpathians. It seems that for many bat species the ability to hunt and maneuver within the habitat is more important than richer food supply (Grindal & Brigham 1999). We also observed higher species diversity in the site with the more open habitat caused by a larger share of the *Nyctalus/Eptesicus/Vespertilio* group. This confirms earlier observations showing that small openings in the forest canopy serve as good foraging grounds for different ecological groups of bats, and bat activity is often higher in these small open areas than in neighbouring tree stands (Patriquin & Barclay 2003, Tibbles & Kurta 2003). Lower levels of bat activity in the cluttered habitat, despite significantly milder microclimatic conditions, suggest that microclimate is perhaps not an important factor influencing the activity of bats in the Western Carpathians. The lack of correlation between microclimatic conditions and the activity of bats was also confirmed in other studies (Seidman & Zabel 2001). However, bat activity is heavily species-specific, and our results may be affected by the substantial proportion of the Daubenton's bat within the bat community. The activity of this water-surface forager is generally not shaped by food abundance or air tem-

perature, while for aerial hawkers biomass of potential prey and air temperature are prominent limiting factors (Ciechanowski et al. 2008).

A possible reason for the lack of seasonal changes in bat activity above mountain streams is the close proximity of caves used for hibernation. Seasonal emigration and immigration of different bat species utilizing the study sites could also explain the apparent lack of changes in activity. This study confirms the results of another study conducted in the nearby Czech Republic, where no seasonal changes in bat activity were observed (Bartonička & Zukal 2003).

There is strong domination by males in mountain stream areas. It seems probable that mountain streams in the Western Carpathians act as suboptimum feeding grounds similar to other sites (e.g. Grindal et al. 1999, Cryan et al. 2000, Russo 2002, Brack et al. 2002).

Our results show that creative management of suitable foraging grounds for bats is possible by creating openings and less cluttered habitats within tree stands surrounding watercourses in the mountains. Reducing clutter by thinning can facilitate foraging by bats, and therefore, can be a good technique to create suitable foraging habitats (Humes et al. 1999). However, such a treatment may have only a temporal effect (Grindal & Bringham 1998). Protection of watercourses with natural openings created by fallen trees and spontaneous plant regeneration seems to be more promising (Lacki et al. 2007).

## Streszczenie

Badania prowadzono w zachodniej części Polskich Karpat, na granicy Beskidu Śląskiego i Kotliny Żywieckiej (woj. śląskie). Na potoku Leśna wybrano dwa stanowiska oddalone od siebie o 500 m i różniące się strukturą przestrzenną środowiska – stanowisko A, typu zamkniętego (nurt osłonięty całkowicie przez korony drzew) i stanowisko B, typu otwartego (szerokie rozlewisko potoku, korony drzew nie osłaniają nurtu). Badania prowadzono w dwóch seriach: od 13 czerwca do 5 lipca i od 27 lipca do 31 sierpnia 2005 roku.

Aktywność nietoperzy wyrażana była jako łączny czas echolokacji zarejestrowany w trakcie 60 minut nagrania wykonywanego godzinę po zachodzie słońca. Rejestrowano sygnały echolokacyjne całego zgrupowania nietoperzy bez rozróżniania gatunków, przy pomocy detektora ultrasonicznego Petterson D220. Równolegle prowadzono odłow nietoperzy w sieci, w celu oceny struktury gatunkowej zgrupowania, a także odłow nocnych owadów latających przy użyciu pułapek świetlnych, w celu oszacowania potencjalnej bazy pokarmowej nietoperzy.

Aktywność nietoperzy okazała się istotnie wyższa w środowisku typu otwartego i nie ulegała znaczącym zmianom między pierwszą a drugą serią badań. Na obu stanowiskach odłowiono zbliżoną liczbę nietoperzy, jednak wyższą różnorodność gatunkową nietoperzy, określoną za pomocą Wskaźnika różnorodności gatunkowej Simpsona, stwierdzono na stanowisku typu otwartego, gdzie wyraźny udział miały nietoperze z grupy *Nyctalus/Eptesicus/Vespertilio*. Na obu stanowiskach dominowały samce. Objętość odłowionych owadów była istotnie wyższa w środowisku typu zamkniętego, choć różnice w liczbie odławianych owadów okazały się nie istotne.

Wyniki badań sugerują, że na aktywność nietoperzy polujących nad potokami w Karpatach Zachodnich decydujący wpływ ma struktura przestrzenna środowiska i zdolność manewrowania wśród roślinności w trakcie polowania. Czynniki te okazują się być dużo bardziej istotne niż dostępność pokarmu.

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