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Short communication

The activity of bats in the Badínsky prales primeval forest

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Abstract

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Primeval forests with their large heterogeneity with regard to composition of tree species, age of trees or canopy coverage are excellent locations for studying various animals, especially bats. In Slovakia, where primeval forests comprise just 0.48% of total forest area any coherent knowledge about basic composition of bat species is lacking. To contribute to knowledge about the occurrence of bat species in Slovakia's natural (primeval or old grown) forests, this study presents a first summary overview of bat species composition with regard to vertical utilization of their foraging habitat. We collected data in the Western Carpathian (Kremnické vrchy Mts) in old-grown primeval beech forest (>200 years) using the passive automatic bat-detector. The device was set up to the tree trunk in 5, 10 and 15 meters above the ground. Altogether was recorded 72 minutes (n = 22,544 bat calls, 311 records in average per night). The total of 10 bat species was determined. The number of recording varied according to height. Number of *Myotis*-group calls did significantly differ in individual recording heights but only between 5 and 15 meters, however such differences were absent in the case of non-*Myotis* group calls, as well as in both types' calls merged together. Calls of *Myotis*-group were the most abundant whereas they represented 96.5% from all determined calls at 5 m above ground, but only 22.7% at height of 15 meters. The family Rhinolophidae (CF; frequency > 80 kHz) was not recorded. Only a small percentages of fast hawking species *Nyctalus noctula* and *Nyctalus leisleri* (≤1%) was recorded. In general, the results are in accordance with similar studies dealing with activity of bats in forests.

Keywords

bat calls, Central Slovakia, primeval forest, tree canopy

Introduction

Primeval forests are complexes of horizontal and vertical structures of living and dead vegetation, that have been shaped or maintained largely by natural disturbances and have enormous biodiversity (Halkka and Lappalainen, 2001; Gilg, 2005; Parviainen, 2005). These unique and rare habitats represent only 1.7% of the total forest area in Europe (Diaci, 1999). Large heterogeneity of these forests with regard to composition of tree species (Jung et al., 2012), tree age (Patriquin and Barclay, 2003) or canopy coverage makes them excellent locations for studying various animals, especially bats. Bat occurrence in forests is associated especially with the presence of tree cavities, crevices, or cracks (Barclay and Kurta, 2007) which bats use as place for roosting, pup rearing and also as a protection against harsh weather (Kunz, 1982). Numerous bat species with various foraging strategies are able to exploit such environment ranging from those who forage on airborne prey, glean food items from the ground or vegetation, or even forage above water surfaces (Russo and Jones, 2003; Kusch et al., 2004, Denzinger and Schnitzler, 2013).

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Numerous studies on bats have been conducted in various European primeval forests, such as the Białowieża Forest in Poland (Rachwald, 1995; Ruczyński, 2006; Ruczyński and Bogdanowicz, 2008), the Carpathian Biosphere Reserve in Ukraine (Postawa et al., 2000), the Bavarian Forest National Park in Germany (Müller et al., 2012; Müller et al., 2013), and the Thayatal National Park in Austria (Plank et al., 2012), mainly with the aim to understand ecological requirements and/or roosting strategies of these animals. In Slovakia, where primeval forests comprise just 0.48% of total forest area (Oz Prales unpublished data) any coherent knowledge about basic composition of bat species is lacking. Attention towards this topic has been paid only recently, and mostly the results were only in the form of faunistic data (e.g., Danko et al., 2007). Using combination of mist netting and ultrasound monitoring techniques some studies examined flight and foraging activity (Ceľuch and Kaňuch, 2004a, b), altitudinal patterns in occurrence of bat species (Kaňuch and Krištín, 2006), or habitat use (Ceľuch and Kropil, 2008) in such forest habitat.

This short communication aims to contribute to the knowledge about the bat species composition and their relative activity with regard to vertical utilization of the foraging habitat in a primeval temperate forest in central Europe.

Material and methods

Data collection was conducted in Badínsky Primeval Forest, central Slovakia, Interior Carpathians (Kremnické vrchy Mts; 48°41′N, 19°03′E; 785 m asl; quadrant 7380 in the Databank of Slovak Fauna; forest stand No. 801; Fig. 1) during June, August and October 2014. Area is characterized as a moderately cold climate region with mean January temperature of –4 °C and mean annual precipitation of 800 mm (Lapin et al., 2002) with predominantly north-eastern exposure. Forest can be characterized as *Fagetum pauper* type with *Dentaria bulbifera-Fagetum* phytocenology (Hačinský, 1972) and Ls5.1 beech and fir–beech forests biotope (Stanová and Valachovič, 2002). Age of trees is estimated to be more than 200 years.

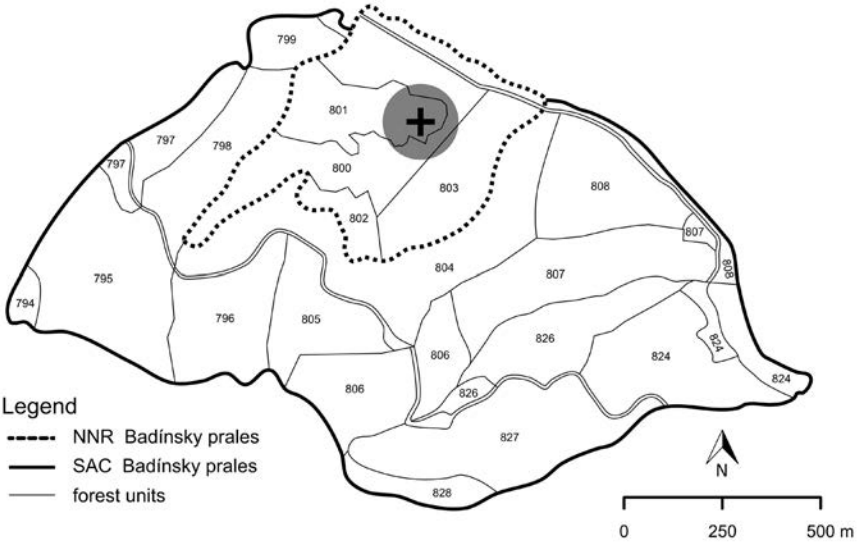

Fig. 1. Study area Badínsky prales primeval forest. Explanations: NNR, National nature reserve; SAC, Special areas for conservation. Location of ultrasound detector is marked with cross.

Recording device – an ultrasonic detector (Batlogger®, Elkon, Switzerland) – was affixed to a same tree trunk at three different heights (5, 10 and 15 m) above ground (five consecutive nights in each height) in at least 100 m distance from the forest edge to minimize ecotone effects (Pettit, 2011). Ultrasonic microphone was fixed in horizontal position (0–180º). Recording began 30 minutes before sundown and continued for 2.5 hours. Recording by Batlogger is not continuous in order to avoid memory overload – it records only sound above some threshold of intensity/frequency (pre-trigger parameter 500 ms, post-trigger parameter 1,000 ms, trigger max time 3,000 ms). Device recorded all frequencies from 15 to 155 kHz. All data collection was performed under ambient temperature from 10 to 18 °C (mean 13.8 °C).

Bat calls were analysed using BatExplorer software (Elekon) with subsequent species and genus determination according to identification keys (www.ceson.org; Ahlén and Baagøe, 1999; Ahlén, 2004; Obrist et al., 2004; Baradaut, 2015). Species-level determination based on parameters of echolocation calls is not possible in some bat species. Strong structural similarity of calls exists between *Myotis mystacinus*, *M. brandtii*

and *M. alcathoe*, therefore, if some calls exhibit parameters similar to calls of these species, we consider them all as Whiskered bats (*M. mystacinus* complex). Similarly, Greater mouse-eared and lesser mouse-eared bat (*Myotis myotis/blythii*), Bechstein's bat and Natterer's bat (*M. bechteinii*/ *nattereri*) were determined as a dual taxon. We categorized bat calls into two groups: *Myotis* group (genus *Myotis*) and non-*Myotis* group (genus *Barbastella*, *Eptesicus*, *Nyctalus* and *Pipistrellus*).

To test the relationship between the number of recordings and recording height for each group (*Myotis*, non-*Myotis*), we used Kruskal-Wallis ANOVA followed by pairwise test for multiple comparisons of mean rank sums (Nemenyi-tests) with significance level of $P = 0.05$ (R-package 'PMCMR'; Pohlert, 2014). All analyses were conducted in R 3.2.2 environment for statistical computing (R Core Team, 2015).

Results and discussion

Only 72 minutes out of 2,700 minutes of recording time contained some sound activity. Totally, 1,559 recordings contained 22,544 calls. Only five species we were able to identify clearly bat species: *P. pipistrellus*, *B. barbastellus*, *E. nilssonii*, *N. noctula*, *N. leisleri* while others were determined as a dual taxon: *M. myotis/blythii*, *M. bechsteinii/nattereri*, *M. mystacinus* complex. Remaining positive recordings were negative for bat calls (sound of rain, wind, and the rustling of leaves and branches). Mean number of recordings per recording night was 74 (range 2–589; both extremes were observed during June). Call frequencies ranged from 16.0 to 68.4 kHz, whereas their substantial part (>580 calls) fell within 40.1–45.0 kHz. Bat calls mean length 4 ms (range 1–37 ms). The median peak frequency (predominantly steep-FM call shape) was 40.6 kHz, which corresponds with *Myotis*-group species (67.9% of all records). Calls with the 15–35 kHz quasi-constant frequency (QCF) signal range (the genera *Barbastella*, *Eptesicus*, *Nyctalus* and *Pipistrellus*) represented only 9.1% of records (Fig. 2).

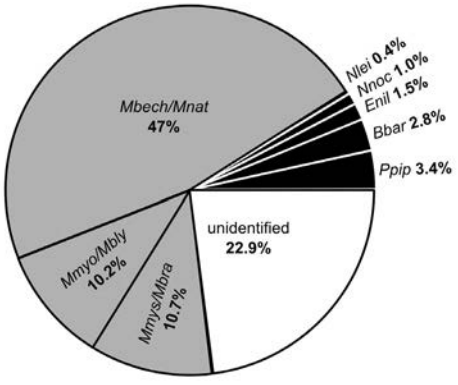

Fig. 2. Percentage of all bat records.

The number of recording varied according to height (Fig. 3). Number of *Myotis*-group calls did significantly differ in individual recording heights ($\chi^2 = 6.0$, df = 2, P = 0.049) but only between 5 and 15 meters (post-hoc test: P = 0.045) however such differences were absent the case of non-*Myotis* group calls ($\chi^2 = 1.7$, df = 2, P = 0.43), as well as in both types calls merged together ($\chi^2 = 3.3$, df = 2, P = 0.19). Calls of *Myotis*-group were the most abundant whereas they represented 96.5% from all determined calls at 5 m above ground, but only 22.7% at height of 15 meters (Fig. 4). The family Rhinolophidae (CF; frequency > 80 kHz) was not recorded. The dominant group comprised mainly such *Myotis* species as *M. bechteinii*/*M. nattereri* (frequency of occurrence = 47.0%, *n* = 469), *M. mystacinus* complex (10.7%, *n* = 107), and *M. myotis/blythii* (10.2%, n = 102). The other recorded species were *B. barbastellus* (2.8%, *n* = 28), *E. nilssonii* (1.5%, *n* = 15), and *P. pipistrellus* (3.4%, *n* = 34). The fast hawking species *N. noctula* (1.0%, *n* = 10) and *N. leisleri* (0.4%, *n* = 4) occurred in only small proportions. Unidentified bat calls represented 22.9% (*n* = 299) of all records (Fig. 2). We identified 31.5% (*n* = 491) of bat calls only to the genus *Myotis*. The most such undetermined records were recorded at 10 m above ground (38.6%) and the fewest at 5 m (4.8%).

This research provides data on the spectrum of bat species occurring in natural forest of the Western Carpathians. Given the research type and duration, the data have predominantly faunistic value. For more detailed insight into bat assemblages it will be necessary to conduct data collection of larger spatio-temporal scale, especially it would be necessary to make recordings from the entire vertical structure of the forest (i.e. within the range of 0–30 m and including tree crowns and above the tree canopy; see Hayes and Gruver, 2000; Plank et al., 2012; Müller et al., 2013). We therefore present these results only as preliminary research. The recordings are also disproportionate inasmuch as we obtained only 75 recordings at 15 m, and that was just 4.8% of all recordings.

Data on the spectrum of bat species in natural (primeval) forests in Slovakia are relatively scarce and can be found only in the study by Danko et al. (2007). Those authors had summarized data from 160 forest locations in Slovakia. Of those locations, just 3.1% (Badín Primeval Forest, Boky National Nature Reserve (NNR), Hrončecký Grúň NNR, Nad vodopádom [Bystrô], and Sitno NNR) occur in the Slovak primeval forest database (Oz Prales 2015 unpubl.). In the Badín Primeval Forest, Danko et al. (2007) had reported the occurrence of three species: *M. bechsteinii*, *M. myotis*, and *M. mystacinus* compley. Within Central Europe, the species spectrum of bats in forests is relatively constant and is above all limited only by habitat preferences, food, and temperature or elevation (Rachwald et al., 2001; Postawa et al., 2000; Kaňuch and Krištín, 2006; Riegel and Nagel, 2007; Plank et al., 2012; Müller et al., 2013).

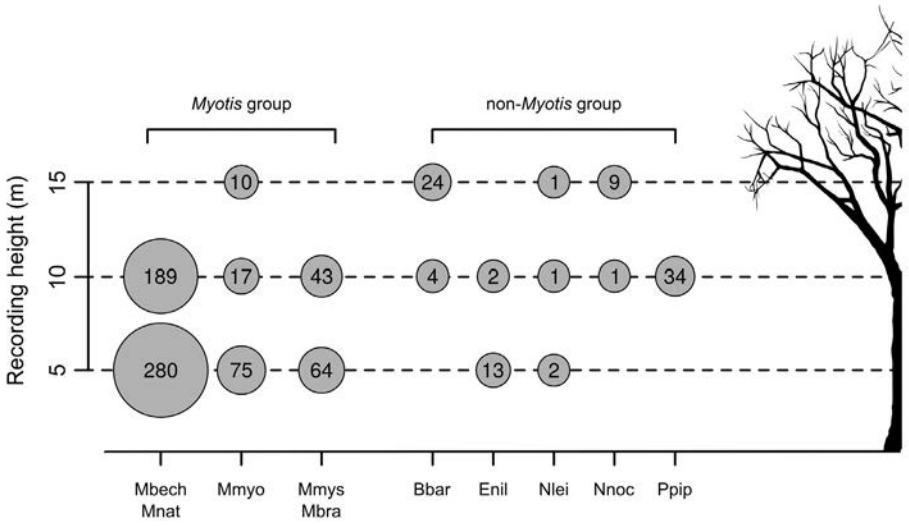

Fig. 3. Number of species records in different height in the tree canopy.

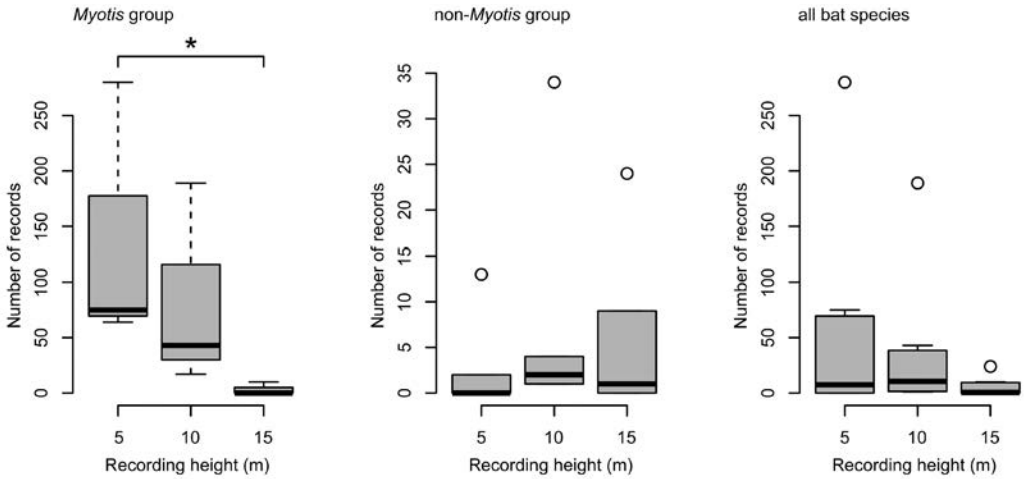

Fig. 4. Comparisons of the number of bat records in different height in the tree canopy according to *Myotis* group, non-*Myotis* group and all bat species. Box-plots represent median, quartiles and non-outlier ranges (outliers are marked as open circles). * – $P < 0.05$.

Comparing the bats' frequency of occurrence and habitat preference in forest environments, we relied mainly upon the study by Kaňuch et al. (2008), who had analysed forest habitat parameters, in relation to bat occurrence. Those authors had determined *E. serotinus* occurrence in beech forests to be positively correlated with the forests' naturalness, which can be characterized by whether they are natural or old-growth forests. We did not capture this species in our recordings. According to Dietz et al. (2009), this species uses primarily forest such corridors as roads and clearings, which confirms that their hunting strategy is open-habitat foraging (Müller et al., 2012). In contrast, the occurrences of *P. pipistrellus* and *N. leisleri* correlated with forests of different ages (Kaňuch et al., 2008). We determined both these species at the present location with occurrence frequencies of 3.4% and 0.4%, respectively. In the same mountain range, 15 km to the south, Ceľuch and Kropil (2008) and Ceľuch and Kaňuch (2004b) had detected at beech–oak forest locations a similar species spectrum as found in our study and with a dominant proportion of species primarily from the *Myotis* group: *M. mystacinus*/*brantii*, *M. myotis*, *M. bechsteinii*, and *M. natereri*. Despite the rather largely disproportionate data from the forest's vertical structure, the proportion of our records from the non-*Myotis* group did increase towards the tree crowns where the canopy is more open and there probably are more gaps in the forest growth. The data obtained only confirm the generally known fact that the vertical occurrence of *Myotis*-group species within the forest stratification corresponds to their hunting strategies and the prey-species spectrum

(Müller et al., 2012). In contrast, non-*Myotis* group species uses in forests primarily open spaces, open edges, and the forests' ecotones. Schnitzler and Kalko had (2001) defined three basic bat foraging guilds: open-habitat foragers (genus *Nyctalus* and *Eptesicus*), edge-habitat foragers (*Myotis*-group, genus *Barbastella,* and *Pipistrellus*), and closed-habitat foragers (*M. bechteinii*/*nattereri* and *Plecotus* sp.). Although the present study found representatives of all three guilds, dominating were closed-habitat foragers from the taxa *M. bechteinii*/*nattereri* and *M. mystacinus* complex, which together comprised nearly 40% of all records. We did not capture records of *Plecotus* sp.

No CF signals, which are typical of the family Rhinolophidae, were captured in our recordings. These are relatively rare species which occur in canopied forests, as seen also in findings from Slovakia (<5% of all records; Kaňuch et al., 2008; Ceľuch and Kaňuch 2004a). Contributing to their rarity in recordings is the fact that when horseshoe bats' echolocation frequencies exceed 80 kHz the signal intensity is relatively weak and so the detector cannot capture them from far away (Motte and Libois, 2002). Data from continuous recording of forest bat species in natural forests within Slovakia is not sufficient. Several primeval forest locations in Slovakia are included within NATURA 2000, which considers the occurrence of bats as one reason for species protection within Special Areas of Conservation (Habitats Directive, Council Directive 92/43/ECC). In general, however, data on the occurrence of bats in such protected locations are for the most part lacking.

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