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Species composition and activity of bats flying over rivers in the Białowieża Primeval Forest

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Bats were netted at two sites over the forest rivers Narewka and Hwoźna in Białowieża Primeval Forest (E Poland), during the summer of 1994 and 1995. A total of 452 bats of 11 species were captured. The number of bats netted each night was positively correlated with the minimum air temperature. The rate at which the three commonest species – *Nyctalus noctula*, *Myotis daubentonii* and *Nyctalus leisleri* – were caught varied significantly through the night, with a major peak after sunset. For *N. noctula* air temperature was apparently positively related to the size of the morning peak.

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Introduction

Information on the composition of the bat fauna of the Białowieża Primeval Forest (BPF), and the relative abundance of the different species, is either fragmentary, or known only for unforested areas transformed by man (Kurskov 1958, 1981, Ruprecht 1976). An earlier work by Rachwald and Nowakowski (1994) was the first to attempt a systematic study of the composition in the bat fauna in the forested areas, but it was based on limited data.

Thanks to its diversified internal structure, the natural forest stands of BPF offer appropriate areas for many bat species of varied habitat preferences. They include: closed (dense) forest (both broadleaved and coniferous), open areas of varying size (gaps in stands created by the wind and the fall of dead trees) and open areas along the valleys of small forest rivers. On the basis of earlier observations, we assumed that bats occurred in greater abundance and diversity in the last habitat, since these areas offer feeding grounds for bats flying from the surrounding tree stands of BPF (Rachwald 1998).

The aim of the present study was to determine the relative abundance of bat species in captures at two study sites located over the forest rivers in BPF, and to obtain information on their night-time activity in the studied habitat. The activity of bats at feeding grounds is in general dependent on the presence of the flying

insects that constitute their basic food source, as well as on weather conditions (Erkert 1982). It was assumed that the frequency of capture would reflect the importance of this habitat to the different species of bats. This assumption would be valid at least in regard to the more abundant species, and in comparison with the data from other habitats (eg Rachwald and Labocha 1996, Rachwald 1998).

Material and methods

Bats were caught from June to August 1994 and from June to the end of July 1995. The two study plots were situated on the rivers Narewka and Hwoźna, at a distance of 2.5 km one from another, in the northern part of Białowieża National Park (52°43'N, 23°54'E). Capture points were located in river valleys with meadow vegetation featuring sedges *Carex* spp. and reeds *Phragmites australis*, and with closed forest on both sides. At the point near the Narewka this was oak-lime-hornbeam forest and mixed forest dominated by *Carpinus betulus*, *Quercus robur*, *Picea excelsa* and *Pinus silvestris*; at the point near the Hwoźna river it was alder carr and marshy pine forest, as well as mixed/pine forest – with *Alnus glutinosa*, *P. silvestris*, *Q. robur*, and *P. excelsa* being dominant. The distance from the forest edge varied from 20 m (Hwoźna) to 50 m (Narewka), while the width of watercourses ranged from 5 to 10 m, and declined in the course of the season.

The bats were caught in mist nets set between 20.00 h and 04.00 h on 29 nights (18 nights in 1994 and 11 in 1995). This fixed schedule was adopted because the times of first and last captures varied little between months, and much less than the change in night length between months might suggest. On each night and at each site, 5 nets (of 2.1 × 6.0 m), were set up 5 m apart across the river (eg Thomas and LaVal 1990). The number of nets and netting period were constant every night. We recorded species and time of capture for each bat and all were released without banding. Such a procedure makes non-registered recaptures possible (although bats were released at some distance from the nets), though it should not make any disturbance to comparisons of activity.

Results

There were a total of 452 captures (346 in 1994 and 106 in 1995) of 11 species (Table 1). The numbers of bats (average ± SD) fell from 26.6 ± 13.3 per night per

Table 1. Number and dominance (in parentheses, in %) of the bats of different species, caught in Białowieża National Park in 1994 and 1995 years, and in total. Proportion (in %) of males (MM) to females (FF) is shown.

Species	1994	1995	Total	MM/FF
Nyctalus noctula	112 (32.4)	21 (19.8)	133 (29.4)	25/75
Myotis daubentonii	59 (17.1)	42 (39.6)	101 (22.3)	36/64
Nyctalus leisleri	61 (17.6)	11 (10.5)	72 (15.9)	21/79
Pipistrellus nathusii	29 (8.4)	9 (8.5)	38 (8.5)	69/31
Vespertilio murinus	28 (8.1)	3 (2.8)	31 (6.9)	44/56
Pipistrellus pipistrellus	17 (4.9)	7 (6.6)	24 (5.3)	38/62
Eptesicus nilssonii	13 (3.8)	5 (4.7)	18 (4.0)	29/61
Barbastella barbastellus	8 (2.3)	3 (2.8)	11 (2.4)	29/61
Plecotus auritus	9 (2.6)	2 (1.9)	11 (2.4)	9/91
*M*yotis *nattereri*	6 (1.6)	3 (2.8)	9 (2.0)	25/75
Myotis brandtii	4 (1.2)	0 (0.0)	4 (0.9)	50/50
Total	346 (100)	106 (100)	452 (100)	

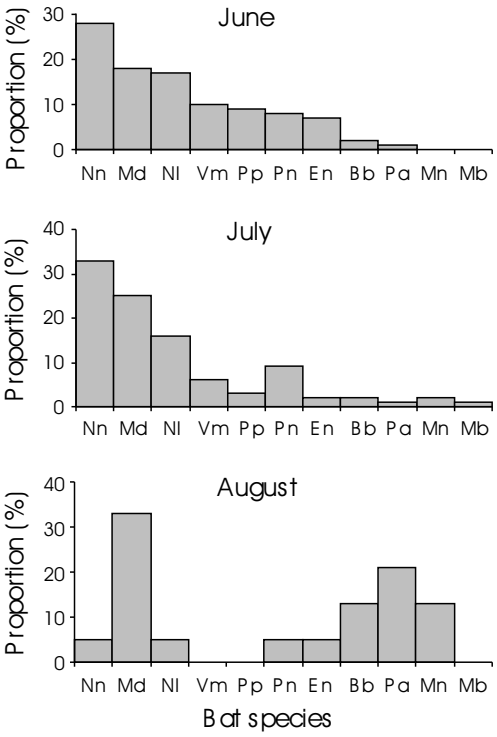

Fig. 1. Percentage composition of the different species of bats captured in June, July and August. Abbreviated names: Nn – *Nyctalus noctula*, Md – *Myotis daubentonii*, Nl – *Nyctalus leisleri*, Vm – *Vespertilio murinus*, Pp – *Pipistrellus pipistrellus*, Pn – *Pipistrellus nathusii*, En – *Eptesicus nilssonii*, Bb – *Barbastella barbastellus*, Pa – *Plecotus auritus*, Mn – *Myotis nattereri*, Mb – *Myotis brandtii*.

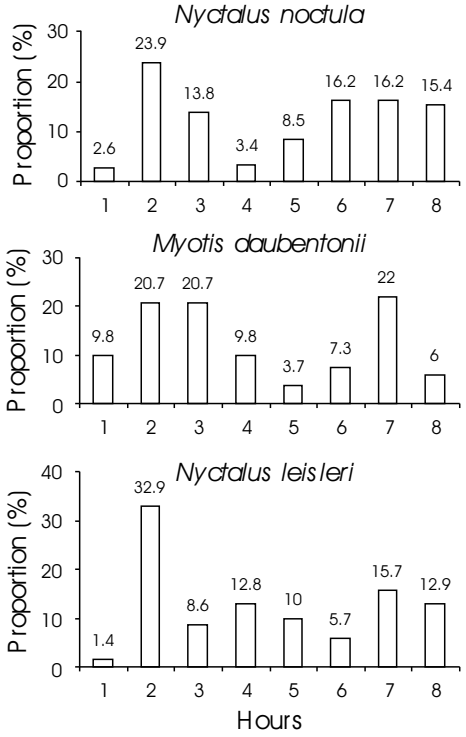

Fig. 2. Proportion of bat activity in subsequent hours of netting (between 20.00–04.00 h) for the three most numerous bat species.

point in July, through 17.9 ± 11.5 in June, to 7.8 ± 5.60 in August. The bats caught most often were *Nyctalus noctula* (29.4% of all captures), *Myotis daubentonii* (22.3%) and *Nyctalus leisleri* (15.9%). *Pipistrellus nathusii*, *Vespertilio murinus*, *Pipistrellus pipistrellus*, and *Eptesicus nilssonii* were also fairly common in June and July. There was a marked change in the relative frequencies of the different species in August, when *M. daubentonii* (33%) was most numerous, followed by *Plecotus auritus* (21%), *Myotis nattereri* (13%) and *Barbastella barbastellus* (13%). None of the other species accounted for more than 5% of captures in this period (Fig. 1).

The percentage activity of most numerous species (*N. noctula*, *N. leisleri* and *M. daubentonii*) varied markedly for the different hours of the netting period (Fig. 2). The distribution of the number of captures in subsequent hours was

significantly diverse (χ^2-test: $\chi^2 = 34.179$, df = 7, $n = 117$, $p \leq 0.001$ for *N. noctula*; $\chi^2 = 25.317$, df = 7, $n = 82$, $p \leq 0.001$ for *N. leisleri*; $\chi^2 = 34.457$, df = 7, $n = 70$, $p \leq 0.001$ for *M. daubentonii*).

There was a significant correlation between minimum air temperature overnight and the total number of captures of all species (Spearman Rank Correlation: $r_S = 0.411$, $p < 0.05$). We analysed the influence of minimum air temperature on the activity of *N. noctula*, the most abundant species, further by dividing the night into four parts of equal length: (1) after dusk, (2) before midnight, (3) after midnight, and (4) before dawn. This generalised partitioning was a reflection of the small sample of some categories. Generally, where minimum temperatures were of $< 10°C$, the activity of *N. noctula* after sunset was visibly higher than that before dawn, whereas at $\geq 10°C$ the evening and the morning peaks of activity were similar. The median number of captures per hour on nights with minimum temperature $< 10°C$ ($n = 7$) was 1.0 (interquartile range: 0.5–2.0), whereas on nights with a minimum temperature $\geq 10°C$ ($n = 17$) it was 4.0 (interquartile range: 1.0–9.0). However the difference in activity was not statistically significant (Mann-Whitney *U*-test for two samples).

Discussion

Mist netting is a common method of sampling the activity and relative abundance of bats (eg Bell 1980, Kurta 1982, Thomas and West 1989, Thomas and LaVal 1990). The result obtained by netting may be biased because not all species or even individuals of the same species may react to a net in the same way. Moreover, the places where the nets are set will often influence the results. Complete elimination of this bias is probably impossible (eg Thomas and West 1989). However, Kunz and Brock (1975) researching the activity of bats over open waters, found that this method gave results similar to those obtained with bat detectors. Generally, netting can underestimate the abundance of bats flying high (eg *N. noctula*), while ultrasound detection overestimates it (Thomas and West 1989, Fenton 1990).

We attempted to eliminate bias through the choice of capture points by setting a number of nets across the whole of the river channel, and by capturing throughout the night. This required a great deal of prior observation with the aid of a bat detector. The objective was to find places for bats that prefer edge and tree habitats, and those that hunt mostly over open areas. This choice of the study points makes the observed species diversity higher.

The number of species recorded is in agreement with the results obtained in earlier studies carried out at different points within BPF (Rörig 1918, Kurskov 1958, 1981, Ruprecht 1976, Rachwald and Nowakowski 1994). The total number of captures is the highest in research carried out to date on the bats of the area. In spite of this, we did not record several species whose possible occurrence in the Forest has been suggested (eg Ruprecht 1976). This was the case for *Myotis myotis*, *M. dasycneme*, *M. mystacinus*, and the big forest species *Nyctalus lasiopterus*. In

the cases of *M. myotis* and *M. mystacinus*, the reason for the absence from captures may be the geographical ranges of the species (with BPF being on their edges, Ruprecht 1983, Gerell 1999, Stutz 1999). Furthermore, the habitat was not suitable for *M. myotis* and partly for *M. dasycneme* (Bauerova 1978, Řehak *et al.* 1996, Britton *et al.* 1997, Verboom 1998). *N. lasiopterus* is an extremely rare species in Poland (Ruprecht 1970, Kowalski and Ruprecht 1981) and may only occur accidentally here. Many captures of *N. noctula* (a species ecologically and morphologically similar) suggest that the selected method of capture should be effective for *N. lasiopterus* also.

It is somewhat surprising that the most frequent species is a high flying, open area specialist. *N. noctula* (Aldridge 1985, Baagoe 1987, Norberg and Rayner 1987, Kronwitter 1988, Ahlén 1990), although earlier studies using ultrasound detection (Rachwald 1992, Rachwald and Labocha 1996) did show this species to be relatively abundant in the Białowieża Forest. Mist nets placed low near the ground would not seem appropriate for catching *N. noctula.* However, our observations suggest that bats may drink water from the river surface in the studied habitat (Ahlén 1981, Miller and Degn 1981, Zbinden 1989, Gloor *et al.* 1995).

Captures at two points in close proximity resulted in encounters with all but one of the bat species recorded to date in BPF (including the Belarusian side – Kurskov 1981). The only exception was the serotine *Eptesicus serotinus*, which has so far proved mainly to be an "urban" species, known only from areas near human settlement (Ruprecht 1965, 1976, Baagoe 1986, Rachwald and Nowakowski 1994).

In our opinion, the high diversity of bats indicates overlap in habitat use by open- or not very cluttered space hunters (genera *Nyctalus*, *Eptesicus* and *Vespertilio*), by bats which hunt close to the water surface (*M. daubentonii*), and by species preferring edge zones (genera *Pipistrellus* and *Barbastella*). Sometimes captures also included bats preferring highly cluttered space (such as *P. auritus*), probably more abundant inside of woods (Limpens and Bongers 1991, Swift 1991, de Jong 1994). The bats of long flight distances (especially *Nyctalus* spp.) and perhaps also *M. daubentonii* (active along the river), may be suspected of flying to the study points from a greater distance. For others these points rather become the local foraging areas at a close distance to day shelters (Kronwitter 1988, Kalko and Braun 1991, Rachwald 1992, Racey 1998).

The observed night-time rhythms of catches in most cases corresponded with the bimodal (evening-morning) pattern of hunting (Gaisler 1979, Erkert 1982). The presumable influence of lower air temperature on the activity of *N. noctula* results from the fact that the time of morning flights coincides with the period of relatively low air temperatures. In this way, the influence of cooling is manifested first through reduced morning activity. A further lowering of the temperature may result in a cessation of early morning flights by *N. noctula*. Unpublished observations by A. Rachwald suggest that 5°C is the critical minimal temperature at which this species ceases flying in the early morning in BPF. Although the present study revealed fewer captures of *N. noctula* on nights when the minimum temper-

ature was < 10°C, the results were not statistically significant. Nevertheless, this may simply be because there were data for only 7 nights with a minimum temperature below 10°C. This is also the case of the second most common species, *M. daubentonii*, which was only caught once on nights with minimum temperature < 10°C.

The numbers of captured bats fell from July to August. A decline in the activity of bats in August has also been recorded using a bat detector (Rachwald 1998). Despite the limited data, the present results still indicate a marked change in the species composition of the bat fauna in August; although air temperature did not differ visibly between the three months (average minimal air temperature vary at around 11°C). Two other factors may have influenced that change. First, water levels in both rivers fell locally over the summer, so that by August the widths of the watercourses had halved, and the banks were rapidly overgrown. Second, the migration of the region's bats begins in the second half of August, by which time there are no longer any permanent breeding colonies and hence a spatial distribution of the groups of bats changes (Strelkov 1969, Masing *et al*. 1987, Rachwald 1992).

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