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Original Investigation

Winter foraging activity of Central European Vespertilionid bats

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ABSTRACT

The winter activity of bats was studied in an area of Bavaria, Southern Germany, for seven consecutive years (2007–2013). Echolocation calls were recorded in known foraging areas between October and March of each winter, and bats were regularly seen on evenings with temperatures above +6 °C, except for the period between mid-December and mid-February, when even bouts of warm weather did not appear to trigger foraging activity. Below +3 °C no bats appeared in the foraging areas. The most frequently recorded species were *Nyctalus noctula*, *Pipistrellus pipistrellus*, *Pipistrellus nathusii* and *Vespertilio murinus*. Final buzzes indicating attempts to catch prey were recorded for these species even in December and February, which supports the idea that the bats were not only in search of water or just moving between roosts. *Myotis* species, on the other hand, which hibernate in roosts offering more constant temperature conditions, were not observed at all between mid-November and March. Further investigations have to show whether warmer winter evenings offer bats an opportunity for casual hunting or whether winter foraging expresses an urgent need for weak individuals.

Introduction

Bats of northern latitudes are known to hibernate in winter and many studies have described conditions and duration of hibernation including arousals and flight activity at the roosts (e.g. Berkova et al., 2002; Daan, 1973; Furmankiewicz and Gorniak, 2002; Hope and Jones, 2012; Johnson et al., 1998; Parsons et al., 2003; Thomas, 1995a,b; Wermundsen and Siivonen, 2010). However, individuals of some bats species are regularly found outside roosts during winter. Often such observations occur because bats move between roosts potentially due to changes of roost climate or disturbances (Sendor et al., 2000). Other reasons for their activity might be dehydration and foraging (Geluso, 2007; Lausen and Barclay, 2006; Speakman and Racey, 1989; Whitaker and Rissler, 1992, 1993) and also mating (Johnson et al. 2012). In North America, winter feeding has been shown at least for some species (Dunbar et al., 2007) and in Western and Southern Europe, where winters are milder, foraging activity occurs regularly (Avery, 1985, 1986; Hays et al. 1991; Park et al., 1999, 2000; Ransome, 2002; Rodrigues et al., 2003). In Central Europe with its long periods below 0 °C, species such as *Pipistrellus nathusii* and *Vespertilio murinus* often fly into houses in late autumn and winter or are found in an exhausted state, probably due to the search for adequate roosts (Liegl, 2004; Meschede, 2004). Noctules (*Nyctalus noctula*) from hibernation colonies swarm close to their roosts on most winter days (Zahn and Clauss, 2003). However, observations of bats in foraging areas during winter are rare in Central Europe. Bat foraging activity is related to climate, especially temperature. Below 8 °C foraging bats are rarely recorded (Zahn and Maier, 1997). Temperatures are lower than this on most winter evenings in Central Europe, presumably preventing the search for food. Nevertheless, warmer nights can occur even in the coldest of months providing bats the opportunity for hunting. It is known that some insects are active in this season (Ressl 1967), and one can expect that bats of low weight interrupt hibernation and try to forage to lower the risk of starvation.

Unfortunately, systematic studies on bat activity in foraging areas during Central European winters are lacking. Therefore it is not known, whether and how frequent winter foraging currently occurs, which makes it impossible to monitor a possible behavioural change of bats as a consequence of a warming climate in the future.

This study therefore focuses on foraging activity in winter in a current study area north of the Bavarian Alps, considering temperature, insect activity and the course of the season. It can be hypothesized that temperature and food abundance influence bat activity during winter and that foraging activity concentrates at sites which offer comparatively abundant food as for example non-frozen rapid flowing rivers. Further it can be expected, that bats species which hibernate in thermally stable underground roosts (e.g. *Myotis*—species) are less active in winter than those species

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which roost in tree-holes or crevices on the outside of buildings where roost temperatures are strongly influenced by ambient temperature.

Material and methods

The winter activity of bats between October and March was studied in Southeastern Bavaria, Southern Germany, for seven consecutive years (2007/08–2012/13) on 116 evenings (Table 1). Most data were obtained at the banks of the river Inn at Waldkraiburg (N48°11′, E12°24′, 66 samples) and in adjoining woodlands, a spruce forest edge (N48°12′, E12°23′; 16 samples) and a deciduous forest edge (N48°10′, E12°23′ 13 samples). Single observations were made at rivers Traun (N47°55′, E12°37′; 5 samples) Mangfall (N47°53′, E11°52′, 8 samples) and Salzach (N47°56′, E12°56′, 8 samples). All the sites were known to be foraging areas of several species during summer or autumn according to unpublished preliminary studies. The bat fauna of the study area is well known (Meschede and Rudolph 2010).

Frequent species consist of *Plecotus auritus, Myotis daubentonii, Myotis mystacinus, Myotis brandtii, Myotis myotis* and *Myotis nattereri, Pipistrellus pipistrellus, Pipistrellus nathusii, Nyctalus noctula* and *Vespertilio murinus.* Species which occur only infrequently in the study area are *Barbastella barbastellus, Eptesicus nilssonii, Eptesicus serotinus, Hypsugo savii, Nyctalus leisleri, Myotis bechsteinii* and *Pipistrellus pygmaeus*.

The echolocation calls were recorded at the sample sites with a Pettersson D1000 bat detector and a batcorder (ecoObs GmbH, type 2.0; instrument adjustment: threshold −36 dB, quality 20). Samples were taken for 30–60 min starting 15 min after sunset and the activity calculated on a 5 min base (records/5 min). Using the D1000, as many records as possible during a study section were made. The batcorder recorded sound samples automatically but a comparison verified that similar numbers of records were obtained with both methods. The records were analysed automatically by the program bcAnalyze 2.0 (ecoObs GmbH,) and verified using batsound software 3.31 (Pettersson,). Additionally we measured the total bat activity (seconds/5 min) and estimated the number of feeding buzzes that could be recorded by the bat detector. Half-way through each sample-taking the air temperature was measured with a conventional digital thermometer. The availability of prey was assessed during sampling with the help of a flashlight by counting the number of insects visible in a standardised flashlight beam during a slow full turn (Taylor and O'Neill, 1988). After five repeats the mean number of insects was calculated.

During sound analysis, many records could not be determined to species level. The species *Vespertilio murinus, Eptesicus serotinus* and *Nyctalus leisleri* were pooled (group "Nyctaloid") following the batIdent software. The genus *Myotis* was treated as a group. However, visual observations indicate, that most samples belong to *Myotis daubentonii*. Further, it was not possible to clearly distinguish between *Pipistrellus nathusii* and *Pipistrellus kuhlii*. According to social calls and many random records of bats found during the study period, only *Pipistrellus nathusii* occurs in the area, although the situation may change in future due to the range expansion of *Pipistrellus kuhlii* in Bavaria (Rudolph et al. 2010).

In *Pipistrellus pygmaeus*, *Eptesicus nilssonii*, *Hypsugo savii*, *Barbastella barbastellus and the* genus *Myotis* we could only state whether or not a species was present on a given evening without quantifying the activity. In these cases we gave the percentage of evenings during which a species could be observed. Only in *Pipistrellus nathusii, Pipistrellus pipistrellus, Nyctalus noctula* and "Nyctaloids" we were able to conduct a quantitative analyses of foraging activity.

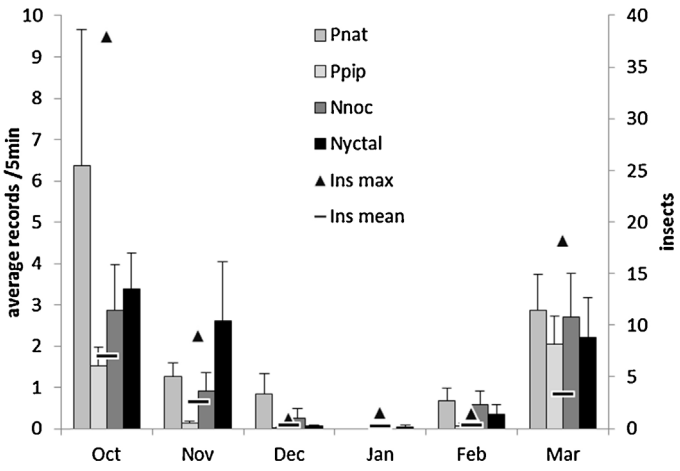

Fig. 1. Activity of *Pipistrellus nathusii* (Pnat), *Pipistrellus pipistrellus* (Ppip), *Nyctalus noctula* (Nnoc), and "Nyctaloids" (Nyctal) at the rivers during seven winters. Given are the average numbers of records in a 5-min-period and the standard error. "Ins mean" refers to the average number of insects and "Ins max" to the maximum number of insects counted in the given month.

Since the data were not normally distributed, Spearman's rho correlation coefficient (nonparametric) was used to analyse the strength of association between the bat activity and the factors temperature (activity against temperature) and insect abundance (activity against insect abundance). To counteract the problem of multiple comparisons, the Holm–Bonferroni correction method was used.

Results

Bat activity at rivers occurred throughout the whole winter but between mid-December and mid-February records were rare even on warm evenings. The most often recorded species were *Pipistrellus nathusii*, *Pipistrellus pipistrellus*, *Nyctalus noctula* and "Nyctaloids", with *Vespertilio murinus* being probably dominant in the latter group. Rarer species were *Pipistrellus pygmaeus, Eptesicus nilssonii, Hypsugo savii, Barbastella barbastellus* and *Myotis spec* (Table 1). In January only two observations were made: A *Vespertilio murinus* was foraging at 7.4 °C with a final buzz audible and a single call of *Pipistrellus nathusii* was recorded at 14.2 °C in spite of severe wind.

Throughout winter, feeding buzzes were recorded in all the bat species present in a given month, thus indicating frequent foraging attempts. In November high numbers of feeding buzzes could be heard regularly and even in the first week of December a *Barbastella barbastellus* was observed patrolling along a woodland edge searching for food. Between mid-December and mid-February buzzes were heard on three of seven evenings with bat activity. In one of these cases a Nyctaloid bat (probably *Vespertilio murinus*) emitted 19 feeding buzzes within a few minutes in late December. From late February onwards buzzes were frequent again in pipistrelles and noctules.

Fig. 1 gives the average activity of the most abundant bat species during winter. *Pipistrellus nathusii*, *Nyctalus noctula* and "Nyctaloids" showed a high activity at the beginning of the hibernation period while in *Pipistrellus pipistrellus* it was more pronounced at the end. The lowest temperature at which foraging activity could be observed was 3.0 °C and above 6 °C several species foraged regularly (Fig. 2). During the main hibernation period between November and February, a distinct correlation (Table 2) was determined between activity in all the species and both insect abundance ($p < 0.05$) and temperature ($p < 0.05$). Insect abundance and temperature were also closely correlated ($p < 0.05$)). Except in *Pipistrellus*