What does bat activity inside the forest tell us about the activity above the canopy?

A method for sensoring bat activity at proposed wind plans in forest

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Introduction

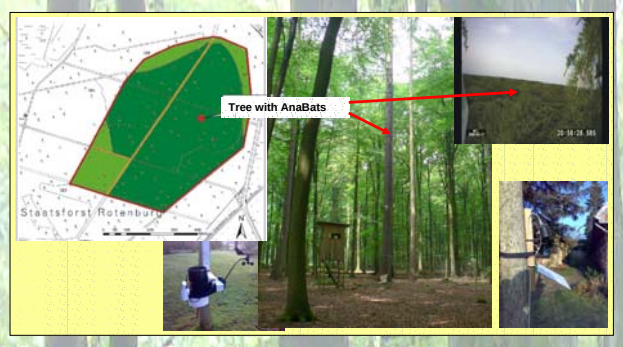
In Germany in recent years, an increasing number of wind turbines are being planned in forests. The bat surveys for impact assessments are carried out on the forest floor using line transects. This method does not take into consideration that bat activity above and below the canopy might differ. So far, few studies have investigated bat activity above the forest canopy in Germany (Aschoff et al. 2006, Fichtner 2004), or elsewhere (Grindal & Brigham 1999, Hayes & Gruver 2000, Kalcounis et al. 1999).

The aim of our study was to test the following hypotheses:

- bat activity and species composition above and below the canopy differs
- wind strongly influences bat activity above the canopy, but less so below the canopy
- assessing bat activity and species composition above the canopy from surveys at ground level is difficult or even impossible

Study area

The study was carried out in a forest consisting mainly of mature beech (*Fagus sylvatica*) which is located between the cities of Bremen and Hamburg (Lower Saxony, Northern Germany). Since 1986, 31 of 40 ha have been protected and no timber harvest has been carried out (see Fig. 1). Ground vegetation cover is less than 5%; canopy cover is about 90%. Other tree species mainly include *Larix decidua*, *Picea abies* and *Pinus sylvestris*.



Definition of bat contacts:

1 bat contact = 1 bat in an AnaBat-file of 15 sec
2 bats in an AnaBat-file of 15 sec. = 2 bat contacts

Methods

The study was carried out with Anabat SD1 systems (Titley electronics). Three microphones were used between 15th June and 3rd November 2007 and between 22nd April and 2nd November 2008 at different heights on a larch tree (*Larix decidua*s) to investigate bat activity in different height strata:

- at 4 m (**station 1**)
- at 15 m (10m below the canopy) (**station 2**)
- at 30 m (above the canopy) (**station 3**)

We used normal microphones in 2007, but HIC-microphones (Titley electronics) in 2008. The sensitivity of the normal microphones varied with the length of the cables used. Therefore, in 2007 we had to use different sensitivity settings for the three Anabat systems to achieve the same recording distance, whereas we could use the same settings for all three AnabBat systems in 2008.

All microphones faced towards the ground. We used a reflection plate (Fig. 2) which allowed us to record bat calls from c. 4m below the microphone to 5-20m above it, depending on the species and its behaviour. Each microphone was connected to an AnaBat -system which was hidden in a box in the ground. Above the canopy the detector range was higher, due to the bats using different echolocation calls in open areas.

We could show that the two lower Anabat-systems did not record sounds from bats flying above the canopy. In 2008, we installed weather stations (Conrad WS 3600 and Davis Vantage Pro 2) at the same tree at 15 m and 30 m above ground and recorded wind speed (in m/s) and temperature (in °C) every hour (Fig 3).

To compare the results of dfferent survey methods, we also recorded bats during point-stop-transects. Point-stop transects were carried out twice a night during 13 nights and stops per point lasted 20 minutes.

Results

Species composition and distribution at different strata

We recorded 23.663 bat contacts of at least six species (*Myotis* and *Plecotus* species were recorded as *Myotis*/*Plecotus* spec.). Bat activity was significantly (p<0,05) different between the three strata. The major part of the activity (58,6 %) was recorded at the station closest to the ground, followed by the second strata (30,2 %). Only a small part of the bat activity (11,2 %).was recorded above the canopy (see Fig. 1).

At all heights, the majority of contacts originated from *Pipistrellus pipistrellus*. At the two highest strata, this species was responsible for more than 50 % (above the canopy even 65 %) of contacts. As suspected *Nyctalus noctula* occurred more frequently above the canopy than below. In contrast, *Eptesicus serotinus* was recorded mainly at the lowest station. Only 11 contacts of this species were recorded above the canopy. In many cases it was not possible to distinguish between *Nyctalus noctula* and *Eptesicus serotinus*. These calls were grouped together and the distribution of these calls was similar to the distribution of *Eptesicus serotinus*.

Surprisingly, bats of the genus *Myotis* and *Plecotus* were found regularly above the canopy (Station 3: n=269, 10 % of bat contacts), although their main activity was recorded at ground level (Station 1: n=2769; 20 % bat contacts). Activity of these two genera was ten times higher at ground level than at the highest strata. The following additional species were found close to station 1 using time expansion recordings and/or mistnetting: *Myotis bechsteinii, M. myotis, M. nattereri and Plecotus auritus*.

These data show that the species composition recorded with the lowest detector does not represent the situation above the canopy.

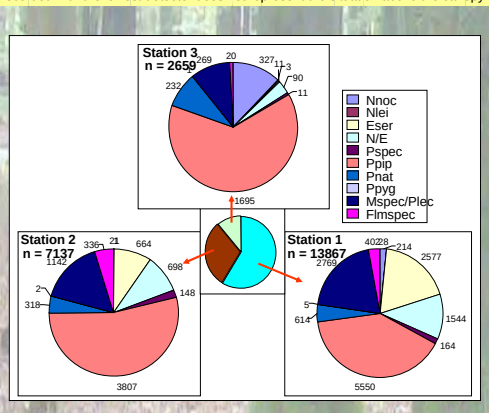


Fig. 1: number of bat contacts per species at three different strata (Nnoc = Nyctalus noctula, Nlei = N. leisleri, Eser = Eptesicus serotinus, N/E = Nyctalus/Eptesicus spec.,Pspec = Pipistrellus spec., Ppip = P. pipistrellus, Pnat = P. nathusii, Ppyg = P. pygmaeus, Mspec(Plec = Myotis/Plecotus spec., Flmspec = undet. bat)

Seasonal species distribution

Species distribution below and above the canopy was different (Fig. 2). At station 1 (ground stratum) Pipistrelle bats dominated during spring but became rare during summer and autumn. A high percentage of bat recordings were from serotine bats at the beginning of June. However, they might be part of the species group *Nyctalus/Eptesicus*, that increased in activity in July and August. In contrast, in the highest stratum, a high percentage of spring activity were from the migrating species *Pipistrellus nathusii*. They also occurred regularly in August/September. During late summer and autumn Pipistrelle bats dominated the activity above the canopy. During this time, the majority of *Myotis/Plecotus* also hunted above the canopy.

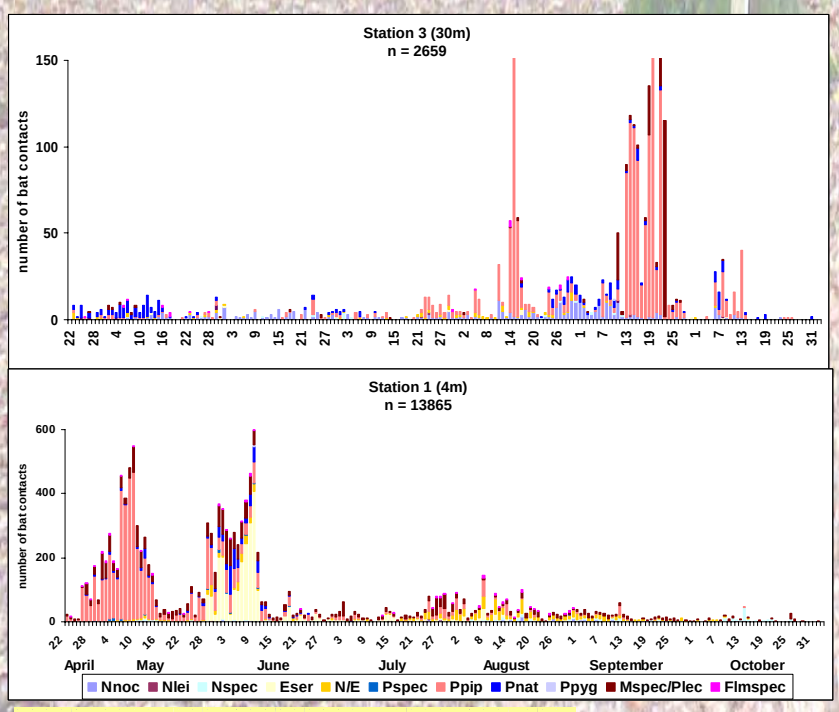


Fig 2: seasonal distribution of species below and above the canopy (note differences in scales)

Diurnal patterns of activity

Because the phenology of the activity between the two strata showed significant differences, we divided the diurnal patterns into spring (April - end of June) and summer/autumn (July – end of October). We concentrated on the species that are relevant for wind farm projects.

In spring, when the activity of all bats much lower above the canopy *Nyctalus noctula* showed a high activity peak in the early night, followed by a strong decrease of activity, whereas the activity was less pronounced below the canopy did not show as much variation throughout the night. In autumn the diurnal pattern showed no significant differences but usually activity was higher above the canopy.

The spring activity of *Pipistrellus pipistrellus* showed a clear peak after midnight inside the forest whereas above the canopy the activity was so low that there was no visible diurnal pattern. After July there was a clear activity peak before midnight in both strata, but the activity above the canopy was higher. After 23:00 the activity above the canopy dropped much stronger than inside the forest.

The diurnal pattern of *Pipistrellus nathusii* differed between the highest and lowest strata in both periods. In spring the activity of Nathusii´s bats showed a clear peak after midnight but no visible peak above the canopy. There was a much higher activity inside the forest than above the canpoy, In contrast, in summer/autumn we found much higher activity above the canopy relative to the lowest strata. but no visible peak in both strata.

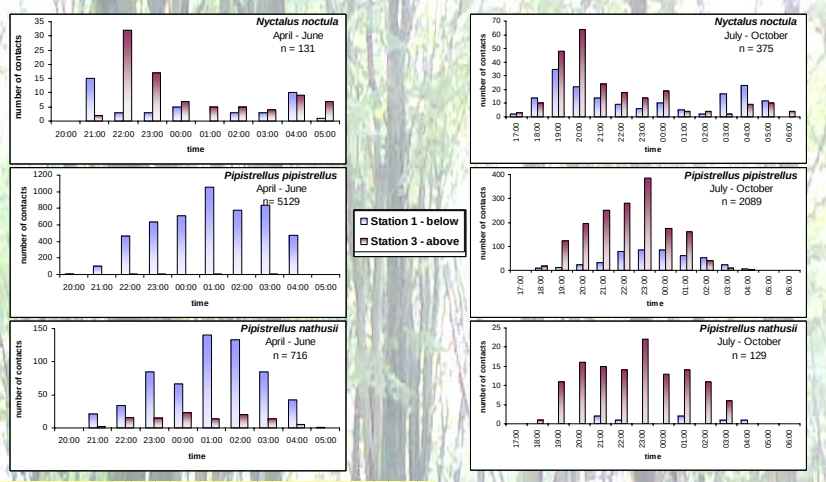


Fig. 3: Diurnal activity of different species in spring and autumn (Station 1 and 3)

Influence of wind on bat activity

Pipistrelle and Nathusii´s bats (T-test, p= 0,018 Ppip and p=0,03 Pnat), but not for Noctules bats (p=0,15). We tested the hypothesis that in higher wind speeds, bats might fly below the canopy rather than above. We compared the mean weighted wind speed of each species (matrices of wind speed weighted against activity of each species). It was significant (*p<0,05) that more Pipistrelle bats occured in higher wind speed below the canopy (8 m/s) than above (4,8 m/s). This was not significant in Noctules (7 resp. 5,8 m/s) and in Nathusii´s bats (5,7 resp. 7,1 m/s), the different mean wind speed was quite obvious..

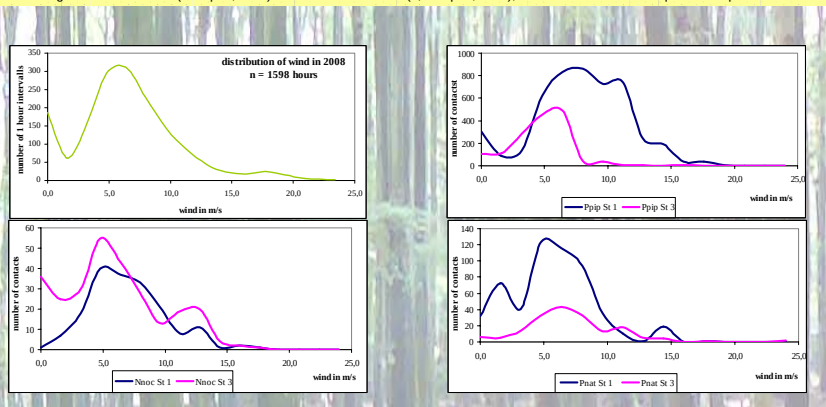


Fig. 4: Influence of wind speed on different species (Station 1 and 3)

Comparison between point-stop-transects and AnaBat monitoring data

We compared data recorded during 13 nights of ground surveys (point-stop-transects) (Tillmann 2009) with AnaBat data from the same nights. The results showed:

- the point-stop transects did not really reflect the species composition of the lowest AnaBat-system recorded during these nights, although there is a slight but not significant correlation (Pearsons coefficient; p=0,09) .
- The data recorded at point-stop-transects and the highest AnaBat (station 3) showed no similarity with the AnaBat data above the canopy (Pearsons coefficient; p=0,17). The percentage of *Myotis, Pipistrellus pipistrellus* and *Eptesicus serotinus* was higher inside the forest than above the canopy, whereas the percentage of *Pipistrellus nathusii* and *Nyctalus noctula* was lower inside the forest than above the canopy.

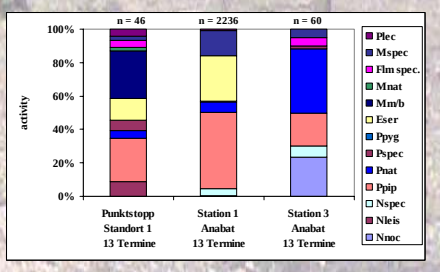


Fig. 5: copmarison of activity and species composition using different survey methods

Discussion

Studies at wind plants in open areas have shown that at 35m above ground or higher, bat activity decreased (Bach & Bach 2009, Bach & Niermann 2011, Collins & Jones 2009). Due to the restricted range of echolocation calls of bats, especially *Pipistrellus* species in open habitats such as meadows and fields it is impossible to assess the real bat activity in high altitudes (50m or more) without using a balloon, zeppelin or kite. We can suspect that species composition is the same using qCF-pulses but that activity is lower. In forests it is even more difficult. This study shows that the species composition of our study site inside and above the forest was very different. Furthermore, the seasonal and diurnal bat activity pattern inside and above the forest were dissimilar. A forest canopy is different in the sense that it is comparable to an "edge habitat" but at 30-35m above ground (see also Grindal & Brigham 1999). The results presented here are different to those from other studies, possibly because we investigated a whole season instead of summer and early autumn only (Kalcounis et al. 1999, Fichtner 2004). Both Fichtner and Kalcounis et al. found higher activity within and above the canopy than on ground level, which is partly similar to our results from late summer and autumn.

The activity of bats foraging above the canopy was influenced by wind speed (see also Bach & Bach 2009). The question arises if bats hunt below the canopy when wind speeds are high above the canopy. We found some evidence that this might be the case, but this should be studied in more detail.

The data from the lowest AnaBat (Station 1) and the point-stop-transects showed clearly, that it is impossible to assess the activity and species composition above the canopy from the ground (see also Kalcounis et al. 1999). Although the range of echolocation calls of *Nyctalus noctula* reaches up to 100m (Skiba 2003), the clutter of the canopy prevent detection from the ground. Detection is even more difficult for *Pipstrellus* species. Therefore for wind turbines in forests it should be compulsory to survey bats from above the canopy. This can easily be done by using automated detector systems.

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