

Bat activity at different wind facilities in Northwest Germany

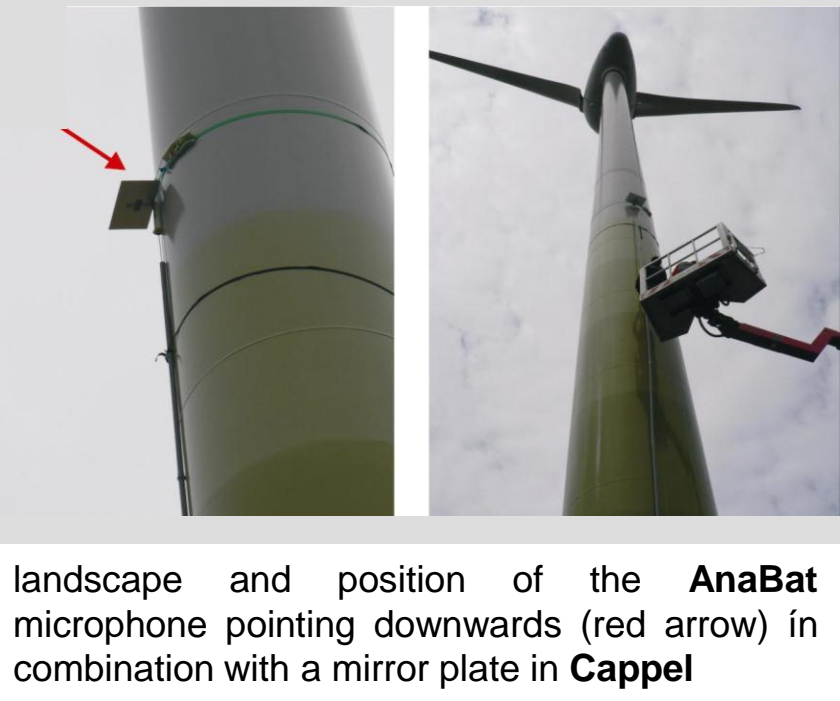
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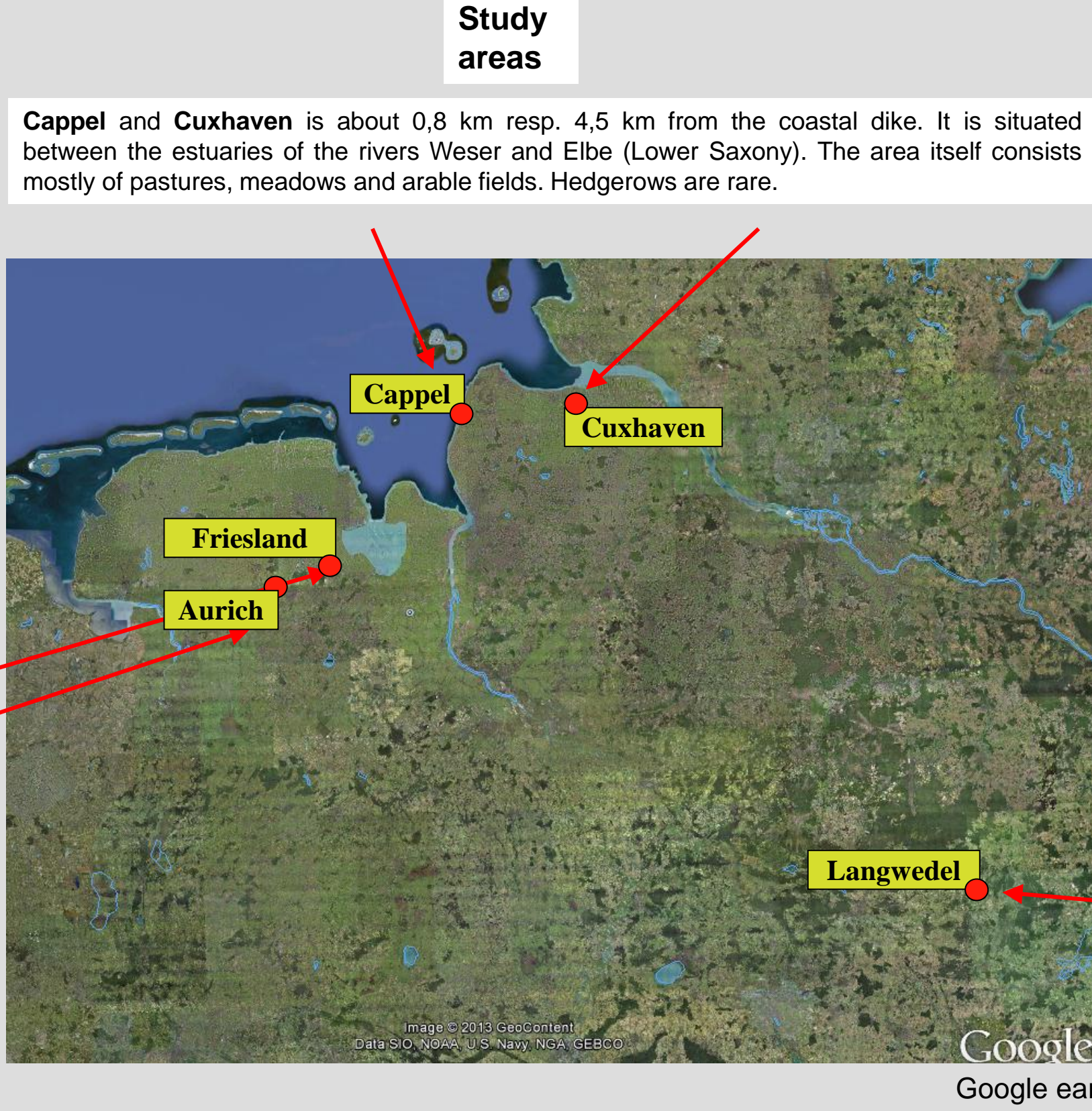
Introduction

One component of post construction monitoring studies is an acoustical survey of bat activity at nacelle height. One aim of this acoustical survey is to investigate the influence of weather conditions (wind, temperature, humidity) on the bat activity in the surroundings of wind turbine blades. These data are needed to define the conditions for switch-off periods during critical periods. In order to save money for post construction monitoring studies by reducing carcass searches it was also thought to try to calculate the number of fatalities out of the bat activity at nacelle height (Korner-Nievergelt et al. 2011). Although Brinkmann et al. (2011) collected important data for the whole of Germany on bat activity and mortality at wind turbines, the north-western part of Germany seems to differ from other areas due to its proximity to the coastline which is a known migration corridor for bats (Bach et al. 2004). During wind facility planning processes it is frequently being discussed whether it is necessary to monitor every wind facility as the assumption is that bats behave similarly in different wind facilities. In this poster we present five of our monitoring studies, located either on the coast or up to 200 km inland. We will concentrate on the influence of wind speed, temperature and technical parameters (nacelle height, blade radius etc) on bat activity. Our hypotheses are:

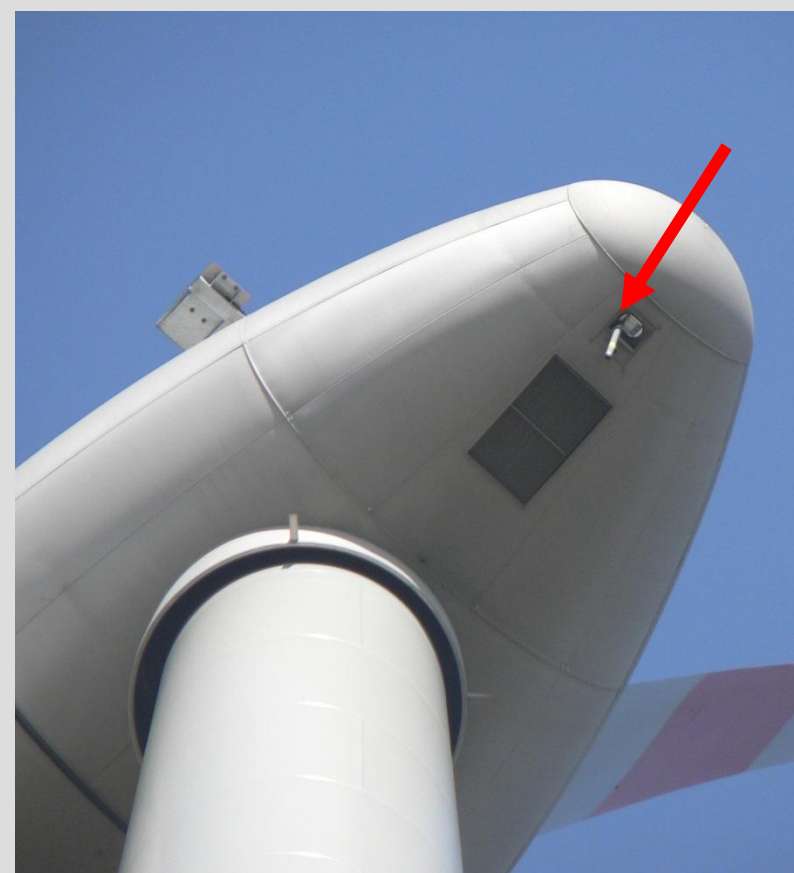
1. Are there factors explaining the variation in the activity of *Pipistrellus nathusii*, a common migrant, e.g. does it decrease with increasing distance to the coast.
2. Bat activity decrease with increasing nacelle heights and there is a correlation between activity at ground level and at nacelle height.
3. The tolerance to wind speed differs between areas for the same species



landscape and position of the AnaBat microphone pointing downwards (red arrow) in combination with a mirror plate in Cappel



Friesland and Aurich belongs also to the northgerman lowlands (Lower Saxony). Aurich is situated in the geest landscape (about 35 km away from the coast). Friesland belongs to the marsh landscape 3,7 km from the coast. Agricultural land use is similar to the Cappel site but Aurich contains more hedgerows.



position of the Avisoft or AnaBat microphone pointing downwards (red arrow)



Langwedel belongs also to the northgerman lowlands (Lower Saxony, Lüneburger Heide) but is situated 190 km from the coast. Agricultural land use is similar to the Cappel site but the site contains more hedgerows. A small woods is situated nearby.

Methods

We did post construction monitoring studies at five different wind facilities (17 wind turbines of different turbine types) in Northwestern Germany. The types and technical parameters are described in table 1. Bats were monitored acoustically and parallel carcass searches were carried out.

To assess the bat activity (acoustic monitoring) we used AnaBat SD1 (Tiley, Ballina, Australia) or Avisoft-Detectors (Avisoft Bioacoustics, Berlin, Germany). In most cases the microphone was situated at the nacelle and pointed downwards at the rear end of the nacelle. In one case, the wind facility Cappel, the AnaBat-microphone was installed outside at the mast at a height of 20 m. In order to record only these bats flying within the range of the blades we installed a reflector plate underneath the microphone, which pointed downwards. Wind speed and temperature was measured at the height of the nacelle at one of the turbines.

At the wind facility Aurich we attached another AnaBat system to the bottom of the wind turbine, running in the same mode. This was done to test the hypothesis that bat activity at ground level is correlated to activity at nacelle height.

Definition of bat contacts:

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

Factors affecting activity at nacelle height, data from *Pipistrellus nathusii*

Table 2: Analysis of *P. nathusii* contacts
General Linear Model (GLM) with backward stepwise selection of variables
SS: sum of square errors, p: error probability, R²: explained variance

Predictor Variable	SS	p
Intercept	9.41	0.0000
contacts		
month of the year	5.95	0.0018
free height	2.29	0.0039
rotor radius	1.57	0.0164
nacelle height		n.s.
wind		n.s.
wind ²	1.82	0.0099
temperature		n.s.
temperature ²	1.41	0.0228
wind x temperature	2.90	0.0012
distance to coast	1.93	0.0080
distance to hedgerows		n.s.
error	42.77	
model R ²	0.26	
model p		0.0000

Explained variance was relatively low (R²= 0.26), which implies that activity of *Pipistrellus nathusii* was to a large part driven by other factors than those present in the analysis. Good candidates for such factors are site-specific peculiarities at each of the wind facilities, which are discussed below. From all factors tested, seasonality had the strongest effect (GLM, SS = 5.95, p < 0.01). Wind turbine dimensions also significantly affected *P. nathusii* activity. Wind speed and temperature exerted a combined and non-linear effect. Distance to the coast had a significant effect, while distance to hedgerows had not.

Overall, *P. nathusii* activity tended to be highest in August and September (Fig. 1), higher at small wind turbines, highest at wind speeds of approx. 3-6 m/s (fig. 2) and higher near the coast.

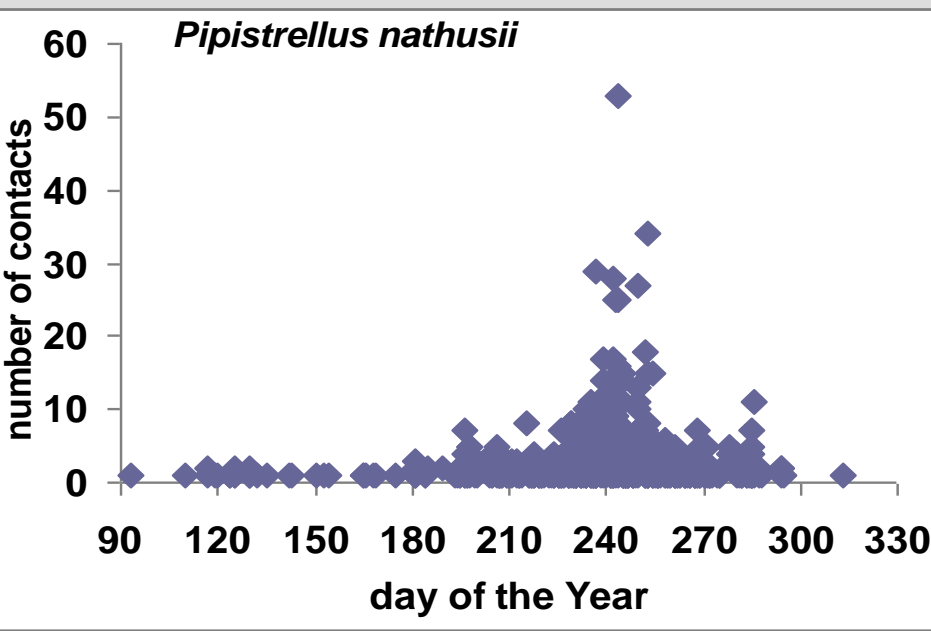


Fig. 1: seasonality of the contacts of *Pipistrellus nathusii* recorded at nacelle height

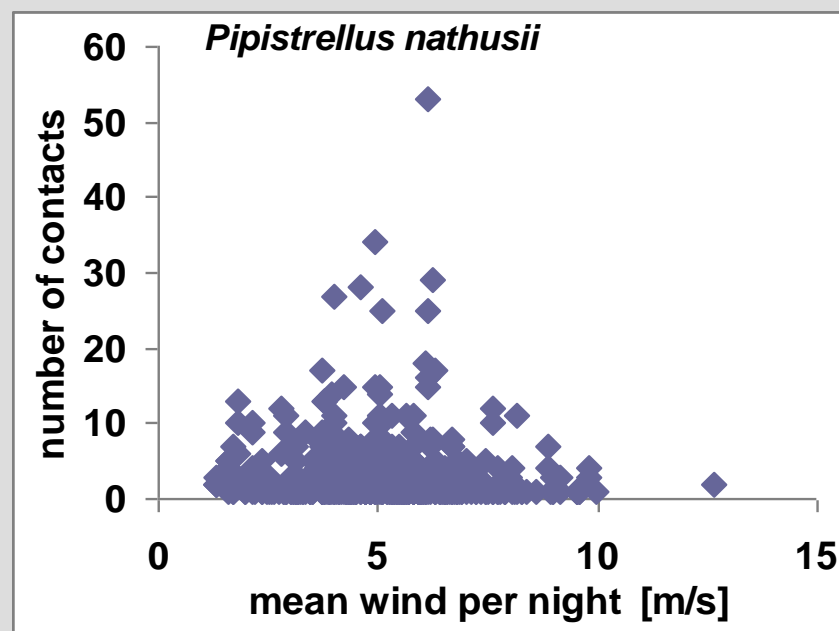


Fig. 2: wind speed and contacts of *Pipistrellus nathusii* recorded at nacelle height

Differences between wind facilities

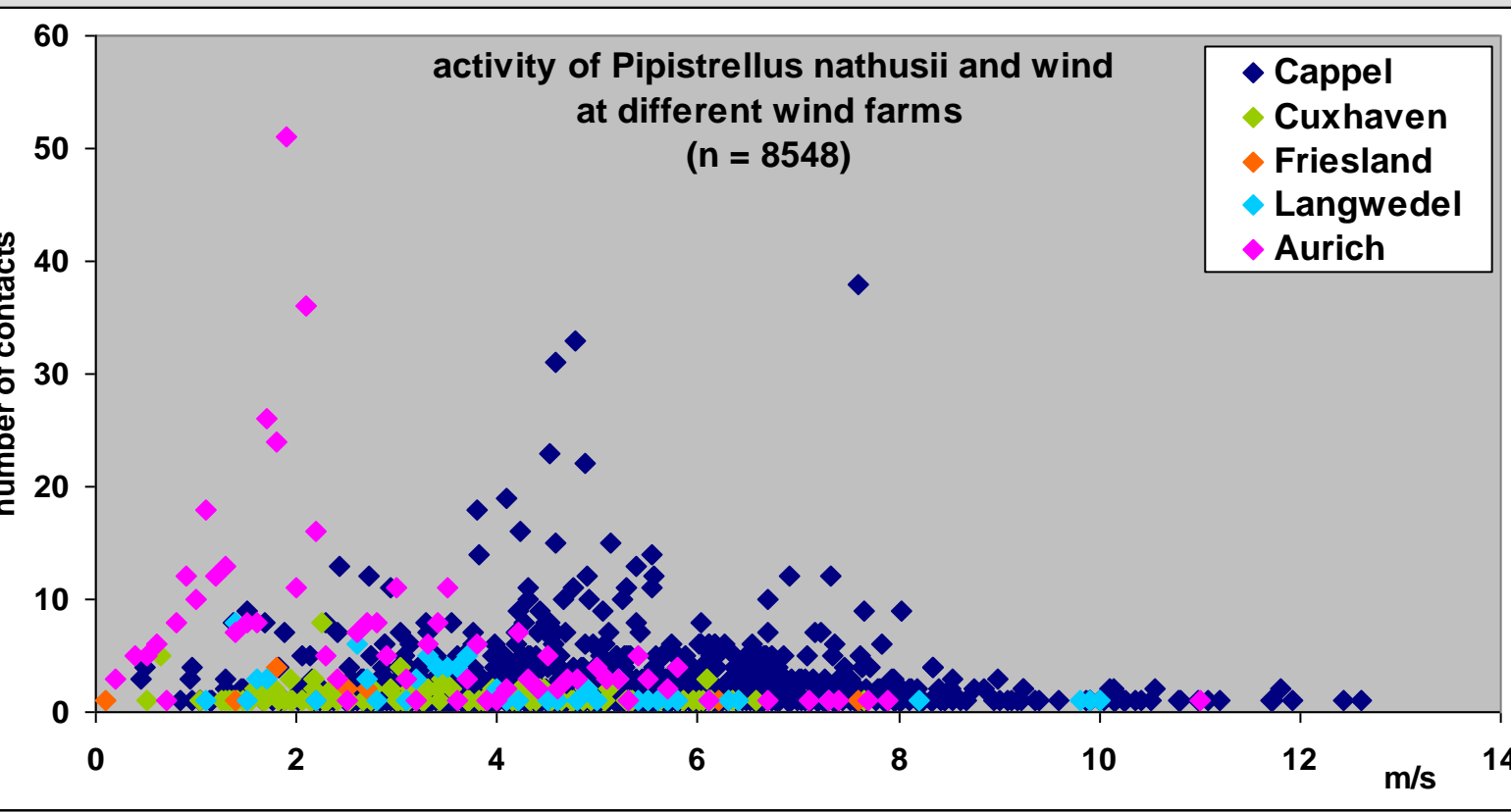


Fig. 3: variation of activity of *Pipistrellus nathusii* at different wind facilities

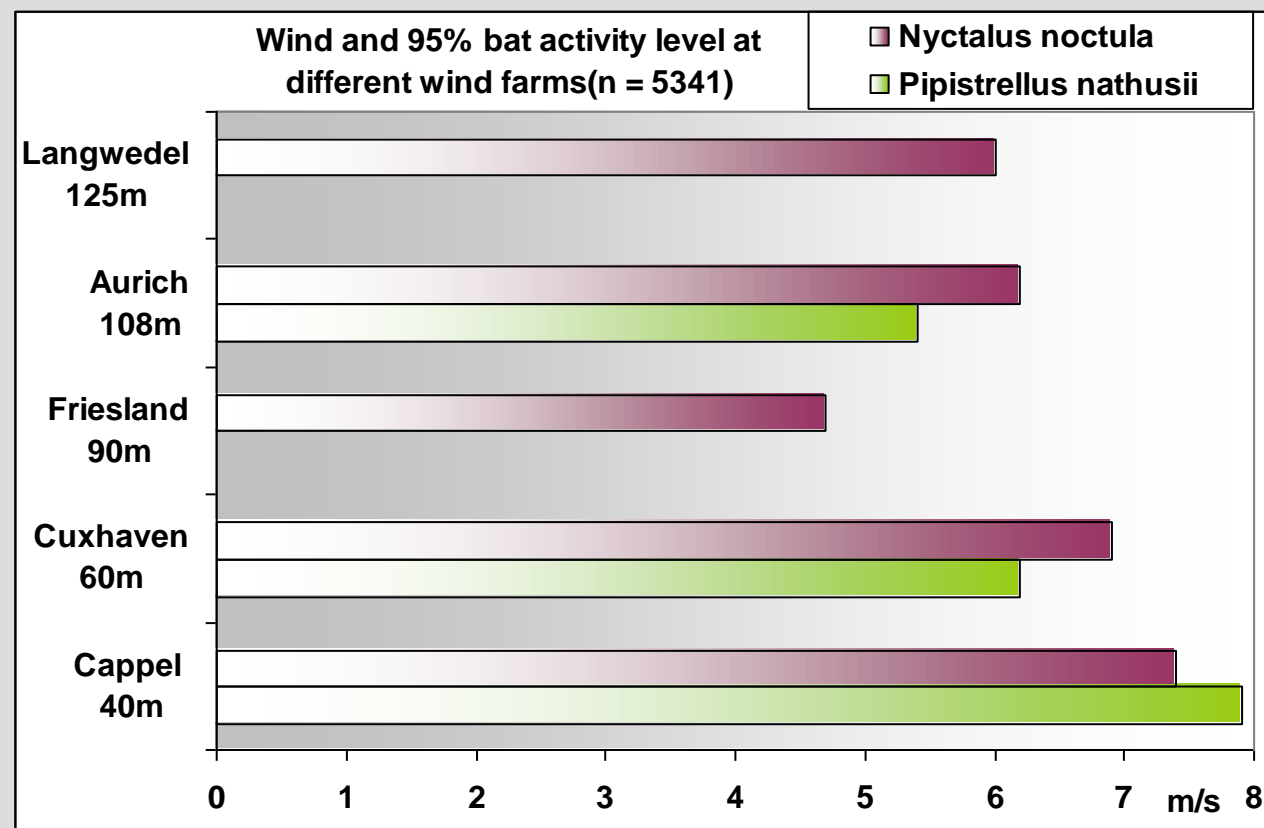


Fig. 4: wind depending variation of 95%-activity level of *Nyctalus noctula* and of *Pipistrellus nathusii* at different wind facilities

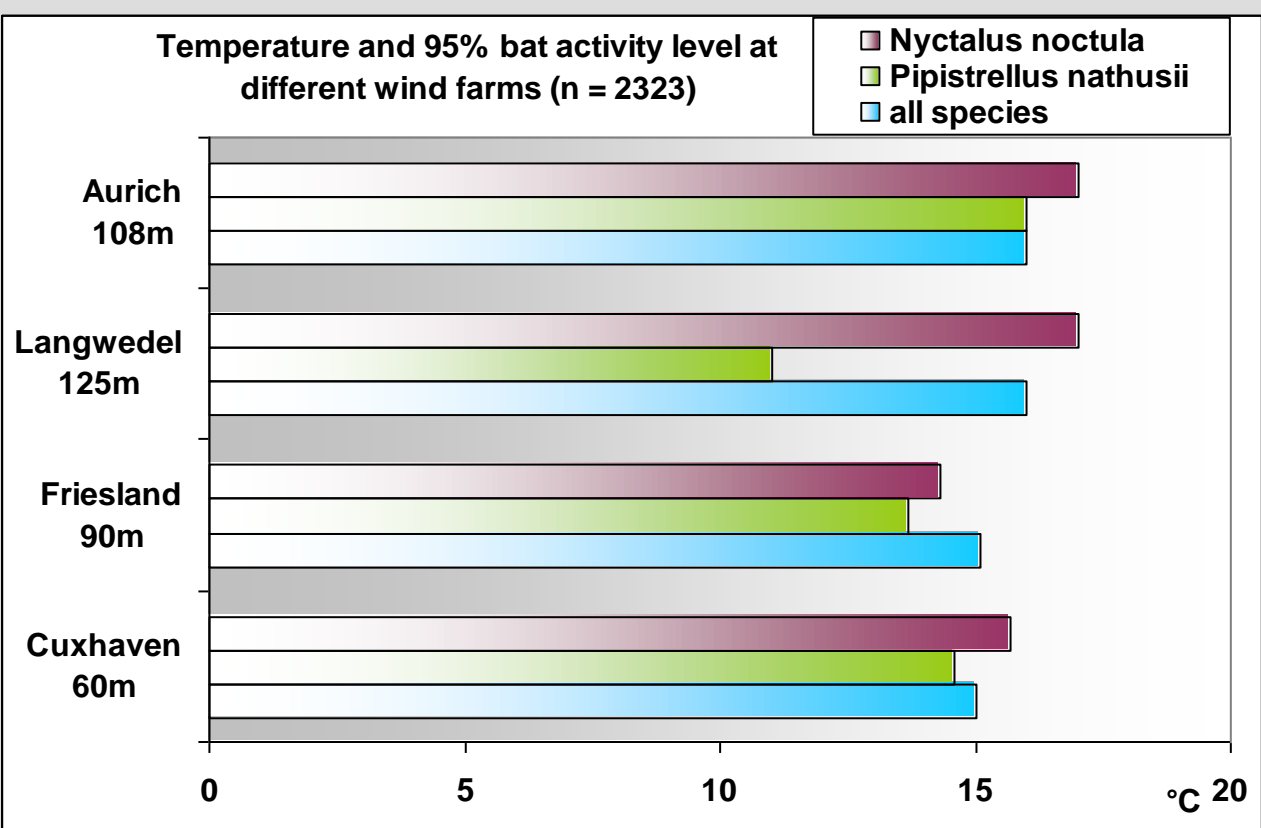


Fig. 5: temperature depending variation of 95%-activity level of bats at different wind facilities

Figure 3 shows the wide variety of activity with wind speed in different wind facilities. In Cappel, which has relative small wind turbines just behind the dike along the coast, *Pipistrellus nathusii* tend to fly in much higher wind speed than in Cuxhaven, which also has small wind turbines and is also situated close to the coast. But in further inland facilities we find no similar pattern.

If we compare the threshold of the wind speed below or temperature above 95% of *Nyctalus noctula* and of *Pipistrellus nathusii* (fig. 4 + 5), we find differences between different wind facilities that cannot explained by nacelle height or any other technical designs of the wind turbines (see tab. 1).

Discussion and conclusions

The direct comparison of bat activity between different wind facilities showed that bats have a different wind speed sensibility at each wind facility. The bats in Cappel seemed to be more wind tolerant than in other facilities. This is also evident in the 95%-activity threshold which differs from one wind facility to another as well as when it comes to the 95%-activity threshold on species level. Temperature was also an attribute which distinguished between different sites and different species. In the facility in which we compared activity at nacelle height with activity at the ground, it is obvious that the activity at the nacelle was only about 3% of the ground activity (see also Collins & Jones 2009) and so much lower as described in Behr et al. (2011). In contrast to older predictions (Dürr & Bach 2004) the proximity to landscape structures such as hedgerows proved to be not relevant. The most relevant factor in our projects seemed to be actually the seasonality in August/September (see also Behr et al. 2011, Arnett et al. 2008), maybe due to higher numbers of juveniles or migrants. But also wind combined with temperature which means that the overall weather situation explains the variation in the activity of *P. nathusii*. The activity of this species also seem to be affected by the distance to the coastline. Another more or less relevant correlation was between activities of *Nyctalus noctula* in different heights. The low R² values of our models suggest that the most important variables which could explain bat activity at wind turbines were not included in our model. We suggest that the inclusion of insect density at different seasons could be an important predictor variable. In order to get a better data base we would like to emphasize that gathering and analysing more monitoring data (mainly not officially available yet) is necessary towards understanding bat activity at wind turbines. As long as we cannot generalize the pictures of bat activity and mortality at wind turbines at least in a natural region, we are forced to treat every new wind facility as separate problem that has to be investigated to find an appropriate solution (switch-off algorithm) for mitigation.

Statistics

To identify driving factors of bat activity as measured by the contacts, we performed a general linear model analysis (GLM). Bat contacts were specified as dependent variable of the model; wind-turbine dimensions, weather data and location parameters were specified as independent variables of the model. The dependent variable was log-transformed $y' = \ln(y+1)$ prior to analysis. Non-linear terms of weather data were included to allow for representation of a hump-shaped relationship between weather and bat contacts in the model. Backward selection of variables was applied to ensure that the final model was exclusively built from significant variables. The analysis was performed using the Statistica for Windows package (StatSoft Inc., Tulsa, OK, USA).

In order to estimate parameters which has influence on activity, we modelled different parameters as landscape, rotor radius etc.. According to the fact that the main threatened species in our investigation is *Pipistrellus nathusii* we concentrate on this species. So bear in mind that the following results in table 2 are restricted to that species!

Prediction of activity at nacelle height from activity data at the ground at the wind facility Aurich

Table 3: Analysis of bat contacts at nacelle height at the Aurich wind facility
General Linear Models (GLM) with backward stepwise selection of variables
SS: sum of square errors, p: error probability, R²: explained variance

	E. serotinus		N. noctula		Nyctaloid		P. nathusii		Remark
Predictor Variable	SS	p	SS	p	SS	p	SS	p	
Intercept	0.04	0.0001	0.19	0.0000	0.09	0.0000	0.99	0.0000	
month of the year	0.12	0.0000	1.04	0.0000	0.37	0.0000	1.54	0.0000	season
contacts at ground level	0.05	0.0000	1.53	0.0000	n.s.	n.s.	0.24	0.0000	activity
wind		n.s.		n.s.		n.s.		n.s.	
wind ²	0.02	0.0054	0.08	0.0051	0.02	0.0117	0.54	0.0000	weather
wind ³	0.01	0.0292	0.04	0.0381	0.01	0.0472	0.37	0.0000	
Error	6.35		25.85		9.24		34.69		
Model R ²	0.06		0.16		0.05		0.10		model quality
Model p		0.0000		0.0000		0.0000		0.0000	

Generally, explained variance was very low (R² = 0.06-0.16), indicating that bat activity at nacelle height was highly erratic with respect to the tested factors.

Generally, activity at nacelle height was weakly correlated with activity at ground level (Fig. 7); only *Nyctalus noctula* showed a relatively stronger correlation. Seasonality was generally the strongest predictor (high SS-values) for the contacts at nacelle height (Fig. 6). Bats flew at nacelle height preferentially during low winds of 3-4 m/s (fig. 8).

Overall, only 3% of bat activity was recorded at nacelle height in the Aurich wind, with some variation between species: 5.2 % for *Nyctalus noctula*, 2.5 % for *Pipistrellus nathusii* and 2% the Nyctaloid group, respectively.

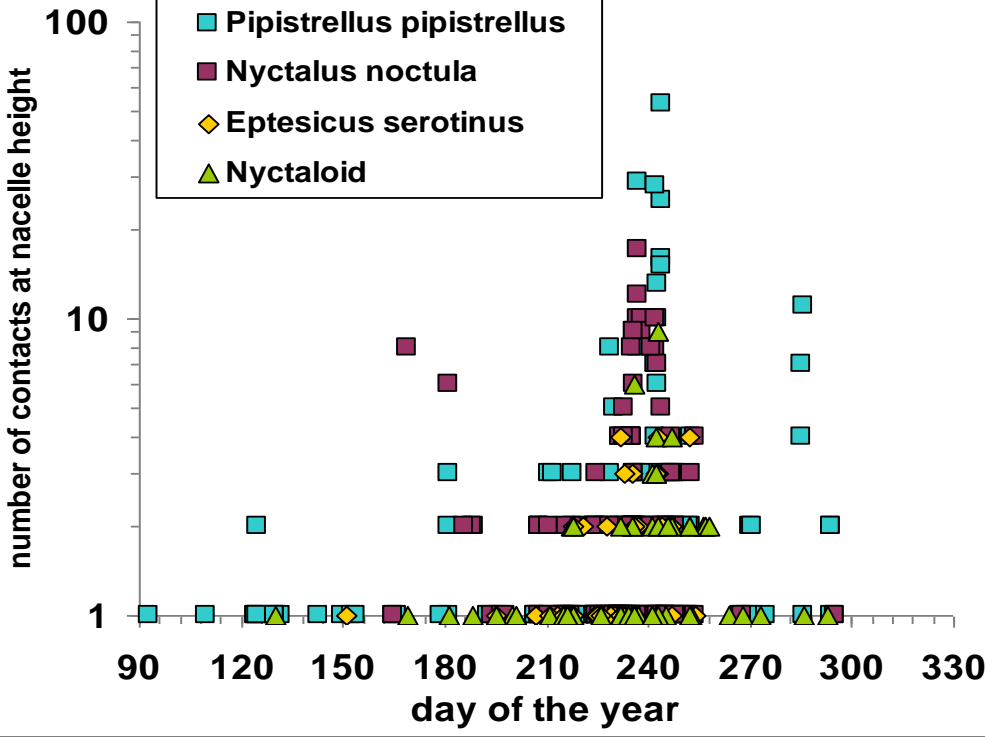


Fig. 6: seasonality of the contacts recorded at nacelle height

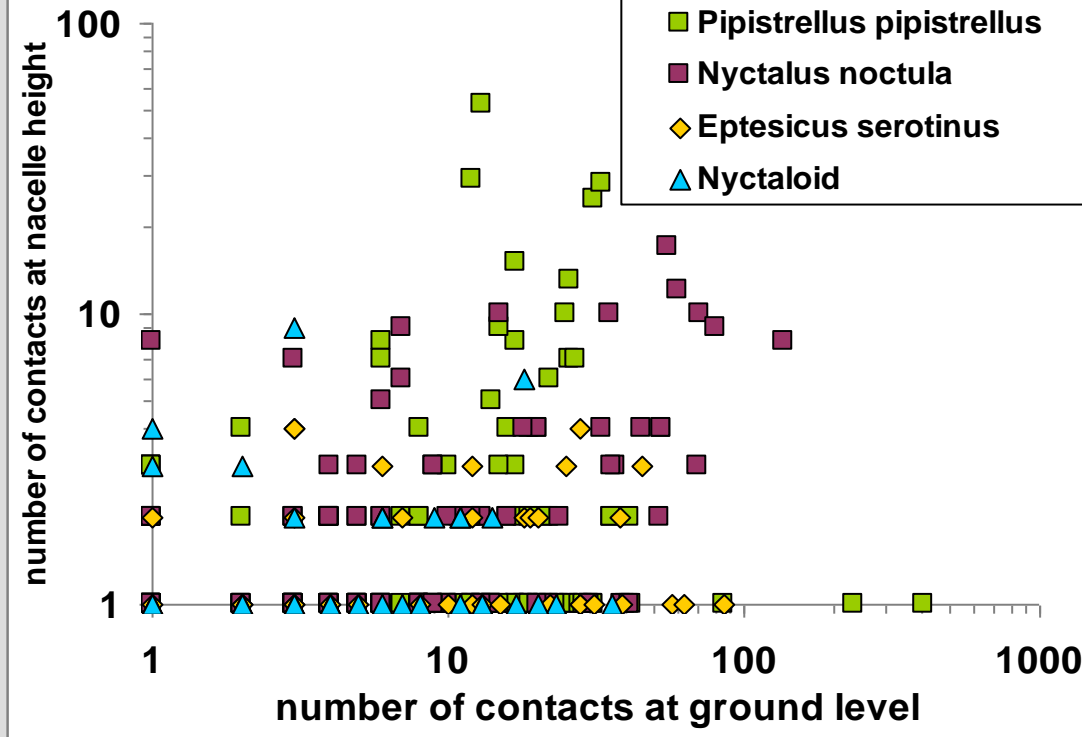


Fig. 7: contacts recorded at nacelle height versus contacts recorded at the ground level

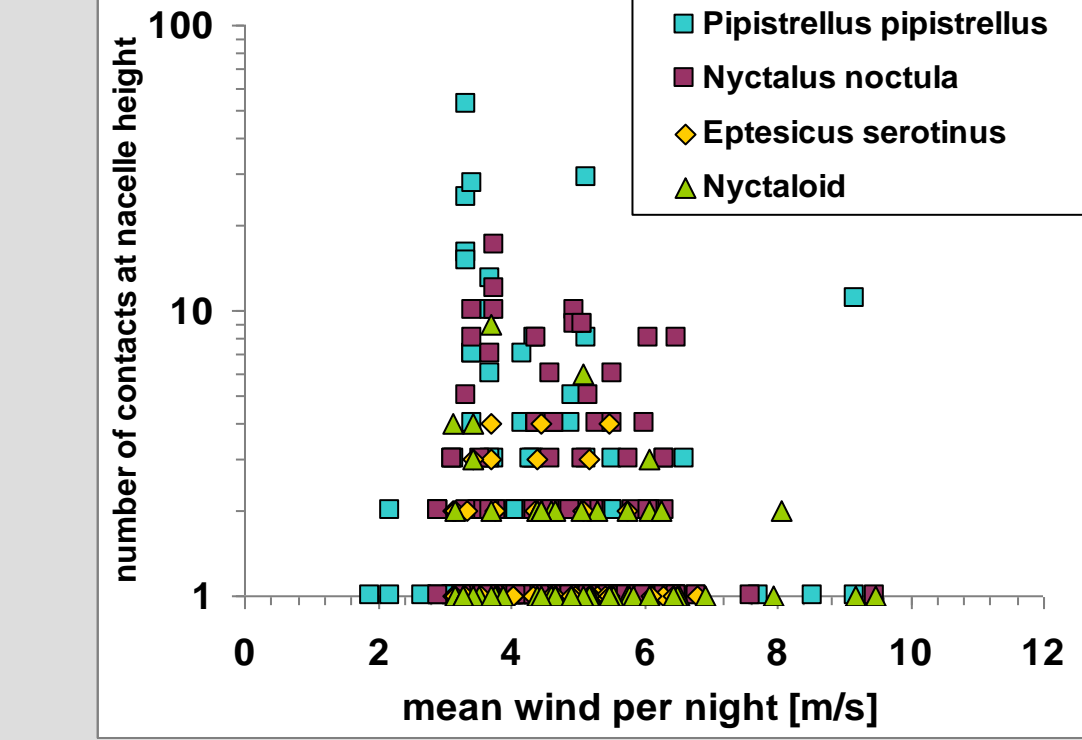


Fig. 8: wind speed and contacts recorded at nacelle height

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