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Currently Known Characteristics of Bat Species Represented in Hamburg in Respect of Wind Turbine Casualties

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Abstract

Bats are animals protected by the law, however many become wind turbine related casualties. To estimate the risk from wind turbines, a systematic literature research has been conducted. A total of 6 groups of bat characteristics have been chosen as relevant for the risk estimation: body dimensions, flight height, flight style and speed, foraging space and distance, response to light, and acoustical characteristics of bat calls. Their values have been presented in this paper for the 7 bat species that are represented in the wind park near Hamburg, Germany. Analyzing the values of the known bat characteristics, conclusions about the species with high collision risk possibility have been drawn. However, these conclusions have not always been supported by the statistics of carcass findings at wind parks across Germany, which raises questions, for instance about the degree of influence of certain characteristics above others, and indicates a need for further research.

Keywords: *bat casualties; bat characteristics; wind turbines.*

1. Introduction

According to the German Federal Law of Nature Protection (Bundesnaturschutzgesetz), bats belong to the category of endangered animals and are particularly protected – it is forbidden to catch, injure or kill them. However, Hochradel et al. (2015) have proven that bats are attracted by wind turbines, and Brinkmann et al. (2011) have estimated that on average 9.5 bats are killed per wind turbine in the period from July to September in Germany.

With the idea of reducing CO_2 emissions and backing out of nuclear energy, Germany is actively increasing the share of renewable energy in its total generation mix. A total of 29248 onshore wind turbines with a cumulative capacity of 53.2 GW were operating in Germany by 30.06.2019 (Deutsche WindGuard GmbH 2019). Thus, the increasing number of wind turbines raises a concern for the bat population.

2. Bats and Wind Turbines

To estimate the risk from wind turbines on different bat species, a systematic literature research has been conducted and several bat characteristics have been selected. In this section, bat species represented in the study area, relevance of the selected bat characteristics and their values, as well as the wind turbine parameters of the study area are discussed.

2.1. Bat Species Represented in Hamburg

There are about 1400 bat species worldwide, of which 25 are represented in Germany (Nature Conservation Directive of the European Union). With the help of acoustical detectors, 7 species were identified in the area of an onshore wind park near Hamburg, Germany, during risk assessment studies in the planning phase (Reimers 2015): Serotine bat (*Eptesicus serotinus*), Daubenton's bat (*Myotis daubentonii*), Common noctule (*Nyctalus noctula*), Nathusius's pipistrelle (*Pipistrellus nathusii*), Common pipistrelle (*Pipistrellus pipistrellus*), Soprano pipistrelle (*Pipistrellus pygmaeus*), Brown long-eared bat (*Plecotus auritus*).

2.2. Relevant Bat Characteristics in Respect of Wind Turbine Casualties

To facilitate data gathering and comparison of different species, 6 groups of bat characteristics have been chosen: body dimensions (body mass, body length, wingspan), flight height (typical height and prediction rate of the bat to fly at heights), flight style and speed, foraging space and distance, response to light, and acoustical characteristics of bat calls (frequency range and intensity).

Bat body dimensions can give a general idea about the size of the carcasses in the event of bat casualties and their distribution possibilities. Comparing a rotor area altitude of a wind turbine with a typical flight height of a bat species, can identify potential conflict and high-risk zones. In the context of "shutdown-on-demand", typical flight speed of bat species can be used to approximate the minimal required distance to detect a bat from the operating wind turbine. Additionally, comparing a typical flight speed of a bat species with a linear speed of a blade at a certain point, one can comprehend the probability for a bat flying in the vicinity of a moving blade to evade it. Preferred foraging habitat by a bat species can to a certain degree predict its presence or absence in a wind park. Maximal foraging distance from a roost could help to estimate the probability of bat species activity near wind turbines, given that the roost locations are known. Bats vision and response to different wavelengths of light are also considered here as relevant, because obstruction lighting of wind turbines can attract or repel some bat species to the turbines.

Frequency range and volume of bat calls are characteristics that limit the acoustic detection distance of bats. Depending on these factors and the settings of the acoustical detector installed in the nacelle of a wind turbine, the detection range can vary greatly, e.g. from 70 m to 10 m (Simon et al. 2015) and less. Often, shut-down algorithms of wind turbines are based on the measured acoustic activity at the nacelle.

Bats are known to be active under certain weather conditions. However, the meteorological parameters are out of the scope of this paper, because they influence bats presence at wind turbines only temporarily. Migration of bat species is not considered for the same reason.

2.3. Known Bat Characteristics in Respect of Wind Turbine Casualties

The species that are represented in the wind park near Hamburg, typically have a head to body length of 35 -80 mm, a wingspan of 190 - 400 mm and a weight of 3 - 30 g (Dietz and Kiefer 2014; Bat Conservation Trust 2008).

According to Dietz and Kiefer (2014), *E. serotinus* bat species typically fly at 10 – 15 m altitudes; for *M. daubentonii* bat species that is 1 – 5 m, and for *P. nathusii* is 3 – 10 m. Seibert et al. (2013) recorded *P. pipistrellus* species at 0.5 – 4.5 m altitudes. Herrchen & Schmitt (2018) name similar values for the flight altitude of the above-mentioned species, and specify the typical flight height of 15 m and more for *N. noctula*, 3 – 6 m for *P. pygmaeus*, and 3 – 15 m for *P. auritus*.

Based on recorded data, Roemer et al. (2017) have predicted the rate of the time bat species spent at higher altitudes, and for the bat species represented in the wind park, the maximum value of 42.7 % is for *N. noctula* and minimum of 0.3 % is for small Myotis group, to which *M. daubentonii* belongs.

Dietz and Kiefer (2014) describe flight styles of *N. noctula* and *P. nathusii* as fast and linear, *P. pygmaeus* as utterly agile, *E. serotinus* as slow. As for *M. daubentonii*, *P. pipistrellus* and *P. auritus*, their flight styles are agile and fast, agile and twisty, agile and slow respectively. Average speed of travel is 5 m/s for *M. daubentonii* (Middleton 2006), more than 14 m/s for *N. noctula* (Dietz and Kiefer 2014) and 4 – 6 m/s for *P. pipistrellus* (Seibert et al. 2013).

Following the classifications of Denzinger and Schnitzler (2013) and of Roemer et al. (2017), *N. noctula* use open foraging spaces, while *P. nathusii*, *P. pipistrellus* and *P. pygmaeus* use edge foraging spaces, and *P. auritus* – narrow foraging spaces; *E. serotinus* and *M. daubentonii* species can use a combination of foraging spaces, open and edge, and edge and narrow respectively. As for the foraging distance, the two extreme examples are *N. noctula* and *P. auritus*. While one species can fly up to 25 km from the roost, the other typically stay within 0.5 – 2 km from the roost (Dietz and Kiefer 2014).

Similar to other characteristics, response to different wavelengths of light is species specific. As red and white lights are used in Germany for wind turbines illumination, only the behavior towards them is considered in this paper. Spoelstra et al. (2017) found no influence of red light on *Plecotus* and *Myotis* species activity and a reduction of it in white light; for *Nyctalus* and *Eptesicus* species, no effect of red or white light on bat activity was observed; Pipistrellus species were observed to be more active in white light and with no change in activity in red light. However migratory bats study by Voigt et al. (2018) revealed that *P. pygmaeus* and with a less extend *P. nathusii* species increased their activity in red light.

For the bat species represented in the wind park, frequency range of calls varied within 17 – 85 kHz (Dietz and Kiefer 2014). The calls intensity measured at 1 m distance for open space aerial foragers, to which belongs *N. noctula*, is 104 – 111 dB SPL; calls intensity for edge space aerial foragers, to which one could allocate *P. nathusii*, *P. pipistrellus* and *P. pygmaeus*, is 101 – 107 dB SPL; for *M. daubentonii* typical call intensity is 120 dB SPL (Denzinger and Schnitzler 2013). *P. auritus* is often described in literature as a quiet or whispering bat, but no explicit values for the call intensities are given.

A summary of the above-mentioned characteristics for bats represented in the wind park near Hamburg is given in the Table 1.

2.4. Wind turbines characteristics

To put things into perspective, the average configuration of new turbines which are being installed in Germany are 3.3 MW nominal power, 133 m hub height and 122 m rotor diameter (Deutsche WindGuard GmbH 2019).

The wind park near Hamburg consists of 5 wind turbines with the nominal power of 2.4 MW and 3.0 MW, hub height of 120 m, rotor diameter of 117 m, operational rotational speed in the range of about 7.5 – 14.1 RPM. The linear speed of the blade tip can vary from 46 to 86 m/s, and the lowest point of the blade tip is 61.5 m above ground. The wind park area is covered dominantly with arable land and grassland with a few ditches, so that wind turbines are located in an open space.

Table 1. Characteristics of bat species represented in the wind park near Hamburg

Characteristics	**Serotine bat (*Eptesicus serotinus*)**	**Daubenton's bat (*Myotis daubentonii*)**	**Common noctule (*Nyctalus noctula*)**	**Nathusius's pipistrelle (*Pipistrellus nathusii*)**	**Common pipistrelle (*Pipistrellus pipistrellus*)**	**Soprano pipistrelle (*Pipistrellus pygmaeus*)**	**Brown long-eared bat (*Plecotus auritus*)**
Body mass	18–25g	6–10g	21–30g	6–10g	3–7g	4–7g	6–9g
Body length	58–80mm	45–55mm	37–48mm	46–55mm	35–45mm	35–45mm	37–52mm
Wingspan	320–380mm	240–275mm	320–400mm	228–250mm	200–235mm	190–230mm	230–285mm
Flight height	5-15m	1-6m	>15m	3-20m	0.5–6m	3–6m	3–15m
Predicted rate	12.7%	0.3%	42.7%	26.7%	11.3%	4.5%	0.5%
Flight style	Slow	fast&agile	fast&linear	fast&linear	agile&twisty	utterly agile	slow&agile
Speed of travel	–	5m/s	>14m/s	–	4–6m/s	–	–
Foraging space	open/edge	edge/narrow	open	edge	edge	edge	narrow
Foraging distance	4.5km	2.3-3.7km	<25km	<6.5km	1.5km	1.7km	0.5–2km
Activity at:-red	retained	retained	retained	retained/increased	retained	retained/increased	retained
-white light	retained	reduced	retained	increased	increased	increased	reduced
Frequency range	22–26kHz	26–85kHz	17–21kHz	35–40kHz	41–46kHz	50–57kHz	24–55kHz
Intensity at 1m	–	100dB SPL	104–111dB SPL	101–107dB SPL	101–107dB SPL	101–107dB SPL	–

3. Discussion

During the conducted literature research, it has been revealed, that the information about body dimensions, typical flight height, flight style, preferred foraging spaces and typical foraging distances from roosts for different bat species is very accessible. Speed of travel or flight speed of different bat species are not very accessible, which is probably due to the agile flight styles of the most bats species in wind park near Hamburg. Bats vision and their response to light is a relatively new research topic, and few studies are published yet, so the information might be refined in the future. Although information about frequency range of calls for different bat species is widely accessible, information about intensity of these calls is not very conclusive, which is probably due to the complexity of the needed setup for a study.

When comparing the data gathered in Table 1 with the description of the wind park, the *N. noctula* species stands out. Due to typically high flight altitudes and preference of an open space for foraging, the habitat of this species highly overlaps with the rotor area of the wind turbines. This indicates a high collision risk possibility, and Dürr (2019) demonstrates that carcasses of *N. noctula* are the most frequently found and registered in Germany with 32.24 % share. The other two species to stand out are *P. nathusii* and *E. serotinus*. Flying typically lower than *N. noctula* and preferring more edge space for foraging, the carcasses finding share is 28.76 % for *P. nathusii* and 1.71 % for *E. serotinus* (Dürr 2019). *P. pipistrellus* and *P. pygmaeus* seem also to have similar characteristics, but their finding share is 19.05 % and 3.65 % respectively (Dürr 2019). The species with the least collision risk possibility for the wind park near Hamburg appear to be *M. daubentonii* and *P. auritus*, which is aligned with findings of Dürr (2019) who documented 0,19 % from all of the found carcasses for each of these species.

The controversy over the finding of Dürr (2019) and the data from the literature research for *P. nathusii*, *E. serotinus*, *P. pipistrellus* and *P. pygmaeus* raise questions about the degree of influence of certain characteristics above others. Do certain wavelengths of light attract some bat species to substantially higher altitudes than they typically use? How will activating obstruction lighting of wind turbines only on need change the found carcass distribution? Are species with frequently found carcasses more represented in the area and what does their frequent killing mean for their population? How to optimize shut down algorithms of wind turbines in order to protect bats? These and other questions are still open and further research is needed.

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