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SUMMARY OF WIND TURBINE IMPACTS ON BATS – ASSESSMENT OF A CONFLICT

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Abstract

The different effects of wind turbines on bat behaviour are discussed here and collisions during bat migrations play an important part. Very little is known about the impacts of turbine ultrasounds. A change in space use due to shifting and loss of summer foraging habitats has been proved for the Serotine bat (*Eptesicus serotinus*), but in the same time the Common Pipistrelle (*Pipistrellus pipistrellus*) was apparently not affected. For wind farm projects it will be necessary in the future, as a matter of principle and as a precaution, to take into consideration the interests of bat conservation.

Introduction

Possible impacts of windmills on bats have been taken into consideration in wind farm projects for quite some time now and have been studied in detail during the last five years (BACH *et al.* 1999a, BERGEN 2001, KRUCKENBERG & JAENE 1999, SCHREIBER 2000, SPRÖTGE 1999).

After the discovery of bat mortality in the U.S.A. the possible effects of wind turbines on bats (BACH 2001, BACH *et al.* 1999b, DÜRR 2001, RAHMEL *et al.* 1999, TRAPP *et al.* 2002, VERBOOM & LIMPENS 2001) were also investigated in Europe. At the beginning wind farms were built on the coast, in open land which is poor in structures and where bat activity is not very important, but nowadays they are set up inland due to the fact that the height of the rotor axle and the output are increasing. They now occupy woods and hedgerow landscape and are also found in the middle of forests; therefore bat habitats are more and more affected. We shall try to summarize here the state of present knowledge on the subject bats and wind turbines.

The problem

The problem appeared for the first time in German literature in1999 (BACH *et al* 1999b, RAHMEL *et al.* 1999). Soon after, during bird mortality studies in the U.S.A., it appeared that the number of dead bats found under wind turbines was sometimes higher than the number of birds (JOHNSON *et al.* 2000). Since then these results have been confirmed by other European studies (AHLÉN 2002, ALCADE pers. comm., DÜRR 2001, TRAPP *et al.* 2002)). The following years, the impacts of wind turbines, which in 1999 were presumed to be negative, appeared to be a reality concerning the hunting habitats of bats (BACH 2002). We now have some data on mortality, but the reasons for it are not clear. The impacts of wind turbines are discussed here, whether they are confirmed or potential.

Four types of problem can be identified (Fig. 1): loss of hunting habitat, barrier effect, mortalitiy due to collision and ultrasound emission. The problems shown on this illustration are all potential impacts associated with wind turbines in operation. But other impacts in relation with the construction and the choose of the site can appear and will also be discussed.

Effects of wind turbines

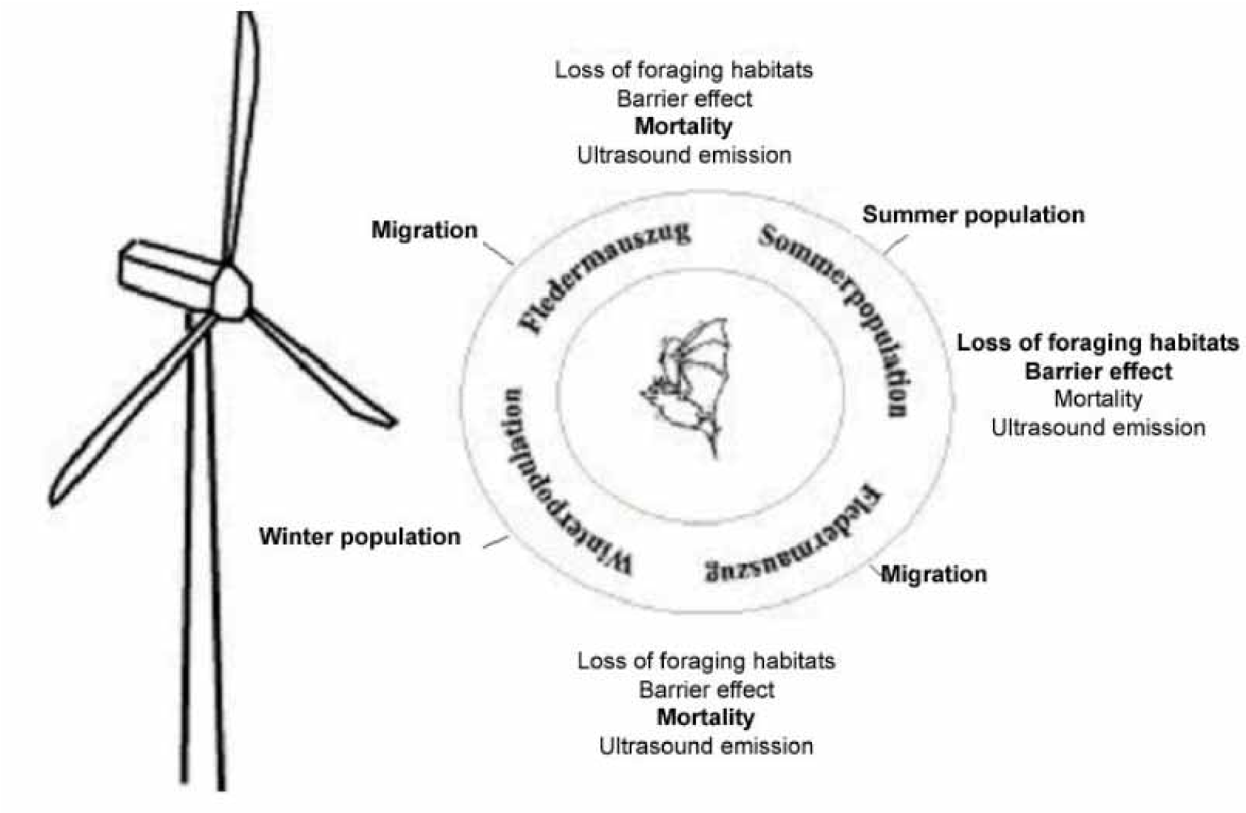

Fig.1: Potential problems of bats with wind turbines (bold in list = supposed main problem)

Disturbance due to ultrasound emission

SCHRÖDER (1997) managed to prove that some types of turbines emit ultrasounds up to 32 kHz, but some others none. Bats react to ultrasounds when intensity and/or frequencies are in the same range as their own sonar calls (NEUWEILER 1980, SCHMIDT & JOERMAN 1986, SIMMONS *et al.* 1978)). However, with the exception of a few single observations, the way bats react to turbine ultrasounds is completely unknown.

Direct loss of foraging habitats

Foraging habitats and foraging behaviour of the different species of bats differ notably. If the Brown long-eared bat (*Plecotus auritus*) has a relatively limited foraging habitat, which in one case was limited to a few trees, the foraging habitat of Natterer's bat (*Myotis nattereri*) – a gleaning species – and of *Myotis brandtii* is much larger, but these 2 species depend greatly on landscape structures and forage along hedges and in the forest. However, besides these species for which no impact due to the rotation of the blades can be expected, there is a whole range of species which are not so much associated with landscape structures but forage along hedges, from *Pipistrellus pipistrellus* and *Eptesicus serotinus* up to *Nyctalus leisleri* and *Nyctalus noctula* which forage regularly in mid-air and up to 150 m above grassland, pastures and forests (KRONWITTER 1988, RUSS *et al.* 2003). In Öland some observations made by Bach and Ingmar Ahlén with a thermal imaging camera show that the Noctule bat flies much higher than the range of the bat detector (max. about 150 m high).

Traditionally most bat species visit probably the same foraging habitats every year. If a wind turbine is set up in this habitat, they will probably learn to recognize the area swept by the blades. One should then expect that bats having an inherited foraging habitat with a new built wind turbine will learn to recognize the windmill due to blades rotation and air turbulences created by the rotor. They will avoid it. Consequently, a wind farm will present a series of individual areas where bats stop to forage. And according to the density of turbines, bats can altogether desert this foraging habitat.

During a 5-year study near Cuxhaven (Lower Saxony, Germany), it was noticed that after the construction of a wind farm (axle height 30 m, rotor diameter 30 m) *Eptesicus serotinus* started to abandon the site as a summer foraging habitat (BACH 2002). However the number of bat observations did not decrease during the same time in a nearby test zone. But in the wind farm, the foraging activity of the Pipistrelle bat increased (Fig. 2, Appendixes I + II) while the number of observations in the test zone was nearly stable. This means that the two species react differently to wind turbines.

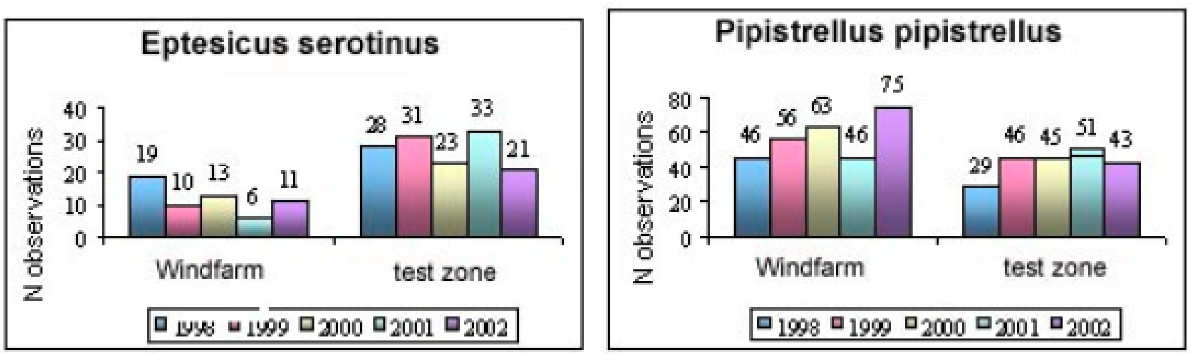

Fig. 2: Evolution in foraging activity of *Eptesicus serotinus* and *Pipistrellus pipistrellus* within the wind farm and the test zone

If the foraging activity around turbines is compared, it is noticeable that *Eptesicus serotinus* stays more than 100 m away (except in 2002 when they foraged along a flight path crossing the wind plant and which was at about 100 m from the nearest turbine). On the other hand, during the 3 years which followed the construction of the wind turbines, the Common Pipistrelle bat foraged increasingly at less than 50 m around the turbines (Fig. 3).

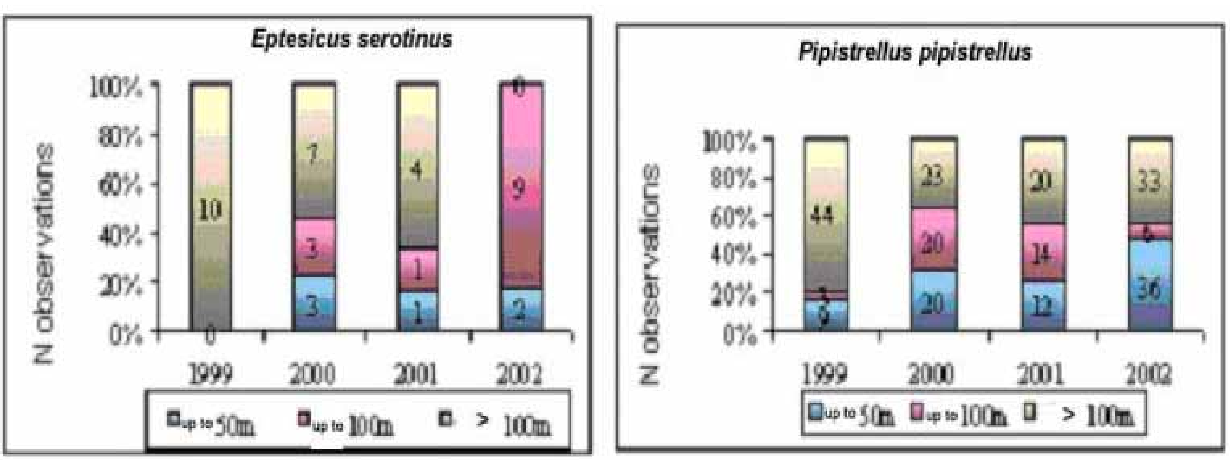

Fig. 3: Foraging activity of *Eptesicus serotinus* and *Pipistrellus pipistrellus* in relation to the distance of rotating wind turbines.

Foraging activity along hedges less than 50 m away from turbines decreased clearly for the Serotine bat, but increased for the Common Pipistrelle to become even stronger than in the hedgerow landscape without turbines (Fig. 4).

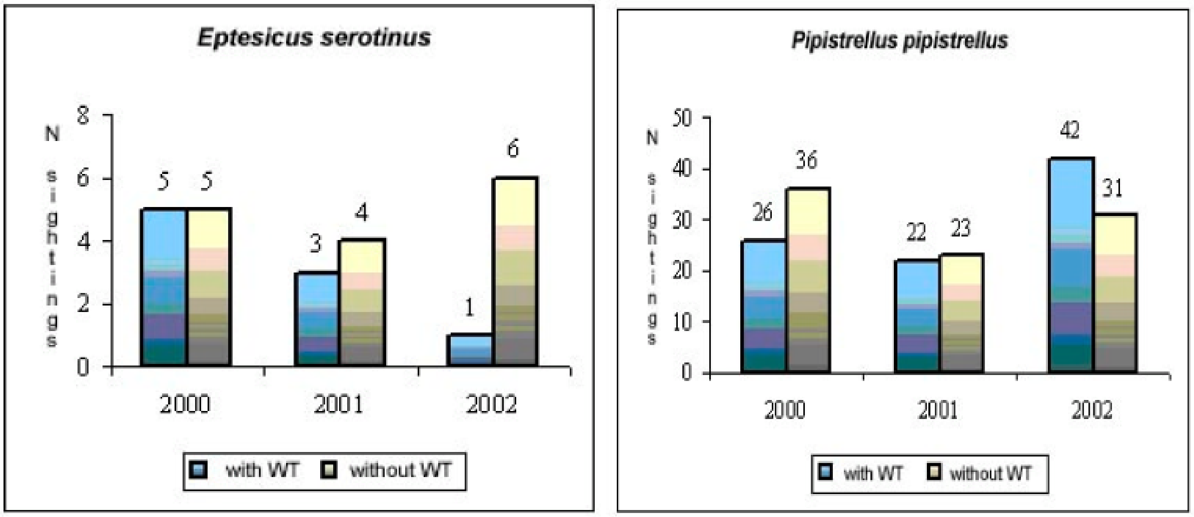

Fig. 4: Foraging activity of *Eptesicus serotinus* and *Pipistrellus pipistrellus* along hedges with Wts (distance < 50 m) and without WTs

Common Pipistrelles even foraged directly in the turbine zone, but their behaviour changed according to the rotor direction in relation to their flight path. When the blades turned parallel to their flight path (a hedge for example), the bats were flying as usual 2- 10 m high along the hedge and flew within 10 m from the rotor. But when the blades were turning at 90° from the bat flight path – the tip being only 10 m from the hedge – the Pipistrelle bats were clearly diving close to the ground (Fig. 5).

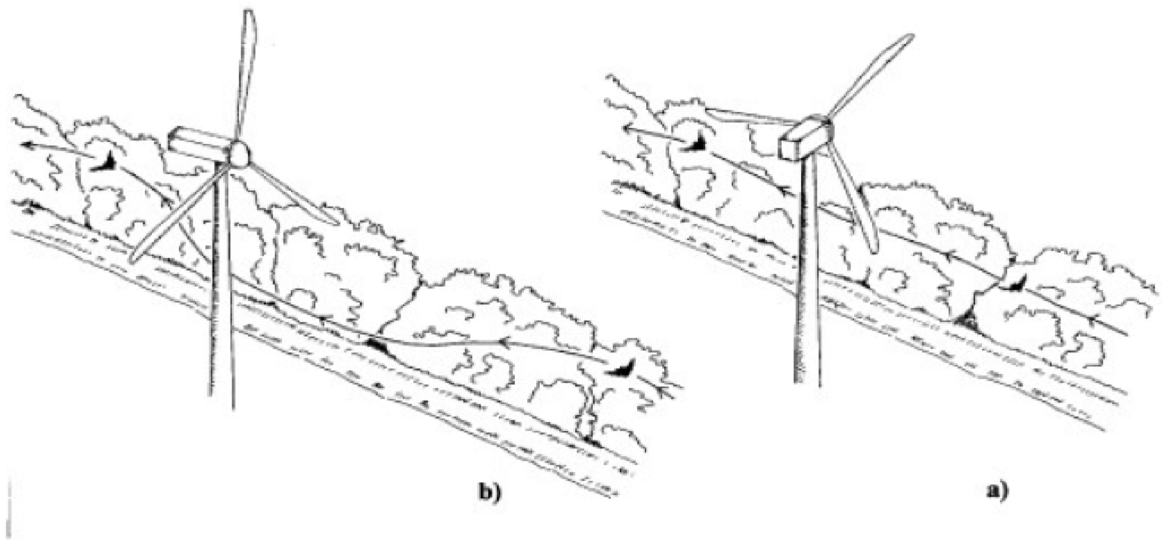

Fig. 5 : Changes in behaviour of *Pipistrellus pipistrellus* in direct vicinity of rotating blades: a) blades rotate parallel to bat flight path, b) blades rotate across the flight path**.**

Altogether and according to Bach's studies (2002), there are some indications that the Serotine bat tends to avoid wind farms while the Common Pipistrelle continues to use these as foraging habitats, but changes behaviour when they come close to turbines. Except Bach's study (2002) that we have just presented, we do not know of any other study on this matter. Only 3 American studies have shown that the presence of large breeding colonies in close vicinity did not result in an increase in summer mortality of the species living close to the wind plants (GRUVER & NICHOLSON *in* JOHNSON in press). But we do not know if these species were also foraging in the wind plant, if they have moved their foraging habitats away from it, etc. This shows the necessity to increase scientific research to collect explanations. This research should include other studies on the Serotine bat and the Common Pipistrelle and extend them to other species such as *Pipistrellus nathusii*, *Nyctalus noctula*, *Nyctalus leisleri* and *Vespertilio murinus*. According to the foraging habits of the two *Nyctalus*, they would probably react as did the Serotine bat, avoid the site and eventually the whole wind farm area. Our own experience in 2002 and 2003 in the district of Stade leads us to think so. We observed Noctule bats avoiding at about 100 m distance a wind farm of 9 medium sized turbines (BACH, SCHIKORE pers. com.). Not a single Noctule bat foraged in the wind farm itself, despite the presence of fallow lands rich in insects, of a hedge and a pond. Here also, Serotine bats were heard only along a track at 70 m away from a middle-sized turbine (one observation for a total of 6 controls).

In addition to the above mentioned impacts, other impacts related to the functioning of the turbines can arise due to the construction of the windmills and the location of the wind farm. The impacts to be expected concern mainly projects in forests. Logging is necessary to create access tracks and clear areas for building the turbines. During the construction phase such operations can mean a loss of foraging habitats for many bats foraging in the woods such as *Myotis myotis, M. bechsteinii, M. nattereri*, etc. The felling of trees can also cause destruction of living quarters. Inside the forest the impacts related to the construction of turbines and to the location of the wind farm may probably be considered as fairly low, as they concern small areas which can be reused by the mentioned species once vegetation has grown again.

Barrier effect: loss or shifting of flight paths

The abandon or shifting of their flight routes or corridors by the bats inside the wind farm is also to be expected and this could bring them to abandon their living quarters altogether. During his study in the district of Cuxhaven, BACH (2002) observed that Serotine bats reduced greatly their foraging habits at the wind farm (see above), but the flight route crossing the wind plant was still used. Common Pipistrelles continued also to follow their flight route (BACH 2002).

For the most concerned species, Noctule bats which fly very high, we have no systematic data. In the already mentioned study in the district of Stade, Noctule bats were observed skirting the turbines at more than 100 m distance. For the two *Nyctalus* species negative turbine-related impacts are expected, but in this particular case one can wonder if these by-pass manoeuvres represent a considerable prejudice.

Collision with the blades (bat mortality)

In addition to the shifting of foraging habitats and the barrier effect for high flying bats, an increase in mortality by collision with the blades has been noted during the last few years. Usually the number of bats killed by turbines is higher than the number of birds (DÜRR & BACH 2004, JOHNSON *et al.* 2000). Mainly migrating species are concerned such as the two *Nyctalus* and *Pipistrellus nathusii* (DÜRR & BACH 2004).

Up to now bat mortality has affected 14 species in Europe and 10 in Germany. Most bat bodies belong to species migrating at the end of summer or in autumn, but some species which are not considered as being typically migrating bats are also affected (DÜRR & BACH 2004). In the U.S.A. cadavers from about one third of the local bat species have been noted (JOHNSON pers. com.) During large scale studies in the U.S.A. about 90% of the victims were found from mid- July and the end of September. Of those 90%, 50% were found in August, but the mortality peak at the end of summer is not due to an increase in dead juvenile bats. This peak corresponds with the migration of the implied species. Up to now it is not clearly understood why collisions occur mainly during the autumn migration and not during spring migration, but it has been mentioned that bats follow other routes in spring and/or have a different migrating behaviour. In the U.S.A. migration of *Lasiurus cinereus* is more widespread throughout the country and less concentrated than in autumn (JOHNSON *et al.* 2003).

This might also apply in the same extend to *Nyctalus spec*. and *Pipistrellus nathusii* in Europe. In Germany also it seems that resident bat populations are not concerned. In the U.S.A. also foraging individuals are thought to be untouched by the blades as bat activity close to wind turbines is too low and aero-generators are situated in habitats unsuitable for foraging. For example, no capture buzz has been recorded with bat detectors (JOHNSON *et al.* 2003). However in Sweden, Ahlén could watch some foraging bats being hit by the blades (AHLÉN 2002).

The reason for bat collisions with wind turbines or other man-made structures (communication towers, etc.) (OSBORN *et al.* 1996, JOHNSON *et al.* 2003) is still unexplained. In relation to this, "bad weather conditions" have been discussed (VAN GELDER 1956) but could not be confirmed (AHLÉN 2002, JOHNSON *et al.* 2003). The other possible reasons are also a greater attraction of the space around the nacelle due to the radiating heat and the consequently higher density of insects in this area during cooler nights (AHLÉN 2002); a "non-perception" of obstacles due to insufficient echolocation during migrating flights (AHLÉN 2002, BACH 2001, CRAWFORD & BAKER 1981, DÜRR & BACH 2004, JOHNSON *et al.* 2003) and a miscalculation of the rotor velocity. It becomes more and more obvious that bats probably have difficulties in correctly evaluating the movement and the speed of the blades, a fact which once more is backed up by the results in the U.S.A. where some animals have been victim of wind turbines, but not from weather towers installed at wind farms (JOHNSON, pers. com.)

It is impossible to express an opinion on the consequences that this mortality will have on bat populations, if only because up to now very little is known on the volume of bat migration. However with the projects which started in 2004 it is obvious that the mortality impact has been up to now largely underestimated due to the lack of systematic studies.
Research on all theses questions has become peremptory to respond to the needs of bat conservation in landscape planning (see RAHMEL *et al.* 2004).

Consequences for nature conservation and sites management

In short, so far 10 bat species living in Germany have been killed by wind turbines (DÜRR & BACH 2004) and probably 2 to 4 species have suffered a loss of foraging habitat. All bat species are protected by law. Because they were threatened by food poisoning (toxic elements in their food), loss of foraging habitats and destruction of their living quarters, etc., nearly all bat species occurring in Germany have been inscribed on the German Red List (BOYE *et al.* 1998). During past years the German Federal Republic has ratified a series of international conventions for bat protection and among others the "Agreement for bat conservation in Europe" (Bundesgesetzblatt 1993, II: 1106-1112). This agreement concedes a very important political position to bat conservation. If only by the political obligation that the German Federal Republic has to protect bats, it is more than ever necessary to take bats into consideration when it comes to projects which might cause considerable harm to this group of animals. According to Louis (1991) the above mentioned arguments about wind turbine impacts on bats make it necessary for detailed studies on bats, within the framework of wind farm projects, to be carried out. The standard methods for these studies will not be discussed here; you can refer to the study procedures published by RAHMEL *et al.* 2004.
To reduce the present lack of knowledge about bat mortality, the influence on foraging behaviour and the use of space by bats, scientific studies over several years in already existing wind farms or BACI studies (Before After Control Impact) for future projects are necessary. These studies should take place in different regions of Germany in order to take into consideration the local results for the different species. At the same time studies should focus on collision causes (see DÜRR & BACH 2004).
On the base of our present knowledge and when it comes to migration periods, the precaution principle must always prevail in the absence of detailed studies to avoid possible harm to bats. When a migrating activity has been noticed this can means that either some turbines or the entire wind farm can be called into question or the turbines will be stopped during migration, this even without knowing precisely the causal relationship. Currently it is impossible to answer all questions put to bat workers by the wind energy industry in order to develop their projects in a perfect technical way. For further research it is important to ask oneself the following:

<u>Migration</u>

- What is the flight altitude of bats during migration?
- What migrating routes/corridors do they use?
- How intensive do they use echolocation during migration?
- What other senses do they use and to which extent?
- Which are the landscape features they use for orientation (coast lines, rivers, other linear structures)?

<u>Problem of bats/wind turbines</u>

- How do high flying species (e.g. *Nyctalus*) behave when they face wind turbines in their foraging habitat?
- Which factors lead to bat mortality by wind turbines (weather, blade rotation)?

- Which consequences has this mortality on bat populations?
- Which methods can be used to investigate bat behaviour confronted with wind mills and bat mortality?
- How can bat mortality be avoided?
- Are there possibilities to increase the notabiliy of wind mills for bats, e.g with automatic ultrasound emitting devices?

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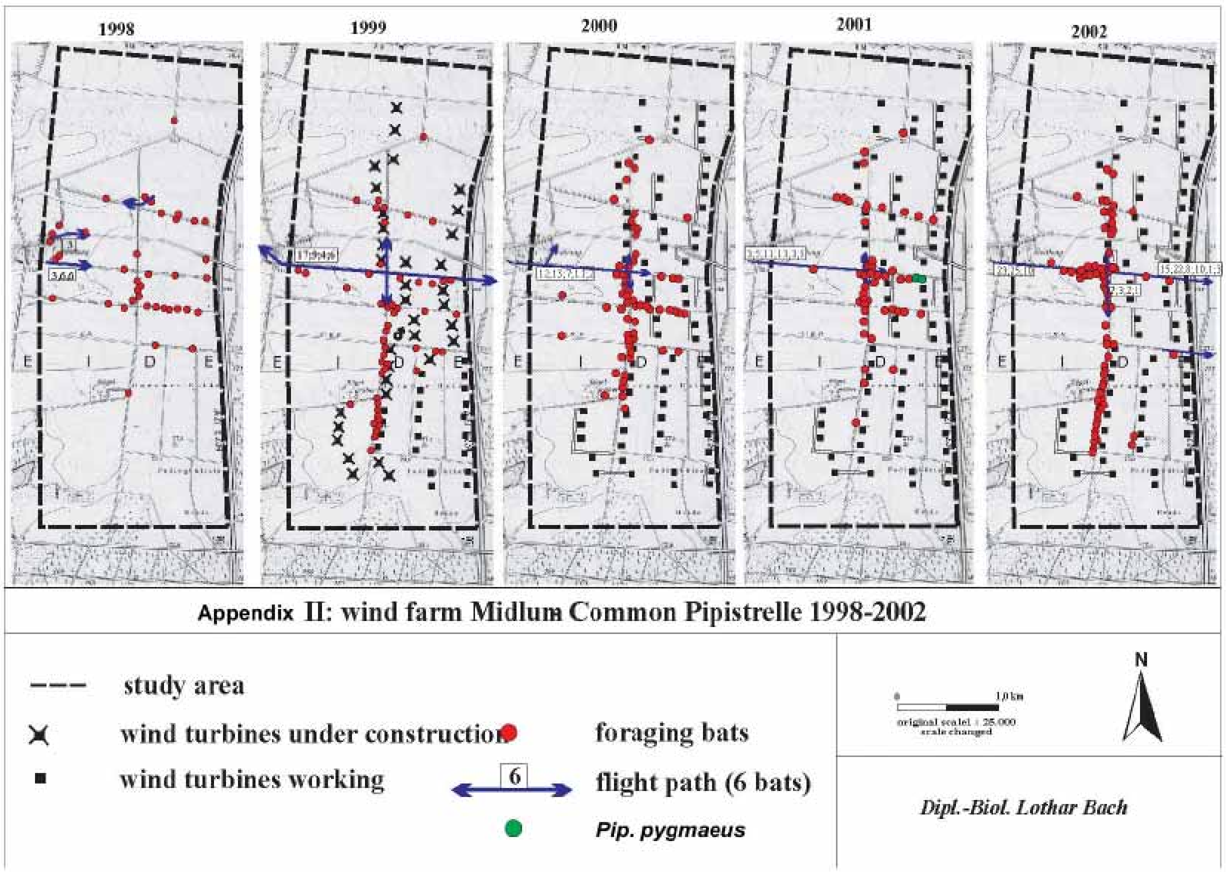
Appendixes

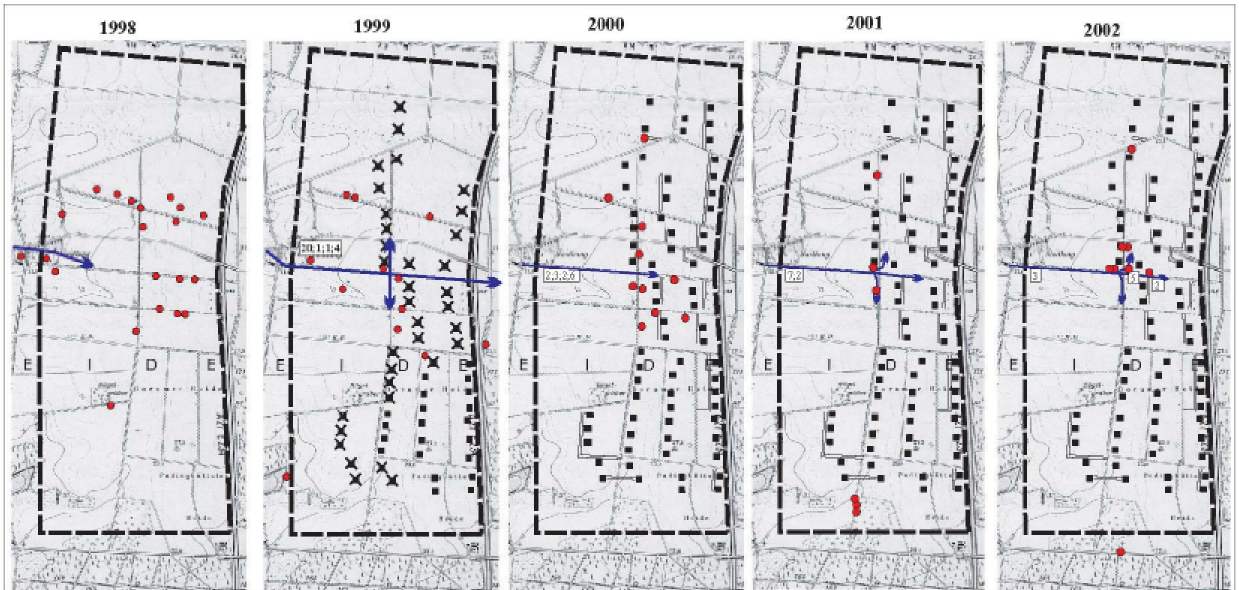
Appendix I: Wind farm Midlum – Common Serotine (*Eptesicus serotinus*) 1998-2002

Appendix II: Wind farm Midlum – Common Pipistrelle (*Pipistrellus pipistrellus*) 1998-2002

Appendixes



Appendix II: wind farm Midlum Common Pipistrelle 1998-2002



Appendix I : wind farm Midlum- Serotine Bat 1998-2002