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Wind turbines and bats — a pilot study

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Summary:
Wind turbines and bats – a pilot study. *Bats killed by wind turbines were detected in Sweden in 1999. A pilot study to examine the problem was conducted in 2002 and 2003 to suggest further research, actions, and recommendations. Field studies were focused on causes of fatalities and importance of location in the landscape. Acoustic attraction of bats was studied by experiments but results did not support the hypothesis. Attraction of insects was found to cause concentration of hunting bats. Observations with heat image camera at the towers showed that bats frequently hunted insects close to the rotors. The ground under 160 turbines in the provinces Gotland, Öland, Blekinge and Skåne was searched once for killed bats and birds. The result was 17 bats of 6 species and 33 birds of 17 species. Around half of the bats belonged to resident species, while the rest were migrants. All were in the group aerial hawking bats. Almost one third of the birds were swallows and swifts, species that like bats hunt flying insects. The location of the turbines in the landscape was evidently important for the risk of fatalities. Investigations needed prior to planning and locating turbines are recommended. Further research is suggested on bat migration, flyways, accumulations, and coastal points where bats leave and migrate across the sea. More knowledge is also needed about critical areas for the resident bat fauna. Experiments are suggested to test how modifications of turbines can minimize the attraction of insects.*

Introduction

In September 1999 several dozen dead bats were reported seen at the foot of a wind turbine on the west coast of Gotland. At that time, the phenomenon was completely unknown in Sweden and a literature search revealed nothing published on the subject. Correspondence with researchers in different countries showed, however, that dead bats of different species had recently been discovered near certain wind turbines in U.S.A., Spain, Germany and Australia. Not yet published data suggested that the problem could be serious and that more knowledge should be drawn together before decisions are made regarding the locations of too many new wind turbines.

Together with Sten Ljunggren, professor in acoustics at Royal Institute of Technology (KTH) in Stockholm, I applied for funds in order to carry out a pilot study. The application was forwarded 2 May 2000. On 18 February 2002, I was informed that 150.000 SEK out of the 429.543 SEK applied for, had been granted. We assessed that it would still make sense to carry out a pilot study, even though it obviously was not possible to implement all that we had planned originally with 35% of the budgeted amount. Sten Ljunggren's role was first and foremost to plan the acoustic part, but he also participated in the interpretation of other results. Other participants in the project work were: Tech. dr. Olivier Fégeant, KTH, Stockholm, Lothar Bach, Bremen, Germany and Johan Ahlén, Stenungsund.

Problem definition

Since all species of bats in Europe use the echo of their own ultrasound (sonar) to avoid obstacles and to find and catch flying prey (mostly insects), wind turbines were not expected

to pose any problem. Explanations are needed as to why bats die in order to be able to do anything about it. It must also be asked whether the placement of the wind turbines in the landscape has an influence on the accidental deaths. Possible steps are, therefore, both whether the wind turbine construction needs to be modified, and whether it is possible to avoid high risk sites. The aim of this pilot study has been to take a closer look at these issues. Some questions are expected to be clarified, other will require further research.

Implementation

The pilot study was carried out with the aid of ultrasound detectors, powerful search-lights and a portable heat-image camera. The work was carried out mostly during late summer and fall of 2002 with certain conclusions made in the fall of 2003. The behaviour of the bats was studied in the proximity of wind turbines and in experiments in order to test the hypothesis of acoustic attraction. The fields surrounding 160 wind turbines were searched for dead bats and birds. Experience from other countries was studied through correspondence, literature and through discussions with experts in other countries, including, amongst others, a visit to U.S.A. in the spring of 2002. The outcome of the study has been formulated and has resulted in some recommendations and suggestions for further research.

Reasons for collisions with wind turbines

Various different hypotheses have been advanced as to why bats collide with wind turbines. When considering how few the bats are, often averaging a few bats pr. km², the likelihood of colliding with a wind turbine should be quite small. In order to explain why several dead bats have been found at certain locations, one must suppose that they have concentrated in certain areas, e.g. through search for food or, when migrating, by following guiding outlines in the landscape and thus passing certain locations. As these areas are near wind turbines, it has also been speculated whether the bats may be attracted by the sound of the blades, or whether it is the turbulence in the air which causes the accidents. The theory has also been advanced that exhausted, migrating bats see the wind turbine as a tree to rest in. It is also widely held that migrating bats do not use their sonar and therefore are more prone to collide with unnatural obstacles.

The hypothesis of acoustic attraction

The blades from certain wind turbines emit a sound which reminds of ‘vinare’, i.e. the instrument used for catching bats in the past. Acoustic sound studies of the blade show that these bring about low frequency AM-sounds that can be heard at a great distance. I have, under favourable conditions, been able to hear sound from a wind turbine from a distance of more than 2 km. Naturally, we first wanted to test the hypothesis of acoustic attraction. The pilot study began by testing whether flying bats reacted or could be attracted by sound like the one emitted by certain wind turbines. Recordings of sound were played through powerful speakers on some of the locations where bats hunt, and where there was sufficient open space for viewing reactions. Later in the season, similar sound recordings were played when migrating bats passed by. We also tried with reconstructions of the ‘vinare’. It is, however, unclear whether the ‘vinare’ worked because of sound or movement. Our observations were, in general, difficult to interpret, because hunting bats usually take many twists and turns. In no cases did we see any reactions that, with no uncertainty, could be interpreted as attraction. It is, however, very difficult to set up objection-free experiments. I was not able to find any instances of acoustic attraction, but cannot reject the possibility that a certain attraction may exist. After this pilot study, however, I judge it to be less probable and, in any case, not the primary explanation of the accidents. In several instances, both in 2002 and 2003, I observed groups of bats that flew quite close to the rotor blades, even during nights without wind when the blades were motionless and did not emit any sound.

The hypothesis that bats do not use echolocation during migration
There is no definite knowledge of how bats orientate themselves back and forth between summer and winter habitats. In all circumstances, it can be excluded that they orientate themselves by normal echoes of their own ultrasound when flying at high altitudes. The opinion has also been that bats emit sound sparingly, in order to save energy, or at least emit sound less frequently, and therefore will collide with unnatural obstacles when flying. The issue is very difficult to study. My observations at the coasts of southern Sweden during migration show that passing bats of migrating species sound normal but have a slower rhythm. This is the case with those bats that just pass by and do not stop to hunt or rest. With regards to the bats that fly at higher altitudes we only know that it seems as if some species fly at very high altitudes. We now know that noctules (*Nyctalus noctula)* at Falsterbo regularly fly up to an altitude of 1200 m and even hunt for insects at this height.

The hypothesis that exhausted bats believe they have found a tree to rest in
It must be very difficult to test this hypothesis. For various reasons I believe it to be less likely and it is hardly the primary explanation of the accidents at land-based wind turbines, as there are often trees nearby. This is more likely to happen at offshore turbines because the bats may be exhausted after flying across the sea.

The hypothesis of insect attraction
Observations were made near wind turbines where several dead bats had been found in order to study the activity and what actually took place. The studies showed immediate results. There was a clear concentration of hunting bats in the area. These were both non-migrating species, which make for the coasts with insect-rich habitats after the time spent in nursery colonies, and migrating species which pass by or come closer to hunt insects. From time to time, they hunted insects very closely to the blades and were seen to fly between the blades several times. On some nights, there was also a clear concentration of flying insects surrounding the wind turbine. One reason for this may be heat radiation from the wind turbine. Using a heat image camera, it could be seen that the top part of the tower, the blades and the generator were warmer than their surroundings during evening and early night. It has, furthermore, long been known that certain groups of flying insects, e.g. butterflies, in some instances gather at high points in the landscape, also known as “hilltopping”. Observations showed that the attraction of insects to the wind turbine caused a concentration of hunting bats of both migrating and non-migrating species. It was the same species that we later found dead near the wind turbine.

Bats killed by wind turbines
We searched the fields by those wind turbines where we had observed bats hunting dangerously close to the blades and found several recently dead bats. In the course of a couple of weeks, we searched the fields below 160 wind turbines in Gotland, Öland, Blekinge and Skåne. In total, we found 17 bats of 6 species and 33 birds of 17 species. For further details see Ahlén (2002). As stated here, it is not possible to express an opinion regarding the extent of the problem on the basis of such a search, but the result does give an idea of which species are involved and where in the landscape it may take place. The bats are exclusively aerial hunters, the species that hunt in open space, and not gleaners, those that hunt close to ground or foliage. It is furthermore clear that both migrating and non-migrating species are killed. It was previously maintained in U.S.A. that it was almost exclusively migrants that were killed. This is not the case in Sweden. The locations in question are situated in the flying corridors of the migrating species and/or the so-called critical areas of non-migrating species (habitats rich in insects early or late in the season), i.e. in both cases areas where bats from time to time concentrate in small areas or passages.

Results

This pilot study has clearly confirmed that wind turbines may pose a serious problem for bats in Sweden, as in several other countries. Bats are slow to reproduce (usually the adult female has one young bat a year) and a long life expectancy (maximum age can exceed 30 years). A new mortality factor cannot be compensated for easily as with several smaller mammals and several bird groups with larger and sometimes more frequent broods. Internationally, the problem is now judged to be more serious for bats than for birds. The results of the pilot study imply that the greatest risk with wind turbines in Sweden arises when bats, migrating and non-migrating, are tempted to hunt insects that concentrate around wind turbines. In order to diminish the chances of accidental deaths, it should be avoided to place wind turbines in areas with a high concentration of bats, i.e. along flying corridors of migrating bats and critical areas of non-migrating bats. It should, furthermore, be attempted to change the construction of the wind turbine in order to reduce insect attraction.

Recommendations until further knowledge is available

Before planning and permitting new wind turbines it is always necessary to assess the risks involved for bats. The highest risk areas seem to be along certain coastlines and other areas which also attract a high concentration of insects, particularly in the autumn. At present, there is quite a lot of information available regarding migration and flight routes, and which types of nature can be critical areas. It is impossible today to exactly predict patterns of movements and utilization of habitats in areas that have not been investigated yet. This implies fieldwork activities for at least one season, before any risk assessment can be made. The need to do so follows clearly from: the Agreement on the Conservation of Populations of European Bats (UNEP/EUROBATS), under the jurisdiction of the Bonn Convention. It was signed by Sweden in 1992 and put into operation 16 January 1994.

With regards to off-shore wind farms, it should not be permitted to place these in line with known migrating corridors. Sites for turbines on land should be avoided along the coastline and near larger lakes. In agricultural areas, the turbines must not be placed in line with rows of trees, avenues, dikes, canals, creeks or lakeside beaches.

Critical areas are habitats where bats congregate late in the season (August-September, possibly also in the beginning of October) as there is a local abundance of insects at a time when there are no flying insects elsewhere. A similar phenomenon takes place during spring. Examples of critical areas are wetlands and groves of deciduous forest close by lakes or watercourses, as well as marsh areas and lagoons in coastal meadows. Wind turbines should, therefore, not be placed in or near critical areas for bats. Locating such areas can only take place through studies with ultrasound detectors.

Suggestions for research and practical experiments

More knowledge and experience is needed in order to solve the problem positively. The two most important issues to continue working on are the significance of the wind turbine site in the landscape and possible modification of the turbines to reduce the risk.

The site in the landscape is of crucial importance to the risks. It is important that present surveys of the bat fauna in the provinces summertime are provided with funds to be able to reach completion. There is a further need for studies of the bat migration in parts of southern Sweden, i.e. investigations of the location of important flyways, with concentrations, collections and points where they take off for migration across the sea. At a meeting in Finland, the countries surrounding the Baltic Sea recently discussed to start a cooperation on these questions which in 2004 will result in a proposal for a project where Sweden is expected to participate in both planning and implementation.

Experimental modification of wind turbines should be able to indicate whether insect attraction can be reduced, e.g. through testing of towers with an open steel structure

(like the Eiffel-tower) in comparison with the present types covered by white plates. Experiments with other colours than white could also be interesting.

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