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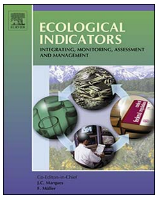

Case study

Effects of wind turbines on spatial distribution of the European hamster

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ABSTRACT

Rapid worldwide growth of wind energy is an important factor that is changing agricultural areas and affecting wildlife. The impact of wind farms on ground-dwelling animals is poorly recognized. Such lack of knowledge is disadvantageous, particularly in the case of rare and protected species, because it may lead to incomplete or inappropriate conservation strategies. We studied whether wind turbines through their vibration and visual or acoustic impact contribute to fragmentation of the environment and change the spatial distribution of the European hamster *Cricetus cricetus* (a small mammal, threatened with extinction) within wind farm areas. The study was conducted at three wind farms in Poland. The hamsters' burrows were counted along 218 transects near turbines (up to 150 m), at intermediate distances (200–500 m), and outside of wind farms (1–5 km). We did not find any evidence that wind farms in their operational phase cause habitat fragmentation for the European hamster and change its spatial distribution. The studied species occurred even near wind turbines, within the zone of the most intense noise and ground vibrations. Possible explanations for the spatial patterns of hamsters' distribution around wind turbines and their implications for the conservation strategy of this endangered species in contemporary agricultural habitats are discussed.

1. Introduction

Agricultural areas provide habitat for many wild animal species (MacDonald and Feber, 2015). The process of adaptation of wildlife to live within farmlands began in Neolithic agricultural times. Following the spread of agriculture in the last few thousand years, many species have considerably expanded their geographical range (Nechay, 2000; Sætre et al., 2012). Since around 1900, agriculture has entered a new phase of modern agronomy characterised by a considerable productivity increase, mechanization, and large-scale monoculture farming with the widespread use of pesticides and fertilizers. This transformation from extensive to intensive farming has had a negative impact on wildlife in agricultural areas and many species that were formerly abundant there have become endangered with extinction (Henle et al., 2008; Surov et al., 2016; Tissier et al., 2016).

Nowadays, an additional factor that is changing agricultural landscape is the construction of wind turbines within cultivated fields. Wind energy is experiencing rapid worldwide growth and many wind turbines are located in agricultural areas (REN21, 2014). Farmers are being encouraged to accept wind turbines on their land by means of financial benefits (steady, not weather-dependent income), the relatively small loss of land from agricultural production, and road infrastructure improvements. The construction of wind turbines on farmlands usually requires an environmental impact assessment (EIA) procedure, which includes an estimate of the effect upon agricultural wildlife (Lintott et al., 2016). Special attention is paid to flying animals (birds and bats) which are exposed to the threat of direct mortality due to collisions with rotor blades (Drewitt and Langston, 2006; Rydell et al., 2010). Much less attention is given to ground-dwelling animals living in the vicinity of wind farms. One of the reasons that such species are not taken into account in the EIA report is the fact that the effects of wind turbines upon terrestrial, non-volant wildlife remain largely understudied and lack of data is interpreted as a lack of influence. Meanwhile, the home ranges of such animals, which in many cases are quite small, may entirely overlap with wind farm areas. Thus, these animals may be permanently exposed to various potentially negative impacts such as destruction and modification of habitat, noise, visual impacts, vibration and shadow flicker effects, micro-climate change, predator attraction; increased fire risk and vehicle-related injuries on wind farm roads (Lovich and Ennen, 2013). The lack of knowledge of the effects of wind farms is disadvantageous in particular for rare and protected species that are already at risk from other forms of human development (Lovich et al., 2011; Lovich and Ennen, 2013). Moreover, the deficiency of scientific information may lead to incomplete or inappropriate conservation strategies resulting from EIA procedures (Lintott et al., 2016).

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In the European Union (EU), an example of a ground-dwelling animal that is typical of agricultural areas is the European hamster *Cricetus cricetus*, a rodent that is now rare and threatened with extinction (Kryštufek et al., 2008; Surov et al., 2016). Nowadays, in western and central Europe, this species is entirely dependent on agriculture because farmlands and human settlements occupy its original fertile steppe habitats (Nechay, 2000). The European hamster is protected in many European countries and is listed in Appendix II of the Bern Convention and EU legislation (Appendix II and IV of the Habitats Directive) (Kryštufek et al., 2008). The effect of construction and functioning of wind farms upon this species is not yet recognized (Ulbrich and Kayser, 2004), which prevents formulation of credible and reasonable conservation strategies for wind farm projects within areas of its occurrence.

The aim of this work was to investigate whether newly constructed wind turbines cause fragmentation of the environment and alter the spatial distribution of the European hamster through vibrations and visual or acoustic impact. We hypothesized that because of the high intensity of noise and ground vibrations near turbines, the density of hamster burrows would be lower there compared to zones situated several hundred meters away and control areas not influenced by the functioning of a wind farm.

2. Methods

2.1. Study area

The study was conducted in the area of three wind farms in south-east Poland (central Europe) in Tyszowce (N50°36′; E23°44′), Jarczów (N50°27′; E23°36′) and Tomaszów Lubelski (N50°26′; E23°30′). All these farms are novel elements in the landscape because they have been operational for just one year. The surveyed farms consist of 15, 17 and 10 wind turbines respectively. The power rating of a single turbine there is 1.8 MW, its tower is 95 m high, and the diameter of the rotor is 100m. All these turbines are located in arable fields within the current geographical range of the European hamster (Ziomek and Banaszek, 2007). The region of the study is characterized by agricultural landscapes with small farms, high fragmentation of field crops and low percentage of wooded areas. Such habitat conditions are suitable for the European hamster.

2.2. Studied species

The European hamster is a solitary burrowing rodent (weighing 220–500 g) which occurs naturally in fertile steppe and grassland habitats; however, the development of agriculture has allowed considerable extension of its range in Europe. It prefers deep, heavy soils where it is possible to dig extensive burrows. Hamsters are strongly territorial and one burrow is used by one individual only (except for the mother with young). Males occupy larger territories (0.5–2 ha) than females (0.1–0.6 ha). The diet of this species mainly consists of green parts of plants and seeds, supplemented by invertebrates and small vertebrates (Kryštufek et al., 2008; Nechay, 2000). This species was common in times of extensive farming but nowadays has declined in almost all European countries, and locally is recognised as extirpated (La Haye et al., 2012; Surov et al., 2016). While endangered or critically endangered over the majority of its European range, in Western Europe it has become a totally conservation-dependent species (Kryštufek et al., 2008; Weinhold, 2008). In Poland, the present distribution of this species covers only about 25% of its former range, as was estimated in the early 1970s (Ziomek and Banaszek, 2007).

2.3. Assessment of hamster occurrence and relative abundance

The method used in this study was based on an inventory of hamster burrows along linear transects situated in arable fields. Transects were five meters wide and about 500 m long. All transects were GPS marked and categorized into three groups depending on the distance from a turbine:

Table 1
Characteristics of transects categorized into three groups depending on the distance from a wind turbine.

	Location of transects		
	up to 150 m from the turbine tower	200–500 m from the turbine tower	1–5 km away from wind farms (control)
No. of transects	79	43	96
Mean length of transects [m]	513 (SD = 42)	501 (SD = 43)	515 (SD = 50)
Total length of transects [m]	40 532	21 523	49 475
Types of crops along transects [% of length]	cereals[a] − 95% canola − 3% other[b] − 2%	cereals[a] − 94% canola − 4% other[b] − 2%	cereals[a] − 95% canola − 4% other[b] − 1%
No of hamsters' burrows found	156	69	175

[a] Wheat, barley, oats.
[b] Peas, sugar beets, and carrots.

(1) The first group of transects was located near wind turbines up to 150 m from the turbine tower within the area mostly affected by noise and vibrations. Detailed characteristics of transects are provided in Table 1. Because the transects had to fit in a circle with a radius of 150 m, each of the 500 m transects consisted of several (usually 2–4) sections situated in neighbouring fields (e.g., 200 + 200 + 100 = 500 m). The fields in the study area are usually narrow and long, and transects were usually oriented along the longer axis of these fields. If possible, we tried to make only one transect line in a single field.
(2) The second group of transects was located 200–500 m from the turbine tower in the area less affected by noise and vibration (detailed information in Table 1). A maximum distance of 500 m from the wind turbine was selected, because at that distance turbine noise is similar to background noise (data from EIA reports). In this type of location we set up transects in a similar manner as near wind turbines i.e., each of the 500 m transects consisted of several (usually 2–4) sections situated in neighbouring fields and we tried to place only one such section within a single field.
(3) The third group of transects was located in control areas 1–5 km away from wind farms (Table 1). Control areas were supposed to represent the crop types, topography, and nature of the surroundings (distance to human settlements, roads, and forests) similar to those around the wind turbines. Also, those control transects were plotted with the same methodology as described above.

The survey was performed in August after the harvest, but before the time of ploughing, so hamster burrows could be counted relatively easily. Every European hamster burrow encountered along transects was recorded with a GPS device. We counted burrows with clear signs of use by animals. For each transect, the types of crops were also recorded (Table 1).

2.4. Data analysis

For easier comparison of results obtained from transects of various lengths, we standardized data using the following formula: $x_i = (a_i*100)/b_i$, where x – number of burrows per 100 m of transects, a – the number of burrows along the *i*-transect, b – the length of the *i*-transect, *i* – the number of the particular transect. The relative abundance of hamster burrows (expressed as the number of burrows per 100 m of transect) was compared between wind farm locations and control sites using a nonparametric one-way ANOVA, with ranks (Kruskal–Wallis