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# Effects of local roads and car traffic on the occurrence pattern and foraging behaviour of bats

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ABSTRACT

The most negative impacts of roads on bats are increased mortality caused by collisions with vehicles, noise pollution reducing both communication and foraging, and barriers to movement. To test the effect of roads and traffic on the occurrence and foraging habits of bats in forested landscapes in western Poland we compared 53 sites located along local asphalt roads of low to medium traffic volume with paired reference sites on unsurfaced forest roads. Acoustical monitoring systems with Anabat detectors were used at night to detect bats at all sites. Overall, we found a strongly significant preference of bats for local asphalt roads; 640 bat passes were recorded at asphalt roads but only 271 at reference sites. Furthermore, significantly more bat taxa, longer activity and a greater frequency of feeding buzzes (calls used during foraging) were also recorded at asphalt roads. However, significant benefits were not shown for all species. This study clearly shows that local asphalt roads in forested landscapes are important foraging areas for several bat species.

## 1. Introduction

The intensive development of road systems has resulted in traffic affecting most animals, especially during migration or dispersal. Roads cause the loss, deterioration and fragmentation of adjacent habitats (Forman and Alexander, 1998). Hence they negatively affect the local populations of many animals, reducing the density and diversity of species (Benitez-Lopez et al., 2010; Summers et al., 2011). Obviously, roads have a more direct effect on individuals via mortality due to collisions with passing vehicles (e.g. Lesinski, 2007; Russell et al., 2009; Lesinski et al., 2011). Chemical and noise pollution may also directly reduce reproductive success and alter the behaviour of animals living in the vicinity of roads (Barber et al., 2011). Noise pollution can reduce hunting success, especially for bats that rely on prey-generated sounds to locate their victims (Siemers and Schaub, 2011).

Previous research has indicated negative impacts of roads on bat populations. Traffic increases bat mortality through collisions with vehicles (e.g. Lesinski, 2008; Gaisler et al., 2009; Russell et al., 2009; Lesinski et al., 2011). However, relatively few articles are based on data that would allow an evaluation of other interactions between bat populations and traffic. Noise pollution from roads has been shown to reduce the foraging efficiency of the greater mouse-eared bat (*Myotis myotis*) which primarily hunts for insects

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moving on the ground and uses passive listening to locate prey (Schaub et al., 2008; Siemers and Schaub, 2011). Detrimental effects on other bat species have also been reported (Bunkley and Barber, 2015; Luo et al., 2015). Berthinussen and Altringham (2012) showed a negative impact of high volume traffic (30–40 thousand vehicles per day) and of wider roads, which caused bats to avoid foraging near the road. For some species, roads are a movement barrier (Kerth and Melber, 2009; Abbott et al., 2012). For example, Indiana bats (*Myotis sodalis*) were reported to avoid crossing roads, especially in the presence of vehicles (Zurcher et al., 2010). Moreover, light pollution can reduce foraging areas and result in negative behavioural changes in foraging bats (Stone et al., 2009, 2012; Polak et al., 2011). On the other hand, there are many examples of the regular use by bats of street lighting in order to forage (e.g. Rydell, 2006), and despite examples of the negative impact of road development on bat populations, some bat species regularly use human-transformed habitats. Some of these species may now be regarded as synanthropic and regularly use buildings for hibernation, daily rest, and reproduction (Hale et al., 2012). Moreover, vehicle lights may lure insects to roads and consequently affect bat foraging behavior, and the presence of some species is positively associated with road cover at a small scale (Bellamy et al., 2013). However, the impact of roads on bats is still not well understood. For example, some papers suggest that bats avoid cars, but this was tested only on larger roads (Bennett and Zurcher, 2013), and there is no single study on the importance of more common road types of low or medium traffic volume, especially in Eastern Europe. In consequence, this prevents the development of specific mitigation measures.

In this paper, we address the question of how local roads affect the number of bat passes, species richness and behaviour of foraging bats. If traffic on roads only has a negative effect on the foraging of bats then we would expect lower bat densities near roads than in reference areas. Moreover, we analyse how the movements of individual cars affected bat foraging patterns. If bats really avoided car traffic then bat activity will be lower when the car is passing, because of an avoidance behaviour in response to an approaching vehicle. However, if bats do not respond to passing cars then we expect that bat activity will be randomly distributed in time, independent of car movements.

## 2. Methods

### 2.1. Study area

The study area in the Wielkopolska region of western Poland included local roads of low to medium traffic volume (up to 250 cars/h at night; asphalt width 5.4–11.2 m) within forests and extended over 170 km in a north-south direction (51°29′–53°01′N) and 60 km east-west (16°49′–17°48′E). The landscape of the studied area is characterized by a high proportion of arable land with many large forest fragments. The average forest cover in this part of Poland is 25% and the human population density is 114 persons per km$^2$ (Łowicki, 2008).

### 2.2. Selection of study sites

In order to select research sites we used satellite images and site visits to assess suitability. We chose six large (> 30 km$^2$) forest fragments in which to conduct the study, thus ensuring relatively large alternative foraging areas for bats. Road sites were located along low to medium traffic volume asphalt roads with one lane in each direction. Within a single forest fragment, sites were separated from one another by at least 1 km to avoid recording the same individual bats, and were also located at least 300 m within the forest to avoid the impact of non-forest environments (including street lights) on bat behaviour. We avoided sites with clearings and young trees that could markedly influence the flight paths of bats. Our control consisted of paired reference sites located 100 m from the asphalt road sites, also at least 300 m from forest edges, on unsurfaced forest roads (width 2.3–5.8 m) with no vehicle traffic at night. This separation distance ensured that noise and light pollution from the asphalt road was not important (Schaub et al., 2008; Siemers and Schaub, 2011; Berthinussen and Altringham, 2012). For both types of roads, there were no street lights within 300 m, and were typically much further away. The recording of bat activity was carried out at 53 pairs of sites (mean number of pairs of sites per forest patch was 8.8 ± 0.9 SE; range: 6–11).

### 2.3. Acoustic monitoring of bats

We used two sets of Anabat detectors to record bat activity (Anabat II, Titley Electronics, Ballina, New South Wales, Australia). During a pilot study, we determined that level 5 was a suitable sensitivity value for the detector. At level 5, we were able to focus the recordings on bat activity on the road and in the immediate surroundings. To eliminate any slight differences in sensitivity between the detector sets, we selected them interchangeably for recording on asphalt road and reference sites. Detectors were equipped with standard directional 'Low Energy' microphones. During recording, detectors were set 20 cm above the ground on the roadside, at 45° to the direction of the gaps in the canopies. We recorded during peak bat activity on eight nights in August 2011. Recordings were carried out only in the absence of rain, and with winds below 5 m/s. We started collecting data no earlier than one hour after sunset and finished 4 h after sunset. Bat activity was recorded simultaneously for 10 min, once at each pair of sites. We also recorded air temperature at each site. In addition, on the asphalt roads, we noted all passing vehicles and their direction of movement. The exact time each car passed was noted manually to a one-second accuracy using a PDA clock. During analysis of the data we corrected the time the car passed by using the characteristic car generated noise recorded by the Anabat detector.