Bat diversity and activity at subalpine grasslands of Varnous and Triklarion Mountains (NW Greece)

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Abstract

Habitat use by bats at high altitudes and particularly subalpine grasslands, is poorly known. Many bats are killed through collision with wind turbines installed on or near mountain tops, showing the need for bat diversity and activity surveys in high altitude areas, especially where wind farms are installed. We studied bat use of subalpine grasslands and beech forests near the tree line, in and near Prespa National Park, NW Greece, mostly at sites where large-scale wind farms have been, or are planned to be, constructed. We applied acoustic transects, point sampling and mist-netting in 2009, 2010 and 2011 in four areas. Both bat diversity and activity were high; we recorded 14 species: *Tadarida teniotis*, *Miniopterus schreibersii*, *Pipistrellus pipistrellus*, *P. nathusii, P. kuhlii, Hypsugo savii*, *Nyctalus noctula, N. leisleri, Myotis mystacinus, M. nattererii, M. blythii, Rhinolophus hipposideros, R. ferrumequinum* and *R. blasii.* These include species at high risk of collision with wind turbines. More species may be present. Two of the sites are heavily used by commuting and foraging bats in summer; in autumn there is still some activity even on cold nights. Our results show that high altitude areas may support important bat fauna, and suggest that the establishment of wind farms may increase bat mortality, as elsewhere in Europe. To reduce potential impacts on bats, long-term pre and post-construction monitoring surveys are of fundamental importance at sites where wind farms are planned or established. The importance of subalpine grasslands for bats should be further assessed through long-term research studies.

Key words: bat activity, Chiroptera, wind farms, mortality risk, bat conservation, Prespa National Park

Introduction

Habitat use by bats at high altitudes and, in particular, over subalpine grasslands is not sufficiently known. However, many bats are killed through

collisions with wind turbines installed on or near mountain ridges (e.g. Rodrigues et al. 2008, Rydell et al. 2010, Georgiakakis and Papadatou 2011). This evidence clearly shows the necessity to survey bat diversity and activity in high altitude areas, especially in the south of Europe where there are many species rich areas, high mountain ranges and large-scale wind farms established or planned to be installed on several mountains (e.g. Georgiakakis and Papadatou 2011).

Greece is a largely mountainous country in Mediterranean Europe and among the richest in terms of bat diversity (Hanák et al. 2001). Although many wind farms are foreseen to be installed or are already operating on top of forested hills and mountain ridges, we know very little about the use of these areas by bats. A recent study revealed high bat mortality on mountain ridges of Thrace, NE Greece, where large scale wind farms have been operating since 2003 (Georgiakakis and Papadatou 2011).

The area of Prespa in NW Greece hosts a uniquely rich bat fauna (Grémillet et al. 2010, Papadatou et al. 2011) with 26 species recorded to date. These include bats capable of hunting in open spaces and well above ground, such as *Nyctalus* and *Pipistrellus* species (Dietz et al. 2009), and hence at high risk of collision with wind turbines. Many of these often cross mountain ridges and passes when commuting between roosting and foraging sites, and when they move seasonally (migrate).

We studied the use by bats of subalpine grasslands and beech (*Fagus sylvatica*) forests near the tree line at high altitudes (up to *ca.* 2000 m asl) in and near Prespa National Park (PNP), mostly where wind farms have been installed or are planned to be constructed. We specifically aimed to assess bat diversity and activity within and between seasons, as well as across years. We report preliminary results from 2009 (Galand et al. 2010) alongside results from 2010 and 2011, when some more sites were included in the survey.

Materials and methods

Study area. The Prespa lakes' watershed is shared between Albania, the Former Yugoslav Republic of *Macedonia* (FYROM) and Greece. The Greek part includes two Natura 2000 sites (GR 1340001 and GR 1340003 respectively), which together constitute the PNP. The geomorphological character of the area is determined by two lakes (Fig. 1) and the surrounding mountain ranges: Mt Vrondero and Mt Devas in the west, Mt Triklarion/Sfika in the south and Mt Varnous in the east-northeast reaching altitudes of over 2000 m asl. We surveyed bat habitat use at the following mountainous and subalpine sites: Bella Voda, Mazi-Kirko and Moutsara (Mt.

Varnous), and Sfika (Mt. Triklarion) (Table 1 and Fig. 1). Study sites at Mt. Varnous (siliceous substrate) are dominated by *Nardus stricta* grasslands with *Vaccinium myrtilus* (bilberry) and *Juniperus communis* ssp. *nana* (creeping prickly juniper), while rocky habitats and patches of *Fagus sylvatica* (beech) and other trees may be present. The site of Sfika consists of calcareous grasslands with great floristic diversity, often with hamaephytes in dense tussocks, such as *Astragalus angustifolius*, and patches of trees or isolated trees such as *Quercus pubescens, Acer campestre, Sorbus aria*, *Prunus* spp (Vrahnakis et al. 2011).

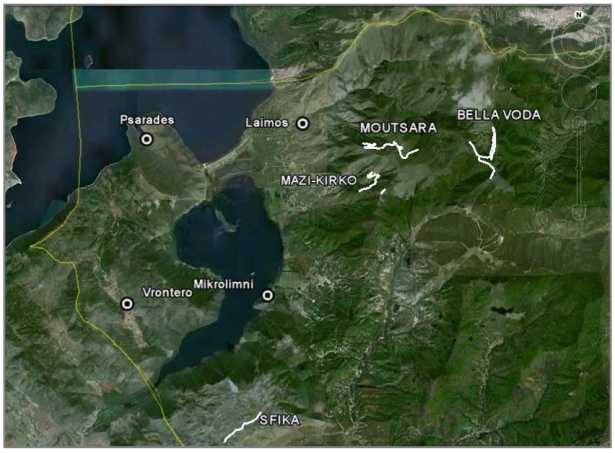

Figure 1. Study sites (in capital letters; white lines are transects (source: Google Earth, 2012)

Field techniques. We used acoustic transects and point sampling, as well as mist-netting, to survey bat habitat use in summer and autumn. A large scale wind farm, consisting of 34 turbines, has already been constructed on Bella Voda. Sites at Mazi-Kirko and Sfika have also been proposed for wind farm development.

We performed within-year repeated surveys at Bella Voda and Mazi-Kirko. Bella Voda was surveyed once in summer 2009 (22/7/2009; Galand et al. 2010), twice in summer (20/07/2010, 2/8/2010) and once in autumn (30/9/2010) 2010. Mazi-Kirko was surveyed once in summer and once in autumn 2010 (31/7/2010 and 1/10/2010 respectively). The rest of the sites were surveyed once in summer 2010 and 2011 (Moutsara: 1/8/2010 and 22/7/2011; Sfika: 24/7/2010 and 21/7/2011). An additional site between Moutsara and Kirko was visited in summer 2011 (24/7/2011). During acoustic transects, observers walked along pre-defined routes (each

approx. 2-4 km long) and recorded the echolocation calls of passing bats using time expansion bat detectors (models: D240x, D980, Pettersson Elektronik). When point sampling, observers stood at fixed points for approx. 3 hours after sunset to record bat calls (with time expansion detectors) and to estimate bat activity (with heterodyne detectors). For further details on the acoustic methods, see Galand et al. (2010). Finally, observers used mist-nets to capture bats in the evening near forest edges, across forest roads or above water pools in summer 2010 (all bats were almost immediately released on site after collection of biometric data).

Acoustic species identification. We identified bat species using frequency and time parameters of their calls through quick species identification or statistical models (Papadatou et al. 2008). Bat recordings were analysed with BatSound Pro 3.32 (Pettersson Elektronik). Several calls were identified on site using heterodyne detectors (Galand et al. 2010).

Results and discussion

Bella Voda. Detailed accounts of the 2009 survey are given in Galand et al. (2010) and in Vrahnakis et al. (2010). Repeated acoustic transects (Fig. 1) showed that the site is generally heavily used by commuting and foraging *Tadarida teniotis* (Table 1) throughout the summer and in both 2009 and 2010. Repeated acoustic point sampling in both years on the mountain pass next to where the first wind turbine is installed (Prespa-Akritas-Florina ridge; Galand et al. 2010) showed that the specific location is heavily used by bats of several species (Table 1 and Galand et al. 2010). We believe these are bats mostly commuting from other areas (e.g. Florina plain and Pisoderi valley) to forage in the Prespa watershed, which is rich in hunting habitats and insect prey. The list includes at least 7 species (Table 1) that have been widely reported to be at high risk of collision with wind turbines (e.g. Rodrigues et al. 2008). Bat activity may differ between nights, even on approximately the same dates with one year difference (Fig. 2).Therefore repeated sampling is necessary to improve the representativeness of sampling. In the autumn, overall activity decreases but there are still bats commuting over the mountain, even on cold nights (approx. 4^{o}C).

Mazi-Kirko. The site (Fig. 1) is heavily used in summer by commuting and foraging bats from several species, including at least 7 species at high risk of collision with wind turbines (Table 1). In autumn, bats still cross the subalpine grasslands to commute or hunt.

Moutsara. Only *N. noctula* was recorded near the highest point of the ridge, whereas the other species were found at lower altitudes, foraging near the tree line and along beech forest edges.

Table 1. Study sites and species or species groups identified

Study site	Altitude (m a.s.l.)	Species
Bella Voda	1900-2000	***Tadarida teniotis, Pipistrellus pipistrellus, P. nathusii, Hypsugo savii, Nyctalus noctula, Miniopterus schreibersii, N. leisleri/ E. serotinus/ V. murinus,*** *Myotis myotis/M. blythii, Myotis* species
Mazi-Kirko	1900-2000	***P. pipistrellus, Hypsugo savii, Nyctalus leisleri, N. noctula, M. schreibersii, T. teniotis, P. nathusii/P. kuhlii, N. leisleri/ E. serotinus/ V. murinus, M. schreibersii/ P.pygmaeus,*** *Myotis myotis/M. blythii, Myotis* species
Moutsara	1700-2000	*Rhinolophus hipposideros, R. ferrumequinum, R. blasii,* ***N. noctula,*** *Myotis blythii, Myotis* species
Sfika	1400-1700	*Myotis mystacinus, M. blythii, M. nattererii,* ***P. pipistrellus,*** *P. kuhlii,* ***H. savii, M. schreibersii, P. nathusii****/P. kuhlii,* ***N. leisleri/ E. serotinus/ V. Murinus***

NOTES: Altitudinal ranges are approximate. In **bold**: species at high risk of collision with wind turbines (e.g. Rodrigues et al. 2008). Some bats were not identified at species level, so it is likely that more species are present.

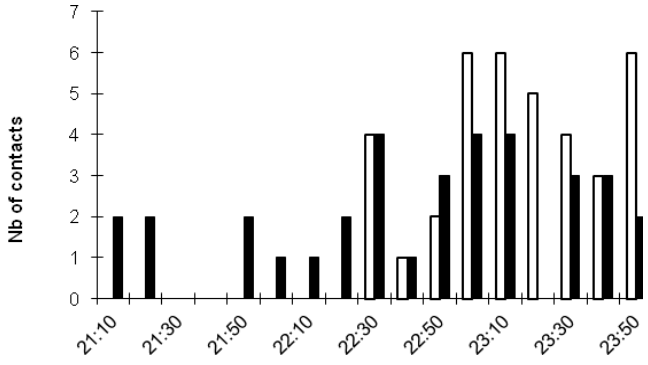

Figure 2. Bat activity on the Prespa-Akritas-Florina mountain pass over two summer nights. White bars: 22/7/2009, black bars: 20/7/2010. Nb of contacts: number of contacts with bats using a heterodyne bat detector.

Sfika. We covered a large area near the Prespa watershed, in Krystallopigi basin (Fig. 1). The highest activity of most species (Table 1) was recorded towards the lower and less exposed locations.

Our results show that subalpine grasslands and forests near the tree line are used by many bats, since both bat diversity and activity were high. The establishment of wind farms may therefore negatively impact on bats, as has been shown in other areas of Europe, including Greece (e.g. Rodrigues et al. 2008, Rydell et al. 2010, Georgiakakis and Papadatou 2011). This is particularly important for species that have been reported to be at high risk of collision with the turbines (e.g. Rodrigues et al. 2008), such as *N. leisleri, N. noctula, P. pipistrellus, P. nathusii, H. savii* and *T. teniotis,* which are present in these areas. Long-term systematic monitoring surveys of the bat fauna are therefore a prerequisite prior to the establishment of wind farms in these areas. Post-construction monitoring surveys are equally essential to assess bat mortality due to collision with turbines (e.g. at Bella Voda). If monitoring reveals bat mortality, mitigation measures such as curtailment of turbines at wind speeds lower than 6.0 m/sec should be implemented during night-time without significant loss in the production of electricity (e.g. Arnett et al. 2011).

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