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Effects of hedgerows on bats and bush crickets at different spatial scales

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ABSTRACT

Biodiversity is threatened by the loss and fragmentation of habitats. The role of hedgerows in maintaining biodiversity is well established, but few studies have addressed the importance for biodiversity of the intrinsic characteristics of hedgerows and the quality of hedgerow networks along a spatial scale. We examined three quality indices providing information at different territorial levels: density in the landscape, structural diversity and wood production. We performed an acoustic survey in a grassland to estimate the species abundance and community composition of bats (9 taxa) and bush crickets (11 species). Using an approach based on species and traits, we assessed how hedgerow quality influenced the activity of these taxa at different spatial scales (from 50 to 1000 m) and focused on three types of traits: bush cricket mobility ability, bat foraging strategy and habitat specialization. In general, our results showed the importance of hedgerow quality for bats and bush crickets, but the strength of the association between taxa and hedgerows varied substantially among the species and the spatial scales. Although it depends on the taxa, the production, density and structural diversity of hedgerows each had an overall positive effect. Our results suggested that these effects were generally more important at large scales. The scale effect of the production index is the best predictor of activity for bat and bush cricket taxa and traits. Our results showed the importance of hedgerow quality for the ecology of bat and bush cricket communities and could be used to improve conservation management.

1. Introduction

Over the last century, agricultural intensification, particularly the increase in agricultural parcel sizes, has had severe consequences for biodiversity (Robinson and Sutherland, 2002). At the landscape scale, one consequence of such intensification is the widespread removal of linear landscape elements in Europe (Robinson, 1997; Sklenicka et al., 2009) and also of large patches of semi-natural habitats, such as forests and grasslands, even though the ecological importance of hedgerows and linear landscape elements has been known for decades (i.e., Burel, 1992; Beier and Noss, 1998; Bennett, 2003). Hedgerows play a role in the control of water flow, water level and water quality (Mérot, 1999; Baudry et al., 2000). They provide breeding habitat, food resources and dispersal pathways for many species of birds (Hinsley and Bellamy, 2000), amphibians (Scribner et al., 2001; Rosenberg et al., 1998; Brown et al., 2006), mammals (Henderson et al., 1985; Pardini et al., 2005) and invertebrates (Burel, 1992; Hannon, 2009).

However, to our knowledge, the effects of the quality of linear elements, such as hedgerows (e.g., their diversity of structure and wood production), at different scales, on biodiversity have been poorly considered in previous studies, except in Pywell et al. (2004) and Dainese et al. (2015). Nevertheless, these effects are of interest because many agri-environmental schemes provide financial support for environmentally sensitive hedgerow management. The effectiveness of such initiatives in terms of both financial costs and biodiversity gains can be improved through a better understanding of the benefits provided by different types of hedgerows in different landscape contexts (Boughey et al., 2011).

In this paper, we present a study of bats and bush crickets, both of which are known to take advantage of the presence of hedgerows, and which have been detected and identified based on their

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calls, recorded by detectors. Bats (Chiroptera) and bush crickets (Orthoptera) represent complementary ecological indicators of biodiversity quality. Bazelet and Samways (2011) identified bush crickets as good bioindicators for the assessment of the habitat quality of ecological networks because they respond strongly to management practices, such as grazing intensity (Jauregui et al., 2008) and mowing regime (Gardiner and Hassall, 2009). Bush crickets belong to an invertebrate group that is abundant in grasslands, have a short life cycle and are at a low level in the food chain (mainly herbivore species and some omnivores) compared to bats. Although the importance of linear landscape elements is poorly understood for bush crickets, they have nevertheless been described to be useful for their dispersal behavior (Berggren et al., 2002) and colonization success (Berggren et al., 2001). Thus, we hypothesized that bush crickets could be sensitive to hedgerows at small spatial scales in accordance with Reinhardt et al. (2005). Bat species have a long life cycle relative to bush crickets. In the study areas, bats are all nocturnal insectivores at the top of the food chain (Dietz et al., 2009). They are considered to be bioindicators (Jones et al., 2009) because they react to several stressors, including the loss of landscape elements, which impacts their abundance, distribution and activity (e.g., Boughey et al., 2011). Moreover, all bat species are protected in Europe (IUCN, 2011). The primary predictor of bat abundance is the quality of the habitat, which is positively related to the availability of vegetation corridors (Walsh and Harris, 1996; Hein et al., 2009) and to the density of linear elements (Verboom and Huitema, 1997). Based on the size of the foraging home range of the bat (see Davidson-Watts and Jones, 2005; Perez-Jorda and Ibañez, 1991), we hypothesized that bats could be sensitive to hedgerows at large spatial scales, in accordance with Bellamy et al. (2013) and Frey-Ehrenbold et al. (2013).

Many studies have been performed on the effects of the density and connectivity of linear landscape elements on the movement and dispersal of species (Erickson et al., 2013; Berggren et al., 2001, 2002; Diekötter et al., 2007; Boughey et al., 2011). However, little is known about how the quality of linear elements affects their use by bats because the only studies that show such effects are 'Boughey et al. (2011) and Verboom and Huitema, 1997', and even less is known about bush crickets; thus, we need to better understand the relationship between biodiversity and the quality of linear landscape elements (Hein et al., 2009).

To study linear element quality, we examined three hedgerow characteristics: (1) density within the landscape (density) (2) potential wood production (production) and (3) structural diversity (diversity). Indeed, each of these three indices provides information at different land levels and involves different stakeholders. Density reflects the history of successive agricultural policies (changing the division of lands) at the landscape scale, whereas production and structural diversity are more linked to local farming practices. Thus, these three indices provided information on the management of the land at different scales, which is important because spatial processes are known to influence the structure and dynamics of animal populations and communities (Cottenie, 2005).

In this study, we used two approaches: 1) a species approach in which we tested the effects of the linear element quality on the activity of the species and 2) a trait based approach in which we tested the same effects on several traits (e.g., habitat specialization, bat foraging strategy and bush cricket mobility ability). The trait approach can provide information on the mechanisms involved in the use of different types of hedgerows by bat and bush cricket communities. Such information is essential for developing effective conservation plans and can be used to improve forest and agriculture management strategies.

2. Materials and methods

2.1. Study area

The study was conducted in western France, in the Loire delta, between the cities Nantes and Saint-Nazaire, in a European network of the protected area "Natura 2000" (Fig. 1). The site is mainly composed of extensively managed grassland grazed by cattle and surrounded by a dense network of hedgerows. The grassland was identified as having a high nature conservation value by Veen et al. (2009).

2.2. Sampling design and scale approach

We employed a random stratified design in which 51 point counts were sampled in the grassland, the dominant habitat in the studied site. The point counts were positioned according to two criteria: 1) more than 50% of grassland in the 500 m buffer and 2) at three classes of distance from the hedgerow: 23 point counts at 0 m (i.e., in the hedgerow), 17 at 25 and 11 at 50 m from the hedgerow. These two criteria, "proportion of grassland in the buffer" and "distance to the hedgerow", were not correlated (rho = 0.09, p value = 0.378) and were therefore included as covariables. To measure the effects of the characteristics of the linear landscape elements at different scales, we used ArcGIS 9.3 and a local landuse database (Geffray, 2010). Previous studies linked environmental variables at a few spatial scales with the abundance of bush crickets (Batáry et al., 2007; Braschler et al., 2009; Diekötter et al., 2007; Penone et al., 2013b) and bats (Bellamy et al., 2013; Lookingbill et al., 2010; Dixon, 2012; Hale et al., 2012), and we defined 11 circular buffers (radii of 50 m and every 100 m until 1000 m) around each point count that defined our sampling plots (a correspondence scale of areas depending on the buffer size used in this study and areas obtained with a doubling of surfaces is provided in Appendix C). Within these circular buffers, we extracted landscape

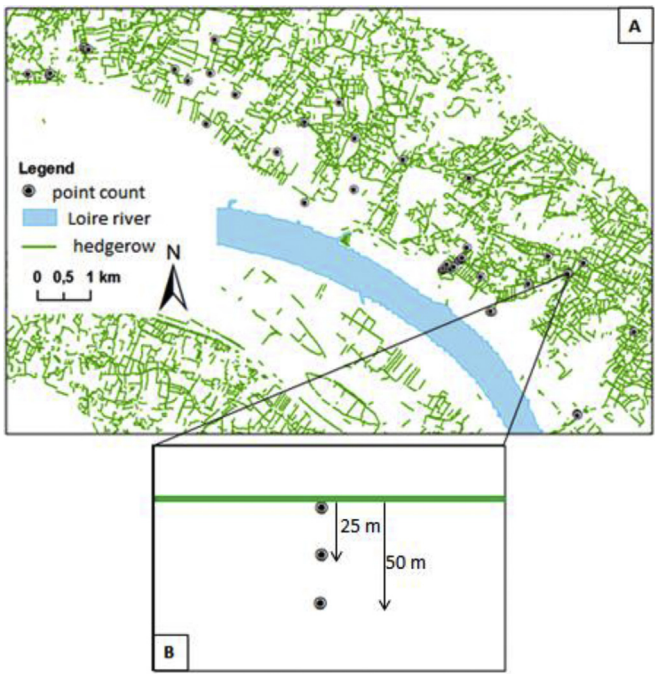

Fig. 1. Positions of point counts in the study site (A) and an enlargement showing the 3 distances from the hedgerow (0 m, 25 m and 50 m) (B).