Effects of landscape composition and native oak forest configuration on cavity-nesting birds of North Africa

Moez Touihri [a],[*], Faouzia Charfi [a], Marc-André Villard [b]

[a] Université de Tunis El Manar, Faculté des Sciences de Tunis, UR11-ES11, Unité de recherche de Bio-Ecologie Animale et Systématique Evolutive, 2092 Tunis, Tunisia
[b] Université du Québec à Rimouski, 300 Allée des Ursulines, C.P. 3300, succursale A Rimouski, QC G5L 3A1, Canada

ABSTRACT

In the Kroumirie ecoregion of northwestern Tunisia, habitat fragmentation and degradation are the main drivers of contemporary landscape change. Continuous native oak forests have been converted into heterogeneous landscapes characterized by small forest fragments surrounded by a scrubby matrix. We examined the response of five species of cavity-nesting birds to these phenomena because they play a keystone role in these forest ecosystems. We quantified the relative effects of landscape composition and the configuration of mature oak forest on the occurrence of the focal species. We hypothesized that the occurrence of all focal species would increase with forest cover, whereas the effects of matrix type and mature forest configuration would be species-specific. For each focal species, we tested a set of 12 candidate models predicting their occurrence. Each model included landscape metrics describing oak forest configuration and landscape composition. We applied multimodel inference and model averaging on generalized linear models. Forest cover at the landscape level was the main driver of species occurrence. Secondary cavity-nesters responded positively to the proportion of oak forest at landscape and local scales, whereas the five focal species responded negatively to the proportion of low scrub. Great spotted woodpecker (*Dendrocopos major*) and Levaillant's woodpecker (*Picus vaillantii*) responded positively to both forest amount and high scrub, suggesting a landscape complementation process. Lesser spotted woodpecker (*D. minor*) was the only species responding to forest configuration, possibly as a result of landscape supplementation. High scrub appeared to moderate the contrast between low scrub and forest fragments for primary cavity-nesters. However, it did not influence the occurrence of secondary cavity-nesters (e.g., Atlas flycatcher *Ficedula speculgera* and short-toed treecreeper *Certhia brachydactyla*). If an increase in the amount of mature oak forest cannot be achieved over the short term, the maintenance of high scrub around forest fragments and an improvement in the quality of low scrub through the addition of vertical structure should increase the frequency of occurrence of many of our focal species in oak forest of the Mediterranean Basin.

© 2016 Published by Elsevier B.V.

1. Introduction

Habitat loss, fragmentation, and degradation have been identified as the main processes altering forest ecosystems worldwide (Harrison and Bruna, 1999; Pimm and Raven, 2000; Foley et al., 2005). In North Africa, continuous native oak forests are being converted into heterogeneous landscapes of variable composition and configuration (Blondel and Aronson, 1999). Few studies have investigated the effects of those processes on biodiversity or ecological processes in this region (Cherkaoui et al., 2009). Yet, oak forests are home to many species of conservation concern (Bergner et al., 2015; Maya-Elizarraras and Schondube, 2015).

Landscape composition refers to the proportion of different cover types whereas configuration refers to their spatial arrangement at a given time. Vegetation cover types should be defined based on the foraging and breeding habitat requirements of focal taxa. For instance, cavity-nesting birds may be associated with specific requirements, e.g. mature forest, large trees, or dead wood (Roberge et al., 2008; Nappi et al., 2015; Touihri et al., 2015), but they may use others elements at landscape level to fulfill certain needs.

The degree of contrast among landscape elements may influence a variety of ecological patterns and processes, including animal movements (Revilla et al., 2004; Umetsu et al., 2008; Villard and Haché, 2012), nest predation (Poulin and Villard, 2011), population size (Kuroe et al., 2011), population persistence (Fraterrigo et al., 2009; Kennedy et al., 2011), species interactions

(Polis et al., 2004), or species richness and composition (Deikumah et al., 2013; Sánchez-de-Jesús et al., 2015). Open-habitat matrices may inhibit dispersal movements of forest birds (Castellon and Sieving, 2006; Ibarra-Macias et al., 2011), whereas matrix types featuring isolated trees may mitigate the effects of forest loss through the provision of complementary resources (Dunning et al., 1992) and those trees may increase functional connectivity (Antongiovanni and Metzger, 2005).

In addition to matrix effects, landscape structure may influence the composition of species assemblages through edge effects. There is a quadratic relationship between habitat amount and total edge length, the length of edge being highest at intermediate habitat amounts (Villard and Metzger, 2014; Wang et al., 2014). Finally, habitat configuration may mitigate the effect of habitat loss when habitat amount is intermediate (Villard and Metzger, 2014), for example through landscape supplementation (Dunning et al., 1992). In other words, favorable habitat configurations may enhance species persistence, e.g. by allowing individuals to use adjacent resource patches.

One of the major conservation concerns in native oak forests of North Africa is the near absence of natural regeneration or plantation of native tree species due to the dryness of the soil and grazing pressure by wild animals and livestock. Nonetheless, strategic tree plantation to enhance forest configuration or matrix permeability may represent a valuable option to conserve forest species. However, this requires critical information on the response of forest specialists to landscape structure.

The objective of this paper is to examine effects of oak forest configuration and landscape composition on the occurrence of five bird species that are strongly associated with mature oak forest for both nesting and foraging: great spotted woodpecker (*Dendrocopos major*), lesser spotted woodpecker (*Dendrocopos minor*), Levaillant's woodpecker (*Picus vaillantii)*, Atlas flycatcher (*Ficedula speculgera*), and short-toed treecreeper (*Certhia brachydactyla*).

We hypothesized that a high scrub matrix including isolated trees would provide higher structural connectivity than low scrub and, thus, we expected that species occurrence would be positively related to the amount of high scrub matrix around sampling points. Moreover, we hypothesized that woodpeckers would be able to cross the matrix and reach isolated habitat patches to supplement their habitat requirements. In contrast, species with lower mobility and smaller home ranges, such as short-toed treecreeper (Géroudet, 1974; Clergeau and Burel, 1997; Cramp et al., 1998), were expected to move less readily across the matrix and to complement within-patch resources by using the nearby matrix when forest amount decreased in the landscape.

2. Methods

2.1. Study area

This study was conducted in native mature oak forests (trees > 30 cm in diameter at breast height) of the Kroumirie ecoregion, in northwestern Tunisia (36°32′N, 8°15′E to 36°27 N, 8°20′E). The forest is dominated by two native oak species: Zen (*Quercus canariensis*) and Cork oak (*Q. suber*). Zen oak forms closed-canopy stands whereas Cork oak is typically associated with scrubby vegetation also known as maquis (see Touihri et al., 2014 for details). The study area covers 40 km^2, of which 26 km^2 are protected as a national park (hereafter Feija NP). Although, intensive silviculture and hunting are strictly prohibited within Feija NP boundaries, the 40 resident families exert some pressure on the ecosystem by grazing livestock and collecting firewood. As a result, natural regeneration of oak and other tree species is severely restricted in portions of the Park. Oak forest is present as fragments within a 2-km band around the Park. This zone is also severely disturbed

by human activities. Mature oak forest (ca. 40 years) is fragmented and embedded in different matrix types (Fig. 1). Fragment area ranges from 2 to 80 ha. The matrix is mainly composed of scrubby, maquis vegetation (e.g., *Erica arborea*, *Arbutus unedo*, *Calycotome villosa*, *Cystus salvifolia*, *C. triflorus*, *Phylleria angustifolia*, *Myrtus communis* and *Pistacia lentiscus*).

2.2. Bird data

We surveyed breeding birds using the point count method (Bibby, 2000) at 46 stations in 2012 breeding season. Point count stations were randomly located within continuous forest within Feija NP, but those retained (n = 22) met the following conditions: they were at least 400 m away from each other and at least 100 m from the nearest edge. Twenty-four stations were selected a priori in the center of mature oak forest fragments using Google Earth.

Each point count station was visited 3 times between 15 April and 15 June 2012. Each count was divided into 3 periods of 5 min each: two silent periods separated by a 5-min playback period. Playbacks consisted of recordings of great spotted woodpecker, lesser spotted woodpecker and Levaillant's woodpeckers drummings and vocalizations of Atlas flycatcher and short-toed treecreeper. We recorded all individuals of focal species detected by sight and sound within an 80-m radius.

Presence-absence data may be biased by low detectability due to imperfect detection (Mackenzie et al., 2002). Therefore, we calculated the detectability of the focal species using PRESENCE software (Hines, 2006). Detectability values varied between 0.85 and 0.9, which is high enough to presume that our models were not biased by false absence rate.

2.3. Landscape data

We adopted a patch-landscape approach (McGarigal and Cushman (2002). Landscape metrics were measured within specific radii from each point count station. We distinguished a local scale (400 m) and a landscape scale (1000 m). Both of these radii are large enough to include the home range of the focal bird species (Cramp et al., 1998; Rolstad et al., 2000; Wiktander et al., 2001; Barrientos, 2010).

We performed a supervised classification of a Landsat TM image (30 × 30 m pixels) dating from July 2012. We first distinguished four land cover types: (1) mature oak forest; (2) high scrub (1.5–5 m high); (3) low scrub (0.5–1.49 m high); and (4) bare ground and grassland (Fig. 1). Then, we ground-truthed this classification at and around the 46 stations. Overall classification accuracy was 85%. Then, we used FRAGSTATS 4.2 (McGarigal et al., 2012) to characterize oak forest configuration and landscape composition at two spatial scales: 400 m and 1000 m radius around each station (Table 1). Following Wang et al. (2014), we selected landscape metrics that are weakly correlated with habitat amount to characterize habitat configuration: PROX_MN index (Gustafson and Parker, 1992), which represents the degree of proximity between forest fragments, and edge density (ED) between mature forest and the matrix. We also measured landscape composition metrics, i.e. the area of matrix (high and low scrub) surrounding each site within 400 m (local scale) and 1000 m (landscape scale) radii. We also measured the area of oak forest within the same radii.

2.4. Selection of candidate models

To determine whether there is evidence for landscape complementation or landscape supplementation in the distribution of our focal bird species, we developed a set of 12 candidate models for each species that were deemed ecologically plausible. A complementation process implies that species responded