Acta Oecologica 83 (2017) 22–28

Contents lists available at ScienceDirect

Acta Oecologica

journal homepage: www.elsevier.com/locate/actoec

How does vegetation structure influence woodpeckers and secondary cavity nesting birds in African cork oak forest?

Amalia Segura*

C/Marques Vega Anzo 3 10º, 33007 Oviedo, Spain

ARTICLE INFO

Article history:
Received 12 October 2016
Received in revised form
8 June 2017
Accepted 8 June 2017
Available online 23 June 2017

Keywords:
Woodpecker
Cork oak tree
Secondary cavity nesting bird
Forest structure

ABSTRACT

The Great Spotted Woodpecker provides important information about the status of a forest in terms of structure and age. As a primary cavity creator, it provides small-medium size cavities for passerines. However, despite its interest as an ecosystem engineer, studies of this species in Africa are scarce. Here, spatially explicit predictive models were used to investigate how forest structural variables are related to both the Great Spotted Woodpecker and secondary cavity nesting birds in Maamora cork oak forest (northwest Morocco). A positive association between Great Spotted Woodpecker and both dead-tree density and large mature trees (>60 cm dbh) was found. This study area, Maamora, has an old-growth forest structure incorporating a broad range of size and condition of live and dead trees, favouring Great Spotted Woodpecker by providing high availability of foraging and excavating sites. Secondary cavity nesting birds, represented by Great Tit, African Blue Tit, and Hoopoe, were predicted by Great Spotted Woodpecker detections. The findings suggest that the conservation of the Maamora cork oak forest could be key to maintaining these hole-nesting birds. However, this forest is threatened by forestry practises and livestock overgrazing and the challenge is therefore to find sustainable management strategies that ensure conservation while allowing its exploitation.

1. Introduction

Biological indicators are used to detect or demonstrate the existence of a particular environmental state, and to monitor changes in that state (McGeoch, 2006), for instance, species that serve to track community-wide processes, creating the conditions for the presence of other species.

Forest birds have proved to be good habitat quality indicators (Moning and Muller, 2008). Woodpeckers have been recognized as indicators of forest bird diversity, indicating forest naturalness (Mikusinski et al., 2001), and as ecosystem engineers (Robles and Martin, 2013), through facilitating the process of cavity excavation and providing critical ecological services such as nesting and roosting opportunities for a wide range of fauna, including other birds (Newton, 1994; Martin et al., 2004; Mikusinski, 2006; Martin, 2015). Woodpecker density is strictly tied to biomass decomposition dynamics, and responds to changes in the relative densities of live- and dead-tree biomass (Fuller, 1995; Petty and Avery, 1990; Virkkala et al., 1994). As such woodpeckers are important model species in conservation biology (Virkkala, 2006).

In particular, Great Spotted Woodpecker, *Dendrocopos major*, requires large amounts of dead wood for nesting and old-growth forests with high structural diversity for foraging (Virkkala et al., 1994; Redolfi de Zan et al., 2014). The presence and abundance of this woodpecker species can provide important information about the status of forests and their resources (sensu Drever and Martin, 2010), making this species an excellent quality indicator of old-forest conditions (structure and age; Pasinelli, 2000) and of the entire hole-nesting bird guild (Rossi de Gasperis et al., 2016) in communities with a large number of secondary cavity nesters (e.g. sensu Martin et al., 2004). In fact, in Mediterranean forests Great Spotted Woodpecker has been shown to have a strong positive effect on the presence of secondary cavity nesting birds (Camprodon et al., 2008; Touihri et al., 2014; Rossi de Gasperis et al., 2016).

Generally, in accordance with their crucial ecological role in forest environments and communities, woodpeckers have been extensively studied in most of the forests of Europe (in Poland, Kosinski et al., 2006; in Switzerland, Pasinelli, 2007; in Spain, Robles et al., 2007 and Segura et al., 2014) and North America

* Corresponding author.
E-mail address: amaliasegura@gmail.com.

http://dx.doi.org/10.1016/j.actao.2017.06.008
1146-609X/

(Jackson, 1994; McClelland and McClelland, 1999; Martin et al., 2004), but only a few studies have been carried out in Africa (Touihri et al., 2015). Population decline and range contractions due to habitat loss and habitat degradation through human activities have been well documented (Winkler and Christie, 2002), and point to these birds being particularly susceptible to forestry practises.

Mediterranean forests have traditionally been subject to strong human pressure through activities such as forestry, charcoal production and vegetation clearing (Blondel and Aronson, 1999). Over recent decades, cork oak forests have experienced a strong decline due to overgrazing, the expansion of agriculture and alien species plantations (Aronson et al., 2009). Currently, cork oak forests occur only in the western Mediterranean, covering 1.5 million hectares in Europe (Portugal, Spain, Italy and France) and 1 million hectares in North Africa (Morocco, Algeria and Tunisia) (Pausas et al., 2009). These specific Mediterranean forests are ecosystems where periodical tree bark harvesting is a major economic activity that may make them particularly vulnerable to disturbances. Cork oak forests provide, in addition, social and ecological services, supporting higher biodiversity than other Mediterranean forests and providing an important habitat for insects (Da Silva et al., 2009), mammals (Rosalino et al., 2009; Berrahmouni et al., 2009; Díaz, 2009) and plants (Díaz-Villa et al., 2003; Bugalho et al., 2009). In addition, their spatial heterogeneity and the presence of an ecotone between open and dense forest habitat (Tellería, 2001), characterizes cork oak forests as one of the richest Mediterranean habitats for breeding birds, and an important area for winter migrant birds coming from northern Europe to Portugal, Spain and Morocco (Tellería, 2001; Cherkaoui et al., 2009; Tellería et al., 2014).

Located in northern Morocco, Maamora forest is the largest single stand of cork oak in the world though it persists now in the plain area of Salé-Kenitra-Tiflet region, having decreased from 135,000 ha in 1920 (Emberger, 1939; Boudy, 1958) to 70,383 ha in 2015 (Lahssini et al., 2015). The main cause of the decline of this forest, whose vigour and protection against external agents and pests has reduced, is human pressure (Fennane and Rejdali, 2015) —acorn picking, overgrazing, and cork harvesting practises having caused the virtual absence of natural regeneration (Marion, 1951; Lahssini et al., 2015).

The aim of this study is to explore the relationships between forest structure and both Great Spotted Woodpecker and secondary cavity nesting birds in the Maamora cork oak forest in Morocco. Specifically, this work investigates whether common structural elements such as snags (standing dead trees) and mature forest extent may influence both Great Spotted Woodpecker and secondary cavity nesting birds as well as the association between this woodpecker and secondary cavity nesting birds, and ultimately suggests conservation measures for the management of Maamora forest.

2. Material and methods

2.1. Study area

The study was conducted in the Maamora forest (northwest Morocco; 34° 02′ 54.19″ N, 6° 27′ 19.24″ W) in low elevation areas (72–185 m a.s.l.) with sandy soil. The climate is Mediterranean, with hot and dry summers, and the annual average rainfall range is from 300 to 500 mm. Maamora forest is dominated by cork oak trees, *Quercus suber*, with scattered endemic wild pear, *Pyrus mamorensis*, and a sparse understory of bush and shrub species such as *Genista linifolia, Cytisus arboreus, Stauracanthus genistoides, Chamaerops humilis, Lavandula stoechas, Cistus salviifolius* and *Thymelaea lythroides.*

2.2. Woodpeckers and secondary cavity nesting birds

In spring 2015, the entire bird community was surveyed in 104 circular plots of 100 m radius (3.14 ha), each of which was separated from the other by more than 300 m. These plots were arranged along 11 daily randomized transects (covering an area of 4000 ha), which were 2.7–3 km long with each incorporating 9–10 plots. Plots were surveyed from sunrise until 10 a.m., the period of maximum bird activity and each transect and plot was visited only once. Following a standard point count method (Blondel et al., 1970; Bibby et al., 2000), all birds heard and seen in 10 min within a 100 m radius were recorded.

The bird plots were selected randomly using a grid system (controlling for the 300 m between them using a buffer) and were joined to form the transects, although this was limited at some points in the field by topography, water courses and availability of paths. The initial plot where the survey started, and the direction of the transect were selected randomly and the survey then progressed by moving to the next plot along the transect (see Appendix A).

The geographical coordinates and elevation of the centre of each plot were obtained using GNSS (global navigation satellite systems).

Secondary cavity nesting birds and woodpeckers were extracted from the full bird dataset (22 species, see Appendix B). Since woodpeckers can move large distances during breeding (Rolstad et al., 1995), they were surveyed carefully to avoid recording the same individual in successive plots along the transect.

2.3. Vegetation structure

In the same time period as the bird survey, i.e. spring 2015, vegetation parameters were assessed inside 15 m radius plots that had the same centre point as the bird point count locations (James and Shugart, 1970). Tree species and number of standing dead trees were recorded, along with tree dasometric variables for all trees in each plot, which included total height, diameter at breast height (dbh) and canopy cover.

A total of nine variables reflecting habitat structure were calculated: number of trees per hectare (TD), basal area (BA) —the area of a given section of land covered by the cross-sections of tree trunks and stems at their base (measured in m^2 of wood divided by the plot surface area), the total basal area of standing dead trees (BAd), dead-tree density (TDd) and mean height —calculated averaging the height of the four trees with the largest diameters. Then to consider forest structure and age, density of trees in each of three categories by dbh were created: <30 cm dbh, 30–60 cm dbh and >60 cm dbh. The final variable included was tree richness —number of other tree species recorded, i.e. not cork oak trees, such as wild pear, wild olive (*Olea europaea*), green olive (*Phillyrea latifolia*) and mastic (*Pistacia lentiscus*).

2.4. Statistical analysis

To study the relation between vegetation structure, Great Spotted Woodpecker and secondary cavity nesting birds, generalised linear models (GLM) with a Poisson distribution were performed. In addition to the nine vegetation variables, bird plot geographic coordinates and elevation were also included in order to take into account (and control for) the potential non-independence of data for close together areas. The time of day and date (month) were originally accounted for in the analysis in order to control for changes in bird detectability; however, none of these temporal variables affected our dependent variables, and worsened the performance of the models. The most parsimonious models were selected using a backward stepwise procedure based on the Akaike