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Spatially explicit conservation issues for threatened bird species in Mediterranean farmland landscapes

Gianpasquale Chiatante[a,*], Mattia Brambilla[b,c], Giuseppe Bogliani[a]

[a] Department of Earth and Environmental Sciences, University of Pavia, via Ferrata 9, 27100 Pavia, Italy
[b] Museo delle Scienze, Sezione di Zoologia dei Vertebrati, Corso del Lavoro e della Scienza 3, I-38123 Trento, Italy
[c] Fondazione Lombardia per l'Ambiente, Settore Biodiversità e aree protette, Largo 10 luglio 1976 1, I-20822 Seveso, MB, Italy

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ABSTRACT

Coupling habitat models based on GIS and on ground variables could help identify suitable areas (by means of landscape models obtained by GIS variables) to concentrate management actions for species' conservation. In this study, the habitat requirements of Lesser Greys (LGS) and Woodchat Shrikes (WS), two threatened farmland bird species declining in Europe, were assessed in Apulia (south-eastern Italy) by means of binary logistic regression at two different levels: landscape (using GIS-measured variables); and, territory (using ground-measured variables) scales. The LGS occurrence at landscape scale was correlated to steppe-like areas and cereal crops. At the territory level, significant effects were detected for deciduous forests and the presence of isolated trees and shrubs. The WS occurrence at landscape scale was promoted by steppe-like areas and cereal crops, whereas, at the territory level significant effects were detected for steppe-like areas positively and suburban areas negatively. The landscape model was extrapolated to the entire region. Within highly suitable areas (occurrence probability higher than 0.66 according to the landscape model), we measured average habitat features and compared them with the optimal mosaic depicted by the territory level models. This allowed us to give spatially explicit and site-specific management recommendations for these two threatened species. LGS will mostly benefit from an increase in isolated shrubs and trees; whereas for WS, the most widespread recommendations are to increase steppe-like habitat and to prevent further urbanisation.

Coupling "coarse" landscape models with the species ecology provided by fine-scaled models can integrate relevant information on species potential distribution and territory level requirements, making planning fine-tuned habitat management (within potentially suitable landscapes) in a spatially explicit way possible.

Introduction

Farmland bird species represent a large proportion of European avifauna, and the populations of several species have suffered a dramatic decline in recent decades, especially in Western Europe (Donald et al. 2002). The causes of this decline have been identified mostly in the changes of agricultural practices, such as heavy mechanisation, increased fertiliser inputs, and a temporal shift of cereal sowing from spring to autumn. In addition, the loss of landscape heterogeneity, through the destruction of hedgerows, shrubs, tree patches, and other natural areas, following intensification (Benton et al. 2003; Donald et al. 2002; Fuller et al. 1995; Newton 2004). These changes have led both to the reduction of refuge and reproduction areas and to the decrease in invertebrate prey, the latter of which is also prompted by the increase in biocide use (Benton et al. 2002; Boatman et al. 2004; Genghini et al. 2006; Wilson et al. 1999). A further cause of farmland species' decline is represented by land abandonment (Donald et al. 2002; Rippa et al. 2011; Suarez-Seone et al. 2002), which is threatening important farmland bird populations in mountain areas (Brambilla et al. 2010).

A set of agri-environmental policies (AEPs) has been initiated to make safeguarding agro-ecosystems and their dependent species possible. Targeting is, therefore, required to direct agri-environment funding to those areas and actions which will provide the greatest environmental results (Thompson et al. 1999; Webster & Felton 1993). Consequently, knowledge of the distribution and characterisation of preferred species' habitats is essential to achieving this goal and, hence, species' conservation and management planning.

Resource Selection Functions can be used to synthesise the process of habitat selection into a mathematical expression in order to predict the distribution of a species (Boyce & McDonald 1999; Boyce et al. 2002; Jedrzejewski et al. 2008). Geographical Information Systems (GIS) are often used for this purpose (Chow et al.

* Corresponding author. Tel.: +39 3331868129.
E-mail address: harrier84@libero.it (G. Chiatante).

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2005; Jedrzejewski et al. 2008; Olivier & Wotherspoon 2005), but GIS environmental layers, although capable of operating at very fine scales in some specific cases, often only give coarse information about a habitat at landscape level (Jaberg & Guisan 2001; Numa et al. 2009; Westphal et al. 2003), which may not be sufficient to provide detailed knowledge of species' ecological needs at a finer scale (Brambilla et al. 2009). As a consequence, it is often necessary to improve GIS-based definitions of suitable areas for a given species by integrating them with a fine-scaled study of habitat preferences based on variables measured in the field in order to plan an operational habitat management scheme for the study species (Boyce 2006; Brambilla et al. 2009; Parody & Milne 2004; Suzuki et al. 2008). Effective habitat management can be developed only if the habitat preferences of a species are known with sufficient detail (Hinsley & Bellamy 2000; Hobbs 1997; Mabry et al. 2010; Moreira et al. 2005).

A spatially explicit map of species' distribution in terms of habitat suitability could assist conservation managers by identifying potentially suitable areas within which to concentrate conservation or management actions (Smith et al. 2007; Traill & Bigalke 2006).

Conversely, when the factors affecting species occurrence and/or abundance operate at a fine-scale and the underlying variables are poorly represented as GIS layers (see above), mapping species' potential distribution can be difficult. In this case, carrying out field surveys of the actual distribution of the species in a portion of the area concerned, in parallel with the measurement of the environmental variables at a small scale, may allow for the identification of potentially suitable areas within which species occurrence is determined by the presence/absence of fine-scale determinants of habitat selection. Combining the use of GIS models with fine-scaled analyses of habitat preferences and habitat features of study areas could, therefore, offer opportunities to plan effective management actions within suitable landscapes. This type of an approach would allow for the identification of the measures needed to increase fine-scaled habitat suitability within "structurally" suitable landscapes and bridge the gap between coarse landscape structure (and relative distribution models) and within-territory habitat (see Brambilla et al. 2009). Previous works suggested a set of measures to be applied at the fine scale within landscapes potentially suitable at the large scale (Brambilla et al. 2009). This approach can be further developed to promote full integration between the information provided by the two different evaluations of habitat preferences by explicitly mapping the area-specific management options required at the territory-level on the basis of fine-scale habitat preferences within areas suitable at the landscape scale and identified on the basis of the GIS model within which the variables affecting fine-scale habitat preferences have also been quantified. Measuring fine-scale variables within potentially suitable landscapes and the relative departure from optimal values for target species would allow for an effective planning of habitat management with site-specific recommendations aimed at maximising fine-scale habitat suitability within areas potentially suitable at the coarse-scale.

The aim of this research was to carry out a two-level assessment of habitat preferences and to propose spatially explicit management recommendations in two species of conservation concern: the lesser grey shrike (*Lanius minor* J.F. Gmelin, 1788); and, the woodchat shrike (*Lanius senator* Linnaeus, 1758). Firstly, we identified potentially suitable landscapes at the regional scale. Secondly, we identified fine-scaled habitat variables affecting occurrence at the territory level in order to develop a conservation strategy through dedicated habitat management in farmland habitats in southern Italy for these two threatened species. After the two-level assessment of habitat preferences on the basis of the fine-scale habitat traits of the potentially suitable areas, we considered specific fine-scale features of each potentially suitable area and proposed management recommendations for each individual area which aim at reducing the discrepancy between actual and optimal habitat composition within the areas. This three-step to a spatially explicit definition of management recommendations based on the integration between landscape models (which identified the areas) and fine-scaled models (which identified habitat features associated with species occurrence) to identify limiting factors within each area specifically.

Methods

Study model

Shrikes (Laniidae) are highly associated with farmed landscapes and have, therefore, suffered significant declines in their population distribution and size (Yosef 1994; Yosef & Lohrer 1995; Yosef & Lohrer 1998; Yosef et al. 2000).

Within this family, considerable attention has been given to three of the five species breeding in western Europe: *Lanius collurio* (see e.g. Brambilla & Ficetola 2012; Brambilla et al. 2009, 2010; Ceresa et al. 2012; Goławski & Meissner 2008; Söderström & Karlsson 2011) and the two species *Lanius excubitor* and *Lanius meridionalis* (e.g. Karlsson 2002; Keynan & Yosef 2010; Kuczyński et al. 2010; Olsson et al. 2010; Padilla et al. 2009). The other two species, *L. senator* and *L. minor*, have been poorly investigated (but see Giralt & Valera 2007; Guerrieri & Castaldi 2000; Guerrieri & Castaldi 2010; Guerrieri et al. 1995; Hernandez 1994; Isenmann & Debout 2000; Moskát & Fuisz 2002).

L. minor inhabits open areas with small woods and scattered trees and is strongly associated with traditional (low intensity) agricultural landscapes (Cramp & Perrins 1993; Harris & Franklin 2000; Lefranc & Worfolk 1997). Since the early part of the 20th Century, this species has suffered a steady decline with the extinction and the reduction of several European populations (BirdLife International 2004; Lefranc 1995; Lefranc & Worfolk 1997). Consequently, the species is listed on Annex I of the Birds Directive (2009/147/EC). One of the main causes of their decline is the intensification of agriculture by landscape alteration, loss of hedges and rows, and the heavy use of fertilisers and biocides. Climate changes in reproductive areas and drought in the wintering areas are thought to be other causes of the species' decline (Kristin & Lefranc 1997; Lefranc 1995).

L. senator is a smaller species mainly associated with Mediterranean areas where it breeds in grassland with shrubs and scattered trees, arid steppes, and semi-desert. This species also breeds in plantations, particularly olive groves. In the northern part of its distribution, it is a typical inhabitant of traditional orchards with scattered trees (Cramp & Perrins 1993; Harris & Franklin 2000; Lefranc & Worfolk 1997). It has undergone a steady decline in past decades throughout its entire range due to agriculture intensification, forestry, and fires (BirdLife International 2004; Hernandez 1997; Lefranc & Worfolk 1997). Climate change leading to more frequent wet springs is also thought to be a major threat to this shrike species. Prolonged droughts and changes in agricultural practices in wintering areas are thought to be the other causes of population decline. In Italy, Spain, and North Africa the species is illegally but regularly poached (Harris & Franklin 2000; Hernandez 1997).

Study area

The study area includes the whole territory of the Apulia region in south-eastern Italy (19,358 km^2) (Fig. 1). The area is dominated by lowland plains with hills and small mountains in the north-western portion of the region (highest peak 1151 m a.s.l.). The