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On habitat characteristics driving meadow passerine densities in lowland hay-meadow systems in France

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ABSTRACT

For meadow bird conservation in Europe, promoting specific farming models in their remaining strongholds could be a necessary complement to the ongoing agri-environmental policy. This study aims at understanding the main drivers of meadow passerine density in the objective of guiding conservation policies. The data were collected in 56 lowland hay-meadow regions important for grassland bird breeding in France. The objective was to explain, using GLMMs, the variation in meadow passerine density, measured annually in 490 12-ha plots during the period 2006–2010 by the count point method. Explanatory variables enabled us to describe farming management, sward structure and habitat size. Passerine density (all species except the skylark *Alauda arvensis*) depended on the extent of habitat available and on the percentage of meadow already mown on June 20. More specifically, the skylark was attracted to low, floristically rich and early mown swards, the whinchat *Saxicola rubetra* and the yellow wagtail *Motacilla flava* to large areas of favourable habitat, and the corn bunting *Emberiza calandra* to floristically rich meadows mown later than June 20. Extensive farming models based on late mowing in the largest habitat units should therefore be a target for meadow passerine conservation. The skylark was an exception. Because of its apparent tendency to use early mown grasslands, we recommend to rather invest on alternative habitats for sustaining the demography of this species.

1. Introduction

Meadow bird populations are declining in Europe (Voříšek et al., 2010). Their reproductive output seems to be too low to compensate for adult mortality (Roodbergen et al., 2012) and available areas of suitable habitats are decreasing with changing agricultural practices (Crockford et al., 1996). In France for example, permanent grasslands have lost two million hectares (−21%) between 1989 and 2014 (Ministère de l'Environnement, de l'Energie et de la Mer, 2016). Current agri-environment policies in Europe were obviously insufficient to halt this decline (Berg and Gustafson, 2006; Breeuwer et al., 2009; Davey et al., 2010; Princé et al., 2012), as shown by the case of one of the most widespread species, the whinchat *Saxicola rubetra* (Bastian and Feulner, 2015). Reconsidering conservation policies is therefore an urgent need, with the aim of securing efficient demographic sources throughout the breeding range of threatened species. The most cost-effective solution could be to focus on the places where meadow bird densities are the highest, since: 1) the efforts expected to adapt farming practices in suboptimal habitat conditions with low population density are in principle stronger, 2) the effects of compensatory spending for a given surface unit may increase in proportion to bird density. Because of possible maladaptive habitat choice (Műller et al., 2005; Gilroy et al., 2011), mismatches may arise between bird distribution and their ability to efficiently reproduce. It would nevertheless be crucial to better understand the main drivers of meadow bird distribution and identify the specific conditions likely to attract and retain high population density in the conservation areas, at least as a prerequisite for implementing measures likely to sustain reproductive efficiency.

In this study, we attempted to explain the variation of meadow passerine density in the main breeding areas at altitudes lower than 300 m in France, with three categories of variables. Was bird density best explained by farming management (grassland fertilization, mowing chronology), by the sward structure (height, density, floristic richness) or by the local amount of favourable habitat and probably correlated population size? Farming management may affect habitat use through more or less significant mortality caused by haymaking (Műller et al., 2005; Grűebler et al., 2008; Broyer, 2009) or through its consequences on the structure

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and the composition of the sward (Vickery et al., 2001). Sward characteristics are likely to influence habitat selection when birds seek to maximise nest concealment (Jones and Dieni, 2007; Kerns et al., 2010; Erdos et al., 2011) or invertebrate-prey abundance and diversity (Atkinson et al., 2005; Devereux et al., 2006; Douglas et al., 2008). At a larger scale, the size of favourable habitat available locally may also be an important driver of grassland bird distribution (Helzer and Jelinski, 1999; Connor et al., 2000; Bakker et al., 2002; Ribic et al., 2009).

2. Material and methods

2.1. Study areas

In France, the most important regions where meadow birds breed have been involved since 2001 in an annual survey (Broyer and Curtet, 2005). This survey is still ongoing. The sampling procedure is based on "survey sites" i.e. large scale agricultural landscape units (alluvial plains, mountain massifs, etc.) which are described by a variable number of "sampling plots". Since there is no available data base for grassland systems still attractive for meadow birds, the survey sites were originally selected by ornithologist experts from each French "département" as landscape units the most likely to harbour a population of at least one of the expected species. The selected meadow areas therefore represent a limited range of grassland systems existing in France, in which the more extreme values of our response variables are unlikely to be found. The present analysis is limited to lowland areas at altitudes <300 m, in 56 survey sites (490 plots without missing data). The size of agricultural units may vary from several ten to several thousand hectares, in which favourable meadow bird habitat was often a cluster of patches scattered within not suitable cultivated or grazed lands. In many situations, the relevant size of survey sites (i.e. the sum of favourable habitat) was then difficult to assess. Plot number per survey sites varied from 3 to 78, roughly in proportion to favourable habitat available. The distribution of lowland survey sites in the northern half of France (Fig. 1) reflects the fact that, in the southern part of the country, grassland birds most often breed in upland meadows. Climatic variation across survey sites was limited by the absence of Mediterranean influences.

2.2. Data collection

The statistical unit for data collection was a 12 ha sampling plot, i.e. the area included within a 200-m-radius circle in which all required information was to be collected. Survey sites were visited annually under the coordination of ONCFS (a governmental Agency), by a network of observers from diverse environmental organizations (Nature Reserves, National Parks, Regional Parks, ONCFS local units, NGO, hunting societies). Training sessions for the different observers have been organized each year since 2000 to standardize the field work methods and application.

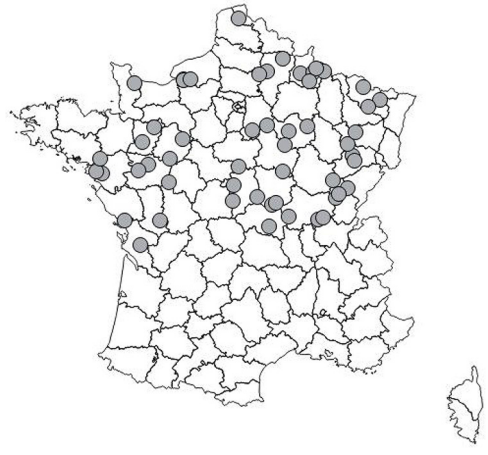

Fig. 1. Map of the lowland regions (<300 m) monitored by the National Hay-meadow Ecosystem Observatory during the period 2006–2010.

2.2.1. Bird abundance

A bird census was performed with the Point Count method by a static observer in the centre of each plot, during two successive sessions of 15 min in the first and the second half of the nesting period, before juvenile fledging time and before the start of mowing. In lowland survey sites, corresponding periods were 5–20 May and 25 May–10 June, with an interval of at least 10 days between the two counts. Since the survey was carried out in open habitat conditions without visual obstacles, no particular recommendation was made for daytime. Observed birds and their movements were systematically mapped as far as specific identification was possible with glasses ×10, in order to limit the duplicate recording of same individuals. Only ground-nesting species were taken into account, i.e. whinchat, stonechat *Saxicola rubicola*, yellow wagtail *Motacilla flava,* skylark *Alauda arvensis,* corn bunting *Emberiza calandra,* reed bunting *Emberiza schoeniclus,* tree pipit *Anthus trivialis,* meadow pipit *A. pratensis*, sedge warbler *Acrocephalus schoenobaenus,* marsh warbler *A. palustris,* and grasshopper warbler *Locustella naevia,* to assess meadow passerine number (sum of individuals) with, for each species, the maximum number recorded in the two 15-min sessions.

2.2.2. Environmental variables

The percentage, within each sampling plot, of total hay-meadow area that was already mown was assessed annually, on June 20 and on July 1. Additional information was collected once every 5 year. The small size of sampling plots was planned to limit the spatial variation of sward characteristics and management. One unique measure of vegetation height, density and flora richness was taken in a place carefully selected for being representative of the entire meadow unit. In some cases, two or more vegetation facies may exist across the hay fields of a same plot. Then, data on vegetation characteristics and meadow management were collected in the facies covering the largest proportion of the plot area. Vegetation height was defined within a 5-m-radius from the observer, as the height (at the nearest cm) at which approximately 80% of the vegetation was growing below, measured using a ruler (Stewart et al., 2001; Fisher and Davis, 2010). We also measured the height of the dense grass cover the most likely to conceal the nests, i.e. the height at which the horizontal visibility through the vegetation was fully intercepted. Grass cover density was described with the help of a 50 × 60 cm white wooden sheet, subdivided in 5 ten-centimeter strata of 6 squares 10 × 10 cm each, which was set vertically within the herbaceous vegetation, 2 m ahead of a squatted observer. The observer had to count the squares of which at least 50% was visible through the plant cover. Moreover, flora richness was quantified along a 10 m × 2 m transect and grassland fertilization was described by questioning the farmers.

This enabled us to describe proximate habitat conditions for meadow birds. But the surrounding landscape was also likely to influence bird abundance in sampling plots. For example, area sensitivity, whereby the pattern of a species density tends to increase with patch area of favourable habitat, may vary according to landscape features (Horn and Koford, 2004; Winter et al., 2006). Considering that: 1) higher meadow bird density may be associated with landscapes where cover types are less diverse (Ribic and Sample, 2001; Rao et al., 2008), 2) landscape openness at