Agriculture, Ecosystems and Environment 257 (2018) 60–67

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Effects of organic farming on bird diversity in North-West Spain

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ARTICLE INFO

Keywords:
Organic farming
Bird diversity
Heterogeneous landscape
Native forest
Mediterranean countries

ABSTRACT

Many studies have investigated effects of organic farming on the abundance and diversity of farmland birds, but few have considered how these effects vary between seasons. We analysed the effects of organic farming during an entire year in a previously understudied region, Galicia (North-West Spain), a relatively heterogeneous landscape which is an important wintering and breeding ground for birds. We compared bird abundance and species richness on farmland in 0.5×0.5 km study squares on 16 paired organic and conventional farms. In addition, at each organic farm we compared bird abundance and species richness between one similar study square with a high and one with a low proportion of organic farming, respectively. During winter, species richness was higher in organic farms compared to conventional ones. Throughout the year bird abundance was higher in squares with a high proportion of organic farming compared to those with a low proportion of organic farming, but only when they were surrounded by land with a low proportion of agriculture. Bird abundance in organic squares increased with the proportion of land being native forest resulting in more mosaic landscapes. Seedeaters particularly benefited from organic farming, with high abundances on organic farms in landscapes with a low proportion of agricultural land. Our results suggest that organic farming can benefit farmland birds in heterogeneous landscapes, particularly during winter, probably due to increased food availability, but future studies are needed to clarify the mechanism behind the effects.

1. Introduction

The ongoing decline of European farmland biodiversity is generally attributed to the intensification of European agriculture during the past half century (Donald et al., 2001; Stoate et al., 2001). Agricultural intensification can occur both at field and at landscape scales (Benton et al., 2003; Concepción et al., 2008). At field scales, intensification involves e.g. increased use of inorganic fertilisers and pesticides and simplified crop rotations. At landscape scales, structural rationalisation and regional specialisation of agriculture drive landscape simplification. Both processes have detrimental consequences for farmland biodiversity. Organic farming has been suggested to be a way of counteracting the decline of farmland biodiversity (Hole et al., 2005). Organic farming benefits biodiversity mainly because of the restricted use of agro-chemicals, choice of crop type and crop rotations (Smith et al., 2010). Ultimately, organic farming is thought to counteract the decline of farmland biodiversity because it has the potential to restore the loss of heterogeneity that agricultural intensification has produced (Benton et al., 2003).

Several studies have analysed the potential of organic farming as a tool to enhance farmland biodiversity in Europe, with results varying mainly because of the moderating effect of landscape complexity (Tuck et al., 2014). Most studies have shown that organic farming increases diversity of invertebrates and birds in homogeneous landscapes (intensively-farmed plains), and that effects level off as the complexity of the landscape increases (Rundlöf and Smith, 2006; Rundlöf et al., 2008; Batáry et al., 2010; Tuck et al., 2014). However, relatively few studies have analysed if organic farming affects biodiversity in Mediterranean countries (Tuck et al., 2014). Since agriculture in Mediterranean countries differs from that in the more well-studied Central and Northern Europe, it is important to address if the effect of organic farming on biodiversity generalizes also to these countries, resulting in a more general understanding of how organic farming affects biodiversity in different biogeographic regions.

Birds have been a prominent group in studies of the biodiversity consequences of organic farming, both because of the public interest in birds and the relative ease by which they can be studied. Still many aspects are understudied also for this group. First, most studies on the

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https://doi.org/10.1016/j.agee.2018.01.020
Received 19 June 2017; Received in revised form 15 January 2018; Accepted 20 January 2018

effect of organic farming on farmland birds have been done during the breeding season (Kleijn et al., 2006; Concepción and Díaz, 2010), and only a few during the migration season (Dänhardt et al., 2010), or in winter (Geiger et al., 2010; Chamberlain et al., 2010; Morales et al., 2015). Since birds are more strongly central-place foragers in spring and summer compared to autumn and winter (see e.g. Smith et al., 2014), and availability of food resources in winter might be a key limiting factor for some bird species, mainly granivorous (Chamberlain et al., 2010), we can also expect birds to differ in their responses to organic farming between seasons, which may provide different resources in different times of the year. No study has analysed effects of farming regime on farmland birds across an entire year. Second, while it is known that organic farming differentially affect species with different ecological traits (Birkhofer et al., 2014), few studies on birds have investigated differential effects of organic farming on functional groups (but see Filippi-Codaccioni et al., 2009; Dänhardt et al., 2010). In particular, because organic farming benefits plants and some arthropod groups (Tuck et al., 2014; Lichtenberg et al., 2017), organic farming can be expected to have contrasting effects on bird feeding guilds (cf. Kragten and de Snoo, 2007). Third, while it is known that the extent of organic farming can affect biodiversity (Rundlöf et al., 2010), only study one study has investigated this for birds (Gabriel et al., 2010).

In this study we investigate if organic farming affects the abundance and diversity of farmland birds in central Galicia (North West Spain) during an entire year. In this region, the extent of organic farming has increased with more than 33% during the last 18 years, but the intended positive consequences for biodiversity (CRAEGA, 2014, 2015) remains unknown. The agricultural landscapes in Northwestern Spain are generally heterogeneous, with small agricultural fields embedded within patches of forest, but experience some intensification at field and landscape scales (Sau et al., 1999). Hence, it is not evident that the positive effects of organic farming on biodiversity that has been found in simplified landscapes in Central and Northern Europe would occur in these landscapes. Furthermore, because Northwestern Spain is an important wintering ground for some Northern European species (SEO/Birdlife, 2012), and a breeding ground for many Southern species, our study not only has local implications, but may inform about the value of organic farming in creating high-quality winter habitat both for local residents and migrants from more northerly areas.

We tested the hypothesis that the abundance and species richness of birds that at least partly utilise farmland benefit from organic farming. We did this through an entire year by (1) comparing organic and conventional farms and by (2) comparing areas with different amounts of land under organic management. We furthermore analysed if the benefits of organic farming on farmland bird assemblages depended on landscape context, since previous studies have shown different effects of open patches of agricultural land on farmland biodiversity depending on landscape complexity. In complex (mixed forest-farmland) landscapes, open agricultural patches benefit farmland bird diversity (Zakkak et al., 2014; Salaverri, 2015). We analysed the effect of landscape context by studying the main effects of landscape features, and the joint effects of farming management and landscape context. Whilst accounting for effects of overall land-use as farmland and forest, we expected a positive effect of the amount of farmland in the landscape on farmland bird diversity. We tested if insect and seed-eating species benefited more from organic farming compared to vertebrate-eaters and omnivorous birds (cf. Kragten and de Snoo, 2007), in particular if any such effect was stronger in winter when insects and seeds are naturally scarce, due to the lack of use of pesticides and other management practices common in organic farming (Chamberlain et al., 2010).

2. Materials and methods

2.1. Study area

We performed the study in the centre of Galicia (Ulloa Shire and surroundings), in the North West of Spain. The study area consisted of a heterogeneous landscape of farmland-forest, of 421 km^2, 550 m over sea level, with 46% of the land being forests and 35% consisting of farmland, with an average field size of 4.7 ha (IGE, 2012). Forests consisted of big patches of native deciduous forest, mainly comprised of oak (*Quercus robur*), chestnut (*Castanea sativa*) and birch (*Betula alba)*, all of which are increasingly replaced by exotic tree plantations of eucalyptus (*Eucalyptus globulus* and *E. nitens)*.

We selected 16 pairs of organic and conventional farms, matched to as far as possible minimise differences not related to farming practice within pairs (cf. Rundlöf and Smith, 2006). We identified organic farms based on whether they were registered in the Galician Regulating Board of Organic Agriculture (CRAEGA). We matched farms to pairs based on proximity (max 20 km apart), and land use (14 pairs of farms with grasslands used both for grazing and mowing, and 2 pairs of wheat farms). The majority ($n = 13$) of organic farms were mixed with animal husbandry and arable production (including fodder), while only two conventional farms were mixed. To minimise variability in landscape structure within pairs, we selected farms so that both farms in a pair had a similar percentage of agricultural land surrounding the centre of the farm (using 500 m radii).

Both organic and conventional farms used liquid manure to fertilize fields, and three organic farms fertilised with composted manure, which is recommended but not mandatory for organic farming in the area (CRAEGA, 2014). Conventional farms typically use synthetic insecticides every spring to control for the crane fly (*Tipula* spp.), irrespectively of the actual densities of crane flies. Six conventional farms rotated grassland and maize annually, ploughing and planting grass after the maize was harvested in late summer, while eight conventional farms had permanent grasslands all year round. In ten of the studied organic farms, farmers kept grasslands for five years approximately, after which they ploughed them, whereas four farms had permanent pastures (Appendix A in Supplementary materials).

We divided the entire 421 km^2 study area into 500×500 m squares in order to obtain study sites containing both organic and conventional fields, as both conventional and organic farms in the study region consisted of several fields interspersed amongst other farms and landscape features. We thereafter chose two study squares to represent each of the 16 organic farms. Because of the farm structure, the squares often contained some conventional managed land; we therefore selected the squares containing the highest and lowest possible percentage of organic land on each organic farm. We chose one study square to represent each of the 16 conventional farms which was as similar as possible in terms of percentage of agriculture than the matched organic squares of its pair. Thus, the total data consisted of 32 organic study squares and 16 conventional study squares. For each study square, we calculated the percentages of agricultural land, shrubs, native forests, exotic plantations and urban areas based on a GIS-vector layer, digitalised based on aerial photographs and field visits, using ArcGIS 9.3 (Esri, 2006).

2.2. Bird censuses

We monitored birds by counting all birds seen and heard, identified to the species level, along 500-m transects situated within each study square, following, as far as possible the diagonal of the square, and walking within the studied fields when possible. We separated transects on the same organic farm with at least 200 m, as it was taken to be the detection radius for birds. The same observer visited the single conventional and the two organic study squares within a pair on the same day to minimise bias (cf. Kleijn et al., 2006), while systematically