Ornis Hungarica 12-13: 33-40. 2003

Conservation of european farmland birds: abundance and species diversity

C. Stoate, M. Araújo and R. Borralho

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Across much of Europe, farmland birds have declined more than those in other habitats; many of the most threatened birds are dependent on extensive farming systems. This paper describes two case studies in which bird abundance was monitored in relation to spatial and temporal differences in agricultural management, one in southern Portugal, the other in central England. In Portugal, bird abundance and species diversity were monitored in 1995 using transects in relation to three agricultural systems. Bird abundance and species diversity were both low in simple intensively managed farmland, and highest in extensively managed farmland incorporating agroforestry systems (Montado). However, species of greatest national and European conservation concern were most abundant in simple, open, extensively managed landscapes. These extensive systems are therefore important for species diversity at national and European scales. In England, a conventionally managed farming system was adapted to encourage gamebirds for shooting, and bird abundance was monitored annually. Transects were conducted within the study area from 1992 to 1998 and additional transects were conducted randomly in the surrounding farmland from 1995 to 1997. Bird abundance increased during the management period and was higher in the study area than in the surrounding area, especially for nationally declining species. However, there was little difference in species diversity across years or sites. Our monitoring demonstrates three important points: 1- Extensive farming systems play an important role in maintaining species diversity at national and European scales, even where abundance and diversity are low at the farm scale. 2- Abundance of nationally declining bird species can be restored rapidly, following population declines, if appropriate management systems are adopted. 3- Bird conservation can be accommodated within multifunctional land-use systems, including agricultural systems incorporating game management.

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1. Introduction

Farmland ecosystems have evolved through the development of agriculture, becoming almost uniquely characteristic plant and animal communities (Potts 1991). However, rapid changes in farming methods in the second half of the 20th century resulted in the partial collapse of this ecosystem (Potts 1997). Throughout most of Europe, farmland birds have declined as a result of simplification of farming systems and increased use of external inputs (Tucker & Heath 1994, Fuller 2000). 43% of bird species associated with arable habitats now have an unfavourable conservation status (Tucker 1999). Such responses to agricultural intensification are particularly well documented in northern Europe, but in southern Europe, abandonment of agricultural land has also caused severe declines in some bird populations (Beaufoy *et al*. 1994). Increasingly, farmland bird species are becoming an important focus for conservation policy (*e.g*. Tucker 1997, Swash *et al*. 2000) and are being used as indicators of wider ecological changes (Tucker 1999).

This paper reviews two studies of farmland bird communities in relation to farming systems in Portugal (Araújo *et al*. 1996) and England (Stoate & Szczur in press, Stoate in press). The Portuguese study compares bird abundance and species diversity between one intensive and two extensive farming systems within one year. The English study monitors bird abundance and species diversity over a seven-year period in which a conventional farming system was adapted to meet the ecological requirements of wild gamebirds. This game management system aims to adapt a modern farming system to provide some of the ecological conditions found in former extensively managed systems, but with minimal economic impact on the farm as a business. The monitoring aims to identify a potential role for such management in the conservation of declining farmland birds.

2. Study areas and methods

2.1. Portugal

The study area included parts or all of five administrative regions in Baixo Alentejo (Ferreira do Alentejo, Aljustrel, Castro Verde, Ourique and Almodôvar) and covered a total area of 155 000ha. Within this region, three land-use systems were recognised: intensive agriculture, extensive agriculture and Montado.

The intensive agriculture category is characterised by a greater frequency (>55%) of heavy soils, much of the area being irrigated. Wheat *Triticum aestivum* and barley *Hordeum distichum* are the main cereal crops and silage grass *Lolium sp*, sunflower *Helianthus annuus*, sugar beet *Beta vulgaris* and oilseed rape *Brassica napus* are also grown. Wheat yields are 2.5-3.5 tonnes/ha^{-1} without irrigation but can be almost doubled with full irrigation (P. Eden *pers comm* 1998). There are short rotations with little or no fallow (*e.g*. sunflower - 1st cereal - 2nd cereal). This system requires frequent use of fertiliser (130 units N_2/ha^{-1} (P. Eden *pers comm* 1998) and herbicides, relative to the other land-use categories. With the exception of some olive *Olea europea* groves, there is little tree cover.

The extensive agriculture category is characterised by thin soils and by the largest average farm size of the three categories. There is no irrigation and fallow area is relatively high. A typical rotation takes the form: plough fallow - 1st cereal - 2nd cereal - fallow - fallow, with fallow periods often lasting five years or more (Rio Carvalho *et al*. 1995). Wheat yields are 1.5-2.5 tonnes/ha^{-1} with yields at the lower end of this range being more common. Triticale *Triticum aestivum* x *Secale cereale* and oats *Avena sativa* are frequently grown in the extensive category, and grazed or cut for silage. The incorporation of a fallow period into the rotation, and the relatively low potential yields are associated with considerably lower annual inputs than in the intensive category.

Montado (equivalent to the Spanish dehesa) is characterised by thin soils and tree cover, dominated by holm oak *Quercus rotundifolia* and cork oak *Q.*

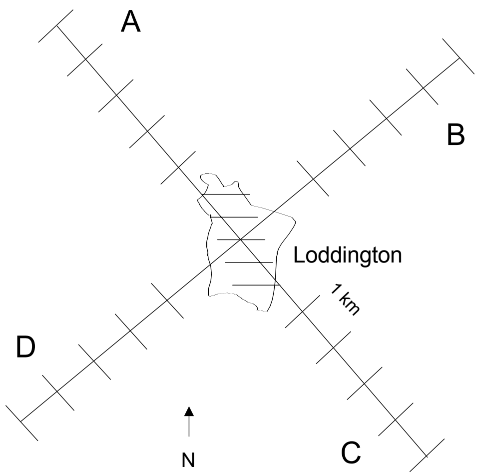

Fig. 1. Location of 1-km bird monitoring transects in relation to the Loddington farm boundary.

suber. Like the extensive category, there is no irrigation and the fallow area is high. A typical rotation is similar to that of the extensive category, although the fallow stage is often longer and it may include forage lupins *Lupinus luteus*. Sheep *Ovis aries*, cattle *Bos taurus* and pigs *Sus scrofa* are kept in all three land-use categories. Zero grazing is adopted on some farms in the intensive category but livestock normally graze fallows. More detailed information on these land use categories is provided by Stoate *et al*. (2000).

One hundred and fifteen 250m transects, starting at 1km grid intersections and stratified by land-use categories, were walked along a random bearing (Intensive: n=42, Extensive: n=42, Montado: n=31). Transect counts were conducted by a single observer in the first three hours after dawn of December 1994, 1995 and 1996, and April of 1996 and 1997. All adult passerines seen or heard, other than those flying across the count area, were recorded. For each category of land use, species were categorised into three levels of conservation concern (1 = rare, 2 = vulnerable, and 3 = other species thought to be declining but for which reliable data were not available) based on the criteria of SNPRCN (1991). In addition, total bird abundance and an overall Shannon-Wiener index of species diversity (Magurran 1988) were calculated for each land use category. Differences in bird abundance and species diversity between land-use categories were tested using ANOVA and LSD post-hoc tests (at $P<0.05$), using transects as sample units and log-transformed data.

2.2. England

The study area comprises approximately 150km^2 of mixed arable and livestock farms in Leicestershire, central England. The area consists of arable fields and grassland enclosed by hedges and there are numerous small woods. Soils are mainly heavy clay and the main crops are wheat, barley and oilseed rape. Within this area, transects (see below) were used to sample breeding abundance of birds in four discrete zones (Fig. 1). The main study area, at Loddington, is located at the centre of the wider study area and covers an area of 3.33km^2. The farm at Loddington is owned and managed as a research and demonstration farm by the Allerton Research and Educational Trust, the main incentive for environmental management being the management of wild pheasants *Phasianus colchicus* for shooting (Boatman & Brockless 1998).

Game management started in 1993, following a year of baseline monitoring. This management included thinning and replanting of woods and active management of hedges in order to increase the area of shrubby vegetation. Gamecrops were planted on 20m-wide mid-field and field-edge set-aside strips in order to provide invertebrate-rich foraging areas for gamebird broods in summer, and cover and seed food in winter. Pesticide use in cereal crops, especially on crop headlands, was restricted in order to increase arable invertebrate abundance (Sotherton 1991). Beetle banks and herbaceous strips in field boundaries were established to provide nesting cover for gamebirds and suitable summer and winter habitat for beneficial invertebrates (Rands 1987, Thomas *et al.* 1991). Legal control of potential nest predators was conducted from April to July each year (Tapper *et al*. 1996) and grain was provided by hand and from hoppers through the winter and early spring.

In the years 1992-1998, transect counts across all habitats at Loddington were used to provide an abundance index for each species. Transect counts were conducted by a single observer in fine weather in May and early June, in the first three hours after dawn. Four counts were conducted on foot each year at approximately fortnightly intervals. Transect routes totalled 11.5km and were constant between visits and years, incorporating well-defined habitats on each side of the transect line (ie the adjacent field and field boundary). All adult passerines seen or heard, other than those flying across the count area, were recorded.

In the years 1995-1997, separate transect counts were used to compare an index of breeding bird abundance at Loddington with that in the surrounding area. For this, five 1km long transects were conducted within Loddington and five transects were conducted at 1km intervals along each of four bearings radiating out from the centre of Loddington. The first bearing was selected at random, with subsequent bearings at 90°, 180°, and 270° to it. These formed four zones lacking wild game management for comparison with Loddington (Fig. 1). Each of the 25 transect counts was conducted once in May in the first three hours after dawn.

Data from the five transects in each area were pooled. Passerine species were divided into three categories: Biodiversity Action Plan (BAP) species (targeted for conservation action), other nationally declining species, and nationally stable or increasing species. In addition, a Shannon diversity index was calculated as a measure of species diversity (Magurran 1988). The index of total bird abundance (all birds counted), the species diversity, and the abundance indices for nationally declining and stable/increasing species at Loddington were all compared with the equivalent measures in the four zones in the surrounding area using log-transformed data and two-way ANOVA (zone×year) followed by contrast analysis (Loddington v average of zones A-D).

3. Results

3.1. Portugal

Overall bird abundance differed between all land-use categories ($F_{2,112}$=23.85, P<0.001), being significantly higher in Montado than in extensively and intensively managed farmland. Abundance of birds in all three categories of Portuguese conservation status differed significantly between land-use categories (Rare: $F_{2,112}$=18.02, P<0.001, Vulnerable: $F_{2,112}$=9.31, P<0.001, Other declining species: $F_{2,112}$=23.78, P<0.001); birds were

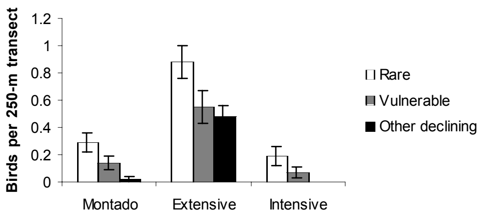

Fig. 2. Abundance of birds (mean ± se) of 'Rare', 'Vulnerable' and 'Other declining' conservationstatus in Portugal in relation to three Alentejo farming systems.

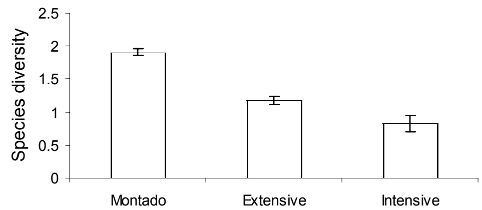

Fig. 3. Shannon-Wiener index of bird species diversity in relation to three Alentejo farming systems.

significantly more abundant in the extensive farming category than in intensive farming or Montado (Fig. 2). Species diversity also differed between land use categories ($F_{2,112}$=40.24, P<0.001), but was significantly higher in Montado than on extensively or intensively managed farmland (Fig. 3).

3.2. England

At Loddington, numbers of birds in the 'nationally declining species' category rose significantly over the seven-year period (r_6=0.87, P=0.01), the main increase occurring between 1992 and 1995, and were 129% higher in the 1995-1997 period than in 1992. Numbers of birds in the 'nationally stable and increasing species' category rose by 42% (r_6=0.66, n.s.) (Fig. 4). The Shannon Index of species diversity at Loddington increased from 1.10 in 1992 to an average of 1.16 in the 1995-1997 period, although this increase over the seven-year period was not significant (r_6=0.69, n.s.) (Fig. 4).

In the 1995-1997 period, there were no zone x year interactions in any of the variables examined. There was no difference in total bird abundance, bird abundance of nationally stable species, species richness or species diversity between Loddington and the average across the four zones in the surrounding area. There was a significant difference in BAP species abundance between Loddington and the average of zones A-D (contrast analysis $F_{1,9}$=7.52, P<0.05). Other nationally declining species were also significantly more abundant at Loddington than in the surrounding area ($F_{1,9}$=16.77, P<0.01; Fig. 5).

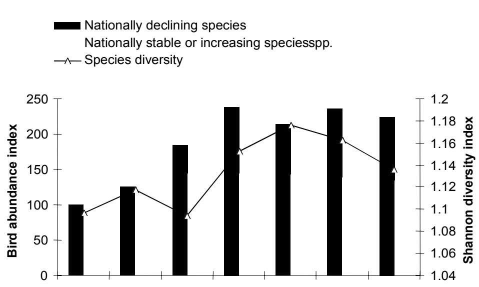

Fig. 4. Bird species diversity and relative abundance of 'nationally declining species', 'nationally stable or increasing species' at Loddington.

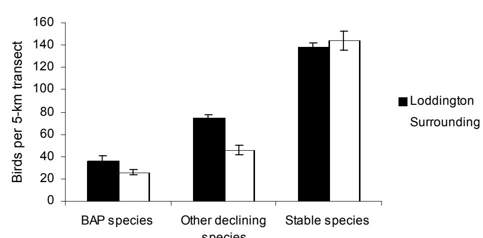

Fig. 5. Abundance (mean ± se) of Biodiversity Action Plan species, other nationally declining species, and nationally stable or increasing species at Loddington.

4. Discussion

Intensively managed farmland in both Portugal and England supports low species diversity and bird abundance. Although lost from England, extensively managed arable systems survive in Portugal where they are represented by such systems as Montado and the extensively managed arable steppe considered in this study. Montado supports both high bird abundance and high species diversity.

Higher species diversity within Montado may be explained by a combination of edge effects and the intermediate disturbance hypothesis. Montado comprises transitional systems between extensive arable steppe and forest and therefore it shares the bird communities of both systems. This is similar to Odum's (1971) 'edge effect' of increasing diversity as a result of the spatial overlap of species from neighbouring assemblages. Montado has intermediate frequency and intensity of disturbance, relative to intensive agricultural systems or old growth Mediterranean forest. Theory predicts higher mortality and lower productivity in highly disturbed areas (e.g. intensive farming), where diversity is low because populations of some species are unsustainable. At low levels of disturbance (e.g. old growth forests), mortality is reduced but diversity is low due to competitive exclusion, as the dominant species eliminate poorer competitors (for a review, see Huston 1994).

In this study, abundance of species of greatest conservation concern was low in Montado, relative to extensive arable steppe. Although Montado supports higher species diversity at the local scale, extensive arable steppes make an important contribution as habitats supporting globally threatened species such as Great Bustard *Otis tarda*, Lesser Kestrel *Falco naumanni* and other species of conservation concern within Portugal. In this study, most species observed within Montado are transitional species which also occur in other habitat types. These generalist species are not as threatened as those dependent on the specific conditions associated with extensive arable steppes. For example, within this habitat Moreira (1999) has shown that fallow area and structural diversity of vegetation influence bird abundance and species diversity. Maintenance of these habitats is therefore essential to the conservation of many farmland species. Nevertheless, even within more intensively managed areas of farmland, agricultural management could be adapted to meet conservation objectives, either by restoring traditional extensive management, or by introducing novel management practices that are designed specifically to meet the ecological requirements of nationally declining birds.

The results from England suggest that this approach can be successful. In this case, the incorporation of a game management system into an otherwise conventional farming system resulted in a greater increase in numbers of species of conservation concern than numbers of other species. However, game management may also benefit some of these less threatened species, as indicated by Stoate e*t al.* (2000) for Corn Bunting *Miliaria calandra* at the Portuguese study site . Although the English study found little change in species diversity at the farm scale, modifications to farming systems, such as the integration of game management, can therefore contribute to maintaining species diversity at the national scale.

Extensive traditional farming systems are currently receiving support in order to meet social and environmental objectives under EU Rural Development Regulation 1257/99. Borralho *et al*. (1999) indicate that a Zonal Programme introduced under an earlier regulation (2078/92) has successfully contributed to bird conservation in the Portuguese study area. In many parts of northern Europe, and in some parts of southern Europe, other innovative approaches to agricultural management may be more acceptable to farmers than a perceived 'reversion' to traditional systems. This is especially likely where management changes have economic, social or cultural benefits to farmers, as well as meeting environmental objectives such as the maintenance of national bird species diversity on farmland.

Acknowledgements. The Portuguese study was part of a wider project on biodiversity of European farming systems and was funded by ERENA and the European Commission Environment Programme (PL93-2239). Peter Eden provided agricultural information. The Game Conservancy Trust and the Allerton Research and Educational Trust funded the English study. We thank Nicholas Aebischer for statistical advice and comments on the text.

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