Bird assemblages of an Iberian cereal steppe

A. Delgado a,1, F. Moreira b,*

a Liga para a Protecção da Natureza, Estrada do Calhariz de Benfica, 187, P-1500 Lisbon, Portugal
b Centro de Ecologia Aplicada ‘Prof. Baeta Neves’, Instituto Superior de Agronomia, Tapada da Ajuda, P-1399 Lisbon Codex, Portugal

Received 22 January 1999; received in revised form 29 June 1999; accepted 12 August 1999

Abstract

The cereal steppes of Castro Verde (Portugal) support many bird species of high conservation value on which agricultural practices can have significant impacts. The aim of this study was to describe the seasonal variations in bird assemblages using the agricultural landscape mosaic and to explore the potential ecological implications of changes in land use on bird populations. Bird densities and habitat variables were measured in four habitat types (cereal fields, fallow land, stubbles, and ploughed land) during 1997/1998, and detrended correspondence analysis used to summarise information on the structure of bird assemblages across habitats in the winter, breeding and post-breeding periods. Pluvialis apricaria L., Vanellus vanellus L., Alauda arvensis L. and Anthus pratensis L. were abundant during winter. During the breeding season, bird assemblages were quite distinct across land use types, with species typical of cereal fields (e.g. Miliaria calandra L.), fallow land (e.g. Melanocorypha calandra L.) and ploughed land (e.g. Anthus campestris L.). After the breeding season, the overlap in bird assemblages increased again, with M. calandra, M. calandra L. and Ciconia ciconia L. being common. Species used different habitats along the year, showing the importance of maintaining the traditional agricultural landscape for preserving the diversity of bird species. The potential impacts of several types of agricultural changes (e.g. agricultural intensification, agricultural abandonment and increase in stocking levels) on the bird populations were discussed on the basis of the results obtained. Any change in the current farming system will probably lead to a decrease in steppe bird diversity. ©2000 Elsevier Science B.V.

Keywords: Landscape; Cereal cultivation; Bird assemblage structure; Impacts of agricultural changes

1. Introduction

Low-intensity farming systems of Europe have a high bird diversity (Tucker, 1997) and, among these, the pseudosteppe of the Iberian Peninsula hold a large proportion of species with unfavourable conservation status (Suárez et al., 1997; Tucker, 1997). Iberian pseudosteppes include semideserts, ‘páramos’ and cereal steppes (Martínez and Purroy, 1993; Tellería et al., 1988a, b). The most common pseudosteppe in western Spain and Portugal is the cereal steppe, created in flat, open landscapes by the extensive cultivation of cereals on a rotational basis, resulting in a mosaic of cereal fields, stubbles, ploughed and fallow land (usually used as sheep pastures) (Suárez et al., 1997; Moreira, 1999). Cereal steppes constitute a stronghold for several threatened
bird species, such as the great bustard, *Otis tarda* L., the little bustard, *Tetrax tetrax* L., the sandgrouse, *Pterocles* spp. and the lesser kestrel, *Falco naumanni* Fleischer (Tucker and Heath, 1994; Suárez et al., 1997).

Cereal steppes represent an economically marginal farming system, with yields of less than half the average European Union yields (Suárez et al., 1997). Consequently, land use of cereal steppes has been changing in the last decades because of agricultural intensification (especially irrigation), land abandonment and afforestation (Tucker and Heath, 1994; Suárez et al., 1997). Thus, this landscape is threatened by habitat degradation and loss, which can have significant impacts on the bird populations (e.g. Baldock, 1991; Díaz et al., 1993; Santos, 1996). The present Common Agricultural Policy (CAP) of the European Union promotes the maintenance of such farmed landscapes through agri-environmental regulation based on the compensation of farmers for maintaining agricultural practices allowing the conservation of threatened species (Robson, 1997).

Several authors (e.g. Baldock et al., 1993; Beaufoy et al., 1994; Tellería et al., 1994; Suárez et al., 1997) have drawn attention to the fact that the scientific basis for establishing practical management actions aimed at maintaining or increasing the bird populations are extremely scarce. Many studies of birds of pseudosteppes have focused on particular species (e.g. Martínez, 1994), season (e.g. Martínez and Purroy, 1993; Martínez and De Juana, 1996) or type of landscape (e.g. Tellería et al., 1988a; Hódar, 1996a, b), but few (e.g. Tellería et al., 1988b in central Spain) have attempted to characterise the seasonal use by bird assemblages of the various components of the mosaic cover created by the extensive cultivation of cereals. This type of data is, however, needed for adequately evaluating the consequences of changes in agricultural practices on bird populations.

The objectives of this paper were:

1. to describe the seasonal variation in land use of an agricultural mosaic of the largest cereal steppe in Portugal;
2. to describe the bird assemblages using each land-use category in this mosaic; and
3. to explore the implications of changes in agricultural practices on both the agricultural landscape mosaic and the bird populations.

### 2. Methods

#### 2.1. Study area

The study site was an area of 5240 ha located approximately at the centre of the cereal steppe of Castro Verde (ca. 37°43’N, 7°57’W), the most important area for steppe birds in Portugal (Grimmet and Jones, 1989). The traditional agricultural system used in this region is as follows: each farm is divided into parcels, each of which lies under cereal cultivation for two years, after which the land is left fallow for 2–3 years. The parcel is then ploughed to re-initiate the rotation cycle. Fallow land is generally used as pasture for sheep. The altitude ranges from 150 to 240 m, the annual average temperature from 15.5 to 16.0°C, and the annual rainfall from 500 to 600 mm. The site was located in the Meso-Mediterranean bioclimatic stage (Rivas-Martínez, 1981), tree cover being restricted to some plantation of olive trees (*Olea europaea* L.). Areas of scrub (*Cistus ladanifer* L.) occurred in rocky outcrops with no agricultural use.

#### 2.2. Land use

The availability of the different land-use classes was assessed by mapping land use in the whole study area (scale 1 : 25 000) in November 1996, using aerial photography and field checks of all farms. From then until August 1997, a monthly survey was made to register land-use changes. The area with each land use type was measured with a planimeter. In each season, i.e. winter (November to February), spring (breeding season, i.e. March to May), and summer (post-breeding, i.e. June to August) the percentage of the area with each land use was calculated by averaging the monthly estimates. Nine land uses were considered i.e. three types of cereals (*Triticum* spp., oats *Avena* sp. and barley *Hordeum* sp.), two types of fallows (recent, i.e. fallows from cereal in the previous spring, and old), ploughed land and three types of stubbles (one per each cereal). A small percentage of dry leguminous crops (ca. 2%) was not included in the calculations. For the purpose of this paper, data were pooled into cereals, fallows, ploughed fields and stubbles.
2.3. Bird counts

Bird counts were carried out within patches of a given land use type, using the Jarvinen and Vaissinen (1975) line transect sampling. Observations were recorded within, and beyond, a main belt of 25 m on both sides of the observer. Only birds within the sampled patch of habitat were registered.

Transects were defined in the land cover map in order to account for two basic conditions: (1) a minimum length of 500 m, and (2) assuring a sample size of at least 10 transects in each land-use type.

Counts were made during the first 3 h after sunrise. Mean travel speed (±SD) was 1.94 ± 0.39 km/h \((n = 358)\). Transect length ranged from 500 to 1125 m (mean = 782 ± 165 m).

Cereal field transects were surveyed monthly and these data were grouped in the following time periods: winter (December to February), breeding (March to May) and post-breeding (June to August). Fallow field transects were counted in winter (in November and again in January), breeding (April) and post-breeding (July). Ploughed land and stubble transects were counted twice in their season of occurrence (respectively breeding and post-breeding).

2.4. Habitat variables

Data on vegetation height and percentage cover were collected in fallows and cereal fields in November (December for cereal fields), January, April and July. Along each transect used for bird counts, the height of the vegetation was measured over the first 100 m of the transect at 10 sites (every 10 m) with a ruler to the nearest cm. The percentage cover in fallows was measured at 5 sites (20 m distance) along the transect. At each site, a 10-m tape was stretched in a random direction and the length of the tape with vegetation cover noted to the nearest 5 cm. For cereal fields, due to difficulties (potential crop damage) in stretching the tape, a quadrat of 50 × 50 cm² was used for estimating visually the cover of vegetation (Hays et al., 1981).

2.5. Data analyses

In half of the birds species considered for data analyses (11 out of 22), no individuals were registered within the main belt in at least one season. Thus, data for each transect were pooled (sum of detections within, and beyond, the belt) and expressed as (birds km⁻¹). Species occurring in <5% of all the counts were not analysed. Counts of both species of the genus Galerida occurring in the area (thekla lark, \(G. \text{theklae} \) Brehm, and crested lark, \(G. \text{cristata} \)) were pooled, due to difficulty in identifying some individuals.

Data for each transect were analysed grouped into season. Winter and post-breeding counts were log transformed to minimise the influence of large flocks in multivariate analysis (see below). When more than one count was made in each transect, data were averaged prior to transformation. For the breeding season the maximum count was used for species using the habitat for nesting and the average for species using the habitat for feeding (e.g. white stork, \(Ciconia \text{ciconia} \), and cattle egret, \(Bubulcus ibis \)), as it was assumed that the maximum count was the best estimate of breeding densities whereas the average would be the best indicator of intensity of use as feeding habitat.

Detrended correspondence analysis (DCA) (Gauch, 1982), was used to summarise the information on bird assemblages across the several components of the landscape. This ordination technique involves the derivation of new axes that maximally account for the structure of the points in a multi-dimensional space, making possible the reduction of dimensionality with minimal loss of information. These new axes maximise the correspondence between habitats and birds species, so that transects with similar bird assemblage composition are placed together, as are species with similar patterns of abundance across transects. DCA was carried out using the program CANOCO(Ter Braak, 1987), with the option for detrending by second-order polynomials.

For habitat variables, each land-use type was characterised by the average vegetation height and cover.

Non-parametric tests (Siegel and Castellan, 1988) were used to compare:
1. transect coordinates of each habitat type in the axes of DCA;
2. bird densities across habitats; and
3. habitat variables in cereal fields and fallows.

On account of the high number of tests when comparing bird densities across habitats, the sequential Bonferroni technique (Rice, 1989) was used to control the
probability of incorrectly rejecting one or more true null hypothesis. Analyses were performed using the SPSS software (Norusis, 1992).

3. Results

3.1. Land use and habitat variables

Seasonal variations in the agricultural landscape mosaic are shown in Fig. 1. During winter, the agricultural mosaic consisted of cereal fields (26% of the land use) and fallows (73%), 27% of which were recent (resulting from the stubbles of the previous summer). In spring, the landscape included ploughed fields (10% of the land cover), rapidly covered with vegetation and classified as fallows in the following summer. In summer, after harvest stubbles averaged 15% of the land cover. Several cereal fields were not harvested due to the low seed production caused by adverse weather conditions in that year.

Table 1 shows the seasonal variation of vegetation height and cover in fallows and cereal fields. Most comparisons (only one exception) yielded significant differences between habitats and seasons (for each habitat). In fallows, vegetation height and cover decreased progressively from winter to summer. For cereal fields, there was a peak in both these variables during spring, when the plants were fully developed.

3.2. Bird assemblage structure

The 60 bird species observed during the field work are listed in Table 2. Of these, only 22 occurred in >5% of the transects.

3.2.1. Winter

The four commonest species wintering in both, fallow land and cereal fields were skylark, *Alauda arvensis* L., golden plover, *Pluvialis apricaria* L., lapwing, *Vanellus vanellus* L., and meadow pipit, *Anthus pratensis* L., all reaching median densities >10 birds km\(^{-1}\) (Table 3). The results of the DCA (Fig. 2) suggest that there were differences in bird assemblage structure between these two components of the landscape, in spite of some overlap. There were significant differences between fallow and cereal transect coordinates in both the first (Wilcoxon test, \(z = -4.06, p < 0.001\)) and the second axis (Wilcoxon test, \(z = -3.07, p < 0.01\)). The first axis separated a group of species which were particularly abundant in some cereal fields, i.e. red-legged partridge, *Alectoris rufa* L., quail, *Coturnix coturnix* L., *Galerida* spp., and fan-tailed warbler, *Cisticola juncidis* Rafinesque. The second axis separated two species associated...
with several fallow transects (stone curlew, *Burhinus oedicnemus* L., and *Tetrax tetrax*) and one species (*Bubulcus ibis*) occurring in high density in two cereal transects. The remaining species were near to the origin of the plot, showing no particular pattern of association with any of the land-use types. A univariate comparison of species abundances between fallow land and cereal fields (Table 3) yielded significant differences for *A. rufa* (Wilcoxon test, $z = -2.88$, $p < 0.01$), *C. juncidis* (Wilcoxon test, $z = -4.74$, $p < 0.001$) and corn bunting, *Miliaria calandra* L., (Wilcoxon test, $z = -3.5$, $p < 0.001$), all more abundant in cereal fields.

### 3.2.2. Breeding season
Each of the habitats had a rather distinctive bird assemblage (Table 4) as clearly shown in the DCA results (Fig. 3), with significant differences between cereal, fallow and ploughed land transect coordinates in the three axes (Kruskal–Wallis test, $p < 0.01$). The patches of ploughed land had a high abundance of short-toed lark, *Calandrella brachydactyla* Leisler (24 birds km$^{-1}$) and relatively high densities (compared to other habitats) of black-eared wheatear, *Oenanthe hispanica* L., *B. oedicnemus*, and tawny pipit, *Anthus campestris* L. Fallows were characterised by the abundance of calandra lark, *Melanocorypha calandra* (19 birds km$^{-1}$) and *Tetrax tetrax* (10 birds km$^{-1}$), as well as a group of other species attaining higher densities in fallows than in other habitats: *B. ibis*, *Ciconia ciconia* and *Otis tarda*.

Cereal fields had a high abundance of *Miliaria calandra* (36 birds km$^{-1}$), *C. juncidis* (12 birds km$^{-1}$), *T. tetrax* (10 birds km$^{-1}$), and *C. coturnix* (2.3 birds km$^{-1}$). This habitat was the only one having exclusive species (*A. pratensis*, *A. arvensis*, *A. rufa* and southern grey shrike, *Lanius meridionalis* Temminck).

Comparison of species abundances across fallows, ploughed land and cereal fields (Table 4) yielded significant differences (Kruskal–Wallis test, $p < 0.05$) for most species.

#### 3.2.3. Post-breeding
The structure of bird assemblages was more variable after the breeding season (Fig. 4 and Table 5) in spite of significant differences between cereal fields, fallow and stubbles transect coordinates (for the first axis, Kruskal–Wallis test, $\chi^2 = 22.7, p < 0.001$; for the second axis, Kruskal–Wallis test, $\chi^2 = 11.8, p < 0.01$).

Fallow were characterised by the abundance of *Melanocorypha calandra* (4.0 birds km$^{-1}$), *C. ciconia* (1.7 birds km$^{-1}$) and *L. meridionalis* (1.4 birds km$^{-1}$). Species more abundant in fallows included the blackbellied sandgrouse (*Pterocles orientalis* L.), *B. oedicnemus*, *C. brachydactyla*, *O. tarda* and *T. tetrax*.
The main feature of cereal fields was the abundance of *C. juncidis* (6.1 birds km\(^{-1}\)), along with the occurrence of *C. ciconia* (1.3 birds km\(^{-1}\)), *L. meridionalis* (0.5 birds km\(^{-1}\)) and *C. coturnix* (0.4 birds km\(^{-1}\)).

Species typical of both, fallow land (*Melanocorypha calandra*) (2.4 birds km\(^{-1}\)) and cereal fields (*Miliaria calandra*) (0.8 birds km\(^{-1}\)) occurred in stubbles. *L. meridionalis* (0.8 birds km\(^{-1}\)) also attained high abundance in comparison with other seasons.

A univariate comparison of species abundance across habitat types (Table 5) yielded significant differences (Kruskal–Wallis test, \(p < 0.05\)) for *Melanocorypha calandra*, *B. oedicnemus* and *C. ciconia*, all more abundant in fallows, and for *C. juncidis* and *C. coturnix*, more abundant in cereal fields.

### 4. Discussion

#### 4.1. Assumptions and data limitations

Open landscapes with a flat topography were studied, in which it was assumed that differences in bird detectability across land-use types did not have a significant influence on the results. The exception could be the well-developed cereal fields during the spring census, where detectability could be reduced. Nevertheless, the fact that during this season there was a clear relationship across habitats between the abundance index (birds km\(^{-1}\)) and the densities (birds/10 ha) estimated using the Jarvinen and Vaisanen method (thus corrected for differences in detectability between habitats) for...
most species suggests that detectability was not a problem.

Landscape-scale effects, which were not taken into account, could influence the composition of bird assemblages mainly through (1) patch size and edge effects, and (2) a different scale of perception by species that select landscape configurations rather than specific patches (Forman, 1997; Farina, 1998). The former problem was minimised by the fact that the plots sampled (with the exception of fallows, which were the matrix of the landscape), had roughly the same size and shape and no distinct edges, such as hedgerows or tree lines. Also, some larger body sized species (e.g. B. ibis, O. tarda and C. ciconia) explored the landscape at a larger scale, and caution should be taken when interpreting the results obtained.

Bird community structure varies in time, both in the presence or absence of species and in their relative abundances (Wiens, 1989). The restricted sampling period did not provide information on potential yearly variations in assemblage structure, but previous data suggest that during the breeding season the dominant species in each land-use type are fairly constant (Leitão and Moreira, 1996; Moreira, 1999).

Nevertheless, assemblage structure might be more variable during winter (Wiens, 1989).

4.2. Seasonal variation in bird assemblages

The winter overlap in the composition of bird assemblages of fallow land and cereal fields was caused by the widespread abundance of four wintering species. The observed differences in habitat structure between these two land uses seemed not to influence bird assemblage composition. It is possible that there was enough food available (mainly leaves and seeds for A. arvensis and A. pratensis, and soil invertebrates for P. apricaria and V. vanellus (Cramp and Simmons, 1983; Cramp, 1988) in both habitats. Díaz and Tellería (1994) have shown that food abundance was not a limiting factor for seed-eating birds wintering in cereal steppes of central Spain, and Santos and Tellería (1985) argue that invertebrate activity during winter, in the Iberian Peninsula, is sufficient for providing the necessary food resources for birds. P. apricaria and V. vanellus could respond to vegetation structure, as they avoid dense and tall vegetation, but vegetation height during this time of year was below the described limits for these species (Cramp and Simmons, 1983). The main differences in wintering species density occurred for species which used cereal fields as breeding habitat (A. rufa, C. juncidis and Miliaria calandra). These species started to define breeding territories in cereal fields at the end of winter, at a time when vegetation height was increasing.

During the breeding season particular bird species were associated with specific habitats. This suggests that vegetation structure was the main determinant of habitat selection during the breeding season, as reported for many bird species (Cody, 1985; Wiens, 1989). Species attached to small breeding territories probably were not able to explore, e.g. for foraging, other landscape patches, in contrast with other seasons when birds were not attached to breeding territories. Ploughed fields were used as nesting habitat by a group of species with a preference for bare ground and short vegetation, particularly C. brachydyactyla (e.g. Cramp and Simmons, 1983; Cramp, 1988; Moreira and Leitão, 1996). In fallow fields, Melanocorypha calandra and T. tetrax were the more abundant species, as recorded in previous studies (Leitão and Moreira, 1996; Moreira and Leitão, 1996; Moreira, 1999).

Table 3
Winter relative densities (birds km$^{-1}$) in fallow land ($n=20$ transects) and cereal fields ($n=29$ transects) in Castro Verde, with median and inter-quartile distance

<table>
<thead>
<tr>
<th>Species</th>
<th>Fallow</th>
<th>Cereal fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alauda arvensis</td>
<td>84.1 (26.6–111.5)</td>
<td>80.0 (28.0–131.0)</td>
</tr>
<tr>
<td>Vanellus vanellus</td>
<td>20.2 (4.9–51.7)</td>
<td>13.3 (0.7–30.1)</td>
</tr>
<tr>
<td>Pluvialis apricaria</td>
<td>18.8 (0.3–80.0)</td>
<td>17.1 (3.4–81.7)</td>
</tr>
<tr>
<td>Anthus pratensis</td>
<td>11.1 (9.6–20.9)</td>
<td>9.7 (6.8–14.4)</td>
</tr>
<tr>
<td>Melanocorypha calandra</td>
<td>4.8 (0.1–15.5)</td>
<td>1.7 (0.5–4.9)</td>
</tr>
<tr>
<td>Miliaria calandra*</td>
<td>1.6 (0–6.5)</td>
<td>6.9 (5.3–10.0)</td>
</tr>
<tr>
<td>Motacilla alba</td>
<td>0.7 (0.1–2.1)</td>
<td>1.4 (0.6–2.7)</td>
</tr>
<tr>
<td>Tetrax tetrax</td>
<td>0 (0–3.1)</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>Alectoris rufa*</td>
<td>NO*</td>
<td>0 (0–0.9)</td>
</tr>
<tr>
<td>Babulcus ibis</td>
<td>0 (0–0)</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>Burhinus oedicnemus</td>
<td>0 (0–0)</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>Ciconia ciconia</td>
<td>0 (0–0)</td>
<td>0 (0–0.5)</td>
</tr>
<tr>
<td>Cisticola juncidis*</td>
<td>NO*</td>
<td>1.1 (0–2.8)</td>
</tr>
<tr>
<td>Coturnix coturnix</td>
<td>NO</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>Galerida spp</td>
<td>NO</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>Lanius meridionalis</td>
<td>0 (0–0)</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>Otis tarda</td>
<td>0 (0–0)</td>
<td>0 (0–0.5)</td>
</tr>
</tbody>
</table>

* Species with significant differences between fallow and cereal field densities (Wilcoxon test).
* Species not observed.
Fig. 2. Plot of the first two axes from detrended correspondence analysis based on the winter data. Transects with similar bird assemblage composition are placed together, as are species with similar pattern of abundance across transects. Eigenvalues are a measure of species spread in the axes. Axis 1, eigenvalue $D_{0.17}$ (20.7% variance); and Axis 2, eigenvalue $D_{0.12}$ (14.9% variance). Code for transect habitats: quadrats, fallow land; and triangles, cereal fields. Codes for species (dots): Aa, Alauda arvensis; Ap, Anthus pratensis; Ar, Alectoris rufa; Bi, Bubulcus ibis; Bo, Burhinus oedicnemus; Cc, Coturnix coturnix; Cic, Ciconia ciconia; Cj, Cisticola juncidis; Gal, Galerida spp.; Lm, Lanius meridionalis; Ma, Motacilla alba; Mc, Miliaria calandra; Mec, Melanocorypha calandra; Ot, Otis tarda; Pa, Pluvialis apricaria; Ti, Tetrax tetrax; and Vv, Vanellus vanellus.

Table 4
Relative densities (birds km$^{-1}$) during the breeding season in fallow land ($n = 20$ transects), cereal fields ($n = 29$ transects) and ploughed land ($n = 10$ transects) in Castro Verde, with median and inter-quartile distance

<table>
<thead>
<tr>
<th>Species</th>
<th>Fallows</th>
<th>Cereal fields</th>
<th>Ploughed land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melanocorypha calandra*</td>
<td>19.7 (14.4–29.7)</td>
<td>1.3 (0–3.4)</td>
<td>1.2 (0–5.0)</td>
</tr>
<tr>
<td>Tetrao tetrix*</td>
<td>10.1 (3.1–16.4)</td>
<td>10.0 (6.4–17.3)</td>
<td>2.8 (0.8–6.0)</td>
</tr>
<tr>
<td>Bubulcus ibis</td>
<td>3.6 (0–8.0)</td>
<td>0 (0–1.9)</td>
<td>0.8 (0–3.1)</td>
</tr>
<tr>
<td>Calandrella brachydactyla*</td>
<td>3.3 (0–5.5)</td>
<td>0 (0–0)</td>
<td>24.4 (20.1–26.8)</td>
</tr>
<tr>
<td>Ciconia ciconia</td>
<td>2.7 (0.2–8.7)</td>
<td>0.8 (0.4–1.1)</td>
<td>0.7 (0–1.5)</td>
</tr>
<tr>
<td>Miliaria calandra*</td>
<td>2.1 (0–8.0)</td>
<td>36.0 (26.7–43.3)</td>
<td>5.7 (3.7–8.9)</td>
</tr>
<tr>
<td>Otis tarda</td>
<td>1.6 (0–6.1)</td>
<td>0.4 (0–2.9)</td>
<td>0 (0–0.2)</td>
</tr>
<tr>
<td>Anthus campestris*</td>
<td>0 (0–0)</td>
<td>0 (0–0)</td>
<td>1.6 (0–4.4)</td>
</tr>
<tr>
<td>Oenanthe hispanica*</td>
<td>0 (0–0)</td>
<td>0 (0–0)</td>
<td>7.0 (3.7–10.0)</td>
</tr>
<tr>
<td>Pterocles orientalis</td>
<td>0 (0–2.0)</td>
<td>0 (0–0)</td>
<td>0 (0–3.9)</td>
</tr>
<tr>
<td>Burhinus oedicnemus</td>
<td>0 (0–1.0)</td>
<td>0 (0–0)</td>
<td>1.0 (0–3.0)</td>
</tr>
<tr>
<td>Cisticola juncidis*</td>
<td>0 (0–0)</td>
<td>12.2 (6.8–20.4)</td>
<td>0 (0–2.5)</td>
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<tr>
<td>Coturnix coturnix</td>
<td>0 (0–0)</td>
<td>2.3 (1.0–4.6)</td>
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<tr>
<td>Galerida spp.</td>
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<td>0 (0–0)</td>
<td>0 (0–0.3)</td>
</tr>
<tr>
<td>Anthus pratensis*</td>
<td>NO*</td>
<td>2.3 (1.1–4.2)</td>
<td>NO</td>
</tr>
<tr>
<td>Alauda arvensis NO</td>
<td>0 (0–0.2)</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Alectoris rufa*</td>
<td>NO</td>
<td>0 (0–2.0)</td>
<td>NO</td>
</tr>
<tr>
<td>Lanius meridionalis</td>
<td>NO</td>
<td>0 (0–0)</td>
<td>NO</td>
</tr>
</tbody>
</table>

* Species with significant differences between habitats (Kruskal–Wallis test).
* Species not observed in the transects.
Fig. 3. Plot of the first two axes from detrended correspondence analysis based on the breeding season data. Axis 1, eigenvalue $D = 0.56$ (19.4% variance); and Axis 2, eigenvalue $D = 0.25$ (13.4% variance). Code for transect habitats: quadrats, fallow land; triangles, cereal fields; and diamonds, ploughed land. Codes for species (dots) similar to Fig. 2 with the additional species: Ac, Anthus campestris; Cb, Calandrella brachydactyla; Oh, Oenanthe hispanica; and Po, Pterocles orientalis.

Fig. 4. Plot of the first two axes from detrended correspondence analysis based on the post-breeding season data. Axis 1, eigenvalue $D = 0.36$ (16.7% variance); and Axis 2, eigenvalue $D = 0.29$ (13.3% variance). Code for transect habitats: quadrats, fallow land; triangles, cereal fields; and asterisks, stubbles. Codes for species (dots) similar to Figs. 2 and 3.

Cereal fields were used mainly by species preferring tall and dense vegetation, such as Miliaria calandra, C. juncidis and C. coturnix (Cramp and Simmons, 1980; Cramp, 1992; Cramp and Perrins, 1994; Moreira, 1999; Borralho et al., 1998). Some individuals which had not started to migrate were also recorded. High densities of T. tetrax were found in cereal fields and fallows. Most studies on habitat selection in this species (Shulz, 1985; Martínez, 1994; Martínez and De Juana, 1996; Moreira and Leitão, 1996; Moreira, 1999) suggest that cereal is not a preferred habitat, but the result obtained might be explained by the fact that due to weather conditions cereal fields did not grow as usual in that particular year.

The appearance of stubbles after the breeding season offered access to a great abundance of seed
resource (Tellería et al., 1988a; Díaz and Tellería, 1994), used especially by *Miliaria calandra* and *Melanocorypha calandra*. *Coturnix coturnix* and *Cisticola juncidis* remained associated to cereal fields, whereas *C. ciconia* used fallows and non-harvested cereal fields as feeding grounds.

Most species used several habitats of the agricultural landscape mosaic along the annual cycle. The maintenance of the mosaic agricultural system is, therefore, essential for preserving the diversity of bird species in this landscape. Other authors have also shown the importance of habitat diversity either for specific species (e.g. Martínez, 1994; Salamonard et al., 1996) and the whole bird community (Donazar et al., 1997).

### 4.3. Implications of agricultural changes

Cereal steppes are threatened by agricultural changes (Baldock, 1991; Díaz et al., 1993; Tucker and Heath, 1994; Santos, 1996; Suárez et al., 1997). The results of this paper and other research made in the Castro Verde region can be used for a preliminary evaluation of the impact of several types of agricultural changes on bird populations, with the assumption of non-adaptation of bird species to a changing environment.

Cereal fields and stubbles are likely to decrease, to be replaced by pastures and fallow land. As a consequence bird species that rely on cereal would probably be reduced, whereas bird species occurring mainly in fallows could be promoted. An increase in stock density would lead to changes in vegetation structure (decreased height and higher cover by bare ground) due to overgrazing, along with increased trampling of nests and eggs (Ausden and Treweek, 1995; Donazar et al., 1997). Thus, populations of *C. brachydactyla*, *Oenanthe hispanica* and *A. campestris* could have an increased area of available habitat, although with a potentially lower reproductive success.

Homogenisation of the landscape, with a progressive increase in vegetation height and shrub cover (mainly *Cistus* spp.) would occur in abandoned fields. In a first stage, this would benefit species like *B. oedicnemus*, *B. ibis* and *Galerida* spp. (Moreira, 1999), but the increase in shrub cover would be equivalent to habitat loss for the steppe birds. Santos (1996) described the bird communities associated with successional stages of vegetation after land abandonment in this region, and showed that *Sylvia conspicillata* Temminck was the only species with Unfavourable conservation status found on scrubland.

The main impact of agricultural intensification would be a loss of fallow land, which would influence
negatively the populations of *T. tetrax* and *M. calandra*. If intensification increased the frequency of cereal cultivation, this could lead to a population growth for species more dependent on cereal fields (such as *C. juncidis* and *Miliaria calandra*).

5. Conclusions

The bird diversity of the farmed landscape of Castro Verde depends on the maintenance of a diverse agricultural mosaic, as promoted by the extensive cultivation of cereals in a rotational system. It is hypothesised that land-use modifications due to agricultural policies will promote changes in bird assemblage structure, namely a loss in steppe bird richness and an increase in specific bird populations, depending on the type of changes. Scientific research in steppic landscapes with varying level of agricultural changes or in sub-regions of Castro Verde where agricultural changes are already taking place would provide tests for these predictions.

Acknowledgements

This research was financed by the LPN project ‘Conservation of steppe birds in Castro Verde region’, partially funded by LIFE programme (Contract 4-3200/95/510) and Fundação Luso-Americana para o Desenvolvimento. We wish to thank Rui Morgado for providing the data on land-use cover. Thanks also due to Pedro Beja, Rui Borralho, Mario Diaz and two anonymous referees for useful comments that significantly improved the manuscript. This paper is a contribution to project PRAXIS XXI/C/AGR/11063/98 “Factores determinants da biodiversidade em pousios de estepes cerealiferas: implicações para definiçäo de normas de gestão agro-ambiental”.

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