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Common cranes *Grus grus* and habitat management in holm oak dehesas of Spain

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Abstract. Changes in agricultural policies have favored tree clearing and removal of shrubs to favor intensive farming in the holm oak *Quercus ilex* dehesas of Iberia. The effect of these changes for bird species wintering in this agricultural landscape has been rarely analyzed. Here the effects are studied of farming changes in traditional holm oak dehesas on population size, social structure and time budget of common cranes *Grus grus* in eight traditional wintering sites in Spain. The role of acorn availability, the principal winter food of the species, in relation to management is also assessed. The number of cranes in each wintering area was not related to degree of agricultural intensification, nor to the availability of acorns. However, crane flock size decreased, and the relative occurrence of isolated family groups increased in less intensively transformed wintering areas characterized by the predominance of fallow lands. The age composition of crane flocks varied with acorn availability since more juveniles were reported in areas with relatively lower acorn availability. Time budget was also related to acorn availability, since cranes spent relatively more time preening in those wintering areas with higher availability of acorns. Globally evidence suggests the need to maintain the fallow land (posíos) to sustain the wintering populations of cranes in Iberia, since this agro-grazing system maintains most of the juvenile cranes using the western migratory route.

Introduction

The agricultural policy in the European Union is causing major changes to methods in traditional land exploitation systems (Tucker and Evans 1997). These changes have been particularly severe for the holm oak *Quercus ilex* 'dehesas' since Spain's inclusion in the European Union in 1986 (Campos 1993). Traditional holm oak dehesas are characterized by a 3-year grain crop rotation in Iberia. Grain is grown 1 year, followed by a 2-year fallow period. During fallow years, the land provides grazing and holm oak acorns for livestock (mainly sheep), resulting in a mosaic of wooded patches of grain, grain stubble (1-year fallow) and 'posíos' (2-year fallow). This agricultural landscape maintains a high biological diversity (Díaz et al. 1997), and is also an important reserve of plant genetic resources tolerant to seasonal drought, poor soils and heavy grazing (Marañón 1988). Similarly, holm oak dehesas are one of the last breeding refuges for endangered species of birds like imperial eagle *Aquila adalberti* and black vulture *Aegypius monachus* (Díaz et al. 1997), and

constitute suitable wintering sites for birds like common cranes *Grus grus* (Franco et al. 2000).

Traditional farming practices on holm oak dehesas are rapidly shifting toward intensive grain production and irrigated crops to improve overall production in Iberia (Marañón 1988). These changes have brought about holm oak clearing and removal of shrubs to favor intensive farming (Marañón 1988; Campos 1993), causing reductions in the range of available resources for many species (Sánchez et al. 1999). Alternatively, extensive areas of dehesa farming are also recently being abandoned by farmers and transformed into areas devoted to big game hunting (Díaz et al. 1997). This abandonment is promoted by the low economic output of the traditional dehesa (Campos 1993) and results in a loss of tree quality and acorn production that might affect the bird populations associated with this system (Díaz et al. 1997).

The common crane is a migratory palearctic species with a wide distribution (Hagemeijer and Blair 1997). Cranes that use the western migratory route breed in northern latitudes and mainly in winter in north Africa, the Iberian peninsula and France (Hagemeijer and Blair 1997). However, 67.0% of these birds still winter in holm oak dehesas of central and south Iberia (Sánchez et al. 1998). Most cranes arrive in Extremadura in November and remain until the end of February (Sánchez et al. 1993). Cranes gather in flocks that feed mainly on holm oak acorns (Avilés et al. 2002a), and the winter pattern of utilization of holm oak dehesas by cranes is correlated with the abundance of acorns (Díaz et al. 1996).

In spite of the importance of the holm oak dehesas as wintering places for cranes, no detailed studies have reported the links among farming practices in this agro system and the social structure and behavior of cranes. The aim of this study was to analyze the relationship between the degree of intensification in the management of holm oak dehesas and the crane population size, social structure and time budget in eight wintering sites that yielded more than 30% of the cranes using the western migratory route (Sánchez et al. 1998). Further, the role of acorn availability in this agricultural landscape with respect to crane number, social structure, and time budget is analyzed.

Methods

Study area

Data collection was conducted from December 1995 to late January 1996 in eight wintering localities in the Serena region of southwestern Spain (Table 1). The winter population in these localities included approximately 31% of the cranes that use the western migratory route (Sánchez et al. 1998). The Serena region in the meso-Mediterranean climate region is characterized by hot and dry summers and mild, wet winters, with frequent freezing from December to

Table 1. Location, type of roost site, transect length, feeding site area, characteristics of the habitats (see Methods) and acorn availability (g per 25 cm × 25 cm) in the eight study areas.

Wintering sites	Roost site during study season	Transect length (km)	Surface of feeding sites (ha)	With holm oaks (%)	With posío (%)	Cereal (%)	Acorn availability
Capilla (38°49′N, 5°00′E)	Zujar river	6.30	16092	83.5	71.1	14.1	
Siruela (39°00′N, 5°11′E)	Zujar and Guadalemar rivers	4.60	11749	100	100	0	4457
Valdecaballeros (39°17′N, 5°11′E)	Artificial pond	7.40	18895	64.8	76.6	13.1	14076
Orellana (39°06′N, 5°29′E)	Artificial pond and Orellana reservoir	9.25	23623	65.8	45.8	18.4	1174
Zarzacapilla (38°46′N, 5°11′E)	Zujar river and artificial pond	4.00	10213	90.0	66.7	9.9	6392
Guadalefra (38°48′N, 5°35′E)	Guadalefra river	2.00	5107	94.4	6.2	64.8	14932
La Guarda (38°47′N, 5°43′E)	Artificial pond	2.00	5100	52.7	14.6	14.6	1098
Cabeza del Buey (38°38′N, 5° 28′E)	Natural pond	7.4	18800	61.4	64.9	8.4	22267

February (Rivas-Martínez 1981). Cranes have visited the Serena region since the early 20th century (Pérez-Chiscano and Fernández-Cruz 1971).

Data collection

In each locality, data was collected over 2 days per 2-week period from early December to late January. Flocks were located in the morning along standardized road transects that permitted a complete survey of each study area. For each flock, flock size and number of juveniles were recorded. Isolated family groups were easily identified on the basis of the red head and neck color of first-winter birds (Cramp and Simmons 1985) in close proximity to no more than two adult cranes and at least 100 m away from other birds.

For time budget observations, cranes were randomly selected within flocks in a number proportional to flock size. Focal cranes were observed for 3 min each with a 20–60 × 60 telescope. Time spent feeding (head down below shoulders), vigilance (head up over shoulders) and preening were measured to the nearest second. To ensure independence of time budget observations among individuals within the same flock, only one mean value per crane for all variables from all focal observations within one flock was obtained (Hurlbert 1984).

Crane counts

In the second week of December the number of cranes in each locality was counted. The number of cranes counted in mid-December is a reasonable estimation of the maximum number of cranes wintering in each locality, since in five of the eight study areas the maximum number of cranes from December to February was recorded at this time (Avilés 1999). Census of the eight areas was simultaneously made when cranes came back to roost sites by teams of 2–8 persons. The number of persons in each locality was approximately related to the number of cranes observed during the survey of the feeding sites. Censuses were repeated the following morning to minimize possible errors due to incomplete surveys. As an estimate of the monthly population in each locality, the maximum of evening and dawn counts was used.

Land use characteristics

Land use in each study area was assessed by determining the type of land use within two 100 m bands, one on each side of a standardized road transect (Table 1). The length of transect was proportional to the available feeding area (Table 1). I obtained three variables that characterized each wintering locality in relation to farming practice: (1) the percentage of the land area covered by holm oaks as estimator of the degree of deforestation; (2) the percentage of the

land area in posío (2-year fallow), and (3) the percentage of the land area under grain cultivation (Table 1). The percentages of the land area in posío and under grain cultivation are inversely related in our region ($r = -0.78$, $P < 0.05$, $n = 8$) since original posíos are currently being replaced by large surfaces with grain cultivation. Thus the percentage of a study area in posío gives a reliable estimation of the degree of agricultural intensification in traditional holm oak dehesas: the lower the percentage, the higher the intensification.

Acorn availability

Since global acorn availability in traditional wintering sites strongly correlates with acorn availability in grain fields with holm oaks (Díaz et al. 1996; Avilés et al. 2002a) acorn availability in the second week of December in each study area in grain fields with holm oaks without livestock grazing on acorns was estimated. Five holm oak trees per each study area were randomly selected. At each tree all acorns within three 25 cm × 25 cm quadrates randomly placed below the canopy were collected and weighed to the nearest 0.2 g. A mean value per tree from the acorns collected in each of the three squares was calculated since acorn availability remained unchanged among squares (Avilés et al. 2002a). Intensive rainfall did not permit to collect acorns in Capilla.

Mean acorn availability in each locality was estimated multiplying the acorn availability in the quadrates by the mean productive canopy area (S). The mean productive canopy area (S) was calculated as $S = \pi r^2$. The mean canopy radius per tree (r) obtained by measuring the distance between the trunk and the canopy border in 60 randomly selected holm oaks in the study area (mean ± standard error 3.66 ± 0.14 m; Avilés 1999) was considered. These values were multiplied by the number of trees per hectare obtained from transects to estimate the availability of acorns in each area in December (Table 1).

Data analyses

Spearman rank correlation coefficients were used to describe the relationship between crane number, flock characteristics and time budget variables with habitat features and acorn availability. Throughout, sequential Bonferroni correction for the probability of a type I error when using two or more tests for checking a common null hypothesis was always applied. A P value of 0.1 was assumed, since 10–15% type I error rates are appropriate levels of control for experiment-wise errors (Chandler 1995).

It has to be noted that the used approach has the potential to detect large effect sizes (power = 0.77; alpha = 0.2; n = 8 sampled populations; Buchner et al. 1997). Since the variation in the degree of intensification among study sites is large, as inferred from among site differences in the percentage of each area

with posío (Table 1), large effects on cranes should be expected. Thus it is reasonable to assume that major farming effects on cranes are potentially detectable in this study.

Results

The number of cranes counted in each area during winter ranged between 462 and 8660 birds, respectively at Siruela and Orellana (Table 2), and was not related to habitat intensification as estimated by the % of land in posío, neither to the percentage of the land area covered by holm oaks, nor to acorn availability in each wintering area (Spearman correlation coefficient: $P > 0.05$ in the three cases). However, crane social structure was affected by agricultural practices since less intensively transformed wintering sites have lower flock sizes and a higher proportion of isolated family groups than highly transformed areas (Figure 1).

Flock age composition was affected by acorn availability, since a higher presence of juvenile cranes in the flocks was associated to a lower acorn availability (Figure 2).

Crane time budget was not directly associated to habitat intensification since no significant relationships were detected among time devoted to feeding, vigilance and preening and the % of land in posío (Spearman correlation coefficient: $P > 0.05$ in the three cases). Further, time budget was not related to the surface of land covered by holm oaks (Spearman correlation coefficient: $P > 0.05$ in the three cases). However, cranes devoted more time to preening in those areas with a higher acorn availability (Figure 3).

Discussion

Previous studies have shown that the use of staging and wintering areas by cranes at a local scale is strongly influenced by human induced changes in food availability due to farming practices (Alonso et al. 1994; Díaz et al. 1996; Franco et al. 2000). Further, studies in central Spain have suggested that the emergence of intensified agricultural systems in one locality could improve habitat suitability for cranes in traditional wintering sites through increased food availability (Sánchez et al. 1999). Current implementation of more intensive methods of land exploitation in the holm oak dehesas of Iberia implies a shift from a system in which fallow periods provide grazing and acorns for livestock is replaced by lands in which grain production is the priority. This change has favored a global increase in the availability of acorns in the holm oak dehesas (Díaz et al. 1996; Avilés et al. 2002a), that constitutes the main food type consumed by cranes throughout winter in this agro system (Avilés et al. 2002a). In spite of the crucial role of holm oak dehesas as staging habitats for wintering cranes using the western migratory route (see Sánchez et al. 1998),

Table 2. Mean percentage (±SD) of time devoted to feeding, vigilance and preening, winter population size, percentage of isolated family groups (see Methods for a description), flock size (±SD) and mean percentage of juveniles by flock (±SD) in eight traditional winter sites of the common cranes in southwestern Spain.

	Capilla	Cabeza Buey	Guadalefra	La Guarda	Orellana	Siruela	Valdecaballeros	Zarzacapilla
Feeding	70.2 ± 28.3 (75)[a]	66.5 ± 26.6 (15)	57.8 ± 34.9 (29)	71.3 ± 23.3 (2)	74.7 ± 32.4 (114)	72.8 ± 31.6 (15)	59.3 ± 35.6 (47)	66.3 ± 37.7 (29)
Vigilance	16.4 ± 15.8 (75)	10.6 ± 3.2 (15)	21.1 ± 21.1 (29)	28.7 ± 23.3 (2)	12.3 ± 14.4 (114)	11.8 ± 12.8 (15)	17.7 ± 17.6 (47)	18.8 ± 24.6 (29)
Preening	13.5 ± 20.7 (75)	22.9 ± 26.8 (15)	21.8 ± 30.4 (29)	0.0 ± 0.0 (2)	12.9 ± 26.2 (114)	15.4 ± 25.7 (15)	23.0 ± 32.4 (47)	16.3 ± 28.2 (29)
Number of cranes	791	2033	1111	489	8660	462	3225	309
Isolated family groups (%)	46.2	28.6	24.4	25.0	47.67	63.33	75.67	52.94
Mean flock size	16.9 ± 48.5 (200)	32.7 ± 78.5 (59)	35.3 ± 79.3 (61)	66.4 ± 125.7 (10)	30.8 ± 130.0 (262)	7.1 ± 21.8 (34)	15.6 ± 37.6 (136)	5.18 ± 7.16 (44)
Mean percentage of juveniles	36.6 ± 20.0 (135)	28.6 ± 14.0 (44)	22.1 ± 14.3 (37)	35.3 ± 17.4 (7)	31.6 ± 14.9 (168)	37.5 ± 8.0 (22)	31.3 ± 13.0 (90)	32.0 ± 10.7 (27)

[a]Sample sizes between brackets are respectively number of focal cranes for the time devoted to feeding, vigilance and preening, and total number of flocks observed for the mean flock size and the mean percentage of juveniles.

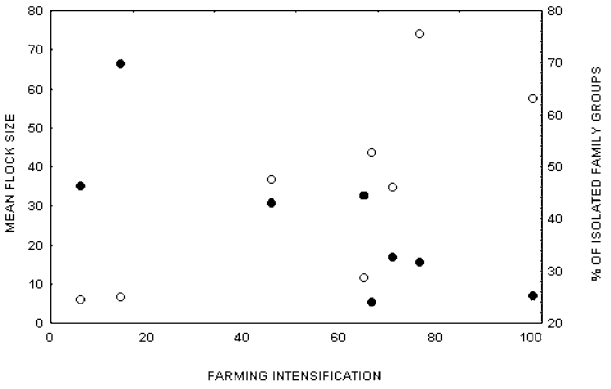

Figure 1. Mean flock size (open circles) and percentage of isolated family groups (closed circles) in relation to the degree of habitat intensification (see Methods for a detailed description) in eight traditional wintering sites for cranes. Mean flock size increased with degree of intensification ($r = -0.80$, $P = 0.014$, $n = 8$) while relative abundance of isolated family groups decreased with degree of intensification ($r = 0.85$, $P = 0.006$, $n = 8$).

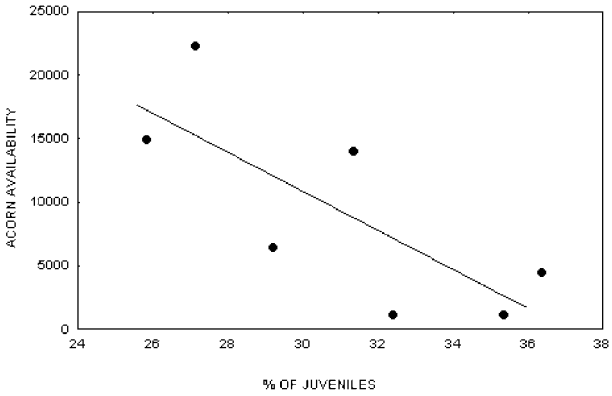

Figure 2. Mean percentage of juvenile cranes by flock in relation to acorn availability (g per 25 cm × 25 cm). The proportion of juvenile cranes decreased with acorn availability ($r = -0.82$, $P = 0.023$, $n = 7$).

information lacks on how changes promoted by current agricultural policies in the EU may affect the social structure and behavior of wintering cranes in Iberia.

In this study evidence of a change in the social structure of the cranes in relation to the degree of intensification of farming practices within the holm oak dehesas was found. Less transformed wintering sites, characterized by a predominance of posíos (2-year fallow lands), showed lower flock sizes and a higher proportion of isolated family groups than those in areas with a higher

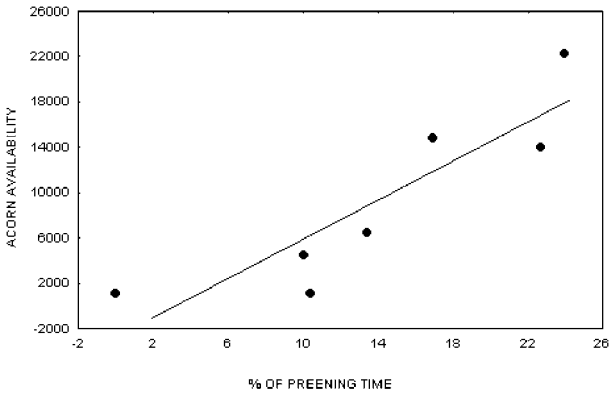

Figure 3. Mean percentage of time devoted to preening in relation to acorn availability (g per 25 cm × 25 cm). Time devoted to preening increased with acorn availability ($r = 0.92$, $P = 0.002$, $n = 7$).

degree of transformation (Figure 1). The most plausible mechanism explaining these results is the existence of a wintering site segregation mediated by parental investment. Cranes feed on acorns under the canopy of holm oak trees, but they can also access bulbs, leaves and stems of herbaceous plants and invertebrates that they obtain foraging in the open in posíos. However, cranes in holm oak dehesas with grain production feed on the readily available acorns under the canopy, and on leaves and stems of grain crops from the surrounding grain fields (Avilés et al. 2002a). Thus, cranes feeding in grain fields tend to be concentrated in large flocks under those holm oak trees. The inclusion of family groups in large flocks gives rise to a large cost for members of family groups, since parents are involved in a large number of aggressive encounters, and have higher handling effort of food than those in isolated family groups (Avilés 2003). Thus current evidence may suggest a preference of family groups for less intensified wintering areas to avoid the high levels of competition that food concentration promotes in holm oak dehesas with sown cereal. This hypothesis is also indirectly supported by the found negative correlation between proportion of juveniles within flocks and acorn availability.

Interestingly, the proportion of juvenile cranes per flock at each locality was not associated with degree of farming intensification, which might indicate absence of a farming intensification effect on crane social structure. However, this result is not surprising since many juvenile cranes are within small familiar groups in which they represent a large fraction of the flock (large percentage of juveniles per flock). Therefore, the proportion of juvenile cranes per flock may not be a reliable estimator of the age crane composition at a particular site because the effect of the farming practices on it may be buffered by changes in the proportion of isolated family groups at this site.

A distribution pattern of wintering cranes according to levels of deforestation should be expected if tree clearing resulted in a change in the range of available resources for cranes. This study failed to find a relationship between the level of deforestation, as expressed by the percentage of land covered by holm oaks, and any of the variables dealing with the social structure, population size and behavior of the cranes in the holm oak dehesas. The most plausible explanation for these results is that current wintering sites still maintain enough areas covered by holm oaks (minimum % found = 52.7%, in La Guarda), which may result in current carrying capacities in these studied areas still covering the crane requirements across winter.

Further indirect evidence of human induced changes in crane winter behavior in the holm oak dehesas comes from the found correlation between time budget and acorn availability. Díaz et al. (1996) suggested that acorn availability is highly correlated with overall food availability for cranes in holm oak dehesas of Iberia. Acorn availability in the dehesas changes throughout winter differently in dehesas with and without livestock (Díaz et al. 1996; Avilés et al. 2002a). Acorns are depressed by livestock when it is present and their availability is very low compared to that in dehesas without livestock (Avilés et al. 2002a). Here it was found that cranes feeding in dehesas with a high acorn availability in midwinter devoted more time to preening than those wintering in areas without such high availability. This may suggest that the current trend in the holm oak dehesas toward sowing of grain may indirectly favor a relaxation of wintering cranes in the holm oak dehesas by increasing acorn availability.

In conclusion, this study confirms the ability of cranes to exploit the new food resources provided by new agricultural systems that has been previously reported (Alonso et al. 1994; Avilés et al. 2002b). Further, although the current agricultural practices may induce an overall increase in food availability by the inclusion of new sown lands of cereal in the holm oak dehesas, and this may promote local increases in the number of wintering cranes, the results of this study point out the need to maintain the fallow land (posíos) to sustain the wintering populations of cranes in Iberia. This traditional agro-grazing system maintains the familiar groups in which are included most of the juvenile cranes using the western migratory route, therefore the long-term stability in the number of cranes using the western migratory route could be threatened if traditional 3-year grain crop rotation in Iberia changes into intensive sowing of cereal without fallow land periods.

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