Does Temporal Variability of Winter Common Cranes in the Dehesas Depend on Farming Practices?

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Abstract.—The inclusion of Spain and Portugal within the European Community has brought about a change in the traditional farming practices in the dehesas of Iberia to intensive cereal and to irrigated crops. Here we use seven-year counts of Common Cranes in 38 wintering sites to evaluate whether habitat structure modified by farming practices in the Holm Oak *(Quercus ilex)* dehesas is an important determinant of variability in winter crane numbers. We extracted, from a set of nine variables that express different levels of human management in the Holm Oak dehesas, two factors that accounted for the 66% of the variance. The first factor was related to livestock utilization of the dehesas, while the second one reflected Holm Oak presence. We ran a general linear model to analyze the influence of farming practices (PC1 and PC2), landscape heterogeneity and roost site stability on inter- and intra-season variability in numbers of winter cranes. Livestock presence, Holm Oak presence, landscape heterogeneity and roost type stability did not explain intra- and inter- season variability in crane numbers wintering in the Holm Oak dehesas of Spain. *Received 9 September 2001, accepted 19 November 2001.*

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Agricultural policy within the European Community is causing major alterations to the Holm Oak *(Quercus ilex)* dehesas in Spain and Portugal (Campos 1993). Holm Oak dehesas have been characterized by a three-year rotation. Cereal is grown one year, followed by two years of set-aside used to provide grazing and acorns (fruit of Holm Oak) for livestock. So, a mosaic of wooded patches of cereal, cereal stubble (one year set-aside) and "posíos" (second year set-aside) is characteristic of this farming system. This agro-ecosystem maintains high plant and animal diversities and it is a breeding refuge for many bird species of conservation concern in Europe (Díaz *et al.* 1997). However, traditional exploitation of Holm Oak dehesas is shifting to a predominance of intensive cereal and irrigated crops to improve field productivity (Marañón 1988). Changes have brought about Holm Oak clearing and removal of the original shrubs in favor of intensive farming (Marañón 1988, Sánchez *et al.* 1999), causing changes in the range of available resources for many bird species.

The Common Crane *(Grus grus) is* a migratory species with a wide distributional range within the Palearctic region (Hagemeijer and Blair 1997). The birds that use the western migratory route breed in northern Europe and mainly winter in North Africa, the Iberian Peninsula, and France (Hagemeijer and Blair 1997). The winter distribution of cranes in these three areas is variable between years and has been related to hunting and food availability mediated by agricultural practices (Bautista *et al.* 1992). Recent increases in agricultural food production in northern Spain and France (Genard and Lanusse 1992; Alonso *et al.* 1994) and the high plasticity of the cranes in exploiting new food resources derived from farming practices (Avilés *et al.* 2001) have probably favored a northward shift of the traditional winter range of the cranes in the last two decades. However, 67 per cent of the western migratory birds still winter in traditional Holm Oak dehesas of central and south Iberia, and their main winter sites are characterized by the predominance of this agrosystem (Sánchez *et al.* 1998). Most cranes arrive from their breeding areas in northern latitudes in November and remain to feed in Holm Oak dehesas until the end of February (Sánchez *et al.* 1993). Crane flocks feed mainly on leaves and stems of sown cereals, bulbs, cereal grain and acorns that are obtained under the canopy of Holm Oaks (Avilés *et al.* 2001). Two studies have suggested that conditions derived from farming intensification of dehesas may be advantageous for cranes. Díaz *et al.* (1996) showed a predilection by cranes for dehesas cultivated with cereals, and also for areas where acorn abundance was not reduced by livestock pressure. Similarly, Sánchez *et al.* (1999) showed that in the main wintering area during the three last decades, the increase in land dedicated to irrigated crops (mainly rice and corn) was positively correlated with the number of cranes in January and February. In addition, Franco *et al.* (2000) have recently shown, for a winter locality in southern Portugal, the cranes' use of open wooded patches within the dehesas, and their avoidance of patches with shrubby vegetation and *Eucalyptus* trees.

In spite of this evidence of how local farming practices in the dehesas influence wintering cranes, there have been no large-scale studies as to how cranes have responded to changes in agriculture. Here we use counts of cranes over seven years at 38 wintering sites to evaluate whether habitat structure affected by farming practices in the Holm Oak dehesas has been important in determining the temporal variability in winter crane numbers.

STUDY AREA AND METHODS

Data were collected in 38 traditional wintering sites of Common Cranes in southwest Spain characterized by the predominance of dehesas but with different levels of human management (Table 1). A detailed description of the habitat types available in each study area can be found in Alonso and Alonso (1990) and Sánchez *et al.* (1993). During the study period (1986-1992), the number of cranes that wintered in the studied areas was 65% of those that used the western migratory route (Sánchez *et al.* 1998). Each study plot varied in area, from 476 ha in Salorino to 94,200 ha in Orellana (Table 1), and all were in the mesomediterranean climatic region (Rivas-Martinez 1981).

Land use characteristics

Habitat features of each wintering locality were obtained from the interpretation of 1: 18,000 scale aerial photos of the study areas taken in 1990. Nine variables were measured for each locality and the percentage of ground in each of the following categories was measured:

1) Rice fields.
2) Irrigation crops excluding rice: mainly corn, sunflower *(Helianthus sp.)* and fruit trees.
3) Olive fields: defined the occurrence of the association of olive trees and vineyards.
4) Intensive cereal fields: cereal crops without periods of set-aside.
5) Traditional cereal fields: typical 3-year cereal rotation of the Holm Oak dehesas in Iberia.
6) Pasture fields: Areas only used to provide grazing for livestock.
7) Shrubland: unsuitable vegetation mainly *Cystus sp.* derived from the abandonment of traditional farming and pastoral use.
8) Holm Oak tree cover: surface of the study area covered with Holm Oak trees.
9) Other trees: surface of the study area covered by Pines *(Pinus pinaster), Eucalyptus globules* and *E. calmadulensis* used for wood production.

Holm Oak trees (variable 8), and intensive and extensive cereal and pasture fields (variables 4, 5 and 6) typically overlapped.

We measured the heterogeneity of the landscape using Simpson's diversity index:

$$D = 1/\Sigma p_i^2$$

Where *Pi* is the proportion of the habitat type *i*. When calculating this index we excluded the variable 8 that overlapped with the variables 4, 5 and 6.

Counts of Cranes

Wintering cranes are gregarious (Cramp and Simmons 1985). Each morning, birds fly from a communal roost to feed in surrounding fields and return at night; counts at roost sites are therefore accurate estimates of local abundance in the species (Bautista *et al.* 1992). The number of cranes returning to their roosts at each locality was counted each year in the first week of January 1986-1992, by teams of two to eight persons. The census of all areas was made during the same week to avoid bias caused by movements of cranes between neighboring areas. Counts were repeated the following morning to check for and correct possible errors due to late arrivals at the roosting sites (Alonso *et al.* 1985). We use the larger of the afternoon and morning counts as the measure of numbers at each locality. Due to logistic problems, all the wintering sites were not monitored every year, although the most important areas were counted at least five times during the study period (Table 1).

To analyze intra-seasonal variation in crane numbers in the wintering season of 1990-91 counts of the species were made at three different times during the winter (last week of November, first week of January and second week of February) on dates that corresponded to the postnuptial, wintering and prenuptial period (Fernández-Cruz *et al.* 1981).

Table 1. Roost type (1: roost sites on ponds or on the edge of close rivers and 2: roost sites on large reservoirs), number of winter counts of Common Cranes from 1986 to 1992 and among and within population variability estimated by the coefficient of variation (CV) in 38 wintering sites in Spain. X_t is the number of cranes counted in year *t* and Y_s is the number of cranes counted in the winter period *s* (prenuptial, wintering and postnuptial) (see methods). The last column shows the area of each wintering site, taken from Sánchez *et al.* (1993).

Wintering site	Roost type	Number of years counted	CV (X_t)	CV (Y_t)	Surface (ha)
Ahillones	1	6	53		4019
Alange	2	7	98	46	10,767
Aldea del Cano	1	6	64	29	29,913
Arroyoconejo	2	7	46	29	4578
Borbollón	2	6	46	25	7333
Brozas	1	6	23	47	38,563
Cabeza del Buey	1	7	28	78	35,172
Capilla	1	3	51	31	2224
Casatejada	1	5	58	73	7327
Cornalvo	2	1		41	2373
Don Benito	1	5	44		8295
Esparragalejo	2	7	53	35	8908
Gabriel y Galán	2	6	22	31	7062
Guadalefra	1	7	61	59	11,644
Guareña	1	6	63	33	7333
Herreruela	1	5	44	102	1379
La Albuera	1	7	34	17	3766
La Guarda	1	7	108	4	3647
La Roca	1	7	39	41	3977
Los Molinos	2	7	96	17	4907
Membrio	1	5	43	24	900
Merinillas	1	1			3234
Monesterio	1	3	83	60	675
Orellana	2	7	42	12	94,198
Peraleda	1	5	96	61	27,315
Retamal	1	7	48	152	10,994
Rosarito	2	5	59		14,854
Salorino	1	1			476
Siruela	1	7	44	58	8669
Talaván	2	6	41	41	3552
Torrecilla	1	4	52		4437
Tozo	2	4	78	30	6847
Usagre	1	6	59	123	11,498
Valdecaballeros	2	6	53	5	8863
Valdecañas	2	6	89	74	16,477
Villanueva del Fresno	2	7	58	50	4838
Villar del Rey	1	7	82	29	7377
Zarzacapila	1	7	44	40	8838

Variability Analyses

The coefficient of variation was used as a measure of variability; CV (X_t) = Standard deviation/Mean * 100, where X_t is the number of cranes counted in year *t* in one locality. Similarly, we estimated intra-season variability of crane numbers using the CV (X_t), where Y_s is the number of cranes counted in the winter period *s* (prenuptial, wintering and postnuptial).

The coefficient of variation could have been affected by the number of years in which cranes were counted because the variance may depend on sample size (Zar 1996). We tested the dependence of CV (X_t) on number of years in which counts were made. No significant correlation was found between these two variables ($P > 0.4$) suggesting that they were essentially independent of each other.

Many studies have shown that variability is dependent on mean abundance, which makes comparisons between samples of different sizes misleading (McArdle et al. 1990). We tested our estimates of between- (CV ($X_{t'}$)) and within- (CV (X_t)) season variability of cranes abundance for independence with crane numbers. Correlations between mean number of cranes in midwinter and the CV estimates were not statistically significant ($P > 0.4$), suggesting the absence of a number effect on our estimates of variability.

Temporal autocorrelation between study years or winter periods may be a problem in measuring temporal variability. However, the Common Crane is migratory in our study areas, and because of frequent site changes within and between seasons (Sánchez *et al.* 1999) we assume that the effects of temporal autocorrelation played a minor role in this study.

Roost Site

Cranes wintering in traditional Holm Oak dehesas used small ponds (used to supply livestock with water), or the borders of rivers as roost sites (Sánchez *et al.* 1993). Suitability of these roost sites is highly dependent on weather conditions, with rainy years generally favoring suitability indicated by the reduction of the daily distance traveled between roost site and feeding areas (pers. obs.). Consequently, roost site availability is highly variable and could be a source of variation in the abundance of cranes. On the other hand, the development of intensive farming practices within the original Holm Oak dehesas involves the creation of large reservoirs to support these practices (Sánchez *et al.* 1999). These new water sources have to be stable to ensure the water supply needed for farming, and their suitability for cranes is probably less affected by between-years variation weather conditions. We classified the available roost sites at each site as 1) roost sites in small ponds or on the edge of nearby rivers; and 2) roost sites on large agricultural reservoirs (Table 1).

Statistical Analyses

The different habitat types shown as percentages represent compositional data, which must be standardized by the method of Aitchison (1986). The n proportions were transformed to n - 1 log-ratios using the proportion of pasture fields as the denominator because was present in all localities. Thus, all proportional habitat types were transformed using the formula:

$$y_i = \ln(x_i / x_j)(i = ,\dots,\mathrm{D}, i\Sigma_j)$$

Log-ratios can then be analyzed using standard multivariate methods (Aitchison 1986). The percentage of each study area covered with Holm Oak trees and Simpson's diversity index were log-transformed to normalize their distributions.

The use of many parameters seems to be appropriate when describing a complex phenomenon such as agricultural intensification. However, many of these variables are inevitably inter-correlated and measure similar habitat attributes. To solve this problem we extracted from the set of variables a few factors that account for the greater proportion of the variance in the data. Principal components analysis (PCA) was performed on the nine habitat variables measured in the data set (Tabachnick and Fidell 1996). The interpretation of the components took into account the sign and loadings of the different variables. In all cases, a biologically meaningful label was assigned to the components.

Inter- and intra-season variability in median number of cranes in the studied sites were compared by the Mann-Whitney test. We used General Linear Model analyses to evaluate the role of landscape structure in explaining the variability in the number of cranes. Variability, measured as CV (X_t) and CV (Y_t), were entered as dependent variables, and the factor scores generated from the two first axes of the PCA, Simpson's diversity index and the roost type as independent variables. We used the default implemented by SPSS software Type III method of sum of squares calculation.

RESULTS

Farming Practices in the Dehesas

The principal component analysis performed on the nine habitat variables yielded two principal components that accounted for 66% of the total variance (Table 2). The nature of these components can be revealed by examining the loadings of each component (Table 2). The variables that contributed to PC1 were related to livestock presence: pasture fields, where the livestock feed on grass contributed positively to scores for this component, and rice fields, traditional cereal fields, shrub land and conifers contributed negatively. Thus, it seems reasonable to consider PC1 as mainly measuring *livestock presence*. PC2 reflects *Holm Oak presence,* as it had the main negative load from Holm Oak tree cover, with the positive loadings on olive fields and intensive cereal fields.

Temporal Variability in Wintering Cranes

The median winter stability of crane numbers among the six study years was 53%. However, this value greatly differed among

Table 2. Loadings of the habitat variable in the two principal componets. Important loadings within each componet (PC) are in bold. When the same variable correlates in the same direction with several componets, only the highest contribution has been highlighted. The three bottom rows give the eigenvalues and variance explained by the two first principal components.

	PC1	PC2
Rice fields	**-0.91**	-0.01
Irrigation fields	-0.52	0.29
Olive fields	-0.55	**0.65**
Intensive cereal fields	-0.34	**0.74**
Traditional cereal fields	**-0.67**	-0.44
Pasture fields	**0.93**	0.05
Shrub land	**-0.64**	-0.47
Holm Oak tree cover	0.03	**-0.71**
Conifers	-0.75	-0.17
Eigenvalue	3.86	2.05
% total variance	43.0	23.0
Accumulated % variance	43.0	66.0

Table 3. Results of GLM analysis of the influence of farming practices, landscape heterogeneity and roost type on temporal variability of wintering Common Cranes in Holm Oak dehesas.

Source	Dependent variable	Sum of squares	d.f.	Square mean	F	P
Corrected model	CV(X_i)	2,405	4	601.3	1.1	n.s.
	CV(Y_i)	5,445	4	1361.4	1.2	n.s.
Intercept	CV(X_i)	1,930	1	1930.2	3.7	n.s.
	CV(Y_i)	1,541	1	1541.5	1.4	n.s.
Simpson's diversity Index	CV(X_i)	231	1	231.8	0.4	n.s.
	CV(Y_i)	21	1	21.7	0.1	n.s.
Livestock presence	CV(X_i)	419	1	419.8	0.8	n.s.
	CV(Y_i)	540	1	540.9	0.5	n.s.
Holm Oak presence	CV(X_i)	1,501	1	1501.1	2.8	n.s.
	CV(Y_i)	699	1	699.2	0.6	n.s.
Roost type	CV(X_i)	105	1	105.9	0.2	n.s.
	CV(Y_i)	2,973	1	2973.5	2.8	n.s.
Error	CV(X_i)	13,491	26	518.8		
	CV(Y_i)	27,415	26	1054.4		
Total	CV(X_i)	120,166	31			
	CV(Y_i)	101,261	31			
Total corrected	CV(X_i)	15,896	30			
	CV(Y_i)	32,861	30			

localities, and ranged between 22% and 108% respectively at La Guarda and Gabriel y Galán (Table 1). The median intra-season stability was 39%, and also this value was highly variable between sites from the 4% in La Guarda to the 152% at Retamal (Table 1). The median inter-season variation in crane numbers within a wintering site characterized by the predominance of the Holm Oak dehesa was significantly higher than the median intra-season one (U = 367, P < 0.01).

Relationships Between Farming Practices in the Dehesas and Temporal Variability of Wintering Cranes

The GLM analyzing the influence of farming practices, landscape heterogeneity and roost stability on inter- and intra-season variability of winter cranes is shown in Table 3. None of the variables considered (livestock presence, Holm Oak presence, landscape heterogeneity, roost type stability) explained either the intra- or inter-season variability in crane numbers in the dehesas of Spain.

DISCUSSION

We did not find any effect of habitat management of the Holm Oak dehesas on the stability of crane numbers in our study. Previous studies have shown that the use of one locality by cranes as staging and wintering areas was strongly influenced by human induced changes in food availability due to farming practices (Alonso *et al.* 1994; Díaz *et al.* 1996). In the same way, studies on Holm Oak dehesas in central Spain suggested that the emergence of intensified agricultural systems would improve habitat suitability in traditional wintering sites by increasing food availability (Sánchez *et al.* 1999). These authors found that cranes altered their settlement pattern, and increased their presence in February after the introduction of irrigation crops in Orellana.

Why Was There No Relationship Between Winter Crane Stability and Agricultural Intensification at the Studied Scale?

Previous works in the Holm Oak dehesas of Iberia only considered habitat intensification effects on one group of cranes (Díaz *et al.* 1996; Sánchez *et al.* 1999). However, cranes wintering in the center and south of Iberia each year occupy a network of some 50 different localities, characterized by different levels of human management (Sánchez *et al.*

1993). These wintering sites are often very close, and movements of cranes between nearby areas are frequent (Sánchez *et al.* 1993). They are probably also favored by the ability of cranes to exploit new food resources provided by new agricultural practices (Avilés *et al.* 2001). Thus, some wintering areas are used facultatively in relation to the changes in availability of food, in turn related to human management of habitat (Sánchez *et al.* 1999). Consequently, high plasticity to exploit new farming situations would maintain the stability of crane numbers in winter, detected in the Holm Oak dehesas of Iberia in this study.

In the wintering areas of Common Cranes in Iberia and in France, numbers are closely related to food availability, and the depletion of the available food brings about the displacement of the cranes (Bautista *et al.* 1992). However, Avilés (1999) found that the number of cranes in winter in one dehesa which was studied was always below the maximum possible, given the food availability and knowledge of the daily food requirements of the cranes. This suggested that the suitability of Holm Oak dehesas for cranes probably remains high, even when food availability is decreased by the inclusion of new farming practices. In fact, the capacity of this farming system in buffering the effect of natural variation in food availability probably makes it the most suitable wintering habitat for cranes, with little effect on population stability of the cranes.

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