J. Zool., Lond. (2002) **256**, 71–79 © 2002 The Zoological Society of London Printed in the United Kingdom DOI:10.1017/S0952836902000092

Food selection of wintering common cranes (*Grus grus*) in holm oak (*Quercus ilex*) dehesas in south-west Spain in a rainy season

Jesús M. Avilés[1,2]*, Juan M. Sánchez[1] and Deseada Parejo[1,2]

[1] Grupo de Investigación en Conservación, Área de Biología Animal, Departamento de Ciencias Morfológicas, Biología Celular y Animal, Universidad de Extremadura, Avda de Elvas s/n, 06071 Badajoz, Spain
[2] Laboratorie d'Ecologie, CNRS URA 258, Université Pierre et Marie Curie, 7 Quai St Bernard, Case 237, F-75252 Paris Cedex 05, France

(Accepted 31 January 2001)

Abstract

In the holm oak *Quercus ilex* dehesas of the Iberian Peninsula, several food types occur that can be selected by birds through the winter. In this framework, diet composition and diet selection of common cranes *Grus grus* was studied during a rainy wintering season. The winter diet of the common crane is mostly herbivorous in the holm oak dehesas of south-west Spain with < 10% of items being of animal origin. Leaves and stems of sown cereal, bulbs, acorns and cereal grain are the most common vegetable food types. The diversity of the overall winter diet was similar among juveniles and among adults with and without juveniles in attendance. However, there were differences in diet composition between juvenile birds and their parents. Furthermore, the diet composition of adult cranes with juveniles in attendance was different from that of adult cranes without juveniles in attendance. Foraging abilities of juvenile cranes did not vary significantly through the winter, suggesting a low effect of experience on diet differences between age classes. Our results point toward the existence of diet differences among the three considered crane categories related with differential habitat selection by family groups. The monthly pattern of choice of each food type differed from those expected according to the monthly pattern of food availability in the study area. Cereal grain was the most preferred food type when it was available. When cereal seed germinated, cranes shifted to acorns and bulbs which were then more profitable.

Key words: common crane, *Grus grus*, food selection, age differences, holm oak dehesas, *Quercus ilex*

INTRODUCTION

The common crane *Grus grus* is a migratory species with a wide distribution range within the Palaearctic region (Hagemeijer & Blair, 1997). The birds that use the western migratory route breed in northern latitudes and mainly winter in Morocco (Thevenot & Salvi, 1987), the Iberian Peninsula (Sánchez, Aviles *et al*., 1998), and France (Salvi *et al*., 1996). Recently, yearly changes in the wintering distribution of cranes among these three regions have been related to an increase of agricultural intensification in Spain and France, and to restrictions in hunting activities (Bautista, Alonso & Alonso, 1992; Salvi *et al*., 1996). The predilection of the cranes for intensively cultivated areas has favoured studies on feeding ecology in highly homogeneous study areas (Alonso & Alonso, 1993; Alonso, Alonso & Bautista, 1994). However, 67% of western migratory birds still winter in the holm oak *Quercus ilex* 'dehesas' of the centre and south of Spain and Portugal (Sánchez, Aviles *et al*., 1998), where differential use of holm oak dehesas by cranes according to their human management has been recorded (Díaz *et al*., 1996).

Common cranes are omnivorous, feeding on animal food during the summer but plant material for the remainder of the year (Cramp & Simmons, 1980). Available information on the wintering diet of the species is scarce and refers to the stomach contents of a few birds found dead on different dates and and in different areas in Spain (Valverde, 1952; Soriguer & Herrera, 1978; González *et al*., 1981), or to indirect evidence from flocks foraging on different habitat types (Pérez-Chiscano & Fernández-Cruz, 1971; Alonso & Alonso, 1988). Only González *et al*. (1981) reported descriptive information on diet variation during the winter from eight stomachs, pointing out the predominance of cereal

*All correspondence to: J. M. Avilés, Laboratorie d'Ecologie, CNRS URA 258, Université Pierre et Marie Curie, è Quai St Bernard, Case 237, F-75252 Paris Cedex 05, France

grain in the first part of the wintering period in holm oak dehesas (October and November), while acorns constituted the primary food resource used by cranes later (December and January). However, low sample size casts doubt on the inferences from their analyses.

The aim of this study is the quantitative assessment of the wintering diet and food type selection of cranes in holm oak dehesas of the south-west of the Iberian Peninsula. The knowledge of diet and food selection will be a basic tool for the development of conservation plans for the species considering the growing intensification of the agricultural practices in the Iberian wintering areas (Bautista *et al*., 1992; Sánchez, Sánchez, Corbacho *et al*., 1999) that will reduce the range of available food types for this species. Monthly diet composition and food selection among adults with and without juveniles (first winter birds) in attendance were compared. We have included two adult categories related to parental investment because parental care plays an important role in the time budget and habitat use of the species during winter (Alonso & Alonso, 1993). Second, to determine the role of bird experience in their winter diet, we compared searching and handling efforts and net intake rates in juvenile birds only eating on acorns (a novel food type for juveniles) between the two first (November and December) and the two last months (January and February) of the winter.

STUDY AREA

Data were collected from November 1995 to February 1996 in the Serena region in south-west Spain (39°03′N, 5°14′W). The study area covers 74 334 ha and is included in the meso-Mediterranean climate region characterized by hot, dry summers and mild, wet winters, with frequent days of freezing from December to February (Rivas-Martínez, 1981). The mean temperature (± SD) in January from the 31 previous years to the study season was 8.17 ± 3.02 °C, and the range was between 5.65 and 23 °C. Although the 10.5 °C registered in the area in the study season is higher than the mean reported, this value is within the normal range of winter temperatures in the study area. The mean annual rainfall (± SD) in January from the 20 years previous to the 1995–96 winter season was 32.5 ± 27.5 l/m^2, with a range between 0 and 113 l/m^2. The accumulated rainfall through January in the study season was 163.8 l/m^2, so our study season could be considered as exceptionally wet (all climatic data come from the meteorological station of Orellana close to the study area).

The great amount of rainfall in the study season is probably of crucial importance to food availability for cranes in the holm oak dehesas. Thus, the availability of acorns on the ground (where the cranes eat them) is probably higher at the beginning of winter than in a normal year when rainfall favours acorn fall (pers. obs.). Likewise, extreme humidity accelerates the putrefaction of acorns and cereal grain (Fiestas, Ramos & Mazuelos, 1966), and then reduces the availability of these foods in the last part of the winter in relation to a season with standard climatic conditions. In the same way, changes in plant production in our study area have been related to rainfall (Figueroa *et al*., 1981), thus the availability of the different plant species consumed by cranes measured in this study is probably not within the standard for the region.

The Serena region has been historically visited by cranes (Pérez-Chiscano & Fernández-Cruz, 1971), and villagers confirmed winter use of the area by cranes since the early 20th century. The feeding areas are the holm oak dehesas situated in the basin of the Zujar River, while the roosts are alongside the river (see Sánchez, Sánchez & Fernandez, 1993 for a detailed description of the study area).

Local farming uses a 3-year cereal rotation. Cereal is grain in 1 year, followed by 2 years of set-aside. The set-aside years are used to provide grazing and acorns of *Q. ilex* for livestock (mainly sheep). So, the study area is characterized by a mosaic of patches of cereal, cereal stubble (1 year set-aside) and 'posíos' (second year set-aside) that occupy about the same surface area through the years. Most cranes arrive from their breeding areas in northern latitudes in November and remain feeding in the holm oak dehesas until the end of February.

METHODS

The feeding areas were crossed by car to locate the flocks of cranes. Feeding birds were observed directly for 3-min periods using a 20–60 × 60 telescope, during which each food item consumed was recorded. All the sightings were reported in the feeding areas when cranes were undisturbed and at maximum distance of 350 m, although most sightings were between 75 and 150 m from birds. To assure enough accuracy to differentiate among all the consumed food types only those 618 sightings in which all food types consumed were clearly identified throughout the 3-min periods were considered in the analyses. To avoid dependence between diet and the number of birds in flocks, diet and food selection were recorded at random from a number of birds proportional to each flock's size. Cranes were classified on the basis of their red head and neck colour (Cramp & Simmons, 1980) as juveniles (first-winter birds) or adults. Adults with and without juveniles could be easily identified by their proximity to juveniles.

Food types were classified into 8 categories: (1) acorns; (2) bulbs; (3) grain; (4) invertebrates other than ants; (5) ants; (6) invertebrates associated with faeces when cranes picked dry cow dung looking for invertebrates; (7) leaves and stems of sprouted cereal; (8) leaves and stems of herbaceous plants. Grain consumption was always in recently sown fields where the cranes walked along a furrow pecking and ingesting. Foraging on bulbs was distinguished from foraging on leaves and stems by the higher pecking frequency without body movements of the former. Similarly, the consumption of

ants is clearly distinguished from the consumption of other invertebrates by the higher pecking frequency around the nests of ants followed by a repetitive number of ingestions.

To estimate the efficiency of acorn consumption by juvenile cranes, focal observations of 3-min each were recorded on randomly selected juvenile birds exclusively feeding on acorns. Habitat influence on the foraging abilities of juveniles eating only acorns is not expected because the surface below the canopy of the holm oak trees where acorns are consumed by cranes is never sown in the study area. The net intake rate was reported as the product of the number of acorns consumed within 3 min multiplied by the mean acorn weight obtained from samples of acorns (see below).

The number of acorns consumed per min was estimated from the number of ingestions reported in each focal observation (counted by a characteristic neck movement). An acorn was completely consumed after 5.06 ± 4.80 ($n = 48$) ingestions (Avilés, 1999). Searching ability and handling ability were estimated from the number of paces and the number of pecks in 3 min, respectively. In each focal observation, the flock size, the percentage of juveniles within the flocks and the time of the day were reported.

Land use availability

Each month a 30.3-km itinerary through the study area by car, recording the type of ground on 2 bands of 100 m situated on each side of the route was carried out. Several land types were considered: sown cereal, pasture land (second year of set-aside, see above), pasture land with shrubs and cereal stubble (first year of set-aside, see above). The density of holm oaks in each ground type were counted and expressed as number of trees/ha. The monthly surface area of each land use type and the proportion of each that was covered by holm oaks were obtained from these monthly itineraries.

Acorn availability

Acorn availability was estimated each month in 328 holm oaks. Each holm oak tree was randomly selected, marked, and monitored monthly. In each tree the available acorns in 3 squares 25×25 cm^2 situated on the ground below the canopy at randomly selected positions were collected and weighed with 0.2 g of precision: (1) at the base of the trunk; (2) under the middle of the canopy; (3) under the border of the canopy. Acorn availability did not significantly vary in relation to position ($F_{2,1306} = 1.71$, $P = 0.18$).

Taking into account the relationships between acorn decline on the ground and the presence of livestock in the holm oak dehesas (Díaz *et al.*, 1996), acorn availability was classified in 2 situations: (1) cereal sown with holm oaks in which livestock do not feed on acorns and cranes can freely access to this food type without competition; (2) pasture and cereal stubble with holm oaks in which livestock feed on acorns from early autumn to late spring, thus restricting access for cranes. The observed pattern was equal in the 2 holm oak dehesas types (interaction holm oak dehesa type × square situation: $F_{2,1306} = 1.13$, $P = 0.32$). The acorns were returned to the original 25×25 cm^2 squares after sampling.

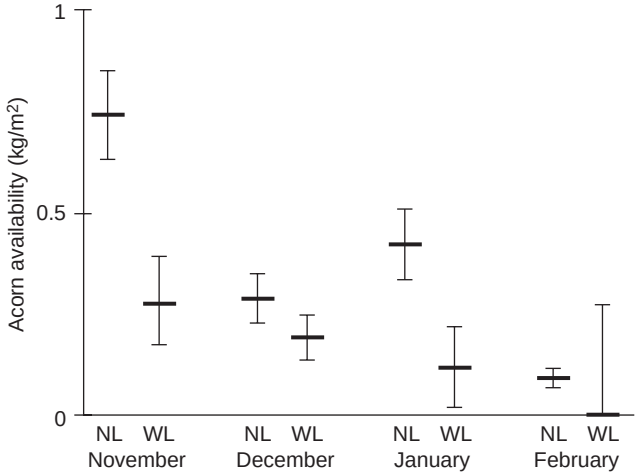

Fig. 1. Monthly acorn availability (kg/m^2) in holm oak *Quercus ilex* dehesas without livestock (NL) and with livestock (WL).

Figure 1 shows the monthly availability of acorns (mean ± SD) in relation to the presence of livestock in the holm oak dehesas in our study area. There were significant monthly differences in the acorn availability ($F_{3,459} = 7.93$, $P < 0.01$; Fig. 1). The availability of acorns was always higher in the holm oak dehesas without livestock ($F_{1,459} = 29.40$, $P < 0.01$), and this pattern did not vary throughout the winter (interaction month × holm oak dehesas type: $F_{3,459} = 1.96$, $P = 0.17$). The monthly acorn availability decreased seasonally in holm oak dehesas with and without livestock ($b = -10.2$ and $b = -2.3$, respectively; Fig. 1). However, a higher decrease was detected in the holm oak dehesas with livestock (ANCOVA, interaction month × holm oak dehesas type: $F_{3,449} = 7.17$, $P < 0.001$; Fig. 1).

A mean canopy radius per tree (r) was obtained by measuring the distance between the trunk and the canopy border in 60 randomly selected holm oaks in sown cereal (mean ± SE 3.66 ± 0.14 m) and 56 in pasture and in cereal stubble (mean ± SE 3.48 ± 0.14 m). There was no significant difference between the mean canopy radii obtained from the 2 types of holm oak dehesa (ANOVA; $F_{1,114} = 0.74$, $P = 0.39$). Mean acorn availability in the 2 types of holm oak dehesa was estimated each month by multiplying the acorn availability in the squares in each type of holm oak dehesa by the mean productive canopy (S). The mean productive canopy surface (S) we calculated in each holm oak dehesa as $S = \pi r^2$. These values were multiplied by the number of trees/ha to estimate the monthly availability of acorns in the area.

Bulbs, invertebrates and leaves and stems of herbaceous plants

The availability of leaves and stems of herbaceous plants and bulbs was estimated in December, coinciding with the maximum number of the cranes in the area. This is a reasonable estimation of the availability of these foods through the winter, taking into consideration that the production of bulbs and herbaceous plants is commonly retarded until early spring in March in the study area (Figueroa *et al*., 1981), and considering the stability of the availability of invertebrates through the winter previously reported in the holm oak dehesas (Díaz *et al*., 1996). One set of 48 square frames (0.25×0.25 m) was placed on the ground at randomly selected places in the feeding areas in the pasture fields, and another 48 square frames in cereal stubble. The soil volume included in the squares was calculated using a depth of 10 cm as an estimation of bill length in the common crane (Cramp & Simmons, 1980). The extracted soil was included in plastic bags and frozen until processing. In the laboratory, each sample was emptied onto a sieve with a mesh of 0.2 cm. After each sample was defrosted, the bulbs, invertebrates and herbaceous plants were separated and weighed to 0.1 g precision. There were no significant differences between the 2 types of holm oak dehesa in the biomass of invertebrates ($F_{1,94} = 0.38$, $P = 0.54$), bulbs ($F_{1,94} = 1.67$, $P = 0.20$), and leaves and stems of herbaceous plants ($F_{1,94} = 0.99$, $P = 0.65$) (Table 1). We obtained the monthly availability of each food type by multiplying the monthly surface of each type of holm oak dehesa obtained from the car itineraries by the mean values shown in Table 1.

Table 1. Wet biomass availability (g, mean ± SD) of invertebrate, bulbs and plant material in 25×25 cm squares in pasture and stubble fields during the winter in holm oak dehesas of south-west Spain

	Invertebrate	Bulbs	Plant material
Pasture fields (48)	0.6 ± 1.0	5.3 ± 12.8	93.0 ± 48.8
Stubble fields (48)	0.5 ± 0.9	2.4 ± 8.7	88.2 ± 56.6

Availability of cereal grains and leaves and stems

When cranes arrive in Extremadura in the middle of October and early November, the sowing of cereals has recently finished. Thus the cranes have to make a variable effort to consume the grains depending on the hardness of the ground and grain depth. The conservative availability of grain on the ground given by Sánchez, Sánchez, Corbacho *et al*. (1999) in holm oak dehesas at the nearby wintering area of Orellana was used. According to these authors, only 5% of the sown cereal (180 kg/ha) was available for the cranes at the beginning of November in the sown fields. The availability of cereal grain in the stubble fields was assumed to be 0 as this food type was not detected on the ground after several inspections in October.

Alonso *et al*. (1994) showed a depletion of cereal grain through the winter related to its consumption by cranes in Gallocanta Lake. In that agricultural framework, cranes can only feed on cereal grain, then the depletion of this food type is probably higher than in the holm oak dehesas. Thus, we assumed that the availability of cereal grain did not change during the study period because no other bird species forage on the cereal before it is > 5 cm high, and also because the amount of this food type consumed by cranes in October is probably insignificant compared with its availability in our holm oak dehesas.

In the first week of November, 56 sown cereal plots that were monitored monthly were randomly selected to assess the percentage of these in which the height of the cereal was < 5 cm. The monthly percentages of the sown cereal plots with cereal < 5 cm high were 100%, 85.72%, 97.30% and 94.74% from November to February, respectively. The monthly availability of leaves and stems of cereal after they were > 5 cm high was obtained from the monthly itineraries (see above), after assuming the existence of a correlation between the biomass per surface of leaves and stems of herbaceous plants and cereal.

Statistical procedures

Diet composition of the 5 most frequent food types was tested with the G statistic on contingency tables by bird categories and months. Subsequently, sequential Bonferroni techniques were applied to correct the level of significance in the successive contingency tables (Rice, 1989). The Fisher exact test was used to check monthly differences in the occurrence of any food type that was not present continuously through the winter, such that the occurrence in 1 cell of the 2×2 contingency table was < 5. The Shannon index of diversity (H') was obtained for each bird category from the occurrence of each food type. t-Tests were used to find out if the diversities of 2 samples were different (Zar, 1996). To test the existence of seasonal changes in the abilities of juveniles to consume acorns, we used ANCOVA after data transformation using flock size, percentage of juveniles within the flock and hour of the day as covariates (Zar, 1996).

Food type selection was tested using the Savage selectivity index (Savage, 1931):

$$W_i = U_i/D_i$$

where $U_i = u_i/u_+$, u_i being the occurrence of each food type in the diet of the cranes, and u_+ the total number of all food types detected; and where $D_i = d_i/d_+$, d_i being the available biomass of each food type, and d_+ the total available biomass of food in the study area.

The Wi index ranges from 0 to infinity; values approach 0 for increasing avoidance, and to infinity for

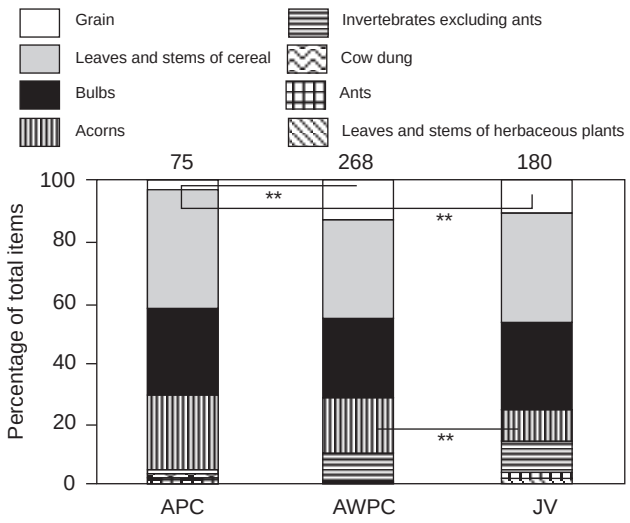

Fig. 2. Overall dietary composition of the common crane *Grus grus* wintering in holm oak dehesas of the south-west of the Iberian Peninsula according to parental care and age. The Fisher exact test was used to check differences among bird categories in food type occurrence. Only $P < 0.05$ are marked (**). APC, adult with parental care; AWPC, adults without parental care; JV, juveniles. Number of detected items for each bird category is shown above bars.

increasing preference. The index has a value equal to 1 when food use is proportional to food availability. The departure of the use of each food type from a distribution proportional to its availability was tested using the statistic $(W_i - 1)^2/\mathrm{es}(W_i)^2$ (Manly, Mcdonald & Thomas, 1993), which follows a χ^2 distribution with 1 degree of freedom. [es(W_i)] is the se of the index given approximately by $\nu[(1 - D_i)/(u_+ D_i)]$ (Manly *et al*., 1993).

RESULTS

Diet composition by age

When monthly data were pooled, there were significant differences in the diet composition among the three categories of cranes ($G_8 = 21.36$, $P = 0.006$; Fig. 2). The diet composition of the juveniles differed from that of their parents ($G_4 = 14.03$, $P < 0.016$), but was similar to that of the adults without juveniles in attendance ($G_4 = 9.85$, $P > 0.08$). Furthermore, the diet composition of adult cranes without juveniles in attendance differed from that of adult cranes with juveniles in attendance ($G_5 = 12.27$, $P < 0.016$; Fig. 2).

The differences in the diet composition among the three bird categories were based on a differential occurrence of cereal grain ($G_2 = 8.22$, $P = 0.02$) and acorns ($G_2 = 8.34$, $P = 0.02$) (Fig. 2). In adults with juveniles in attendance, cereal grain comprised only 2.63% of all detected food items ($n = 76$), while in juvenile birds and adults without juveniles cereal grain comprised respectively 10.55% ($n = 180$) and 12.68% ($n = 297$) of all the detected food types. On the other hand, acorns were more frequently consumed by adults without juveniles in attendance (23.68%) than by juveniles (10.55%; Fig. 2). The diversity of the diet was similar among the three bird categories: $H' = 1.62$, $H' = 1.57$, and $H' = 1.47$ for juveniles, adults without juveniles in attendance and adult with juveniles, respectively (t-test, $P > 0.05$).

Monthly variation in the diet

Cereal grain only occurred in the diet of the cranes in November and December. Its relative importance was higher in November in the diet of the three bird categories (Fig. 3). Monthly differences in grain occurrence were not explained by the age and parental situation of the cranes ($G_2 = 5.37$, $P = 0.07$).

Bulbs were included in the crane diet throughout the winter (Fig. 3), and their monthly occurrence did not vary among the three bird categories ($G_6 = 11.76$, $P = 0.07$).

Acorns occurred in the diet throughout the winter, and their monthly relative importance varied significantly among the three bird categories ($G_6 = 17.41$, $P < 0.01$). The monthly occurrence of acorns did not vary between juvenile birds and their parents ($G_3 = 0.385$, $P = 0.94$). However, significant differences in the monthly occurrence of this food type were found between these two groups and the adults without juveniles in attendance ($G_3 = 11.84$, $P < 0.01$ and $G_3 = 11.01$, $P < 0.05$, respectively; Fig. 3).

Invertebrate consumption associated with cow dung was sporadic in adults with juveniles in attendance (5.88% in December), while in juvenile birds it comprised only 2% of the all consumed prey items in November and December (Fig. 3). However, this food type was not in the diet of adults without juveniles in attendance.

Ants occurred in the diet of cranes only in January, comprising the smallest component of the diet in the three bird categories, but with significant differences among these ($G_2 = 153.0$, $P < 0.01$; Fig. 3).

Leaves and stems of herbaceous plants are a minimum fraction of the diet in the three categories (Fig. 3). They were present regularly in the diet of juvenile birds from November to January, and sporadically in the diets of the two categories of adults (Fig. 3).

Leaves and stems of cereal have a high relative importance in the diet composition of the cranes in the holm oak dehesas throughout winter (Fig. 3). The monthly occurrence of this food type varied among the three crane categories ($G_6 = 14.68$; $P < 0.05$). Statistical differences in monthly occurrence of leaves and stems of cereal were found among adults without juveniles in attendance and the other two bird categories (juveniles *vs* adults without juveniles in attendance, $G_3 = 10.85$, $P < 0.05$; adult with juveniles in attendance *vs* adults without juveniles in attendance $G_3 = 7.81$, $P < 0.05$). However, no significant differences were detected in the

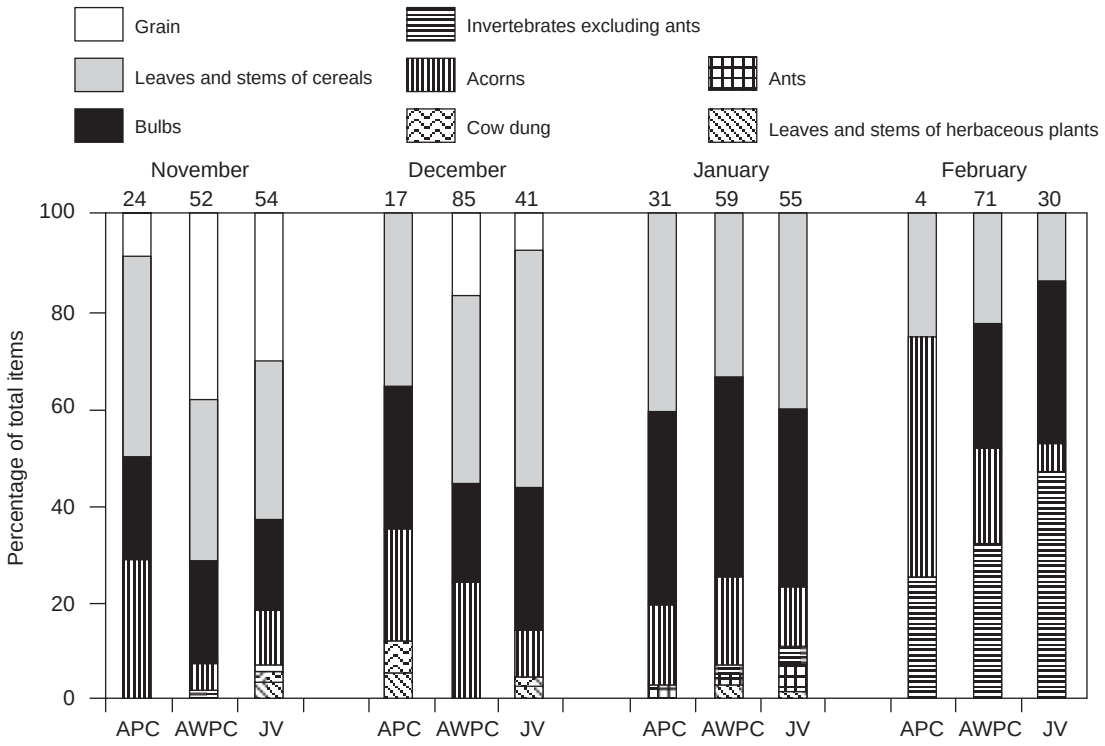

Fig. 3. Monthly diet composition of the common crane *Grus grus* wintering in holm oak dehesas of the south-west of the Iberian Peninsula according to parental care and age. APC, adult with parental care; AWPC, adults without parental care; JV, juveniles. Monthly number of detected items for each bird category is shown above bars.

monthly occurrence of this food type between juveniles and their parents ($G_3 = 1.68$, $P = 0.641$).

Searching and handling acorns

No statistical differences were found in the searching and handling effort of juvenile birds throughout winter (Table 2). Also, the net intake rate did not significantly vary, contrary to that expected from an increase in juvenile experience between the two study periods (Table 2).

Table 2. Feeding effort (mean ± SD) in relation to the experience of juvenile *Grus grus* foraging exclusively on acorns in holm oak *Quercus ilex* dehesas

	November–December (18 birds)	January–February (10 birds)	Analyses of covariance $F_{1,19}$	P
Net intake rate (g/min)	2.7 ± 2.9	0.7 ± 0.5	0.81	0.37
Paces/min	15.1 ± 11.2	22.9 ± 25.9	0.84	0.37
Pecks/min	20.5 ± 10.0	20.8 ± 12.6	0.07	0.78

Food availability and selection of food types

The monthly available biomasses were 3.56 tonnes/km^2 in November, 4.14 tonnes/km^2 in December, 4.30 tonnes/km^2 in January and 4.06 tonnes/km^2 in February. Leaves and stems of herbaceous plants comprised 70.68% of the available biomass of food in the study area. The following important food types in relation to their available biomass were the leaves and stems of cereal (18.15%), bulbs (5.15%), acorns (4.80%), invertebrates excluding ants (0.68%) and cereal grain (0.34%). Figure 4 shows the monthly relative importance of the available biomass of the six more frequent food types in the holm oak dehesas.

Cereal grain was the food type most preferred by the three crane categories during November and December (Table 3). Crane preferences shifted to bulbs in January, and to acorns and invertebrates excluding ants in February (Table 3). Only leaves and stems of cereal were clearly taken by cranes throughout winter (Table 3).

DISCUSSION

Diet composition

The wintering diet of the common crane is mostly vegetarian in the holm oak dehesas of south-west Spain. Leaves and stems of sown cereal, bulbs, acorns and cereal grain are, in rank order, the most consumed vegetable food types. The predominance of plant components in the winter diet of the common crane had

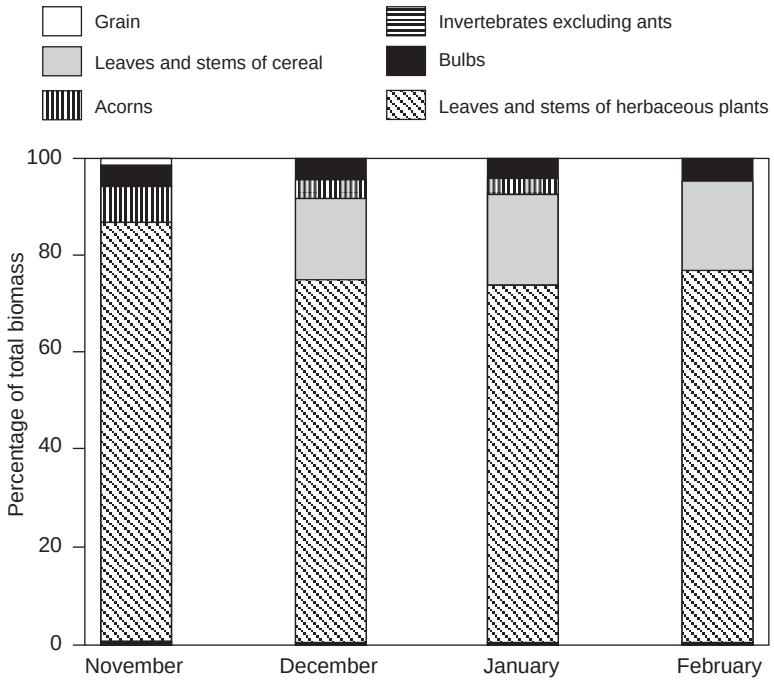

Fig. 4. Monthly composition of the available biomass of food in the study area.

Table 3. Food type selection by cranes *Grus grus* of the six most available food types in the holm oak *Quercus ilex* dehesas of south-west Spain in relation to the month and bird category. Numbers are values of the Savage index (*Wi*). Significant food type selections are marked in bold

	Cereal grains	Bulbs	Invertebrates excluding ants	Acorns	Leaves and stems of cereal	Leaves and stems of herbaceous plants
Adults with parental care						
November	6.90	0.40	0.00	**3.30**	0.00	0.00
December	**124.30**	**7.30**	0.00	**5.70**	2.00	**0.01**
January	0.00	**10.60**	**6.70**	**5.20**	2.10	0.00
February	0.00	0.00	**48.37**	**144.90**	**1.33**	0.00
Adults without parental care						
November	**36.60**	**4.80**	3.30	0.70	0.00	0.00
December	**122.90**	**52.20**	0.00	**6.30**	**2.30**	0.00
January	0.00	**11.50**	0.00	**5.90**	1.80	**0.05**
February	0.00	**6.50**	**62.70**	**57.10**	1.20	0.00
Juveniles						
November	**5943.77**	0.91	0.69	**0.31**	0.00	**0.01**
December	**54.88**	**7.64**	0.00	2.49	**2.95**	**0.03**
January	0.00	**9.57**	7.24	**3.96**	**2.15**	**0.02**
February	0.00	**8.53**	**90.31**	**154.06**	0.69	**0.00**

already been reported in previous studies in Iberia (Valverde, 1952; Soriguer & Herrera, 1978; Cramp & Simmons, 1980; González *et al*., 1981). However, the differential relative importance of the vegetable food types probably reflects the absence of stratification in data collection in these studies.

A low occurrence (10%) of animal components was reported in the winter diet of the cranes. However, although the availability of animal items was low, they were always present in the diet of juvenile birds. Fernández-Cruz *et al*. (1981) have suggested that animal components play an important role in the winter diet of cranes. This food type has been found in the stomach contents from all the dead birds previously analysed in Iberia (Valverde, 1952; Soriguer & Herrera, 1978; González *et al*., 1981). Furthermore, in other crane species of the *Grus* genus that live in America, a winter decrease of animal components in the diet has been detected, though they always occurred (Perkins & Brown, 1981; Iverson, Tacha & Vohs, 1982). This has been explained as the need to get a balanced diet, taking into account the difficulty of obtaining proteins and calcium from plant material (Reinecki & Krapu, 1986; Davis & Vohs, 1993). In the holm oak dehesas of the

Iberian peninsula, acorns, bulbs, wild herbaceous plants and cereals give a high portion of sugars but a low portion of proteins (Fiestas *et al.*, 1966; Sánchez, Sánchez, Fernández *et al.*, 1993). The consumption of invertebrates could be crucial for the cranes because of their high protein value.

Monthly variation in the diet

Cereal grain constitutes a basic component of the crane diet when the birds arrive in the holm oak dehesas in Extremadura. The relative high availability of recently sown cereal between the end of October and the beginning of December as compared to January and February, and its high caloric value in relation to green matter probably favours its use by the species. However, in January and February, cereal grains do not occur in the diet of the cranes due to their germination.

The more frequent elements in the diet of the cranes through the winter are leaves and stems of sown cereal, bulbs and acorns. The continuous occurrence of acorns in the diet is a new contribution to the current knowledge of the diet of cranes in winter. For instance, Pérez-Chiscano & Fernández-Cruz (1971) gave importance to this food type only at the end of the wintering in the holm oak dehesas. The high nutritive value of acorns (Sánchez, Sánchez, Fernández *et al.*, 1993) and their high availability make them an important food for cranes through the winter, although the high rainfall in the study season probably favoured their early consumption.

Age-classes differences in the diet

The differences between the three bird categories in the monthly consumption of the three most frequent food types in the diet of the cranes are probably not determined by juvenile experience in searching and handling unknown food types because juvenile abilities did not seem to change seasonally. Previous studies on cranes did not show diet variation in relation to age in any period of the year (Cramp & Simmons, 1980), though they did not consider parental care. However, in those studies where the winter activity budgets of the cranes are detailed in relation to parental care, variations in feeding time and habitat use are shown (Alonso & Alonso, 1993). Families tend to select different habitats from non-breeders, and this probably brings about differences in their diets. Thus, the diet of juveniles was probably similar to that of their parents simply because they feed together. Future studies on the habitat selection of family and non-family groups in the holm oak dehesas may confirm this point.

Diet selection

In November, cranes did not select the stems of herbaceous plants even though this food type made up 80% of the available biomass, and the cranes positively selected cereal grains even though this food type was scarce in the environment. This is probably because of the higher caloric content of cereal grains in relation to the highly available green material. Furthermore, cereal grains are previously known to juvenile cranes that have migrated through staging areas where they are the main food resource (Alonso *et al.*, 1994). Just after migration it could be advantageous for the cranes to feed on cereal grains, which the juveniles know, and to avoid the available food types in the holm oak dehesas that are unknown to the juveniles.

In December, cereal grains are the preferred food items again, while herbaceous plants are a non-preferred food. Acorns were only positively selected by adult birds, while juvenile birds feed on this food type as expected from its availability in the holm oak dehesas. Previous experience was not the cause of this difference in acorn selection because no seasonal changes in the abilities of juveniles feeding on this food type were detected.

When cereal grains are not available, cranes shift to feeding on bulbs and acorns, which are then probably the most profitable food types in the holm oak dehesas on the basis of their high nutritive contents (Sánchez, Sánchez, Fernández *et al.*, 1993) and availabilities (this study). This dependence on natural food types continues in February with bulbs and acorns being the preferred food items, though they are scarce.

Avilés (1999) found that the monthly availability of food for cranes in the holm oak dehesas through the winter was higher than needed according to the number of cranes and their absolute intake rate each month. Even, when food availability in the holm oak dehesas is probably diminished by the extremely high rainfall in the study year in relation to a standard season (see above), the holm oak dehesa offers to cranes a wide range of food types relative to more homogeneous wintering and staging areas in northern latitudes. This fact permits a more diverse selection of diet and gives an important role to the selection of winter diet in the species.

Considering that two-thirds of the cranes that use the western migratory route regularly winter in the holm oak dehesas of Extremadura, the maintenance of traditional farming practices in the holm oak dehesas is probably crucial for assuring the stability of the populations of the species in the western Palaearctic. Opposite to the situation in highly intensified, agricultural wintering areas as in Gallocanta and France, where depletion of the only available food type brings about the displacement of the cranes (Bautista *et al.*, 1992), in the holm oak dehesas the cranes have access to a wide range of resources that are temporarily abundant. Thus, when some of the available food resources are naturally (i.e. by extreme climatic conditions) depleted or diminished, the cranes can vary their diets. Consequently, the capacity of this ancient traditional exploitation system to provide the natural variation in

food availability, probably makes it the most suitable wintering habitat for cranes.

Acknowledgements

We are grateful to Francisco J. Medina for his excellent fieldwork, and to the many people from the G.I.C. who helped us with data collection. We are also grateful to Dr Mario Díaz and Dr T. Morris and two anonymous referees for valuable comments on the manuscript. We are especially grateful to Dr Luis M. Bautista for useful comments on previous drafts of the manuscript and his supervision.

REFERENCES

Alonso, J. A. & Alonso, J. C. (1988). Invernada de la Grulla común (*Grus grus*) en la Península Ibérica. In *Invernada de aves en la Península Ibérica. Monografías S. E. O*. No. 1: 123–136. Tellería, J. L. (Ed.). Madrid: S.E.O.

Alonso, J. A. & Alonso, J. C. (1993). Age-related differences in time budgets and parental care in wintering common cranes. *Auk* **110**: 78–88.

Alonso, J. C., Alonso, J. A. & Bautista, L. M. (1994). Carrying capacity of staging areas and facultative migration extension in common cranes. *J. appl. Ecol*. **31**: 212–222.

Avilés, J. M. (1999). *Dieta, preferencias alimentarias y patrones de actividad de la Grulla común en dehesas del centro de la Península Ibérica*. Unpublished thesis, University of Extremadura, Spain.

Bautista, L. M., Alonso, J. C. & Alonso, J. A. (1992). A 20-years study of wintering common cranes fluctuations using time series analysis. *J. Wildl. Manage*. **56**: 563–572.

Cramp, S. & Simmons, K. E. L. (1980). *The birds of the western Palearctic* **2**. Oxford: Oxford University Press.

Davis, C. A. & Vohs, P. A. (1993). Role of macroinvertebrates in spring diet and habitat use of sandhill cranes. *Trans. Nebr. Acad. Sci*. **XX**: 81–86.

Díaz, M., González, E., Muñoz-Pulido, R. & Naveso, M. A. (1996). Habitat selection patterns of common cranes *Grus grus* wintering in holm oak *Quercus ilex* dehesas of central Spain: effect of human management. *Biol. Conserv*. **75**: 119–123.

Fernández-Cruz, M., Alonso, J., García Rúa, A., Pereira, P., Pérez-Chiscano, J. L. & Veiga, J. P. (1981). La migración e invernada de la Grulla común (*Grus grus*) en España. Resultados del proyecto *Grus* (Crane Project). *Ardeola* **26–27**: 1–164.

Fiestas, J. A., Ramos, F. & Mazuelos, F. (1966). La industrialización de la bellota. *Rev. Sociedad Española para el Estudio de Pastos* **7**: 147–169.

Figueroa, M. E., Marañón, T., Fernández, R. & García Novo, F. (1981). *Fluctuaciones del pastizal seminatural mediterráneo en relación con el régimen de precipitaciones*. Actas de XXI Reunión Científica de la SEEP. León, Spain.

González, J. L., Llandres, C., González, L. M., Palacios, P. & Garzón, J. (1981). Análisis de ocho contenidos estomacales de Grulla común (*Grus grus*). *Ardeola* **26–27**:154–156.

Hagemeijer, W. J. M. & Blair, M. J. (Eds) (1997). *The EBCC atlas of European breeding birds. Their distribution and abundance*. London: T. & A. D. Poyser.

Iverson, G. C., Tacha, T. C. & Vohs, P. A. (1982). Food contents of sandhill cranes during winter and spring. *Proc. Int. Crane Workshop* **3**: 95–98.

Manly, B. F. J., Mcdonald, L. L. & Thomas, D. L. (1993). *Resource selection by animals. Statistical design and analysis for field studies*. London: Chapman & Hall.

Pérez-Chiscano, J. L. & Fernández-Cruz, M. (1971). Sobre *Grus grus* y *Circus pygargus* en Extremadura. *Ardeola* **26–27**: 510–574.

Perkins, D. L. & Brown, D. E. (1981). The sandhill crane in Arizona. *Ariz. Game Fish Dept. Spec. Publ*. No. 11: 1–47.

Reinecki, K. J. & Krapu, G. L. (1986). Feeding ecology of sandhill cranes during spring migration in Nebraska. *J. Wildl. Manage* **50**: 71–79.

Rice, W. R. (1989). Analyzing tables of statistical tests. *Evolution* **43**: 223–225.

Rivas-Martínez, S. (1981). *Memoria del mapa de series de vegetación de España*. Madrid: Ministerio de Agricultura Pesca y Alimentación. ICONA.

Salvi, A., Riols, C., Petit, P. & Moreau, G. (1996). New data on the common crane *Grus grus* in France. *Vogelwelt* **117**: 145–148.

Sánchez, J. M., Avilés, J. M., Medina, F. J. & Sánchez, A. (1998). Status and trends of the common crane *Grus grus* on the western route. *Bird Int. Conserv*. **8**: 269–279.

Sánchez, J. M., Sánchez, A., Corbacho, C. & Muñoz del Viejo, A. (1999). Influence of farming activities in the Iberian Peninsula on the winter habitat use of common crane (*Grus grus*) in areas of its traditional migratory routes. *Agric. Ecosyst. Environ*. **72**: 207–214.

Sánchez, J. M., Sánchez, A., Fernández, A. & Muñoz, A. (1993). *La Grulla común (**Grus grus**) en Extremadura. Status y relación con el uso del suelo*. University de Extremadura Edition, Spain.

Savage, R. E. (1931). The relation between the feeding of the herring off the east coast of England and the plankton of the surrounding waters. Fishery Investigation. *Min. Agric. Food Fish*. Ser. 2. **12**: 1–88.

Soriguer, R. C. & Herrera, C. M. (1978). Análisis de dos contenidos estomacales de Grulla común (*Grus grus*). *Ardeola* **24**: 217–219.

Thevenot, M. & Salvi, A. (1987). Wintering of common cranes (*Grus grus*) in Morrocco from 1980 to 1985. *Aquila* **93**: 233–235.

Valverde, J. A. (1952). Le passage des Grues cendrées en Castille. *Nos Oiseaux* **21**: 196–198.

Zar, J. H. (1996). *Biostatistical analysis*. New Jersey: Prentice Hall.