HABITAT AVAILABILITY AND ROOST-SITE SELECTION BY THE STONE CURLEW *BURHINUS OEDICNEMUS* IN AN ARID CULTIVATED LANDSCAPE (LOS MONEGROS, NE SPAIN)

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INTRODUCTION

The major european steppe areas actually remain in the Iberian peninsula. Los Monegros is one with the biggest ornithological richness (De Juana *et al.*, 1988). This unprotected area is seriously threatened : during the last 150 years an accelerated process of habitat loss due to agricultural pression has transformed this area into the most damaged Iberian steppe (Suárez *et al.*, 1992). Furthermore, imminent land irrigation projects threaten its actual richness (Balsa & Montes, 1991).

Los Monegros still holds an important breeding population of Stone Curlews (*Burhinus oedicnemus*) (Grimmet & Jones, 1989), a steppe species for which habitat destruction by modern farming is a major threat to its survival in Europe (De Juana *et al.*, 1988 ; Tucker, 1991 ; Blanco & González, 1992). However, so far studies about its habitat selection have been conducted only in some breeding populations from Britain (Green & Giffiths, 1994 ; Green & Taylor, 1995). In Los Monegros, Stone Curlews gather together late in the post-breeding season at a large diurnal roost site in a steppe area intensively transformed by farming. Our aims are to determine a) the present habitat fragmentation and habitat availability, and b) the roost site selection by the Stone Curlew in this area, suggesting some conservation measures.

STUDY AREA

The study was carried out in the endorreic area of Monegros Sur (Ebro Valley, NE Spain). This plain of approximately 250 km^2, between 300-360 m a.s.l., consists of limestone and gypsum of tertiary origin and fifteen saline lakes that are temporarily flooded (Balsa *et al.*, 1991). The climate is mediterranean continental

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semi-arid with 350 mm of rainfall concentrated in spring and autumn, extreme temperatures in summer and winter (40 °C to -5 °C), and thermic winter reversal. Vegetation (Braun-Blanquet & De Bolós, 1987) is naturally of the Association *Rhamneto-Cocciferetum thuriferetosum*, but the area has been converted into an extensive cereal plain (pseudo-steppe) with crops of wheat *Triticum sp.* and barley *Hordeum sp.*. Surrounding the saline lakes is an evergreen halophytic vegetation characterized by the Association *Suaedetum verae*. The non halophytic natural vegetation (Alliances *Salsolo peganion* and *Hordeion leporini*) is restricted entirely to the road edges where nitrophic conditions occur as a result of anthropogenic actions.

METHODS

The Stone Curlew roost is located on a 1 ha natural vegetation belt surrounding a saline lake. Birds gather there from August to early winter with a maximum of 183 birds in late September (J. I. Pino, pers. com., Authors unpubl.). The roost was occupied at least the last five years. Other potentially suitable areas (250 km^2 in Los Monegros, and with less intensity 7250 km^2 of Ebro Valley) were also surveyed. No other roosts were found.

The habitat available in a sample of 7429 ha of cultivated landscape around the roost was evaluated during October 1992. Due to the habitat simplicity, it was possible to estimate habitat availability from 1 : 50000 maps. The surface of non halophytic steppe vegetation was estimated taking 52 equidistant measurements of road edge width along 26 km of roads randomly selected throughout the study area, then multiplying the average obtained by the total length of existing roads. The area occupied by crops was calculated subtracting saline lakes and road edge areas from the total surface area. The proportion occupied by each different crop was estimated on the basis of the 127 crops bordering the 26 km of transects. We assumed, using this sample size, that each crop occupied an equal surface area (Alonso & Alonso, 1990).

To evaluate roost habitat selection, measurements were taken at the following sites :

— *Halophytic vegetation belts* : At the roost site area (approximately 100×100 m) we took three perpendicular transects to the saline lakeshore 30 m apart, which we also used to calculate the width of the vegetation (VW) belt. In each transect we took 4 plots also 30 m apart. For the rest of vegetation belt not occupied by Stone Curlews and for the other seven saline lakes we also performed transects but at every 400-500 m (plots the same at every 30 m). To measure the width of the belts of these latter lakes we made four additional transects, around the main one, separated by 10 m. Therefore, the number of main transects per belt (2-5) and plots per transect (1-5) depended on the size of the lake and its belt. As a measurement of isolation from human disturbances, distance from the edge of the vegetation belt to the nearest road was taken from the nearest and farthest points of the vegetation belt to the road.

— *Cereal farms* : 40 plots were randomly taken from the 127 crops. Each crop stage was represented in the same proportion than its availability ($\chi^2 = 0.04$, d. f. = 3, p = 0.99).

— *Road edges* : 52 equidistant plots were taken along the 26 km covered.

In each plot the following descriptive variables were recorded : vegetation cover (VC), vegetation height (VH), and vegetation heterogeneity (HI) by Wiens's Index (Wiens, 1973). Firstly VC was estimated using a 1 m^2 frame divided in nine square sectors scaled from 0 to 5 (0 = 0 %, 1 = 0-10 %, 2 = 10-25 %, 3 = 25-50 %, 4 = 50-75 %, 5 = 75-100 %). To measure the VH, a rule was inserted in the centre of each square and the height of the nearest plant in a 3 cm radius was taken, with the exception of the central square, where the height of the two nearest plants was measured. In this way 10 measurements by plot were performed, and the average was obtained for statistical treatment.

The differences in vegetation type were tested by Mann-Whitney U Tests (between the roost-site and other areas), and diversities were found by Shannon-Wiener indices.

RESULTS

HABITAT LOSS AND AVAILABILITY

Sample surveys show that the natural vegetation has been reduced to 3.5 % of the surface area. 58.4 % of this vegetation (2.1 % of the total) consists of herbaceous plants and small bushes restricted to the edges of roads. These strips have an average width of 3.40 m (sd = 3.48, range = 0-21) occuring as a discontinuous and reticulated margin along 162.3 km of sand roads. The climax vegetation of this area (Association *Rhamneto-Cocciferetum thuriferetosum*) is no longer found in the area although remnants of this vegetation are indicated by the occurrence of scattered *Juniperus thurifera* trees. The remainder of the original vegetation (41.6 %, or 1.4 % of the total) is mainly restricted to eight belts around the lakes. The width of these ($\bar{X}$ = 54.92 m, sd = 52.19, range = 0-225, n = 103) depends on the surrounding farming pressure. Seven other saline lakes and their respective vegetation belts have disappeared as a result of ploughing.

In 1992, the 92.1 % of this area was occupied by agriculture. 85.2 % were wheat crops and 14.8 % barley crops. In autumn these were either in their initial growing stage (44.9 %), just harvested (38.6 %), under fallow (11.8 %) or abandoned (4.7 %). The habitat structural diversity is very low (H' = 0.51), but increases when considering the different crops stages (H' = 2.02).

ROOST-SITE SELECTION

There was no difference between the vegetation structure of cultivated areas and the vegetation structure of the roost (Table I). Regarding to the different saline lakes, Stone Curlews selected the one with the widest belt (Table II). Within this belt the birds chose the area with larger width and larger vegetation height. Vegetation height is more heterogeneous in the roost than in the rest of units, with the exception of the road edges. However, these road edges are not apropriate for roosting Stone Curlews because of their high fragmentation (see above), farming disturbances and traffic.

TABLE I

Vegetation height (VH), vegetation cover (VC) and vegetation heterogeneity (HI) of each structural type of vegetation. Differences between roost site and the rest of vegetation units were tested by Mann-Whitney U-Tests.

	VH			VC			HI
	$\bar{X}$	sd	n	$\bar{X}$	sd	n	
Roost-site belt within roosting area	12.64	10.28	12	2.41	1.24	12	1.57
Roost-site belt outside roosting area	11.29	12.34	19	2.68	1.76	19	1.28
	(P = 0.028)			(n.s.)			
Other saline belts	14.23	13.35	50	2.84	1.65	50	0.99
	(n.s.)			(n.s.)			
Crops	10.42	10.04	40	2.27	1.44	40	1.37
	(n.s.)			(n.s.)			
Edge roads	12.19	13.43	52	3.69	1.62	52	2.20
	(n.s.)			(p = 0.01)			

TABLE II

Width of the vegetation belt surrounding the lake (VW) and the distance to the nearest road (RD) in the roost-site and other places. Differences were tested by Mann-Whitney U-Tests.

	VW			RD		
	$\bar{X}$	sd	n	$\bar{X}$	sd	n
Roost-site belt within roosting area	170.64	23.79	4	230	170.7	4
Roost-site belt outside roosting area	55.95	56.78	22	287.8	277.0	8
	(p = 0.007)			(n.s.)		
Other saline belts	48.61	44.67	78	309.9	297.4	32
	(p = 0.001)			(n.s.)		

There were no significant differences between the roost and the other saline belts in distances to roads, which would suggest that human disturbance does not determine the roost-site selection.

DISCUSSION

Stone Curlews occupied an area of halophytic vegetation differing from other similar vegetation stands in its larger vegetation belt width, height and heterogeneity. These characteristics would allow camouflage of a greater number of birds than could be accomodated at the other vegetation types in the area. This could be interpreted as an antipredator response. The selection of this place would be conditioned by natural predation pressure, mainly by birds of prey and not by human activities. In fact, the Stone Curlew is reported as prey of the Peregrine Falcon (*Falco peregrinus*) in this area (Oro & Tella, 1995 ; unpubl. data), and other potential predators as the Golden Eagle (*Aquila chrysaetus*) are abundant during gathering period (Authors, unpubl. data). Human disturbance is important in other populations of shorebirds (Pfister *et al.*, 1992 ; Yalden, 1992), but in our study area human density is very low (approximately 10 hab./km^2) and human activities are mainly restricted to short periods of labours.

Vegetation of crops during the roosting season was not structurally different to roost site vegetation. However, the fast growing rate of crops as well as annual rotation make habitats temporally unstable and less predictable, while halophytic vegetation shows higher constancy throughout each year and from year to year. Roost-sites in crops would have to change frequently, but this would be contrary to the pronounced roost-site fidelity shown by the species. Furthermore, the stone curlews would be more conspicuous inside the green crops than in the brown belts of the saline lakes, and predation risks would increase. In addition, microclimatic conditions (Walsberg, 1986), which could provide better protection from strong NW winds, may also possibly be of importance.

The cereal crops of Los Monegros are used by an important Stone Curlew population as a feeding and breeding area. However, following breeding, roosting Stone Curlews select clearly differentiated natural vegetation patches. Nowadays, this vegetation is highly fragmented and occupy only the 1.4 % of the total surface. Thus, preservation of adequate pieces of this vegetation type is necessary, given the importance of the post-breeding period in avian demography (e.g. Cave & Visser, 1985 ; Bairlein, 1991) and the role of communal roosts on bird survival (Cody, 1985 ; Donázar *et al.*, in press). Furthermore, the maintenance of patches with natural vegetation and grassland reserves could be too an useful conservation measure to breeding Stone Curlew populations in farmland areas (Green & Hirons, 1991). The creation of reserves would require a previous design (Wiens, 1989 ; Pearson, 1993) to avoid further undesirable effects (e.g. Suárez *et al.*, 1993). These initiatives, together with the maintenance of wide margins between fields and little « islands » of vegetation, would favour the present agrosystems (Von Klinger, 1987 ; Thomas *et al.*, 1991 ; Serrano *et al.*, 1992 ; Boatman, 1994), the availability of insects (Dover, 1991) and thus the whole steppe bird community. Species such as Sandgrouses (*Pterocles alchata* and *P. orientalis*) and Lesser Kestrel (*Falco naumanni*) which are especially sensitive to habitat loss (Estrada & Curcó, 1991 ; Donázar *et al.*, 1993), as well as others closely associated with traditional agro-pastoral systems (Great Bustard, *Otis tarda*, Alonso & Alonso, 1990 ; Little Bustard, *Tetrax tetrax*, Martinez 1993 ; Chough, *Pyrrhocorax pyrrhocorax*, Bignal & Curtis, 1989), would then be also favoured in this area.

Finally, since our study was restricted to a unique roost site in Los Monegros, more studies on habitat selection by roosting and breeding Stone Curlews would be advisable in other areas highly transformed by farming, in order to establish wider conservation strategies.

SUMMARY

In Los Monegros, one of the main Iberian steppe areas and one of the most transformed by farming, an important population of Stone Curlew (*Burhinus* *oedicnemus*) gathers in an unique post-breeding roost. We evaluated habitat availability and roost-site selection in 1992. Natural vegetation was found over only 3.5 % of the total surface area, restricted to road edges or to the vegetation belts of several saline lakes. Stone curlews selected one sector within one of these belts, where the width, height and vegetation heterogeneity were larger. These results are interpreted as an anti-predator strategy. Crops are not suitable due to its temporal unstability. Taking into account the high habitat loss suffered, we finally propose some conservation measures, such as the maintenance of natural vegetation reserves and wide margins, to favour this and other bird species.

RÉSUMÉ

Une importante population d'Oedicnèmes criards (*Burhinus oedicnemus*) se concentre après la nidification dans Los Monegros (NE de l'Espagne), l'une des principales régions steppiques de la péninsule ibérique et aussi l'une des plus transformées par l'agriculture. L'habitat disponible et la sélection des sites de rassemblement ont été évalués en 1992. Il est apparu que la végétation naturelle, restreinte aux bordures de routes ou aux ceintures végétales de plusieurs lacs salés, ne recouvrait plus que 3,5 % de la surface totale. Les Oedicnèmes criards sélectionnent un secteur dans ces ceintures où la largeur, la hauteur et l'hétérogénéité de la végétation sont les plus grandes. Ces résultats sont interprétés en termes de stratégie anti-prédateurs. Les cultures ne conviennent pas en raison de leur instabilité dans le temps. Prenant en compte la forte perte d'habitat, quelques mesures de conservation sont proposées comme le maintien de réserves et de larges lisières de végétation naturelle pour favoriser cette espèce et bien d'autres.

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