Information about the habitat use of salines and fish ponds by wintering waders in Cadiz Bay, southwest Spain

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Cadiz Bay, recently declared as a Natural Park, is an important area for wintering waders in Spain. In the last few years mudflats and salines in Cadiz Bay have been claimed for human activities with adverse impacts on their shorebird populations. Thus, the importance to shorebirds of the salines and fish ponds adjacent to the Bay could be increasing if they are used as alternative feeding areas. In general the birds used the salines and fish ponds both for feeding and roosting: some 66% of waders in salines at low tide were feeding. However, not all the birds used the different habitats in the same way or at the same state of tide. Some implications of the use made by waders of these areas to their energetic requirements, morphological adaptations and prey availability are discussed.

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INTRODUCTION

The wetlands of Cadiz Bay (between 36°23'N, 6°08'W and 36°37'N, 6°15'W, southwest Spain) extend over 18,000 ha, and include many different and productive habitats; intertidal mudflats, salines, fish ponds, lagoons and semi-natural salt marshes (Figure 1). These support a large number of wintering waders (30,000 birds approximately, Alberto *et al.* 1987). Due to the strategic geographic position of the Bay on the East Atlantic Flyway it is possibly an important staging area for migrating waders.

Nonetheless, only a few general studies have been undertaken in relation to the wader populations of Cadiz Bay and their links with other Iberian wetlands (Alberto & Velasco 1988; Dugan 1980; Hortas 1990; Smit in press). There has also been little work on the use that some waders make of the feeding habitats here (Perez-Hurtado & Garcia 1990; Perez -Hurtado & Hortas 1990).

Although 10,000 ha of Cadiz Bay have recently been declared a Natural Park, a great number of changes have taken place over the last 20 years of human activity in the salines and mudflats. A high proportion of salines (62% of the original area) have been deserted or drained and, in some cases, the ponds have been filled to allow house building. Other ponds have been deepened and transformed into fish ponds (25% of the area). These changes clearly affect the waders using these areas.

The human management regime in the remaining fish ponds also strongly affects birds. In general, ponds are emptied in

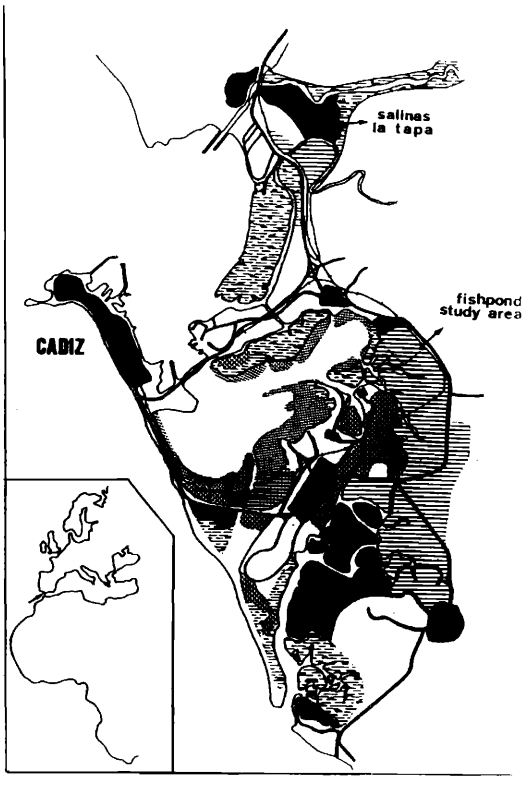
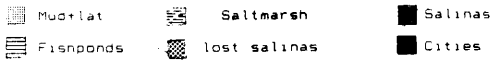


Figure 1. Location of Cadiz Bay in the East Atlantic Flyway (inset) and the distribution of different habitats in the Bay. The map also shows the study areas selected: 'Salinas la Tapa' and the fishpond study area.

Key to habitat types



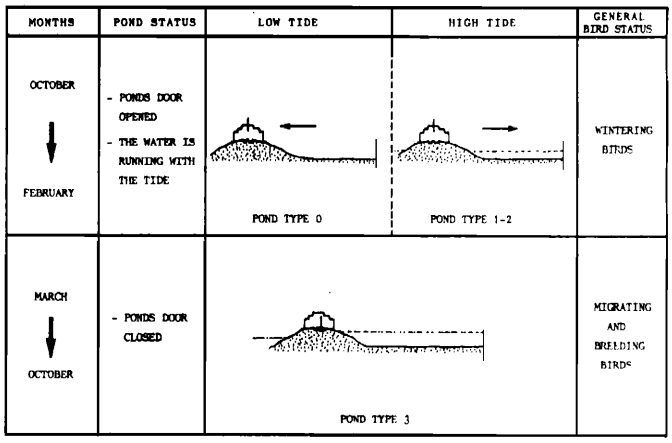


Figure 2. Annual management regime of the fish ponds in terms of water level, season and tidal cycle.

October or November to collect fish; after, this, pond sluices are opened and sea-water can move in and out with the tide. During this period, from November to February, a large amount of marine nutrients enter the ponds with the tide, perhaps augmenting the production of prey biomass. From February to the following October, the sluices of the pond are closed to allow fish cultivation (Figure 2).

The mudflats have been adapted for the culture of the bivalve mollusc *Venerupis semidecussata* in two ways that reduce prey availability to waders considerably. The mud is removed and mixed with gravel, creating a new surface layer to a depth of approximately 12 cm. In some cases, nets are also placed on the surface.

We think that the importance to shorebirds of the salines and fish pond habitats comes from their use as alternative feeding grounds which may help waders to obtain their daily energy requirements when feeding opportunities are limited on the mudflats. Given the changes in the habitats that have taken place, it is very important to know how bird numbers and distribution have changed in the area over recent years and how waders use these habitats. The aim of this work was thus to investigate the use by birds of two contrasting habitats in Cadiz Bay: a modern salina and a representative fish pond (Figure 1). Some implications related to tidal cycle, morphological adaptations and energetic requirements are also discussed.

METHODS

The data were collected each winter in a modern salina from 1987, and in a representative marine culture (fish pond) area from 1988. To make the observations we used two 15 x 60 telescopes and a car to move through the area.

We selected one of the typical modern salines in the Bay. The 'Salinas la Tapa' has a high salt production, of about 40,000 tonnes and holds about 10% of the total number of waders in the Bay. For censusing and studying bird distribution, we also made observations on the mud beside Guadalete River close to these salines. Finally, we selected a representative fish pond and mudflat area close to Puerto Real village (Figure 1). In these habitats, data were collected in good weather conditions at low tide, in December or early January, when wintering numbers are more stable in Cadiz Bay. We also collected qualitative information about habitat use, at high tide, in the fish pond area selected.

To understand the habitats used by different waders, we recorded the locations of those observed on habitat maps. We identified four habitat categories: mudflats, walls (with and without vegetation) and five sub-categories of ponds:
Type 0 = Wet ground but no water
Type 1 = Shallow water < 3 cm
Type 2 = Water level 3–11 cm
Type 3 = Water level 11–20 cm
Type 4 = Water level > 20 cm

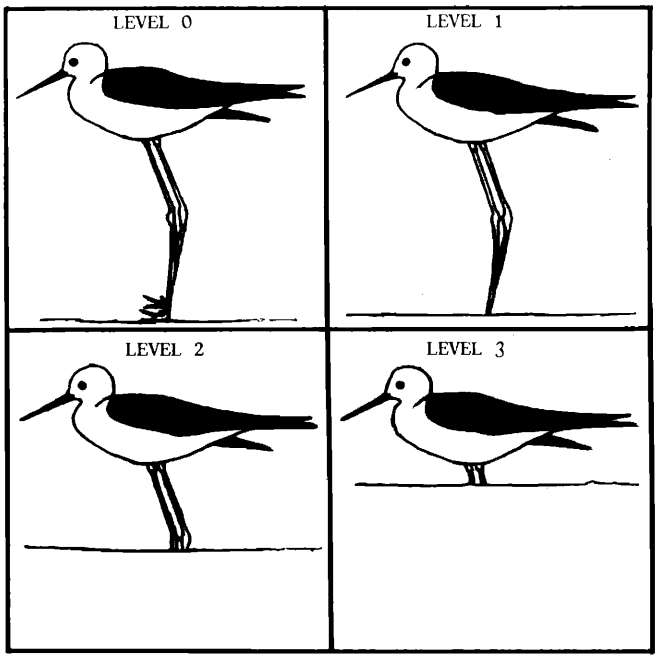


Figure 3. Four categories for estimation of water level in ponds in relation to the Black-winged Stilt leg.

Type 0 = Wet ground but no water Type 1 = Shallow water < 3 cm
Type 2 = Water level 3–11 cm Type 3 = Water level 11–20 cm

The habitat and water level were recorded for each bird observed. To estimate water level we used a scoring system based on the mean 'leg level' of birds feeding in the pond, divided into four categories (Figure 2). Bird activity was scored as feeding or not feeding.

Table 1. Habitat preferences of feeding wading birds at low tide in 'Salinas la Tapa' (S) and the mudflats of the Guadalete River (M) in Cadiz Bay. The estimated numbers are based on peak counts from the December or January census.

	Winter 1987/88				Winter 1988/89				Winter 1989/90				Winter 1990/91			
	M	S	%(M)	%(S)	M	S	%(M)	%(S)	M	S	%(M)	%(S)	M	S	%(M)	%(S)
Haematopus ostralegus					4		100		5		100					
Himantopus himantopus		6		100		31		100		42		100		20		100
Recurvirostra avosetta		197		100	1	285	3	99	69	160	30	70	1	300	3	996
Charadrius hiaticula	67	57	54	46	82	65	56	44	16	113	12	82	223		100	
Charadrius alexandrinus	151	172	47	53	140	134	52	48	103	289	26	74	434	58	88	12
Pluvialis squatarola	16	29	36	64	64	67	49	51	36	91	28	72	50	89	36	64
Calidris alba	6	4	60	40	19		100		5	10	33	67	55	30	65	35
Calidris minuta	2	35	5	95		21		100		15		100	8	21	28	72
Calidris ferruginea	1	28	3	97	15	10	60	40	4	4	50	50	3		100	
Calidris alpina	40	505	7	93	399	411	49	51	247	661	27	73	1287	98	93	7
Limosa limosa		395		100	1	146	7	99		120		100		146		100
Limosa lapponica		1		100	21	1	96	4	2		100					
Tringa totanus	65	150	31	68	175	54	76	24	52	106	33	67	230	99	70	30
Arenaria interpres		1		100	6	3	67	33	2	1	67	33	6		100	
TOTAL WADERS	348	1580			927	1228			541	1614			2299	861		
HABITAT USE (%)			18	82			43	57			25	75			73	27

RESULTS AND DISCUSSION

The importance of the salines and fish ponds for feeding varies greatly between species. In 'Salinas la Tapa', Oystercatcher *Haematopus ostralegus*, Bar-tailed Godwit *Limosa lapponica*, Grey Plover *Pluvialis squatarola* and Turnstone *Arenaria interpres*, mainly concentrated their feeding on the mudflats at low tide. Others such as Black-winged Stilt *Himantopus himantopus*, Black-tailed Godwit *Limosa limosa*, Little Stint *Calidris minuta* and Avocet *Recurvirostra avosetta*, fed nearly exclusively in the salines and fish ponds (Table 1)

Several small species (Ringed Plover *Charadrius hiaticula*, Kentish Plover *Charadrius alexandrinus*, Dunlin *Calidris alpina*, and Sanderling *Calidris alba*) fed on mudflats at low tide (Table 1) but in the salines and fish ponds for the rest of the day. Rufino (1984) showed similar patterns to those found here for Kentish Plover, Bar-tailed Godwit and Black-tailed Godwit in the Algarve of South Portugal. In general the salines are used at all times of day by waders for feeding and for roosting. They are also used at night (Rufino *et al.* 1984; Batty 1988).

The proportion of birds in 'Salinas la Tapa' which were feeding was about 66% at low water (Table 2 & 4). The habitats selected most frequently were ponds with a wet substrate, but

Table 2. Numbers of birds feeding and not feeding at low tide in 'Salinas la Tapa'.

	January 1989		January 1990		January 1991	
	Feeding	Not feeding	Feeding	Not feeding	Feeding	Not feeding
Haematopus ostralegus						
Himantopus himantopus	66	2	10	6	3	17
Recurvirostra avosetta	65	125	4	125	1	275
Charadrius hiaticula	43	61	95	26		
Charadrius alexandrinus	100	269	153	56	58	
Pluvialis squatarola		98	8	76	2	87
Calidris alba	6	3	10		30	
Calidris minuta	17		13		21	
Calidris ferruginea	5		2			
Calidris alpina	527		795		76	22
Limosa limosa	159		81		27	119
Limosa lapponica						
Tringa totanus	125	4	70	4	89	4
Arenaria interpres	2					
TOTAL WADERS	1115	562	1241	293	307	524
ACTIVITY PERCENTAGES	66.5	33.5	80.9	19.1	37.0	63.0

Table 3. Habitat types selected by waders at low tide in 'Salinas la Tapa'. WWV = Saline walls with vegetation, WNV = Saline walls with no vegetation, P0–1 = Pond types 0 & 1 (water < 3 cm), P2–3 = Pond types 2 & 3 (water 3–20 cm), P4 = Pond type 4 (water > 20 cm).

	January 1989					January 1990					January 1991				
	WWV	WNV	P0-1	P2-3	P4	WWV	WNV	P0-1	P2-3	P4	WWV	WNV	P0-1	P2-3	P4
Haematopus ostralegus															
Himantopus himantopus			2	66		6			10			8			
Recurvirostra avosetta				190			125		4			35		265	
Charadrius hiaticula			104				2	119							
Charadrius alexandrinus	1	11	353	4				209					58		
Pluvialis squatarola	26	41	31				30	54				16	39	34	
Calidris alba		3	1					10					25	5	
Calidris minuta			17					13					20	1	
Calidris ferruginea			5					2							
Calidris alpina			527					795				15	35	48	
Limosa limosa				159				81						146	
Limosa lapponica															
Tringa totanus			100	29				69	14			2	7	90	
Arenaria interpres			2												
TOTAL WADERS	27	55	1142	453			6	157	1352	28		76	184	601	

Table 4. Habitat use at low tide, in 'Salinas la Tapa' and muds of Guadalete river.

ACTIVITY	January 1989 Number of total waders	January 1990 Numbers of total waders	January 1991 Numbers of total waders
Feeding on mud	927	541	2299
Feeding on salines	1115	1241	307
Roosting on salines	562	293	524
TOTAL WADERS	2604	2075	3130

no surface water, and ponds with shallow water (Table 3), where the prey (*Hydrobia ulvae,* Chironomid larvae and nymphs, Polychaete worms and Ephidridae) would be more available than in deeper ponds (pers. obs.).

The last four tables show a different habitat use in January 1991. In that year fewer waders fed in the salines while a greater number fed on the mud. This difference was particularly obvious in the smaller species; Kentish Plover, Ringed Plover, Dunlin, Sanderling and Curlew Sandpiper. These species preferentially used mud (Table 1), while in previous winters they also used salines, feeding on pond type 0–1 (Table 3). The reason for this change could be related to a delay in the normal management activities of the ponds in 1991; the pond sluices were not yet opened in January and so the water level of the ponds exceeded a depth of 20 cm.

The use made of the salines and fish ponds varied according to the body size of the bird. Large species, such as Grey Plover, which take larger prey fed only at low tide on the mudflats and at high tide roosted on the walls (see Tables 5 & 6). However, small species such as Ringed Plover, Kentish Plover and Dunlin, fed throughout the day on mud or in the ponds at low water, and in ponds at high water. They mainly used ponds with wet substrate or shallow water. Small species fed for a greater part of the day and so depended most on the high tide feeding areas provided by the salines and fish ponds.

The ponds with water depth of 1–20 cm were primarily used by the long-legged species, such as Black-winged Stilt, Avocet and Black-tailed Godwit. Ponds with greater depth of water were used by Avocet only. Thus the same ponds can be used for feeding by different species depending on water level, this being determined by human action and morphological adaptations such as bill and leg length.

On the other hand, some species with very similar morphology, like Black- and Bar-tailed Godwits did not feed in the same habitats in Cadiz Bay (Table 5 & 6). Black-tailed

Table 5. Distribution of feeding (F) and roosting (R) waders at low tide, in different habitats of a fish pond in Cadiz Bay (habitat codes as Table 3) in January 1991.

	WWV	WNV	P0-1	P2-3	Mud
Himantopus himantopus	29 R		40 F	38 F	
Recurvirostra avosetta				10 F	1 F
Charadrius hiaticula			28 F		70 F
Charadrius alexandrinus			11 F		4 F
Pluvialis squatarola		8 R			76 F
Calidris alba					
Calidris minuta			6 F		
Calidris alpina					250
Limosa limosa			2 F	43 F	
Limosa lapponica					134 F
Tringa totanus			79 F		8 F
Actitis hypoleucos			9 F		
Arenaria interpres					5 F
TOTAL WADERS	29	8	139	91	548

Table 6. Distribution of feeding (F) and roosting (R) waders at high tide, in different habitats of a fish pond in Cadiz Bay (habitat codes as Table 3) in January 1991.

	WWV	WNV	P0-1	P2-3	Mud
Himantopus himantopus	15 R		1 F	25 F	
Recurvirostra avosetta				8 F	
Charadrius hiaticula		53 R	20 F		
Charadrius alexandrinus		5 R	10 F		
Pluvialis squatarola		112 R			
Calidris minuta			7 F		
Calidris alpina		28 R	132 F		
Limosa limosa			8 F	31 F	
Limosa lapponica					
Tringa totanus			33 F	12 F	
Actitis hypoleucos			7 F		
Arenaria interpres		4 R			
TOTAL WADERS	15	202	218	76	

Godwit used pond Type 1 and 2 throughout the day, while Bar-tailed Godwit fed only on the mudflats at low tide.

The continuing loss of mudflat areas in Cadiz Bay increases the importance of the salines and fish ponds as alternative feeding areas. The problem of mudflat loss is most acute for the small species (Kentish and Ringed Plovers, Sanderling, Dunlin and Curlew Sandpiper) which need to feed throughout the day to obtain all their daily energy requirements.

The different morphological adaptations and energetic requirements of the various species allow them to feed at a range of different water levels. However, water level is most critical to smaller waders, because at high tide they can only feed in ponds with no or shallow water. It is very important to know how different fish pond management regimes could affect the food intake rates of waders and how different waders with different diets, morphological adaptations and energetics requirements use these habitats, and the relative importance of these different habitats to the birds. These are the aims of our continuing field work.

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