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LOW-WATER USE OF THE MONDEGO ESTUARY (WEST PORTUGAL) BY WADERS (CHARADRII)

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SUMMARY.—*Low-water use of the Mondego estuary (West Portugal) by waders (Charadrii).* From October 1993 to October 1994 a study was carried out in the Mondego estuary (west Portugal) in order to characterize the patterns of occurrence and use of habitats by waders. An accumulated total of about 14000 birds distributed over 17 species was recorded. The winter was the most important season of occurrence, although many birds were also present during the migratory periods, especially in spring (April and May). Mudflats were the prefered feeding areas for most species, but nearly all used the «salinas» as complementary feeding areas (only two species did not fed at all in this habitat). Marked seasonal differences were observed in the use of «salinas». *Only 15% of the total population of all species occurred there in winter.* Conversely, 65% used the habitat during summer, while during the migratory passages of spring and autumn we recorded intermediate but similar values (24% and 26%, respectively). The winter wader assemblage in the Mondego estuary was similar to those of the Atlantic estuaries of the western Portuguese Atlantic coast (excluding the Tagus), but it was different from those of the Algarve coast. Some possible explanations for the differences found among the main Portuguese estuaries are presented and discussed. Overall, the importance of the wader assemblages in the Mondego estuary seems to have been somewhat under-estimated until now.

Key words: Assemblage description, Mondego estuary, Portugal, use of habitat, waders.

RESUMEN.—*Uso del estuario del río Mondego (oeste de Portugal) por la comunidad de limícolas (Charadrii).* Desde Octubre de 1993 a Octubre de 1994 se llevó a cabo en el estuario del río Mondego un estudio para caracterizar los patrones de presencia y uso del hábitat de la comunidad de limícolas allí presentes. Se registró un total de 14000 individuos pertenecientes a 17 especies. El período con mayor presencia de aves fue el invierno, aunque también se registró un gran número de individuos durante los períodos migratorios, sobre todo en primavera (abril y mayo). Los fangos intermareales fueron las áreas preferidas por la mayoría de las especies para alimentarse, mientras que las salinas fueron utilizadas por casi todas las especies como zonas complementarias de alimentación (sólo dos especies no las utilizaron en absoluto). Se observó un uso diferencial de las salinas en función de la estación. Sólo el 15% de la población total de todas las especies estuvo presente en las salinas durante el invierno. Por el contrario, el 65% utilizaron las salinas durante el verano, mientras que durante los pasos migratorios de primavera y verano se obtuvieron valores intermedios y similares entre sí (24% y 26%, respectivamente). La comunidad de limícolas invernantes en el estuario del río Mondego fue similar a las descritas en los estuarios occidentales atlánticos de la costa portuguesa (excepto la del río Tajo), y diferentes a las descritas en la costa del Algarve. Se discuten posibles explicaciones para las diferencias encontradas entre los distintos estuarios portugueses. En términos generales, parece que la importancia de las comunidades de limícolas presentes en el estuario del río Mondego había sido infravalorada hasta la fecha.

Palabras clave: Descripción de la comunidad, estuario del río Mondego, limícolas, Portugal, uso del hábitat.

INTRODUCTION

The Mondego river is 234 km long and drains an hydrological basin of approximately 6670 km². Its estuary is the location of the Figueira da Foz harbour, which has considerable regional importance (Marques *et al.*, 1993a). Apart from the harbour facilities and related periodic dredging operations, the estuary is under increasing human pressure due to fish-farms, «salinas», and also to the nutrient and chemical discharges from agricultural fields in the lower river valley (Marques *et al.*, 1993a). Altogether, these factors create a significant environmental stress, which has gradually been determining

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structural changes in the biological communities.

Despite all these problems, there was virtually no information on the structure and functioning of the biological communities in the estuary until 1985. Several research projects were undertaken since then in order to provide reference data on the intertidal and subtidal macrozoobenthic communities (Marques *et al.*, 1993a, 1993b, 1994; Pardal *et al.*, 1993). Nevertheless, there is still an important lack of knowledge regarding the higher levels of the estuarine trophic chain, namely the avian predators. Apart from some winter censuses of aquatic birds undertaken during the 1980's (Rufino, 1979, 1989, 1990; Rufino & Neves, 1986), there was almost no available data on the bird assemblages of the estuary. A more exhaustive study, regarding the whole estuarine macrohabitats and inventorying all avian species found was further carried out (Múrias & Ferrand de Almeida, 1991), but none of these studies extended throughout an entire annual cycle and/or included the whole area of the estuary potentially available to birds.

Since waders (Charadrii) constitute, along with gulls, the most important group of birds present in the estuary, and since they are generally accepted as one of the most important group in many estuarine trophic chains (see Baird *et al.*, 1985, for a review), we selected them as target group for the ongoing research in the estuary (e.g., Múrias, 1993; Cabral *et al.*, 1996).

The goal of the present paper was to provide a reference study on this segment of the estuarine fauna, which could serve as a basis for future work. Therefore, we aimed (i) to present a preliminary characterization of the wader assemblages of the Mondego estuary, (ii) to describe yearly patterns of occurrence, (iii) to characterize the general use of the main macrohabitats of the estuary and (iv) to place the Mondego wader assemblage in the Portuguese national context.

MATERIALS AND METHODS

Study site

The Mondego estuary consists of two arms, northern and southern, surrounding an island, the Morraceira (Fig. 1). The two arms of the estuary appear to constitute clearly different sub-systems with regard to the physico-chemical characteristics of water and sediments and to the macrobenthic communities (Marques *et al.*, 1993a, b). The southern arm of the estuary, where the study was carried out, is heavily silted-up, and the water circulation depends mainly on tides and on the usually small freshwater imput of a tributary, the Pranto river (Fig. 1). The intertidal mudflats in the southern arm, specially those bordering the Morraceira Island, present an important area covered by a *Spartina maritima* salt-marsh (Fig. 1), while a small zone of *Zoostera noltii* meadow can also be encountered, namely in the downstream area. In the innermost areas of the southern arm of the estuary the margins are close to rice fields.

In the northern arm, the intertidal sediments did not attract the waders during the study period as a consequence of a combination of factors, namely their small area and the faunal impoverishment partly caused by dredging operations (Marques *et al.*, 1993a, b), and also because they are too close to the Figueira da Foz harbour, and therefore subjected to a stronger human disturbance.

Many «salinas» (mostly artisanal ones) and fish-farms are located in the Morraceira island and the left margin of the southern arm, corresponding to a total area of about 286 ha, 193 (67.4%) of which are in the Morraceira island. A small group of «salinas» also existed until the mid-eighties in the northern arm, but they have been drained or abandoned since then.

Each «salina» is formed by three sets of pans (storage, evaporation and crystallisation pans) connected through a set of sluices. In the Mondego, most of the «salinas»' surfaces are occupied by the storage and evaporation pans (70%-80% on average), and the average size of a salina is about 4 ha (Lopes, 1955). A series of channels (locally called «viveiros») drains the water from the estuary directly into the pans. These channels are usually 1-1.5 m in width and 50-80 cm in depth, and their S shape facilitates water circulation. They occupy most of the area between the «salinas». In general, one «viveiro» feeds several pans (Lopes, 1955). A small area (about 21 ha) of industrial «salinas», which are not fed by

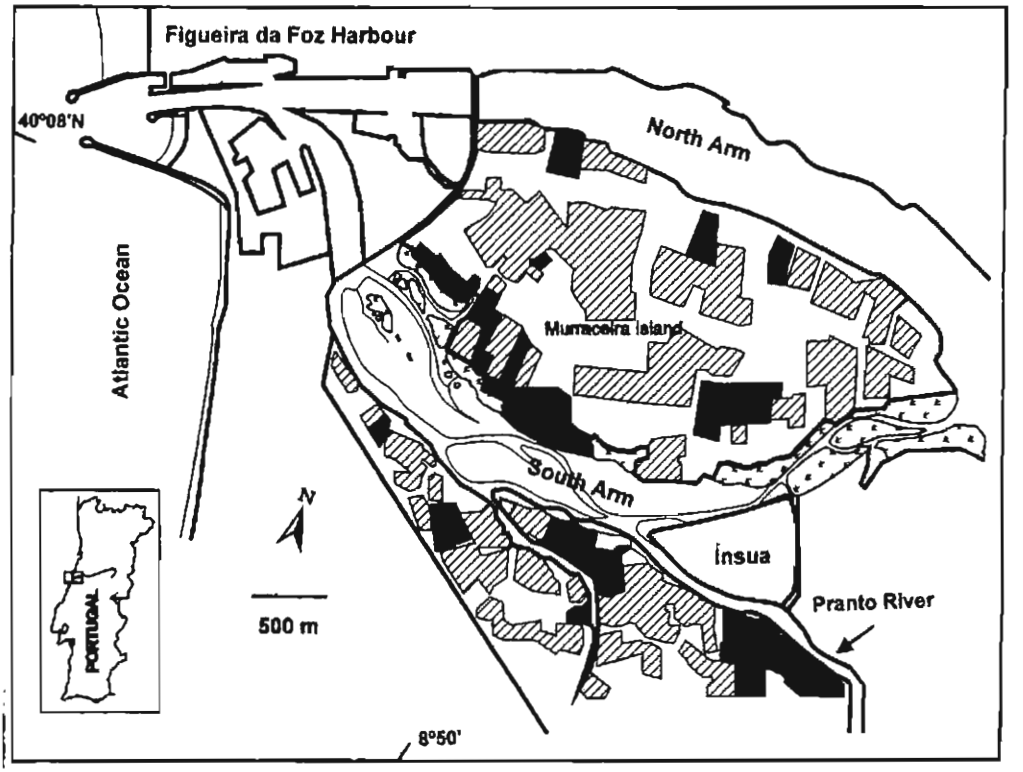

FIG. 1.—The study area, showing the mudflaats as they appear at low-tide, the saltmarshes on the borders of the Morraceira Island, the artisanal (striped) and industrial (dark grey) «salinas», and the fish-farms (light grey) spread over the south arm bank and the Morraceira Island.
[Mapa del área de estudio mostrando los fangos intermareales tal y como aparecen en marea baja, las marismas situadas en las orillas de la isla Murraceira, y las salinas, artesanales (rayado) e industriales (gris oscuro), y piscifactorías (gris claro) que se distribuyen a lo largo del brazo sur del estuario y de la isla Morraceira.]

estuary water, is found in the eastern part of the southern arm. A considerable area of the «salinas» (about 33%) has been abandoned in the last few years.

Field work

From October 1993 to October 1994, monthly (until January 1994) or forthnightly (from February onwards) censuses were carried out in the main habitats for birds in the estuary, namely a) the intertidal mudflats in the southern arm and b) the «salinas» (both the active and abandoned ones), saltmarshes and fish-farms in the Morraceira island. Three vantage points were chosen in the southern arm, from which all the intertidal area could be observed, while 21 «salinas» (excluding the area of «viveiros») and 5 fish-farms (about 60% of the total number in the Morraceira island, in both cases), as well as the surrounding saltmarshes were surveyed. Preliminary observations showed that, during low tide, the waders' use of the «salinas» and fish-farms in the southern arm, which constituted about 34.5% of the total supratidal area potentially available to the waders, was negligible, and therefore these areas were not taken into account. Counts were made during daytime, in spring tides, around dead low-water (±2 hours), with 10 × 50 binoculars and a ×30-90

telescope, in order to minimise any bias due to the movements between the roosting sites and the feeding areas. In fact, earlier observations (Múrias, 1993) have shown that birds settled in their preferred feeding areas during the period considered, so that movements between areas were virtually absent.

Low-water counts are likely to underestimate the birds present in an area due to a greater dispersion over the feeding sites (Prater & Lloyd, 1987). In our case, however, it was the only practical way of assessing the wader numbers, because the birds did not use fixed high-tide roosts, changing frequently from place to place in response to any minimal disturbance, thus increasing the chances of overestimations. As it was virtually impossible to control all the potential high-tide roosts in a reasonable period of time, due to logistic problems and to access difficulties to some sites, we opted for low-water counts. In fact, the particular location and the relatively small area of the mudflats, allowed us to establish a set of observation plots from which all potential feeding areas could be scanned. As the «salinas» did not present any particular censusing problem, we believe that a good coverage of the estuary was achieved. Nevertheless, some species, particularly the smaller ones, may have been somewhat underestimated.

All the observed birds were counted and identified, and their positions plotted on a map drawn using published aerial photos from the area. In the case of the two *Numenius*, as it was not always possible to distinguish between *N. arquata* and *N. phaeopus* (although *N. arquata* was found to be more abundant in the winter), they were simply clustered as «*Numenius* spp.».

Data analysis

In order to allow for comparisons of results, the monthly censuses were averaged for each species. Before using parametric tests, data were submitted to the Kolmogorov-Smirnov test to assess normality (Zar, 1984). The area of the mudflats and saltmarshes was calculated from aerial photographs taken at low-water, while the areas of the other supratidal habitats («salinas» and fish-farms) were taken from Lopes (1955). Bird numbers in each habitat were then divided by the correspondent area to derive bird densities (no. birds/ha). The whole area of the southern arm mudflats was used to calculate bird densities, while densities in the supratidal habitats refer only to the Morraceira Island. As few birds were observed in the southern arm's supratidal habitats, this may have caused a slight over-estimation of the densities calculated for these habitats, but no attempt was made to correct this. The widely-used indices of Shannon-Weaver and Pielou (Washington, 1984), for diversity and equitability, respectively, were employed to measure the diversity in the use of the habitats by the waders' assemblage.

Factorial Analysis of Correspondence (Legendre & Legendre, 1984) was used to study the affinities of the main Portuguese estuaries, and the position of the Mondego in the national context, regarding the available data on the composition of their wintering bird assemblages. A matrix of 22 wader species x 8 sites (estuaries) was constructed, using the database of the winter national census, in order to compare global numbers with our own data for the same period. For each species and zone, we averaged the number of waders for the period 1991-93 (Rufino, 1991, 1992; Rufino & Costa, 1993), with the exception of the Ria de Aveiro, for which only data for two years (1992 and 1993) were available. This method presented the advantage of reducing inter-annual variability. The following zones (from north to south) were taken into consideration: the Minho estuary, on the Portuguese northern border, the Ria de Aveiro, the Mondego, Tagus and Sado estuaries, in the western atlantic coast; the Rias de Alvor and Formosa, in the western and central Algarve, respectively; and the saltmarsh of Castro Marim, in the Guadiana estuary (eastern Algarve). The calculations were performed with the program NTSYS-PC, version 1.7 (Rohlf, 1992).

RESULTS

The waders in the Mondego: species composition and relative abundances

An accumulated total of 13923 birds, distributed over 17 species, was counted between October 1993 and October 1994 (Table 1). Numerically, the Mondego's assemblage was

TABLE 1

Number of birds per month in the estuary of Mondego during the study period (October 1993 to October 1994). Average values were taken for those months in which more than one census was conducted. Monthly totals and accumulated totals for each species are presented, as well as their contribution (in %) to the grand total.

[Número de aves según meses en el estuario del río Mondego a lo largo del periodo de estudio (de octubre de 1993 a octubre de 1994). Se dan los valores medios. Para los meses en que se realizó más de un censo se dan los valores de todos los censos realizados. Se dan además los totales mensuales y los totales acumulados para cada especie, así como la contribución de estos últimos (en tantos por ciento) al gran total.]

Month *[Mes]* / Number of censuses: / Bird species	Oct. 1	Nov. 1	Dec. 1	Jan. 1	Feb. 2	Mar. 2	Apr. 2	May 2	Jun. 2	Jul. 2	Aug. 1	Sep. 2	Oct. 2	Total 21	%
Charadrius hiaticula	204	136	45	163	46	93	45	15	1	0	319	39	30	1136	8.2
Charadrius alexandrinus	89	79	243	79	46	74	73	39	95	80	170	159	76	1032	7.4
Pluvialis squatarola	22	108	167	217	140	88	46	28	3	0	0	0	5	824	5.9
Numenius spp.	0	0	0	8	10	5	0	4	3	11	5	3	2	51	0.4
Arenaria interpres	0	0	0	0	0	0	6	6	0	0	0	0	0	12	0.1
Limosa limosa	1	0	3	0	718	0	0	0	0	0	8	23	5	758	5.4
Limosa lapponica	0	0	0	0	0	0	1	22	1	0	0	12	5	40	0.3
Actitis hypoleucos	10	6	8	10	14	2	2	0	0	1	12	2	5	72	0.5
Tringa totanus	11	0	0	0	1	16	13	2	1	24	20	32	2	122	0.9
Tringa nebularia	0	0	0	0	0	0	0	0	0	0	0	0	3	3	<0.1
Philomachus pugnax	1	0	0	0	0	2	0	0	0	0	0	3	7	13	0.1
Calidris canutus	0	22	5	0	1	0	0	0	0	0	0	21	0	49	0.4
Calidris alpina	352	821	1226	1093	619	248	115	263	4	3	142	269	68	6223	44.7
Calidris ferruginea	0	0	0	0	0	0	0	0	0	0	4	5	0	9	0.1
Calidris minuta	24	221	11	11	28	16	12	0	0	0	2	0	0	325	2.3
Recurvirostra avosetta	82	283	730	815	496	143	0	0	0	0	0	0	0	2549	18.3
Himantopus himantopus	0	0	0	0	0	47	125	57	72	89	39	5	0	434	3.1
Total	795	1676	1329	2386	2419	734	439	436	180	208	721	573	208	13923	

dominated by Dunlin *Calidris alpina* (44.7% of the accumulated totals) and Avocet *Recurvirostra avosetta* (18.3%). Three plover species, Kentish Plover *Charadrius alexandrinus* (8.2%), Ringed Plover *Charadrius hiaticula* (7.4%) and Grey Plover *Pluvialis squatarola* (5.9%) were also well represented (> 5%). The Black-tailed Godwit *Limosa limosa*, which also accounted for more than 5%, was present in significant numbers only during the February counts (Table 1).

Temporal patterns of occurrence

The total counts were quite changeable throughout the yearly cycle (Fig. 2). The largest numbers of birds were found during the winter (November to February), while numbers were lower during the migratory periods (April and May and August to October). The number of birds counted was nevertheless higher during the spring passage (a maximum of about 1500 birds) than in autumn (a maximum of less than 1000 birds). During the summer (June and July), almost only the breeding species (see below) were present in low numbers. The number of species found was relatively low in early and mid-winter (November to January) (8-9), increased in late winter (February to March) and during the migratory periods (10-12), and decreased to a minimum during summer. The average number of species found during the whole study period was 9.4 ± 0.4 (SE).

We did not find an absolute prevalence of a single species along the yearly cycle. Moreover, since there was a strong variation in the number of both birds and species present, the most abundant species also changed (Fig. 3). Thus, the winter months (November-January) were characterized by the prevalence of the Dunlin (which also dominated the assemblage in the spring months) and Avocet. In June and July, the most important species were the two breeding ones, the Black-winged Stilt and the Kentish Plover. Conversely, the autumn months (August-October) were characterized by the predominance of three species, although at different times: the Kentish and Ringed Plovers and the Dunlin (Fig. 3). The remaining 10 species only acquired some importance during the migratory passages and in early winter (July to November). The peak

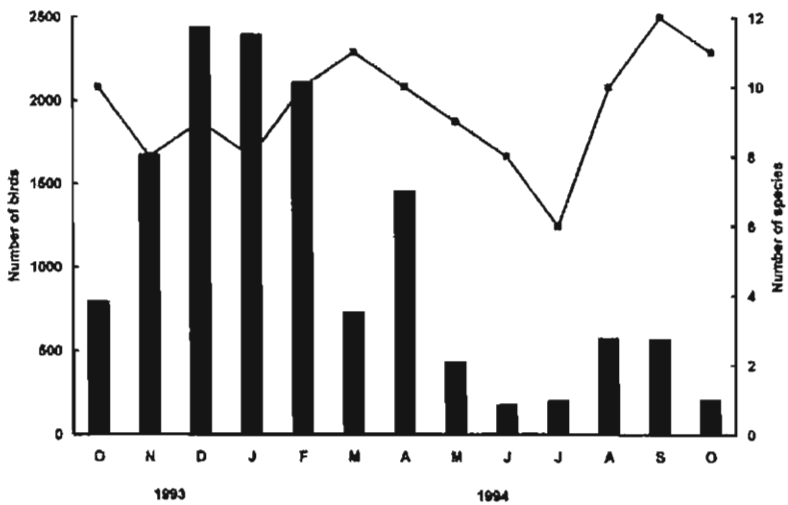

FIG. 2.—Monthly varriation in the number of waders (bars) and in the number of species (lines) in the Mondego estuary, from October 1993 to October 1994. Values as in Table 1.
[Variación mensual del número de individuos (barras) y de especies de limícolas (líneas) presentes en el estuario del río Mondego entre octubre de 1993 y octubre de 1994. Los valores se corresponden con los de la Tabla 1.]

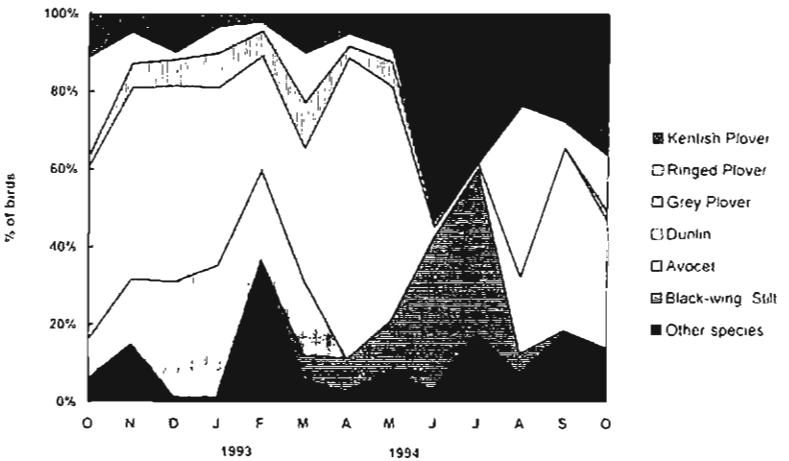

FIG. 3. Monthly variation in the percentage by number of birds present in the Mondego estuary, from October 1993 to October 1994. Values as in Table 1

[Variación mensual de la contribución porcentual de cada especie de limícola en relación al número total de individuos presentes en el estuario del río Mondego entre octubre de 1993 y octubre de 1994. Los valores se corresponden con los de la Tabla 1.]

reached in February was mainly due to the presence of large numbers of the Black-tailed Godwit (see above, and also Table 1).

Spatial patterns of occurrence and habitat use

During the study period, the birds used only two of the four habitats available to them in the Morraceira Island: the mudflats and the «salinas». In general, bird densities were higher in the mudflats than in the «salinas» (t = 2.79, P < 0.01, df = 20) (Table 2). The number of species was also found to be significantly higher in the mudflats (t = 3.15, P < 0.01, df = 20). The observed differences reveal an interesting pattern, since the total area available is higher in the «salinas» (51.5‰) than in the mudflats (27.4‰). Nevertheless, 43.3 ± 12.6‰ of the species were commonly found in both habitats, and there were no significant differences with regard to diversity (t = 0.53, P > 0.05, df = 20) and equitability (t = 1.57, P > 0.05, df = 20) values.

Although the intertidal mudflats were, in general, more used by birds as feeding habitats than the «salinas», there were seasonal variations in their utilization (Fig. 4). Fewer birds used the «salinas» during winter (with the exception of December, due to a series of bad weather days) (range: 1-41%; average ± SE: 15 ± 9‰; n = 4), but this proportion increased during the spring passages (March-May; range: 21-27‰; average ± SE: 24 ± 8‰; n = 3), reaching the maximum in the summer (June and July; range: 63-67%; average ± SE: 65 ± 2‰; n = 2), mainly due to the presence of breeding species in the estuary (these species used the «salinas» for nesting), and returning again to intermediate values during the autumn passage (August to October; range: 8-60‰; average ± SE: 26 ± 10‰; n = 5). The poor use of the «salinas» during winter may be partly explained by the fact that some particularly abundant species (e.g., Grey Plover and Avocet) did not seem to be attracted to this habitat. In fact, the species present exhibited different responses regarding the use of the «salinas» (Table 3). Only two species (Black-winged Stilt *Himantopus himantopus* and Curlew Sandpiper *Calidris ferruginea*) were found exclusively in this habitat. A group of four species (Turnstone *Arenaria interpres*, Redshank *Tringa totanus*, Ruff *Philomachus pugnax* and Little Stint *Calidris minuta*) used

TABLE 2

Average (± SE) densities of birds (no. birds/ha), number of species (*S*), diversity (Shannon's *H'*) and equitability (*J*) in the south arm mudflats and in the supratidal habitats. The percentage values given for the supratidal habitats refer only to the Morraceira Island, not to the overall supratidal area of the estuary. Also excluded was the area of "viveiros" of the Morraceira, as no waders used this habitat during the study period (see text).

[Valores medios (± SE) para la densidad de aves (número ha), número de especies (S), diversidad (índice H' de Shannon) y equitabilidad (J) en los fangos intermareales del brazo sur y en los distintos tipos de hábitats supramareales del estuario del río Mondego. Los porcentajes dados para los hábitats supramareales se refieren sólo a la isla Morraceira, no al conjunto de áreas supramareales de todo el estuario. También ha sido excluida el área de «viveiros» de la isla Morraceira, ya que ningún ave utilizó este hábitat durante el período de estudio (véase texto).]

Hábitat	Area (ha)	%	Bird density *[Densidad]* (no. birds/ha)	*S*	*H'*	*J*
Mudflats ..... *[Fangos intermareales]*	133.4	27.4	6.2 ± 0.4	7.3 ± 2.2	0.52 ± 0.16	1.18 ± 0.31
Saltpans .... *[Salinas]*	155.1	51.5	1.5 ± 0.1	6.6 ± 2.5	0.50 ± 0.30	1.30 ± 0.30
Saltmarshes ..... *[Marismas]*	113.0	37.5				
Fish farms ... . *[Piscifactorías]*	33.3	11.0				

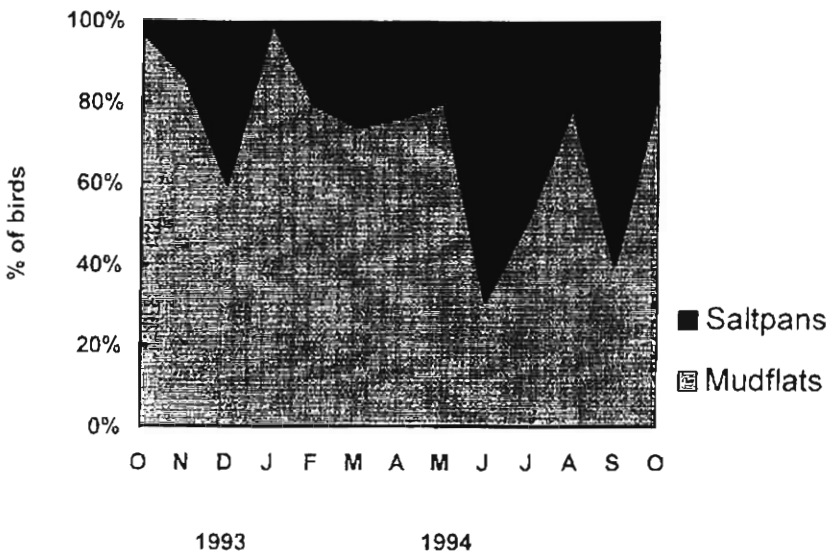

FIG. 4.—Monthly variation in the percentage by number of birds present in the mudflats and in the «salinas» in the estuary of Mondego, from October 1993 to October 1994. Values as in Table 1.

[Variación mensual de la contribución porcentual de las aves censadas en los fangos intermareales (área rayada) y en las salinas (área oscura) en relación al número total de individuos presentes en el estuario del río Mondego entre octubre de 1993 y octubre de 1994. Los valores se corresponden con los de la tabla 1.]

TABLE 3

Average (±SE) percentage of birds in the saltpans during the year of 1993/94, and number of months in which each species was present in the estuary. Number of counts as in Table 1.
[Porcentajes medios (± SE) de la población de cada especie que ocupó las salinas del estuario del río Mondego durante el año 1993/94, y número de meses en que la especie estuvo presente en dicho estuario. El número de conteos para cada mes puede verse en la Tabla 1.]

	Presence of the species in the estuary (number of months) *[Número de meses en que la especie estuvo presente]*	% of the population in saltpans (±SE) *[Porcentaje de la población que empleó las salinas]*
Himantopus himantopus	7	100.0 ± 0.0
Calidris ferruginea	2	100.0 ± 0.0
Arenaria interpres	2	87.5 ± 12.5
Tringa totanus	10	79.8 ± 10.1
Philomachus pugnax	4	75.0 ± 25.0
Calidris minuta	8	73.3 ± 5.7
Actitis hypoleucos	11	52.0 ± 10.5
Limosa limosa	6	49.3 ± 22.0
Charadrius alexandrinus	13	28.5 ± 7.9
Calidris canutus	4	25.0 ± 25.0
Calidris alpina	13	23.1 ± 8.6
Limosa lapponica	5	16.7 ± 16.7
Numenius spp.	9	16.7 ± 11.8
Charadrius hiaticula	12	13.7 ± 5.1
Pluvialis squatarola	10	0.4 ± 0.4
Recurvirostra avosetta	6	0.0 ± 0.0
Tringa nebularia	1	0.0 ± 0.0

the «salinas» intensively, but not exclusively (between 73% and 88%), Common Sandpiper and Black-tailed Godwit used both mudflats and «salinas» equitatively (49% and 52%, respectively), and Kentish Plover, Knot and Dunlin were frequently found in the «salinas» (between 20% and 30%). Finally, four species, Ringed Plover, Bar-tailed Godwit *Limosa lapponica* and Curlew and Whimbrel *Numenius* spp., were found in the «salinas» in less than 20% of the occasions. Besides Avocets, no Greenshanks *Tringa nebularia* were ever observed in the surveyed «salinas» during low-tide.

Despite of this general pattern, there were strong seasonal differences in the use of the «salinas» (see the high values of SE of some species) in many cases, which suggests that some species showed opportunistic behaviour.

Wintering wader assemblages in the Portuguese estuaries

The results from factorial analysis of correspondence showed the projection of both wintering wader species and the different estuaries and rias considered along the Portuguese coast in the space of the first two axis of variability (Fig. 5). The Tagus estuary was clearly opposed to the other zones along axis one (which accounted for 65.1% of the total variability), being characterized by the presence of Black-tailed Godwit. Along the axis two (21% of the variability), the separation was especially made between the Algarve zones (namely the Rias de Alvor and Faro) and the estuaries of the Atlantic coast, excluding the Tagus. Species like Curlew Sandpiper, Turnstone, Knot *Calidris canutus*, Black-winged Stilt, Kentish Plover, Dunlin, Oystercatcher

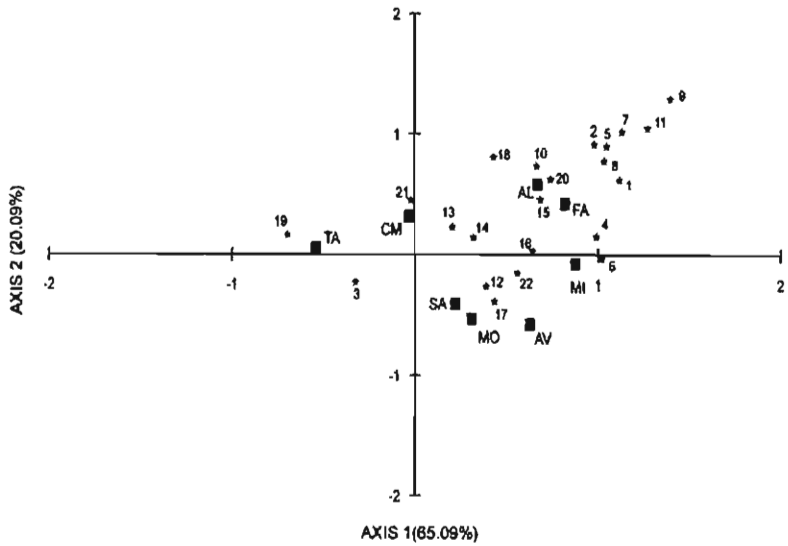

FIG. 5.—Analysis of the winter distribution of waders among the most important Portuguese estuaries, as resulted from the application of a correspondence analysis to the matrix of species × sites (estuaries). See text for further information. **TA** - Tagus estuary; **CM** - Castro Marim saltmarsh; **AL** - Ria de Alvor; **FA** - Ria Formosa; **SA** - Sado estuary; **MO** - Mondego estuary; **AV** - Ria de Aveiro; **MI** - Minho estuary. Numbers refer to the following species (in brackets are given the scientific names of those species never found in the Mondego. See text for the others): **1.** Oystercatcher (*Haematopus ostralegus*); **2.** Black-winged Stilt; **3.** Avocet; **4.** Ringed Plover; **5.** Kentish Plover; **6.** Grey Plover; **7.** Turnstone; **8.** Dunlin; **9.** Curlew Sandpiper; **10.** Little Stint; **11.** Knot; **12.** Sanderling (*Calidris alba*); **13.** Redshank; **14.** Spotted Redshand (*Tringa erythropus*); **15.** Greenshank; **16.** Green Sandpiper (*Tringa ochropus*); **17.** Curlew; **18.** Whimbrel (*Numenius phaeopus*); **19.** Black-tailed Godwit; **20.** Bar-tailed godwit; **22.** Common Sandpiper.
*[Resultados del análisis de correspondencia de la matriz de especies × estuarios, que muestra la distribución invernal de las diferentes especies de limícolas entre los estuarios portugueses más importantes (véase el texto para más información). **TA** - estuario del Tajo; **CM** - marismas de Castro Marim; **AL** - Ria de Alvor; **FA** - Ria Formosa; **SA** - estuario del Sado; **MO** - estuario del Mondego; **AV** - Ria de Aveiro; **MI** - estuario del Miño. **1.** Ostrero* (Haematopus ostralegus); ***2.** Cigüeñuela; **3.** Avoceta; **4.** Chorlitejo Grande; **5.** Chorlitejo Patinegro; **6.** Chorlito Gris; **7.** Vuelvepiedras; **8.** Correlimos Común; **9.** Correlimos Zarapitín; **10.** Correlimos Menudo; **11.** Correlimos Gordo; **12.** Correlimos Tridáctilo* (Calidris alba); ***13.** Archibebe Común; **14.** Archibebe Oscuro* (Tringa erythropus); ***15.** Archibebe Claro; **16.** Andarrios Grande* (Tringa ochropus); ***17.** Zarapito Real; **18.** Zarapito Trinador* (Numenius phaeopus); ***19.** Aguja Colinegra; **20.** Aguja Colipinta; **21.** Combatiente; **22.** Andarrios Chico.*

Haematopus ostralegus, Little Stint, Greenshank and Bar-tailed Godwit, characterized these southern Portuguese wetlands. Conversely, the group of estuaries of the Atlantic coast, including the Mondego, was not clearly distinguished by the presence of particular species, although the positions of Curlew *Numenius arquata*, Sanderling *Calidris alba* and Common Sandpiper *Actitis hipoleucos* seemed to be more linked to these areas.

According to Farinha & Trindade (1994), the Mondego estuary only accounted for less than 0.5% of the total number of wintering waders in the Portuguese areas for the period 1989-92, so that this estuary is in the third position among the four smaller estuaries and rias of Portugal (the others being Minho, Alvor and Castro Marim). This proportion increased to 1.3% if data for 1994-96 are used instead, making the Mondego the second most important of the smaller areas, after Castro Marim.

The increase in ranking of the Mondego should, however, be attributed more to a better coverage of the area during the winter counts than to a real increase in numbers.

Discussion

The composition of the wader assemblage of the Mondego estuary did not differ too much from those of other estuaries in the south temperate European flyway. Dunlin was found to be the main species present, as in many other sites along the European coast (Cramp & Simmons, 1983; Smit & Piersma, 1989). The relevance for Avocet was not surprising either, as the major Portuguese estuaries and rias (Aveiro, Tagus, Sado and Ria de Faro) are among the main wintering areas for this species (Smit & Piersma, 1989). In fact, we believe that the lack of records of important numbers of this species before 1987 (see Rufino, 1979; Rufino & Neves, 1986) is probably due to a deficient coverage of the area during the winter counts before 1987, as large flocks ranging from 300 to 900 birds according to the years have been observed, usually in the same area of the estuary, since 1988. The relative importance of the two small plovers (*Charadrius*) in the estuary is also in agreement with the location of their main wintering areas in southwestern Europe (Smit & Piersma, 1989). As to the seasonal occurrence of the several species, the pattern observed in the Mondego did not differ in its general trends from those reported for other Portuguese areas (Batty, 1992; Encarnação, 1993; Luís, pers. comm.). Moreover, this study reinforces the idea that the Portuguese estuaries, even the smaller ones, may be important stop-over sites during the migratory periods, particularly in spring, for the populations of some species, as the high numbers of Dunlin reached in April (which represents 60% of the winter census) suggest. This finding stresses the need of increasing the year-round counts in more Portuguese estuaries, particularly in the Tagus and Sado, in order to obtain a better picture of the importance of the Portuguese coastal areas for the migratory populations of waders.

Despite the presence of a large «salinas» complex in the Mondego, most waders used the mudflats as main feeding habitats. This suggests that the «salinas» probably constitute a complementary low-tide feeding area, which is in accordance with the findings of other authors (Rufino *et al.*, 1984; Velazquez & Hockey, 1992). The clear seasonal changes in the use of feeding habitats support this hypothesis. In fact, «salinas» were mainly used during the energetically demanding periods of spring and autumn migrations, whereas during winter its use was much reduced. A similar pattern was described by Velazquez *et al.* (1990) for the Berg River estuary in South Africa. In winter, in contrast with Ria de Aveiro (Luís, pers. com.) or Ria Formosa (Batty, 1992), and Cádiz Bay in southern Spain (Perez-Hurtado & Hortas, 1991, 1993), few birds used the «salinas». The reasons for this are not clear. A possible explanation is that the competitive pressure in the Mondego estuary mudflats is not so high as to force many birds to move to alternative supratidal feeding areas, as are the «salinas». Also, most of the exclusive «salinas» users (e.g. Black-winged Stilt, Ruff) are not present in winter. Another possibility is that the «salinas» may fail in providing enough energetically-rich food, or perhaps most waders can take up enough energy only by feeding in the mudflats (by day and by night). Physical factors such as the water depth and the presence of vegetation may also influence the use of this habitat, at least for feeding, which is probably the case with regard to saltmarshes, where the bird presence was residual, and fishfarms, were no feeding birds were ever found. Further studies should address these questions in detail in order to determine the importance of each feeding habitat for the waders, both in low-tide and in high-tide. This information may be vital for the implementation of correct management measures for the area. On the other hand, the importance of the «salinas» during the breeding period seems obvious, and was already documented by Jardim (1984) and Rufino & Neves (1992) for other Portuguese estuaries. Recent data indicate that, from the beginning of this decade, an average of 42 pairs of Black-winged Stilt and at least 30-40 pairs of Kentish Plover (minimum estimate), nested on the Morraceira Island (Rufino & Neves, 1991; pers. obs.).

The position of the Mondego in the multivariate analysis is consistent with its geographic location in the middle of the Portuguese

Atlantic coast, and suggests that all estuaries and rias of this coast, with the exception of the Tagus, belong to the same biogeographic unit. The clear separation along the axis two of the factorial analysis between the Algarve coast and the Atlantic sites, on the other hand, probably reflects different biogeographic realities. In fact, the Algarve connects three major geographic areas, the Atlantic, the Mediterranean and North Africa. Its advantageous position in the important migratory route of the East Atlantic flyway, combined with highly favourable climatic conditions, creates unique conditions for both the migratory and the wintering populations of many species (Smit & Piersma, 1989). On the other hand, the Ria de Faro was, until the early 1990s, the northern limit for the wintering population of the Black-winged Stilt (Smit & Piersma, 1989; Rufino & Neves, 1995).

The isolated position of the Tagus was partly due to the high numbers of Black-tailed Godwits present, more than 85% of the national totals for the period 1991-94 (Rufino, 1991, 1992; Rufino & Costa, 1993; Costa & Rufino, 1994). This is only part of the picture, however, as the Tagus really differs from the other atlantic Portuguese estuaries. In fact, it is considered one of the most important wintering areas of Europe, holding more than 54000 birds per year in the period 1975-1989 (Smit & Piersma, 1989). Certainly, this is not due just to its geographic position, or the presence of a single species. The example of the Tagus illustrates the fact that a set of factors (e.g. diversity of sediment types, size, area, geographic position, climate, food supply) must be taken into account in order to understand the distribution of the wintering waders, advising against simplistic interpretations. This is a complex task, so it requires extensive data sets (see, for example, Hill *et al.*, 1993) which are still unachievable in Portugal. Nevertheless, the preliminary results presented in this study suggest that such a study could reveal interesting patterns.

Overall, this study reveals that the Mondego estuary, despite its relatively small area and severe human pressure, still holds considerable assemblages of wader species, whose importance for the national network of estuarine wetlands, both qualitatively and quantitatively, has been under-estimated to date.

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