Autumn migration of the Ringed Plover *Charadrius hiaticula* on the Atlantic Iberian coast

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INTRODUCTION

There are few studies in Spain that analyse the migration of shorebirds and particularly the postnuptial migration of the Ringed Plover (Ramón 1989; Figuerola & Martí 1994; Hortas 1997a, 1997b). The autumn migration of this species has been well studied on the Atlantic coast further north, but information from the Iberian coast is very scarce, even though this coast seems to be very important for waders (Hortas 1997a). The Bay of Cádiz, for example, holds 3.8% of the East Atlantic flyway population of Ringed Plovers (Pérez-Hurtado *et al.* 1993; Pérez-Hurtado & Hortas 1994). For this reason and in terms of the conservation of this and other species, it is of interest to know more about the migration pattern and the breeding origins of birds using these areas. The objective of this study was to investigate the migration pattern of the Ringed Plover in the Bay of Cádiz (south-west of Spain).

METHODS

The study was carried out in an industrial saline named "La Tapa" (400 ha.) and the adjacent mudflats (28 ha.) in the Bay of Cádiz (36° 28' N, 6° 11' E) (Figure 1). This saline is a very important feeding area for waders on migration, regularly supporting 7-10% of the Ringed Plovers in the Bay (Hortas 1997a). The physical state of the saline was similar during the two study years, with fluctuations in the water level according to the extraction process of the salt. A total of 44 counts were carried out over the two seasons, from the 26 July until 5 October in 1988, and from the 17 July until 9 October in 1989 with 22 counts in each season. The counts were carried out in the period between two hours before and two hours after low tide, and also at high tide (cf. Hortas & Figuerola in press). To compare numbers during post-nuptial migration with those at other times of year, we counted Ringed Plovers during four consecutive years at irregular intervals (103 counts between December 1985 until January 1990) (Hortas 1997a).

For each year (1988 & 1989), the maximum count for each five day period was plotted beginning 17 July (Tiedemann 1992, Figuerola & Martí 1994) (Figure 1) and, to investigate the differences in numbers and phenology between years, counts were grouped into ten-day periods beginning 22 July. This grouping was necessary to apply a mixed model two-way ANOVA, where the year and period were considered as independent variables and the counts as dependent variables. The periods were fixed for the analysis, since the purpose of the study was to establish the pattern of autumn migration and the years were selected as random factors (Tiedemann 1992). Assuming that the data follow a Poisson distribution, they were transformed before the analysis by calculating the square root of the two census results in each ten-day period (Sokal & Rohlf 1979). Prior to transformation 0.5 was added to each zero observation to carrying out the ANOVA, in accordance with Tiedemann (1992). The data adjusted to a normal distribution (Kolmogorov-Smirnov test, Dn= 0.156, $p>0.20$). For more details about methodology see Hortas & Figuerola (in press).

RESULTS

The post-nuptial migration of this species was similar during the two study years, with a maximum peak at the end of August and another in mid September. However in 1988 numbers increased from the end of September until the end of the study period, whereas in 1989 an increase was followed by a decrease until the beginning of October (Figure 2). Significant differences were found with respect to the number of birds between the periods ($F_{7,7}= 5.41$; $p= 0.02$), but no differences occurred between years ($F_{1,32}= 0.03$; $p= 0.86$). The migration pattern was similar between years as suggested by the non-significant interaction between period and year effects ($F_{7,32}=2.25$; $p= 0.08$).

Exhibited in Figure 2, the postnuptial migration showed

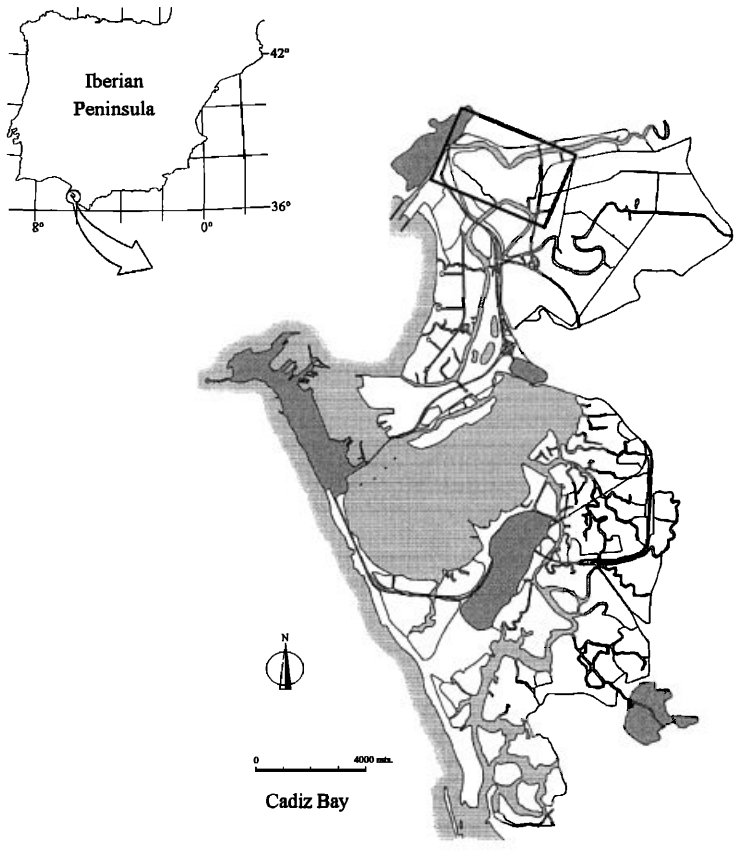

Figure 1. Cádiz Bay and study area (rectangle).

two peaks, one at the end of August and one at the end of September beginning of October. The increase at the beginning of October may indicate that postnuptial passage was later in 1988 and this is consistent with the average annual migration pattern (Figure 3) as revealed by the less regular year-round counts.

DISCUSSION

In the Bay of Cádiz the annual migration of this species presents two maxima: one in May and the other in September with a peak in December for the wintering population (Figure 3) (Hortas 1997a, 1997b). The largest numbers of birds are observed in the Bay during autumn migration, 31% more than are present in winter, with peak numbers occurring in September.

The results of this more detailed study of phenology of post-nuptial migration shows that an initial peak occurs at the end of August, a week before that reported in the Ebro Delta (northeast of Spain) (Figuerola & Marti 1994), but coincident with that reported for Lower Rhine and the Camargue area in France (Andrés & Reeber 1992, Cramp & Simmons 1983). Kestenholz & Peter (1998) and Figuerola & Martí (1994) showed a peak migration in early September in Mallorca island (182 km south of the Ebro Delta) and the Aiguamolls de l'Empordà (350 km north of the Ebro Delta) respectively.

The autumn migration of Ringed Plover on the Iberian Atlantic coast is observed between August and October (Galarza 1984, Ramón 1989). In the Ría de Arosa y Ortigueira (northwest Spain) birds appear in July and increase in number until November (Domínguez & Rabunal, 1989). These authors detected a maximum by mid August with strong increases at the beginning of September and October. In the south Atlantic (Ría Formosa in Portugal, Odiel Marshes in Huelva, Strait of Gibraltar), the postnuptial migration runs from August until October with a greater number of birds in September (Telleria 1981, Rubio 1986, Rufino & Araujo 1987, Finlayson 1992, Encarnaçao 1992, Garrido 1996, Hortas 1997a, 1997b). According to Batty (1992) the autumn peak coincides with the migration of the northeast part of the Neartic and northwest European population to the west of Africa (Cramp & Simmons 1983). This general pattern is consistent from the Rhine valley south and west to the Straits of Gibraltar with the exact timing of the peak in numbers varying according to the year in which observations took place.

Recoveries in the Iberian Peninsula of ringed birds show the importance of south west Spain as a staging and wintering area for birds originating from the west

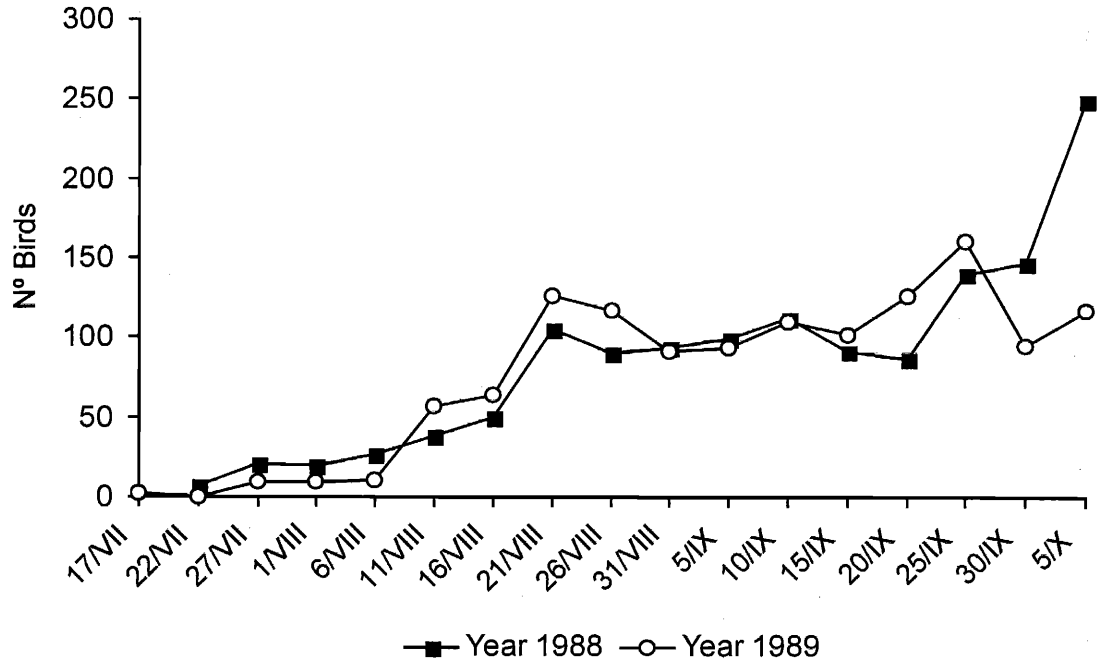

Figure 2. Postnuptial migration in Cádiz Bay. Maximum number of Ringed Plovers censused for each period of five days. Each period is indicated by its first day.

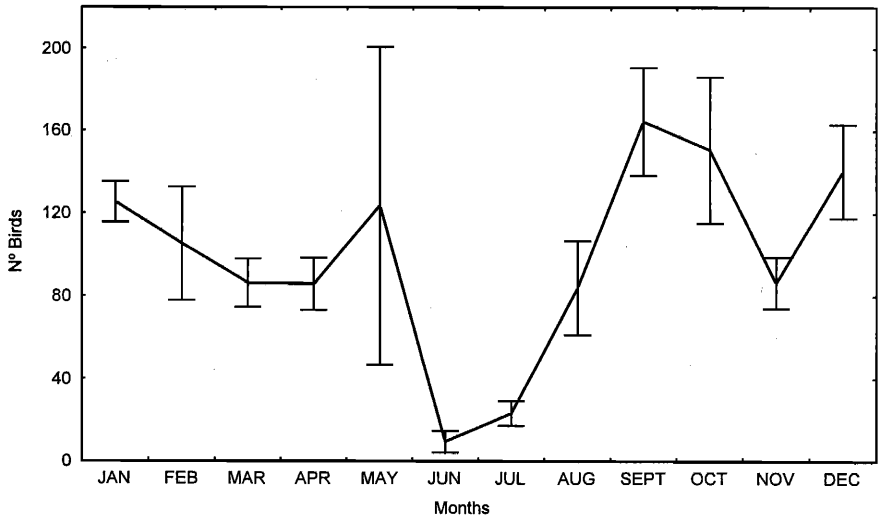

Figure 3. Mean annual variation and standard error of Ringed Plovers in Cádiz Bay.

continental Europe and British Isles; furthermore, adult birds ringed in Spain during the winter haven been recovered at breeding areas in Greenland and Iceland (Diaz *et al.* 1996). It may be that the two maxima observed in the Bay of Cádiz reflect a first wave of movements by adult birds and a second one by juveniles (Gromadzka 1992, Figuerola & Marti 1994). The subspecies *hiaticula* departs the Wadden Sea during the autumn migration to wintering areas mainly in southwest Europe and northwest Africa (Smit & Piersma 1989), at the same time as *tundrae* makes it to wintering areas in west Africa. During the postnuptial migration *hiaticula* depart mid august, while *tundrae* move during August-September and even October (Meltofte *et al.* 1994). Therefore, we suggest that two observed peaks are the subspecies *hiaticula* moving through the region first and *tundrae* moving through later. Ringing studies are now needed to clarify these subspecies movements during the autumn migration and provide evidence for the hypothesis of the two subspecies moving through south west Spain in distinguishable waves.

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