The wader communities of a saline and an intertidal site on the Ria Formosa, Portugal

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Comparisons are made between the two sites in relation to the permanence time of species, seasonal variations in abundance and species composition.

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INTRODUCTION

The Ria Formosa is a tidal lagoon system along the eastern section of the south coast of Portugal. It stretches about 60 km from Ancao/Quinta do Lago (36°58'N, 8°02'W), 20 km west of Faro, eastwards to Cacela/Manta Rota (37°03'N, 7°32'W) east of Tavira (Figure 1). The first published count of waders in the Ria Formosa was made in January 1975 by CEMPA (the ornithological section of the *Servico Nacional de Parques, Reservas e a Conservacao da Natureza*). This gave a total of 12,775 birds of 20 species (Rufino 1978), and the following years – 1976 and 1977 – produced counts of 20,068 and 21,383 waders respectively. During the period 1975–78 the average January counts on the principal Portuguese estuaries and lagoon systems were as follows: Tejo estuary 54,560, Ria Formosa 18,800, Ria de Aveiro 13,460, Sado estuary 12,570 (Rufino 1978). The most recent published count, for January 1988, was of 17,883 waders of 24 species (Rufino 1988), although the coverage was not complete. The Ria Formosa also provides habitat for large numbers of ducks, coots, egrets, storks, gulls, terns and other aquatic species which breed and/or winter there.

Of the 8,350 ha lagoon system, the following are the areas of the major aquatic habitats from Teixeira & Alvim (1978):

Saltmarshes, mudflats and sandbanks	4,800 ha
Channels, creeks and bottoms	3,550 ha
Salines for extraction of sea-salt	900 ha
Aquaculture tanks	200 ha

Rufino *et al.* (1984) and Bijlsma *et al.* (1985) showed the importance of the salines of the Ria as feeding an/or roosting areas for large numbers of waders. They also showed that there are marked movements of some species between the salines and intertidal areas, whilst other species generally feed either on the salines or on the intertidal areas.

Rufino *et al.* (1984) gave the following values for the percentage of the total wader population feeding and/or resting on the salines at high tide: January 36%, February 24% and March 29%. They also pointed out the variation between species in the use of salines – Black-tailed Godwit *Limosa limosa*, for example, being almost exclusive to salines even at low tide, Kentish Plover *Charadrius alexandrinus* roosting there in considerable numbers but also using the Ria for feeding, and Bar-tailed Godwit *Limosa lapponica* not using the salines at all.

However, no published information exists on wader numbers and species composition during the complete annual cycle on the Ria Formosa, although Rufino & Araujo (1987) described seasonal variations between the end of November and the end of May. This paper presents information on the complete annual cycle on a saline and an intertidal site, and makes comparisons with the work of Rufino *et al.* (1984) and of Rufino & Araujo (1987), as well as with the salines of the Camargue, southern France (Britton & Johnson 1987) and the lagoons of Andalusia, southern Spain (Amat 1984).

STUDY SITES AND METHODS

The study saline was a large evaporation tank in the south-central section of the saline complex at Ludo, near Faro (Figure 2). This was chosen because of its easy access and the fact that it holds waders throughout the year. This saline is 230 m by 190 m (4.37 ha.). The saline is subdivided by internal ridges into eight rectangular sections, although most of the ridges have become so eroded that they are under water for most of the summer, and only start to appear as the water level drops in October owing to drainage and evaporation. The one main ridge which remains reaches a height of about one metre, and it and surrounding banks have a sparse covering of halophytic vegetation.
The invertebrate fauna of the saline is dominated by the brine

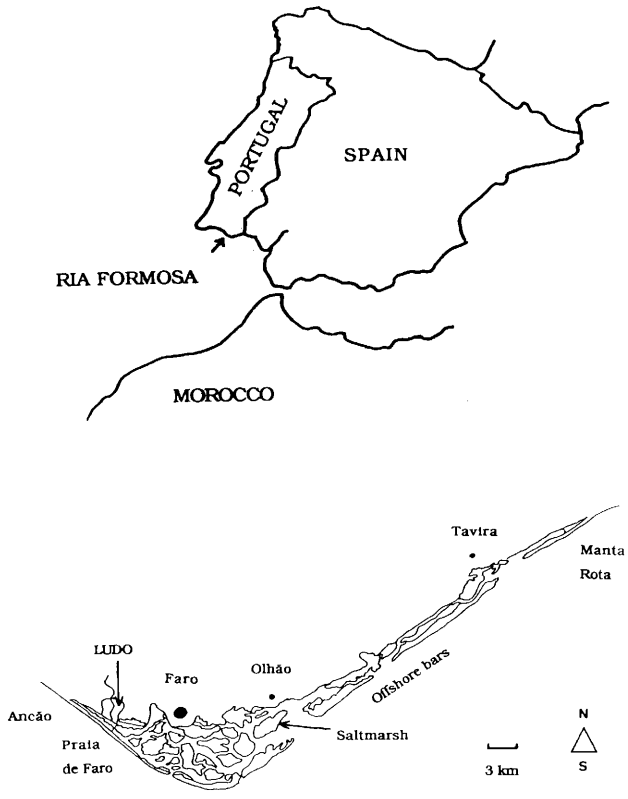
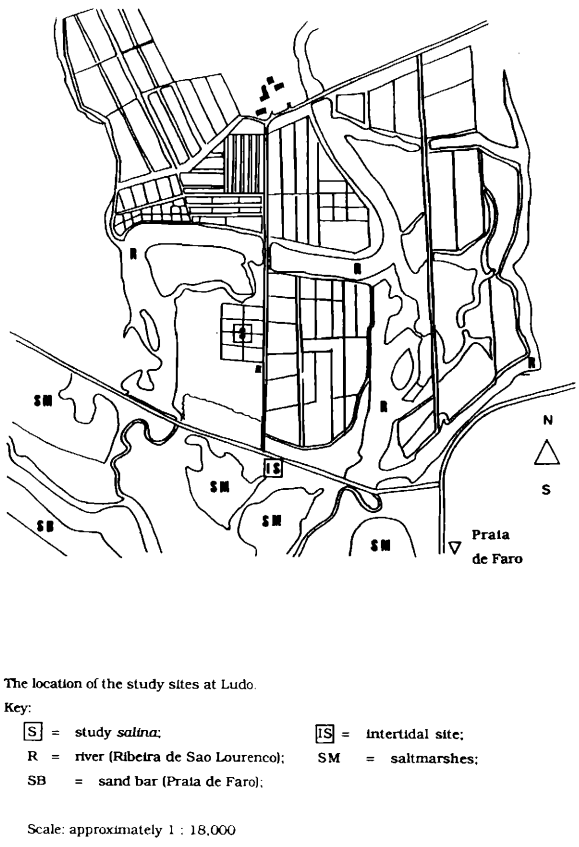


Figure 1 The location of the Ria Formosa and the Ludo study area.



The location of the study sites at Ludo.
Key:
S = study *salina*;
R = river (Ribeira de Sao Lourenco);
SB = sand bar (Praia de Faro);
IS = intertidal site;
SM = saltmarshes;

Scale: approximately 1 : 18,000

Figure 2 The location of the study sites at Ludo.

shrimp *Artemia*, larvae, pupae and adult insects of the families *Ephydridae* and *Chironomidae*, and beetles of the family *Hydrophilidae*.

The saline is usually filled with sea water during April, and remains full, with some slight fluctuations, until the salt extraction process finishes during October. During October the water level begins to fall through evaporation and drainage, and is diluted by autumn and winter rains. The salinity of the water varies throughout the cycle from about 8°/₀₀ to over 112°/₀₀, being lowest in winter and early spring because of rainfall, and highest in summer and early autumn because of evaporation.

The intertidal site is an area of 6 ha, about 380 m due south of the saline, bounded on its northern side by a sea wall and a thin strip of saltmarsh, and on its southern and western sides by saltmarsh. It empties and fills with tidal water from a channel which runs in from the eastern end, and the substrate is more or less entirely soft mud. It was chosen as a study site because of its proximity to the saline complex, its well-defined boundaries and ease of access and observation. The invertebrate fauna is dominated by polychaete worms, especially of the genus *Nereis* and *Heteromastus*, but there are also molluscs – *Scrobicularia plana* and *Hydrobia ulvae* – and crustaceans – *Uca tangeri, Carcinas maenas* and *Cyathura carinata.*

Both these study sites are obviously small in relation to the habitats they represent and it is difficult to say to what extent they are typical. However, they presented a practical size for detailed studies (Batty 1991) whose results should be able to serve as a reference point for further work.

Counts were made at the saline and the intertidal area up to four times a month, as near to the neap and spring tides as possible, from February 1987 to April 1989. Counts were made on the saline for up to 4 hours until the published time of high water, and on the intertidal site for up to 4+ hours from the published time of low water. In this way the periods of maximum numbers in each site were covered. In total 337 counts were made on the intertidal site during 74 visits, and 380 counts were made on the saline during 94 visits, covering a total of 132 different days.

Various authors have reviewed mudflat bird census methods (e.g. Storer 1951; Jehl 1963; Recher 1966; Gerstenberg 1972) and, whilst some workers tend to aim for a census of the maximum number of birds present, others aim for an average number of birds using the area at different times of the tidal cycle. Recher (1966) considered that an accurate assessment of species composition is best made on a falling tide after 30–60% of the tidal mudflat has been exposed, which, according to Storer (1951), is the period of maximum

numbers on a mudflat. However, for reasons related to other studies undertaken during the course of the project (Batty 1991), counts were made during rising tides.

RESULTS AND DISCUSSION

Permanence time of species

During the annual cycle, different species occurred on the study sites over different periods depending on their migration and breeding phenologies. The number of months in which a species may be present in an area has been called its 'permanence time ' (Amat 1984), and Table 1 shows the permanence time of waders on the study sites during the annual cycle. It should be noted that this permanence time refers to the species and not to individuals, which may be present for much shorter periods.

There are interesting differences between these results and those of Amat (1984) for Andalusian lagoons, and Britton & Johnson (1987) for Camargue salines. Amat (1984) found no wader species occurred for a duration of 11–12 months of the year, and only two species (Kentish Plover and Lapwing *Vanellus vanellus*) occurred for a duration of 9–10 months whereas Lapwing are only winter visitors on the Ria Formosa. Absent from the Camargue salines in winter were Black –winged Stilt *Himantopus himantopus* and Kentish Plover, which occur only as breeding summer visitors. These differences are probably due to geographical position (in the case of the Camargue) and the general difference between salines and natural salt lakes referred to by Britton & Johnson (1987) (in the case of the Andalusian lagoons).

Seasonal variations in the numbers of each species

Prater (1981) suggested that there are "almost innumerable possibilities" in presenting monthly variations in bird numbers, but concluded that the average peak count indicates average maximum usage of the site. This was used in this study to analyse monthly variations in the numbers of each species. For each species the maximum number recorded on each visit in each month of the year was taken and the mean value calculated, and full details are given in Batty (1991). Table 2 indicates the seasons in which each species showed peak numbers on each site.

Of 13 species showing peaks on one of the study sites in winter, and three showing peaks in spring, all except Greenshank *Tringa nebularia* were so listed by Rufino & Araujo (1987), although they gave no information for Golden Plover *Pluvialis apricaria*, Lapwing and Snipe *Gallinago gallinago* which were winter visitors to the saline, showing a peak in December/January. Portuguese ringing recoveries (Candeias & Castro 1982) of Golden Plovers ringed as migrants or wintering birds in Holland, suggest that the birds at Ludo were from the population breeding in Fenno–Sandia/northern Russia (Cramp & Simmons 1983), whilst most Lapwing may have been from the central European population of West Germany, Holland and Belgium (Candeias & Castro 1982), a January peak indicating the importance of hard weather movements in bringing Lapwings to the Algarve.

Although there is a small breeding population of Avocet

Table 1. Permanence time of waders on the study sites during the yearly cycle (s = saline; i = intertidal site).

	Number of months					
	1-2	3-4	5-6	7-8	9-10	11-12
Himantopus himantopus						s
Recurvirostra avosetta			s			
Charadrius hiaticula					si	
C. alexandrinus						si
Pluvialis apricaria		s				
P. squatarola				s	i	
Vanellus vanellus		s				
Calidris canutus	i		s			
C. alba					s	
C. minutus					s	
C. ferruginea	i	s				
C. alpina						si
Philomachus pugnax				s		
Gallinago gallinago	s					
Limosa limosa				si		
Numenius phaeopus				i		
N. arquata		i				
Tringa erythropus		s				
T. totanus						si
T. nebularia	s				i	
Actitis hypoleucos		s		i		
Arenaria interpres					i	s

	Winter Nov-Feb	Spring Mar-May	Summer Jun-Jul	Autumn Aug-Oct
Himantopus himantopus			s	
Recurvirostra avosetta	s			
Charadrius hiaticula	i			s
C. alexandrinus	s			i
Pluvialis apricaria	s			
P. squatarola	i			s
Vanellus vanellus	s			
Calidris canutus		s		i
C. alba		s		
C. minutus	s			
C. ferruginea				si
C. alpina	si			
Philomachus pugnax				s
Gallinago gallinago	s			
Limosa limosa	s			i
Numenius phaeopus				i
N. arquata	i			
Tringa erythropus				s
T. totanus				si
T. nebularia	s			i
Actitis hypoleucos				si
Arenaria interpres	s	i		

Table 2. Seasons of peak numbers of each species on the study sites (s = saline; i = intertidal site).

Recurvirostra avosetta on the Ria Formosa, the peak in November at Ludo coincided with the period of post-moult migration of north European adults from the Heligoland Bight and Dutch Delta (Cramp & Simmons 1983; Boere & Smit 1983).

Little Stint *Calidris minutus* were present in the study area mainly from September to February, with a peak on the saline in February. Many of the autumn birds were probably migrating on to Africa, and winter fluctuations in numbers (Batty 1991; Rufino & Araujo 1987) may have been due to late onward post-moult movements referred to by Cramp & Simmons (1983).

Peak numbers of Dunlin *Calidris alpina* were reached on both sites during the winter, as confirmed also for the Ria in general by Rufino & Araujo (1987). Autumn migration through the Algarve begins with the passage of adults of the continental *schinzii* race in late July. These continue on to NW Africa and are followed during August-October by the juveniles, and the adults and juveniles of the Icelandic population, the later arrivals remaining to winter in the Algarve. Some *alpina* are present during September-October, the adult Dunlin population in the Algarve containing a much higher proportion of this race than does the juvenile population, and some at least can be assumed to pass on to Morocco. More arrive in the late autumn, to winter in the Algarve after moulting on the Wadden Sea and the Wash. Small numbers of *arctica* also seem to be present, both as autumn passage and as wintering birds. The wintering birds leave during March, at which time passage also starts of those birds which have been wintering in NW Africa. This passage reaches a peak in late April with *arctica* and Icelandic *schinzii* being a dominant element.

Rufino & Araujo (1987) described Black-tailed Godwit *Limosa limosa* as mainly a winter visitor, but also a spring migrant in the Ria Formosa. However, a peak on the intertidal study site in August/September shows that it is also an autumn migrant. The passage migrants were probably from the European population, which winters mainly in Africa north of the equator (Cramp & Simmons 1983), including many from Holland (Candeias & Castro 1982), whilst the wintering population may also include Icelandic birds (Prater 1975). The peak on the saline coincided with return passage which occurs in February. Most birds in the study area used the saline, except during autumn passage when the intertidal site was also used.

The substantial wintering population of Knot *Calidris canutus* indicated in Rufino & Araujo (1987) was poorly represented on the study sites, as these were away from the main feeding areas. The peak on the saline was in May, coinciding with the peak on the Ria as a whole, as wintering birds pass through en route to their north-central Siberian breeding grounds (Dick *et al* 1987; Rufino & Araujo 1987). The peak on the intertidal site was in September, coinciding with the autumn migration of the Siberian breeding population. Rufino & Araujo (1987) assumed that the wintering population on the Ria is of Nearctic origin, although Cramp & Simmons (1983) mention the most southerly wintering population of Nearctic birds as in western France, and Kersten *et al.* (1983) concluded that the Moroccan wintering population is of Siberian origin. It is more likely that the Knots wintering on the Ria Formosa are from Siberia, and that the decline in numbers after December is due to regional inter-estuarine movements.

As Rufino & Araujo (1987) only included data for November to

May, they attributed to other seasons all species which had main peaks on the study sites during summer and autumn. Black-winged Stilt *Himantopus himantopus* were present in peak numbers on the saline in summer owing to the presence of adults and juveniles of the breeding population, but were listed with species showing a mid-winter peak by Rufino & Araujo (1987). A second peak in September may have been due to migrants from northern Iberia and France (Cramp & Simmons 1983), and there was also a small wintering population.

There were two peak periods for the Ringed Plover *Charadrius hiaticula*, a main autumn peak coinciding with the passage of NE Nearctic and NW European birds to west Africa (Cramp & Simmons 1983), and a second peak from January to March (shown also by Rufino & Araujo 1987) which may indicate that return migration from NW Africa starts in January, or that there is a late winter movement of birds from northern Europe. The small passage in May of African birds en route to the arctic, as shown by Rufino & Araujo (1987) was not represented on the study sites.

Kentish Plover *Charadrius alexandrinus* were present on both the saline and the intertidal study site during all months. Peak numbers on the intertidal site in August coincided with the period of autumn migration, and there were secondary peaks on the saline in February (and March) during the period of reoccupation of breeding sites and spring migration and during June when large numbers of juveniles were present.

Rufino & Araujo (1987) described Whimbrel *Numenius phaeopus* as having a a small wintering population and a peak passage in April, but they missed the main peak which occurs, as indicated on the intertidal study site, during return passage in July and August.

Autumn migration of Redshank *Tringa totanus* appears to begin in July with the arrival of some adults and juveniles from northern Europe, and peak numbers were reached on the study sites in August (Rufino & Araujo (1987) gave peak numbers for winter). Migration continues during September and October with a large majority of juveniles in September and a small majority of adults in October, possibly as a result of the onward movement of juveniles to NW Africa and/or the arrival of post-moult adults. Although a few of the juveniles seem to be from northern Scandinavia and Spain, the majority are from the countries of north-central Europe, especially Denmark, Germany and Holland. Most of the adults seem to be from Spain, with a smaller number from north-central Europe. Numbers drop to the winter level in November, when the population is presumably made up of a mixture of Spanish and north-central European birds. There is a small return passage in February-April, peaking in March, only a few remaining until June.

Community composition

The relative abundances of the commonest species of waders on the saline and intertidal site throughout the year, calculated on the basis of the average monthly peak counts, are compared in Figure 3. Figure 4 shows the variations in species richness (number of species) of both sites. The most abundant wader on both sites was clearly Dunlin, followed by Kentish Plover, and with Redshank almost as abundant as Kentish Plover on the intertidal site though not on the saline. Redshank however, appeared to be more abundant on some other salines, especially those nearer the intertidal area and during summer there was a tendency for this species to roost on saltmarshes rather than on salines.

In comparison Rufino & Araujo (1987) showed that for the whole Ria, Dunlin were about four times as abundant as any other species from the end of November to early March. Bar-tailed Godwit was the most abundant other species, and Kentish Plover and Redshank were in about sixth and fourth

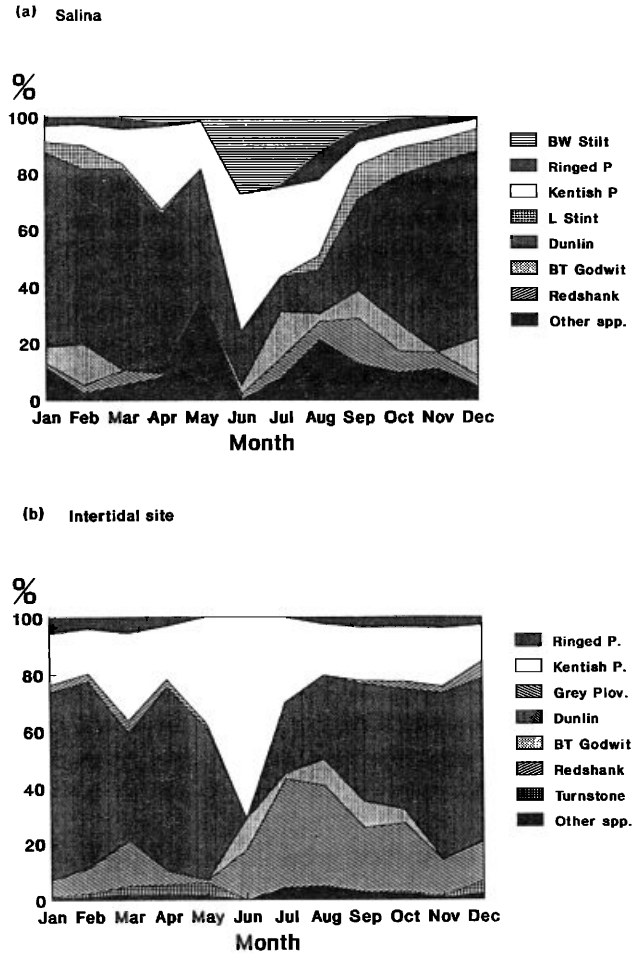


Figure 3. The species composition of the wader communities on a) the saline and b) the intertidal site during the annual cycle, based on average monthly peak counts. (BW Stilt = Black-winged Stilt; Ringed P. = Ringed Plover; Kentish P. = Kentish Plover; Grey Plov. = Grey Plover; L Stint = Little Stint; BT Godwit = Black-tailed Godwit).

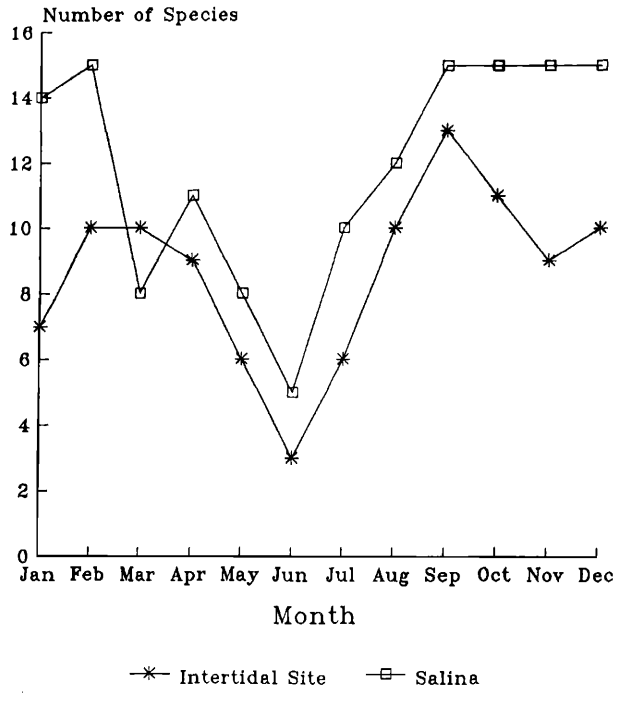


Figure 4. Variations in the species richness (number of species) of the wader communities of both sites during the year.

places. Bar-tailed Godwit was absent from the intertidal study site as it is a species largely restricted to sandy substrates with a good flow (Cramp & Simmons 1983), and is not found at all on salines. In May, Dunlin and Knot comprised 70% of birds present in the whole Ria but Knot was absent from the intertidal sites.

Notable differences between sites include the abundance of Black-winged Stilt on the saline during summer but its complete absence from the intertidal site. Little Stint were also absent from the intertidal study site (although present in other intertidal areas. The saline was also used by a greater proportion of other species, especially during spring and autumn migration periods. These included species such as Sanderling *Calidris alba* which fed elsewhere in the Ria during low water, and less coastal species, such as Ruff *Philomachus pugnax*, for which the salines resemble inland waters which are a more favoured habitat. Grey Plover *Pluvialis squatarola* also rested on the saline during May and September/October, en route to and from wintering areas in southern Africa (Cramp & Simmons 1983). The large increase in relative abundance of Kentish Plover in June is a combined result of the presence of juveniles from the breeding population and the seasonal decline of Dunlin and other species.

At first it seemed that the Ria Formosa has a small wader population in relation to its size when compared with northern European estuaries. However, a very high proportion of the Ria is occupied by a "patchwork" of saltmarshes and creeks, with few areas of extensive mud- or sand-flats. However, calculations using data on the intertidal areas from Teizeira & Alvim (1978) and on winter wader numbers from Rufino *et al* (1984) gave densities of 5.6-8.6 birds ha^{-1} representing a moderate to high density in relation to average winter densities in intertidal areas in Britain (Batty 1991). Considering those birds which use the salines for feeding or roosting during at least the high water period, figures from Rufino *et al.* (1984) of 6,426 waders in January, on 900 ha of salines, give an average density on the salines of 7.14 birds ha^{-1}. However, a total density of 106 birds ha^{-1} was reached on the study saline in January and a feeding density of 79.6 birds ha^{-1} in February. On the intertidal study site the density was up to 30.5 birds ha^{-1} and the highest density of 41.7 birds ha^{-1} was reached in August.

Although the construction of salines has been considered detrimental to waders and other birds of coastal wetlands, in removing intertidal feeding areas (Smit *et al.* 1987), those on the Ria Formosa may have improved the area for waders and other aquatic species, as the majority of salines have been built on saltmarshes rather than intertidal areas. They have increased the area of shallow water and mud available for feeding, supplied supplementary high-water feeding areas for many intertidal foraging species, and sheltered, still-water areas for species which are usually restricted to inland waters, and have provided artificial banks suitable for nesting.

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