Habitat partitioning and the distribution and seasonal abundances of migratory plovers and sandpipers in Los Alamos, Rio Negro, Argentina

Patricia M. Gonzalez

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Between September 1989 and December 1990, field studies were conducted on the population fluctuations of migratory plovers and sandpipers and on their use of foraging habitats along 4 km of coastline near Los Alamos, San Antonio Oeste, Rio Negro, in Argentina. Eight species were observed, of which four breed in northern North America. The largest flocks (up to 2,550 birds) arrived from the Northern Hemisphere in the second half of November and were present in significant numbers until early April. The greatest number of birds was recorded in March (8,500 birds), when *Calidris canutus* and *C. fuscicollis* were migrating northward. The first month of the southern winter was characterized by the presence of *C. alba* and *Charadrius falklandicus*, common species whose numbers increased substantially thereafter. The most commonly used foraging habitat was rock covered with patches of sandy sediment and water up to 3 cm deep. Similarities in the use of microhabitats are discussed. The most similar species morphologically (*C. alba* and *C. falklandicus*) also showed a positive correlation in time. Nesting and the seasonal variations in the numbers of people, dogs and vehicles were recorded. The Los Alamos coast is considered a 'vital site' (Clark 1974) for the conservation of migratory plovers and sandpipers.

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Entre septiembre 1989 y diciembre 1990, se estudiaron la fluctuación poblacional y el uso del hábitat de alimenta ción de chorlos y playeros migratorios en 4 km de costa con restinga en las cercanías de 'Los Alamos', San Antonio Oeste, Rio Negro, Argentina. Se observaron 8 especies de las cuales 4 se reproducen en el norte del continente americano. Los grupos más conspícuos provenientes des Hemisferio Norte (2 550 ejs.) aparecieron en la 2da. mitad de noviembre registrándose abudancias importantes hasta los 1ros. días de abril. El máximo de aves ocurrió en marzo, cuando el sistema albergó más de 8 500 limícolos simultáneamente: principalmente *Calidris canutus* y *C. fuscicollis* en paso migratorio hacia el Hemisferio Norte. El 1er. mes del invierno austral se caracterizó por la presencia de *C. alba* y *Charadrius falklandicus*, especies frecuentes que entonces exhibieron su mayor abudancia. El ambiente de alimentación más utilizado fue la roca cubierta con películas de sedimentos arenosos en machones y agua hasta 3 cm de profundidad. Se discuten similitudes en el uso de microhábitats; las especies más parecidas estuvieron además correlacionadas positivamente en el tiempo (*C. alba* y *C. falklandicus*). Nidificación y variación temporal en el número de personas, perros y vehículos, fueron registrados. Se estima que la costa de Los Alamos representa un sitio vital (Clark 1974) para la conservación de chorlos y playeros migratorios.

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Entre septembre 1989 et décembre 1990, on a étudié sur le terrain les fluctuations de populations de pluviers et de Scolopacidés migrateurs et leur utilisation des habitats d'alimentation sur une portion longue de 4 km du littoral du fleuve Negro dans la région de Los Alamos, San Antonio Oeste, en Argentine. Huit espèces, dont quatre se reproduisent en Amérique du Nord, ont été observées. Les vols les plus importants — 2 550 oiseaux — sont arrivés de l'hémisphère Nord au cours des deux dernières semaines de novembre et y sont demeurés en grand nombre jusqu'au début d'avril. La plus grande concentration a été enregistrée en mars (8 500 oiseaux), au moment où *Calidris canutus* et *C. fuscicollis* migraient vers le Nord. Le premier mois de l'hiver austral a été caractérisé par la présence de *C. alba* et de *Charadrius falklandicus*, des espèces communes dont le nombre a par la suite augmenté. L'habitat d'alimentation le plus fréquemment utilisé était constitué de roches recouvertes de plaques de sédiments sableux et d'au plus 3 cm d'eau. Les auteurs traitent des similitudes dans l'utilisation des habitats. Les espèces morphologiquement les plus semblables (*C. alba* et *C. falklandicus*) ont aussi présenté une corrélation positive dans le temps. On a aussi enregistré la densité de nidification et les variations saisonnières du nombre de personnes, de chiens et de véhicules. On considère que la côte de Los Alamos est une «région vitale» (Clark 1974) pour la conservation des pluviers et des Scolopacidés.

Casilla de Correo 84, Pedro Moron 384, 8520 San Antonio Oeste, Provincial de Rio Negro, Argentina.

Introduction

Despite its interesting abundance and diversity of birds, no studies have yet been conducted on the avifauna of the coastal area of Bahia de San Antonio and the coastal zone bordering the Gulf of San Matias, with the exception of censuses carried out by Morrison & Ross (1989).

The objectives of this project were as follows:

(1) to provide information on the composition and abundances of shorebirds throughout the year along the coast near the Los Alamos Technological Institute of Mining and Groundwaters (ITMAS) in San Antonio Oeste, Rio Negro, and

(2) to describe the partitioning of foraging habitats by the various species of plovers and sandpipers for purposes of establishing (i) the importance of this site for migratory shorebirds, (ii) the status of shorebird populations prior to the full functioning of a Solvay manufacturing plant, whose construction has been under way for some time in Punta Delgado, and (iii) the biological grounds for seeking political action to minimize the impact of large enterprises and proposing management plans.

Study area

The Los Alamos coast is located on the Gulf of San Matias (64°55'W, 40°45'S), close to the city of San Antonio Oeste and the Las Grutas seaside resort in the District of San Antonio, Province of Rio Negro, Argentina. It is the coastal sector that extends from ITMAS to the entrance of the Antoine de Saint Exupery Airport (Figure 1).

The zone is arid and mesothermic with a mean tidal amplitude of between 0.64 and 8.26 m. On the coast of Los Alamos, the receding tide uncovers a shoal (up to 1 km) perpendicular to the high-water line. It is a horizontal, smooth, slightly convex, greenish-yellow surface, which has fracture joints running in various directions in the limolite of the Patagonia Formation (marine Miocene) (Angulo *et al.* 1981).

The study area that was selected owing to its abundance of birds included the non-sloping coastal sector of the Patagonia Formation. Its upper limit is marked by fixed or shifting dunes 1.5–3 m high, which are higher (10 m) and more unstable in front of ITMAS. The intertidal coastal strip, located between the dunes and the exposed shoal, corresponds to the area included between the high-tide limits during spring and neap tides (Figure 2). It has a variable width of some 50 m, except in front of ITMAS, where it is about 100 m wide. There are sediment deposits ranging from fine sands to smooth rocks (20 cm diameter) and mollusc shells.

For more information, see Angulo *et al.* (1981), Gonzalez Diaz & Malagnino (1984), Piola & Scasso (1988) and the San Antonio Oeste Environmental Charter (Underdirectorate of the Environment, Department of Economics of Rio Negro).

With respect to continental vegetation, the region is included in the phytogeographic province of El Monte (Cabrera 1976); with respect to ornithogeographics, it falls under the coastal province (Narosky & Yzurieta 1987).

Material and methods

Observations were made every two weeks from September 1989 to December 1990, except for the first two weeks of March, between 3 p.m. and 8 p.m. (later in the summer and earlier in the winter) on clear days with wind speeds under 40 km/h. I observed the birds with 16 × 50 binoculars.

Patterns of distribution and seasonal abundance

The coast was studied at high tide when the shoal was flooded and the species, numbers, behaviour and moulting status (where possible) of shorebirds present were recorded. Pedestrians, dogs, vehicles and other disturbances were also recorded. Passing airplanes were not included.

The reliability of the estimates was substantiated by recounting the birds afterwards or by using photographs. The species were grouped according to where they bred, as described in Myers & Myers (1979).

Partitioning of foraging habitat

Observations were made between 5 November 1989 and 24 November 1990. The zone between the coastal dunes up to 100 m of exposed shoal was selected for observations, as the birds gathered there to feed.

Three homogeneous macrohabitats were recognized. These were subdivided into microhabitats that were temporary because of draining and drying through the tidal cycle. The species and numbers of birds in each microhabitat were recorded under different tidal conditions (given by roman numerals). When possible, notes were made of the number of birds at rest (rest being considered any activity other than foraging).

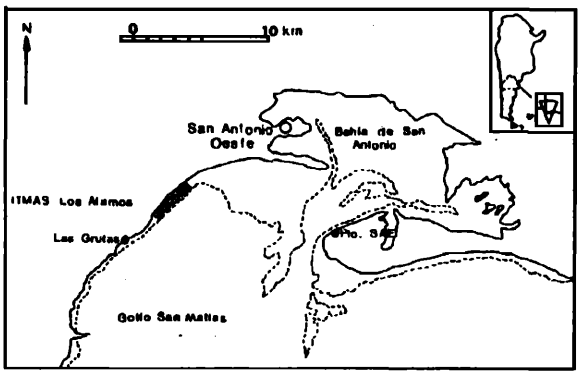

Figure 1. Map of the Bahia de San Antonio and Gulf of San Matias hinterland. The dotted area indicates the Los Alamos coast, and the dotted line shows the low-tide condition.

The macrohabitats were identified with letters and the microhabitats with Arabic numerals. Habitats not used by plovers were marked with a dash.

The specific aspects of the different microhabitats encountered in the study area are shown in Table 1, and the macrohabitats are described below:

Intertidal (S): Described in Study area and shown in Figure 2. The observations were carried out simultaneously along the route used for censusing bird numbers. The tidal conditions were (I) incoming high tide, high tide and slack tide and (II) outgoing high tide without uncovering the shoal.

Typical shoal (A): Represents more than 90% of the upper shoal. Patchy deposits of sand and fine sediments (0–3 cm deep). It faces low dunes with vegetation. The tidal conditions were (III) outgoing tide uncovering 50 m of shoal perpendicular to the coast and (IV) outgoing tide uncovering 100 m of shoal.

Shoal with sediment (B): The remaining surface consists of deposits of sand and fine sediments up to 30 cm thick and decreasing seaward for about 50 m. This macrohabitat faces high, shifting or plant-covered dunes (Figure 2A). The tidal conditions were (III) outgoing tide uncovering 50 m of shoal perpendicular to the coast and (IV) outgoing tide uncovering 100 m of shoal.

Census divisions consisting of 100 m of shoreline reaching back 50 or 100 m from the shore were established according to the height of the tide. The corresponding intertidal surface area of the census divisions was determined by projection. A census was carried out on a total of four divisions shown in Table 1 in the following order: BIII, AIII, BIV and AIV. Macrohabitat B was uncovered first (see Figure 2A).

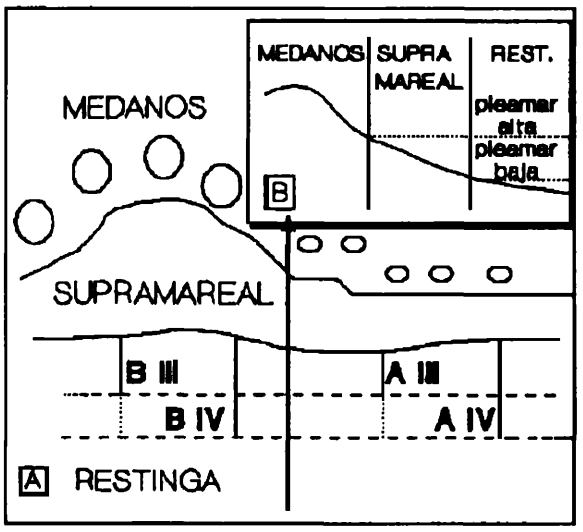

Figure 2. (A) Diagram of the layout of sections in which the habitat division project was carried out. The large circles indicate high, shifting or plant-covered dunes. The smaller circles indicate low, plant-covered dunes. The dotted lines show the height of the tide. (B) Sketch of the outline of the coast (not to scale). medanos = sand dunes; supramareal = intertidal; restinga = shoal; pleamar alta = high tide; pleamar baja = neap tide.

Fortnightly visits were carried out during low tides following a route perpendicular to the coast towards the sea, and the presence or absence of shorebirds and human activity was recorded.

Data processing

The Simpson Diversity Index was used to analyse diversity. I used the Dominance Index to relate the highest number of birds for each species to the total number of birds seen (all species combined). The Bucher and Herrera Index of Relative Importance (Bucher & Herrera 1981) was used as an index to describe the relative numbers of each species in the population.

The Spearman coefficient (r_s) (Southerwood 1971) was used to measure the intensity of association between the annual patterns of different species.

The following index, which is similar to the Bucher and Herrera Index of Relative Importance and which relates the relative intensities of foraging and resting, was used to estimate the feeding activities of each species in the intertidal sector: relative importance (feeding/rest) or RI (f/r) = (Nf/Nt) (Mf/Mt) 100, where Nf = the number of birds feeding in all the censuses; Nt = the number of birds in all the censuses; Mf = the number of censuses in which the species is feeding; and Mt = the number of censuses in which the species is present.

The frequency of habitat use by a species was calculated as the number of observations of each

Table 1. Designation of microhabitats. Different numbers for a microhabitat indicate a different spatial location or a different substrate.

Macrohabitats and tide				
SI	SII	AIII–IV	BIII–IV	Microhabitats
1	1	1	1	DRY SEDIMENT
2	2	2	2	DRY BACKWATER (deposits of algae and dry grass)
3				WET BACKWATER
4	8	15	20	BORDER 1: zone alternatively covered and uncovered by waves
5	9	16	21	BORDER 2: deeper than BORDER 1, covered by at least 3 cm of water
6	6			SEMI-PERMANENT POOLS (>5 cm)
	7	13	7	ALGAE recently deposited by the sea
	10	10/11	17	WET SEDIMENT
		12	18	SEDIMENT COVERED IN WATER (0–5 cm deep)
		14	19	ROCK covered in film of sediments in patches and water up to 3 cm deep
				PATCHES OF MUSSELS 10–30 cm wide with variable lengths
				LARGE TIDE POOLS (up to approximately 30 cm deep)
				HIGH ROCK FORMATIONS (up to 100 cm high)
				ROOTED GREEN ALGAE

species in each microhabitat divided by the total number of observations made of this species. The chi-squared test (χ^2) was used to analyse frequency.

The Mean Taxonomic Distance Index (MTD) (Sokal 1965) was used to identify similarities in foraging habitat use among species. The mean linkage technique (Sokal & Sneath 1963) was used for group analysis. Graphic representation was done using dendrograms; the cophenetic correlation coefficient (r) of Sokal & Rohlf (1969) was used to measure distortion between the similarity matrices (Crisci & Lopez Armengol 1983).

The segregation of pairs of species that were very similar in their use of habitat and tide was carried out using the Wilcoxon signed-ranks test (Sokal & Rohlf 1980).

Results

Eight species of shorebirds belonging to the Charadriidae (4) and Scolopacidae (4) were identified.

Patterns of abundance and seasonal distributions

The highest numbers of birds were seen from mid-November to mid-July; there were no numbers exceeding 100 birds/census at other times of the year (Figure 3).

The annual pattern showed three phases: (1) the sudden abundance of birds in November, due mainly to the arrival of *Calidris fuscicollis* from North America, (2) the northern migration of all the species in early fall and (3) the increase in early winter due to *C. alba* and *Charadrius falklandicus*.

The Simpson Diversity Index ranged between 0.0 and 2.06 on the northern migration. The seasonal variation in dominance showed a definite pattern in the succession of dominant species: *C. fuscicollis* dominated from mid-November to early April (Simpson Diversity Index > 0.93), interrupted only by the arrival of *C. canutus*, which then became dominant (Simpson Diversity Index = 0.79).

Once the migration of the Nearctic plovers had occurred, *C. falklandicus* became dominant until the next season. North American sandpipers (Scolopacidae) dominated from mid-spring to early fall, when plovers (Charadriidae; Patagonian species) exercised full dominance.

The annual balance studied by means of the relative importance values is consistent with the results described above (Figure 4).

Overall, the Scolopacidae occurred in far larger numbers than the Charadriidae (RI = 59.68) owing to the migration of large flocks and not because of a constant movement of sandpipers into the area.

A positive correlation was found between the seasonal patterns of *C. alba* and *C. falklandicus* (r_s = 0.5937; $p < 0.01$).

Most of the observers along this coastline were sports fishermen. In the summer, there were larger numbers of tourists during high-tide periods. At low tide, the human presence decreased, and a typical activity at that time was the collection of

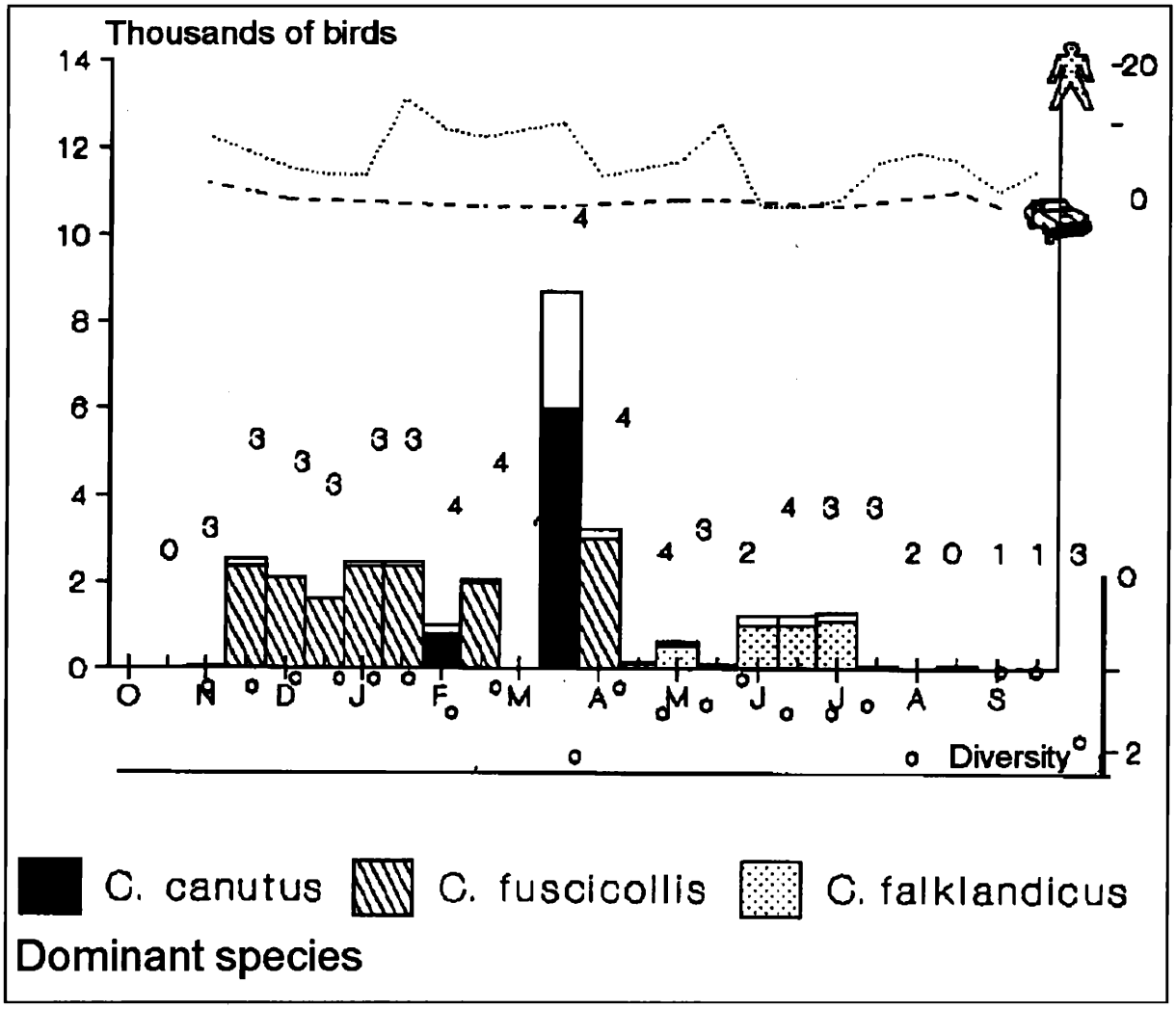

Figure 3. *Frequency diagram:* Seasonal variation in the total number of plovers and sandpipers, showing the contribution of the dominant species. The number on each bar indicates the number of species present. *Lines:* Seasonal variation in the number of people and vehicles. Lines were used to indicate possible trends, but the variables are discrete. *Points:* Seasonal variation in species diversity (Simpson). Observations are for the period between October 1989 and October 1990.

small octopuses. The number of dogs ranged between 0 and 4; 50 goats and 1 boat were also recorded. The groups that interacted most with the birds were passers-by, dogs and vehicles (Figure 3).

Species observations

North American
Family Scolopacidae

Ruddy Turnstone *Arenaria interpres*

One bird in non-breeding plumage was observed on 5 November 1989, and two birds with advanced transitional plumage (verging on breeding plumage) were observed on 15 February 1990.

Sanderling *Calidris alba*

Sanderlings used the study area as a migratory stop on their way south in November and north in March, even though low numbers were often observed in the summer (Figure 4). During the southern fall and winter, there were birds that did not migrate. Similar observations involving juvenile birds were made in Peru by Castro & Myers (1987). Contrary to observations in Peru, the birds did not moult to breeding plumage in Los Alamos, except for one bird sighted on 16 June 1990. These could be sexually immature birds that, like their counterparts in California, did not acquire breeding plumage, although the latter do migrate (Myers *et al.* 1985a, cited in Castro & Myers 1987). The birds sighted in March were beginning a body moult.

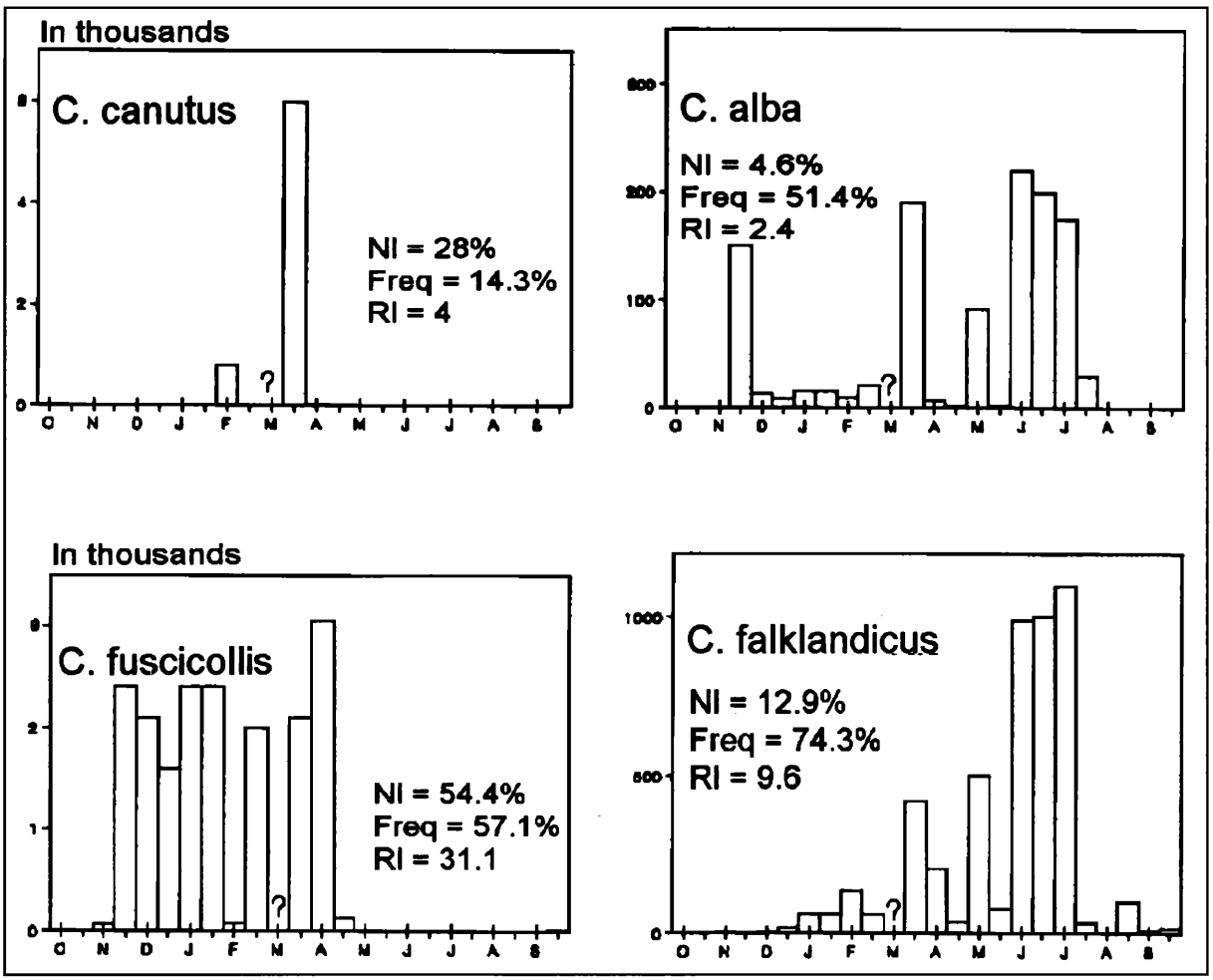

Figure 4. Seasonal variation in the number of individuals for the species with the highest relative importance (RI), indicating numerical importance (NI) and Frequency (Freq.) Observations are for the period between October 1989 and October 1990.

On other beaches in the region, this species was present for a large part of the annual cycle (pers. obs.). In January 1982, Morrison & Ross (1989) reported 490 *C. alba* on the beaches of the east canal that links the Bahia de San Antonio to the Gulf.

Red Knot *Calidris canutus*

The Red Knot was seen in large numbers during the migration to its breeding grounds (Figure 4). Its pattern of seasonal distribution is consistent with that observed by other researchers (Harrington & Morrison 1980; Blanco, Pugnali & Rodríguez Goñi 1988), whereby the species uses different southward and northward migration routes. In February and November, the Red Knots were in breeding plumage. Birds seen in March had begun a body moult (approximately 30% complete). In March, approximately 30 Red Knots with colour bands were sighted; these included birds with orange bands from Punta Rasa, Argentina, birds with dark green bands from the United States and some birds with light green bands from an unknown location.

White-rumped Sandpiper *Calidris fuscicollis*

The White-rumped Sandpiper used this coastline during its northward and southward migrations as well as during the austral summer (Figure 4). Although the large groups appeared in the second half of November (>2,400 birds), the first flocks (7–61 birds) were seen in early November 1989 and in late September 1990. One non-migratory bird was recorded in June.

Patagonian
Family Charadriidae

Tawny-throated Dotterel *Oreopholus ruficollis*

On 1 January 1989, one bird fed for a few minutes in the dry sand at high tide and then flew away (pers. obs.).

Two-banded Plover *Charadrius falklandicus*

This species was recorded in Los Alamos almost all year (Figure 4). Widely fluctuating numbers from the end of January to March and May suggest that at least part of the population consisted of birds migrating north. By contrast, no spring peaks were observed. The winter resident population showed the highest numbers of the year (1,100 birds). The lowest population densities were during the breeding season. Two chicks were observed: one on 31 December 1989 and another on 16 January 1990 (possibly the same bird), confirming that the species was nesting in this area.

Observations were made in September of birds with breeding plumage, which they wore until January, when moulting began. In March and until late April, most birds wore non-breeding plumage. This agrees with the observations of Blanco, Pugnali & Rodríguez Goñi (1988) for Punta Rasa. In May, the plovers showed very advanced transitional plumage, verging on breeding plumage, in contrast with that observed on the previous visit. This possible lack of synchrony in moult could be related to the genetic variability of populations that may alternate in their use of the same site.

Magellanic Plover *Pluvianellus socialis*

A species from the south, it is a resident of the study area during the non-breeding season. Although local records show little latitude in its known range of non-breeding dispersion up to the Valdes Peninsula (Jehl 1975), I have received more recent reports from the southern part of the province of Buenos Aires (Grupo Becasa, San Antonia Ouest, unpubl. data). Three specimens were observed on 18 September 1989; 2 were seen on 18 April, 13 on 16 and 28 June and 9 on 13 July 1990. Out of 13 birds, 7 had yellow feet and whitish spots on the back (juveniles), 2 had reddish-orange feet (older juveniles?) and 4 had red feet (adults).

Brazilian–Paraguayan
Family Charadriidae

Collared Plover *Charadrius collaris*

One bird was seen in the wet sand of the intertidal region on 25 September 1990, close to four *C. falklandicus* at rest.

Relationship between foraging and resting birds

Except for the Red Knots, the shorebirds normally rested in groups at high tide and fed on the shoal when it was uncovered by the sea. The knots would rest even with 100–150 m of the shoal still exposed. The proportion of feeding birds was quantified for the intertidal region at high tide (condition I–II): *P. socialis* and *C. alba* comprised the highest proportion of feeding birds (RI(f/r) = 27.02 and 10.20, respectively). The index relating resting and feeding in *C. canutus* was only 1.50 (very low despite having the highest number of foraging individuals) owing to their lesser significance; at tide condition IV, no more than 360 birds out of 4,800 (7.5%) were feeding. Most of the *C. fuscicollis* remained at rest (RI(f/r) = 0.19).

On 16 June and 13 July 1990, *C. alba* and *C. falklandicus* remained at rest, even when tidal waters exposed about 400 m of shoal.

Frequency of feeding habitat use

Intertidal habitat

At high tide (SI), the microhabitat most used ($p < 0.005$) by all species was Border 1 (35%), an environment repeatedly covered and uncovered by waves (Figure 5). *Calidris alba* used the greatest number of resources for the longest time, whereas *C. fuscicollis* and *C. canutus* fed only at Border 1.

When the tide began to ebb (SII), the diversity of foraging habitats increased. The Charadriidae and *C. alba* both significantly preferred to forage on wet sediment ($p < 0.005$). In similar fashion, *C. fuscicollis* preferred Border 1 ($p < 0.005$), and *C. canutus* waded across the border at greater depths ($p < 0.005$).

The shoal

When the shoal was uncovered, the plovers dispersed. For a certain period of time, the water drained from the rock in a laminar flow. As the slope was not steep, the border environments became quite wide and shallow, with small waves. With the shore about 50 m away (condition AIII), *C. fuscicollis* chose algal deposits on the shoal ($p < 0.005$), which were in variable supply. *Charadrius falklandicus* preferred algae deposited by the sea, sediment with water and rock covered in sediment and water ($p < 0.005$), although no significant differences were found in the use of these three environments. *Pluvianellus socialis* used the low border.

In condition AIV (sea at 100 m), the species preferred rock partly covered (>62%) in a film of fine sediment and water up to 3 cm deep (microhabitat 14) ($p < 0.005$ for the sum of individuals of all species and for each individual species).

As the typical shoal was the most available environment and the greatest food supply was in this macrohabitat (microhabitat 14), it was obvious that this was the most important feeding environment in the upper intertidal zone.

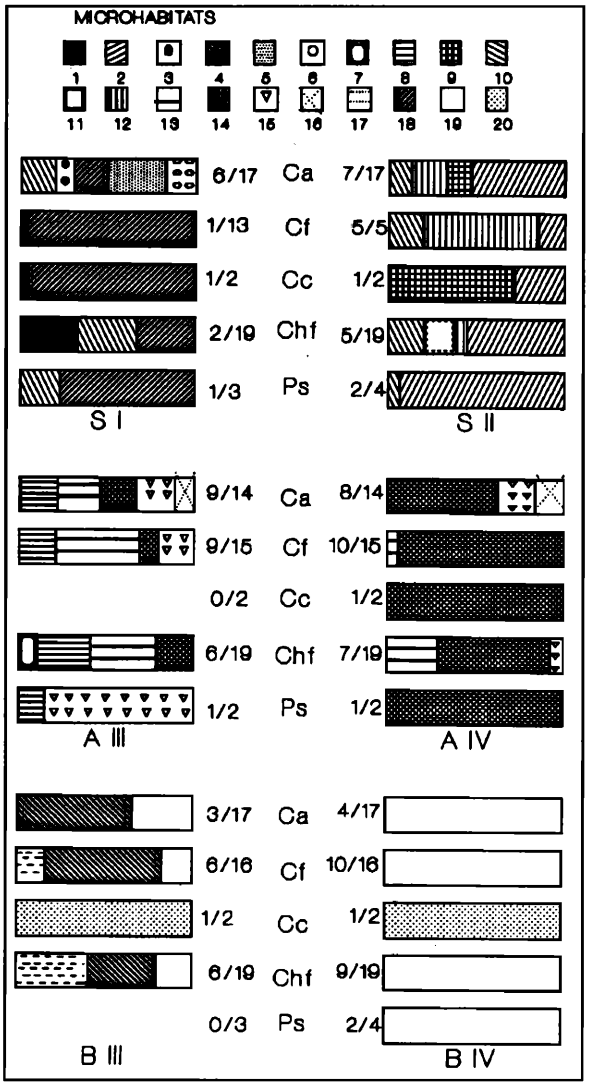

Figure 5. Relative annual use — by species — of feeding microhabitats (Arabic numerals) in various macro-environments (capital letters) and tide conditions (Roman numerals). The fractions point out the relationship between the number of samples in which the species used that habitat and tide condition (numerator) and the total samples in which it was represented (denominator). The species are indicated by the initials of their names; macrohabitats, micro-habitats and tide as in Methods. Observations are for the period between 5 November 1989 and 24 November 1990 (from Southerwood 1971; Jehl 1975; Myers & Myers 1979; Harrington & Morrison 1980; Sokal & Rohlf 1980; Myers *et al.* 1987; Narosky & Yzurieta 1987; Piola & Scasso 1988; Morrison & Ross 1989).

In condition BIII, *C. alba* and *C. fuscicollis* fed more on sediment covered with water (microhabitat 18) than on rocks (microhabitat 19) ($p < 0.005$); as the sea went out farther (BIV), the latter microhabitat became more available, and its frequency of use — including *C. falklandicus* and *P. socialis* (which did not use BIII) — increased to levels of over 95%. Only *C. canutus* showed a marked preference for the low border ($p < 0.005$).

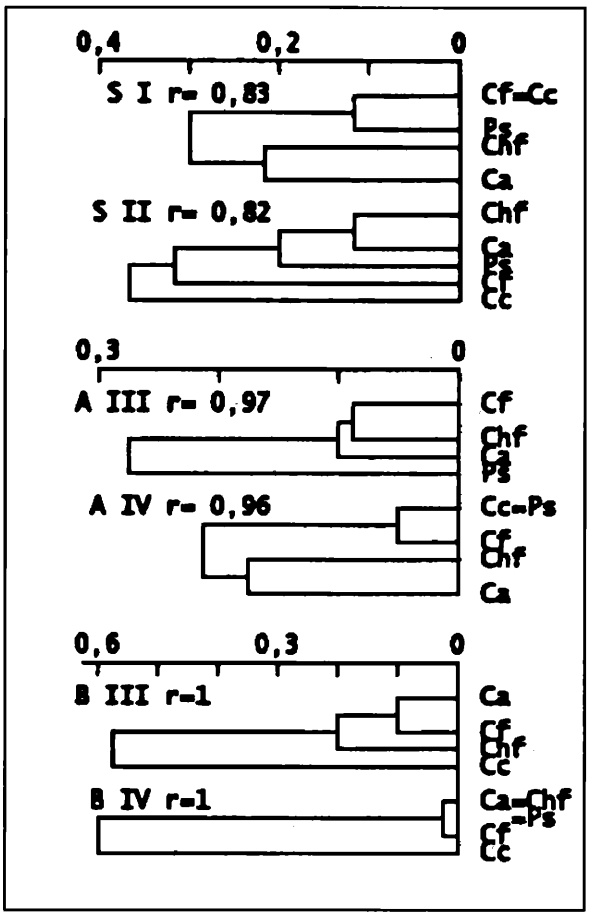

Figure 6. Dendrograms of Similarity (MTD) of feeding habitat use between species for various macrohabitats (capital letters) and tide conditions (Roman numerals). r = cophenetic correlation coefficient; names of species listed by initials; macrohabitats and tide conditions listed in Methods.

In general, *C. alba* used a greater number of microenvironments (17); *C. fuscicollis* and *C. falklandicus* used 15 and 14, respectively; *C. canutus* and *P. socialis* were present in the region for less time, foraging in only 7 environments. Plovers and sandpipers were always present at low tide. Feeding areas were located in the upper, middle and lower intertidal zones.

Similarities between species

The analysis of similarities between pairs of species (Figure 6), which included all the experimental conditions simultaneously, was significant for the following distance relationships (MTD) (note: the species are identified by the initials corresponding to their names):

Ca-Chf < Ca-Ps (*)
Ca-Chf < Ps-Chf
Ca-Cf < Cc-Chf
Ca-Chf < Ca-Cc
Ca-Chf < Cc-Chf (*)
Ps-Chf < Ca-Cc

Ca-Cf < Ca-Cc
Cf-Chf < Cc-Chf
Cf-Chf < Ca-Cc

$p < 0.05$ except where marked (*), where $p < 0.025$.

Calidris alba was similar to *C. falklandicus*; *C. canutus* and *P. socialis* were further apart. As there were no significant differences between Ca-Chf and Ca-Cf and no similarity could be drawn between *P. socialis* and *C. canutus*, it is proposed that the species be segregated in the following three groupings that best describe associated and independent species that use the foraging habitat at Los Alamos. These are (1) Ca, Chf and Cf, (2) Ps and (3) Cc.

Discussion

Patterns of abundance and seasonal distribution

The Los Alamos coast is only one of the various sites of shorebird concentrations in the Bahia de San Antonio and the Gulf of San Matias. Could the patterns obtained here be extrapolated to the rest of the region?

This study showed that large numbers of plovers arrived from the north until the second half of November. However, at other sites, peak numbers were reached at the end of September in 1990 (pers. obs.). These observations suggest that plovers used the habitats at different times. Conclusions can therefore not be drawn on habitat use by the plovers based exclusively on the results obtained from Los Alamos.

On 20 and 29 October 1988, about 2,400 *C. fuscicollis* and 400 *C. alba* were recorded at Los Alamos, and similar concentrations were observed near Punta Delgado (pers. obs.). This indicates that patterns may change from year to year. The variation may be due to causes that are internal or external to the system or to the scheduling of the censuses, which may not reflect the actual pattern, as significant numbers of plovers and sandpipers may come and go between censuses.

How many birds depend on the site?

The information obtained suggests that there was some turnover in the numbers of North American species (although it was not quantified) during the non-breeding season. By contrast, the similar numbers of *C. alba*, *C. falklandicus* and *P. socialis* throughout the three consecutive censuses and the distinguishable plumages of shorebirds presumably on their way north indicated that these species were resident during the southern winter.

The figures obtained from the recounts tended towards underestimations, but they offer reliable figures on the minimum numbers of birds using this area.

The results show the importance of the site for the species observed: at least 3,050 *C. fuscicollis*, 6,000 *C. canutus*, 600 *C. alba* and 1,100 *C. falklandicus* used the Los Alamos coast during the 1989–1990 winter.

Feeding habitats

In the course of these field studies, it appeared to me that most birds at rest fed later in the upper intertidal zone. The time during which the birds used this zone, and whether or not shorebirds coming from other roosting sites used it, could not always be determined.

There were similarities in feeding habitat use between the most common species (*C. fuscicollis*, *C. alba* and *C. falklandicus*) and the less common species (*C. canutus* and *P. socialis*), although they remained widely apart. The correlation in the patterns of abundance and seasonal distributions between *C. alba* and *C. falklandicus* is interesting, because these species were not only similar in their use of habitat but also not segregated in time. This leads to the assumption that the habitat and feeding resources were not limiting and that there would thus be no competition; however, it is still unknown whether they were segregated on the feeding axis.

Trophic dynamics

The greatest numbers of plovers and sandpipers were observed during the months of February to April. This is especially relevant, because the highest values of chlorophyll 'a' in the coastal waters of Las Grutas were obtained during that period based on sampling carried out by G.B. Domecq Chantry in 1986 (unpubl. data). Since the period during which the system maintains the most migratory shorebirds coincides with the phytoplankton bloom, this indicates a positive relationship between primary marine productivity and the availability of bottom-dwelling prey for birds.

Conservation

In order to ensure the conservation of migratory shorebirds at the hemispheric level and the critical habitats they require, it is important to determine the significance of this site in Argentina. These birds gather in specific areas at times that are related to the seasonal availability of resources. Plovers make maximum use of the food available at these sites (Evans 1979, cited in Myers *et al.* 1987; Goss-Custard 1979; Schneider & Harrington 1981), which means that birds displaced by habitat degradation will be in a desperate situation by being forced to use sites already used to capacity.

The conservation strategy set out by Myers *et al.* (1987) calls for the protection of important sites used sequentially by shorebirds, thus forming critical links in the international chain. The data presented in this paper demonstrate the significance of this coastline to shorebirds in Los Alamos and the need for the implementation of protection measures in the future.

Conclusions

This study demonstrated the importance of the Los Alamos coastline for migratory shorebirds. According to the guidelines in Clark (1974) regarding the management of coastal areas, it is a 'vital' coastal area, *i.e.* it should be protected because of its role in maintaining the essential ecological processes of this ecosystem. The overall role of the San Antonio Oeste region in the migratory cycles of shorebirds remains to be determined.

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