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# Spatial and temporal distribution of migrant shorebirds (Charadriiformes) on Caranguejos Island in the Gulf of Maranhão, Brazil

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**RESUMO: Distribuição espacial e temporal de aves limícolas (Charadriiformes) na Ilha dos Caranguejos, Golfão Maranhense, Brasil.** Objetivou-se descrever a distribuição espacial e temporal de aves limícolas (Charadriiformes) na Ilha dos Caranguejos, Maranhão, Brasil. Os censos foram realizados sazonalmente de setembro/2007 a julho/2008. Utilizou-se os métodos de ponto fixo, transecção e estimativa. A distribuição temporal das aves mostrou elevada abundância nos meses setembro a novembro (migração de outono) e dezembro a fevereiro (inverno), diminuindo nos meses de março a maio e valores baixos nos meses de junho a agosto, período de reprodução no Ártico. *Calidris pusilla* foi a espécie mais abundante em todos os períodos. A distribuição espacial se deu de acordo com a variação de maré. A Ilha dos Caranguejos se mostrou como um importante sítio de inverno de aves limícolas migratórias, sendo fundamental a conservação dessa área para a manutenção desse grupo de aves.

**PALAVRAS-CHAVE:** abundância sazonal; forrageamento; aves limícolas; migrantes.

**ABSTRACT: Spatial and temporal distribution of migrant shorebirds (Charadriiformes) on Caranguejos Island in the Gulf of Maranhão, Brazil.** This study describes the spatial and seasonal abundances of migratory shorebirds (Charadriidae and Scolopacidae) on Caranguejos Island in the Gulf of Maranhão, northern Brazil. Fixed-point and transects counts, and population estimates were conducted seasonally between September, 2007 and July 2008. Numbers of shorebirds peaked from September to November, during the fall migration and during the overwintering period from December to February (seasons refer to North Hemisphere). Shorebird numbers decreased from March to May, and reached minimum levels from June to August, when birds are breeding in the Arctic. The Semipalmated Sandpiper *Calidris pusilla* was the most abundant species throughout the study. The spatial distribution of birds varied according to tidal levels. Caranguejos Island was identified as an important wintering site for migratory shorebirds, thus requiring a systematic approach to the monitoring and conservation of its bird populations and other fauna.

**KEY-WORDS:** seasonal abundance; foraging distribution; shorebirds; migrants.

A number of sites located along the Brazilian coast, between the northernmost state of Amapá and southernmost Rio Grande do Sul, play an important role in the conservation of migratory shorebird populations (Charadriidae and Scolopacidae) in the Western Hemisphere (Morrison and Ross 1989, Azevedo-Jr. and Larrázabal 1994, Rodrigues 2000, 2001, 2007, Telino-Jr. *et al.* 2003). The coastline located east of the Amazon River estuary, from Belém in the state of Pará to São Luís in Maranhão, is locally known as the “Salgado” (in Pará) and the “Reentrâncias” (in Maranhão) and has been identified as an important wintering area for shorebirds along the Western Atlantic Flyway (Morrison and Ross 1989, Rodrigues 2000, 2007, Silva 2007).

Caranguejos Island is found within the Pindaré River estuary sub-unit of the “Baixada Maranhense” Environmental Protection Area (EPA), which was created

by a decree of the government of the state of Maranhão. The only published data on the avifauna of this island are those from aerial surveys carried out during the 1980s (Morrison *et al.* 1987, Morrison and Ross 1989). Morrison and Ross (1989) considered the area relatively rich in shorebirds, with a total of 22,780 “small, medium, and large” shorebirds recorded. Roth and Scott (1987) also surveyed three areas within the region, including the Pindaré and Mearim Rivers and the Mearim estuary, where Caranguejos Island is located, although results for the latter-named area appeared as an unpublished report.

A number of studies have recorded significant declines in the populations of some migratory shorebirds in North and South America, mainly due to habitat loss and degradation (*e.g.*, Clark *et al.* 1993, Collazo *et al.* 1995, Page *et al.* 1997, Morrison *et al.* 2004). Therefore, the understanding of the distribution and relative

abundances of populations of migratory shorebird species at different sites along their routes is essential to implement long-term conservation programs. In this context this paper describes the spatial and temporal distribution of migratory shorebirds on Caranguejos Island.

## MATERIAL AND METHODS

### Study Area

Caranguejos Island ( $02^{\circ}43'26.16''\text{S}$ ,  $44^{\circ}29'27.73''\text{W}$  and  $03^{\circ}01'31.9''\text{S}$ ,  $44^{\circ}05'16.5''\text{W}$ ) is located in the southern Gulf of Maranhão (known as São Marcos Bay)

at the mouth of the Mearim River in north Brazil (Figure 1). The island has an area of 345.08 km<sup>2</sup> and a tidal range of about 8 m (Mello *et al.* 2000). The area has been classified as a “middle estuary”, with the highest tidal amplitude of the entire Brazilian coastal zone (FSADU/UFMA 2004). Main vegetation type is mangrove forest, dominated by the red mangrove *Rhizophora mangle*.

Two areas were selected for data collection (Figure 1). The northern sector stretches from the site called Island Point ( $02^{\circ}43'26.16''\text{S}$ ;  $44^{\circ}29'27.73''\text{W}$ ) to Forage Point ( $02^{\circ}44'24.4''\text{S}$ ;  $44^{\circ}30'55.1''\text{W}$ ) and includes sandbanks (known locally as *lavados de areia*; Fortes 2004), and tidal sand- and mudflats. The southern sector mainly consists of mudflats, between “Jurará” ( $03^{\circ}01'31.9''\text{S}$ ;

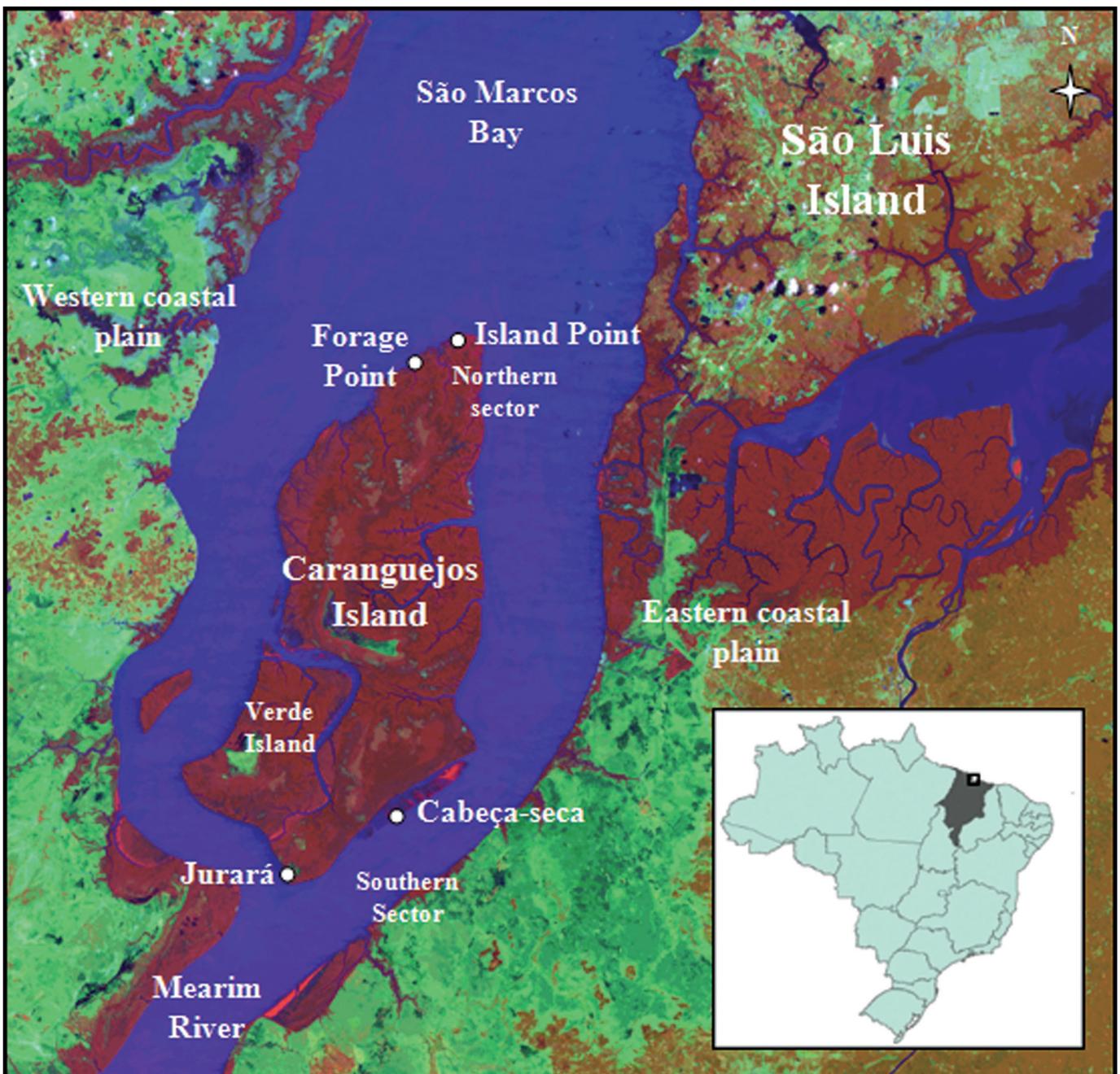


FIGURE 1: Satellite image showing Caranguejos Island in the Gulf of Maranhão, northern coast of Brazil.

**TABLE 1:** Maximum number of migratory shorebirds (Charadriidae and Scolopacidae) recorded on the northern and southern sectors of Caranguejos Island, Maranhão, northern Brazil, in 2007-2008.

Species	Fall migration	Overwintering period	Spring migration	Breeding season
<b>Northern sector</b>				
<i>Pluvialis squatarola</i>	10	328	75	10
<i>Charadrius semipalmatus</i>	27	500	70	320
<i>Charadrius collaris</i>	0	0	2	9
<i>Numenius phaeopus</i>	80	56	370	105
<i>Limnodromus griseus</i>	368	0	12	6
<i>Actitis macularius</i>	1	1	0	0
<i>Tringa melanoleuca</i>	1	0	0	0
<i>Tringa semipalmata</i>	1160	310	1530	12
<i>Tringa flavipes</i>	2	0	1	0
<i>Arenaria interpres</i>	3	60	3	17
<i>Calidris canutus</i>	7000	200	0	0
<i>Calidris pusilla</i>	3000	4100	2060	5500
<b>Southern sector</b>				
<i>Pluvialis squatarola</i>	10	74	2	5
<i>Charadrius semipalmatus</i>	13	5	0	10
<i>Numenius phaeopus</i>	12	77	30	36
<i>Tringa melanoleuca</i>	4	0	0	0
<i>Actitis macularius</i>	2	7	0	0
<i>Tringa semipalmata</i>	5	154	14	10
<i>Arenaria interpres</i>	0	1	0	1
<i>Calidris alba</i>	0	390	0	0
<i>Calidris pusilla</i>	35000	35000	20000	30

44°05'16.5"W) and "Cabeça-Seca" (02°57'36.02"S; 44°28'57.17"W).

Data were collected twice a month, from September 2007 to July 2008. The direct count method (Bibby *et al.* 1992) was used for estimating the number of shorebirds. Observations were carried out with 10 x 50 mm binoculars. Due to logistic difficulties, two areas denominated "northern" and "southern" sectors (Figure 1) were surveyed only in two monthly excursions, representing each of the four phases of birds' life cycle: September and October (fall migration), December and February (overwintering period), March and April (spring migration), and June and July (Arctic breeding season). Throughout this paper all seasons refer to Northern Hemisphere, where shorebirds breed.

### Data Analysis

Species richness was defined as the number of species present in an area at a given moment. Mann-Whitney's U test was used to compare the abundances of shorebird species during each stage of the annual cycle (southward migration, overwintering, northward migration, and breeding season) between the northern and southern sectors of the island. The Kruskal-Wallis nonparametric analysis of variance was used to evaluate temporal variations in the abundances of shorebirds in the two sectors independently, as well as the overall numbers during the

different phases of the migration cycle between the two sectors.

## RESULTS

Thirteen species of shorebirds, including 3 charadriids and 10 scolopacids, were recorded on Caranguejos Island. The relative numbers of each species varied according to tide level, with the main influx of birds occurring from the second hour of the ebb tide onwards. Species richness was highest in the northern sector of the island with 13 species recorded there, while 10 species were recorded in the southern sector, including tens of thousands of *Calidris pusilla* (Table 1). *Calidris pusilla* was the most abundant species in both sectors over all periods, except during the northward migration in the northern sector when *Calidris canutus* was the most abundant shorebird. *Pluvialis squatarola*, *Charadrius semipalmatus*, and *Arenaria interpres* exhibited similar patterns of seasonal abundance, with reduced numbers during the northward migration and large numbers during the overwintering phase in the north sector. This was followed by declining numbers during the northward migration and lowest values during the breeding season. The numbers of *Tringa semipalmata* and *Numenius phaeopus* peaked during the northward migration. *Limnodromus griseus* was abundant during the southward migration, but rare in all subsequent periods. The numbers of *Pluvialis squatarola*,

*Charadrius semipalmatus* and *Calidris alba* peaked during the overwintering period.

Abundance of shorebirds in the northern sector did differ among migratory periods (Kruskal-Wallis  $H = 1.0163$ , d.f. = 3,  $P = 0.7973$ ). In the southern sector, while peaks of abundance were recorded in the northward migration and overwintering periods, the differences among periods were also not statically significant ( $H = 4.1596$ , d.f. = 3,  $P = 0.2447$ ).

While the abundance of shorebirds in the northern and southern sectors contrasted considerably in each phase of the migratory cycle (Figure 2), the differences were not statically significant for any of the periods (southward migration: Mann-Whitney  $U = 44.00$ ,  $Z = 0.7107$ ,  $P = 0.4773$ ; overwintering period:  $U = 48.50$ ,  $Z = 0.3909$ ,  $P = 0.6959$ ; northward migration:  $U = 38.00$ ,  $Z = 11.371$ ,  $P = 0.2555$ ; breeding season:  $U = 45.00$ ,  $Z = 0.6396$ ,  $P = 0.5224$ ). This was due

primarily to the influence of the abundance of *C. pusilla* (Table 1) on the overall values (Figure 2).

In terms of overall abundance (Figure 3), there were peaks during the fall migration and overwintering periods, followed by a sharp decline through the spring migration to the breeding season, although the differences among periods were not statically significant ( $H = 28.892$ , d.f. = 3,  $P = 0.4090$ ). The marked peak during the first two periods was mainly related to the arrival of large numbers of *C. pusilla* and *C. canutus* in September 2007.

At high tide in the northern sector of the island, *P. squatarola*, *C. semipalmatus*, *N. phaeopus*, *L. griseus*, *T. semipalmata*, and *C. pusilla* exhibited the same spatial distribution, remaining perched on the branches of *R. mangle* and *Avicennia* spp. near the sandbanks and sand/mudflats. As the tide starts to ebb, and tidal plains are exposed, birds return to this area to forage. During the ebb tide, it was only possible to see solitary individuals or small flocks flying over the area. As the tide starts to flood, flocks move back towards the mangrove.

*Calidris canutus* were always observed during the later part of the day in September 2007, and February 2008 also during the rising tide. These birds arrived from the western channel of the Gulf of Maranhão, and were invariably observed at rest. During high tide, they flew towards the center of the island, and were not observed during other periods of the tidal cycle.

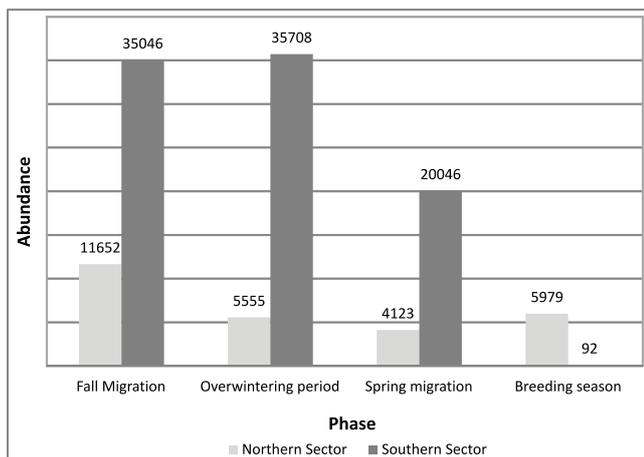
Huge flocks of *C. pusilla* were observed in the southern sector, perching on the branches of *R. mangle* until the mudflats were exposed. When this happened, flocks of *C. pusilla* occupied the area and after 2-3 hours, the birds spread themselves throughout the flats, remaining there for about six hours until the tide starts to rise again.

*Numenius phaeopus* and *T. semipalmata* were observed arriving from other areas after around two hours of the ebb tide, when sediments were still very wet and less dense and where crabs (*Uca* spp.) are abundant. *Tringa melanoleuca*, *T. flavipes*, and *A. macularius* were observed foraging and flying over the sandbanks and near the mangrove, respectively, during low the rising tides.

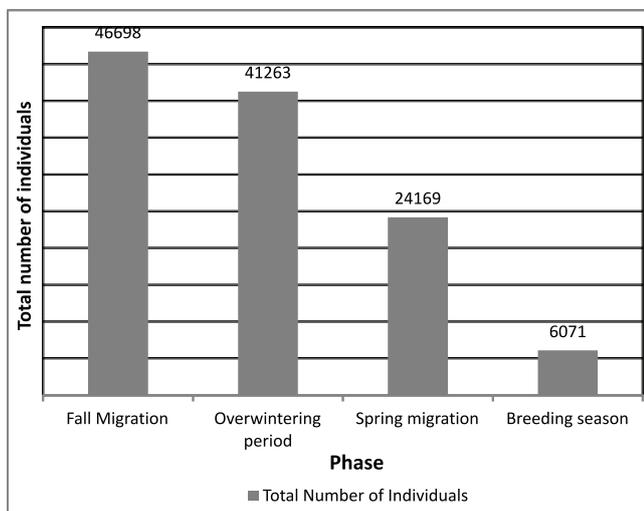
The distribution of *C. alba* in the northern sector was similar to that of *C. canutus*, arriving in similar numbers and aggregating near the mangrove, but at high tide they fly towards the center of the island. This species was observed in the same area in both months, in the late afternoon.

## DISCUSSION

*Calidris pusilla* was the most abundant species observed during the aerial surveys of Morrison and Ross (1989) on the northeastern coast of Brazil and in other studies in this region (Rodrigues 2000, 2001, 2007, Lopes 2003, Kober 2004, Silva 2007). In the study area,



**FIGURE 2:** Overall abundance of migratory shorebirds (Charadriidae and Scolopacidae) recorded on the northern and southern sectors of Caranguejos Island, Maranhão, northern Brazil, in 2007-2008.



**FIGURE 3:** Overall abundance of migratory shorebirds (Charadriidae and Scolopacidae) recorded on Caranguejos Island, Maranhão, northern Brazil, in 2007-2008.

the species exhibited abundance peaks during the fall and spring migrations, a pattern similar to that found by Rodrigues (2000, 2001) for the Gulf of Maranhão. According to Rodrigues (2000) these peaks reflect the arrival in northern Brazil of migrants from further north stopover areas in South America (*i.e.*, Suriname and the Guianas), although the presence of birds in breeding plumage in the Gulf of Maranhão in August suggests the arrival of birds directly from North America.

The coast of Brazilian Amazon is an important wintering area for *C. pusilla* in South America (Rodrigues *et al.* 2007), together with the Guiana coast (French Guiana, Suriname and Guyana), where abundance peaks occurred during the fall (Spaans 2003, Ottema and Spaans 2008). A total of 7,000 *Calidris canutus* were recorded during the fall migration, the period after which the numbers decrease. This species has two main wintering areas in South America, one in Tierra del Fuego (Chile and Argentina), and another in Maranhão (Baker *et al.* 2005, Atkinson *et al.* 2006, Niles *et al.* 2008). Smaller number of birds also spend non-breeding season in the French Guiana and Venezuela (Morrison and Harrington 1992). Rodrigues (2000) recorded some individuals in Maranhão during the fall and spring migrations, suggesting that the relative scarcity of the species during the spring migration may be related to the use of other areas of the coast of Maranhão.

Variation in numbers of *Tringa semipalmata* and *Numenius phaeopus* was similar to that recorded by McNeil (1970) and Spaans (1978) respectively in Venezuela in Suriname, where abundance peaks were noted during spring migration. On Cajual Island (Rodrigues 2000) and in the Raposa Channel (Silva 2007), both located within the Gulf of Maranhão, *T. semipalmata* was most abundant during the breeding season, while *N. phaeopus* during the overwintering period. Rodrigues (2000) compared the data on the seasonal variation in abundance with those of McNeil (1970) for Venezuela and Spaans (1978) for Suriname. According to this analysis, the abundance of *T. semipalmata* peaks much earlier (mid-August) in Surinam and the Gulf of Maranhão, suggesting that this species reaches the northern coast of Brazil from North America through non-stop flights over the Atlantic Ocean. Data on *N. phaeopus* suggests that it departs from the Guyanan coast to Maranhão.

As in the present study, Rodrigues (2000), and Silva (2007) recorded abundance peaks of *Limnodromus griseus* during the fall migration. Soares (2008) considered this species to be one of the most conspicuous at Santo Amaro Lake, in the Lençóis Maranhenses National Park (eastern Maranhão) during the rainy season, April-June. Apparently, *L. griseus* uses the coast of Maranhão as a stopover area during the spring, before moving to southward wintering sites.

The abundances of *P. squatarola*, *C. semipalmatus*, and *C. alba* peaked during the overwintering period, in

December and February. Rodrigues (2000) recorded the highest abundance of these species during the same period in the Gulf of Maranhão. Birds in breeding plumage were observed in during the fall migration, indicating that they possibly engage trans-oceanic flights between North America and the coast of Maranhão.

*Charadrius semipalmatus* was one of the most abundant species recorded by Roth and Scott (1987) in the coastal plains surrounding the Gulf of Maranhão, between August and October. This would explain the reduced numbers of *C. semipalmatus* on Caranguejos Island at this time which is the local dry season. During the subsequent rainy season, the coastal plain is flooded, forcing birds to move to other areas.

Habitat use by shorebirds is influenced by environmental variables, such as tidal fluctuations, salinity, and availability of alternative habitats (Collazo *et al.* 1995). Because of this, the higher species richness observed on the northern sector of Caranguejos Island was probably due to the greater variety of habitats at this site, which included sandbanks and sand/mud flats. Silva (2007) also recorded a higher richness of shorebirds on the sandy/muddy sediments of the Raposa Channel. While the differences were not significant, shorebirds were more abundant in the southern sector of the island, except during the breeding season, probably due to the muddy substrates and other variables, such as the lower salinity, related to the discharge of the Mearim River.

The overall abundance of shorebirds in both regions of the island during the different phases of the annual migratory cycles also did not vary significantly, despite the considerable differences between the fall migration (total of 46,698 individuals) and overwintering period (41,263 birds) and the breeding season (6,071 birds). A similar pattern was recorded by Collazo *et al.* (1995), Rodrigues (2000), and Silva (2007). The relative high abundance of shorebirds during the breeding season is probably related to the presence of immature birds (non-breeding subadults) or adults that have been unable to reach the body weight necessary for the return migration (Rodrigues, 2001).

*Calidris pusilla*, *Limnodromus griseus*, *Numenius phaeopus*, *Tringa semipalmata*, *Pluvialis squatarola*, and *Arenaria interpres* were all observed perching in *Rizophora mangle* and *Avicennia* spp. trees during high tides. Similar behavior was observed by Rodrigues (2007) on São Lucas Island in Maranhão.

The birds seen flying towards the western coastal plain and the Gulf of Maranhão (*i.e.*, *P. squatarola*, *C. semipalmatus*, *N. phaeopus*, *T. semipalmata*, and *A. interpres*) after foraging at low tide may have been looking for different sites to forage, specifically in areas further west along the coast in the "Reentrâncias", a pattern which was also observed by Rodrigues (2000, 2001, 2007) Rodrigues *et al.* (2007), Soares (2008), and Silva

(2007). Use of other foraging areas may explain the behavior of *C. canutus* in the northern sector and *C. alba* in the southern sector of the island. The birds probably arrived from the western channel of São Marcos Bay to rest, and move towards the center of the island at high tide, thus not being observed during other tidal phases.

The preferences of *N. phaeopus* and *T. semipalmata* for areas located on sandy/muddy substrates may be explained by the fact that these species are mainly crab-eating shorebirds (Backwell *et al.* 1998). Silva (2007), for example, observed high densities of these two shorebirds in areas typically inhabited by *Uca* spp. crabs.

On the beaches of Caranguejos Island, no sandy areas remain uncovered adjacent to the feeding grounds at high tide, forcing shorebirds to seek refuge further inland, especially on Verde Island, which harbors areas appropriate for resting. In satellite images, Verde Island appear to be covered by salt marshes, although Fortes (2004) explains that this is due to the presence of mangrove trees of the genus *Avicennia*, which have relatively low biomass.

One of the most important factors contributing to variation in the abundance of shorebirds on Caranguejos Island is probably the relatively reduced levels of anthropogenic impact. Site fidelity appears to depend on habitat quality, while species' relative abundances may be determined by the sizes of available habitats (Rodrigues 2001, 2007, MMA 2005, Rodrigues *et al.* 2007). The island is nevertheless characterized by highly dynamic tidal forces, which often sweep away the marginal vegetation and form new channels (Fortes 2004). In addition to these natural forces, the island suffers a number of anthropogenic impacts, including accumulation of household waste deposited by the tide and the predatory exploitation of animal resources by local fishermen, shrimpers, and crabbers. Given the importance of Caranguejos Island as an overwintering area for migratory shorebirds, especially *Calidris pusilla*, further studies are needed in order to better understand the habitat use by the different species and the local patterns of abundance and diversity, as well as identifying key factors for the conservation of the local avifauna.

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