EFFECTS OF THE SHOREBIRDS PREDATION ON THE ESTUARINE MACROFAUNA OF THE PATOS LAGOON, SOUTH BRAZIL.

Washington L. S. Ferreira ¹, Carlos E. Bemvenuti ² & Leonardo C. Rosa ³*

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ABSTRACT

A field experiment was performed between February and May 2002 to evaluate the predation effects of migratory shorebirds on the macrofauna structure at an intertidal mudflat of the estuarine region of the Patos Lagoon. Predators were excluded by use of the metallic cages (20 x 20 x 30 cm). The macrofauna densities in shorebird exclusion treatments were always lower or equal to controls, indicating a no significant predation effect. The lower macrofauna densities in shorebird exclusion cages were probably associated to crab intrusion, which had been benefited by protection of this treatment. The low shorebird predation effects observed in this study can be related to biological characteristics of these predators associated to the local environmental conditions during the realization of these experiments.

INTRODUCTION

Shorebirds are some of the most important consumers of the intertidal communities due to their high energetic requirements and efficiency in acquiring food (sensu Goss-Custard, 1984). However, studies have shown that the effects of the shorebirds predation on the intertidal communities can be highest variable depending on the birds densities, their feeding rates, and prey population dynamics (Wilson, 1991). In some cases, shorebirds have been to control the densities (Quammen, 1984; Mercier & McNeil, 1994) and size frequency distribution of their prey (Zwarts & Esselink, 1989; Wilson, 1991) while in other cases they may only affect the densities of the most abundant species (Schneider, 1978).

Mudflats in bays and estuaries are essential feeding sites along the shorebird migratory route between breeding and wintering grounds (Goss-Custard, 1984). In the estuarine region of the Patos Lagoon, studies about distribution, abundance and diversity of the shorebirds (Ihering, 1885; Vooren, 1997) had suggesting that the intertidal mudflats of this lagoon can be important stop-over sites in the migratory shorebirds route, specially to families Charadriidae and Scolopacidae (Vooren, 1997).
However, despite the impact of this predators on intertidal communities being still unknown.

The main goal of this study is to evaluate the predation effects of migratory shorebirds on macrofauna structure at an intertidal mudflat of the estuarine region of Patos Lagoon. In these intertidal areas, the presence of the burrowing crab Chasmagnathus granulatus is also common, which may reach densities up to 98 ind. m$^{-2}$ (D’Incao et al., 1990). This crab is an important controller of the intertidal communities by affecting abundance and distribution of organisms through sediment disturbance (Iribarne et al., 1997; Botto & Iribarne, 1999; Rosa & Bemvenuti, 2004). Thus, an exclusion experiment was performed so that the shorebirds predation effects could be distinguished from the probable C. granulatus effects or the other predators/bioturbator organisms.

**MATERIALS AND METHODS**

The study was carried out at intertidal mudflat (ca 0.2 ha) located in the south portion of the Pólvora Island (32° 01’ S; 52° 06’ W) although four consecutive field experiments realized from February to May of 2002. For predators exclusions were utilized metal cages (dimensions: 25 by 25 by 30 cm) recovered with a metallic mesh size of 4 mm. Each experiment had three treatments: (1) total exclusion (i.e., shorebirds plus crabs; where border cages was buried 15 cm into sediment); (2) shorebirds exclusion (border cages standing 5 cm over sediment) and, (3) control (25 by 25 cm previously marked areas without any manipulation). In all cases treatments had 8 replicates and were randomly distributed into study area.

After 30 days of the experiment implementation, following the maximum time recommended to similar environments (Dumas & Witman, 1993; Sutherland et al., 2000), one biological sample by treatment replicate was taken using a corer tube (0.008 m$^2$ of area and 20 cm depth) and, the treatments were randomly replaced in the study area again. Biological samples were in situ sieved through a 0.3 mm mesh size and fixed in 4% buffered formaldehyde. In the laboratory, organisms were sorted under a stereo microscope, counted and preserved in 70% alcohol. The density of benthic invertebrates was expressed as number of individuals per m$^2$.

Weekly shorebird censuses (30 minutes of duration from early morning) were made by an observer standing approximately 50 m from the experimental area and using a 10 X 25 binoculars to identify species and count the numbers of individuals. Monthly mean abundance of shorebirds was achieved by mean of 4 weekly censuses.

One-way ANOVA was used to compare macrofaunal density among the treatments at each experimental period individually. All data were tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Cochran test and standard deviations-mean plots) prior to their use in statistical analyzes (Underwood, 1997). Data were log (x+1) transformed to assure variance homogeneity and

<table>
<thead>
<tr>
<th>Species</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
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<tbody>
<tr>
<td>Charadriidae</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pluvialis dominica</td>
<td>2.7 (± 2.5)</td>
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<tr>
<td>Vanellus chilensis</td>
<td>1.3 (± 2.5)</td>
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<tr>
<td>Scolopacidae</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Calidris fuscicollis</td>
<td>4.5 (± 9)</td>
<td>4.3 (± 7.5)</td>
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<td></td>
</tr>
<tr>
<td>Calidris camutus</td>
<td></td>
<td>15.7 (± 27.1)</td>
<td></td>
<td></td>
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<tr>
<td>Tringa flavipes</td>
<td>5 (± 8.7)</td>
<td>0.3 (± 0.6)</td>
<td>2 (± 2.8)</td>
<td></td>
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<tr>
<td>Limosa haemastica</td>
<td>10.5 (± 21)</td>
<td></td>
<td></td>
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<tr>
<td>Recurvirostridae</td>
<td></td>
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<tr>
<td>Himantopus himantopus</td>
<td>2 (± 3.5)</td>
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Table 1. Composition, mean abundance and standard deviation (in parentheses) of shorebirds in the study area during each experimental period.

Total 1.3 (± 2.5) 20 (± 28.3) 25.3 (± 41.3) 2 (± 2.8)
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ANOVA results showed significant differences (p < 0.05) in macrofauna densities among the treatments in all periods, except for experiment realized in May (Fig. 1-4). In February, the gastropod *H. australis* shown significant differences (p < 0.05) among the treatments, where highest densities was observed at exclusion total than control and birds exclusion (Fig. 1). The polychaetes *L. acuta*, *H. similis* and *N. fluviatilis* shown densities significantly lower at birds exclusion.

Fig. 1-4. Mean density (ind. m⁻²) of the dominant organisms among the treatments for experimental period of: (1) February; (2) March; (3) April and, (4) May of 2002. Asterisks indicate significant differences (p < 0.05) among treatments determined by SNK test. (Kal: Kalliapseudes schubartii; Het: Heteromastus similis; Lae: Laeonereis acuta; Hel: Heleobia australis; Uro: Uromunna peterseni; Nep: Nephtys fluviatilis).

RESULTS

Eight shorebird species belonging to three families (Table 1) make use of the study area during the four experimental periods. Lower values of richness and abundance were registered in February (i.e., 1 specie with mean abundance of ca. 1 individual) and in May (1 specie and 2 individuals), while highest values were observed in April (6 species and mean abundance of 25 individuals).

Regarding to macrofauna, there was collected a total of the 9,505 individuals. The most abundant organisms were the tanaid *Kalliapseudes schubartii*, the isopod *Uromunna peterseni*, the polychaetes *Laeonereis acuta*, *Heteromastus similis* and *Nephtys fluviatilis*, and the gastropod *Heleobia australis*, which pooled corresponding to 95% of the total fauna. Other organisms less frequent and/or abundant were the pelecypod *Erodona mactroides*, the cumacean *Diastylis sympertegiae*, the tanaid *Sinelobus stanfordi*, the amphipod *Mellita mangrovi* and juvenile of the decapods *Callinectes sapidus* and *Chasmagnathus granulatus*.

Similarities of macrofauna community structure among treatments for each experimental period were determined by non-metric multidimensional scaling ordination (MDS) on square root transformed data, using Bray-Curtis similarity index (Clarke & Warwick, 1994), and formal significance tests for differences were performed a priori by one-way ANOSIM test (Clarke, 1993). In cases in which ANOSIM results indicate differences, the contribution of each species for mean dissimilarity among treatments was determined through SIMPER analysis routine (Clarke & Warwick, 1994).
In turn, MDS (Fig. 5-8) ordinations don’t show a clear differentiation in macrofauna structure among the treatments, except to March experiment (Fig. 6), where control samples were clustered separately of both exclusion treatments.

**DISCUSSION**

The results showed no significant effect of the shorebirds predation on macrofauna in the intertidal mudflat of the Pólvora Island. In all experimental periods, the macrofauna densities at shorebirds exclusion treatments were lower or equal than control. The main differences observed among treatments were: (1) low densities of the polychaetes *L. acuta*, *H. similis* and *N. fluviatilis* in the shorebird exclusions in March and April period, and (2) higher densities of the *K. schubartii* and *U. peterseni* at control sites during April.

In both March and April experimental periods, the shorebird exclusion cages were invaded by juveniles of the burrowing crab *C. granulatus*, which can have contributed to decrease of polychaete densities in this treatment. This crab intrusion indicate an artifact effect (Reise, 1985), situation where the treatment act as an attractive to predators mainly by promoted protection to determinate organism size classes. However, there exist none evidence that this crab, especially juvenile forms, selectively preys on these polychaetes. In other
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hand, most studies had shown that the sediment disturbance resulting of construction and maintenance of the burrows by these crabs could to affect the distribution and densities of these macrofaunal organisms (Botto & Iribarne, 1999; Rosa & Bemvenuti, 2004).

In the same way that *C. granulatus* was benefited by cages presence, others subtidal predators, like as the blue crab *Callinectes sapidus* or fishes, could also be benefited by this protection during intertidal flooding times. Consequently, the lower polychaete densities into shorebirds exclusion cages are probably related to *C. granulatus* disturbance or to predation by subtidal organisms, or to interaction of both factors.

Higher densities of the *K. schubartii* and the *U. peterseni* at control sites during April experiment could be due to high spatial variability of these organisms. Peracarid crustaceans such as *K. schubartii* and *U. peterseni* have a highest aggregated distribution, especially during recruitment time when juveniles settle around the females. In the region, recruitment period of these species occurs from summer to early autumn (Bemvenuti, 1987; Fonseca & D'Incao, 2003; Leite et al., 2003). Considering that the experiments coincided with macrofauna recruitment period and, that to each experimental period the treatments were replaced into study area, it's more plausible that differences in peracarid densities among treatments is resultant of spatial distribution patterns then.

The absence of a significant shorebird predation effect can probable be related to biological characteristics of these predators associated to local environmental conditions of study area during the realization of experiments.

Shorebirds have a higher energetic requirement (Evans, 1976) and, consequently, both the distribution and the abundance then are associated with food availability (Goss-Custard, 1984; Goss-Custard et al., 2002). Comparing to other birds of similar size, the shorebirds have higher metabolic rates due to elevated energetic consumption during migratory trips (WILSON, 1991). In this way, not only the food amount but also the quality of the alimentary resource is responsible for the distribution pattern of these predators (Goss-Custard, 1984; Wilson, 1991; Goss-Custard et al., 2002). The food requirement degree associated with displacement easiness makes with that the shorebirds select predetermined feeding places, instead of trying to randomly search food (Verkuil et al., 1993; Backwell et al., 1998).

Nevertheless, environmental conditions may to affect feeding activities of shorebirds in these places (Goss-Custard, 1984). For example, if in a determinate feeding place the flooding conditions inhibit to prey capture the shorebirds may easiness is displacing to other feeding areas.

The Patos Lagoon estuary has a singular hydrodynamic, which are strongest influenced by rain and wind resulting in irregularly flood intertidal habitats (Costa et al., 1998). This intertidal habitats can remain emerged by prolonged times, however, little alterations in the wind regime makes with that this mudflats are flooded quickly. After experiment implementation, the study area was flooded many times, that probably reflected at the lower observed shorebird densities. Besides to affect shorebird densities, the intertidal flooding conditions also reduced the effective predation time and, thus inhibit that an effective shorebird predation could be detected.

However, the fact of our results indicate no significant shorebird predation on intertidal macrofauna just reflect the local environmental conditions during experiment time. Thus, for effectively to evaluate the shorebird predation effects on intertidal macrofauna of the Patos Lagoon estuary are need to repeat these experiments on others environmental conditions and, preferentially, in more different stop-over sites.

Furthermore, the presence of juveniles individuals of the *C. granulatus* inside shorebird exclusion cages indicate a protection effect promoted by these treatment and, consequently, suggest a possible predation effect of shorebirds on these individuals as once registered at others similar estuaries (Iribarne & Martínez, 1999). However, the utilization of juveniles of the *C. granulatus* as food resource by shorebirds in the intertidal flats of the Patos Lagoon estuary will have to be considered in future researches also.
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