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Atlantorchestoidea brasiliensis (CRUSTACEA: AMPHIPODA) AS AN INDICATOR OF DISTURBANCE CAUSED BY URBANIZATION OF A BEACH ECOSYSTEM

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ABSTRACT

This study analyzed a comparison of the *Atlantorchestoidea brasiliensis* (Crustacea: Amphipoda) density of a preserved area with that of an urbanized one, both on Peró Beach, Cabo Frio, Rio de Janeiro state. Seasonal samplings were conducted of the population of talitrideos and an estimation of the number of swimmers in these areas was made. The lowest frequency of swimmers was recorded in the preserved area regardless of sampling period. In the urbanized area swimmers were most frequent in January (550 individuals/m^{-1}). The statistical tests showed the absence of *Atlantorchestoidea brasiliensis* in the urban area, indicating that this species is extremely sensitive to the urbanization of beaches. The use of the Talitridae family as an indicator of the impact of urbanization on the ecosystems of sandy beaches is also discussed.

RESUMO

Este trabalho é um estudo comparativo da densidade de *Atlantorchestoidea brasiliensis* (Crustacea: Amphipoda) no trecho urbanizado e no trecho preservado da praia do Peró, Cabo Frio, Rio de Janeiro. Foram realizadas coletas sazonais da população de talitrídeos, assim como uma estimativa do número de banhistas nessas áreas. Na área preservada foi registrada a menor freqüência de banhista independente dos períodos amostrados, enquanto que no trecho urbanizado a maior freqüência ocorreu no mês de Janeiro (550 indivíduos/m^{-1}). As análises estatísticas mostraram a ausência de *Atlantorchestoidea brasiliensis* na área urbanizada em todos os períodos amostrados, indicando que essa espécie é bastante sensível à urbanização das praias. É discutida também a utilização da família Talitridae como indicadora de impactos oriundos dos efeitos de urbanização nos ecossistemas de praias arenosas.

Descriptors: *Atlantorchestoidea brasiliensis*, Sandy beach, Urbanization.
Descritores: *Atlantorchestoidea brasiliensis*, Praia arenosa, Urbanização.

INTRODUCTION

Beaches are without doubt among the most popular and attractive areas for humans, because in addition to their scenic beauty, they provide diverse uses and benefits. The importance of beaches for the growth of the tourist industry has been discussed by several authors (DE RUYCK et al., 1997; WESLAWSKI et al. 2000b, SCAPINI, 2003; ORAMS, 2003). Tourism has been increasing considerably in coastal areas in recent decades and has become the economic base of various cities, regions, and even countries (SANTANA, 2003). The economic benefits of tourism provide a significant increase in cash flow, in addition to the development and diversification of commercial activities (DE RUYCK et al., 1997; ORAMS, 2003). Although when in its initial stages, tourism is widely viewed as positive, a significant number of cases point to environmental degradation as a consequence of urbanization and growth of infrastructure to provide facilities for bathers (DE RUYCK et al., 1997; MOFFETT et al., 1998; SCAPINI, 2003; ORAMS, 2003; JEDRZEJCZAK, 2004; FANINI et al., 2005; VELOSO et al., 2006).

With regard to the impact generated by tourist activities, various studies have discussed the negative effects, such as the loss of plant cover, erosion, decrease in biomass and the associated fauna, and interference with succession processes and energy transfer to the adjacent ecosystems, of the passage of vehicles and of human trampling, on dune ecosystems (HOSIER; EATON, 1980; VAN DER MERWE, D.; VAN DER MERWE, D., 1991; RICKARD et al., 1994; ANDERSEN, 1995; DAVENPORT, J.; DAVENPORT, J. L., 2006). Studies on impacts on beaches are still few, and little is known about the consequences to the structure and functioning of the beach ecosystem caused by urbanization and trampling by bathers (MOFFET et al., 1998; VELOSO et al., 2006; WESLAWSKI et al., 2000a; BARCA-BRAVO et al., 2008; UGOLINI et al., 2008; VELOSO et al., 2008).

One of the most frequent activities worldwide on urbanized and tourist beaches is trash removal, principally on beaches where there is a large accumulation of stranded algae (LLEWELLYN; SHACKLEY, 1996; COLOMBINI et al., 2000; WESLAWSKI et al., 2000a; FANINI et al., 2005; VELOSO et al., 2006, 2008; BARCA-BRAVO, 2008). The trash left by bathers consists mainly of cans, plastic articles, paper, cigarettes and the remains of food (SANTOS et al., 2005; OIGMAM-PSZCZOL; CREED, 2007). Studies on this subject indicate that cleaning is one of the factors that damage biodiversity and natural decomposition processes (LLEWELLYN; SHACKLEY, 1996) because of the resulting removal of individual organisms and food sources. Detritus and stranded algae provide food and shelter for such various organisms (SCAPINI et al., 1997; JEDRZEJCZAK, 2002a; COLOMBINI et al., 2000; HARRISON, 1997) as Coleoptera, Mollusca, Oligochaeta, Nematoda, Isopoda, and principally Amphipod of the family Talitridae. Talitrids are the first colonizers of stranded algae, and have been the most studied (STENTON-DOZEY; GRIFFITHS, 1983; INGLIS, 1989; MARSDEN, 1991a,b; COLOMBINI et al., 2000).

The sensitivity of amphipods of the family Talitridae to human occupation has been reported in various studies. Trampling and beach cleaning are most often indicated as responsible for the drastic decrease of populations of *Talitrus saltator* Montagu, 1808 (LLEWELLYN; SHACKLEY, 1996; WESLAWSKI et al., 2000b; FANINI et al., 2005; VELOSO et al., 2008; BARCA-BRAVO, 2008) on highly frequented beaches in Europe. In addition to amphipods, according to Barros (2001), the ghost crab *Ocypode cordinama* had significantly fewer burrows on urban than on non-urban beaches in New South Wales. Barros suggested this species as a possible indicator of human impact. The consequences of trampling for beach macrofauna and meiofauna have been discussed in the studies of Moffett et al., 1998, Weslawski et al., 2000a, Moellmann and Corbisier, 2003, and Veloso et al. 2006.

In spite of the existence of many studies on their period of activity (FALLACI et al., 1999), orientation (BORGIOLI et al., 1999; D'ELIA et al., 2001; MARCHETTI; SCAPINI, 2003), migration (SCAPINI et al., 1992), consumption (ADIN; RIERA, 2003; JEDRZEJCZAK, 2002a, 2002b), and response to disturbances (WESLAWSKI et al., 2000b; FANINI et al., 2005; BARCA-BRAVO, 2008), this information is concentrated on *Talitrus saltator* of the Atlantic and Mediterranean coasts of Europe. These studies reveal that *T. saltator* shows peaks of activity concentrated in the early hours of the morning and late afternoon and that the species is influenced by outgoing tides and oriented by environmental and intrinsic factors (e.g., sex, age, asymmetry of the eye). Furthermore, individuals of this species are great consumers of algal material stranded on the beach. The distribution of *T. saltator* along the upper zone of the beach face and on the post-beach coincides with the area customarily occupied by bathers (UGOLINI et al., 2008), thus exposing the individual amphipods to human trampling.

By contrast, studies on the life strategy of *Atlantorchestoidea brasiliensis* are still very few (VELOSO et al., 1997a,b; CARDOSO, 2002) in spite of its ecological importance (VELOSO et al., 1997a; VELOSO; CARDOSO, 2001) and the threat of its disappearance from urbanized beaches on the coast of Rio de Janeiro (VELOSO et al., 2006; 2008). Information on its vertical distribution in the sediment, and experiments on its sensitivity to trampling are still sparse.

In this study, the population density of *A. brasiliensis* has been evaluated in an urbanized beach area and in a pristine beach region (see VELOSO et al. 2008), the main difference from the previous study being that this beach is not cleaned, which eliminates one of the factors responsible for the changes in talitrid populations, leaving only the factors of absence of dunes and trampling. On Peró Beach in the state of Rio de Janeiro, the vegetated dunes had been removed for the construction of a wide walkway and a kiosk adjacent to the supralittoral. The greatest frequency of bathers occurs mainly in summer. The present study sought to test the hypothesis that the density of *A. brasiliensis* is the same in the urbanized and preserved stretches. It also investigated the burrowing depth of this species and the effect of trampling on individual amphipods by means of experiments, and discussed whether *A. brasiliensis* is a good indicator of human impact on exposed sandy beaches.

MATERIAL AND METHODS

Sampling and Laboratory Procedures

The samples were collected on Peró Beach in the Lake District of the northern coast of Rio de Janeiro in August and November 2007 and January 2008. This beach is 6 km long and is located within an environmental protection area (APA Pau-Brasil). The collections were made in two different areas, one preserved and the other urbanized. The urbanized stretch is about 1 km long and 46 m wide, and here the dunes were removed for the construction of a lighted public walkway, an avenue, parking areas and kiosks. There are few permanent residents; the locality receives most visitors on weekends and holidays, and large numbers of bathers during the summer. In the urbanized stretch, the beach is cleaned sporadically and trucks are not used. The preserved area has dunes and vegetation, which impedes the passage of cars and makes access inconvenient for bathers. The number of visitors to this area is, therefore, small even in summer. In this area the beach is not cleaned.

In each area of the beach, 10 transects 5 m apart were established from the dune line to the sublittoral zone. Each transect was divided into 11 levels, from the base of the dunes to the lower limit of the lowest tide. Samples were taken from each level in a 0.04 m² quadrat, to a depth of 20 cm. The samples were washed at the sampling location, on a 0.71 µm mesh. In the laboratory, the amphipods were sorted, counted, and preserved in 70% ethanol.

In order to test whether human trampling affects the distribution of the amphipods, two plastic wading pools, 60 cm in diameter by 15 cm in height were used. The pools were filled to a depth of 10 cm with sand from the same beach. The sand was taken from an area where no amphipods were present, and was previously sorted to eliminate the possibility of introduction of other organisms. A screen 50 cm high was attached to the sides of each pool, to prevent organisms from escaping. Amphipods were caught and placed in the pool. After 30 minutes, the time needed for the amphipods to burrow into the sand, trampling was initiated in one of the pools, by a person weighing approximately 70 kg. The other pool, where no trampling occurred, was used as a control. The trampling lasted for approximately 15 minutes. Next, the sand was removed and the organisms were carefully sorted in the field; the live and dead individuals in the experimental and control pools were separated and counted.

To investigate the burrowing depth of the amphipods, a plastic tube 4.5 cm in diameter, sectioned every 5 cm, was used. This tube was inserted into the sediment to a depth of 25 cm, at points between 5 and 17 meters from the waterline, totaling 60 replicates. This procedure was repeated in August 2007 and January 2008, which correspond to midwinter and midsummer, respectively. The individual amphipods were sorted in the field, with the aid of plastic trays containing water, to prevent the amphipods from escaping.

In the preserved and urbanized stretches, the density of visitors was estimated for an area of 50 m². The number of people in this area was counted for a period of 15 minutes. The data were collected over 9 hours (08:00 hs to 17:00 hs) on the days of the collections.

Physical Characterization

To estimate mean grain size, samples of sediment were taken with a plastic sampler 3.5 cm in diameter, inserted to a depth of 10 cm, in the supra-, mid- and sublittoral zones. In the laboratory, the samples were dried at 70ºC and passed through a series of sieves of -2.5, -2.0, -1.0, 0.0, 0.5, 2.0, 2.5, 3.0 and 4.0 phi, to determine the mean grain size (FOLK; WARD, 1957). The results were expressed in millimeters.

The slope of each area was estimated on the days of collection, in accordance with Emery (1961). Dean's parameter (Ω; SHORT; WRIGHT, 1983) was calculated to assess the morphodynamic state of the beach: $\Omega=H_b/ W_s. T$, where H_b is the wave height in cm, W_s the velocity of sedimentation in cm s^{-1} (GIBBS et al., 1971), and T the wave period in seconds.

Statistical Analysis

The T-test for independent samples was used to test differences in abiotic variables between the two sampling sites.

Data for the number of visitors and the density of amphipods were log-transformed to base (x+1) for use in the statistical tests.

A two-way ANOVA was used to test for statistical differences in the number of bathers between the preserved and urbanized areas and Tukey's *a posteriori* test was used for differences among the months of the study.

Differences among the months of collection for the faunal density in the preserved stretch were tested by one-way ANOVA, and then by Tukey's *a posteriori* test.

To assess the differences between the faunal densities at the different burrowing depths in the months sampled, the Kruskal-Wallis non-parametric analysis was used, followed by Dunn's *a posteriori* analysis.

The results of the trampling experiments were assessed by the T test, through comparison of numbers of live and dead individuals following the trampling.

RESULTS

Peró Beach showed a maximum Ω = 0.85 and a minimum Ω = 0.83, and is therefore classified as reflective. The T-test did not show any statistical differences between the two sites sampled (Table 1).

Table 1. T-test for independent samples between preserved and urbanized area.

Physical variables	t-value	df	P
Grain size	-1,51017	16	0.150495
Wave period	-0.531518	14	0.603392
Wave height	1.830511	18	0.083782
Slope	-0.126852	26	0.900033

The urbanized area was more frequented by bathers during the months of the study, with the highest frequency occurring in January (550 indv/m^{-1}) because of the summer season and school holidays. In contrast, the preserved area showed little change in the number of visitors between the stretches observed (Fig. 1).

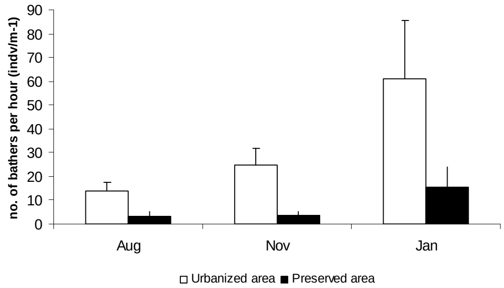

Fig. 1. Mean numbers of bathers per hour in the urbanized and preserved areas of Peró Beach during a 9-hour period. Vertical lines indicate one standard deviation.

The analysis of variance indicated significant differences between the areas and months analyzed (Table 2). Tukey's *a posteriori* test showed a significant value of p = 0.00124 for January.

Table 2. Tukey's test for the number of bathers (visitors) in the months sampled.

	SS	MS	F	P
Intercept	229.196	229.196	5320.094	0.000
Area	7.075	7.075	164.229	0.000
Month	3.961	1.980	45.972	0.000
Área x Month	0.132	0.066	1.533	0.226

The amphipod fauna was represented only by *Atlantorchestoidea brasiliensis.* The urbanized area was characterized by an absence of fauna during all the months of the study, whereas the preserved area contained amphipods during the entire period. The highest density of *A. brasiliensis* was observed in January (20875 indv/m^{-1}) (Fig. 2).

The analysis of variance for the density of Amphipoda during the months of collection in the preserved stretch indicated a significant difference, with a value of p= 0.0369 and F= 3.738. The results of the *a posteriori* Tukey's test indicated that there was a significant difference in the density of *A. brasiliensis* between August and January (Table 3).

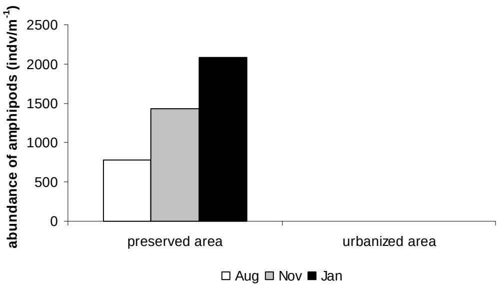

Fig. 2. Abundance of *Atlantorchestoidea brasiliensis* per linear meter on Peró Beach during the months of collection.

Table 3. One-way analysis of variance for the density (ind/m^{-1}) of *Atlantorchestoidea brasiliensis* during the months sampled.

Months compared	**Q**	**P**	
August x November	2.079	P>0.05	Ns
August x January	3.863	P<0.05	*
November x January	1.784	P>0.05	Ns

In both seasons of the year, the highest concentrations of individuals occurred in the first 10 cm of depth (Fig. 3). In winter, no individuals were found below 20 cm.

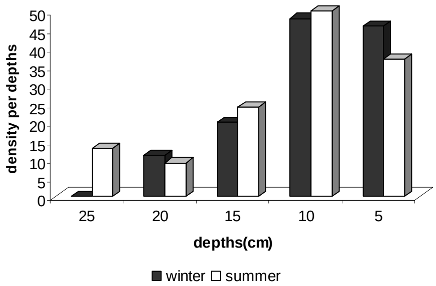

Fig. 3. Density of individuals of *Atlantorchestoidea brasiliensis* at different depths in the winter and summer periods on Peró Beach.

The faunal density at the different depths showed a significant difference in the two periods observed, with P<0.0001 and Kw= 36.666 in summer, and P=0.0296 and Kw= 8.979 in winter. In winter, no individuals were found at the 25 cm depth.

The *a posteriori* Dunn's test for the summer period indicated a highly significant difference between the depths of 25 and 10 cm, and 20 and 10 cm, as well as a significant difference between the depths of 25 and 5 cm, and 20 and 5 cm. During the winter, the depths between 20 and 10 cm showed a significant difference. Although the 15-cm depth contained twice the density of individuals as the 20-cm depth, the non-parametric test did not indicate a significant difference.

The effect of trampling on individuals of *A. brasiliensis* was highly significant, with a value of P= 0.0017 and T= 7.521 for the numbers present before and after trampling.

DISCUSSION

Several investigators have shown that beach morphodynamics can influence the density of populations, with some species showing higher densities in a certain morphodynamic type (JARAMILLO; MCLACHLAN, 1993; VELOSO; CARDOSO, 2001; CARDOSO et al., 2003; DEGRAER et al., 2003; LERCARI; DEFEO, 2003; DEFEO; GOMEZ, 2005; DEFEO; McLACHLAN, 2005). Comparisons within the same beach arc reduce the influence of the natural environmental factors, in spite of the variations in these parameters along the beach. The differences in the density of *Atlantorchestoidea brasiliensis* between the two stretches of Peró Beach do not appear to be related to the possible natural variations in the environmental parameters. This species has been previously recorded from different morphodynamic and granulometric types of beach, showing wide ecological plasticity (VELOSO; CARDOSO, 2001; VELOSO et al., 2003b). Thus, as with other morphodynamic parameters, the granulometric variations observed on Peró Beach due to sediment transport do not explain the absence of *A. brasiliensis* from the urbanized stretch. The results obtained in this study are similar to the findings of Veloso et al. (2006, 2008), which provided evidence of the sensitivity of the family Talitridae to the environmental changes resulting from beach urbanization.

Another problem inherent in evaluating the consequences of urbanization is that many actions are adopted or occur simultaneously, making it difficult to distinguish which one may be responsible for the decrease or loss of biodiversity. In general, urbanized stretches have large groups of people, mechanical cleaning, and an absence of dunes, which complicates the determination of the influence of each factor on changes in the population density of species.

On Peró Beach, cleaning is the least-intensive factor because it is done manually and infrequently (Veloso pers. obs.), which helps to separate the effects of cleaning from those of trampling, because the presence of these factors together leads to inconclusive results. For *A. brasiliensis*, beach cleaning can not only directly compromise its survival by reducing its population abundance, but also indirectly by removing the stranded material, which can be made available for lower trophic levels (COLOMBINI; CHELLAZZI, 2003). Removal of this material from the system can also affect higher trophic levels; for instance, it is a food source for birds (CARDOSO, 2002; DUGAN et al., 2003).

Dune removal is another factor that affects the occurrence of *Talitrus saltator* (LLEWELLYN; SHACKLEY, 1996; SCAPINI et al., 1997). Studies on this species have shown that it is capable of moving to primary dunes, according to climate and tide conditions (WILLIAMS, 1980; SCAPINI et al., 1992; FALLACI et al., 1999), requiring protection because it is sensitive to immersion. Because *T. saltator* is always associated with stranded algae and plant detritus, these amphipods constantly travel along the beach (SCAPINI, 1997; SCAPINI et al., 1997; COLOMBINI et al., 2000). Individuals of *A. brasiliensis* have not been recorded in dunes, although this species is also sensitive to immersion (pers. obs.). *Atlantorchestoidea brasiliensis* has a distribution perceptibly different from that of *Talitrus saltator*: the adults locate in the midlittoral zone and the juveniles locate in the lower part, near the swash line, and also travel along the beach (CARDOSO; VELOSO, 2001; CARDOSO, 2002). On reflective beaches of the coast of Rio de Janeiro there is little stranded seaweed, and the greater part of the detritus is composed of dead marine animals and insects (CARDOSO, 2002). The dune system appears to be important for the exchange of matter and energy in these systems (McLACHLAN; BROWN, 2006), because it contributes deposited organic matter of terrestrial origin, mixing with the deposited material of marine origin, and can serve as an area of shelter from waves and storms.

Population fluctuations are common for *A. brasiliensis*, which reaches its highest density in summer (VELOSO et al., 2003a). Higher numbers of juveniles and ovigerous females appear in February (CARDOSO; VELOSO, 1996). The greatest frequency of bathers in summer coincides with the highest density of *A. brasiliensis*, because of the breeding season of this species (CARDOSO; VELOSO, 1996). This factor can increase the negative interaction during this period, because the amphipods are present on the same beach levels as the bathers, approximately 35 m from the waterline, which may affect the mortality of the amphipods precisely during their breeding season.

The results of the experiments on burrowing depth indicated that more than 80% of the population occurs to a depth of 10 cm. This is the same depth found in studies of the activity of *T. saltator*, which have reported its distribution concentrated at depths of from 5 to 10 cm (BORGIOLI et al., 1999; D'ELIA et al., 2001). In the winter period, individuals occurred in the more superficial layers, and were absent at a depth of 25 cm. The higher temperature of the sand, and the smaller amount of moisture in the sediment provide evidence of the low tolerance of the species to desiccation (WILLIAMSON, 1951; SCAPINI, 1997). These factors can explain the greater burrowing depth in the summer, and the low tolerance. Also, trampling by bathers intensifies greatly during the warmer months. According to Veloso et al. (2008), the increase in the number of visitors on Barra da Tijuca Beach could easily expose individuals, even buried ones, of *A. brasiliensis* to the impact of trampling, because the shallow burrowing depth can facilitate the movement of the individuals to the surface.

Although the effect of trampling in a confined location does not provide the same conditions as the natural medium (UGOLINI et al., 2008), the experiments demonstrated an immediate impact of human trampling on the amphipods. The negative effects of human trampling in controlled experiments were first examined by Moffet et al. (1998), who submitted individuals of *Donax serra* to different trampling intensities (number of passes) in a restricted environment (wooden boxes with steel-screen bottoms). High mortality of *D. serra* and greater fragility of young individuals were observed in this study; nevertheless, comparisons in the field between the density of this species in open areas of the beach and beneath volleyball courts revealed an absence of disturbance. In contrast to the donacids, talitrids are saltatory organisms that actively explore the sediment surface during low tide (WILDISH, 1998; SCAPINI et al., 1992; CARDOSO, 2002), and that, probably because of this life strategy, are more susceptible to impacts. In this context, trampling experiments with enclosed organisms (UGOLINI et al., 2008; present study) are attempts to simulate the restricted environment to which the talitrids are subjected when there are high densities of bathers in the zone of their natural distribution (VELOSO et al., 2006; 2008) along the entire beach arc.

Barros (2001) discussed the advantages of adopting an indicator species to detect human impacts on beach ecosystems. This type of evaluation has previously been used in other ecosystems. The application of this methodology can benefit monitoring of exposed sandy beaches, since field studies on the entire macrofauna require a large sampling effort. Because a beach is a very dynamic environment, temporal variability must also be considered, and temporal repetition is necessary, which involves more expense. Nevertheless, the choice of indicator species presents advantages and disadvantages. Counting the number of burrows may not provide a true estimate of the abundance of members of the family Ocypodidae, because these crabs can construct closed burrows (BARROS, 2001). Species with larval development can impede the analyses of fluctuation of density through time, because the beach can receive recruits from different localities (CARDOSO et al., 2003). *Emerita brasiliensis* (Decapoda) and *Donax hanlyanus* (Pelecypoda), filter-feeders of the swash zone, are apparently less vulnerable to urbanization pressures, because they are always present in urban areas; although their population densities there are lower than in preserved areas (VELOSO et al., 2006).

Amphipoda (peracarids), have direct development and occur in the middle and supralittoral zones, where the bathers stay. Amphipods offer an advantage for studies because they can be observed during the morning and evening periods, when they rise to the surface in search of food, at times when bathers are still present (CARDOSO, 2002; VELOSO et al.,1997a VELOSO et al., 2003b).

The stimuli for the occupation of small coastal cities are provided by public agencies that envisage economic development through the expansion of real estate and tourism (SANTANA, 2003). Thus, beaches that were formerly little frequented are now subject to strong occupation pressure and exploitation of their natural resources. The absence of planning, inventories, intensive monitoring, environmental education, and management of protected areas has maximized the problems and impeded initiatives to conserve the beach ecosystems. Simple preservation measures could minimize environmental problems on beaches located in environmental preservation areas, such as the establishment of passage corridors, prohibition of civil construction, and prohibition of vehicles on the beaches and dunes. Management of coastal areas must ensure the sustainability of the system and guarantee the maintence of key processes such as sediment transport and organic-matter cycling.

Environmental protection areas in the coastal and marine region have shown themselves to be efficient tools for conservation, contributing to the preservation of biodiversity and the maintenance of ecological processes (FERNANDEZ et al., 2000; GARCIA-CHARTON et al., 2000; VELOSO et al., 2006). Plans for management and preservation must be based on scientific information about the structure, processes, and patterns, to attain their objective of maintaining the integrity and sustainable use of this ecosystem as a priority above the comfort of bathers and economic development (JEDRZEJCZAK, 2004).

Atlantorchestoidea brasiliensis has several interesting characteristics for an indicator species:

direct development, its distribution on the beach, shallow burrowing depth, ease of visual identification, and short life cycle (CARDOSO, 2002; CARDOSO; VELOSO, 1996); and thus could, together with other species such as *Ocypode* sp., be useful for monitoring the beach ecosystem.

The evaluation of impacts on beaches is not an easy task. Among the problems is the lack of previous faunal surveys, which makes post-impact comparisons impossible (UNDERWOOD, 2001; JONES, 2003). The variations in the environmental factors and the intense natural fluctuations in the population densities of the majority of species make long-term studies necessary (CARDOSO;VELOSO, 1996; VELOSO et al., 1997a,b; VELOSO et al., 2003a).

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