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SPATIAL DISTRIBUTION OF AND ANTHROPOGENIC IMPACTS ON GHOST CRAB *Ocypode quadrata* (CRUSTACEA, OCYPODIDAE) BURROWS IN MACEIÓ, BRAZIL

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ABSTRACT

Human impacts on sandy beaches have increased year by year. In proof of the existence of these disturbances, several species which live in these environments function as potential bioindicators of the environmental health by oscillating the density of individuals in the population. Ghost crabs, or marias-farinhas, as they are known in Northeast Brazil, have been effectively used to measure levels of anthropic influence on their habitat. This study shows that human disturbances, e.g. recreational activities and pollution, have a great influence on the abundance of ghost crab burrows. Burrow abundance decreased considerably on the urban beach (Avenida beach) when compared with the non-urban beach (Pontal sand bar). It was also observed that burrows were randomly distributed at both beaches.

Key words: crustaceans, environmental health, supratidal zone, maria-farinha.

RESUMO

Os impactos do homem em praias arenosas têm crescido ano após ano. Como prova da existência de tais distúrbios, várias espécies que vivem neste ambientes funcionam como (ou podem ser) bioindicadores potenciais da qualidade ambiental através da oscilação da densidade de indivíduos na população. Os caranguejos-fantasmas, ou marias-farinhas, como são conhecidos no nordeste do Brasil, têm sido utilizados eficientemente para medir os níveis de influência antrópica em seu hábitat. O presente estudo mostra que distúrbios antrópicos, como atividades recreacionais e poluição, têm uma grande influência na abundância de tocas do caranguejo-fantasma. A abundância de tocas foi consideravelmente menor na praia urbana (praia da Avenida) quando comparada à da praia não-urbana (restinga do Pontal). Observou-se também que as tocas estavas distribuídas aleatoriamente em ambas as praias.

Palavras-chave: crustáceos, qualidade ambiental, supra-litoral, maria-farinha.

INTRODUCTION

The anthropogenic impacts on sandy beaches have been widely studied in order not just to make humans aware of their destructive capacity but also to find a way of reducing the impacts. The most common anthropogenic disturbances are the destruction of sandy dunes (construction of roads and buildings), and the recreational activities (Barros, 2001), which causes the compaction of sand and the destruction of burrows made by the organisms of the infauna.

Coastal regions get more and more urbanized and the environmental disturbances increase from year to year, affecting both organisms directly associated to the upper beach and those which live in the open ocean (Lerman, 1986). In these environments, the biological communities gradually reduce their diversity and the survivor organisms often face more selective barriers. Anthropic disturbances include from recreational activities to discharges of sewage systems into the ocean. Many times, the beaches act as giant trash boxes, where animals have to face inorganic garbage (plastic bags, cans and chemical pollutants) so as to construct the burrows where they live.

The use of biota as a tool to assess human impacts on a specific environment has increased successfully. The invertebrates are the most used organisms due to the fact that they are considered sensitive to changes in their habitats (Veloso *et al*., 2006).

The *Ocypode* (Weber, 1795) species (ghost crabs) seem to be an effective bioindicator of the health of sandy beaches. They are the largest permanent residents of the upper beach and, therefore, an important member of the beach community as scavengers and predators (Lerman, 1986). However, the ghost crab populations have been changed by the destruction of dunes by humans.

Boschi (2000) established fourteen marine zoogeographic provinces for the Americas. The *Ocypode* species were present in nine of these provinces. The species *Ocypode quadrata* (Fabricius, 1787) (Crustacea, Ocypodidae) showed to be widely distributed: from provinces of warm-temperate waters (California province) in the North America to provinces of cold-temperate waters (Carolinian and Virginian provinces) in the South America. This tolerance to a wide range of temperatures must be taken as an euryterm niche. This species is the only one found on the Brazilian coast (Melo, 1996).

The ghost crabs are organized on a conspicuous zonation: the young crabs burrow near the water and their burrows are covered by high tides for a time, the mature crab burrows are located farther from water on the upper beach (Williams, 1984).

In spite of their large occurrence area (throughout the Indo-Pacific region and along the coasts of North and South America), records of ghost crabs being harvested either for food or for bait are rare. The ghost crabs are used for food in southern Mozambique and for bait along most of the KwaZulu-Natal coastline, likewise are the mole crabs (Kyle *et al.*, 1997).

Several researchers have studied the *Ocypode* crabs. The studies include their reproduction (Haley, 1969; Negreiros-Fransozo *et al.*, 2002), locomotion energetics (Blickhan & Full, 1987; Full, 1987) and kinematics (Blickhan *et al.*, 1993), urine chemical composition (De Vries *et al.*, 1994; Weihrauch *et al.*, 2004), age structure (Alberto & Fontoura, 1999), morphology (Schenk & Wainwright, 2001) and burrows architecture (Chan *et al.*, 2006).

This study aims to provide knowledge about the spatial distribution and pattern of dispersion of ghost crab burrows on sandy beaches of Maceió, Brazil, as well as to confirm that these organisms function as a tool for rapid assessment of human impacts in such environments, making use of rapid and easy calculations.

MATERIALS AND METHODS

Studies were conducted at two beaches (Figure 1) on the coast of Maceió, Alagoas, Brazil, between October/2006 and March/2007. The sampled beaches were Avenida beach and Pontal sand bar. Two sampling was done on each area. Avenida beach was sampled on October 30, 2006 and February 27, 2007. Pontal sand bar was sampled on November 8, 2006 and March 7, 2007. Avenida beach (an urban beach) had most of its dunes destructed by humans to the construction of roads and buildings. Instead of dunes, there is a concrete wall inserted between the beach and the roads. Moreover, Avenida beach is polluted by the waters from the Salgadinho stream, which is polluted by the sewage system of Maceió. Pontal sand bar (a non-urban beach) is located in a Permanent Preservation Area (PPA). It presents low levels of recreational activities and no concrete wall.

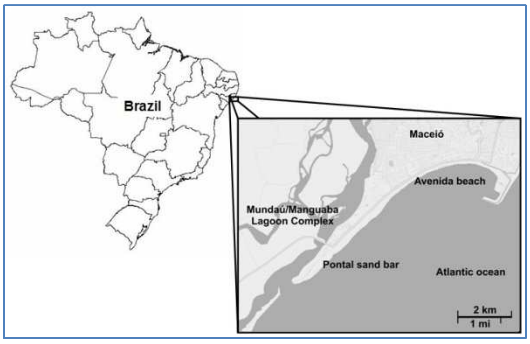

Figure 1 – Map of the studied area, showing Pontal sand bar and Avenida beach.

All the sampling was done in the day-time. To delimitate the sampling area, it was used a 100 meters long transect aligned parallel to the shoreline (Figure 2). Data were collected within an area of 600 m^2 (100 m x 6 m). In order to enable the dispersion analysis, checkered plates were used as maps of the sampled areas. The locations of burrows were recorded on the plate according to their distance from the transect. On Avenida beach, the transect was established from 9º40’16.8” S - 35º44’36.4” W to 9º40’18.0” S - 35º44’39.6” W. On Pontal sand bar it was from 9º42’08.4” S - 35º46’56.9” W to 9º42’10.9” S - 35º46’59.0” W. Burrows were signalized with small flags to facilitate the distribution analysis (Figure 3). Average density was calculated for each sample by dividing total number of burrows by area. Samples of seawater were brought to laboratory for measurement of salinity and pH using salinity and pH meters, respectively. During the sampling, air temperature was measured with mercury thermometer. One-tailed Student’s t-test was performed to test the null hypothesis that Avenida beach is statistically equal to Pontal sand bar regarding to burrow abundance.

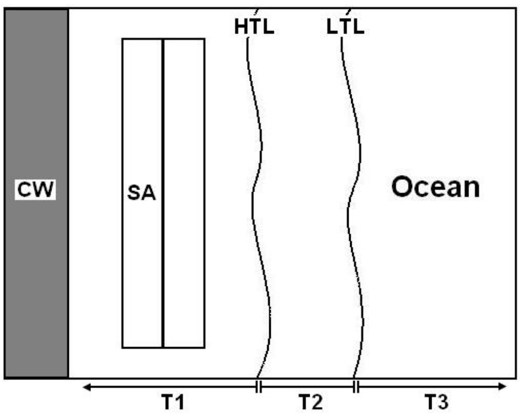

Figure 2 – Schematic diagram of the sampled region of the beach. CW = concrete wall (absent on Pontal sand bar), SA = sampled area, HTL = high tide level, LTL = low tide level, T1 = supratidal zone, T2 = intertidal zone, T3 = subtidal zone.

Figure 3 – Small flags signalizing burrows. (Photo by the author)

RESULTS

Results clearly show that the number of ghost crab burrows on non-urban beaches is statistically different from that on urban beaches. The distribution of burrows on the sampled areas ranged between 0 and 3 burrows m^{-2} on Avenida beach, and from 0 to 5 burrows m^{-2} on Pontal sand bar.

Although the variation between the minimum and maximum number of burrows per m^2 was not so different at both beaches, larger gaps (i.e. non-burrowed areas) were found on the urban area, which presented densities of about 0.0550 burrow m^{-2} in 2006 and 0.0783 burrow m^{-2} in 2007, while on the protected beach there were densities of 0.2150 burrow m^{-2} and 0.2817 burrow m^{-2} in the respective years. The large gap on Pontal sand bar in 2006 was result of strong winds which covered burrows with sand, making difficult their localization.

It was also observed that the abundance of burrows on Pontal sand bar was about 290.91% and 259.57% higher than on Avenida beach in 2006 and 2007, respectively. One-tailed Student's t-test (t = 0.044; df 1; p 0.05) shows that Avenida beach is statistically significantly different from Pontal sand bar regarding to ghost crab burrow abundance.

At both beaches, burrows were randomly distributed along the studied areas, implying that there is no apparent rule involved in the positioning of burrows in relation to one another (Figures 4 and 5).

The different data found in the studied areas resulted from the different levels of urbanization on the sampled beaches: while the Avenida beach showed high levels of recreational activities (e.g. soccer matches, people walking) and inorganic garbage on the sand, and a sewage system flowing into it, Pontal sand bar did not appear to be as impacted as the urban beach, though inorganic garbage was also found there.

Salinity and pH of seawater and atmospheric temperature did not seem to influence the results due to the fact that they were similar at both beaches, ranging from 36.0 psu to 37.1 psu (salinity of seawater), from 7.81 to 8.24 (pH of seawater) and from 27℃ to 30℃ (atmospheric temperature).

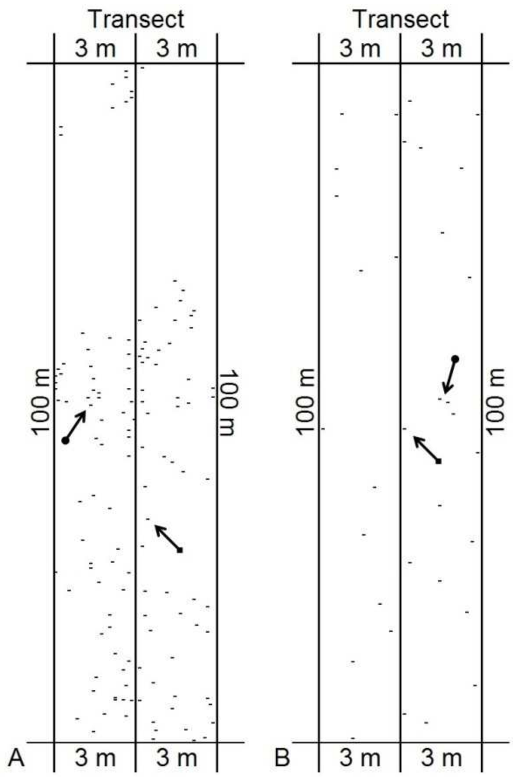

Figure 4 – Random dispersion of the ghost crab burrows on Pontal sand bar (A) and Avenida beach (B); first sample, circle-tailed arrows = aggregated burrows, square-tailed arrows = single burrows.

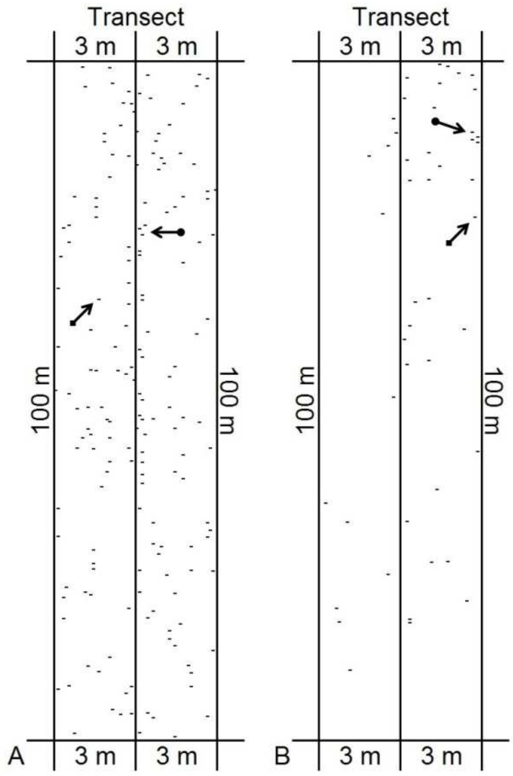

Figure 5 – Random dispersion of the ghost crab burrows on Pontal sand bar (A) and Avenida beach (B); second sample, circle-tailed arrows = aggregated burrows, square-tailed arrows = single burrows.

DISCUSSION

Considering as a perfect density results of 2.13 burrows m^{-2} found by Blankensteyn (2006) in beaches of Santa Catarina, Brazil, it is found that both studied beaches (Avenida beach and Pontal sand bar) are somehow affected by any factor (biological, physical or chemical).

The markedly greater number of burrows observed on the protected beach must be attributed to the fact that anthropogenic impact on this beach was minimal, what must also explain the small amounts of inorganic garbage found there, what facilitates the construction of burrows by crabs and, thus, contributes to the higher number of organisms in the population.

Inorganic garbage which is dumped into the sea and on the beaches each year is believed to cause mortality and this hypothesis can be found in the occurence of small bits of plastic in plankton tows and in the digestive tracts of marine animals, causing intestinal blockage (Nybakken, 2001).

By studying the ghost crab *O. cordimana* on Australian beaches, Barros (2001) found out that the presence of a concrete wall on urban beaches may leave part of crabs´ habitat out and, thus, decrease the mean density of the population. This condition is similar to what was observed on Avenida beach. Moreover, it was also discussed that if burrows do not represent true estimate of the crab abundance, so ghost crabs display distinct behaviour on urban and non-urban beaches, what means that urban crabs may not construct open burrows or may not maintain their burrows, as non-urban crabs do on their respective habitat.

Neves & Bemvenuti (2006) observed that at Tramandaí beach, vertical distribution of ghost crab burrows was restricted by the presence of a strip where there were kiosks offering protection from the traffic. This fact was also observed by Strachan *et al.* (1999) when it was studied the ecology and behaviour of the ghost crab *O. cursor*. Although it is known that anthropogenic influence on sandy beaches may usually decrease ghost crab abundance, Blankensteyn (2006) concluded that human impacts may also increase abundance of crabs by discarding food detritus during the daytime, action practiced by tourists, what benefits crabs, which display a nocturnal behaviour. A positive correlation was found by Strachan *et al.* (1999) between the presence of crabs (burrow counts) and the number of people using sections of beaches.

Alberto & Fontoura (1999) studied the distribution and age structure of *O. quadrata* along the coast of Rio Grande do Sul, Brazil. Their results showed that ghost crabs burrow more often on the central large strip of the beach and the density of burrows up to an altitude of 2.0 m ranged between 0.12 and 0.24 burrows m^{-2} and the highest densities of 0.69 and 0.70 burrows m^{-2} were found at altitudes of 2.2 and 2.4 m. These results are much higher than those ones found in this study and must be attributed to the levels of anthropic influence to which beaches are exposed and to the methods used in the density analysis.

According to Hill & Hunter (1973), there is a significant decline in the concentration of burrows in the upper foreshore of unprotected beaches due to the vehicle traffic, most of which is confined to the hard packed sands of this zone of the beach where driving conditions are best.

Other studies on sandy beaches indicate that human-disturbed areas display different vegetation than dunes in less-disturbed areas. Disturbed dunes usually have native dune vegetation destroyed, what provides gaps in which generalist, alien, and other native dune taxa can invade (Rodgers, 2002). It has been noticed that some other species such as *Emerita brasiliensis* (Crustacea) and *Phaleria testacea* (Insecta) display lower densities at urbanized beaches when compared to protected ones (Veloso *et al.*, 2006), which may imply that these species may also function as bioindicators of the environment health related to recreational activities.

This research provides evidence that anthropic disturbances has significantly affected sandy beach communities. Through the use of the species *Ocypode quadrata* as a bioindicator of the environment health, it was possible to observe the great variation of the ghost crab burrow density between the two beaches which showed different levels of human influence. It could also be noticed that the amount of inorganic garbage on the sand had an effect on the amount of burrows on the beach. That means, garbage has a negative influence in sandy beaches communities and more ominous is that it does not readily decompose, a worrying fact.

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