DISTRIBUTION OF *OCYPODE QUADRATA* (FABRICIUS, 1787) ON SANDY BEACHES OF NORTHEASTERN BRAZIL

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RESUMO

DISTRIBUIÇÃO DE *OCYPODE QUADRATA* (FABRICIUS, 1787) EM PRAIAS ARENOSAS DO NORDESTE DO BRASIL

A distribuição, abundância e morfometria das tocas de *Ocypode quadrata* foram analisados em doze praias arenosas de Pernambuco (NE-BR – 7º51'- 8º45'30" S; 34º49' 35º06' O), com diferentes níveis de impacto ambiental. Esta espécie é típica da margem supralitoral, a mais impactada área da praia por atividades recreativas. A densidade de tocas de *O. quadrata* foi maior em praias não urbanas, e próximo do limite superior das preamares. O diâmetro das tocas aumentou em direção à terra, com forte correlação com a quantidade de matéria orgânica. Este estudo foi uma maneira rápida e fácil de analisar o impacto antrópico, mas é necessário especificar os impactos e fatores locais que estão influenciando a distribuição de maria-farinha.

PALAVRAS-CHAVE: impacto antrópico, manejo e conservação, bioindicador, Crustácea

ABSTRACT

The abundance, distribution and morphometry of *Ocypode quadrata* (Fabricius, 1787) burrows were analyzed in twelve sandy beaches of Pernambuco (NE- Brazil; 7º51'- 8º45'30" S; 34º49' 35º06' W), with different grades of anthropic impact. This species is typical of the supralittoral fringe, which are the more impacted beach´s area due to the recreational activities. The density of *O. quadrata* burrows was higher at non-urban beaches, and near the strand line. The burrow diameter increases land ward, with strong correlation with organic matter mass. This analysis was a quick and easy way to identify anthropic impact, but other studies specifying the impacts and the local factors that are influencing the distribution of ghost crabs are necessary.

KEY WORDS: Anthropic impact; Management and conservation; bioindicator, ghost crab

INTRODUCTION

Sandy beaches are marine environments strongly influenced by hydrodynamic factors (McLachlan 1983) that cause changes on granulometry, slope, morphology, water circulation and consequently on the faunal composition (Amaral *et al.* 2003). They are suffering different anthropogenic impacts, which intensity varies along the beach. Human activities, such as pedestrians crossing the beach, traffic of off-road vehicles (ORV) and construction of roads and buildings, have also an enormous impact on beaches, principally on the supralittoral area. According to previous studies the traffic of vehicles destroys the dunes vegetation, drive away birds, and kill insects and crustaceans that live in the upper beach (Steiner & Leatherman 1981, Wolcott & Wolcott 1984, Foster-Smith *et al.* 2007)

The supralittoral zone is more sensitive to human impacts than the intertidal. Generally, these areas are habitated by few specialized crabs and insects, which are adapted to an arid, salty and windy place. However, Jaramillo *et al.* (1996) analysed the effect of recreational beach users on the abundance of the intertidal macroinfauna, concluding that the presence or recreational beach users did not produce significant effect on the macroinfauna. The organisms of the intertidal are adapted to constant perturbation of waves, which remobilize the substrate every tide. On the other hand, artisanal fisheries on intertidal animals affect the structure of invertebrates of these areas. The human harvesting on sandy beaches bivalves affected their distribution patterns (Defeo & Alava 1995).

The most common genus of crabs that lives on sandy shores in the world is *Ocypode*. The species *O. quadrata* lives on all sandy coasts of Brazil. Its distribution ranges from Rhode Island, in the United States (42°N and 70°W) to Rio Grande do Sul, Brazil (30°S and 50°W) (Melo 1996).

O. quadrata is large, lives on the upper beach (supralittoral fringe) and its burrows are easily identified. For this reason, it could be a good candidate as bioindicator of human activities on sandy beaches. The counting of *Ocypode quadrata* burrows is a simple and fast technique to obtain the density of the species. Warren (1990) showed that there was a good correlation between the density of the burrows and the number of individuals in another species of *Ocypodidae,* and others authors use currently this analysis (Barros 2001, McPhee & Skilleter 2002, Moss & McPhee 2006).

The recreational impacts on the distribution of *O. quadrata* were studied by Steiner & Leatherman

(1981). Foster-Smith *et al.* (2007) and Moss & McPhee (2006) found that the distribution of crabs on the shore was evidently linked to vehicle use. The impact of off-road vehicles on macroinvertebrates of a sandy beach was analysed by Wolcott and Wolcott (1984), and predicted population mortalities were calculated from observed kills of *O. quadrata* per vehicle-km. This number ranged from 14 to 98% for 100 vehicle passes.

Ocypode cordimanus is more abundant on non-urban beaches (Barros 2001). This species has higher densities on beaches without traffic of off-road vehicles (Moss & McPhee 2006).

The Pernambuco Coast consists of urban and non-urban sandy beaches, most of them presenting coastal reefs. *O. quadrata* is present on all sandy beaches of this State, and could be a good indicator of the impact of human on this part of the Northeast Brazil.

This study aimed to determinate the impact of human activities on the density of *Ocypode quadrata* on these beaches, by estimating the abundance and the distribution of the population of *Ocypode quadrata* in relation with different morphodynamics.

MATERIAL AND METHODS

SAMPLING PROCEDURE

The selected twelve sandy beaches (Fig. 1) were sampled once, on spring low tides from March to April 2006. Physical characteristics measured at each beach included: intertidal width, slope, sediment characteristics, and wave regime. The dunes of urbanized beaches are modified, with few or no vegetation, with bar or Sport's structures, and others urban facilities. The strand line of these beaches is removed every day by road sweepers.

The *O. quadrata* density's was determined by the presence of burrows with signals of recent activity. Three lines, parallel to the shoreline, were sampled in each beach; the first at the drift line, the second 3 m below and the third 3 m above. The number of burrows was recorded in 30 quadrats (1 m^2), aligned parallel to the drift line, with a total of 90 samples (quadrats) per beach.

The length of *O. quadrata* was estimated by the size of burrow. Two largest diameters of each burrow were determined. These two measures were used to determine the ellipse area of each burrow.

The organic matter at the high tide drift line was estimated with two quadrats of 1 m side. The animal and vegetal debris were weighed and dried at 60ºC during 24 hrs. After that, they were weighted again.

DATA ANALYSIS

The Bartlett's test was used to verify the homoscedasticity of data. These were analysed by ANOVA one-way. The Kruskal-Wallis analysis was made with heterocedastic data. The differences between burrows of urban and non-urban beaches were analysed with Kruskal-Wallis and Dunn tests. The comparison among Burrows' diameters were tested with ANOVA and the Tukey's post hoc test

Qui-Square (χ^2) analyses were made for compare amount of debris between each beach.

Morphodynamics states were computed employing the dimensionless fall velocity parameter $\Omega = \frac{H_b}{W_s T}$ (Dean, 1973), where H_b is the breaker height, W_s is the mean fall velocity of intertidal sand and T is the wave period (Wright et al., 1982).

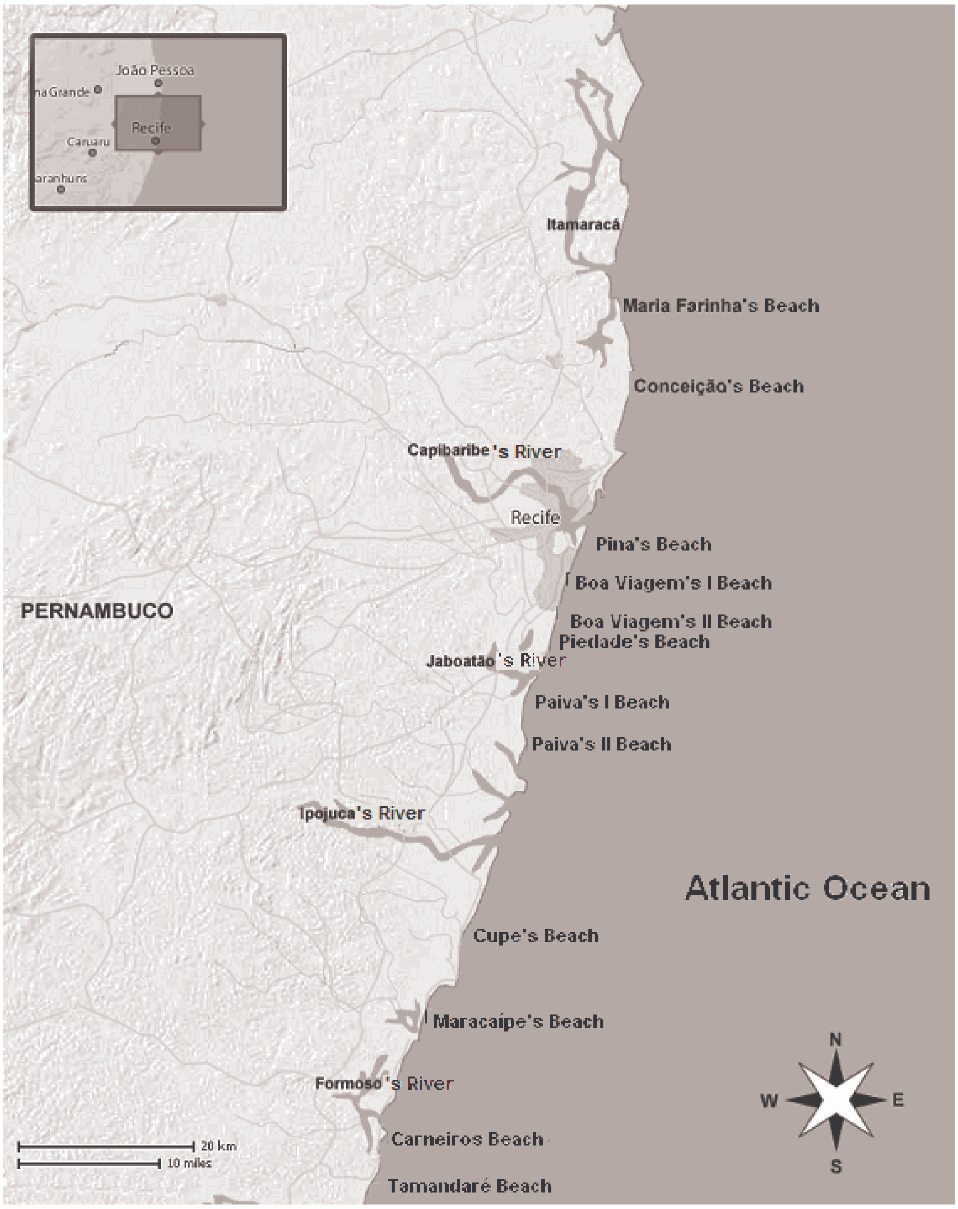

FIGURE 1 – Study area, showing locations of the 12 sandy beaches surveyed on the Pernambuco Coast (7º51'-8º45'30" S; 34º49' 35º06' W

RESULTS

The mean grain size in the low intertidal ranged from medium to very fine sand (Table 1). The beaches morphodynamics ranged from reflective to intermediate state, with beaches that presents reefs showing presented a mean Ω of 1.67, and those without reefs showing a mean Ω of 3.45.

The mean burrow's density was low, ranging from 0.03 to 0.57 holes/m^2 (n= 1,080 quadrats). Most of burrows were found near to the strand line in most of the beaches (means= 0.30; s.e= 0.33; n= 360), but it was higher below the strand line at Boa Viagem1 and Maracaípe; conversely on the beaches Carneiros and Tamandaré the highest densities were found near the dunes.

The non-urbanized beaches presented a significant higher number of burrows than urbanized ones (Kruskal-Wallis/Dunn: $z_{(1;1078)}$=4.266; $p<0.05$) (Fig. 2). On the other hand, there is no statistical difference between protected and non protected beaches. There was no relation between morphodynamics and *O. quadrata*'s abundance.

TABLE 1 – Characteristics of the beaches studied. S= slope (%); grain= mean grain size (mm); Hb= wave height (cm); T= wave period (s); Ω= Dean's parameter

Beach	*Urban*	*Reefs*	*S*	*grain*	*Hb*	*T*	*Ω*
Boa Viagem 1	Yes	Yes	5.8	0.209	50	8.3	2.24
Boa Viagem 2	Yes	No	4.8	0.124	45	6.7	4.38
Conceição	Yes	Yes	4.2	0.187	22	7.7	1.25
Maria Farinha	Yes	Yes	5.7	0.449	20	7.7	0.37
Piedade	Yes	No	7.2	0.157	45	7.3	3.46
Pina	Yes	No	5.6	0.209	42	10.3	1.52
Carneiros	No	Yes	5.4	0.150	27.7	9.3	1.76
Cupe	No	Yes	9.4	0.183	55	8.7	2.85
Maracaipe	No	No	10.6	0.223	110	9.0	4.17
Paiva 1	No	No	4.9	0.190	50	7.3	2.90
Paiva 2	No	No	6.2	0.160	70	9.0	4.26
Tamandaré	No	Yes	4.0	0.157	28.7	10.3	1.55

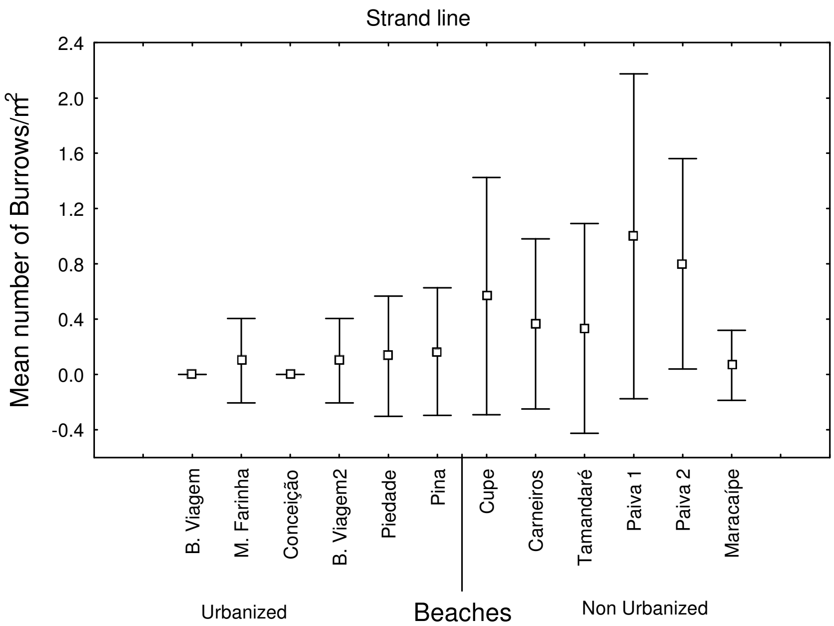

FIGURE 2 – Strand line burrow's abundance of *Ocypode quadrata* on urban and non-urbanized beaches of Northeast Brazil. Vertical bars are Standard Deviation, n=90 samples per beach).

The difference of individual size (burrow´s diameter) of *O. quadrata* throughout the beach was significant, with the intertidal size smaller than the strandline and supralittoral areas, $F_{(2,\ 223)}=9.973$, $p<0.001$ (Fig. 3). The individuals holes were significantly larger in beaches without reefs ($F_{(1,\ 224)}=6.3421$, $p=0.0125$), but no significant differences in size were found between urban and non-urban beaches ($F_{(1, 224)}= 0.056$, $p= 0.813$).

The regression between the log organic matter mass, left by tides in the drift line, and the log of *O. quadrata* burrows number was significant (Ln Burrows = -0.0820 + 1.0321 * Ln Organic Matter) (Fig. 4). The mass of organic matter in the drift line explained 48.38 % of the burrows distribution.

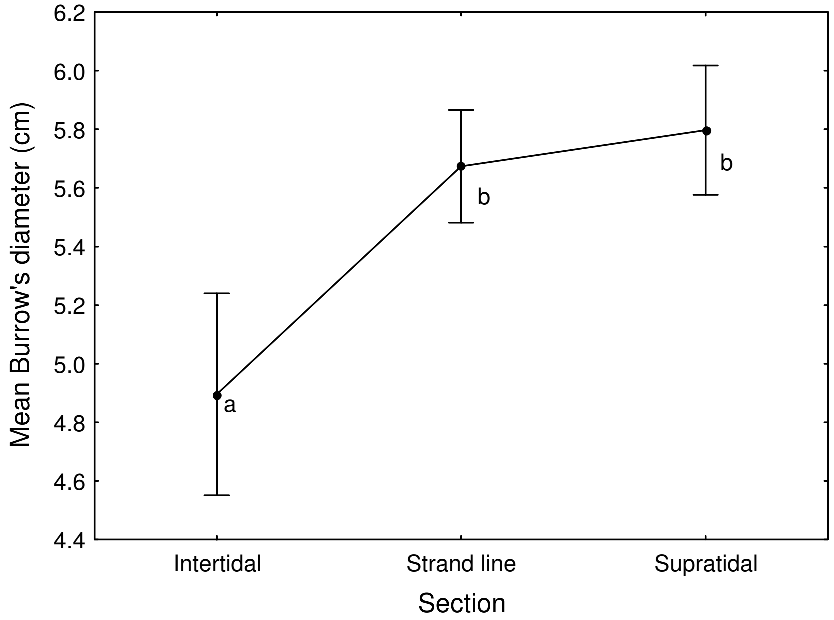

FIGURE 3 – Mean burrow's diameter of *Ocypode quadrata* across the beach. Vertical bars denote 0.95 confidence intervals. Bars with distinct letters differ significantly ($p < 0.05$; Kruskal-Wallis' test followed by Dunn's test).

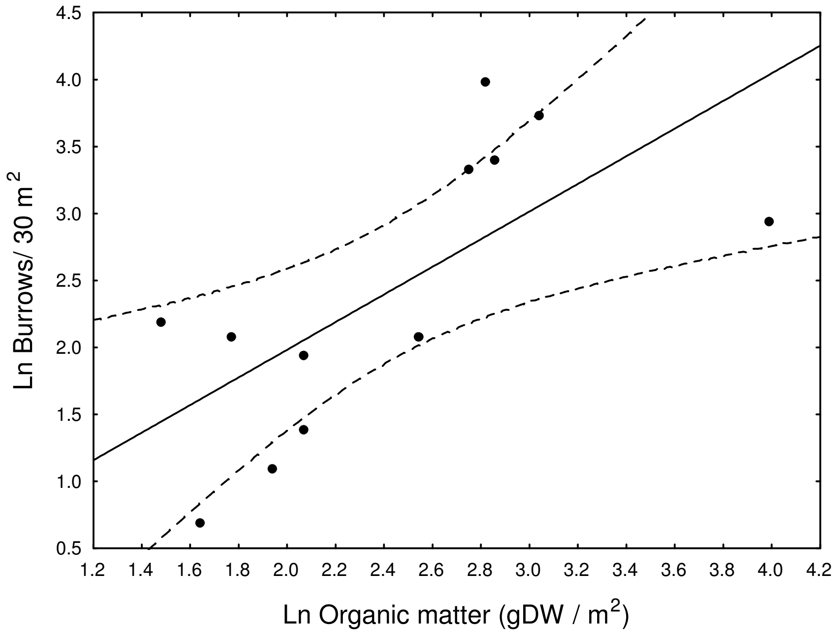

FIGURE 4 – Regression between the organic matter of the drift line and the burrows of *Ocypode quadrata*, in twelve beaches, NE-Brazil. Dashed lines are the 95% confidence intervals for the best-fit line.

DISCUSSION

The higher abundance of *Ocypode quadrata* was at the drift line in most of the beaches of Pernambuco Coast. This pattern was found in other beaches (Dahl 1952, Souza & Gianuca 1995, Turra *et al.* 2005), and seems to be related to food sources; it is common to found holes of this species near to the carrion. The strong correlation between *Ocypode*´s burrows and stranded organic matter (r=0.696) supports this idea.

The non-urbanized beaches presented a significant higher number of burrows than the urbanized. The higher density of *O. quadrata* at beaches with lower anthropic impact was also found by other authors (Barros 2001, Blankensteyn 2006, Neves & Bemvenuti 2006, Foster-Smith *et al.* 2007). Steiner & Leatherman (1981) studied different recreational uses and beaches impact's on the distribution of *O. quadrata* on Maryland (USA). Human usage has a pronounced effect on ghost crab densities: areas subject to ORV traffic had significantly lower densities of crabs. Moss & McPhee (2006) found the same results. A different result was found by Barros (2001), where the ghost crab *Ocypode cordimana*'s burrows abundance was greater in urban beaches than in non-urban beaches. Steiner & Leatherman (1981) also said that pedestrian impacts could had a beneficial effect on ghost crabs densities, mainly because of the food wastes left by them. However, Barros (2001) warned that Steiner and Leatherman's study must be considered with caution, because of its minimal spatial replication. In the current study it was not possible to evaluate the effect of off-road vehicles on the beaches because this traffic is forbidden on Pernambuco Coast.

The burrows diameter had no significant differences between urban and non-urban beaches, and no relation were observed between the mean grain size and burrows diameter. But, Turra *et al.* (2005) found a tendency of smaller burrows in areas with coarser sand grains and higher tourism on southeastern brazilian sandy beaches.

Although in this study we did not find relation between morphodynamics and *O. quadrata'*s abundance, others factors may be influencing its distribution, as waves and food availability, and we need to distinguish the variation in ghost crab burrows due to the human impact from others factors. The urbanization on brazilian beaches causes many impacts: Off-road vehicles, recreational use, digging intertidal organisms, discharges of sewage effluents and cleaning the beach by road sweepers, but the most significant impact at Pernambuco´s beaches are indeed the recreational use and cleaning. The scarcity of intertidal fauna on urban beaches without explotation of organisms, may be explained by the road sweepers activity, which remove the food brought by tides and pedestrians. Veloso *et al.* (2006) found a relation between abundance of some invertebrates of sandy beaches and its urbanization. *Pseudorchestoidea brasiliensis* was absent at most urbanized beaches; *Emerita brasiliensis* and *Phaleria testacea* were present in lower densities at urbanized beaches, which could be related with cleaning services and removal of organic matter.

Thus, we conclude that at Pernambuco Coast the density and morphometry of *Ocypode quadrata*'s burrows can indeed be used for the avaliation of anthropic impact on the sandy beaches, once they are significantly more numerous on non-urban beaches. However, as its size is not significantly different between urban and non-urban beaches, it seems to be necessary to investigate others factors which can be important to the specie's ecology.

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