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Biometric differences in Ucides cordatus (LINNAEUS, 1763) (Crustacea; Brachyura; Ocypodidae) as an indicative of environmental stress

Growing urban development, port expansion, and the deployment of industries along the northeast coast of Brazil are some of the major threats to crustacean fauna that depend directly on the mangrove ecosystem to survive. In response to these environmental changes, the swamp ghost crab (Ucides cordatus) presents biological dysfunctions in body size to invest in mechanisms that regulate homeostasis. The present study aimed to evaluate the size and condition factor of crabs from two distinct mangrove areas, being an impacted area and a reference area. Male crabs were collected through the braking technique, weighed with an analytical balance and the width and length of the carapace were measured with a digital caliper. We used a t test to observe differences between two areas and different periods, and the power function (y = axb) for the ratio between the weight and width of the carapace of each individual was used in order to observe the type of growth. There were significant differences between the weight and length of the individuals between the two sample areas and the growth classified as negative allometric.

Keywords: Condition factor; Mangrove; Environmental impact; Adaptive strategies.

Diferenças biométricas de Ucides cordatus (LINNAEUS, 1763) (Crustacea; Brachyura; Ocypodidae) como indicativo de estresse ambiental

O crescente desenvolvimento urbano, a ampliação de portos e a implantação de indústrias ao longo da costa nordeste do Brasil são algumas das principais ameaças a fauna de crustáceos que dependem diretamente do ecossistema manguezal para sobreviver. Como resposta a essas mudanças ambientais, o caranguejo-uçá (Ucides cordatus) apresenta disfunções biológicas no tamanho corporal para investir em mecanismos que regulem a homeostase. O presente estudo teve por objetivo avaliar o tamanho e o fator de condição de caranguejos de duas áreas de mangue distintas, sendo uma área impactada e uma área de referência. Caranguejos machos foram coletados através da técnica do braceamento, pesados com auxílio de balança analítica e as medidas de largura e comprimento da carapaça foram mensuradas com auxílio de paquímetro digital. Utilizou-se test t para observar diferenças entre as áreas e entre os períodos, a função potência (y = axb) para a razão entre o peso e largura da carapaça de cada indivíduo foi usada para detectar o tipo de crescimento. Houve diferenças significativas entre o peso e comprimento dos indivíduos entre as duas áreas amostradas, sendo o crescimento classificado como alométrico negativo.

Palavras-chave: Fator de condição; Mangue; Impacto ambiental; Estratégias adaptativas.

Topic: **Desenvolvimento, Sustentabilidade e Meio Ambiente**

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INTRODUCTION

Mangroves play a vital role in coastal zones, as they act as an important primary producer in estuarine environments (SOUZA et al., 2014), providing several living resources. This environment constitutes a natural nursery for different species that use this environment for spawning, refuge, reproduction, growth and feeding (OLIVEIRA, 2013).

In this ecosystem, crabs are closely related to the substrate, acting at different levels of the trophic chain either as herbivores, predators, necrophages or prey of other taxonomic groups (FERREIRA et al., 2014). Among the main species found in mangroves, the swamp ghost crab Ucides cordatus (LINNAEUS, 1763) (Crustacea; Brachyura; Ocypodidae) is a semi-terrestrial crustacean from typically estuarine regions, occurring from northern Florida to the coast of Santa Catarina in Brazil (LEITE et al., 2014; WELLENS et al., 2015; WUNDERLICH et al., 2008).

This species is an important component of the benthic fauna (ABDULLAH et al., 2016; MORAES et al., 2015), widely used as a food source in several Brazilian regions and it is economically important because it contributes to the income of many fishermen (HATTORI et al., 2003).

Despite the ecological relevance, the habitat of this species has been altered due to overexploitation of forest products and expansion of human populations in coastal zones (FERREIRA et al., 2016). Consequently, the quality of the environment is threatened by physical and chemical components (ADAMCZUK et al., 2015), such as sedimentation, eutrophication, pollution by toxic substances, heavy metals among others (AVIGLIANO et al., 2015; TIQUIO et al., 2017).

The effects of these natural and anthropogenic stressors may reflect on the body development of some species of crabs, since organisms present in more impacted areas present greater body asymmetry due to the energy expenditure to control the stress promoted by the environment in which they live (LEZCANO et al., 2015; MATHESON et al., 2012). This ecological imbalance can alter the entire reproduction cycle of a given species (JERÔNIMO et al., 2012).

In this sense, species biometry is able to provide information about structure and morphological maturity (LIMA et al., 2006), to estimate the type of growth that organisms present when the conditions are favorable (isometric) or unfavorable (allometric) to their well-being (RODRIGUES et al., 2015), besides showing possible adaptive differences (MORAES et al., 2015) and unequal growth rates in impacted areas in comparison to populations of more preserved areas (ARAÚJO et al., 2012).

According to Moraes et al. (2015), there are no studies comparing the size of Ucides cordatus among mangroves in areas of greater anthropic impact with those of more preserved areas within the same geographic region. Thus, the main objective of this study is to evaluate possible differences between body measurements of crabs in different areas in order to infer about the influence of environmental integrity on the biometrics of these animals.

MATERIALS AND METHODS

Study area

The samplings were carried out in two distinct areas on the island of Maranhão. The impacted area (IA) comprises the Coqueiro region (02º43’43.5’’ S and 44°21’44.5’’ W) and receives the influence of the port complex of Itaqui.

This port is part of the second largest port cargo handling complex in the country and has an important activity in the transportation of mainly minerals, petroleum and its by-products (GOBBI et al., 2017), which imply different environmental impacts for this area (SAMARITANO et al., 2013).

In this area, studies such as that of Silva et al. (2014) evaluated and verified contamination of water and sediment by metals (Cu, Pb, Zn, Cd, Ni, Fe, Al and Mn), in addition to environmental and social changes caused by the installation of a thermoelectric plant near the port.

The reference area (RA) located in the region of Raposa (2° 26' 48.3'' S and 44° 04 '41.6'' W) (Fig. 1), in the Bay of São José and it is characterized by the absence of direct anthropic impacts, which are visible in its surroundings, due to its difficult access resulted from the distance from inhabited areas.

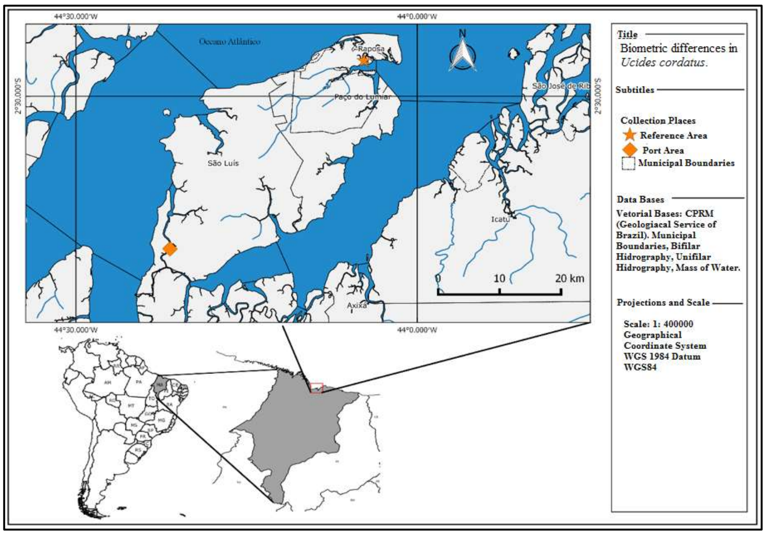

Figure 1: Location of sampling points on the island of Maranhão.

Animals sampling

Crabs were collected in the dry and rainy periods, between October and December 2015 and between March and May 2016, through the braking technique (ARAÚJO et al., 2013).

The sexual characterization of the organisms was obtained macroscopically, since these individuals present evident sexual dimorphism in the abdomen (AMARAL et al., 2014), in this way, only the male individuals were collected.

Measurements of carapace width and length were measured using a digital caliper and body mass was determined on a digital scale (0.01g).

Statistical analysis

Normality of data distribution was assessed using a Shapiro-Wilk test and the equality of variances or homoscedasticity was analyzed by Levene's test (FARAWAY, 2002). For data with normal distribution, a t test was used in order to evaluate the existence of differences of biometric data between the two areas and between different periods.

The ratio between the weight of each individual and the width of the carapace (Hw x Cw) were defined from potential equations $y = ax^b$. Regression analysis by the potential function was used to verify types of growth through the b value. In relation to Hw x Cw, the type of growth is classified as: isometric ($b = 3$), positive allometric ($b > 3$) or negative allometric ($b < 3$). Analyzes were conducted on the R version 3.2.5 platform (R CORE TEAM, 2016).

RESULTS

A total of 104 specimens of Ucides cordatus were measured and weighted, being 52 of AR and 52 of AI. Individuals collected in the reference area were distinguished by their size and weight in relation to the individuals collected in the AI. These organisms showed carapace length ranging from 39-71 cm; Carapace width varied between 50-81 cm and the weight varied between 80 and 217 g, while organisms collected in the AI were smaller on average in all biometric aspects evaluated (Table I).

Table I: Biometric data with mean and standard deviation values for sampling periods and locations.

Dry	Weight (g)	Width (mm)	Length (mm)
RA*	150.73 ± 36.43	66.46 ± 7.16	49.0 ± 5.41
IA*	87.57 ± 22.65	61.16 ± 5.32	46.38 ± 3.58
Rainy	Weight (g)	Width (mm)	Length (mm)
RA	150.88 ± 27.93	69.03 ± 5.19	52.92 ± 5.13
IA	104.80 ± 25.92	63.80 ± 4.72	47.11 ± 4.26

RA-Reference area (Raposa); IA- Impacted area (Coqueiro).

Between dry and rainy periods, only carapace length showed significant differences ($p < 0.05$). The carapace weight, width and length were significantly different between RA and IA ($p < 0.05$) (Fig 2).

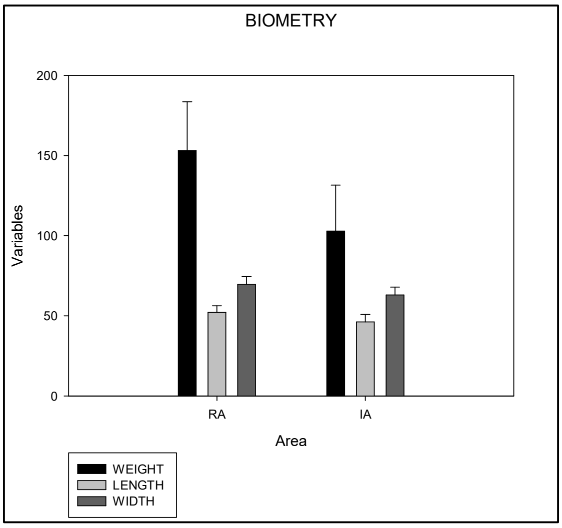

Figure 2: Values of weight (g), width (mm) and carapace length (mm) for Ucides cordatus crab between RA and IA.

The relationship between carapace weight and width was stronger in RA (R2 = 0.62). Equations between Hw x Cw for RA (b = 1,8) and IA (b = 2,6) showed constant values lower than 3 and indicated negative allometric growth (Figure 3).

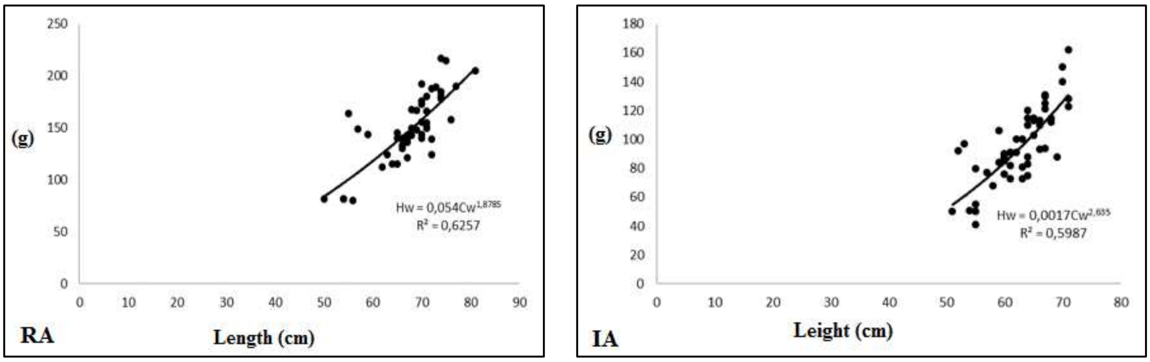

Figure 3: Weight and length relationship for Raposa and Coqueiro (RA = reference area, IA= impacted area, Hw = weight (g), Cw = carapace width (cm)).

DISCUSSION

Data from the present study show significant differences between weight and length of individuals between two sampled areas. Individuals of the AI presented significantly smaller size and body weight when compared with AR individuals. These differences may be related to the high concentrations of metals found in São Marcos Bay (SILVA et al., 2014), due to the presence of a port complex and an expressive number of dwellings that can make the environment harmful to aquatic and terrestrial biota (SOUZA et al., 2013).

Research carried out in estuaries of Pernambuco state showed that the crabs in more impacted areas were smaller when compared to low impact areas (CASTIGLIONI et al., 2009). Similar results were found by Araújo et al. (2012) when observing that the growth rates of Ucides cordatus were unequal between mangroves of Ariquindá and Mamucabas due to the deforestation and the deposition of residues found in this last estuary.

According to Moraes et al. (2015), these differences may be result of ecological strategies adopted by species to adapt to poor environmental quality found in many coastal areas. Therefore, it is believed that in situations of environmental stress, crabs tend to spend more energy to maintain homeostasis and, consequently, the availability of energy to invest in other physiological processes will be lower.

One of the main impacts on mangrove ecosystem is related to pollution by domestic and industrial effluents which directly influence the concentration of heavy metals in the soil (SUNDARAMANICKAM et al., 2016) and in the roots and leaves of different mangrove species (QINHANG et al., 2014), which are an integral part of the diet of U. cordatus (NORDHAUS et al., 2007). The greater the contribution of contaminants in the area, the greater the risk of absorption by biota. In this sense, species with low mobility accumulate higher concentrations of metals (CHAPMAN et al., 2013), so the effect of biomagnification in the trophic chain can lead to bioaccumulation of xenobiotics in organisms and interfere in growth of these species (PINHEIRO et al., 2012).

CONCLUSIONS

Another factor to be considered is the intense commercial exploitation of these organisms, which can interfere in density (DUARTE et al., 2016), yield and size of these animals (NASCIMENTO, 2017). Branco (1993) found minimum values of 53 mm and maximum values of 96 mm of width in crabs in the state of Santa Catarina, being larger than those of the northeastern region. According to the author, even with favorable climatic conditions, the demand for consumption is more intense in this region and exploitation influences the development of individuals. Tourism is also a relevant factor in over-exploitation of this species (AMARAL et al., 2014).

Thus, contamination levels in São Marcos Bay (SILVA et al., 2014), coupled with constant exploration of this species, since it is an area with easy access to the collectors, can favor the observed biometric differences.

The results found in this study are important for management plans since they allow evidencing and monitoring of environmental impacts in coastal zones. In addition, this work opens doors for other studies to be carried out in this region in order to evaluate the concentration of metals in crabs' tissue, as well as the use of specific biomarkers in order to obtain a diagnosis of biota health before toxic effects are triggered, as well as food poisoning of local population through consumption of crab meat.

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