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Ingestion of plastic debris affects feeding intensity in the rocky shore crab *Pachygrapsus transversus* Gibbes 1850 (Brachyura: Grapsidae)

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The aim of this study was to investigate the plastic consumption by the rocky shore crab *Pachygrapsus transversus* and its effects in the species feeding activity. Specimens were collected monthly from August 2019 to January 2020 in a coral reef located in the north-eastern Brazilian coast, taken to the research laboratory, where they had their stomach removed, degree of fullness determined for each stomach and presence/absence of plastic debris assessed. Frequencies of occurrence of each degree of fullness were compared between sexes and contaminated/non-contaminated individuals. At total, 209 specimens were sampled and high levels of plastic contamination were detected: 47.4% of the sample had plastic fibres in the foregut. All contamination consisted only of nylon filaments, suggesting that irregularly discarded fishing equipment is the source. The frequencies of contaminated individuals among sexes did not differ. However, differences were detected in the comparison between degrees of fullness, demonstrating that there is significant influence of plastic ingestion in the stomachs volume. It is possible that the discrepant frequencies of occurrence of gut fullness were due to false satiation effects and blockage of the digestive tract provided by the fibres.

Key words: Pollution, decapoda, ecology, brachyura.

INTRODUCTION

Anthropogenic disturbances and pressures reduced the natural products in such a way that society has opted for plastic products for daily use purpose and it becomes a major component of human routine. The plastic material takes several decades to decompose and its waste is now considered a global problem. Due to these factors, natural and artificial ecosystems became vulnerable from natural and other hazards. These anthropogenic disturbance have adversely affected microbial activities, decomposition processes and nutrient cycling due to the fact that these processes depend on substrate quality and environmental factors (Pruter, 1987; Upadhyay et al., 1989; Bargali et al., 2018; Bargali et al., 1993, 2015, 2019; Andrady; 2011; Reisser et al., 2013; Lambert et al., 2014). In order to illustrate the scenario, since the mass production of plastics begun, in the 1950s, about 6.22

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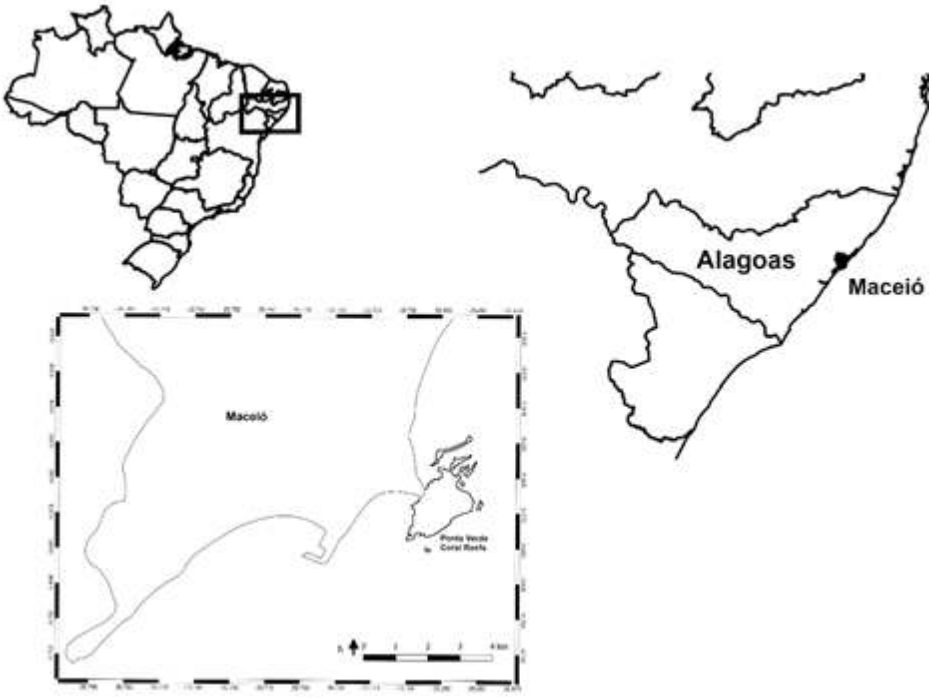

Figure 1. Location of the study site.

billion tonnes of plastic garbage had been discarded in the environment, with a majority being of single use goods (Geyer et al., 2017).

The accumulation of solid debris is a huge and growing concern for the conservation of marine biota. The less apparent impacts are primarily caused by the smaller particles of plastic, given that this material gradually decomposes in the environment. Microplastics tend to have increased availability to invertebrates in the base of the food web, which are commonly not affected by larger debris. Also, there is a higher probability of passive ingestion by planktivores (Browne et al., 2008; Fossi et al., 2012; Wright et al., 2013). Laboratory studies showed that many invertebrates are able to ingest plastic material (Wright et al., 2013; Cole and Galloway, 2015; Hall et al., 2015), although it is important to consider that the ingestion of this material is affected by the feeding dynamics of each taxon (Setälä et al., 2016). Impacts such as diminution in the overall body condition and feeding intensity following plastic ingestion were observed in a significant amount of studies (Murray and Cowie, 2011; Welden and Cowie, 2016; Bordbar et al., 2018).

The crab *Pachygrapsus transversus* (Gibbes, 1850) is a small brachyuran crab inhabiting consolidated substrata in several coastal regions in the Atlantic Ocean. It is known for having an omnivorous and generalist feeding strategy (Abele et al., 1986) and presenting importance in what comes to structuring communities as active grazers, controlling algae and sessile invertebrates abundance (Christofoletti et al., 2010). Thus, it is a key-specie to characterizing environments. Therefore, this study aimed to report data on plastic ingestion by the crab *P. transverus* and investigate impacts on the organism's feeding intensity under the hypothesis that ingested plastic material is able to decrease natural feeding rates by causing false satiation.

MATERIALS AND METHODS

The specimens were collected monthly by hand, at low tide, between August 2019 and January 2020, at the coral reefs located at Ponta Verde Beach, municipality of Maceió, Alagoas, Brazil (9°39'40" - 9°40'50" S and 35°41' - 35°42'W) (Figure 1), with a tidal amplitude around 2 m. Correia and Schlenz (1997) gave a brief description of this area, which is characterized by being a typical fringing reef, having the top of its platform constantly exposed to low tides and presenting a considerable amount of calcareous algae. Since it was composed of one slightly homogeneous rock, no sampling sites were adopted in this experimental design in order to assure independent sampling, considering that the studied crabs are fast moving, have high facility of dispersal and the area has no natural barriers around the rocky environment. Only crabs in the intermoult stage were captured. Right after capture, the specimens were put in a bucket containing ice in order to reduce enzyme activity, avoid any regurgitation and slow down the digestion processes (Figure 1).

In the research laboratory, the crabs were dissected and had their foreguts removed monthly in laboratory. Before analysing the gut content, the degree of gut fullness was determined visually by ranking with a score (¼, ½, ¾ and full). Although this estimation is slightly subjective, it is known that assessment of gut fullness in

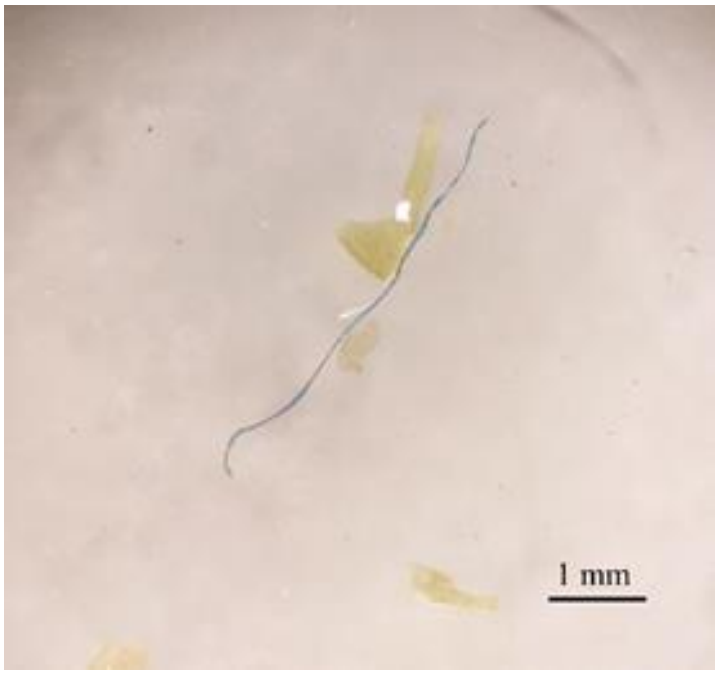

Figure 2. Nylon filament and algae fragment found in the stomach of *P. transversus*

decapod crustaceans can have an acceptable degree of reliability, since the stomachs of this organisms are not distensible as it is in fishes (Maller et al., 1983; Goes and Lins-Oliveira, 2009). The foreguts were then slit open in a volumetric petri dish containing distilled water and examined under a stereomicroscope with 400x magnification. The presence/absence of plastic material was then determined. Frequencies of occurrence of each level of gut fullness were compared between the contaminated and non-contaminated individuals by means of the Chi-square test (X^2) to address the hypothesis that the presence of plastic fibres in the stomach affects the feeding activity. Thus, to reject the null hypothesis, contaminated individuals should be significantly more frequent with empty or less filled stomachs. Also, the frequency of occurrence was compared between the two sexes. All analysis and graphing were realized by usage of GraphPad Prism 8 software version 8.0.01. The confidence level to reject null hypothesis was considered to be below 5%.

RESULTS AND DISCUSSION

A total of 209 specimens of *P. transversus* were sampled, being 102 males and 107 females. High levels of plastic contamination were detected in the sample: 47.4% of the individuals had one or more plastic fibres in the foregut. All plastic debris consisted of nylon filaments (Figure 2), enforcing the assumption that there is a single source of contamination in this particular site: irregularly discarded fishing apparatus. This is a common source of pollution by plastic debris (Ryan et al., 2009; Murray and Cowie, 2011; Reisses et al., 2013; Bordbar et al., 2018; Haward, 2018). The Chi-Square test demonstrated that there is a significant association between plastic consumption and degrees of fullness, indicating that fibres presence in the foregut can affect feeding activities ($X^2 = 65.18$, $p < 0.001$). The individuals that happened to ingest plastic debris had higher frequency of occurrence with empty and 25% filled stomachs (Figure 3). No significant differences in plastic consumption were detected between sexes ($X^2 = 1.33$, $p > 0.05$).

Plastic ingestion by decapod crustaceans is a big issue that may affect ecological processes, given that these organisms have a crucial importance in influencing the structure of benthic communities, diverse role in the food chain, behavioral plasticity and regulating trophic cascades (Cannicci et al., 1999; Branco et al., 2002; Boudreau and Worm, 2012; Barros-Alves et al., 2018). Also, this issue has the potential of negatively affecting commercial fishing (Possatto et al., 2011; Foekema et al., 2013). The direct and indirect impacts of plastic ingestion, such as false satiation and blockage of the digestive tract can also be sources of disturbance in life story traits and general health condition of crustaceans (Watts et al., 2015; Welden and Cowie, 2016; Bordbar et al., 2018; Jabeen et al., 2018), as well as in other groups of organisms (Lavers, 2016; Cardozo et al., 2018; Clukey et al., 2018; Forrest and Hindell, 2018).

Conclusion

It is clear that plastic consumption by *P. transversus* affected feeding activities in the studied specimens. We

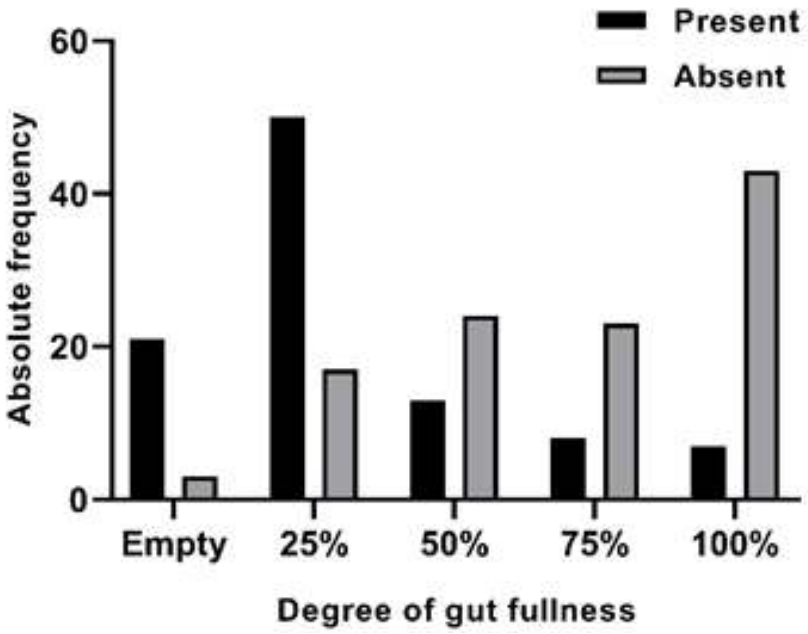

Figure 3. Occurrence frequency for each degree of fullness for individuals with present and absent plastic material.

hypothesized that the influence of plastic ingestion in the degrees of fullness is related to the false satiation or blockage of the digestive tract caused by the fibres. Also, plastic ingestion by decapod crustaceans should be a central issue when studying solid pollutants in the oceans, addressing the individual, population and ecosystem effects. The authors suggest that *P. transversus* can be used as indicator specie when it comes to monitoring coastal regions in a regional scale because of its high abundance and diverse diet.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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