Vol.48, n. 2 : pp. 267-274, March 2005
ISSN 1516-8913 Printed in Brazil

BRAZILIAN ARCHIVES OF BIOLOGY AND TECHNOLOGY

AN INTERNATIONAL JOURNAL

Effects of the Burrowing Crab *Chasmagnathus granulata* (Dana) on Meiofauna of Estuarine Intertidal Habitats of Patos Lagoon, Southern Brazil

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ABSTRACT

This study aimed to evaluate the effects of the burrowing crab Chasmagnathus granulata on meiofauna at three intertidal habitats across a tidal exposure gradient (i.e., an emerged salt marsh, an emerged mudflat and a submerged mudflat) in an estuarine embayment of Patos Lagoon, Southern Brazil. Meiofauna community was dominated by nematodes and ostracods, following by copepods and turbellarians. Densities of all studied organisms varied significantly among habitats. Highest values were observed in submerged mudflat while lower in salt marsh. Nematodes were unaffected by crab in either habitat, whereas ostracod, copepod and turbellarian densities were significantly lower in disturbed than control areas in both mudflat habitats. Any meiofaunal group was affected in salt marsh, probably due to a less intense disturbance. The results showed that the burrowing crab C. granulata could play an important role on meiofauna community structure in estuarine intertidal habitats of Patos Lagoon, because crab disturbance seemed to affect mainly surface populations, especially in mudflat. However, the meiofauna response to crab disturbance was variable among habitats depending of the intensity and the frequency of the disturbance.

Key words: Burrowing crab, *Chasmagnathus granulata*, meiofauna, disturbance, natural experiment, Southern Brazil

INTRODUCTION

The importance of biological disturbance in structuring marine benthic assemblages is well-established (Virnstein, 1977; Brenchley, 1981; Sherman et al., 1983; Probert, 1984; Palmer, 1988). Macroinvertebrates and juvenile fish affect meiofaunal community structure directly by predation, and indirectly by changing the physical-chemical characteristics of the sediment environment (Bell et al., 1978; Ólafsson et al., 1990; Warwick et al., 1990; Ólafsson and Elmgren, 1991; Ólafsson and Ndaro, 1997; Austen et al., 1998; Schratzberger and Warwick, 1999; Aarnio, 2000), hereafter referred to as "disturbance".

In estuarine region of Patos Lagoon, the highest meiofaunal density are found at first upper layer (0-2 cm of depth) of sediment and most of the organisms such as copepods and ostracods live near the sediment-water interface (Ozorio, 2001). Recently, it has been observed that meiofauna community structure is influenced by physical-chemical sediment characteristics as well as prolonged tidal exposure of intertidal habitats of Patos Lagoon (Rosa and Bemvenuti, *unpublished*

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data). Another factor that could affect the meiofaunal community is the presence of the burrowing crab *Chasmagnathus granulata* (Dana) in intertidal habitats. Such crab is one of the most abundant macroinvertebrates in the SW Atlantic estuaries (Capitoli et al., 1978; D'Incao et al., 1990; D'Incao et al., 1992; Iribarne et al., 1997); it is distributed from Rio de Janeiro (Brazil) to Patagonia (Argentina) (Boschi, 1964). In the Patos Lagoon's estuary, this crab commonly inhabits salt marshes dominated by *Spartina alterniflora* (Loiseleur) and adjacent mudflats (Capitoli et al., 1978; Bemvenuti, 1997), reaching densities up to 98 ind. m^{-2} (D'Incao, 1992). These crabs excavate and maintain semi-permanent open burrows, and remove large amounts of sediment during feeding and burrow maintenance forming a surface mound around burrows (Iribarne et al., 1997; Botto and Iribarne; 2000).

Table 1 - Mean values and standard deviation (in parenthesis) of the abiotic parameters measured in control and disturbed conditions at each habitat.

Parameter	Submerged mudflat		Emerged mudflat		Emerged salt marsh	
	Control	**Disturbed**	**Control**	**Disturbed**	**Control**	**Disturbed**
Mean grain size (ϕ)	2.87 (0.01)	2.83 (0.04)	3.42 (0.23)	3.34 (0.16)	3.47 (0.42)	3.49 (0.31)
Sorting (ϕ)	0.67 (0.04)	0.6 (0.04)	1.62 (0.37)	1.36 (0.25)	1.35 (0.6)	1.43 (0.37)
Fines (%)	7.1 (0.67)	5.3 (1.04)	20.9 (5.62)	16.7 (2.39)	22.4 (12.5)	22.5 (8.27)
Organic matter (%)	0.29 (0.07)	0.34 (0.16)	0.6 (0.25)	0.55 (0.1)	0.83 (0.28)	1 (0.48)
Eh (mV)	-97 (39)	-125 (61)	-216 (22)	-228 (57)	-248 (67)	-270 (38)
pH	7.1 (0.15)	6.97 (0.35)	5.64 (0.33)	5.97 (0.34)	5.25 (0.4)	5.57 (0.33)

In contrast to pseudofaecal pellets produced by ocypodid crabs (Ólafsson and Ndaro, 1997), mounds of *C. granulata* persist throughout several tidal cycles, accumulating at the surface (Botto and Iribarne, 2000). Several studies have showed that this continuous sediment deposition affects the sedimentary characteristics and also benthic organisms, especially during summer when crab activity is intense (Iribarne et al., 1997; Botto and Iribarne, 1999; 2000).

In spite of this behavior, abundance and widely distribution, no information is available about the effects of this crab on the structure of the meiofauna community in the Patos Lagoon's estuary. Hence, an experiment was carried out to evaluate the effects of this burrowing crab on meiofauna at three different habitats in an estuarine embayment of Patos Lagoon.

MATERIALS AND METHODS

This study was carried out during January/2000 (summer) in an area located near the east margin of Pólvora Island. Three habitats were selected across a tidal exposure gradient: (1) an emerged salt marsh dominated by *Spartina alterniflora*, (2) an emerged mudflat and (3) a submerged mudflat. The mean density of *C. granulata* burrows in each habitat was 23, 34 and 14 burrows m^{-2}, respectively.

At each habitat three sampling sites were established at same tidal level. At these sites, triplicate samples were taken at the mounds of the burrow (DISTURBED), and in adjacent undisturbed areas distant approximately 30 cm from the crabs burrow (CONTROL). Meiofaunal samples were taken using a corer tube (5.31 cm^2 area and 2 cm depth), fixed in 4 % buffered formalin and stained with vital stain Bengal Rose. At the same time, abiotic parameters such as pH and Eh were measured with an electronic meter (DIGIMED/DM2) and, surface sediment samples (from the first 2 cm) were collected in order to determine the granulometry and the organic matter content.

In the laboratory, meiofauna was manually extracted by elutriations in flowing water and the supernatant was sieved through a set of 500, 250, 125, 63 and 42 µm sieves. Meiofaunal organisms were sorted, identified to the highest taxonomic level and counted under a stereoscopic microscope. Granulometry data were obtained through sieving and pipette analysis and, dried samples were then combusted at 550 °C for 60 min in order to determine organic matter content through weight loss (Suguio, 1973).

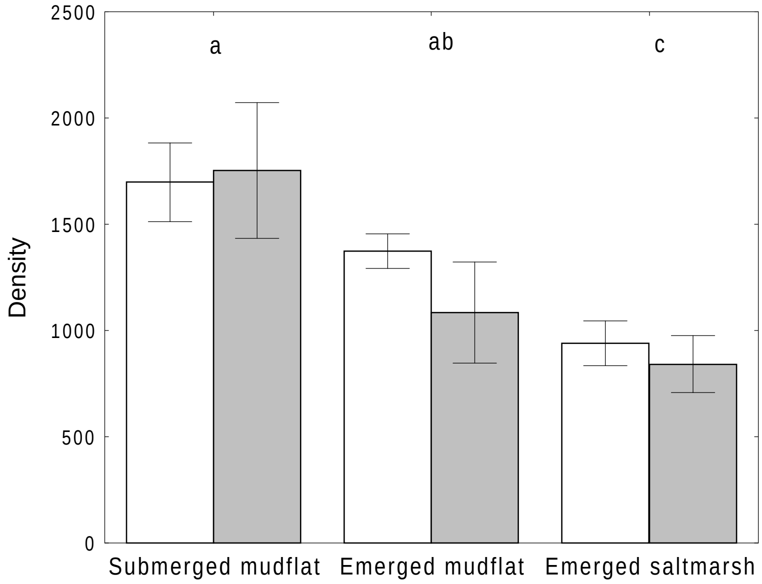

Figure 1 - Mean density (ind. m^{-2}) of nematodes in both habitats and situations. Bars with same letters above them are not significantly different from each other using Tukey's multiple comparison tests for effects of habitat. Error bars are ± 1 SD. Asterisks designate the level of significance between situations (control and disturbed) on same habitat (* $p<0.05$, ** $p<0.01$). Open bars: control; closed bars: disturbed.

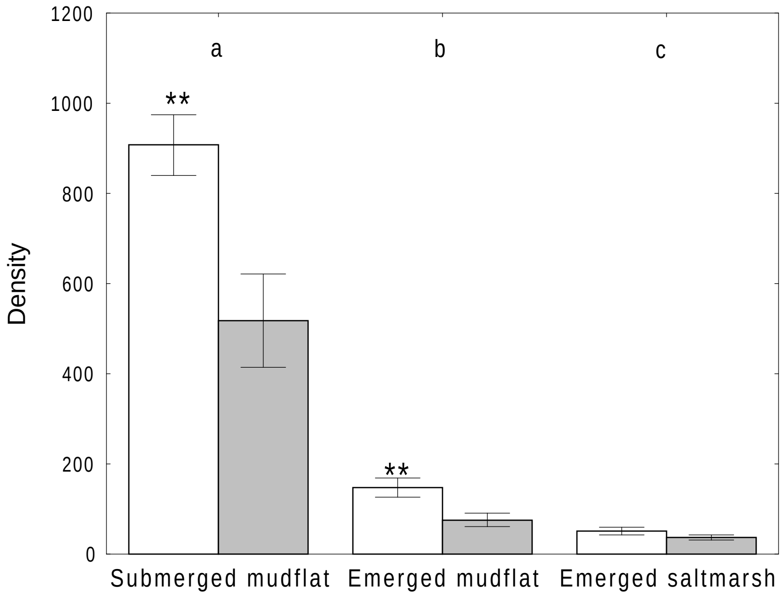

Figure 2 - Mean density (ind. m^{-2}) of ostracods in both habitats and situations. Bars with same letters above them are not significantly different from each other using Tukey's multiple comparison tests for effects of habitat. Error bars are ± 1 SD. Asterisks designate the level of significance between situations (control and disturbed) on same habitat (* $p<0.05$, ** $p<0.01$). Open bars: control; closed bars: disturbed.

Statistical analyses were based in a two-way ANOVA to test the differences in both meiofaunal data and abiotic parameters between habitats and situations (CONTROL and DISTURBED). All data were tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Cochran test and standard deviations-mean plots) prior to their use in statistical tests (Underwood, 1997). Biological data were transformed to log (x+1) to assure variance homogeneity and normal distribution. In cases in which the ANOVA result was significant ($p < 0.05$), Tukey's multiple comparison test was applied to determine specific differences (Underwood, 1997).

RESULTS

All abiotic parameters varied significantly ($p<0.05$) between the habitats. Sediment composition ranged from moderately sorted fine sand to in the submerged mudflat to very poorly sorted finest sand in both emerged habitats. Fine fractions and organic matter significantly increase from submerged to emerged habitats, while redox potential (Eh) and pH decreased (Table 1). However, differences observed among situations were no significant ($p>0.05$) at all habitats. Also, habitat by situation interactions were no significant ($p>0.05$).

Meiofauna community was dominated by nematodes and ostracods, followed by copepods and turbellarians. A significant difference ($p<0.01$) in densities of all meiofaunal groups was found among habitats. Also, significant differences ($p<0.01$) were found for densities of ostracods, copepods and turbellarians among situations. In no case was the habitat by situation interaction significant ($p>0.05$).

Densities all organisms were highest in submerged mudflat than emerged salt marsh (Fig. 1 to 4). However, differences of nematodes densities among the situations were no significant in neither habitat (Fig. 1) while ostracod, copepod and turbellarian densities were highest in control than in disturbed areas at both mudflats habitats (Fig. 2 to 4). In salt marsh, significant differences between control and disturbed areas were no found for the densities of neither meiofaunal group (Fig. 1 to 4).

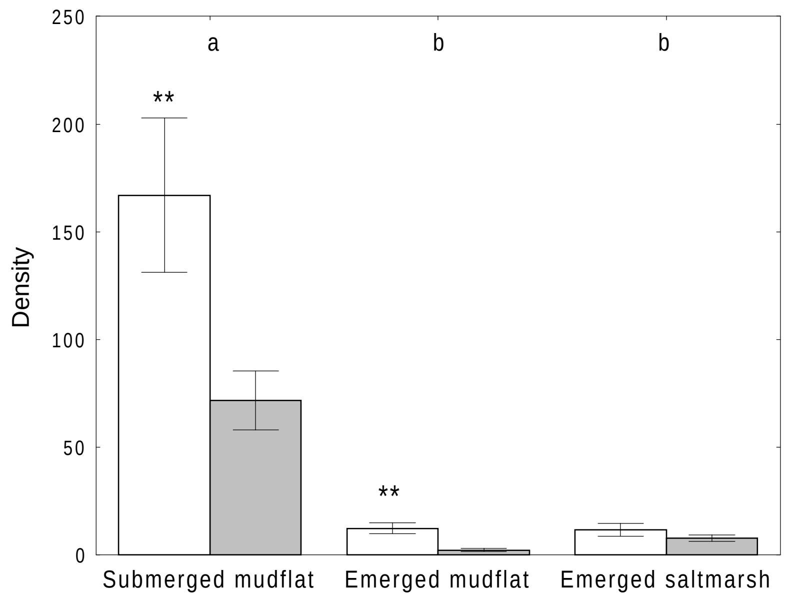

Figure 3 - Mean density (ind. m^{-2}) of copepods in both habitats and situations. Bars with same letters above them are not significantly different from each other using Tukey's multiple comparison tests for effects of habitat. Error bars are ± 1 SD. Asterisks designate the level of significance between situations (control and disturbed) on same habitat (* *p*<0.05, ** *p*<0.01). Open bars: control; closed bars: disturbed.

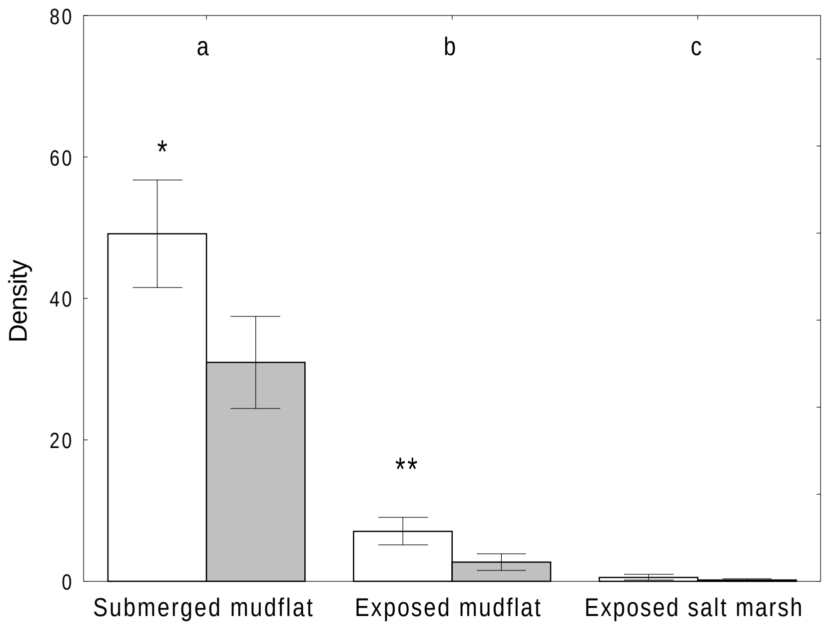

Figure 4 - Mean density (ind. m^{-2}) of turbellarians in both habitats and situations. Bars with same letters above them are not significantly different from each other using Tukey's multiple comparison tests for effects of habitat. Error bars are ± 1 SD. Asterisks designate the level of significance between situations (control and disturbed) on same habitat (* p<0.05, ** p<0.01). Open bars: control; closed bars: disturbed.

DISCUSSION

The results showed the meiofauna community structure was negatively affected by *C. granulata*, resulting in lower densities of the ostracods, copepods and turbellarians in sediment mounds at both mudflats habitats. However, nematodes were not affected in either habitat. Also, none meiofaunal group were affected in salt marsh habitat. The burrowing crab *C. granulata* is a deposit feeder but there are no evidences that this crab selectively preys upon meiofaunal organisms (D'Incao et al., 1990; Iribarne et al., 1997; Botto and Iribarne, 1999). The effects of this crab on meiofauna community structure are mainly related to an intense sediment disturbance because of the burrowing activities. Thus, it's quite plausible that crab disturbance caused by continuous sediment deposition around the burrow mainly affect the surface populations like copepods and ostracods.
The crustacean meiofauna regularly seemed to be most quickly affected by a perturbation event (Coull, 1988; Giere, 1993). Organisms such as harpacticoid copepods respond more quickly to reworked sediment (Alongi, 1985) or faecal casts (Thistle, 1980; Ólafsson et al., 1990). These organisms generally move easily, are good swimmers and may actively migrate to the water column during surface sediment disturbance (Bell and Sherman, 1980; Palmer and Molloy, 1986; Palmer, 1988). In several studies, it has been observed that harpacticoid copepods are affected by crab disturbance resulting in lower densities around burrows (Bell et al., 1978; Warwick et al., 1990; Ólafsson and Ndaro, 1997). Similar to copepods, ostracods can also display movements through water column (Palmer and Molloy, 1986; Keyser, 1988), thus, the lower densities around burrows may be due to active migration of the ostracods in response to bioturbation in superficial sediment layer. However, there are no studies evaluating the effects of burrowing crabs on these organisms.
Nematodes were not affected by burrowing crab in neither habitat, which suggested that these organisms could be well adapted to caused-crab disturbance. Similar results were found by Ólafsson and Ndaro (1997), which evaluated the

effects of two mangrove crabs (*Uca annulipes* and *Dotilla fenestrata*) on meiofauna through a microcosm experiment. After 10 days of enclosure, the authors found two nematode assemblages at microcosm, one in the surface layer and other in the deeper down. However, the crabs did not alter the structure of these assemblages. According to these authors, the nematode fauna is well adapted to the intense bioturbation and is not effectively eaten by crabs.

Many studies indicate that surface bioturbation has little or no effect on nematode assemblage (Sherman et al., 1983; Ólafsson et al., 1990; Ólafsson and Elmgren, 1991), though in other cases significant differences have been found (Warwick et al., 1990; Schratzberger and Warwick, 1999). Warwick et al., (1990) examined the effects of sediment disturbance by the soldier crab *Mictyris platycheles* on meiobenthic community using a natural experiment in Tasmania, Australia. Although species richness, species diversity and evenness were significantly reduced in disturbed than in undisturbed areas, the total abundance of nematode was unaffected (Warwick et al., 1990).

There would be two explanations for answering why we did not detect any crab effects on meiofauna at salt marsh. One possible reason could be related to meiofauna densities, which were too low for suffering a detectable field effect. However, copepods were affected only at emerged mudflat, although their densities had be significantly lower in both salt marsh and emerged mudflat (see Fig 3). The most reasonable cause was probably related to the differences in both intensity and frequency of crab disturbance among these habitats. A recent study (Iribarne et al., 1997) has shown that individuals of *C. granulata* from *Spartina*-marsh and mudflats differ in sediment processing rate and burrow dynamic. Sediment turnover rate was much lower in salt marsh areas (mean = 2.4 kg m^{-2} d^{-1}) than in mudflat (mean = 5.9 kg m^{-2} d^{-1}) and, burrows were also much less dynamic in marsh areas, in terms of percentage of active burrows per day (Iribarne et al., 1997). These differences result in less intensity and frequency of crab disturbance in salt marsh area, which do not affect the meiofauna in this habitat, like observed in this study.

Nevertheless it is clear that biological disturbance may be important in structuring meiofaunal communities, it remains difficult to make general predictions concerning how soft-bottoms communities will react to biotic disturbance. This is because biological disturbance is species specific, variable within and between habitats and difficult to scale according to intensity and frequency (Ólafsson and Ndaro, 1997). These results showed that the burrowing crab *C. granulata* could play an important role in determining meiofauna community structure in estuarine intertidal habitats of Patos Lagoon. However, crab disturbance seemed to affect mainly surface populations, especially in mudflat. Furthermore, the lack of effect observed in salt marsh was probably related to a less intense disturbance, suggesting that meiofauna response to crab disturbance was variable among habitats depending on the intensity and frequency of the disturbance.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Nilton Abreu for great help at the Benthic Invertebrates Ecology Laboratory. The study received financial support from the Brazilian Long Term Ecological Research (CNPq – Proc. # 520188/98-5) and L. C. Rosa was supported by a scholarship from the Coordenadoria de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

RESUMO

Este trabalho avalia os efeitos do caranguejo *Chasmagnathus granulata* sobre a meiofauna em três ambientes intermareais, durante um prolongado período de exposição (uma marisma emersa, um plano de lama emerso e outro submerso), numa enseada estuarina da Lagoa dos Patos. Nematódeos e ostrácodes foram os organismos dominantes, seguidos por copépodes e turbelários. As densidades dos organismos variam significativamente entre os hábitats. As maiores densidades foram registradas no plano de lama submerso e as menores na marisma. Os nematódeos não foram afetados pelo caranguejo em nenhum hábitat. As densidades dos ostrácodes, copépodes e turbelários foram significativamente menores nos sedimentos perturbados do que nas áreas controles de ambos os planos de lama. Nenhum efeito foi observado na marisma, provavelmente devido a uma menor intensidade de

perturbação. Os resultados obtidos mostram que o caranguejo *C. granulata* pode ter importante papel sobre a estrutura da meiofauna em ambientes intermareais do estuário da Lagoa dos Patos. No entanto, a perturbação causada por este caranguejo parece afetar essencialmente organismos superficiais e, em especial nos planos de lama. Adicionalmente, a resposta da meiofauna à perturbação variou entre os hábitats, dependendo da intensidade e freqüência da perturbação.

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Received: May 26, 2003;
Revised: March 23, 2004;
Accepted: August 18, 2004.