

Is the occurrence of caprellid amphipods associated with *Sargassum* (Phaeophyta) influenced by algal and hydrozoan epibiosis?

Fernando Lima R. Cunha¹, Amanda Ferreira Cunha¹ & Giuliano Buzá Jacobucci¹

¹Universidade Federal de Uberlândia, Instituto de Biologia, Rua Ceará s/n, Campus Umuarama, 38402-400, Uberlândia, MG, Brazil. E-mail: fernandolrcunha@yahoo.com.br; amandaf_cunha@yahoo.com.br; jacobucci@inbio.ufu.br

Abstract. The presence of epiphytic organisms can influence the distribution of macroinvertebrates associated with algae. This study evaluated the influence of *Sargassum* epibiosis by epiphytic algae and hydroids on the occurrence of caprellid amphipods. The sampling was carried out on *Sargassum* beds of Ubatuba beaches, northern coast of São Paulo state, in October 2006. The presence of epiphytic algae and hydroids on *Sargassum* fronds was evaluated using five cover categories. Epiphytic algae showed significant cover differences among beaches, while hydroids occurrence was more uniform, without significant differences on the levels of epibiosis. None of the caprellid species identified showed differences in its density among beaches. Despite the epibiosis variation, it was not a determinant factor in the distribution of caprellid species.

Key words: Caprellidea, *Sargassum*, epibiosis, Hydrozoa.

Resumo: A epibiose por algas e hidrozoários influencia a ocorrência de anfípodes caprelídeos associados a *Sargassum* (Phaeophyta)? A presença de epibiontes pode influenciar a distribuição de macroinvertebrados associados a algas. Neste trabalho avaliou-se a influência da epibiose de *Sargassum* por algas epifitas e hidrozoários na ocorrência de anfípodes caprelídeos. Foram realizadas coletas em bancos de *Sargassum* em praias da região de Ubatuba, litoral norte do Estado de São Paulo, em outubro de 2006. A presença de algas epifitas e hidrozoários nas frondes de *Sargassum* foi avaliada utilizando-se cinco categorias de cobertura. As algas epifitas apresentaram variação significativa de cobertura entre as praias e os hidrozoários ocorreram de modo mais uniforme. Nenhuma das espécies de caprelídeos identificadas apresentou diferença de densidade entre praias. Apesar da variação na epibiose, este não foi um fator determinante na distribuição das espécies de caprelídeos.

Palavras-chave: Caprellidea, *Sargassum*, epibiose, Hydrozoa.

INTRODUCTION

The suborder Caprellidea is one of the main epifaunal peracarid crustaceans associated with macrophytes, following gammaridean amphipods in dominance order. The caprellids are known to inhabit a great variety of marine environments (GUERRA-GARCIA & GARCÍA-GÓMEZ, 2001), occurring in many different types of substrata (CAINE, 1978). They present morphological adaptations to maximize food acquisition (CAINE, 1977), and to cling to substrata like algae and hydroids (AOKI, 1997).

Several environmental factors influence the occurrence of the amphipods associated with algae.

For instance, wave action (FENWICK, 1976; MASUNARI & FORNERIS, 1981) and structural characteristics of macrophytes are mentioned in several studies as important factors that explain diversity patterns of crustacean assemblages (EDGAR, 1983; HACKER & STENECK, 1990; LEITE & TURRA, 2003; LEITE *et al.*, 2007).

The epibiosis of macrophytes, normally represented by the load of sessile invertebrates and epiphytic algae, is also a main factor to be considered. For most species of caprellids, the occurrence of epiphytic algae is an essential feature for substrate colonization (DUFFY, 1990; EDGAR, 1991). They influence the associated fauna by offering substrate, food resources (directly or indirectly, trapping detritus

and favoring periphyton growth) and refuge from fish and invertebrate predators (HICKS, 1986; HACKER & STENECK, 1990).

Hydroids also represent an important substrate for the macrofauna associated with macrophytes, being colonized by many vagile epifaunal species, like caprellids (GILI & HUGES, 1995). When present, the hydroids offer more space to live, since they constitute a highly branched substrata when attached to *Sargassum* fronds (JACOBUCCI *et al.*, 2002), raise filter-feeding species into the water column, increasing their food supply, offer shelter from predators, place to mate and lay eggs, and can represent a food resource to some epifaunal species (BRADSHAW *et al.*, 2003).

In southeastern Brazil, the subtidal rockshores with macroalgal beds are usually dominated by *Sargassum*, especially in the Rio de Janeiro and São Paulo state coasts (SZÉCHY & PAULA, 2000). Although the caprellid amphipods are one of the most conspicuous taxa on *Sargassum* in Brazilian waters (JACOBUCCI & LEITE, 2002), the biology of this group is still poorly understood. Only a few ecological studies specifically focused on this group of crustaceans (TAKEDA, 1981; JACOBUCCI *et al.*, 2002).

The aim of this study was to evaluate how the epibiosis by epiphytic algae and hydrozoan could influence the occurrence of caprellid amphipods associated with *Sargassum* beds of Ubatuba, in the northern coast of São Paulo State, Brazil.

MATERIALS AND METHODS

Study sites

The study was carried out in *Sargassum* beds located in five beaches of Ubatuba in October 2006. At Fortaleza inlet, sampling was performed at Domingas Dias (23°30'W; 45°09'S) and Lázaro (23°30'W; 45°08'S), and at Flamengo inlet, at Lamberto (23°30'W; 45°07'S), Perequê-Mirim (23°29'W; 45°07'S) and Enseada (23°30'W; 45°06'S) beaches (Fig.1).

All *Sargassum* fronds were collected in the sublittoral zone by snorkeling, during periods of similar tide conditions. The selection of sampling sites was



Figure 1. Localization of sampling sites (◆) at Ubatuba.

done considering similar water movement conditions to minimize the possible influence of hydrodynamics on caprellid assemblages. To ensure that the *Sargassum* beds selected had very similar physical conditions, water movement and particulate suspended solids were evaluated.

Sampling and processing

Hydrodynamics were measured by the dissolution of plaster structures built with frames and PVC tubes submerged in *Sargassum* beds of the sampling stations. In each location, three plaster structures were positioned at five meter intervals among them, and brought in after 24 hours (adapted from GUERRA-GARCÍA & GARCÍA-GÓMEZ, 2001). The plaster structures were made from quick drying odontological plaster in fixed volume proportions (70% plaster and 30% water) and molded in disposable plastic cups fixed by screws (adapted from GUERRA-GARCÍA & GARCÍA-GÓMEZ, 2001). After drying for three days at room temperature (~25°C), their weights were obtained using a digital semi-analytical balance. Differences between the plaster structures weights before and after their positioning in the sampling stations corresponded to the plaster's dissolution rate, which permitted local hydrodynamics estimation, in grams per hour.

Three bottles of 517 mL each were used to collect water from the same places where the plaster

structures were positioned. The water collected was filtered in a vacuum filter using a Millipore membrane with 0.22 μm of pore size, to determine the amount of suspended sediment (JACOBUCCI, 2005). The difference between the membrane dry weights, obtained from an analytical balance before and after filtering, offered an estimation of the local particulate suspended solids in the sampling period.

In each sampling site six fronds of *Sargassum* were randomly sampled. The fronds were scraped off with the help of a spatula and wrapped in cloth bags with 200 μm mesh size. These bags were placed in containers with seawater and transported to the laboratory. The collections were carried out using snorkeling. Each frond was placed separately in a tray with a solution of 5 % formaldehyde in seawater and submitted to four successive washings to remove fauna. The washes from this process were filtered through a screen with a 200 μm mesh size for retention of the caprellid amphipods which were then fixed in 70% alcohol. The caprellids were identified to species level and counted under a stereomicroscope.

The *Sargassum* fronds were identified according to FORTES-XAVIER (2000) and fixed in 5% formaldehyde for epibiosis measurements. The epibiosis was separately estimated for hydrozoans and epiphytic algae using five frond cover categories: 0 = absence of epibiosis, 1 = 0 to 25% cover, 2 = 25 to 50% cover, 3 = 50 to 75% cover e 4 = 75 to 100% cover (JACOBUCCI, 2000). Weights of *Sargassum* fronds were obtained after a three day drying period at room temperature ($\sim 25^{\circ}\text{C}$).

Data analysis

To standardize data, the abundance of caprellids were expressed in terms of density (mean + S.E.), that is, as the number of individuals per gram of *Sargassum* dry weight.

Comparisons related to the amount of suspended solids and hydrodynamics among sampling stations were made through one-way ANOVA, considering the data normality and homocedasticity, and its transformation when necessary to attend Analysis of Variance premises (ZAR, 1999). The G-test was performed to compare epiphytic algae and hydroid cover in *Sargassum* fronds among sampling stations.

Similarities among samples were compared using non-metric multidimensional scaling (nMDS), which is an ordination method preferable than correspondence analysis in cases of species abundance matrices (CLARKE & WARWICK, 2001).

RESULTS

The sampling sites showed similar physical conditions without significant differences of suspended solids ($F_{5,12} = 0,82$; ns) and water movement ($F_{5,12} = 2,99$; ns) (Fig.2).

Two species of *Sargassum* were identified in the sampling sites. At Lázaro and Domingas Dias algal beds, the species sampled was *Sargassum cymosum* C. Agardh, 1820, and at Lamberto, Perequê-Mirim and Enseada, *Sargassum stenophyllum* Martius, 1828.

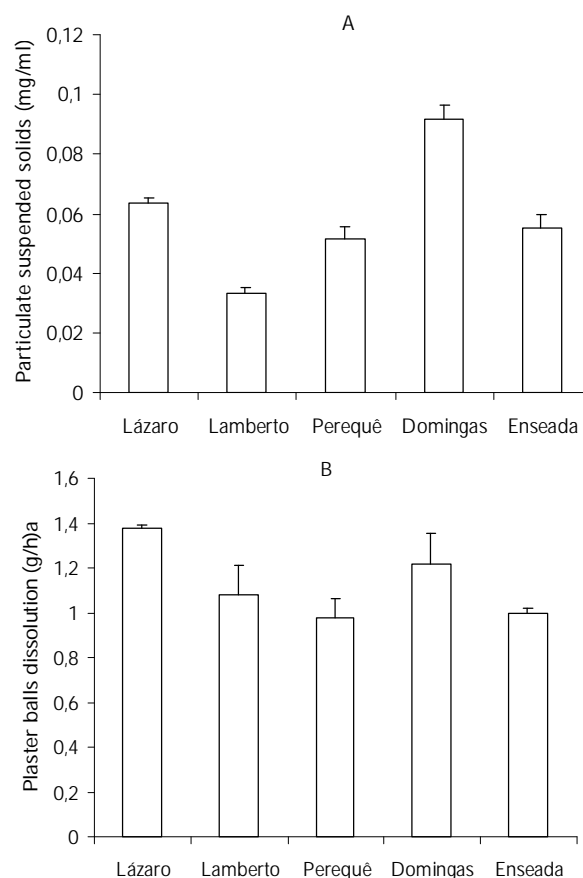


Figure 2. Particulate suspended solids (A) and plaster structures dissolution (B) (average + standard error), in the sampling areas.

In all *Sargassum* fronds with epiphytes, the only algal species recorded was the rodophycean *Hypnea musciformis* (Wulfen) J.V. Lamouroux 1813. Significant differences were verified among the epiphytism levels of the five beaches sampled ($G = 26.982$; $p = 0.042$), with epiphytic cover varying from zero to high levels. It was noted a higher cover constancy in Lázaro, Lamberto and Perequê beaches, with high load of epiphytes in *Sargassum* fronds, while in Domingas Dias and mostly in Enseada beach, a higher epiphytic variation was found (Fig.3A).

In relation to the occurrence of hydroids in *Sargassum* fronds, no significant differences were found among the epibiosis levels for the beaches sampled ($G = 13.949$; $p = 0.603$). All sampling sites showed constant cover levels at 0 and 1 categories, except Lázaro beach, in which a great variation in epibiosis was verified, since 0 until the epibiosis interval of 75-100% (Fig.3B).

We recorded 207 amphipods belonging to six caprellid species, the Caprellidae *Caprella scaura* Templeton, 1836, *Caprella danilevskii* Czerniavski,

1868, *Caprella equilibra* Say, 1818, *Caprella dilatata* Krøyer, 1843, *Falлотritella montoucheti* Quitete, 1971 and the Pariambidae *Paracaprella tenuis* Mayer, 1903. Only *C. danilevskii* e *P. tenuis* occurred in all sampling sites.

Significant differences in densities of caprellid species among sampling sites, were not recorded (Tab.1). At Lázaro *Sargassum* bed, *Caprella equilibra* was the most abundant species, at Domingas Dias *Caprella danilevskii* and at Enseada, *Paracaprella tenuis*. For the other two sampling sites caprellid species densities were similar (Fig.4).

The nMDS analysis showed no corresponding sampling groups (Fig.5). Only Domingas Dias samples appeared to be a bit distinct from the others, probably because in this site, three of the five caprellid species were not found. In most part of the sampling sites, the five caprellid species were found.

Table 1. Results of ANOVA comparing densities of each caprellid species among sampling sites (ns = not significant).

Species	df	F
<i>Caprella scaura</i>		
Templeton, 1836		
Sampling site	4	1.19ns
Residual	25	
<i>Caprella danilevskii</i>		
Czerniavski, 1868		
Sampling site	4	1.83ns
Residual	25	
<i>Caprella equilibra</i>		
Say, 1818		
Sampling site	4	1.58ns
Residual	25	
<i>Falлотritella montoucheti</i>		
Quitete, 1971		
Sampling site	4	2.25ns
Residual	25	
<i>Paracaprella tenuis</i>		
Mayer, 1903		
Sampling site	4	0.91ns
Residual	25	

Caprella dilatata was not evaluated because it was only recorded at Domingas Dias.

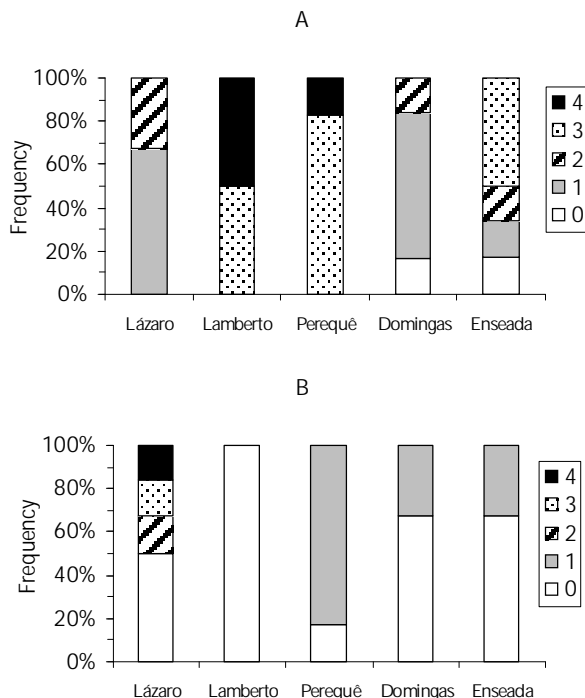


Figure 3. Relative frequency of cover by epiphytic algae (A) and hydroids (B). Categories: 0 - 0%; 1 - 0 to 25%; 2 - 25 to 50%; 3 - 50 to 75%; 4 - 75 to 100%.

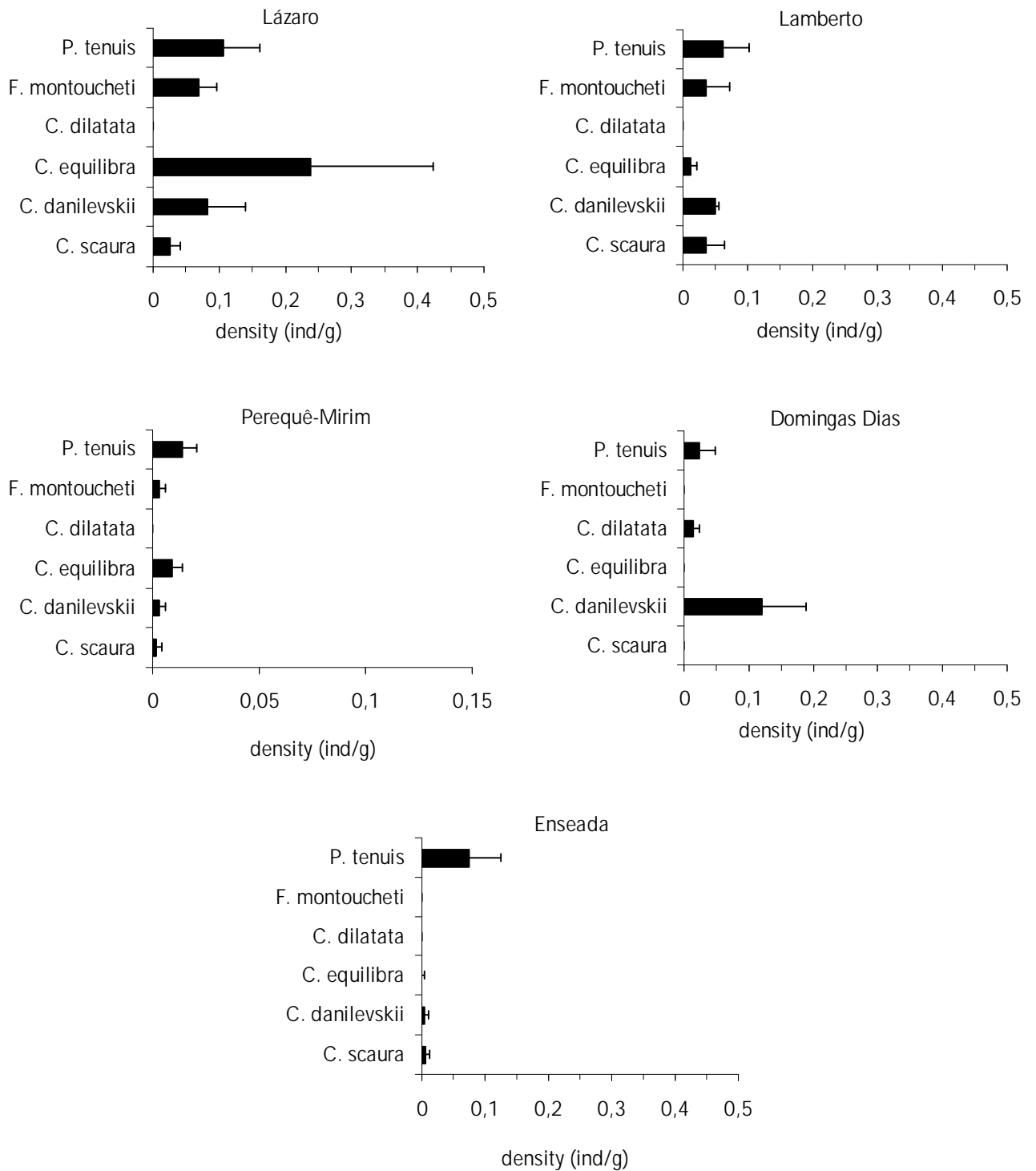


Figure 4. Densities (average + standard error) of caprellid species (number of individuals /g of *Sargassum*) in the five sampling sites.

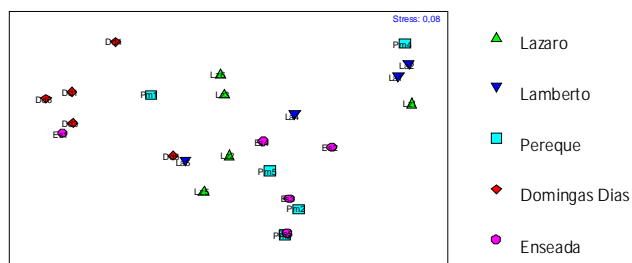


Figure 5. Non-metric multidimensional scaling (nMDS), comparing caprellid samples of different sites.

DISCUSSION

The similarities in the hydrodynamic conditions and quantity of suspended solids could indicate equivalent relations between the levels of epibiosis in *Sargassum* fronds and the occurrence of caprellid species, since epiphytic algae and hydroid abundance in *Sargassum* fronds have a clear relationship with those conditions, especially with the levels of wave exposure (EDGAR, 1983; SZÉCHY & PAULA, 2000). However, this fact was not verified in the present study, since the differences in epiphytism levels of the sampled fronds were not followed by differences in caprellid densities.

Epiphytic algal cover varied among samples, fact that was verified by another study performed in the same area (GÜTH, 2004). Furthermore, we recorded higher levels of *Sargassum* epibiosis at Lamberto's beach compared to that study. This result is probably related to sampling period differences. For instance, temporal fluctuations in factors like solar incidence and nutrient availability could generate differences in the epiphytes growth.

The distribution patterns of epiphytic algae can also be explained by the host's suitability. Those hosts with a great quantity and diversity of epiphytic species can be classified as "favorable" hosts, while those species of host which are found without or with less epiphytes can be considered "nonfavorable" hosts (BALLANTINE, 1979). Considering that the structure of *Sargassum* fronds can influence the intensity of *Hypnea* epiphytism they sustain (LEITE & TURRA, 2003), fronds of the sampled beaches may have

supported or not the same amount of epiphytic algal growth, resulting in the varying levels of epiphytism verified in this study.

Differences in the levels of epibiosis by hydroids were not verified, even though there was a great quantity of epiphytic hydroids present in Lázaro beach, in relation to the other sampled beaches. The similarity in hydrodynamics among sampled beaches could have led to similarities in the levels of epibiosis by hydroids, since hydrodynamics influences patterns of hydrozoan zonation and succession (BOERO & FRESI, 1986). Furthermore, it is important to consider that each hydroid species has a characteristic distribution pattern related to ecological conditions (KATO *et al.*, 1961), and because of that, there are many variables that could influence its distribution in *Sargassum* fronds.

Considering that epiphytic algae and hydroids can contribute to an increase in the habitat complexity of its host macrophyte (HALL & BELL, 1988; MARTIN-SMITH, 1993; BRADSHAW *et al.*, 2003), it is expected that more complex environments should contain a higher density of species, specially due to the higher amount of space available for living (DOWNES *et al.*, 2000). However, in this study this pattern was not observed. A possible explanation would be that the recorded levels of epibiosis on *Sargassum* fronds may have not led to significant differences in habitat complexity, that would influence caprellid densities.

Caprellid species recorded in this study have been also observed in the region by other authors and the differences in composition, abundance and number of species were mainly attributed to variations in local environmental characteristics of the sampling sites, such as pollution, depth and hydrodynamics, and also to natural temporal fluctuations in caprellid populations (JACOBUCCI, 2000; JACOBUCCI *et al.*, 2002; GÜTH, 2004).

It is well known that specific hydrodynamic and turbidity conditions can influence caprellid species abundance (GUERRA-GARCÍA & GARCÍA-GOMEZ, 2001), since hydrodynamic factors can be a determinant primary condition to amphipod distribution (KRAPP-SCHICKEL, 1993). Considering the similarities in hydrodynamics and suspended solids of the sampled

beaches, the absence of differences in caprellid densities among sites may have reflected those relations.

We strongly recommend further investigations upon the interaction between epibionts and caprellid assemblages on Brazilian coast. Field and laboratory experiments should be conducted to directly address this relationship leading to a broader understanding over these interactions of important peracarid group.

ACKNOWLEDGMENTS

We would like to thank the laboratory staff for field work assistance and A. Z. Güth for data analysis support.

REFERENCES

- AOKI, M. 1997. Comparative study of mother-young association in caprellid amphipods: is maternal care effective? *Journal of Crustacean Biology* 17 (3): 447-458.
- BALLANTINE, D.L. 1979. The distribution of algal epiphytes on macrophyte hosts offshore from La Parguera, Puerto Rico. *Botanica Marina* 22: 107-111.
- BRADSHAW, C.; COLLINS, P. & BRAND, A.R. 2003. To what extent does upright epifauna affect benthic biodiversity and community composition? *Marine Biology* 143: 783-791.
- BOERO, F. & FRESI, E. 1986. Zonation and evolution of a rocky bottom hydroid community. *Marine Ecology* 7 (2): 123-150.
- CAINE, E.A. 1977. Feeding mechanisms and possible resource partitioning of the Caprellidae (Crustacea: Amphipoda) from Puget Sound, USA. *Marine Biology* 42: 331-333.
- CAINE, E.A. 1978. Habitat adaptations of north american caprellid Amphipoda (Crustacea). *Biological Bulletin* 155: 288-296.
- CLARKE, K.R. & WARWICK, R.M. 2001. Change in marine communities: An approach to statistical analysis and interpretation. Second edition. Primer-E Limited. Plymouth, UK. 172 p.
- DOWNES, B.J.; LAKE P.S.; SCHREIBER, E.S.G. & GLAISTER, A. 2000. Habitat structure, resources and diversity: the separate effects of surface roughness and macroalgae on stream invertebrates. *Oecologia* 123: 569-581.
- DUFFY, J.E. 1990. Amphipods on seaweeds: partners or pests? *Oecologia* 8: 267-276.
- EDGAR, G.J. 1983. The ecology of south-east Tasmanian phytal animal communities. I. Spatial organization on a local scale. *Journal of Experimental Marine Biology and Ecology* 70: 129-157.
- EDGAR, G.J. 1991. Artificial algae as habitats for mobile epifauna: factors affecting colonization in a Japanese *Sargassum* bed. *Hidrobiologia* 226: 111-118.
- FENWICK, G.D. 1976. The effect of wave exposure on the amphipod fauna of the alga *Caulerpa brownii*. *Journal of Experimental Marine Biology and Ecology* 25: 1-18.
- FORTES-XAVIER, A.C.M. 2000. O gênero *Sargassum* C. Agardh (Phaeophyta – Fucales) no litoral brasileiro. Tese de Doutorado. Universidade de São Paulo. 135p.
- GILI, J. & HUGHES, R.G. 1995. The ecology of marine benthic hydroids. *Oceanography and Marine Biology: an annual Review* 33: 351-426.
- GUERRA-GARCIA, J.M. & GARCIA-GOMEZ, J.C. 2001. The spatial distribution of Caprellidea (Crustacea: Amphipoda): A stress bioindicator in Ceuta (North Africa, Gibraltar). *Marine Ecology* 22 (4): 357-367.
- GÜTH, A.Z. 2004. A comunidade fital: Variação espacial e nictemeral da epifauna, especialmente anfípodos, associada à alga parda *Sargassum* spp. em quatro praias de Ubatuba, litoral norte do estado de São Paulo. Dissertação de Mestrado. Universidade Estadual de Campinas. 78p.
- HACKER, S.D. & STENECK, R.S. 1990. Habitat architecture and body-size-dependent habitat selection of a phytal amphipod. *Ecology* 71: 2269-2285.
- HALL, M.O. & BELL, S.S. 1988. Response of small motile epifauna to complexity of epiphytic algae on seagrass blades. *Journal of Marine Research* 46: 613-630.
- HICKS, G.R.F. 1986. Meiofauna associated with rocky shore algae. pp.36-56. In: MOORE, P.G. & SEED, R. (eds). *Ecology of Rocky Coasts*. London, Hodder and Stoughton.
- JACOBUCCI, G.B. 2000. Distribuição vertical e flutuação sazonal da macrofauna vágil associada a *Sargassum cymosum* C. Agardh, em uma praia do litoral norte do Estado de São Paulo. Dissertação de Mestrado. Universidade Estadual de Campinas. 109 p.
- JACOBUCCI, G.B. & LEITE, F.P.P. 2002. Distribuição vertical e flutuação sazonal da macrofauna vágil associada a *Sargassum cymosum* C. Agardh, na praia do Lázaro, Ubatuba, São Paulo, Brasil. *Revista Brasileira de Zoologia* 19 (supl.1): 87-100.
- JACOBUCCI, G.B.; MORETTI, D.; SILVA, E.M. & LEITE, F.P.P. 2002. Caprellid amphipod on *Sargassum cymosum* (Phaeophyta): depth distribution and population biology. *Nauplius* 10 (1): 27-36.
- JACOBUCCI, G.B., 2005. Interações *Sargassum*-epífitas-anfípodes herbívoros na região de Ubatuba, litoral norte do estado de São Paulo. Tese de Doutorado. Universidade Estadual de Campinas. 119p.
- KATO, M.; NAKAMURA, K.; HIRAI, E. & KAKINUMA, Y. 1961. The distribution pattern of Hydrozoa on seaweed with some notes on the so-called coaction among hydrozoan species. *Bulletin of the Marine Biological Station of*

- Asamushi 10 (3): 195-202.
- KRAPP-SCHICKEL, G. 1993. Do algal-dwelling amphipods react to the 'critical zones' of a coastal slope? *Journal of Natural History* 27: 883-900.
- LEITE, F.P.P.; TANAKA, M.O. & GEBARA, R.S. 2007. Structural variation in the brown alga *Sargassum cymosum* and its effects on associated amphipod assemblages. *Brazilian Journal of Biology* 67 (2): 215-221.
- LEITE, F.P.P. & TURRA, A. 2003. Temporal variation in *Sargassum* biomass, *Hypnea* epiphytism and associated fauna. *Brazilian Archives of Biology and Technology* 46 (4): 665-671.
- MARTIN-SMITH, K.M. 1993. Abundance of mobile epifauna: the role of habitat complexity and predation by fishes. *Journal of Experimental Marine Biology and Ecology* 174: 243-260.
- MASUNARI, S. & FORNERIS, L. 1981. O ecossistema fital - Uma revisão, pp: 149 – 172. *In: Seminários de Biologia Marinha*. Rio de Janeiro. Academia Brasileira de Letras.
- SZECHY, M.T.M. & PAULA, E.J. 2000. Padrões estruturais quantitativos em bancos de *Sargassum* (Phaeophyta, Fucales) do litoral dos estados do Rio de Janeiro e São Paulo, Brasil. *Revista Brasileira de Botânica* 23: 121-132.
- TAKEDA, A.M. 1981. Aspectos do crescimento e da alimentação de *Caprella scaura typica* Mayer 1890. Dissertação de Mestrado. Universidade de São Paulo. 65 p.
- ZAR, J.H. 1999. *Biostatistical Analysis*. 4thed. Upper Saddle River, NJ. Prentice Hall. 663p.

Recebido: 26/05/2008
Revisado: 02/11/2008
Aceito: 25/11/2008