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Spatial distribution and shell utilization in three sympatric hermit crabs at non-consolidated sublittoral of estuarine-bay complex in São Vicente, São Paulo, Brazil

Distribución del espacio y del uso de conchas por tres especies de cangrejo ermitaño en el sublitoral no consolidado del complejo bahía-estuario de São Vicente, São Paulo, Brasil

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Resumen.- El objetivo de este estudio fue definir la distribución de tres especies de cangrejo ermitaño y la utilización de conchas en el sublitoral no consolidado del complejo bahía-estuario de São Vicente, Provincia de São Paulo, en Brasil. Las muestras fueron retiradas mensualmente durante dos años consecutivos. Factores ambientales como temperatura, salinidad y profundidad, también fueron registrados todos los meses. Las tres especies de ermitaños *Clibanarius vittatus*, *Loxopagurus loxochelis* e *Isocheles sawayai* fueron capturadas con la utilización de la concha de seis especies de gasterópodos; 92,7% de los individuos utilizaron conchas de *Stramonita haemastoma*. Los resultados indicaron una fuerte asociación entre la distribución espacial de los ermitaños y la salinidad, que mostró ser el principal factor límite de su distribución en ese estuario. *I. sawayai* fue la única especie presente en todos los lugares muestreados en este estudio; *C. vittatus* fue capturado solamente en los lugares de menor salinidad y *L. loxochelis* estaba presente sólo donde la salinidad se mantuvo con altos niveles.

Palabras clave: *Clibanarius*, *Loxopaguros*, *Isocheles*, Anomura

Abstract.- The objective of the present study was to characterize the spatial distribution and shell utilization of three hermit crab species in the estuarine-bay complex of São Vicente, São Paulo State, Brazil. Monthly samples were done throughout two years, in the non-consolidated sub-littoral at the estuarine-bay complex. The environmental factors, such as temperature, salinity and depth, were measured every month. The three hermit crab species, *Clibanarius vittatus*, *Loxopagurus loxochelis* and *Isocheles sawayai*, were captured utilizing shells from six gastropods species; 92.7% of the hermit crabs utilized *Stramonita haemastoma*. The results suggest a strong correlation between hermit crabs spatial distribution and salinity, which was considered the main environmental factor limiting their distribution in the estuary. *I. sawayai* was the only species present in all transects sampled; *C. vittatus* was captured only in regions with low salinity and *L. loxochelis* occurred only in high salinity waters.

Key words: *Clibanarius*, *Loxopaguros*, *Isocheles*, Anomura

Introduction

To characterize the spatial distribution of any species is necessary to search information about the animal biological aspects, such as the way of feeding and behavior. However, it is also necessary to analyze the local characteristics to evaluate the geological history and the environmental factors' variations (Fernandes-Góes 1997).

Abiotic factors must be carefully considered because some ecological interactions are the main cause of

seasonal and spatial distribution of individuals (Buchanan & Stoner 1988). There are many studies confirming the influence of interactions among abiotic factors. One of them is Fransozo *et al.* (1992) study, which associated the brachyurans' distribution to organic matter rate, where some species only occurred in places of higher indices of organic matter; in Ubatuba bay, Southeast of Brazil, Negreiros-Fransozo *et al.* (1997) found the same correlation with anomurans in this location. Although the influence of organic matter in the crustaceans distribution verified in the studies above, it is important to stand out that in most cases there are several factors that determine the occurrence and distribution of benthic organisms, as verified by Fernandez-Góes (2000) who studied an anomuran community in the Southeast of Brazil.

Despite of the great importance of the environmental conditions to the anomurans distribution, mainly in hermit crab populations, it should also be considered the biogenetic factor and the shell availability (Negreiros-Fransozo *et al*. 1997), because of its dependence of bigger shells throughout its life for survival. Hermit crabs are dependent of the gastropod shells, and this fact, according to Reese (1969), is the main adaptation of this group, allowing its dominance of the intertidal region.

In the lack of gastropod shells, hermit crabs have been recorded using bottle caps, bamboo pieces (Imafuku & Ando 1999) and even shells of land gastropods (Meireles & Mantelatto 2003, Sant'Anna *et al*. 2005). The shell is a so important resource that the use of other structures or shells with the invert spiral, can deform the hermit crab abdomen (Blackstone 1985), and in a similar way, inadequate shells can delay the crab growth (Osorno *et al.* 1998) and reproduction (Bertness 1981).

The aim of the present study was to characterize the spatial distribution and shell utilization by the three hermit crab species: *Clibanarius vittatu*s (Bosc, 1802), *Loxopagurus loxochelis* (Moreira, 1901) and *Isocheles sawayai* Forest & Saint Laurent, 1967 in the bay-estuary complex of São Vicente, São Paulo, Brazil.

Material and methods

The hermit crab specimens were monthly captured in São Vicente (SP) from September 2000 to August 2002. A shrimp fishing boat equipped with an otter-trawl net (length: 7.5 m; aperture: 3.7 m and height: 2.0 m) with 10 mm mesh size was used to capture the animals during a 20-min sampling at four transects: Transect 1 (T1): Itararé beach, between Porchat and Urubuqueçaba islands; Transect 2 (T2): in front of Paranapuã beach, behind of Porchat island; Transect 3 (T3): São Vicente square, between Pênsil and Mar Pequeno bridges and Transect 4 (T4): São Vicente square, between Mar Pequeno and Barreiros bridges (Fig. 1).

Hermit crabs were sorted from other fishery products and identified according to Melo (1999), and the gastropods shells, according to Rios (1994).

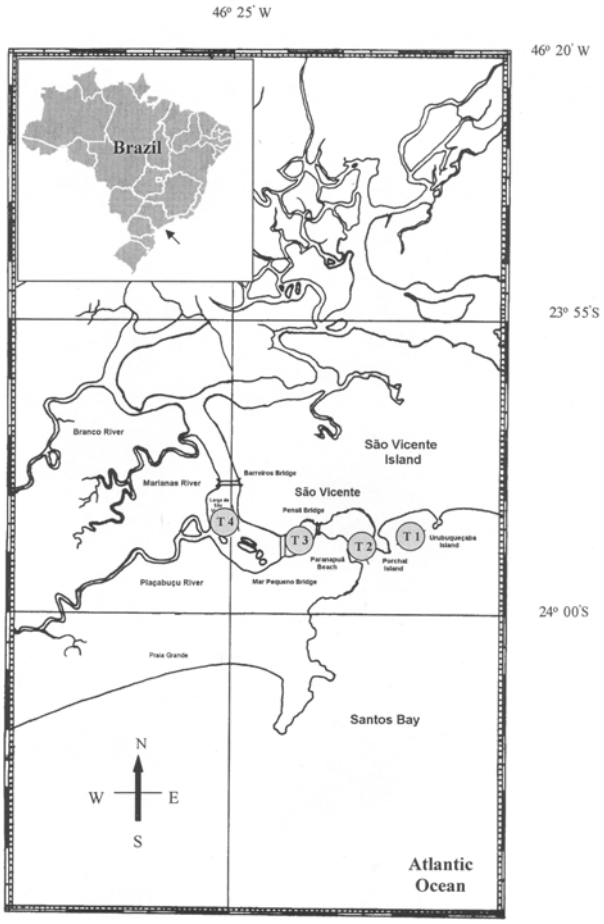

Figure 1

Studied area in the bay-estuary complex of São Vicente, São Paulo, Brazil. Transects:T1, T2,T3 and T4

Área de estudio en el complejo estuario-bahía de São Vicente, São Paulo, Brasil. Transectas: T1, T2, T3 y T4

The water was monthly sampled with a Nansen bottle. The water temperature and salinity were measured using a graduated thermometer (1ºC) and a refractometer, respectively; the depth (m) was registered using a tapeline.

Environmental factors data were tested by a one-way ANOVA to identify statistical differences among transects. Environmental data were associated with hermit crab spatial distribution and tested by Pearson Linear Correlation Analysis ($P<0.05$) to determine the influence of each abiotic factor, according to Sokal & Rohlf (1995).

Results

Three hermit crab species composing 166 individuals were captured; 39 C*libanarius vittatu*s (Bosc, 1802), 19 *Loxopagurus loxochelis* (Moreira, 1901) and 108 *Isocheles sawayai* (Forest & Saint Laurent, 1967) were registered, utilizing shells of six gastropods species. More than 92% of the collected individuals were associated to *Stramonita haemastoma* (Linnaeus, 1767) shells. The other gastropods shells used by hermit crabs are presented in Table 1.

Isocheles sawayai showed high abundance when compared to other hermit crab species, and it was present along all transects sampled. *C. vittatus* was not found in transect 1 and *L. loxochelis* was collected in transects 1 and 2 (Fig. 2).

Temperature (ºC), salinity (psu) and depth (m) data are presented in Table 2. Statistical differences from environmental data among transects was verified for salinity ($F=16.88$, $P<0.01$), which varied from 15 to 36 psu and depth ($F=15.38$, $P<0.05$), from 2 to 6 m. The Pearson Correlation between abiotic factors and hermit crabs distribution showed a positive correlation between salinity and abundance of *C. vittatus* (in T3; $r=0.48$, $P=0.01$ and T 4, $r=0.46$, $P=0.02$) and *L. loxochelis* (in T1; $r=0.50$, $P=0.01$).

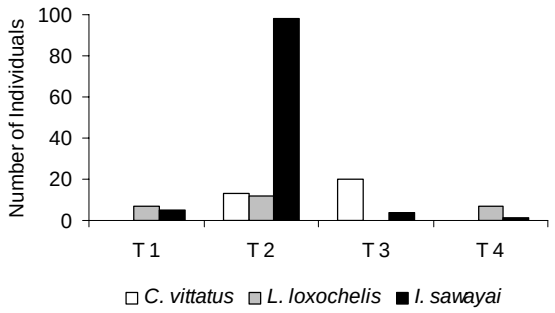

Figure 2

Distribution of hermit crabs at São Vicente estuary-bay complex, Brazil. T: transect

Distribución de cangrejos ermitaños en el complejo bahía-estuario de São Vicente, Brasil. T: transecta

Table 1

Gastropod shells species used by hermit crabs at São Vicente estuarine-bay complex, Brazil

Conchas de gasterópodos utilizadas por cangrejos ermitaño en el complejo bahía-estuario de São Vicente, Brasil

Gastropod species	*C. vittatus*	*I. sawayai*	*L. loxocheles*	Total (N / %)	
Stramonita haemastoma	39	99	16	154	92.77
Buccinanops gradatum	-	-	1	1	0.60
Olivancillaria urceus	-	1	2	3	1.81
Cymatium parthenopeum	-	3	-	3	1.81
Nassarius vibex	-	3	-	3	1.81
Tegula viridula	-	2	-	2	1.20
Total	39	108	19	166	100

Table 2

Environmental data (mean ± standard deviation) registered at four sampled transects in São Vicente estuarine-bay complex, Brazil

Datos ambientales (promedio ± desviación estándar) registrados en cuatro transectas de muestreo en el complejo bahía-estuario en São Vicente, Brasil

	Temperature (°C)		Salinity (psu)		Depth (m)	
Transect	$\overline{X}$	±s	$\overline{X}$	±s	$\overline{X}$	±s
1	24.13	3.21	33.58	1.91	5.29	0.68
2	24.24	3.30	32.36	2.63	3.96	1.02
3	24.49	3.16	29.61	4.42	4.00	1.04
4	24.69	3.02	27.38	3.50	5.92	1.75
Total	24.38	3.20	30.73	4.07	4.79	1.46

Discussion

According to Vernberg & Vernberg (1970), the spatial distribution of marine organisms is determined by environmental factors interactions. In estuarine areas, the gradient of salinity is the main limiting factor to the distribution of the crustaceans (Taissoun 1969, Abreu 1980, Zangrande *et al*. 2003). The portunid *Arenaeus cribrarius* (Lamarck, 1818) represents a typical example for the relationship between the spatial distribution and environmental factors variation (Pinheiro *et al.* 1996). According to Pita *et al*. (1985) and Zangrande *et al*. (2003), the water salinity was a limiting factor for this Portunidae species, which occurs only in regions with high-salinity water, while for the hermit crab *L. loxochelis* distribution, the very fine sand fraction was the most important abiotic factor (Bertini *et al.* 2004).

The hermit crab *L. loxochelis*, studied by Mantelatto *et al*. (2004), showed an association between the spatial-temporal distribution and high depth, fine sand and high values of organic matter in sediment. In the present study, the distribution of *L. loxochelis* was associated to high-salinity water, a different pattern from that observed by Santos *et al.* (2000), who collected this hermit crab species in an estuarine region.

According to Melo (1999), *C. vittatus* is found from Occidental Atlantic (east of USA) to Southern Brazil (Santa Catarina), living in estuarine regions, coral reefs and in sand's bottom in low waters (up to 22 m of depth). In São Vicente Estuary, this hermit crab species showed a large distribution and was not present only in the transect 1. The highest abundances occurred in regions with low salinity.

The hermit crab *Isocheles sawayai* shows tolerance to low salinity and usually occurs in regions influenced by freshwater (Negreiros-Fransozo *et al*. 1997). In the present study, the same situation was verified, due to the presence of this hermit crab in all transects. According to the observed pattern of this hermit crab distribution, it is possible to conclude that salinity is the main factor limiting *L. loxochelis* and *C. vittatus* spatial distribution, but not for *I. sawayai*.

The utilization of gastropod shells by hermit crabs is a result of several interactions, which involve competition among these crustacean communities to the resource of available shell, adequate for its occupation. The shell availability is an important factor (Negreiros-Fransozo *et al*. 1991), which in many situations may indicate a high abundance of gastropod species in the region (Pinheiro *et al*. 1993, Reigada & Santos 1997).

According to Reigada & Santos (1997), who studied the biology and shell utilization of *C. vittatus* in the intertidal region of Bay-Estuary Complex of São Vicente, there is a high occupation of *S. haemastoma* shells, and in the present study the same pattern was observed. Moreover, in laboratory tests, Turra & Fosca (2002) observed that *C. vittatus* preferentially utilized shells of *S. haemastoma*, different of the pattern found in environmental observations of the same study. In the

first study the shell aperture was related to the hermit crab size, Pinheiro *et al.* (1993) also observed that *I. sawayai* utilized gastropod shells preferentially of the species more available in the region, *S. haemastoma*, in the same way that *C. vittatus* in the Reigada & Santos (1997) study. Martinelli (1998), studying a *L. loxochelis* population, found that the shells of the most available gastropods were occupied for this hermit crab, being respectively *Olivancillaria urceus* (Röding, 1798) and *Buccinanops gradatum* (Deshayes, 1844). The results of Peres (2005), corroborated with Martinelli (1998), where a population of *L. loxochelis* in a close region, utilized the same shell resources. The gastropod *S. haemastoma*, the most utilized species by hermit crabs in the present study, is common and abundant in the rocky shore near the sampled locality, and consequently it corresponds to the great part of shell availability for hermit crab populations.

Finally, the salinity seems to be the main abiotic factor limiting the distribution of the three sympatric anomurans species in São Vicente Estuarine-Bay Complex and the shell utilization may reflect the most abundant gastropod species in the region.

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