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Hermit Crab (Decapoda, Anomura) Attraction to Dead Gastropod Baits in an Infralittoral Algae Bank

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ABSTRACT

*Hermit crabs use gastropod shells as shelter and are adapted to follow chemical cues released from tissues of dead or injured gastropods as a way to find new and more adequate shells. The species composition, crab size, shell types adequacy and physical condition were compared between attracted individuals and crabs collected in previous samples. The previous sampling was carried out in five areas before each experiment. Then, five baits of crushed gastropods in nylon net bags were installed in these areas. Three samples were taken at 30min intervals, capturing all crabs within a circle of 60cm diameter. Attraction of hermit crabs was tested for four different gastropod baits to verify specificity of the chemical cues. *Clibanarius antillensis*, *Pagurus brevidactylus* and *Paguristes tortugae* were collected in the study area. *Pagurus brevidactylus*, the smallest species, turned out to be more attracted than the 2 other species. The results showed that attracted crabs utilized more gastropod shell types than that collected in previous samples, however shell utilization pattern did not differ between them. Attracted animals were slightly smaller (shield length) than those collected in the previous samples but did not present significant differences in shell adequacy and condition. The four experimental baits attracted the crabs in similar ways not indicating a specific response from the crabs. The fact that attracted animals were smaller suggested that the attraction to dead gastropods might enable the acquisition of a new and larger shell and, consequently, chains of shell exchange between the attracted crabs.*

Key words: Hermit crab, chemical attraction, gastropod predation sites, shell use, shell condition

INTRODUCTION

Intertidal hermit crabs need to carry and live in gastropod shells to protect themselves against predation and desiccation. Shells are also a limiting resource for these crabs and may regulate their fecundity (Childress, 1972; Bertness, 1981a), growth (Markham, 1968; Fotheringham, 1976; Bertness, 1981b), survival (Vance, 1972; Bertness, 1981c), copulatory success (Hazlett & Baron,

1989), and intra- and interspecific interactions among them (Bach et al., 1976, Bertness, 1981a). Empty shells are generally scarce in the field. Thus new shells must be obtained through exchanges among the crabs or by encountering gastropods that are dead or injured. McLean (1974) made the first observation of chemical signals associated with a hermit crab attendance to predation sites (gastropods being eaten by a predator gastropod species). He described the behaviour of the

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attracted crabs and the consequent establishment of a dominance hierarchy for the new available shell.

Therefore, hermit crabs can be attracted to predation sites or simulated gastropod predation events (McLean, 1974; Rittschof, 1980; Hazlett & Herrnkind, 1980; Gilchrist & Abele, 1984; Wilber & Herrnkind, 1984; Lepore & Gilchrist, 1988) by chemical cues from gastropod flesh (Rittschof, 1980). Attraction of hermit crabs is associated with behavioural plasticity that is modulated by intrinsic characteristics of the crab as its size or of the used shell (adequacy, physical condition, and diversity) (Gilchrist & Abele, 1984).

The aim of this work was to investigate the species and sizes of hermit crabs attracted to dead gastropod baits in a Sargassum bed. In addition, shell utilization (type, size, adequacy, and physical condition) was compared between attracted and previously collected individuals to discuss the causes and consequences of this particular behaviour.

MATERIAL AND METHODS

The study was carried out in the rocky shore of Preta Beach, São Sebastião Channel, São Paulo State, Brazil (23°30'S; 49°20'W). The area is a narrow rocky shore that presents a steep slope. The experiments were conducted in a flattened part of this rocky shore, in order to facilitate observations and the sampling procedure.

Four experiments were carried out, using different gastropod species as baits: *Stramonita haemastoma* (Linnaeus, 1757), *Tegula viridula* (Gmelin, 1791) *Morula nodulosa* (C. B. Adams, 1845) and *Pisania pusio* (Linnaeus, 1758). The shells of these gastropods are frequently used by hermit crabs in this rocky shore (Gandolfi, 1996). The baits were previously collected and frozen one day before each experiment. Five attraction points were chosen, in which all crabs that were inside a circle of 60cm diameter were collected. These crabs constituted a previous sample. Then, five traps consisting of nylon net bags containing one crushed gastropod were installed in these points. The traps were put on the bottom, submerged at about 0.5m deep, and 2.5 m apart from each other.

Three samples were taken collecting the crabs in 30min intervals. The crabs collected in the traps were considered "attracted" to the baits. This procedure was carried out for each species of bait gastropod.

All individuals (attracted and collected in the previous sample) were removed from their shells, identified and measured with callipers and optic microscopes with millimetric oculars. Shells were also measured and had their adequacy evaluated based in a visual index modified from Abrams (1978): 1. Hermit crab not visible; 2. Pereopods visible but chelipeds not, 3. Angle up to 90° between chelipeds and the plan of the shell aperture; 4. Obtuse angle between chelipeds and the plan of the shell aperture; 5. Chelipeds closing the aperture; 6. Shield exposed. The physical condition of the shells was also estimated using a modification of the condition index proposed by McClintock (1985): 1. Shells undamaged and shells covered by epibionts up to 20% of their surface; 2. Shells covered by epibionts, incrustations and perforations or broken in less than 4 mm in the aperture; 3. Shells strongly incrustated and with damages larger than 4 mm; 4. Shells totally damaged and fragmented.

Data analyses were based on Zar (1984) and were performed at the 0.05 significance level. The log-likelihood G test was used to compare shell utilization patterns, i.e., shell types, condition, and adequacy, between crabs collected in the previous sample and in the attraction sites (treatment baits). This test was also performed to contrast the frequencies of the crabs of each species collected in these both situations. Analyses of variance (ANOVA) were conducted to compare the mean size of the individuals of the species collected, and to test the null hypothesis that all gastropod baits attract the crabs in the same way. Student's t test was used to compare the mean size and number of individuals of each species between previous samples and attraction sites.

RESULTS

The previous sample revealed that hermit crab assemblage was composed by three species: *Pagurus brevidactylus* (Stimpson, 1859) (46

individuals, 29.41%), *Paguristes tortugae* Schmitt, 1933 (67 ind., 49.26%), and *Clibanarius antillensis* Stimpson, 1862 (23 ind., 16.91%). These crabs occupied a total of 12 gastropod shell types. *Cerithium atratum*, *Costoanachis* sp., *Morula nodulosa*, *Pisania auritula*, and *Stramonita haemastoma* were the most used ones. Attracted crabs used 14 shell types (Table 1). Shell utilization comparisons between previous samples and attracted crabs were carried out with only the most used shells, and differences were found only for *P. tortugae* ($G=23.32$, $df=3$, $p<0.001$). Individuals of this species occupied mainly shells of *P. pusio* in previous sample, while the attracted crabs more frequently used those of *M. nodulosa* and *S. haemastoma*. Such a difference was not verified for *P. criniticornis* ($G=3.24$, $df=3$, ns), and not tested for *C. antillensis* due to insufficient data.

The proportion of individuals of each species differed between previous samples and attraction sites ($G=9.56$, $df=2$, $p<0.01$). *Paguristes tortugae* occurred mainly in the previous sample and *P. brevidactylus* in attraction sites (Table 1). *Clibanarius antillensis* did not differ between these

two situations. The four gastropods used as baits attracted the crabs in similar ways (ANOVA, $F=0.813$, $df=3$, $p=0.505$). The chemical cues released by the gastropod baits also attracted other organisms as the gastropod *Costoanachis* sp., the portunid crab *Callinectes* sp. and some fishes. The three hermit crab species differed in size in the previous sample (ANOVA, $F=78.995$, $df=2$, $p<0.001$) (Table 2), with *P. tortugae* presenting higher shield length than *P. brevidactylus* (Tukey: $p<0.001$) and *C. antillensis* ($p<0.001$). The two latter species presented similar sizes ($p=0.952$). Attracted individuals of *P. brevidactylus* and *P. tortugae* presented smaller sizes than those collected in the previous sample (Table 2). This was not verified for *C. antillensis*.

Shell condition did not differ between attracted crabs and those collected in the previous sample ($G=2.04$, $df=3$, ns) (Fig. 1). However, attracted crabs showed a tendency to use more fragmented shells than recorded in the previous sample. The adequacy of the shells were the same for the two groups of crabs ($G=5.4$, $df=5$, ns) (Fig. 2).

Table 1 - Gastropod shells occupied by the three species of hermit crabs collected in the previous and in the attraction samples in the rocky shore of Preta Beach, São Sebastião, São Paulo State, Brazil.

Gastropods	Previous sample			Attraction sample		
	<i>Clibanarius antillensis</i>	<i>Pagurus brevidactylus</i>	<i>Paguristes tortugae</i>	<i>Clibanarius antillensis</i>	<i>Pagurus brevidactylus</i>	<i>Paguristes tortugae</i>
		<i>s</i>			<i>s</i>	
<i>Anachis lyrata</i> (Sowerby, 1832)	1	0	0	1	1	3
<i>Cerithium atratum</i> (Born, 1778)	1	11	8	3	12	6
<i>Columbella mercatoria</i> (Linnaeus, 1758)	1	1	0	2	0	0
<i>Costoanachis</i> sp.	4	14	0	1	16	0
<i>Cymatium partenopeum</i> (von Salis, 1793)	0	0	3	0	0	1
<i>Leucozonia nassa</i> (Gmelin, 1791)	0	0	0	0	1	2
<i>Littoraria flava</i> King & Broderip, 1832	0	5	0	0	11	0
<i>Nassarius vibex</i> (Say, 1822)	0	0	0	2	1	0
<i>Olivella minuta</i> (Link, 1807)	0	2	0	0	3	0
<i>Pisania auritula</i> (Link, 1807)	0	0	0	0	0	5
<i>Pisania pusio</i> (Linnaeus, 1758)	0	0	15	0	0	1
<i>Stramonita haemastoma</i> (Linnaeus, 1767)	0	1	5	1	1	11
<i>Tegula viridula</i> (Gmelin, 1791)	0	0	5	0	2	3
<i>Morula nodulosa</i> (C.D. Adams, 1845)	11	5	5	7	14	16
Unidentified fragments	5	7	5	8	15	2

Total 23 46 67 25 77 50

Table 2 - Size (shield length, mm) comparisons (Student's t test) between *C. antillensis*, *P. brevidactylus* and *P. tortugae* collected in the previous and in the attraction samples. (SD, standard deviation; df, degrees of freedom)

Hermit crab	Previous sample			Attraction samples			t	df	p
	n	\bar{x}	SD	n	\bar{x}	SD			
<i>C. antillensis</i>	17	3.03	0.53	22	2.71	0.63	1.655	37	0.106
<i>P. brevidactylus</i>	29	2.87	1.41	62	2.34	0.55	2.562	89	0.012
<i>P. tortugae</i>	62	7.24	2.09	45	5.01	2.01	5.530	105	<0.001

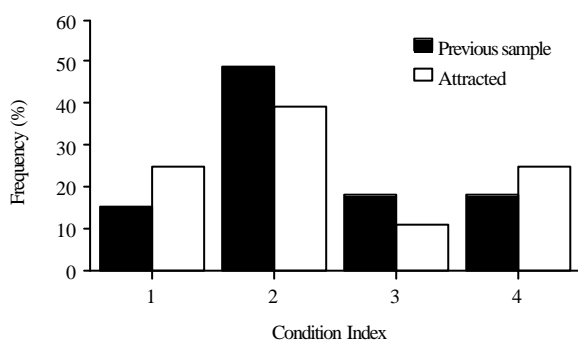


Figure 1 - Shell condition of hermit crabs (pooled the three species) collected in the previous sample and attracted to baits. (Indices: 1 to 4, see text).

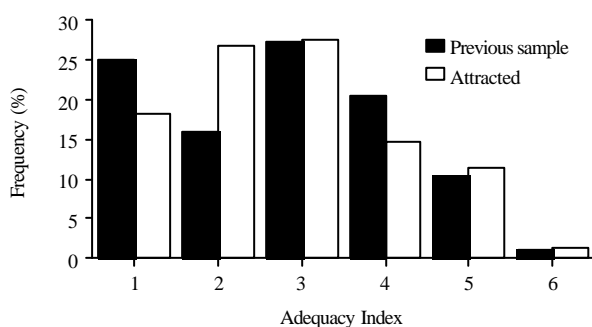


Figure 2 - Shell adequacy to hermit crabs (pooled the three species) collected in the previous sample and attracted to baits. (Indices: 1 to 6, see text).

DISCUSSION

The three hermit crab species collected in this rocky shore were common species in intertidal and low subtidal regions in São Paulo State (Fransozo & Negreiros-Fransozo, 1996) and in São Sebastião Channel (Leite et al., 1998). Shell utilization differed among species and was associated with size differences among them, as also verified by Leite et al. (1998). *Pagurus brevidactylus*, the population with the smallest individuals, both in the previous samples and attracted, utilised shells of reduced dimensions. These shells were commonly located on macroalgae (*A. lyrata*, *Costoanachis* sp.), in the sediment (*C. atratum*, *O. minuta*, *N. vibex*), and on rocky shores (*M. nodulosa*). The small size of these individuals was associated with the environment selected for this study: a macroalgae bed. These sites are very commonly occupied by recruits of hermit crabs and other species (F. P. P. Leite, pers. obs.), and were considered as nursery for such populations. The two other crab populations (*C. antillensis* and *P. tortugae*) were larger in size and utilized larger shells, which were very common at this location. Rittschof (1980) showed that some species of hermit crabs restricted themselves to preferred gastropod baits, suggesting that chemical attraction

could be specific. However, the crabs at Preta Beach did not show preferences for a given gastropod species, thus suggesting that the chemical cues are not so specific.

The choice of a macroalgae bed, formed mainly by *Sargassum* and *Acanthophora*, as experimental area, certainly influenced the hermit crab's attraction behavior. This assertion was based on the fact that the high complexity generated by macroalgae made hermit crab's movement and orientation to the chemical cues released by the gastropod baits difficult. In addition, attraction of hermit crabs in rocky intertidal zone was less evident than in sloping sandy beaches or mudflats (Hazlett, 1996). This was probably the explanation for the weak evidence of attraction specificity of hermit crabs to gastropod baits at this site.

Gilchrist & Abele (1984) observed that hermit crabs attracted by chemical signals from injured tissues of gastropods had also carried inadequate and damaged shells, when compared to a non-attracted group of crabs. We expected to find similar differences in the shell quality, but our results were not significant, possibly as a result of the poor quality and the presence of encrustation and physical injuries in all the utilized shells in the study area. Another possibility is that the attraction was not effective due to the presence of the algae as described by Hazlett (1996).

In general, attracted crabs were smaller, had a wide size range and utilised more gastropod shell species than in the previous sample. These trends agreed with similar studies (Gilchrist & Abele, 1984; Rittschof, 1980; Rittschof et al., 1992), but the larger number of shell species utilised by the attracted group could be a reflection of their smaller size. There were more gastropod species of small size in the study area, and smaller number of species that could grow into a large size (Leite et al., 1998). As a consequence, larger crabs will have few shell species that can fit them. Small crabs can use a wider range of shell species but they need to be constantly acquiring new shells as they grow and moult. This may account for the attraction of smaller individuals they need to constantly change their shells in order to grow. Large adult individuals carrying adequate shells may not respond to the baits, possibly because they do not need a new shell, and so they will be poorly

represented at predation sites. This can explain the fact that responsive crabs carry shells of poor quality as also verified by Hazlett & Herrnkind (1980).

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RESUMO

Ermitões utilizam conchas de gastrópodes para abrigo. Conchas novas e mais adequadas podem ser encontradas pelos ermitões pois estes são atraídos por substâncias químicas liberadas pelos tecidos de gastrópodes feridos ou mortos. A adequação, condição e tipo das conchas e a composição de espécies e o tamanho dos ermitões foram comparados entre indivíduos atraídos e os coletados em amostras prévias. Estes últimos ermitões foram coletados em 5 áreas antes de cada experimento. Nestes experimentos, sacos de tela de nylon contendo um gastrópode amassado foram colocadas nas áreas de atração. Foram obtidas 3 amostras por área em intervalos de 30 minutos, coletando-se todos os ermitões dentro de um raio de 30cm em volta da isca. Foi testada a atração a iscas de 4 espécies de gastrópodes para observar a possibilidade de especificidade ao sinal químico. *Clibanarius antillensis*, *Pagurus brevidactylus* e *Paguristes tortugae* foram coletados na área de estudo. *Pagurus brevidactylus*, a menor espécie, mostrou ser mais atraída do que as outras duas espécies. Verificou-se que os ermitões atraídos utilizaram maior número de tipos de conchas do que os coletados nas amostras prévias, contudo o padrão de utilização de conchas não diferiu. Os ermitões

atraídos foram ligeiramente menores (comprimento do escudo cefalotorácico) do que os coletados nas amostras prévias mas não mostraram diferenças significativas na condição e adequação das conchas. Os 4 experimentos utilizando diferentes iscas atraíram os ermitões de forma semelhante não havendo indicação de resposta específica. O fato dos ermitões atraídos serem menores que os das amostras prévias sugere que a atração aos gastrópodes mortos pode possibilitar a aquisição de conchas novas e maiores e, conseqüentemente, a ocorrência de uma cadeia de trocas de conchas entre os ermitões atraídos

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