

SHELL OCCUPANCY BY THE HERMIT CRAB *CLIBANARIUS ERYTHROPUS*  
(CRUSTACEA) ON THE SOUTH COAST OF SÃO MIGUEL, AÇORES

Pedro Rodrigues<sup>1</sup> & Roshan K. Rodrigo<sup>2</sup>

<sup>1</sup> CIBIO-Pólo Açores, Department of Biology, University of the Azores, 9501-801 Ponta Delgada, São Miguel, Azores, Portugal. e-mail: pedrorodrigues@uac.pt

<sup>2</sup> Faculty of Science, Department of Zoology, University of Colombo, Colombo 7, Sri Lanka

ABSTRACT

The importance of gastropod shells to hermit crabs is well known. The strong association between hermit crabs and their adopted shells influences almost all aspects of their biology and there is a strong correlation between the sizes of the shell and the crustacean. The hermit crab *Clibanarius erythropus* is abundant on the rocky shores of the Açores. However, there are few references to the ecology of this species. The aim of the present study was thus to evaluate the occupancy of mollusc shell species by *C. erythropus* on the south coast of the island of São Miguel. Shells of *Columbella adansoni* had the highest occupancy rate followed by *Mitra cornea* and *Stramonita haemastoma*. The significant differences in the estimated shell volumes available for *C. erythropus* suggests that juveniles choose *Nassarius incrassatus*, medium sized hermits prefer *Pollia dorbignyi*, *C. adansoni* and *M. cornea*, and the largest adults opt for *S. haemastoma* shells.

RESUMO

A importância das conchas de gastrópodes para os bernados-eremitas é bem conhecida. A forte associação entre os bernados-eremita e as suas adoptadas conchas influencia grandemente quase todos os aspectos da sua biologia, existindo uma forte correlação entre o tamanho da concha e o tamanho do crustáceo. O bernado-eremita *Clibanarius erythropus* é uma espécie muito abundante nas costas rochosas. Todavia, são raras as referências à ecologia e à biologia desta espécie. O presente estudo teve como objectivo avaliar a ocupação de conchas de espécies de moluscos por *C. erythropus* na costa sul de São Miguel. Conchas de *Columbella adansoni* obtiveram a maior taxa de ocupação, seguidas de *Mitra cornea* e de *Stramonita haemastoma*. As diferenças significativas no volume de concha estimado acessível a *C. erythropus* sugerem que os juvenis escolhem conchas de *Nassarius incrassatus*, os de tamanho médio preferem conchas de *Pollia dorbignyi*, *C. adansoni* e *M. cornea*, e os adultos maiores optam por conchas de *S. haemastoma*.

INTRODUCTION

The importance of gastropod shells to hermit crabs is well known; such shells particularly supplying protection against predators (Vance, 1972) and physical stresses (Reese, 1969) due to the fact that the crabs have a soft, vulnerable abdomen. Shells can be found either empty, obtained by confrontations between individual crabs, or by removal of the gastropod (Elwood & Neil, 1992).

The availability of shells is the main factor limiting populations of hermit crabs (Kellog, 1976) and they usually partition shell resources according to size (Bertness, 1981; Scully, 1983; Neil, 1985) and/or their own body size (Mitchell, 1975), shell shape, weight and volume (Reese, 1963; Kuris & Brody, 1976; Conover, 1978). Interspecific competition among hermit crabs for shell resources may also be avoided by partitioning habitats. Partitioning also occurs between

hermit crabs and other species such as sipunculans (Morton & Britton, 1995).

Hermit crabs that occupy large shells can better resist to desiccation, thermal stress and predation (Rittschof *et al.*, 1995). However, heavy shells may limit reproduction and growth because of the high-energy cost of locomotion (Bertness, 1981). For another hand, small shells render the crabs more vulnerable to predation and may reduce their growth rate (Hazlett, 1981; Angel, 2000). The strong association between hermit crabs and their adopted shells influences greatly almost all aspects of their biology (Hazlett, 1981) and there is a strong correlation between shell and crab sizes (Abrams *et al.*, 1986; Botelho & Costa, 2000; Sant'Anna *et al.*, 2006).

The hermit crab *Clibanarius erythropus* (Latreille, 1818) is a common species along the Mediterranean shores and Atlantic coasts from United Kingdom to the Açores (Ingle, 1993). In the Açorean archipelago, *C. erythropus* is abundant on rocky shores, including tide pools (Morton *et al.*, 1998). However, references to the general ecology and biology of this species are few (Gherardi, 1991).

The aim of the present study was to evaluate the occupancy of mollusc shell species by *Clibanarius erythropus* in the south coast of São Miguel island.

## MATERIAL AND METHODS

The study was carried out on the south coast of São Miguel during July 2006 as part of the 3<sup>rd</sup> International Workshop on the Malacology and Marine Biology of the Açores covered in Vila Franca do Campo, São Miguel, Açores.

Five populations of *Clibanarius erythropus* were studied for shell occupancy (Figure 1).

The hermit crabs were hand-sampled by snorkelling for ten minutes to stan-

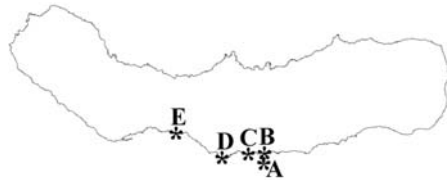


FIGURE 1. Location of the sampling sites on São Miguel. A. Ilhéu de Vila Franca do Campo; B. Vila Franca do Campo Harbour; C. Roída da Praia; D. Ponta da Galera; E. Baía do Cruzeiro.

dardize capture effort and brought alive to the laboratory where individuals and shells were identified according to Wirtz (1995) and Morton *et al.* (1998). The occupied shells were measured (total shell length and shell width) using vernier callipers to the nearest 0.01 mm. The volume of each shell was estimated according to Morton & Britton (1995) by squaring the shortest linear measurement (width) and multiplying this value by the longest linear measurement (length).

A Chi-square test was applied to the five most common occupied shell species. The relationship between those and the estimated volume was also subjected to analysis of variance (ANOVA) against the null hypothesis that different shell species have the same volume available for *Clibanarius erythropus*.

## RESULTS

Eleven species of gastropod shells occupied by *Clibanarius erythropus* were collected and frequency of occupation at each site is identified in Table 1. *Columbella adansonii* Menke, 1853, *Mitra cornea* (Lamarck, 1811) and *Stramonita haemastoma* (Linnaeus, 1766) were the most commonly occupied shells, followed by *Pollia dorbignyi* (Payraudeau, 1826) and *Nassarius incrassatus* (Ström, 1768).

TABLE 1. The frequency of mollusc shells occupied by *Clibanarius erythropus* from the different sampling sites on São Miguel.

Mollusc shell	Site A	Site B	Site C	Site D	Site E	TOTAL
<i>Pollia dorbignyi</i> (Payraudeau, 1826)	6	1	0	34	0	41
<i>Columbella adansoni</i> Menke, 1853	54	41	51	67	31	244
<i>Stramonita haemastoma</i> (Linnaeus, 1766)	6	15	81	25	15	142
<i>Mitra cornea</i> (Lamarck, 1811)	1	46	0	27	84	158
<i>Nassarius incrassatus</i> (Ström, 1768)	10	4	5	4	0	23
<i>Calliostoma lividum</i> Dautzenberg, 1927	1	0	0	0	0	1
<i>Coralliophila meyendorffii</i> (Calcara, 1845)	0	4	0	0	0	4
<i>Melarpe neritoides</i> (Linnaeus, 1756)	0	0	0	1	0	1
<i>Littorina striata</i> King & Broderip, 1832	0	0	0	0	5	5
<i>Jujubinus</i> sp.	0	0	0	0	1	1
<i>Bittium cf. latreillii</i> (Payraudeau, 1826)	0	0	0	0	2	2
TOTAL:	78	111	137	158	138	622

The Chi-square test, comparing the total number of the five commonest occupied shells from the different sampling sites, indicated a significantly different proportion of species occupied by *Clibanarius erythropus* ( $\chi^2 = 386.1$ ,  $p < 0.05$ ).

Significant differences were also obtained in the estimated volume of each mollusc shell species available for *Clibanarius erythropus* (ANOVA,  $F = 27.11$ ;  $df = 607$ ;  $p < 0.05$ ). *Stramonita haemastoma* had the highest estimated mean shell volume and *Nassarius incrassatus* the smallest. The other three species did not show any significant differences related to estimated shell volume (Table 2).

## DISCUSSION

The present study is consistent with others undertaken by Botelho & Costa

(2000) on the same species, by Morton & Britton (1995) on *Anapagurus laevis* (Bell, 1845) from São Miguel and by Sant'Anna *et al.* (2006) on *Clibanarius vittatus* (Bosc, 1802) from Brazil. These studies report that the hermit crabs occupied a similar number of gastropod shell species and revealed that there is a close relationship between the crab size and the size of the occupied shell.

Shells of *Columbella adansoni* had the highest occupancy rate followed by *Mitra cornea* and *Stramonita haemastoma*. The significantly different proportions of shell species occupied by *Clibanarius erythropus* at the five different sampling sites was probably due to their different wave-exposures.

Shells have been shown to be a limiting resource for hermit crabs (Scully, 1983; Abrams *et al.*, 1986), and the avail-

TABLE 2. The mean length, width and estimated volume of shells occupied by *Clibanarius erythropus*.

Mollusc shell	N	Mean Length (mm)	Mean Width (mm)	Mean Volume (mm <sup>3</sup> )
<i>Pollia dorbignyi</i> (Payraudeau, 1826)	41	16.9	8.8	1344.9
<i>Columbella adansoni</i> Menke, 1853	244	15.9	10.4	1753.3
<i>Stramonita haemastoma</i> (Linnaeus, 1766)	142	20.8	12.8	4807.3
<i>Mitra cornea</i> (Lamarck, 1811)	158	19.8	9.2	1814.9
<i>Nassarius incrassatus</i> (Ström, 1768)	23	11.2	6.1	430.8

ability of certain gastropods influences their pattern of shell utilization in the natural habitat as the crabs tend to be opportunistic with regards to the shells they inhabit (Botelho & Costa, 2000). The significant differences in the estimated shell volume available for *Clibanarius erythropus*, the presence of empty shells (personal observations), and that the crab requires different shell sizes at different stages of their growth (Morton & Britton, 1995), suggests that juvenile *C. erythropus* individuals choose *Nassarius incrassatus* shells, middle size individuals prefer *Polia dorbignyi*, *Columbella adansoni* and *Mitra cornea* shells, and larger adults opt for *Stramonita haemastoma* shells. This is in accordance with the study of Botelho & Costa (2000) where it was reported that hermit crabs of < 8.6 mm occupied all shell species, whereas those > 8.6 mm were found only in *S. haemastoma* shells. Smaller crabs occupied *Littorina striata* and *N. incrassatus* shells.

#### ACKNOWLEDGMENTS

We are grateful to Professor António M. de Frias Martins for the opportunity to undertake this research, and Professor Brian Morton for the review of this paper. This project was supported by the Third International Workshop on Malacology and Marine Biology, Vila Franca do Campo, São Miguel, Açores

The experiments performed for the present study comply with the laws of the country in which they were performed.

#### LITERATURE CITED

- ABRAMS, P.A., C. NYBLADE & S. SHELDON, 1986. Resource partitioning and competition for shells in a subtidal hermit crab species assemblage. *Oecologia*, 69: 429-445.
- ANGEL, J.E., 2000. Effects of shell fit in the biology of the hermit crab *Pagurus longicarpus* (Say). *Journal of Experimental Marine Biology and Ecology*, 243(2): 169-184.
- BERTNESS, M.D., 1981. The influence of shell-type on hermit crab growth and clutch size. *Crustaceana*, 40(2): 197-205.
- BOTELHO, A., & A.C. COSTA, 2000. Shell occupancy of the intertidal hermit crab *Clibanarius erythropus* (Decapoda, Diogenidae) on São Miguel (Azores). *Hydrobiologia*, 440: 111-117.
- CONOVER, M., 1978. Importance of various shell characteristics to the shell selection behavior of the hermit crabs. *Journal of Experimental Marine Biology and Ecology*, 32: 131-142.
- ELWOOD, R.W., & S.J. NEIL, 1992. *Assessments and Decisions*, 192 pp. Chapman & Hall, London.
- GHERARDI, F., 1991. Relative growth, population structure and shell-utilization of the hermit crab *Clibanarius erythropus* in the Mediterranean. *Oebalia*, 17: 181-196.
- HAZLETT, B., 1981. The behavioural ecology of hermit crabs. *Annual Review of Ecology and Systematics*, 12: 1-22.
- INGLE, R., 1993. *Hermit Crabs of the Northeastern Atlantic Ocean and the Mediterranean Sea*, 495 pp. Chapman & Hall, London.
- KELLOG, C.W., 1976. Gastropod shells: a potentially limiting resource for hermit crabs. *Journal of Experimental Marine Biology and Ecology*, 22: 101-111.
- KURIS, A.M., & M.S. BRODY, 1976. Use of principal components analysis to describe the snail shell resource for hermit crabs. *Journal of Experimental Marine Biology and Ecology*, 22: 69-77.
- MITCHELL, K.A., 1975. An analysis of shell occupation by two sympatric

- species of hermit crab. I. Ecological factors. *Biological Bulletin*, 149: 205-213.
- MORTON, B., & J.C. BRITTON, 1995. Partitioning of shell resources by *Aspidosiphon muelleri* (Sipuncula) and *Anapagurus laevis* (Crustacea) in the Azores. IN: MARTINS, A.M.F. (ed.), *The Marine Fauna and Flora of the Azores (Proceedings of the Second International Workshop of Malacology and Marine Biology, São Miguel, 1991). Açoreana, Supplement [4]: 67-77.*
- MORTON, B., J.C. BRITTON & A.M.F. MARTINS, 1998. *Ecologia Costeira dos Açores*, x + 249 pp. Sociedade Afonso Chaves, Ponta Delgada.
- NEIL, S.J., 1985. Size assessment and cues: studies of hermit crab contests. *Behaviour*, 92: 22-38.
- REESE, E.S., 1963. The behavioral mechanisms underlying shell selection by hermit crabs. *Behaviour*, 21: 78-126.
- REESE, E.S., 1969. Behavioral adaptations of intertidal hermit crabs. *American Zoologist*, 9: 343-355.
- RITTSCHOF, D., J. SARRICA & D. RUBENSTEIN, 1995. Shell dynamics and microhabitat selection by striped legged hermit crabs, *Clibanarius vittatus* (Bose). *Journal of Experimental Marine Biology and Ecology*, 192(2): 157-172.
- SANT'ANNA, B., C.M. ZANGRANDE, L.D.A. REIGADA & M.A.A. PINHEIRO, 2006. Shell utilization pattern of the hermit crab *Clibanarius vittatus* (Crustacea, Anomura) in an estuary at São Vicente, State of São Paulo, Brazil. *Iheringia, Série Zoologia*, 96(2): 261-266.
- SCULLY, E.P., 1983. The behavioural ecology of competition and resource utilization among hermit crabs. IN: REBACH, S., & D. DUNHAM (eds.), *Studies in Adaptation: The behavior of higher Crustacea*, pp. 23-55. John Wiley, New York.
- VANCE, R.R., 1972. The role of shell adequacy in behavioural interactions involving the hermit crab *Pagurus longicarpus*. *Marine Biology*, 104: 31-39.
- WIRTZ, P., 1995. *Unterwasserfuhrer Madeira-Kanaren-Azoren*, 247 pp. Stephanie Naglschmid, Stuttgart.

