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SHELL AVAILABILITY AND USE BY THE HERMIT CRAB CLIBANARIUS VIRESCENS ALONG THE EASTERN CAPE COAST, SOUTH AFRICA

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Patterns of shell availability and use of the intertidal yellow-banded hermit crab *Clibanarius virescens* were studied by means of field sampling. Data were collected at three sites (Dwesa, Nqabara and Mendwana) along the Eastern Cape coast, South Africa. The most striking result was that at all three sites there was a difference between observed frequencies of shells used compared to that which was expected from their availability as live animals or empty shells on the rocks and the strandline. This suggests selection by the crabs. Crabs commonly used shells of *Burnupena cincta* and *Burnupena pubescens* and amongst other types, rarely used the shells of *Cymatium dolarium* and *Stramonita capensis*. Fewer types of shells were used than were available. A wider diversity of shell species were occupied at Dwesa (N = 11) and Nqabara (N = 10) than at Mendwana (N = 6). The diversity of shells used by the hermit crabs in this study falls within the globally predicted levels given body size of the study species and the latitude of the studied population.

Key words: *Clibanarius virescens*, gastropod, habitat selection, hermit crab, shell preference, shell utilization

INTRODUCTION

It is important to identify habitat preferences and to establish what kind of role the particular factors are likely to play, as habitat requirements or as mere preferences. This is because if the main limiting factor (e.g. shelter, food) is abundant and therefore not limiting numbers, the population will increase until other factors such as predation limit population growth (KRUUK *et al*. 1998). One way to determine habitat use is by identifying the disproportionate use of habitats (JOHNSON 1980). Common aims of habitat use studies are to determine whether a species uses habitats available at random, to rank habitats in order of relative use, to compare use by different groups of animals, to relate use to variables such as food abundance, or to examine the effects of habitat on movement and home range size (AEBISCHER *et al.* 1993). Why an animal uses a particular habitat can be better understood by correlating use to the acquisition of primary resources (e.g. food, shel-

ter, mate, and host) and the avoidance of sources of stress (e.g. predators, thermal extremes, dehydration) (BARBARESI *et al.* 1997).

Mollusc shells are often used by other organisms. Some organisms use the shell as a substratum for incrustation, others facultatively use it as a burrow, while others, the hermit crabs, are obligate users to prevent mechanical damage to the abdomen (BARNES 2003). Hermit crabs have become a famous and well-studied example of a taxon mostly governed by the requirement to serially find and replace a home as they grow, generally using gastropod shells (BARNES & DE GRAVE 2002). They may select gastropod shells based on one or more of a number of characteristics such as shell weight, volume, height, aperture length, width and colour (e.g. BROWN *et al.* 1993, GARCIA & MANTELATTO 2001, BRIFFA & ELWOOD 2006). Often, availability of empty gastropod shells is a limiting factor to populations of many species of hermit crabs (e.g. FOTHERINGHAM 1976, SCULLY 1979) and the sizes of shells occupied by hermit crabs are usually well correlated with crab size owing to mechanisms such as mutual gain shell exchange (HAZLETT 1981, 1983). The biology of hermit crabs has been reviewed (HAZLETT 1981, LANCASTER 1988, ELWOOD & NEIL 1992).

There is little information on habitat use of southern hemisphere hermit crabs and South African species in particular (EMMERSON & ALEXANDER 1986, WALTERS & GRIFFITHS 1987, REDDY & BISESWAR 1993). The yellow-banded hermit crab *Clibanarius virescens* is the most common hermit crab associated with rocky shores along the east coast of southern Africa (BRANCH & BRANCH 1981). In Mozambique it appears to be dominant along less heterogenous shores whereas other species are more dominant elsewhere (DE GRAVE & BARNES 2001). They appear to prefer the mid-shore zones (BARNES 1997). There are no published data on shell use in relation to availability for this species. In KwaZulu-Natal they use shells of 23 gastropod species, most (18) of which have high spires (REDDY & BISESWAR 1993).

Understanding patterns of habitat use or shell use by hermit crabs requires appreciation of use at all scales (see BARNES 2003). This can be analysed at a broader scale (as done by BARNES 2003) but also needs to be done at a local scale (as done here) and for use in large scale pattern analysis.

This paper tests the prediction that *C. virescens* along the Eastern Cape Coast uses some species of gastropod shells disproportionately to their availability.

MATERIALS AND METHODS

Data were collected from Dwesa (32°18’35’’S, 28°49’49’’E), Mendwana (32°16’8’’S, 28°53’9’’E) and Nqabara (32°20’21’’S, 28°47’24’’E) along the South eastern African coast,

Transkei region, Eastern Cape Province, South Africa. Vegetation types mainly consist of Coastal Forest and Thornveld and valley Bushveld with *Acacia karoo* as the dominant tree species (ACOCKS 1988). The area has a warm temperate climate with precipitation during all months with the coldest month being between –3°C and 18°C and the warmest months below 22°C, but at least four months above 10°C. Annual precipitation is 875 mm (GREYLING & HUNTLEY 1984).

At each site, the abundance of *C. virescens* was estimated using 20 quadrats (50 × 50 cm) placed randomly on the rocky surface at low tide during the day. All gastropod shells (occupied or not) within each quadrat were collected, identified and counted. To determine availability and diversity of shells along the strandline another 20 quadrats (50 × 50 cm) were placed here at each site and shells found within these quadrats were collected, counted and identified. DAY (1974), RICHARDS (1981) and KILBURN and RIPPEY (1982) were used to identify the gastropod shells.

Shell diversity was compared between sites using species richness (number of species), species evenness (relative abundance of species), Simpson's and the Shannon-Wiener indices (KREBS 2001).

RESULTS

At all study sites *C. virescens* occupied shells of *B. cinta* and *B. pubescens* more than all other shells (Fig. 1). Fewer types of shells were used than were avail-

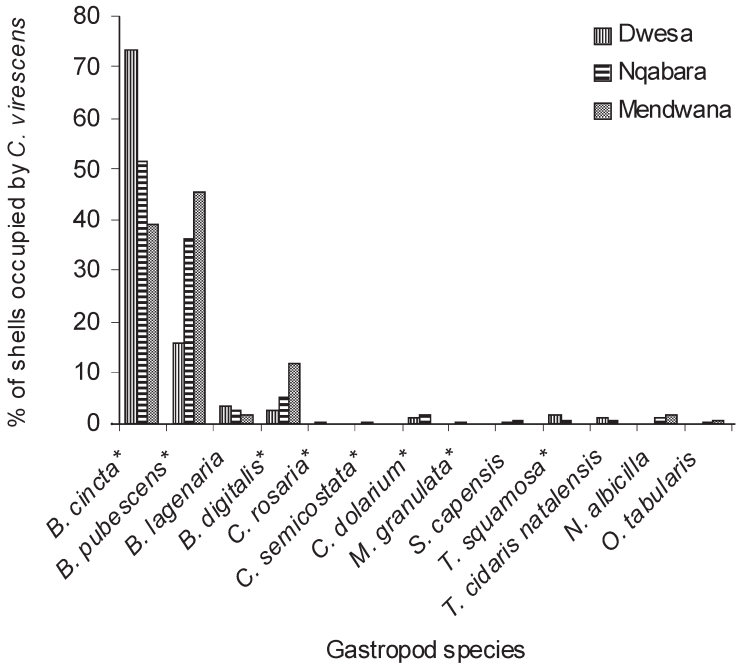

Fig. 1. Species of gastropods and percentage of shells occupied by *C. virescens* at three different study sites: Dwesa (n = 235), Nqabara (n= 347) and Mendwana (n = 273) based on 20 quadrat samples at each site. An * indicates high spired species.

Table 1. Species of gastropod shells and percentage available for occupancy by hermit crabs at three sites: A = Dwesa, B = Nqabara and C = Mendwana

Species	% live gastropods			% empty shells on rocks			% empty shells on strandline		
	A	B	C	A	B	C	A	B	C
Burnupena cincta	17.10			23.08	27.27	33.33	15.71	24.75	13.04
Burnupena pubescens	19.69			7.69	15.15	16.67	18.10	21.29	18.84
Burnupena lagenaria			16.67	3.85			4.29	4.46	2.90
Bullia digitalis			0	11.54	21.21	50.00	15.24	6.93	43.48
Cymatium dolarium					3.03		0.95	5.45	0.00
Cymatium klenei								0.99	0.00
Coriocella nigra								3.96	0.00
Clivatula subventricosa							0.48		0.00
Conus tiniunus								0.50	0.00
Cypraea tigris								0.50	0.00
Fusinus ocelliferus							0.48		0.00
Monodonta australis							0.48		0.00
Nerita albicilla	34.20		16.67				3.81	3.96	0.00
Oxystele tabularis	26.42	25.00	66.67	38.46	24.24		19.05	16.83	15.94
Oxystele tigrina	1.55	65.00					1.43	3.47	0.00
Oxystele sinensis								0.50	0.00
Stramonita capensis				11.54	9.09		10.48	1.98	2.90
Thais squamosal							2.38		0.00
Turbo cidris natalensis				3.85			6.19	3.47	2.90
Turbo sarmaticus								0.99	0.00
Turbo coronatus	1.04	10.00							0.00
Tricolia kochii							0.95		0.00
N	193	20	12	26	33	6	210	202	69

Table 2. Diversity of shells found in the field and used by hermits crabs *Clibanarius virescens* along the Transkei Wild coast

Index of diversity	Used			Available								
				Live gastropods			Empty shells on rocks			Empty shells on strandline		
	A	B	C	A	B	C	A	B	C	A	B	C
No species	11	10	6	6.00	3.00	3.00	7.00	6.00	3.00	15.00	16.00	7.00
Shannon-Wiener H	1.4	1.69	1.64	2.10	1.24	1.25	2.38	2.36	1.46	3.15	3.16	2.23
Evenness E	0.41	0.51	0.63	0.81	0.78	0.79	0.85	0.91	0.92	0.81	0.79	0.79
Dominance D	0.44	0.6	0.63	0.75	0.53	0.55	0.79	0.81	0.73	0.87	0.85	0.74

able (Fig. 1 & Table 1). A wider diversity of shell species were occupied at Dwesa and Nqabara than at Mendwana (Fig. 1 & Table 2). Diversity of shells available for use was also highest at Dwesa (Table 2). Of the available shells those found empty on the strandline had the highest diversity (Table 2). At all three sites *C. virescens* were found significantly more often in high-spired than short-spired shells (Fig. 1) (Dwesa: t = 0.95, df = 9, p 0.001; Nqabara: t = 1.18, df = 11, p 0.01; Mendwana: t = 1.29, df = 11, p 0.01).

DISCUSSION

The most striking result was that at all three sites our data suggest that there was a difference between observed frequencies of shells used compared to that which was expected from their availability. This also held for observed and expected when comparing observed with only live animals, only empty shells and only those collected on the strandline. This suggests selection by the crabs.

This selection appears to be for shells of *B. cinta* and *B. pubescens* (Fig. 1). This may be owing to the spire heights which, as the shells *C. virescens* were found in were mostly high-spired.

A wider diversity of shell species were occupied at Dwesa and Nqabara than at Mendwana. This may be owing to the diversity of shells available for use also being highest at Dwesa. Although the diversity of shells found on the strandline was higher than those found on the rocks and those of living gastropods these shells may not be available to the hermit crabs. The hermit crabs were not observed walking up the beach. However the diversity of shells on the rocks and living gastropods was lower than those used by hermit crabs. We therefore predict another source of shells or that the hermit crabs do migrate to the strandline to get shells, perhaps at night or that the crabs exchange their shells with other crabs that do migrate to the strandline. The shells may also be washed back down to the rocky area during a high tide and then become available to the crabs. Another possibility is that there is a source of shells further down than we could sample.

Our prediction that, as in most species of hermit crabs, *C. virescens* uses some species of gastropod shells disproportionately to their availability appears to be upheld.

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