Hermit crab shell fit, condition, and morphotype distributions in two shore zones

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Abstract: Shells inhabited by hermit crabs at Playa Sirena in Corcovado National Park, Costa Rica, appeared to decrease in physical condition with increasing distance from the ocean. Given that most shells are probably marine in origin, crabs closest to the ocean should have the greatest selection of shells and should inhabit shells of best fit and condition. We assessed shell fit, condition, and diversity on the upper edge of the Playa Sirena and along the estuary of the Rio Claro. A greater proportion of crabs in the beach site had well-fitting and better condition shells than those at the estuary. Shell morphotype dominance varied with zone, and shell morphotype diversity was greater at the beach site. The differences in shell morphotype abundance at the estuary and beach site may be important in explaining the differences in hermit crab fit and shell condition observed between sites. We also observed three different morphotypes of hermit crabs in different shore zones of the Playa Sirena, which could be a subject for future research.

Key Words: gastropod, Nerita, Neritina, *Paguridae, shell distribution*

Introduction

Hermit crabs (Crustacea: Paguridae) occupy empty gastropod shells to protect their soft, vulnerable abdomen (Burnaford et al. 1992). As crabs become larger, they outgrow their shells and search for new ones. We assumed that the main source of shells for the crabs is marine gastropods, and thus hypothesized that the crabs closest to the ocean should have the greatest selection of shells. If shells are transferred through crab communities to areas farther from the ocean, there is likely to be a decrease in the variety of shell morphotypes, as well as a decrease in a crab's chance of finding a good fit, farther from the ocean. Shells will also accumulate damage with age and use, so shell condition is likely to be poorer farther from the ocean where access to new shells is lower. Alternatively, if all crabs have equal access to new shells from the ocean (i.e., all hermit crabs travel to the ocean to find shells rather than pick up shells abandoned by other crabs), there should be no change in shell diversity, fit, or condition with increasing distance from the ocean. We characterize shell diversity, fit and condition in sites differing in distance from the ocean (the upper edge of the beach and the estuary) to determine if shell characteristics differ between sites. We also provide notes on the distribution of hermit crab morphotypes, which may represent different species.

Methods

We selected two crab-inhabited sites near Estación Sirena in Corcovado National Park, Costa Rica: the shore of the Rio Claro about 150 m inland from the open ocean (the estuary site), and the upper edge of the Playa Sirena near the entrance to the Sendero Naranjo where a small freshwater stream crosses the beach (beach site). In both sites we sampled an area of high hermit crab density using 25 0.25 m^2 quadrats placed according to randomly generated coordinates. We counted all gastropod shells, whether occupied or not, in each quadrat and scored each shell's morphotype, occupancy, fit, and condition. The fit of the shell was categorized as "small" (the retracted crab protruded from the shell aperture), "fit" (the retracted crab's claws were flush with the aperture), or "large" (the aperture extended over the retracted crab).

Condition of the shell was ranked from 1 to 4: 1) good condition, no chips or holes; 2) one small hole or chip on aperture; 3) two or more small holes or chips on aperture; and 4) large holes or chips on aperture.

For each site, we calculated the Shannon-Weiner diversity index for the morphotypes of shells either empty or inhabited by crabs. We used a chi-squared analysis to determine the effect of site on fit and condition of hermit crab shells from the beach and estuary sites.

Results

Sixty-nine percent of crabs in the beach site had "fit" shells, while 43% had "fit" shells at the estuary; 38% of the crab shells were large at the estuary versus 12% at the beach site; and approximately 19% of the shells were too small at both sites (Fig. 1). The average proportion of these shell types differed significantly between the two sites ($\chi^2 = 28.74$, df = 2, $P < 0.0001$). Sixty-one percent of beach site shells were of the best condition, while only 37.5% of estuary shells were of the best condition. The proportion of shells in poorest condition was 6.3% in the estuary and only 1.4% in the beach site (Fig. 2). The average proportion of shell conditions differed significantly between sites ($\chi^2 = 20.45$, df = 3, $P < 0.0001$).

We found 35 distinctly recognizeable shell morphotypes across our study sites (Table 1). Shell morphotype dominance varied with site; *Neritina latissima* and *Nerita funiculata* shells (Soto and Jiménez 1994) were most common in the estuary and the beach site, respectively. The beach site had higher shell morphotype diversity than the estuary, but the diversity of the estuary was more even (Table 1).

We also sampled the low intertidal zone and encountered two other hermit crab morphotypes (see Appendix I); we did not, however, use these in our analysis of shell characteristics.

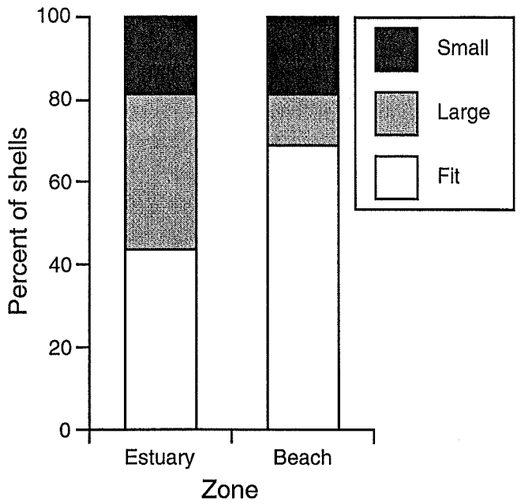

Fig. 1. Shell size in relation to hermit crab size in two shore zones, from the Rio Claro estuary (n = 80) and the upper edge of the Sirena beach (n = 418). Fit categories: "Fit" designates the retracted crab is flush with the shell aperature, "Large" the retracted crab is fully inside the shell, and "Small" the retracted crab protrudes from the shell. The proportion of shell morphotypes in the two habitats differed significantly (see text).

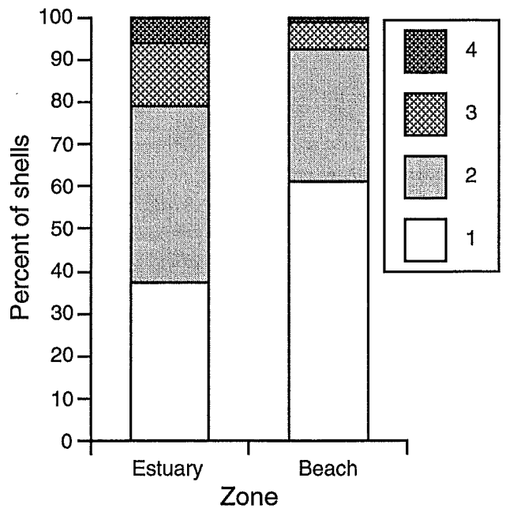

Fig. 2. Physical condition of hermit crab shells from the Rio Claro estuary (n = 80) and the Sirena beach (n = 418). Quality categories: 1 (good quality, no chips or holes), 2 (one small hole or chip on aperture), 3 (two or more small holes or chips on aperture), 4 (large holes or chips on aperture). The proportion of shell morphotypes in the two habitats differed significantly (see text).

Table 1. Characteristics of shell morphotypes occupied by hermit crabs in estuary and beach zones. Morphotype numbers are given as percentages of the total shells counted.

Morphotypes present	Rio Claro estuary	Sirena beach
Neritina latissima	54.1%	8.5%
Nerite funiculata	22.4	51.4
Cylichna luticola	8.2	0.0
ID 17	5.9	3.9
Polinices uper	3.5	0.0
Cerithium stercusmuscarum	0.0	22.6
ID 22	0.0	2.5
other	5.9	11.1
Total shells counted (n)	86	438
Number of morphotypes	10	24
Dispersion index (Variance/mean number morphotypes per quadrat)	0.7	3.1
Shannon-Weiner Diversity Index (H)	1.45	1.66

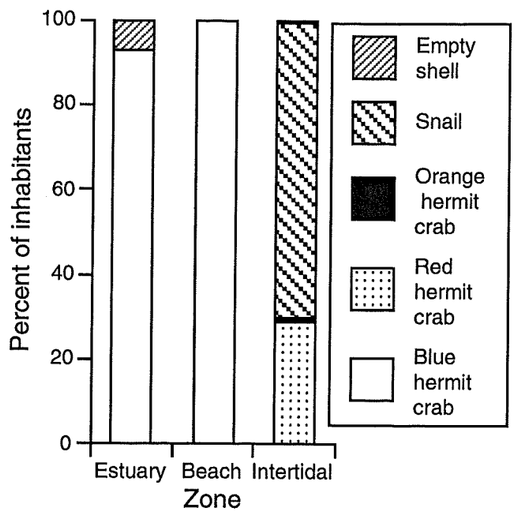

Fig. 3. Percentage of shells inhabited by snails, different morphotypes of hermit crabs, and empty shells, found at the Rio Claro estuary (n = 86), the upper edge of the Sirena beach (n = 439), and the Sirena beach intertidal (n = 881). See appendix for details.

Discussion

A greater proportion of crab shells in the beach site were of better fit and condition than at the estuary, suggesting that hermit crabs on the beach have a greater choice of shells. The higher diversity of shell morphotypes at the beach site further indicates that crabs there have a greater selection of shells.

The difference in dominant shell morphotypes at the estuary and beach sites, however, may be important in explaining the differences in fit and condition observed between sites. For instance, *Neritina latissima*, is the dominant shell type used by hermit crabs at the estuary (54%), but only rarely at the beach (8.5%, Table 1). *Neritina latissima* always appeared to be too large for crabs as a consequence of its flared aperture, and large holes occurred more frequently on *N. latissima* shells than on other shell morphotypes. The prevalence of this morphotype may influence the average fit of hermit crabs in their shells, as well as condition of shells in the estuary site as much as does distance from the ocean.

The high prevalence of *N. latissima* shells used by hermit crabs at the estuary site may reflect the possibility that the gastropod may be an estuarine snail (Soto and Jiménez 1994). (We did not, however, find *N. latissima* snails in the Rio Claro, despite extensive searching.) The lower diversity of marine gastropod shells at the estuary, as well as the lower average condition of the marine shells used by crabs there, suggests that crabs living in the estuary must obtain other gastropod shells from crabs living closer to the ocean. Further study on the mechanisms of shell dispersal and on the level of protection afforded by shells of different conditions and morphotypes could help to explain observed patterns of hermit crab distribution.

Literature Cited

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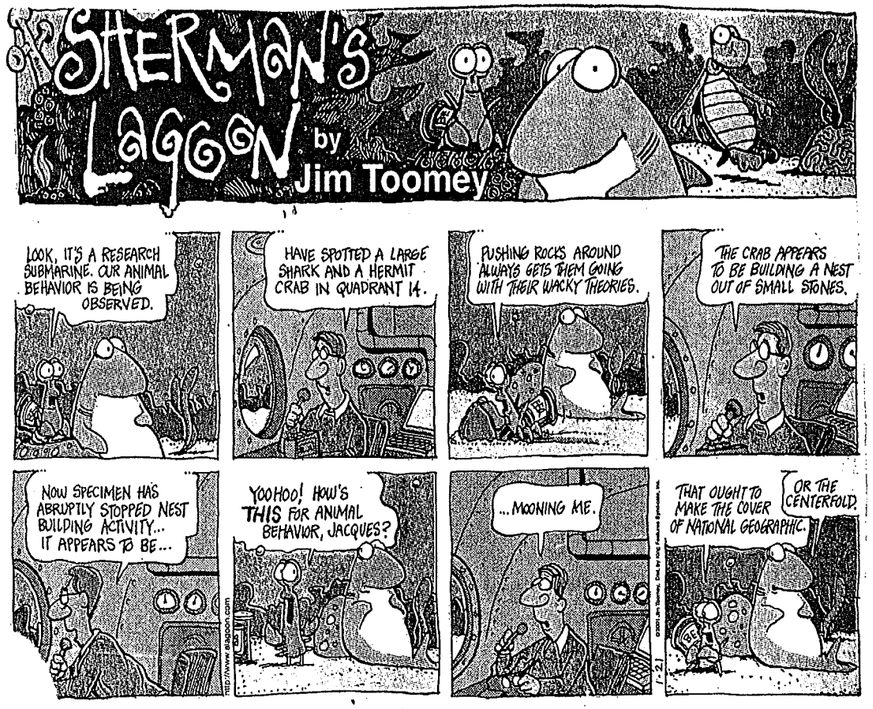
Appendix

We repeated the same quadrat samples described in Methods on the hard mud substrate of the low intertidal zone. We decided to exclude these data from our analysis because we observed that the intertidal hermit crabs were of different morphotypes and sizes from the crab morphotype at the Rio Claro estuary and at the Playa Sirena. We suggest these may be different species. In the absence of taxonomic references, we provide descriptions of these "species" here. "Blue" crabs were found in the estuary and upper beach zones, while "Red" and "Orange" types were found only in the intertidal. Live gastropods were also only observed in the intertidal (Fig. 3).

"Blue" hermit crabs: legs and claws ranging in color from bluish gray to rust, gray or bluish antennae, large claws, body folded up into a compact mass to block the aperture of the shell, would emerge from shell while being held.

"Red" hermit crabs: black legs and claws with white tips, red antennae, tiny claws, legs retracted far into shell when crab is withdrawn, somewhat reluctant to emerge from shell while held.

"Orange" hermit crabs: legs gray, claws turquoise edged with bright orange, orange antennae, eyestalks with white "iris" below black tips, very reluctant to emerge from shell while being held or observed. All specimens found were relatively large, and most were found in turban shells.