ENVIRONMENTAL PREFERENCE AND SHELL SELECTION IN HERMIT CRABS

MELISSA A. BARGER, GABRIEL H. CALVI,
TIMOTHY R. MATSUURA AND JONATHON C. RAFFENSPERGER

Abstract: On the Playa Sirena beach at low tide, there are aggregations of crabs at two locations, one near the water and one near the trees above high tide line. The crabs nearest the trees are larger than those near the water, and also differ in morphology and in the shells they inhabit. We explored patterns in crab size, morphology and shell size between the two aggregations, and used experimental displacements and mark-recapture techniques to investigate habitat preferences. We found that the crabs in each group preferred the habitat in which they were found. The differences in size, morphology and shells between the groups may be explained simply by the tendency of large crabs to move higher on the beach, where resources may be more abundant. Larger crabs are expected to have proportionally larger claws, due to allometric relationships,. A shortage of large shells may explain the tendency for the larger crabs to have shells into which they could not fully retract.

Key Words: habitat preference, Paguridae, Playa Sirena

INTRODUCTION

Hermit crabs (Paguridae) are abundant on the shores of Playa Sirena in Corcovado National Park, Costa Rica. Previous studies have found two aggregations of crabs on the beach at low tide, one close to the forest edge near the high-tide mark and the other approximately 100 m from the tree line near the low-tide mark, with few crabs in between (Dudycha et al. 1992). Furthermore, the crabs higher on the beach are larger than the crabs found in tidal pools near the low-tide mark (Biedron and Theoharides 2003). Previous researchers hypothesized that resource availability and competitive exclusion could account for these trends (Karlsberg and Hubbard 1995). Large crabs could take advantage of high food abundances at the high water mark and exclude smaller crabs, forcing them to scavenge in tide pools (Biedron and Theoharides 2003).

An alternative explanation, that these aggregations represent two distinct populations, is implausible because hermit crabs return to the water to mate and reproduce, so that genetic mixing is likely (although assortative mating remains a possibility). We predicted that crabs from the two zones would not move between them (apart from reproductive events, which we did not observe). We also documented patterns in crab size and morphology, as well as shell size and morphology, between the two groups.

METHODS

To test for movement between the two environments, we distinctively marked 80 crabs near the surf at the low tide mark and 270 crabs at the forest edge, both in 10 m x 2 m plots during low tide, near the outlet of Sendero Naranjos, on 2 February 2005. We recaptured crabs during the following high tide, in the "terrestrial" plot, and low tide, in both the intertidal and terrestrial plots. We also tested environmental preference by placing 20 crabs from the forest edge and 20 from the water's edge (randomly selected) equidistant from the low tide line and forest, and recorded direction of movement for each individual over a 5 min interval.

We haphazardly selected four 1 m^2 plots along the forest edge and six along the low tide line and captured all crabs in each. The two additional plots in the low tide zone were needed to obtain similar sample sizes, because crabs occur at a lower density there. For each crab in our plots, we measured shell width (across aperture), length (laterally, perpendicular to width), and height. We also measured the distal segment of the second pereiopod and recorded the presence or absence of an enlarged cheliped. We recorded how far the crab retreated into its shell (inside, flush with, or partially outside the shell). We recorded shell shape (which we labeled conical, spherical, or "flat"). These were quite distinct. We did not calculate shell volumes because assumptions needed to use simple formulas would confound analyes. (Note, however, that volumes of shells could be measured quite accurately, by sealing apertures and measuring water displacement in a graduated cylinder).

We decided not to report ratios of metrics because this would have required careful assessment of the allometric relations between those metrics, with increase in size of both crabs and shells. Allometric relations typically involve changing ratios among metrics due to size alone (e.g. claw size has been shown to increase greatly, relative to overall crab size), as crabs grow. Because the two crab groups differ substantially in mean size, comparisons between them in the ratios among metrics, would give rise to misleading (spurious) patterns.

Environment preference, shell shape, and distance of retreat into shell were analyzed using Chi Squared tests. Data met or were log transformed to meet the assumptions of parametric tests (JMP 5.0.1).

RESULTS

We recaptured eight of the 270 marked terrestrial crabs within the 10 m x 2 m plot in which they were marked and five more about 20 m into the forest. Twenty-eight of the 80 marked marine crabs were found within the 10 m x 2 m intertidal plot. No marked terrestrial crabs were found in or near the water, nor were any marked marine crabs found near the forest (though we did not quantify that search effort or area). In preference tests, 18 of 20 (90%) of crabs from the forest edge returned to the dunes and two moved to-

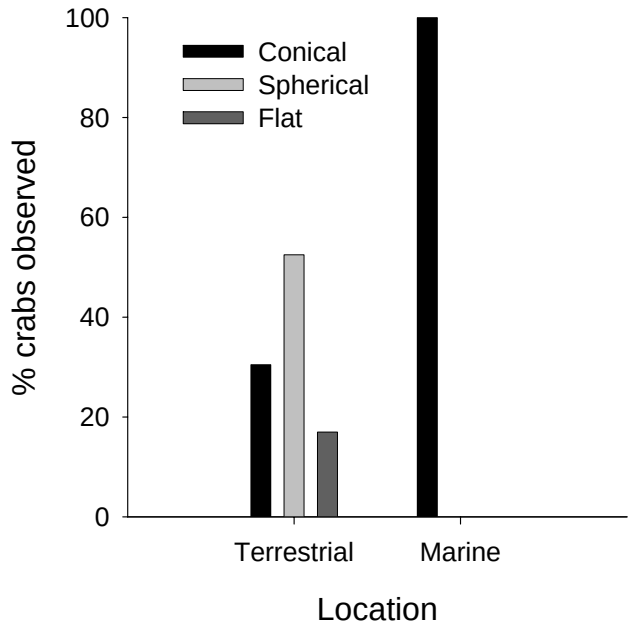

Figure 1. Percent of terrestrial and marine hermit crabs with conical, spherical, and flattened shell types at Playa Sirena, Corcovado National Park, Costa Rica. Terrestrial crabs were found in all shell types, whereas marine crabs were found exclusively in conical shells ($X^2 = 63.611$, df = 2, $P < 0.0001$).

wards the water but did not enter it. Eleven of 20 (55%) crabs from the water's edge moved towards the water and nine did not move ($X^2 = 39.54$, df = 2, $P < 0.001$).

All sampled marine crabs had conical shells (60 of 60), while spherical shells were most common among terrestrial crabs (31 of 59; Fig. 1). Marine crabs also retreated completely into their shells (60 of 60), while terrestrial crabs were often flush with or protruding from their shell aperture (combined 41 of 59; Fig. 2). All terrestrial crabs had an enlarged cheliped (59 of 59), while its presence is rare in marine crabs (10 of 60).

DISCUSSION

Our failure to locate crabs that had been marked near the forest edge near the water, or marked crabs from the water's edge near the forest, suggests that there is little or no movement of individuals between the two aggregations of crabs. Although nine of the crabs from the water's edge did not move in the habitat preference test, this result is consistent with our informal observation that these crabs were less active than those near the forest edge. The lack of large claws in most crabs near the water's edge is consistent with expectations from allometry, as noted above.

Because hermit crabs generally select shells (if available) into which they can fully withdraw, it is likely that large shells appropriate for the large crabs near the forest edge are in short supply. Competition

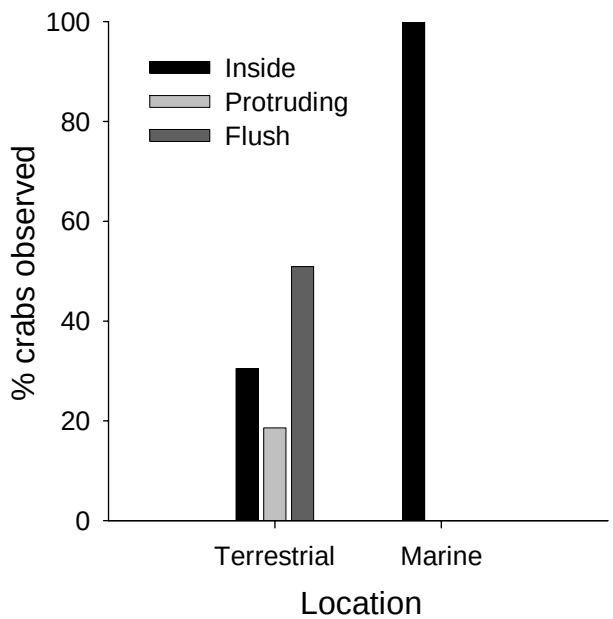

Figure 2. Percent of terrestrial and marine hermit crabs that retreated fully inside of, protruded from, or were flush with their shells. All marine crabs could fully withdraw into their shells, whereas terrestrial crabs exhibited all three behaviors ($X^2 = 63.611$, df = 2, $P < 0.0001$).

among these crabs for large shells may therefore be intense.

Hermit crabs prefer conical shells (Burnaford et al. 1992). Some crabs can sense and locate dying gastropods, whose shells they may then acquire (Small and Thacker 1994). We found crabs at the water's edge exclusively in conical shells, possibly because of this preference, their close proximity to the gastropod resources, and perhaps an abundance of suitably sized shells. Forest edge crabs used all three shell types, which may reflect a limited availability of large shells.

LITERATURE CITED

Beidron, I. S., and K. A. Theoharides. 2003. Habitat partitioning by hermit crabs (Paguridae) at Playa Sirena, Corcovado National Park, Costa Rica. Dartmouth Studies in Tropical Ecology, p. 108-110.

Burnaford, J. L., K. A. Isaacs, and J. V. Ko. 1992. Shell preference in hermit crabs (Paguridae). Dartmouth Studies in Tropical Ecology, p. 93-95.

Dudycha, J. L., J. J. Stachowicz, and S. L. Soucy. 1992. The intertidal zone: Crabs and their community. Dartmouth Studies in Tropical Ecology, p. 88-92.

Karlsberg, S. D., and J. M. Hubbard. 1995. Size distribution and habitat preference in hermit crabs. Dartmouth Studies in Tropical Ecology, p. 76-80.

Simon, K. E., J. P. Casler, and G. M. Ferrie. 2003. Too hot to handle? Diel variation in hermit crab distribution and abundance in beach and forest habitat. Dartmouth Studies in Tropical Ecology, p. 87-89.

Small, M. P., and R. W. Thacker. 1994. Land hermit crabs use odors of dead conspecifics to locate shell sources. Journal of Experimental Marine Biology and Ecology, 182: 169-182.