The Relationship between the Shell Attributes and Locomotion of the Hermit Crabs: Suggestion of Potential Strategy for the Environmental Disturbance

Abstract

Hermit crabs are known to select their shells by the size and shell shapes. Although larger size of the shells is desired for the crabs' growth and protection from predators, the increase weight can limit their locomotion; the irregular shape of the shell can also be disadvantageous. This study attempted to examine the relationship between these shell attributes and the ability of hermit crabs to move. Hermit crabs were buried in the sand and measured their time required to emerge up to the surface. In the present study, there was no significant relationship found between the emergence time and shell weight or shell shape: Moreover, many crabs did not move under the sand. Therefore, it may be their adaptation strategy to wait until the disturbances in the upper environment disappears rather than to waste energy by making effort to go up. Further researches on the behavioral adaptation of hermit crabs to their habitat are desired.

Introduction

Marine organisms are under the various pressures such as limited resources, disturbances, competition and so on. Such pressures are key driving factors of adaptation to the habitat; thus the physical and behavioral characteristics of organisms in a particular habitat reflect the survival strategies in the habitat. Intertidal to subtidal zone of the coral reef is the habitat for many hermit crab species. Researches suggest the patterns of habitat preference reflect the availability of shells suitable for the crab body size (Bach & Hazlett 2009; Ismail 2010; Shih & Mok 2000). Although large individuals may be reproductively successful (Gherardi & Nardon 1997), increased drag forces and weight of larger shells they occupy may limit their locomotion. On the other hand, the shape of the shell can also affect the crabs' ability to survive in subtidal, where the surge can be strong (Bach & Hazlett 2009). Therefore, the size, weight and shape of shells are critical factors determining the hermit crabs' survival by influencing on their movement.

This study aims at studying the influence of these factors on the locomotion of hermit crabs by their time to emerge out of the sand in which they are buried as the measurement of their ability to move. Hermit crabs in natural environment can be buried under the sand by cyclone or dredging. This situation can be more frequent, considering that climate change (and increased frequency of cyclones) and coastal dredging are concerned as threats to their reef habitat (Great Barrier Reef Marine Park Authority 2009). It is expected the heavier weight of the shell is disadvantageous for the upward movement to emerge out of the sand. In addition, the less occupied shell shapes may have disadvantages in movement (which is assumed to be the reason why they are not preferred), that prevents them from emerging. Therefore, the following hypothesizes are constructed:

H1. The emergence time for heavier individuals is longer.

H2. The emergence time for those in the less commonly occupied shell shapes is longer.

Methods

Hermit crabs were collected from the beach rock and reef flat zone of Heron Island Reef under low tide conditions at the end of September, 2013. Crabs were kept in the same aquarium which was well oxygenated by continuous flow of seawater. Before the trial, length, width and shapes (and species if possible) of the shells (shape classification and identification based on Wilson 2002) and weight of the individuals (the total weight including the shell with the water drained) were recorded and crabs were returned to the tank until they are taken back the laboratory again for trial. In the laboratory, three identical cylindrical containers (diameter: 12cm, height: 10cm) filled by seawater and sand (up to 6.5cm) collected from the southern beach of the island were prepared. Hermit crabs were individually buried into the sand until the surfaces of their shells were 2cm beneath the surface. The time of emergence was measured by a stopwatch, from when the depth was confirmed until the two eyes of the crabs were clearly out of the sand. If the crabs did not emerge within one hour, the trial was abandoned. As soon as one trial is finished, crabs were dag out and next trial was initiated; up to three trials were undertaken at the same time in the separate containers. The relationship between emergence time and crab weight was analyzed in relation to crab species using ANCOVA.

Results

18 individuals of hermit crabs are collected over three days including four species: six of *Calcinus latens*, four of *Dardanus lagopodes*, three of *Dardanus megistos*, and five of *Clibanarius corallinus*.

D. lagopodes and *D. megistos* were significantly heavier than *C. latens* and *C. corallinus* (t-test, $p<0.05$), and *C. latens* and *C. corallinus* were similar in weight (t-test, $p=0.29$). 10 out of the 18 individuals managed to emerge out of the sand, among which are four *C. latens*, three *C. corallinus*, two *D. lagopodes*, and one *D. megistos*. Their size, shell attributes and emergence time are shown in Table 1 and Figure 1.

Table 1. Profiles and emergence time of hermit crabs collected in Heron Island, Australia, in September 2013. The identification number of individuals corresponds to the number inserted in Figure 1. The individuals whose experiment was abandoned are indicated by the emergence time noted as “n/a”.

	Species	Shell	Shell type	Length (cm)	Width (cm)	Weight (g)	Time (sec.)
1	*C. latens*	*Conus* sp.	biconical	5.8	3.4	24.68	n/a
2	*C. latens*	*Conus* sp.	biconical	5.2	2.7	15.59	2830
3	*C. latens*	*Rhinocalvis* sp.	turreted	3.3	1.2	2.76	n/a
4	*C. latens*	*Nodilittorina pyramidalis*	turbinate	1.9	1.7	4.09	290
5	*C. latens*	*Turbo* sp.	turbinate	1.9	1.8	3.20	309
6	*C. latens*	*Natica* sp.	turbinate	2.0	1.6	2.29	1201
7	*C. corallinus*	*Planaxis sulcatus*	turbinate	2.5	1.2	4.33	n/a
8	*C. corallinus*	*Planaxis sulcatus*	turbinate	2.5	1.4	4.27	n/a
9	*C. corallinus*	*Planaxis sulcatus*	turbinate	2.6	1.9	4.11	1467
10	*C. corallinus*	*Planaxis sulcatus*	turbinate	2.6	1.3	3.85	186
11	*C. corallinus*	*Planaxis sulcatus*	turbinate	2.7	1.8	5.21	104
12	*D. lagopodes*	*Conus* sp.	biconical	5.3	3.0	23.01	307
13	*D. lagopodes*	*Conus anemone*	biconical	5.8	2.9	21.04	n/a
14	*D. lagopodes*	*Conus* sp.	biconical	5.5	3.2	27.37	n/a
15	*D. lagopodes*	*Conus* sp.	biconical	6.3	3.9	44.32	168
16	*D. megistos*	*Conus capitaneus*	obconical	7.3	5.8	75.54	n/a
17	*D. megistos*	*Conus* sp.	biconical	6.2	3.7	51.98	n/a
18	*D. megistos*	*Conus mustelinus*	biconical	6.9	3.8	58.33	90

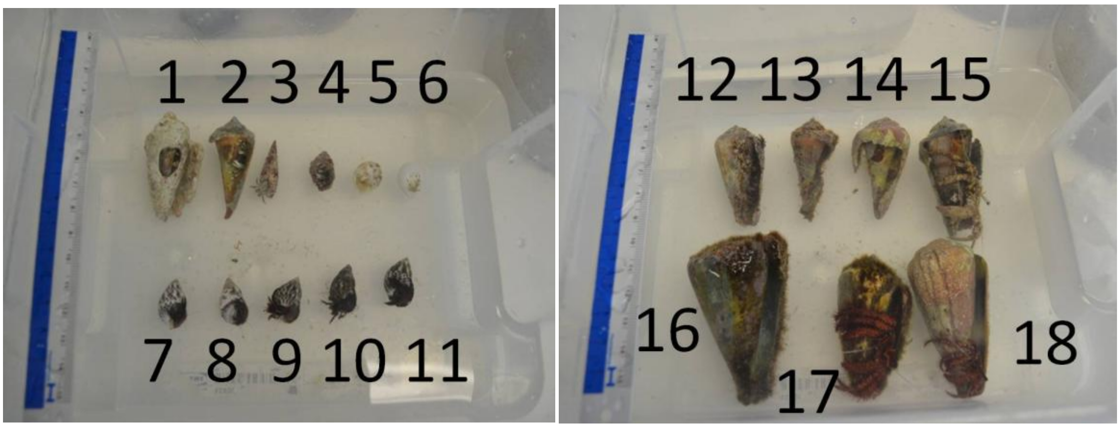
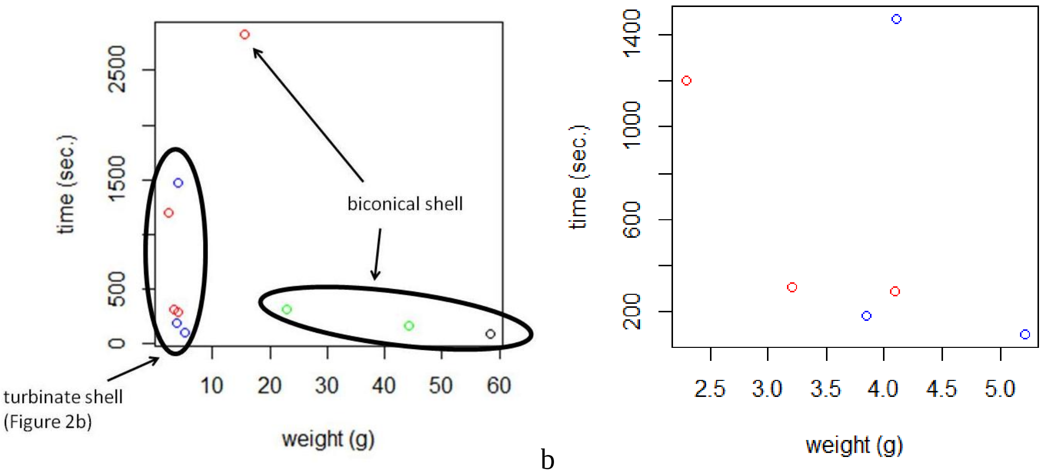


Figure 1. Hermit crabs collected from Heron Island. The blue scale on the left side is 15cm. The numbers correspond to the individuals in Figure 1.

There was no obvious trend found in the emergence time in relation to the weight or the shell shape in general (Figure 2a).The emergence time of *C. latens* and *C. corallinus* individuals of overlapping weight ranges (all of them with turbinate shell form) was compared using ANCOVA; but neither species nor weight had a significant relationship with surface time (n= 3, $P_{species}$=0.97, P_{weight}=0.30, Figure 2b).



a b

Figure 2. Scatter plots of surface time in relation to crab weight and species. a. All results with shell shapes indicated. b. The results of *C. latens* and *C. corallinus* of weight range 2.0-5.5. Each point represents an individual. Red; *C. latens*, blue; *C. corallinus*, green; *D. lagopodes*, and black; *D. megistos*.

Discussion

Both hypotheses based on the potential disadvantage of heavier or irregular shaped shells are rejected by the result that neither of the shell weight or shape had any notable relationship with the time required for emergence. The simplest interpretation of the result is that the disadvantages by shell attributes are not critical but can be overcome by the physical strength by the crab. Of the ten individuals that managed to emerge from the sand, six were in turbinate shells (Table 1) and the rest were in biconical shells; those in bonical shells were larger than those in turbinate shells (Figure 2a). Although a half of the samples occupied shells of *Conus* sp. when all 18 samples are considered, it may be because of the size of the crabs as is suggested by the shell selection experiments by Shih and Mok (2000). Thus, if the actual preference of the shell shape is turbinate (and if it is more locomotion-efficient), those large individuals in biconical shells are disadvantaged both by the weight and the shell shape. Nevertheless, those individuals often emerged more quickly than smaller, supposedly less burdened individuals. Therefore, the large individuals may be stiff tough enough to manage the shell weight and shape, thereby be able to take advantage of their large size in competition and reproduction.

However, the fact that eight of the samples did not emerge out of the sand cannot be dismissed. In fact, no surface movements of the sand were observed for most of these abandoned experiments; but when the crabs were dag out, they were not damaged from their appearance. This observation casts question about the adequacy of the emergence time from the sand as the measurement of the locomotion of hermit crabs. As some of the small individuals as well as large ones made no movement, it may not be necessary for hermit crabs to get out of the sand immediately. It may be their strategy to wait until the sand covering them is taken away rather than to make efforts to emerge which can potentially waste energy in the situation that they do not know how deep they are buried. Or, they may wait because the threat in the upper environment which caused them buried in the sand may still remain. It is unknown from this experiment if there is a threshold of waiting time exists: but as long as the crabs can stay in the sand, “no movement” can be a strategy in the field where there can be disturbances such as cyclones or dredging which can last more than an hour. Another constrain of this study was the small sample size. If each of the species was collected in larger number, for overlapping sizes, the direct comparison of all species may have been possible, which could have led to any relationship between these factors.

Conclusion

Despite the limitations and non-significant relationship found between the shell attributes and the emergence time, the present study suggests the potential of new perspectives developed on the classic shell selection experiments by attempting to find the result of shell selections. Understanding the behaviors of hermit crabs can be beneficial to measure the adaptability of these crabs in their reef habitat, which are currently under the pressure of climate change and coastal development (Great Barrier Reef Marine Park Authority 2009). Furthermore, the ease of collection of hermit crabs can allow them to be good model organisms of the benthic organism. Therefore, further development of the research on the behavioral adaptation of hermit crabs is encouraged for the better management of the reef system.

Reference

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