Bio331 Home

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"Hermit crabs and the choices they make"

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long-clawed hermit crab

Pagurus longicarpus

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Independent Research Project on shell selection of *Pagurus longicarpus*

when presented with similar sized shells that have drastically different weights

long claw on sea lettuce

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I. Title:

Shell selection of *Pagurus longicarpus* when presented with similar sized shells that have drastically different weights.

II. Introduction:

Pagurus longicarpus, the long clawed hermit crab, is a marine crab that inhabits the Northern Atlantic waters. *P. longicarpus* along with all other crabs, shrimps, and lobsters belong to the phylum Arthropoda and class Malacostraca (Bliss, 1982). The class Malacostraca are animals with compound eyes on stalks and 19 segments in the body (Bliss, 1982). Within the class Malacostraca is the order Decapoda. The animals in this class have five pairs of legs which is a characteristic of the class (Bliss, 1982). Hermit crabs are a unique in that they have a hard cephalothorax and a soft abdomen. It is due to their soft abdomens that cause them to find a shell to inhabit and protect themselves from the elements and predators (Bliss, 1982).

Classification Tree (Whitney Laboratory, 2003)

Family = Paguridae
Superfamily = Paguroidea
Infraorder = Palinura
Suborder = Pleocyemata
Order = Decapoda
Superorder = Eucarida
Class = Malacostraca
Subphylum = Crustacea
Phylum = Arthropoda

Under natural cicumstances in Massachusetts, *P. longicarpus* will choose to inhabit periwinkle (*Littorina obtusata*), mud snail (*Nassarius obsoleta*), or oyster drill shells (*Urosalpinx cinerea*) (Abbott, 1968). They wrap their uropod, abdomen, around the whorl of the shell (Bliss, 1982). Small legs with rough bottoms help brace the crab in the shell (Bliss, 1982). Their common range is from Massachusetts to Florida in rocky tidal zones, salt marshes, and open shores (Whitney Lab, 2003).

Waterman states that animals in the order decapoda do have the ability to see (1961). Light sensitivity and vision depend on the naupliar eye, the compound eye, and a generalized light sensitivity (Waterman, 1961). His research shows that the compound eye is the best developed for vision in the decapods, but is not as well developed as that of fish, birds, or mammals (Waterman, 1961). Less than 200 neurosensory cells are devoted to vision in the decapods copmpared to the millions of cells elsewhere in the central nervous system (Waterman, 1961). This information was necessary to review because my research is focused on *P. longicarpus* finding a shell. It is only if the crab finds a shell that the rest of the experiment can be completed.

Interesting research has shown that hermit crabs (*P. middendorffii*) will determine which shell will be selected based on their growth rate (Wada et al. 1997). Crabs that know they are going to moult soon have been shown to specifically choose a larger shell to accomodate their larger size (Wada et al., 1997).

The goal of my research is to place *P. longicarpus* without a shell in a tank with shells of different weights and record which shell the crab inhabits for more than ten minutes. My hypothesis is that the crab will choose the lightest weighted shell amongst the three shells presented to it. This is a significant question to address because heavier shells present different constraints compared to lighter shells. Having a lighter shell may be more adaptive in the marine environment allowing for faster movements to catch prey and avoid predators. A heavier shell may also be more difficult to manuever. In this paper, I limit my research to consider shell weight as the only character considered by *P. longicarpus* during shell selection.

My collabortator was Bonnie McClennan. Both of our animals need to have a hard shell as in the case of the hermit crabs or make a hard outerlayer as in the case of barnacles (*Balanus balanus*) to survive.

III. Materials and Methods:

Materials Used:

The hermit crabs were kept in a cold marine tank set at 12 degrees Celsius. An aerator was placed in the tank to maintain adaquate dissolved oxygen levels. The following is a complete list of all the materials used to carry out the experiment.

- seven long claw hermit crabs (*P. longicarpus*)
- cold water marine tank
- loose periwinkle shells for experiment
- PC-7 or other epoxy
- parafilm to mix epoxy on
- small lead weights
- forceps
- bunsen burner
- matches
- small tanks for transport and experiment
- aerator for water
- instant ocean salt
- calipers
- gram scale

Methods Used:

The first task was to measure the current size of the shells of the seven crabs. Calipers were used to measure the length of the shell at the widest point and the width of the opening of the shell. All measurements were taken in centimeters. Next, the same measurements of the loose shells were recorded. The loose shells were also weighed on a gram scale and weights were recorded to hundreds of a centimeter.

The next step was to pair crabs up with loose shells of similar measurements. Crabs that had at least three comproable shells were deemed worthy for the experiment.

A litlle time was used to practice extracting a crab from its shell using the flame method prior to begining the actual experiment.

Salt water was needed to carry out the experiment. One full scoop of InstantOcean sea salt was dissolved in five gallons of deionized water. This was done in the cool room which is set at twelve degrees centigrade and is the desired temperature of the final salt water. A hydrometer was used to check the specific gravity of the solution. A reading of 1.025 meant that the water had a correct salinity of 35 parts per thousand.

When the salt water was the correct salinity and temperature,about one liter of water was poured into one of the small holding tanks. The first crab was chosen based on comparable shells available for it and was removed from its shell.

To remove the crab from its shell, a bunsen burner was set up and lighted. Holding the shell of the crab with forceps, it was gently waved over the flame. Eventually, the crab would emerge from the shell and land in the small tank of water below.

Now, with the crab out of the shell, the three predetermined loose shells were placed in a line at the opposite end of the tank and the naked crab was turned so its posterior end was facing the shells. The crab was given up to 24 hours to choose a shell. When the crab lived in a shell for at least ten minutes, it was determined that that shell was the chosen one. All observations were recorded in a lab notebook. The other shells were removed from the small tank and the crab was removed from the chosen shell.

The final shell that was inhabited for more than ten minutes would receive the greatest amount of weight, about three (3) lead balls. The other shells would receive less weight or no weight and a smear of PC-7 to act as a control. When the epoxy was dry, the second trial could begin.

This trial was set up and carried out in the same manner as the first trial. All observations were recorded in a lab notebook for later analysis. Once the crab chose a shell and inhabited it for at least ten minutes, the experiment was over. The crab was removed from the shell once more and allowed to return to its original shell. Repeated trials with the same crab were conducted ten times. The shells were arranged differently in each trial so that the crab would not encounter the same shell twice. Two other crabs were used, but for a single trial only.

The data that was quantified by recording which shell was inhabited by the crab for at least ten minutes. The number of times each shell was chosen by each crab was the data used to determine the validity of my hypothesis. No averages were taken that was pertinent information to the hypothesis.

IV. Results

The length and width of the crab shells were recorded to get a base size of the crab's original shells. The same was done for the loose shells so that three shells could be chosen for the crabs based on the size of their original shells See table 2 and table 3.

Ten trials were completed with crab number 1. One trial was completed with crab number 3 and crab number 5.

In the unweighted trial, crab 1 chose to inhabit shell 14 for at least ten minutes. To remove any bias the crab may have toward that shell, number 14 was made the heaviest. See table 4. In the trials, crab 1 chose to inhabit the lightest shell #2 seven times and the heaviest shell #14 three times. Shell #11 was never inhabited for more than ten minutes. See figure 1 and table 1.

Figure 1. Results of Crab 1 trials

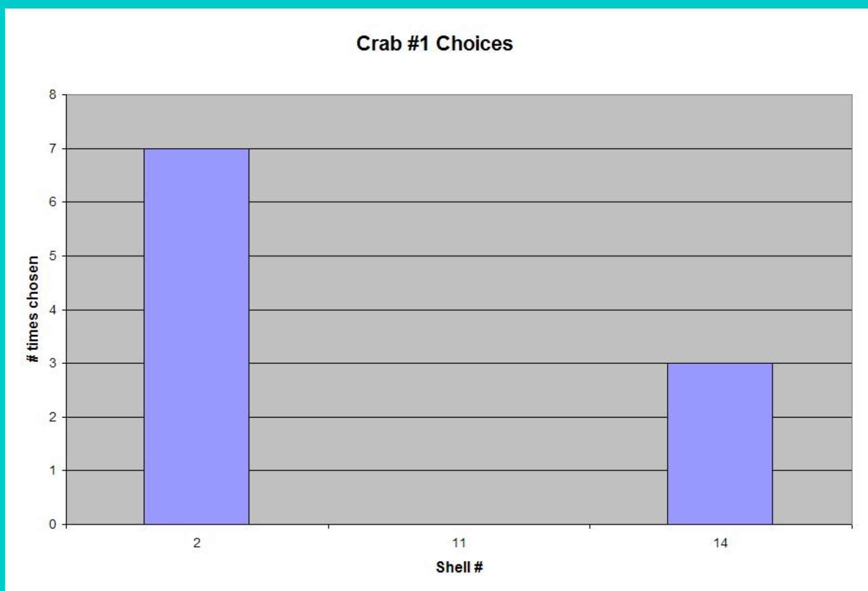

Table 1. Results of Crab 1 trials

Trial	Shell 2	Shell 11	Shell 14
1	-	-	X
2	-	-	X
3	-	-	X
4	X	-	-
5	X	-	-

6	X	-	-
7	X	-	-
8	X	-	-
9	X	-	-
10	X	-	-

In the unweighted trial, crab 3 was presented with shells 6, 9, and 12. Crab 3 chose to inhabit shell 9. To remove any bias the crab may have toward that shell, number 9 was made the heaviest. See table 4. In the weighted trials, crab 3 chose to inhabit shell 12 for more than ten minutes.

In the unweighted trial, crab 5 was presented with shells 1, 3, and 16. Crab 5 chose to inhabit shell 16. To remove any bias the crab may have toward that shell, number 16 was made the heaviest. See table 4. In the weighted trials, crab 5 chose to inhabit shell 1 for more than ten minutes.

V. Discussion and Conclusions

Based on the results of crab 1, it can be concluded that *P. longicarpus* will choose the lightest weighted shell presented to it. The heaviest shell was rarely inhabited. The results from crab 3 and crab 5 were not used to determine any conclusions because only one trial for each crab was performed. All conclusions are based on data gathered from crab 1.

In the weighted trials with crab 1, it often chose shell 11 to inhabit first, but quickly moved into shell 14 or 2. Shell 14 was the heaviest and was inhabited for the first three trials. Aftter the thrid trial, crab 1 consistently chose to inhabit shell 2 which was the lightes shell available. See figure 1 and table 1. Shell 11 was never inhabited for more than ten minutes probably due to the fact that that shell had a hole on its side that may be an undesirable characteristic for *P. longicarpus* when choosing a shell to inhabit. The hole is in a place that would allow a predator easy access to the crab's soft abdomen. This may have skewed my data because the crab may not have minded the extra weight on shell 11, but the hole in the shell was what made the crab not inhabit it for at least 10 minutes. This defiled shell should have been eliminated from the trials, but there were not any other loose shells that would have been a similar size as the crab's original shell.

All of the shells that received only PC-7 increased weight by 0.3g or less. The medium weighted shells increased an average of 3.0g. The heaviest shells increased an average of 4.3g. If there was a non messy way to weigh the shell while the epoxy was being added, I think more weight would have made the increase between the three shells more dramatic. Sizes of the shells also played a role in the amount of epoxy being used; large shells needed more epoxy while small shells required less epoxy. See table 3 and table 4. To account for these differences, next time crabs of similar sizes would be used so that an average weight increase could be used for the shells. That would eliminate any need to take into account weight increases on a small shell as opposed to a large shell.

Bonnie and I did not have any significant results in terms of our collabortation efforts. To have made the experiment results collaborate better, I would suggest conducting the shell selection trials in a flow tank.

I was not able to witness any of the crabs choosing specifically larger sized shells during the trials. I can assume based on research by Wada et al. that none of the crabs were going to moult soon (1997). This is probably due to the stress that they are under while in captivity.

All of the shells were periwinkle shells collected at Goose Rocks Beach in Kennebunkport, Maine. I was limited in the number of shells I could present the crab due to the measurements of the original crab shell. Because only three shells of different weights were presented to the crab it could be said that the crab did not like one of the shells and therefore would not inhabit it. This was not a variable that I could account for while runnning the experiment.

A follow up experiment could be examining the same weighted shell preference while in a flow tank. This would better address the adaptations of *P. longicarpus* in the changing marine environment. This would also be a good experiment to collaborate with a barnacle flow experiment.

It was very difficult working with live animals. The flame extraction method was probably not the most humane method to use. It was also not the quickest. Many of the crabs flat out refused to leave their residence. Unfortunately, this resulted in one casualty. RIP crab 1

.VII. Appendix

Table 2. Original Crab Shell Measurements

Crab	Length (cm)	Width (cm)
1	4.00	2.83
2	3.35	3.05
3	2.98	2.00
4	3.31	2.59
5	3.39	2.58
6	3.77	3.10
7	2.95	2.30

Table 3. Loose Shell Measurements

Shell	Length (cm)	Width (cm)	Weight (g)
1	3.90	3.08	4.8
2	3.40	2.94	3.0

3	3.56	2.85	2.7
4	2.80	2.46	0.7
5	2.69	2.57	0.7
6	2.92	2.51	1.4
7	3.30	2.88	2.2
8	3.28	2.81	1.8
9	3.12	2.68	1.5
10	3.32	2.38	2.7
11	3.50	2.82	2.5
12	3.04	2.68	1.8
13	3.00	2.61	1.4
14	3.46	2.79	3.7
15	3.31	2.76	1.8
16	3.85	2.87	4.6
17	3.30	2.77	2.0

Table 4. Pre and Post-weights of Shells

Shell	Pre-weight (g)	Post-weight (g)	Weight Increase (g)
2	3.0	3.2	0.2
11	2.5	5.5	3.0
14	3.7	7.9	4.2
1	4.8	5.1	0.3
3	2.7	7.0	4.3
16	4.6	10.6	6.0
6	1.4	3.1	1.7
9	1.5	5.2	3.7
12	1.8	2.1	0.3

VI. Bibliography

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Credits

long-clawed hermit crab

long claw on sea lettuce

Thank you Adam H. Villa for helping me construct my webpage. Your constant availability and expertise was greatly appreciated.

Lisa's Links

Woods Hole Boat Trip

Ocean Conservancy

[Greenpeace]