Defense responses of *Diadora aspera* to predatory asteroids: an observational study

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Introduction

The keyhole limpet *Diadora aspera* is generally found low in rocky intertidal habitats and sub-tidally. Here desiccation is not a large threat, however many more predatory sea stars exist in this type of a habitat. *D. aspera* is not a true limpet as the top of its shell has an opening for a siphon and respiration. While traveling, part of its mantle will often be showing around the bottom edge.

As seen with many intertidal invertebrates like the sea cucumber, *Parastichopus califonicus* and the heart cockle, *Clinocardium nuttallii*, a fixed or wired response is shown when an individual of *D. aspera* is exposed to a predator. Typically *D. aspera* does not respond by out running their attacker, but shows a well-developed defensive behavior of extending their mantle. Robert Morris describes this response, "The mantle flap, ordinarily underlying the edge of the shell, is divided at its margin into a series of low ridges or folds. Two of these folds become greatly extended; one extends downward, covering the side of the foot, and the other extends up to cover the outside of the shell" (1980). Limpets in general have been shown to have a variety of escape responses including mushrooming, backing up and making swift turns.

The Pacific Northwest is host to a variety of asteroid predators many of which feed in the same habitat that *D. aspera* resides in. Four accessible species found locally in the intertidal are *Evasterias troschelii*, *Leptasterias hexactis, Pisaster ochraceus*, and *Pycnopodia helianthoides*. These asteroids were noted by Mauzey et. al. in 1968 to have varying diets including many limpet species. This led me to consider if there is any difference in the defensive response of *D. aspera* depending on which asteroid it is exposed to or is it simply a fixed response for all potential predators. By observing *D. aspera* in the absence and presence of a sea star predator, I predicted there would be a variety of defensive responses used against the four asteroid predators.

Materials and Methods

To conduct this exploratory, I collected nine individuals of *Diadora aspera* from the rocky intertidal habitat of Fossil Point in Charleston, Oregon. I collected *Pisaster ochraceus*, *Leptasterias hexactis* and *Pycnopodia helianthoides* from Cape Arago. *Evasterias troschelii* was used as the fourth predator in this experiment. All individuals were given a few days to

settle into the tank environment and the asteroids were kept solitary to keep them from prey species and subsequent feeding. I identified the nine *D. aspera* with nail polish so that accurate observations could be made later on.

For the individual trials I used three randomly selected limpets from the group of 9 for the four separate trials. I placed the three limpets on top of a large transparent grid marked in centimeters for them to settle into the environment for at least 20 minutes. I observed the limpets' behaviors without an asteroid species present including recording speeds in cm/s using a stopwatch. I then introduced one of the asteroids to the water table. I let the sea star cruise the tank to find the *D. aspera* in each case. If contact was made I recorded and observed the individual behaviors of each limpet. If the sea star did not make contact on its own I would induce contact by simply moving the sea star near the limpet to see if a response would occur. I looked for mantle response/extension, speed change, direction change and lifting of the shell (figure 1). A defensive response included any of the previously mentioned behaviors. If the individual of *D. aspera* did not change their previous behavior it was considered to have no response.

Results

From the trials conducted it is clear that behavioral defense responses were shown in 100% of the individuals and 100% of the time. Through the four trials I observed four distinct responses to the asteroid species. Table 1 and Table 2 both summarize the different responses displayed in each of the trials. Table 1 includes any response displayed as well as recorded speed increases, which were only seen 25% of the time in response to the predators. The mantle extension of *D. aspera* was seen in all cases except for one instance where only a slight speed increase was shown.

Discussion

It was clear that various defensive behaviors were present in *D. aspera*, however the observations show inconclusive results for specific behaviors to specific asteroid species. The results did not support my hypothesis predicting differing behaviors for different asteroid species. I tested a relatively small number of *D. aspera* with only one trial per asteroid

species; a larger number of individuals and trials would show clearer results in this experiment.

Extension of both the mantle and siphon (figure 1) was preferred by 91.6% of the individuals observed. During the trials several of the limpets were being pursued by the asteroid species once tube feet made contact with *D. aspera*'s mantle, the mantle extended immediately, but did not extend until touched. I observed *Pisaster ochraceus*, *Leptasterias hexactis*, and *Evasterias troschelii* attempt to grab hold of the keyhole limpets. In all cases the tube feet failed to grab the slimy mantle that covered the edge of the shell as well as provided protection around the bottom edge of the shell and through the siphon opening. The act of extending the mantle covers all edges and openings of the shell protecting *D. aspera* from the asteroid.

A study done by Bullock in 1953 described the response of several limpet species to asteroid tube feet. He too found no defensive responses until the first contact of tube feet with the mantle. He also found that "much of the most effective parts of the starfish are the tube feet... a response which was almost as vigorous as that to a whole starfish was obtained by placing a single tube foot torn from a starfish, in contact with the shell margin." This leads me to believe the size of the asteroid touching the mantle does not have an effect on whether or not a defensive response occurs; the physical touch of the tube feet are what induce the responses. In addition, *Leptasterias hexactis*, a small mid intertidal species of asteroid was noted by Bullock to induce vigorous responses out of larger limpets as their stomach can expand outward and digest the limpet individual.

The three other defense response styles I observed during this experiment were almost always used in conjunction with mantle extension. Only 25% of the *D. aspera* individuals increased their speed. Even then it was often too slow for the Asteroid species, as tube feet would touch them repeatedly after changing their speed. Turning the direction of their shell happened only two times and it was also done with lifting of the shell, which occurred 33% of the time. This behavior was done in the presence of all the asteroid species except *L. hexactis*, which cruised over the top of all three *D. aspera* in trial 4. Here it is not clear why they were doing this response, as there were no similar behaviors of the three asteroids. In the three cases the shell was always lifted on the side the tube feet were present. It did expose more

mantle to the asteroid, but was very different from mushrooming behavior seen in some true limpet species.

To further investigate the behavior of *D. aspera* in the presence of asteroid predators it would be useful to perform more trials with more individuals of both the keyhole limpets and also more individuals of asteroid species. Since I was handling all individuals often to either mark them for identification or to place in the water table for the trials there is some concern that some could have become desensitized or my trials could've shown false results. The *D. aspera* species were also contained in a smaller container for over a week with out food species. This could have had an effect on the levels of energy to show various escape responses to the asteroid species.

I would like to investigate further on what causes the mantle extension and other escape responses. In the next experiment the use of Henricia leviuscula, the blood star, which is not a predator of gastropods, and possibly the use of other invertebrates like crabs may show differing responses or further support the notion that the mantle response is wired.

References

Bullock, Theodore Holmes. "Predator Recognition and Escape Responses of Some Intertidal Gastropods in Presence of Starfish." Behaviour 5 (1953): 130-140.

Mauzey, Karl P., B. Charles, P.K. Dayton. "Feeding Behavior of Asteroids and Escape Responses of their Prey in the Puget Sound Region." Ecology 49 (1968): 603-619.

Morris, Robert H., Donald P. Abbott, and Eugene C. Haderlie. Intertidal Invertebrates of California. Stanford, CA: Stanford University Press, 1980.

Table 1. Types of behavioral responses shown after contact with predatory asteroids: *Evasterias troschelii, Pycnopodia helianthoides, Pisaster ochraceus* and *Leptasterias hexactis.*

Trials		Behavioral Responses: Limpet 1	Limpet 2	Limpet 3	# Responded
Evasterias	Before	Speed = 0.029cm/s	Speed = .073cm/s	Speed = 0.029cm/s	100%
	After	Mantle extension, turned away, shell lifted	Mantle extension	Mantle extension, speed increase = 0.051	
Pycnopodia	Before	No movement	No movement	No movement	100%
	After	Mantle extension	Speed increase = 0.011cm/s	Mantle response, speed increased = 0.067cm/s, shell lifted	
Pisaster	Before	Speed = 0.063cm/s	Speed = 0.017cm/s	No movement	100%
	After	Mantle extension, turned away, lifted shell	Mantle extension	Mantle extension, shell lifted	
Leptasterias	Before	Speed = 0.021cm/s	No movement	No movement	100%
	After	Mantle extension	Mantle extension	Mantle extension	

Table 2. The types of behaviors shown in response to predatory asteroids and the percent of individuals that displayed them.

Behavioral responses	Mantle extension	Increased speed	Turned away	Lifted shell
% Displayed	91.60%	25%	16.60%	33.30%

Figure 1. A view of the extended mantle (A) and a view of Diadora aspera lifting its shell to expose its mantle in the presence of an asteroid predator (B).