Prey Response to Intertidal Predator *Pycnopodia helianthoides*
by: Khoury Hickman

Almost every animal in the world has a natural predator, and therefore also has a way to defend itself from that predator. *Strongylocentrotus purpuratus* and *Tectura scutum* are no different. The predator *Pycnopodia helianthoides* is an opportunistic carnivore that lives in the low to mid intertidal zone. *Pycnopodia* is known to feed upon both of these species in the wild, and therefore will be able to induce the escape response from the two prey species while in the laboratory setting.

When in the company of a predator, both the limpet (*Tectura scutum*) and the sea urchin (*Strongylocentrotus purpuratus*) respond by moving away from the sea star (*Pycnopodia helianthoides*). To escape predation, the limpet moves rapidly up a vertical surface (Phillips, 1975). The sea urchin moves in a direction that takes it away from the sea star, and it also employs use of pedicellariae which are mouth-like organs that it can project from its test and use as a chomping defense against the sea stars tube feet. This pedicellariae response was demonstrated by D. W. Phillips in 1978.

I will be observing exactly what *Tectura scutum* and *Strongylocentrotus purpuratus* do to escape predation. I will also investigate whether or not *S. purpuratus* are able to communicate the presence of a predator to their neighbor. I am most interested in finding the distance between predator and prey required to initiate a response, and then what that response is. My hypothesis says that direct contact is required to initiate the response in both prey species being tested.

Methods:

I obtained five urchins from the South Cove of Cape Arago, and I used four limpets that were collected from an unknown area. The *Pycnopodia* used was one that inhabits one of the water tanks at OIMB. I also used a sheet of plexi-glass that had a grid consisting of one centimeter squares already drawn on it from an experiment preformed by a classmate.

I would first measure the diameter of the urchin being tested, and then I would place it on the plexi-glass and observe its movement for about a minute. Next, I would place the sea star at least 10 cm away from the urchin, and observe what happened. I watched for pedicellariae action on the urchin and recorded the distance between the two animals when the first pedicellariae were present. I allowed the experiment to continue until either the sea urchin escaped or the sea star gave up chase or changed direction. I would then remove both animals, and repeat the test using a new sea urchin. I did virtually the same method for testing the limpets, except I didn't measure their size because they were all relatively equal in size. I stopped the limpet tests once the sea star overpowered the limpet.

To do the group communication test, I placed all five urchins into one container with fresh seawater, and introduced the sea star. I waited until one urchin showed its pedicellariae and then observed the others to see if they responded in the same fashion. I stopped the test once the sea star would change direction. To do repeat tests, I would change the water in the tank in order to minimize the amount of residual chemical from the sea star. I also used tube feet to try to lower the amount of chemicals from the sea star in hopes that it would cause the same reaction in the urchins.

<u>RESULTS</u>:

I found the average distance required for the urchins to show their pedicellariae was 4.4 centimeters. For the group test, I didn't find any visible communication involving the use of pedicellariae. In the limpet tests, I found the distance required to initiate a response was between one and two centimeters, and they would respond by drastically increasing their speed of locomotion from 1 cm / 137 seconds to 1 cm / 7.2 seconds.

DISCUSSION:

The distance required ranged from 3 cm in the small urchins up to 7 cm in the larger urchins. This makes sense to me because the larger urchin most likely has more sensitive chemoreceptors, or a greater number of them. I expected their response to be the display of pedicellariae and to move away from the *Pycnopodia*, and found that is in fact what they do. For the group test, I expected the urchins to use some type of chemical communication to inform neighbors that there was a predator nearby, and found that this wasn't the case. There seemed to be no communication about predators between any of the sea urchins. While using the entire sea star to initiate a response, I found there was some universal response of the animals, but when I modified the test and used just the tube feet, I found that only the urchin touched with the tube foot responded by displaying the pedicellariae. I believe this is because they aren't all directly related animals, so it would be better for your neighbor to get eaten than to get consumed yourself.

For the limpets, I found the distance required for response to be between 1 and 2 centimeters, and they would respond by increasing their speed greatly. Two of the limpets tested showed no movement without the presence of the predator, and the other two showed very little movement in the absence of a predator. Once *Pycnopodia* was added, all of the limpets began to move rapidly. The fastest moved at a rate of 1 cm/3.9 sec, and the slowest moved at a rate of 1 cm/8.2 sec. I believe the reason the limpets don't normally travel at this rate is due to energy efficiency. During times where there isn't a predator present, the animal is grazing on algae that don't move, so it doesn't require a quick locomotion rate in order to catch its meal. Once the predator is introduced, the animal is going to speed up because it needs to avoid being eaten. This speed increase is going to consumer a lot of energy and therefore the animal is unable to keep it up for long periods. Due to that, it is likely that the limpet only employs its speed bursts in order to avoid death, and as a final attempt to escape predation.

My experiment had a few flaws in it. I feel that I should have used multiple *Pycnopodia* to get better results. The first test for each animal went well, but by the last one, the sea star seemed uninterested in the prey. It would move towards it, but then it would turn around before it ever reached the prey animal. A second way to improve this experiment would be more tests. Had there been multiple predators, it would have been easier to perform more tests on each animal group, because fatigue wouldn't be a factor. Also, a separate tank for each test would be helpful because it would eliminate any residual chemicals left behind by the sea star.

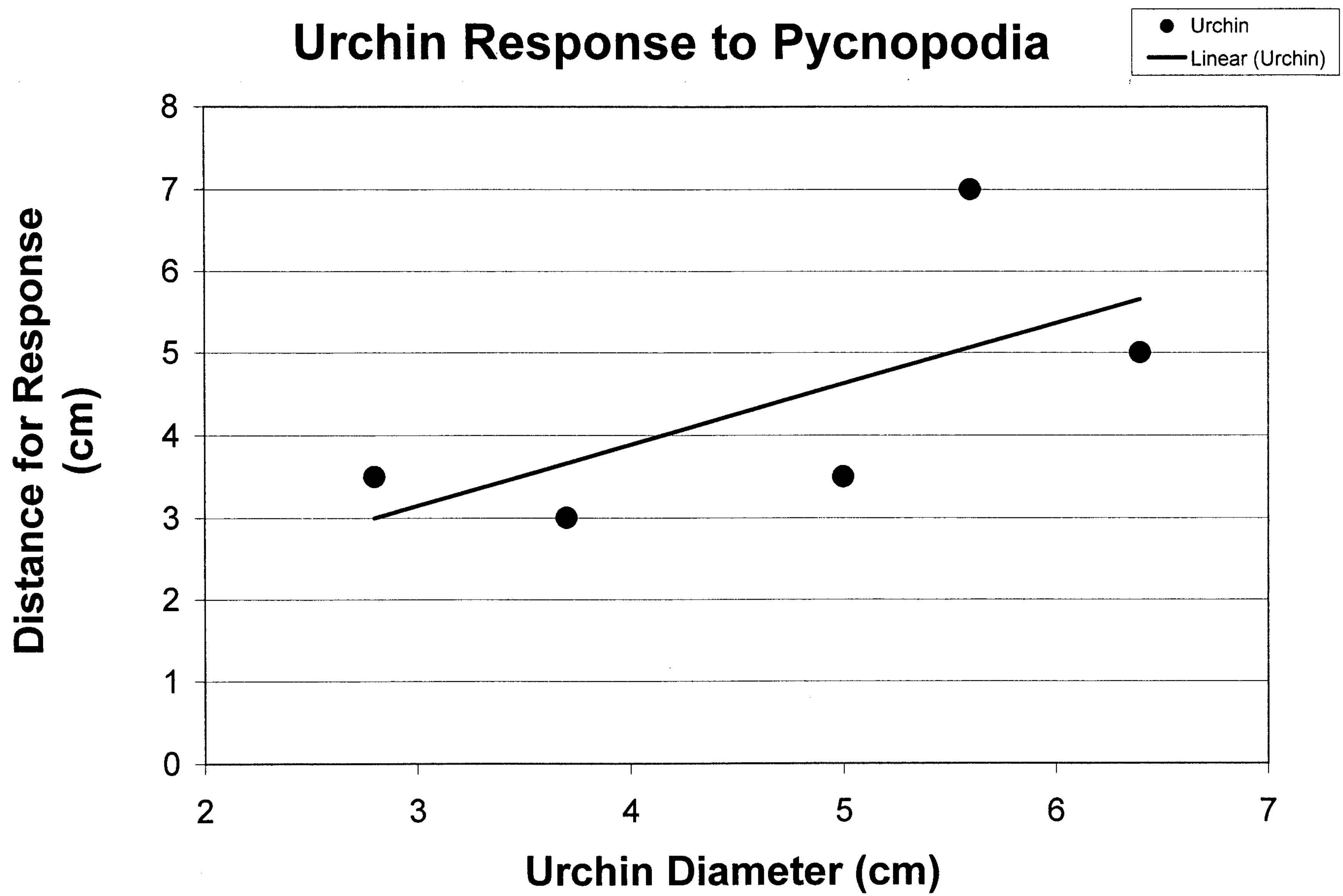
For future experiments, I would like to look at the escape response between *Strongylocentrotus purpuratus* and *Strongylocentrotus franciscanus*. The two sea urchins respond to the presence of a predator in different ways, and I would be interested to find out how the responses affect survival rates. *S. franciscanus* responds by using its long spines as weapons which pinch the attacking sea star, and *S. purpuratus* uses the pedicellariae to defend itself, which is less effective than the former method (Moitoza 1979).

WORKS CITED:

1) Moitoza, D.J.. "Prey defense, predator preference, and nonrandom diet: The interactions between *Pycnopodia helianthoides* and two species of sea urchins." Marine Biology 53.4(1979): 299-304.

2) Phillips, D.W.. "The effect of a species-specific avoidance response to predatory starfish on the intertidal distribution of two gastropods." Oecologia 23.2(1976): 83-94.

3) Phillips, D.W.. "Chemical mediation of invertebrate defensive behaviors and the ability to distinguish between foraging and inactive predators." Marine Biology 49.3(1978): 237-243.



Urchin Response to Pycnopodia
Urchin
Linear (Urchin)
Distance for Response (cm)
0
1
2
3
4
5
6
7
8
2
3
4
5
6
7
Urchin Diameter (cm)