Laurie Goodman

Adaptations of Marine Organisms

7/31/05

Secondary alarm cues of *Strongylocentrotus purpuratus*

Introduction

Marine organisms have a wide variety of mechanisms used for defense. These mechanisms can range from being chemical in nature to behavioral. Each mechanism has been fine tuned to respond to signals indicating that a particular predator is in the vicinity. This has happened through an evolutionary pathway, which has favored the ability of prey to respond to physical and chemical cues of the predator (Parker, *et al.* 1986).

Several species of sea urchins have been found to respond to chemical signals released from their predators. Once the urchin has sensed the predator it may respond in a number of ways; they can lower their spins and then stick their pedicellariae up, bring their tube feet in, and move away to seek shelter. This primary cue can facilitate a secondary chemical cue that is released by the urchin. The secondary cue has been found to act as a warning signal for urchins in the surrounding area. Urchins that receive the secondary cue have been found to respond by exhibiting escape and defensive behaviors in past studies.

Studies by D.A. Parker and M.J. Shulman found that five out of seven species of sea urchins in the Caribbean, demonstrated an alarm response to the secondary chemical cue of conspecific and heterospecific species (1986). It has also been found that juvenile red sea urchins, *Strongylocentrotus franciscanus* exhibit an alarm response to a secondary cue released by adult *S. franciscanus* (Nishizaki, 2005). Due to this knowledge

I hypothesize that the purple sea urchin, *Strongylocentrotus purpuratus,* will first show alarm signals in the presence of a predator and will then produce a secondary chemical cue that will facilitate an alarm response in surrounding *S. purpuratus.* It is also believed that with increasing distance of the surrounding urchins to the primary sea urchin, response time should increase.

Methods

Ten *S. purpuratus* and one small *Pycnopodia helianthoides* were collected and kept in separate salt water holding tanks until the experiments were run. Water velocity of the saltwater table was first tested by adding ten drops of Fluorocein. The time it took the dye to travel 150cm was measured to get an accurate water velocity. This was done each time experiments were run to make sure the water velocity was unchanged. To make sure the water flow would stay consistent the tube bringing fresh saltwater to the tank was taped to the side of the tank and the valve was kept at a consistent water flow.

After the water velocity was established *P. helianthoides* was placed in a container with seawater and a sea urchin, we will call this the primary sea urchin, was then placed in the container with *P. helianthoides.* The primary urchin was kept in the water for two minutes so that it would have time to display alarm responses of lowering the spins and sticking the pedicellariae up. The primary urchin was then placed in the salt water table near the water flow to disperse any secondary chemical cues it may release to the four test urchins that were placed in a parallel line down stream 0.25m away from the primary urchin. Once the primary urchin was placed in the tank the amount of time for the four test urchins to show an alarm response was recorded. An alarm response was counted as lowering of the spins, showing pedicellariae, and moving down stream, or a combination of the three. Results were recorded for up to five minutes and six trials were run for three different lengths; 0.25m, 0.50m, and 1.00m. Between trials both the primary and test urchins were allowed to rest for ten to twenty minutes or until the pedicellariae were retracted. It should also be noted that a new primary sea urchin was used after every two trials so that the urchins would not get stressed and to insure that adequate levels of the secondary chemical cue was being released.

Results

The average time for *S. purpuratus* to respond was found at each of the three lengths, 0.25m, 0.50m, and 1.00m. The average time at 0.25m was 49 seconds, at 0.50m the average time was 91 seconds, and at 1.00m the average time was 165 seconds. See figures 1, 2, and 3 for the number of urchins to respond and the time of response at each trial.

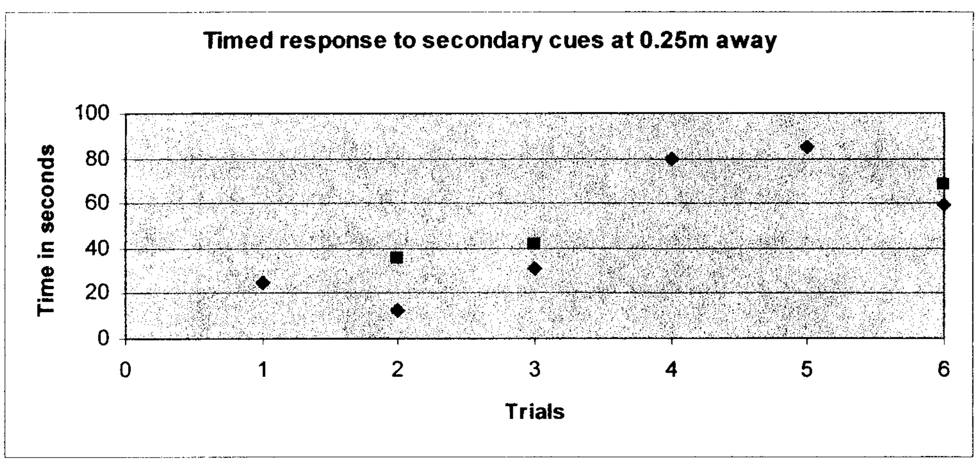

Figure 1

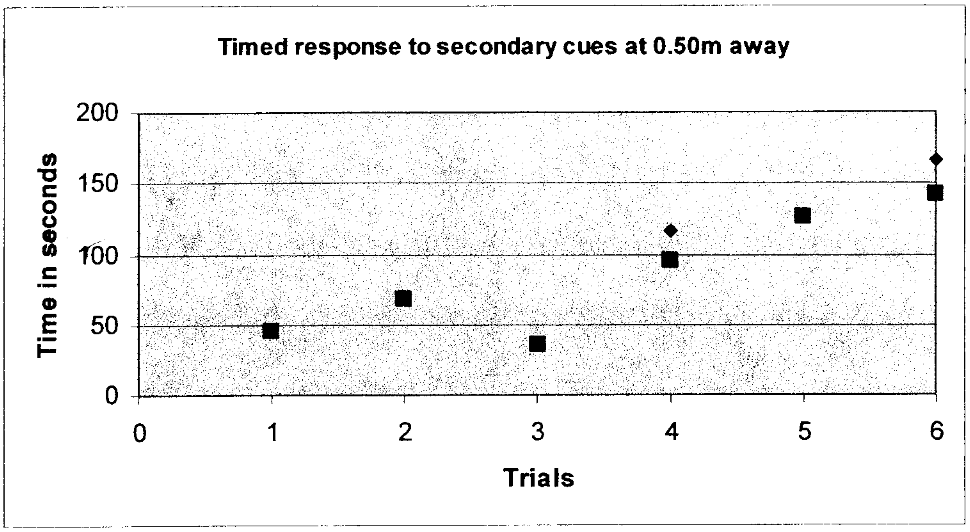

Figure 2

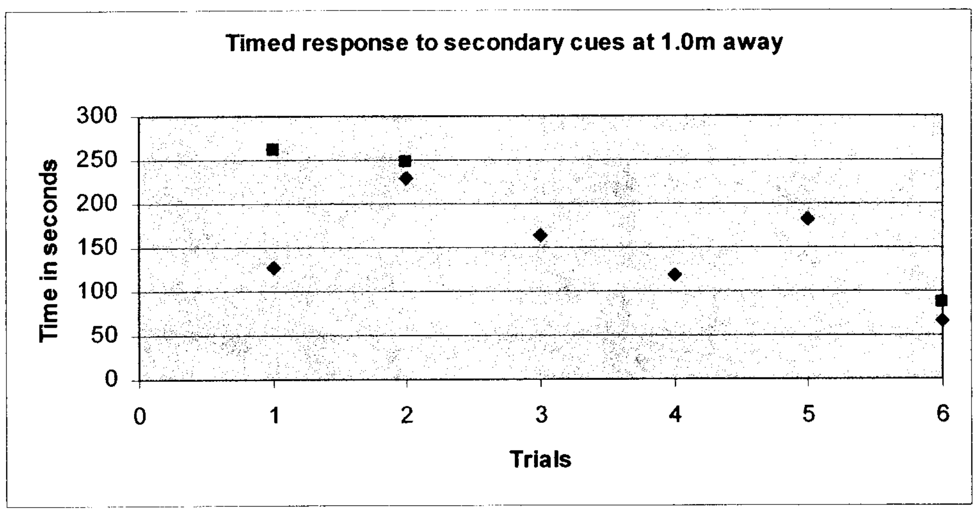

Figure3

Discussion

Based on the data collected both hypotheses are supported. When the primary urchin was placed in the holding container with *P. helianthoides* the urchin exhibited escape responses of lowering the spins, extending the pedicellariae, and attempting to move away. Once placed in the saltwater table with the test urchins the primary urchin continued to exhibit the alarm responses for up to 45 minutes. Observations were made that the test urchins no longer responded to the primary urchin after the primary urchin had been used for three or more trials. To make sure the primary urchin was not exposed to too much stress and did not use all its possible secondary chemical cues it was replace with a new primary urchin after two trials and was allowed to rest for one day. This could be a source of error since the same urchin was not used for every trial.

The results show that *S. purpuratus* does produce secondary chemical cues that can act as a warning that a predator is in the area for surrounding sea urchins. The test sea urchins showed an alarm response at each of the three test lengths although the time of response and number of urchins that responded were not consistent. The highest amount of sea urchins to respond at a given trial was two. It is unknown why only two and at times one sea urchin responded to the primary urchins chemical cues, but one reason could be due to inconsistent water flow throughout the tank. The urchins that did respond at each trial were observed to extend their pedicellariae and move downstream from the primary urchin. The responses of the test urchins correlate to a past study where *Strongylocentrotus droebachiensis* was found to reverse the direction of movement when exposed to extract of a crushed conspecific (Hagen, 2001). It should also be noted that the average time it took the urchins to respond increased as the length increased between the primary sea urchin and the four test urchins. Further studies should be done to see if *S. purpuratus* can detect secondary alarm cues from the red sea urchin *S. franciscanus,* which can be found living in close proximity to *S. purpuratus.*

References

Hagen, N.T., Andersen, A., and Stabell, O.B. 2001. *Alarm responses of the green sea Urchin, Strongylocentrotus droebachiensis, induced by chemically labeled durophagous predators and simulated acts of predation.* Marine Biology. 140: 365-374.

Parker, D.A., and Shulman, M.J. 1986. *Avoiding predation: alarm responses of Caribbean sea urchins to simulated predation on conspecific and heterospecifics sea urchins.* Marine Biology. 93: 201-208

Nishizaki, MT, and Ackerman, JD. 2005. *A secondary chemical cue facilitates juvenile-adult postsettlement associations in red sea urchins.* Limnology and Oceanography. 50: 354-362

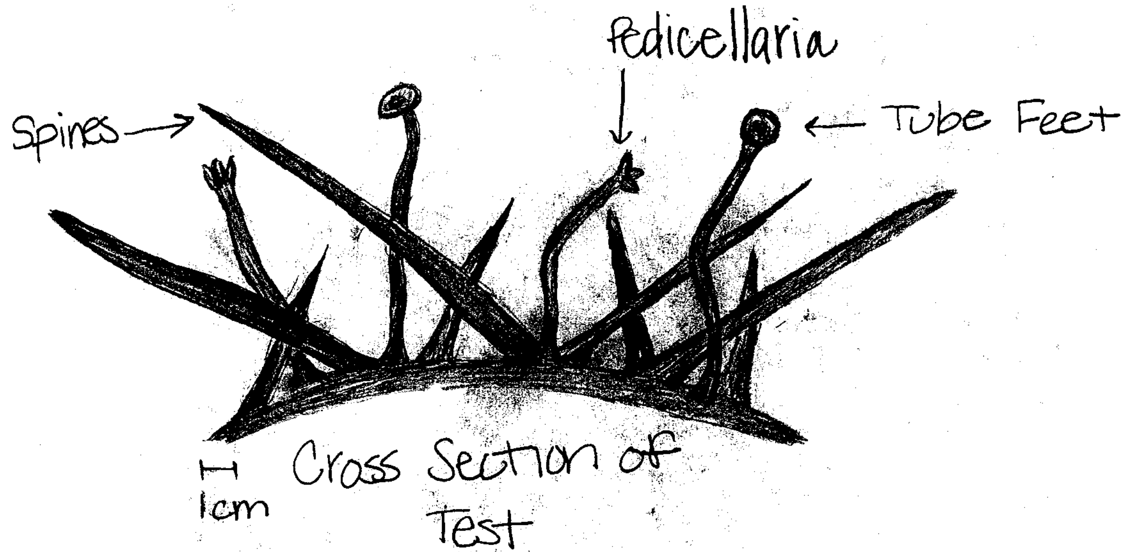

Figure 5