Burrowing Activity of *Amphiodia occidentalis* in Response to Touch

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Introduction

The brittle star *Amphiodia occidentalis* has a few color morphs, either mustard yellow or light purple. The disc may reach 11mm in diameter. The arms are considerably long, and can reach 9-15 times the length of the disc diameter (Morris 1980). *Amphiodia occidentalis* is located generally in sediment or under rocks in the mid-intertidal zone, to depths of 360 meters (Lamb 2005). After *Amphiodia occidentalis* buries itself, its arms are extended above the substrate so the animal may filter feed (Emlet 2006). According to Lamb, escape response in ophiuroids may be stimulated by touch receptors (2005). This information led to the question of whether or not burrowing as an escape response was stimulated by the touch of any animal or by the touch of a predator. The hypothesis that arose for this experiment was that brittle stars would burrow faster no matter what kind of animal touched them. In order to test this hypothesis, I used two different carnivores, *Leptasterias hexacti* and *Pycnopodia helianthoide*. An *Idotea wosnesenskii* was also used because it is not a carnivore.

Question: whether burrowing could be stimulated by the touch of another animal.

Materials and Methods

All 10 brittle stars (*Amphiodia occidentalis*) used in this experiment were gathered from North Cove, Cape Arago in Oregon. The fine sediment used in this experiment was that in which brittle stars were found. Overall, there were 30 trials: five stars tested in the absence and presence of *Leptasterias hexacti, Pycnopodia helianthoide*, or *Idotea wosnesenskii*; 15 trials were run during the middle of two sunny days and 15 trials were run just before sunset another day. In order to test for a control, each star was first tested by being placed in a bowl with just

sediment. The timer was started when the brittle star began to pick up the sediment with its tube arms, then stopped when the disc was completely covered. For the manipulated trials, the star was extracted from the sediment and replaced in the same bowl. Either *Leptasterias hexacti, Pycnopodia helianthoide, Idotea wosnesenskii* was then added to bowl and placed in contact with at least one of the brittle star's arms. The same *Leptasterias, Pycnopodia,* and *Idotea* were used for both the mid-day and sunset trials. All time measurements were in the form minute:second.

Results

The diameter of the disc of each brittle star was measured from one arm socket to the opposite side (see Figure 1).

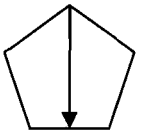

Figure 1. Diagram of disc diameter, using a pentagon as a model.

The burrowing time of each brittle star in the absence and presence of either a carnivore or an herbivore was recorded (see appendix) from which the mean values were calculated (Table 1, Table 2). The time difference column reflects the difference calculated when the control time was subtracted from the manipulated time. In the mid-day trials, the mean disc size of the brittle stars used in the *Leptasterias* trials was 8mm; the mean burrowing time of the stars by themselves was 1:21 (min:sec), and the mean burrowing time after the addition of a *Leptasterias* was 1:11; the mean difference between the presence and absence of *Leptasterias* was -0:12. For the set of trials involving *Pynopodia*, the mean disc diameter of the

five stars used was 7mm, the mean lone burrowing time was 1:14, the mean burrowing time after the addition of a *Pycnopodia* was 0:52, and the mean difference was -0:22. In the trials involving the addition of an *Idotea*, the mean disc diameter of the stars used was 7mm, the mean lone burrowing time was 1:21, the mean burrowing time after an *Idotea* was added was 0:57, and the mean difference between presence and absence of the *Idotea* was -0:24.

Table 1: Mean Values for Each Condition During Mid-Day

	Disc Diameter (mm)	Burrowing Time, Lone Star (min:sec)	Burrowing Time, Carnivore or Herbivore Added (min:sec)	Time Difference (min:sec)
Carnivore: *Leptasterias*	8	1:21	1:11	-0:12
Carnivore: *Pycnopodia*	7	1:14	0:52	-0:22
Herbivore: *Idotea*	7	1:21	0:57	-0:24

For the Sunset trials, the mean disc size of the brittle stars used in the *Leptasterias* trials was 8mm; the mean burrowing time of the stars by themselves was 1:28, and the mean burrowing time after the addition of a *Leptasterias* was 1:18; the mean difference between the presence and absence of *Leptasterias* was -0:02. For the set of trials involving *Pynopodia*, the mean disc diameter of the five stars used was 7mm, the mean lone burrowing time was 1:04, the mean burrowing time after the addition of a *Pycnopodia* was 1:02, and the mean difference was -0:03. In the trials involving the addition of an *Idotea*, the mean disc diameter of the stars used was 8mm, the mean lone burrowing time was 1:06, the mean burrowing time after an *Idotea* was added was 1:02, and the mean difference between presence and absence of the *Idotea* was -0:05.

Table 2: Mean Values for Each Condition Just Before Sunset

	Disc Diameter (mm)	Burrowing Time, Lone Star (min:sec)	Burrowing Time, Carnivore or Herbivore Added (min:sec)	Time Difference (min:sec)
Carnivore: *Leptasterias*	8	1:28	1:18	-0:02
Carnivore: *Pycnopodia*	7	1:04	1:02	-0:03
Herbivore: *Idotea*	8	1:06	1:02	-0:05

After conducting a few trials, it was observed that not all stars burrow in the same manner. Some stars spread their arms out almost immediately after touching the substrate. The tube feet could be observed moving particles over the legs. Soon after, the disc proceeded to twist back and forth, shoveling sediment out of the way as it descended. Another method of burrowing was not as stationary as the first. The star would slowly pull itself along and dip its disc down so that it moved into the sediment as it moved forward. When *Leptasterias* and *Idotea* were introduced into the bowl, most of the brittle stars reacted by coiling their arms away from the other animal. When the *Pycnopodia* was introduced, the brittle stars had an obvious reaction. Some of the brittle stars coiled the arms that were closest to it, while others attempted to flee by crawling across the substrate or pushing off the substrate and elevating themselves as they moved away.

Discussion

When comparing the mean time differences for each respective set of trials (mid-day and sunset), it is clear that the brittle stars reacted with very similar burrowing speeds, no matter which animal was added to the bowl. This information supports the hypothesis, which

was that brittle stars will burrow faster no matter what kind of animal touches it. Based on the results, it is important to notice that the brittle star responses times to the addition of the three test animals (*Leptasterias, Pycnopodia, Idotea*) were considerably greater during the mid-day trials than during the sunset trials. *Amphiodia occidentalis* are naturally found either buried or hidden in rock crevices (Fager 1968). This could explain why some of the burrowing times were fastest during the day when the sun was brightest versus just before the sun went down (raw data, appendix). Some color morphs may not have UV protection. The speed with which they burrow may have been greatly affected by the sun since there was no shading in the bowl. This is why the sunset trials were conducted; the stars may have been more comfortable with the fading daylight.

Many different factors (sources of error) could have had an effect on the burrowing rate of the stars used in this experiment. Some stars may have been comfortable in the sediment even when its disc wasn't completely covered (some were observed to move around in different directions under the sediment before being covered), so the timing may not necessarily reflect the true ending of the burrowing response. The rising water temperature when exposed to full sunlight and not necessarily the animal added may have caused the stars to burrow fastest. There may be a relationship between disc size and burrowing speed, since it was observed that some stars exceeding 9 mm did not appear to cover their discs at all. Sediment compactness and size could also slow burial; also, obstacles such as rocks or shells in the sediment could potentially block a brittle star when it was burrowing. Also, the stars were gathered weeks before they were used in this experiment. Food availability in the water tables could therefore have affected their metabolism, resulting in decreased energy and a slower

burrowing rate. The predators added might not have been effective if they weren't hungry during the trials. Some of the brittle stars may have burrowed differently after having gained some distance from the added animal. The brittle stars may also have lost sensitivity to disturbance after being moved around so much between trials.

For future research, it would be interesting to develop a method that would allow one to measure about how much sediment it takes for a star to cover itself. Also, it would be interesting to test burrowing speed or rate in different sediment types, maybe by comparing fine to coarse.

Appendix

Tables A-1, A-2, and A-3 list raw data for the mid-day trials involving the addition of either *Leptasterias hexactic, Pycnopodia helianthoides,* or *Idotea wosnesenkii.*

Table A-1: Mid-Day, Carnivore Added: *Leptasterias hexactis*

Star Number	Disk Diameter (mm)	Burrowing Time: No Predator	Burrowing Time: *Leptasterias* added	Time Difference
1	8	1:16	1:32	+0:16
2	6	1:21	0:46	-0:75
3	8	1:28	1:18	-0:10
4	9	1:32	1:21	-0:11
5	9	1:18	1:00	-0:18

Table A-2: Mid-Day, Carnivore Added: *Pycnopodia helianthoides*

Star Number	Disk Diameter (mm)	Burrowing Time: No Predator	Burrowing Time: *Pycnopodia* added	Time Difference
1	6	0:47	0:17	-0:30
2	6	1:20	0:26	-0:54
3	8	1:02	0:52	-0:50
4	7	1:19	1:16	-0:03
5	7	1:42	1:31	-0:11

Table A-3: Mid-Day, Herbivore Added: *Idotea wosnesenkii*

Star Number	Disk Diameter (mm)	Burrowing Time: No Predator	Burrowing Time: *Idotea* added	Time Difference
1	8	1:58	0:58	-1:00
2	8	1:52	1:28	-0:24
3	7	0:35	0:31	-0:04
4	7	0:48	0:40	-0:08
5	5	1:30	1:07	-0:23

Tables A-4, A-5, and A-6 list raw data for the sunset trials involving the addition of either *Leptasterias hexactic, Pycnopodia helianthoides,* or *Idotea wosnesenkii.*

Table A-4: Sunset, Carnivore Added: *Leptasterias hexactis*

Star Number	Disk Diameter (mm)	Burrowing Time: No Predator	Burrowing Time: *Leptasterias* added	Time Difference
1	8	2:02	2:15	+0:13
2	9	1:05	0:53	-0:52
3	8	1:49	1:43	-0:06
4	7	0:59	0:53	-0:06
5	8	1:25	0:46	-0:39

Table A-5: Sunset, Carnivore, *Pycnopodia helianthoides*

Star Number	Disk Diameter (mm)	Burrowing Time: No Predator	Burrowing Time: *Pycnopodia* added	Time Difference
1	6	0:44	0:43	-0:01
2	7	0:48	0:55	+0:07
3	8	0:48	0:43	-0:05
4	8	1:11	1:09	-0:02
5	8	1:47	1:31	-0:16

Table A-6: Sunset, Herbivore, *Idotea wosnesenkii*

Star Number	Disk Diameter (mm)	Burrowing Time: No Predator	Burrowing Time: *Idotea* added	Time Difference
1	8	1:37	1:22	-0:15
2	8	0:51	0:37	-0:14
3	8	0:50	0:55	+0:05
4	8	1:05	0:50	-0:15
5	9	1:09	1:25	+0.16

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