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Marine Adaptations

Inducible Defenses in the California Mussel, *Mytilus californianus* in Response to the sea star, *Pisaster ochraceus*

Introduction

Organisms subject to predation have adapted inducible defenses that help their chances of survival in situations involving strong predation pressures. These responses are phenotypically plastic traits that increase resistance to predators (Harvell, 1990.) When mussels are exposed to chemical cues of predators (i.e sea stars), they are known to increase the strength of byssal attachment (Leonard et al. 1999.)

Mytilus californianus, also known as the California Mussel, has a thin bluish-black periostracum over their shells. They can get up to 25cm long and are found on exposed rocky shores in the low to mid-intertidal zone, to depths of 100m. Their habitat ranges from Alaska all the way to Mexico. Their predators include sea stars, predaceous snails, crabs, gulls, sea otters, and humans.

They are sessile organisms, attaching themselves to rocks with keratinous threads called byssal threads. Byssal threads are secreted as a liquid by the byssus gland located in the foot. The liquid then flows down a groove on the foot and sticks to the substrate where each thread becomes tightly fastened (Figure 5.) Byssus production is said to be a plastic response, and therefore should be able to be induced when the mussel is exposed to a predator (Cheung et al. 2004.)

I questioned if the mussel, *Mytilus californianus*, will produce more byssal threads when exposed to the sea star, *Pisaster ochraceous*, compared to when there is no predator present. Knowing that Byssal thread production is a plastic response, I hypothesized that the mussels will produce more byssal threads when exposed to *Pisaster ochraceous*.

Materials and Methods

I collected 4 individuals of the species *Mytilus* californianus, and 1 *Pisaster ochraceus* from Sunset Bay in Charleston, Oregon. Then, to begin my experiment, I had to create an apparatus where the sea star and mussels could be in the same space, but also, so the sea star was unable to come in contact with the mussels and feed on them. So I drilled 3 holes in each side of a 44cm x 35cm plastic tub. This allowed for constant water flow through the tub (Figure 4.) I then glued plastic mesh across the halfway mark of the tub to create a barrier between the mussels and the sea star (Figure 3.)

I used 4 glass dishes that were 6cm in diameter each to hold each of the 4 *M. californianus*. I let the mussels sit for 24 hours to let their byssal threads attach to the dish. I then performed 2 different experiments: one where I counted the number of byssal threads present on 4 *Mytilus californianus* each day when the mussels were in the presence of the sea star, *P. ochraceus*, (experimental 1-4) and one where the mussels were not in the presence of the sea star (control 1-4.)

I first put the 4 dishes with their respective mussels on the right side of the fence and left the right side empty. I recorded the initial number of byssal threads that were present and then proceeded to count the amount of byssal threads present at 24 hours, 48 hours, and 72 hours, and recorded my results. After 72 hours, I detached the mussels from the glass dishes, cleaned the glass dishes, and put the mussels back in them. I let the mussels sit for 24 hours again to reattach themselves to the dishes. I then put them back in the right side of the tub, but this time I added the *P. ochraceus* to the left side (Shown in Figure 3.) Again, I counted the initial number of byssal threads that were present, and then counted the amount of byssal threads present at 24 hours, 48 hours, and 72 hours and recorded my results. I also recorded where the sea star was located on the left side of the fence at every 24-hour mark.

When the whole experiment was done, I compiled my data into tables and graphs to better compare the difference in the number of byssal threads produced when the mussels were or were not in the presence of the sea star.

Results

At 24 hours, experimental 1 went from 4 byssal threads to 8 byssal threads, experimental 2 went from 0 to 10, experimental 3 went from 3 to 5, and experimental 4 went from 6 to 14 byssal threads. At 48 hours, experimental 1 went from 8 byssal threads to 10 byssal threads, experimental 2 went from 10 to 13, experimental 3 went from 5 to 9, and experimental 4 went from 14 to 18 byssal threads. At 72 hours, experimental 1 went from 10 byssal threads to 15 byssal threads, experimental 2 went from 13 to 17, experimental 3 went from 9 to 13, and experimental 4 went from 18 to 23 byssal threads (Figure 1.) The sea star remained in the same place for the entire three days, and that was attached to the sidewall next to mussels 1 and 3.

At 24 hours, control 1 went from 7 byssal threads to 14 byssal threads, control 2 went from 6 to 7, control 3 went from 3 to 8, and control 4 went from 8 to 11 byssal threads. At 48 hours, control 1 went from 14 byssal thread to 17 byssal threads, control 2 went from 7 to 13, control 3 went from 8 to 12, and control 4 went from 11 to 14 byssal threads. At 72 hours, control 1 went from 17 byssal threads to 19 byssal threads, control 2 went from 13 to 19, control 3 and 4 did not gain any byssal threads. The average number of byssal threads gained over 72 hours by the 4 experimental *M. californianus* was 11 byssal threads, and for the 4 controls it was 10 byssal threads (Figure 1.)

The average number of byssal threads gained when *P. ochraceous* was present at the 0 hour was 3.25, at 24 hours they gained an average of 6, at 48 hours they gained 3.25, and at 72 hours they gained an average of 4.5 byssal threads. The average number of byssal threads gained when *P. ochraceous* was not present at the 0 hour was 6, and then they continued to consistently produce an average of 4 byssal threads during the 24-hour, 48-hour, and 72-hour blocks (Figure 2.)

Number of Byssal Threads Present Daily in the Control and Experimental *Mytilus californianus*

Mytilus californianus #	0 hour	24 hour	48 hour	72 hour
Control 1	7	14	17	19
Experimental 1	4	8	10	15
Control 2	6	7	13	19
Experimental 2	0	10	13	17
Control 3	3	8	12	12
Experimental 3	3	5	9	13
Control 4	8	11	14	14
Experimental 4	6	14	18	23

Table 1: The number of byssal threads present at each 24-hour mark in the control mussels and the experimental mussels for 72 hours.

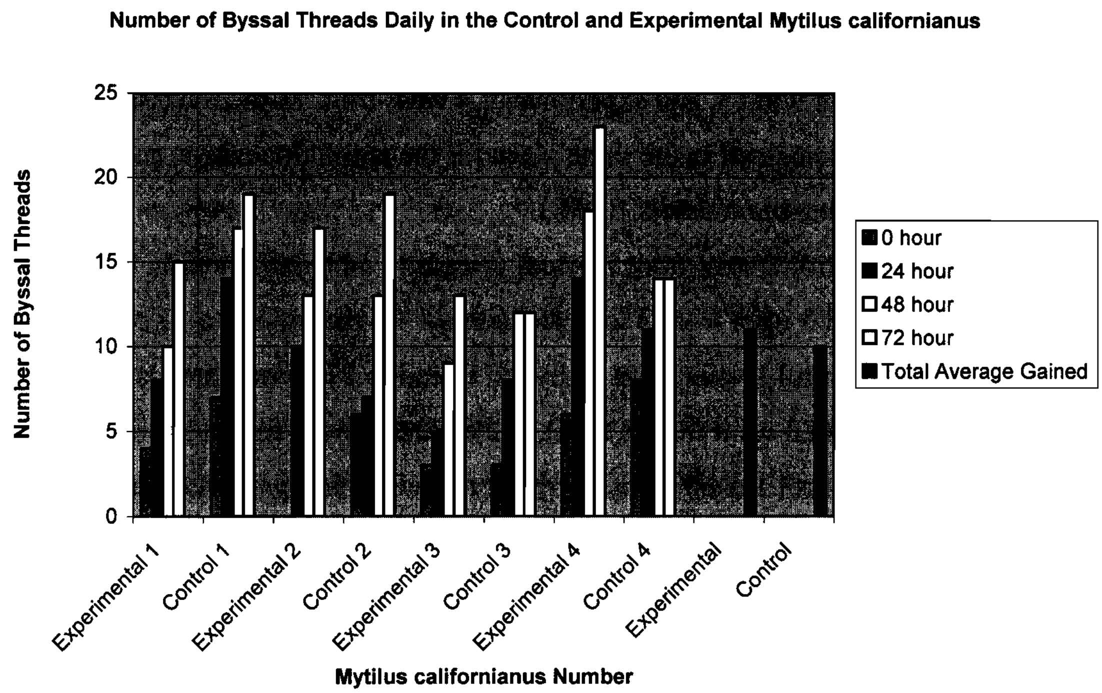

Figure 1: Shows the number of byssal threads that all 4 experimental and all 4 control *Mytilus californianus* had at each 24-hour mark for 72 hours. It also shows the average number of byssal threads gained throughout the 72 hours in the experimental and control.

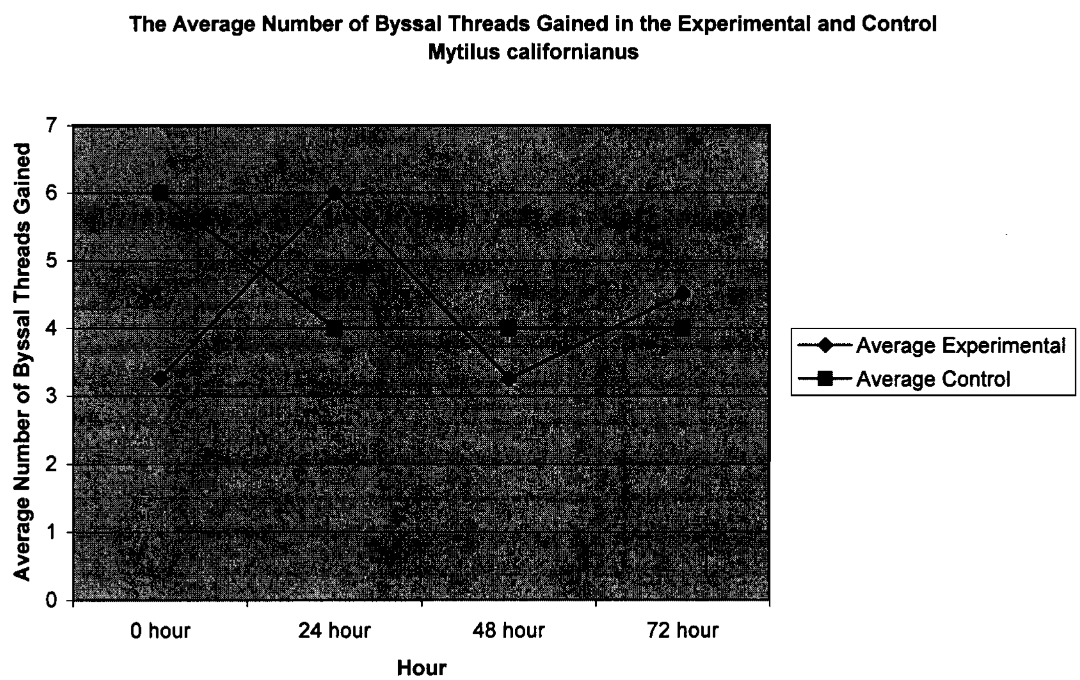

Figure 2: Shows a comparison in the average number of byssal threads gained in both the control and experimental *Mytilus californianus* for 72 hours.

Discussion

These results support my hypothesis that the California mussel, *Mytilus californianus* will produce more byssal threads when in the presence of its predator, *Pisaster ochraceous*. Overall, the *M. californianus* in the presence of *P. ochraceous* produced a total average of 11 byssal threads, which is 1 more than the total average number of byssal threads produced by the *M. californianus* that were not in the presence of *P. ochraceous* (Figure 1.) Although the experimental mussels only produced an average of 1 more byssal thread compared to the control mussels, Figure 2 suggests that if this experiment were to be continued for an extended period of time, then the results would be more conclusive.

The *M. californianus* that were in the presence of *P. ochraceous*, on average, produced the most byssal threads within the first 24 hours, and then the average went down at 48 hours, and back up at 72 hours. Whereas the control mussels decreased the average byssala thread production rate within the first 24 hours and then continued to produce a consistent average for the following 2 days (Figure 2.) These are the same results that were concluded by Cheung et al. in a similar experiment. He concluded that the highest byssus production rate in the presence of a predator occurred in the first 6 hours in the mussel *Perna viridis*. He also concluded that there was a larger total volume of byssal threads produced by *P. viridis* when exposed to a predator. These are essentially the same results that I received. The mussels that were closest to the predator, experimental 3 and 4, produced a total of more byssal threads than control 3 and 4 (Table 1.) Although experimental 1 and 2 produced a total of less byssal threads than control 1 and 2, they still had a larger average rate of production of byssal threads (Figure 2) suggesting that a longer trial period would have produced more conclusive results. My results also concluded that the mussels that were closest to the sea star, experimental 3 and 4, produced more byssal threads within the 72- hour period than experimental 1 and 2, which were further away from the predator. This suggests that byssal thread production is increased when *P. ochraceous* is present because the closer the mussels were to the sea star, the more byssal threads they produced.

Overall, I would further investigate the question of whether or not *M. californianus* produces more byssal threads in the presence of *P. ochraceous* by extending the experiment to last for a week rather than 3 days. This would allow me to collect more data and therefore receive more conclusive results. I would also use damaged conspecifics along with a live predator to test whether or not *M. californianus* responds to chemical cues as well as the presence of the predator. This would further examine if *M. californianus* is capable of inducing predation responses through chemoreception.

References

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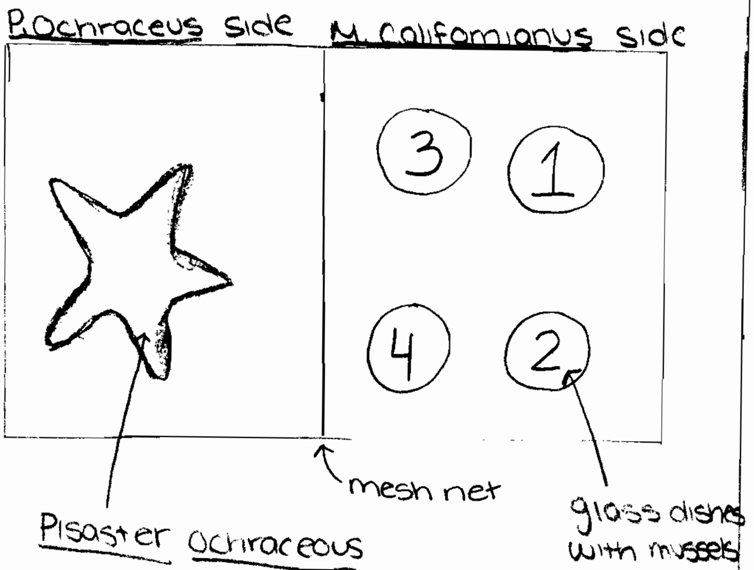
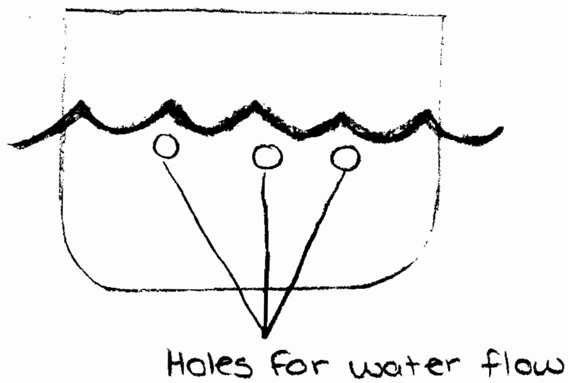
Figure: 3



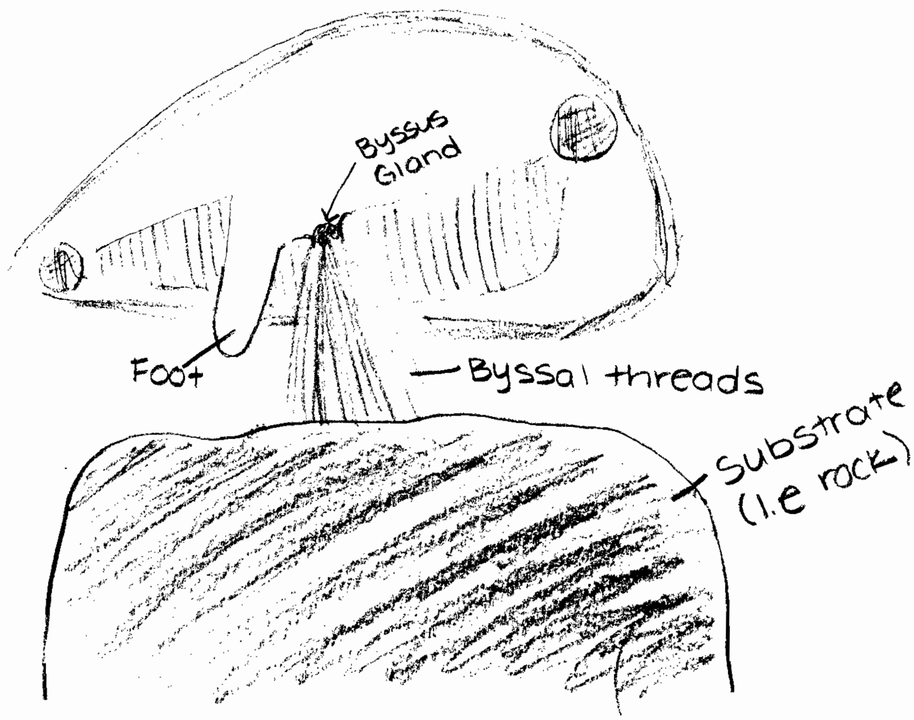
Arial view of setup

Figure: 4



Side view of setup

Figure: 5



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Side view of *Mytilus californianus*