Behavioral Adaptations of *Aplysiopsis enteromorphae* to differing light and heat conditions

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Introduction

Aplysiopsis enteromorphae occurs on Pacific Northwest shores of Oregon and Washington. This opistobranch has a "local distribution occurring (1) in high intertidal, open coast pools on filamentous green algae and (2) in bays and estuaries on green algal mats" (Trowbridge, 1993). This species only occurs in the summer months. Similar species are found around the world in the same types of habitats. Cynthia Trowbridge has noted, in a conversation, that these species all have a similar black pigment that could protect the individuals from sun exposure. Much is known about the biology, feeding habits and reproduction of this sea slug, however information on various behavioral adaptations are missing.

Locally, *A. enteromorphae* live in the gently sloping mudflats of Metcalf marsh with in tide pools and tidal channels that are also home to the green alga *Cheatomorpha.* I was curious if individuals are ever stranded outside of these water habitats. If they are stranded, do they find their way back to the water or do they burrow within the sediment, much like many of their fellow mudflat neighbors? Another sacoglossan found at Metcalf Marsh, *Alderia modesta*, moves around on *Vaucheria* mats in the daytime, however slugs burrow into the algal mats with increased emergence time, particularly on warm or bright days (Trowbridge, 2002).

In addition, does light and heat affect the behavior of *A. enteromorphae*? I believe they will burrow into the sediment if sunlight or extreme heat is present and water cover is absent. When the individuals are covered by water I expect them to be unharmed and to maintain normal behavior under varying light/heat conditions. Alternatively, the *Aplysiopsis* will have no change in behavior between different light/heat exposures with or without water. I will look specifically for the presence of burrowing behavior and aversion to heat and light exposure, including exposure to high sun levels.

Methods & Materials

To examine the behavior of *Aplysiopsis enteromorphae* in different light and heat conditions I collected 12 individuals from Metcalf Marsh in Charleston, Oregon. Here I found the species within a large tidal channel in the mid to high zone of the mudflat. I

collected the sediment they were living on, but only the top layer to ensure I had an adequate and accurate layer for the potential burrowing. I also collected *Cheatomorpha* for the individuals to feed on to maintain similar field lifestyle.

I set up 4 equal, shallow containers with sediment about 2 cm deep. I placed three individuals in each container for my four study groups. I allowed the slugs to settle in the tank environment for two days before beginning my trials. My four trials were as follows: (1) No additional light exposure, (2) One light exposure, (3) Two light exposure and (4) Full sun exposure. The lights I used were standard desk lamps containing 69-watt bulbs. I used the same light for the 2^{nd} trial to ensure no irregularities in light and heat increase/decrease. In the fourth trial, I took advantage of an unusual sunny day in Charleston to test for differing behaviors due to increased heat, light and UV exposure. I ran the 4 replicates for trial 1, 2 and 3 for ten minutes each while I ran trial 4 for 15 minutes each to study the behavior more closely.

The four different trials were repeated twice with two controls (containers exposed with 1.5cm of water and two experimental (containers without water and completely exposed sediment. After performing the first trial with no additional light exposure I used the behaviors noted and temperatures as controls for the following trials. Here the "normal" behavior noted consisted of foraging and movement around the container, while noted behavior for the containers without water is a lack of movement. For the other trials I looked for these specific behaviors as the control behavior while noting behaviors that differed. I quantified the number of individuals that displayed them. I also looked at the temperature increases for the different trials and the differences between them.

Results

Behaviors seen in Trial 2 were the control behaviors observed in Trial 1. The temperature increases (figure 1) of the water-covered containers, used as the control portion of the trial, showed a change. The temperature increases for the containers without water increased at a more extreme rate. The results for Trial 3 began to show burrowing behavior (figure 4) in two individuals as well as two individuals finding shade and water refuge when the container was empty (figure 2). In the fourth trial (figure 3),

more burrowing behavior was observed in experiments done without water cover. It was seen in 3 individuals while no movement (control behavior) was seen in one individual. Containers with water coverage showed individuals with control/normal behavior. The majority of the slugs began showing differing behavior within 5 minutes of the start of the exposure.

Discussion

Through the trials I found *Aplysiopsis enteromorphae* to display adaptive behaviors for their environment. I observed *A. enteromorphae* to find refuge in the shade (while under water) and in small pools of water, while slugs left out of water and exposed to intense light and heat displayed burrowing behavior. The individuals that displayed burrowing behavior were unsuccessful in completely covering themselves. However this could be due to a lack of time in my trials.

Many sacoglossans are able to perform kleptoplasty, the ability to sequester undigested algae so as to create a source of carbon for the slug, (Trowbridge, 2002). However, *A. enteromorphae* are an exception to this rule and do not sequester chloroplasts. This leads me to think that *A. enteromorphae* has no benefit of staying in the sunlight, and instead would benefit from desiccation stress prevention by burrowing or heading for shelter in an algal canopy. Trowbridge states that, "Atlantic species with functional chloroplasts oriented toward light whereas aposymbiotic species avoided light. If this pattern were general, then most northeastern Pacific species should avoid light or perhaps be nocturnal because of the general lack of functional kleptoplasty" (2002).

There were sources of error in my exploratory that could have contributed to some of the inconclusive behaviors. My inability to maintain an uncovered container without small pools of water could be a source of error in slug behavior, especially if they ended up starting in one of these pools. However I do feel that bumpy topography allowing for small pools is indicative to their natural habitat, and therefore more realistic. It would have also been a good idea to run the trials for the same amount of time, either 10 minutes or 15 minutes so that my temperature increases were more accurate with one another. Due to the nature of the exploratory, defining individuals behavior is difficult and sometimes not clear. Performing more trials would have allowed me to see more

examples and variations on the same behavior. That way I could have identified them more accurately. Further exploration of this subject could include performing the same trials, but adding in algae to see if they move to the protection. I could examine whether or not they have a habitat preference or the ability to move to the deeper water or under algal shelter. This is especially after noticing their tendency to settle next to the thermometer and shady edge of container.

References

Trowbridge, Cynthia. "Northeastern Pacific Sacoglossan Opisthobranchs: Natural History Review, bibliography, and Prospectus." The Veliger. 45 (2002): 1-24.

Trowbridge, Cynthia [personal conversation].

Trowbridge, Cynthia. "Population Structure of Two Common species o f Ascoglossan (=Sacoglossan) Opisthobranchs on the Central Coast of Oregon, USA." The Veliger. 36 (1993): 99-106

Figure 1. Display of temperature changes in the series of trials with no light added (1), one light exposure (2), two light exposure (3) and exposure to full sun (4).

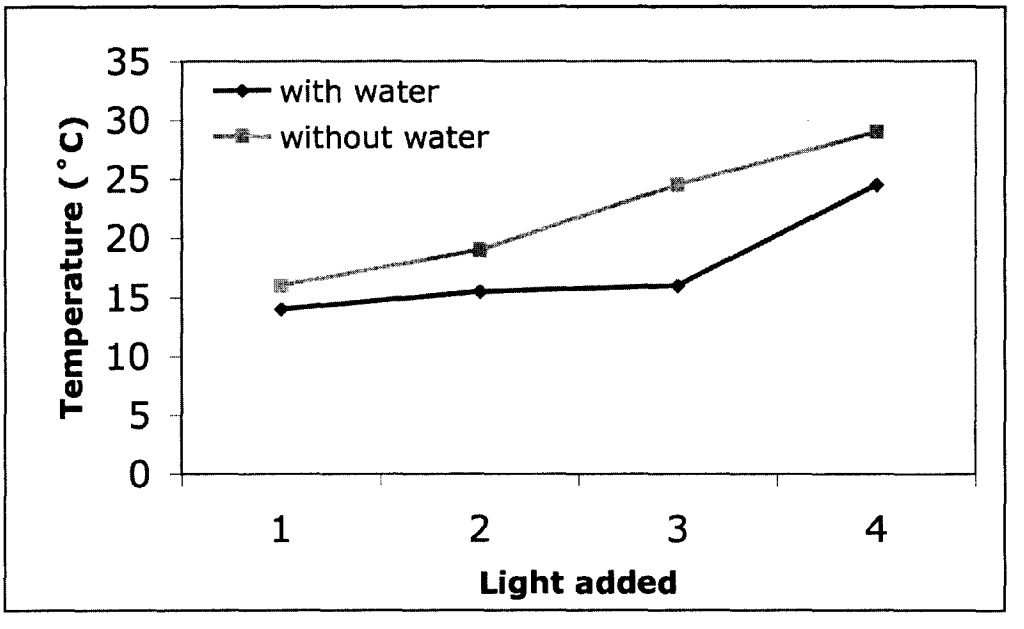

Figure 2. Graph of various behaviors by individual *Aplysiopsis enteromorphae* noted during Trial 3 (two light exposure).

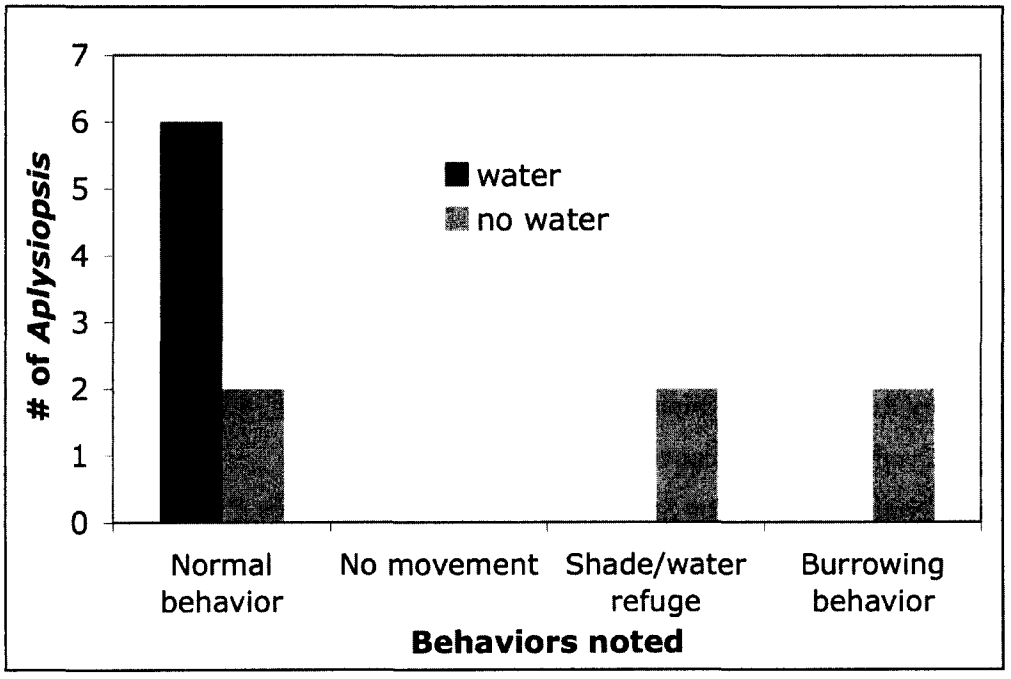

Figure 3. Graph of various behaviors by individual *Aplysiopsis enteromorphae* noted during Trial 4 (exposure to full sun).

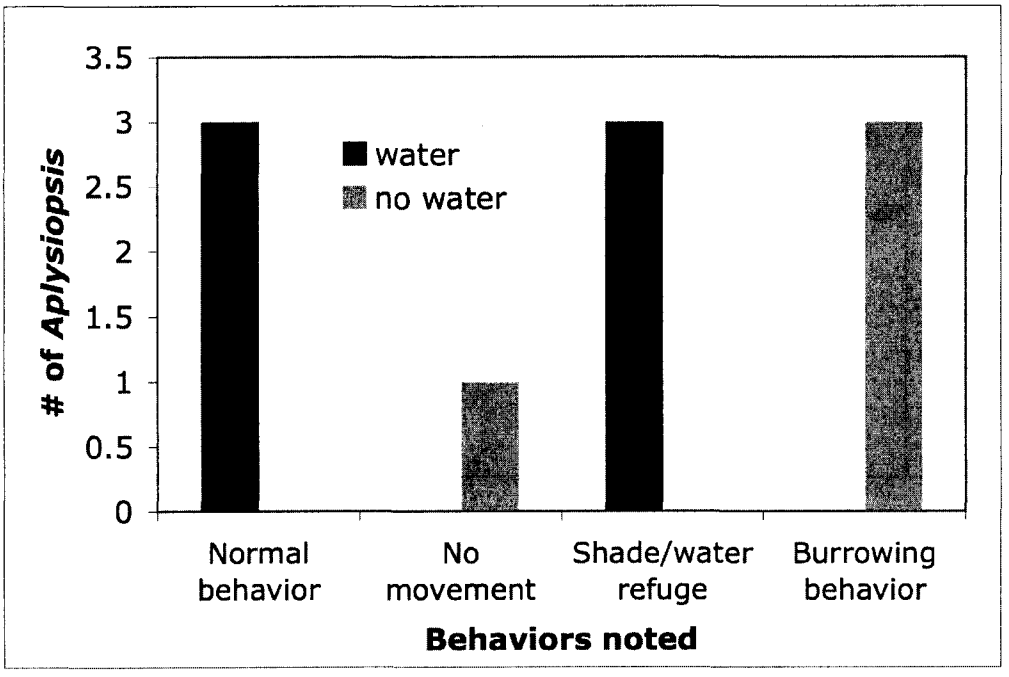

Figure 4. Aplysiopsis enteromorphae burrowing behavior is seen here with both individuals. Note the sediment covering which is achieved by mucous secretions and twisting of the slug to cover itself.