LITTORINA SNAIL (GASTROPODA) PREFERENCE FOR *MAZZAELLA FLACCIDA* OVER *CHONDRACANTHUS CORYMBIFERA* AND *CHONDRACANTHUS EXASPERATA* (GIGARTINALES, RHODOPHYTA)[1]

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Abstract: I collected ten samples of *Mazzaella flaccida* (Setchell *et* N. L. Gardner) Fredericq *in* Hommersand, Guiry, Fredericq & Leister and ten samples of *Chondracanthus corymbifera* (Kutzing) Guiry *in* Hommersand, Guiry, Fredericq & Leister and *Chondracanthus exasperata* (Harvey *et* Bailey) Hughey *in* Hughey, Dudash & Kjeldson at Pigeon Pt, San Mateo County, California during low tide on November 13. Each of the samples was weighed and snails were extracted from the blades and counted. I ran a 2 sample paired t-test to test for the difference between the ratios of snails per wet weight (in grams) for both types of algae. The relatively small p-value of 0.01339 supports the claim that there is a significant difference between the ratios. This difference may be due to preference of snails towards *M.flaccida* as a superior food and/or habitat option to *C. corymbifera and C. exasperata*.

Introduction

Ecological studies on an animal, its food and its habitat can become complex when an animal's food and habitat cannot be separated. Examining the life histories of various parasites and their adaptations to sparse and temporal habitats sheds some light to food-as-habitat solutions. Animals whose habitat is also their food are not necessarily parasites. Such is the case for a *Littorina* snail, whose body is extremely small in comparison to some of the macrophytes it consumes and whose pace is relatively slow. At least for a certain period of time its habitat and its food are one in the same. It is quite possible that the snail weathers both desiccation and wave action attached to its habitat. This study is based on the difference in food-as-habitat preference of *Littorina* snails to *Mazzaella flaccida* compared with *Chondracanthus* – species *Chondracanthus corymbifera* and *Chondracanthus exasperata.* These two algal choices are based on their distinct morphology differences. *M. flaccida* is thin and rubbery with a relatively smooth surface. Both *C. corymbifera* and *C. exasperata* are much thicker than *M. flaccida*, have a waxy and unbending texture and have large bumps all across the blades. *C. corymbifera* and *C. exasperata* are very similar in morphology and thus I did not separate them, but placed them into the same category to be compared with *M. flaccida.* (Kim and DeWreede 1996, Harley 2003, Thornber et al. 2006).

Biological factors such as herbivory and competition have been known to affect distribution of various algae in the low to mid intertidal zones. In a study on the upper intertidal zone, *Littorine* snails preferred *Mazzaella flaccida* to two fucoids (Kim and DeWreede, 1996). *M. flaccida*, *C. corymbifera* and *C. exasperata* are closer in morphology. Both consist of clumps of blades (or singular blades) attached to rocks by small holdfasts and both share the common characteristics of Phylum Rhodophyta. Studies based on these two types of algae might shed some light into the distribution of the algal species in the low to mid intertidal zone. The goal of this study was not to define algal distribution in the area, but simply to determine whether there was a preference of the snails for one or the other algae species.

Methods

I collected my samples on November 13 during low tide at Pigeon Point, San Mateo County, California. It took several hours to collect all twenty samples which were then transported back to the lab at Moss Landing.

The samples were determined using Microsoft Excel random numbers generator; ten samples were collected of *M. flaccida* and ten samples were collected of both *C. exasperata* and *C. corymbifera*. I lay down a thirty foot transect with both ends about equidistant from the shore. The length of the transect traveled roughly the same topography throughout, and *M. flaccida*, *C. exasperata* and *C. corymbifera* blades were found nearby the transect. Each sample consisted of all the blades attached to a single holdfast. At each random sample point on the transect, I located the closest sample of *C. exasperata* and *C. corymbifera* (if it was one of the first ten sample points) or *M. flaccida* (if it was one of the last ten sample points). Samples were labeled M1-10 and C1-10, placed in separate plastic bags within a cooler, and taken back to Moss Landing Marine Laboratories. Each sample was examined individually, one after the other. Snails were first removed and counted and then the algal blades were blotted with paper towels and weighed. There are several species of *Littorina* snails throughout California. Since they can all be easily distinguished as small black snails, I did not concern myself with identifying individual species but placed them into one category. I recorded wet weights of algal blades with and without epiphytes.

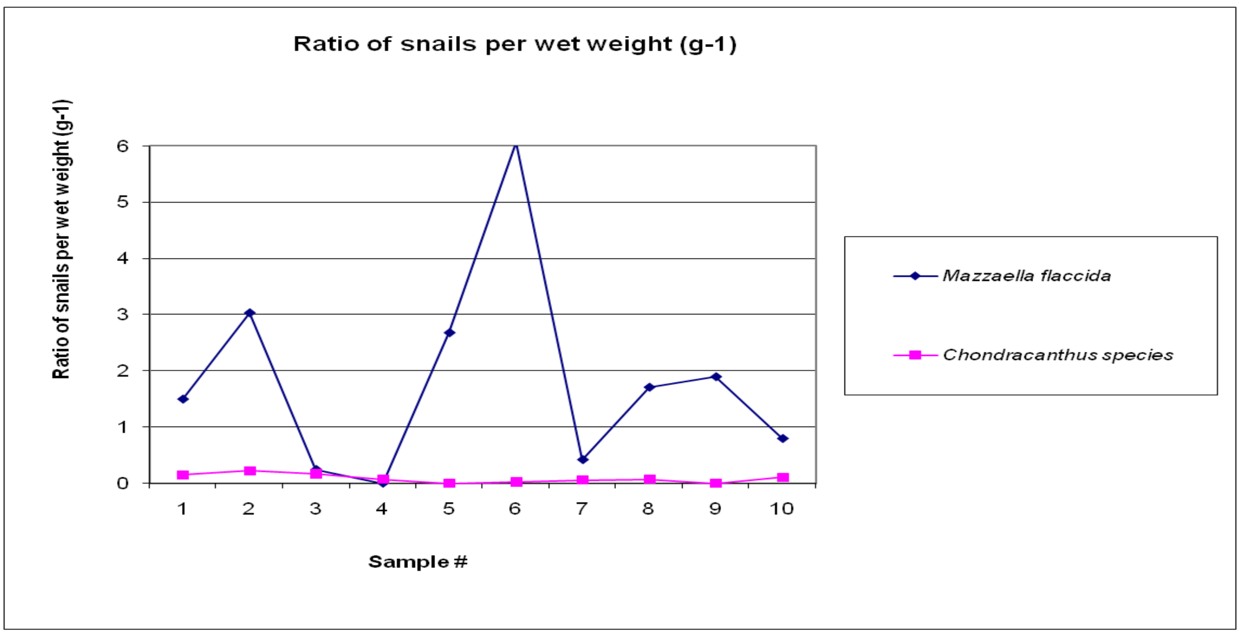

Figure 1 – Ratio of *Littorina* snails per wet weight for each type of algae. The *Chondracanthus* species ratio is more uniform and smaller than the *M. flaccida* ratio.

Data Analysis

For my data analysis, I decided to compare the average ratio of amount of snails per wet weight in grams for the two types of algae (See Figure 1 above). The average ratio for *M. flaccida* was 1.831452507 with a standard deviation of 1.706702654. The average ratio for *C. corymbifera and C. exasperata* was 0.085761274 with a standard deviation of 0.074740231. I used MacAnova 5.03 Release 1 program to conduct a 2 tailed 2 sample t-test. The test results were: t-value of -3.0659, df of 9.0311, and a p-value of 0.01339. The p-value shows a significance of < 0.05 chance that there is no difference in the data sets. I also used scatter plots of amount of snails per wet weight in grams for *M. flaccida* and then separately for *C. corymbifera and C. exasperata.* I ran a linear regression line, and found an equation of $y = 1.084x$ and an R^2 value of 0.5084 for *M. flaccida* For *C. corymbifera and C. exasperata* the equation is $y = 0.0598x$ with an R^2 value of 0.3012. Finally, I ran a linear regression for a scatter plot of wet weight of both algae types in grams (with epiphytes) verses wet weight of both algae types in grams (with epiphytes removed). The equation of the linear regression is $y = 0.968x - 0.213$ with an R^2 value of 0.9974.

Results: The small p-value obtained from the 2 sample t-test supports the claim that there was a difference between the ratio of snails per wet weight for *M. flaccida* to the ratio of snails per wet weight for *C. corymbifera and C. exasperata*. There didn't seem to be a direct correlation to the number of snails and the weight wet for either *M. flaccida* or *C. corymbifera and C. exasperata.* However, in Figure 1 there appears to be a uniform distribution of the ratios for *C. corymbifera and C. exasperata.* Finally, epiphytism was not a huge factor as evidenced by the direct correlation and equation with x-coefficient close to one, and so I did not run tests for both values with and without epiphytes, but only ran the t-test for the wet weight values with epiphytes.

Discussion: The significant difference in ratios of amount of snails per wet weight suggests that *Littorina* snails prefer *M. flaccida* to *C. corymbifera and C. exasperata.* However, since there seemed to be no direct correlation between number of snails and the wet weight (at least obviously for *M. flaccida*), there may have been a number of factors overlooked. Thornber et al. 2006 conducted a study on selective herbivory on *Mazzaella flaccida* which demonstrated that the snail *Tegula funebralis* greatly preferred gametophyte reproductive tissue over other types. I did not examine different types of tissues but considered the whole alga. I took the liberty of using the wet weights with epiphytes but without snails because the weights were so similar to those with epiphytes removed. Unfortunately using mainly tweezers and razor blades I was not very skillful at removing epiphytes which sometimes also burrow a little into the seaweed thallus so I considered the wet weights including epiphytes to be more accurate than the wet weights excluding them. However in Monitoring Rocky Shores Murray et al. suggest not including epiphytes in wet weight values. One thing to keep in mind is that epiphytes are a variable which cannot be controlled in the field, but perhaps in a laboratory setting. In order to make sure that epiphytes are not a contributing factor to snail preference I would need to conduct laboratory experiments with epiphytized verses non-epiphytized *M. flaccida* specimens and *C. corymbifera and C. exasperata* specimens (different containers for each).

Another factor which may have been overlooked is the position of the snails on the blades, as well as the size of the blades. This could of course be remedied by conducting another study, this time using surface area instead of biomass as a variable, and also measuring the position of each snail on the blade. Of course this is very tedious and would need to be done at very low tide with plenty of available sunlight and people to help take measurements. My simple experiment took most of the low-tide period which at that point was several hours in the early afternoon at a fairly decent low tide. Obviously this would take a lot of planning. Also, one of my samples contained 57 snails, so I can imagine this study would be time-consuming and thus measuring the biomass is a better option for a general, quick overview of snail preference. I cannot imagine measuring distances for 57 different snails I thought it was tedious enough picking them off the algae. Also, since I was only interested in comparing the morphological differences between the two types of algae, I overlooked the age and degradation of blades. However most of the blades appeared to me to be healthy in appearance though many of the edges of the *M. flaccida* were ragged from being worn down by waves. (Mach et al. 2007) I am not sure if this raggedness has an effect on the snails, one would guess the snails would be found farther away from the ragged edges and closer to the holdfast possibly safe from waves and predators.

I chose to compare the *C. corymbifera and C. exasperata* and *M. flaccida* specimens not only because they are morphologically distinct from each other and I observed snails on blades of both algal types, but also because as members of Phylum Rhodophyta they share similar characteristics including chemical properties. Algae are divided into three groups – Rhodophyta, Chlorophyta and Phaeophyta, although classification varies depending on which phylogeny model is used. These groups are commonly referred to as the reds, greens and browns respectively. Members of Rhodophyta share similar life history, morphology and chemical characteristics that are different than the other two groups. Many of the algae on the Pacific Coast at Northern California locations belong to the group Rhodophyta. The kelps however belong to Phaeophyta and are also prominent along the Pacific Coast. There is much greater diversity of reds along the coast than either of the groups. Rhodophyta has about thirteen orders, some of which of course are subject to change. *M. flaccida* and *C. corymbifera and C. exasperata* both belong to the order Gigartinales of Rhodophyta which is considered a more derived group than others. Rhodophyta is considered the most primitive of the algal groups but Gigartinales is one of the less primitive groups among the most primitive algal phylum. While members of Gigartinales are mostly distinct from other groups they do not share characteristics that define them as a group.

For example one group might have a defining characteristic of cruciate tetrasporangia (shape of a reproductive structure) but Gigartinales will include members which have different shapes of tetrasporangia. Basically, if it is unknown what group a red algae belongs to, and it is a less primitive algae, it is thrown into the category Gigartinales. Therefore the fact that *C. corymbifera and C. exasperata* and *M. flaccida* belong to Gigartinales is of no consequence in determining similar characteristics between them. However, the fact that both of these algal types are in the Phylum Rhodophyta means that there are characteristics, including chemicals, they share and which differ to the other two phyla. While I am hypothesizing that morphology might be a factor the snail takes into consideration when choosing one algal blade over the other, I cannot rule out chemical, life history and other factors without conducting more research. (Rhodophyta)

Because of taking Marine Botany at the time of the study, I was much more familiar with knowledge of algae as compared to knowledge of snails. I basically used my algal knowledge as the basis for the study. I have also taken invertebrate zoology both semesters but it is not as fresh in my mind. However, the snails part of this experiment needs to be taken into greater consideration. Snails eat by using a radula – basically teeth are attached on a ribbon which rolls as the snail moves along, similar in concept to an old fashioned lawn mower. Based on that analogy, one can see why it might be easier for the snail to consume a flat blade like *M. flaccida* rather than a bumpy blade like *C. corymbifera and C. exasperata*. However *M. flaccida* is more stretchy and could possibly be hard for the snail to grip. Lab experiments are required to test the snail's teeth and the amount of energy required to use those teeth to tear the two algal type. D. K. Padilla, in his paper "Structural resistance of algae to herbivores," reminds researchers that the biomechanics of the teeth are important, not just the algal morphology.

Originally, researchers had assumed hard coralline algae were the hardest for herbivores to consume because of the hardness of the those algae compared to most other algae. Coralline algae often form hard crusts or brittle branches and their hardness comes from calcium carbonate which they use for structure. Padilla argues that this argument does not stand on it's own because limpets have teeth which contain iron and/or silica, much harder minerals than coralline algae (nearly twice as much). While limpets are not snails and neither of the algal types are calcified, Padilla's observation is important to this study. In order to understand deterrence or preference of the snail for algal types, the snails morphology also needs to be known thoroughly and how it interacts physically with its possible food. This information needs to be taken into consideration under the hypothesis that preference of one algal type above the other is due to food and not habitat. (Padilla 1985)

There is a significant difference in the ratios of the snails per wet weight algae. The next step in this research would be to perform experiments and determine why there is a significant difference. The two basic categories are food and habitat. Do *Littorina* snails prefer *M. flaccida* blades to *C. corymbifera and C. exasperata* blades because they prefer to eat or to live on them? Is this due to morphology (perhaps it is just too tough for the snails to eat *C. corymbifera and C. exasperata* or to habitat? One problem with determining this is the fact that there were a lot more *M. flaccida* blades in the area I performed my study than *C. corymbifera and C. exasperata* blades. *M. flaccida* blades are simply more abundant in that area and though I was able to find a transect with both *M. flaccida* and *C. corymbifera and C. exasperata* blades with similar lengths away from the transect, they was definitely a greater number of *M. flaccida* blades. The snails might just be more familiar with *M. flaccida* blades than with *C. corymbifera and C. exasperata.*

In order to test this idea laboratory experiments can be made testing various amounts of *M. flaccida* to *C. corymbifera and C. exasperata* blades with a control being equal amounts of both. Also different test sites in the field can be used as well if there is more *C. corymbifera and C. exasperata* in the area compared to *M. flaccida* etc. After conducting the same experiment in areas of varying abundance of the algal types statistical analyses can be made to determine if there is a significant difference between data sets indicating familiarity as a factor. Again, I would say *M. flaccida* was a dominant algae at Pigeon Point and therefore it would be unlikely for me to find an area with mostly *C. corymbifera and C. exasperata* compared to *M. flaccida.* Also the two different seaweeds, competitive for rock space, may thrive at different physical conditions. In this case, the conditions *M. flaccida* prefers might just coincide with the conditions the *Littorina* snails prefer as well.

While the results of this study suggest that *Littorina* snails prefer *M. flaccida* to *C. corymbifera and C. exasperata,* further studies should be done to support or refute the claim. Studies that will shed light on the other variables such as age and position of snails (to estimate minimum length of time in habitat) should also be conducted to further understanding of the habitat-as-food for *Littorina* snails. This study is just a stepping stone for further studies about food verses habitat dilemmas. There are many studies undergone to understand relationships between small herbivores and their food/habitats which provide ample methodologies to use in determining preference based on food or habitat. These questions are an integral part of understanding principles in ecology as they also apply to insect-plant relationships on land. As humans we try to eliminate insects from crop plants and increasing concern for the environment allows many people to be skeptical of common pesticides. Better understanding of these ecological relationships has many applications for the well-being of mankind. (Cronin et al. 1996)

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