Two of the Most Dangerous Threats to Staghorn Coral, Caused by One Species

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I. Introduction: There is great need for conservation efforts in the coral reefs of our oceans; they are bleaching rapidly and need our immediate attention. It is known that many things are currently damaging the coral, such as increases in temperature (Boyett et al. 2007), UV radiation (Boyett et al. 2007), pH (Doney 2006), salinity (Anderson et al. 2001), nutrient levels (Pittock 1999), predation (Lesser et al. 2007), and disease (Lesser et al. 2007). Of these, two of the most harmful factors are predation and disease (Lesser et al. 2007). The aquatic snail *Coralliophila abbreviata* has been shown to play a significant role in both of these factors because it not only feeds on the coral (Miller 2001), but also spreads disease among the coral colonies (Williams and Miller 2005). Previous studies have also shown that between *Acropora cervicornis* and *Acropora palmata*, the snail causes the most damage to *A. cervicornis*, or the staghorn coral (Williams and Miller 2005). The staghorn coral has only one known disease, white band disease (WBD), and it is commonly described as a band of bleaching on the branches of a colony (Williams and Miller 2005). Using this knowledge from previous studies, the next step should be to determine whether the effect of predation by the snail or disease spread by the snail is more damaging to *A. cervicornis*. In addition, it is necessary to determine whether removing the snails or removing the disease on the snails is more effective in preventing the spread of disease among coral colonies.

II. Objective and Prediction: Despite the abundant research, there are still many questions that are important in understanding coral-snail relationships, and thus conservation of the coral. In this proposal, two of the most important questions concerning this relationship are addressed. The first question asks whether snails cause more harm to corals by eating them or by spreading disease among the coral colonies. It is important to determine this so that future conservation efforts can focus on the more damaging effect. The second question asks whether a removal of the snails or a removal of the disease on the snails is more effective in preventing the spread of disease among coral colonies. It is also important to determine this so that future research can determine the best way to carry out the more effective method of either removing the snails or removing the disease on the snails. To help answer these questions through experimentation, there are two testable critical predictions of the questions. The first critical prediction is if some snails are allowed to eat the coral and others are allowed to spread white band disease to it, then the snails that spread the disease will cause more damage to the coral than the snails that preyed on it. This prediction is likely to be correct because there are other organisms that feed on the snail to help control the number of snails, and thus, predation even if it has started on a colony, but there is nothing to stop the disease once it has been spread to a colony by the snail. It provides a critical test of the question because it will show whether the snails cause more harm by disease spread or by predation. The second critical prediction is if one coral is exposed to snails that have white band disease and have been treated with antibiotics and another coral has not been exposed to snails, disease, or antibiotics, then the coral without exposure will show less disease. This prediction is likely to be correct because there are two ways to spread white band disease among coral colonies, which are though coral tissue contact and through snails moving from one coral colony to another; even if a removal of the disease from the snails proves to be effective, there could still be exceptions when it is not effective. However, if the snails are removed from an area and the colonies are separated, there will be no method of disease spread among the colonies. This prediction provides a critical test of the question because it will show whether a snail removal or a removal of the disease from the snail is a more effective method in preventing the spread of disease.

III. Methods: The subjects of this experiment are the individual colonies of *A. cervicornis* in each tank. They will be taken from one area in the Caribbean Reefs where they are both known to live (Miller 2001). Six hundred *C. abbreviata* individuals along with twenty healthy corals and forty diseased corals plagued by white band disease with about the same amount of progression of disease will be removed over the period of this study. There will be thirty snails, one healthy coral, and two diseased corals collected per replication. Only a small amount of healthy coral will be removed from the wild because it has been shown that healthy coral will regenerate when broken up and reattached to rocks by epoxy resin (Ammar et al. 2000). Once a healthy coral is removed from nature, the branches will be broken off, mixed up, and randomly assigned to one of six tanks. Then, once it is assigned to a tank, the broken part of the branch will be covered with epoxy resin and attached to a rock. It will be allowed to regenerate and grow to a size that resembles the ones taken from nature. Once they have grown to this size, measurements will be taken to determine the surface area in mm^2. When the snails are collected, they will be mixed up and randomly assigned to a tank. Each tank will have a different set of treatments, but the conditions used to control extraneous variables will remain the same, such as temperature, UV radiation, salinity, pH, and nutrient levels. The temperature will be kept at 26°C and the UV radiation level will be kept at 280 nm (Gleason and Wellington 1993). The salinity, pH, and nutrient levels of the water will be at the same levels because it will come from one area.

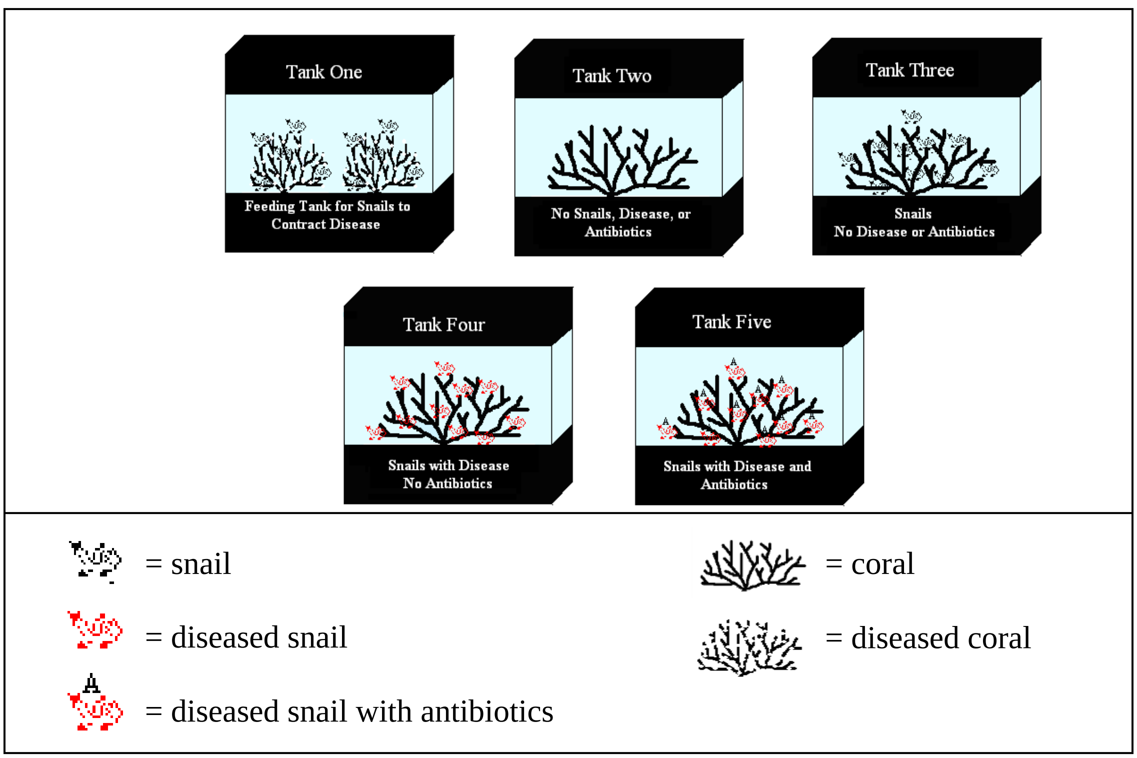

Figure 1.1: A diagram depicting the treatment of each of the six tanks in this experiment.

Tank One (Figure 1.1) will contain two diseased corals of about the same progression of disease that will feed and transmit disease to the thirty snails used for each replication. No measurements will be taken from Tank One because it is only used as a means for the snails to eat and contract white band disease. Tank Two (Figure 1.1) will be the control tank. It will contain one healthy coral that has been regenerated, with no predation or disease from snails. It will demonstrate the effects on the coral without predation, snails, disease, or antibiotics. Tank Three (Figure 1.1) will contain one healthy coral that has been regenerated with ten snails placed on the coral, which are then allowed to feed on it. This tank will show the amount of damage done to the coral due to predation by the snail. Tank Four (Figure 1.1) will contain one healthy coral that has been regenerated with ten snails. These snails will have contracted white band disease in Tank One and will placed on the healthy coral and allowed to feed on the it until a visible feeding scar is made, and then they will be removed. A previous study has shown that this will be an appropriate amount of time to reduce the amount of damage from predation and yet long enough to transmit the disease (Williams and Miller 2005). This will show the amount of damage done to the coral due to disease spread by the snail. Tank Five (Figure 1.1) will contain one healthy coral that has been regenerated with ten snails added. These snails will have contracted white band disease in Tank One will be administered antibiotics to remove the disease. Then they will be allowed to feed on the healthy coral until they make a visible feeding scar. This tank will show the amount of disease on the coral that has been spread by the snail with antibiotics without introducing the predation variable. See Figure 2.1 for a table summarizing the treatments of each tank.

Table 2.1: Treatments applied to each tank and the logic for the treatment.

Tank	Coral Health	Snails	Predation	Disease	Antibiotics	Measurements
1	Diseased	30	N/A	N/A	N/A	No
2	Healthy	No	No	No	No	mm^2
3	Healthy	10	Yes	No	No	mm^2
4	Healthy	10	No	Yes	No	mm^2
5	Healthy	10	No	Yes	Yes	mm^2

Notes on tanks
1 = A means for the snails to eat and contract white band disease,
2 = Shows the effects of coral without snails, disease, predation, or antibiotics introduced.
3 = Shows the amount of damage to the coral due to predation.
4 = Shows the amount of damage to the coral due to disease spread.
5 = Shows the amount of disease on the coral when the disease is removed from the snail.

Each replication will run for a period of ten days, or 240 hours. Measurements will be taken from Tanks Two, Three, Four, Five, and Six in which the amount of damage will be recorded on each coral in mm^2. This will be compared to initial measurements taken after the healthy coral has been allowed to regenerate but before treatment is applied. After each replication has been completed, thirty snails, one healthy coral, and two diseased corals will be removed from nature, more specifically, from one area in the Caribbean Reefs. This will be repeated for a total of twenty replications. Once the experiment is complete and the data have been collected, several statistical tests will be run on them to determine the significance of the results. In compliance with ethical standards, all snails and healthy coral will be returned to nature after each replication. The snails will be given antibiotics to remove any disease so as not to introduce any extra disease to healthy coral. As described above, the healthy coral can be removed from the tanks and reattached in nature. This experiment includes the three critical aspects of experimental design, which are control, noise, and bias. It provides control of extraneous variables by making each tank have all variables that are not being controlled for the same, such as each tank is the same size, has a set number and size of corals, a set number of snails, the same temperature, salinity, pH, nutrient levels, UV radiation, and the diseased corals will have about the same progression of disease. It reduces noise by having twenty replications of the experiment. This experiment also reduces bias by randomizing the subjects. When the healthy coral is taken from nature and is broken up, the branches are mixed up and distributed randomly to different tanks. In addition, once the snails are collected, they will also be mixed up and randomly assigned to their tank.

IV. Possible Results: The first critical prediction made in this experiment is if some snails are allowed to eat the coral and others are allowed to spread white band disease to it, then the snails that spread the disease will cause more damage to the coral. The second critical prediction is if one coral is exposed to snails that have white band disease and have been treated with antibiotics and another coral has not been exposed to snails, disease, or antibiotics, then the coral without exposure will show less disease. In the following graphs, the amount of damage due to predation and disease and the amount of disease with antibiotics and snail removal are compared to the amount of damage and disease in the control to account for the damage and disease due to transplanting the coral from nature. If the results collected from this experiment were to confirm the first critical prediction, they would be represented by Figure 2.1.

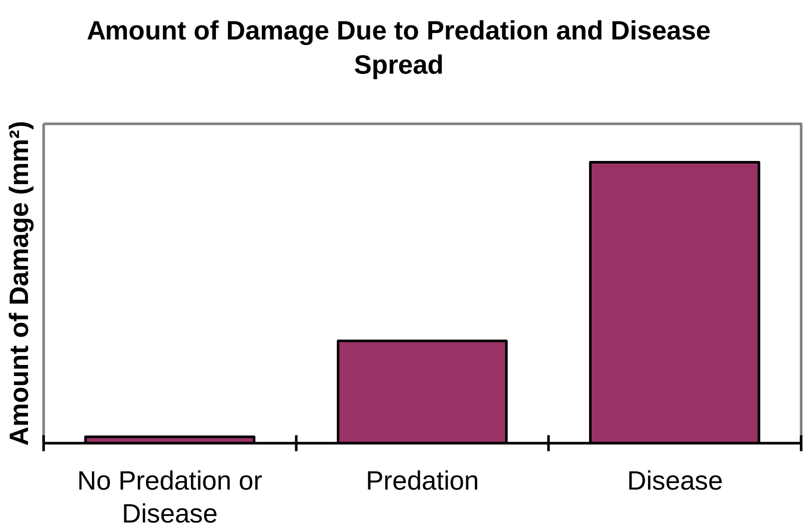

Figure 3.1: A graph showing the amount of damage to the coral in the treatments of Tank Two, Tank Three, and Tank Four (see Figure 2.1). The amount of damage done by disease is greater than the damage done by predation, which is greater than the damage done without predation or disease.

However, if the results did not confirm the critical prediction, they may be represented by Figure 3.2 or Figure 3.3.

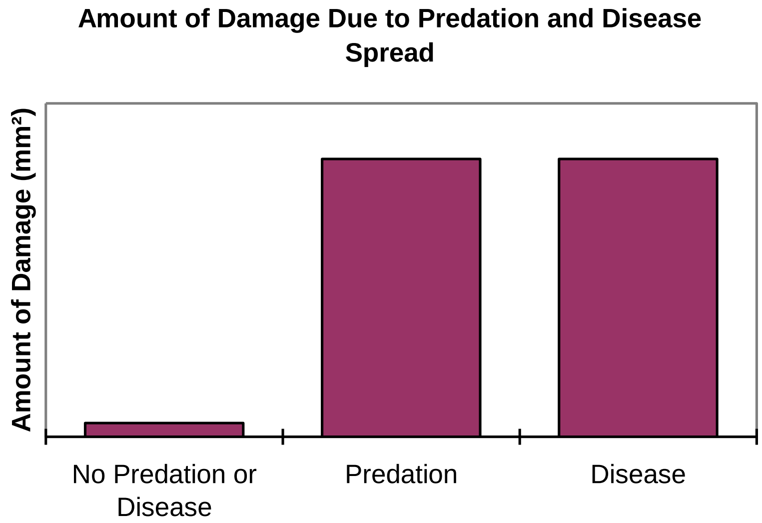

Figure 3.2: A graph showing the amount of damage to the coral in the treatments of Tank Two, Tank Three, and Tank Four (see Figure 2.1). The difference in the amount of damage done by predation and disease spread is insignificant, and the amount of damage done by both is greater than the damage done without predation or disease.

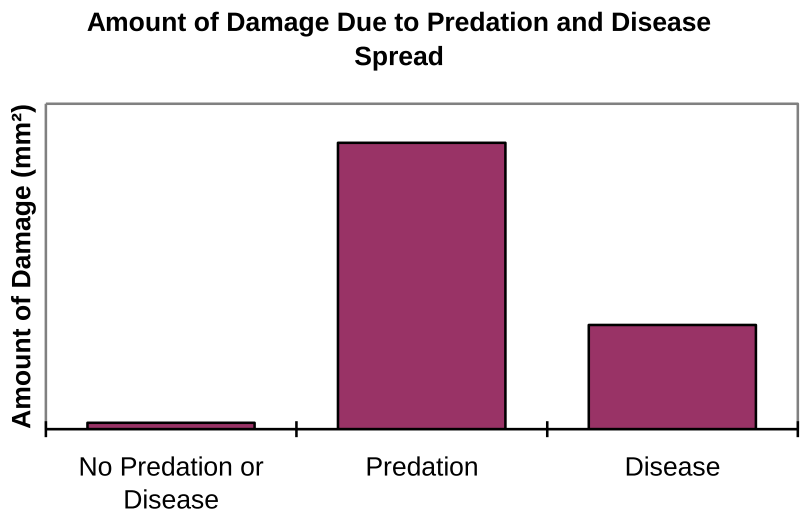

Figure 3.3: A graph showing the amount of damage to the coral in the treatments of Tank Two, Tank Three, and Tank Four (see Figure 2.1). The amount of damage done by predation is greater than the amount of damage done by disease, which is greater than the amount of damage done without predation or disease.

If the results were to confirm the second critical prediction, they would be represented by Figure 4.1.

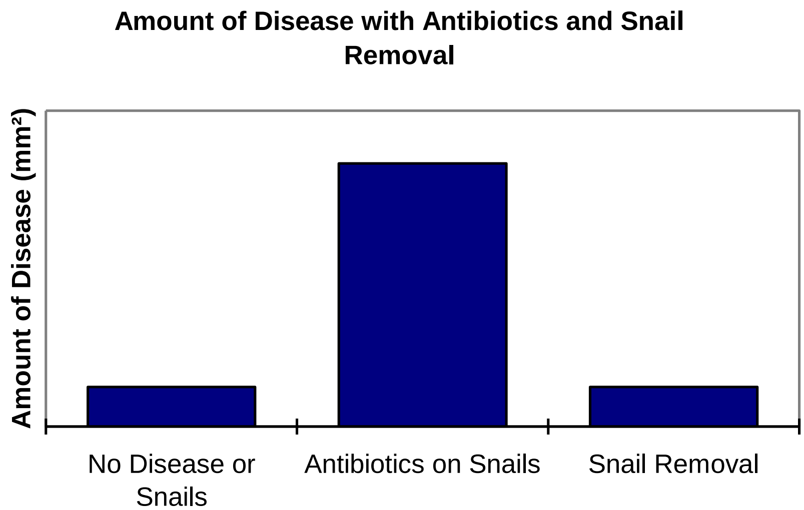

Figure 4.1: A graph showing the amount of disease on the coral in the treatments of Tank Two, Tank Five and Tank Six (see Figure 2.1). The amount of disease is higher in the application of antibiotics to the snails than the amount of disease in the removal of the snails, which is higher than the amount of disease in the control without disease, antibiotics, or snails introduced.

However, if the results did not confirm the critical prediction, they would be represented by Figure 4.2 or Figure 4.3.

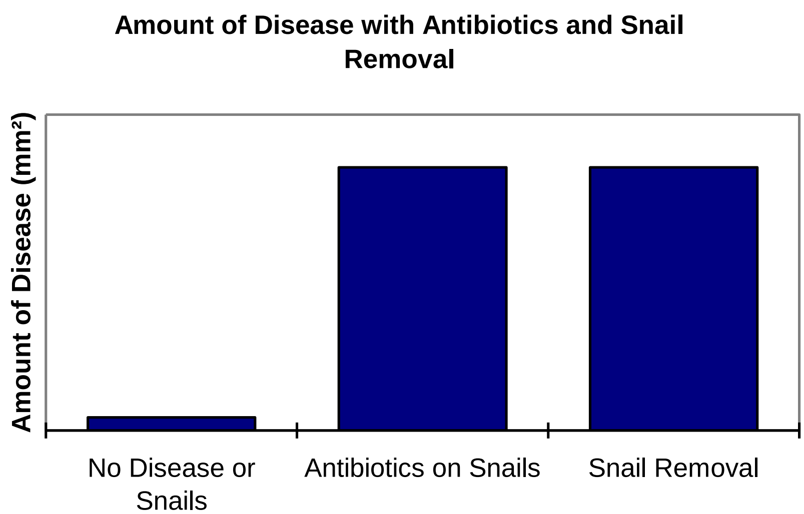

Figure 4.2: A graph showing the amount of disease on the coral in the treatments of Tank Two, Tank Five and Tank Six (see Figure 2.1). The difference in the amount of disease with the antibiotics on the snails and the amount of disease with the snail removal is insignificant, and they are both higher than the amount of disease in the control without disease, antibiotics, or snails introduced.

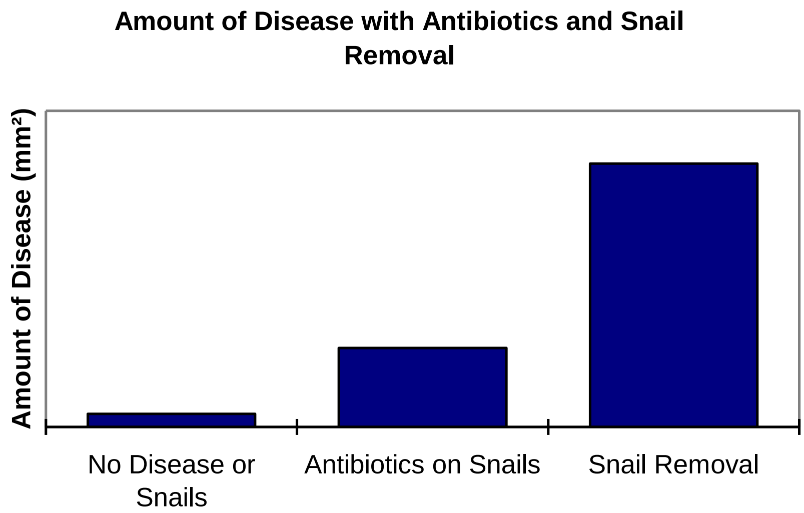

Figure 4.3: A graph showing the amount of disease on the coral in the treatments of Tank Two, Tank Five and Tank Six (see Figure 2.1). The amount of disease with antibiotics on the snails is lower than the amount of disease with the snail removal, and they are both higher than the amount of disease in the control without disease, antibiotics, or snails introduced.

V. Significance: It is important to know which effect *C. abbreviata* has on *A. cervicornis* is more damaging because once the more damaging effect is determined, future conservation efforts can focus on ways to control it. It is also important to know whether a removal of the snails or a removal of the disease from the snails is a more effective method of controlling the spread of white band disease because once the more effective method is determined, further research can determine the best way to administer it. If this research proposal is granted, the results from this experiment could be significant in solving the problems of the staghorn coral because they will expand our knowledge of the relationship between the snail and the coral. The results of this experiment could expand our knowledge of this relationship even further because they help set up questions for future research. One possibility for future research is in finding what species prey on the snail and how the population sizes of the snail's predators affects the population size of the staghorn coral. Another research possibility is determining how long it takes for the snail to contract WBD from a diseased coral compared to how long it takes for the snail to transmit WBD to a healthy coral, and also how much damage it can do by feeding on the coral in that time period. Once there is a better understanding of the snail and coral relationship, a method can be discovered to help the staghorn coral better survive. Then there can be even further research to help solve the problems of other types of coral since an understanding of the conservation of the staghorn broadens our understanding of conservation of coral in general. This experiment is able to broaden our understanding of coral in general because it focuses on two of the most harmful factors that all corals face: predation and disease. If future research can help eliminate or even decrease the effects of predation and disease, it would greatly increase the overall health of the corals, and thus, help conserve their diversity. Once that is done, conservation efforts can focus on the other factors that are harmful to corals, such as increases in temperature, UV radiation, pH, salinity, and nutrient levels. By improving the health of coral on a small scale, the health and diversity of communities can be also conserved because there are many other species that rely on coral. If the health and diversity of communities can be maintained, then perhaps biodiversity can be improved or maintained on much larger scales, such as ecosystems. Therefore, since the experiment focuses on conserving a species that interacts with and is relied on by many others, it not only helps conserve the staghorn coral, but also contributes to our understanding of conserving biodiversity in general.

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