Predation on Microbivalves in Graham’s Harbor, San Salvador Island, The Bahamas

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Introduction

The Pliocene-Pleistocene boundary was responsible for the loss of ~70% of the carnivorous snails in the Atlantic-Gulf Coast region (Allmon et al., 1993). These predatory snails, Moon Snails, drill holes into microbivalve shells with their radula to eat the muscles within. A loss of carnivorous snails should be reflected in the occurrence of predation on bivalves (Merges, 2018). The boundary resulted in massive variation in the predation levels ranging from 0-24% predation. It is unclear if the predation variation is a result of a mass extinction event or from a facies change. There has been sufficient evidence of predation rates changing based on modern locality and facies in southeastern North Carolina (Grant et al., 2014). This project aims to analyze evidence of predation in microbivalves sampled from twelve different localities in Graham’s Harbor, one at French Bay, and one at Victoria Hill to determine if there is predation variation between facies as compared to an extinction event. Microbivalves were chosen to be studied because they are easier to collect and reflect the entire population. It is hypothesized that there is a difference in the percentage of predation based on locality and facies in San Salvador Island, The Bahamas. Samples of microbivalves were collected from the sand from two different environments across San Salvador Island - sand flats and grass flats - across fourteen locations along the perimeter of the island.

Geologic Setting

Fourteen samples were collected from three locations along the shoreline of San Salvador Island; Graham’s Harbor, Victoria Hill, and French Bay (Figure 1). Each sample location was approximately four meters water depth. Within the three locations, two facies were identified; sand flats and grass flats. Sand flats are areas of unconsolidated sand in sediment in the lower intertidal region (Figure 2). It is subject to constant change due to the waves and currents. Grass flats are manatee and turtle grass held in the sand by rhizomes and roots to prevent them from being carried away by strong currents (Figure 2). Small and juvenile species live in this habitat due to the lack of large predators and a diversity of species.

Figure 1. Satellite image of San Salvador Island in The Bahamas. Locations of study are Graham's Harbor, Victoria Hill, and French Bay.

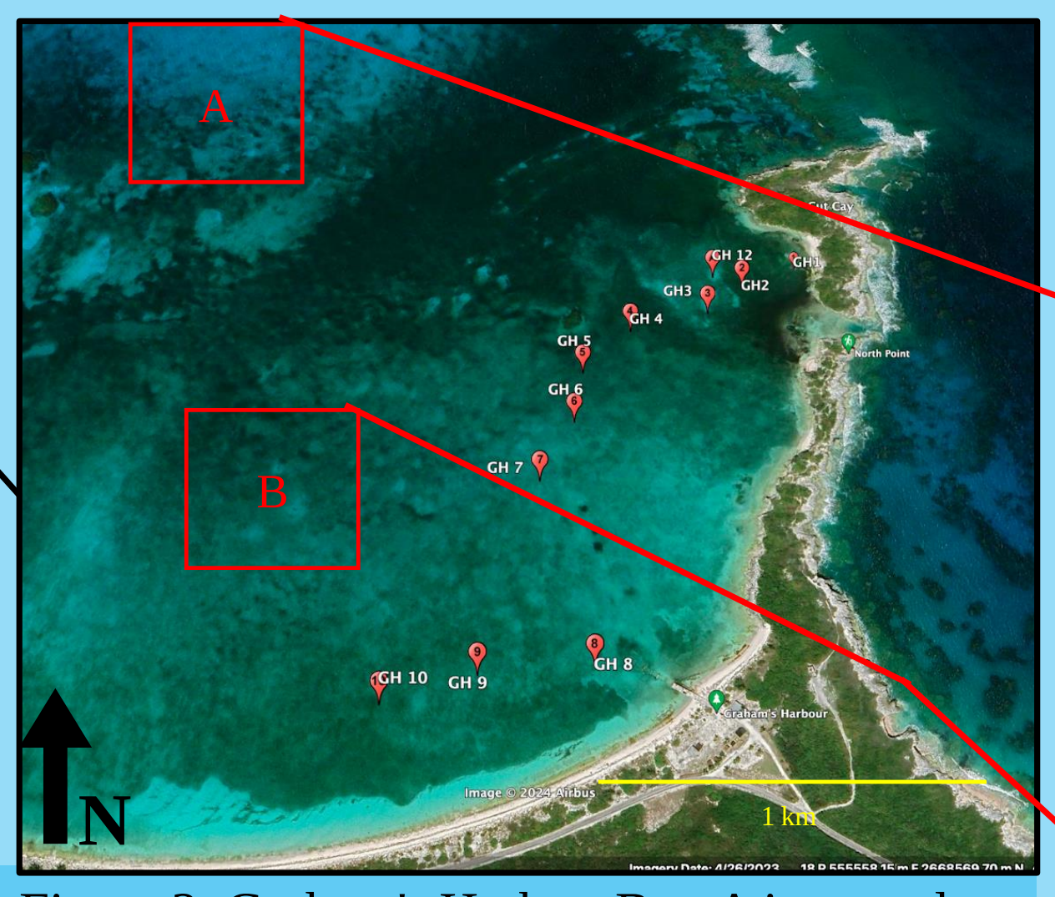
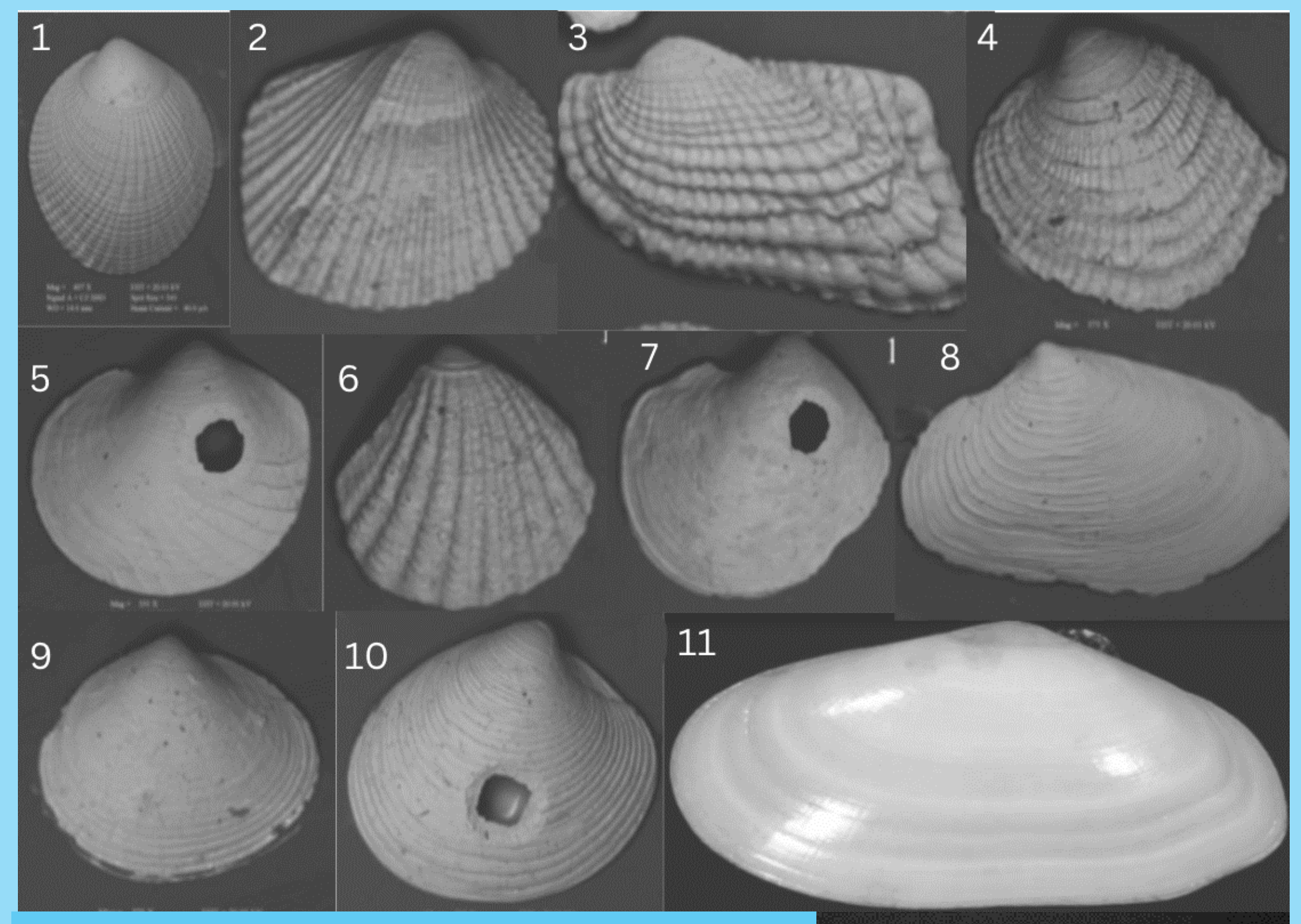


Figure 2. Graham's Harbor. Box A is a sand flat facies and Box B is a grass flat facies. This is reflective of the general vegetation cover in these areas. The grass flat has grass covering the surface which absorbs sunlight and darkens the appearance. The sand flat has sand covering the surface and little to no vegetation, this reflects more sunlight appearing lighter in color. The labeled points are the locations in Grahams Harbor where samples GH-1 though GH-12 were taken.

Methods

Sand was collected from the localities by diving and gathering approximately 300-500 grams of sand using a cup (Figure 3). This would ensure that at least 30 microbivalves were present in each sample. In the lab, the samples were cleaned and organized. They were then run through a 0.125 millimeter sieve to separate any particles that were too big or to consider as microbivalves (Figures 4 and 5). Using a microscope, any microbivalves that were detected were then removed from the sample and glued to a slide. There was one slide per locality and at least 30 (average of 31) micobivalves were taken and used from each sample. Once secured on the slides, the microbivalves were identified and recorded. Recorded information included the species (Figure 6), whether the specimen was the right or left valve of the original organism (or both, in some cases), and whether the microbivalve had drill holes in it (evidence of predation). The numbers of the percent of microbivalves that were drilled were used to calculate the chi-square value to determine if the predation observed is as expected from site to site.



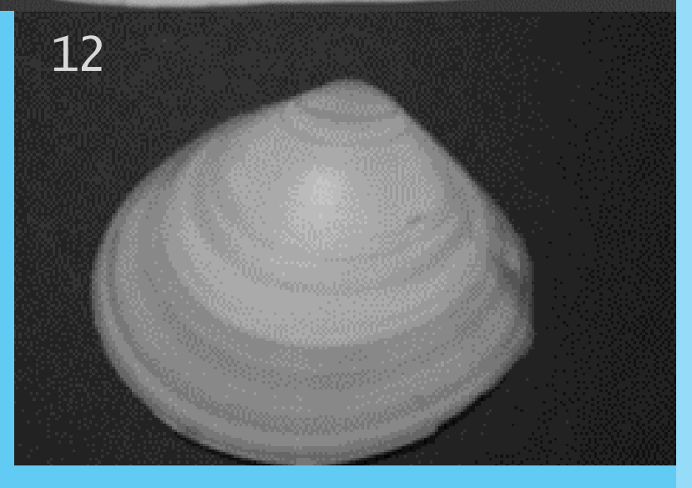


Figure 6. Species of microbivalves found in the samples. 1 - Rough Lima (*Lima scabra*), 2 - Eared Ark (*Anadara notabilis*), 3 - Red-Brown Ark (*Barbatia cancellaria*), 4 - Cross-Barred Venus (*Chione cancellata*), 5 - Cross-Hatched Leucine Clam (*Divalinga quadrisulcata*), 6 - Comb Bittersweet (*Glycymeris pectinata*), 7 - Great White Leucine (*Codakia orbicularis*), 8 - Bean-Like Tellin (*Fabulina fabula*), 9 - Pennsylvania lucia (*Linga pensylvanica*), 10 - Princess Venus (*Periglypta listeri*), 11 - Tellin Clam (*Tellina unimaculata*), 12 - Favored Tellin (*Tellina fausta*). Numbers 5, 7, and 10 have drill holes (evidence of predation).

Results

To understand and interpret the data collected, a chi-squared test and a t-test had to be run. The null hypothesis for the t-test was that there is no significant difference between the difference in predation as facies change. The calculated t-value for the t-test was 0.83. This was determined by using the percent of microbivalves drilled at each location, a degree of freedom of 12, and a significance level of $\alpha = 0.10$. The p-value came out to be 0.42 which is less than the significance level, 0.10. This would normally mean that the null hypothesis fails to be rejected. However, the critical value, 1.4, is higher than the t-value, 0.83. This means that the null hypothesis is rejected. The t-value is a more accurate and reliable calculation so it will be used for inferences. For the chi-squared test, a significance level of $\alpha = 0.05$ was used and the x^2 value came out to 32.0. The degree of freedom was 13 and the p-value was 0.002. With a p-value this low, lower than the significance level, the results are significant, and the null hypothesis is rejected.

In regards to the data collected, there did not appear to be a significant difference between the predation in the grass flats compared to the predation in the sand flats. However, once the calculations were done, there was a significant difference. There was a potential outlier in the Victoria Hill sample, with a higher percent drilled than all the other locations (21.9%), which increased the average of percent drilled in the sand flat samples (to 11.6%). Disregarding this sample datum brought it down (to 9.6%) to almost exactly the grass flat average of percent drilled, which is 9.2%.

Figure 3: Sarah collecting sample GH-12 from a sand flat in Grahams Harbor using a cup.

Figure 4: Sample being rinsed through a 0.125 mm sieve to remove all organic matter and sea water.

Figure 5: Microscope view of a sand sample. The first 30 bivalves found in the sample were collected for analysis. A bivalve in the image is indicated by a red circle.

Discussion

There is a difference between the percent predation in grass flat facies compared to sand flat facies. On average more predation on microbivalves by carnivorous snails occurs in the sand flats compared to in the grass flats. This is theorized to be because there are fewer places for the microbivalves to hide and perhaps an increased predatory gastropod population in the sand flats. Also, with the chi-squared and t-test results where the null hypothesis was rejected, the data does support a significant difference between the percent predation in the grass flats and the sand flats. In addition to observing the amount of predation per locality and facies, the different species and drilled frequency were also examined. The most preyed upon species, number of bored microbivalves compared to the number of that species recorded in each sample, were the Cross-Hatched Leucine Clam and the Favored Tellin (33% and 29% bored, respectively). This could be because their shells are weaker or perhaps their defense mechanisms are not as efficient as other microbivalves. Regardless, they were preferred by carnivorous snails. There does not seem to be a preference for the right or left valve, probably because they have the same structure and are symmetrical, therefore offering the same opportunity for hole drilling. A total of 436 microbivalves were sampled. This gives a confidence interval greater than 95%. Further supporting that this change is not due to a mass extinction between the Pliocene-Pleistocene boundary but could be explained by facies differences.

Table 1. Summary of the data collected. The clam number and common name correspond to the number and name in Figure 6. The number of each species in the grass and sand flats. Then the total number or microbivalves found. Listed both are the total number of each species and the total number of microbivalves found from every sample. The percentages show the relative amounts and act as representatives for the entire population of each species. They show if right or left valves are preferred by predators to bore through. Then the total number of microbivalves that had drill holes in them per species and the percentage of each species that were bored. Number 13, named “Unknown”, is the category that any unidentifiable or unknown species that were observed were placed.

Clam #/ Common Name	Number from Grass Flats	Number from Sand Flats	Total Number	Percent Total (%)	Percent Left (%)	Percent Right (%)	Percent Both (%)	Number Bored	Percent Bored (%)
1- Rough Lima	107	56	163	37	54	43	3	6	4
2- Eared Ark	11	17	28	6	32	61	7	3	11
3- Red- Brown Ark	4	29	33	8	52	45	3	0	0
4- Cross- Barred Venus	12	7	19	4	42	42	16	0	0
5- Cross- Hatched Leucine Clam	2	4	6	1	67	33	0	2	33
6- Comb Bittersweet	11	1	12	2	50	40	10	0	0
7- Great White Leucine	9	2	11	3	64	36	0	2	18
8- Bean- Like Tellin	14	17	31	7	55	45	0	3	10
9- Pennsyvania Lucia	46	26	72	17	44	53	3	10	14
10- Princess Venus	22	21	43	10	63	37	0	8	19
11- Tellin Clam	4	4	8	2	63	38	13	0	0
12- Favored Tellin	3	4	7	2	71	29	0	2	29
13- Unknown	3	0	3	1	0	100	0	0	0
AVERAGE	-	-	-	8	47	46	4	-	11
TOTAL	248	188	436	-	-	-	-	36	-

References

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