# The Association of Urchin Density and Phytoplankton Abundance at Rodney's Rock and Champagne Bay, Dominica

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## Abstract

The density of phytoplankton was analyzed from several high and low urchin density areas in both Champagne Bay and Rodney's Rock, Dominica. Observations were made of the types, abundance, and degree of pigmentation of the specimens collected. The microorganisms were divided into broad categories: single filamentous algae with clear pigmentation, single filamentous algae with faint to no pigmentation, algae on sand particles, branching algae, and other. There was a strong association of urchin density and the density of single filamentous algae at each site. I also found that an increase in clearly pigmented algae was correlated with increased local urchin populations. There was an association with "other" types of algae between high and low-density sites and also between Champagne Bay and Rodney's Rock. The capacity of my experiment did not allow the analysis of the biological significance of relation of this category to urchin density.

## Introduction

Four species of urchins are commonly found along the reefs of Dominica: *Diadema antillarum*, *Echinometra lucunter lucunter*, *Tripneustes ventricosus*, and *Eucidaris tribuoides* (Felix et al., 2004). These urchins feed on macro and micro algae and detritus by using their spines and tube feet to collect particles in the water column. In 2004, the Felix et al. group from Texas A&M University Study Abroad conducted a study on urchin densities at Rodney's Rock and Champagne Bay, Dominica, and suggested that urchin density may be related to algae density. They stated that urchins prefer to be in " . . . close proximity to their food source . . . (Felix et al., 2004)." Urchins are known to be selective feeders and must balance preferential feeding with algal availability (Vadas, 1977). This study focuses on the association between urchin density and phytoplankton density in the water column. Collections were gathered from both Rodney's Rock and Champagne Bay in order to more accurately examine if there is, in fact, a correlation between the density of local urchin populations and phytoplankton.

## Methods and Materials

For sampling at Rodney's Rock and Champagne Bay, I used a plankton net that funneled specimens into a small rubber hose that could be closed with a small plastic hose clamp. I placed a rock in the bottom for added weight underwater. I then placed the plankton net in a zip lock bag and carried it with me to each testing site. For collecting and preserving specimens, I used Corning 50 mL plastic test tubes. Each one was individually labeled as either high density or low density and a letter– A, B, C– according to collection sequence.

First, I identified an area of high density, classified as at least seven urchins in close proximity to one another, and swept the plankton net over the rock above the urchins exactly three times. The net was then placed in the zip lock bag and brought back to shore. I emptied the net into a test tube and rinsed with marine water that was collected before sampling, away from either test site, to avoid bias. I repeated this process two more times over the high-density area for a total of three collections. After each test tube was filled, they were placed in a cool, dark place to halt any primary productivity that could potentially affect results. After the high density samples were complete, I identified an area of low urchin density, preferably on a similar size rock, with at least one but no more than three urchins that appeared more spread out on the rock surface. The same process was used to sweep and collect plankton for a total of three samples.

All samples were transported back to the lab and immediately looked at under a Spencer compound microscope at 10X and 43X magnifications. In the lab I prepared at least 25 slides per test area; observations were illustrated and described in my journal. I then classified each specimen as occurring rarely, occasionally, commonly, or abundantly. When I viewed the slides from the second collections at Champagne Bay and Rodney's Rock, I conducted counts of a slide (chosen at random before it was viewed) from each test tube A, B, and C. I divided the specimens into broad categories and tallied the number per category viewed under the microscope. Categories may be viewed in the Results section in Table 1. I started at one edge of the slide and brought the slide directly across the scope until reaching the other side of the slide. All specimens that passed the view of the scope were recorded. After collecting from each beach one time, I conducted water quality tests for nitrates, nitrites, and phosphorus. There were no significant differences in the results between Rodney's Rock and Champagne Bay, so I discontinued water quality tests.

## Results

The most abundant algal type in all areas was an alga that clung to sand particles on the rocks and urchins. There was a slight trend of decrease in abundance of these algae from high density to low density with this algal type, however no significant difference was found (Table 4). Branching algae had no trend from high to low urchin density at either site. The second most abundant type of microorganisms in both high-density areas consisted of representatives of the Chlorophyta (Table 2;Littler et al., 1989). These were single filamentous algae with a clear to light green membrane and clearly pigmented green cells inside (Fig. 1). Some strands could be seen without the aid of a microscope and reached up to 33mm in length.

The variety of microorganisms that were seen in the slides from high-density areas at Rodney's Rock and Champagne Bay also included representatives of the Chrysophyta, Rhodophyta, and

Cyanophyta (Fig. 2- 4), as described in Littler et al. (1989). These organisms composed the "other categories." There was a slight trend in decline between high and low density sites at Rodney's Rock with the "other" category of algae; the trend at Champagne Bay was much stronger (Table 5). The "other" category contained a variety of organisms that could not be identified; therefore, it is difficult to interpret the trend of these organisms with urchin density between high and low-density sites. Table 1 shows the averages of certain types of phytoplankton and their abundance in high-density areas.

Representatives of the Chlorophyta were the second most abundant type of algae present in both low- density areas (Table 3, Littler et al., 1989). This resembled the most abundant algae of the high-density areas, but with faint to no pigmentation (Fig 5). Members of the Chrysophyta and Cyanophyta were also found in low-density areas at both Champagne Bay and Rodney’s Rock (Fig 6- 7). Table 1 shows the averages of certain types of phytoplankton and their abundance in low-density areas.

**Fig. 1 Chlorophyta common in High Density Areas.**

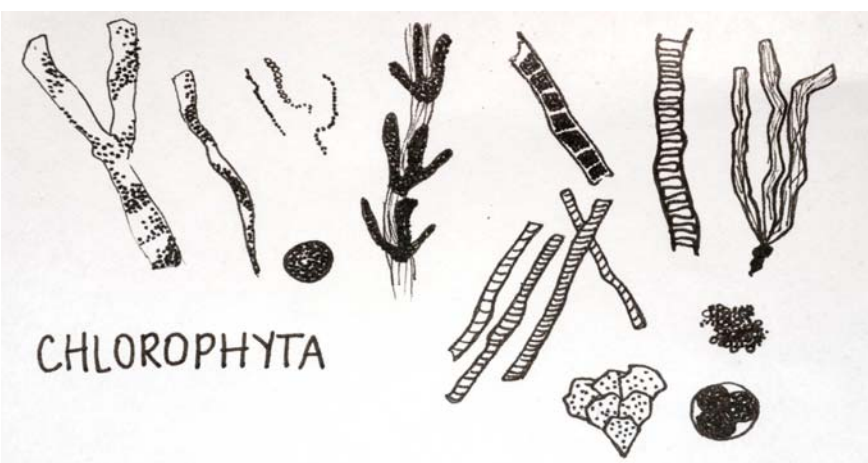

**Fig. 2 Chrysophyta common in High Density Areas**.

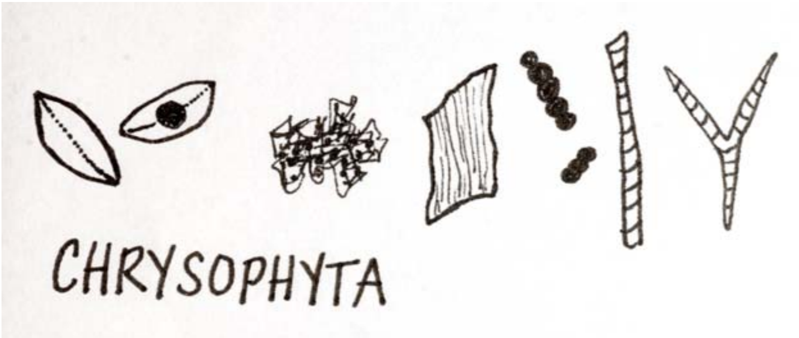


**Fig. 3 Cyanophyta common in High Density Areas.**


**Fig. 4 Rhodophyta common in High Density Areas**.

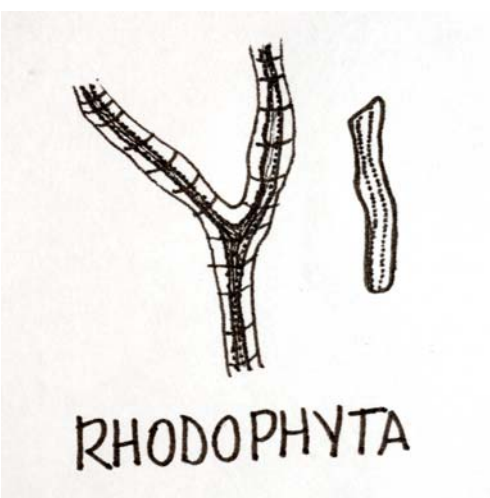

**Fig. 5 Chlorophyta common in Low Density Areas**.

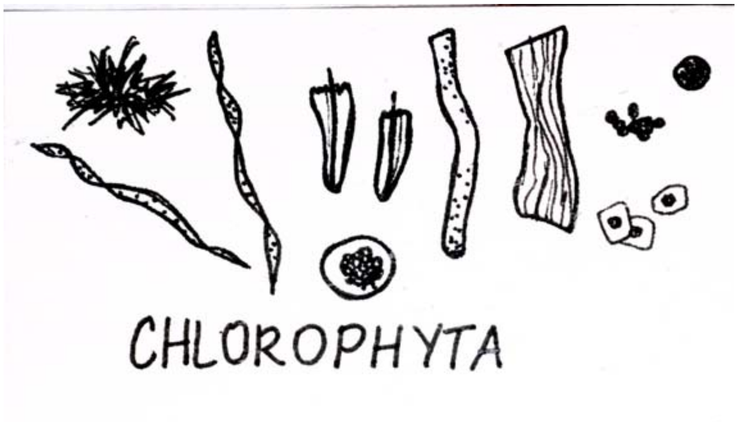


**Fig. 6 Chrysophyta common in Low Density Areas**.


**Fig. 7 Cyanophyta common in Low Density Areas**.

**Table 1. Mean Number of Phytoplankton in High and Low Density Samples from Rodney's Rock and Champagne Bay (n=3).**

| | Single Filament; Chloroplasts Pigmented | Single Filament; Chloroplasts with Faint to No Pimentation | Algae on Sand Particles | Branching Algae | Other |
|---|---|---|---|---|---|
| Champagne Bay High Density | 32.3 | 10.6 | 42 | 3 | 13.3 |
| Champagne Bay Low Density | 2.6 | 6.3 | 30.6 | 2.3 | 3.3 |
| Rodney's Rock High Density | 35.6 | 2.6 | 60 | 2 | 4.3 |
| Rodney's Rock Low Density | 5.3 | 12.3 | 39.6 | 0.3 | 3.6 |

**Table 2. Two-way analysis of variance of Single Filamentous Algae with Highly Pigmented Chloroplasts**.

**Tests of Between-Subjects Effects**

Dependent Variable: SFAWC

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 2727.333[a] | 3 | 909.111 | 11.388 | .003 |
| Intercept | 4332.000 | 1 | 4332.000 | 54.263 | .000 |
| SITE | 27.000 | 1 | 27.000 | .338 | .577 |
| DENSITY | 2700.000 | 1 | 2700.000 | 33.820 | .000 |
| SITE * DENSITY | .333 | 1 | .333 | .004 | .950 |
| Error | 638.667 | 8 | 79.833 | | |
| Total | 7698.000 | 12 | | | |
| Corrected Total | 3366.000 | 11 | | | |

a. R Squared = .810 (Adjusted R Squared = .739)

**Table 3. Two-way analysis of variance of Single Filamentous Algae With Faint to No Chloroplasts.**

**Tests of Between-Subjects Effects**

Dependent Variable: SFAWOC

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 171.333[a] | 3 | 57.111 | 4.204 | .046 |
| Intercept | 768.000 | 1 | 768.000 | 56.540 | .000 |
| SITE | 3.000 | 1 | 3.000 | .221 | .651 |
| DENSITY | 21.333 | 1 | 21.333 | 1.571 | .246 |
| SITE * DENSITY | 147.000 | 1 | 147.000 | 10.822 | .011 |
| Error | 108.667 | 8 | 13.583 | | |
| Total | 1048.000 | 12 | | | |
| Corrected Total | 280.000 | 11 | | | |

a. R Squared = .612 (Adjusted R Squared = .466)

**Table 4. Two-way analysis of variance of Algae on Sand Particles.**

**Tests of Between-Subjects Effects**

Dependent Variable: AOS

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 1366.667[a] | 3 | 455.556 | 2.484 | .135 |
| Intercept | 22188.000 | 1 | 22188.000 | 120.970 | .000 |
| SITE | 533.333 | 1 | 533.333 | 2.908 | .127 |
| DENSITY | 768.000 | 1 | 768.000 | 4.187 | .075 |
| SITE * DENSITY | 65.333 | 1 | 65.333 | .356 | .567 |
| Error | 1467.333 | 8 | 183.417 | | |
| Total | 25022.000 | 12 | | | |
| Corrected Total | 2834.000 | 11 | | | |

a. R Squared = .482 (Adjusted R Squared = .288)

**Table 5. Two-way analysis of variance of "Other" Algae.**

**Tests of Between-Subjects Effects**

Dependent Variable: O

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 207.000[a] | 3 | 69.000 | 6.677 | .014 |
| Intercept | 456.333 | 1 | 456.333 | 44.161 | .000 |
| SITE | 56.333 | 1 | 56.333 | 5.452 | .048 |
| DENSITY | 85.333 | 1 | 85.333 | 8.258 | .021 |
| SITE * DENSITY | 65.333 | 1 | 65.333 | 6.323 | .036 |
| Error | 82.667 | 8 | 10.333 | | |
| Total | 746.000 | 12 | | | |
| Corrected Total | 289.667 | 11 | | | |

a. R Squared = .715 (Adjusted R Squared = .608)

## Discussion

The specimens viewed from high-density slides were overall more numerous and more diverse than the low density slides. Filamentous algae with clear pigmentation were 12 times more abundant in Champagne Bay and 6 times more abundant at Rodney's Rock. This greater abundance of phytoplankton in high-density areas might be associated with why urchin density was greater in these areas. Since the high and low-density areas were at similar depths, the local abundance of phytoplankton may be associated with small-scale increases in urchin populations. Since urchins are selective feeders (Vadas, 1977), they may inhabit areas where photosynthetic productivity is higher, increasing chances of a more varied diet. A higher amount of clearly pigmented algae and greater diversity of microorganisms in the water column may indicate this increase in productivity. The trend with "other" types of algae does have a significance interaction between sites and density, with the abundance of algae declining more quickly at Champagne Bay than Rodney's Rock. It was not possible to evaluate the biological meaning of this category because the specimens could not be identified.

## Acknowledgments

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