Effect of Intertidal Height on Basal Diameter of *Balanus glandula*

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Abstract

This study explores the relationships between abiotic and biotic factors within the intertidal and how they influence the size and composition of its inhabitants. Barnacles are often studied in intertidal environments because of their prevalence and the role they play in the lives of other intertidal organisms. The basal diameter sizes of the barnacle *Balanus glandula* were compared between the low, mid, and high intertidal heights of the Vancouver, BC shoreline in October 2020. These three intertidal heights vary significantly with the presence of certain abiotic and biotic factors that the organisms which live there are exposed to; and their effect on *B. glandula* diameter was analyzed. No differences were found in the sizes of the barnacles from each height of the intertidal, however, this may have been due to a few different causes. A more thorough exploration of the relationship between intertidal height and barnacle size could lead to interesting insights about the effects of predation, competition, weather, or desiccation on the barnacle life cycle and growth rates.

Introduction

The intertidal zone of any marine coast is defined as the area which is underwater at high tide and exposed to the air during low tide. The three sections of the intertidal zone include the high intertidal: covered at the peaks of daily high tides but remains dry for long stretches of time; the mid-intertidal: the largest of the three zones over which the tide ebbs and flows twice a day;

and the low intertidal: normally remains underwater except at the lowest of low tides a few times a month (NOAA, 2020). The intertidal zone in the Vancouver area of British Columbia, Canada ranges from 0 m to ~5.2 m in the winter, which was when this study was performed. The low intertidal ranges from 0-1.4 m, the mid-intertidal from 1.5-3.4 m, and the high intertidal from 3.5-5.2 m (these are all vertical heights). Organisms that live in the intertidal are essential to the understanding that we have about the ocean. Since intertidal organisms are exposed to both marine and aerial conditions, they can give insight into both environments. These extreme ranges of conditions that intertidal animals and algae are exposed to, especially when uncovered from the water, means that they have to be quite robust, making them even more interesting to study. Each intertidal zone (low, mid, and high) has a slightly different organismal composition due to these ranging conditions within this small zone of the shoreline.

One of the most common animals in any intertidal area tend to be barnacles, which have the added hardship of being sessile and unable to move to more favorable conditions when the tides change. The distribution, abundance, recruitment, and size of intertidal barnacles is influenced by predation, interspecific & intraspecific competition (Rashidul Alam & Noda, 2016), and abiotic factors such as temperature, wave action, and weather (Scrosati, 2020). *Balanus glandula*, more commonly known as the acorn barnacle, is the most common species of barnacle found along the Vancouver shorelines (Walton, Donohue, Wang, & Li, 2019). The high abundance of this species makes it ideal for analyzing intertidal conditions and how those affect different factors of the barnacle's life cycle.

This study explored the relationship between the size of *B. glandula* and the different abiotic and biotic factors within each intertidal zone. Basal plate diameter was used as a proxy for size and barnacle measurements were taken from each of the three intertidal zones. I hypothesized that if there is a high rate of biotic disturbance in the low intertidal and a high rate of abiotic disturbance in the high intertidal, then *B. glandula* will be able to grow to the largest size in the mid-intertidal. Although no significant differences were found between barnacle sizes and intertidal heights, further study could better indicate the relationship of barnacles with their different biotic and abiotic factors within the intertidal zones of Vancouver. This information can help further biological understanding of the intertidal zones of British Columbia and further comprehension of how closely its organisms interact with each other and with their environment.

Materials & Methods

Specimens of *Balanus glandula* were measured in the morning of October 19th, 2020 between midnight and 1 am near low tide (low tide was at 2:07 am with a height of 0.6 m) on the shores of Stanley Park in Vancouver, Canada (49.303°N, 123.127°W). The distance from the water's edge to the high tide mark was measured as 20.2 m. Low intertidal measurements were taken from barnacles on rocks found closest to the water's edge, mid-intertidal measurements were taken from barnacles on rocks about 8 meters up from the water's edge, and high intertidal measurements were taken from barnacles on rocks about 19.5 meters from the water's edge. A ruler was used to measure the basal plate diameter of each barnacle, if the plate was not circular, the longest length was measured.

At each intertidal height, eight rocks were selected randomly, approximately the same distance from the water, and five barnacles were measured on each rock. The five barnacles measured on each rock were also chosen randomly and this resulted in a total of 40 barnacle measurements from each intertidal zone. The distances from the water corresponded to tidal heights of about: low – 1 m, mid – 2.9 m, high – 4.8 m.

B. glandula basal plate measurements were entered into an excel sheet and converted to a csv file and uploaded into the statistical analysis program R. A one-way ANOVA was performed on the data then a Tukey post-hoc test was performed to determine the specific differences in measurements between each intertidal height.

Results

The basal diameter measurements were collected from the 40 barnacles at each intertidal height and the distribution of those measurements can be seen in Figure 1.

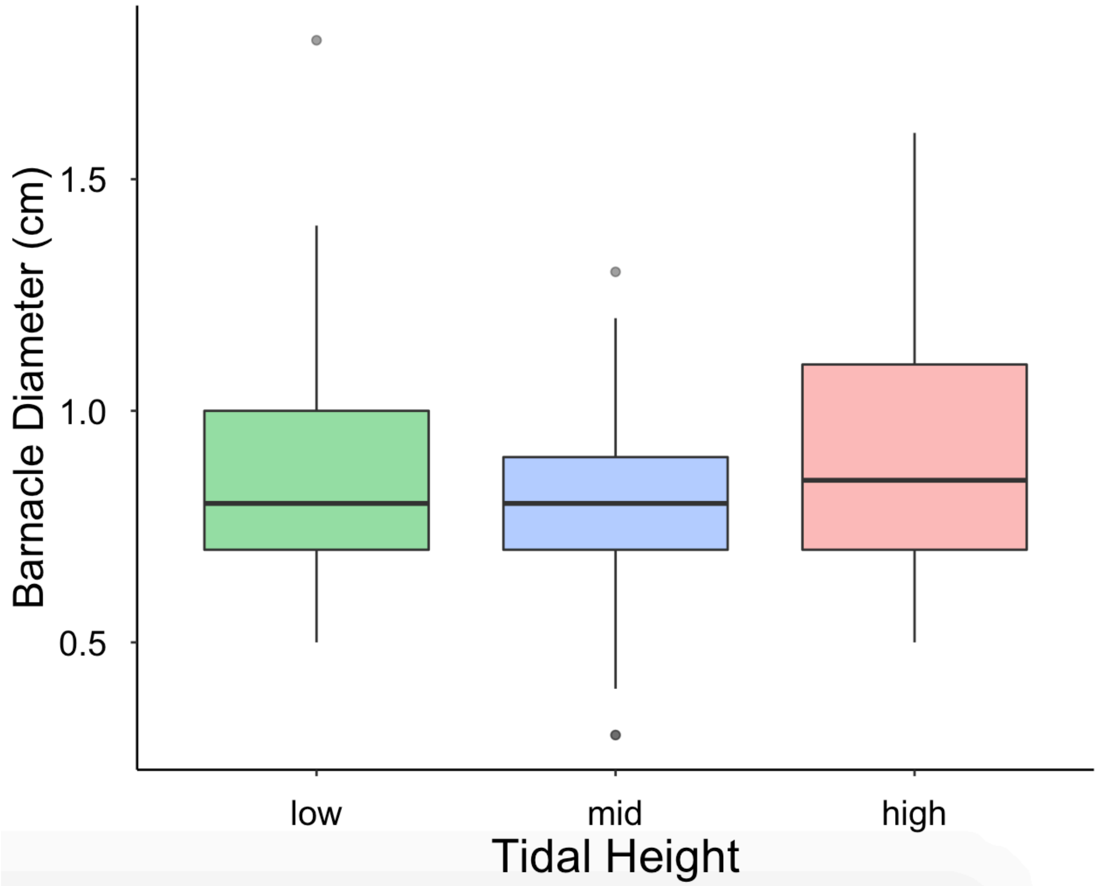

Figure 1. Boxplot distribution of barnacle basal plate diameters (in cm) across different intertidal heights (low, mid, & high). The median diameter for both low and mid intertidal is 0.8 cm and the median diameter of the high intertidal is 0.85 cm, shown by the bolded line of the boxes. Gray dots represent outlier data points.

The basal diameter ANOVA run in R gave a non-significant p-value ($p = 0.0846$; $\alpha \leq 0.05$) and the subsequent Tukey post-hoc test showed continued non-significant relationships between each of the pairings of intertidal heights (low & mid = 0.275; low & high = 0.797; mid & high = 0.078). In addition to the median diameter's being relatively the same between intertidal heights, the means and standard deviations were also similar (mean : standard deviation; low – 0.86 : 0.26; mid – 0.77 : 0.25; high – 0.895 : 0.28).

Discussion

There are a few possible reasons for why a significant difference in the basal diameter sizes of *Balanus glandula* were not seen between different heights of the intertidal. Firstly, I had noticed that the barnacles on rocks in the high intertidal were more spaced out from each other than those in the mid or low intertidal. Therefore, the barnacles may have all been approximately the same size because of different limiting factors at each intertidal height. In the high intertidal, barnacle growth could be limited by nutrients since they are able to feed less often than those animals at lower intertidal heights, as they are covered by water for less time. Whereas in the low or mid intertidal, there is more competition for space (Minchinton & Scheibling, 1993) causing barnacle growth to be limited by that lack of space to grow into.

Secondly, the results may not have been significant because I did not standardize the size of rock that I took the barnacle measurements from nor the area of the rock from which I measured the barnacles. Many of the low and high intertidal rocks on which I measured *B. glandula* were quite a bit smaller than the mid-intertidal rocks that I measured barnacles from. Additionally, I measured barnacles on rocks from the low and mid intertidal which were all in a patch together compared to the high intertidal where I measured barnacles that were from different sides of the rock. The difference in rock size and placement on the rock may have affected the basal diameter measurements because of potential differences in predation or wave exposure, skewing the sizes of the barnacles that I measured.

The last reason for which the barnacles might have all been approximately the same size is because of differences in growth rates and ages. At low tidal heights, barnacles grow more quickly and also get predated upon more quickly, causing them to not grow as large as they could without predation (Bertness, 1989). At high tidal heights, barnacles grow more slowly because they are predated upon less and have less consistent access to nutrients (Bertness, 1989). Therefore, the barnacles I measured at high intertidal heights may have been older than those at lower intertidal heights, causing their basal diameters to be more similar than if the age of the barnacle was accounted for. This would have been difficult to do though without tracking the growth of the barnacles starting from their larval stage up until adulthood.

Further research could be explored with a larger sample size across the three intertidal zones and a starker difference might be observed if barnacle size was not only compared at one location, but multiple intertidal areas around the Vancouver shoreline. This was done by Scrosati (2020) on the east coast of Canada with a closely related species of barnacle *Semibalanus balaoides*. He compared barnacle size between high and mid intertidal heights at several locations along the shores of Nova Scotia and found significant differences between the sizes, larger barnacles being found at mid-intertidal heights (Scrosati, 2020). This finding was attributed to abiotic extremes found in the high intertidal limiting growth rate and a higher food availability in the mid-intertidal leading to larger animals; these two conditions are also true for the intertidal zones of the west coast around Vancouver. Therefore, if this experiment was run again using quadrats and a larger sample size, a similar result to this east coast experiment would be expected.

Conclusion

This study explored the size differences of the intertidal barnacle *Balanus glandula* between the low, mid, and high intertidal heights at Stanley Park in Vancouver, BC. No difference was observed between the sizes of *B. glandula* at each intertidal height (Fig. 1) which may have been due to a number of factors. Further research relating to barnacle and other intertidal organism differences between sections of the intertidal will help to understand the complex relationships between abiotic marine and terrestrial conditions and the organisms that have to endure them.

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