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Relationship Between Canopy Location and Tensile Strength of Leaves of Heteromeles arbutifolia in Malibu, CA
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Abstract
Our hypothesis is that canopy location has an effect on the characteristic tensile strength of leaves, with the leaves on the top of the canopy having greater strength than those on the bottom. We tested our experiment by sampling leaves from the top and bottom of three H. arbutifolia specimens, obtaining raw measurements of size, and testing the tensile strength of each leaf using the Instron machine. We performed t-tests on the data to determine if the average length, width, thickness, and tensile strength were statistically different depending on if our p-values were <0.05 when top and bottom leaves of the same tree were compared. We chose a chapparal stand removed from heavy human traffic and influence, eliminating as many extraneous variables as possible by taking leaves from the same tree of the same age from the same position on the branch and chose three trial specimens of similar height in the same area to reduce the possibility of varying sunlight exposure or water supply from affecting leaf morphology in a way that canopy position would not. The results show that blade length between top and bottom is statistically significantly different, while blade thickness and lateral strength at midsection were not statistically different. From our analysis of the data, it is clear that leaves on the bottom of the plant were longer and broader than leaves on the top, but we determined that canopy location does not have a major effect on tensile strength or thickness, supporting a null hypothesis.

Introduction
It has been found that leaves exposed to sun and shade have unique morphological adaptations due to factors such as photosynthetic efficiency (Givnish 1988). With this in consideration, we speculated about whether these modifications would lead to a difference in tensile strength. In further refining our idea, we chose to see if this concept was applicable to leaves on the same plant. We chose to study the native chapparal Heteromeles arbutifolia, which would enable our findings to have an impact on the local level as well as be extrapolated to areas around the world that share the same Mediterranean-type climate. A better understanding of the distinctive alterations within a single plant assists in knowing how this plant will respond in times of stress—most notable is the summertime, when plants are subjected to water and heat stress (Nahal 1981). Findings show that leaves in the shade are adapted to have greater chloroplast and stomatal size in addition to having an increased thylakoid to grana ratio (Givnish 1988). Further, the venation of shade leaves has been shown to have a higher hydraulic resistance than leaves in the sun (Nardini et al. 2005). Due to this difference in structural make-up, we hypothesized that leaves gathered from the bottom of the plant (“shade” leaves) would have greater tensile strength than those collected from the canopy (“sun” leaves). To conduct experimental testing, we sought to gather 24 leaves (12 top, 12 bottom) from three individual H. arbutifolia plants located in the same stand on Pepperdine campus. Utilizing the Instron, we planned to then amass data on the mechanical strength of our samples and statistically analyze our findings to determine if a difference existed between leaves collected from the top and bottom.

Study Site
Specimens were collected from an isolated chapparal stand on Pepperdine Campus and data were collected in the Botany laboratory of Pepperdine University in Malibu, California in April of 2014.

Materials and Methods
Figure 1. (Left and right) Twelve leaf samples were each taken from the top and bottom of 3 different H. arbutifolia plants using hand clippers.
Figure 2. (Below) Leaf specimens were tested for tensile strength using the Instron machine in the Natural Science laboratory.
Figure 3. (Above) Digital calipers were used to determine thickness to the nearest mm at midrib, tip, and edge and then averages for each leaf were calculated.
Figure 4. (Above) Leaves were cut systematically into 25mm x 46mm sections along the midrib using razors and scissors.

We identified H. arbutifolia as the species for investigation and sampled 12 leaves from the topmost branch and the bottommost branch of three specimens of approximately the same height, taking the sixth youngest leaf from the tip of each branch. The leaves were collected at approximately 3 o’clock in the afternoon in a chapparal stand on a steep hill across from the soccer fields on Pepperdine University’s campus. The thickness, length, and tensile strength (lateral strength at midsection) of each leaf were tested using digital calipers, a metric ruler, and the Instron machine.

Results

Young’s Moduli of Top and Bottom Leaf Tensile Strengths

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Top Young’s Modulus (N/mm²)</th>
<th>Bottom Young’s Modulus (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.254x + 85.608</td>
<td>-0.774x + 81.19</td>
</tr>
</tbody>
</table>

Figure 5: Figure 5 shows a scatter plot of the data collected from the Instron machine, displaying the Young’s modulus of each leaf as a function of position. The similar slopes of the best fit lines as well as the statistical analysis of paired t-tests that show that t=0.3466 and p=7.304, therefore the top and bottom tensile strengths are not significantly different.

Conclusion
Our findings lead us to conclude that:
• Bottom leaves have greater blade length than top leaves.
• Bottom leaves are better adapted to shady environments with increased leaf length and size.
• Canopy location does not have a significant effect on the thickness or tensile strength of H. arbutifolia leaves.

It is possible that further observation and experimentation may support a definite relationship between leaf canopy position and water status.

Literature Cited

Acknowledgements
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