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Effect of Petiole-to-Branchlet Angle on Tensile Stress and Tensile Strength in Heteromeles arbutifolia

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Abstract

Heteromeles arbutifolia an important chaparral species of southern California, Is a food source for mule deer (*Odocoileus hemionus).* This predation has become more pronounced as the climate shifts to hotter, drier, and longer summers. Other species that the deer normally feed on cannot survive these harsh conditions, while *Heteromeles* arbutifolia is able to persevere.(Letourneau, 2004) We decided that there must be mechanisms involved in the petiole of leafs to keep them from being pulled off by deer and strong winds. Our group hypothesized that as the angle between the petiole and branchlet increased, the tensile strength of the petiole would decrease. Testing was completed on an Instron® tension tester to gather data about the petiole's strength. The subject of this experimentation was adult *Heteromeles arbutifolia* (Toyon) from the Pepperdine campus in Malibu, California.

By measuring both natural and anthropogenic angles we were unable to see any correlation between the angle and Modulus of strength. In future studies perhaps more samples would be able to tease out a trend unseen in the data points collected by our group. The petiole's resistance to pulling may also be more dependant on other evolutionary factors, such as petiole diameter and fibrous content.

Introduction

The leaf plays many important roles in the life of the plant including: photosynthesis, transpiration, heater emitter, etc. Chaparral, like *Heteromeles arbutifolia*, which is an evergreen chaparral species, rely on their leaves to maintain life and endure the hot, dry Mediterranean climate of the Santa Monica Mountains.(Ackerly, 2004) *H. arbutifolia* like other chaparral in the Santa Monica's are also susceptible to predation – from deer – and heavy winds – from the Santa Ana's or Costal tides. To reduce leaf shed, plants could possibly use a combination of the phytohormones: auxins, bibberellins, cytokinins, abscisic, and ethylene; by using these hormones in response to predation, wind or other factors reducing leaves.(Vosesenek, 1996) The Santa Ana winds are dry, north-easterly winds known to produce winds having speeds in excess of 25 knots, 46 kilometers/hour (Santa Ana, 2010).

It is apparent that the leaves play a key role in chaparral shrubs so they must have a complex system for conserving them, but what? Our lab group decided to investigate what role/roles the petiole plays in the retention of leaves, in particular how the leaf is able to resist damage from pulling either it be from predation or wind.

This study delves into the two matters of *H. arbutifolia* leaf physiology: 1) the Modulus (N/mm^2) of petioles at their natural angle and 2) the tensile strength of petioles at anthropogenic manipulated angles. When conducting research in preparation for this study our team was unable to find any information that references how petiole angles are related to predation or high wind factors, also we were unable to find how the petiole strength relates to general leaf retention. It was hypothesized as the angle between the petiole and the branch grows larger, when measured from the tip of the stem towards the axillary meristem, the tensile strength of the petiole will decrease.

Materials/Methods

Heteromeles arbutifolia leaves attached to branchlets were gathered from the population on Pepperdine campus in Malibu, CA for testing

Tensile testing was done on a Instron® Universal Testing Machine to gather data about the strength of the petiole

Figure 1. Modulus (Automatic Young's) (N/mm^2)

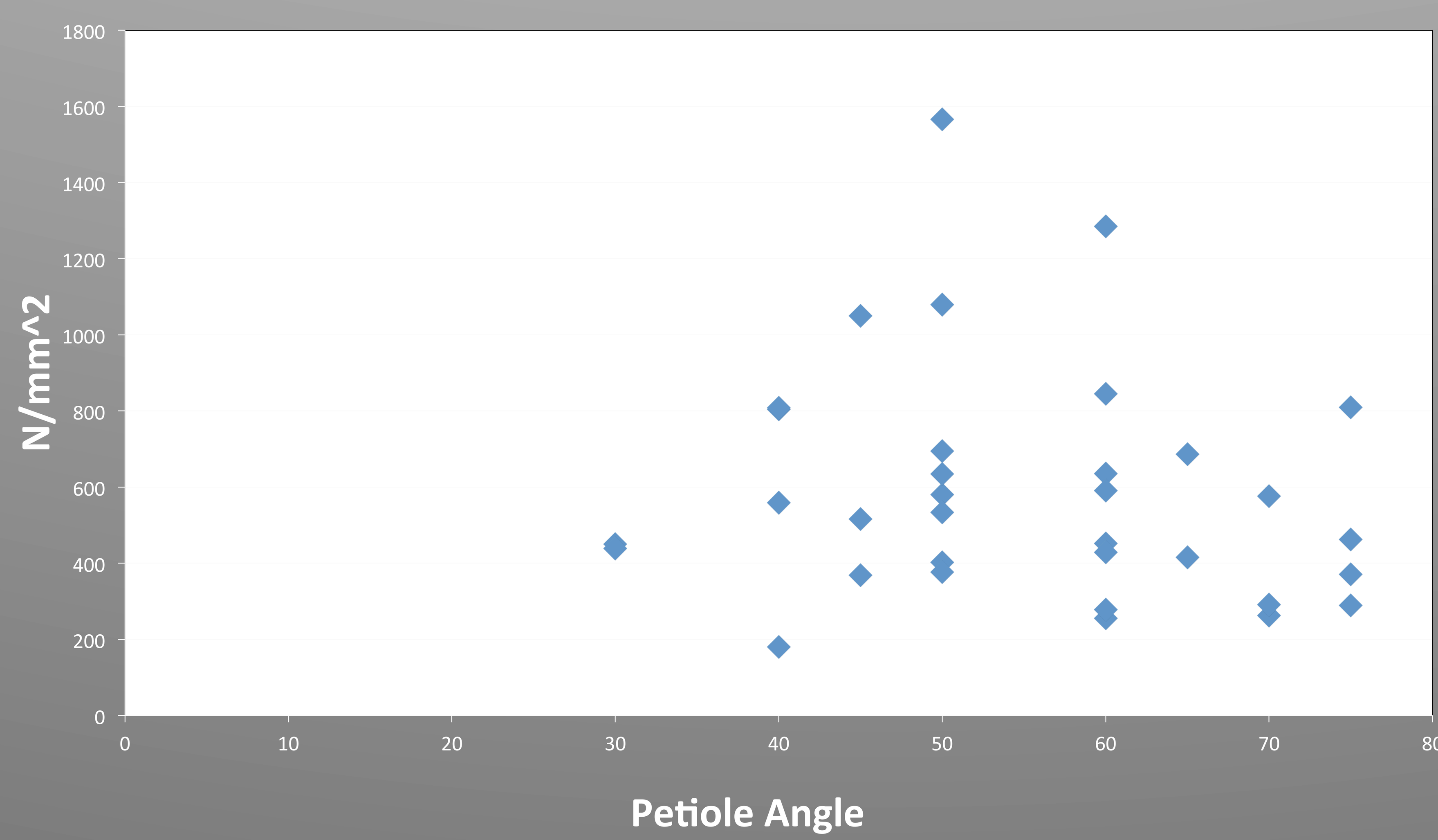

Figure 2. Instron® Tension-Tester

Figure 3. Mule Deer grazing on vegetation in southern California

Sample	Angle	Modulus (Automatic Young's) (N/mm^2)
1	75	462.35396
2	75	371.18509
3	75	288.82569
4	70	262.78065
5	60	452.37665
6	50	402.77133
7	40	180.44812
8	70	575.90199
9	60	255.937
10	60	278.34846
11	50	580.90979
12	30	450.3228
13	30	438.98103
14	70	291.24719
15	50	376.82662
16	40	804.17483
17	40	558.68859
18	45	1050.3024
19	50	694.8155
20	50	634.48664
21	60	845.68738
22	60	1285.03861
23	60	635.27396
24	45	368.88399
25	50	533.89985
26	75	809.8854
27	50	1079.45022
28	60	428.349
29	65	686.6037
30	65	415.23795
31	60	590.70832
32	40	808.63475
33	50	1565.69658
34	45	516.74067

Table 1. Young's Modulus of petiole in relation to the angle of the petiole

Data/Results/Discussion

The data collected from the 34 samples tested did not show any significant trends. This can be seen from the data displayed in Figure 1. This was simply one of the measurements that was gathered, but all of the graphs display the same random data, from which no trends can be teased.

From this data, it was determined that there is no correlation between the petiole-to-branchlet angle and the tensile strength of the petiole in *Heteromeles arbutifolia*. Our group still feels there may be some correlation, however our data does not support this. Perhaps the limitation in time and samples has something to do with no trends emerging. In an ideal future experiment, many more samples would be tested, preferably from a larger population. It is also possible that there is no correlation, as the data suggests, and the strength is derived from another factor, such as transverse area of the petiole, or fibrous composition in the petiole and branchlet.

Conclusion

The Modulus of an adult *Heteromeles arbutifolia* petiole varied between 180 – 1566 N/mm^2

The average transverse area of a *Heteromeles arbutifolia* petiole varied $1mm^2$- $5.94mm^2$

The natural angle of leaves on a *Heteromeles arbutifolia* varied between 30° - 75°, with 50° being the most abundant organic angle.

By measuring both natural and anthropogenic angles we were unable to see any correlation between the angle and Modulus of strength. In future studies perhaps more samples would be able to tease out a trend unseen in the data points collected by our group.

Additional studies could also be conducted to compare the difference in Modulus' of strength between organic angles and anthropogenic anlges.

n future studies measuring the modulus of plants that are being exposed to different environmental stresses might provide data exposing how petiole strength correlates to aforementioned environmental stresses.

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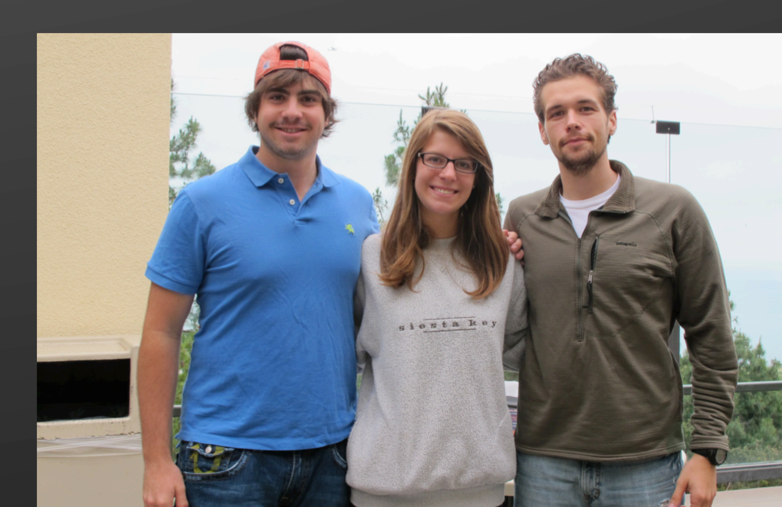

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