2009

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Abstract

In observing chaparral species' resistance to abiotic plant stresses, this investigation sought to study plant defense against UVA radiation in sun and shade leaves. We predicted that sun leaves would have higher absorbance of UV radiation considering their day-long exposure to sunlight.

UVA (350 nm-400nm) absorbance in sun and shade leaves of *Heteromeles arbutifolia* and *Malosma laurina* were measured using a integrating sphere. Four leaves from each group were surveyed for reflectance and absorbance. Using the spectrophotometer, reflectance in the green wavelengths (500-600 nm) was measured and divided by reflectance in the red (600-700 nm) to give a quantitative estimation of the redness of the samples and thus the anthocyanin content. Samples were cross-sectioned and examined under the microscope to measure cuticle size and determine and the location of anthocyanin pigments.

There showed no correlation between either cuticle thickness or amount of red pigmentation and absorbance in the UVA spectrum ($R^2 < .90$), nor were the sun leaves of either species *H. arbutifolia* and *M. laurina* significantly better at absorbing UVA radiation than shade leaves ($P > .05$). Anthocyanins were present mainly in the leaves' palisade layers in each species.

Introduction

Given the extremes of California's unique Mediterranean climate, its hardy chaparral species have developed several defenses against harmful abiotic stress. For example, many can survive a much lower water potential than plants in other climate types (Jarbeau *et al.* 1995), and many have adopted resprout and seedling growth mechanisms to withstand wildfire (DeSouza *et al.* 1986). Our investigation follows this trend, suspecting that defense against UV radiation would be evident in chaparral species, especially since plants are immobile, having to endure day-long exposure to sunlight.

In observing two such species *(Heteromeles arbutifolia* and *Malosma laurina)*, it was noted that sun leaves and shade leaves varied in levels of anthocyanin pigmentation. This study was then focused on comparing UV absorbance in sun and shade leaves in chaparral, expecting that sun leaves would have the higher absorbance of the two. Two distinct physiological differences, specifically anthocyanin levels (Woodwall and Stewart 1998) and cuticle width (Solovchenko and Merzlyak 2003), were measured against UV absorbance.

Determining the source of plant defense against UV radiation would have broad implications in human fields, including commercial products and medicine.

Averages of UVA Absorbance in the Studied Leaf Types

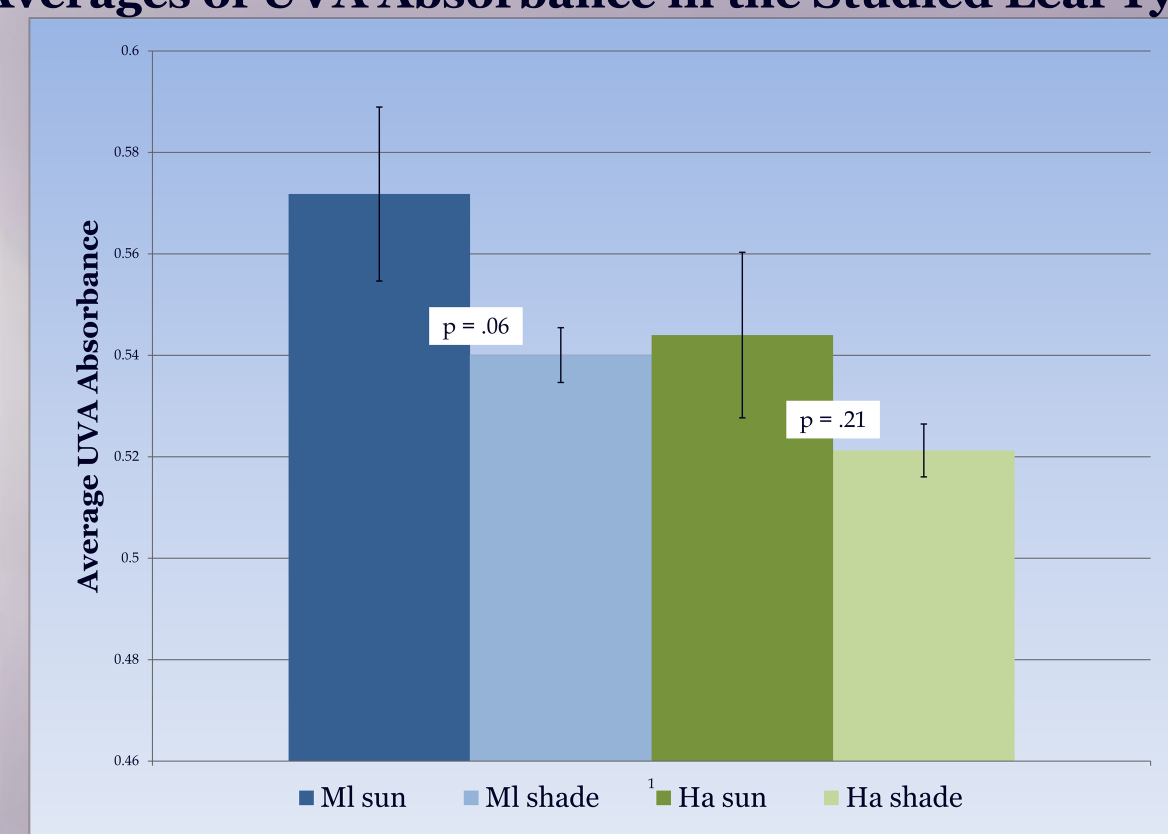

Figure 1: The average absorbance rates of sun leaves in H. arbutifolia and M. laurina were not significantly higher than their shade counterparts on the 5% confidence level, despite the mutual exclusivity of the standard error bars.

Cuticle Size vs. UVA Absorbance

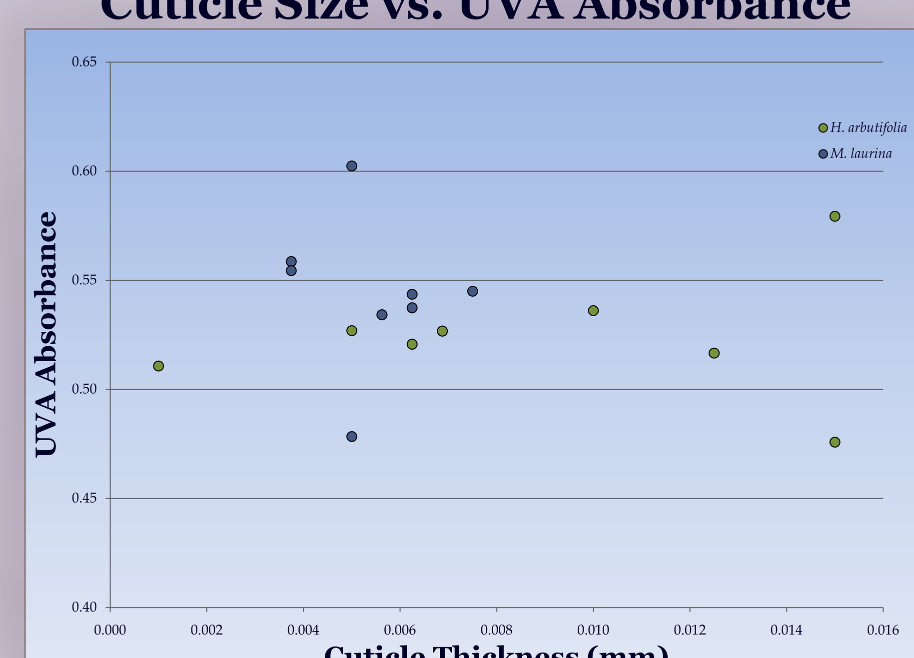

Figure 2: Data indicates that there is no correlation between cuticle thickness and absorbance.

Green to Red Ratio vs. UVA Absorbance

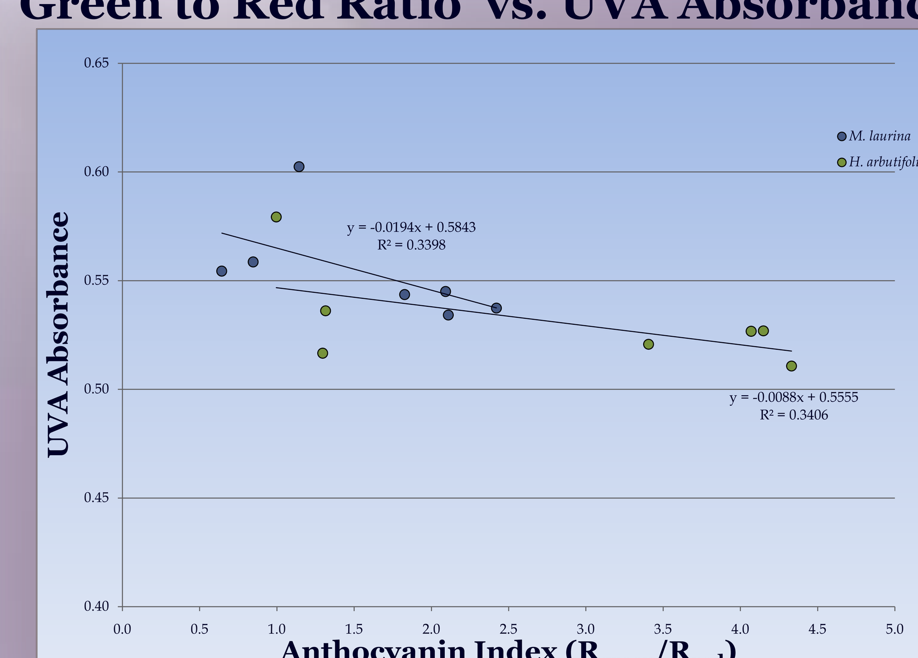

Figure 3: The anthocyanin index refers to the ratio between reflectance of green wavelengths and red wavelengths (add sp. values) calculated for each leaf. The figure shows no correlation between this index and UVA absorbance in either species as R_2 approximately equals .34 in both data sets.

Cross Sections of the Studied Leaf Types

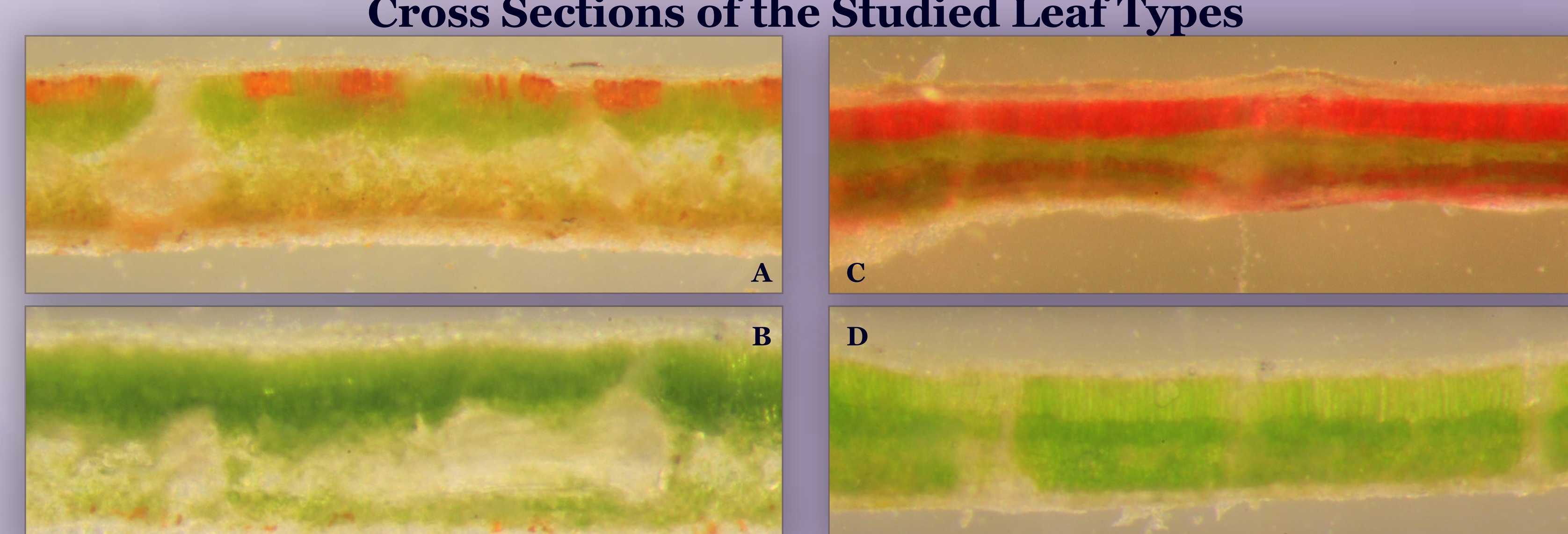

Figure 4: Cross sections of a) *Heteromeles arbutifolia* sun leaf b) *Heteromeles arbutifolia* shade leaf c) *Malosma laurina* sun leaf and d) *Malosma laurina* shade leaf show that anthocyanin pigments are localized close to the upper epidermis , whereas chlorophyll is concentrated in the interior of the leaf, below the palisade mesophyll.

Acknowledgements

We would like to thank Dr. Stephen Davis, Marcus Heffner, and the Natural Science Division at Pepperdine University for their support, generosity, and counsel.

Methods

Samples of red sun leaves and green shade leaves were collected from *Heteromeles arbutifolia* and *Malosma laurina*. From each of these four categories, four large leaves were selected and labeled. The integrating sphere and UV camera were used to measure the UVA transmittance and reflectance of each leaf across a range of 350 nm to 400 nm. Absorbance was calculated from these values using

$$1 = T + R + \alpha. \qquad \textbf{(Eq. 1)}$$

Figure 1 shows the averages of the absorbance data relative to each leaf type.

Each leaf sample was analyzed in the spectrophotometer to measure reflectance of green and red light (500-600 nm and 600-700 nm, respectively). Reflectance across the green spectrum was divided by the reflectance across the red spectrum to calculate an inverse anthocyanin index value for each leaf. These specific values were plotted against UVA absorbance, as seen in Figure 3.

Cross sections of each leaf were made and examined under a microscope at 400x zoom. The scope micrometer was standardized using a calibration slide to measure the thickness of each leaf's cuticle. These date were also plotted against UVA absorbance, which is displayed in Figure 2.

Conclusion

- There is no significant difference between ultraviolet-A absorption and reflectance in sun and shade leaves of *Malosma laurina* and *Heteromeles arbutifolia*. ($P > .05$, n=3/4)
- No significant correlation between estimated anthocyanin levels under the epidermal layer and UVA absorbance. ($R^2 < .5$)
- There is also no significant correlation between cuticle thickness and UVA absorbance. ($R^2 < .5$)
- Much of the anthocyanins are found in the palisade layers of both species, dominating much of the pigments present in these layers, by cross-section inspection. Much of the chlorophyll was concentrated below the palisade layers in the mesophyll cells.

Our data suggests that sun leaves have no advantage over shade leaves. However, our small sample size and limited UV range might render our study inconclusive.

Literature Cited

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