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Comparison of Photosynthetic Ability In Single and Double Palisade Parenchyma Leaves in Southern California

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ABSTRACT

Melaleuca quinquenervia is a myrtle (family Myrtaceae) with a propensity for invasiveness. The leaves feature an isobilateral orientation: vertically aligned with a layer of palisade parenchyma on both the adaxial and abaxial sides. *Quercus agrifolia* (Fagaceae) is a native evergreen with one layer of palisade parenchyma. Due to this structural difference, it was hypothesized that *Melaleuca* would have a higher rate of photosynthesis (*Pn*) and less reflectance (NDVI) of green light than *Quercus*. These two variables were compared using an unpaired t-test, yielding p-values of 0.1366 for NDVI and 0.04428 for photosynthetic rate. No significant difference was found between the NDVI of the two species, but a significant difference was observed in photosynthetic rate (with *Melaleuca* having the greater *Pn*). Thus we found evidence that appears to support our hypothesis in part, though the results concerning NDVI were inconclusive.

INTRODUCTION

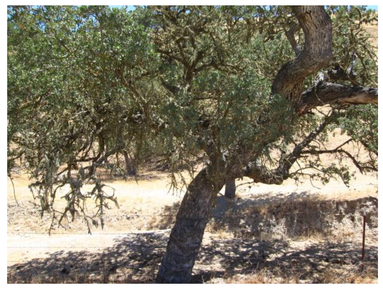
Myrtles, trees that are representative of the family Myrtaceae, appear to have a special propensity for becoming weedy and invasive species (Impson) in foreign ecosystems, including some in North America. *Melaleuca quinquenervia* (paperbark tree) is a tree native to the humid marshlands and littoral swamp forests of Eastern Australia, and the savanna of New Caledonia. Its introduction to the Florida Everglades resulted in widespread bioinvasion, due to near-absence of mitigating factors such as predation. It currently still contributes to the ongoing ecosystemic degradation felt by this region. In California, another myrtle, the closely-related *Eucalyptus globulus* (blue gum eucalyptus) is a known and effective displacer of native plant communities. It may be profitable to study features peculiar to the Myrtaceae that advance their survival and flourishing.

The leaves of myrtles are somewhat unique in that they are isobilateral: the leaves are arranged vertically rather than a more typical horizontal position. The consequence of this is a double layer of palisade parenchyma, with chloroplasts on both sides. This enables photosynthesis to continue throughout daylight hours; as sunlight shines along the horizontal plane, it strikes the front and back sides; thus plants with this feature would presumably maximize this resource and photosynthetic energy yield. If this grants the plant a significant advantage it may in part contribute to its effectiveness at colonizing other ecosystems. A direct comparison was desired with a plant possessing only a top layer, in order to measure any difference in performance.

Quercus agrifolia (coastal live oak) is a species of evergreen tree (family Fagaceae, or "beech trees") distributed widely in southern California. It commonly occurs in a variety of biomes, and is tolerant of numerous stressful conditions (e.g. water stress). It has standard leaves with a single palisade layer for photosynthesis. The leaves are thick and spiny, to avoid both drought stress and predation.

We hypothesized that leaves with an adaxial and abaxial layer of palisade parenchyma would 1)have a higher photosynthetic rate than those with only an adaxial layer, and 2)there would be a difference in absorbance of green light (495-575 nm) between the leaves of the two types of plants.

Melaleuca quinquenervia

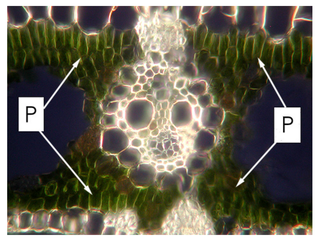


Quercus agrifolia

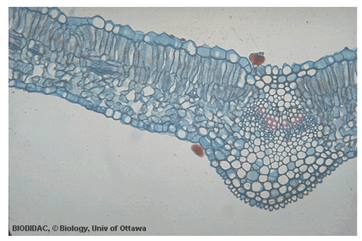
MATERIALS AND METHODS

Part 1: LiCor 6400XT gas exchange system
For this study, we selected three specimens of *Melaleuca* and three of *Q. agrifolia*. The LiCor gas-exchange system was brought to each site; one leaf on each specimen was placed inside the cuvette and analyzed. The rates of photosynthesis and stomatal conductance were measured and recorded. In total, we tested 6 leaves (one leaf for each tree).

Part 2: Unispec spectral analysis system
Live branches with leaves were removed from both the *Melaleuca* and *Q. agrifolia* (these were taken from the same specimens used in the gas exchange analysis). In total, we collected leafy branches from three *Melaleuca* trees; branches from three *Q. agrifolia* individuals were also harvested. The branches were placed in individual plastic bags and stored in an ice chest before analysis. In order to measure reflectance and absorbance of each leaf, we used the Unispec apparatus. We tested three leaves from each individual tree. In total, 18 leaves were tested.



Double-sided Palisade Parenchyma



Single-sided Palisade Parenchyma

STUDY SITE

The study site for our project was Pepperdine University. For *Quercus agrifolia*, the plants used were growing wild in the area around the university campus. Our specimens were located along a staircase going down from Main Campus towards Firestone Fieldhouse, and on the Dana Martel trail (located across from the Lovernich housing complex). For *Melaleuca*, the trees were cultivated: part of the landscaping near the freshmen dorm Crocker Hall, across from the CAC.

RESULTS AND DISCUSSION

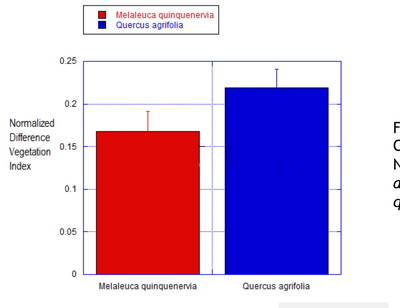


Figure 1 - Comparison of Leaf NDVI between *Q. agrifolia* and *M. quinquenervia*

Results:

Student t Test for unpaired data with equal variance
Group 1: Melaleuca quinquenervia
Group 2: Quercus agrifolia

	Group 1	Group 2
Count	9	9
Mean	0.168097	0.218627
Variance	0.00490383	0.00444695
Std. Dev.	0.0700273	0.0666854
Std. Err	0.0233424	0.0222285

Mean Difference	-0.05053
Degrees of Freedom	16
t Value	-1.5676
t Probability	0.1365

Figure 3 - Student t-test for the NDVI comparison

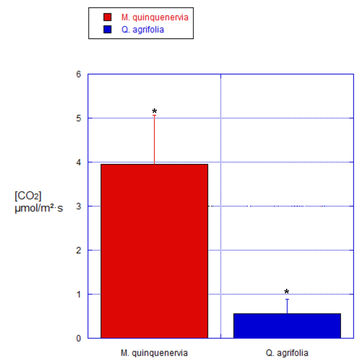


Figure 2 - Comparison of photosynthetic activity between *Q. agrifolia* and *M. quinquenervia*

Results:

Student t Test for unpaired data with equal variance
Group 1: M. quinquenervia
Group 2: Q. agrifolia

	Group 1	Group 2
Count	3	3
Mean	3.94667	0.553667
Variance	3.79373	0.32311
Std. Dev.	1.94775	0.568428
Std. Err	1.12453	0.328182

Mean Difference	3.393
Degrees of Freedom	4
t Value	2.8964
t Probability	0.04428

Figure 4 - Student t-test values for the photosynthetic rate comparison

- With a p-value of 0.1366, we found no significant difference between the NDVI of *Quercus agrifolia* and *Melaleuca quinquenervia*.
- A p-value of 0.04428 for a difference in photosynthetic rate gives us statistical significance: ~95% confidence.
- The sample size used in this study likely did not incorporate enough individual plants (n=3) to provide truly conclusive information.
- We assume that the higher photosynthetic rate in *Melaleuca* could be attributed to the dual presence of adaxial and abaxial layers of palisade parenchyma

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