Temperature Acclimation of Six Tropical Tree Species in the Biosphere 2 Rainforest

Andrew Hernandez and Dr. Joost van Haren
The University of Arizona, Biosphere 2 REU

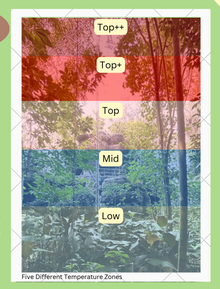
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1. Introduction

- Climate change will increase temperature in tropical rainforests, which many researchers have suggested are highly sensitive to temperature increases
- The photosynthetic apparatus (photosystem II) and chlorophyll in leaves are considered most vulnerable to high temperatures
- We expected that higher temperatures in the Biosphere 2 rainforest canopy would decrease the photosynthetic capacity of tropical leaves and that recovery from heat stress would be slow due to heat impact and slow repair of the photosynthetic machinery

2. Methods And Materials

- Leaves from six species were chosen: *Clitoria fairchildiana*, *Pachira aquatica (upper canopy), Annona muraciata, Coffea arabica*, *Piper auritum*, and *Theobroma cacao* (understory).
- We measured leaves at five different temperature levels in Biosphere 2



Five Different Temperature Zones

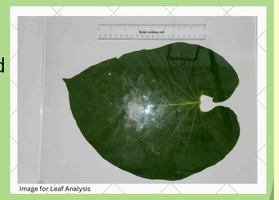
Leaf Fluorescence Measurements


Sensor placement on P. auritum

- Micro-Pulse Amplitude Modulated (Micro-PAM, Walz, Effeltrich, Germany) sensors measured chlorophyll fluorescence following a saturating light pulse every 30 minutes in the dark (3am-4am) and 15 minutes under ambient light (7am-7pm)
- The Micro-PAM sensors reported: photosynthetic active radiation (PAR), leaf temperature, dark adapted leaf (Fv/Fm), electron transport rate (ETR), non-photochemical quenching (NPQ), and effective photochemical yield of photosystem II -Y(II).
- We moved sensors betwen leaves every three to four days

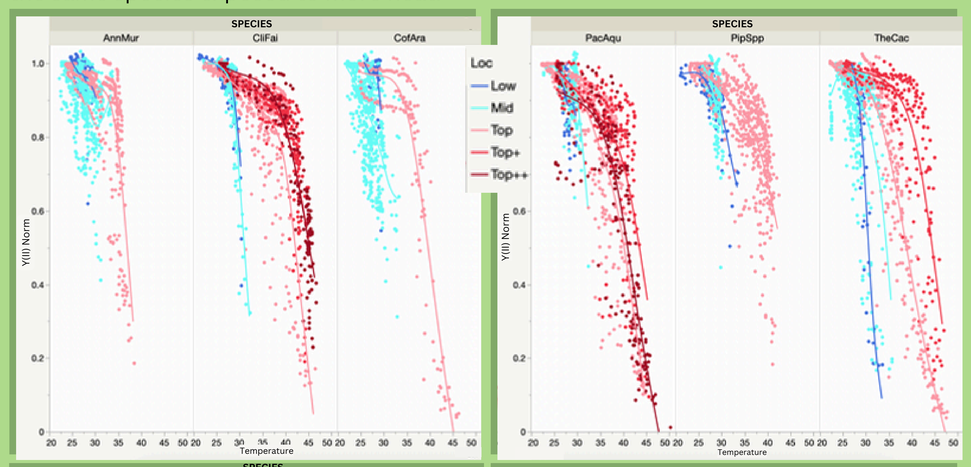
Leaf Analysis

- After we removed the sensors from a leaf, we sampled the leaf for trait analysis (leaf water content (LWC) and leaf mass area (LMA))
- Leaf samples were weighed wet and dry to determine water content and mass, and were photographed to determine its area using ImageJ (https://imagej.net)


Image for Leaf Analysis

3. Results

Fig 1. Tropical leaves can acclimate to higher temperature. The effective photochemical yield of chlorophyll fluorescence -Y(II)- decreases at higher temperatures in leaves from the same species exposed to more heat.



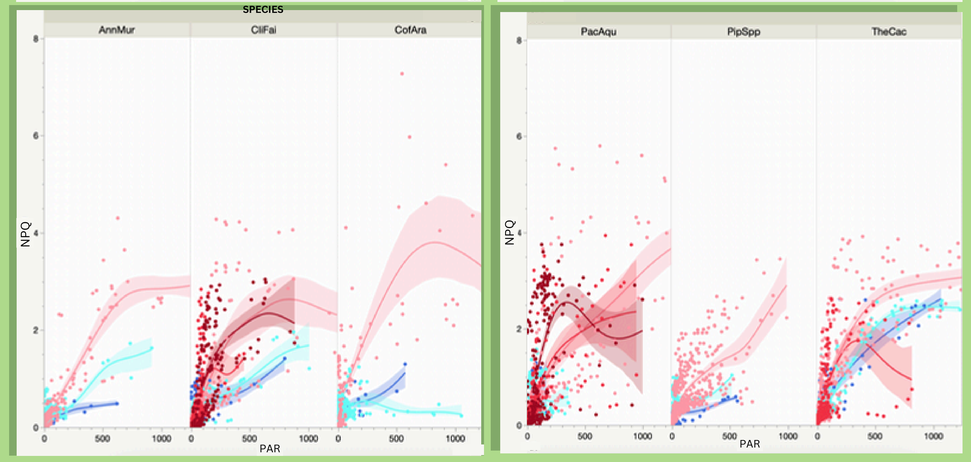


Fig 2. Energy loss through non-photochemical quenching (NPQ) increases both with increasing light (PAR) and with increasing temperature (warmer colors). NPQ appears to be an efficient way for tropical forest leaves to deal with temperature increases.

Data Analysis WinControl was used to collect the data, which we analyzed in JMP-16 and Excel.

Fig 3. The maximum electron efficiency represents the largest photosynthetic energy production per photon of light

The electron Transport Rate (ETR) increases with Photosynthetic Active Radiation (PAR) up to a maximum rate

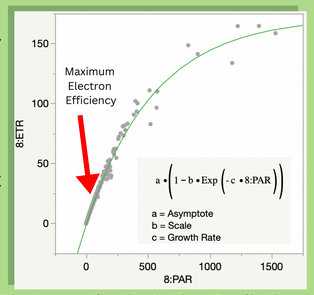
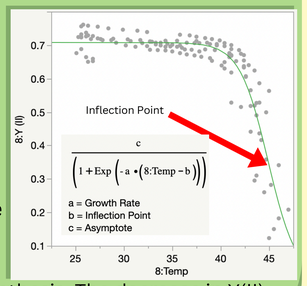


Fig 4. The modeled inflection point of the effective photochemical yield of photosystem II -Y(II)-with temperature provides a repeatable measure of temperature influence on photosynthesis. The decrease in Y(II) indicates non-photochemical energy loss.



3.2 Results (cont'd)

Species	Average LMA (mg/cm^2)	Average LWC (g)	Fv/Fm	ETR Efficiency with PAR
Annona muraciata	4.2 ± 4.6	83	0.766±0.004	0.33±0.01
Clitoria fairchildiana	16.5 ± 0.6	67	0.784±0.005	0.33±0.01
Coffea arabica	5. ± 6.2	78	0.754±0.01	0.33±0.01
Pacquira aquatica	5.7 ± 5.7	77	0.772±0.005	0.33±0.01
Piper auritum	3. ± 2.8	85	0.77±0.008	0.33±0.01
Theobroma cacao	5.4 ± 3.2	61	0.774±0.008	0.34±0.01

Table 1 Leaf and Photochemical Traits

- Leaf mass area appeared to increase with temperature exposure, though the sampling size was too small to be significant
- All species had similar maximum ETR efficiencies with PAR, which suggests that leaves of many tropical forest species are ready to make use of any light they get
- Maximum photochemical yield of photosystem II (Fv/Fm) values were consistent for all species, indicating that temperature affected leaves recovered photochemical yield overnight

4. Conclusions

- Our study suggests that some tropical forest leaves can acclimate to heat exposure leaf, suggesting tropical forest trees could survive higher temperatures caused by climate change
- Although high temperatures do affect tropical leaf photosynthesis negatively, the leaves are able to resume optimal photosynthesis efficiency by the next day
- Longer term heat exposure, especially under drought conditions might still be severely damaging to tropical forest species

Acknowledgements

NSF Grant: 2051145
REU Site: Environmental and Earth Systems Research at Biosphere 2
Jason Deleeuw - Terrestrial Biome Manager and climber extraordinare

Biosphere 2 NSF REU:
Katerina Dontsova - Director
Kevin Bonine - Co-director
Benjamin Karls - On-site Facilitator