The leaf heat tolerance of epiphytic bromeliads

By Joseph Shiina

Guzmania lingulata

Guzmania monostachia

Aechmea nudicaulis

Overview

Research Question

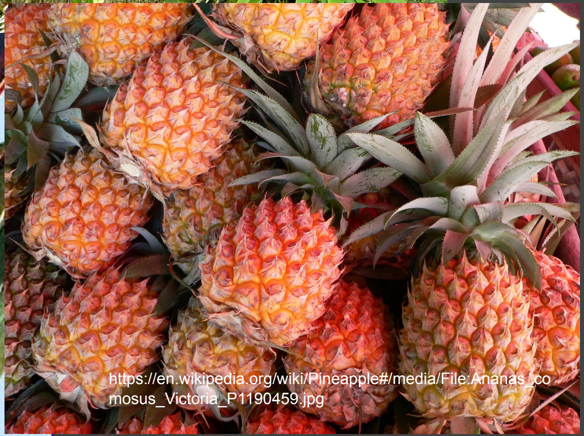
Does the heat tolerance of bromeliads differ in association with their photosynthetic pathway (C3, CAM, or CAM-C3) and distributions within the canopy?

↓

How will plants respond to the projected rising temperatures?

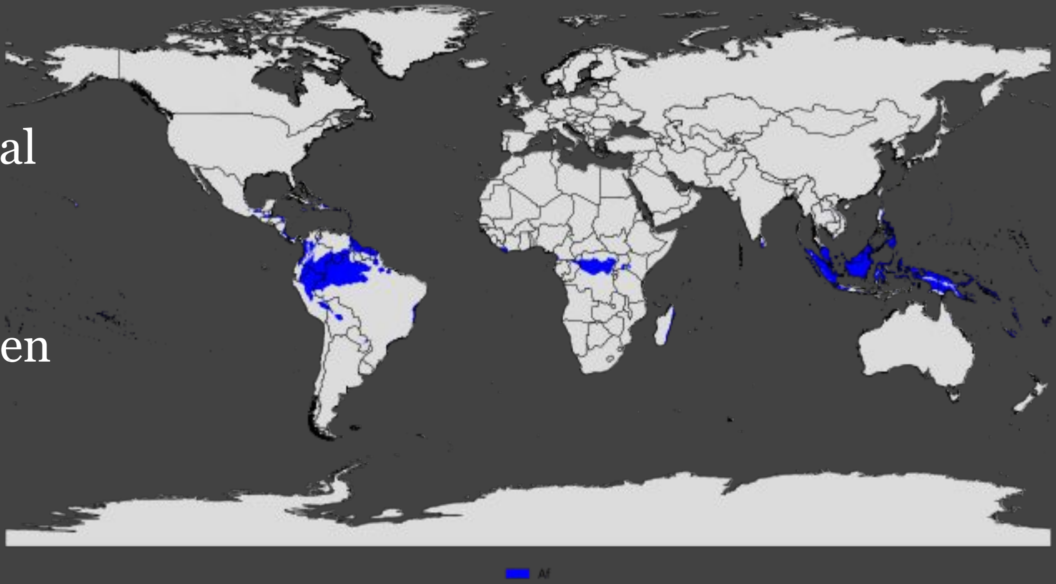
Background: Bromeliads

- ➢ Epiphytes
  - ○ Where on trees? Depends.
  - ○ Water shortage, light/shade, temperature
- ➢ Various leaf functions
- ➢ Tank or atmospheric
  - ○ Tank: a house for many species



Background: Tropical Rainforest Biome

- ~46% of world's living terrestrial carbon pool (Soepadmo, 1993)
- Relatively stable climate...
  - Species vulnerable to sudden changes (Tewksbury et al., 2008)



https://en.wikipedia.org/wiki/Tropical_rainforest#/media/File:Koppen-Geiger_Map_Af_present.svg

Background: heat tolerance

Water loss

Oxidative stress

Inhibition of seed germination

Alteration in photosynthesis

Reduction of crop quality

Heat stress

Yield reduction

Alteration in phenology

Alteration in dry matter partitioning

(Hasanuzzaman et al., 2013)

Hypothesis

Guzmania lingulata

Shade tolerance
Lower canopy
C_3

<

Guzmania monostachia

Sun group
Higher canopy
C_3-CAM

<

Aechmea nudicaulis

Sun group
Higher canopy
CAM

1. (individual species)
   Higher canopy = higher tolerance
2. (across 3 species)
   CAM = higher tolerance

   C_3-CAM = additional step needed

Materials and Methods: Photosynthetic efficiency

- ➢ An indicator for plant stress
- ➢ With heat stress, efficiency deteriorates
  - heat tolerant samples less affected by heat
- ➢ stress = decline in carbon fixation = excess light (unused for photosynthesis)

Materials and Methods: Chlorophyll Fluorescence

- ➢ Nonproductive pathways

Light → Reemission as heat

Light → Fluorescence (High = less used for photosynthesis, inefficient)

Light → Transfer to oxygen → Reactive Oxygen Species (ROS)

- ➢ Measured via chlorophyll fluorometer
- ➢ Measuring parameter: Fv/Fm
  - ○ Ratio showing maximum potential photosynthetic efficiency
  - ○ Lower under stress

(Optisciences, Inc.)

Expected results: Within Species

Chaves et al. (2018):

- ➢ D_{50}: Critical time when 50% of initial Fv/Fm reduced
- ➢ "detected a significantly **higher** thermal tolerance in **shaded** *A. nudicaulis* than in **sun-exposed** plants"
- ➢ More constant conditions along days and years of shade environments seems to increase and stabilize (i.e. reduce the plasticity) their thermotolerance

Table 1
Means and standard errors of projected D_{50} values of all experimental groups at 15:00 in the rainy season. Same letters represent values statistically equal among all groups.

Species	Environment	Leaf region	D_{50} (min.)
A. nudicaulis	Sun-exposed	Top	80.86 ± 11.8 [b]
		Basal	103.17 ± 5.3 [b]
	Shaded	Top	157.87 ± 17.4 [a]
		Basal	163.66 ± 28.1 [a]
V. minarum	Sun-exposed	Top	73.19 ± 4.8 [b]
		Basal	81.56 ± 2.3 [b]
V. bituminosa	Shaded	Top	70.59 ± 1.8 [b]
		Basal	73.02 ± 0.9 [b]

Chaves et al. (2018)

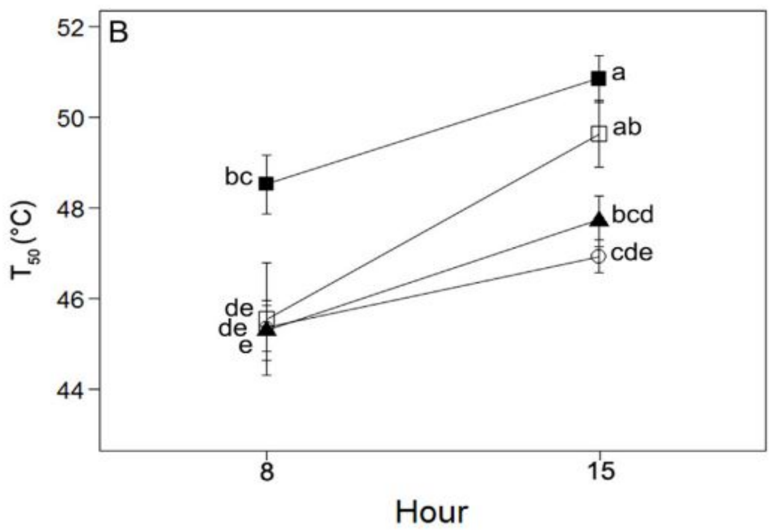
Expected results: Across Species

Chaves et al. (2018):

- ➢ *Vriesea minarum* more heat sensitive than *Vriesea bituminosa* and *Aechmea nudicaulis* (widely distributed)
- ➢ Species with narrow distribution patterns: heat sensitivity *not* high, but heat tolerance plasticities *very low*

Weng and Lai (2005), Yamada et al. (1996), Chaves et al. (2018):

- ➢ CAM bromeliad *Ananas comosus* showed greater heat tolerance than some C3 and C4 species
- ➢ C3 and C4 species have relatively high heat sensitivity compared to CAM



Chaves et al. (2018)

T50 variations of sun-exposed (open squares) and shaded (closed squares) *A. nudicaulis*, *V. minarum* (open circles) and *V. bituminosa* (closed triangles)

References

Chaves, Cleber & Simões Santos Leal, Bárbara & Lemos‑Filho, José. (2015). Temperature modulation of thermal tolerance of a CAM-tank bromeliad and the relationship with acid accumulation in different leaf regions. Physiologia Plantarum. 154. 500-510. 10.1111/ppl.12295.

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