A case study on the epiphyte *Asplenium australasicum* and climate change

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Introduction

- *A. australasicum* (pictured right) grows along the east coast of Australia in trees.
- Along with all plants, it reproduces via alternation of generations with a haploid gametophyte stage (G) and diploid sporophyte stage (S).
- Ferns are unique in that each of their generations are free living, making life in the canopy doubly challenging as both must be adapted to an epiphytic lifestyle.
- Fern gametophytes and sporophytes are physiologically distinct, with Gs being small, one cell layer thick, and in equilibrium with the environment while Ss are vascular, large, and regulate water loss via stomatal control. Basket forming sporophytes must start without litter and water capturing baskets and must be drought tolerant.
- To understand how plants will adapt to a changing climate, their ontogeny must be considered as they change over time.[2]
- *A. australasicum* is a perfect case study organism as it has three distinct phases of its ontogeny.

Fig. 1. Flow chart showing natural ontogeny of *A. australasicum.* Epiphytic gametophytes give rise to immature sporophytes with no basket forming morphology. Mature sporophytes develop a large basket which traps water and nutrients to cope with the epiphytic environment.

Methods

- 64 day drought experiment: measure photosynthesis on young and old fronds
- Grow gametophytes at 24 °C and 26 °C: measure growth rates
- Obtain climate data from bioclim.org and species collection data from gbif.org: run MaxEnt[3] SDM (species distribution model)
- Project model onto 2070 climate change variables

Fig. 2. LiCor photosynthesis gas analyzer measuring *A. australasicum* photosynthetic rate during drought experiment.

Abstract

Epiphytes are plants that grow on trees. As they grow disconnected from the soil high in the canopy, they experience extreme growing conditions such as high light and hot days, extreme drought, and low nutrients. Basket-forming epiphytes such as the fern *A. australasicum* are adapted to the epiphytic environment via the formation of large baskets which trap falling leaf litter and water to survive the long dry season. This morphology has evolved over time in response to harsh living conditions, but rapid climate change may cause a sharp loss of suitable habitat for *A. australasicum* and other basket forming ferns in Australia and across the globe. Here, I investigate the physiology of this basket forming fern across its ontogeny in response to drought and increased temperature and model its future distribution in the face of anthropogenic climate change.

Results and Discussion

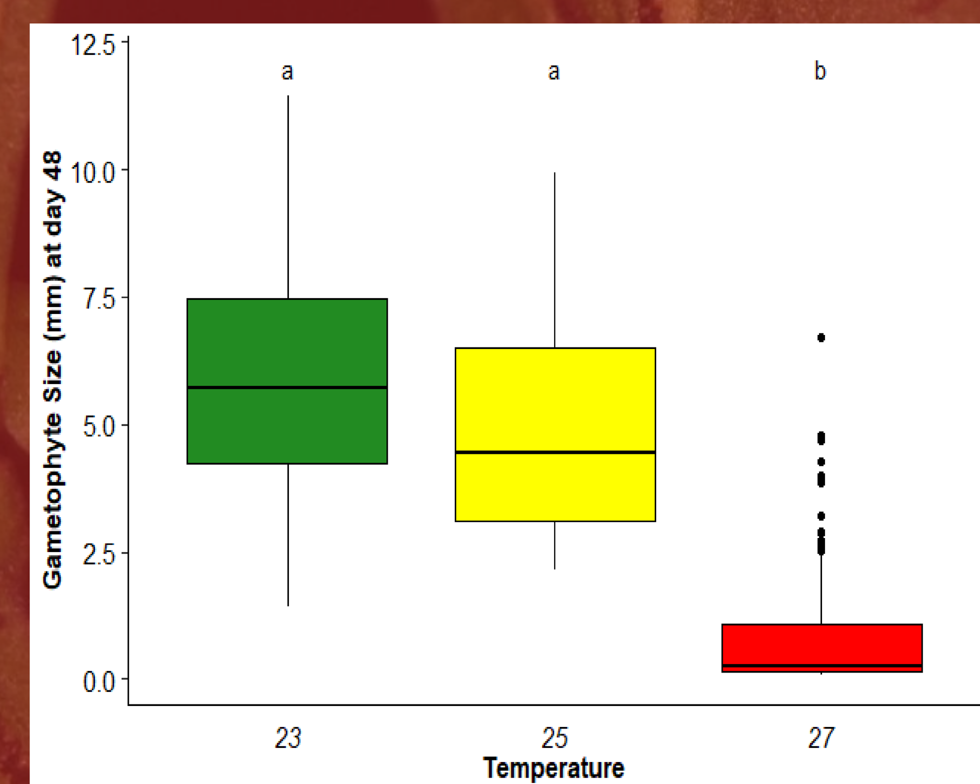

Fig. 2. Gametophyte size at day 48 grown at different temperatures. Larger temperatures result in smaller gametophytes ($F_{2,170}$ = 123, $p < 0.0001$).

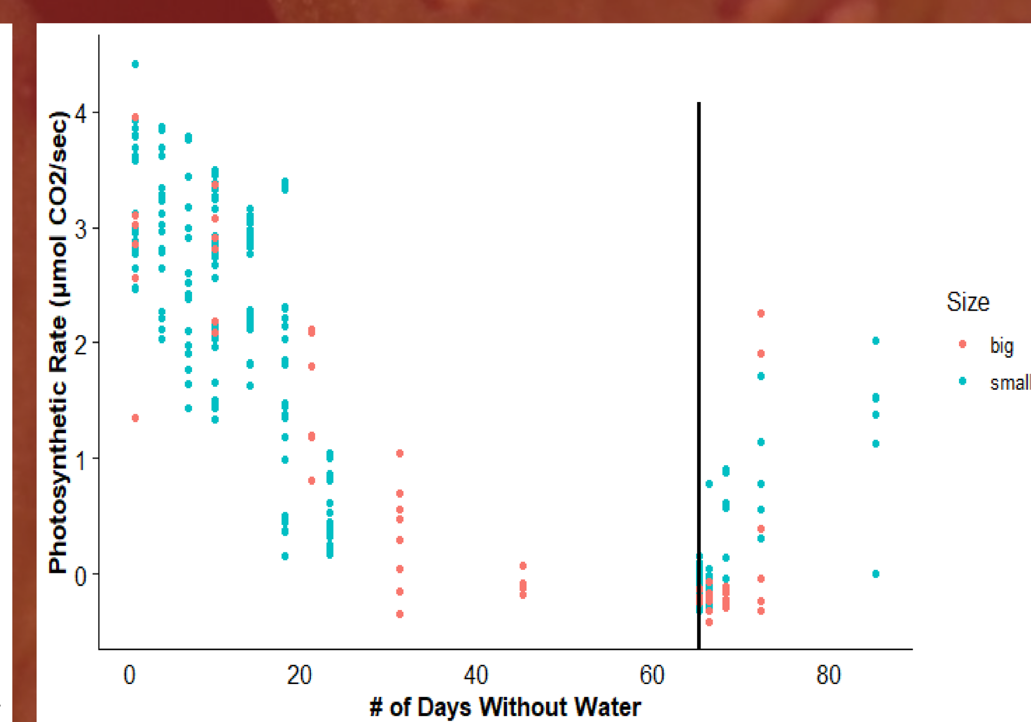

Fig. 3. Photosynthetic rates of *A. australasicum* during a 64 day drought treatment. The black line indicates rehydration. Both immature and mature sporophytes recover quickly after a long drought.

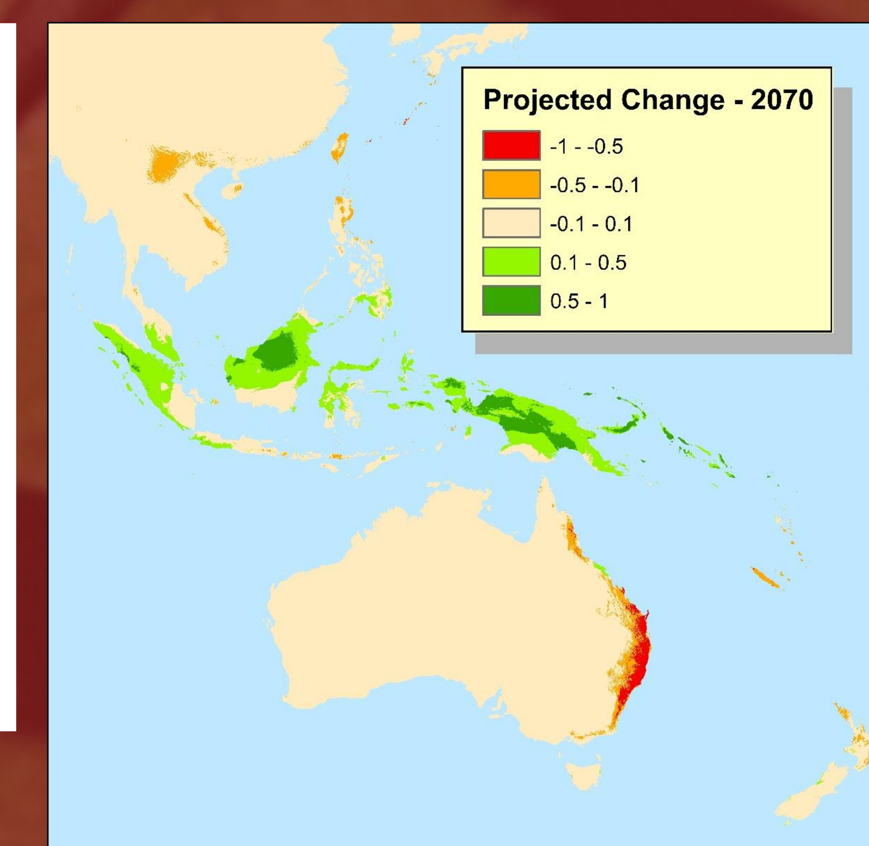

Fig 4. Projected range shift in 2070 for *A. australasicum* with red indicating a decrease in probably of occurrence (POC) and in green indicating an increase in POC. Results based on worst case scenario global climate model (GCM).

- All stages of the *A.* australasicum ontogeny were effected by a changing climate.
- The small, avascular gametophytes, which are shown to be drought tolerant[1], are negatively affected by increased temperatures (Fig. 2).
- The large, vascular sporophytes were remarkably drought tolerant, with a single leaf surviving and recovering from 64 days of drought, even the immature individuals which had not yet formed a basket morphology (Fig. 3).
- MaxEnt model results suggest that A. australasicum will be forced to shift North to the wetter SE Asian islands, loosing most of its suitable habitat in NSW, Australia due to a drying and warming climate.

Future Research

- Due to COVID-19, I was unable to collect ecophysiological measurements in the field.
- In the future I would conduct systematic presence and absence field observations to improve model accuracy.
- I would expand the study to other epiphyte species with different morphologies and distributions.

Young *A. Australasicum* in situ in Minnamurra Rainforest, Australia. A testament to the importance of each ontology stage to the effect of climate change on species distribution.

Literature Cited: **1: Watkins Jr, J. E., Mack, M. C., Sinclair, T. R., & Mulkey, S. S. (2007).** Ecological and evolutionary consequences of desiccation tolerance in tropical fern gametophytes. New Phytologist, 176(3), 708-717.
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3: Phillips, S. J., & Dudík, M. (2008). Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography, 31(2), 161-175.
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