Evaluating the vulnerability of rainforest plants to heat events

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This study forms part of a broader initiative identifying adaptation options to future climate change across biota in south-east Queensland. The study aimed to (i) investigate morphological and physiological responses of rainforest tree seedlings to a heat-stress event to determine vulnerability and resilience of species from cooler and warmer climates, and (ii) determine measurements which may be used to evaluate plant traits for risk assessment of performance and survival of rainforest flora with exposure to elevated temperatures.

Seedlings of six rainforest tree species were grown in a controlled environment chamber at 28°C for 10 weeks prior to two weeks of elevated temperature at 39°C (heat event) aimed to mimic heat events that are predicted to increase in frequency and severity in the future climate. Plants were well-watered during the experiments as only the effect of temperature on plant performance was tested. During measurement of CO_2 fixation and transpiration, leaves were also heated to 44°C.

The heat event resulted in slowing of growth of several species and considerable physical damage in young, developing leaves in four out of five species, while fully mature leaves and new leaves that formed during the heat event were undamaged and only showed a minor and reversible decline in leaf health as indicated by chlorophyll fluorescence. The damage to young developing leaves resulted in necrosis over large sections of the leaf, especially tips which indicates that leaves were water limited. A possible explanation that requires further research is that transpiration rates exceeded water supply due to less-well developed leaf cuticle.

During the heat event all species exhibited increased rates of dark respiration when compared to values prior to the heat event, and only one of the six species did not show higher rates of transpiration (*Waterhousia floribunda*). This indicates that greater use of water and photosynthates accompanies heat events, as has been described before in Amazonia rainforest species. In contrast, net CO_2 fixation rates remained unchanged in all species, except *Argyrodendron actinophyllum* which exhibited a statistically significant decline. Upon return to a cooler glasshouse, all species continued growth and produced new leaves indicating that the heat event did not cause irreparable damage.

No traits evaluated in our study differed consistently between ‘cool-adapted’ species from higher altitudes or coastal regions *versus* ‘warm-adapted’ species from low altitude or inland regions. However, performing a ranking based on all measured traits, species in cool-adapted group ranked in a higher risk category than the warm-adapted group, indicating that the former are at greater risk of reduced performance during heat events.

Greater vulnerability of the more cool-adapted species has implications for the adaptation potential of these species to a future climate with regular heat events. The two ‘most vulnerable’ ranked species identified here, *A. actinophyllum* and *Lenwebbia prominens* occur at altitudes above 600 m. The combination of greater damage during heat events in combination with a limited ability to shift their altitudinal distribution upwards, confirms that species from higher altitudes are more vulnerable to climate change. Our study demonstrates that short-term assessment of species in controlled conditions as performed in our study is a potentially useful tool for prioritisation of conservation action.

Future studies should examine a larger suite of species subjected to multiple heat-stress periods of varying duration and intensity to explore whether the responses identified in our study are maintained over time. Further stresses have to be evaluated, especially drought and low nutrient availability that are likely to accompany heat events, to determine interactions of several stresses to ensure that species are tested in realistic conditions. Evaluation of survival and performance of seedlings and trees *in situ* should accompany *ex situ* studies to determine vulnerability and resilience of subtropical rainforest species under likely climatic changes.