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Thesis abstract

Ontogenetic ecophysiology of secondary hemi-epiphytic vines

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Secondary hemi-epiphytes start their life as ground-dwelling plants. Like other vines, the plant then climbs the host, but when the plant reaches maturity, the oldest portion of the stem dies. The plant then loses its stem connection to the soil and becomes semi-epiphytic. However, true secondary hemi-epiphytism is probably not as common as thought, since, in most cases semi-epiphytic vines reconnect to the soil through aerial roots. The change in soil connection during the ontogeny of these species may have physiological and anatomical consequences. As they eventually live in the canopy environment, it is feasible that secondary hemi-epiphytes might develop adaptations to cope with the stressful canopy environment, especially water stress during dry periods. However, there is a lack of understanding on the ecophysiology of secondary hemi-epiphytes in rainforests.

There is a paucity of information on the anatomy and physiology of secondary hemi-epiphytes, once they lose their stem connection to the soil, compared with the terrestrial early stage of development. To address this knowledge gap, characteristics of stem water transport, leaf anatomy and physiology, and soil water resource partitioning were examined in this research. Two species were selected for the study: *Freycinetia excelsa* F. Muell (Pandanaceae) and *Rhaphidophora australasica* F.M. Bailey (Araceae), which occur naturally in the Wet Tropics area of north Queensland. The general objective of this research is to better understand the ecophysiology of secondary hemi-epiphytes during their ontogenetic development.

The capacity of *F. excelsa* and *R. australasica* stems to conduct water differed between plants of different developmental phases. Adult individuals of *F. excelsa* and *R. australasica* had wider vessels than younger plants. Hydraulic architecture parameters, i.e. hydraulic conductivity, stem specific conductivity and leaf specific conductivity, were also higher in adult plants than for intermediate and juvenile individuals. These results indicate that adult plants had a higher capacity to conduct water through the stem to the leaves than did individuals at an earlier stage of development.

As the plants became more mature and longer, they tended to have low hydraulic conductivity at the stem base. This finding is supported by the fact that the size of xylem vessels was found to decrease in the basipetal direction: the base of the stem had narrower vessels than the middle part of the stem. However, the low hydraulic conductivity at the base of the stem may also be related to the fact that monocotyledonous plants lack secondary development. Therefore, the stem base contains the oldest shoot tissues and the vessels might be less functional. Wider vessels and higher hydraulic conductivity in adult individuals of *F. excelsa* and *R. australasica* show that the change in plant-soil connectivity during ontogeny of these species does not physically restrict water transport.

Adult individuals of *F. excelsa* and *R. australasica* had larger stomata than conspecific juveniles. However, adult plants also had more stomata per unit area, which gives them more control of the opening and closing of stomata in certain areas of the leaves. These characteristics of leaf anatomy suggest that secondary hemi-epiphytes are well-adapted to the canopy environment.

Juvenile plants of these two study species appear to be more sensitive to the onset of drought than plants of later developmental stages. Within each dry and wet season, the water potential of leaves from all growth forms were similar but the patterns of daily CO_2 exchange differed, with CO_2 uptake by juvenile plants most affected by dry season conditions. However, the CO_2 exchange rates were similar for adult, intermediate and juvenile plants during the wet season. High water availability in the wet season and relatively low evaporative demands provide excellent conditions for plants to absorb CO_2. The significant down-regulation of CO_2 exchange in the dry season in the juveniles is related to the lower hydraulic conductivity of their stems. Water supply to juveniles may be restricted during the dry season, such that down-regulation of CO_2 uptake and stomatal opening are necessary to diminish water loss and maintain water potential. Water supplied to intermediate and adult plants by aerial roots growing from a number of places along the stem is evidently sufficient to sustain higher rates of CO_2 exchange and water loss.

Plants of different ontogenetic stages had different behaviours towards soil water resources. Based on the hydrogen stable isotopes of water derived from different layers of the soil profile, matched with isotope signatures of the stem water, water uptake by juvenile individuals was limited to the area near the soil surface; on the other hand, adult plants utilized water from all soil layers studied. This consequently affects the capacity of plants to exploit all available soil water sources across seasons, which influences the performance of individuals of different ontogenetic stages in response to environmental conditions.

Variations in the ecophysiological attributes of the secondary hemi-epiphytes *F. excelsa* and *R. australasica* indicate differences in the ability of these plants to survive during their development. This study showed that smaller size juveniles may have a higher potential susceptibility to stressful environmental conditions compared to larger adult congeners. Based on ecophysiological characters, these two secondary hemi-epiphytic have not adapted especially to the epiphytic habit as they climb the host and live in the canopy. The plants' soil connections through aerial roots provide access to soil, avoid the stem basal hydraulic bottle neck and contribute to more options for soil water resource acquisition.

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