An investigation of the functions of leaf surface modifications in the Proteaceae and Araucariaceae.

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Abstract

Plant leaves exhibit a remarkable diversity of size, shape, developmental patterns, composition, and anatomical structures. Many of these morphological variations are assumed to be adaptations that optimize physiological activity and thus assist plants to survive in a range of different habitats. This study aimed to investigate the function of some of these leaf modifications, including leaf wax, stomatal plugs and stomatal crypts.

Investigations using *Leucadendron lanigerum* (Proteaceae) indicated that the amount of waxy coverage and the shape of wax crystals varied with the age of the leaves and the season. Wax coverage was found to significantly lower cuticular water loss but had no impact on reflectance. There was a significant increase in photosynthesis and transpiration rates in leaves from which wax had been removed. This increase was most likely due to an increase in stomatal conductance of the leaves after removing epicuticular wax. Despite the lack of effect on leaf reflectance, removal of wax prior to exposure to high light resulted in significant decreases in efficiency relative to control leaves. Overall, these results suggest that the presence of wax on the epidermis and at the entrance of stomata of *L. lanigerum*, in addition to restricting water loss, may also provide some protection against photodamage.

The impact of stomatal plugs on gas exchange in *Agathis robusta,* a rain forest tree from the Araucariaceae was investigated. Under saturating PFD, leaves with plugs had significantly lower transpiration rates, stomatal conductance and photosynthetic rates, but higher leaf temperatures than unplugged leaves. Water loss in detached leaves kept in the dark was significantly greater in unplugged than plugged leaves. In contrast, plugs had no impact on water film formation and

both plugged and unplugged leaves had similar electron transport rates when wet. These results suggest that stomatal plugs in *Agathis robusta* present a significant barrier to water loss but do not prevent water films from forming.

It was also demonstrated that the establishment of stomatal plugs in *Agathis robusta* occurs annually and, unlike trichomes in other species, stomatal plugs could be replaced at least during the first two years of leaf life. Investigation of leaves infected by fungi showed that waxy plugs blocked the penetration of stomata by fungal hyphae. Hyphae penetrated the leaf tissue either through stomata that lacked waxy plugs or at later stages of infection, directly through the cuticle. This suggests that stomatal plugs in *Agathis robusta* present a significant barrier to fungal penetration through stomata, and so help to prevent fungal infection of leaves. This function is important for trees living in rain forest environments where fungal attack is common.

Finally, investigation into the impact of stomatal crypts on cuticular water loss in *Banksia* species indicated that, contrary to previous speculation, stomatal crypts play little or no role in increasing resistance to water loss. No relationship was found between crypt depth and rates of transpiration over a range of VPDs, in the 14 *Banksia* species studied. A strong positive relationship between leaf thickness and crypt depth was found, while a negative relationship was observed between leaf thickness and stomatal density.