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The function of nocturnal transpiration

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Nocturnal transpiration is an important source of water loss, accounting for up to 25% of daytime transpiration in some species. Nocturnal water losses cannot be explained under the prevailing 'paradigm' of optimizing carbon gain while minimizing water loss because carbon fixation does not occur at night. Alternative explanations regarding the function and potential evolutionary advantage of nocturnal transpiration have been proposed, such as enhanced nutrient uptake and transport or delivery of O_2 to parenchyma cells for respiration. However, recent evidence suggests that the role of nocturnal transpiration in supplementing the overall plant nutrient budget is relatively small, and the O_2 hypothesis is difficult to test experimentally.

Here, we propose that the main function of nocturnal transpiration (and water transport) is to prevent catastrophic xylem failure by restoring depleted stem 'capacitors' and enhancing early morning CO_2 uptake, as stomata 'prepare' for daytime conditions. Nocturnal sap flux was highest in Eucalyptus grandis trees in the field following a heat wave (reaching 47C with VPDs > 8kPa in the daytime) generating maximal daytime water losses compared with cooler and lower VPD periods, indicating the importance of nocturnal stomatal conductance for stem refilling. Moreover, we observed that the time for stomata to respond to light early in the morning (dawn) across 25 different genotypes of E. camaldulensis in a glasshouse was shortest in those genotypes with highest nocturnal stomatal conductance, which was also correlated with higher daytime photosynthesis. This observation is consistent with previous observations that nocturnal stomatal conductance is partially controlled by the clock, which is utilised to anticipate daytime conditions. Data from the literature suggests that eucalypts respond similarly to other C3 species, suggesting that mechanisms regulating night-time transpiration may be universal.