The enigma of effective path length for (18) O enrichment in leaf water of conifers

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The Péclet correction is often used to predict leaf evaporative enrichment and requires an estimate of effective path length (L). Studies to estimate L in conifer needles have produced unexpected patterns based on Péclet theory and leaf anatomy. We exposed seedlings of six conifer species to different vapour pressure deficits (VPD) in controlled climate chambers to produce steady-state leaf water enrichment (in (18) O). We measured leaf gas exchange, stable oxygen isotopic composition (δ(18) O) of input and plant waters as well as leaf anatomical characteristics. Variation in bulk needle water δ(18) O was strongly related to VPD. Conifer needles had large amounts of water within the vascular strand that was potentially unenriched (up to 40%). Both standard Craig-Gordon and Péclet models failed to accurately predict conifer leaf water δ(18) O without taking into consideration the unenriched water in the vascular strand and variable L. Although L was linearly related to mesophyll thickness, large within-species variation prevented the development of generalizations that could allow a broader use of the Péclet effect in predictive models. Our results point to the importance of within needle water pools and isolating mechanisms that need further investigation in order to integrate Péclet corrections with 'two compartment' leaf water concepts.

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