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# Physiological and morphological controls on the impact of high evaporative demand across different plant types

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Plant responses to climatic variability rely on both physiological and morphological adaptations which operate at different scales for different means, and will therefore have important consequences for responses to a change in the average climatic conditions. With the increasing temperatures predicted across Europe and the Mediterranean in the coming century, the incidence of heat waves and periods of high evaporative demand are anticipated to become more frequent. As conditions during these events can pass species' tolerance thresholds, they can have a disproportionate impact on species composition. We have investigated the response to a strong diurnal-scale increase in atmospheric vapour pressure deficit (VPD) in four species representing temperate broadleaf (*Fagus sylvatica*, *Quercus robur*), Mediterranean broadleaf (*Q. ilex*) and Mediterranean conifer (*Pinus nigra*) growth types. Small (∼1.5 m) potted trees of all species were maintained under the same conditions outside, and during the course of the experimental day VPD increased from 0.8 to 3.2 kPa (∼40% relative humidity) within 6 hours. Leaf-level responses to the sharp increase in evaporative demand were investigated using a combination of gas exchange and isotopic measurements.

All species experienced stomatal closure with increasing VPD, but there was a clear difference in the response between the Mediterranean and temperate region species. In the beech and English oak, stomatal conductance decreased to ∼0.02 mol $m^{-2}$ $s^{-1}$ and was at near minimum values at a VPD of 1.5 – 2.0 kPa, whereas in the pine and Holm oak, minimal stomatal conductance was ∼0.05 mol $m^{-2}$ $s^{-1}$ and was reached at a VPD of 2.5 kPa. Consequently transpiration rates were 2 – 3 times greater in *Q. ilex* and *P. nigra* compared to the temperate broadleaves, and similar between the two species (1 – 2 mmol $m^{-2}$ $s^{-1}$). While there was a clear separation between the two groups of different origin in the physiological data, the leaf water isotope data revealed a separation based on morphology. All species had similar early morning leaf water isotopic composition ($\delta^{18}O_l$ of 4 – 5 ‰), and all became progressively enriched during the day. However, despite similar transpiration and conductance values, end of the day enrichment was greater in *Q. ilex* ($\delta^{18}O_l$ of 19 ‰) compared to *P. nigra* (12 ‰), but neither appeared to reach isotopic steady-state. Leaf-water enrichment in the two other low transpiration broadleaf species was similar to that in *Q. ilex*, and did appear to reach isotopic steady-state coinciding with stability in gas exchange responses. These results show that while both the southern latitude sclerophyllous *Q. ilex* and pine are less sensitive to conditions of high evaporative demand, lower leaf-water turnover rates in the conifer species may also potentially provide stronger buffering against persistent dry atmospheric conditions.