Squandering water in arid regions:
The water use strategy of *Ziziphus lotus* in a groundwater-dependent ecosystem

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Introduction

Plant productivity in arid regions is limited by water availability[1]. Climate change and groundwater depletion pose a major risk for species that have access to stable groundwater sources. This is the case of phreatophytes that support groundwater dependent ecosystems (GDEs)[2], whose decoupled productivity from climate conditions represents a critical ecosystem function for arid regions.

We investigated two aspects related to the water use strategy of a keystone species that dominates one of the few terrestrial GDEs in European drylands (*Ziziphus lotus* L. (Lam)): 1) where to obtain water from and 2) how to regulate its use.

1. R.H. Nolan, et al. Contrasting ecophysiology of two widespread arid zone tree species with differing access to water resources. *Journal of Arid Environments* **2018**, 153: 1–10
2. D. Eamus, et al. Groundwater Dependent Ecosystems: Classification, Identification Techniques and Threats. In A. J. Jakeman, et al. [eds.], Integrated Groundwater Management, 313–346. Springer International Publishing, Cham, **2016**.

Materials & Methods

Multiple isotope approach to evaluate plant's water sources and use patterns

Stable isotopes of groundwater, xylem water and precipitation (δ^2H and $\delta^{18}O$) were analyzed, as well as carbon stable isotopes in leaves ($\Delta^{13}C$)

Plant's water potential to characterize *Z. lotus* into the iso/anisohydric continuum

The slope (σ) of the regresion between predawn (Ψpd) and midday (Ψmd) water potential refers to extreme isohydric plants (σ = 0), extreme anisohydric plants (σ > 1) and intermediate between the two extremes (0 < σ < 1)

Foliar gas exchange rates to evaluate plant's response to increasing water stress along a depth-to-groundwater (DTGW) gradient

The relationship between $\Delta^{13}C$ and DTGW was also assessed

Results

Water source. Stable isotopes revealed that *Z. lotus* behaves as a facultative phreatophyte as there was not a perfect match between the values of xylem water and groundwater. We observed a mean isotopic offset between groundwater and xylem water of -4.1‰ for δ^2H and 1.4‰ for $\delta^{18}O$, and the increase of xylem water stable isotopes with depth (Fig 1).

Water transport. The slopes of the Ψmd:Ψpd regressions (σ) revealed the extreme anisohydric behavior of *Z. lotus* (σ = 1.43), which was more pronounced in spring (σ = 1.37) than in summer (σ = 0.85). Along the DTGW gradient, more anysohidric behavior was observed in plants at shallow water tables.

Plant-water relationship. The transpiration rate (E) of *Z. lotus* increased with atmospheric water demand, from spring to summer (Fig 2). However, we observed a reduction of mean E and stomatal conductance (g_s) with increasing DTGW up to 14m. Foliar carbon isotope discrimination ($\Delta^{13}C$) showed a similar pattern (Fig 3).

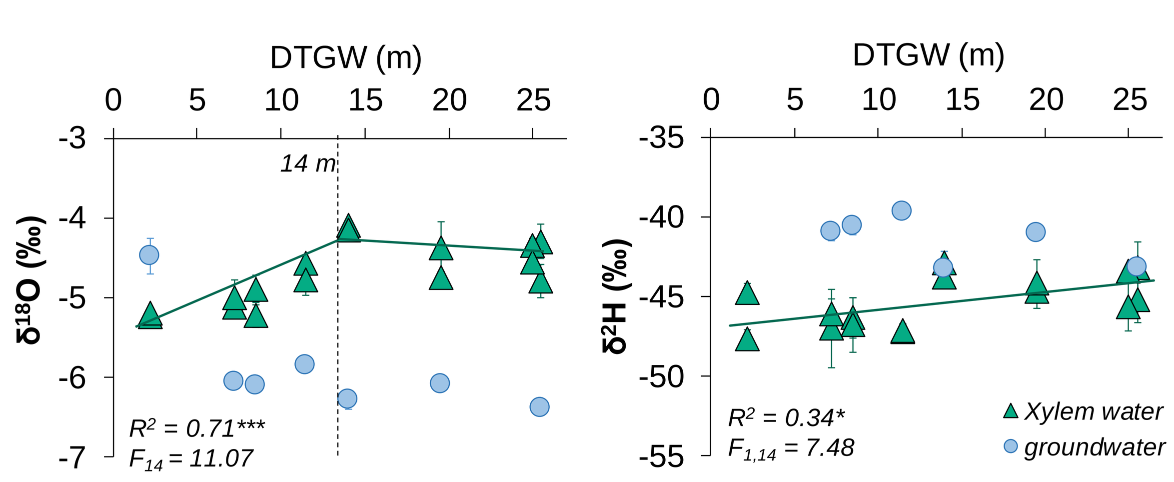


Fig 1. Relationship between xylem water stable isotopes ($\delta^{18}O$ and δ^2H) in *Z. lotus* (green triangles) and depth to-groundwater (DTGW). Light-blue circles represent groundwater values. Significance values: ***: P < 0.001, **: P < 0.01.

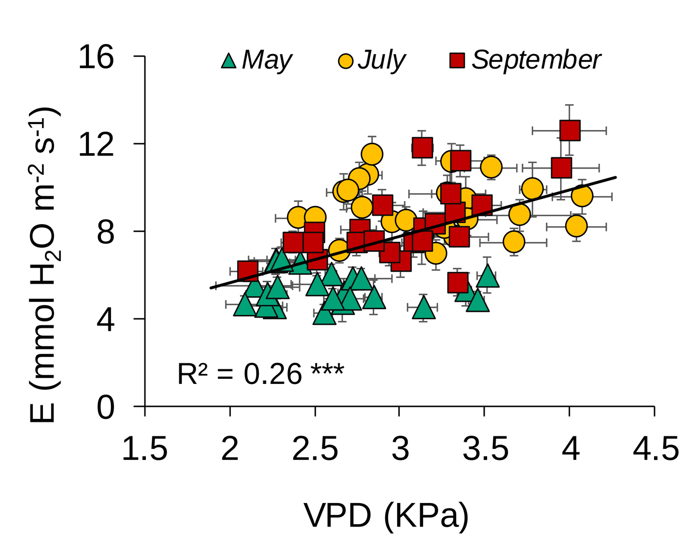


Fig 2. Relationship between atmospheric Vapor Pressure Deficit (VPD) and transpiration rate (E) in *Z. lotus*. Significance values: ***: P < 0.001

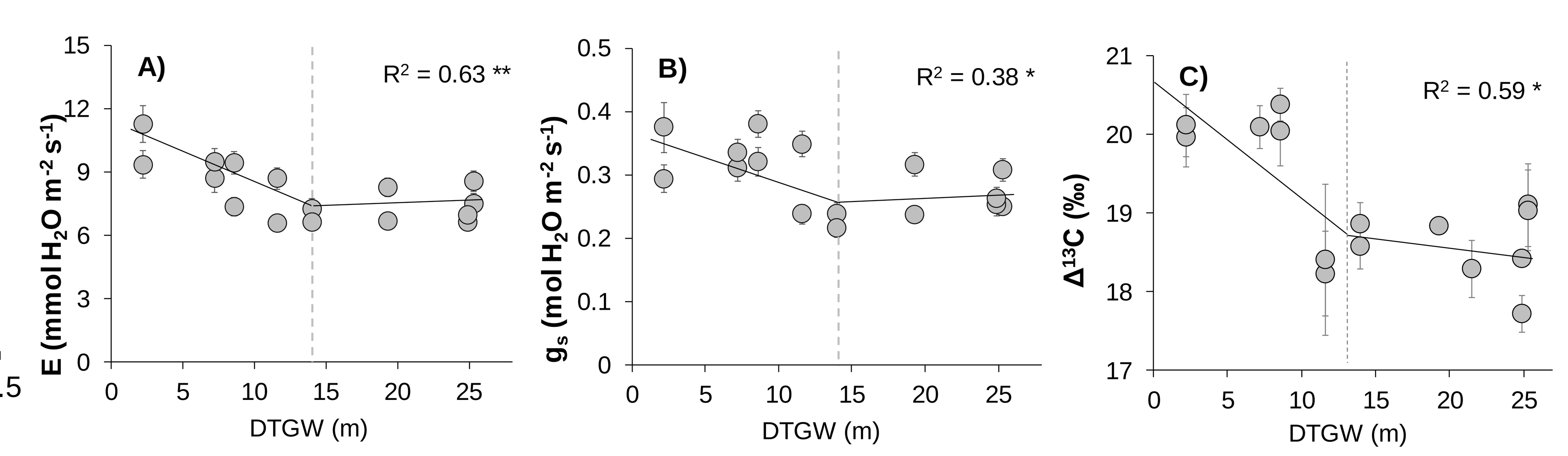
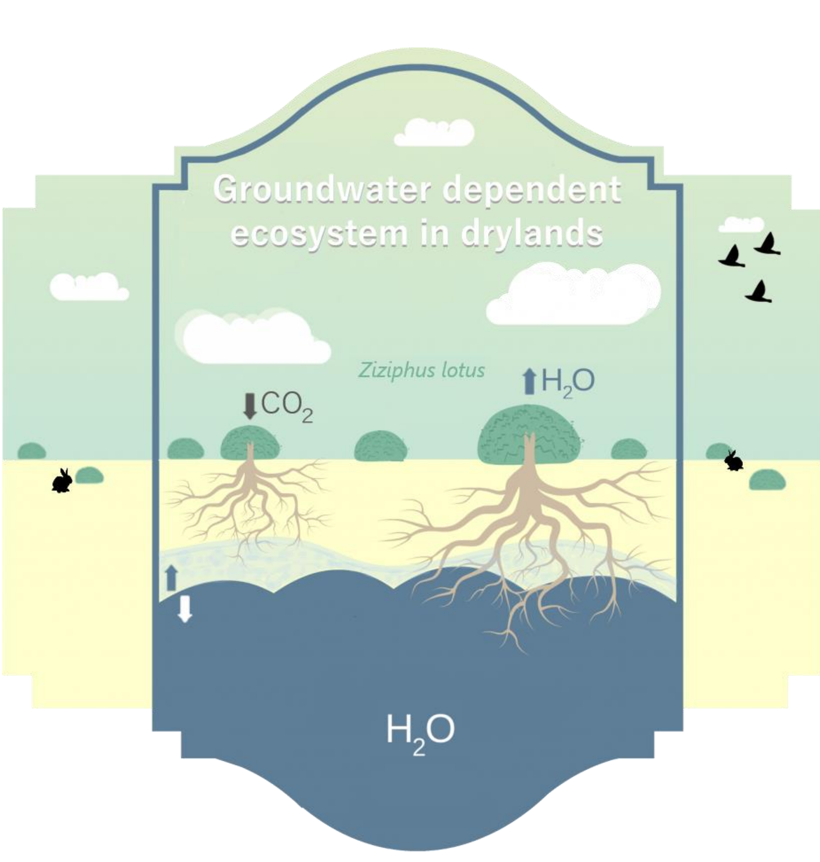


Fig 3. Relationship between (A) transpiration rate, E, (B) stomatal conductance, gs, and (C) carbon isotope discrimination in leaves, $\Delta^{13}C$, and depth-to-groundwater (DTGW). Solid lines represent significant segmented regressions (**: P < 0.01, *: P < 0.05), and dashed lines, the breakpoint of each regression (≃ 14 m)

Discussion



⇒ *Z. lotus* behaves as a facultative phreatophyte with extreme anisohydric stomatal regulation.

⇒ However, as DTGW increases, *Z. lotus:* 1) reduces the use of groundwater, 2) reduces total water uptake, and 3) limits transpiration water loss while increasing water use efficiency.

⇒ A physiological threshold at 14 meters depth to groundwater was found, which could indicate maximum depth beyond which optimal plant function could not be sustained.

⇒ Species such as *Z. lotus* survive by squandering water in arid regions because of a substantial groundwater uptake. However, the identification of DTGW thresholds indicates that drawdowns in groundwater level would jeopardize the functioning and productivity of these GDEs.

Ackowledgements

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