Variation in hydrogen stable isotopes in cellulose and n-alkanes: phylogenetic signal and related traits

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Background

Hydrogen (H) stable isotope analysis of specific plant organic compounds has become of interest as a tool for ecological, environmental and palaeoclimatological studies. Aside from the influence of leaf water evaporative enrichment on the δ^2H composition of organic compounds, hydrogen isotope fractionation occurs during carbon metabolism in the plant. Using a large set of species in the eudicot clade, we explored the variation of δ^2H in cellulose and n-alkanes, and its relationship with phylogeny and other plant traits with the aim of identifying the source of species-specific δ^2H.

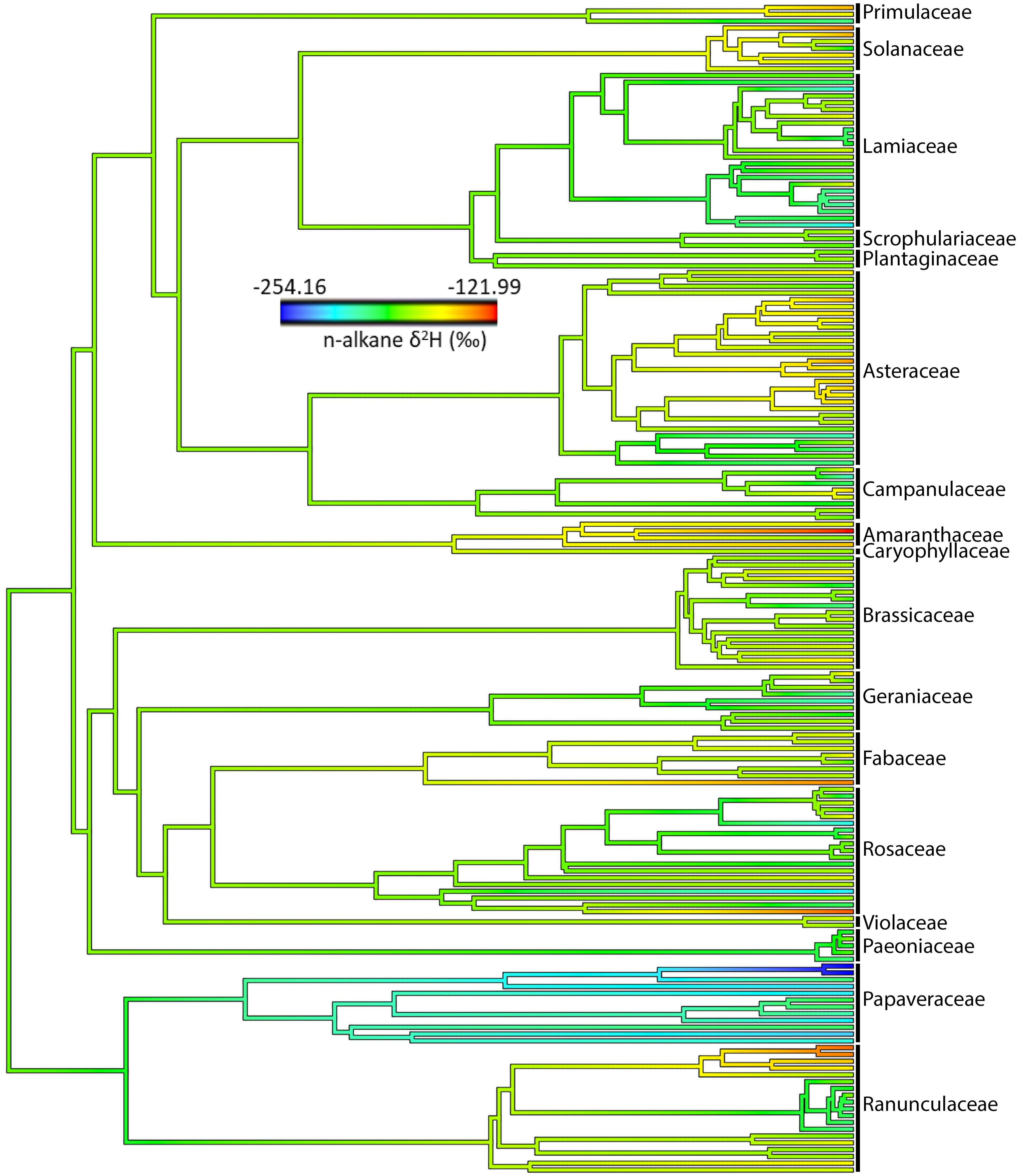

Figure 1: $\delta^2H_{n\text{-alkane}}$ shows a strong phylogenetic signal (Pagel's λ = 0.855; p<0.001), meaning that closely related species have similar $\delta^2H_{n\text{-alkane}}$ values. The *Papaveraceae* family in particular shows more depleted n-alkane δ^2H values, which provides a clear target for further investigation of the drivers of species $\delta^2H_{n\text{-alkane}}$ variation.

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References:

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Objectives

1) Explore the variability of cellulose and n-alkane δ^2H values in plants that grow in a common environment and detect if the observed variability is specific for taxonomic groups **(Fig. 1)**
2) Determine if n-alkane and cellulose δ^2H values covary across species within a location **(Fig. 2)**
3) Explore (integrated) physiological traits that can help explain δ^2H variation **(Fig. 3)**

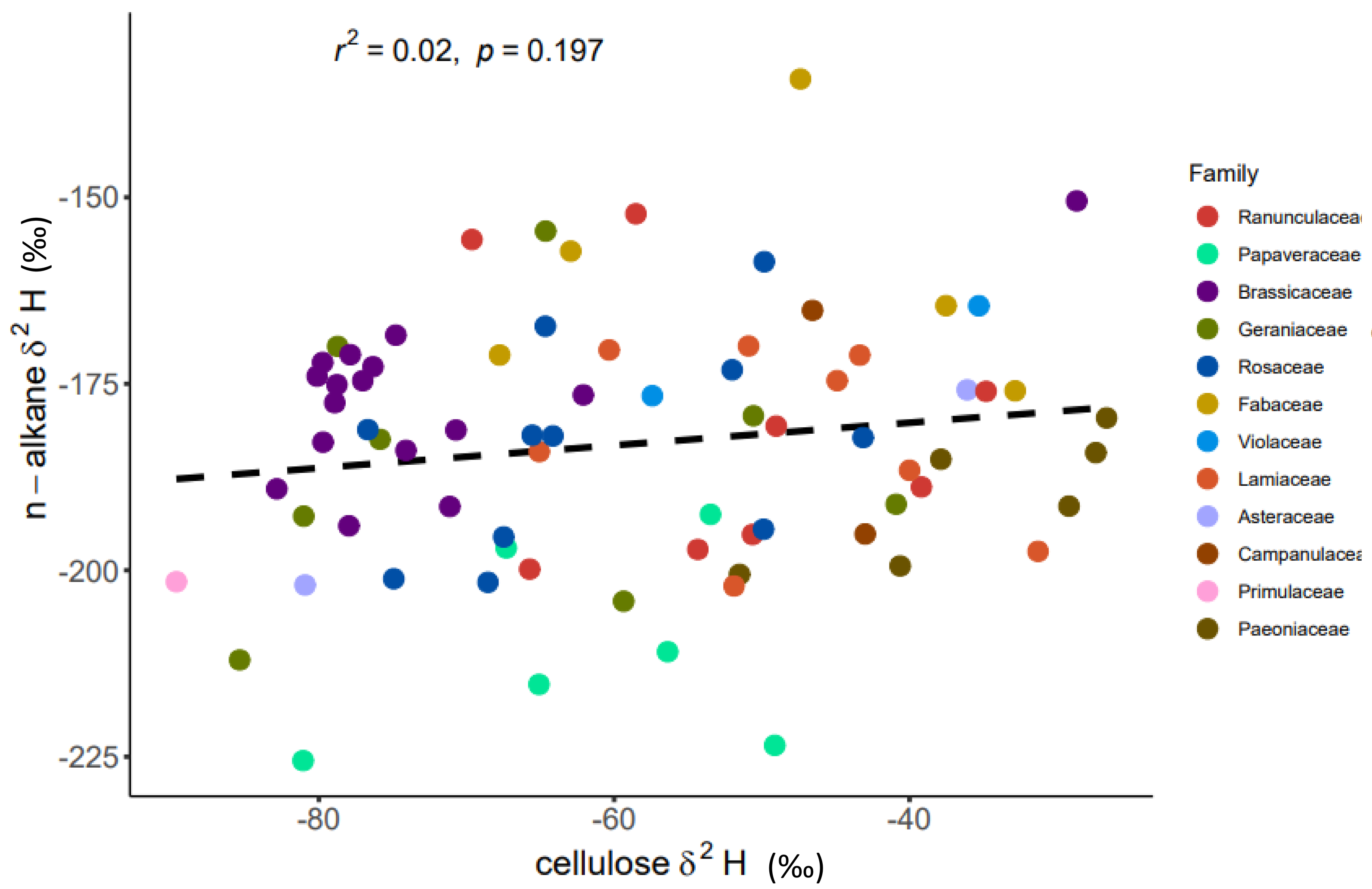

Figure 2: There was no relation between $\delta^2H_{n\text{-alkane}}$ and $\delta^2H_{cellulose}$ across different species, even though both compounds are synthesized in the same leaf water pools. Therefore variation in leaf water δ^2H through evaporative enrichment is likely not a main driver for organic compound δ^2H differences between species within a location.

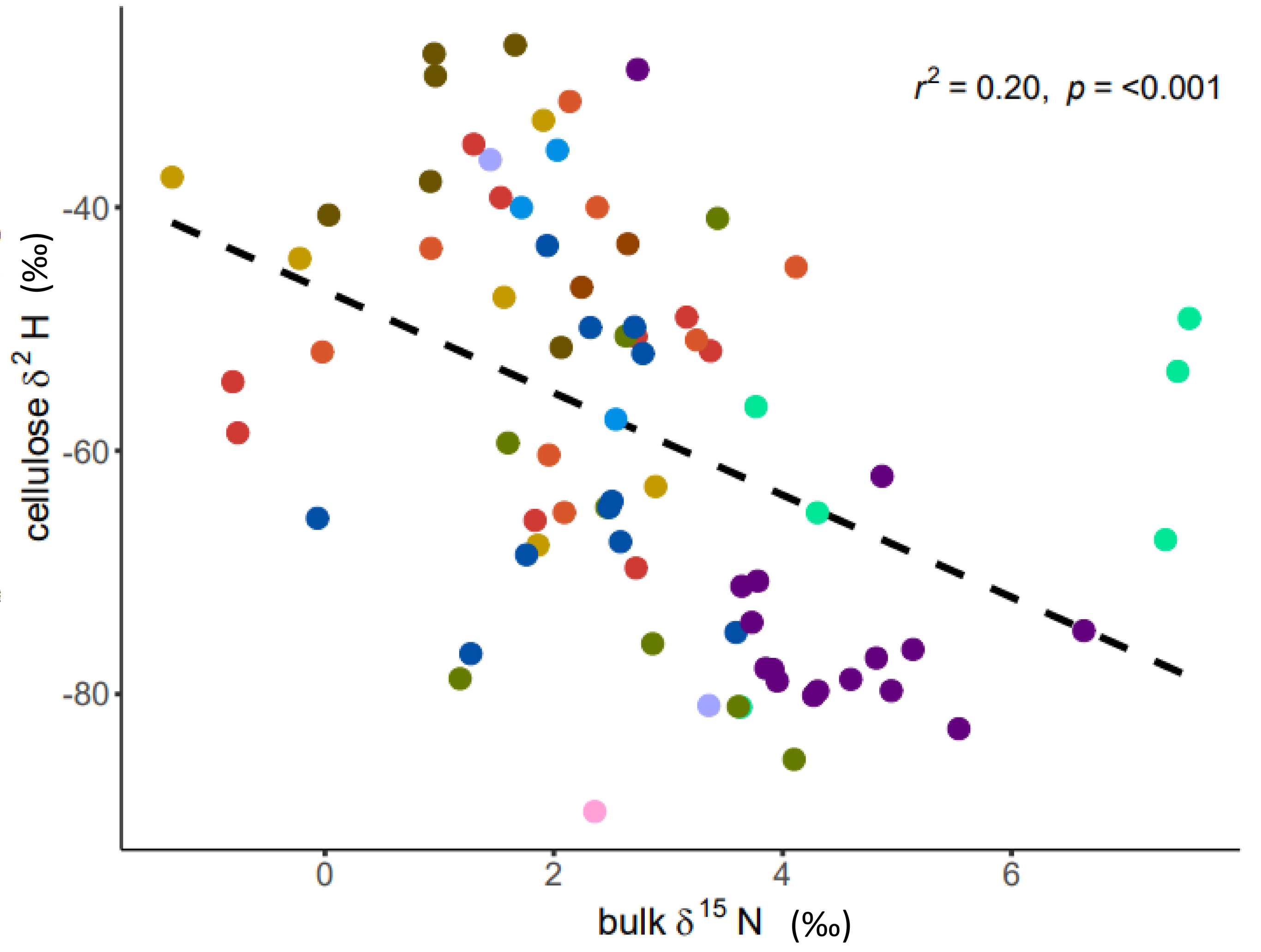

Figure 3: Higher $\delta^{15}N_{bulk}$ was related to more depleted $\delta^2H_{cellulose}$. If $\delta^{15}N$ values are interpreted in terms of nitrate reductase activity (NRA), higher $\delta^{15}N$ values would be associated with higher NRA[1]. NRA is associated with N-assimilation, the extent of which can influence C-allocation[2]. It is surmised that ^2H enrichment of sugars occurs via post-photosynthetic exchange reactions with water, where the greater the futile cycling of metabolites, the greater the opportunity for exchange[3].

Conclusions

1) δ^2H values show a strong variation within the eudicot clade (132‰ range in n-alkane δ^2H) and $\delta^2H_{n\text{-alkane}}$ is strongly related to phylogeny
2) Cellulose and n-alkane δ^2H values do not co-vary across species within a location
3) Cellulose δ^2H is related to bulk $\delta^{15}N$, showing a possible link to nitrogen assimilation