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Drought does not affect hydrogen isotope fractionation during lipid biosynthesis by the tropical plant Pachira aquatica

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Hydrogen isotope ratios ($^2H/^1H$) of plant waxes and other lipids preserved in sediments are increasingly used as a paleohydrologic proxy for past water isotopes. The relationship between precipitation $^2H/^1H$ ratios and those of plant waxes in surface sediments is linearly correlated at a global scale. However, there are large residuals in this relationship, and the offsets in $^2H/^1H$ ratios for the same compound produced by different species growing at the same site, as well as for different compounds produced within the same plant, can approach the magnitude of continental scale variability in precipitation isotopes. This indicates that lipid $^2H/^1H$ ratios are influenced by significant factors besides the $^2H/^1H$ ratios of local precipitation. One possibility is that plant metabolic responses to stresses such as drought cause changes in $^2H/^1H$ fractionation during lipid synthesis.

In order to assess the effects of drought on $^2H/^1H$ fractionation during plant lipid synthesis, we grew Pachira aquatica seedlings in controlled growth chamber conditions, with half of the individual plants experiencing drought conditions (soil moisture content reduced to ~10%) and half serving as well-watered controls (soil moisture content ~25%). We used position-specific ^{13}C-pyruvate labeling to assess if there were changes in lipid production under drought, and focused on a diverse range of compounds including palmitic acid, n-C_{29} and n-C_{31}-alkanes, phytol, squalene, and sitosterol. We also measured natural abundance $^2H/^1H$ ratios from the same compounds and from cryogenically extracted leaf water to quantify biosynthetic H isotope fractionation (ε_{Bio}).

Biosynthetic $^2H/^1H$ fractionation spanned a 150‰ range among compounds, with palmitic acid being the least ^2H-depleted compound (ε_{Bio} = -140 ± 10‰) and phytol being the most ^2H-depleted compound (ε_{Bio} = -317 ± 7‰). These fractionation factors did not change under drought, although ^{13}C-pyruvate labeling indicated that the compounds were being actively produced. There was no change in the production rate of any compound under drought, however. Differential

incorporation of ^{13}C depending on whether the 1st or 2nd carbon in pyruvate was labeled showed clear distinctions among compound classes, with the acetogenic compounds only becoming enriched from the C2 label, and isoprenoids using roughly equal proportions of carbon from each position. These results suggest that under this level of drought stress, Pachira aquatica did not make any changes to its lipid metabolism, and lipid $^{2}H/^{1}H$ ratios were therefore unperturbed. If replicated in additional plants types and under more severe drought, this result is encouraging for the use of plant lipid $^{2}H/^{1}H$ ratios as robust paleohydroclimate tracers.