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Stable carbon and oxygen isotope variability of modern pollen from nine abundant European tree species.

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A detailed understanding of the carbon and oxygen isotope ratios of modern pollen is crucial for the interpretation of fossil $\delta^{13}C_{pollen}$ and $\delta^{18}O_{pollen}$ values. To broaden our knowledge of pollen-isotope ratios we investigated the isotope ranges of nine abundant tree species from central and northern Europe (vegetation periods 2015 and 2016).

In general, the isotope values of modern pollen are highly species-specific and yield site-specific patterns. Trees of different locations revealed distinct $\delta^{13}C_{pollen}$ and $\delta^{18}O_{pollen}$ patterns for maritime and continental growing conditions and for high and low altitudes. Furthermore, pollen-isotope ratios reflect the time of blossoming. $\delta^{13}C_{pollen}$ values of broad-leaved species flowering before leaf proliferation (Janurary to March; *Alnus glutinosa* and *Corylus avellana*) are on average 2.6‰ lower in comparison to broad-leaved and coniferous trees flowering during late spring and early summer (April to June; *Acer pseudoplatanus*, *Betula pendula*, *Carpinus betulus*, *Fagus sylvatica*, *Picea abies*, *Pinus sylvestris* and *Quercus robur*). $\delta^{18}O_{pollen}$ values yielded similar results, which are on average 3.1‰ lower for species flowering early in the year. An intra-annual analysis of Betula pendula and Pinus sylvestris pollen revealed increased $\delta^{18}O_{pollen}$ values during the last stages of pollen-maturation, whereas $\delta^{13}C_{pollen}$ values of both species remain consistent during late pollen development. Additionally, pollen-isotope values vary markedly within individual trees. Circumferential and height-dependent variations within single trees can be as high as 3.5‰ for $\delta^{13}C_{pollen}$ and 2.1‰ for $\delta^{18}O_{pollen}$.

Our results suggest that local environmental conditions are generally reflected in the carbon and oxygen pollen-isotopes, but some species seem to reflect the conditions more closely than others. The data indicate that it may even be feasible to reconstruct intra-annual climate conditions by analysing isotopes of species whose pollen develop during different seasons throughout the year.