Epicuticular wax lipid composition of Betula species and its chemotaxonomic significance

J. Weber¹, L. Schwark¹,²

¹ Christian-Albrechts-University, Institute of Geosciences, Kiel, Germany
² Curtin University, WA-OIGC, Perth, Australia

(jan.weber@ifg.uni-kiel.de, lorenz.schwark@ifg.uni-kiel.de)

Birches (Betula) are common angiosperm trees and shrubs in diverse habitats of the Northern Hemisphere, ranging from moderate to boreal and to cold-temperate climate zones in Northern America, Eurasia, East Asia, and Circumpolar regions. The number of species ascribed to the genus Betula ranges from 30 to 60 different taxa within 4 to 6 subgenera (De Jonge, 1993; Skvortsov, 2002; Ashburner and McAllister, 2013). Recent birch species can be distinguished by their leaf and catkin shape, whereby their evolutionary relation and phylogeny is difficult to assess due to intensive hybridization. Recognition of birch species in geological archives is restricted by a lack of well-preserved leaves or catkins. Most commonly, paleovegetation reconstruction in sediments is based on pollen rather than macro-remnants. Unfortunately, differentiation of birch species by pollen is challenging, due to similar morphological traits, e.g. shape, diameter and depth of pollen (Mäkelä, 1996). Due to contrasting habitat and climate requirements of birch species with virtually identical pollen morphology, any paleovegetation and paleoclimate reconstruction based on palynology would benefit from complementary molecular birch paleovegetation proxies.

In an attempt to distinguish birch species on the molecular level, we analysed the epicuticular wax compound classes (n-alkanes, n-alcohols, n-alkanoic acids, n-alkyl esters) from 22 Betula species to determine their chemotaxonomic characteristics. 16 of the birches grew under equal environmental conditions at the Botanical Garden of Kiel University (Northern Germany). We sampled another 12 birch species from an arboretum in Freiburg, located 700 km to the south to cover a range in recent climate conditions in Germany. Colder and more humid conditions in Kiel contrast warmer and less humid conditions in Freiburg. To address altitudinal effects on birch wax we sampled B. glandulosa leaves at different elevations in the Canadian Rocky Mountains. As leaf abscission occurs in autumn, at the end of the growth period, we harvest recent leaves at this time to obtain the wax composition that is incorporated into sediments or soils.

Results indicate that not only the cumulative lipid concentrations vary between species but also between separate wax lipid classes on the species level (Fig. 1). For instance, the total lipid content ranges from 540 µg/g dry leaf in B. nana up to 6300 µg/g dry leaf within B. platyphylla. Alkyl esters in B. nigra reach up to 80%, while they constitute <10% in B. glandulosa. Further taxonomic information can be derived from n-alkyl homologue distribution within wax classes, whereby the distribution of n-alkanes ranges from C23 to C33, n-alcohols (C20 – C32), n-alkanoic acids (C22 – C30) and alkyl esters (C34 – C50) as shown in the figure. Presently, a wax lipid chemotaxonomy of morphologically defined subgenera cannot be established, an observation shared with genetic phylogeny (Järvinen et al., 2004, Wang et al., 2016). The average chain lengths of n-alkanes (ACL) often applied in paleovegetation studies varies within subgenera, limiting e.g. chemotaxonomic distinction between shrubby and tree birches. Adaptation to environmental conditions is reflected by an increase in wax lipid concentration with decreasing mean annual temperature in some species and has to be considered in paleo-applications.
Figure: Epicuticular wax lipid distribution of birch species from the Botanical Garden of Kiel University and the Canadian Rocky Mountains (B. glandulosa). Birch species are native to: EU = Europe, W-A = West Asia, E-A = East Asia, A = Asia, N-Am = North America. In all wax classes the alkyl lipid concentrations span two orders of magnitude and differential enrichment in individual lipid classes as well as analogue distributions occur on species level.

References: