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Combination of branched GDGTs and testate amoebae for the reconstruction of past climate change in a French peatland

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Peatlands are important archives for the reconstruction of past environmental changes because of their high rates of peat accumulation due to the low rate of plant litter decomposition. Branched glycerol dialkyl glycerol tetraethers (GDGTs) are complex lipids of high molecular weight, recently discovered in soils and suggested to be produced by anaerobic bacteria. The relative distribution of branched GDGTs in soils correlates with environmental variables: the degree of methylation, expressed in the methylation index of branched tetraethers (MBT), depends on mean annual air temperature (MAAT) and to a lesser extent on soil pH, whereas the relative abundance of cyclopentyl rings of branched GDGTs, expressed in the cyclisation ratio of branched tetraethers (CBT), is related to soil pH. The MBT/CBT proxies are increasingly used for the reconstruction of past air temperatures, but have rarely been applied in peatlands. Testate amoebae are common and diverse unicellular eukaryotes in peatlands. They build shells that are preserved in peat. They are good indicators of changing environmental conditions in peatlands and are thus used in both ecological and paleoecological studies, especially for reconstructing surface moisture.

The aim of this study was to examine the applicability of branched GDGTs and testate amoebae as indicators of environmental changes (temperature and moisture) in temperate peatlands. Within the PEATWARM project, both GDGTs and testate amoebae were studied at high resolution in a 4 m peat core collected in Frasne mire (French Jura Mountains) and covering the last 7,400 years BP.

GDGT-inferred temperatures ranged between 8 and 12 °C until 250 cm depth and were higher than present measured mean annual air temperature (ca. 6 °C). Temperature estimates in the top part of the bog were most consistent with spring and summer mean air temperatures recorded in the peatland (ca. 11.5 °C), suggesting that branched GDGT-producing bacteria might be more active during the warmest months of the year. At 250 cm depth, reconstructed temperature showed a pronounced shift, likely reflecting both a change in climatic conditions but also in the composition of the peat. Indeed, drier conditions were indicated by testate amoebae at the bottom of the peat core, whereas wetter conditions occurred at the top. Interestingly, temperature variations inferred from MBT/CBT proxies were weakly linked with moisture variations inferred from testate amoebae until 150 cm depth ($r = -0.41$, $p = 0.06$). Therefore, the distribution of branched GDGTs might also depend on peat moisture level, in addition to air temperature and pH. Our data suggest that the joint use of MBT/CBT and testate amoebae is a promising approach to estimate past climate change, but that more research is required to calibrate and apply with confidence these proxies in peatlands.