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Possibility of climate reconstruction on monthly/seasonal scales by oxygen isotope ratios in tropical ringless trees

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Tree rings have been used as one of the best natural archives of past climate, resulting in tree-ring networks available in various regions of the world. However, the terrestrial tropics have produced the fewest tree-ring records because most of tropical trees do not form annual rings. Recent progress in isotope dendrochronology, on the other hand, reveals that oxygen isotope ratios of tree cellulose are primarily governed by two climatic factors, i.e., oxygen isotope ratios of source water and relative humidity, both of which are considered to vary significantly according to hydroclimatic seasonality. It is therefore expected to obtain past climate records on seasonal/monthly or perhaps weekly scales by measuring oxygen isotope ratios of tropical trees lacking annual rings.

One tree sampled from each of two even-aged plantations (3 and 2 years old, respectively, in Paksuun and Nong Boua) of Eucalyptus, with a distance of 30 km between them, in central Laos was utilized for this study. The stem diameters (1.3m above the ground) of the sampled trees from Paksuun and Nong Boua were 11.5 cm and 12.8 cm, respectively. A $4 * 6$ mm radial section extending from the pith to cambium was cut from a stem disc, and was subsampled on a rotary microtome at 20 um increments. Twenty-five slices were then aggregated into a single sample for a sampling resolution of 0.5mm. Following the standard practice in isotope dendrochronology, whole wood was extracted to cellulose through a series of chemical steps. In the case of Nong Boua, 2-slice sample out of 25 slices was only subjected to removal of resins, whereas the remaining 23-slice sample was extracted to cellulose, in the same way as the samples from Paksuun. This aims to know the extent to which isotopic variations are correlated between wood and cellulose samples, and thus to know whether large number of samples can be rapidly prepared without extracting cellulose. Oxygen isotope ratios of cellulose and wood samples were determined by an isotope ratio mass spectrometer interfaced with a pyrolysis-type elemental analyzer (TCEA?IRMS). The standard deviation derived from repeatedly measured standard material was 0.2 per mill.

The oxygen isotope ratios from Paksuun and Nong Boua showed similar variations in spite of a distance of 30 km between the sites, indicating that common signals related to regional climate were recorded in the sampled trees. The oxygen isotope ratios are then compared with 15-day moving averages of relative humidity at the Paksan meteorological station located near the sampling sites. Large periodic oscillations, which correspond to wet and dry seasons, appearing in relative humidity were found in the isotope records. Intra-seasonal variations of the isotope records were also correlated with those of relative humidity. Growth rates were the highest in the rainy season, in which the sampling interval of 0.5 mm corresponded to weekly resolution. Oxygen isotope ratios of whole wood samples were highly correlated with those of cellulose samples ($r = 0.97$, $p < 0.001$), suggesting that measuring whole wood instead of cellulose is now feasible to rapidly process large number of samples.

Keywords: Oxygen isotope ratio, Cellulose, Relative humidity