# Examination of stable oxygen isotope as a tree ring proxy of tropical ring-less trees

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Tree rings have various information on the growing conditions. However, it is difficult to utilize this information in tropical region because most tropical trees lack visible growth rings. In this study, the author discussed the application of stable oxygen isotope ratio ($\delta^{18}O$) to tree ring study in tropical region.

The necessity of extracting α-cellulose for xylem $\delta^{18}O$ analysis was tested in Chapter 1. The author concluded that α-cellulose extraction is unnecessary for the purpose of growth ring detection, and hence bulk sample was analyzed in the following chapters. Skipping α-cellulose extraction step greatly reduced the analytical time and labor of $\delta^{18}O$ measurement.

In Chapter 2, whether precipitation $\delta^{18}O$ has a certain annual trend and the trend is recorded in xylem $\delta^{18}O$ was examined using *Tectona grandis*, a tree species forming visible annual rings in seasonally dry forests in northeast Thailand. Precipitation $\delta^{18}O$ has a decreasing trend from spring to summer during research period from 2015 to 2018, and this trend seems to be a typical seasonal pattern in northeast Thailand. Xylem $\delta^{18}O$ of *T. grandis* had a negative peak at each growth boundary, and the following decrease in the later growth of each year would reflect the decreasing trend of precipitation $\delta^{18}O$ from spring to summer. Thus, the radial cycle of xylem $\delta^{18}O$ could be interpreted as one year's growth of the trees in this study site, even if they do not have visible growth rings.

The applicability of high-voltage DC pulse marking was tested for trees without visible growth rings in seasonally dry forests and a tropical rainforest in Chapter 3. Trees' sensitivity to the DC pulse marking was different between sites and seasons. DC pulse marking failed to inscribe marks in some trees in the seasonally dry forests, whereas the marking successfully inscribed marks in almost all studied trees in the tropical rainforest. It seems that cambial activity of trees in the tropical rain forest is more active than that in the seasonally dry forests, affecting the successful rate of the marking. Effects of marking were similar to those reported in the previous studies in temperate tree species; thin walled wood fiber, deformed ray parenchyma, and crushed vessel. In addition to these, cell deposit was observed in trees in the tropical rainforest. Reaction to DC pulse marking would be various depending on species; for example, traumatic resin canals in *Shorea* spp.. It is necessary to examine suitable conditions and species for effective use of DC pulse marking.

Growth ring detection using xylem $\delta^{18}O$ variation was tested for trees without visible growth ring in seasonally dry forests in Chapter 4. Assuming that seasonal variation of precipitation $\delta^{18}O$ was recorded in trees grown in the same site in the same way, growth boundaries of trees without visible ring were detectable from xylem $\delta^{18}O$ variation and the result was consistent with the result of DC pulse marking. Xylem $\delta^{18}O$ would be a reliable tree ring proxy in this region, but more case studies are needed.

Trees in a tropical rainforest have more complex xylem $\delta^{18}O$ pattern compared to those in seasonally dry forests probably because poor seasonality in precipitation and source water $\delta^{18}O$ (Chapter 5). Although annual radial variation of xylem $\delta^{18}O$ was confirmed to be similar across several rings in *Peronema* *canescens*, long-term observation about climate, source water $\delta^{18}O$, and phenology is needed to apply seasonal variation of xylem $\delta^{18}O$ to growth ring detection.

There are several methods for growth ring detection, but none of them are applicable globally. Xylem $\delta^{18}O$ has a potential to provide valuable information for tree ring research both in temperate and tropical regions. However, to interpret the information adequately, other information as anatomy or phenology is indispensable. Combining plural methods based on different discipline and accumulated knowledge on climate and forest will develop the dendrochronology in tropics.