

## Detection of growth dynamics in tree species of a tropical mountain rain forest in southern Ecuador

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### Introduction

Dendrochronology in tropical areas has made substantial progress during the last years, as documented in several overviews (Wimmer and Vetter 1999, Roig, 2000a, Worbes 2002). Several studies reported about occurrence and climatological explanation of annually formed tree rings in neotropical wood species (e.g. Devall et al. 1995, Tomazello Fo et al. 2000, Roig 2000b). Thus, there are new perspectives to close important gaps in paleoclimatic information in the inner tropical regions that exist between tree-ring chronologies in Mexico (Stahle et al. 1998, Biondi 2001, Cleaveland et al. 2003) and the southern Andes (e.g. Villalba et al. 1997, Roig et al. 2001).

The study area is located at ca. 4°S in the province of Loja (southern Ecuador), in the Podocarpus National Park. The climate shows a high spatial variability due to the complex topography of the area that drastically modifies the general climatic conditions (Richter 2003). Along a east-west transect over the eastern Andes (Cordillera Real), the average annual rainfall varies from ca. 2200 mm (Zamorra, 970 m a.s.l.) in the eastern foreland, ca. 2500 mm (San Francisco, 1800 m a.s.l.) in a valley in the central Andes to 835 mm in the intra-andine basin of Vilcabamba (1570 m a.s.l.) to the west of the mountain chain (Hagedorn 1991). In the same direction, the seasonality of the rainfall distribution increases: perhumid conditions prevail on the eastern side of the Andes, whereas in Vilcabamba, which lies on the leeward side of the Andean chain, only 3 months per year (February-April) show humid conditions. Besides an east-west gradient, altitude has a strong impact on average temperature and on the amount of rainfall. At the upper timberline at approx. 3200 m elevation, more than 7500 mm of annual precipitation occur, in addition, approx. 2750 mm of water input by cloud and fog have to be taken into account (Bendix et al., 2004, Fabian et al. 2005).

### Detection of growth dynamics

The first task was to realise a wood anatomical screening of approx. 250 different tree species that occur in the area to select some target species which form clear anatomical growth boundaries. As examples of such tree species we show photographs of *Cedrela montana* and *Tabebuia chrysantha* (Fig. 1). Several cores of *Cedrela montana* were measured to compare the inter- and intra-tree variability of these growth zones. Two radii of *Cedrela* allowed crossdating (Fig. 2). The two cores show a Gleichläufigkeit (sign-test) of 94% and a t-value (Baillie and Pilcher) of 8.9. Crossdating was not achieved yet between different trees, although some growth similarity was observed.

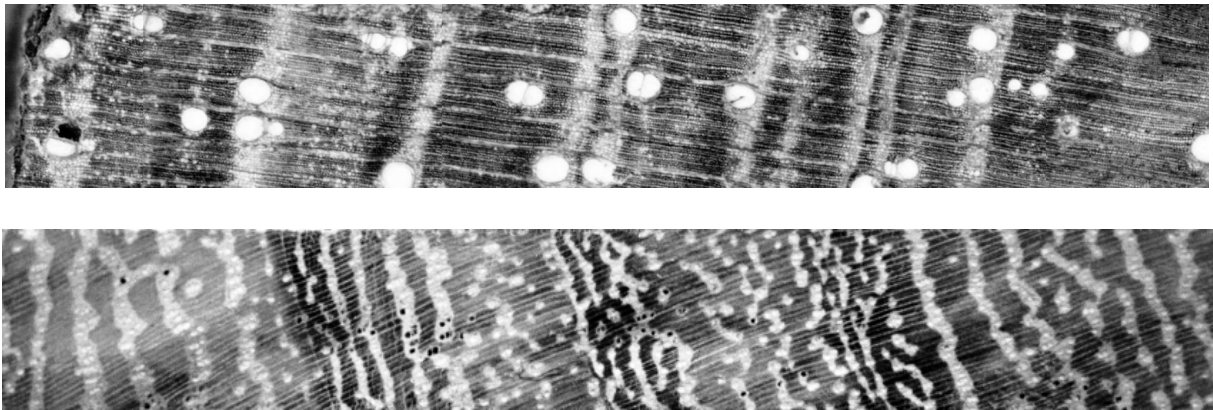


Figure 1: Macroscopic images of *Cedrela montana* (upper photo) and *Tabebuia chrysantha* (lower photo). Both species exhibit clear anatomical growth zones.

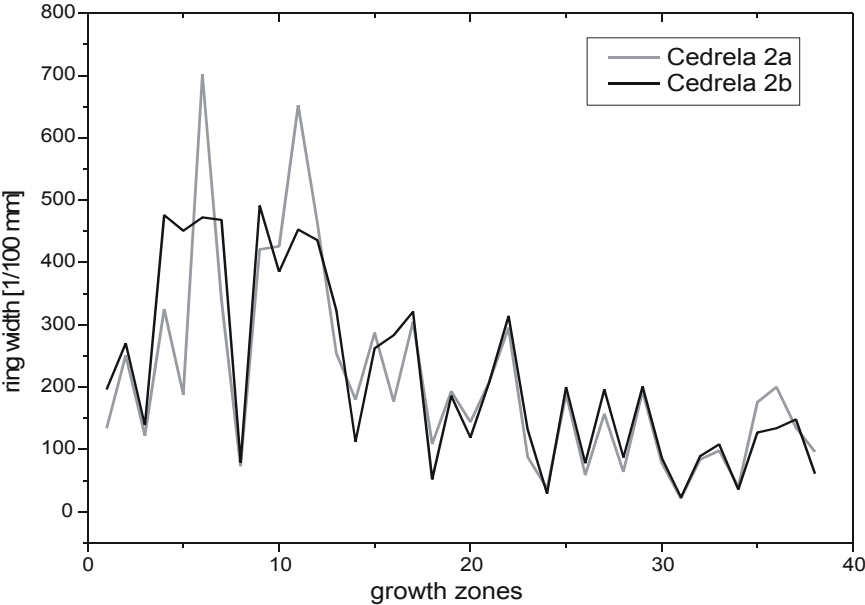


Figure 2: Synchronisation of growth zones within two radii of *Cedrela montana*

One study site where growth dynamics of selected species are studied in detail is located on the western declivity of the Podocarpus plateau at an elevation of 2100 m. The site is located in a transition zone between tropical humid evergreen cloud forest and semi-deciduous forest. Growth dynamics in tree species without distinct ring boundaries has often been studied by the so called ‘pinning-method’, a controlled wounding with needles (e.g. Nobuchi et al. 1995). To achieve a higher temporal resolution and a better control of the seasonal formation of different anatomical types of wood tissues, we collected small wood samples in two-week intervals with an increment puncher (Forster et al. 2000). Microsections with a thickness of 20  $\mu\text{m}$  are produced, stained with solutions of safranin and astrablue and photographed. In addition, we installed dendrometers to register stem swelling and shrinking in 30 min. intervals.

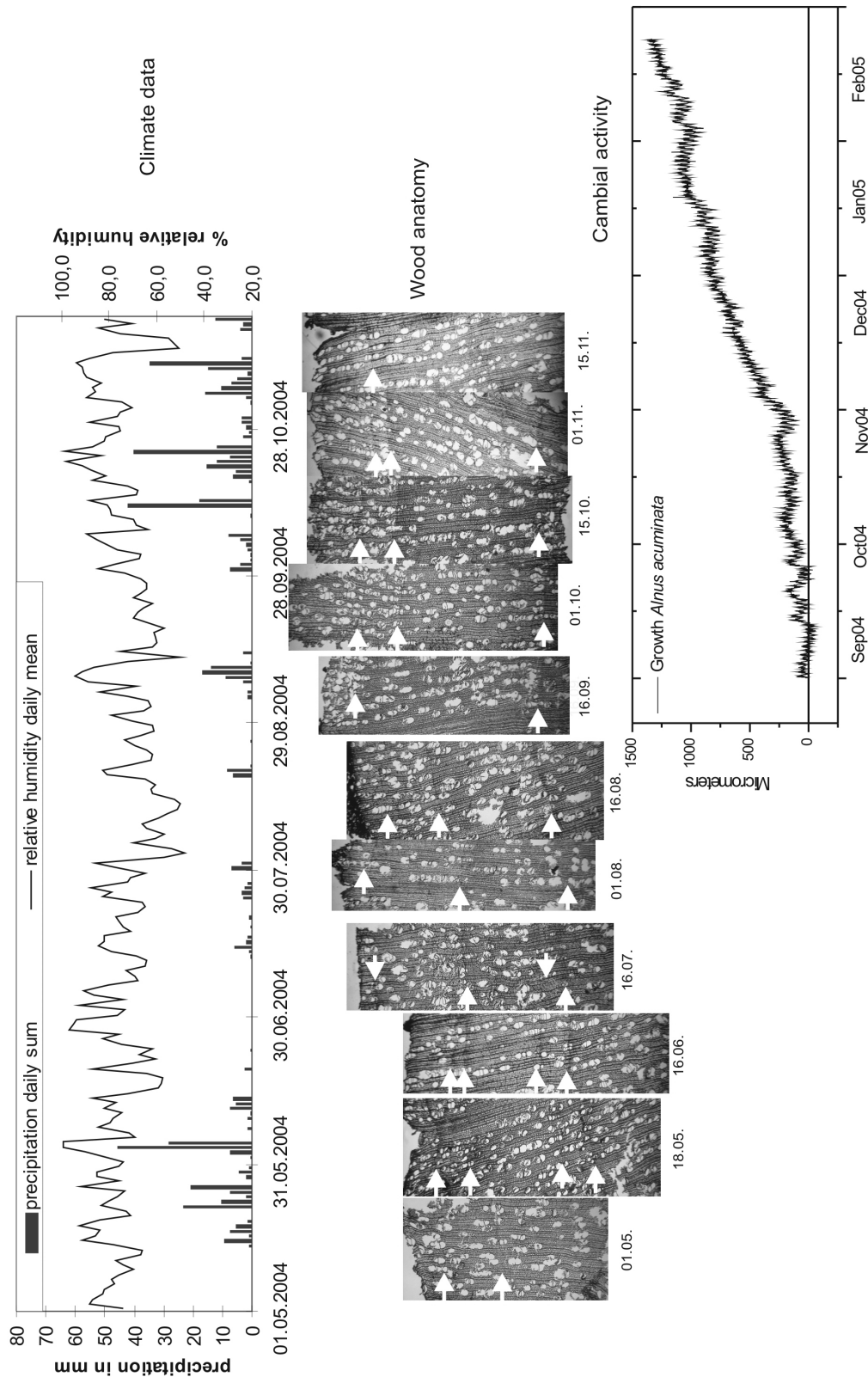


Figure 3: Comparison of climate data (precipitation daily sum and relative humidity daily mean), wood anatomy (microscopic images of biweekly increment puncher samples) and cambial activity (increase of girth recorded by dendrometer) of one *Alnus acuminate* tree in 2004. The white arrows indicate corresponding continuous lines on all samples.

A climate station measuring temperature, relative humidity and precipitation was installed in a distance of ca. 1 km. The pioneer species *Alnus acuminata* has been successfully used for ecological tree-ring studies on fire and landslide dynamics in subtropical Argentina, an area that shows distinct hygric seasonality (Grau et al. 2003).

Three tree species are abundant at the study plot and were selected for dendrometer measurements. The first is the pioneer species *Alnus acuminata* (Alnaceae). Further species are *Cedrela montana* (Meliaceae) and *Prumnopitys montana* (Podocarpaceae). To disentangle wood formation in relation to climate seasonality and girth changes, analyses of micro-sections, growth information from dendrometers and climate data have been combined. An example of this approach for *Alnus acuminata* is shown in Fig. 3 from growth season of 2004.

*Alnus* did not show formation of new cells during a relatively dry period without rainfall around 1st of May 2004. Probably as a reaction to the early June rainfall, new cells were formed between June 16<sup>th</sup> and July 16<sup>th</sup>. The pronounced band of thick-walled wood fibres serves as a marker in the two successive microsections. Between mid June and end of September, almost no rainfall occurred and relative humidity was rather low. *Alnus* did not exhibit formation of new cells. After the rainfalls during October, *Alnus* shows a swelling of the stem which is registered by the dendrometer. Then, according to the dendrometer and climate data, new wood tissue was formed consistently.

To discern seasonality in tropical woods, as many information as possible on the temporal succession of formation of different tissues is necessary. Visual control of the formation of different cells in the increment puncher cores combined with continuous measuring of cambial activity by dendrometer and climate data may help to achieve this goal.

This example illustrates how information about growth seasonality and its relation to local climate can be achieved by a combination of wood anatomy and growth measurements. Unfortunately, it requires regular maintenance of all instruments which is difficult at remote places under humid tropical conditions. Longer periods of overlapping information of all studied parameters are required to fully clarify the seasonality of wood formation at this site. This basic information about tree growth behaviour in a tropical mountain climate may then be used to interpret growth variations found on long increment cores. Finally, we hope to be able to construct tree-ring chronologies that provide new information on climate history in a region that is still largely devoid of high-resolution paleoecological data.

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