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Seasonal growth dynamics and its climate forcing in a tropical mountain rain forest in southern Ecuador

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Introduction

Tree ring series are a well established data source to derive urgently needed long-term palaeoclimate information. In contrast to formerly widely accepted assumptions, even in the humid tropics trees do not grow continuously. Irrespective of the formation of clearly distinguishable ring boundaries, many tropical tree species show pronounced growth variations triggered by fluctuations in temperature, water availability and phenology (Bauch et al. 2006; Bräuning & Burchardt 2006; Détienne 1989; Devall et al. 1995; Dünisch et al. 2002; Sass et al. 1995; Verheyden et al. 2004). An understanding of the linkage between growth dynamics and seasonal climatology is fundamental to derive climate reconstructions from tree-ring analysis. Stem diameters can vary on diurnal (day-night cycle), short-term (water shortage) and long-term (stem growth by cambial activity) time scales. Long-term variations are the result of radial growth, whereas short-term stem diameter variations reflect changes of the internal water status. This study sheds light on seasonal and short-term growth variations of tropical trees and relates them to climate and local site conditions.

Material and Methods

The study area is located at ca. 4°S at the northern rim of Podocarpus National Park in Southern Ecuador. The three sites A, B and C are located on a slope with northern exposure at an altitude of 2030 m, 1970 m and 1980 m a.s.l., respectively. Sites A and B are located in straight slope positions, whereas site C is located in a small valley. Electronic dendrometers were attached to a total number of 11 trees in the three sites. Among the many species present, trees from the species *Prumnopitys montana* (Podocarpaceae), *Cedrela cf. montana* (Meliaceae), *Inga acreana* (Mimosaceae) and *Nectandra laevis* (Lauraceae) were selected because of their wood anatomy that allows the detection of more or less distinct growth boundaries (Fig. 1). The studied species belong to different life forms: While *Inga* and *Nectandra* are evergreen broadleaved species, *Cedrela* is deciduous broadleaved and *Prunmopitys* is an evergreen conifer.

The use of dendrometers is a standard approach to register growth rates of trees inside and outside tropical climate zones (e.g. Biondi et al. 2005; Hauser 2003). Band dendrometers that measure changes in the circumference of a tree stem are not able to detect short-term variations in the stem size as a result of fluctuations in the water status of the tree. Therefore, they integrate the long-term water status of a stem and long-term growth rates, but they are not suited to study the process of real xylem growth and short-term growth rhythms of trees (Homeier 2004; Kuroda & Kiyuno 1997). In March 2006, we installed point dendrometers in a height of ca. 1.5 m of the stems at a position parallel to the slope to avoid a possible influence of reaction wood. Measurements of stem radius changes were taken in 30 min. intervals and stored in a data logger.

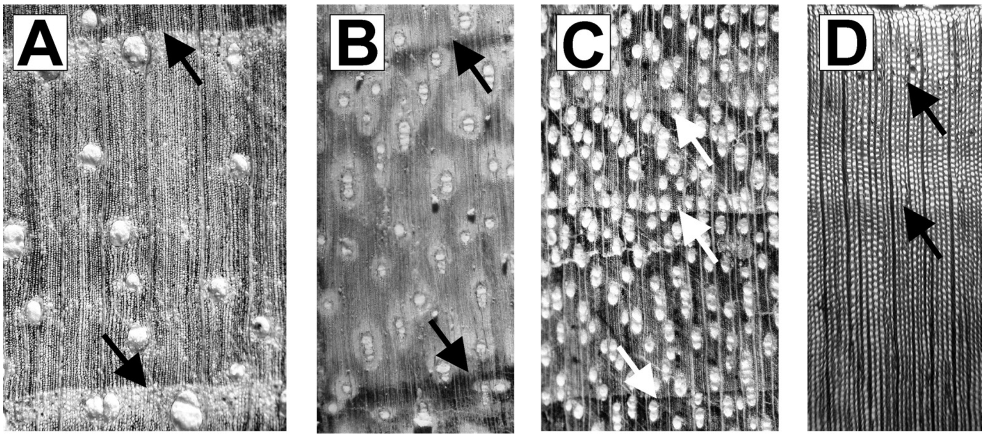

Figure 1: Macroscopic images of Cedrela montana (A), Inga acreana (B), Nectandra laevis (C) and Prumnopitys montana (D). Growth boundaries are marked with arrows.

Climate data were collected from a climate station in ca. 1 km horizontal distance of the study plots in an altitude of 1950 m a.s.l. Mean annual temperature is around 16°C and shows only marginal seasonal variations (Bendix et al. 2006). Annual mean rainfall amounts to 2176 mm, in addition ca. 120 mm of available water from cloud and horizontal rain water deposition have to be considered. Maximum rainfall amounts are registered during March to July. Between August to February, average monthly rainfall amounts between ca. 110-160 mm. However, even in the relatively drier months, monthly sums of rainfall exceed evaporation, so that climate conditions are humid in all months of the year (Bendix et al. 2006). However, it becomes clear that rainless periods of more than two consecutive weeks may occur (Fig. 2).

Results

Figure 2 shows the dendrometer curves for 2006. Unfortunately, some missing values occurred after several weeks of measurement.

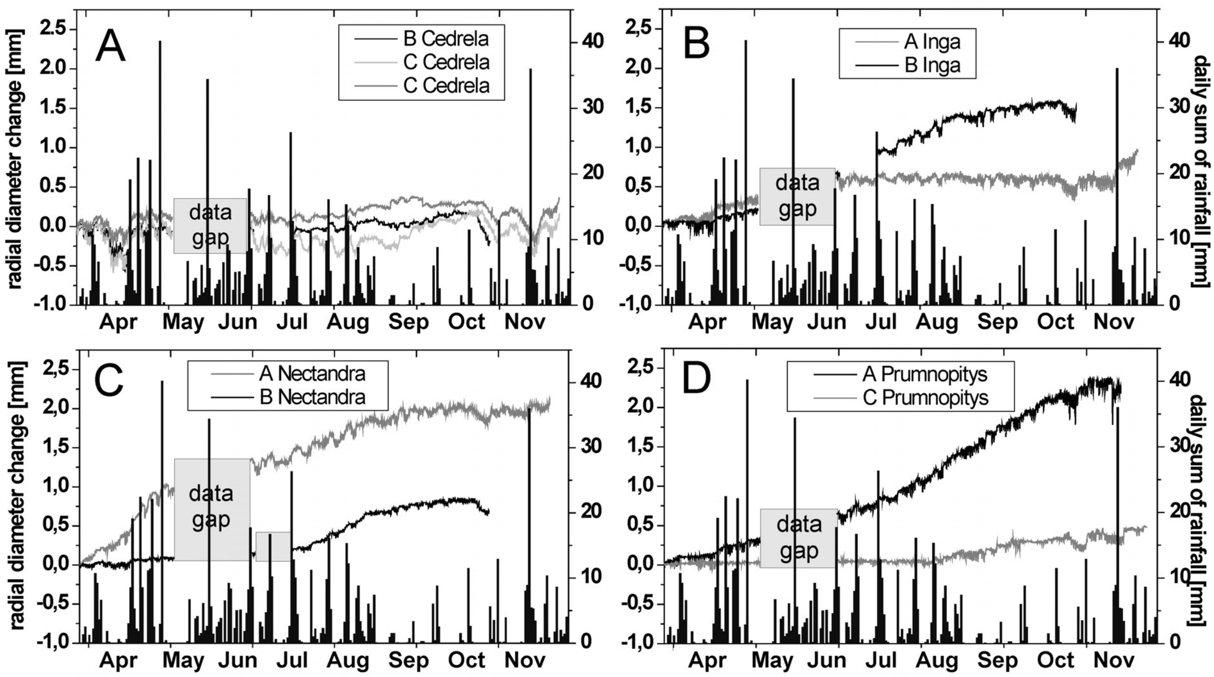

Figure 2: Dendrometer growth curves for Cedrela montana (A), Inga acreana (B), Nectandra laevis (C) and Prumnopitys montana (D).Capital letters A, B and C in the legend point to the trees' location in the respective study plot.

Nevertheless, the growth curves reveal several interesting facts:

- Different tree individuals of the same species but from different study plots show widely varying absolute growth increment rates during the studied period.
- Despite differences in absolute growth rates, short-term stem diameter fluctuations are astonishingly synchronous among all trees. This applies not only for individuals of the same species, but for all trees of all studied species and live forms.
- Periods of stem shrinkage can be attributed to time periods without rainfall. After only several days without precipitation, growth increments stop or stem diameters even start to shrink. The degree of stem diameter shrinkage is different between individual trees and probably depends on the water storage capacity of the local soils.

Discussion

We found that even in an environment with very humid average climatic conditions, tree growth is limited by water availability. Cambial activity reacts very sensitively to moisture supply and after only several days without rain, increment rates drop and stem diameters start to shrink since transpiration rates probably exceed water uptake. Absolute growth rates are strongly influenced by the local soil conditions and probably also by crown competition and social tree status (Bräuning et al. 2007). Further investigations shall combine growth increment measurements with wood anatomical studies to study the interrelation between water shortage, growth increment and the formation of visible growth boundaries (Bräuning & Burchardt 2006). This will be the basis for an interpretation of tree-ring series derived from increment cores and for the climatological interpretation of ring width chronologies.

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