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Anatomy of growth rings at the Yucatán Peninsula

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Abstract

The dendrochronological characteristics of 52 tree species from the semi-tropical forests of the Yucatán Peninsula were opportunistically explored in a salvage dendrochronological study. The existence of clear growth rings in these trees is a key prerequisite for further studies and a convincing demonstration of the dendrochronological potential of tropical tree species will allow the development of future research programs concerning the ecology of the species and inferences about past environmental changes detected from tree rings. Many aspects of the conservation and management of Yucatec forests should be urgently addressed to aid in the development of improved strategies beyond the scope of more traditional agricultural uses. Development of tree-ring analyses from selected local species can be of substantial assistance in these initiatives.

Keywords: Growth rings; Tropical dry forests; Yucatán; Mexico

Introduction

Tropical dry regions are some of the most threatened ecosystems in the world. Economic and demographic changes, climatic instability and inappropriate agricultural practices are the principal drivers of land use changes and the ongoing degradation of land quality, often leading to desertification. Radical procedures for the management of these dry forests are essential to improve forest production and preserve or recover endangered areas. Tree-ring analysis can contribute significantly to the measurement of forest sustainability and ecosystem resilience in these semi arid regions.

The usefulness of tree-rings derives from their annual resolution, precise dating, and sensitivity to climatic variables. A variety of environmental stressors (including climate) affect the physiology of trees and these variations are recorded in the tree rings. Thus, dendrochronology has been extensively employed in environmental studies of temperate and high altitude forests, but there have been few applications to date from the tropics (Roig, 2000). One of the main reasons is that many tropical trees do not produce anatomically distinctive annual growth rings that can be used for the

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development of reliable tree-ring chronologies (Stahle et al., 1999). However, many tropical forests experience a seasonal climate that result in the formation of distinct, annual rings in their woods. Therefore, several research contributions on tropical dendrochronology have been published in the last years worldwide (e.g., Bormann and Berlyn, 1981; Pant, 1983; Jacoby, 1989; Bhattacharyya et al., 1992; Buckley et al., 1995; Eckstein et al., 1995; Pumijumnong et al., 1995; Stahle et al., 1999; Roig, 2000; Worbes, 2002; Schöngart et al., 2004).

In Yucatán, the dry forests have been subjected to a variable degree of anthropogenic modification, especially by shifting cultivation, sisal (*Agave fourcroydes* Lem.) plantation and cattle farming activities. Low deciduous forests that originally covered an area of 1.8×10^6 ha have been reduced to ca. 4×10^5 ha, and, for example, 2×10^5 ha have been deforested simply for the production of sisal. The pressures on these forests were particularly strong during the 19th and the first half of the 20th after which commercial sisal cultivation declined (González-Iturbe et al., 2002). Now, the abandoned cultivated fields slowly recover. Contrary to these aggressive agricultural practices, the Maya culture traditionally promoted the use and protection of native species in the home gardens (Solares). Within these agricultural units the Mayas have employed trees for different purposes, such as for fodder, medicine or just as protection for their houses and cattle.

Little information exists on the dendrochronology of trees from the deciduous low-stature tropical dry forests of northern Yucatán and cultivated trees from the Solares. The absence of tree-growth information significantly hampered studies of the productivity and development of natural, recolonizing and cultivated forests in this region. In the fall of 2002, hurricane Isidore devastated a large part of this region felling large areas of forest and woodland providing abundant deadfall. This paper reports initial results of a salvage dendrochronological survey of cross-sections of some of this material that sought to identify suitable species to be used in tree-ring analysis, particularly through the recognition of anatomical properties defining the growth rings. This would provide valuable information to be used in programs concerning tree-growth estimation and studies based on interactions between tree growth and varying environmental controls. These studies could provide future guidelines to improve the management of natural forests and Solares ecosystems.

The study area and wood collections

Sampling was carried out in northwestern Yucatán during April 2003 (Fig. 1A). Most of this territory is a karst flat plain developed on Pleistocene limestones, on which precipitation infiltrates into a well developed underground drainage system. Soils are thin, calcareous and with a high percentage of rocks in the surface (Aguilera, 1958). The climate is semi-arid warm tropical (Aw_0 according to Köppen's classification; García, 1973), with a seasonal rainfall in May–October (Fig. 1C–D). This rain fall pattern is modulated by trade winds and by the northward displacement of the Intertropical Convergence Zone (Mosiño and García, 1974). As a result of a south-to-north precipitation gradient there is a dry area in the north of the Yucatán Peninsula, with marked drought conditions during November to April (rainfall amounts to only 30% of the annual precipitation).

The precipitation gradient and the rainfall seasonality, strongly influences the physiology of plants causing leaf fall and reduced growth. In the north of the Peninsula, deciduous trees are dominant while toward the south there is a preponderance of evergreen trees (Flores and Espejel, 1994; see Fig. 1B). Vegetation types at the north are classified as low-stature and spiny deciduous forest and median-stature sub-deciduous forest, with differences in species composition, tree height and rainfall stress. Leguminosae constitute the dominant tree species in all of these vegetation types (Flores, 2001).

Wood samples were collected at Chicxulub site (CIC code), at the north of the study region (Fig. 1A). Toward the south, collections were made at Hocaba (HOC) and Sahcaba (SAH) sites and at the Jardín Botánico from the Centro de Investigación Científica de Yucatán, Mérida (HEC). Hocaba and Sahcaba correspond to zones with permanent agricultural population and the species collected are those traditionally conserved and cultivated in the Solares systems. Wood sample preparation included cutting, polishing, and staining. Ring anatomy definition follows the IAWA nomenclature (IAWA, 1989). Samples were examined under a Wild M8 stereomicroscope. All samples are stored at the Wood Collection of the Laboratorio de Dendrocronología, Mendoza.

Results

Table 1 contains a list of the collected species studied, sorted by botanical family. 52 species from 22 families were analyzed in this study. Other 19 species were collected (RES site as in Fig. 1A) but remain to be taxonomically identified and therefore were not included in this analysis. About 35% of the taxa we analyzed show distinct growth ring boundaries and ring boundaries can be identified with some difficulty in a further 52%. Almost 88.5% of woods display porosity of the diffuse-porous type, supporting the general trend for