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Project Title : Ecological Importance of large old native trees in the sustainable management of sacred protected areas : Implications for the Conservation of Floristic and Faunal Biodiversity in Benin (West Africa)

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To fluke and upgrade sustainable management of native forest species in tropical areas data on morphological growth parameters as well as on ages are needed. They allow to determine how climatic events of one region can modify external development or even anatomical structure of one forestry species. The objectives of this part of the research were to identify futures prospects for tropical dendroecology through an application of primary steps to the identification of rings of tropical native species for future climate reconstruction of cultural landscapes (March-June 2025)

Activities

1. ***1-*** **Data collection**

In view of the sacred nature of the trees, permission could not be obtained for the sacred old trees. However, after negotiation with the local authorities of one cultural landscape located in Guinean zone, permission was obtained for some young individuals of two priority species for conservation, notably *Afzelia africana* and *Antiaris toxicaria*. The bibliographical analysis allowed us to develop a research protocol for the different data collection methods and processing tools. This part of study was conducted in one agricultural landscape of southern Benin near to Kpassè sacred Forest located between latitudes 6° 21′ 53″ N and longitudes 2° 05′ 45″ E. A total of 6 young individuals and 6 old trees of species of *A. africana* & *A. toxicaria* was considered for this part of the research. On each individual tree the geographical coordinates was reported and the following dendrometric parameters were measured. These are :

- The total height (H) in meters (m) ;
- The diameter (D) at 1.30 m ;
- The diameter of the crown (Hp) in m.

The samples of young individual trees ranging from 53 to 67,3cm, were collected from trees that have no sign of obvious rot and damage in the stem. Since we were confronted with the unsuitability of the incremental drill, we took samples of living trees after obtaining permission from administrative authorities in one agricultural landscape.

The differents discs had thickness between 3 & 4.5 centimeter. Each disk was labelled with a code. In addition the use of the cross-sectional area of the washers offers dendrochronologists the possibility to follow the path of the rings over the entire surface, contrary to the use of cores. The samples were dried under shade to avoid cracking of the disks. The dried samples of the two species were transported to the dendrochronological laboratory of Erlangen in Germany for wood anatomical examination and detection of tree-ring dendrochronological potential. This was made possible with the help of an additional grant (TWAS-DFG cooperation visit).

***2.* Samples preparation**

The stem disks of the study species were prepared for wood anatomical examination and detection of growth rings following standard dendrochronological methods. These selected samples were sanded using the RO 150 Geared eccentric sander with finer grades of sanding paper of grit size (P80 to P2000). After polishing a vacuum blower (cleaner) was used to remove the dust to improve visibility of the growth ring boundaries. The result is a very smooth surface that is satisfactory for macroscopic reading of the rings (Photo 1).

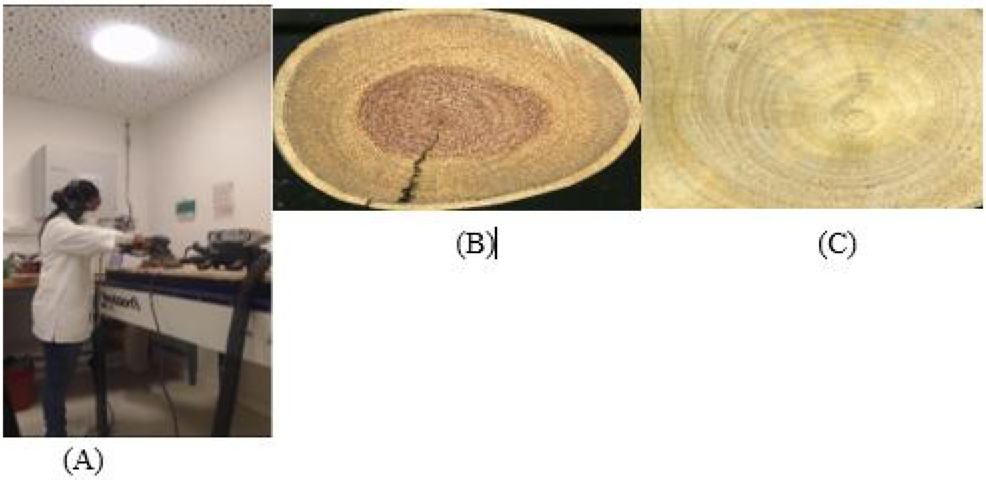


Photo 1 : (A) Washer preparation with an orbital sander (Festool Rotex RO 150 FEQ) ; (B-C) Washer of *Afzelia africana* and *Antiaris toxicaria* after preparation

3. Dendrometric Characteristics of the Sample

The dendrometric results of the sampled individuals of *Afzelia africana* and *Antiaris toxicaria* are presented in Table 1. Analysis of Table 1 shows that the inventoried individuals of *Afzelia africana* and *Antiaris toxicaria* are morphologically different. They have respectively an average height of 12.16 and 13.46 m, an average diameter at 1.30 m of 45.73 and 62.33 cm.

Indeed, the standard deviation noted in *Antiaris toxicaria* is much greater at the diameter at 1.30 m from the ground. Thus, the high standard deviations show that there is a large difference between sampled individuals reflecting a high intra-site variability.

Table 1 : The Results of the statistic

	Diameter at 1.30 (cm)	Height (m)
Afzelia africana	45.73 ± 2.53	12.16 ± 0.76
Antiaris toxicaria	62.33 ± 4.04	13.46 ± 1.12

4. Morphological Structure of Growth Rings

The study reveals that *Afzelia africana* has thin, clear, sharp rings (Fig. 1(B), Fig. 2A). These rings are limited by narrow bands of parenchyma associated with vessels, woody rays, and fibrous tissue. These large or small vessels may be solitary, in pairs or in radial rows. *Antiaris toxicaria*, on the other hand, forms very distinct ring boundaries characterized by a marginal band of parenchyma, which surrounds the entire stem disc. These rings are visible to the naked eye and are quite limited (Figure 1(C), Fig. 2(B)). By the dating each detected ring estimated ages varying from 19 to 36 years old for the nine species. The number of total samples used has been problematic and impeded exactly building tree-ring chronologies. These findings advance and confirm that tree-ring analysis should actually be applied on more individual tree species from different areas to obtain accurate, site-specific growth data.

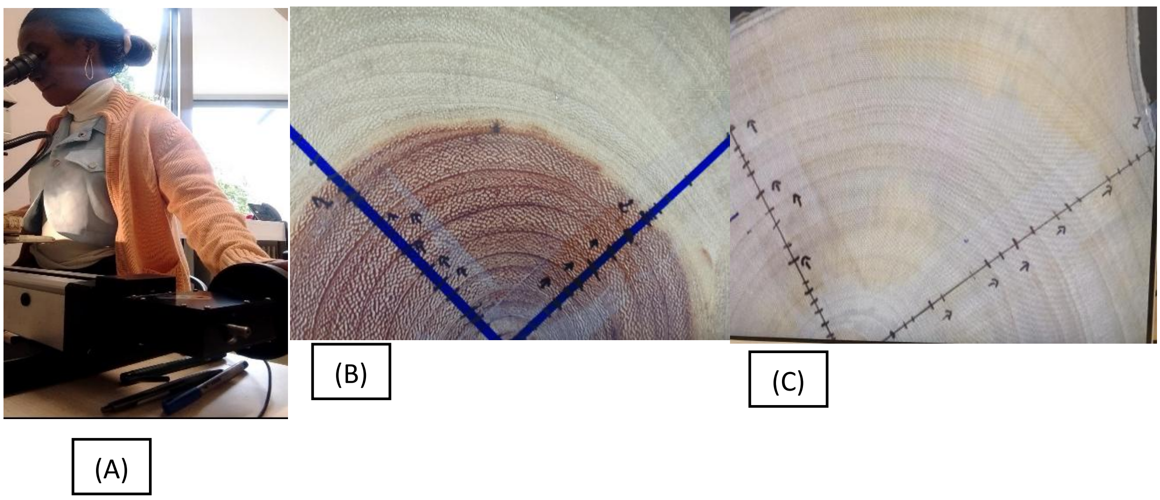
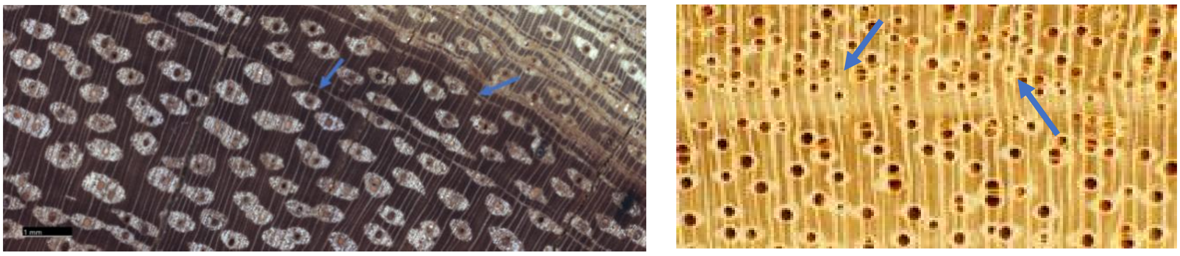


Figure 1 : Morpho-anatomical structure of the rings of *A. africana* and *A. toxicaria* (A) Reading of tree-ring by use of Microscope RINNTECH LINTAB^{TM} 6, (B-C) the arrows indicate the limits of the rings of *A. africana* and *A. toxicaria* species respectively.



(A) (B)

Figure 2: Arrows indicate the ring boundary's view through microscope of A) *Afzelia africana,* B) *Antiaris toxicaria*

5. Cumulative growth curves

Age-**radius** relationships were estimated using cumulative growth and species Mean_sensitivity First_order_autocorrelation. Autocorrelation in this study measures the temporal dependence between successive observations in a series. Strong autocorrelation could indicate signal persistence. We have observed that *A. toxicaria* presents Very low autocorrelation, almost non-existent or slightly negative while *A. africana* presents Moderate, positive autocorrelation, which suggests that successive values in the series are partially correlated. Also, weak correlations between time series of different trees of the same species were observed. This suggests that trees of the same species do not react very consistently to a common signal. Also, the PSE analysis in this study measures the representativeness of a sample of individuals to describe a population : Acceptable threshold : PSE ≥ 0.85. Both values are below 0.85, indicating that the available data series are not sufficiently reliable for a robust dendrochronological analysis (Figure 3).

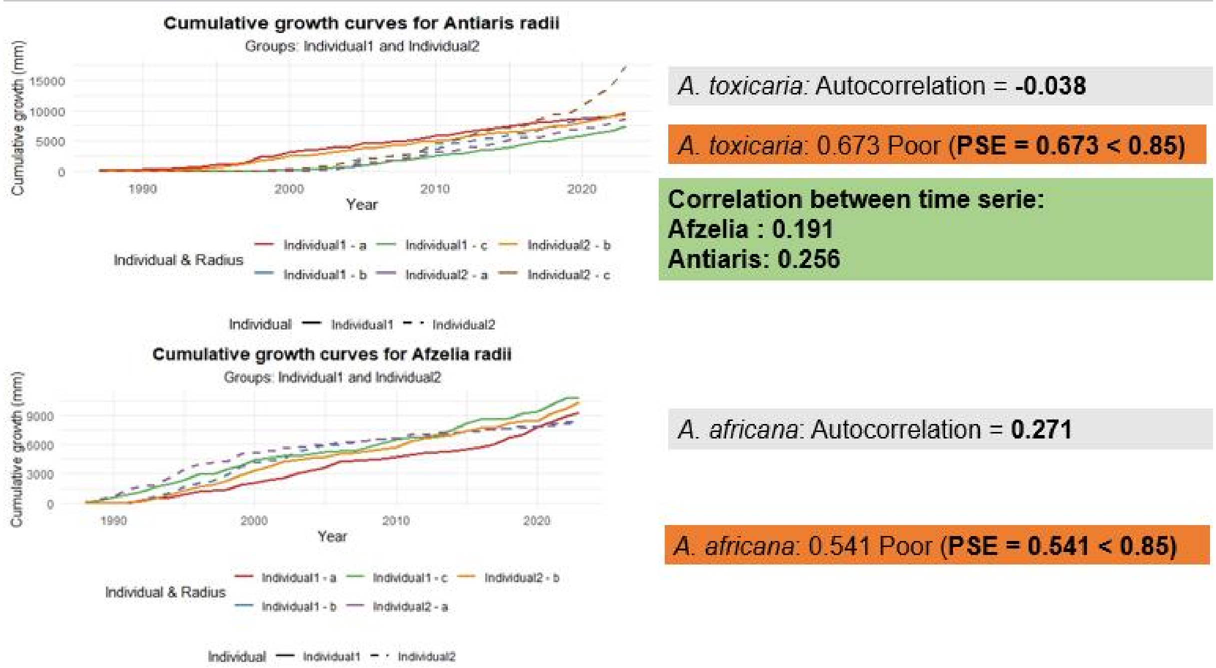


Figure 3 : Age-**radius** relationships were estimated using cumulative growth and species Mean_sensitivity First_order_autocorrelation & Inter series correlation

Assessment of Wood density of each species

A dependent correlation comparison test was performed to compare the correlation coefficients between density and the other variables (Dbh, Height, Age) for each species. Numbers in orange represent tree ages of young individuals determined using dendrochronological tools while those in blue represent tree ages of old individuals obtained by extrapolation between those obtained using dendrochronology and dendrometric parameters (Table 2).

For *Afzelia* we have noted that the wood density increases with tree diameter (Dbh) and age and it is weakly and negatively related to height. This indicates that wood density increases markedly with tree age, which is biologically plausible (older trees often produce denser wood) (Figure 4)

For *Antiaris* we have noted that the Wood density here decreases slightly with Dbh, height and age. All correlations follow the same trend: the taller, fatter or older the tree, the lower its wood density. This could be explained by changes in wood structure with growth (less dense heartwood formation, larger cavities) (Figure 5.)

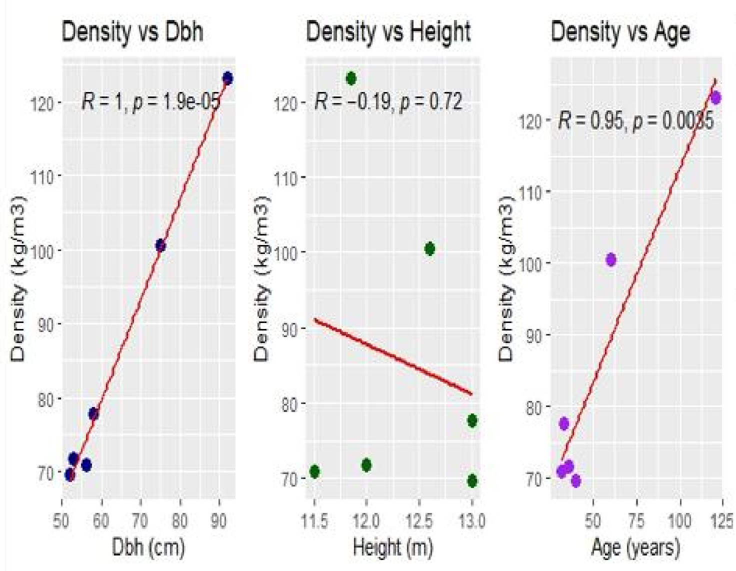


Table 2:

Species	Dbh (Cm)	Hauteur(m)	Densité(Kg/m3)	Age
Afzelia	56,2	11,5	70,86	32
Afzelia	53	12	71,66	36
Afzelia	58	13	77,69	33
Afzelia	92	11,85	123,24	121
Afzelia	52	13	69,66	40
Afzelia	75	12,6	100,47	60

Correlation Density - Height: -0.192
Weak and negative correlation

Correlation Density - Dbh: 0.996
Correlation Density - Age: 0.951
Very strong and positive correlation

Figure 4: Dependent correlation comparison test between density and the other variables (Dbh, Height, Age) for *Afzelia africana*

Correlation Density - Dbh: -0.482
Correlation Density - Height: -0.429
Correlation Density - Age: -0.429
Moderately negative correlation

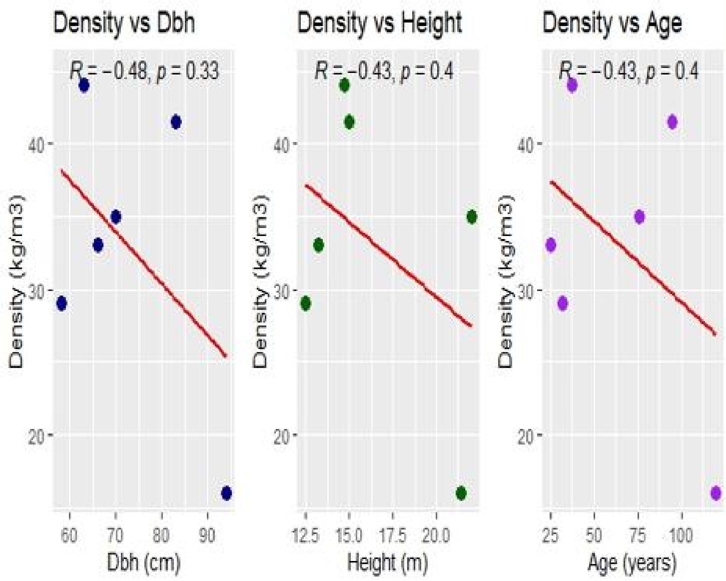


Table 2

Species	Dbh(Cm)	Hauteur(m)	Densité(Kg/m3)	Age
Antiaris	63	14,7	44	37
Antiaris	66	13,2	33	25
Antiaris	58	12,5	29	32
Antiaris	94	21,45	16	120
Antiaris	83	15	41,5	95
Antiaris	70	22	35	76

Figure 5: Dependent correlation comparison test between density and the other variables (Dbh, Height, Age) for *Antiaris toxicaria*

ACKNOWLEDGMENTS

We are grateful to the Rufford Foundation (Principal funding granted) and TWAS-DFG cooperation reserach visit (additional funds) for giving us the opportunity to carry out these activities. These activities are of great interest to face climate change and to prove how by the use of dendrochronology tools, tropical native trees species can be used as indicator for future climatic reconstruction of cultural landscape through the exact presence of their rings in Benin and better in Sub-saharan Africa. Our thanks also go to the Laboratory of Applied Ecology (LEA) at the University of Abomey-Calavi, our home institution, for providing us with field equipment and assistance. Our thanks also go to the team from the Institute of Geography at Friedrich-Alexander University (FAU), Erlangen-Nürnberg (Germany), who assisted us with the dendrochronological analysis of the wood samples. We’re finally grateful to the field guides, owner of agricultural land, traditionnal village chiefs, loggers, forestry agents and local authorities of the cultural landscape for accepting the project and contributing to the success of the activity.