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Dendrochronological Potential and Impact of Climate Factors on Radial Growth of Two Species in the Sahelian Zone: *Boscia senegalensis* (Pers.) Lam. ex Poir and *Sclerocarya birrea* (A. Rich) Hoscht (Ferlo Nord/Senegal)

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Abstract

The objective of this study is to analyze the dendrochronological potential of two Sahelian species (*B. senegalensis* and *S. birrea*) and to evaluate the relationships between their growth rings and the climate. The study was conducted in 2016 in the Ferlo area of Senegal. The biological material consists of wood slices, taken from the trunks of these adult woody species at 0.30 m and 1.30 m from the ground after they have been felled. The technique used to examine the slices consists in identifying their rings, establishing their structures, inter-dating them and studying the relationship between the identified rings and climatic factors. The results showed that the species had thin, clear, highly visible and sharp rings. The limit of growth is marked by a line of parenchyma. Intradatation series carried out on the chronologies made it possible to estimate the ages of the individuals, which vary from 10 to 38 years for *B. senegalensis* and from 29 to 50 years for *S. birrea*. Their average growth rates are estimated at 0.906 mm/year and 0.89 mm/year respectively. The chronological sequences are 29 years (1987-2016) for *B. senegalensis* and 38 years (1964-2012) for *S. birrea*. The results revealed that there is no signifi-

cant correlation between the growth chronologies of *B. senegalensis* and the climatic regressors (temperature and precipitation). In contrast, the ring-climate relationship shows that in *S. birrea* winter precipitation positively influences ring growth while temperature has no effect on ring growth in this species. This study provides a better understanding of the response of forest ecosystems to possible climate change, particularly in the current context of sustainable forest management.

Keywords

Dendrochronology, Cerne, Climate, *Boscia senegalensis*, *Sclerocarya birrea*, Ferlo

1. Introduction

Climate change scenarios for Africa include higher temperatures across the continent; likely to increase at a rate of 0.2°C per decade [1]. In the Southern, Central and Northern African eco-zones and especially in the Sahel where this study was conducted, very erratic rainfall is noted associated with sustained declines in productivity [2].

Faced with these environmental challenges, which are largely related to climate change and the recurrent effects of desertification, Africa, and in particular the Sahel, is doomed to face up to them.

In the Ferlo area, several studies have already mentioned the increasing decline in biodiversity and the negative impact of drought on tree growth [3] [4] [5] [6].

Thus, understanding species responses to climate change, particularly the dominant and most vulnerable species in these ecosystems, is of paramount importance for the development of adaptation and mitigation strategies for climate change.

The control of these parameters must imperatively pass through the knowledge of the impact of climatic hazards on the dynamics of biodiversity and especially on tree growth, which can be studied through dendrochronology. From there, this study uses dendrochronology to study the growth in diameter of trees, which allows their history to be read in the rings of their wood where past events are recorded [7]. It is a scientific method increasingly used in forestry research to evaluate the impact of climate on tree growth [8].

Today, environmental impacts are assessed by many scientists using the dendrochronological approach. Tree ring analysis is a “retrospective photograph” of the tree’s life [9].

Dendrochronology studies the growth rhythms and reactions of trees to ecological parameters such as rainfall, parasitic or anthropogenic attacks such as bush fires (which cause new and sudden defoliation) [10]. In regions where the climate imposes alternating periods of growth and rest, trees form each year a ring of wood that can be observed on a cross section of a trunk or on a core [7].

Thus, it is important to note that this technique is rarely applied to semi-arid ecosystems [11] because it has long been assumed that tropical trees do not form annual rings of wood [12] [13] [14].

However, studies have used the technique in Africa on tropical trees [15] [16] [17] [18] [19]. In recent years, the literature has grown (e.g. [20] from Mali, [21] from Ghana and [22] from Burkina Faso). Their work has shown that the study of tree rings by the dendrochronological approach in tropical woody species presents great untapped possibilities.

In the Sahel, dendroecological studies are fragmentary and focus on a few rare species and are the work of a few authors [23] [24] [25]. The results of their work reveal variable dendrochronological performances depending on the species. This gives great hope to dendrochronological studies in the Sahelian zone.

This dendrochronological study focuses on the species *Sclerocarya birrea*. (A. Rich) Hoscht and *Boscia senegalensis* (Pers.) Lam. ex Poir, two species that have a very wide geographical distribution in the Sahelian zone and play a socio-economic role for the local population [26] [27] [28] [29]. Our work will thus complement that carried out in the Ferlo zone on the species *Acacia senegal*, *Acacia radianna* and *Balanites aegytiaca*.

The objective of this study is to analyze the dendrochronological potential of these two species. It is a question of describing the morphological structure of the rings, to determine the age of the individuals, to evaluate their growth dynamics and the relations existing between this growth and the climate.

2. Materials and Methods

2.1. Study Sites

To study the growth dynamics of the two species, two sites are selected. These are the Widou-Tessékéré axis and the Widou Thiengoly Hole Pond axis (**Figure 1**) whose coordinates are respectively between 15°56'56.95"N and -15°13'27.79"W and between 15°55'50.8"N and -15°14'55.75"W.

The climate of the region, of semi-arid tropical type is characterized by an alternation of a long dry season from October to June and a short rainy season between July and September. Average annual rainfall in recent decades rarely reaches 300 mm [30] and is unevenly distributed in time and space. The months of August and September, which record the maximum rainfall (about 150 mm), are considered the heart of the rainy season. Temperatures vary throughout the year with minima of 15°C and maxima of 46°C - 48°C [31] (**Figure 2**).

The bibliographical analysis allowed us to develop a research protocol for the different data collection methods and processing tools.

Before felling, the geographical coordinates of each stand were taken and the following dendrometric parameters were measured [32] (**Figure 2**).

These are:

- The total height (H) in meters (m);
- The diameter (D) at 1.30 m and 0.3 m from the ground;
- The diameter of the crown (Hp) in m.

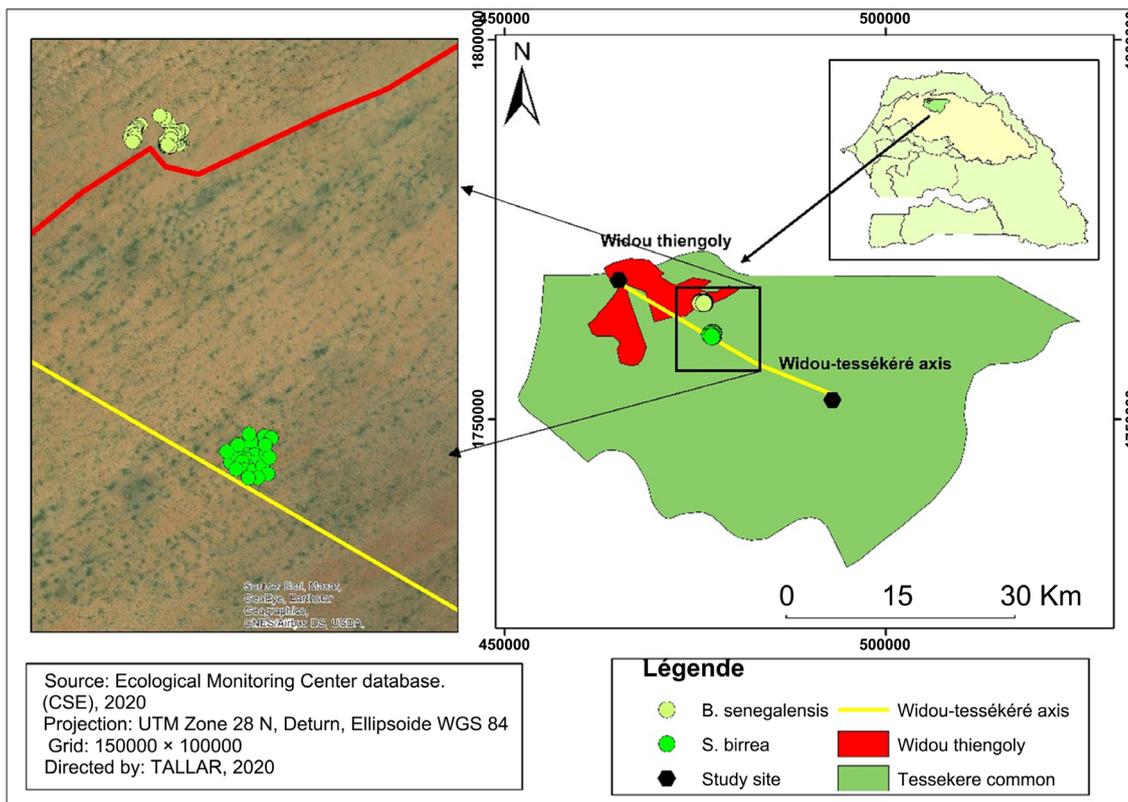


Figure 1. Representation of study sites.

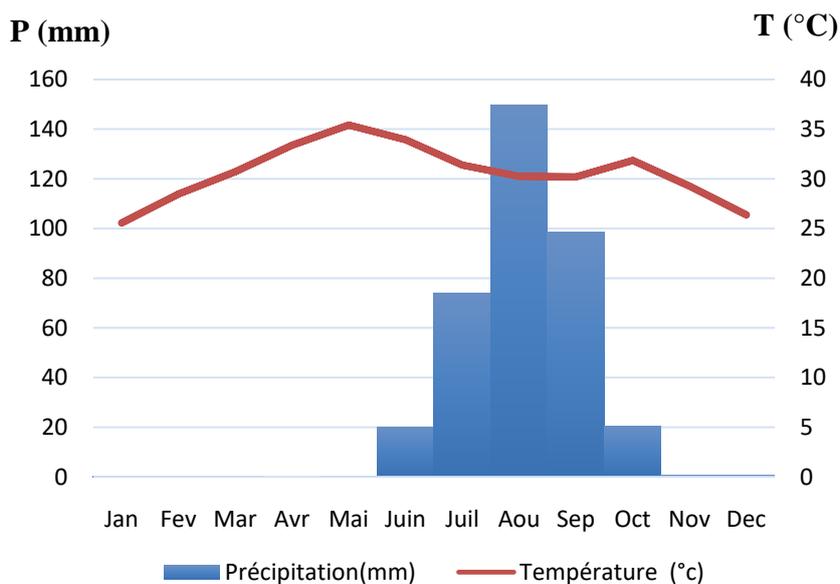


Figure 2. Ombrothermal diagram of the study site, precipitation (mm) and temperature (°C) data (1960-2016) were obtained from the Dahra research station, which is the nearest station.

2.2. Sampling

Fifty-two (52) adult individuals of *B. senegalensis* and 20 individuals of *S. birrea* were sampled, the latter being chosen at random and this choice was motivated

by their health conditions. The number of individuals sampled per species is justified by the abundance of the latter in this area. The sample size of *S. birrea* is limited by the fact that the population of the species is threatened in this region [30].

Boscia senegalensis, being a multi-stemmed shrub, we selected the central stem and the four other stems from different positions according to the four cardinal points (East, West, North and South) for sampling discs.

Using a motorized chainsaw, samples of wood discs about 2 cm thick were taken towards the base of the trunk at heights between 30 and 40 cm for *B. senegalensis* since it is a shrub species. For *S. birrea*, the slices were taken at a height of 1.30 m from the ground (Figure 3).

The use of the cross-sectional area of the washers makes it easier to read the rings and makes dating measurements more reliable and accurate [33]. In addition, it offers dendrochronologists the possibility to follow the path of the rings over the entire surface, contrary to the use of cores.

2.3. Preparation of the Washers

In the laboratory, the extracted washers were dried in an oven at 30°C model UN75. The washers with fewer growth defects were then sorted according to [34]. These were anomalies such as insect attacks, fragmentation or wood malformations.

These selected samples were sanded using a 350W DIAM electric orbital sander. 150MM equipped with increasingly fine-grained sandpaper (60 and 80; 120; 240; 320; and 600) in order to improve the legibility of the rings according to conventional techniques [35]. The result is a very smooth surface that is satisfactory for macroscopic reading of the rings [36] (Figure 4).

2.4. Measuring and Counting Rings

The technique of identification, measurement and counting of rings is the one used by [37]. On each selected washer, two or three scoring radii were traced from the pith to the bark and along each radius a numbering on the millimetre scale was performed (Figure 5(A)). The pointing radii of the washers were



Figure 3. Rondelle de *Sclerocarya birrea* (A) et *Boscia senegalensis* (B).

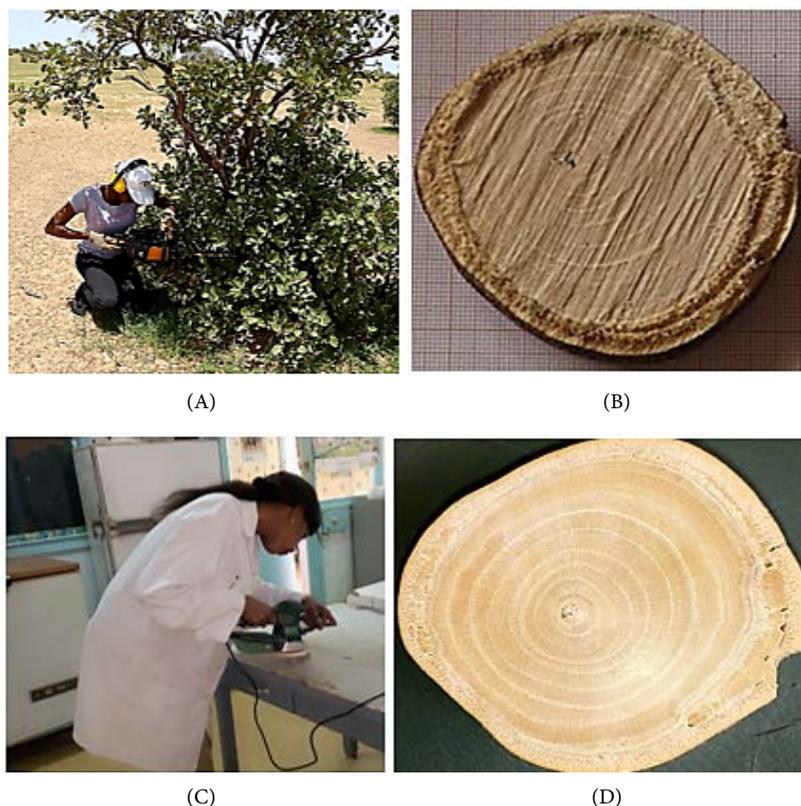


Figure 4. Picking and preparation of washers. (A) Washer pickup with a motorized chainsaw; (B) Example of washer removed; (C) Washer preparation with an orbital sander; (D) Washer after preparation.

photographed and high-resolution images were obtained with the Leica[®] M80 binocular magnifier (**Figure 5(B)**).

The images obtained are gathered with Adobe Photoshop Elements 8 (Windows-Version 8) software, which allowed us to obtain measurement transects for each radius. These have been processed with CDendro Coorecorder software (version 9.3.1) which allows us to identify and measure the width of the rings.

2.5. Dating of Rings

Knowing the date of formation of the last ring under the bark, assigning an age to each ring in the direction of the marrow seems possible.

The dating of the rings is therefore carried out with the CDendro software, which makes it possible to identify the morpho-anatomical structure of the rings and to count them. The Coorecorder software brings out the graphs, the results of dating (intra and interindividual) and the correlation coefficients considered satisfactory at $R = 0.32$ in dry tropical areas [38]. After identification and marking of the rings, we assigned each ring its year of training.

This allowed us to determine an elementary series for each radius. The elementary series for each tree (R1 and R2) were correlated to obtain a chronology specific to each tree or individual chronology: this is the intradating.

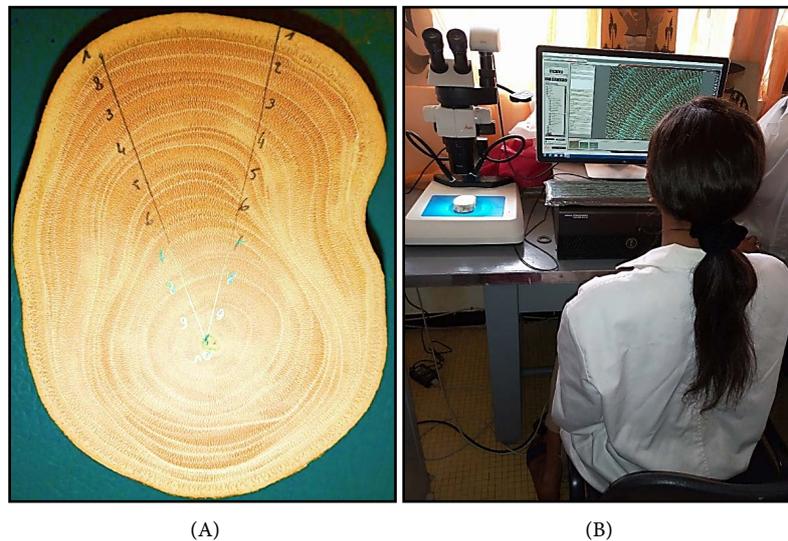


Figure 5. A washer with two pointing radii (A), and observation of rings using a binocular magnifying glass (B).

Following intradating, an interdating of the different trees was performed.

It consists in crossing all the individual chronologies to build the reference chronology. During the construction of the reference chronology, individuals that were badly interdated or not significantly correlated were excluded from the analysis (following several attempts at dating and correlation).

The quality of interdatation was evaluated using the cross-correlation algorithm developed by [39]. The application of this technique finally made it possible to retain the best washers in the sample. Thus on the whole sample: 17 individuals were retained on *B. senegalensis* whose elementary series are perfectly dated covering the period from 1987 to 2016, *i.e.* 27 years; and 15 individuals on *S. birrea* with an average chronology of 48 years from 1962-2012.

2.6. Climatic Data

Daily climate data for the period 1930 to 2016 from the Linguère weather station located 100 km away were collected from the National Meteorological Agency of Senegal (ANMS). Rainfall and average monthly temperatures were obtained from daily data which were monthlyized and rainfall which was accumulated over several months of the rainy season.

2.7. Treatment of Dendrochronological Series

The treatment of dendrochronological series is inspired by the method developed by [8]. All the information provided by the time series used for the two species is first of all briefly summarized by a few simple statistical parameters (mean annual increase, mean sensitivity, the interdatation coefficient and the autocorrelation coefficient of order 1), the detailed definition of which can be found in the work of [34].

The Method of [40] was used for the detection of characteristic years, it is

based on the presence of sufficiently strong variations in growth from one year to the next observed on a sufficiently high number of trees.

For each tree in each plot, the relative deviation ER of the ring width LC between the years k and $k - 1$ is calculated according to the formula:

$$ER_k = \frac{LC_k - LC_{k-1}}{LC_k}$$

The year k is considered characteristic at the plot level when at least % of the trees show (1) a relative deviation of the same sign (positive in years of strong growth, negative otherwise), and (2) an absolute value of relative deviation above a certain threshold called the mean relative deviation (ERM).

When the relative deviations are positive, the Positive Pointer Year (PPY) is considered positive; conversely, the Negative Pointer Year (NPY) is considered negative.

The parameters to be filled in are:

- Minimum threshold ERM (positive integer value): average relative deviation value.
- Minimum % of trees (integer value between 1 and 100): minimum percentage of trees that should have a significant relative deviation of the same sign.

In order to see the relationship between climate rings and climate rings, it is necessary to go through standardization, which is a key step in the treatment of dendrochronological series [41] [42]. It consists in standardizing the width of the individual growth rings of the dendrochronology program library in the statistical software R dplR [43]. The trend is the estimation and suppression of the biological growth of the tree. The normalization is done by dividing each series by an estimate to produce dimensionless growth series, without the autocorrelation caused by internal biological growth trends.

The climate relationship analysis consisted of a series of Pearsonian correlations between master growth chronologies (standardized curve) and precipitation (monthly, seasonal) and temperature for a common 54-year period (1962-2016).

All statistical analyses were performed using the R software (R version 3.6.0 and Tinn-R using the extensions (or packages) dedicated to dendrochronology [43] [44] [45] [46] as well as the scripts developed under the DENDRO 5.1 application [8].

3. Results

3.1. Dendrometric Characteristics of the Sample

The results of the stand structure of the *Sclerocarya birrea* and *Boscia senegalensis* individuals sampled are presented in **Table 1**.

Analysis of **Table 1** shows that the inventoried populations of *Sclerocarya birrea* and *Boscia senegalensis* are morphologically different. They have respectively an average height of 7.36 and 2.07 m, an average diameter at 0.30 m of 23.75 and 7.47 cm, a diameter at 1.30 m of 20.75 and 3.48 cm and an average crown diameter of 6.9 and 2.87 m.

Indeed, the standard deviation noted in *B. senegalensis* is much greater at the diameter at 0.30 m from the ground. And a much greater variability is noted with the diameter at 1.30 m in *S. birrea*.

Thus, the high standard deviations show that there is a large difference between sampled individuals reflecting a high intra-site variability.

3.2. Morphological Structure of Growth Rings

The study reveals that *Boscia senegalensis* has thin, clear, sharp rings (Figure 6(A)). 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.

Sclerocarya birrea, 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 6(B)).

Table 2 shows the characteristic criteria for tree rings.

Table 1. The results of the statistic.

	Diameter at 0.30 (cm)	Diameter at 1.30 (cm)	Height (m)	Diameter of the Crown (m)
<i>Boscia senegalensis</i>	5.76 ± 1.26	2.87 ± 1.18	2.03 ± 0.47	2.79 ± 0.8
<i>Sclerocarya birrea</i>	24.83 ± 6.35	21.54 ± 7.33	7.22 ± 1.15	6.79 ± 2.01

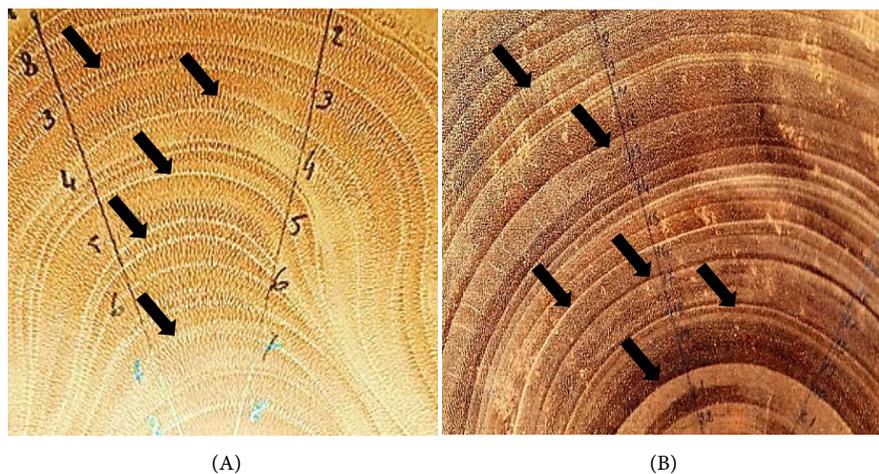


Figure 6. Morpho-anatomical structure of the rings of *Boscia senegalensis* (a) and *Sclerocarya birrea* (b), the arrows indicate the limits of the rings.

Table 2. Some characteristic criteria for ring analysis.

	Dark colored final wood	Continuous or interrupted terminal line	Possibility of reading the rings	Dark circles null or partially null	Presence of false rings	Presence of double rings
<i>Sclerocarya birrea</i>	++	+-	++	0	-	0
<i>Boscia senegalensis</i>	--	+-	++	+-	0	+-

++: Always present; +-: more or less present or distinct; 0: rare; -: Absent.

In *Sclerocarya birrea*, the end wood is dark in color and sometimes the terminal line can be continuous. Null rings and double rings have not been noted in this species, and false rings are rarely present.

However, in *Boscia senegalensis* we found few, partially indistinct and locally missing false rings near the bark in most samples. The final wood is not dark in color, double rings were noted as well as null rings.

For example, on some pucks in *B. senegalensis*, the observable rings show a real possibility of reading over the entire length of the sample and in others, there is a huge difficulty in reading the rings. The pucks sampled show, in general, a very eccentric heart, resulting from unbalanced growth around the trunk, and a large number of “growth abnormalities” such as double and discontinuous rings, scars left by human actions and animal attacks (**Figure 7**).

3.3. Dendrochronological Characteristics

All the information provided by the time series used for the two species is first summarized by a few simple statistical parameters (mean annual increase, mean sensitivity, the interdatation coefficient and the first-order autocorrelation coefficient), the detailed definition of which can be found in the work of [34]. The dendrochronological characteristics of the populations of *B. senegalensis* and *S. birrea* are summarized in **Table 3**.



Figure 7. Some examples of *Boscia senegalensis* washers.

Table 3. Dendrochronological characteristics of *Boscia senegalensis* and *Sclerocarya birrea* species at Widou Thiengoly (Ferlo/Senegal).

	<i>Boscia senegalensis</i>	<i>Sclerocarya birrea</i>
Total chronology	1987-2016	1964-2012
Average annual radial increase (mm)	0.906	0.981
Intra-dating coefficient	0.80	0.90
Inter-dating coefficient	0.80	0.70
Autocorrelation coefficient mean	0.08	0.09

The results obtained show that the radial growth of *B. senegalensis* and *S. birrea* species is slow, with an average increase of 0.906 mm/year and 0.981 mm/year respectively.

The intra- and inter-datation coefficients reflect a good homogeneity of the interannual variations in the radial growth of the individuals of the two species. These coefficients are, in fact, all the higher as the trees in the stand show well marked synchronous interannual variations. As for the autocorrelation coefficient of order 1, it reaches a rather low average value of 0.08 for *B. senegalensis* and 0.09 for *S. birrea*.

3.4. Dating of Rings and Determination of the Age of Individuals

The correlation between the radii of the same pucker gave the age of the individuals (Table 4).

The intra datation results obtained showed very good correlations between the radii of the same pucker with coefficients generally higher than 0.70 for both species. Individuals sampled from *B. senegalensis* at Widou had ages ranging from 10 to 38 years, with a mean age of 20 years. For *S. birrea* species the age varies from 29 to 50 years with an average of 38 years.

3.5. The Creation of the Average Reference Chronologies of the Area for the Two Species

The “master chronologies” or average reference chronologies (Figure 8) represent the variation in the width of the rings as a function of the years. These are 29 years (1987 to 2016) for *B. senegalensis* and 48 years (1964-2012) for *S. birrea*.

Table 4. Intradatation coefficient and age of trees.

	Site	Coefficient de corrélation	Age (years)		
			Minimum	Average	Maximum
<i>Sclerocarya birrea</i>	Widou Tèssékéré Axis	80	29	38	50
<i>Boscia senegalensis</i>	Widou	72	10	20	38

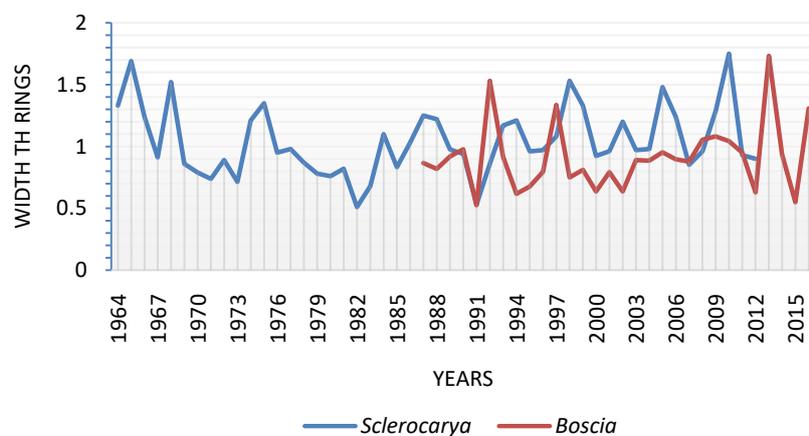


Figure 8. Standardized reference chronologies.

They are established from the different centred averages of the ring thickness (mm) observed on the rings of the trees and shrubs selected.

Following the different ways of standardizing the final chronology, three growth index chronologies were created. Despite a similarity between the ring width index series, we will retain the double standardization which has more refined results.

3.6. The Characteristic Years

Over the period 1987-2016 (*i.e.* 29 years), *B. senegalensis* has 16 characteristic years, defined from the characteristic maxima and minima, *i.e.* a frequency of about 55%. They are divided into 8 years of low growth (narrow rings) and 8 years of high growth (wide rings).

For *S. birrea*, 35 characteristic years were identified over the period 1964-2012. These represent a rate of 72% over the entire chronology obtained.

The most pronounced positive characteristic years correspond to a very wide ring in 100% of cases and the most pronounced negative characteristic years correspond to a very narrow ring in 100% of cases.

Overall, the positive characteristic years are equal to the negative characteristic years for both species (Figure 9).

3.7. Relationship Climate rings: Correlation Function

The analysis of the relationship between annual growth indices and climate regressors (temperature and precipitation from July to October of year $n - 1$) over the period 1960 to 2016 generated Figure 10. This figure shows the values of Pearson coefficients (r) between the growths of the two species and the climatic variables.

The months are indicated by numbers (1 for January to 12 for December, etc.). Hence, T_6 and P_6 are the temperature and precipitation on June, respectively. Dark bars indicate significant coefficients at the threshold chosen by the user (here, 95%). Grey bars represent the non-significant correlations.

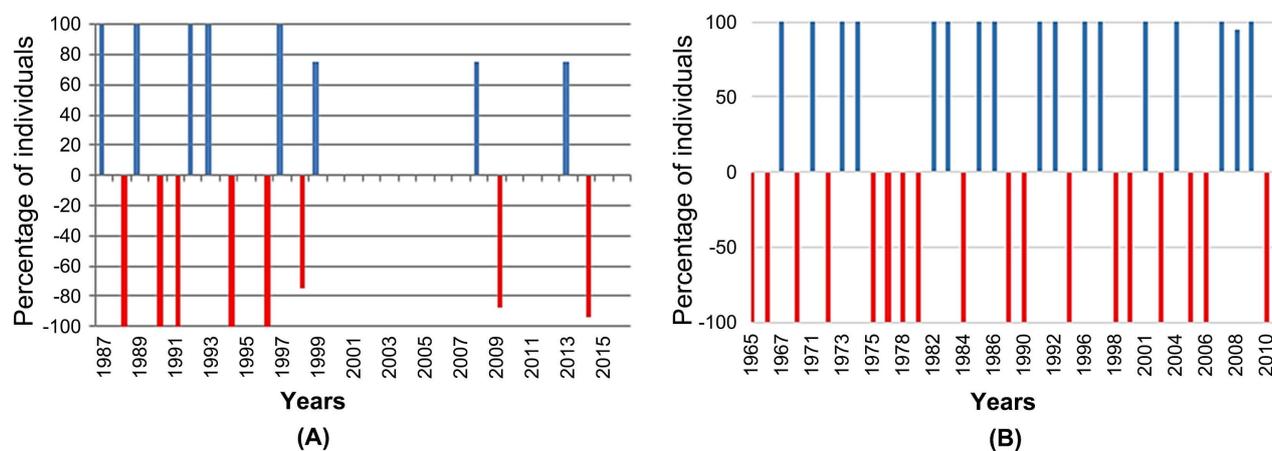


Figure 9. Characteristic years from 1964 to 2016 according to Merian's Pointer Year method (2010) for (A) *B. Senegalensis*, and (B) *S. Birrea* (positive characteristic years are in blue and negative characteristic years in red).

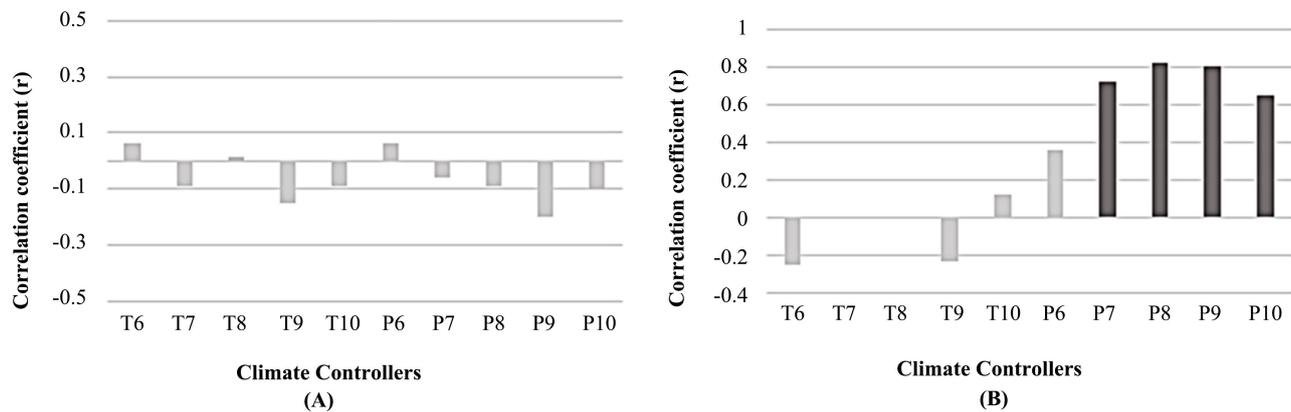


Figure 10. Bootstrap correlation coefficient between the growth chronologies of *B. senegalensis* (A) and *S. Birrea* (B) and climate. T: temperature, P: precipitation.

The results revealed that there is no significant correlation between growth chronologies of *B. senegalensis* species and climatic regressors (temperature and precipitation).

For *S. birrea*, response functions showed that the species responds positively to rainfall in August, September and October of year $n - 1$ with good correlation coefficients ranging from 0.6 to 0.8. However, temperature has no influence on the growth of *S. birrea*.

4. Discussion

The choice of the study site plays an extremely important role in dendrochronological studies because, on a given site and for a given species, it is the environmental conditions that modulate the local climate. Most often, we are interested in sensitive sites [8] [47], with respect to factors that mark or limit tree growth. Such sites are suitable for dendrochronological studies.

On this basis, the two sites Widou Thiengoly and Widou Téssékéré axis were selected for this dendrochronological and dendroclimatological study on the two species.

Anatomical observation of the cross section of the wood of *B. senegalensis* species showed that the rings were visible and characterized by lines of parenchyma. Vessel density is moderate and growth following the boundaries of the rings appears free of vessels. This structure observed on *B. senegalensis* appears as described by [48].

The structure of the species *Sclerocarya birrea* characterized by distinct rings with marginal bands of parenchyma is also revealed in the work of [49]. These authors explain the structure observed through the phenology of the species. According to them, the formation of annual growth limits is triggered by the end of leafing which occurs after 8 months.

The present study has made it possible to specify the age range of the populations studied. Individuals of *Boscia senegalensis* at Widou have ages ranging from 10 to 38 years while the age of *Sclerocarya birrea* varies from 29 to 50 with

coefficients generally higher than 0.70 for both species. According to the study by [38], intradating is a guarantee of good tree age determination when the correlation coefficient (CorrC) is in the range (0.32 - 0.83) for series of comparable length. This allows us to state that our dating results are satisfactory.

However, one of the major difficulties in our study lies in the interdating of shrubs. And this difficulty could generally be due to the physiological behavior of each shrub, the irregularities of the observed trunks resulting from the washers with growth anomalies and very off-centered cores. Also, it is noted that the species undergoes a strong anthropic action (fodder, food, medicine, etc.). Whose impact (pruning, bark wounds...) causes some individuals to present discontinuous, incomplete and sometimes blurred rings that alter the quality of the inter-dating.

Our hypotheses agree with those of [9] [17] [50] which state that the genetic processes and adaptation mechanisms developed by certain individuals can also affect the quality of interdating.

According to [51], other factors such as weather, phenology or the position of the sampled trees in the field (slope, slope, shallows) can have a significant influence on the formation of rings, making the development of a chronology a difficult task.

Despite these major difficulties, average reference chronologies have been elaborated thanks to the satisfactory results of inter-tree correlation. The success of crosses between individuals of the same species proves that a similar variation in their growth pattern is not a coincidence [16], and that an external factor influences in the same way the growth of trees corresponding to periodic wood formation [17] [52].

The results of the ring/climate analysis showed in *Boscia senegalensis* an absence of correlation between ring growth and climatic factors (temperature and precipitation from July to October of year $n - 1$). This means that the growth rates of this species are not controlled by the climatic parameters taken into account in this study. Thus similar results were supported by [53] and [50] on other Sahelian species. Their analyses showed the absence of correlation between annual or monthly rainfall and ring growth.

However, the results of the correlation function revealed that the growth of *Sclerocarya birrea* trees is influenced by seasonal rainfall levels, as has been observed in many studies in tropical regions and elsewhere [17] [54]-[61].

These results could mainly be explained by the high sensitivity of tree ring growth to water inputs at the beginning of the rainy season. Indeed, it has been reported in some studies [17] [55] that the growth rate is stronger at the beginning of the rainy season and decreases later in the season.

However, the difference observed between *Boscia senegalensis* and *Sclerocarya birrea* in terms of response to rainfall fluctuations is not surprising, and could be justified by the physiological, functional traits or abiotic requirements specific to each species.

Functional differences between the species could influence the growth res-

ponses of both species to climate.

The case of *B. senegalensis*, which has a strong adaptive capacity in arid zones [62]. These authors justify its presence in various bioclimatic regions by the presence of various anatomical devices allowing it to store the water it uses in the dry season. [40] mentions that *B. senegalensis* has a strong resistance to drought. This would be linked to its high sclerophyll content [63].

Moreover, some studies [57] [61] have shown that two or more species evolving under the same environmental conditions may have the same sensitivity to rainfall but at different seasons.

However, a different trend was observed on the correlation of ring growth and temperature with no significant correlation between the growth of the two species and temperature. These results reveal that summer temperature variability in years $n - 1$ is not favourable for radial growth of the species. Our results corroborate the conclusions of [49] in Ethiopia It remains understood that drought [64], is not the only characteristic factor in the Sahel. Temperature, latitude and the environment in which the tree is located are all factors that influence annual growth [65].

According to [10], tree growth in tropical environments is strongly associated with many exogenous and edaphic factors such as bush fires, the extent of drought, competition between species, soil type, etc. [60].

However, this study could be deepened by using other methods such as the extraction of climate signals. Probably, the data could be useful for assessing climate-induced growth trends. Stable isotopes as surrogates could have given better relationships between climate and growth, relative humidity, or verified whether certain climate indices have an influence on their growth ring data by using analytical data.

Thus, to better understand and benefit from the relationships between climatic factors, much more in-depth studies must be carried out taking into account the sampling, study sites, pedology and especially the microclimatic variability of the Sahelian dry zones.

5. Conclusions

The study of radial growth and the relationship between the latter and the climate of the two species *Boscia senegalensis* (Pers.) Lam. ex Poir and *Sclerocarya birrea*. (A. Rich) Hoscht au Ferlo using the dendroecological approach showed the potential of these species to form annual rings under Sahelian arid conditions.

The distinction of characteristic years allowed highlighting the role of climatic regressors (precipitation and temperature) in the radial growth of the species.

Thus, in *Sclerocarya birrea*, the driest years are generally the most unfavourable for growth. On the other hand, wet years correspond to strong growth. The study of the interannual variability of growth, measured by the Persian correlation coefficient, proved to be very informative.

In *Boscia senegalensis*, the results of our analyses showed a lack of correlation between rainfall and ring growth rates.

On the other hand, temperature has no effect on the growth of rings in either species. This study complements the dendrochronological database conducted in this area.

In the current context of environmental instability, it is desirable to increase this type of study and to use the results in the perspectives of growth modeling as well as in the prediction of scenarios of climate effects on ecosystem health.

In particular, our study suggests that, in the future, phenological and seasonal growth monitoring should be conducted to better understand and explain the influence of monthly precipitation.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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