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Population Structure and Toposequence Distribution of *Boscia senegalensis* (Pers.) Lam. ex Poir and *Sclerocarya birrea* (A. Rich) Hoscht in the Ferlo (Senegal)

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Abstract: The general objective of this study is to describe the demographic structure and distribution according to topographic units of two woody species, *Boscia senegalensis* (Pers.) Lam. Ex Poir and *Sclerocarya birrea* (A. Rich) Hoscht in Widou Thiengoly (Ferlo) in northern Senegal. Stratified random sampling was used to carry out the study taking into consideration the topographic units (low background, pouring and tray). The ligneous inventory method consisted in carrying out vegetation surveys using a dendrometric approach with a minimum area of 2500 m^2. The results obtained indicate that in the study area, the population of *B. senegalensis* is denser (42 ± 7.3 ind/ha) compared to that of *S. birrea* (6.1 ± 3.4 ind/ha). Topographic variability has a great influence on the life of the species. The study of the structure of individuals in diameter and height classes has shown that the population of *B. senegalensis* is shrubby and is generally renewed itself well, unlike that of *S. birrea*, which is more mature and whose lack of regeneration seems to compromise the renewal of the population. Given the total lack of regeneration of the species, this population, therefore requires more effective conservation strategies for its restoration.

Keywords: *Boscia senegalensis*, *Sclerocarya birrea*, Distribution, Structure, Topography, Ferlo, Senegal

1. Introduction

Since the adoption of the idea of building the Great Green Wall (GMV), the need to share knowledge on the functioning of Sahelian ecosystems, constitutes a crucial step guaranteeing the maximum of chances program success [1, 2]. Thus, in the context of global changes that have started since the 1970s, long-term management strategies for Ferlo ecosystems, require a better understanding of the processes of the dynamics of different forest species [3, 4]. The period 1946-1969 was the best reference for the dynamics of Sahelian environments, it is also the time when the landscapes had not yet been modified by the creation of permanent water points by borehole [5]. This period is abundantly commented by the mapping and characterization of the Ferlo landscapes in the 1950 [6]. This study allowed to realize modifications induced by drought series on the Ferlo ecosystems.

This evolution can be read through the floristic composition, the chorology of the species encountered in the different types of landscapes of Ferlo [7].

The nomenclatures used in the description of the current landscapes of the Ferlo evoke the predominance of woody savannas dominated by woody trees such as *Balanites aegyptiaca* Delile, *Boscia senegalensis* (Pers.) Lam. ex Poir, *Acacia tortilis* (Forssk.) Hayne subsp. raddiana (Savi) Brenan, and *Calotropis procera* (Aiton) W. T. Aiton [8, 9]. The area is largely dominated by *Boscia senegalensis* and *Balanites aegyptiaca*. The Combretaceae which had occupied this environment have mostly migrated to the south where they are considered to be an indicator of the bioclimatic transition in Ferlo [7]. Several other studies have highlighted the process of dynamic degradation of Ferlo ecosystems which results in a regression of certain species correlated with the expansion of others [10, 11]. This study describes the current state of the populations of *Boscia senegalensis* and *Sclerocarya birrea* (structure and distribution) whose evolutionary dynamics are almost opposite in this environment. This description takes into account the variabilities linked to topographic micro-habitats.

2. Materials and Methods

2.1. The Study Area

The study was carried out in Widou Thiengoly, a village located in the municipality of Tessekere in northern Senegal in the silvopastoral zone of Ferlo (figure 1) in a plant facies where populations of *Sclerocarya birrea* and *Boscia senegalensis* co-evolve. The Ferlo belongs to the Sahelian bioclimatic zone [12, 13]. It occupies an area of 70.000 km^2 located between latitudes 15° and 16° 30 North and longitudes 13° 30 and 16° West [14].

The climate of the region, 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 precipitation over the last decades rarely reaches 300 mm and is unevenly distributed in time and space [9]. The months of August and September which record the maximum rainfall (around 150 mm) are considered to be the heart of the rainy season. Temperatures vary throughout the year with lows of 15°C and highs of 46 to 48°C [15].

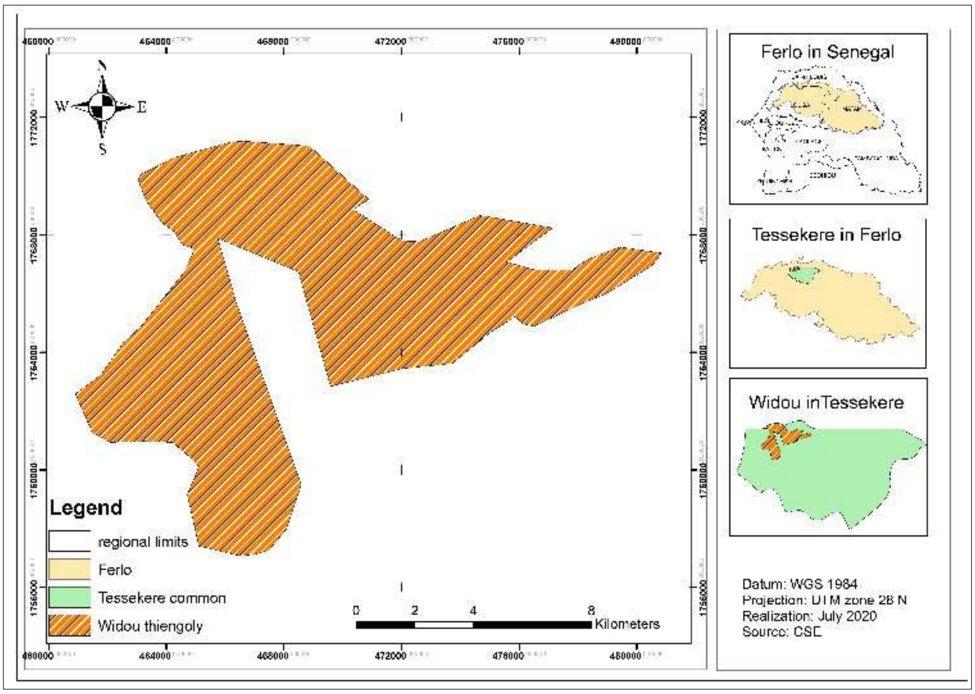

Figure 1. *Representation of the study area (Widou Thiengoly).*

The Ferlo is home to a treed to shrub steppe dominated by woody species such as *Balanites aegyptiaca* (L.) Del., *Boscia senegalensis* (Pers.) Lam. Ex Poir, *Acacia senegal* (L.), *Acacia tortilis* (forsk.) Hayne ssp. raddiana (Savi) Brenan, and *Calotropis procera* (Aiton) W. T. Aiton [8, 9]. On the morpho-pedological level, the study area belongs to the sandy Ferlo characterized by a succession of dunes and low-lying lowlands with a different type of soil depending on whether one is on a dune summit or at the bottom of slope [16]. It's possible to distinguish the physicochemical characteristics of the soils of the lowlands and the ledges which are the most extensive topographic units [17]. The soils of the plateaus are sandy and present unfavorable physical and biochemical constraints, unlike that of the lowlands which have a balanced texture. They have much better agro-pastoral potential thanks to their higher contents of exchangeable bases, phosphorus, nitrogen, organic matter and cation exchange capacity [17].

2.2. Collection of Data

The study of the populations of the two species was carried out by means of a forest inventory following a dendrometric study. The inventory targeted the routes where populations of these two species have been identified. Within each population, sampling was stratified in order to take into account the heterogeneity of the environment [18]. The vegetation surveys were carried out according to the toposequences [19]. Three relief units have been retained: low background or ponds, pouring and tray. The plant faces formed by the succession of these three units are particularly targeted. The density of the populations studied was taken into account in determining the sample size. It was calculated from the formula of [20]:

$$n = \mathrm{U}^2 1 - \alpha/2 \; \frac{P(1-P)}{d^2} \tag{1}$$

With

$U_{1-\alpha/2}$=1.96 (≈ 2) et 1≤ d ≤15

P = percentage of species

A = (the ratio of the density of the species studied to the total density of woody plants),

d = is the error rate,

U = is the u of the normal distribution which is read from the table.

On the basis of this calculation, the study involved 44 plots distributed as follows: 9 plots in the low background, 16 on the pouring and 21 plots on the tray.

The imbalance of the sample is mainly justified by the variable area of the different topographic units. The minimum inventory unit was 0.25 ha (50 m x 50 m). The delimited plots were successively positioned at the level of the three geomorphological units and georeferenced using a GPS. Only adult individuals with a diameter at 0.30 m from the ground greater than or equal to 0.35 cm were measured. Individuals less than 3.5 cm in diameter were considered suckers and their numbers were assessed. The dendrometric measurements of the trees concerned the total height (Ht), the diameter at 0.30 and 1.30 m from the ground (D at 0.30 and D at 1.30 m) and the diameter of the crown (Cd).

2.3. Data Processing and Analysis

The following formulas were used for the treatment of dendrometric parameters.

1. Density N (ind/ha)
   This is the average number of adult trees per plot, it is expressed in stems/ha and is given by the formula:

$$N = {}^{n}/_{s} \tag{2}$$

n: total number of trees in the plot

s: plot area (s = 0.25 ha)

2. Basal area G (m^2/ha)
   It is the sum of the basal sections of all the adult trees found in the plot, it is expressed in m^2/ha:

$$G = \frac{\pi/4 \sum_{i=1}^{n} di^2}{S} \tag{3}$$

n: total number of mature trees in the plot.

di: diameter of tree *i* (m), *s*: area of the plot.

3. Regeneration rate Rr (%)
   The regeneration rate of the stand is given by the percentage ratio between the total number of young plants and the total number of the population.

$$\mathrm{Rr} = \frac{(\text{Total number of young plants})}{(\text{Total number of population})} * 100 \tag{4}$$

Rr = Regeneration rate

All of these dendrometric parameters have been the subject of descriptive statistical processing (calculation of the mean, standard deviation, coefficient of variation, and standard error).

R software version 3.6.0 was used to perform analysis of variance (ANOVA) for the treatment of dendrometric variables. As the ANOVA conditions were not met, the Kruskal and Wallis nonparametric test was used to assess the significance of the differences between the groups of parameters. The relationship between the different dendrometric variables and the topographic units was established by Principal Component Analysis (PCA).

Minitab 17 software was used to establish the diameter and height structures of the population of *Sclerocarya birrea* and *Boscia senegalensis*. These structures were fitted to the theoretical Weibull distribution based on the maximum likelihood method [21]. The Weibull distribution with three parameters (a, b and c) is characterized by a probability density function, f (x), which takes the following form [22]:

$$f(x) = \frac{c}{b}\left(\frac{x-a}{b}\right)^{c-1} exp\left[-\left(\frac{x-a}{b}\right)^{c}\right] \tag{5}$$

Where x is the diameter or height of trees and f (x) is its probability density value:

a = is the position parameter,

b= is the scale or size parameter, c = is the shape parameter linked to the observed structure.

To test the adjustment of the observed structure of the theoretical Weibull distribution, a log-linear analysis, a method of analysis of variance carried out on the logarithm of the densities of the classes, was carried out using the SAS 9.1 software [23].

3. Results

3.1. Dendrometric Characteristics of the Two Species Studied According to Topographic Units

Table 1 presents the dendrometric characteristics of *Boscia senegalensis* and *Sclerocarya birrea* in the different topographic units. The mean values of the dendrometric parameters and their respective standard deviations are indicated therein.

Table 1. *Dendrometric characteristics of populations of Boscia senegalensis and Sclerocarya birrea according to topographic units (low background, pouring, tray).*

Species	Relief units	Dendrometric parameters					
		N (ind/ha)	G (m^2/ha)	Ht (m)	Cd (m)	D (cm)	Rr (%)
Boscia senegalensis	Low background	43.8 ± 8.4 *a*	0.26 ± 0.1 *a*	2.8 ±0.6 *a*	2.9 ±1.05 *a*	6 ±4.7 *a*	0.68 ± 10 *a*
	Pouring	28.5 ± 6.7 *b*	0.26 ± 0.2 *a*	2.0 ±0.7 *a*	5.3 ±3.2 *b*	6.6 ±3.7 *a*	0.52 ± 8.2 *a*
	Tray	51.5 ± 7.1 *c*	0.11 ± 0.02 *a*	1.95 ± 0.6 *a*	3.1 ±0.8 *c*	5.9 ±2.9 *a*	0.47 ± 7.9 *a*
	Population	42 ±7.3	0.2 ± 0.05	2.0 ±0.5	4.1 ±1.2	6.8 ±3.1	0.55 ± 5.3
Sclerocarya birrea	Low background	6.6 ±4.6 *a*	0.8 ±0.2 *a*	12 ±1.4 *a*	10.1 ±0.8 *a*	43.2 ±12 *a*	0
	Pouring	6.4 ±3.5 *a*	0.62 ± 0.4 *a*	10.6 ± 1.5 *a*	10.5 ±1.7 *a*	35.4 ±9.6 *b*	0
	Tray	5.33 ± 2.1 *a*	0.61 ± 0.3 *a*	9.2 ±3.1 *a*	10.2 ±1.9 *a*	30.8 ±3.1 *b*	0
	Population	6.1 ± 3.4	0.68 ± 0.3	10.4 ± 2.4	10.3 ±1.6	35.3 ±6.5	0

The values of the same parameter assigned the same letter are not significantly different (N = total density, G = total basal area, D = average diameter at 0.3 m, Ht = average total height, Cd = average diameter of the crown, Rr = regeneration rate, Population)

1. Density

In the study area, the population of *Boscia senegalensis* is denser (42 ± 8.4 ind/ha) compared to that of *Sclerocarya birrea* (6.1 ± 3.4 ind/ha). The results obtained indicate that the topographic microsite's have a great influence on the distribution of *Boscia senegalensis*. In fact, this population of *Boscia senegalensis* is present at a higher density at the level of the tray (51.5 ± 7.1 ind/ha) followed by the low background (43.8 ± 8.4 ind/ha) and in the end of the pouring (28.5 ± 6.7 ind/ha) with highly significant differences ($p < (0.001)$. Regarding S*clerocarya birrea*, the distribution of individuals is relatively homogeneous and statistical tests indicate non-significant differences ($p > 0.05$). The densities obtained are: (6.6 ± 4.6 ind/ha) on the low background, (6.4 ± 3.5 ind/ha) on the pouring and (5. 33 ± 2.1 ind/ha) on the tray.

2. Size and basal area

The population of *Boscia senegalensis* has a small kidney (6.8 ± 3.1 cm), a basal area of 0.19 ± 0.05 m^2/ha. These two parameters seem independent to the topography because the differences obtained are not significant ($p > 0.05$) at the level of the pouring (6.6 ± 3.7 cm or 0.26 ± 0.2 m^2/ha), low background (6 ± 4.7 cm or 0.26 ± 0.1 m^2/ha) and tray (5.9 ± 2.9 cm or 0.11 ± 0.02 m^2/ha). The species *Sclerocarya birrea* has very large individuals 35.3 ± 6.5 cm, a basal area of 0.68 ± 0.31 m^2/ha. The largest individuals are found in the shallows (43.2 ± 11.9 cm or 0.83 ± 0.23 m^2/ha) compared to the pouring (35.4 ± 9.6 cm or 0.62 ± 0.44 m^2/ha) and on the tray (30.8 ± 3.1 cm or 0.61 ± 0.32 m^2/ha).

3. Diameter of the crown

The population of *Boscia senegalensis* has an average crown diameter of (4.1 ± 1.2 m). The diameter of the crown of individuals would depend on the topography, those attached to the slopes have the highest average diameter (5.25 ± 3.2 m), followed by the tray (3.1 ± 0.8 m). Individuals from the low background have the smallest average crown diameter (2.9 ± 1.05 m). These differences are statistically verified with a p-value well below the threshold ($p < 0.05$). On the other hand, in the species *Sclerocarya birrea*, one do not note a significant difference between the various values of the diameter of the crown with (10.1 ± 0.76 m) for the low background, (10.48 ± 1.7 m) on the pouring and (10.2 ± 1.9 m) at the level of the ledge.

4. Height

The population of *Boscia senegalensis* consists mainly of shrubs of 2.0 ± 0.5 m on average. The height of the individuals varies little according to the relief units ($p > 0.05$): 2.8 ± 0.6 m at the bottom, 1.97 ± 0.7 m on the pouring and 1.95 ± 0.6 m of the tray.

As for the population of *Sclerocarya birrea*, it consists of trees with an average height of 10.3 ± 1.6 m. Relief also has a weak influence on the height of individuals of the species ($p > 0.05$). It is 12 ± 1.4 m in the shallow, 10.6 ± 1.5 m of the pouring and 9.2 ± 3.1 m at the level of the tray.

5. Regeneration rate

In the medium studied, the population of *Boscia senegalensis* regenerated (0.55 ± 5.3%) unlike that of *Sclerocarya birrea*, which is characterized by a total absence of regeneration in the medium. The results showed that *Boscia senegalensis* regenerates better in the low background with a rate of (0.68%) followed by the pouring (0.52%) and on the tray the rate is (0.47%).

3.2. Influence of Topographic Units on the Typology of Populations

Table 2. *Eigenvalues and percentage of inertia of the axes of the PCA.*

Species	Dimension	Eigenvalue	Percentage variance (%)	Cumulated percentage (%)
Boscia senegalensis	Dim 1	3.07	51.2	51.2
	Dim 2	2.52	42.5	93.7
	Dim 3	0.40	6.8	100
Sclerocarya birrea	Dim 1	3.77	75.2	75.2
	Dim 2	1.21	24.5	99.7
	Dim 3	0.006	0.1	100

The structural forms of organization of the populations of the two species which represent the spatial heterogeneity linked to the topography are highlighted by a Principal Component Analysis (PCA). Table 2 shows the eigenvalues and proportion of information concentrated on the axes of the PCA. The first two dimensions (Dim 1 and Dim 2) alone explain more than 90% of the information for each species. Their respective inertia percentages are 51.2% and 42.5% for *Boscia senegalensis*, 75.2 and 24.5% for *Sclerocarya birrea*.

The projection of the dendrometric parameters of the plane formed by the first two axes of the PCA made it possible to demonstrate the influence of topographic determinism on the structure and distribution of the population of *Boscia senegalensis* (figure 2) and of *Sclerocarya birrea* (figure 3).

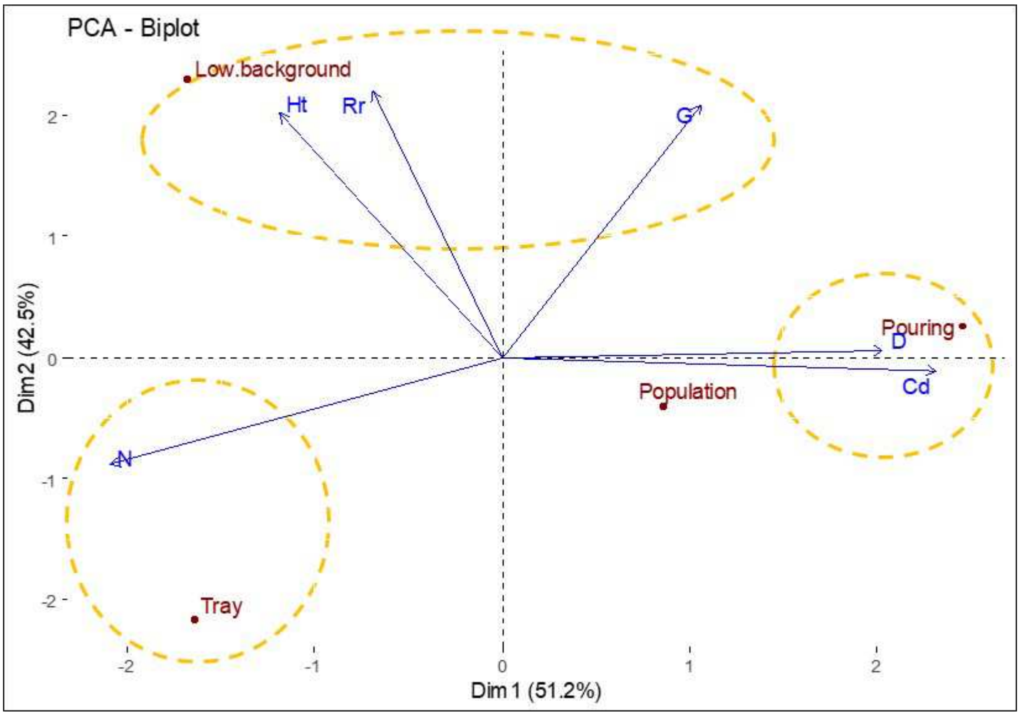

Figure 2. *Influence of topographic units on the population structure of Boscia senegalensis.*

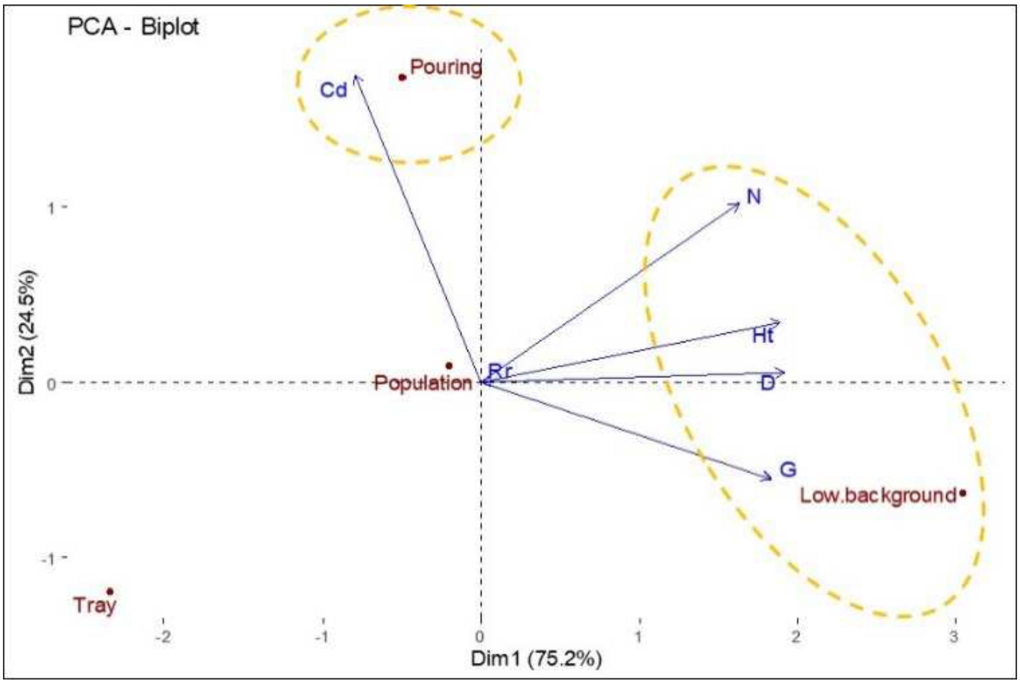

Figure 3. *Influence of topographic units on the structure of the Sclerocarya birrea Population (N = total density, G = total basal area, D = mean diameter at 0.3 m, Ht = mean total height, Cd = mean crown diameter, Rr = regeneration rate).*

Analysis of Figures 2 and 3 shows that all three landform units in one way or another influence the survival parameters and population structure of *Boscia senegalensis* and *Sclerocarya birrea*. The determining topographic units are the pouring and the low background. Thus, the following main characteristics can be retained for *Boscia senegalensis* and *Sclerocarya birrea*:

1. The ecological conditions in the low background are very favorable for the development of *Sclerocarya birrea*. The individuals are more numerous (N) and more developed (Ht. D. G). On this relief unit, the species *Boscia senegalensis* shows better turnover (Rr), good height growth (Ht) and a large basal area (G),
2. The ecological conditions of the beds are more favorable to the development of *Boscia senegalensis* compared to *Sclerocarya birrea*. They provide the population of *Boscia senegalensis* with the best survival conditions since its density (N) is greater there compared to other relief units,
3. n the pouring, *Sclerocarya birrea* develop their crowns better, while *Boscia senegalensis* takes advantage of the ecological conditions of this unit to ensure good growth in size (D) and good canopy development (Cd) of the individuals

3.3. Diameter Class and Height Class Structure of the Populations of the Two Species

3.3.1. Population Structure of Boscia Senegalensis

Figure 4 illustrates the distribution into classes of diameters and heights of the individuals of the population of *Boscia senegalensis* (4A) and according to topographic units (4B).

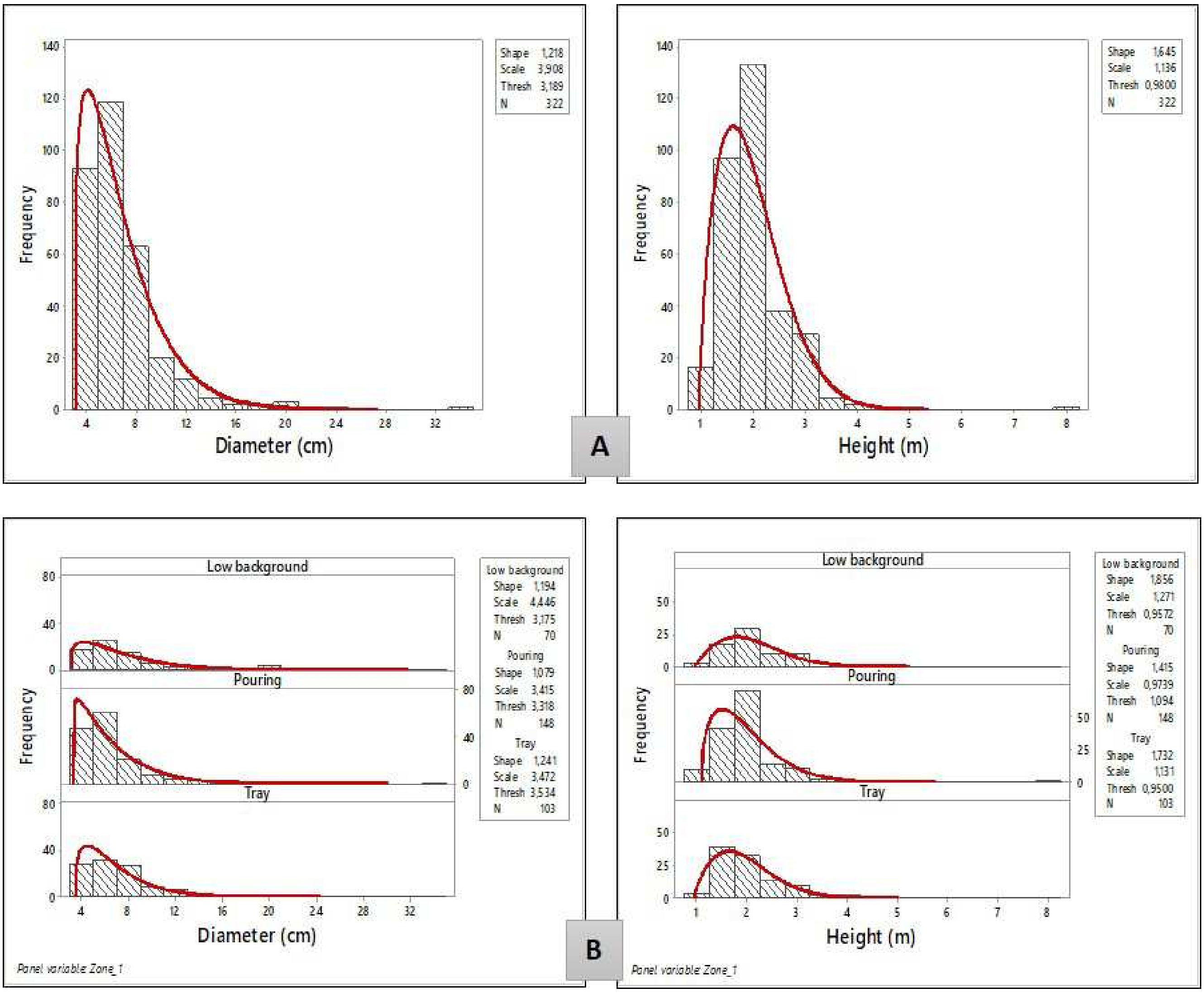

Figure 4. *Histogram of class distribution of diameters and heights of the Boscia senegalensis population (A) and according to topographic units (B) (Thresh (a) = position parameter, Scale (b) = scale parameter, Shape (c) = shape parameter of the Weibull distribution).*

The distribution of individuals of the *Boscia senegalensis* population in diameter and height class (Figure 4A) shows an asymmetric left distribution, indicating a clear predominance of young individuals. This population is made up of more than

50% of individuals less than 10 cm in diameter and less than 3 m in height. The Kruskal Wallis test confirms that the distribution in diameter class and in height class of individuals of *Boscia senegalensis* does not vary according to topographic units (p-value> 0.05). Thus, individuals with a diameter between 3 and 9 cm are best represented in the three units, but their proportion is greater at the level of the tray and pouring where the largest individuals are also distributed. In terms of height, there is a predominance of individuals whose height is between 1.5 and 2.5. This stratum is better represented respectively at the level of the pouring and tray.

3.3.2. Population Structure of Sclerocarya Birrea

Figure 5 illustrates the distribution into classes of diameters and heights of the ligneous plants of the population of *Sclerocarya birrea* (5A) and according to topographic units (5B).

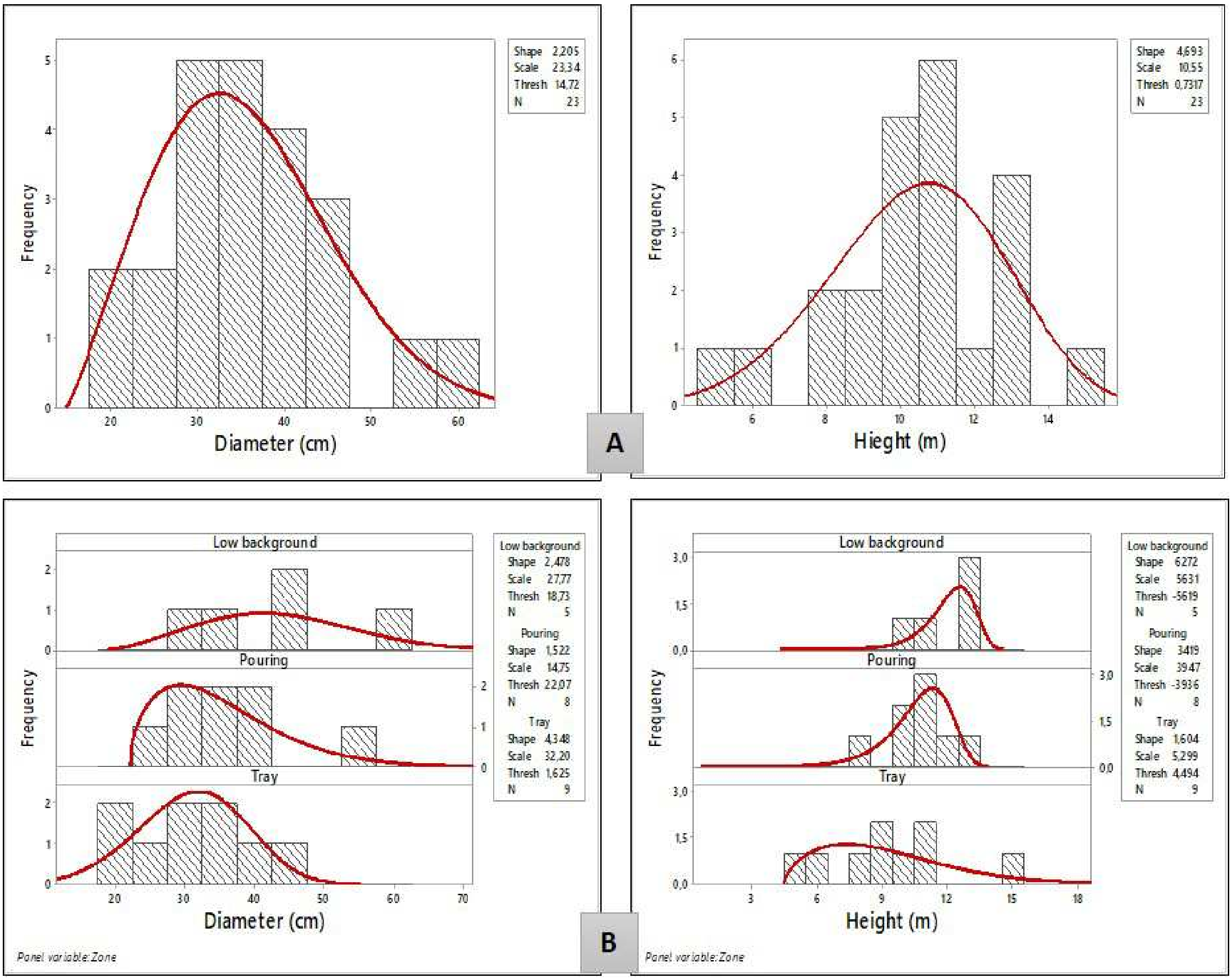

Figure 5. *Histograms of class distribution of diameters and heights of the population Sclerocarya birrea (A) and according to topographic units (B) (Thresh (a) = position parameter, Scale (b) = scale parameter, Shape (c) = shape parameter of the Weibull distribution.*

The diameter class structure of the *Sclerocarya birrea* (5A) population shows a bell shape with a strong deficiency in individuals of small diameters (less than 20 cm). The same trend was observed with the vertical structure of individuals characterized by the predominance of individuals around 10 m in height. The shrub layer is hardly represented in the population of the species (Figure 5B).

Topography has a very remarkable influence on the horizontal and vertical structure of individuals in the population. The low bottom shows a very irregular distribution in the diameter classes, with however a good representation of individuals with small diameter (c = 2.47). Individuals subordinate to areas of ledges are characterized by a left asymmetric distribution (c = 3.6) characteristic of populations predominantly of large diameter individuals.

The structure in height at the level of the low bottom and the pouring shows a left asymmetry that supposes the predominance of individuals of large size. This low background and pouring population are dominated by trees with heights greater than 10 m.

Within the tray, the vertical structure shows a predominance of individuals of small sizes (c = 1.6) with a good presence of individuals between 4 m and 10 m height).

4. Discussion

The study of dendrometric characteristics at Ferlo indicates that topographic microsite's have a great influence on the distribution of populations of *Boscia senegalensis* and *Sclerocarya birrea*. The results showed that Boscia senegalensis offers a higher rate of regeneration, good height growth and a large basal area in low background. These results are consistent with those obtained in Niger [24]. Thus, in the Sahelian savannah, *Boscia senegalensis* regenerates well, this great plasticity of the species gives it a wide ecological range, hence the importance of the areas covered in the Sahel [25]. The main limiting factor at the low background level is light because the species will compete with large trees, hence the low density noted there. The tray offers the best conditions for survival because the population density of the species is greater there. This adaptation of the species at the level of the ledges is physiological in nature. In fact, the presence of excess bundles at the roots increases the plant's capacity to absorb and conserve water from the soil [26]. Thus, this capacity of adaptation reported in Capparaceae would explain the preponderance of the species *Boscia senegalensis* on the tray as noted in this study [27]. These results are in line with those of [24].

The slopes are colonized by a small proportion of individuals, but who find the best conditions for the development of their foliage (crown), their wood production and their growth in size. These results can be explained by the pedological characteristics of the slope, a sandy soil of the tropical ferruginous type with less leaching, more or less favoring the infiltration of water and the development of vegetation. The results obtained thus make it possible to say that the low background does not meet all the conditions necessary for the blooming of *Boscia senegalensis*. However, *Boscia senegalensis* is a species adapted to a hostile climate and that thanks to its anatomical structures, allowing it a great resistance to drought and high temperatures and its great capacity of survival for poor to much degraded soil.

Indeed, the population of *Boscia senegalensis* survives abundantly without benefiting from the best conditions for their vegetative development. The phenological rhythm of *Boscia senegalensis* was only slightly affected by the drought [28]. As for *Sclerocarya birrea*, the results show that the low background is the most suitable topographic unit for the development of the species with better wood production, significant growth in height and size. These results indicate that humidity is an important ecological factor for the survival of the species. This explains its predominance during wet periods, as pointed out [6].

With regard to density, the distribution of individuals is weak and relatively homogeneous over the three topographic units. This low density observed on topographic units could be explained by several factors such as anthropogenic pressure (cutting and clearing) exerted by populations of this valuable species in addition to the natural dissemination of the species. The lack of regeneration of the species noted on all the relief units' results in its lack of renewal in the environment causing the aging of the population.

These results are supported by the work that had obtained a very low density of this species in Niger [29]. The lack of regeneration of the species noted on all the relief units' results in its lack of renewal in the environment causing the aging of the population. In addition to clearing, the absence of juveniles may be linked to a zoo-anthropogenic exploitation (animal grazing, collecting nuts by women) which probably caused severe damage to juvenile individuals [30].

Studies examining the explanatory factors for the dynamics of tree regeneration in tropical forests have revealed that it can be influenced by environmental factors such as soil structure, canopy cover, direction and speed of the trees, winds and local topography [31, 32]. At Ferlo, work revealed a clear regression of *Sclerocarya birrea* [33]. The finding was also made in the Sudanese savannas and in the Arly National Park in Burkina Faso [34, 35]. Thus, the decrease of the most mesophilic species such as *Grewia bicolor*, *Sclerocarya birrea, Combretwn glutinosum* in favor of more xerophilic species in this case *Acacia raddiana*, *Boscia senegalensis* and *Balanites aegyptiaca* can be explained by the rainfall deficit [36]. This phenomenon is materialized at the local level by the withdrawal of certain species such as *Sclerocarya birrea* towards the lowest relief units (pouring and low background).

The deepening of such studies is of great importance in the planning of forest areas. As it stands, it would be important to define a development plan around these useful species for local populations with a view to their sustainable conservation.

5. Conclusion

The study of the distribution and structure of the populations of *Boscia senegalensis* and *Sclerocarya birrea* in this part of Ferlo has contributed to the knowledge of their ecology and to the understanding of their evolution in their environment. The results of this study show that the evolution of the target species is antagonistic with a progressive evolution of the population of *Boscia senegalensis* and a regression of that of *Sclerocarya birrea* in the area. The low background given their humidity, have contributed to the conservation of the *Sclerocarya birrea* population. Topographic variations have a noticeable influence on the distribution and structure of the population of *Boscia senegalensis* in which the preference for pouring and tray areas relates to its light requirements. It is therefore a pioneer population that settles down when large woody plants decline. Faced with these issues of conservation of plant biodiversity in this context of the great green wall, it is important to reverse the evolutionary scenario of the population of *Sclerocarya birrea*, whose forestry should receive special attention. These innovative multiplication and monitoring techniques should be integrated into forest management plans to ensure the regeneration and sustainable conservation of Sclerocarya birrea in Ferlo ecosystems.

Conflicts of Interest

The authors declare that they have no competing interests.

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