Scientific Research Publishing

Open Journal of Ecology, 2024, 14, 1-16
https://www.scirp.org/journal/oje
ISSN Online: 2162-1993
ISSN Print: 2162-1985

Diversity and Structure of the Woody Stand in a Sudano-Sahelian Transition Zone in Senegal

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How to cite this paper: Sarr, O., Sagna, M.B., Bakhoum, A., Diatta, S. and Guissé, A. (2024) Diversity and Structure of the Woody Stand in a Sudano-Sahelian Transition Zone in Senegal. *Open Journal of Ecology*, **14**, 1-16.
https://doi.org/10.4236/oje.2024.141001

Received: May 20, 2023
Accepted: January 13, 2024
Published: January 16, 2024

Abstract

The main objective of the study was to investigate the diversity of the woody stratum of the vegetation in intercommunity rangelands in the department of Koungheul based on an ecological inventory using vegetation surveys. The results indicate a rich flora of 70 species divided into 54 genera and 27 families where *Ceasalpiniaceae* and *Rubiaceae* are dominant (5 genera each). They are followed by *Combretaceae* and *Euphorbiacea* (4 genera each) and by *Capparaceae*, *Fabaceae* and *Mimosaceae* (3 genera for each family). But at the specific level, it is the *Combretaceae* which dominates with 10 species and *Rubiaceae* (7 species). It is more representative at the level of the rural community of Lour Esacale. The different values of vegetation parameters from one site to another indicate variability in community rangeland management practices. The woody stand, dominated by small *Combretaceae*, shows a relatively stable level of organization with an average equitability of about 45% for the two rural communities studied. Species such as *Cordyla pinnata, Sclerocarya birrea, Adansonia digitata and Sterculia setigera* contributed strongly to the basal and aerial cover of the overall stand. The regeneration of the stand is very good (about 85% on average) but it represents very few species, especially of the *Combretaceae* family. This shows a tendency to a progressive loss of species richness in the woody stratum.

Keywords

Flora, Woody Species, Vegetation Surveys, Regeneration, Kaffrine Region

1. Introduction

The Sudano-Sahelian zone has been marked by a climatic deterioration in recent decades. Certain anthropogenic factors have weakened production systems that are essentially based on rain-fed agriculture. This has resulted in a decline in

agricultural production due to soil impoverishment.

In order to make up for this deficit, the only recourse of the populations is to look for new land, either by deforestation or by recovering fallow land, with the result that plant and animal diversity has been greatly affected. Thus, the natural wooded formations are in perpetual change. This is the case for the vegetation of the Kaffrine region, which was once a wooded savannah that has undergone major changes.

The strong regression of the vegetation cover in general and woody cover in particular noted with a massive mortality of certain species [1] can constitute a real threat for the ecological balance. Indeed, in addition to its ecological role [2], the tree constitutes an essential food source for animals and humans [3].

It is therefore urgent to provide rapid solutions that will first require a good knowledge of the composition of the woody flora and certain parameters.

The present work studies the woody stratum of the vegetation using a number of parameters such as: floristic diversity, cover (basal and aerial), density, etc., using diversity indices.

2. Material and Methods

2.1. The Study Area

The study was conducted in central Senegal, in the administrative region of Kaffrine located between latitudes 12˚06 N and longitudes 15˚33 W. It is bordered to the north by the regions of Diourbel, Louga and Matam, to the south by the Republic of Gambia, to the east by the region of Tambacounda and to the west by the region of Kaolack (**Figure 1**). The study was conducted specifically in two rural communities in the Kaffrine region, Lour Escale and Ida Mouride. This is an ecological transition zone between the pastoral Sahelian north and the Sudanese south, which hosts or through which many ruminants transit during the dry season, and where the advancing agricultural front is putting strong pressure on available woody resources.

The dry tropical climate is of the Sudano-Sahelian type. The average monthly minimum and maximum temperatures are 16.2˚C (January) and 42.1˚C (May) respectively. The average annual temperature is around 29.6˚C. Rainfall is irregular: the average rainfall (between 1965 and 2008) is 704.32 mm at the reference station (Koungheul). Koungheul has been characterized by a persistent rainfall deficit since 1970, with a large proportion of biologically dry years, leading to a total amount of rain collected that is less than the annual average corresponding to 23 years of deficit. The rainy season occurs from May to October, which classically distinguishes two periods in the year: a dry period ($P < 2T$) of 7 to 8 months (from October to May) and a rainy season ($P > 2T$) of 4 to 5 months. The months of July, August and September, which account for 79.31% of rainfall, constitute the biologically wet period, with August being the wettest month (32%) [3] [4].

The Kaffrine region belongs to the sedimentary formations of the continental terminal [5]. The soils are sandy, sandy-clay or clayey-sandy and support vegetation characterized from north to south by grassy savannah, shrubby savannah,

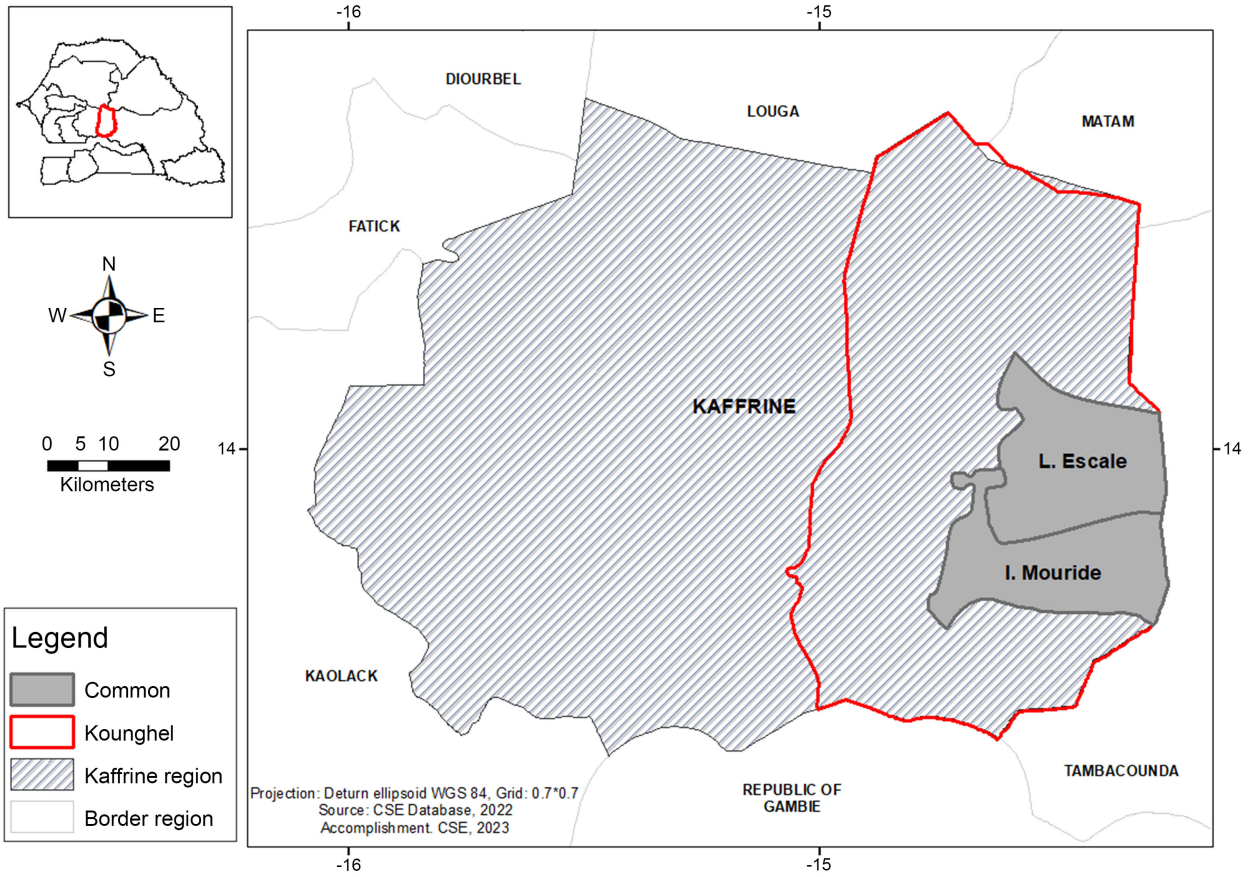

Figure 1. Geographic location of the study area (rural communities of Lour Escale and Ida Mouride).

tree savannah and wooded savannah. Agriculture, mainly rain-fed, and extensive livestock farming are the main activities of the region.

2.2. Data Collection Methods

Five villages have been selected for each rural community In Lour Escale, we have: Lour Village (LE), Koura Mouride (KM), Sobel Diam-Diam (SDD), Darou Dame Leye (DDL) and Yetty Khaye (YK). For the Ida Mouride site, the villages selected are Ida Village (IV), Fass Diabel (FD), Ndawène Saragnama (NS), Maka Katal (MK) and Arafat Mbayène (AM). These villages were selected on the basis of the size of their populations and their willingness to host transhumant herders.

For each village, 20 plots of 50 m × 50 m (2500 m^2) in the rangelands were used to study vegetation parameters. In each plot, the flora inventory and tree measurements were carried out. Height and trunk circumference at 0.3 m from the ground to establish stand structure, crown diameter to assess crown cover, and the distance between the 2 closest trees were measured for each tree to calculate actual and theoretical densities for each site.

Species naming was based on the flora of Senegal [6], the book of "vernacular names of plants" [7] and the catalog of vascular plants of Senegal. Synonyms

have been updated on the basis of the enumeration of African flowering plants [8].

2.3. Data-Processing

All the data was entered and processed in an Excel spreadsheet. A floristic list was established and the specific richness of the flora, the density and some parameters of the woody stand were evaluated.

For the evaluation of the diversity parameters, we used the diversity index (H') of Shannon Weaver (1949) and the evenness (E).

The Shannon index is the most commonly used. It expresses the relative importance of the number of abundant species in a given environment. Its value gives an estimate of the uncertainty with which one can correctly predict the species to which the next individual collected belongs. The index is minimum when all individuals belong to the same species. It is maximum when each individual represents a distinct species [9]. It is given by the following relationship:

$$H' = -\Sigma \text{pilog2 pi}$$

In terms of evenness, it provides information on the distribution of species abundances in the stand. According to [10], the regularity index appears to be a more rigorous comparison term. It is between 0 and 1. It tends towards 0 when all the individuals correspond to a single species. It tends towards 1 when each species is represented by the same number of individuals [11]. Its value is obtained by using the following formula:

$$E = H'/H'_{\max}$$

With H' = Shannon index; $\boldsymbol{H'_{max} = \log 2S}$, S being the total species richness.

For woody stand structure, we used Sturge's rule to define the number of classes and the interval between each class for a sample size of n.

$$\text{Number of classes} = 1 + (3.3 \log n)$$

$$\text{Class interval} = (X_{\max} - X_{\min})/\text{Number of classes}$$

With $X_{\max}$ and $X_{\min}$, respectively the largest and smallest value of X in the statistical series.

From $X_{\min}$ we obtain the class limits or class boundaries by successive addition of the class interval.

3. Results

3.1. Status of the Woody Stand

- **Floristic composition:**

The flora of the two rural communities (RCs) studied has a total of 70 species, 51 of which were recorded in the RC of Lour Escale and 45 in Ida Mouride. They are unevenly distributed in 54 genera and 27 taxonomic families (**Table 1**).

In total, 26 species are common to both RCs, compared to 40 species present in one and the other RC.

Table 1. Floristic list of the two rural communities.

Families	Genres	Species	LE	IM
Anacardiaceae	*Lannea*	*Lannea acida*	1	1
	Sclerocarya	*Sclerocarya birrea*	1	1
Annonaceae	*Annona*	*Annona senegalensis*	0	1
	Hexalobus	*Hexalobus monopetalus*	0	1
Apocynaceae	*adenium*	*Adenium obesum*	1	0
	went down	*Baissea multiflora*	0	1
Arecaceae	*Borassus*	*Borassus flabellifer*	1	0
Asclepiadaceae	*Calotropis*	*Calotropis procera*	1	0
	Leptadenia	*Leptadenia hastata*	0	1
Balanitaceae	*Balanitis*	*Balanites aegyptiaca*	1	0
Bignoniaceae	*Stereospermum*	*Stereospermum kunthianum*	1	1
Bombacaceae	*Adansonia*	*Adansonia digitata*	1	1
	Bombax	*Bombax costatum*	1	1
Burseraceae	*Commiphora*	*Commiphora africana*	1	0
Ceasalpiniaceae	*Bauhinia*	*Bauhinia rufescens*	0	1
	Parkinsonia	*Parkinsonia aculeata*	0	1
	Cassia	*Cassia sieberiana*	1	1
	Cordyla	*Cordyla pinnata*	1	1
	Piliostigma	*Piliostigma reticulata*	1	1
Capparaceae	*boscia*	*Boscia angustifolia*	1	0
	Cadaba	*Cadaba farinosa*	1	0
Celastraceae	*Maerua*	*Maerua angolensis*	1	1
	Maytenus	*Maytenus senegalensis*	1	1
Combretaceae	*Anogeissus*	*Anogeissus leiocarpus*	1	1
	Combretum	*Combretum aculeatum*	1	0
	Combretum	*Combretum glutinosum*	1	1
	Combretum	*Combretum lecardii*	1	0
	Combretum	*Combretum micranthum*	1	1
	Combretum	*Combretum nigricans*	1	0
	Guiera	*Guiera senegalensis*	1	1
	Terminalia	*Terminalia albida*	1	0
	Terminalia	*Terminalia avicenniodes*	1	1
	Terminalia	*Terminalia macroptera*	0	1
Ebenaceae	*Diospyros*	*Diospyros mespiliformis*	1	1
Euphorbiaceae	*Securinega*	*Securidaga virosa*	1	0
	Euphorbia	*Euphorbia balsamifera*	0	1
	Imenocardia	*Imenocardia acida*	0	1
	Jatropha	*Jatropha curcas*	0	1

Continued

	Lonchocarpus	*Lonchocarpus laxiflorus*	1	0
Fabaceae	*Erythrina*	*Erythrina senegalensis*	0	1
	Pterocarpus	*Pterocarpus erinaceus*	1	1
Loganiaceae	*Strychnos*	*Strychnos spinosa*	1	1
Meliaceae	*Azadirachta*	*Azadirachta indica*	1	1
	Khaya	*Khaya senegalensis*	1	0
	Acacia	*Acacia Machrostachya*	1	1
	Acacia	*Acacia nilotica var adansonii*	1	1
Mimosaceae	*Acacia*	*Acacia seyal*	1	1
	Dichrostachya	*Dichrostachya glomerata*	0	1
	Prosopis	*Prosopis africana*	1	0
	Ficus	*Ficus itheophylla*	0	1
Moraceae	*Ficus*	*Ficus sp*	0	1
	Ficus	*Ficus glumosa*	1	0
Myrtaceae	*Eucalyptus*	*eucalyptus alba*	1	0
	Eucalyptus	*Eucalyptus camaldulensis*	0	1
	Ziziphus	*Ziziphus mauritiana*	1	1
Rhamnaceae	*Ziziphus*	*Zizipus gola*	0	1
	Ziziphus	*Ziziphus mucronata*	1	0
	Crossopteryx	*Crossopteryx februfiga*	1	0
	Feretia	*Feretia apodanthera*	1	1
	Gardenia	*Gardenia erubescens*	1	0
Rubiaceae	*Gardenia*	*Gardenia ternifolia*	1	0
	Gardenia	*Gardenia triacantha*	0	1
	Mitragyna	*Mitragyna inermis*	1	0
	Pavetta	*Pavetta oblongifolia*	1	0
Simaroubaceae	*Hannoa*	*Hannoa undulata*	1	0
Sterculiaceae	*Sterculia*	*Sterculia setigera*	1	1
	Grewia	*Grewia bicolor*	1	1
Tiliaceae	*Grewia*	*Grewia flavescens*	1	0
	Grewia	*Grewia villosa*	0	1
Ulmaceae	*Celtic*	*Celtis integrifolia*	0	1

RC: Rural community; IM: Ida Mouride; LE: Lour Stopover; 1: present; 0: missing.

On the generic level, the best represented families are the Ceasalpiniaceae and Rubiaceae (5 genera each). They are followed by Combretaceae and Euphorbiacea (4 genera each) and by Capparaceae, Fabaceae and Mimosaceae (3 genera for each family). 6 families are represented by two species and 10 families by only one species.

At the specific level, only the genus Combretum is represented by 4 species. 4 other genera are represented by 3 species. These are Acacia, Ficus, Gardenia and

Terminalia. Considering the families, the Combretaceae family alone has 10 species, followed by the Rubiaceae with 7 species and the Ceasalpiniaceae and Mimosaceae (5 species each).

- **Distribution and specific importance according to the selected sites:**

The presence or absence of a species in a village is coded (Table 2) by the values (1 or presence and 0 or absence).

Table 2. Sociogram of specific links between the different sites.

	CR Lour Esclale					CR Ida Mouride				
Species	THE	KM	DDL	SDD	Y.K.	AM	IM	NS	MK	FD
Acacia Machrostachya	1	1	1	1	1	1	1	1	1	1
Acacia nilotica var adansonii	0	0	1	0	1	1	1	1	0	0
Acacia seyal	0	1	0	1	1	1	1	1	0	1
Adansonia digitata	1	1	1	1	1	0	0	1	1	1
Adenium obesum	0	0	0	1	1	0	0	0	0	0
Annona senegalensis	0	0	0	0	0	0	0	1	1	0
Anogeissus leiocarpus	1	1	1	1	1	0	0	1	0	0
Azadirachta indica	1	1	1	0	0	0	1	1	1	1
Baissea multiflora	0	0	0	0	0	0	0	0	1	0
Balanites aegyptiaca	0	0	0	1	0	1	0	1	0	0
Bauhinia rufescens	0	0	0	0	0	0	0	1	0	0
Bombax costatum	0	0	1	0	1	0	1	0	1	1
Borassus flabellifer	1	0	0	0	1	0	0	0	0	0
Boscia angustifolia	1	1	0	1	0	0	0	0	0	0
Cadaba farinosa	0	0	0	0	1	0	0	0	0	0
Calotropis procera	0	0	1	0	0	0	0	0	0	0
Cassia sieberiana	0	0	0	0	1	1	1	0	0	0
Celtis integrifolia	0	0	0	0	0	1	0	0	0	0
Combretum aculeatum	1	1	1	0	0	0	0	0	0	0
Combretum glutinosum	1	1	1	1	1	1	1	1	1	1
Combretum lecardii	0	0	0	0	1	0	0	0	1	0
Combretum micranthum	1	1	1	1	1	1	0	1	1	1
Combretum nigricans	1	1	1	1	1	0	0	0	0	1
Commiphora africana	1	1	1	0	1	1	0	0	1	0
Cordyla pinnata	1	1	1	1	1	1	1	1	1	1
Crossopteryx februfiga	0	0	0	1	1	0	0	0	0	0
Dichrostachya glomerata	0	0	0	0	0	1	1	1	1	1
Diospyros mespiliformis	0	0	1	1	0	0	0	1	0	0
Erythrina senegalensis	0	0	0	0	0	0	0	1	0	0
eucalyptus alba	0	0	1	0	0	0	0	0	0	0
Eucalyptus camaldulensis	0	0	0	0	0	0	1	0	0	1
Euphorbia balsamifera	0	0	0	0	0	0	0	0	0	1

Continued

Feretia apodanthera	1	1	1	1	1	1	1	1	1	1
Ficus glumosa	1	0	1	0	0	0	0	0	0	0
Ficus itheophylla	0	0	0	0	0	0	0	0	1	0
Ficus sp	0	0	0	0	0	1	0	0	0	0
Fluggea virosa	0	0	0	0	1	0	0	0	0	0
Gardenia erubescens	1	1	1	1	1	0	0	0	0	0
Gardenia ternifolia	0	0	1	0	0	0	0	0	0	0
Gardenia triacantha	0	0	0	0	0	1	1	1	1	1
Grewia bicolor	1	1	1	1	1	1	0	1	0	0
Grewia flavescens	0	1	1	1	1	0	0	0	0	0
Grewia villosa	0	0	0	0	0	0	0	0	0	1
Guiera senegalensis	1	1	1	1	1	1	1	1	1	1
Hannoa undulata	1	1	1	1	1	0	0	0	0	0
Hexalobus monopetalus	0	0	0	0	0	1	1	1	0	1
Imenocardia acida	0	0	0	0	0	0	1	0	0	0
Jatropha curcas	0	0	0	0	0	0	0	0	0	1
Khaya senegalensis	0	0	0	0	1	0	0	0	0	0
Lannea acida	1	0	1	1	1	0	0	0	0	0
Leptadenia astata	0	0	0	0	0	1	1	1	0	1
Lonchocarpus laxiflorus	0	0	0	0	1	0	0	0	0	0
Maerua angolensis	0	1	1	0	1	0	1	1	1	1
Maytenus senegalensis	1	1	1	1	1	0	1	0	0	1
Mitragyna inermis	0	0	0	1	1	0	0	0	0	0
Parkinsonia aculeata	0	0	0	0	0	0	0	1	0	0
Pavetta Oblongifolia	0	1	1	0	0	0	0	0	0	0
Piliostigma reticulata	1	1	1	1	1	1	1	1	0	1
Prosopis africana	1	0	0	0	1	0	0	0	0	0
Pterocarpus erinaceus	0	1	1	1	1	1	0	1	1	0
Sclerocarya birrea	1	1	1	1	1	1	1	1	1	1
Securidaga virosa	0	0	0	0	0	0	1	1	1	1
Strychnos spinosa	0	1	0	1	1	1	1	1	1	1
Sterculia setigera	1	1	1	1	1	1	0	0	1	0
Stereospermum kunthianum	0	1	0	0	0	1	1	1	1	1
Terminalia albida	0	1	1	0	1	0	0	0	0	0
Terminalia avicenniodes	0	0	0	0	1	1	1	1	0	0
Terminalia macroptera	0	0	0	0	0	0	0	1	0	0
Ziziphus gola	0	0	0	0	0	0	0	1	0	0
Ziziphus mauritiana	1	1	1	1	1	1	1	1	1	1
Ziziphus mucronata	0	1	1	0	1	0	0	0	0	0

Examination of this table allowed us to classify the species into 3 groups:

The first group is made up of species present in six (6) to ten (10) sites; these are highly common species, and they could constitute the very common or true indifferent species, these species are very frequent and widely distributed throughout the sites; they are 22 in number.

The second group is made up of common but infrequent species present in three (2) to six (5) sites;

And the third group is made up of differential species that are present in only one (1) site. These species reveal specificities of the environment.

Specific diversity is assessed by calculating the specific richness per village and for each RC. The total and average species richness (TSR) for each site are determined and their values are given in Table 3.

3.2. Characteristics of the Woody Stratum

We have presented some parameters of woody vegetation for each RC: these are density, species diversity, cover and regeneration of woody species (Table 4 and Table 5).

The level of organization

The Shannon index was 3 bits at the Lour Escale RC route set (Table 4). It ranged from 2.52 (at KM) to 3.13 (at YK). The SDD village showed the same index as that observed for all the routes in the RC.

However, regularity was lower at the RC level (0.52), while it was higher at SDD (0.61) and YK (0.59). It had the same value (0.53) for the villages of LE and DDL; this would suggest a similar level of organization for these two sites.

Table 3. Total and average species richness by site.

	Sites	RST	RSM
CR Lour Escal	THE	25	6.5
	KM	30	7
	DDL	34	7
	SDD	28	7
	Y.K.	40	8
	CR Lour	51	7.1
CR Ida Mouride	AM	26	5
	IM	25	8
	NS	33	6
	MK	24	3
	FD	27	7
	CR Ida	45	6.8

Table 4. Diversity and density in the Lour Escale RC.

	KM	DL	SDD	THE	Y.K.	CR Lour
Shannon index	2.68	2.72	3	2.52	3.13	3
Regularity index	0.54	0.53	0.61	0.53	0.59	0.52
Basal area (m^2/ha)	1.76	3.09	8.88	2.48	4.24	4.09
Recovery (%)	17.54	18.95	21.25	17.94	27.97	20.73
Actual density (n/ha)	233.66	316.66	371	783.77	411.77	361.22
Theoretical density	878.73	1191.26	806.44	1052	836.18	984.34
Average distance (m)	3.37	2.5	3.52	3.08	3.45	3.18
Regeneration (%)	11.51	7.54	14.03	33.56	16.26	82.93

Table 5. Diversity and density in the Ida Mouride RC.

	IM	MK	AM	NS	FD	CR Ida
Shannon index	1.68	1.22	1.24	2.3	1.19	1.52
Regularity index	0.52	0.39	0.38	0.65	0.36	0.4
Basal area (m^2/ha)	5.97	10.5	6.04	14.92	8.79	9,244
Recovery (%)	31.63	22.58	30.39	32.98	22.5	28
Actual density (n/ha)	54	21	52	17	25	34
Theoretical density	238	64	182	67	625	235
Average distance (m)	6.51	12.5	7.33	12.23	4.01	8.51
Regeneration (%)	18.97	15.74	21.72	5.24	28.79	90.48

In the Ida Mouride RC, as in LE, there is also a difference between the Shannon diversity index values for the three sites. The values obtained show that diversity is greater at the NS (2.3) and IM village (1.68) sites (**Table 5**). It is in these two sites where the value of the Shannon index exceeds that of the RC (1.52). The regularity indices are also higher (0.65 and 0.62) for NS and IM village respectively.

- **Woody cover**

For the site, the basal area is 4.09 m^2/ha. It is much higher at SDD (8.88 m^2/ha), ie, double that obtained for all the rangelands of the RC, and lower at Koura Mouride (1.76 m^2/ha).

The highest basal area values are found in the IM RC sites. They vary from 5.97 m^2/ha in IM village to 14.92 m^2/ha in the NS site.

The aerial cover is 20.73% when considering the whole of the Lour Escale CR. On the other hand, from one station to another, canopy cover values varied from 8.95% at DDL to 27.97% at YK, passing through values of 17.54% at KM and 17.94% at LE respectively. For the Ida Mouride RC, the overall coverage is 28%. It is slightly higher than that observed in Lour Escale. The villages of IM and LE had the highest coverage values.

- **Density**

The observed and theoretical densities show a significant difference in all two RCs studied. Theoretical to observed density ratios per site are very high. At the overall level of the Lour Escale RC, this ratio is 3, whereas it is higher in the Ida Mouride RC (7).

At the rural community level, this ratio is 2.72.

The average distances between feet used to calculate actual density by site vary from one RC to another and from one site to another.

- **Regeneration**

The number of seedlings counted in all the inventory plots is 15,797 or 82.93% of the woody stand of the Lour Escale RC.

When considering the sites, this rate varied greatly. Thus, it is 7.54, 11.51, 14.03, 16.26 and 33.56% of the stand for the DDL, KM, SDD, YK and LE village sites respectively.

The Ida RC, on the other hand, has a higher regeneration rate (90.48%). This rate varies from one RC site to another. The highest rate is found in FD (28.79%), while the lowest rate (5.24%) is obtained in NS.

3.3. Woody Stand Structure

The structure of the woody stand is characterized by the distribution of individuals in trunk diameter and tree height classes.

- **Size distribution**

When we consider the distribution of woody species according to their size in the Lour Escale RC (**Figure 2**), we realize that even if all classes are represented, almost all the individuals are grouped in the first two classes. The class 3 - 12 cm alone represents more than 78% of the individuals. Species such as *Combretum glutinosum* and *Guiera senegalensis* contributed the most to this proportion. They represent respectively 45% and 24% of the total contribution. The third dominant species, Cordyla pinnata, is absent in the first class. It contributes more to the higher classes.

In the Ida Mouride RC, the distribution is similar to that of Lour Escale, marked by a very high concentration of individuals in the first class (3 - 15) of diameter. This class represents nearly 80% of the woody stand and species such as *Combretum glutinosum* and Piliostigma reticulatum largely dominate it (45% and 25% respectively) (**Figure 3**).

- **Height distribution**

The height class distribution of woody plants shows a unimodal structure for both RCs studied (**Figure 4** and **Figure 5**). All classes are represented even if the lower strata are dominant.

In the Lour RC (**Figure 4**), the 1 - 3 m stratum is by far the most important. There is a strong contribution of *Combretum glutinosum* and *Guiera senegalensis* in this one.

In the Ida Mouride RC (**Figure 5**), it is the second stratum (3 - 6 m) that contains the greatest number of individuals, even though the first stratum (1 - 3 m) has a significant presence.

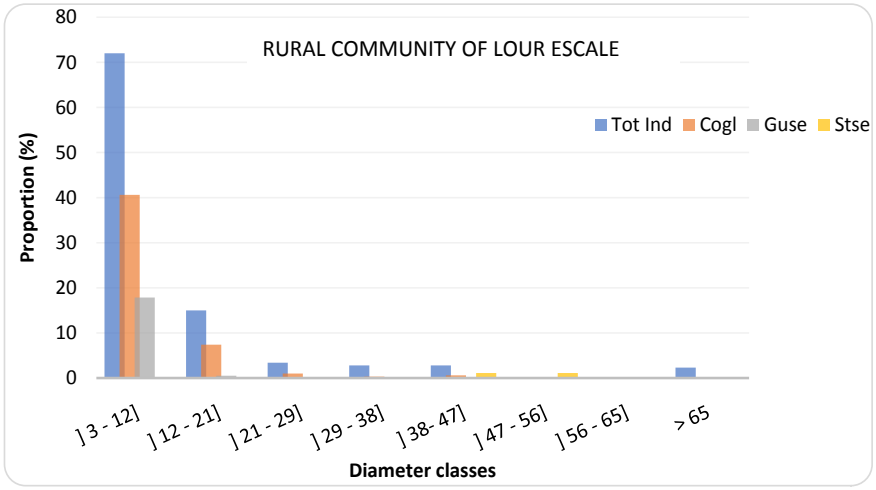

Figure 2. Distribution of the stand and the three dominant species in the Lour Escale RC by diameter classes.

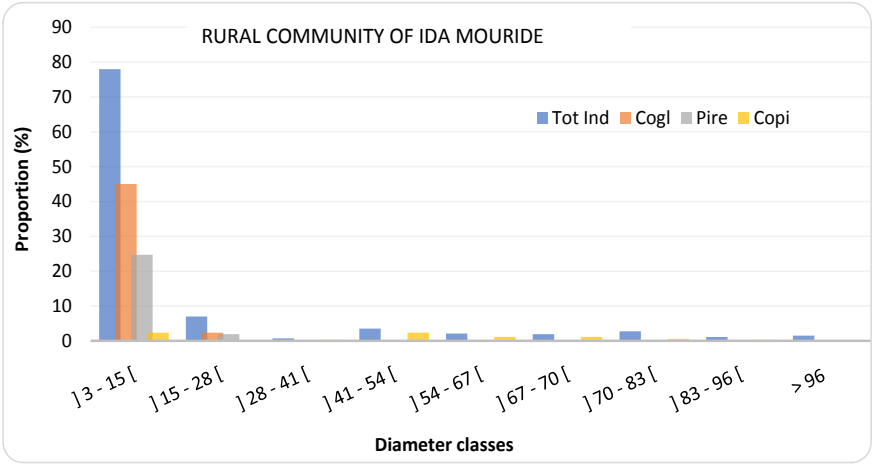

Figure 3. Distribution of the stand and the three dominant species in the Ida Mouride RC by diameter classes.

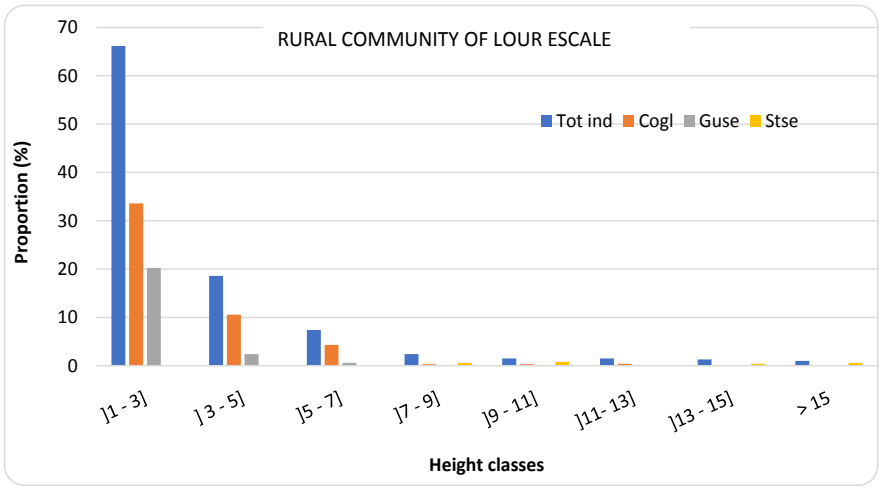

Figure 4. Distribution of the Stand and the Three Dominant Species of the Ida Mouride RC by Height Classes.

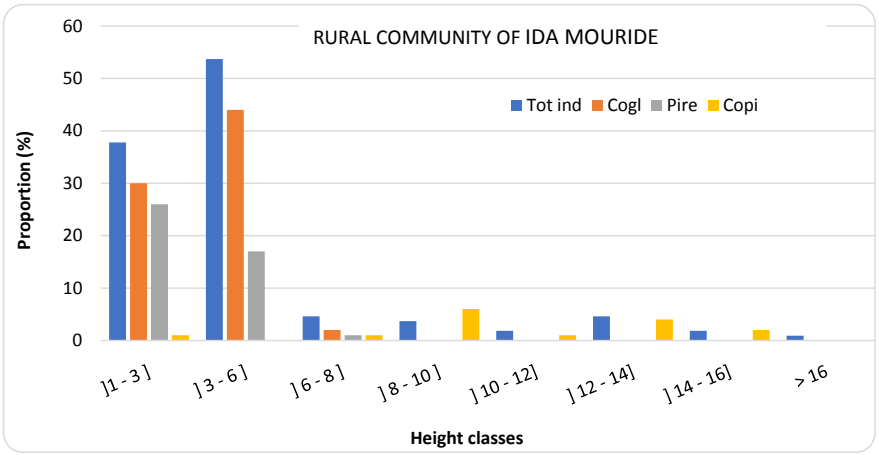

Figure 5. Distribution of the population and the three dominant species of the RC of Ida Mouride according to the height classes.

As for Cordyla pinnata and Sterculia setigera, we note that they appear in the upper strata, unlike species such as *Combretum glutinosum*, *Guiera senegalensis* and *Piliostigma reticulatum*.

4. Discussion and Conclusion

The floristic procession consists of 70 woody species distributed in 54 genera and 27 families. It is more important at the CR of Lour Scale where there are 51 species. This situation is probably due to the fact that the rural community of Ida Mouride is more exposed compared to the national road, therefore more accessible on the one hand, on the other hand, it is occupied by a large number of cultivating marabouts exploiting surfaces important. This is the same number of species that [12] has identified in the territory of the Nema (in Sudano-Sahelian zone). It is important compared to the woody flora of 3 community forests in Sine-Saloum (Center-West of the Senegal), in the same eco-climatic zone) which is 43 species divided into 34 genera and 23 families [13].

The specific importance has varied. There are very frequent species, moderately frequent species and rare species. Species like Aogeissus Leiocarpa, Acacia Seyal, Grewia Bicolor and Feretia Apodanthera are quite frequent but are not very abundant in the routes. Characteristic species such as Multiflora decrease, Bauhinia Rufescens, Calotropis Processra, Celtis integrifolia, Cassia Sieberiana, Boscia Angustifolia, etc., are generally uncommon or rare species in rural communities; they reveal by their presence an ecological specificity of the biotope [14].

The dominant species belong to the Combretaceae family (*Comretum Glutinosum, Guiera senegalensis*). This corresponds to the description made by [1]: the Sudano-Sahelian area is characterized by a savannah in Combretaceae.

The rural community of Lour has a more stable level of organization. Indeed, the values of the indices of Shannon (3) and regularity (52%) in Lour are greater than those obtained in Ida Mouride (1.52 for Shannon and 40% regularity). But

overall, this level of organization remains low in view of the values obtained. This attests that individuals are not well distributed through families and that despite an acceptable specific richness, only a few species constitute the essential of woody settlement [2].

The burrow surface of the woody settlement is 4.09 m^2/ha for the CR of Lour and 9.24 m^2/ha for Ida Mouride, it is relatively low. It should be noted the important contribution of species with a strong circumference such as Adansonia Digitata, Sterculia Setige, Cordyla pinnata, etc., despite their low densities. This therefore confirms the absence of correlation between density and burrow surface [15].

The aerial cover of the CR of Lour Escalle (20.73%) is less important than that of Ida Mourida (28%). Work carried out by Thiaw in 2009 in a village in the rural community (Haffé) shows a fairly similar overlap (23%). It is also comparable to the limit value established by Houerou in 1980 by characterizing the canopy in Sudano-Sahelian zone as between 10% - 20% in sandy soils. Indeed, in the rural community, sandy soils (Dior soil and Dior Deck soil) dominate.

The theoretical density almost triples the real density in the routes of the CR of Lour. This same observation is also observed in the CR of Ida Mouride. This shows a heterogeneous distribution of the woody settlement in places sometimes in groves, sometimes sparse, due to the high variability of the variation of variation associated with the average distance between two trees [16].

The regeneration of the settlement is 82.93% of all the routes of Lour and 90% in those of Ida. The number of young plants is therefore much greater than the number of adult plants in the courses of the two CRs studied. *Combretum glutinosum* and *Guiera Senegalensis* contribute two about 80% of this regeneration to them.

The species like *Feretia apodanthera* and *Grewia bicolor* are quite present but by far less important than the first two cited. This is due to the fact that they are much more paved by cattle.

Most of the species identified are under cover of adult plants, this is understandable insofar as, shade helps in regeneration of the woody [17]. However, under cover of *Sterculia setigera*, regeneration hardly exists. Only *Comretum glutinosum* resists fairly well under its cover, however, is very often stunted.

The structure of the woody settlement shows a very large distribution of small individuals at the level of the first two established classes. This indicates that the course areas in the two CRs are essentially shrub. The dominant species (*Combretum glutinosum* and *Guiera senegalensis* or *Piliostigma reticulatum*) presented almost all of their individuals in this margin. They have to some extent, imposed their structure on the settlement. However, species like *Combretum glutinosum* and *Guiera senegalensis* are more used for the production of coal or to serve as firewood despite their importance [4] [18]). This significant proportion of individuals of small sizes highlights a real potential for regeneration [19].

Large individuals are present but with a very much lower proportion than small sizes. They are divided between S*terculia setigera, Adansonia digitata,*

Cordyla pinnata, Pterocarpus erinaceus,…; They are unfortunately very attacked either for human food (fruit and leaf of *Adansonia digitata*, *Cordyla pinnata* fruits, *Sterculia setigera gum*) or animal, or to make ropes (bark of Adansonia digitata), or for wood construction or energy (*Cordyla pinnata* and *Pterocarpus erinaceus* trunk), finally to serve as curative means in the face of certain diseases (*Cordyla pinnata, Pterocarpus erinaceus*). They are therefore species for multiple uses [20].

The study made it possible to characterize the woody settlement of two rural communities of the department of Koungheul in the region of Kaffrine.

We have thus determined at the level of the two rural communities studied a flora with 70 species including 51 identified in the CR of Lour Escale and 45 to Ida Mouride. They are unevenly distributed in 54 genera and 27 taxonomic families.

The families of Casalpiniaceae and Rubiaceae have the greatest number of genera (5 each). They are followed by the *Combretaceae* and *Euphorbiacea* (4) and by the *Capparaceae, Fabaceae* and *Mimosaceae* (3).

The low burrow surface obtained and the high concentration of individuals in the first structural classes indicate that the settlement is very young.

This very good regeneration is unfortunately not observed in all species. It is most of the Combretaceae that best adapt to the dryness that regenerates the most.

Acknowledgements

The authors would like to thank the Observatoire Homme Milieu (OHMi) of Téssékéré, IRL 3189 of the CNRS, for their invaluable contribution to this work.

Conflicts of Interest

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

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