



FLORISTIC COMPOSITION AND DENSITY OF MAIN WOODY SPECIES OF THE PARKLANDS IN TWO PHYTOGEOGRAPHICAL ZONES IN BURKINA FASO

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ABSTRACT

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This study carries out in three villages belonging to the two phytogeographical zones (South-Sudanian and North-Sudanian sectors) in Burkina Faso. It intends to describe the floristic composition and calculate three main woody species density of the agroforestry parks in those two phytogeographical zones. The methodology consisted, on the one hand, to measure the area of fields and, on the other hand, the floristic species inventory. The results show that parklands in Bala (South-Sudanian phytogeographical zone) contains 14 species from 14 genus and 9 botanical families: Fabaceae-Caesalpinioideae, Fabaceae-Faboideae-Mimosoideae, Bombacaceae, Anacardiaceae, Meliaceae Combretaceae, Sapotaceae, Moraceae, and Verbenaceae. The parklands of Toessin and Bonogo (North-Sudanian sector) are rich of 51 species, 36 genus and 22 families which are, in addition to those cited in Bala Rubiaceae, Fabaceae-Faboideae, Ebenaceae Rhamnaceae, Balanitaceae, Annonaceae, Myrtaceae, Bignoniaceae, Moringaceae, Apocynaceae, Sterculiaceae and Lythraceae. The calculation of trees density showed that the dominant woody species in the parks of Bala are in order of importance *Vitellaria paradoxa*, *Parkia biglobosa* and *Tamarindus indica*. Their maximum densities are respectively 66; 8 and 1 trees/ha. On the other hand, in Toessin and Bonogo, north-sudanian sector *Lannea microcarpa*, *Vitellaria paradoxa*, *Parkia biglobosa* predominate with maximum densities respectively from 34, 38 and 3 trees/ha.

Contribution/Originality: This study contributes to the existing literature concerning floristic composition and density of the ligneous in the parklands. This study uses a new estimation methodology: measure, survey. This study is one of the very few studies which have investigated in these aspects. This study documents the knowledge on the ligneous and distribution.

1. INTRODUCTION

Agroforestry is defined as land use system in which the trees are kept in association with crop and livestock production in a given space and where there are both ecological and economic interactions between other components of the system and the Woody [1].

In rural zones of sub-saharan of Africa, trees are included of the traditional farming. They are regularly kept because they provide traditional medicines, food commodities and firewood. In parts of West Africa, about 75% of

the harvest of timber and non-timber products comes from agroforestry parks [2]. Trees are also kept to manage and improve the physical and chemical soil properties [3-6]. This reconstruction of the fertility and the physical and chemical properties require fallow. The effects of the fallow depend on such conditions the initial state of the fallow, the type of exploitation, the rigor of the climate and its duration.

In West Africa, fallows are often owned by groups of families. The criteria for selection of the trees in the parks will also depend on ethnicity. This selection is one of the factors of the diversity and floristic composition of the trees in agricultural areas [7]. Moreover, the appropriation of land by natives peoples to the detriment of migrants has implications on the management and maintaining of the species tree in the parkland because the rights held on trees depend on the mode of access [7, 8]. The maintaining of the trees in the Sudanian zone of Burkina Faso seems related to the old of the agricultural system. This agricultural technique had the advantage of diversification of the age of settlement of the trees but with evolution toward permanent agriculture, they are the emergence of a single generation of woody species [9].

In Burkina Faso and other African countries, the choice of crops and farm tools can also have consequences on the maintaining of the trees. Mechanized cultivation, although allowing for the increase of agricultural production, causes the degradation of the parklands [10, 11].

In western Burkina Faso, cotton, this cash crop is responsible for the tree destruction of these parklands. Furthermore, the cotton plant is a sun-loving and annual plant with delicate cultivation and requirement development conditions. It requires heat throughout the vegetative and productive cycle. Heat is thus a favorable element for the development of cotton plants. The insufficient thermal conditions lead to an extension of its growth cycle [12]. The preference of the cotton by the farmers leads thus to the systematic cutting of the trees in the farms because of the effect of the shade. It leads to aging of trees because of the lack of natural regeneration, to the decrease of the density of the trees and therefore affects the physiognomy of the parklands. Thus, forms of agricultural development promoted by states institutions preferring the monoculture in the farms excluded more in more tree cover [13]. Diversity and floristic composition, however, are the essential elements that perform the function of parklands. Despite preferences of local populations for commercial species [14] few studies conducted on the floristic composition of parklands in the different phytogeographical zones, except those conducted by Nikiema [15] which focused on the comparison of the ligneous flora in classified forests and parks in South-Saharan and North-Sudanian zones in Burkina Faso. The association of the trees to the other components of the parklands system depends on the ecological conditions in the environment which affects the phenology and the distribution of the tree species. However, the flora of Burkina Faso is distributed following a north-south climate gradient. This distribution corresponds to the phytogeographical subdivision proposed [16]. The North-Sudanian zone is the most intensively cultivated because of the high population growth and the vegetation, the rustic landscapes dominated by protected species. On the other hand, due to the low population density, the vegetation of the South-Sudanian zone presents the less disturbed forest areas [17]. The aim of this article is to study the floristic composition of the species in the agricultural areas of the phytogeographical zones, North-Sudanian and South-Sudanian. Specifically, the study intends to describe the floristic composition of ligneous and to estimate the density of the main ligneous species of parklands.

2. MATERIAL AND METHOD

2.1. Presentation of the Study Area

2.1.1. Village of Bala

Bala is located in the department of Satiri (Houet province). The data collected from the national meteorology of Bobo-Dioulasso station indicate that the annual average rainfall between 1986 and 2015 are 1080 mm, distributed on 4 at 6 months, from May to October. The below Figure 1 shows that the average temperatures have a maximum value of 33°C in April and a minimum value of 26, 2°C in December.

The choice of the data of the meteorological station in Bobo-Dioulasso is due to the absence of reference station in the department of Satiri and also the proximity of the village to study with this town (Bobo-Dioulasso). Indeed, Bala is located 50 km from Bobo-Dioulasso. As shown in Figure 2, it is located in the South-Sudanian phytogeographical zone and therefore, in the South-Sudanian climate zone according to the classification of Guinko.

Four types of soil are found in the village of Bala: soils on the breastplate, tropical ferrallitic and ferruginous soils, alluvial soils and hydromorphic soils [18].

The main subsistence crops are millet, sorghum, and corn. Cotton is the cash crop. Farming is put on poultry, cattle, sheep and goats. According to Serpantié [4] the South-Sudanian savannahs are partly cotton and received migrants. The annual growth of land use was 2% between 1986 and 1998. The northeast region of Bobo-Dioulasso is the center of Burkina Faso official cotton zone. In 1998, this area produces half the cotton of Burkina Faso. The proportion of cotton in crop rotation is around 25% of the acreage (12% in 1975, 19.4% in 1986; 23% in 1998). The part of crops has progressed strongly since 1985; following the evolution of the populations. At Bala, the cotton is almost the only cash crop and occupies more than half of agricultural land. Manual cropping systems concerns 13,6% of the farms, mechanized cropping systems occupy about 68,2% of farms. Motorized agricultural systems concerns 18,2% of the farms. This agricultural system essentially concerns the production of cotton, maize, millet and sorghum.

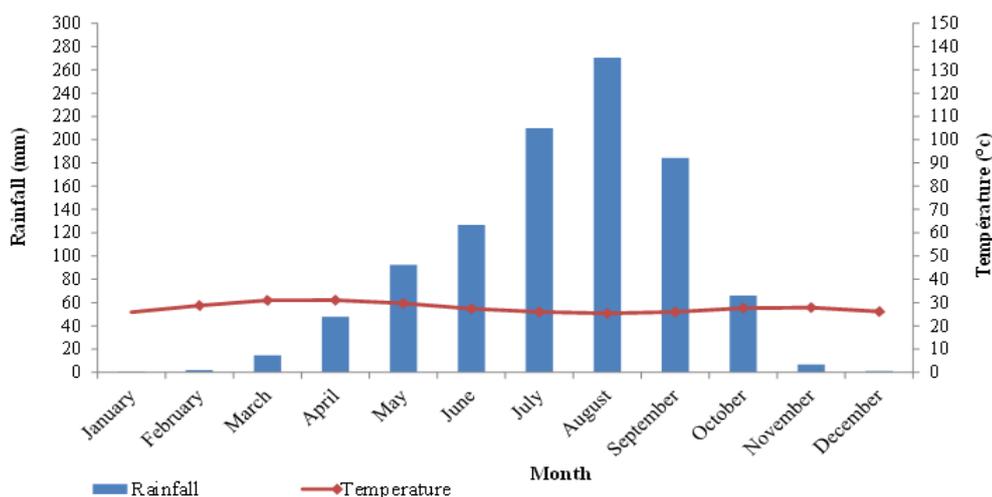


Figure-1. Ombrothermic Diagram of the Bobo Dioulasso station (1986-2015).

Source: Data of the National Agency of the Meteorology of Burkina Faso.

2.1.2. Villages of Toessin and Bonogo

Toessin is located in the department of Samba (Passore province) and Bonogo in the rural zone of Sapone (Bazega province). These two villages belong to the North-Sudanian phytogeographical zone Figure 2. Their climate is sudano-sahelian.

Thus, the climate of Toessin and Bonogo is characterized by a dry season from October to May, and a rainy season from June to October. Climate data obtained at the national meteorology indicate that the annual rainfall average of the town of Yako between 1986 and 2015 is 707,2 mm by year Figure 3. Monthly temperature averages indicate also minimum of 27,7°C in January and maximum temperature 35,2°C in April.

In absence of meteorological station in the Samba department, the choice has been done on the climate data from the town of Yako, reference station. On the other hand, the village of Bonogo is located about 7 km from the commune of Sapone held the meteorological station.

Furthermore, the villages of Toessin and Bonogo are characterized by ferruginous soils, grit spreader soils or clayey, sandy soils, and hydromorphic soils [19, 20]. Agriculture occupies the whole of the active population. It had an extensive character with rudimentary tools. Nowadays, agriculture is more and more semi-mechanized and

motorized, using animal traction, manure and a few chemical fertilizers. The land used rate was between 60% and 90%. Cereals stretched more than 80% of cultivated areas [20]. The crops are millet, sorghum, maize, rice and voandzou. The cash crops include sesame, peanut and voandzou.

Maize and sorghum stretched respectively 28500 ha and 43000 ha between 2008 and 2011, whether a growth rate of 17% by year. This hold on the land causes destruction of the vegetation, the desertification and the extinction of species. Livestock is the second economic activity after agriculture. Sheep, goats and poultry are dominant in the number of livestock in the village of Toessin.

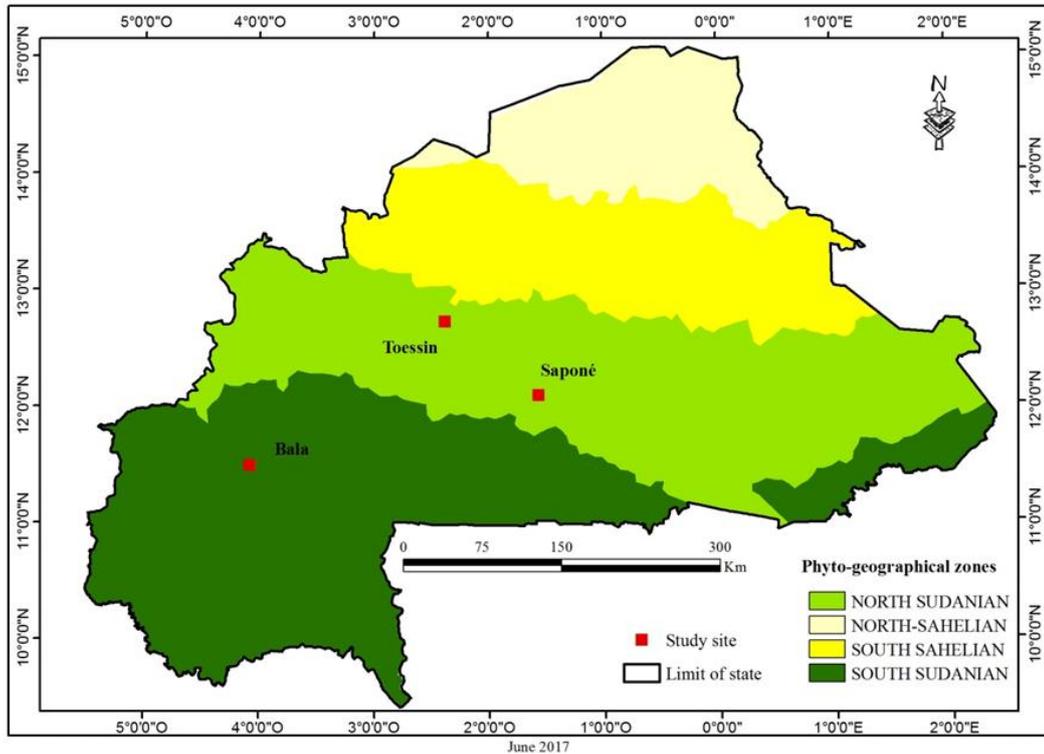


Figure-2. Location of study areas.

Source: IGB

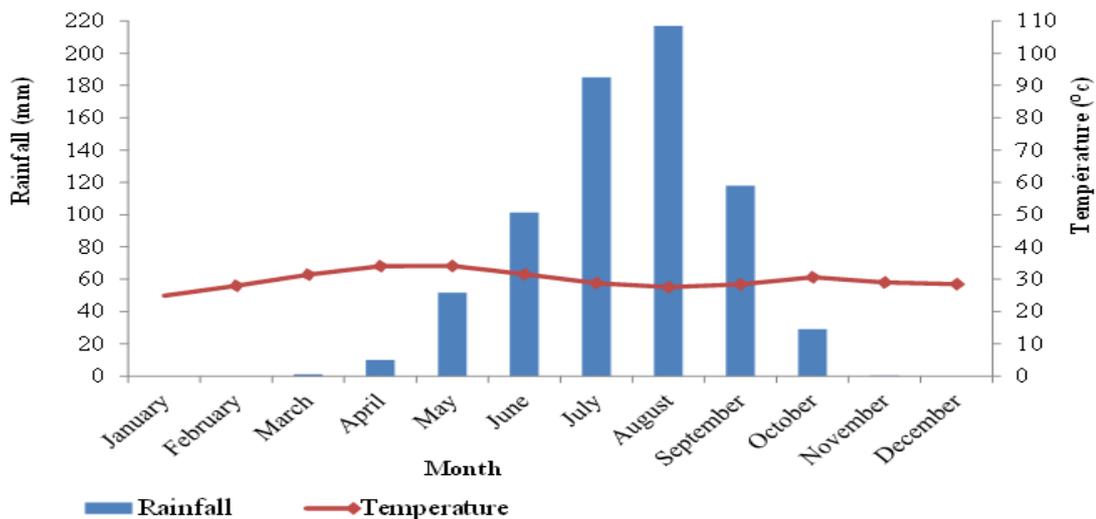


Figure-3. Ombrothermic Diagram of the Yako station (1986-2015).

Source: Data of the National Agency of the Meteorology of Burkina Faso.

2.2. Data Collection

2.2.1. Choice of Plots

The study was conducted between January-March 2015 and February 2016. The study concerned the plots cultivated in the three villages. The plots are those that have been exploited in cereals (millet, maize, sorghum) for Bonogo and Toessin, in cotton (for Bala village) during the campaign preceding this study. Statistics gathered from the departmental direction of the Ministry of agriculture showing that in 2012, 49%, 29% and 20% of the areas of Bonogo were cultivated respectively in sorghum, millet and maize whereas Toessin these crops occupied 75%, 22% and 2% of the surfaces. In Bala village, cotton, maize and sorghum occupied 29%, 28% and 30% of the areas respectively; 13% was devoted to the millet.

In order to determine the cultivated plots, we asked help from the councillors of decentralization of each village. As shown in [Figure 4](#), the plots were selected along two transects oriented from West to East and South to the North and were positioned on the plains. In total, 50 plots selected for the study whose 15 for each of the villages of Toessin, Bonogo and 20 plots for Bala. The choice has done on the plots of bush because they are very large and cultivated in cereals and cotton. The number of ligneous species that they contained is higher than for the parklands near the villages [21].

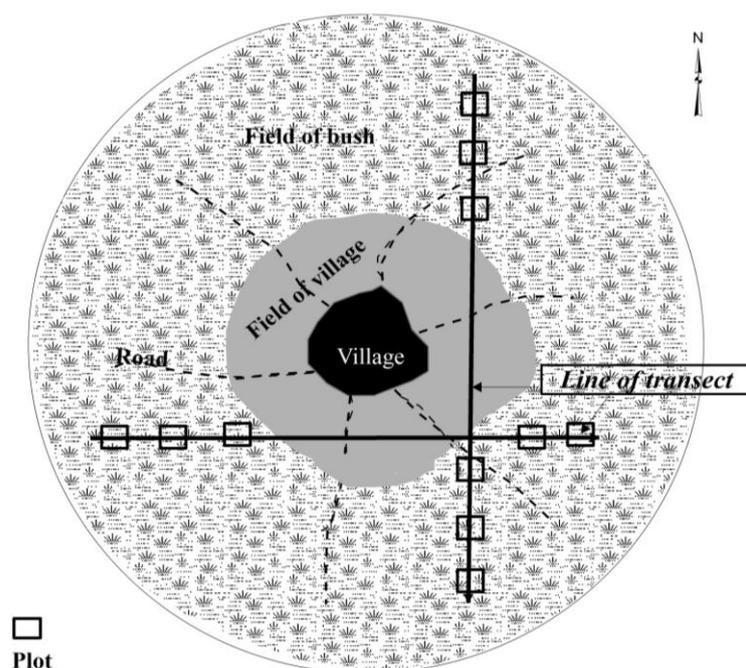


Figure-4. Location of the transects and plots inventoried.

Source: Field survey, 2016.

2.2.2. Measure of the Plots Superficies

To determine the area of the plots, we proceeded to the recognition of the limits of the cultivated plot. The surface was measured automatically by using the GPS navigation garmin 60.

2.2.3. Inventory of the Dominant Species

In each plot, we first conducted an inventory of the ligneous species. Later on, we appreciated the general physiognomy of vegetation and counted the trees ligneous species. After this count, we have classified the ligneous species in order of numerical importance in order to identify the first three dominant ligneous species on each agricultural plot. The selected ligneous species are those whose height is superior to or equal to 7 meters in order to

consider the category of big trees, according to the classification of the ligneous stratum made by [Bandré, et al. \[22\]](#). The determination of the height of these trees has been made using a graduated pole.

2.3. Analysis of the Data

2.3.1. Determination of the Species

The plant species encountered during the floristic inventory and the surveys were identified directly by their names in French or in local names (in mooré or dioula). In addition, interpreters have had an important role in identifying and naming local species names. In cases where species have not been identified, samples are taken and compared to specimens from the Herbarium of the National Center for Scientific and Technological Research of Burkina Faso.

To determine the scientific names, local names were compared to the floristic lists of [Bélem \[18\]](#); [Bélem \[19\]](#) for the Toessin site and the hippopotamus pond and the list obtained by [Abegg, et al. \[23\]](#) for the Sapone forest. The concordance of scientific and families names was determined using the nomenclature used in the catalog of Burkina Faso vascular plants of [Thiombiano, et al. \[24\]](#). It is the nomenclature of the African Plants Database (APD) of the Conservatory and Botanical Garden of the City of Geneva and the South African National Biodiversity Institute, Pretoria for Tropical Africa. Thus, we have also opted for their system on the classification of botanical families.

2.3.2. Calculation of the Density of the Species

Areas of the plots being measured using the GPS and the numbers of ligneous species known, density per hectare of each of the dominant species was obtained from the following general formula:

$$D = \frac{N}{S}$$

D: number of feet per hectare

N: number of feet of the species concerned

S: surface

3. RESULTS AND DISCUSSION

3.1. Ligneous Floristic Composition by Phytogeographical Zone

3.1.1. Ligneous Floristic Composition in Bala

Ligneous inventoried in the Bala village are rich of 14 species, distributed in 14 genus belonging to 9 families. The Fabaceae-Caesalpinioideae, Fabaceae-Faboideae-Mimosoideae, Bombacaceae, Anacardiaceae and Meliaceae, each have two species and represent 71% of the total of species. The other families Combretaceae, Sapotaceae, Moraceae and Verbenaceae have each species and constitute in total 29% of the species [Table 1](#).

The numbers of species and families of species we identified are lower than those obtained by previous studies in the same phytogeographical zone. Indeed, the inventories accomplish by [Mahamane \[1\]](#); [Dalliere \[25\]](#) on the lower glacia and the plateaus of Bondoukuy, [Nikiema \[15\]](#) in the Nahouri, Zoundweogo and [Bondé, et al. \[26\]](#) in the Tuy, in Burkina Faso. These authors had identified respectively 53 species and 23 families; 94 species and 34 families; 41 species and 20 families; 76 species and 26 families in the South-Sudanian parklands. They had also noted the same dominant families but the exception of the Meliaceae and Bombacaceae. The numbers of species and families what they have listed show a great diversity in the floristic composition of the parklands in these zones. Studies conducted by each of these authors show that parklands are also colonized by species from the families whose the Acanthaceae, Balanitaceae, Bignoniaceae, Boraginaceae, Brassicaceae, Amarantaceae, Celastraceae, Cochlospermiaceae, Chrysobalanaceae, Ebenaceae, Hypericaceae, Hymenocardiaceae, Myrtaceae, Olacaceae,

Opiliaceae, Palmaeae, Papillionaceae, Polygalaceae, Rhamnaceae, Rosaceae, Rutaceae, Sterculaceae, Annonaceae, Apocynaceae, Capparidaceae, Loganiaceae, Euphorbiaceae, Tiliaceae and Fabaceae-Faboideae.

According to Mahamane [1] and Bondé, et al. [26] the topography determines the floristic diversity of parklands and their composition. Parklands on up of topography position would be relatively more diversified in species that encountered at the bottom of the topography. Thus, the glaxis contains more species that the shallows which would justify the number of species and families identified by these authors. The preponderance of the Fabaceae-Faboideae (31%) and Rubiaceae (5%) observed in cultivated areas is related to this change in topography between glaxis and shallows. For Mahamane [1] this variation in the floristic composition of the parklands also depends on the ecological conditions of the environment that justify the choice on some species by farmers. They realize a selection of the *Parkia biglobosa* and *Vitellaria paradoxa* in favorable environments allowing the development of these species. Moreover, these two authors estimate the diversity of species and families would be also dependent on the weak traditional clearing, not mechanized which have existed in the past and would have kept intact the roots and the stump of some species. These grow again a few years later and contribute to their sustainability in cultivated areas.

Similarly, for Nikiema [15] and Dalliere [25] floristic composition in cultivated areas is justified by the ability to regenerate species and this is due to the fallow been preceded the cultivation. The difference with our results is probably due to the evolution of culture and agriculture systems. The South-Sudanian became the main cotton zone of Burkina Faso [4, 12]. But according to Mallet [11]; Kessler and Boni [27] the choice of this crop by farmers resulted in mechanization agricultural leading to the systematic and progressive trees cut in the fields. The facts that some trees don't produce edible fruits or wish to reduce the effect of the shadow on the crops are other main reasons for trees destruction.

Table-1. List of ligneous species identified in the Bala parklands.

Families	Species	Local name (mooré)
Anacardiaceae	<i>Lannea microcarpa</i> Engl. et K. Krause	Sanbga
	<i>Sclerocarya birrea</i> (A. Rich.) Hoschst	Noabga
Bombacaceae	<i>Bombax costatum</i> Pellegr. et Vuillet	Voaka
	<i>Adansonia digitata</i> Linn.	Toèega
Fabaceae-Caesalpinioideae	<i>Tamarindus indica</i> Linn	Pusga
	<i>Cassia sieberiana</i> D.C	Kumbrisaka
Combretaceae	<i>Terminalia macroptera</i> Guil. et Perr	Goondré
Meliaceae	<i>Azadirachta indica</i> A. Juss	Neem
	<i>Khaya senegalensis</i> (Desr.) A. Juss.	Kuka
Fabaceae-Faboideae-Mimosoideae	<i>Parkia biglobosa</i> (Jacq.) R.Br. ex G. Don	Roanga
	<i>Faidherbia albida</i> (Delile) A. Chev	Zaanga
Moraceae	<i>Ficus gnaphalocarpa</i> (Miq.) Steud. ex A.Rich	Kankanga
Sapotaceae	<i>Vitellaria paradoxa</i> Gaertn.	Taanga
Verbenaceae	<i>Tectona grandis</i> L. f.	Tec

Source: Field survey, 2016.

3.1.2. Ligneous Floristic Composition in Toessin and Bonogo

Toessin and Bonogo parklands are composed of ligneous from 51 species in 36 genus and 22 botanical families. These are the Fabaceae-Faboideae-Mimosoideae (8 species, 16%), Fabaceae-Caesalpinioideae (6 species, 12%), Combretaceae (6 species, 12%), Anacardiaceae (5 species, 10%), Moraceae (5 species, 10%), Bombacaceae (2 species, 4%), Meliaceae (2 species, 4%), Rubiaceae (2 species, 4%), Fabaceae-Faboideae (2 species, 4%). Table 2 shows that the Sapotaceae, Ebenaceae, Rhamnaceae, Balanitaceae, Anonnaceae, Myrtaceae, Bignoniaceae, Verbenaceae, Moringaceae, Apocynaceae, Sterculiaceae, Capparaceae and Lythraceae have every 1 species whether 13 species or 25% of ligneous.

Table-2. List of ligneous species encountered in the Toessin and Bonogo parklands.

Families	Toessin	Bonogo	Species	Local name (mooré)
Anacardiaceae	x	x	Lannea microcarpa A. Rich	Sanbga
	x	x	Sclerocarya birrea (A. Rich.) Hoschst	Noabga
	x	x	Mangifera indica Linn	Manguui
	x	x	Lannea acida A. Rich	Sanbtoulga
		x	Lannea velutina A. Rich	Waãm-sanbga
Annonaceae	x		Annona senegalensis Pers.	Barkudga
Apocynaceae	x	x	Saba senegalensis (A. D.C)	Weedga
Balanitaceae	x	x	Balanites aegyptiaca (l.) delile	Kieelga
Bombacaceae	x	x	Adansonia digitata Linn.	Toeèga
	x	x	Bombax costatum Pellegr. Vuillet	Voaka
Bignoniaceae	x		Stereospermum kunthianum Cham	Vulga
Fabaceae-Caesalpinioideae	x		Cassia sieberiana D.C	Kumbrisaka
	x		Cassia siamea Lam.	Cassia
	x		Cassia singueana Del.	Gyel-poonsre
	x	x	Piliostigma reticulatum (D.C) Hochst.	Bâguendé
	x	x	Tamarindus indica Linn	Pusga
Capparaceae		x	Detarium microcarpum Guill. et Perr.	Kaaga
	x		Capparis sepiaria L. var. fisheri (Pax) De Wolf.	Silkoré
Combretaceae	x	x	Terminalia macroptera Guil. et Perr	Goond-poko
	x		Terminalia mollis M.A.Lawson	
		x	Terminalia laxiflora Engl. et Diels	Goondré
	x		Terminalia avicennioides Guill. et Perr.	Goondré
	x		Combretum micranthum G. Don	Randga
	x	x	Anogeissus leiocarpus (D.C) Guill. Perr.	Siiga
Ebenaceae	x	x	Diospyros mespiliformis Hochst ex A. D.C	Gaanka
Fabaceae-Faboideae		x	Lonchocarpus laxiflorus Guill. et Perr.	Yiiga
		x	Erythrina senegalensis A. DC.	Kulin-tiiga
Lythraceae	x		Lawsonia inermis L.	Lallé
Meliaceae	x	x	Khaya senegalensis (Desr.) A. Juss.	Kuka
	x	x	Azadirachta indica A. Juss	Neem
Fabaceae-Faboideae-Mimosoideae	x	x	Parkia biglobosa (Jacq.) R.Br. ex G. Don	Roanga
	x	x	Acacia senegal (L.) Willd.	Gon-pèelega
		x	Acacia macrostachya (Welw) C.C. Bury	Zamnega
	x	x	Prosopis africana (Guill. et Perr.) Taub.	Duanguanga
	x		Albizia malacophylla (A Rich.) Walp.	
	x	x	Acacia polyacantha (Willd.)	Kâon-peelga
	x		Acacia gourmaensis A.Chev.	Gon-sabelga
Moraceae	x	x	Faidherbia albida (Delile) A. Chev	Zaanga
	x	x	Ficus gnaphalocarpa (Miq.) Steud. ex A.Rich	Kankanga
	x	x	Ficus ingens (Miq) Miq	Kunkwiiga
		x	Ficus iteophylla Miq	Kunkwi-peelga
		x	Ficus thonningii Blume	Kilusga
	x	Ficus platyphylla Delile	Kamsaogo	
Moringaceae		x	Moringa oleifera Lam.	Arzan-tiiga
Myrtaceae	x	x	Eucalyptus camaldulensis Dehnh	Eucaluptis
Rhamnaceae	x	x	Ziziphus mauritiana Lam	Mougounouga
Rubiaceae	x	x	Gardenia erubescens Stapf. et Huch.	Subdga
	x		Feretia apodanthera Del.	Kitinga
Sapotaceae	x	x	Vitellaria paradoxa Gaertn	Taanga
Sterculiaceae		x	Cola cordifolia (Cav.) R. Br.	Puka
Verbenaceae		x	Vitex doniana Sweet.	Anda

Source: Field survey, 2015.

Our results corroborate those of Akpo, et al. [28] and Yossi [29] which had also identified the Fabaceae-Faboideae-Mimosoideae, Fabaceae-Caesalpinioideae, Combretaceae, Anacardiaceae, Moraceae, Rhamnaceae and Meliaceae as the main families in the North-Sudanian zone in Senegal and Mali. However, additionally the last author had inventoried the Tiliaceae, Convolvulaceae, Fabaceae-Faboideae, Malvaceae and the Capparidaceae. The difference occurs in the post-cultural state of the plots that were farms or fallows. According to Belem, et al. [30] *Vitellaria paradoxa*, *Lannea microcarpa*, *Parkia biglobosa* and *Tamarindus indica* would be among the common species to the provinces of the Central Plateau including the localities of Bonogo and Toessin.

In North of Togo, in the same ecological zone, the results of Koumoui and Lare [7] in accordance with our results, show that the parklands are characterized by the dominance of one or three species such as *Vitellaria paradoxa*, *Lannea microcarpa* and *Parkia biglobosa*. The variation in the floristic composition is related to climate and soil for each phytogeographical zone. For these authors, it is pledged to farming practices that may vary in accordance with the communities because the physiognomy of the parklands is the result that each community will modify in its environment. These two authors estimated the arboreal settlement of agricultural areas is an indicator of the strategy implemented by each society regarding its environment.

Tindano [16]; Adomou [31]; Thiombiano, et al. [32] estimate there is an increase of the number of species in the Rubiaceae and Combretaceae from the North-Sudanian zone to South-Sudanian zone. This is dependent on the gradual increase in rainfall from the North climatic zone to South Sudanian climatic zone. This induces a distribution of the trees compared with humidity and changes in floristic composition.

3.2. Trees Density Studies

3.2.1. Density of the Three Main Dominant Species in the Parklands of Bala

The inventory carried out in the plots of Bala indicates that *Vitellaria paradoxa*, *Tamarindus indica* and *Parkia biglobosa* are the 3 main dominant species. Moreover, as shown in Figure 5, *Vitellaria paradoxa* is important in number of trees with a density between 5 to 66 trees/ha, with an average of 17 trees/ha. *Parkia biglobosa* is the second dominant species, its presence varies between 1 and 7 trees/ha whose an average of 3 trees/ha. *Tamarindus indica* is one of the species to NTFP frequently associated to the *Vitellaria paradoxa* and *Parkia biglobosa*. Its density is 1 tree/ha. Our results are in accordance with those of Kaboré, et al. [33] in South-Sudanian zone concerning the maximum densities found. In fact, these authors estimated between 23 and 85 trees/ha the number of the stool of *Vitellaria paradoxa* in Sobaka parklands. The results of the study of Kessler and Boni [27]; Nyberg, et al. [34] are in accordance with us. These authors have assessed between 10 and 30 trees/ha the average density of the Shea-tree in Burkina Faso. The values of the *Vitellaria paradoxa* densities we found are identical to those of Lafleur [35] estimating 23 trees/ha in Togo and 30 trees/ha in Chad.

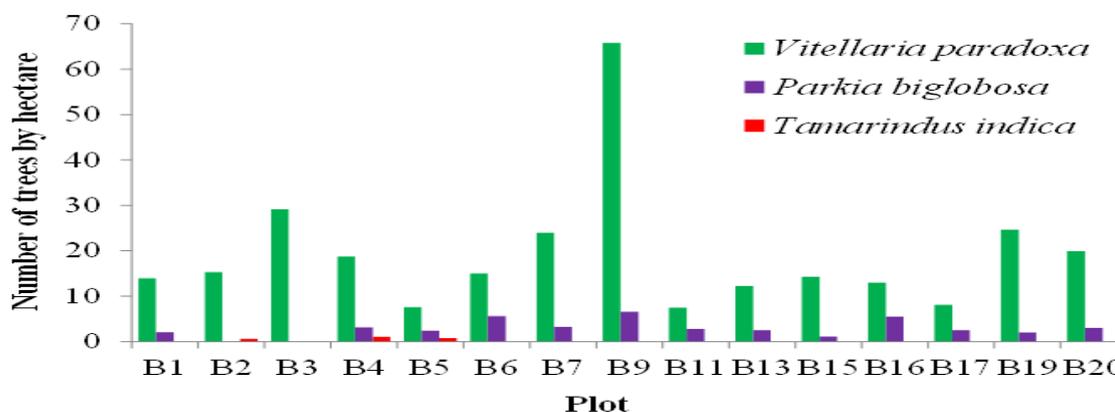


Figure-5. Density of 3 dominant ligneous species in the Bala plots.

Source: Field survey, 2016.

3.2.2. Density of the Three Main Dominant Species of Toessin and Bonogo Parks

In the plots of Toessin and Bonogo, from the north-sudanian phytogeographical zone, the 3 dominant species are *Lannea microcarpa*, *Vitellaria paradoxa*, *Parkia biglobosa*. Figure 6 shows that in Toessin, *Lannea microcarpa* is one of the dominant species. Indeed, the density of the *Lannea microcarpa* is estimated between 2 and 34 trees/ha in the plots whose an average of 16 trees/ha.

Contrariwise, in Bonogo, *Lannea microcarpa* has a density reaching 8 trees/ha and is less abundant and frequent. *Vitellaria paradoxa* is predominant in Bonogo village, Figure 7. In these two localities, Shea-tree density varies from 1 to 38 trees/ha with an average of 18 trees/ha. Finally, *Parkia biglobosa* is the third predominant species in the cultivated plots of the two villages. The density of this species is 3 trees/ha in the parklands.

The average of trees density of the *Vitellaria paradoxa* we found is characteristic of the area of distribution of this species and seems to corroborate the results of Douamba [36] in the province of Tapoa in the same phytogeographical zone (North-Sudanian zone). They had estimated between 16 to 21 trees/ha the density of *Vitellaria paradoxa* in fallows.

Our results seem to be in accordance, with those of Douamba [36] who has found 1 tree/ha in the Tapoa (north-sudanian zone). Douamba [36] has also estimated between 1 to 2 trees/ha the density of *Parkia biglobosa* in Burkina Faso.

The average value of 16 trees/ha for *Lannea microcarpa* we have found in Toessin, are near to those estimated at 13,71 trees/ha by Agbogon, et al. [37] in the North of Togo. According to these authors, *Lannea microcarpa* fits the deep soils of the plains or low plateaus. This accords with our case because the plots were selected in the plains. Furthermore, this great density of *Lannea microcarpa* in Toessin is due to the importance of the use of fruits in the nourishment. Fruits are used in the preparation of sugary beverage and sugary porridge in the households.

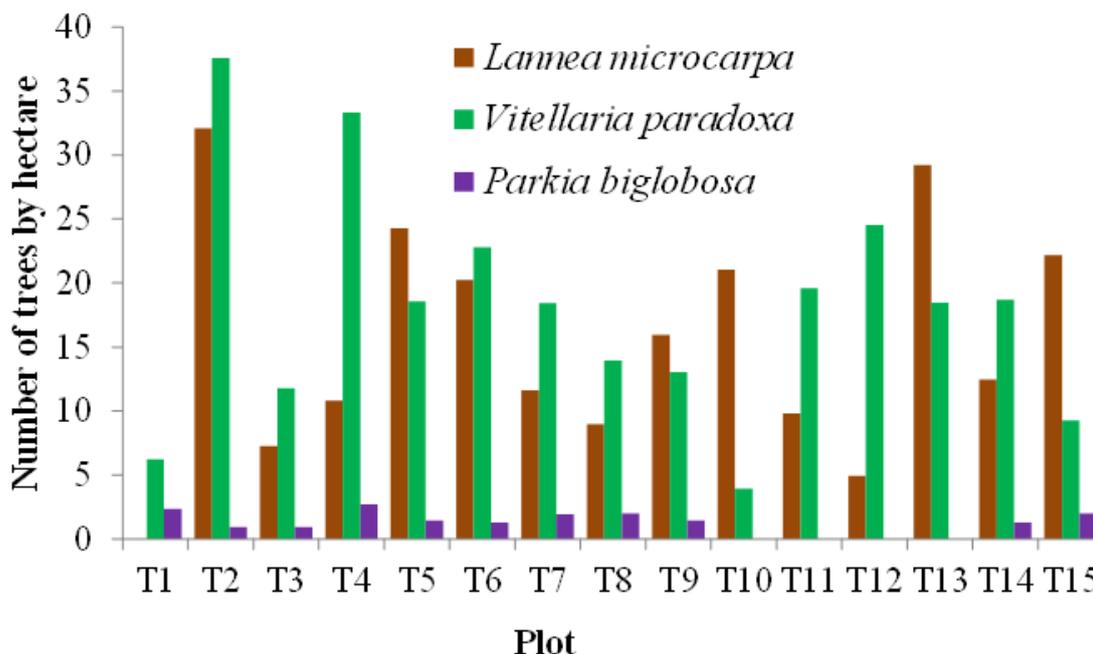


Figure-6. Density of 3 dominant ligneous species in the Toessin plots.

Source: Field survey, 2015.

Vitellaria paradoxa is clearly dominant in the parklands of Bonogo and Bala than those of Toessin. This is related to the difference in rainfall observed. Furthermore, Bala, rainier, receives 1080 mm/year and Bonogo 900 mm/year while Toessin has only 700 mm/year. Bala village is dominated by ferrallitic and ferruginous soils, which are the place of great density of Shea-tree (55 trees/ha). On the tropical ferruginous soils, like those of Toessin, the density is estimated at 24 trees/ha. Moreover, the wish of the farmers to have some lot of nuts Shea-tree by year

leads them to increase the density of *Vitellaria paradoxa* in the parklands. Then it could correspond to a desire to ensure the durability of the settlement.

The average densities of 3 trees/ha and 1 tree/ha of *Parkia biglobosa* obtained to explain the state of extinction of this specie. It is more impend over in the North-Sudanian zone than in South-Sudanian.

Otherwise, *Lannea microcarpa* density is greater in north-sudanian zone than south-sudanian zone. The differences may be explained by the climate and the soil because according to Agbogon, et al. [37]; Sakandé [38] the topography and type of the soil have an impact on the distribution of this species.

The density of *Tamarindus indica*, less 1 tree/ha, inventoried in our study, indicates that this species is infrequent or even absent in the phytogeographical zones North-Sudanian and South-Sudanian. These results rejoin those found by Bourou [39] in Senegal and Fandohan, et al. [40] in Benin in phytogeographical sudanian zone. These authors estimated 7 trees/km², whether 0,07 tree/ha and 2,04 trees/ha or 0,02 tree/ha, the density of *Tamarindus indica* in these two countries. The studies carried on by Douamba [36] in Barpoa (south-sudanian phytogeographical zone in Burkina Faso) confirm the rareness of *Tamarindus indica*. In fact, this author had obtained 0,3 tree/ha. In Togo, differences of the density of the trees, for the dominant species, are due according to Koumoi and Lare [7] the mode of access to the land, subsequently rights of use on parklands trees.

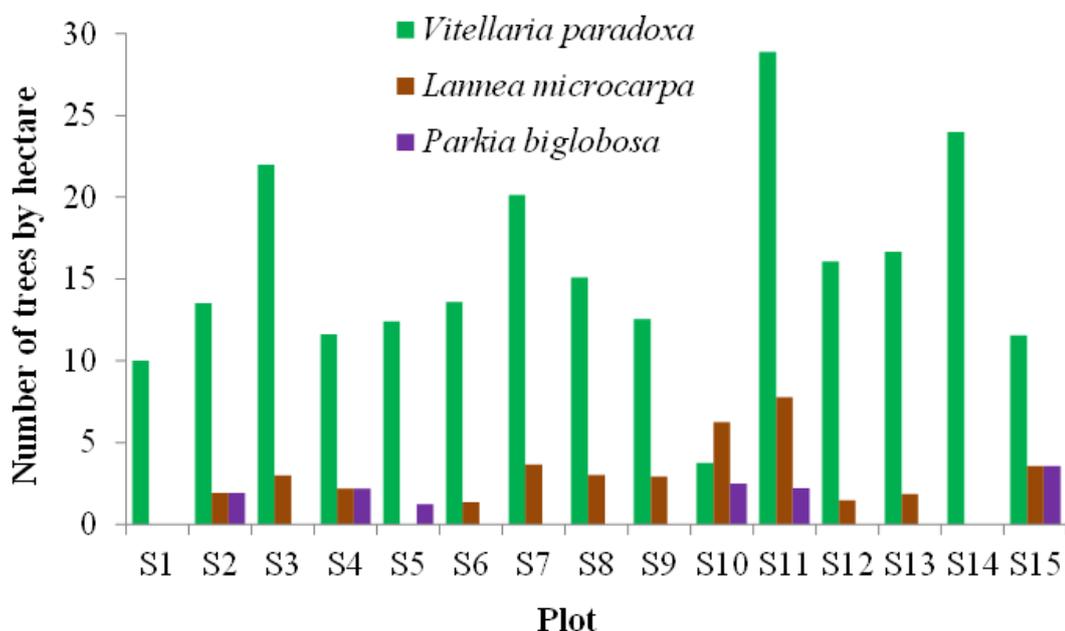


Figure-7. Density of 3 dominant ligneous species in the Bonogo plots.

Source: Field survey, 2015.

4. CONCLUSION

This study has allowed us to realize that ligneous flora of parklands in phytogeographical South-Sudanian zone includes species of the Fabaceae-Caesalpinioideae, Fabaceae-Faboideae-Mimosoideae, Bombacaceae, Anacardiaceae and Meliaceae. However, the results we have obtained are inferior to the previous which have revealed the presence more species in the family Rubiaceae, Euphorbiaceae, Fabaceae-Faboideae, Annonaceae, Rutaceae, Boraginaceae, Ebenaceae, Tiliaceae, Celastraceae, Myrtaceae.

Contrariwise, in the phytogeographical North-Sudanian zone, parklands are dominated by species of the Fabaceae-Faboideae-Mimosoideae, Fabaceae-Caesalpinioideae, Combretaceae, Anacardiaceae and Moraceae.

These differences in the floristic composition between these two phytogeographical zones would be tributary to climatic conditions.

In the parklands of the phytogeographical South-Sudanian zone, *Vitellaria paradoxa*, *Parkia biglobosa* and *Tamaridus indica* are 3 predominant species. The density of *Vitellaria paradoxa* reached 66 trees/ha, which an

average of 19 trees/ha. *Parkia biglobosa* has a maximum value of 7 trees/ha and the tamarind 1 tree/ha. In North-sudanian, *Tamarindus indica* is commuted by *Lannea microcarpa* to form the 3 dominant species with *Parkia biglobosa* and *Vitellaria paradoxa*. Their maximum densities respectively are 32, 38 and 3 trees/ha.

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