Diversity and structure of Prunus africana stands in the Tchabal forest massif: A case study from Adamawa Cameroon

Journal:	*Annals of Silvicultural Research*
Manuscript ID	ASR-2022-0031.R1
Manuscript Type:	Research Paper
Date Submitted by the Author:	30-Nov-2022

Complete List of Authors:	Kouam, kamning Paulette; University of Maroua, Biological Sciences Noiha, Noumi Valery; University of Ngaoundere, Life Science Betti , Jean Lagarde; University of Douala, Biological Sciences Tchobsala, a; University of Maroua, Biological Sciences Awé, Djongmo Victor; University of Ngaoundere, Biological Sciences Zapfack , Louis; University of Yaounde I, Biological Sciences

Keywords:	Biodiversity, Prunus africana, Cameroon

Title: Diversity and structure of *Prunus africana* (Hook.f.) Kalkman stands in the Tchabal forest massif: A case study from Adamawa Cameroon

ABSTRACT

The aim of this work is to provide basic data for a better knowledge of *Prunus africana* (Hook.f.) Kalkman stands through a non-exhaustive floristic inventory in the Sudano-Guinean zone of Cameroon. Transects of 2,000 x 20 m² were installed in these stands in the Tchabal forest massif. The inventory concerned timbers with dbh ≥ 10 cm. Herbaceous were counted according to the "sigmatiste zuricho-montpelléraine" method. In total, 25 families distributed in 41 genera and 46 species and for herbaceous, 19 families distributed in 42 genera and 46 species were recorded in the stands. The stands of Bontadji and Horé-Déo are the richest. Euphorbiaceae, Fabaceae, *Ficus thonningii* Blume and *Croton macrostachyus* Hochst. ex Delile are the most abundant taxa in each site. The Fongoy I locality stands are the most diversified (ISH: 0.87 ± 0.07; H': 0.99 ± 0.01). There is a floristic similarity of about 30% between localities. The stands of Fongoy I are very dense and basal area (D=394 ± 0.31 individuals/ha and BA= 25.80 ± 8.05 m²/ha). Structural analysis shows an "L" shape attesting to the presence of future stems. This observation is supported by the vertical structure of the stands. This information constitutes an important argument for the protection of the environment.

KEYWORDS: Biodiversity, *Prunus Africana* (Hook.f.) Kalkman, Cameroon.

Introduction

Congo Basin is considered as the second largest forest in the humid tropics after the Amazon Basin in terms of natural resources and biodiversity (FAO 2007). It contains an extraordinary biodiversity that constitutes an invaluable potential for the socio-economic development of the region (SCDB 2009). However, in the African zone, the perpetual growth of the population leads to the degradation of biodiversity (Wezel and Haigis 2000). This degradation of natural ecosystems is accentuated by climatic factors that have become a worrying phenomenon in the Sudanian zone (Thiombiano 2005). It may lead to the erosion of certain forest species that are still unknown (Tiokeng et al. 2015). Indeed, (Triébré et al. 2016) pose the problem of plant species conservation and sustainable management of forest ecosystems in the face of risks of reduction and disappearance in an environment subject to strong anthropogenic pressure.

In addition, interest in Non-Timber Forest Products (NTFPs) in Cameroon is growing. This interest in NTFPs is due to a decline in the purchasing power of populations whose financial means can no longer ensure good health and food coverage (Kémeuze et al. 2012) and to exponential demand on the international market (Betti et al. 2016). This exponential demand is obviously accompanied by an increase in the level of exploitation of NTFPs. In recent years, concerns have emerged regarding their sustainability. This situation has prompted many researchers to be alarmed by the disastrous management of these species in their natural environments (Guedje 2002, Jiofack et al. 2005, Nkuinkeu and Wanty 2007). Faced with this situation, suggestions have been made for a more rational use of these NTFPs. Among them, those of (Nkuinkeu and Wanty 2007) on sustainable harvesting techniques for *Prunus africana* (Hook.f.) Kalkman bark. Many resources in natural ecosystems are becoming scarce due to high anthropogenic pressure. It is therefore necessary to meet the needs of present and future local populations for plant resources while ensuring the conservation of native taxa.

Faced with the seriousness of environmental degradation on our planet, the safeguarding of biodiversity has become one of the major issues of the 21st century (SCBD 2010). It is in this perspective that many forest inventories have been conducted in different ecological systems including those of (Tchouto et al. 2006, Gonmadjé et al. 2011, Tiokeng et al. 2015, Zapfack et al. 2015, Noiha et al. 2015a, Noiha et al. 2015b, Tabué et al. 2016, Zapfack et al. 2016a, Zapfack et al. 2016b, Noiha et al. 2017, Noiha et al. 2018a, Noiha et al. 2018b, Noiha et al. 2018c, Awé et al. 2021). Furthermore, the conservation of an ecosystem requires a good knowledge of its contents. It is in the same way of idea that (Kent and Coker 2003, Cisse et al. 2020, Gnoumou et al. 2020) argue that floristic inventories and studies of plant groupings are the essential basis for the management and conservation of ecosystems. The purpose of this study is to assess the current status of *Prunus africana* stands in the Tchabal forest massif (MFT) in an era when natural ecosystems are disappearing at an alarming rate.

Methods

Study area

The study was conducted in the Adamawa-Cameroon, more precisely in the Faro and Déo department located between 7°26'16" N and 13°33'34" E (Fig.1). In the subdivisions of Kontcha and Galim-Tignere of this department of the Sudano-Guinean zone, which covers an area of 10,435 km^2, six localities were selected (Fongoy I and II, Yangaré, Bontadji, Horé-

Déo, and Waldé-Doumbi). These localities have a transitional subtropical climate. Rainfall ranges from 1,000 to 2,000 mm. Temperatures vary from 15°C in December to 30°C in March, with an annual average of 23°C. The soil is described as red or yellow ferralitic and black alluvial (MINFOF 2018). The landform is rugged, consisting of a succession of mountain and plateau at the top. The vegetation is represented by shrub savanna with the predominance of *Daniellia oliveri* (Rolfe) Hutch. & Dalziel and *Lophira lanceolata* Tiegh (Letouzey 1985). The peasant populations, with a density of 4 inhabitants/km^2, are mostly composed of Mbororos, Fulbe and Nyem-Nyem. Agriculture and livestock are important activities. Among the plant products frequently harvested in the forest, *Prunus africana* is sought after for its medicinal properties (MINFOF 2018).

Here Figure 1

Data collection

The surveys were conducted in 24 transects of 2,000 m x 20 m installed in 6 localities; 4 transects in each locality for a total sampling area of 96 ha. These transects were positioned in a north-south direction using a GPS, a compass and string. In each plot, all timbers with a dbh ≥ 10 cm were systematically measured and counted using a tape measure. The diameter was measured at 1.30 m aboveground for trees and at 0.30 m and 0.50 m for shrublets and shrubs respectively. Herbaceous were considered and sampled using the "Zuricho-montpelléraine" method known as "sigmatiste" method (Fig. 2). The species were recorded end preserved according to the rules of the art of systematics and then sent to the National Herbarium of Cameroon in Yaoundé (HNY) for identification. The adopted classification method is that of APG III (2009).

Here Figure 2

Taxonomic diversity

The inventory sheets were manually filled out and then entered into Excel. The data from these floristic surveys were used to calculate ecological parameters such as the relative frequency, relative dominance and relative density of each species. The sum of the values of these parameters was used to obtain the importance of each species in relation to the other species on the site through the IVI (Index Value Importance) (Curtis and MacIntosh 1950, Kent and Coker 2003). This index is frequently used in tropical forests to describe the ecological importance of species (Yao and N'Guessan 2005, Gonmadjé et al. 2011, Agbodjogbe 2011). The Family Importance Value Index (FIV) of Cottam and Curtis (1956) used by several authors (Yao and N'Guessan 2005, Gonmadjé et al. 2011, Awe et al. 2021) was also used to assess the role of each family in the structure of the plant stand. The analysis consists of determining the parameters that allow appreciating the floristic composition and structure.

The different parameters studied are expressed through the following formulas:

- Specific richness defined as the total number of species recorded in a considered space and beta diversity (diversity-β) which is a quantitative measure of community diversity were adopted for this study (Bisby 1995, Tchouto et al. 2006, Rajemison 2010, Gonmadjé et al. 2011, Agbodjogbe 2011). The Shannon Weaver index (H') and Piélou equitability were chosen to quantify this diversity.
- The effective species richness (N) indicates the number of species responsible for the observed diversity. It is given by the formula: $N = 2^H$; 2 is the base of the logarithm used to calculate the Shannon diversity index H;
- The Shannon Diversity Index (ISH): $ISH = -\sum (ni/N) \, Log_2 (ni/N)$, with ni= number of species i, N= number of all species; ISH is expressed in bits and varies from 1 to 5;
- The Equitability of Piélou (EQ) (1966): $EQ = ISH/Log_2N$. (Frontier and Pichod-viale 1992) and is between 0 and 1;
- Simpson's index: D =1 - S [(ni ' (ni - 1)) / (N ' (N - 1))];
- Coefficients of similarity: (2C/A+B) with A the number of species in environment 1; B the number of species in environment 2 and C the common number of species in both environments;
- The index of importance value of the species (IVIE) (Curtis and Macintosh 1950):

IVIE = Relative dominance (Species) + Relative density (Species) + Relative frequency (Species), it is expressed in %;

- Density (D): D= n/S; D: density (trees/ha), n: number of trees present on the considered surface and S: considered surface (ha);
- Relative dominance = (total basal area for one species/total basal area of all species) × 100;
- Relative density = (number of individuals of the species/total number of individuals of all species) × 100;
- Relative frequency = (frequency of the species/sum of all frequencies of other species) × 100;
- Relative diversity = (number of species in the family/total number of species present) × 100;

- Family importance value index (FIV) = relative dominance + relative density + relative diversity.

Floristic structure

The floristic structure refers to the horizontal and vertical distributions. The timbers were arranged in diameter and height classes. The diameter classes were grouped into eight modalities of amplitude 10 and the histograms of stem distribution were drawn up to characterize the diametric structure of the vegetation. From the height measurement results, individuals were grouped into 5 cm amplitude classes.

Statistical analyses

The data were encoded in the EXCEL spreadsheet and then analyzed using STATGRAPHICS plus 5.0 and R software. Significance and correlation tests were performed using ANOVA and Duncan's 5 % test.

Results

Floristic composition

Inventories of woody plants revealed 25 families distributed in 41 genera and 46 species. The understories of the Bontadji and Horé-Déo localities were the most represented in term of species (27 species; Tab.1)

Here Table 1

The understory woody species in *Prunus africana* stands that have a high value index (VI) are: *Croton macrostachyus* in the localities of Fongoy II, Horé-Déo, Bontadji and Waldé-Doumbi. In Foungoy I locality, *Ficus thonningii* Blume and *Croton macrostachyus* Hochst. ex Delile are ecologically important. In the Yangaré locality, *Ficus insipida* Willd. and *Croton macrostachyus* are the most important species (Tab. 2).

Here Table 2

Fabaceae is the most abundant family in the localities of Bontadji, Horé-Déo and Foungoy II (Tab. 3). In Yangaré and Fongoy I, Moraceae and Euphorbiaceae are dominated. In Waldé-Doumbi, Euphorbiaceae and Fabaceae families have the highest IVI values.

Here Table 3

Inventories of herbaceous plants revealed 19 families distributed in 42 genera and 46 species were recorded. The Understory of the Fongoy II locality is the richest (20 species; Tab. 4). *Cyathea spinulosa* Wall. ex Hook, *Tithonia diversifolia* (Hemsl.) A.Gray, *Kalanchoe pinnata* (Lam.) Pers., *Hyparrhenia rufa* (Nees) Stapf, *Mimosa pudica* L., *Centella asiatica* (L.) Urban, *Chromolaena odorata* (L.) R.M.King & H.Rob, *Sida rhombifolia* L., *Andropogon tectorum* Schumach. & Thonn., *Panicum repens* L., *Sporobollus pyramidalis* Beauv., and *Ageratum conyzoides* L. are the dominant herbaceous species in the flora of the Tchabal forest massif (Fig. 3). Poaceae, Asteraceae, Cyatheaceae, Crassulaceae, Mimosaceae, Apiaceae, Malvaceae and Rubiaceae are the most abundant families (Fig. 4).

Here Table 4

Here Figure 3

Here Figure 4

Ecological diversity

Table 5 shows that between localities and subdivision, the analysis of variance does not show any significant difference in the values of Shannon's diversity indices, Piélou's equitability and Simpson's indices between the different understories of *Prunus africana* stands ($P < 0.05$). Between localities, the Shannon index was higher in the Fongoy I locality (0.87 ± 0.07 bit). On the other hand, between the two subdivisions, the Shannon index is higher in the subdivision of Kontcha (0.55 ± 0.29 bit). Between localities and subdivisions, Piélou's equitability values are very low and Simpson's index values are very high (H'=0.99 ± 0.01).

Here Table 5

Floristic similarities

Similarity indices are generally high, with floristic affinities greater than 50%, except between the Horé-Déo locality and the localities of Fongoy II, Fongoy I, Yangaré and Waldé-Doumbi, and Yangaré and Bontadji (Tab. 6).

Here Table 6

Structural characterization

The analysis of variance attests to significant differences in density and basal area values within the different understories of *Prunus africana* stands (P > 0.05) between the localities. Between the two subdivisions, no significant difference was found in density (P < 0.05) but a significant difference was found in basal area (P > 0.05). Between locations, density and basal area values are higher in Fongoy I (394 ± 0.31 individuals/ha and 25.80 ± 8.05 m²/ha) (Tab. 7).

Here Table 7

Analysis of the diameter structure of understory timbers in *Prunus africana* stands shows an “L” shape in the Waldé-Doumbi localities. These three L-shaped structures fit best to polynomial functions of degree six. These three "L" structures show that the class 0-10 cm is more represented in terms of number of individuals. On the other hand, between the Fongoy I, II, Horé-Déo, Yangaré and Bontadji localities, the analysis of the diameter structure of the woody plants in the understory of *Prunus africana* stands shows a "bell-shaped" appearance. These three bell-shaped structures also fit better to polynomial functions of degree six. These three "bell" structures show that the numbers of the highest individuals are centered respectively in the classes 20-30 cm for the Horé-Déo and Yangaré localities and 30-40 cm for the Bontadji locality (Fig. 5).

Here Figure 5

Height structure of understory trees in Prunus africana stands

Analysis of the height structure of the understory timbers in *Prunus africana* stands shows an "L" shape in the localities of Fongoy I, II and Waldé-Doumbi. These "L" structures show that the classes 0-5 cm are the most represented in terms of number of individuals. On the other hand, between the Horé-Déo, Yangaré and Bontadji localities, the analysis of the height structure of the Understory of *Prunus africana* stands shows a "bell" shape. These three "bell" structures show that the highest numbers of individuals are centered in the classes 0-10 cm, 0-5 cm; 0-5 cm and 10-15 cm respectively for the localities of Horé-Déo, Yangaré, Fongoy II and Bontadji (Fig. 6).

Here Figure 6

Discussion

The results of this study provide information on the structural and taxonomic characterization of *Prunus africana* stands in Faro and Déo. A total of 25 families distributed in 41 genera and 46 species. These results are similar to those of Ngueguim et al. (2010) who recorded 26 families, 42 genera and 46 species in *Mansonia altissima* A. Chev., *Lovoa trichilioides* Harms and *Terminalia ivorensis* A. Chev. stands. However, these results are superior to those of Ibrahima and Abib (2008) who recorded 21 species belonging to 14 families in tree and shrub facies in the Sudano-Guinean savannahs of Cameroon and Awé et al. (2021) who recorded 17 families, 20 genera and 36 species in cashew plantations in the northern parts of Cameroon. This floristic richness is highest in Horé-Déo and Bontadji with 27 species each. The subdivision of Galim-Tignère has the lowest number of individuals. Among the localities, Waldé-Doumbi, Yangaré and Fongoy I have the lowest number of species (14 species). This difference could be explained by accentuated anthropogenic activities such as overgrazing and overexploitation of resources, as well as inaccessibility in some localities. According to Wezel (2004), more than the climatic factor, it is the anthropogenic pressure that completes the disappearance of species and therefore of biodiversity after the climatic changes that lead to the loss of density of timbers (Gongalez 2001). In the understory of the *Prunus africana* stands, Euphorbiaceae and Fabaceae are the most dominant families. The dominance of these two families could be justified by the fact that the ecological conditions are favorable to their regeneration and also their adaptability to the anthropogenic disturbances present in the studied sites.

The specific frequencies of *Croton macrostachyus* and *Ficus thonningii* are very high in the understory. The dominance of these two species may be due to biotic and abiotic factors favorable to their development (Tiokeng et al. 2015). This could also be justified by the presence of anthropogenic activities that substitute the dominance of *Lophira lanceolata* and *Daniellia oliveri* in the Sudano-Guinean zone (Letouzey 1985). In general, in all six localities, herbaceous species are the most developed with the Poaceae family dominating the flora. This result is similar to those of Kodji et al. (2021) and Tchobsala et al. (2010) who state that when trees are overcut, there is a re-colonization of the vegetation by the herbaceous layer. However, the high proportion of Poaceae in the site may be due to the fact that these taxa have a very high possibility of tillering and a high speed of regrowth after grazing when the environmental conditions are favorable (Kouassi et al. 2014), or else the species of this family are more resistant to climatic hazards and pathogens.

Floristic diversity indices are objective criteria for assessing the diversity of a plant community. The Shannon index varies from one stand to another. Diversity is low when ISH< 3; medium if ISH is between 3 and 4, it is high when ISH > 4 (Yédomonhan 2009). In the whole understory of the studied *Prunus africana* stands, the Shannon index value is lower than 3 and the equitability is close to 0. This confirms that we are in the presence of an ecosystem in a "highly degraded" state. These results are much lower than those obtained by several authors (Gonmadje et al. 2011, Tiokeng et al. 2015, Awé et al. 2021). The differences noted here show that despite its potential, the Tchabal Forest Massif is under high pressure due to: *(i)* the superposition of several groups of actors (herders, hunters and farmers) with different objectives (Kabelong 2013), *(ii)* the massive influx of populations coming from unstable areas (Nigeria and the NW of Cameroon) and *(iii)* the poor exploitation of *Prunus africana* barks. In addition, there is the roaming of animals and the absence of local initiatives for tree planting and conservation (Jiagho 2021). These low values can also be explained by the fact that only a few species have a high cover (Honvou et al. 2021). Furthermore, these results reflect an increased demand for Non-Timber Forest Products (NTFPs) due to the economic crisis, logging, bush fires, soil conditions and conversions of Sudano-Guinean savannahs to crops that have taken on major importance in recent years in subtropical Africa and in particular in the Adamawa region (Ibrahima et al. 2006).

A pairwise comparison of the floristic composition of the six localities, using Sorensen's method, indicates a similarity threshold between 34 and 78%, which is relatively low and thus shows that some of the localities surveyed are part of different floristic ensembles. The relative heterogeneity between some localities shows that an inventory with a larger sampling rate should be considered to obtain more precise characteristics. However, the diversity index shows greater similarity between localities in the same subdivision.

Comparing localities, it should be noted that the stand in Fongoy I locality is denser (394 ± 0.31 individuals/ha) and contains the largest basal area (25.80 ± 8.05 m^2/ha). Compared to the work of Samb et al. (2018), Noiha et al. (2018c), Temgoua et al. (2019), Awé et al. (2021), this large difference can be linked on the one hand to ecological characteristics, notably soil types, cover, and altitude, and on the other hand by the impact of anthropogenic activities in the localities, such as poor practices observed during debarking, firewood felling, and the collection of medicinal species and other NTFPs. In addition to this, there is the divagation of animals with their devastating actions and the absence of local tree planting and conservation initiatives (MINFOF 2018).

The analysis of the structure according to the diameter classes shows that the understory of the stands obtained in Fongoy I, Fongoy II and Waldé-Doumbi describes an "L" shape while in Horé-déo, Bontadji and Yangaré it describes a bell shape. This "L" shape reflects the overexploitation of large diameters and good regeneration of the stands through the importance of individuals from smaller diameter classes. This indicates that the soils have certain fertility favorable to this dynamic. The bell-shaped distribution characterizes mono-specific stands with a predominance of small diameter individuals. Such a distribution is typical of stable populations likely to be renewed by natural regeneration (Mbayngone et al. 2008) which deduces the fertility of the soil. This pattern has also been described by several authors such as Sambou (2004), Ouédraogo et al. (2006), Sahu et al. (2007), Awé et al. (2021) who concluded that this structural pattern hides a degradation process that affects the populations of certain species with high economic potential, such as the exploitation of *Prunus africana* barks, a species used in the manufacture of medicines for the treatment of benign prostatic hyperplasia, which has increased significantly with the exponential demand. However, the height class distribution exhibits a bell-shaped structure except in the Fongoy I locality which exhibits an "L" shape. This L-shaped structure is similar to that of Tchobsala et al. (2010), observed in the Sudanian zone, who consider this structure to be an indication of degradation.

Conclusion

The understory of *Prunus africana* stands in Faro and Déo contains a significant diversity of species. The species richness and density of trees are much lower than the results found by other researchers. Fabaceae and Euphorbiaceae have the highest values of importance. Analysis of individuals larger than 10 cm in diameter shows that effective natural regeneration is generally good in the small diameter classes. However, increasing anthropogenic pressure during NTFP harvesting and devastating cattle activities could lead to irreversible erosion of understory species in the little known *Prunus africana* stands. This anthropogenic pressure is therefore leading to an alarming destruction of the largest trees of this species and prompts reflection on viable management strategies for this important resource for the farming populations in the Subtropical Africa.

Acknowledgment

This study is part of the action plan and update of the non-detriment finding for *Prunus africana* (Hook.f.) Kalkman. We sincerely thank MINFOF, the National Herbarium of

Cameroon and the people of Tchabal Forest Massive for their valuable financial and logistical support for this study.

References

Agbodjogbe G.J. 2011- *Analyse de la Structure des Galeries Forestières de la Réserve Totale de Faune de Tamou (RTFT) en République du Niger*. Thèse de Master international, Muséum national d'histoire naturelle, Paris, IRD, Sud expert plantes, Université de Dschang, Université Abdou Moumouni, 59 p.

APG III 2009- *An update of the AngiospermPhylogeny Group classification for the orders and families of flowering plants: APG III.* In Botanical Journal of the Linne and Society 161(2):105-121.

Awé D.V., Noiha N.V., Vroh B.T.A., Zapfack L. 2021- *Biodiversity management under cashew agro-ecosystems in central Africa: A case study from Cameroun*. Open Journal of agricultural research 1(2): 45-61.

Betti J.L., Ngankoué C.M., Dibong S. D., Singa A.E. 2016- *Etude ethnobotanique des plantes alimentaires spontanées vendues dans les marchés de Yaoundé, Cameroun*. International Journal of Biological and Chemical Sciences 10 (4): 1678-1693.

Bisby F.A. 1995- *Characterization of biodiversity.* In "Global Biodiversity Assessment, Heywood", VH, Watson RT (eds). UNEP; Cambridge University Press: Cambridge : 192–294.

Cisse A., Ouattara M., N'Guessan E.A., Abrou J.E.N. 2020 - *Diversité végétale et usages des plantes dans une zone de savane soudanienne: cas de la localité de Ferkessédougou (Nord, Côte d'Ivoire).* International Journal of Biological and Chemical Sciences 14 (8): 2807-2825.

Cottam G., Curtis J.T. 1956- *The use of distance measures in phytosociological sampling.* Ecology 37 (3): 451-460.

Curtis J.T., McIntosh R.P. 1950 - *The interrelations of certain analytic and synthetic phytosociological characters.* Ecology 31:434-455.

FAO 2007- *Forest monitoring and assessment for climate change reporting: partnerships, Forest Resources Assessment.* Working Paper 142. Rome. 90p.

Frontier S., Pichod-Viale D. 1992- *Écosystèmes: structure, fonctionnement, évolution*. Annales de géographie 101 (565) :343-344.

Gnoumou A., Salfo S., Thiombiano A. 2020- *Les groupements végétaux de la réserve de la Comoé-Léraba: caractérisation et impact des sols sur leur distribution*. International Journal of Biological and Chemical Sciences 14 (9): 3168-3187.

Gonmadje F., Doumenge C., Mckey D., Tchouto G.P.M., Sunderland T.C.H., Balinga M.P.B., Sonké B. 2011- *Tree diversity and conservation value of Ngovayang's*.

Guedje N.M. 2002- *La gestion des populations d'arbres comme outil pour une exploitation durable des produits forestiers non ligneux: l'exemple de Garcinia lucida (sud-Cameroun). Kribi et Université Libre de Brussels : The tropembos-Cameroon programme.*

Honvou S.H.S., Aboh B.A., Sewade C., Teka O., Gandonou B.C., Oumorou M., Sinsin B. 2021- *Diversité floristique, structure et distribution des groupements végétaux des parcours d'accueil des transhumants dans la Basse et Moyenne Vallée de l'Ouémé au Bénin.* International Journal of Biological and Chemical Sciences 15 (1): 81 -96.

Ibrahima A., Abib F. C. 2008- *Estimation du stock de carbone dans les faciès arborés et arbustifs des savanes soudano-guinéennes de Ngaoundéré Cameroun*. Cameroon journal of expérimental Biology 1:1 -11.

Ibrahima A., Mapongmetsem P.M., Hassan M. 2006- *Influence de quelques facteurs zoo-anthropiques sur la phytodiversité ligneuse des savanes soudano-guinéennes de l'Adamaoua, Cameroun*. Faculté des Sciences, University de Yaoundé I, série Science.de la Nature Et de la vie 36 (3) :65-85.

Jiagho E.R., Kabelong B.L.P.R., Feumba R.A. 2021 - *Diversité de la flore ligneuse à l'intérieur du Parc National de Waza (Cameroun).* International Journal of Biological and Chemical Sciences 15 (3):1158-1175.

Jiofack T., Kemeuze V., Pinta Y.J. 2005 - *Les loranthacées dans la pharmacopée traditionnelle du groupement Bafou.* Cameroon Journal of Ethnobotany 2 : 29-35.

Kabelong B. L.P.R. 2013 - *Influences des activités anthropiques sur la ressource ligneuse dans la périphérie du Parc National de Waza.* Mémoire de Master Professionnel, Université de Yaoundé I, Cameroun, 92 p.

Kémeuzé V.A., Mapongmetsem P.M., Tientcheu M.A., Bernard-Aloys N., Kongmeneck B.A., Jiofack R.B. 2012 - Boswellia dalzieliiHutch *: Etat du peuplement et utilisation traditionnelle dans la région de Mbé (Adamaoua-Cameroun).* Sécheresse 23: 278 –283.

Kent M., Coker P. 2003 - *Vegetation Description and Analysis : A PraticalApproch* .(ed). Belhaven Press: London.

Kodji P., Tchobsala, Adamou I. 2021- *Impacts des réfugiés sur la contribution spécifique et le stock de carbone des herbacées de la savane de Minawao (Cameroun).* Journal of Applied Biosciences 164 : 16970-16982.

Kouassi A.F., Koffi K.J., N'Goran K.S., Béranger I.J. 2014 - *Potentiel de production fourragère d'une zone pâturée menacée de destruction : cas du cordon littoral Port-Bouët et Grand-Bassam.* Journal of Applied Bioscience 82: 7403-7410.

Letouzey R. 1985 - *Notice de la Carte Phytogéographique du Cameroun au1/500000.* IRA Yaoundé, Inst. Cart. Intern. Végétation: Toulouse. 240 p.

Mbayngone E., Thiombiano A., Hahn-hadjoli K., Guinko S. 2008 - *Caractéristiques écologiques de la végétation ligneuse du sud-est du Burkina Faso (Afrique de l'Ouest) : le cas de la réserve de Pama*. Candollea 63 (1):17-33.

MINFOF 2018- *Rapport de la mise en œuvre des plans de gestion du* Prunus africana *dans la région de l'Adamaoua.* MINFOF, Cameroun. 46 p.

Ngueguim J.R., Zapfack L., Youmbi E., Riera B., Onana J., Foahom B., Makombu J.G. 2010 - *« Diversité floristique sous canopée en plantation forestière de Mangombe-Edea (Cameroun) ».* Biotechnologie, Agronomie, Société et Environnement 1(14): 167-176.

Nkuinkeu R., Wanty P. 2007 - *Vulgarisation des techniques d'exploitation des produits forestiers non ligneux :* Prunus africana *(Hook. F.) Kalkmann, plante médicinale surexploitée du Cameroun.* Cameroon Journal of Ethnobotany 1: 74-78.

Noiha N.V., Zapfack L., Mbade L.F. 2015a - *Biodiversity Management and Plant Dynamic in a Cocoa Agroforest (Cameroon).* International Journal of Plant & Soil Science 6(2): 101-108.

Noiha N.V., Zapfack L., Ngueguim J.R., Tabue M.R.B., Ibrahima A., Mapongmetsem P.M. 2015b - *Sequestered Standing Carbon Stock in Selective Exploited Timbers Grown in Tropical Forest: A Case Study from the National Park of Lobeke (Cameroon).* Research and Reviews: Journal of Botanical Sciences 4(2):19-24.

Noiha N.V., Zapfack L., Awe D.V., Witanou N., Nyeck, B., Ngossomo, J.D., Hamadou M.R., Chimi D.C., Tabue, M.R.B. 2017- *Floristic structure and sequestration potential of cashew agroecosystems in Africa: A case study from Cameroon.* Journal of Sustainable Forestry 36 (3): 277-288.

Noiha N.V., Zapfack L., Hamadou M.R., Awe D.V., Witanou N., Nyeck B., Ngossomo J.D., Tabue M.R.B., Mapongmetsem P.M. 2018a- *Floristic diversity, carbon storage and ecological services of eucalyptus agrosystems in Cameroon.* Agroforestry Systems 92 (1): 2039-2250.

Noiha N.V., Awe D.V., Nyeck B., Tabue M.R.B., Zapfack L. 2018b - *Vegetation structure, carbon sequestration potential and species conservation in four agroforestry systems in Cameroon (Tropical Africa).* Acta Botanica Brasilica 32 (2): 212-221.

Noiha N.V., Zapfack L., Adamou B.B., Ngueguim J.R., Chimi D.C., Awé D.V., Ngossomo J.D., Hamadou R.M., Nyeck B., Witanou N., Tabue M.R.B. 2018c- *Floristic Diversity and Structure of Cocoa Agro-Ecosystems in Southeastern Cameroon.* Journal of Agriculture and Ecology Research International 14 (4):1-9.

Ouédraogo A., Thiombiano A., Hahn-Hadjali K., Guinko S. 2006 - *Diagnostic des peuplements de quatre espèces ligneuses en zone soudanienne du Burkina Faso.* Sécheresse 4*:* 485-491.

Rajemison A.H. 2010 - *Typologie de la végétation rémanente en vue d'une restauration écologique. Cas du site d'Ankafobe-Tampoketsa d'Ankazobe Hautes terres centrales de Madagascar*. Mémoire DEA, université d'Antananarivo, 83 p.

Sahu S.C., Dhal N.K., Reddy S.C., Pattanaik C., Brahmam M. 2007 - *Phytosociological study of tropical dry deciduous forest of Boudh subdivision, Orissa, India*. Research Journal of Forestry 2: 66-72.

Samb C.O., Faye E., Dieng M., Sanogo D., Samba S.A.N., Koita B. 2018 - *Dynamique spatio-temporelle des plantations d'anacardier (*Anacardium occidentale *L.) dans deux zones agro-écologiques du Sénégal*. Afrique science 14 (3): 365-377.

Sambou B. 2004 - *Evaluation de l'état, de la dynamique et des tendances évolutives de la flore et de la végétation ligneuses dans les domaines soudanien et sub-guinéen au Sénégal.* Thèse de doctorat, UCAD Dakar, 210 p.

SCDB 2009 - *Biodiversité et gestion forestière durable dans le bassin du Congo.* Rapport. Montreal. 34 p.

SCDB 2010 - *Gestion durable des forêts, diversités biologique et moyen d'existence: un guide des bonnes pratiques.* Montréal. 47 p.

Tabué M.R.B., Zapfack L., Noiha N.V., Nyeck B., Meyan-Ya D.R.G., Ngoma L.R., Kabelong B.L.-P., Chimi D.C. 2016 - *Plant Diversity and Carbon Storage Assessment in an African Protected Forest: A Case of the Eastern Part of the Dja Wildlife Reserve in Cameroon.* Journal of Plant Sciences 4(5): 95-101.

Tchobsala, Amougou A., Mbolo M. 2010 - *Impact of woodcut on the structure and floristicdiversity of vegetation in the peri-urban zone of Ngaoundéré (Cameroon).* Journal of Ecology and the Natural Environment 2 (11): 235-258.

Tchouto G.P, Yemefack M., De Boer W.F., De Wilde J.J.F.E., Cleef A.M. 2006 - *Biodiversity hotspots and conservation. priorities in the Campo-Ma'anrainforests, Cameroon.* Biodiversity Conservation 15 : 1219–1252.

Temgoua L.F., Momo S.M.C., Boucheké R.K. 2019- *Diversité Floristique des Ligneux des Systèmes Agroforestiers Cacaoyers du Littoral Cameroun: Cas de l'Arrondissement de Loum*. European Scientific Journal 15 (9): 1857-7881.

Thiombiano A. 2005 - *Les Combretaceae du Burkina Faso: Taxonomie, écologie, dynamique et régénération des espèces*. Thèse de doctorat d'Etat, Université de Ouagadougou, 271 p.

Tiébré S.M., Ouattara D., Vroh B.T.A., Gnagbo A., N'Guessan K.E. 2016 - *Diversité floristique et disponibilité des plantes utilitaires en zone soudanienne de la Côte d'Ivoire.* Journal of Applied Biosciences 102: 9699 – 9707.

Tiokeng B., Mapongmetsem P.M., Nguetsop V.F., Tacham W.N. 2015 - *Biodiversité floristique et régénération naturelle sur les Hautes Terre deLebialem (Ouest Cameroun).* International Journal of Biological and Chemical Sciences 9 (1): 56-68.

Wezel A., Haigis J. 2000- *Farmer's perception of vegetation changes in semi-arid Niger.* Land Degradation and Development 11: 523-534.

Wezel A. 2004 - *Local knowledge of vegetation changes in sahelian Africa- implication for local management.in the sahel currentpolitics in westAfrica- the use of knowledge in applied research- participation in project planning and capacity building, serein occasional* paper 17: 37-51.

Yao A.C.Y., N'Guessan E.K. 2005 - *Diversité botanique dans le sud du parc national de Taï, Côte d'Ivoire.* Afrique Science 01 (2): 295 – 313.

Yédomonhan H. 2009 **-** *Plantes mellifères et potentialités de production de miel en zones guinéenne et soudano-guinéenne au Bénin.* Thèse de Doctorat, Université d'Abomey-Calavi, Bénin, 273 p.

Zapfack L., Noiha N.V., Dziedjou K.P.J., Zemagho L., Fomete N.T. 2015 - *Deforestation and Carbon Stocks in the Surroundings of Lobéké National Park (Cameroon) in the Congo Basin.* Environment and Natural Resources Research 3(2): 78-86.

Zapfack L., Noiha N.V., Tabue M.R.B. 2016a - *Economic estimation of carbon storage and sequestration as ecosystem services of protected areas: a case study of lobeke national park.* Journal of Tropical Forest Science 28 (4): 406–415.

Zapfack L., Chimi D.C., Noiha N.V., Zekeng J.C., Meyan-ya D.G.R., Tabue M.R.B. 2016b- *Correlation between Associated Trees, Cocoa Trees and Carbon Stocks Potential in Cocoa Agroforests of Southern Cameroon*. Sustainability in Environment 1(2): 71-84.

LIST of FIGURE

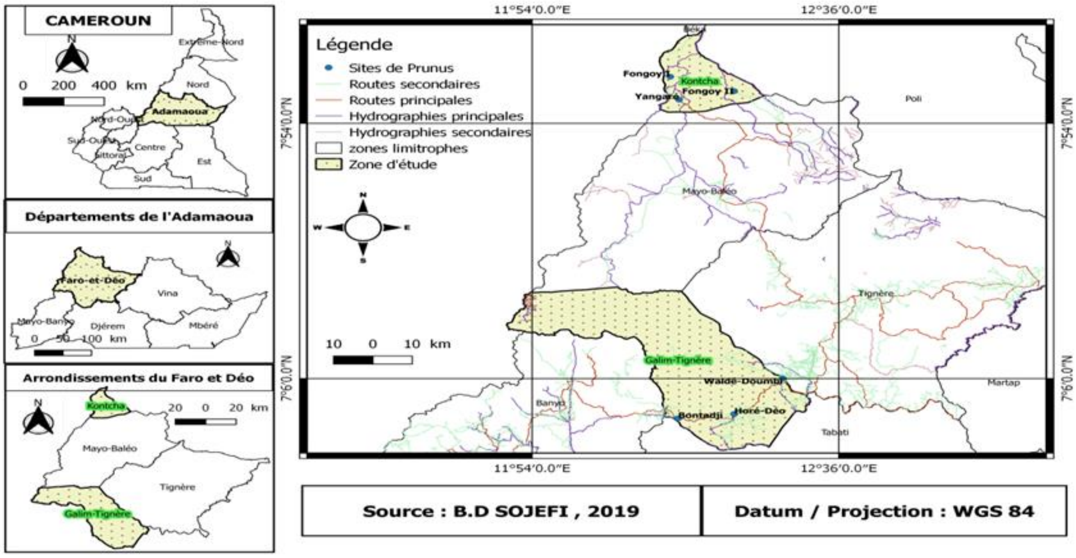


Figure 1: Geographic location of the study area

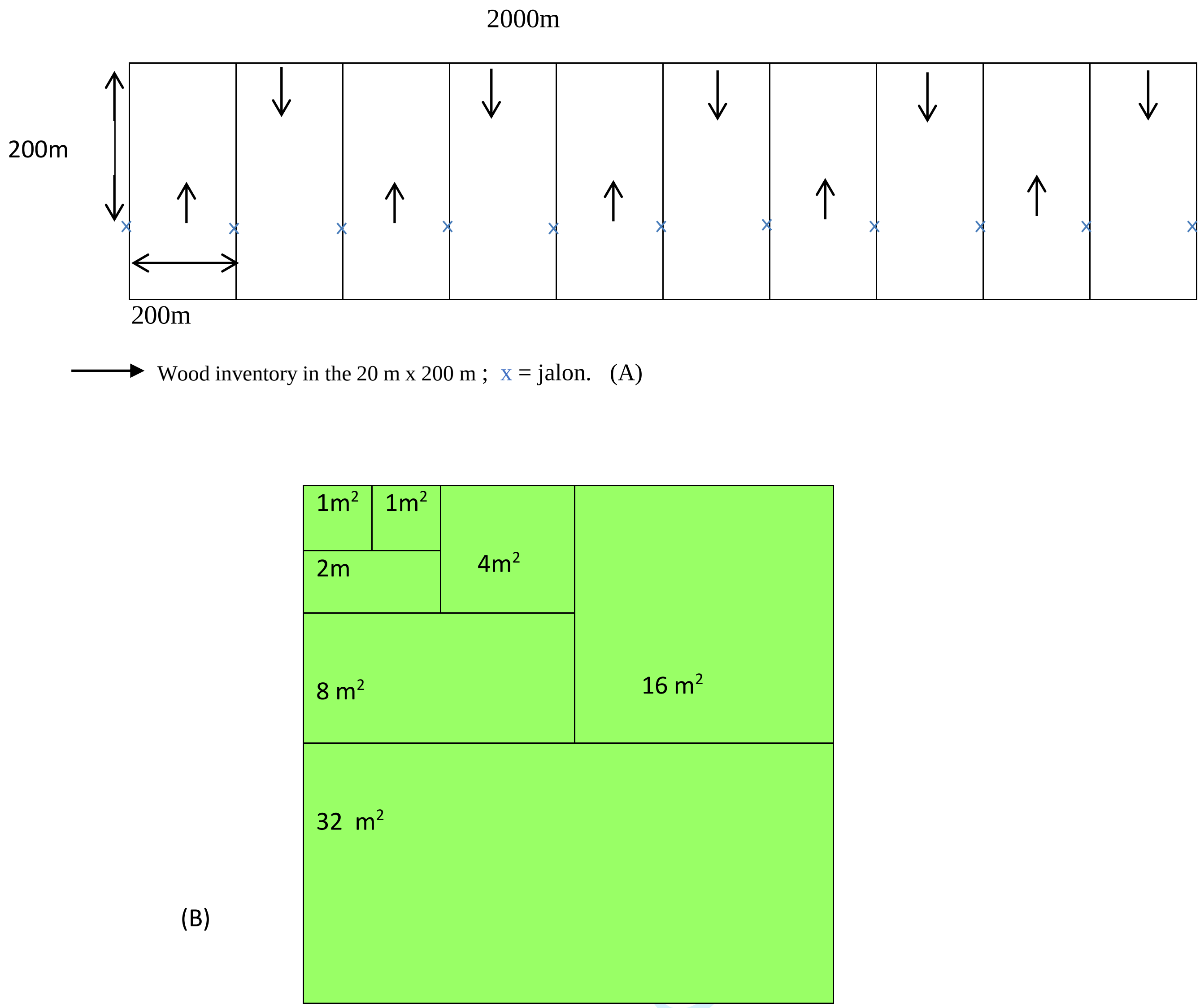


Figure 2: Illustration of the sampling method for woody species (A)and herbaceous (B).

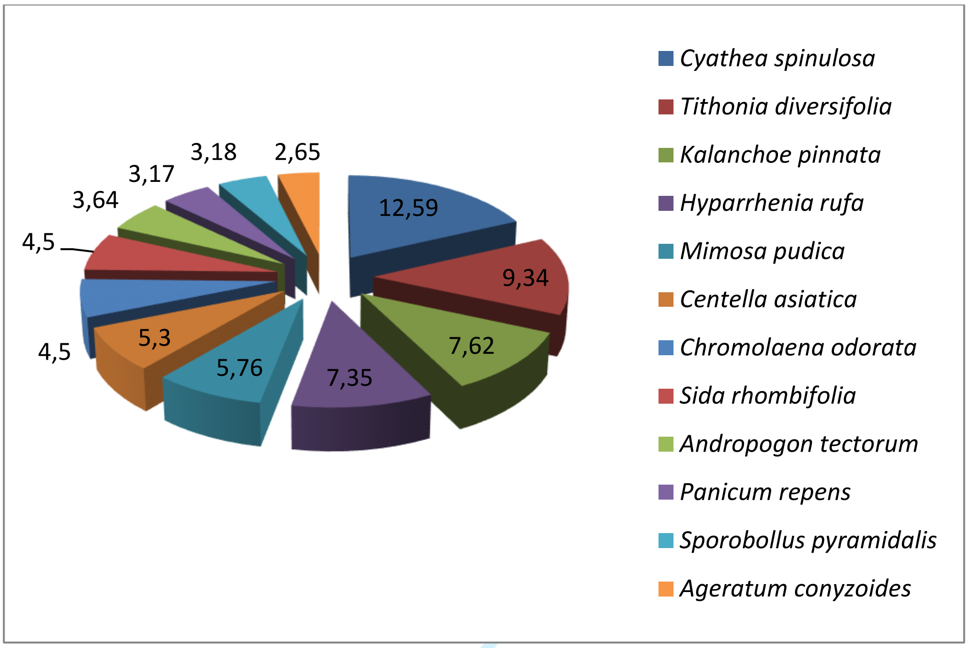


Figure 3: Relative abundance of herbaceous

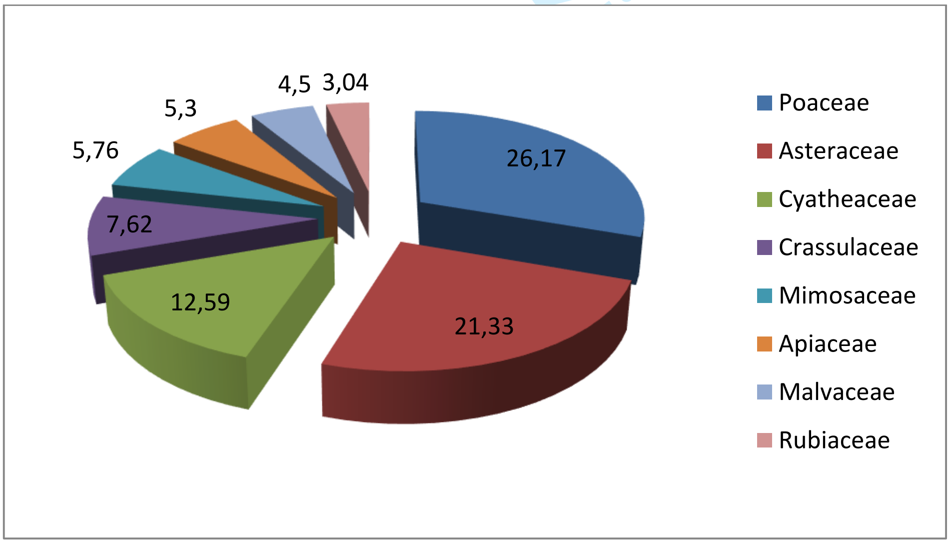
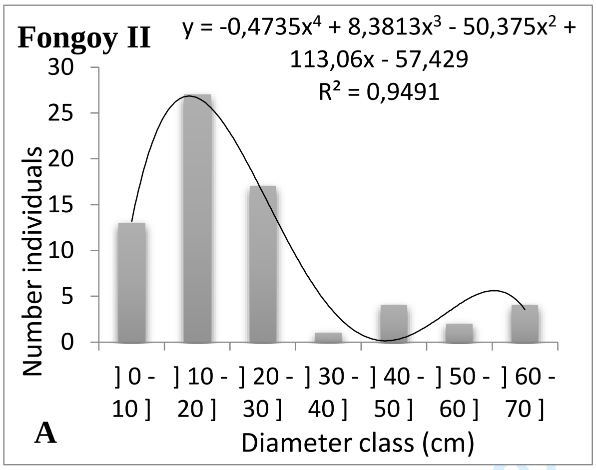
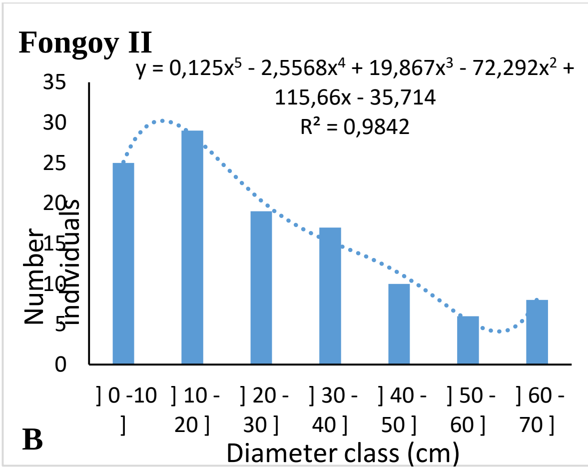
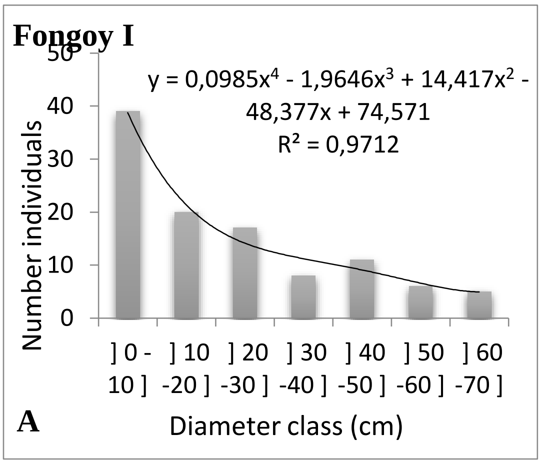
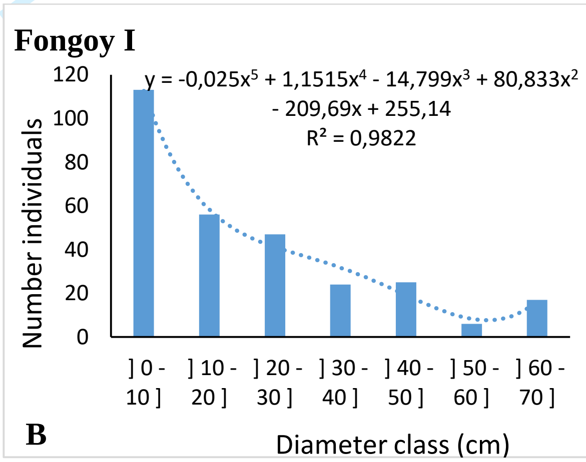


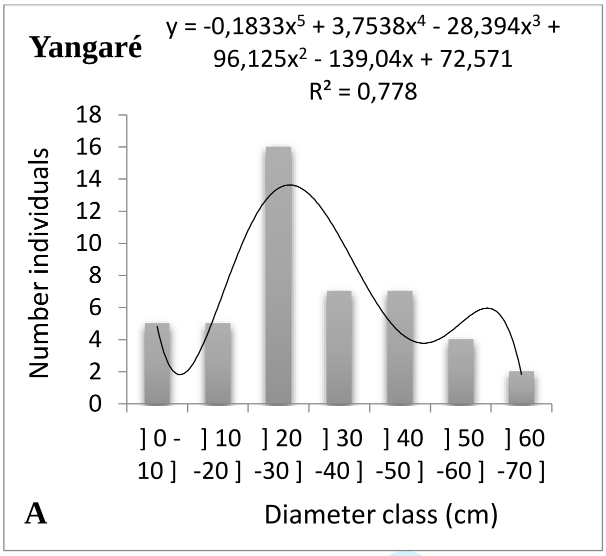
Figure 4: Relative abundance of families

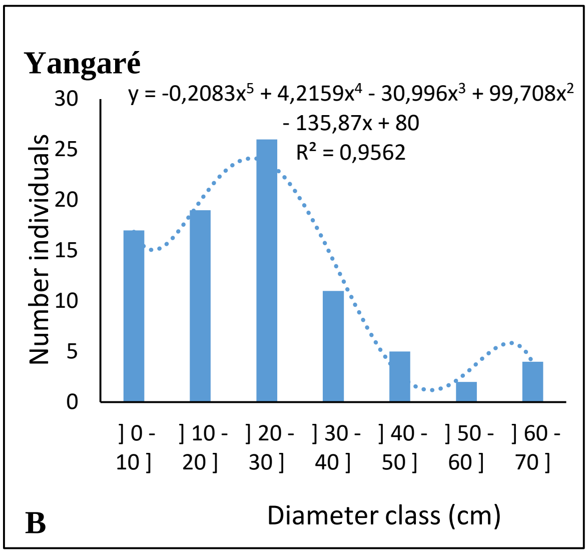

Fongoy II
y = -0,4735x⁴ + 8,3813x³ - 50,375x² + 113,06x - 57,429
R² = 0,9491
30
25
20
15
10
5
0
Number individuals
] 0 - 10]
] 10 - 20]
] 20 - 30]
] 30 - 40]
] 40 - 50]
] 50 - 60]
] 60 - 70]
A
Diameter class (cm)

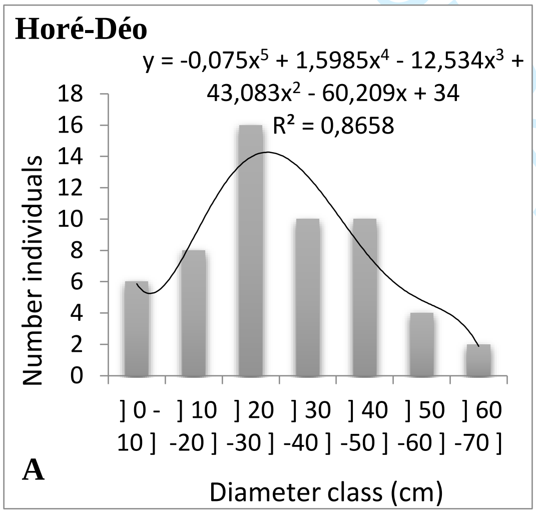

Fongoy II
y = 0,125x⁵ - 2,5568x⁴ + 19,867x³ - 72,292x² + 115,66x - 35,714
R² = 0,9842
35
30
25
20
15
10
5
0
Number individuals
] 0 -10]
] 10 - 20]
] 20 - 30]
] 30 - 40]
] 40 - 50]
] 50 - 60]
] 60 - 70]
B
Diameter class (cm)

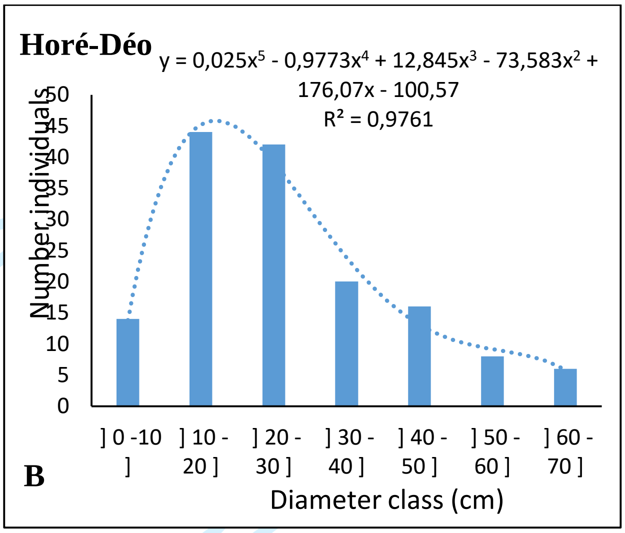

Fongoy I
50
40
30
20
10
0
y = 0,0985x⁴ - 1,9646x³ + 14,417x² - 48,377x + 74,571
R² = 0,9712
Number individuals
] 0 - 10]
] 10 -20]
] 20 -30]
] 30 -40]
] 40 -50]
] 50 -60]
] 60 -70]
A
Diameter class (cm)

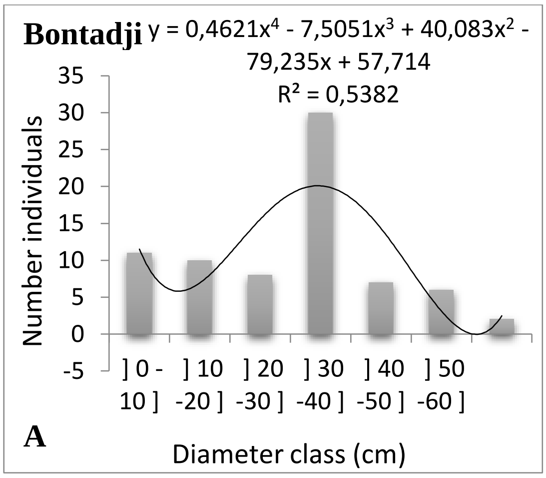

Fongoy I
120
100
80
60
40
20
0
y = -0,025x⁵ + 1,1515x⁴ - 14,799x³ + 80,833x² - 209,69x + 255,14
R² = 0,9822
Number individuals
] 0 - 10]
] 10 - 20]
] 20 - 30]
] 30 - 40]
] 40 - 50]
] 50 - 60]
] 60 - 70]
B
Diameter class (cm)

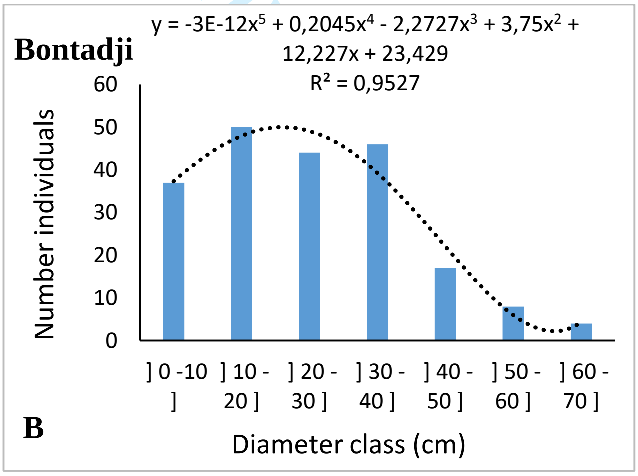

Yangaré
y = -0,1833x⁵ + 3,7538x⁴ - 28,394x³ + 96,125x² - 139,04x + 72,571
R² = 0,778
Number individuals
18 16 14 12 10 8 6 4 2 0
] 0 - 10]] 10 -20]] 20 -30]] 30 -40]] 40 -50]] 50 -60]] 60 -70]
A
Diameter class (cm)

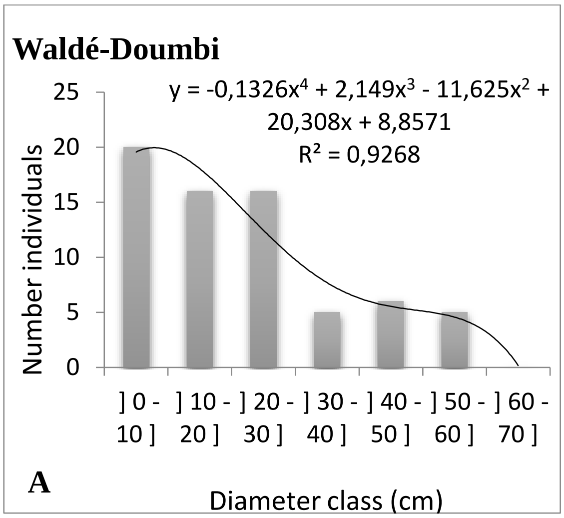

Yangaré
y = -0,2083x⁵ + 4,2159x⁴ - 30,996x³ + 99,708x² - 135,87x + 80
R² = 0,9562
Number individuals
30 25 20 15 10 5 0
] 0 - 10]] 10 - 20]] 20 - 30]] 30 - 40]] 40 - 50]] 50 - 60]] 60 - 70]
B
Diameter class (cm)


Horé-Déo
y = -0,075x⁵ + 1,5985x⁴ - 12,534x³ + 43,083x² - 60,209x + 34
R² = 0,8658
Number individuals
18 16 14 12 10 8 6 4 2 0
] 0 - 10]] 10 -20]] 20 -30]] 30 -40]] 40 -50]] 50 -60]] 60 -70]
A
Diameter class (cm)


Horé-Déo
y = 0,025x⁵ - 0,9773x⁴ + 12,845x³ - 73,583x² + 176,07x - 100,57
R² = 0,9761
Number individuals
50 45 40 35 30 25 20 15 10 5 0
] 0 -10]] 10 - 20]] 20 - 30]] 30 - 40]] 40 - 50]] 50 - 60]] 60 - 70]
B
Diameter class (cm)


Bontadji
y = 0,4621x⁴ - 7,5051x³ + 40,083x² - 79,235x + 57,714
R² = 0,5382
Number individuals
35 30 25 20 15 10 5 0 -5
] 0 - 10]] 10 -20]] 20 -30]] 30 -40]] 40 -50]] 50 -60]
A
Diameter class (cm)


Bontadji
y = -3E-12x⁵ + 0,2045x⁴ - 2,2727x³ + 3,75x² + 12,227x + 23,429
R² = 0,9527
Number individuals
60 50 40 30 20 10 0
] 0 -10]] 10 - 20]] 20 - 30]] 30 - 40]] 40 - 50]] 50 - 60]] 60 - 70]
B
Diameter class (cm)



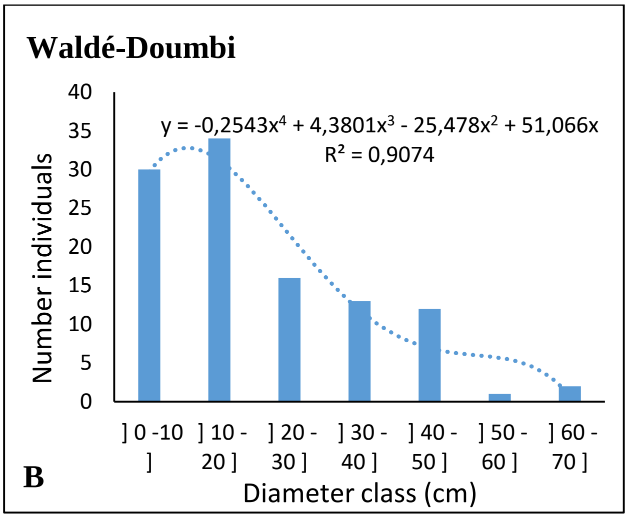
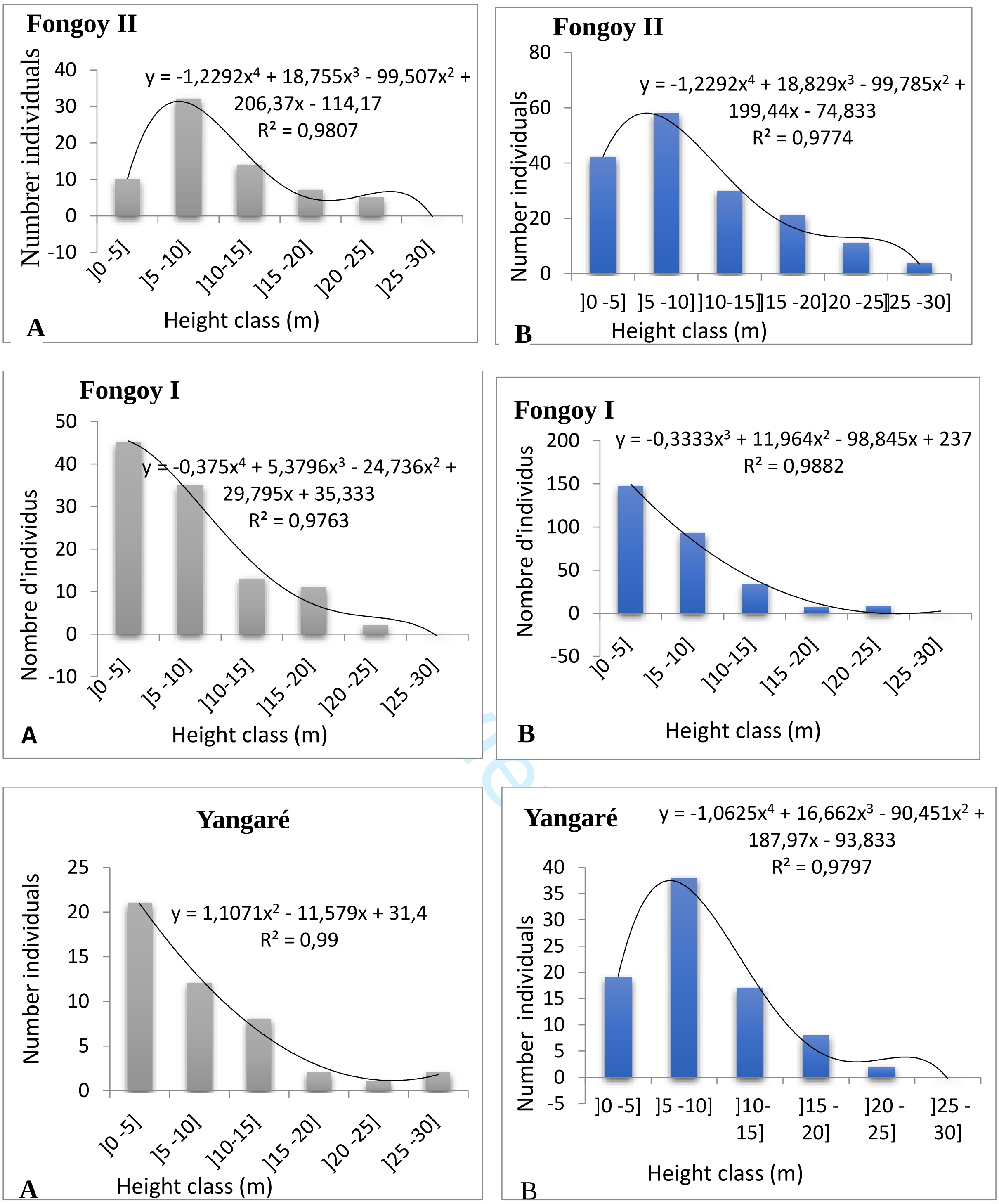


Figure 4 : Distribution of species individuals according to the diameter classes of *Prunus africana* stands in the MFT.


Fongoy II
Numbrer individuals
y = -1,2292x⁴ + 18,755x³ - 99,507x² + 206,37x - 114,17
R² = 0,9807
]0 -5]
]5 -10]
]10-15]
]15 -20]
]20 -25]
]25 -30]
Height class (m)
A
Fongoy II
Number individuals
y = -1,2292x⁴ + 18,829x³ - 99,785x² + 199,44x - 74,833
R² = 0,9774
]0 -5]
]5 -10]
]10-15]
]15 -20]
]20 -25]
]25 -30]
Height class (m)
B
Fongoy I
Nombre d'individus
y = -0,375x⁴ + 5,3796x³ - 24,736x² + 29,795x + 35,333
R² = 0,9763
]0 -5]
]5 -10]
]10-15]
]15 -20]
]20 -25]
]25 -30]
Height class (m)
A
Fongoy I
Nombre d'individus
y = -0,3333x³ + 11,964x² - 98,845x + 237
R² = 0,9882
]0 -5]
]5 -10]
]10-15]
]15 -20]
]20 -25]
]25 -30]
Height class (m)
B
Yangaré
Number individuals
y = 1,1071x² - 11,579x + 31,4
R² = 0,99
]0 -5]
]5 -10]
]10-15]
]15 -20]
]20 -25]
]25 -30]
Height class (m)
A
Yangaré
Number individuals
y = -1,0625x⁴ + 16,662x³ - 90,451x² + 187,97x - 93,833
R² = 0,9797
]0 -5]
]5 -10]
]10-15]
]15 -20]
]20 -25]
]25 -30]
Height class (m)
B

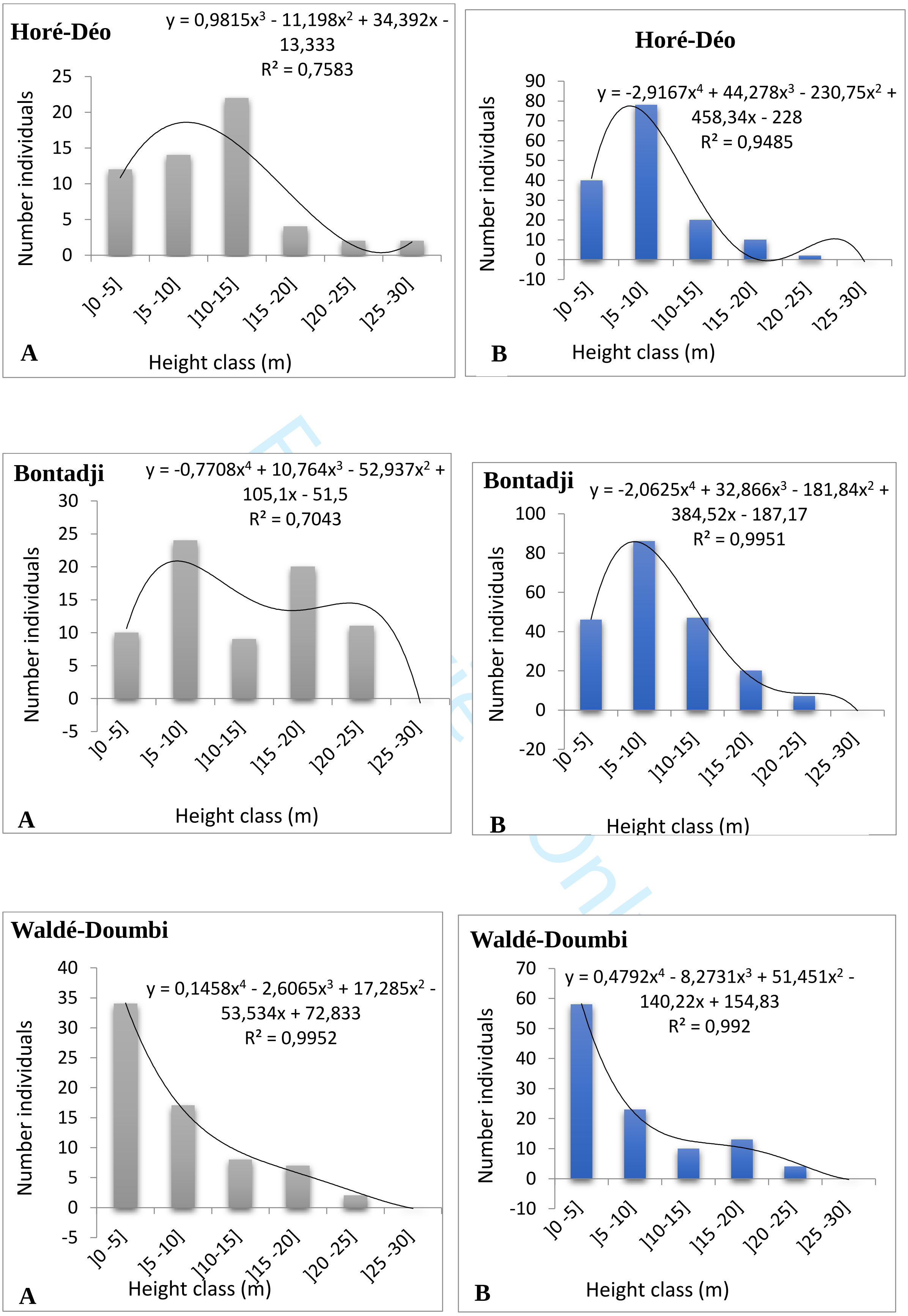


Figure 5: Distribution of species individuals according to the height classes of *Prunus africana* stands in the MFT.

LIST OF TABLE

Table 1 - Understory species richness of *Prunus africana* stands.

Subdivision	Localities	Genera	Species	Families
KONTCHA	Fongoy II	12	14	11
	Yangaré	10	14	9
	Fongoy I	18	21	13
	Total	**27**	**20**	**15**
GALIM-TIGNERE	Horé-Déo	24	27	19
	Bontadji	23	27	15
	Waldé-Doumbi	14	14	11
	Total	**40**	**33**	**24**
	Total General	**41**	**46**	**25**

Table 2 - Relative frequency, relative dominance, relative density and importance value index of the most represented species in the Understory of *Prunus africana.*

Localities	Species	FeRe	DoRe	DeRe	IVIE
Fongoy II	*Croton macrostachyus*	2.95	1.84	2.95	7.75
	Pterocarpus erinaceus	2.67	0.93	2.67	6.29
	Albiziacoriaria	1.26	1.81	1.26	4.35
	Vitex doniana	0.56	1.89	0.56	3.02
	Other species	92.56	93.53	92.56	278.58
Yangaré	*Ficus insipida*	2.81	7.08	2.81	12.72
	Croton macrostachyus	1.54	1.16	1.54	4.25
	Vitex doniana	0.28	1.67	0.28	2.24
	Ficus thonningii	0.84	0.42	0.84	2.11
	Other species	94.53	89.67	94.53	278.68
Fongoy I	*Ficus thonningii*	4.50	13.77	4.50	22.78
	Croton macrostachyus	7.60	5.30	7.60	20.52
	Vernonia tinctoria	2.67	0.08	2.67	5.43
	Syzygium guineense var. *Guineense*	1.12	1.91	1.12	4.17
	Other species	84.11	78.94	84.11	247.1
Horé-Déo	*Croton macrostachyus*	1.97	0.92	1.97	4.86
	Burkeaafricana	0.56	1.51	0.56	2.64
	Vitex doniana	0.56	1.01	0.56	2.14
	Bombax costatum	0.42	0.90	0.42	1.75
	Other species	96.49	95.66	96.49	288.61
Bontadji	*Croton macrostachyus*	2.95	1.51	2.95	7.43
	Ficus thonningii	1.40	2.14	1.40	4.96
	Afzelia africana	1.54	1.41	1.54	4.51
	Albiziacoriaria	1.26	1.13	1.26	3.67
	Other species	92.85	93.81	92.85	279.43
Waldé-Doumbi	*Croton macrostachyus*	2.81	1.78	2.81	7.41
	Ficus thonningii	0.70	1.44	0.70	2.85
	Albizia coriaria	0.98	0.39	0.98	2.36
	Vernonia tinctoria	1.12	0.03	1.12	2.28
	Other species	94.39	6.36	94.39	285.1

Table 3 - Relative frequency, relative dominance, relative density and importance value index of the most represented families in the Understory of *Prunus africana.*

Localities	Families	FeRe (%)	DoRe (%)	DeRe (%)	IVIF(%)
Fongoy II	Fabaceae	3.66	2.4	3.66	9.73
	Euphorbiaceae	2.95	1.84	2.95	7.75
	Moraceae	1.12	1.88	1.12	4.13
	Other families	92.27	93.88	92.27	278.37
Yangaré	Moraceae	4.22	8.33	4.22	16.78
	Euphorbiaceae	1.54	1.16	1.54	4.25
	Lamiaceae	0.28	1.67	0.28	2.24
	Other families	93.96	88.84	93.96	276.73
Fongoy I	Moraceae	7.04	16.09	7.04	30.18
	Euphorbiaceae	8.3	5.6	8.31	22.22
	Myrtaceae	1.4	2.93	1.4	5.74
	Other families	83.26	75.38	83.26	241.86
Horé-Déo	Fabaceae	1.83	2.81	1.83	6.47
	Euphorbiaceae	1.97	0.92	1.97	4.86
	Anacardiaceae	0.84	1.45	0.84	3.14
	Other families	95.36	94.82	95.36	285.53
Bontadji	Fabaceae	5.21	4.62	5.21	15.05
	Euphorbiaceae	3.09	1.67	3.09	7.87
	Moraceae	1.97	2.81	1.97	6.75
	Other families	89.73	90.9	89.37	270.33
Waldé-Doumbi	Euphorbiaceae	2.95	1.8	2.95	7.72
	Fabaceae	2.11	0.97	2.11	5.2
	Moraceae	0.7	1.44	0.7	2.85
	Other families	94.24	95.79	94.24	284.23

Table 4 - Herbaceous species richness in *Prunus africana* stands.

Subdivision	Localities	Genera	Species	Families
KONTCHA	Fongoy II	20	20	17
	Yangaré	14	14	11
	Fongoy I	14	15	10
	Total	**28**	**29**	**18**
GALIM-TIGNERE	Horé-Déo	11	12	6
	Bontadji	14	15	10
	Waldé-Doumbi	16	17	11
	Total	**28**	**31**	**14**
	Total General	**42**	**46**	**19**

Table 5 - Ecological diversity indices of *Prunus africana* stands.

Item	Fongoy I	Yangaré	Fongoy II	Horé-Déo	Bontadji	Waldé-Doumbi
ISH	0.87 ± 0.07a	0.28 ± 0.01a	0.51 ± 0.03a	0.45 ± 0.05a	0.62± 0.06a	0.39 ± 0.04a
EQ	0.27 ± 0.04a	0.09± 0.00a	0.16 ± 0.02a	0.14 ± 0.01a	0.19 ± 0.01a	0.12 ± 0.00a
H’	0.99 ± 0.01a	0.99 ± 0.01a	0.99 ± 0.01a	0.99 ± 0.01a	0.99 ± 0.01a	0.99 ± 0.01a

Table 6 - Similarity between localities.

Localities	Fongoy II	Yangaré	Fongoy I	Horé-Déo	Bontadji	Waldé-Doumbi
Fongoy II	100					
Yangaré	57.14	100				
Fongoy I	62.85	51.42	100			
Horé-Déo	43.90	34.14	45.83	100		
Bontadji	58.53	43.90	58.32	51.85	100	
Waldé-Doumbi	78.56	57.02	57.14	43.90	53.64	100

Table 7 - Structural characterization of the understory of *Prunus africana* stands.

Item	Fongoy I	Yangaré	FongoyII	Horé-Déo	Bontadji	Waldé-Doumbi
D	394 ± 0.31c	130 ±0.52a	234 ± 0.14a	206 ± 0.19a	280 ±0.17b	176 ± 0.31a
BA	25.80 ± 8.05e	11.77 ± 2.81c	9.77 ± 1.01b	11.18 ± 2.91c	15.14 ± 2.13d	5.12 ± 1.61a

Note. D : Density, BA : Basal area