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Evaluation of the Floristic, Phytosociological and Geographic Characteristics of the Understorey of an Ex-plantation of *Guarrea cedrata* (A Chev.) in the Yangambi DR. Congo

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The aim of this study was to evaluate and compare the floristic diversity, phytosociological spectra and geographical characteristics of the understorey of the old abandoned plantation of the Yangambi Biosphere Reserve, using the Martineau and Blanc-étoc silvicultural methods. This was

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done to fill gaps in our knowledge of the latter. The experimental setup consisted of 50*50 m (Martineau method, 2023) and 50*50 m (Blanc-étoc, 2023). All undergrowth species with a diameter of 5.0 cm or greater were inventoried using Letouzey's [1] established technique. Technical abbreviations were clearly explained upon first use. The websites www.tropicos.org and www.ville-ge.ch/musinfo/bd/cjb/africa and the catalogue-flora of vascular plants in the Kisangani and Tshopo districts of the DR Congo were consulted to determine the phytosociological and geographical spectrum. After analysis, it is apparent that the Strombosio-Parinarietea species carry more significance than other varieties found in Martineau and Musanga-Terminalietea in Blanc-étoc. Compared to the other vegetation types studied, our observations show that the endemic species from Guinea and Congo are more abundant in the understorey. Consequently, the study shows a complete geographical convergence, while phytosociologically there is a complete divergence between the two silvicultural methods observed.

Keywords: Characteristics floristic, phytosociological, geographic, ex-plantation and Yangambi.

1. INTRODUCTION

Since 1949, *Guarea cedrata* plantations have been established in the Yangambi Biosphere Reserve in order to assess the diversity of economically valuable species and to determine the preferred method of artificial regeneration to promote rapid growth of these species in plantations located mainly on heterogeneous soils. Unfortunately, for various reasons, the plantations have been abandoned and neglected, resulting in forest regeneration. In this regard, Brosset [2] notes that plantations are disturbed habitats that support mainly generalist and common native species, often pioneer species, with little heritage value. However, the biodiversity, structure and functioning of an ecosystem can change over the course of its evolution and can fluctuate in response to periodic stress events and occasional large-scale disturbances [3]. In the Democratic Republic of Congo, especially in the Yangambi region, many small forest plantations have been established in recent decades, but the understorey phytosociology, phytogeography and floristic diversity have not been extensively studied. Therefore, the aim of this study was to compare the two silvicultural methods (Martineau and Blanc-étoc) used in the study area with respect to the floristic, phytosociological and phytogeographical diversity of the understorey of the old abandoned *Guarrea cedrata* (A. CHEV.) PELLEGR plantation.

2. MATERIALS AND METHODS

2.1 Study Environment

The study was carried out in the Lowe block of the Yangambi Biosphere Reserve, located in the central Congolese Basin, in the abandoned former plantation of Guarrea cedrata (A. CHEV.) PELLEGR. The biosphere reserve covers an area of approximately 250,000 ha, between 0,48° N and 24,28° E. Administratively, it is part of the Tshopo Province, Isangi Territory, Turumbu Sector, about 100 km north-west of the provincial capital, Kisangani. It is bounded to the north by the village of Yakako, to the south by the village of Yambuya, to the east by the Congo River and to the west by the slopes of the Isalowe River valley (this study).

The climate in Yangambi is classified as Af in Köppen's classification and class B in Thornthwaite's classification (Gilson et al., 1957). The average annual temperature ranges around 25°C, and the annual rainfall falls between 1,500 and 2,000 mm, with an average of 1,750 mm (Vandenput, 1981).

We used a metric tape measure (to measure tree circumference at 1,30 m above the ground), a high-precision compass with Qibla on a smartphone (to align transects during experimental set-up), an Android smartphone, Techno Camon 19 (to record tree diameter values), and a Garmin 64 SX GPS (to record geographic coordinates for mapping).

After setting up the experimental equipment, all plant species in the understorey with a diameter of 5.0 cm or more were measured. The corresponding measurements were recorded on the data collection form (by telephone). Species identification was made according to the method of Letouzey [1], which takes into account various morphological characteristics of the plant, including the shape of the stem at the bottom, the texture of the bark, the color of the notches, the smell, the exudation, the type and shape of the leaves, the branching of the crown and the reproductive characteristics, in particular the flowers and fruits in the field.

The inventory was followed by the classification of the phytosociological and geographic spectrum according to Lebrun [4]; Schnell [5]; Raunkiaer [6]; Danserau and Lems [7]; Evrard [8]; Duvigneaud [9]; Mullenders [10,11]. The work of Schmitz [12] and the catalogue-flore of the vascular plants in the districts of Kisangani and Tshopo, DR Congo, describe the anatomical and morphological characteristics of the plant, which define its vegetative apparatus, its habit and its physiognomy. As the previous databases are accessible, this information serves as a reliable basis for future studies.

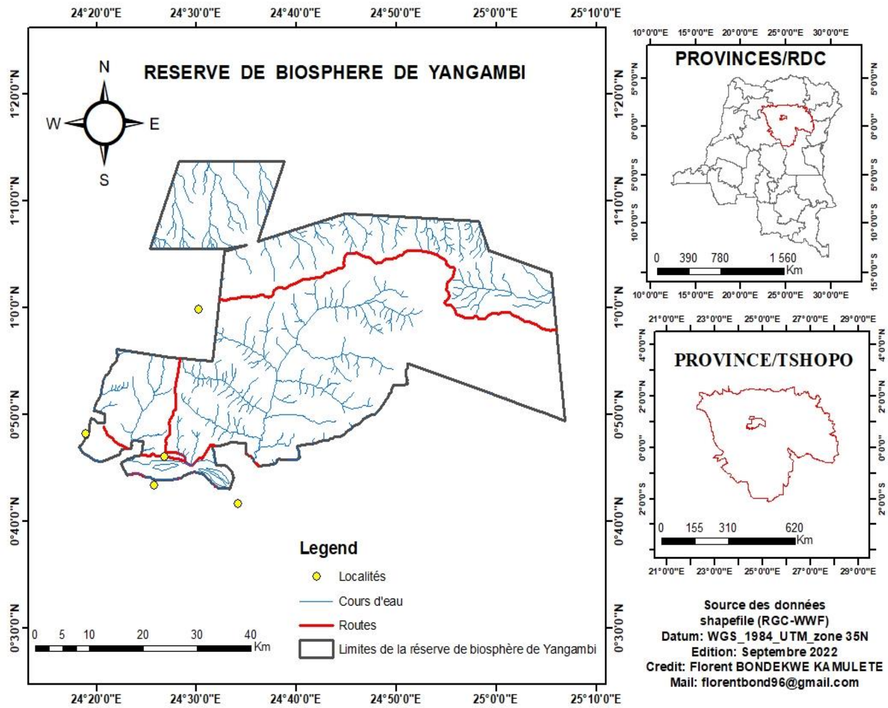

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Fig. 1. Map of the Yangambi Biosphere Reserve
(Source: Bondekwe, 2022)

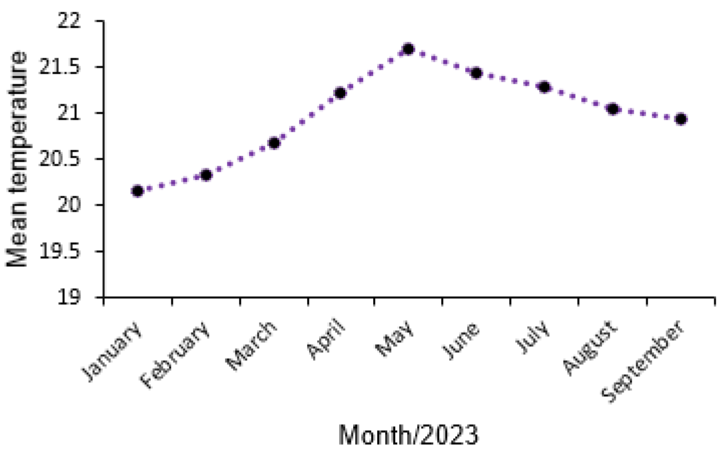

Fig. 2. Map of the variation in mean temperature at Yangambi from january to september 2023

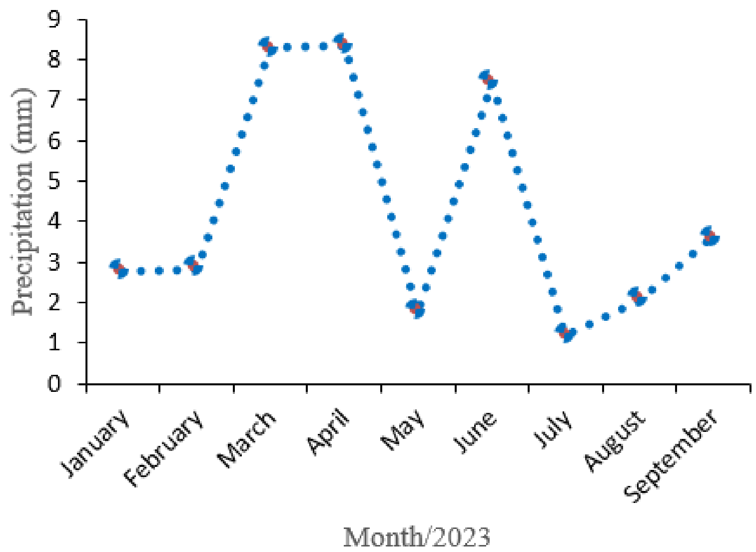

Fig. 3. Map of the variation in rainfall at Yangambi for the period january to september 2023

2.2 Data Analyses

Calculations of abundances, dominances, importance value indices and analyses of diversity indices of the floristic, phytogeographic and phytosociological aspects studied were carried out using Excel and R software version 4.3.1. by *Vagam* package version 1.1 (Han Lin Shang et *al.*, 2018). We characterised the diversity indices of the phytosociological and phytogeographical spectra according to their abundances, dominances and indices of ecologically important species in the ecosystem studied.

The diversity of plant groupings was analysed using the following indices:

2.2.1 Specific richness (S)

It is calculated as follows

$$\text{Ar} = \frac{Nombre\ d'individus}{Nombre\ total\ d'individus} * 100$$

Legend: Ar = Relative abundance

2.2.2 Relative dominance

Dominance, an often-used term, is used to describe how dominant species are in an ecosystem. It is typically used within a taxonomic group rather than across the animal/plant kingdom. Dominance can be calculated as the ratio of the number of datasets containing the species under study (Pi) to the total number of datasets (P) expressed as a percentage [13,3].

It is calculated as follows

$$\text{Dr} = \frac{Surface\ terrière\ d'un\ échantillons}{Surface\ terrière\ totale\ de\ l'échantillon} * 100$$

Legend: Dr = Relative dominance

2.2.3 Importance Value Index (IVI)

It is calculated as the sum of the percentage of species richness and basal areas. Its range is from 0 to 200, which means that the sum of the maximum index values of all species in a plot is 200. This index follows the traditional principles of scientific writing, like Curtis and McIntosh, [14] in Lisingo, [15]. It is calculated using the following formula:

$$\text{IVI} = Abondance + Dominance$$

Legend: IVI = Importance Value Index

2.2.4 Shannon index

The index measures the complexity of a stand, with a higher value corresponding to a population comprising a large number of species with low representativeness. Logical structure with causal connections between statements is maintained, and a balanced view is kept without bias. On the other hand, a low value suggests that one species dominates a stand or that the stand has few species but a high degree of representativeness [16].

The calculation of this value is done using the formula below:

$$H' = -\sum (ni / N) \log2 (ni / N)$$

Legend: ni = Number of individuals of the species of rank i and N = total number of individuals.

2.2.5 Simpson index (1-D)

Also referred to as the index of dominance or the distribution of individuals among species in a community, the index calculates the likelihood that two individuals selected at random from a sample belong to the same species. This diversity index gives more significance to abundant species than rare ones, and incorporating uncommon species in a sample scarcely alters the value of the index. The result indicates the possibility that two arbitrarily selected individuals belong to the same species. The concept of dominance is employed to indicate the prevalence of a species when it approaches 0 or fluctuates between 0 and 1 [17,18]. It is calculated using the following formula:

$$D = \sum_{i=1}^{S} \left(\frac{ni(ni-1)}{N(N-1)}\right)$$

Legend: 1-D = Simpson index ; S = number of species; ni = number of individuals of species i and N = total number of individuals.

2.2.6 Magarlef index

This index is utilised to estimate absolute species richness disregarding the sample size and is employed to evaluate diversity in diverse sites. It has the advantage of not having a particular threshold and also allows sample size to be weighted. However, the index may be dependent on sampling effort and its calculation is straightforward. It is calculated using the following formula:

$$D = \frac{(S-1)}{In\,(N)}$$

Legend: D = Magarlef's D diversity index S = Number of species and N = Number of individuals.

2.2.7 Equitability of pielou (J')

This is a precise comparative parameter, which is independent of the number of species, and is beneficial for comparing potential dominance among sites, whether interzone, intrazone, or floristic groups. It can assess imbalances that the diversity index cannot estimate. The closer the value is to 1, the more balanced the stand. The level of diversity attained by a stand or floristic group is reflected by this measure, whose value is derived from the ratio of the Shannon and Weaver diversity index (H), or real diversity, to the maximum theoretical diversity value (Hmax), as defined by Frontier et al. [19].

The R index assesses the weight of each species in occupying the space and ranges from 0 to 1. The index tends towards 1 (maximum) when species are equally abundant in the stand (or when each species is represented by the same number of individuals) and towards 0 (minimum) when the majority of numbers correspond to a single species.

It is calculated using the following formula:

$$J' = \frac{H'}{H'max} = \frac{H'}{InS}$$

Legend: H' = Shannon and Weaver index and Hmax = ln S (with S = total number of species).

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Species richness and diversity indices

Table 1 above shows low species diversity in the ecosystem studied, since the diversity index values do not tend towards the maximum (1). Regarding the gradient, the Martineau method outperforms the Blanc-étoc method: 21 families comprising 38 species and 14 families comprising 30 species, respectively.

3.1.2 Floristic characterisation (species and families)

Table 2 examination indicates that *Staudtia gabonensis* is the most abundant (13,00%), dominant (14,10%) and ecologically significant (27,10%) species in Martineau, followed by Garcinia punctata (8,50%; 9,47% and 17,97% respectively), *Scorodophloeus zenkeri* (7,50%; 8,10% and 15,60%) and finally, other species with lower abundance, dominance, and ecological importance value index. In Blanc-étoc, *Trilepisium madagascariense* is the most abundant (18,10%), dominant (19,03%) and important (37,13%) species, followed by *Petersianthus macrocarpus* (15,55%; 15,82% and 31,37%) and *Celtis tessmannii* (9,10%; 8,30 and 17,40%). All other species have low values.

Myristicaceae is the most prevalent family (22,6%), being the most dominant (22,60%) and significant (46,10%). Subsequently, Fabaceae (19,50%; 19,10% and 38,60%), Clusiaceae (8,50%; 9,47% and 17,97%), Moraceae (7,50%; 6,12% and 13,62%), and other families with less substantial values in the Martineau approach follow. In Blanc-étoc, the families with the highest abundance are Moraceae and Fabaceae (17,10%), but they differ in dominance and ecological importance values: Fabaceae shows values of 16,38% and 33,48%, respectively, while Moraceae shows values of 19,93% and 37,03%. The next most abundant family is Lecythidaceae (15,82%), followed by Meliaceae (12,66%) and other families with lower values. The study reveals a divergence in family distribution across the two silvicultural methods used in the ecosystem.

3.1.3 Phytosociological types

Analysis of Table 4, which shows the abundance, dominance and relative importance index of the phytosociological spectra of vegetation (undergrowth) in the abandoned plantation studied, shows that Strombosio-Parinarietea species are more abundant, dominant and significant in Martineau than Musanga-Terminarietea and Mitragynetea. However, the Musanga-Terminalietea species are more abundant, dominant, and significant in the Blanc-étoc method, followed by Strombosio-Parinarietea and finally Mitragynetea which is in the last position. After carrying out the Student's t-test on the raw values of the observations, there was a significant difference between the two silvicultural methods ($p = 0.0001 < 0.05$).

3.1.4 Geographical distribution

The analysis of the results in terms of phytogeographic types (Table 5) shows that Martineau has a higher representation of Lower Guinean-Congolese, Omniguinean, Central Guinean and Congolese species (endemic Guinean-Congolese or regional species) compared with Blanc-étoc. Both areas have a similar representation of Afro-American species (species with a wide geographical distribution), while Blanc-étoc has a better representation of Afro-tropical species (link species) than Martineau. The Student's t-test indicates that the difference is not significant ($p = 0.2426 > 0.05$).

3.2 Discussion

The ecosystem under examination displays limited species diversity, but there exists dissimilarity in the richness of species between the two silvicultural techniques. The results of this study are consistent with previous studies by Solia [20] on the growth of *Afzelia bipindensis* in the Loweo primary forest of the Yangambi Biosphere Reserve, D.R. Congo, Shutsha et al. (2017) on the understory of the Yoko Forest Reserve (Tshopo Province, D.R. Congo), and Likolokolo [21] in the Esekelende primary forest of the Yangambi Biosphere Reserve, D.R. Congo. Sabatier and Prévost's observation of forest stands in French Guiana in 1990 confirmed that floristic distances are small in certain survey groups. This justifies the overlap between surveys of plant groups and spatially closest surveys with floristic similarities.

Table 1. Species richness and diversity indices of two forests under study

Diversity indices	Martineau	White-etoc	graduate
Specific wealth	38 species	30 species	M>B
Number of families	21	14	M>B
Simpson 1 - D	0,46	0,44	M>B
Shannon_H	0,65	0,63	M>B
Margalef	0,24	0,26	M<B
Fairness_J	0,94	0,91	M>B

Legend: M (Martineau) and B (Blanc-étoc)

Table 2. Abundance, dominance and importance value index of species in two silvicultural methods

Species	Martineau			White-etoc		
	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Albizia adianthifolia (Schumach.) W. Wight, 1909	0,50	0,52	1,02	1,56	1,75	3,31
Aidia micrantha (K. Schum.), 1969	5,00	4,27	9,27	0,00	0,00	0,00
Anonidium mannii (Oliv),1990	1,00	1,38	2,38	0,00	0,00	0,00
Anthonotha macrophylla (P.Beauv.), 1806	0,00	0,00	0,00	0,61	0,48	1,09
Antiaris toxicaria (Sri Lanka), 2013	2,00	1,51	3,51	0,00	0,00	0,00
Autranella congolensis (A.Chev), 1917	0,00	0,00	0,00	0,61	0,74	1,35
Barteria nigritana (Hook.F), 1861	0,00	0,00	0,00	1,21	0,75	1,96
*Canarium schweinfurthii (*Engler), 1906	1,00	0,69	1,69	0,00	0,00	0,00
Carapa procera (DC), 1824	1,00	0,69	1,69	7,1	5,74	12,84
Celtis tessmannii (RENDLE), 1915	0,50	1,32	1,82	9,1	8,3	17,40
Chrysophyllum africanum (L), 1753	1,00	1,30	2,30	3,5	3,58	7,08
Coelocaryon preussii (L), 1753	7,00	5,58	12,58	0,61	0,47	1,08
Cola lateritia (Karl Moritz Schumann), 1899	5,00	4,99	9,99	1,59	1,25	2,84
Dacryodes edulis (G.Don H.J.Lam), 1932	1,00	1,32	2,32	0,00	0,00	0,00
Dialium excelsum (L.), 1767	4,00	4,10	8,10	5,00	4,79	9,79
Entandrophragma angolensis (C.DC.),1894	1,00	2,10	3,10	0,00	0,00	0,00
Garcinia punctata (L.), 1753	8,50	9,47	17,97	0,00	0,00	0,00
Glyphaea brevis (Spreng), 1948	0,00	0,00	0,00	0,61	0,48	1,09
Greenwayodendron suaveaolens (Engl et Diels) 1901	0,50	0,34	0,84	0,00	0,00	0,00
Guarea cedrata (A.chev.), 1933	0,50	0,39	0,89	0,00	0,00	0,00
Klainedoxa gabonensis (Pierre), 1905	0,00	0,00	0,00	0,61	0,40	1,01
Massularia acuminata (G. Don), 1937	1,50	1,62	3,12	0,00	0,00	0,00
Microdesmis yafungana (J.Léonard), 1961	1,00	1,39	2,39	0,00	0,00	0,00
Millettia drastica (Wight et Arn), 1834	0,00	0,00	0,0	1,60	1,7	3,30
Myrianthus arboreus (P. Beauv), 1805	2,00	3,10	5,10	2,35	1,74	4,09
Newtonia glandulifera (Pellegr.), 1888	1,00	0,80	1,80	0,00	0,00	0,00
Pancovia harmsiana (De Wild), 1799	1,00	0,86	1,86	0,00	0,00	0,00
Pancovia laurentii (De Wild), 1799	0,00	0,00	0,00	0,61	0,36	0,97
Paramacrolobium coeruleum (J. Léonard), 1954	0,00	0,00	0,00	0,61	0,94	1,55
Parkia bicolor (A. Chev), 1956	0,00	0,00	0,00	1,29	1,01	2,30
Petersianthus macrocarpus (Merr.), 1916	2,00	2,75	4,75	15,55	15,82	31,37

Species	Martineau			White-etoc		
	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Prioria balsamifera (Griseb.), 1860	0,50	0,55	1,05	0,00	0,00	0,00
Pycnanthus angolensis (L.), 1753	3,50	2,90	6,4	0,00	0,00	0,00
Psydrax acutiflora (Hiern Bridson), 1985	0,00	0,00	0,00	0,61	0,91	1,52
Pterocarpus soyauxii (Hooker), 1895	6,00	5,10	11,10	0,00	0,00	0,00
Quassia africana (A. Chevalier), 1936	0,00	0,00	0,00	2,10	2,52	4,62
Rinorea laurentii (Aubl.), 1775	0,50	0,68	1,18	0,00	0,00	0,00
Scorodophloeus zenkeri (Harms), 1901	7,50	8,10	15,60	5,00	4,86	9,86
Staudtia gabonensis (Warb.), 1897	13,00	14,10	27,10	2,10	3,10	5,20
Sterculia tragacantha (Aubréville), 1959	0,00	0,00	0,00	1,25	1,5	2,75
Strombosiopsis tetrandra (Engl), 1897	0,50	0,40	0,90	0,00	0,00	0,00
Synsepalum subcordatum (A. DC. Daniel), 1852	0,50	0,49	0,99	0,00	0,00	0,00
Tabernaemontana crassa (Bentham), 1966	3,00	2,75	5,75	8,10	12,4	20,5
Tetrapleura tetraptera (Schum et Thonn.), 1891	0,00	0,00	0,00	0,61	0,74	1,35
Thomandersia congolana (De Wild.), 1899	4,50	4,45	8,95	0,00	0,00	0,00
Treculia africana (Decne.),	0,00	0,00	0,00	2,10	0,89	2,99
Trichilia gilgiana (Harms), 1896	0,00	0,00	0,00	4,10	3,10	7,20
Trichilia monadelpha (Thonn.), 1966	5,00	2,55	7,55	0,61	0,34	0,95
Tridesmostemon omphalocarpoides (Engl.), 1905	0,00	0,00	0,00	1,20	0,95	2,15
Trilepisium madagascariense (DC), 1825	5,00	4,57	9,57	18,10	19,03	37,13
Vernonia conferta (Bentham), 1973	1,00	1,50	2,50	0,00	0,00	0,00
Vitex welwitschii (De Wild.), 1928	1,50	1,37	2,87	0,00	0,00	0,00

Legend: Ar (abundance), Dr (dominance) and IVI (importance value index)

Table 3. Abundance, dominance and species importance value index for two silvicultural methods

Familles	Martineau			White-etoc		
	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Annonaceae	1,50	1,72	3,22	0,00	0,00	0,00
Apocynaceae	3,00	2,78	5,78	8,23	12,40	20,63
Asteraceae	1,00	1,51	2,51	0,00	0,00	0,00
Burseraceae	2,00	2,02	4,02	0,00	0,00	0,00
Cannabaceae	0,50	1,33	1,83	9,49	8,30	17,79
Clusiaceae	8,50	9,47	17,97	0,00	0,00	0,00
Fabaceae	19,50	19,10	38,60	17,10	16,38	33,48
Irvingiaceae	0,00	0,00	0,00	0,63	0,40	1,03
Lamiaceae	1,50	1,39	2,89	0,00	0,00	0,00
Lecythidaceae	2,00	2,75	4,75	15,82	15,82	31,64
Malvaceae	5,00	5,01	10,01	3,79	3,24	7,03
Meliaceae	5,50	5,68	11,18	12,66	9,16	21,82
Moraceae	7,50	6,12	13,62	17,10	19,93	37,03
Myristicaceae	23,50	22,60	46,10	3,16	3,54	6,70
Pandaceae	1,00	1,39	2,39	0,00	0,00	0,00
Rubiaceae	7,00	5,90	12,90	0,63	0,92	1,55
Sapindaceae	1,00	0,87	1,87	0,63	0,36	0,99
Sapotaceae	2,00	1,70	3,70	5,70	5,29	10,99
Simaroubaceae	0,00	0,00	0,00	2,53	2,52	5,05
Strombosiaceae	0,50	0,40	0,90	0,00	0,00	0,00
Thomandersiaceae	4,50	4,48	8,98	0,00	0,00	0,00
Urticaceae	2,50	3,10	5,60	2,53	1,74	4,27
Violaceae	0,50	0,68	1,18	0,00	0,00	0,00
Total	**100**	**100**	**100**	**100**	**100**	**100**

Legend: Ar (abundance), Dr (dominance) and IVI (importance value index)

Table 4. Abundance, relative dominance and relative importance value index

Methods	Statut phytosociologique	Ar (%)	Dr (%)	IVI (%)
Martineau	Mitragynetea	2,53	3,00	5,53
	Musango-Terminalietea	27,41	27,00	54,41
	Strombosio-Parinarietea	70,05	70,00	140,05
	Total	**100**	**100**	**100**
White-etoc	Mitragynetea	1,33	1,24	2,57
	Musango-Terminalietea	58,67	60,40	119,07
	Strombosio-Parinarietea	40,00	38,20	78,20
	Total	**100**	**100**	**100**

Legend: Ar (abundance) Dr (dominance) and IVI (importance value index).

The floristic characterisation of the studied undergrowth in the vicinity varies significantly from that of the Yoko Forest Reserve as reported by Shutsha et al. (2017) on the undergrowth of the DRC; however, it shares some similarities with Solia's 2016 findings on the stands under *Afzelia bipindensis* in the Yangambi Biosphere Reserve, where the more represented families

Table 5. Density, abundance, dominance, relative basal area and importance value index of geographical statuses

Methods	Types geographical	Ar (%)	Dr (%)	IVI (%)
	Afro- American	1,5	1	2,5
	Afro-Tropicales	3	2,7	5,7
	Lower Guinean-Congolese	48	49,2	97,2
Martineau	Congolese central forest	6	6,9	12,9
	Omniguineans	41,5	40,2	81,7
	Total	**100**	**100**	**100**
	Afro-American	7,59	5,77	6,68
	Afro-Tropicals	6,96	6,82	6,89
	Lower Guinean-Congolese	48,1	44,48	46,29
White-etoc	Congolese central forest	5,69	5,7	5,69
	Omniguineans	31,66	37,23	34,45
	Total	**100**	**100**	**100**

Legend: Ar (relative abundance); Dr (relative dominance) and IVI (importance value index).

were Moraceae, Myristicaceae, Meliaceae, Sapotaceae, Fabaceae and Clusiaceae. The family composition in this study affirms the classification of undergrowth strata in tropical forests.

There are a large number of endemic species in the Guinean Congo region, particularly the Bas-Guinean-Congolese and Ommiguinean species. As a result, the ecosystem is primarily comprised of forests located in the central forest sector of the region. These results are in line with similar observations made by Nshimba on Mbiye Island in [22], Shutsha et al. in Yoko and Masisa in [23] in Yangambi.

The study's discussion centred on findings from similar studies conducted in the region of Yangambi within the province of Tshopo/RD of Congo [24-27].

4. CONCLUSION

The purpose of this investigation was to evaluate the floristic, phytosociological, and phytogeographical diversity of the understorey in the former Guarrea cedrata plantation located in the Yangambi Biosphere Reserve. This research exposed that:

- The vegetation in the ecosystem under study is primarily dominated by several key families, including Myristicaceae (46,10%) and Fabaceae (38,60%), followed by Clusiaceae (17,97%), Moraceae (13,62%) and other families with low values according to the Martineau method. In contrast, the Blanc-étoc method reveals that the primary families are Fabaceae (37,03%), Moraceae (33,48%), Lecythidaceae (31,64%), Meliaceae (21,82%), and other families with low values. Notably, there is a discernible divergence of families between the two silvicultural methods utilized in this study.
- Bas-Guinéo-Congolais accounts for 48,10% of the recorded endemic species in Blanc-étoc and 48,00% in Martineau.
- According to the phytosociological spectra, Strombosio-Parinarietea species represent the highest abundance (70,05%) in Martineau. This is followed by Musanga-Terminalietea (27,41%) and Mitragynetea (2,53%). Furthermore, in the Blanc-étoc method, Musanga-Terminalietea species occupy the highest percentage (58,67%), while Strombosio-Parinarietea (40,00%) and Mitragynetea (1,33%) are the least abundant.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Letouzey R. Manual of forest botany, tropical Africa. Volume 1 general botany. Tropical Forestry Technical Center. 1982;461.
2. Brosset A. Bird populations in eucalyptus plantations in the Pointe-Noire region, Congo. Rev. Ecol (Terre Vie). 1997;52:133-151.
3. Triplet P. Encyclopaedic dictionary of biological diversity and nature conservation. Ninth edition; 2023.
   ISBN 978-2-9552171-7-7.
4. The brown J. Vegetation of the alluvial plain south of Lake Edouard. Expl. Nat. Park. Albert, Mission J. Lebrun (1937-1938). Fasc. 1, Brussels, Inst. national parks of the Belgian Congo. 1947;467.
5. Schnell R. Introduction to the phytogeography of tropical countries. Flight. II: environments, plant groups. Gauthier-Villars, Paris. 1971;951.
6. Raunkiaer C. The life forms of plants and statistical plant geography. Oxford, Clarendon Press. 1934;632.
7. Danserau P, Lems K. The grading of dispersal types in plant communities and their Ecological significance. Contrib. Inst. Bot. Univ. Montreal. 1957;71:52.
8. Evrard C. Ecological research on the forest population of hydromorphic soils of the central Congolese basin. Publ. INEAC, Ser. Sc. 1968;110:295.
9. Duvigneaud P. The savannahs of Bas-Congo. Topographic Phytosociology Essay. Lejeunia 1949;10:1-192.
10. Mullenders W. Preliminary communication on an attempt at pedological and phytosociological mapping in the Haut-Lomami. In Focan, A. and Mullenders, W. Bull. Agr. Belgian Congo, Brussels, XL,: 512-532pp, Comm. No. 137, Conf. Afr. Soils, Goma 1949;1948.
11. Mullenders W. Preliminary communication on an attempt at soil mapping and phytosociology in Haut-lomami. In Focan, Brussels, XL, 1: 512-532pp, Comm. No. 137, Conf. Afr. Soils, Goma. 1949;1948
12. Schmitz A. Overview of the plant groups of Katanga. Bull. Soc. Roy. Bot. Belgium. 1963;96:233-447pp.
13. Legendre P, Legendre L. Numerical ecology. Developments in Environmental Modeling, 20, Elsevier Science B.V., Amsterdam. 1998;853.
14. Curtis T, McIntosh P. The interrelations of certain analytic and synthetic phytosociological characteristics. Ecology 1950;31:434-455.
15. Lisingo J. Spatial organization of tree species diversity in tropical forests in the north-eastern basin of the Cuvette Centrale Congolaise. PhD thesis, University of Kisangani. 2016;169pp. +18 p appendages.
16. Frontier S, Pichod D. Ecosystems: Structures, Collection d'Ecologie 21. Masson, 2nd edition, Paris. 1995;477.
17. Odum P. Ecology. A link between the natural sciences and the humanities. Montreal, Quebec, Holt, Rinehart & Winston (eds). 1976;253.
18. Belesi H. Floristic, phytogeographic and phytosociological study of the vegetation of Bas-Kasaï in the Democratic Republic of Congo. PhD thesis, University of Kinshasa. French. 2009;565.
19. Frontier S. Sampling strategies in ecology. Masson-Paris & P.U. Laval. Quebec. 1983;494.
20. Solia E. Study of ecological conditions of Afzelia hipindensis Harms (Fabaceae) in the region of Kisangani, DR Congo. PhD thesis, University of Kisangani. 2016; 234.
21. Likolokolo E. Comparative analysis of the floristic diversity and structure of two forest reserves (Loweo and Esekelende) in the Yangambi region, DR Congo. Dissertation IFA-Yangambi. 2020;40.
22. Nshimba S-M. - Floristic, ecological and phytosociological study of the flooded forests of Mbiye Island in Kisangani, (DR Congo), DEA, ULB. 2005;101.
23. Masisa I. Ecological analysis of the Scorodophloeus zenkeri Harms forests in the Yangambi Biosphere Reserve, DR Congo. Dissertation IFA-Yangambi. 2020; 38.
24. Hui F et al. Semiparametric regression using variational approximations, Journal of the American Statistical Association, forthcoming; 2018.
25. Onyekwelu, Olabiwonnu A. Can forest plantations harbor biodiversity similar to natural forest ecosystems over time Int. J.

Biodivers. Sci. Ecosystem. Serv. Manag. 2016;12(1-2):108-115.
26. Ramade F. Elements of ecology. Fundamental ecology 2. Ediscience international, Paris. 1994;579.
27. Senbeta F, et al. Native woody species regeneration in exotic plantations at Munessa-Shashemene Forest, southern Ethiopia. New For. French. 2002;24:131-145.

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