Original Research Article

Floristic, phytosociological and geographical Investigation of Undergrowth in the Former Plantation of *Guarrea Cedrata* (A. CHEV.) Abandoned PELLEGR in the Yangambi Biosphere Reserve, DR Congo

ABSTRACT

The present research paper aims at characterizing and comparing understorey phytoecological diversity between the Martineau and Blanc-étoc methods in the abandoned former *Guarrea cedrata* (A. CHEV.) PELLEGR plantation, with a view to increase the adequate policy (strategies) in order to complete knowledge gaps of these ones. The experimental devices used are 50*50 m (Martineau method, 2023) and 50*50 m (Blanc-étoc, 2023). All understorey species which reached a diameter greater or as equal as with 5,0 cm were numbered according to Letouzey (1982). In order to specify the phytoecological spectra (biological types, morphological types, diaspora types, temperament, leaves size and types). We used catalogue flora of vascular plants from Kisangani Districts and Tshopo Province in DR Congo. After analysis, it has been shown clearly that sarcochores, mesophylls, shade-tolerant species, simple trees and leaves are more or heavily observed and there is heterogeneity of understory species. It is noticed that the Martineau method has got 38 species and 22 families. Whereas Blanc-étoc, 30 species and 15 families. This proves that there is common remark between the two methods for ecosystem.

Keywords : Phytoecology, undergrowth, plantation, sustainable management, Martineau, Blanc-étoc and DR of Congo.

1. INTRODUCTION

A restored ecosystem is capable of indefinite persistence under current environmental conditions and maintains itself to the same extent as its reference ecosystem. However, the biodiversity, structure, and functioning of the ecosystem can undergo changes during natural evolution, as well as fluctuations in response to periodic stress events and occasional disturbances of greater magnitude (Triplet, 2023).

Furthermore, it is imperative to conduct an evaluation of vulnerable or neglected ecosystems to determine the measures that ought to be prioritized and to devise the most fitting tactics for bridging the gaps in biodiversity information. This will enable a comprehensive overview to be formulated regarding the distribution and preservation status of the various constituents of biodiversity (Triplet, 2023).

Marien and Mallet (2004) ; Brockerhoff. J Parrotta, Quine. C.P and Sayer. J (2008) report that plantation areas may have higher levels of biodiversity than adjacent anthropized areas, such as agricultural land or grassy savannahs.

Finally, Tassin and colleagues propose a comparison of plantations based on species diversity, including both local and exotic levels. In order to discern the floristic richness of an ecosystem, knowledge of understory species is crucial, in addition to the study of large trees. Regrettably, studies in this area still remain scarce as the establishment of plantations for indigenous species is often challenging due to a shortage of knowledge on the biology, ecology and forestry of the species in question (Senbeta D, Teketay and Näslund, 2002 ; Onyekwelu and Olabiwonnu, 2016). The Yangambi region is greatly affected by the environmental challenges posed by its vegetation cover. These challenges are a result of fragmentation and degradation of the vegetation cover caused by human activities, leading to the loss, disappearance, and/or scarcity of certain biodiversity species. The Yangambi Biosphere Reserve comprises numerous forest plantations established in recent decades. Others are abandoned and not maintained or subjected to silvicultural treatments. Many studies have focused on showing the richness and diversity of the flora, phytoecology in the forest canopy or tropical forest ecosystems, but to date very few studies have analysed the flora and ecology of abandoned or fragile forest ecosystems (understorey) in this region in particular and Kisangani in general. Thus, this study has made it possible to carry out a phytoecological analysis of the vegetation (undergrowth) of the former *Guarrea cedrata* (A. CHEV.) plantation abandoned by PELLEGR, in order to identify suitable alternatives for its rational and sustainable management.

2. MATERIALS AND METHODS / METHODOLOGY

2.1. MATERIALS USED

The following materials were used in this study :

CHART 1. MATERIALS WERE USED IN THIS STUDY

N^o	Hardware	Functions
01	GPS	Acquisition of geographical coordinates.
02	Compass	Orientation of experimental washes.
03	Pentadecameter	Delineate plots and measure distances

		between plots and strata.
04	Diameter tape	Measure the diameter of the feet of trees.
05	Painting	Marking the feet of inventoried trees.
06	Machetes	Opening of layons.
07	Notebooks and pens	Taking notes or data.
08	A computer equipped with software (Word, Excel, R software version 4.3.1, Google Earth, Envi and QGIS)	Text entry, calculations, creation of graphs and tables, processing and analysis of data and creation of maps.

2.2. ENVIRONMENT STUDY

The study was carried out in the former plantation of *Guarrea cedrata* (A. CHEV.) Abandoned PELLEGR, Lowe Block of the Yangambi Biosphere Reserve, DR Congo. North and 24,28° East and covers an area of about 250000 ha. Administratively, it is located in the Tshopo Province, Isangi Territory, Turumbu Sector, about 100 km northwest 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 slope of the valley of the Isalowe Creek (this study).

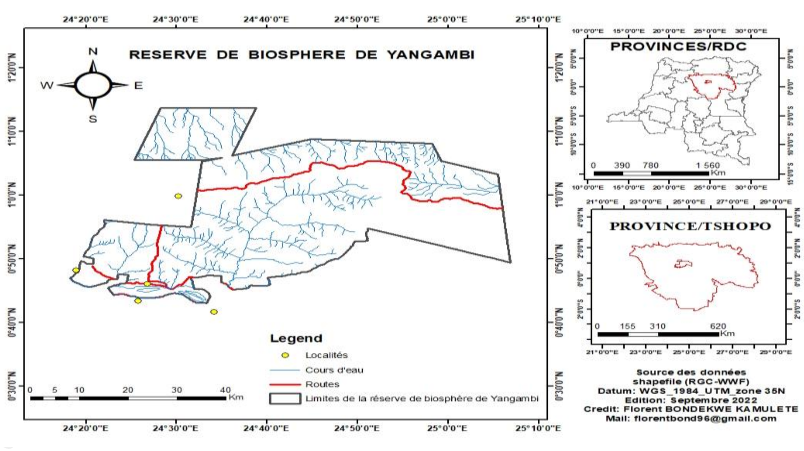

Figure 1: Map of the Yangambi Biosphere Reserve (Source : Bondekwe, 2022)

2.3. METHODS

2.3.1. Sampling

After the installation of the sampling or experimental device of one hectare including 50 * 50 m for Martineau and 50 * 50 m for Blanc-etoc, all species of undergrowth with a diameter at chest height greater than or equal to 5,0 cm were identified botanically. (genus, species and family) using morphological characteristics such as stem shape at base, bark texture, notch colour, odour, exudation, leaf type and shape, crown branching and reproductive characteristics, i.e. flowers and fruits in the field, on all plots of the two silvicultural treatments studied. These were measured using a forest tape and the corresponding values were recorded on the data collection sheet. After the inventory, the classifications of Raunkiaer, 1934 and Lebrun, 1947 as well as the vascular plant catalogue of the districts of Kisangani and Tshopo were used to characterise the phytoecological spectra, DR Congo (Lejoly JS, Lisowski S and Ndjele MB, 2010), which has been used by many authors who refer to the anatomical and morphological devices that characterise its vegetative apparatus and distinguish its habit and physiognomy, and previous work making available the databases of related data, have been consulted and exploited.

2.3.2. Data analysis

Analyses focused on diversity indices of biological types, diaspores, leaf size, morphological, foliage. The ecological spectra considered in this study, their characterisation and diversity indices were calculated to identify the most abundant, dominant, important and diversified in the former plantation (Martineau and Blanc-étoc) studied. The above analyses were carried out using the Vegam package (Hui, F. K. C. ; Shang, H. L. ; You, C. and Mueller, 2018) and Excel spreadsheets, using R software version 4.3.1.

The analysis of the diversity of plant groups was carried out using the following indices

- **Specific richness (S)**

This is the number of identified plant species. This indicator is insufficient to measure specific diversity because it does not distinguish between plant communities with the same number of species but with different numbers (Lejoly, 1995 in Nshimba, 2005).

- **Relative abundance**

Abundance refers to the number of individuals in an area or volume. It is an absolute value that is only determined for the most enumerate groups of animals and plants (Leigh and Loo De Lao, 2000 in Triplet, 2023).

It is calculated as follows :

$$\mathbf{Ar} = \frac{\text{number of individuals}}{\text{Total number of individuals}} * \mathbf{100}$$

Legend : Ar = relative abundance

- **Relative dominance**

Dominance (a more commonly used term) also expresses the influence of a species in a community. It is often expressed within a particular systematic group rather than for the whole animal or plant kingdom. It is expressed as the ratio of the number of surveys containing the surveyed species (Pi) to the total number of surveys (P), expressed in percentage (Legendre and Legendre, 1998 in Triplet, 2023).

It is calculated as follows :

$$\mathbf{Dr} = \frac{\textit{Land area of a sample}}{\textit{Total land area of the sample}} * \mathbf{100}$$

Legend : Dr = Relative dominance

- **Importance Index (IIA)**

This is an index that calculates the sum of species richness and basal area, all in percentage. It varies between 0 and 200, i.e. the sum of the maximum index values of all species in a plot is 200, Curtis and McIntosh, 1950 in Lisingo, 2016.

It is calculated using the following formula :

IIA = Abundance+Dominance

Legend : IVI = Importance Value Index

- **Shannon Index**

Index used to measure biodiversity. The Shannon and Weaver index only has ecological significance if it is calculated for a community of species that perform the same function within the biocenosis. It measures the degree and complexity of a stock. The higher it is, the more it corresponds to a stand composed of a large number of species with low representativeness. Conversely, a low value reflects a stand dominated by one species or a stand with a small number of species with high representativeness (Frontier and Pichod-Viale, 1995).

It is calculated using the following formula

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

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

- **Simpson's index (1-D)**

Also known as the dominance or distribution index of individuals among species in a community, it is the probability that two individuals randomly selected from a sample belong to the same species. It is a diversity index that gives more weight to common species than to rare species, and adding rare species to a sample does not change the value of the diversity index. It measures the probability that two randomly selected individuals belong to the same species. It is used to express the dominance of a species when it tends to 0 or varies between 0 and 1 (Odum, 1976 in Belesi, 2009).

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's index;

S = number of species;

ni = number of individuals of species i and

N = total number of individuals.

- **Magarlef Index**

This specific richness index is used to estimate absolute specific richness independent of sample size. It is used to check diversity at different sites, has the advantage of not having a defined threshold and also allows weighting of sample sizes. This index is easy to calculate but can be highly dependent on sampling effort.

It is calculated using the following formula :

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

Legend: D = Magarlef Diversity Index D S = Number of species and N = Number of individuals.

- **Equitability of Piélou (J')**

Rigorous comparative parameter, independent of specific richness, very useful for comparing potential dominances between sites (between and within zones or floristic groups). It allows the assessment of imbalances that cannot be estimated by the diversity index. The closer its value is to 1, the more it reflects a balanced stand. It reflects the degree of diversity achieved by a stand or floristic group and its value is obtained from the ratio of the Shannon and Weaver diversity index (H) or actual diversity to the value of the maximum theoretical diversity (Hmax).

The R index makes it possible to evaluate the weight of each species in the occupation of space and varies between 0 and 1. It tends to 1 (maximum) when species are equally abundant in the stand (or when each species is represented by the same number of individuals) and to 0 (minimum) when the majority of the numbers correspond to a single species (Piélou, 1966 in Belesi, 2009).

It is calculated according to the following formula :

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

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

3. RESULTS AND DISCUSSION

3.1. RESULTS

Basic statistics of Dbh (Diameter at the breast height) and area

Table 1: Basic statistics of DBH and area

Variables	**Dhp**		**Bottom area**	
Methods	**Martineau**	**Blanc-étoc**	**Martineau**	**Blanc-étoc**
Minimum	5,00	5,00	0,20	0,20
Maxima	9,80	9,80	0,75	0,75
Median	5,30	6,15	0,22	0,29
Average	**5,88±0,65**	**6,59±1,45**	**0,28±0,19**	**0,35±0,17**
CV (%)	11,05	22,00	67,85	48,7

Legend : cv (coefficient of variation)

Table 1 above shows a high homogeneity of dhp and heterogeneity of basal area in both methods: means, maxima, minima, medians, standard deviations and coefficients are in variable quantities.

Indices of specific richness and diversity

The diversity indices and the specific richness of two silvicultural methods (martineau and blanc-étoc) of the former plantation shows that both methods are less diversified and less rich in species (38 and 30 respectively), (38 and 31 genera) and family (22 and 15 respectively), because the indices of simpson, margelef and equity of pielou do not tend towards the maximum; this indicates heterogeneity in the distribution of individuals and a greater prevalence of diversity in Martineau compared to Blanc-étoc. In terms of species, Staudtia gabonensis is the most prevalent, accounting for 13%, followed by *Garcinia punctata* at 8,5%, *Scorodophloeus zenkeri* at 7,5 %, *Coelocaryon preussii* at 7 %, *Trilepisium madagascariense* and *Aidia micrantha* at 5,5 %, Cola bruneelii at 5,0 %, with other species being the least abundant. It is important to note that all technical term abbreviations have been explained upon their first usage.

Table 2. Specific richness and diversity indices of two silvicultural methods employed in the plantation being investigated.

Diversity indices	Martineau	Blanc-étoc	Graduating
Specific wealth	38 species	30 species	M>B
Number of families	22	15	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
Equitabilité_J	0,94	0,91	M>B

Legend: M (Martineau) and B (White-etoc).

The diversity indices demonstrate that Martineau has a higher species diversity than Blanc-etoc. The two methods used for the old plantation resulted in lower species and family diversity, as Simpson, Shannon_H and Margelef indices did not approach the maximum value (1). However, regarding the evenness of Pielou, the values tend towards maximum.

Species Diversity

Table 3 displays the species richness, abundance, dominance, and value index percentages for the former plantation surveyed. Technical abbreviations will be explained when first used. It is noteworthy that Staudtia gabonensis has the highest representation, closely followed by Garcinia punctata in Martineau. While in White-etoc, Trilepisium madagascariense occupies the first position, followed by Petersianthus macrocarpus and other species such as Table 3.

Table 3. Species diversity of the two silvicultural methods of the plantation studied.

Species	**Martineau**			**Blanc-étoc**		
	Ar (%)	**Dr (%)**	**IVI (%)**	**Ar (%)**	**Dr (%)**	**IVI (%)**
Albizia adianthifolia	0,50	0,52	1,02	1,56	1,75	3,31
Aidia micrantha	5,00	4,27	9,27	0,00	0,00	0,00
Anonidium mannii	1,00	1,38	2,38	0,00	0,00	0,00
Anthonotha macrophylla	0,00	0,00	0,00	0,61	0,48	1,09
Antiaris toxicaria	2,00	1,51	3,51	0,00	0,00	0,00
Autranella congolensis	0,00	0,00	0,00	0,61	0,74	1,35
Barteria nigritana	0,00	0,00	0,00	1,21	0,75	1,96
Canarium schweinfurthii	1,00	0,69	1,69	0,00	0,00	0,00
Carapa procera	1,00	0,69	1,69	7,1	5,74	12,84
Celtis tessmannii	0,50	1,32	1,82	9,1	8,3	17,40
Chrysophyllum africanum	1,00	1,30	2,30	3,5	3,58	7,08
Coelocaryon preussii	7,00	5,58	12,58	0,61	0,47	1,08
Cola lateritia	5,00	4,99	9,99	1,59	1,25	2,84
Dacryodes edulis	1,00	1,32	2,32	0,00	0,00	0,00
Dialium excelsum	4,00	4,10	8,10	5,00	4,79	9,79
Entandrophragma congoense	1,00	2,10	3,10	0,00	0,00	0,00
Garcinia punctata	8,50	9,47	17,97	0,00	0,00	0,00
Glyphaea brevis	0,00	0,00	0,00	0,61	0,48	1,09
Greenwayodendron suaveaolens	0,50	0,34	0,84	0,00	0,00	0,00
Guarea cedrata	0,50	0,39	0,89	0,00	0,00	0,00
Klainedoxa gabonensis	0,00	0,00	0,00	0,61	0,40	1,01
Massularia acuminata	1,50	1,62	3,12	0,00	0,00	0,00
Microdesmis yafungana	1,00	1,39	2,39	0,00	0,00	0,00
Millettia drastica	0,00	0,00	0,0	1,60	1,7	3,30
Myrianthus arboreus	2,00	3,10	5,10	2,35	1,74	4,09
Newtonia glandulifera	1,00	0,80	1,80	0,00	0,00	0,00

Pancovia harmsiana	1,00	0,86	1,86	0,00	0,00	0,00
Pancovia laurentii	0,00	0,00	0,00	0,61	0,36	0,97
Paramacrolobium coeruleum	0,00	0,00	0,00	0,61	0,94	1,55
Parkia bicolor	0,00	0,00	0,00	1,29	1,01	2,30
Petersianthus macrocarpus	2,00	2,75	4,75	15,55	15,82	31,37
Prioria balsamifera	0,50	0,55	1,05	0,00	0,00	0,00
Pycnanthus angolensis	3,50	2,90	6,4	0,00	0,00	0,00
Psydrax acutiflora	0,00	0,00	0,00	0,61	0,91	1,52
Pterocarpus soyauxii	6,00	5,10	11,10	0,00	0,00	0,00
Quassia africana	0,00	0,00	0,00	2,10	2,52	4,62
Rinorea laurentii	0,50	0,68	1,18	0,00	0,00	0
Scorodophloeus zenkeri	7,50	8,10	15,60	5,00	4,86	9,86
Staudtia gabonensis	13,00	14,10	27,10	2,10	3,10	5,20
Sterculia tragacantha	0,00	0,00	0,00	1,25	1,5	2,75
Strombosiopsis tetrandra	0,50	0,40	0,90	0,00	0,00	0,00
Synsepalum subcordatum	0,50	0,49	0,99	0,00	0,00	0,00
Tabernaemontana crassa	3,00	2,75	5,75	8,10	12,4	20,5
Tetrapleura tetraptera	0,00	0,00	0,00	0,61	0,74	1,35
Thomandersia congolana	4,50	4,45	8,95	0,00	0,00	0,00
Treculia africana	0,00	0,00	0,00	2,10	0,89	2,99
Trichilia gilgiana	0,00	0,00	0,00	4,10	3,10	7,20
Trichilia monadelpha	5,00	2,55	7,55	0,61	0,34	0,95
Tridesmostemon omphalocarpoides	0,00	0,00	0,00	1,20	0,95	2,15
Trilepisium madagascariense	5,00	4,57	9,57	18,10	19,03	37,13
Vernonia conferta	1,00	1,50	2,50	0,00	0,00	0,00
Vitex welwitschii	1,50	1,37	2,87	0,00	0,00	0,00

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

Ecological characterisation

from the study made, it appears that the species of the sarcochore type are more abundant, dominant and more important, followed by barochore, pterochore, ballochore and finally pogonochore in the last position in martineau than in white-etoc, there is the total absence of species of the pogonochore and pterochore types in white-etoc compared to the types of diaspores. it appears that species of the mesophanerophyte type are more abundant, dominant and important, followed by Megaphanerophytes and finally Microphanerophytes, which are less represented in Martineau and absent in White-etoc. Student's t-test shows that there is no significant difference (P = 0,73).

In terms of leaf size, a remarkable frequency of abundance, dominance and value index of importance of species of the mesophyll type followed by those of the microphyll type in the two silvicultural methods of the plantation under study. From a morphological point of view, trees are more abundant, dominant and important than shrubs in the ecosystem studied.   As for foliage types, species of the simple foliage type are more weighted in terms of abundance, dominance and ecological importance in the two methodological forest types.

The analysis of species temperament shows that shade-tolerant species rank first in Martineau in terms of abundance, dominance and importance value index, followed by non-pioneer species and then pioneer species. On the other hand, shade-tolerant species are more abundant than non-pioneer and pioneer species in the Blanc-étoc. We note that the pioneer index is generally high for both methods of the former plantation studied, with a PI of 58,86 % (Blanc-étoc) and 51,17 % (Martineau). This value is higher than 50 %, indicating that the vegetation is generally very disturbed.

Table 4. shows the representativeness of the phytoecological characterisation according to two silvicultural types of the former plantation studied in the yangambi biosphere reserve.

Silvicultural methods	**Phytosociological status**					
	Martineau			**Blanc-étoc**		
Types of diaspores	**Ar (%)**	**Dr (%)**	**IVI (%)**	**Ar (%)**	**Dr (%)**	**IVI (%)**
Ballochores	5,59	5,88	11,47	2,66	2,84	5,50
Barochores	12,19	12,88	25,07	13,33	12,57	25,90
Pogochores	1,01	1,52	2,53	0,00	0,00	0,00
Pterochores	7,61	7,21	14,82	0,00	0,00	0,00
Sarcochores	73,60	72,50	146,1	83,33	84,57	167,90
Total	**100**	**100**	**100**	**100**	**100**	**100**
Biological types	**Ar (%)**	**Dr (%)**	**IVI (%)**	**Ar (%)**	**Dr (%)**	**IVI (%)**
Megaphanerophytes	38,00	33,98	71,98	37,97	40,10	78,07
Mesophanerophytes	52,50	51,52	104,02	62,03	59,90	121,93
Microphanerophytes	9,50	14,50	24,00	0,00	0,00	0,00
Total	**100**	**100**	**100**	**100**	**100**	**100**

Types of leaf sizes	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Heterophylls	5,00	5,10	10,10	0,00	0,00	0,00
Leptophylls	0,00	0,00	0,00	8,86	8,86	17,72
Macrophylls	0,00	0,00	0,00	8,24	7,38	15,62
Mesophylls	71,50	69,97	141,47	70,26	72,89	143,15
Microphylls	16,00	16,83	32,83	12,00	9,67	21,67
Nanophylls	7,50	8,10	15,60	0,64	1,20	1,84
Total	**100**	**100**	**100**	**100**	**100**	**100**

Morphological types	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Trees	61,00	59,67	120,67	91,88	87,60	179,48
Shrubs	49,00	40,33	89,33	8,22	12,40	20,62
Total	**100**	**100**	**100**	**100**	**100**	**100**

Types of foliage	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Simple	74,50	84,81	159,31	58,86	62,48	121,34
Composed	15,50	15,19	30,69	41,14	37,52	78,66
Total	**100**	**100**	**100**	**100**	**100**	**100**

Temperament	Ar (%)	Dr (%)	IVI (%)	Ar (%)	Dr (%)	IVI (%)
Non-pioneer species	25,50	27,18	52,68	33,54	32,46	66,00
Pioneer species	17,00	15,19	32,19	25,32	26,82	52,14
Shade tolerant species	57,50	57,63	115,13	41,14	40,72	81,86
IP	**51,17 %**			**58,86 %**		
Total	**100**	**100**	**100**	**100**	**100**	**100**

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

3.2. DISCUSSION

The types of diaspores of the ecosystem studied, the inventoried undergrowth, highlight the numerical superiority of sarcochores (73,60 %), barochores (12,19 %) and pterochores (7,61 %) and ballochores (5,59 %) in Martineau than in Blanc-étoc, sarcochores, barochores and ballochores.

Many authors have made the same observations, the predominance of Sarcochores and Barochores species, presumably spread by fruit consumers in tropical forests: Mandango, 1981; Lubini, 1997 in the Luki Biosphere Reserve; Belisi, 2009 in the vegetation of Bas-Kasai; Nshimba, 2008 in the Western Forest of Cameroon. The vegetation studied is dominated by sarcochores (phanerophytes), species with fleshy fruits that characterise the flora of equatorial and humid tropical zones.

In terms of biological types, the results of this study are consistent with those obtained by Maley and Brenac, 1998 ; Lisingo, 2016 in Yoko, who observed a dominance of megaphanerophytes (63,80%) followed by mesophanerophytes (30,00%) in the sites that were the subject of their respective studies.

The observations made for the leaf sizes of the species of the studied ecosystem are also similar to those of, Masisa (unpublished results), 2020 ; Guillaumet, 1967 ; Lubini, 1997 and Belisi, 2009 ; Schimitz, 1963 ; Mbutabuba, 2018, which show the predominance of mesophyll and microphyll species, characterizing evergreen species that mark the behaviour of the foliage in the study area.

Among the morphological types of the ecosystem studied, trees dominate shrubs at 51,00 %. This observation was also made by Nsongola, 2017 ; Shutsha R, Asimonyio JA, Omatoko JM, Kambale K, Angoyo RA et *al* 2017, (2017) in the Yoko/DR Congo Forest Reserve, where shrubs predominate at 72,00 %. When compared with the results of the present study, it turns out to be a total demarcation.

Regarding the results obtained in this study, it should be noted that shade-tolerant species are more weighted than others. Our observations only confirm those found by Mbayu, 2016 in the monodominant forest of Gilbertiodendron dewevrei in Yoko and in the forests of Marantaceae in Biaro (DR Congo) ; Lisingo, 2016 in the forests of UMA, RFO and Rubi-Tele (DR Congo) ; for the pioneer index, the ecosystem indicates ancient disturbance over large areas, similar to observations by Hawthorne, 1996 in the forests of Ghana; Doucet, 2003 in the forests of central Gabon; Adou et *al*., in the vegetation of Tai National Park, Ivory Coast ; Gonmadje, 2012 In the Ngovayang massif in Cameroon, a high proportion of pioneer heliophilous species indicates recent disturbance over a significant area, and a high proportion of non-pioneer heliophilous species indicates ancient disturbance over large areas.

The Pioneer Index was calculated to measure the level of disturbance to the ecosystem under study, and this showed that the ecosystem is still highly disturbed, despite its recovery. This observation is similar to those made by Mbayu, 2016 in Marantaceae forests in Yoko and Lokonda, 2018 in mixed forests in Yoko, where all forests in the region found a pioneer index above 50 %, showing a low rate of specific richness of heliophilous pioneer species. Our results do not support those of Mbayu, op. cit. in the monodominant forest of *Gilbertiodendron dewevrei* in Yoko and the forests of Marantaceae in Biaro; Lisingo, 2016 in the forests of UMA, RFO and Rubi-tele and Masisa, 2020 in the *Scorodophloeus zenkeri* forest of the Yangambi Biosphere Reserve (DR Congo).

4. CONCLUSION

This study was carried out on the understorey vegetation of the Guarrea cedrata (A. CHEV.) Abandoned PELLEGR plantation in the Yangambi Biosphere Reserve (Tshopo) in the Democratic Republic of Congo. The aim was to analyse some ecological aspects of the latter. The study revealed a floristic richness of at least 22 families with 38 species according to the Martineau method and 15 families with 30 species according to the Blanc-étoc method. The most represented families in Martineau are Myristicaceae, Fabaceae, Clusiaceae, Moraceae and Rubiaceae. In Blanc-étoc, on the other hand, Fabaceae, Maraceae, Lecydaceae, Meliaceae and, finally, Cannabaceae are represented. Shade-tolerant species are more balanced than others. There is a numerical superiority of Sarcochores, Barochores and Pterochores and Ballochores in Martineau than in Blanc-étoc, Sarcochores, Barochores and Ballochores, which confirms the characterization of tropical forests in general. This study, responded to the hypotheses formulated, knowledge of the vegetation (undergrowth) of the ecosystem under study.

REFERENCES

Abla S, Zanndouche O, Abdoun F. Phytomasse evaluation of Pistacia lentiscus L. for rational exploitation of natural resources in a periuban forest of Alger. Indian ecological newspaper. 2022 ;49(4):1252-7

Adou C, Blom K, Dengiieadhé R, Van Rompaey K, N'Guessan G, Wittebolle F, et al. Floristic diversity and vegetation in the Taï National Park, Ivory Coast. Tropenbos-Ivory Coast, series, Tropenbos International, Wageningen. 2005. Accessed May 9, 2023. Available: www.troDenbos.org. French.

Belesi. K.K. Floristic, phytogeographic and phytosociological study of the vegetation of Salonga National Park (Bas-Kasai – DR Congo). International Journal of Innovation and Applied Studies. 2016; ISSN 2028-9324 Vol. 14 No. 3 Feb. 2016, p. 709-720. French.

Bouzid A, Bouzid K, Benabdeli K. Analysis methods contribution of failure modes and evaluation of criticality for rehabilitation of liege chain forests (Quercus suber) in Tlemcen forest (Algérie). Manajemen Hutan Tropika newspaper. 2 Aug 2022 ; 28 (2) : 191-.

Brockerhoff. J Parrotta, Quine. C.P and Sayer. J. Plantation forests and biodiversity: oxymoron or opportunity. Biodiversity Conserv. 2008; 17, 925–951.

Curtis JT and R.P. McIntosh RP. The interrelations of certain analytic and synthetic phytosociological characteristics. Ecology. 1950; 31:434-455.

Doucet.JL. The delicate alliance of management and biodiversity in the forests of Gabon. Doctoral thesis, University Faculty of Agricultural Sciences of Gembloux, Belgium, 323 pp. Available: www.gembloux.ulg.ac.be French. 2003.

Frontier S and Pichod-Viale D. Ecosystems: Structures, Ecology Collection 21. Masson, 2nd ed. Paris. 1995. French.

Gonmadje CF. Diversity and biogeography of Atlantic African forests: the case of the Ngovayang massif (Cameroon). Doctoral thesis, University of Montpellier II, 2012. Available: www.ur-forests-societes.cirad.fr French.

Guillaumet JL. Research on the vegetation of Bas-Cavally (Ivory Coast). Overseas Scientific and Technical Research Office, ORSTOM Paris. 1967. French.

Hawthorne. W, Holes and the sums of parts in Ghanaian forest: regeneration, scale and sustainable use. Proceedings of the Royal Society of Edinburgh. Section B. Biological Sciences. 1996; 104:75–176.

Hui, F.K.C.; Shang, H.L.; You, C. and Mueller, S. Semiparametric regression using variational approximations. Journal of the American Statistical Association, forthcoming. 2018

Lebrun J. The vegetation of the alluvial plain south of Lake Edouard. Expl. Nat. Park. Albert, Mission J. Lebrun (1937–1938), 467 p. Fasc. 1, Brussels, Inst. national parks of the Belgian Congo; 1947. Available: www.script.org French.

Legendre P. and Legendre L. Numerical ecology. Developments in environmental modeling. 20. 2nd ed. Elsevier, Amsterdam. The Netherlands; 1998.

Leigh EG. and Loo De Lao S. Measuring tree diversity. Center for Tropical Forest Science. 2000; 7-12.
Lejoly JS, Lisowski S and Ndjele MB. Computerized catalog of vascular plants from the Kisangani and Tshopo sub-regions. 3rd ed. Faculty of Sciences ; 2010. Available: www.worlcat.org French.
Lisingo W. Spatial organization of the specific diversity of trees in tropical forests in the northeastern basin of the Cuvette Centrale Congolaise. Doctoral thesis. UNIKIS. Faculty of Sciences. 2016. Available: www.researchgate.net French.
Lokanda W. Forest structure, physicochemical properties of the soil and pedoanthracological disturbance indices compared between the monodominant Gilbertiodendron dewevrei (De Wild.) J. Léonard forest and the adjacent mixed forest. Case of the Yoko Forest Reserve, DR Congo. Doctoral thesis, Unikis. 2018. Available: www.agritrop.cirad.fr French.
Lubini AC. Vegetation of the Luki Biosphere Reserve in Mayombe (Zaire). Jard. Bot. Nat. Belgium. Opera Meise 10. 1997. French.
Maley J and Brenac P. Vegetation dynamics, Palaenvironments and climatic changes in the Forest of West Cameroon. BP. Rev. Palaeobotany and Palynology. 1998; 99:157-187.
Mandango M. Flora and vegetation of Tundulu Island in Kisangani. Diploma of higher studies (D.E.S.), Faculty of Sciences, University of Kisangani. 1981. French.
Marien J and Mallet B. New perspectives for forest plantations in Central Africa. Wood Forests of the Trops. 2004 ; 282(4), 67–79. French.
Mbayu ML. Marantaceae forest and its impact on woody regeneration in the Yoko forest reserve (Ubundu, Tshopo Province, DR Congo), Doctoral thesis, Unikis. 2016. Available: www.abctaxa.be French.
Nshimba M. Floristic, ecological and phytosociological study of the forests of Mbiyé Island in Kisangani, DR Congo. Doctoral thesis, Université Libre de Bruxelles, Belgium. 2008. French. Available: www.difusion.ulb.ac.be
Nsongola G. Floristic and phytogeographic analysis of coastal and sublittoral vegetation in Kouilou (Republic of Congo). International Journal of Innovation and Applied Studies. 2017; ISSN 2028-9324 Vol. 19 No. 1 Jan. French.
Odum EP. Ecology: A link between the natural sciences and the human sciences. Montreal, Quebec, Holt. 1976. French.
Onyekwelu and Olabiwonnu AA. 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.
Pélissier R and Couteron P. An operational, analytical framework for species diversity partitioning and beta-diversity analysis. Journal of Ecology. 2007; 95 : 294–300,

Pielou EC. Species diversity and pattern diversity in studies of ecological succession. J. Theor. Biol. 1966 ; 10: 370-3

Raunkiaer C. The life forms of plants and statistical plant geography. Oxford Clarendon Press. 1934 ; 632 p.

Schmitz A. Overview of the plant groupings of the Katanga. Bull. Soc. Roy. Bot. Belg.1963 ; 96 : 233–4

Senbeta D, Teketay and Näslund B. Native woody species regeneration in exotic tree plantations at Munessa-Shashemene Forest, southern Ethiopia. New For. 2002 ; 24 , 131–145 .

Shutsha R, Asimonyio JA, Omatoko JM , Kambale K, Angoyo RA et al 2017. Floristic, phytosociological and phytogeographical studies of the herbaceous vegetation and understory of the Yoko Forest Reserve (Tshopo Province, DR Congo). International Journal of Innovation and Applied Studies. ISSN 2351-8014 Vol. 29 No. 2 Mar. 2017, pp. 101-1 119-1 French.

Su R, Xie T, Yao H, Chen Y, Wang H, Dai X, Wang Y, Shi L, Luo Y. Principales réponses et mécanismes de tolérance de Koelreuteria paniculata : une nouvelle plante potentielle pour la phytoremédiation durable des sols contaminés par le plomb. Journal international de recherche environnementale et de santé publique. 14 novembre 2022;19(22):14968.

Tassin AP, Missamba and Marien JN. Biodiversity of eucalyptus plantations. Wood Forests of Too. 2011 ; 309(3), 27–35.

Triplet. P. Encyclopedic Dictionary of Biological Diversity and Nature Conservation. Handbook of ecology 9th ed. ISBN 978-2-9552171-7-7, 2023. French.

Vleminckx J. The influence of soil factors and anthropogenic disturbances on tree species assemblages in central African forests. PhD thesis. Free University of Brussels, Belgium. 2015. Available : www.diffusion.ulb.ac.be French.