INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 9, No. 4, p. 20-33, 2016
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Floristic characterization of the ecotonal zone between the *Gilbertiodendron dewevrei* (De Wild) *J. Leonard* (Fabaceae) Forest and the semi-deciduous mixed forest in Mbiye island (Congo Basin, DR Congo)

Kambale Katembo Bienfait[1], Shalufa Assani Nicole[1], Ntahobavuka Habimana Honorine[2], Mangambu Mokoso Jean de Dieu*[3]

[1]*Département d'Ecologie et de la Biodiversité des Ressources Terrestres, Université de Kisangani, Kisangani, D. R. Congo*

[2]*Département d'écologie et Gestion des Ressources Végétales, Université de Kisangani, Kisangani, D. R. Congo*

[3]*Département de Biologie, Université Officielle de Bukavu, Bukavu, D. R. Ccongo*

Article published on October 30, 2016

Key words: Floristic characterization, Ecotonal zone, Mixed forest, *Gilbertiodendron dewevrei* forest.

Abstract

The study intended to determine the floristic composition of an ecotonal forest zone between the *Gilbertiodendron dewevrei* forest and the mixed forest of Mbiye Island Forest Reserve. Data were collected from a 50 m x 100 m plot set in each investigated biotope (ecotonal forest (interface), *Gilbertiodendron dewevrei* Forest and mixed forest). These diversity indices were computed using PAST and BIODIV R 1.0. A total of 736 specimens grouped into 153 species and 71 families were investigated. *Coelocaryon botryoides* Verm. was represented in all the three investigated biotopes, and it was the most abundant species in the ecotonal forest. While, *Gilbertiodendron dewevrei* (De Wild) J. Leonard was the most abundant species in the remaining two biotopes. The most dominant family in the ecotonal forest was the Myristicaceae, while the Fabaceae family dominated in the other two biotopes. The terrier area was estimated at 28.2 m^2/ha, 22 m^2/ha and 21.8 m^2/ha in *Gilbertiodendron dewevrei* Forest, mixed forest and the ecotonal forest, respectively. A strong similarity was detected between the two first biotopes (communities) (0.57) compared to the mixed forest (0.43).

***Corresponding Author:** Mangambu Mokoso Jean de Dieu ✉ mangambu2000@yahoo.fr

Introduction

The sustainable management of the tropical forests relies basically on the extrapolation of the existing knowledge, the intuition and the principle of precaution (Morneau, 2007). The results of the management studies carried out on such bases in a complex ecosystem are generally unforeseeable (Morley, 2000; White and Endwards, 2001; Leigh *et al.*, 2004).

Along the River Congo, in the central sector of the Congo Basin, there are different components of forest types; these include dry land or main land forests, flooded forests and island forests. These forests harbor exceptional biodiversity and support the livelihoods of revering communities. Among the most known and used island forests, there is Mbiye Island (forest), located in the eastern part of Kisangani Town. Mbiye Island forest is relatively well conserved and covers about 1400 ha area; it is composed of three types of forest, including: dry land, seasonally flooded and swampy forests (Nshimba, 2008). An ecotonal zone is growing between the *Gilbertiodendron dewevrei* (De Wild) J. Leonard and the mixed forests, and the status of this heterogeneous zone remains unclear to the classic description.

The hypothesis of this study is to verify the theory that the Forest of *G. dewevrei* mono dominance would tend to invade the Forest mixed through the contact area by imposing its juvenile due to his aggregative trend. The main objective here is to characterize floral of the contact area between the Forest *G. dewevrei* and the joint Forest Island Mbiye in order to identify its floral composition. That's why we want to characterize the floral composition of this transitional zone often ignored by researchers and two interfaces (Forest mono dominant *G dewevrei* and the Forest mixed).

To verify this hypothesis and reach our goal, we compare the structure and the diversity of compartments plant of these three types of mature Forest of Mbiye Island.

We will exactly compare local diversity, differential and global mixed Forest to the *G. dewevrei* forests and the interface forest. About the structure, we are interested in density, land surfaces of dominance (Collinet 1997; Shalufa, 2014; Mangambu, 2016; Imani *et al.*, 2016). This type of approach was adopted in the *G. dewevrei* forests and mixed wood of Ituri in the Democratic Republic of Congo by Hart *et al.* (1989) and Makana *et al.* (2004). An ecotype is a population or a group of populations that have evolved particular traits in response to natural selection under specific habitat conditions (Vande Weghe , 2004).

Materials and methods

Study area

The study was carried out in Mbiye Island Forest Reserve, upstream of the Wagenia falls, between 0° 31' N and 25° 11' E, 376 m alt. The island is located close to the equator, in the opposite side of Kisangani Town, its maximal length is about 14 km and the maximal width is 4 km (Lomba et Ndjele, 1998). The climate is equatorial, characterized by high and constant temperatures oscillating around 25°C with abundant rainfall (Nshimba, 2008).

Sampling

Data were collected from a 50 m x 100 m plot set in each investigated habitat, including the ecotonal zone, the *Gilbertiodendron dewevrei* forest and mixed forest. All the specimens were counted and their circumferences dbh≥10 cm measured. The preliminary species identification was done from the field, and then confirmed in the herbaria of the University of Kisangani (DRC).

Data Analysis

We used three indices, Shannon-Wiener and Simpson diversity to calculate liana diversity in the 20-ha plot. These indices were selected based on their discriminant ability, sensitivity to sample size and popularity. Relative density of species and families were assessed for each species and family (relative diversity).

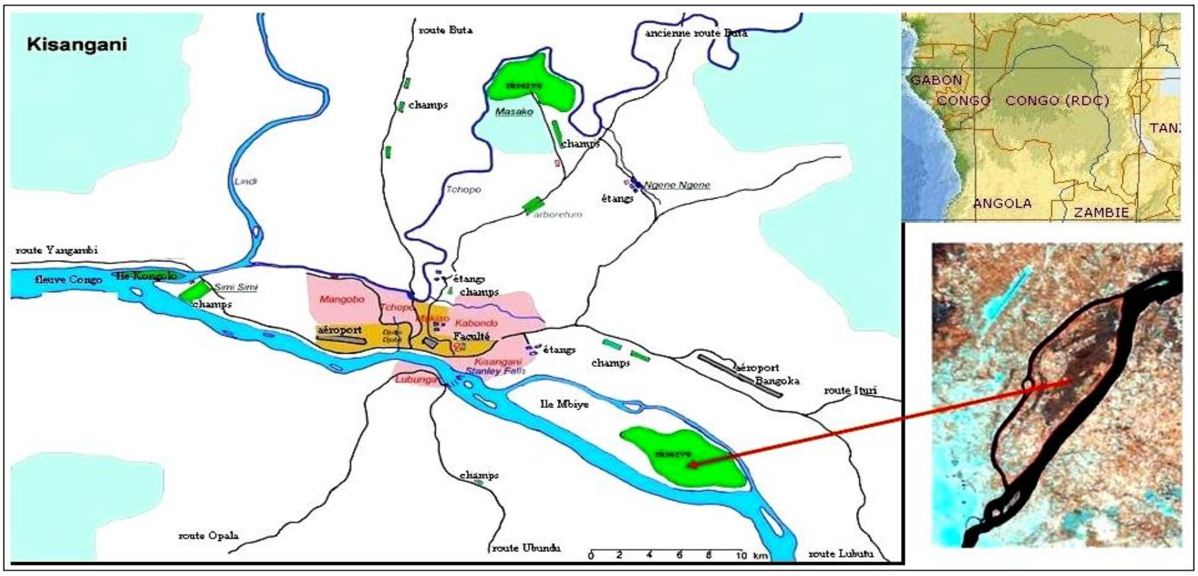

Fig. 1. Map showing Mbiye Island Forest Reserve and its surroundings (modified from Nshimba, 2008).

We also considered the relative frequency of species in the forest layers.

These floristic parameters are defined as follows (Sonké and Lejoly, 1998)

Relative density = (number of individuals of a species x 100)/ total number of individuals of all species.

Relative frequency = (number of plots containing a species × 100)/ sum of frequencies of all species.

Relative diversity = (number of species of a family X 100)/total number of species of all families.

The Shannon-Wiener diversity index emphasizes the contribution of rare species and the Simpson diversity index gives more weight to common species in a sample (Magurran, 2004). The Shannon-Weiner's index, as well as the Simpson 1-D and Fisher alpha indices were used for species diversity measures within the plots.

Shannon -Wiener index is calculated as:

$$H' = -\sum\left[(Ni/N)*\log_2(Ni/N)\right]$$

Where: Ni = fraction of the entire population made up of species I; S = numbers of species encountered and Σ = sum from species 1 to species S.

Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species)

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

Where: S is the number of species, N*:* is the total percentage cover or total number of organisms and n is the percentage cover of a species or number of organisms of a species. In this form, D ranges from 1 to 0, with 1 representing infinite diversity and 0 representing no diversity.

We considered the Simpson's Index of Diversity 1 – D which represents the probability that two individuals randomly selected from a sample will belong to different species.

Fisher's alpha is defined by the formula:

$$S = a * \ln\left(1 + \frac{n}{a}\right)$$

Where S is number of taxa, n is number of individuals and a is the Fisher's alpha.

These diversity indices were computed using PAST (Hammer and Ryan 2008).

To account for common and rare species, we considered the diversity indices of orders 0, 1 (exponential of the Shannon index) and 2 (inverse of Simpson index). The diversity of order zero is completely insensitive to species frequencies and is better known as species richness (Magurran, 2004). We used the Chao 1 index for diversity of order 0. This approach uses the numbers of singletons and doubletons to estimate the number of missing species because missing species information is mostly concentrated on those low frequency counts. The jackknife and minimum variance unbiased estimator (MVUE) were considered to estimate diversity of orders 1 and 2. These estimators were computed using the SPADE package (Chao Et Shen, 2003).

Results

Species richness and diversity in three studied forest habitats

In total, 736 specimens were counted (sampled) from the three investigated habitats, from which 251 specimens in the *G. dewevrei* forest, distributed in 40 species and 20 families; 242 specimens in mixed forest, distributed in 59 species and 29 families; and 243 specimens in ecotonal zone, distributed in 54 species and 22 families. *Coelocaryon botryoides* Verm. and *G. dewevrei* (De Wild) J.

Leonard were found as dominant species in the three studied habitats.

Table 1. The diversity indices for the three forest types.

Indices	Ecotonal Zone	Mixed Forest	*Gilbertiodendron* Forest
Simpson	0.92	0.93	0.75
Shannon	3.17	3.37	2.25
Eveness	0.79	0.82	0.6
Fisher alpha	21.52	24.8	13.42
Margalef	3.46	10.8	7.05

The *Gilbertiodendron dewevrei* (De Wild) J. Leonard, *Coelocaryon botryoides* Verm., *Uapaca guineensis*, G. Don ex Hook., *Symphonia globulifera* L.f. and *Cleistanthus mildbraedii* Jabl. were found as dominant species and the Fabaceae, Myristicaceae, Euphorbiaceae and Olacaceae were found as in dominant families in the mixed forest. In the ecotonal zone, *Coelocaryon botryoides* Verm., *Gilbertiodendron dewevrei* (De Wild) J. Leonard, *Uapaca guinneensis* G. Don ex Hook., *Musanga cecropioides* R.Br. & Tedlie and *Cleistanthus mildbraedii* Jabl. were the most abundant among the species; and Myristicaceae, Euphorbiaceae, Malvaceae, Olacaceae and Urticaceae were found the most dominant families. Whereas, the Fabaceae was the most predominant family in both *Gilbertiodendron dewevrei* forest and mixed forests. The considered diversity indices revealed that the mixed forest and the ecotonal zone were more species diversified than the *Gilbertiodendron dewevrei* forest (Table 1).

The coefficient of Sorensen showed significant similarity (S = 0.57) between the ecotonal zone and the *Gilbertiodendron dewevrei* forest; while nonsimilarity (S= 0.43) was found between the ecotonal and the mixed forest. The results reveal an existing similarity in floristic composition between the ecotonal zone and *Gilbertiodendron dewevrei* forest, e.i these two biotopes share several common species. Suggesting that with time, the *Gilbertiodendron dewevrei* forest could invade the ecotonal zone as well.

The analysis showed that some species namely were limited in some types of forests (Fig. 2). It further showed that floristic distances between the three investigated habitats were short, but the analysis revealed a clear classification in the ordination of heterogeneity in the ecotonal zone, as showed in Fig. 3.

Results from the l analysis are summarized by the Correspondence Analysis in the fig. 4. Three main studied forest habitats groups were identified. At the first subdivision, one between the *Gilbertiodendron dewevrei* forest group immediately the ecotonal zone distinguished itself from others giving rise to an and the mixed forest group which later partitioned into two other forest.

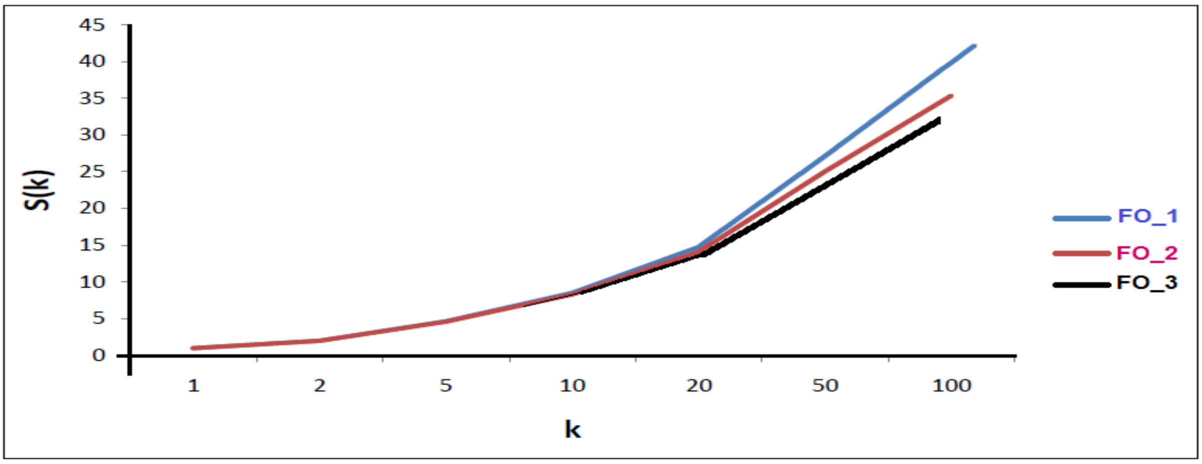

Fig. 2. Species rarefaction curves of communities in Mbiye Island from the three investigated habitats. The Y axis reflects the expected number of species for a k individuals sampling. The abscissa corresponds to the number of individuals. S(k) was computed using BiodivR (Hardy, 2005). Legend: FO_1= *Gilbertiodendron* forest, FO_2 = ecotonal forest and FO_3 = mixed forest.

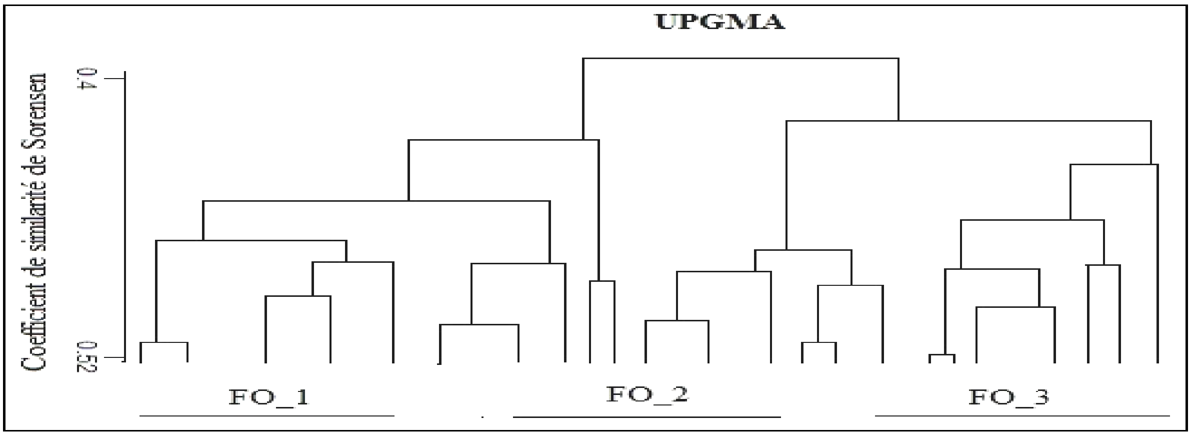

Fig. 3. Dendrogram showing the three investigated types of forests. Legend: FO_1= *Gilbertiodendron* forest, FO_2 = ecotonal forest and FO_3 = mixed forest. The coefficient of Sorensen similarity varies between 0 and 1. UPGMA= Unweighted Paired Group Median Average method: this method gives an equal weight to each of the points in each forest.

Vegetation characterization in the ecotonal zone

Relative abundance of species and families in the ecotonal zone

Coelocaryon botryoides Verm. was found as the most abundant species (20.2%); followed by *Cleistanthuses milbraedii* (12.8%); *Musanga cecropioides* R.Br. & Tedlie (6.6%); *G. dewevrei* (De Wild) J. Leonard and *Symphonia globulifera* L.f., each with 4.5%, respectively (Fig. 5a). While, other species, including were poorly represented in this habitat, with about 51.4% altogether, as showed in Fig. 5a.

Among the families, Myristicaceae was the most represented with about 25.5% of the total habitat' species; followed by Euphorbiaceae (22.2%), Fabaceae (12.2%), Urticaceae and Clusiaceae with 6.6% each, (Fig. 5b).

Whereas, the other remaining families were poorly represented with about 26.9% of the total habitat' species altogether, (Fig. 5b).

Relative dominance of species and families in the ecotonal zone

Coelocaryon botryoides Verm. was found as the most dominant species in the ecotonal zone with 23.4%; followed *by G. dewevrei* (De Wild) J. Leonard (13.1%), *Uapaca guineensis* G.Don ex Hook. (8.8%), *Musanga cecropioides* R.Br. & Tedlie (8.3%) and *Cleistanthus mildbraedii* Jabl. (5.6%) (Fig.5a). While, the remaining other species represented about 40.8% altogether, (Fig. 6a).

Among the families, Myristicaceae was the most dominant with about 26.3% of relative dominance; followed by Euphorbiaceae and Malvaceae with 18.4% each, Olacaceae and Urticaceae with about 9.3% and 8.3% of relative dominance, respectively (Fig.6b). Whereas, the remaining other families represented about 19.3% of the relative dominance altogether (Fig.6b).

Specimens distribution into diameter classes in the ecotonal zone.

The diameter class distribution analysis showed that Class 1 (10 -19.99 cm) was the most represented in the ecotonal zone with 154 specimens (Fig. 5). This was followed by Class 2 represented with 43 specimens; while Class 7 (70 -79.99 cm) was the least represented with only 1 specimen, as showed in Fig. 7. The above results reveal a strong forest regeneration capacity and high floristic diversity in the ecotonal zone.

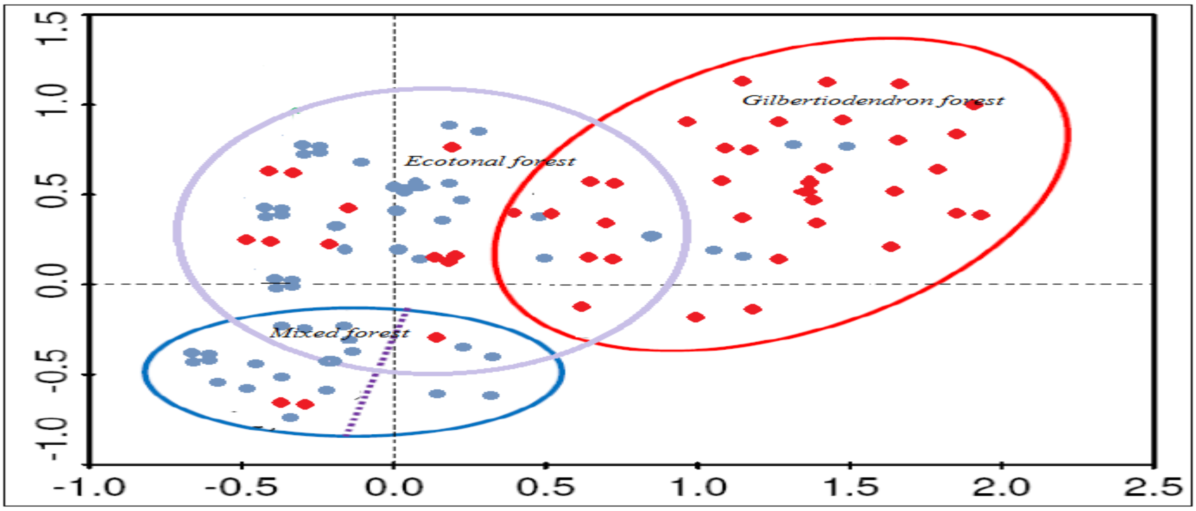

Fig. 4. Correspondence Analysis showing the three studied forest habitats.

Vegetation characterization in the mixed zone

Relative density of species and families in the mixed zone

In the mixed zone, *Coelocaryon botryoides* Verm. was found as the most abundant species with about 19%, followed by *G. dewevrei* (De Wild) J. Leonard (12%), *Cleistanthus mildbraedii* Jabl. (5.8%) and *Dichostemma glaucescens* Pierre, *Symphonia globulifera* L.f. and *Uapaca guineensis* G. Don ex Hook. with 4.1% each. While, the remaining other species were represented with 50.9% altogether, as showed in Fig. 8a.

Among the families, Myristicaceae was the most represented with 23.1% of the total habitat' species; followed by Fabaceae (20.2%), Euphorbiaceae (16.1%), Clusiaceae (5.8%) and Olacaceae (3.7%). The other remaining families were represented with 31.1% of the total habitat' species altogether, as showed in Fig. 8b.

Relative dominance of the species and families in the mixed forest

Gilbertiodendron dewevrei (De Wild) J. Leonard was the most dominant species in the mixed forest with 22.5%; followed by *Coelocaryons botryoides* Verm. (21.5%), *Uapaca guineensis* G. Don ex Hook. (7.1%),

Symphonia globulifera L.f. (6.9%) and *Cleistanthus mildibraedii* Jabl. (61%) (Fig. 9a).

The other remaining species (55) represented only 35.9% of the relative dominance in the mixed forest (Fig. 9a).

Among the families, Fabaceae was the most dominant with 30.5%; followed Myristicaceae (24%), Euphorbiaceae (15.1%), Clusiaceae (7.8%) and Olacaceae (3.8%) (Fig. 9b).

The other remaining families represented only 18.8% of the habitat' family dominance (Fig. 9b).

Specimens distribution into diameter classes in the mixed zone

The diameter class distribution analysis revealed Class 1 (10 -19.99 cm) as the most represented in the mixed forest with 148 specimens (10 -19.99 cm); while Class 6 (60 -69.99 cm) and Class 8 (80 -89.99 cm) were not represented with any specimen in this habitat, as showed in Fig. 10. The results indicate strong habitat regeneration.

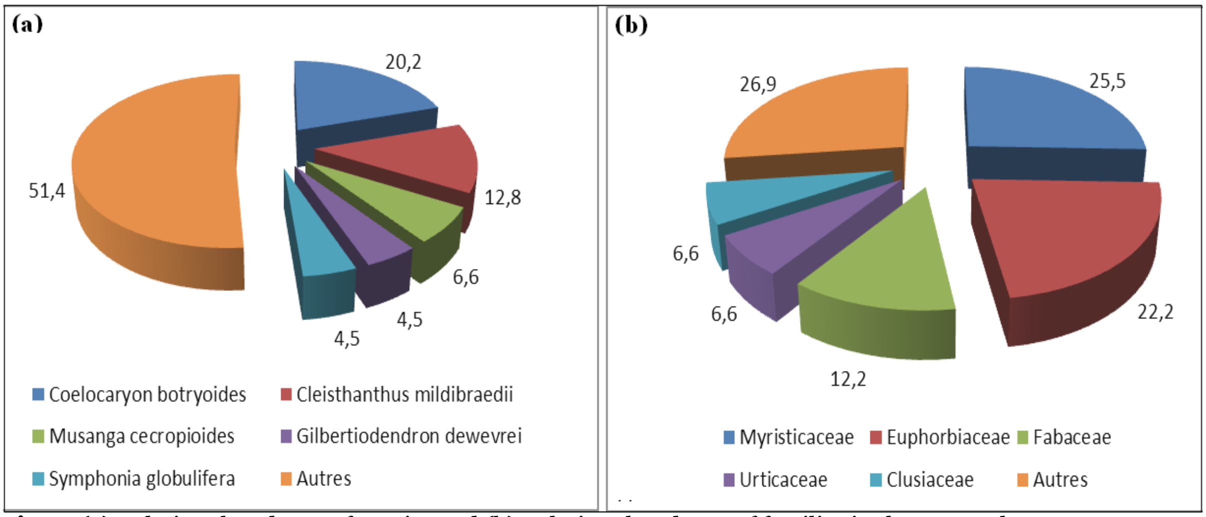

Fig. 5. (a) Relative abundance of species and (b) Relative abundance of families in the ecotonal zone.

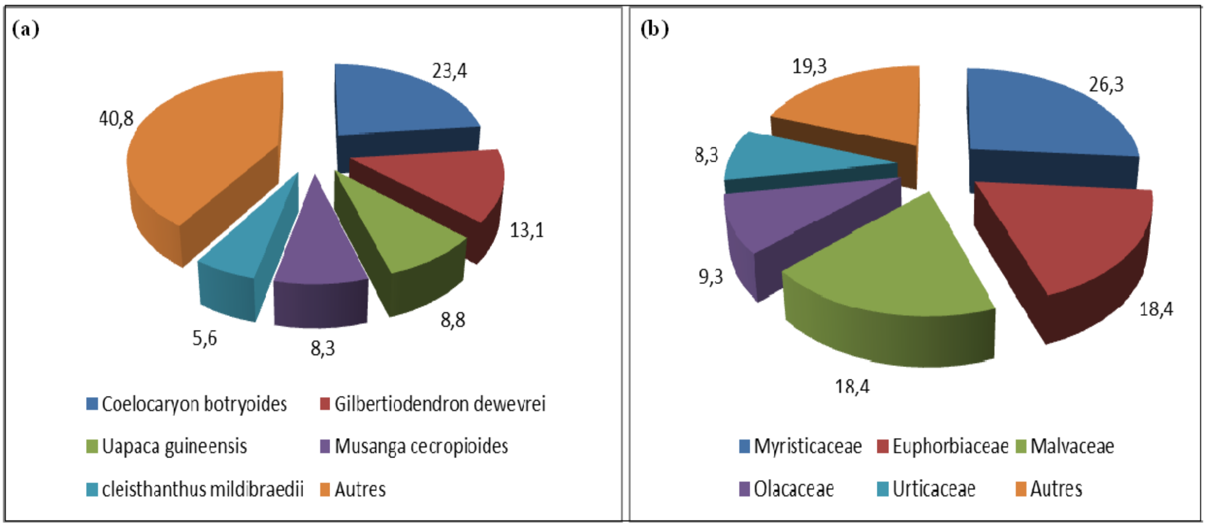

Fig. 6. (a) Relative dominance of species and (b) Relative dominance of families in the ecotonal zone.

Vegetation characterization in the Gilbertiodendron dewevrei forest

Relative abundance of species in G. dewevrei forest

Coelocaryon botryoides Verm. was found as the most abundant species with 25.1%; followed by *Gilbertiodendrons dewevrei* (De Wild) J. Leonard (17.5%), *Diospyros boala* De Wild. (4 .8%), *Pycnanthus angolensis* (Welw.) Exell and *Cleistanthus mildbraedii* Jabl. with 3.6% each (Fig. 9a).

Among the families, Myristicaceae was the most represented with 49.4%; followed by Fabaceae (19.9%), Euphorbiaceae and Ebenaceae with 6% each and Rubiaceae with 4% (Fig. 11b). While, the other remaining families were represented with only 14.7% altogether (Fig. 11b).

Relative dominance of species in G. dewevrei forest

Gilbertidendron dewevrei (De Wild) J. Leonard was the most dominant species with 55%, followed by *Coelocaryons botryoides* Verm. (23 %), *Anthonotha fragrans* (Bak. F.) Exell & Hillcoat (3.3%), *Diospyros boala* De Wild. (2.5%) and *Cleistopholis patens* (Benth.) Engl. & Diels (1.7%) (Fig. 10a). While, the other remaining species were represented with 147% altogether (Fig.11a).

Among the families, Fabaceae was the most dominant with 611% (Fig. 12b) This family was followed by Myristicaceae (25.1%), Ebenaceae (3.1%), Euphorbiaceae (1.9%) and Annonaceae (1.8%) (Fig. 12b).

The other remaining families in the forest were dominated by *G. dewevrei* (De Wild) J. Leonard represented with 7% (Fig. 12b).

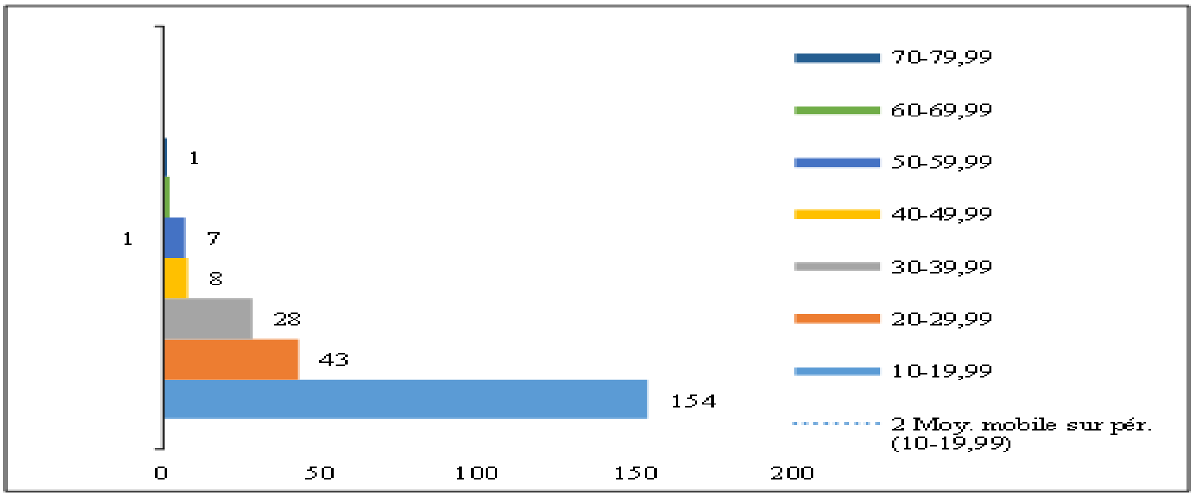

Fig. 7. Specimens distribution into diameter classes in the ecotonal zone.

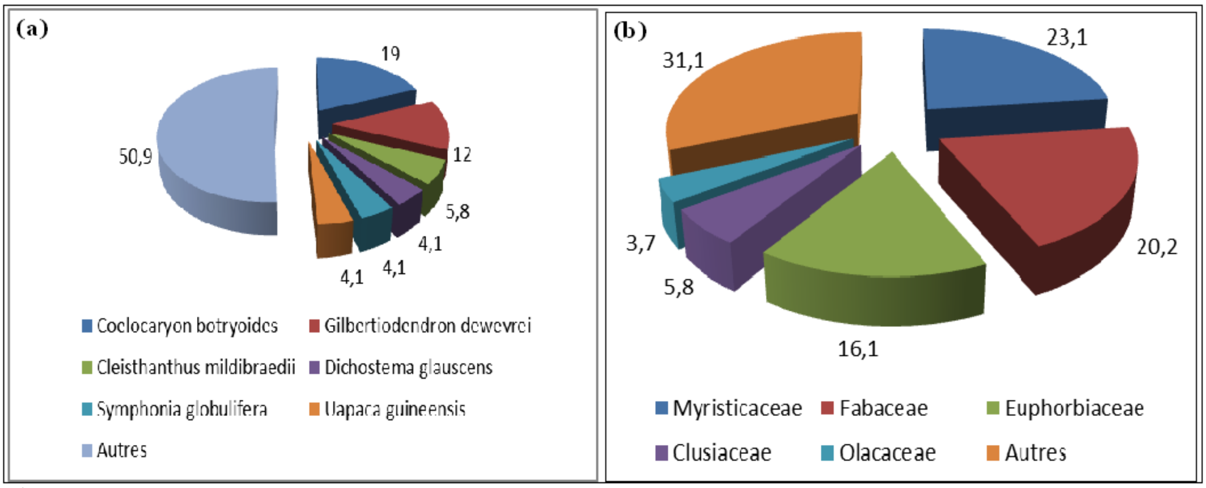

Fig. 8. (a) Relative abundance of species and (b) Relative abundance of families in the mixed zone.

Specimens distribution into diameter classes in Gilbertiodendron dewevrei forest

The diameter class distribution analysis showed that Class 1 (10 -19.99 cm) was the most dominant class, representing nearly half of the sampled specimens in the *Gilbertiodendron dewevrei* forest (Fig. 13). While, Class 7 (70 -79.99 cm) was the least represented with only three specimens. The present results demonstrate that the three investigated types of forests are still young, being all dominated by Class 1 (youngest tree specimens).

Discussions

Species diversity and the ecosystems functioning

The present study revealed that the species *Coelocaryon botryoides* Verm. and *G. deweivrei* were dominant within the three studied biotopes (ecotonal zone, mixed forest and *Gilbertiodendron dewevrei* forest). And the species *Coelocaryon botryoides* Verm. was found both the most abundant and dominant within two biotopes (Ecotonal zone and mixed forest). The studies carried out in the neighboring Yoko forest reserve indicated *Piptadenistrum africanum* (Hook. F.) Brenan, *Cynometra alexandrii* C. h. Wright and *G. dewevrei* (De Wild) J. Leonard as the most dominant species (Lomba & Ndjele, 1998; Lomba, 2012).

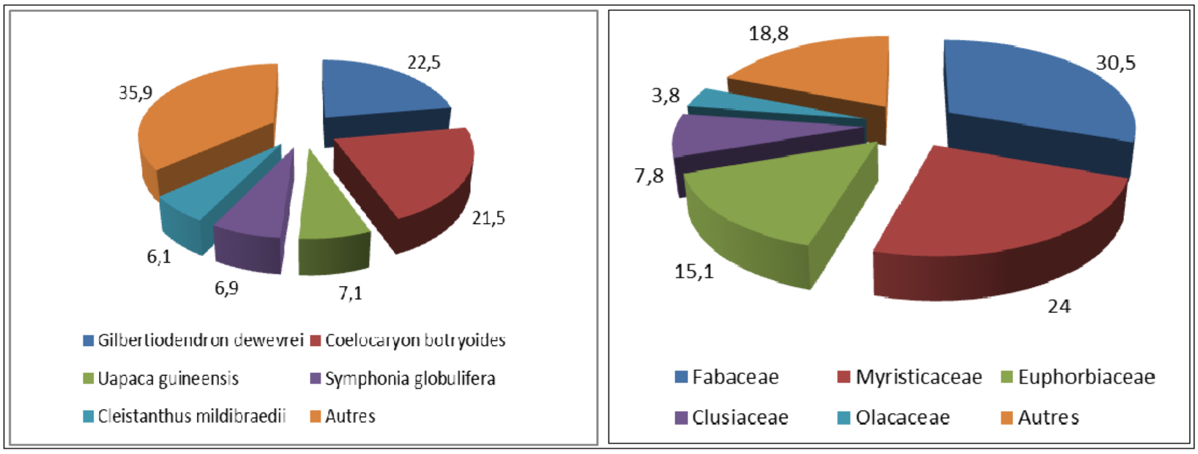

Fig. 9. (a) Relative dominance of species and (b) Relative dominance of families in the mixed zone.

In a structural study carried out in the Ivory Coast tropical forest, Kahn (1982) evidenced a progressive development of the arborescent population during a stage prior to the climax.

In addition, he found three more frequent species, including *Funtumia africana* (Benth.) Stapf, *Fagara macrophylla* (Oliv.) Engl. and *Albizia zygia* (DC.) J.F.Macbr.) in a reconstitution stage (process); and four species, including *Fagara macrophylla* (Oliv.) Engl., *Funtumia elastica* (Preuss) Stapf, *Terminalia superba* Engl. & Diels and *Xylopia aethiopica* (Dunal) A. Rich) in aged stage.

There is an indication that these could be replaced by a mixed or mono dominant forest in its climax status. The notion was confirmed by Mokosa (1995), who stated that in the major evergreen Congo basin forest, *G. dewevrei* (De Wild) J. Leonard, *Brachystegia laurentii* (De Wild.) Louis ex Hoyle, *Julbernardia seretii* (De Wild.) Troupin, *Cynometra alexandrii* C. h. Wright, *Scorodophloeus zenkeri* Harms, *Diospyros ituriensis* (Gùrke) R. and *Anonidium mannii* (Oliv.) Engl. & Diels are the dominant species. Lomba et Ndjele (1998) and Shalufa *et al.* (2014) found out similar results in their studies carried out in the Yoko forest reserve, close to the investigated areas.

White (1986) revealed that the ombrophile evergreen and semi-deciduous forest in the major part of the Congo basin is found in form of small islets of forests, generally dominated by Caesalpinioidae (Fabaceae) species, namely *Gilbertiodendron dewevrei* (De Wild) J. Leonard, *Brachystegia laurentii* (De Wild.), Louis ex Hoyle, *Jubernardia seretii* (De Wild.) Troupin and *Cynometra alexandrii* C. h. Wright. The above results corroborate with the current findings in which Fabaceae was found as the most dominant family in two biotopes, notably mixed and *Gilbertiodendron dewevrei* forests; while Myristicaceae was a dominant family in the ecotonal zone.

Similar to the current findings, Lomba (2012), Shalufa (2014) and Kumba *et al.* (2013) also found Fabaceae, Annonaceae, Euphorbiaceae, Rubiaceae, Ebenaceae and the Meliaceae constituting most important families of the region.

The Mbiye Island Forest Reserve is renowned for its highest diversity in tree species and families (Shimba, 2008).

Floristic variability

The floristic variability in the three (3) studied biotopes was mainly explained by the geographical distance between the plots. Similar results were found at a small scale in the northwest of Bornéo (Potts *et al.* 2002) and in the Amazon (Condit *et al.* 2002, Tuomisto *et al.* 2003).

However, other studies carried out in the Amazon found out different results (Philips *et al.* 2003).

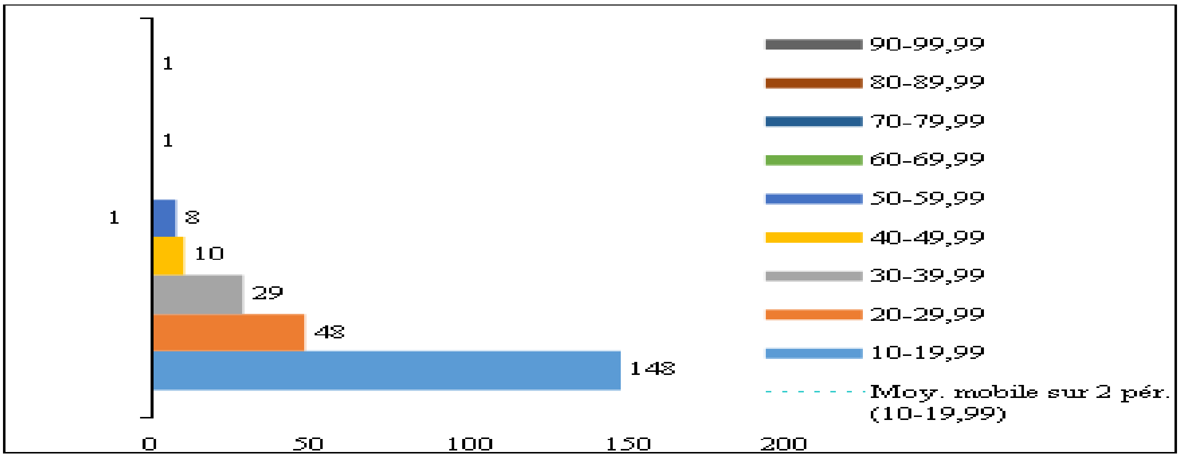

Fig. 10. Specimens distribution into diameter classes in the mixted zone.

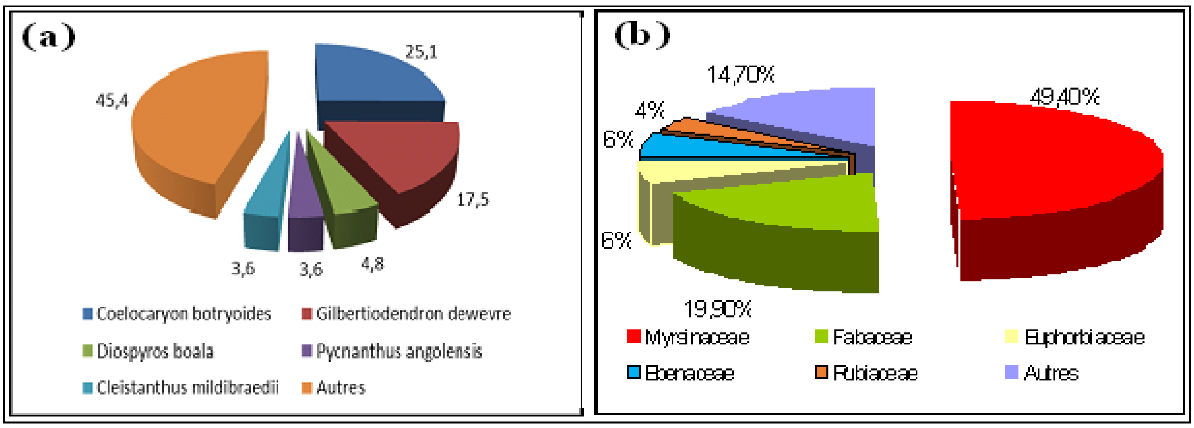

Fig. 11. (a) Relative abundace of species and (b) Relative abundace of families in *Gilbertiodendron dewevrei* forest.

Coelocaryon botryoides Verm. revealed to be among the most abundant and dominant species, this could result from the fact the species is found into its natural habitat, in addition to its preference for the ombrophile, swampy, flooded and riverine forests (Mandango, 1982 ; Tailfer, 1989).

As for *G. dewevrei* (De Wild) J. Leonard, it is known for its preference to the sandy soils, which is the major substrate in the eastern part of the Congo basin where it constitutes practically the major populations on the dry land, although it can also be found sporadically in flooded, riverine or swampy forests as in the present case (Mandango, 1982). Furthermore, according to Nshimba (2008), *G. dewevrei* (De Wild) J. Leonard is known as very gregarious species; this, associated to the sandy soil of this flooded forest, could confer to this species a presumably aggregated spatial distribution.

The present results demonstrated that the species distribution was determined by the biotope ecological conditions, unlike Legendre & Legendre (1998), who stated that the species distribution was acquired in advance. The positive correlation between the floristic and the geographical distances suggest that the floristic variance was essentially continuous and weakly influenced by the environmental heterogeneity. In other words, the distinguished vegetation groups do not correspond to the real discontinuities; but they are rather essentially generated by the sampling luckiness.

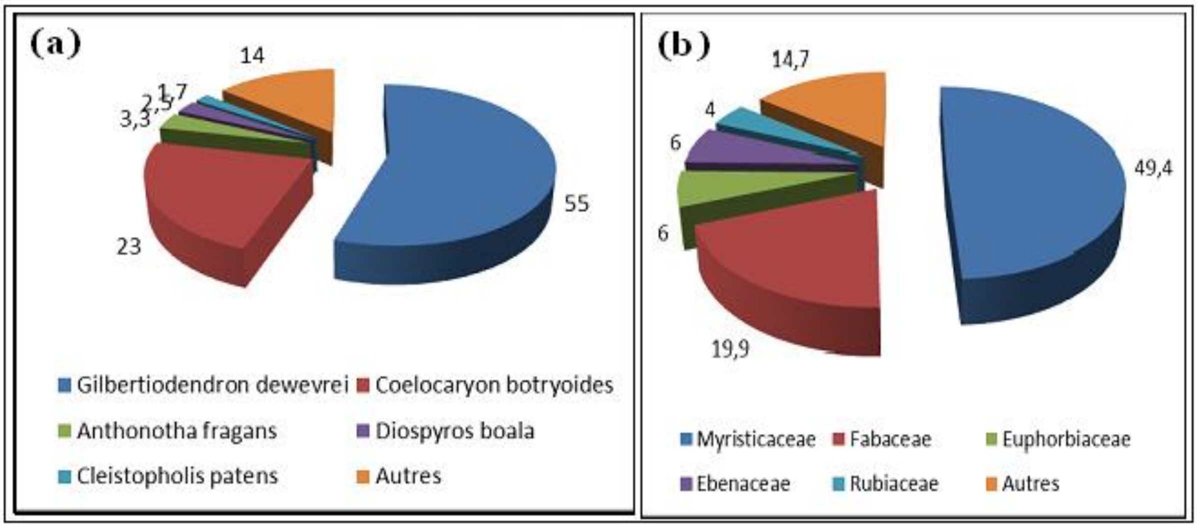

Fig. 12. (a) Relative dominance of species and (b) Relative dominance of families in *Gilbertidendron dewevrei* forest.

The diameter class distribution and terrier Area

Species diversity in the investigated biotopes was remarkably high compared to those of the mixed and *G. dewevrei* forests of the Guinéo-Congolese domain, with the exception of the Yangambi Forest in the DRC, in the small classes of diameters (Connell Et Lowman, 1989).

This is also valid compared to other mixed and mono dominant forests of Africa and America (Connell et Lowman, 1989).

The studied biotopes were also species rich compared to those of the Ituri forest, where in average, 57 and 46 species per hectare were found from totals of 372 and 343 trees' specimens, respectively (Makana *et al.* 2004).

That is also valid compared to the *Dicymbe corymbosa* forest, South America, where 37 and 56 species per hectare were found from totals of 276 and 433 trees' specimens, respectively (Henkel, 2003). In general, the specific diversity at a local scale in the *Gilbertiodendron dewevrei* forests is very variable (Makana *et al.* 2004).

The poorest record noticed was less than a half of species compared to those from Mbiye Island. This situation could partly be due to the sampling luckiness, but also from the maturity of the explored populations. In the senescent parts of a population, the trees of the small classes of diameters are generally rare and the species richness low, therefore, that is not the case in the young parts.

The results also noticed an existing floristic correlation between the *Gilbertiodendron dewevrei* forest and the two other heterogeneous forests.

The terrier area was small in the ecotonal zone, but near to that of the mixed forest, the zone also carried the three specimens majorly of small diameters, these results corroborate with the findings from the Dja forest, in Cameroon (Sonke, 1999) and that of Mbayu (2006), who found a terrier area of about 25.3 m²/ha in the mixed forest of the Yoko Forest Reserve, in the DRC.

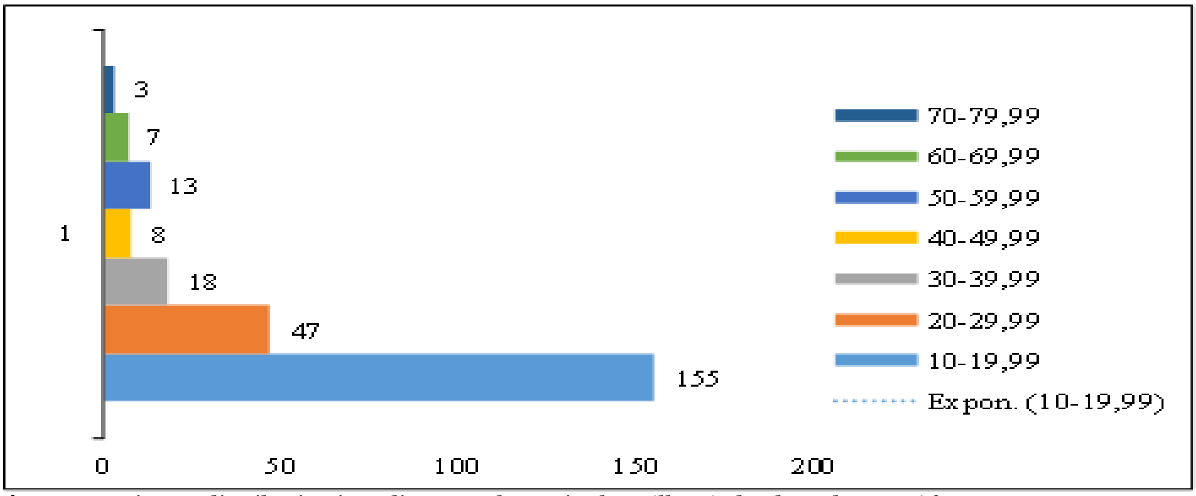

Fig. 13. Specimens distribution into diameter classes in the *Gilbertiodendron dewevrei* forest.

However, the terrier area found in the *Gilbertiodendron dewevrei* forest was small compared to the findings of Ewango (1994), who found a terrier area of about 35,6 m²/ ha in YOKO and those of Lomba (1998) and Sunderland (2004), who reported terrier areas of about 35.7 m²/ ha and of 37.4 m²/ ha Yoko respectively. The above differences could be explained by the ecological conditions between the Mbiye Island Forest Reverse, which is seasonally flooded and the dry land forests in which the previous researchers (Ewango, 1994; Lomba, 1998; Sunderland, 2004) carried out their studies.

Conclusion

Studies of the Congo basin forests started since the colonial time, with the main objective of providing guidelines for sustainable management, biodiversity conservation and livelihoods of local communities depending upon these forest resources in the sub region.

The present results noted that the three different biotopes shared a big number of common species, making unclear the limits between the mixed and the *Gilbertiodendron dewevrei* forests.

Floristic diversity was generally higher in the ecotonal zone; this was attributed to its location as transitional zone located between two forest blocks, containing species number from two ecosystems.

It is thought that, the faunal interactions such as mammals' movements between the different biotopes and pollination could also participate to the dispersal process of the some plant species from the two biotopes (mixed and *Gilbertiodendron dewevrei* forests) into the ecotonal zone.

To confirm the present results, some other factors including the multiple interactions between biotic factors (sylvigenetic cycle, dissemination), edaphic, biomass and on the other hand floristic variance explained of other sides to recheck the current hypothesis that is affirmed in this study.

Acknowledgement

The results of this study have been achieved thanks to financial supports from the Belgian International Forestry Research (CIFOR) and United Nations Educational, Scientific and Cultural Organization (UNESCO).

We are thankful to the Mbiye Island for their cooperation and hospitality during field works. Special thanks are addressed to everyone who took an active part in the data collection campaign.

References

Chao A, Shen T. 2003. Program SPADE (Species Prediction And Diversity Estimation). Program and User's Guide published at http://chao.stat.nthu.edu.tw

Connell J, Lowman MD. 1989. Low-diversity tropical rainforests: some possible mechanisms for their existence, American Naturalist **134,** 88-119.

Collinet F. 1997. Essai de regroupements des principales espèces structurantes d'une forêt dense humide d'après l'analyse de leur répartition spatiale (Forêt de Paracou-Guyane). Thèse de doctorat, Université Claude Bernard, Lyon I, 203 p.

Ewango N. 1994. Contribution à l'étude structurale de la forêt Monodominante à *Gilbertiodendron dewevrei* de la réserve de faune à Okapi, Mémoire inédit Faculté des Sciences, Université de Kisangani/RDC

Hammer O, Ryan P. 2008. PAST-PAlaeontological Statistics, ver. 1. 77.

Hardy OJ. 2005. BiodivR 1.0: a program to compute statistically unbiased indices of species diversity within samples and species similarity between samples using rarefaction principles.

Henkel TW. 2003. Monodominance in the ectomycorrhizal *Dicymbe corymbosa* (Caesalpiniaceae) from Guyana. Journal Tropical and Ecology **19,** 417–437.

Imani M, Zapfack L, Mangambu M, Penedimanja P, Mwanga Mwanga I, Boyemba F, Amani C. 2016. Caractérisations Structurale, Floristique et biomasse ligneuse du peuplement À *Hagenia abyssinica* du Parc National de Kahuzi-Biega (Rift Albertin, RDC). European Scientific Journal **12(15),** 198-209.

Kumba S, Nshimba H, Ndjele L, De Cannière C, Visser M, Bogaert J. 2013. Structure spatiale des trois espèces les plus abondantes dans la Réserve Forestière de la Yoko, Ubundu, République Démocratique du Congo. Tropicultura, **31(1),** 53-61.

Kahn F. 1982. La reconstitution de la forêt tropicale humide ; sud ouest de la cote d'ivoire ; orstom ; Paris 150 p.

Lomba B, Ndjele M. 1998. Utilisation de la méthode de transect en vue de l'étude de la phytodiversité dans la réserve de Yoko (Ubundu R.D.C.) Annales de la Faculté des Sciences, Université de Kisangani, **11,** 35- 46.

Leigh EG, Davidar P, Dick CW, Terborgh J, Puyravaud JP, Ter Steege H, Wright SJ. 2004. Why do some tropical forests have so many species of trees? Biotropica **36(4),** 447-473.

Hart TB, Hart JA, Murphy PG. 1989. Monodominant and species-rich forests of the humid tropics: causes for their occurrence, American Naturalist **133,** 613 633.

Lomba BL 2012. Systèmes d'Agrégations et structures diamétriques en fonction des tempéraments de quelques essences dans les dispositifs permanents de la Yoko et Biaro (Ubundu, Province Orientale, R.D. Congo). Thèse de doctorat, Université de Kisangani/RDC.

Makana JR, Hart TB, Hart JA. 1998. Forest structure and diversity of lianas and under story Treelets in monodominant and mixed stands in the Ituri Forest. Democratic Republic of the Congo. Man and The Biosphère series, **20,** 429-446.

Makana JR, Hart TB, Liengola I, Ewango C, Hart JA, Condit R. 2004. Ituri forest dynamics plot, Democratic Republic of Congo. In: Losos EC, Leigh Jr EG (Eds) Forest diversity and dynamism: findings from a large-scale plot network. University of Chicago Press, Chicago, 492–505.

Mandango M. 1982. Flore et végétation des îles du fleuve de Zaïre dans la Sous Région de la Tshopo (Haut-Zaïre). Thèse de doctorat, Université de Kisangani.

Mangambu M. 2016. Diversité, Biogéographie et Ecologie des Ptéridophytes en Afrique Centrale : Cas de massif montagneux du Parc National de Kahuzi-Biega à l'Est de la RD. Congo. Editions universitaires européennes, 354 p.

Mbayu F. 2006. Etude dendrométriques de la forêt mixte de la Yoko. Mémoire inédit, Faculté des sciences Agronomiques, Université de Kisangani/RDC.

Morley RT. 2000. Origin and Evolution of Tropical Rain Forests. John Wiley & Sons, Ltd,New York, 362 p.

Mokosa M. 1995. Technique international de la FAO sur les ressources phyto génétiques de la RD Congo ; Leipzig 17 p.

Nshimba S. 2008. Etude floristique, écologique et phytosociologique des forêts de l'île Mbiye à Kisangani, RD Congo. Thèse de doctorat, ULB/Belgique.

Shalufa A, Robbrecht E, Katusi L, Nshimba M, Ntahobavuka H, Mangambu M. 2014. Structure, dispersion spatiale et abondance de la population à *Guarea thompsonii* Sprague et Hutch. (Meliaeae) dans la forêt à Scorodophloeus zenkeri Harms (Fabaceae) dans la Réserve Forestière de la Yoko (République Démocratique du Congo). Journal of Animal and Plant Sciences **22(1),** 3569 -3587.

Tailfer Y. 1989. La forêt dense d'Afrique Centrale. Identification pratique des principaux arbres. Agence de Coopération culturelle et Technique et CTA, Wageningen, Tome **2**, 759- 762.

Sonke B. 1998. Etudes floristiques et structurales des forêts de la réserve de Faune du Dja Thèse de doctorat, ULB/Belgique.

Sonké B, Lejoly J. 1998. Biodiversity study in Dja Fauna Reserve (Cameroon): using the transect method. In: C.R. Huxley, J.M. Lock & D.F. Cutler (eds.) Chorology, Taxonomy and Ecology of the Floras of Africa and Madagascar, Royal Botanic Gardens, Kew, 171-179 p.

Tuomisto H, Ruokoleinen K, Yli-Halla M. 2003. Dispersal, environment, and floristic variation of western Amazonian forests. Science **299**, 241-244.

White F. 1986. La végétation de l'Afrique. Mémoire accompagnant la carte de végétation de l'Afrique UNESCO/AETFAT/UNSO. ORSTOM et UNESCO. Paris, collection ; Recherches sur les Ressources Naturelles, **20,** 1-384.

White L, Endwards A. 2001. Conservation en forêt fluviale africaine : méthodes de recherche, édition française, 456.

Vande Weghe JP. 2004. Forêts d'Afrique centrale. La Nature et l'Homme. Edition Lannoo SA, Tielt Belgique, 367.