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Flora diversity and characterization of plant groups in Atlantic Forests of Cameroon

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Abstract

Atlantic forests are part of the Guinean Low land and are known for their rich flora and fauna. A thorough botanical study has never been carried out at the level of the forest management units (FMU) located in these forests. This research therefore sought to characterize the vegetation using diversity indices and structure, to describe the plant diversity and to analyze the chorological types encountered in these forests. Twelve permanent one hectare plots were established in the two FMU's. Trees with dbh (diameter at breast height) ≥10 cm were identified, counted, measured, marked and tagged in each hectare. A total of 6425 individuals belonging to 317 species, 212 genera and 60 families were obtained. Three plant groups were described based on their similarity to variables such as altitude, the soil content and rainfall. The Fabaceae-Caesalpinioideaeare the most diverse in term of number of individuals. *Garcinia lucida* (Clusiaceae) found only in Group 1, is the most abundant species with an IVI=23.71. The Shannon diversity index (H'≥3.5)shows a forest with high species abundance and diversity. The chorological analysis reveals a predominance of Guineo-Congolese species with zoochore species being the most dominant in all three plant groups.

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Introduction

The "Lower-Guinea" center of endemism (White, 1983) is found in Central-West Africa around the Gulf of Guinea and its vegetation has been classified by White (1983). Letouzey (1985) using the phytogeography map of Cameroon identifies the forest in guinea-congolian region, evergreen rain forest domain, and atlantic or nigero-cameroono-gabonese sector. This atlantic forest consists of four atlantic districts: (1-the western-north atlantictype district, with submontane forest and poor in Caesalpinioideae, 2-the biafran atlantic district particularly rich in gregarious Caesalpinioideae, 3-the littoral atlantic district relatively poor in Caesalpinioideaecompare to the later, 4-the central and eastern atlantic districts, also poor in Caesalpinioideae but incontestably containing atlantic elements)(Caballé, 1978; Doumenge *et al.*, 2001; Letouzey, 1968; 1985).

Several studies conducted in this forest have led to good inventories of the atlantic forest of Cameroon compare to the other types of vegetation (Onana, 2011), planttaxa richness, endemism and floristic hotspots are well described (Davis *et al.*, 1994; Doumenge *et al.*, 2003; Gonmadje *et al.*, 2012; Linder, 2001; Onana, 2011; Onana, 2013; Onana and Cheek, 2011; République du Cameroun, 2014; Tchouto *et al.*, 2009; Tchouto *et al.*, 2006; White, 1983). Also, a high richness in fauna was revealed by several researchers working in this area. Many mammals and endemic birds threatened to extinction according to the UICN red listhave been reported in the "Lower Guinea" area (Djama, 2001; Kam*et al.*, 2002; Vivien, 1991). People living in this region depend on forests to meet their daily needs such as wood for energy, arable land, non-timber forests products (FAO, 2006). Thus, there is human pressure on the forests, although at its lower proportion compared to other tropical forests for which deforestation has reached treshold of 673000 ha per year, implying an annual extraction rate of 0.28% from the year 2000 to 2005 (Holmgren *et al.*, 2007).

Cameroon is documented among the top country in tropical Africa with plant species diversity of more than 5000 species per degree square in part of the lower guinea forest of Southwest Region. The flora richnessCameroon (c. 8500 vascular plant species) is the second most diversified of the Congo Basin after Congo-Kinshasa (c. 10 000) (Cheek and Onana, 2011). In recent decades, these forests have undergone an extensive conversion. The annual rate of deforestation is estimated at 0.9% with the lost of 220 000 ha of forest per year according to Global Forest Resource Assessment Report (République du Cameroun, 2014). Half of the initial forest areas have been cleared for agriculture and villages settlements. The exploitation of forests for farming is the main cause of deforestation; as rapid opening of large areas of remaining primary forests is mostly done in the South-east of the country (Bikié *et al.*, 2000).

Numerous works on biodiversityhave been carried out in Central Africa forests (Beina, 2011; Campbell *et al.*, 2006; Gonmadje *et al.*, 2012; Kouob, 2009; Senterre, 2001; 2005; Sonké, 1998; Sunderland *et al.*, 2003; Tchiengué, 2004; Tchouto, 2004; White, 1996). In forest management units, inventories have been conducted for forest management purposes withparticular emphasis on timber species. In the FMU 00 004 and 11 001, studies conducted have been focused specificallyon faunaand has little or no importance to plants (Bobo, 2012; Ekobo, 2008).

Botanical inventory carried out in the National Park of Korup close to FMU 11 001 revealed an important plantrichness of which some are endemic (Kuper *et al.*, 2004). In EBO reserve near FMU 00 004, a high number of animals belonging to class A such as elephants, chimpanzee, gorilla and other primates were observed. With regards to plants, apart from phytogeographical study realized by (Letouzey, 1985), more detailed researches are needed within these littoral (FMU 00 004) and southwest (FMU 11 001) forests. The purpose of this study is to characterize the vegetation structure using diversity indices while describing the flora diversity and to realizing chorological vegetation analysis.

Materials and methods

Area of study

The sites of the various research devices were selected based on the concessionaire's determination to preserve them from any compromising human activity that might reduce their qualities as research site dedicated to biodiversity exploration.

This study was carried out in two types of forests:

- Yinguiforest (FMU 00 004 at 10°20' and 10°40' of North latitude and between 4°30' and 4°50' longitude) is administratively located in Yingui District of Nkam Division. This forest is situated on a slope of the high plateau towards the sea and on Precambrian formations, in particular the inferior Precambrian. Thus, a part of the area has an altitude of up to 1300 meters, and the other part is located at relatively lower altitude (Gasel, 1957). This area receives more than 2000mm rainfall per year with two seasons yearly; a long dry season from mid-november to mid-march and a major rainy season from mid-march to mid-november;
- Okoroba forest (FMU 11 001) is located in the Eyumedjuck, Manyu Division, south west Region (5°18' - 5°37' N latitude and 9°05' - 9°23'E longitude). In its northern part, the relief is fairly flat and corresponds to the bottom of water-bed. Generally, the region's latitude ranges from 100 to 1.400m between Eyumojock and Akwaya.In this area, soils are ferralitic and often sandy. At the level of lowlands, the intense erosion on the flanks of hills forms sandy-clay soil (Effala, 2007).

Climatic data of the site was taken from the meteorological station of Mamfe. The maximum rainfall occurs in august (445.69mm) while the minimum is observed in january (17.46mm). This region has an equatorial climate type characterized by rainy and dry seasons similar to the one of the FMU 00 004.

Vegetation of the bothstudy areas belong to theevergreen forest or the nigero-cameroono-gabonese sector (Letouzey, 1968; Onana, 2013). These are atlantic forests more or less rich in Caesalpinioideae with four districts which threeare characteristics of our study area. The western-north atlantic district, poor in Caesalpinioideae have a high number of elements which are incontestably atlantics with few or no elements of semi-deciduous forests. Elements of neighboring forests penetratedthe meridional biafra forests in the southern North of Mamfe. The littoral atlantic district are relatively poor in Caesalpinioideae and geographically occupy the littoral plain about 0 to 200m in altitude (Letouzey, 1968; Onana, 2013). The biafran atlantic district particularly rich in gregarious Caesalpinioideae. Fig.1. presents the administrative localization of sites chosen for this study.

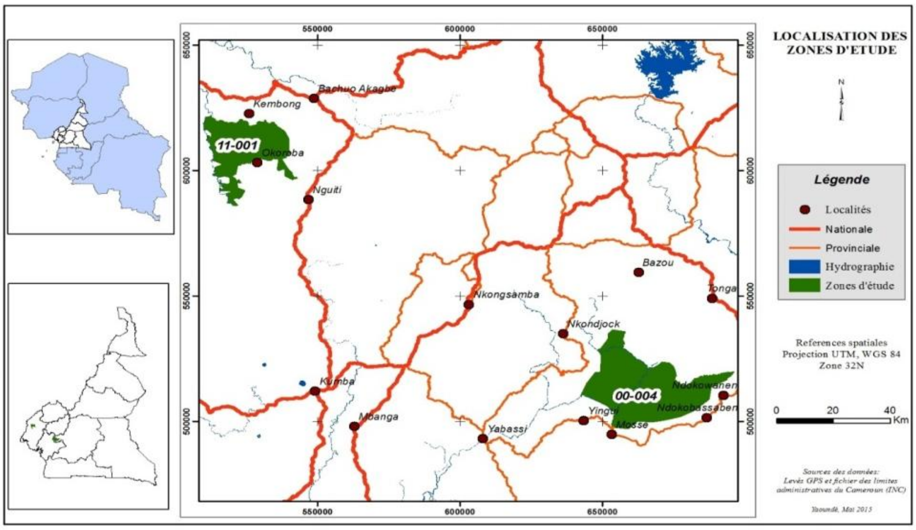

Fig.1. Localisation of FMU 00 004 (Yingui forest) and 11 001 (Okoroba forest).

Flora inventory

Twelve permanent plots of one hectare (100m x 100m) were established in the two FMU's with six plots in each FMU's. Each hectare was divided into 25 subplots of 20m x 20m. Thesesubplots assisted in the determination of the distribution of species. The field study permitted to identify elements of each plot with a GPS and a field sheet was used to describe each sampled plot.

In order to estimate plants resources of these areas,forest companies committed in the process of forest management generally used a systematic network of linear trails with the distance of 1 to 3km. These transects, divided into georeferenced plots, covering the forest massif, have been profitably used for flora inventory of this study. Trees of dbh≥10cm identified within each plot were measured, marked and tagged. The dbh ≥ 10cm was chosen to facilitate the structural study of both forests. Measures of dbh of trees with stilt roots were taken at 1.30m above the ground level with a measuring tape and at 10cm above foothills or stilt roots. Such measurements were done at the level with no deformations observed. A number was attributed to all trees identified and it was marked on an aluminum tag about 30 or 40cm from the measured point depending on the state of the tree.

Data analysis

Diversity indices

For the vegetation characterization, specificrichness (S), which is the number of species in a community or of a sample, was used andthe calculations of diversity indices carried out.

Shannon-Wiener H' diversity index

It derives from the theory of information and measures the entropy of a sample, namely the "saturation" of the community (Kent and Coker, 1992); it measuresuncertaintly the randomselectionof particular species from the sample. The index is given by the formula: $H' = - \Sigma^{s} i=1 ((Ni / Ns) \log_2 (Ni / Ns))$.

S being the total number of present species, Ni the number ofthe species i in the sample and Nsthe totalnumber. H' varies from 0 when there is a single species, to log2 S, when all species present have an equivalence abundance.

Piélou equitability

Equitability constitute a second fundamental dimension of diversity, (Ramade, 1984). It is the ratio of the maximum diversity (Hmax), it is expressed as follows:

$E= H' / Hmax$

$Hmax= Log2 (S)$

S is the number of species forming the population.Equitability makes it possible to compare the structures of population**.**

Simpson index

This expression is probability for two individuals selected randomly among the studied population to belong to the same species. In a community it determines the way individuals are distributed among species of a community; it is also an inverse measure of diversity.

$D = 1/\Sigma(Ni/N)2$

Structure indices

To determine the most important species in each type of vegetation, we used*importance index value* (IVI).

IVI = relative abundance + relative dominance + relative frequency. The species were then classified according to be their IVI, the with the important IVI is considered to be the most important in the plot (Curtis and McIntosh, 1951). To establish the relative importance of families, Familial Index Value (FIV) was used. FIV = relative abundance + relative dominance + relative diversity. FIV is obtained by summingthe relative value of abundance, diversity and relative dominance (Cottam and Curtis, 1956; Mori *et al.*, 1983). Values of IVI and FIV are between 0 (absence of dominance) and 300 (monodominance). These indices identify the dominant entity of a community in a compartment, implying species and families which ecologic value.

Reitsma (1988) consider that a species or a family is ecologically dominant when IVI or IFV >10. Similar to previous works carried out by several authors like Danserau and Lems (1957); Evrard (1968); Mandango (1982), White (1979; 1983); Apema (1995);Sonké (1998); Yongo (2004);Senterre (2005);Kouob (2009);Beina (2011) on chorology and phytogeography, diaspores, ecological characteristics of tropical forest species of Central Africa,we have defined the chorological types, phytogeographical types, types of diaspores and distribution modes of vegetation of both forests in this study.

Statistical analysis

Correspondence analysis (AC) was used to determine different groups from the environmental variables such as altitude, rainfall, and diversity indices. For that, a BiodiversityR package (Kindt and Coe, 2005) of the software program R (R Core Team, 2015) was used. The diversity indices of the different groups were compared using ANOVA and the Turkey HSD test when a significant difference was observed. These analyses was performed using a package Recommender (Fox, 2005) of the same software.

Results and discussions

Distribution of groups

The results of the multivariate analysis CA present the distributionof the 12 selected plots of both study areas into three significant distinct groups (Fig. 2.). The first group, consisting of plot 1 and 2 of FMU 00 004, differs from the other two groups on axis1, which contributes essentially 90.13% of the variability. Axis 2 expresses about 7.17% of the remaining variability and distinguishes the three groups obtained. Group 2 consists of the other four plots of FMU 00 004 (plots 3, 4, 5 and 6) whereas the last group represents all the plots of FMU11 001 (plots 7, 8, 9, 10, 11 and 12). The projection of the different vectors on the two axes have provided an explanation on altitude to distinguish group 1 on the first axis, such that plot 1 was at 956m of altitude and plot 2 at 963m being the highest altitudes.

The high clay content (axis 2) and the high precipitation level (axis 1) also justify the grouping of the four plots of group 2. Finally, all indices showing richness and diversity of plots located in the South Region (S) and diversity indices, Shannon (H'), Piélou (E) and Simpson (D) contributed in the distinction of the six plots in group 3.

The dendogram obtained from clustering analysis (Fig.3.) confirms the groupings shown in figure 2. Distances obtained at the end of the analysis (value on the left bar), however, indicate that among the 12 study plots, plots 7-8 and 10-12 are the closest plots. Within group 2, plots 4 and 6 are the closest; they are also closer to plot 5 than to plot 3. In group 3, the four plots 9, 10, 11 and 12 are cluster within a subgroup, plots 10 and 12 being closer to plot 9 than to plot 11.

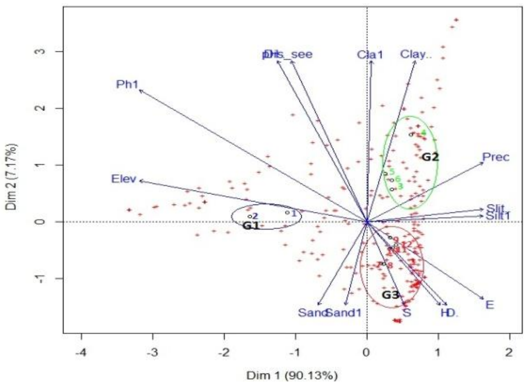

Fig. 2. Representation of the two first axes based on factorial analysis of correspondences showing the distribution of 12 study plots.

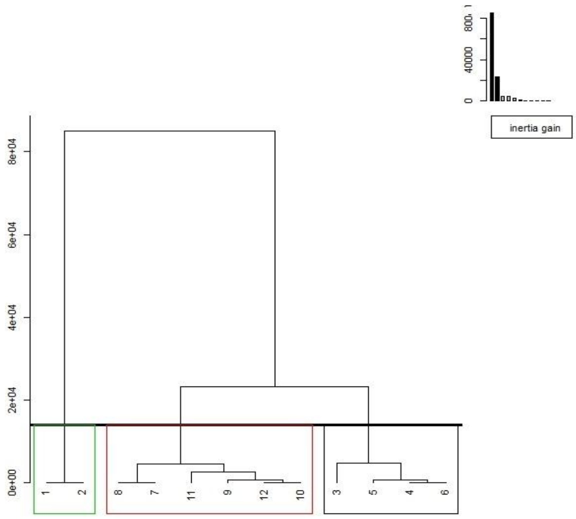

Fig. 3. Dendrogram resulting from the cluster analysis showing affinities between 12 plots.

Descriptionof plant groups

Group 1 (G1): Submontane Forest rich in Clusiaceae

This group is characterized by the predominance of Clusiaceae. According to Letouzey, this group belongs to western-north Atlantic district. The main species of this group are *Garcinialucida*, *Afrostyrax kamerunensis, Angylocalyxzenkeri, Cleistopholis patens, Beilschmiediaobscura, Drypetes grossweileri, Fagaramacrophylla, Garcinia staudtii, Guarea mayombensis, Keayodendron bridelioides, Leonardoxa africana, Milletia barteri, Omphalocarpum procerum, Phyllocosmus scalothyrsus, Quassia undulata, Stachyothyrsus staudtii, Sterculiamildbraedii.* These species are reported as characteristic species offorests (Doucet, 2003; Gonmadje *et al.*, 2012; Letouzey, 1985; Senterre, 2005; Tchiengué, 2004; Tchouto, 2004).

Results of the AC analysis show that plots 1 and 2 of G1 arecorrelated withthe altitude. Nevertheless, there is a good number of species of low altitude of the dense forest that overlap in this submontane landscape (Letouzey, 1985). The demarcation between the submontane forest and lowland forest is physiognomic. Forests of low altitude constitute the emerging ones because they occupy the highest peaks of this forest and are recognized by the presence of individual with very large diameters.

On the contrary, in the submontane forest there is a large proliferation of individuals with small diameters and sporadicallywith few rare trees of large diameters (Gonmadje *et al.*, 2012). This situation is clearly described in group 1 where diameters of individuals do not exceed 110cm, while in the other two groups at medium and low altitude, individuals reach diameter of dbp≥140cm.

In this group, there are abundant species such as *G. lucida*, *G. staudtii* (Clusiaceae) and *Santiriatrimera* (Burseraceae) which are characteristics of submontane forests (Letouzey, 1985). Similar observations have been carried out in Mont Koupé, at 1200m of altitude (Tchiengué, 2004).

Group 2 (G2) - Lowland and medium altitude forest rich in Fabaceae-Caesalpinioideae

Fabaceae-Caesalpinioideae which are characterize the low and medium altitude formations are the most important in this grouping. This classification consisting of plots 3 to 6 is correlated with the clay content of soil and the quantity of rainfall.

Characteristic species of this family such as *Brachystegia mildbraedii*, *Detarium macrocarpum*, *Dialium bipindensis*,*Distemonanthus benthamianus*, *Gilbertiodendron dewevrei, Didelotia brevipaniculata* etc. This group is found in the littoral atlantic district according toLetouzey (1985). The presence of many species which characterizing forests of low and medium altitude *Coulaedulis*, Oubanguia *africana, Coelocaryon preussii*, *Staudtia kamerunensis*, *Desbordesia glaucescens* were observed. Annonaceae constitute the second dominant family in this group. Dominant species of this family are *Annickiachloranta*, *Hexalobus crispiflorus*,*Myrianthus arboreus*, *Xylopia aethiopica*, *X. staudtii*. In this group also, there is an important presence of medium altitude to submontane species such as *Cola anomala, Pouteria aningeri*, *Trichilia dregeana*, *Santiria trimera*, *Sterculia tragacantha*, *Garcinia mannii*, *Ceiba pentandra*, *Trilepisium madagascariense*.

Group 3 (G3) - Low forest with Fabaceae-Caesalpinioideae and Fabaceae-Papilionoideae

Results of CA analysis show correlation of diversity indices with plots (7-12) of this group. The abundant species are *Calpocalyxdinklagei*, *Treculiaobovoidea*, *Parinari hypochrysea*, *Microberlinia bisulcata*, *Bikinialetestui*, *Detarium macrocarpum* corresponding to biafra atlantic district rich in gregarious Caesalpinioideae describe byLetouzey (1985). Species of the families Myristicaceae (*Pycnanthusangolensis*, *Coelocaryon preussii)* and Burseraceae (*Canarium schweinfurthii)* were also found.With regardsto this group, most of the species are from forests of low and medium altitude, no sub highland species was observed; some species with sub highland affinity present densities that are relatively low. Discriminating species of this group are *Plagiostyles africana* and *Staudtia kamerunensis*.

Floristic richness and diversity

Flora surveys carried out in the 12 plots of one hectare set up in Yingui forest (FMU 11 001) and Okoroba forest (FMU 00 004) resulted in the identification of 6425 individuals plants.

The tree species flora of these two forests is rich in 317 species, 212 genres and 60 families were observed. The number of species per group varies from 82 to 130 among the 12 plots and the mean number of species in G1 is 100.50 ± 17.68, in G2 is 93.00±6.48 and 119.17 ± 9.13 in G3 (Table 1). Statistical analysis revealed that groups varied significantly (P=0.0066).

The Shannon diversity index between plots varies from 3, 6 to 4, it has been stated that 4 indicates a rich and diversified forest (Gonmadje *et al.*, 2012; Kent and Coker, 1992). This assertion is confirmed with values obtained in the three groups. The specific diversity has a high value inG3 (4.19 ± 0.16), while values of the two other groups are relatively similar(3.79 ± 0.29for G1) and (3.88 ± 0.18 for G2). High specific plant diversity is observed in a biotope whose capacity is high compared to G1 and G2, G3 would therefore be one of the most interesting areas based on the flora. Values of Pielou and Simpson indices showed no significant differences among the three groups. These values indicate a relative stability within these forests.

Table 1. Summary of diversity indices observed in the three groups.

Parameter	Group1	Group 2	Group 3	P.value
Specificrichness (S)	100,50 ± 17,68ab	93,00 ± 6,48a	119,17 ± 9,13b	0,0066
PiélouEquitability (E)	0,821 ± 0,02a	0,85 ± 0,03a	0,88 ± 0,03a	0,104
Shannon Weaver (H)	3,79 ± 0,29a	3,88 ± 0,18a	4,19 ± 0,16b	0,0339
Simpson index	0,95 ± 0,02a	0,96 ± 0,2a	0,97 ±0,01a	0,12

Different letters which are on the same line indicate a significant difference among groups to P<0,05.

The scarcity are-species curve shows a fairly rapid increase up to 240 species and thereafter tends towards stabilization. The sampling level at which the species accumulation curve level out is approximately 300 species. This reflects the majority of species in the inventory area that have been recruited implying that plant diversification has been attained with few unrevealed exceptions.

Taxonomic diversity

The most important families in terms of number of individuals areFabaceae-Caesalpinioideae, Euphorbiacea, Fabaceae-Papilionoideae, Clusiaceae, Meliaceae and Annonaceae (Fig. 5.). The most abundant species are *Garcinia lucida*, *Ochthocosmos calothyrsus*, *Calpocalyxdinklagei, Oxystigmaoxyphyllum*, and *Klainedoxa microphylla*, these five species represent 16.4% ofthe total number of individuals (Fig. 6.). The most diversified genus are *Cola* (9 species), *Diospyros* (6 species), *Xylopia* (6 species), *Entandrophragma* (4 species), *Sterculia* (4 species) and *Dialium* (4 species).

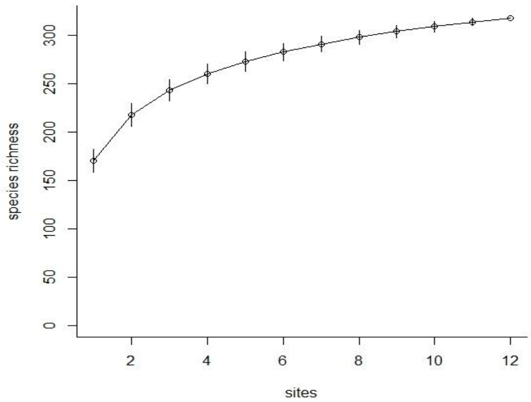

Fig.4. Scarcity areas-species curve of 12 inventoried plots.

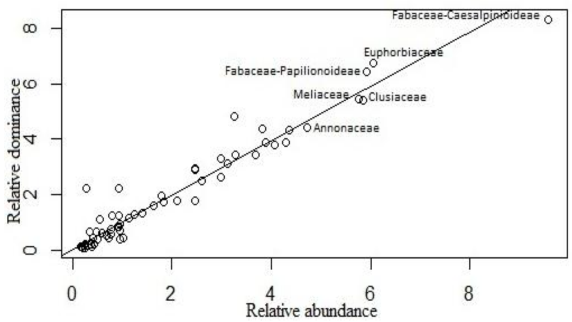

Fig.5. Relationship between the relative abundance and dominance of families within the two forest massifs.

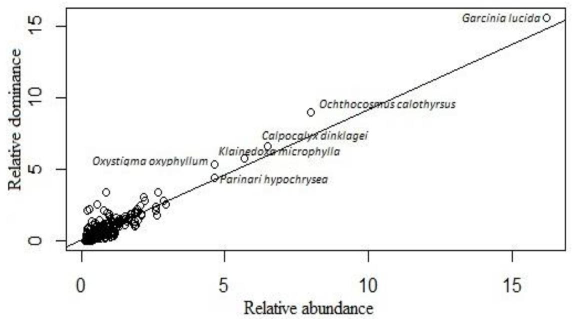

Fig.6. Relationship between the relative abundance and dominance of species within the two forest massifs.

Fabaceae-Caesalpinioideae (43 species) are the most diverse in terms of species, followed by Annonaceae (21 species), Euphorbiaceae (19 species), Rubiaceae (17 espèces), Malvaceae (15 species) and Meliaceae (15 species). The Fabaceae-Caesalpinioideae family is the most important in terms of FIV (26.74) in this inventory.

It is followed by Clusiaceae (21.37), Euphorbiaceae (17.08), Meliaceae (15.05), Annonaceae (14.06), Strombosiaceae (13.02) Olacaceae (12.89), Fabaceae-Papilionoideae (12.73), Malvaceae (11.27) and Flacourtiaceae (11.25) (Table 2).

Ten families with FIV> 10 constituting one fifth (1/5) of the total number of families surveyed, account for 20% of all inventories. The results based on the global inventory reveal that *Garcialucida* is the main key species in terms of IVI= 116.83, then *Ochthocosmuscalothyrsus* (61.60), *Calpocalyx dinklagei* (46.89), *Klainedoxa microphylla* (43.14), *Oxystigma oxyphyllum* (40.31), *Parinari hypochrysea* (32.50), *Blighiawel witschii* (22.63), *Rinorea* sp. (21.90), *Diospyros simulans* (20.90) and *Uapaca guineensis* (19.31) (Table 3).

Table 2. List of the first 10 most important families (in bold) in terms of FIV by grouping.

Familyspecies	FIVI global	G1	G2	G3
Fabaceae-Caesalpinioideae	**26,74**	**20,51**	**23,79**	**35,91**
Clusiaceae	**21,37**	**50,62**	5,66	7,82
Euphorbiaceae	**17,08**	**16,54**	**17,22**	**17,47**
Meliaceae	**15,05**	**19,32**	**11,85**	**13,99**
Annonaceae	**14,06**	**11,88**	**18,62**	**11,67**
Strombosiaceae	**13,02**	**12,96**	**18,04**	8,05
Olacaceae	**12,89**	**16,65**	**17,27**	4,75
Fabaceae-Papilionoideae	**12,73**	3,89	8,61	**25,69**
Malvaceae	**11,27**	5,2	**17,81**	**10,79**
Flacourtiaceae	**11,25**	8,88	10,73	**14,13**
Irvingiaceae	10,86	**15,81**	10,25	6,53
Anacardiaceae	9,90	**14,63**	3,39	11,67
Ixonanthaceae	9,77	1,52	**18,02**	---
Moraceae	9,24	4,56	8,34	**14,83**
Violaceae	8,69	---	**12,25**	5,12
Ebenaceae	8,65	4,33	**13,44**	8,17
Rubiaceae	7,72	3,63	7,12	**12,42**
Sapindaceae	6,74	**9,38**	6,59	5,96
Fabaceae-Mimosoideae	6,16	5,09	4,42	**8,96**

Table 3. List of the most abundant first ten species (in bold) in term of IVI per grouping.

Scientific names	G1	G2	G3	MeanIVI
Garcinia lucida	**116,83**	--	--	**116,83**
Ochthocosmuscalothyrsus	--	**61,60**	--	**61,60**
Calpocalyxdinklagei	--	--	**46,89**	**46,89**
Klainedoxamicrophylla	**43,14**	--	--	**43,14**
Oxystigmaoxyphyllum	--	**40,31**	--	**40,31**
Parinarihypochrysea	--	--	**32,50**	**32,50**

Blighiawelwitschii	**28,88**	**19,32**	**19,70**	**22,63**
Rinoreasp.	--	**36,41**	07,39	**21,90**
Diospyrossimulans	--	**36,29**	05,23	**20,76**
Uapacaguineensis	**43,16**	05,12	09,64	**19,31**
Oubanguiaafricana	**28,45**	03,94	**22,57**	18,32
Garcinia mannii	**26,81**	11,90	11,89	16,87
Garcinia staudtii	**31,96**	--	01,56	16,76
Gilbertiodendrondewevrei	--	03,12	**29,88**	16,50
Drypetessp.	09,68	**26,35**	10,49	15,51
Santiria trimera	**34,48**	02,00	08,55	15,01
Treculiaobovoidea	07,94	02,40	**33,82**	14,72
Greenwayodendronsuaveolens	--	**20,05**	08,32	14,19
Sorindeiagrandifolia	**31,14**	04,30	04,96	13,47
Lepidobotrysstaudtii	**31,17**	03,55	03,17	12,63
Cynometrasanagaensis	04,01	--	**19,18**	11,60
Oncobaglauca	05,81	**23,15**	01,69	10,22
Elaeisguineensis	--	02,56	**17,12**	09,84
Strombosiascheffleri	04,34	**22,22**	01,69	09,42
Homaliumletestui	04,55	04,73	**18,58**	09,29
Diogoazenkeri	03,90	**22,00**	01,51	09,14
Homaliumsp.	06,72	03,79	**13,68**	08,06

Phyto-geographic patterns

The flora of the both studies areas are composed essentially of species within endemic regional centers of guineo Congolese (GC), Southern Guinea (BG), Guinean (G) and Centro-guineo-congolese (CG) forests. These results reflect those obtained in the flora composition above indicating the most important species. These include *Garcinia lucida (IVI* = 116.83), *Ochthocosmus calothyrsus* (61.60), *Calpocalyxdinklagei* (*IVI* = 46.89), *Klainedoxa microphylla* (43.14) and *Oxystigmaoxyphyllum* (*IVI* = 40.31). *Garcinia lucida, Calpocalyxdinklagei* and *Klainedoxa microphylla* are endemic to the guineo-congolese center, *Ochthocosmus calothyrsus* represents the low guinea center and *Oxystigmaoxyphyllum* is found in the Centro-guineo-congolese area.

There is a clear dominance in guineo-congolese region with a gross spectrum of 86.11% and an average spectrum of 89.5% of the total population.
Widely distributed species and related species are poorly represented; theseresults are similar those value obtained by Lubini (2001) in Democratic Republic of Congo. The analysis of table 4 reveals an unequal representation of species between the guineo-congolese (GC) elements and the southern-guinea (BG) and guineans (G) elements with 133, 65 and 39 species respectively. Western guinean (WG) and southwestern cameroonian species (SW-Cam) present small percentages of two and one species respectively.

Table 4 indicates the phytogeographical distribution of plant species in the two study areas translated mainly three chorological types. It was observed that mainly endemic species present exclusively in Africa and Malagasy Island were found and these represent almost the total flora of these study areas.

Species with a large geographical distribution (Beina, 2011) found in various areas in the world contribute 8% of the flora in these regions followed by linking species that characterize transitions zones with centers of endemic species contributing about 6% of the flora.

Table 4. Global analysis of phytogeographical distribution for species types observed in both site.

	TP	Number of species	T/species	T/Individuals	Gross spectrum (%)	Weighted spectrum (%)
Species with a large geographical distribution (LDI)	AnT	1	26	384	8,2	5,71
	AM	1				
	AA	2				
	AT	19				
	Pal	1				
	Pan	2				
Endemic species (EEN)	BG	65				

	BGC	6				
	CG	27				
	GC	133	273	5751	86,11	89,5
	G	39				
	SW-Cam	1				
	WG	2				
	GC-SZ	8				
Linking species (ELI)			18	290	5,73	4,11
	GC-Z	10				

Based on the chorological types (BG, BGC, CG, GC, and G), the flora of these areas is made up of 86% species having guineo-congolese characteristics. This guineo-congolese chorological status is confirmed by the zoning proposed by White (1979). The flora of these areas is present above the gradient of Guineo-congolese affinity according to the description of Senterre (2005). This is justified by the following classification Mbaiki forest (56%), Okoroba and Yingui forests (86%), Dja Biosphere Reserve (RBD) (88%), National Park of Monte Alen (92%) and Ndoté Reserve (95%) (Beina, 2011). Flora of Okoroba and Yingui forestsis characterize by a percentage of guineo-congolese species overlapping between Mbaiki and RBD. According to Senterre (2005), the percentage of guineo-congolese endemism increases as towards the sea. This assertion is not verified here, because Okoroba and Yingui forests are probably closer to the sea than the RBD. This phenomenon could be explained by the relatively high rate of species of other chories, which represent a total of 14% species of linkage and species with a wide geographical distribution.

Moreover, based on the guineo-congolese species, Okoroba and Yingui forests would have a fairly high proportion of species as a semi-deciduous forest. However it should be noted that guineo-congolese species are better represented in the forests studied. Such a level of endemism is paleo-climatic, aspointed by Maley (1996) there exist forest refuges where the convergence of ideas of the great majority still suffers from the relevance of this concept.

Chorological types

Modes of dissemination have been determined for the types of diaspores, the gross and the chorological spectra of slide types of all groups are recorded in table 5. This table shows that the sarcochore type gathers the largest number of species (58.99%) and the best cover (63.45%) in front of the ballochore and pterochore types. The other types, although been present, are poorly represented in both spectra. The smallest proportions are recorded by pogonochore type with 1.26% of the gross spectrum and 0.51% of weighted spectrum.

Table 5. Analysis types of dissemination in the three groups.

Types	Number of species	Number of individuals	Gross spectrum (%)	Weighted spectrum (%)
Ballochores (Ballo)	42	889	13,25	13,83
Barochores (Baro)	34	476	10,73	7,4
Pogonochores (Pogo)	4	33	1,26	0,51
Ptérochores (Ptéro)	40	844	12,62	13,13
Sarcochores (Sarco)	187	4077	58,99	63,45
Sclérochores (Scléro)	10	106	3,15	1,64
Total	317	6425	100	100

Table 6. Gross and weighted spectra and diaspora types.

Diaspores types	G1	G2	G3	Pvalue
Ballochores	6,82±1,61 ^{a}	10,56±3,18^{ab}	14,06±2,16^{b}	0,0155
	3,41±1,97 ^{a}	6,73±3,88 ^{a}	17,07±6,43^{b}	0,014
Barochores	11,62±3,58	8,84±0,89	8,79±1,46	0,158
	6,36±2,19	8,05±5,92	11,98±7,55	0,507
Pogonochores	0,44±0,625	1,62±0,63	1,39±1,00	0,318
	0,08±0,10	2,78±2,38	6,79±10,38	0,537
Pterochores	6,63±1,87	11,87±1,46	12,19±2,98	0,055
	2,09±0,10	12,92±11,54	16,15±5,59	0,146

Sarcochores	63,93±2,80 [a]	67,57±19,02 [a]	96,88±2,49 [b]	0,0035
	82,95±5,02[b]	26,37±25,51[a]	38,17±16,36[a]	0,023
Sclerochores	3,35±1,52	3,87±4,11	2,11±0,747	0,553
	1,24±0,87	2,81±2,48	8,29±9,51	0,39

The first line represents the gross spectrum while the second line represents the weighted spectrum. Following each line different letters indicate a significant difference at the 5% threshold.

Looking at table 6, it is noticed that only ballochores and sarcochores diaspores are statistically significant. However, gross spectrum of ballochores species of G1 and G3 are found to vary significantly while between G1-G2 and G2-G3 show no difference. Concerning the sarcochores species, there is significant difference between G1-G3 and G2-G3, while G1-G2 do not vary significantly for P<0, 05. The primacy of species which made up the sarcochore diasporesin the forest formations have been emphasized by several authors. Howe (1984) cited by Doucet (2003) suggests that in paleotropical forests, 35 to 48% of trees that occupy the highest peaks of the forest are zoochores and 70 to 80% occur in the inferior strata. Moreover, Evrard (1968) notes that the fleshy diaspores, in this case the sarcochores, are the most frequent in most of the undergrowth. Kouka (2000) indicates the prevalence of zoochoryfound between 70 and 78% in this type of formation in Congo. In Cameroon, Sonké (1998) emphasizes the importance of sarcochores diaspores, which account for almost 83% of all species.

Conclusion

This work constitutes the first result of a series of research undertaken in order to enrich knowledge or evidences on the biodiversity of atlantic forests.The most diversified genus is *Cola* (9 species) followed by *Diospyros* (6 species). Fabaceae-Caesalpinioideae (43 species) are the most diverse in terms of species. With regard to IVI, *Garcinia lucida*is the most important specie with *(IVI* = 116.83). The high level of diversity and specificity of group three indicates its priority in conservation area. However, the decision concerning the delimitation of this sector for conservation is based on a compromise between the economic and environmental interest of the studied areas. Further research is required to determine the conservation status and the level of endemism of these forests. In order to achieve this, it would be important to increase the sampling size by integrating other forests of the sub region that are part of this massif.

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