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Floristic Structure and Diversity of a Tropical Sub-Montane Evergreen Forest, In the Mbam Minkom Massif (Western Yaoundé)

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Abstract

The aim of this work was to study the floristic structure and diversity of the sub-montane forest of the Mbam minkom massif of Yaoundé region, in order to establish its structure and its features in relation to the other submontane forests of Africa and Madagascar, and Neotropical zones.

We listed all plant species of evergreen sub-montane forests on the upper summits of 12 hills (1000 to 1295m) of the Mbam minkom massif. An area of 0.5 ha was inventoried per hill, using randomly 5 surfaces 25 × 40m (0.1 ha) plots, of a total area of 6 ha. Ligneous plants (≤1 cm diameter at breast height) were inventoried:

- 324 vascular species, 65 genera and 42 families were recorded;
- 150 herbaceous species;
- 122 shrubs 1≤ dbh < 10cm;
- 146 ligneous species 10cm ≤ dbh.

The species-accumulating curves showed a high diversity in the category 10cm ≤ dbh than those of shrubs 1 < dbh >10 cm. The minimal area was reached at 5.5 ha inventoried.

For the category 10 cm ≤ dbh, stem density was 544 stems ha^{-1} and basal area 52.72 m^2 ha^{-1}.

Species diversity as measured by Shannon diversity index was 4.95. Most species (67, at least 77%) were common (densities > 1 stem ha^{-1}), and widely distributed among hill forests (36, at least 41%). *Gacinia lucida* is the species having the highest IVI value (58.52) and *Clusiaceae* the family having the highest FIV value (60.01), is mesothermal. The forest is also marked by the abundance of *Sterculiaceae, Burseraceae, Myristicaceae, Meliaceae, Oleaceae, Leguminosae, Annonaceae, Apocynaceae* and *Olacaceae*. These are megathermal families (or hydromegathermal) that present their maximum occurrence at the basal and average altitudes.

The Mbam minkom submontane forest presents the features of an ecotone. The hydromegathermal families such as *Leguminosae* present relative density and basal area indices that decrease with altitude. The hydromesothermal families as *Clusiaceae* find there their ecological preferendum with relative density and basal area indicesthat increase upto 1295m. The hydro-oligothermal families as *Rubiaceae* show relative density and basal area indices that increase with altitude. This increase goes along with increasing cold weather. The family with 15 species comes behind the *Orchidaceae* (20 species) when the herbaceous species are taken into consideration in denumbering of the diversity. This unique forest massif is not yet endangered but needs to be conserved as a priority.

Keywords: Forest inventory, Mbam minkom massif, Plant diversity, Submountane forest, Western Yaoundé, Cameroon

1. Introduction

The Mbam minkom chain (3°52'-4° N latitude, 11°20'-11°27' E longitude) constitutes a morphological unit of the Yaoundé massif, oriented South-West to North-East and situated at 10km on the western side of Yaoundé city. It is formed of hills associated in ranges of juxtaposed and unequal altitudes. It is entirely covered with a continuous forest of low and middle altitudes and a non continuous submontane forest, at the summits from 900m of altitude and above. This last constituted the delimitation of the present survey. The submontane rainforest occupies the high hill summits (Letouzey, 1985).

The massif is characterised by remarkable feature such as:

- Its relative continentality. The massif is situated at 200km from the Atlantic coast. Thus, the monsoon flux reaches it already relieved of a high quantity of its humidity (Suchel, 1972);

- Its volumetric and altitude importance; effect of mass elevation (Massenerhebung) (Steenis, 1935-36) capable of enabling highland altitudinal plant species, to live at lower altitude on reliefs of little importance;

- Its relief of juxtaposed hills (the altitude varying continually between 800 to 1295m) (fig. 1C);

- Its proximity to the zones of clouds and mists: ''Nebelwalds'' (Engler, 1908); mist forest (Letouzey, 1985);

- Its geographical location between the equatorial climate on the South, Zamengoué side; and the tropical climate of the North, Okola side.

Numerous studies on biodiversity have been achieved in the African, Malagasy and neotropic forests of low and middle altitudes (Villanueva, 1991 ; Spichiger et al., 1992, 1996 ; Lejoly, 1995; Rabevohitra et al., 1996 ; Lejoly, 1996; Gesnot et al., 1996; Collin, 1998; Sonke, 1998; Collin, 1998; Rakotomalaza and Messmer, 1999; D'amigo and Gautier, 2000 ; Senterre et al., 2004 ; Senterre, 2005). The studies made in submontane rainforests in Cameroon are phytogeographic studies (Letouzey, 1968, 1985; Achoundong, 1985, Tagne, 2007; Madiapevo, 2008; Noumi, 2012) and phytosociologic (Noumi, 1998). But no research has yet established the qualitative and quantitative synthetic data, of the Mbam Minkom.

Around the massif and in low and middle altitudes, a high proportion of this forest type has been destroyed due to subsistence agricultural expansion. There is no severe ongoing anthropogenic pressure on the forest inside the massif because it is located in sites less accessible for agriculture and is therefore undisturbed. Investigating population dynamics and structural characteristics of Mbam Minkom sub-mountane forest can provide insights into the responses of that forest to the climate componenent contrasts and the environmental changes as variation in altitude. Is it possible to establish its particular quantitative and qualitative indices?

The objective of this survey was to establish the forest type in order to appraise forest dynamics and assess plant demography at the time of the study using a census on hill summits considered as plots. An inventory of vascular plants was conducted on 12 summits of hills located in the 1000-1295m altitude in the Mbam Minkom massif, to assess species richness and diversity, stem densities and basal area. We compared the floristics and structure of the studied forests to those of other sites and to the SacredSecrad Forest Kouaghap, on an isolated summit, located 200km further West in the higher plateaux of Cameroon.

2. Study area

The massif of Mbam minkom (3°52'-40 N latitude and 11°20'-11°27' E longitude), is constituted by rocky domes (Mbam Minkom in Ewondo language), that is part of the granulites of Yaoundé, dated 604 millions years (Nzenti, 1987). It is located 10km west of Yaoundé city (figure 1).

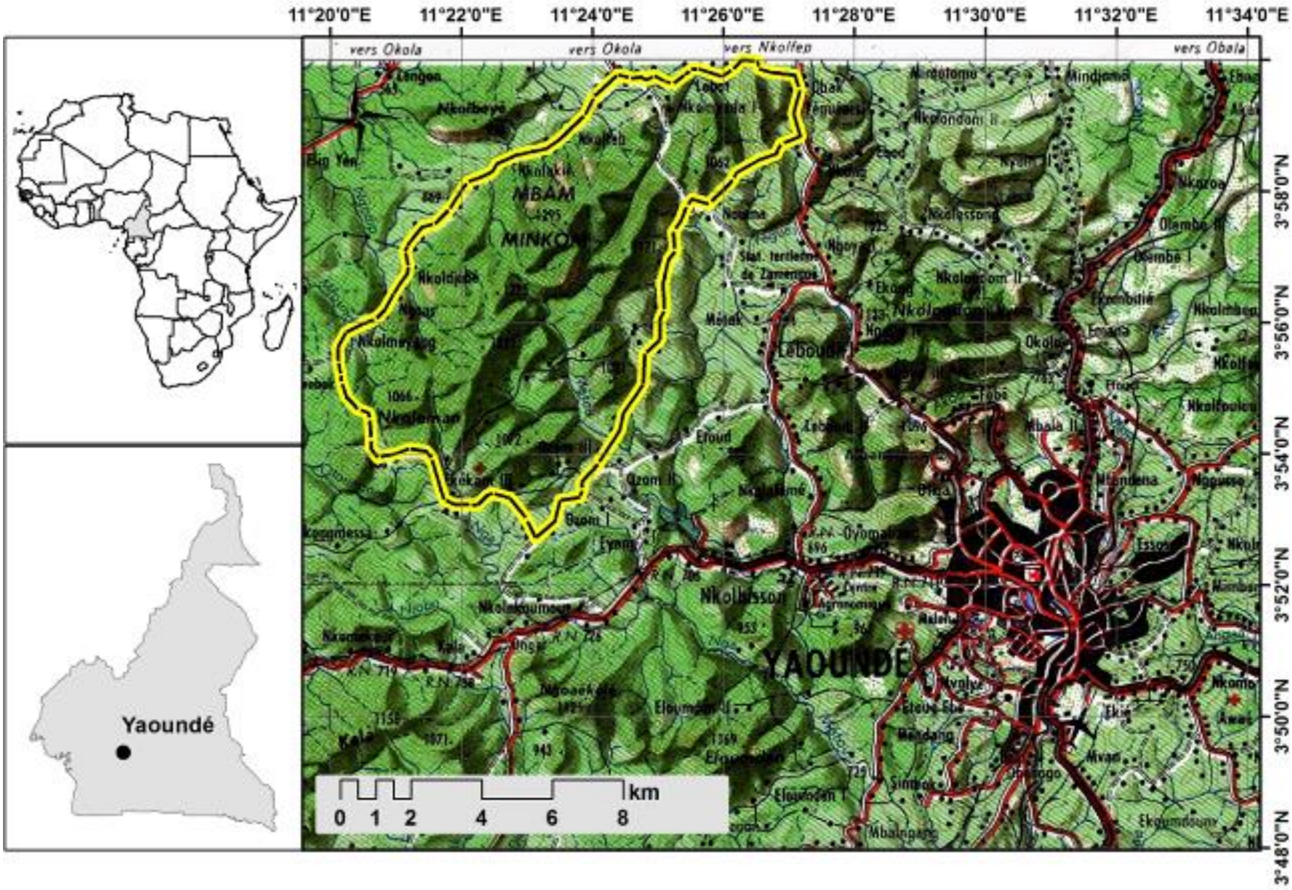

Figure 1. Base map of the Mbam Minkom massif, Western Yaoundé. Its perimeter is delimited in yellow line. (Excerpt of the Yaoundé topographic map 3D, 1/50,000, by Dr Pr Sonké Bonaventure).

The massif of Mbam Minkom is a catchment where many streams take their rise: Some (Ya, Jobé and Lekié) empty into the Sanaga River and others (Osso, sondolo and Mefou) empty into the Nyong River (Figure 2). The massif is formed of the hills that culminate between 1015 and 1295m (Figure 2 and 3).

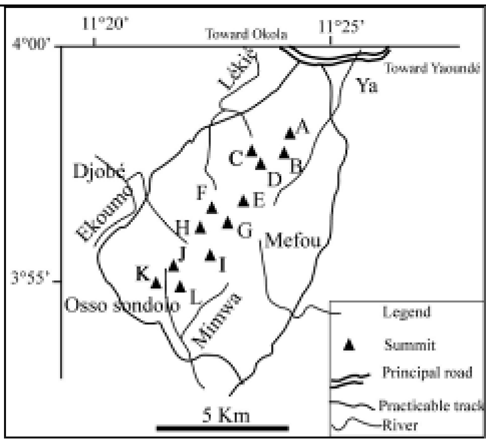

Figure 2. Localization of the 12 sampled hills (5000 m^2 sampled by hill). A: Nkolfeb (1177m of altitude), B: Mbem Minkom (1171m), C: Nkolakié (1185m), D: Mbam Minkom (1295m), E: Zoabissima (1120 m), F: North Odou (1076m), G: South Odou 1225m), H: Nkoldjobé (1181m), I: Mbikal (1221m), J: North Nkolobot (1105m), K: Nkoloman (1060m), L: South Nkolobot (1015m).

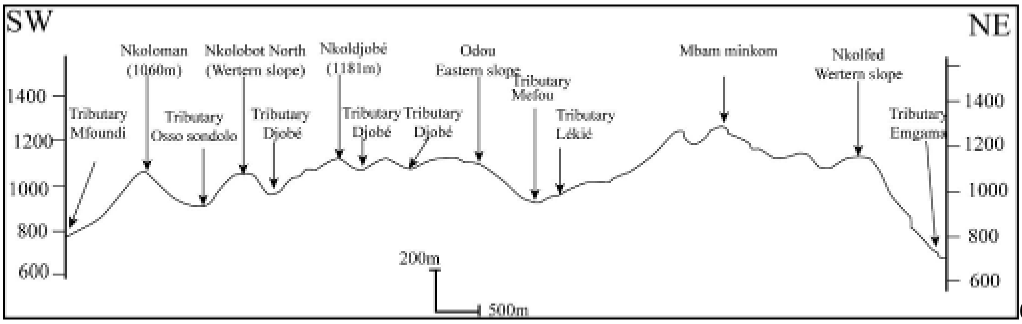

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Figure 3. Topographic profile passing by Nkoloman and Mbam minkom (by Dr Njonfang Emmanuel, Associated Professor).

Source of information: Map of Yaoundé 3D, 1/50,000).

The climate in the study area is hot and humid with temperatures ranging from 23 to 25 °C and an average of 23.8 °C. Cloud was frequent from December to February. Mbam minkom receives most of its rain from the SW monsoon. The mean annual rainfall was around 1605mm at Yaoundé, but could be more in the study area due to its geographical situation, its altitude and the forest. The dry season lasts about 3 months (Figure 4). The relative humidity reaches 79.6% on average per annum. The climate is subequatorial with equatorial tendency, of the western subtype with small accentuated dry season (Suchel, 1972). Current disturbance is minimal except for hunt of the small vertebrates and the harvest of the non woody forestry products, sold in the local markets.

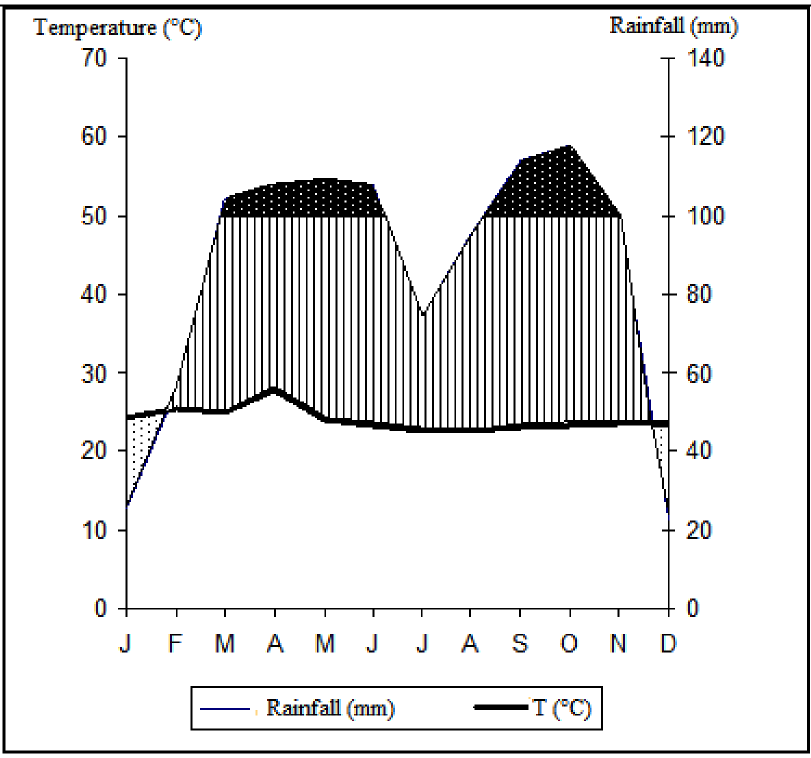

Figure 4. Ombro-thermic diagram. Curve of the monthly mean of rainfalls [scale reduced to 1/10 from 100mm, grey part, according to the Walter and Lieth (1964) method of monthly mean temperatures. Data obtained from the Meteorological Station of Yaoundé (Military Airport), 1991 to 2005. There are no monthly mean values of rainfall and temperature in Mbam minkom, but these values are assumed to be closest to those of the Military airport of Yaoundé Station, situated 10 km to eastern side.

3. Methods

Field work was conducted from November 2007 to December 2010. The inventory was done using 0.5-ha plot per summit for 12 hills. That surface was constituted of 5 subplots (25 x 40m) (0.1 ha), laid randomly within each summit and were considered as sampling units. On that surface all vescular plants were collected, ligneous with a diameter at breast height of at least 1cm, were taken into account. For each tree ≥ 10cm dbh, diameter was measured. Specimens of most of the individuals were collected

The total area sampled was 6 ha. All plants were inventoried in 12 summits of hills on 5000m^2 per hill, divided into rectangular quadrats (25 x 40m subplots) and the number of species in each tallied. All plant herbaceous and ligneous plant species of ≥1cm dbh (diameter at breast height) were collected and identified. The sampling in the forested hill summit was terminated when the species-accumulation curve reached an asymptote. The plant specimens were identified by comparing with already identified species using various floras (Aubréville, 1963-1997, 1962-1998; Hutchinson and Daziel, 1954-1972) and specific document (Vivien and Faure, 1985). Nomenclature followed Lebrun and Stork (1994-1998). Identification of sample specimens was confirmed at the National herbarium of Cameroon (YA). Herbarium specimens were deposited at Department of Biological Sciences, Higher Teachers' Training College of the University of Yaoundé I.

From the original data, we calculated the density of trees and basal area. To assess forest structure, (a) all vascular plant were grouped in families and (b) trees were grouped in diameter classese. The results were plotted in histograms.

Using standard methodology (Curtis and McIntosh, 1951; (Cottam and Curtis, 1956), Mori et al., 1983), the following parameters were calculated. At specific and family level: relative density and relative dominance; at specific level only: relative frequency; at the family level only: relative diversity. From these data, Impartance Value Index (IVI) and Family Importance value (FIV) were calculated for species and families respectively.

In order to construct species-area curve, the number of additional species determined in each consecutive sub-sample unit (40 x 50m, five times on each summit) was plotted against surface increment.

The sampling in the larger rain forest was terminated when the species-accumulation curve reached an asymptote. It has clearly been demonstrated that comparisons of diversity between strata must take in account the sampling effort expressed in terms of number of tallied individuals (Condit et al., 1996).

Species-individual curves were constructed exactly as were species-area curves: the number of additional available species count in all the plots was plotted on Y-axis, but instead of the horizontal axis (X-axis) we used the cumulative number of individual in creasing order.

The floristic diversity was considered in a synthetic manner through the main physiognomic and phytogeographic spectres. The Biologic Types (BT) were distinguished according to the classification of Raunkiaer (1934), done by Schnell (1970) and the species were designated as: mesophanerophyte, 10-30m high (Msph); microphanerophyte, 2-10m (Mcph); nanophanerophyte, 0.4-2 m (Nnph); ligneous phanerophyte climbing (Phgr). Information pertaining to the geographical distribution of each species was obtained from the literature (Schnell, 1970; Letouzey, 1985; White, 1983). The phytosociologic units (PU) are based on the classification of Lebrun and Gilbert (1954), the works of Noumi (1998) and of the synthesis of Schmitz (1988).

4. Data Analysis

For the floristic analyses, all the data were pooled and the total number of species and individuals were tallied. Using the pooled data the overall species richness, genera and family level richness, were calculated. For $1 \leq$ dbh < 10cm, stem densities 0.5-ha^{-1}, species diversity and basal area (m^2 ha^{-1}) were calculated. The dominant species were considered to be those that were the most abundant in the inventory, and the dominant family was that represented by the most number of stems.

The number of summits in which each species was recorded was determined and the frequency of occurrence ranges from 1 to 12 with a frequency of 12 indicating that the species was recorded in all the hill summits.

Basal area was calculated using the formula: $(dbh)^2 *(\pi/4)$. Basal area was calculated using the dbh values for the main stem (trunk) and not for low branches.

To measure the specific diversity from a list of species, the Shannon diversity index (*H')* was then used (Shannon & Weaver, 1948).

$$H' = -\sum Ni/N \log_2 Ni/N$$

where Ni is the strength of the species "i" and N the strength of all species. It is expressed in bits.

5. Resultats

5.1 Floristic Composition

A total of 324 species (herbaceous species in Appendix 1, and ligneous species in Appendix 2, including one not identified were recorded. The nomenclature follows Lebrun and Stork (1991-1997).

The authors of the scientific name appear in appendices 1 and 2. These species are regrouped into 32 genera and 95 families. The richest families are the *Orchidaceae* represented by 20 families, the *Rubiaceae* and *Euphorbiaceae* (13 species each), *Annonaceae* and *Leguminosae* (*Fabaceae*, *Caesalpiniaceae* and *Mimosaceae* together with 12 species each).

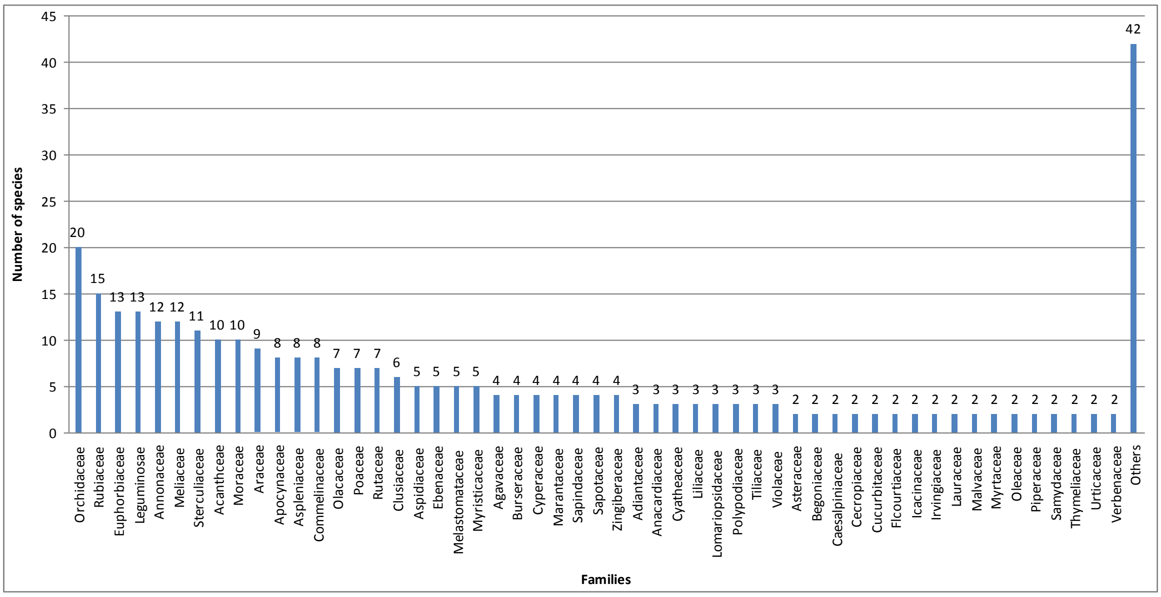

Figure 5. Specific diversity of some families counted in the survey of the Mbam Minkom submountane forest. The numbers of recorded species are indicated for every family. Others = 42 families with 1 species each.

The distribution of species number according to families shows a reversed J-shaped curve (Figure 5). The species counted in Mbam Minkom belong to 19 different biological types regrouped into 4 morphological types. In a general manner, there is an arborescent trees domination (148, at least 45%) and shrubby species (56, at least 17%). The proportion of liana species (19, at least 5%) is lower although the lianas mark the forest by their stems that rise until the plug of some big trees. The last morphological type, the herbaceous (100, at least 30%), is well represented on the soil (h; 60, at least 18%), on the trees (ep; 28, at least 8%) and in the soil (gr; 21, at least 6%) (Figure 6).

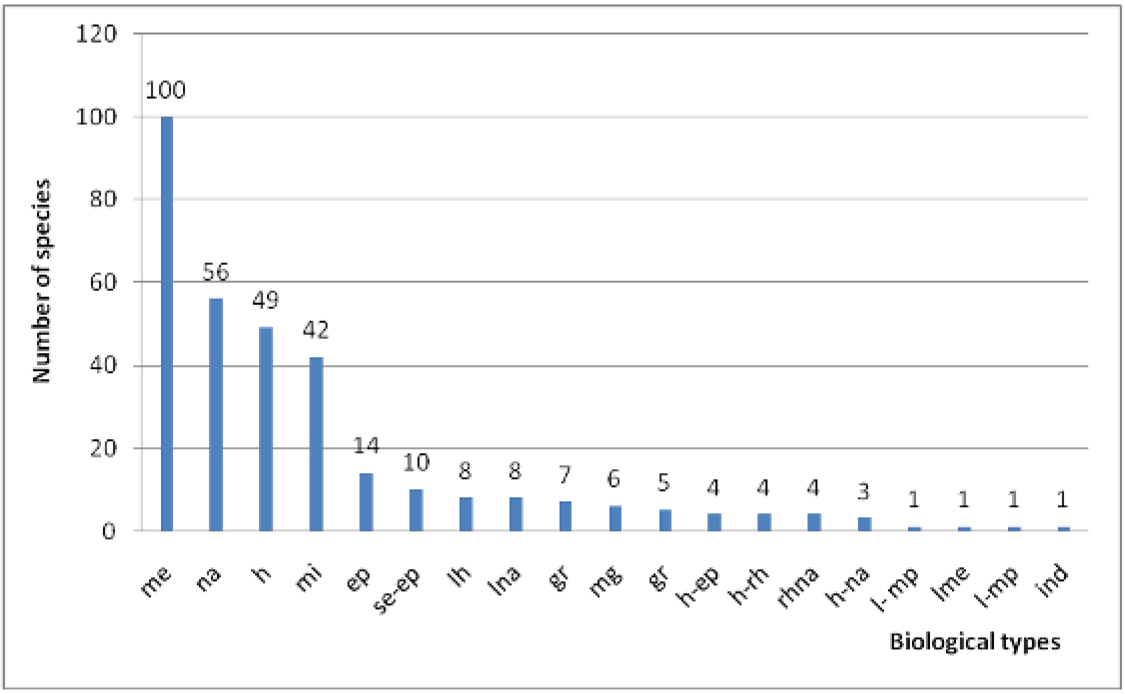

Figure 6. Biological types of the species counted in the Mbam Minkom submountane forest. The numbers of recorded species are indicated for every biological type.

Legend of Figure 6.

Life-form types	Abbreviation	Life-form types	abbreviation
Epiphyte	Ep	Liana-megageophyte	l-mp
Geophyte-rhizome	Gr	Liana- nanophanerophyte	lna
Herbaceous	H	Mesophanerophyte	me
Herbaceous- epiphyte	h-ep	Mega-geophyte	mg
Herbaceous- nanophanerophyte	h-na	Microphanerophyte	mi
Herbaceous-rhizome	h-rh	Nanophanerophyte	na
Indeterminate	Ind	Rhizome-nanophanerophyte	rh-na
Liana- herbaceous	Lh	Semi- epiphyte	se-ep
Liana	L		

The inventory of all plants 1cm ≤ dbh and herbaceous species recorded in 12 hill summit forests of total area 6-ha in the Mbam Minkom submontane forest. The adopted methodology enabled the denumbering of 324 species on the 6-ha sampling site, giving an appreciation of the diversity of the forest. Among these species, 153 over 254 were herbaceae (Table 1).

Table 1. Number of species, genera and families of morphological types in the submontane forest of Mbam Minkom. The density of the woody type individuals is also indicated.

	All species, (herbaceous and ligneous)	All herbaceous species	All ligneous species			Ligneous species in different forest stages		
Variables			dbh ≥1 cm	Shrubs, 1≤ dbh<10 cm	dbh ≥10 cm	dbh ≥1 cm stictement <10 cm	dbh ≥10 cm without shrubs	dbh ≥10 cm with shrubs
Species richness	324	153	171	122	146	25	49	97
Number of genera	65	52	125	91	109	23	46	74
Number of families	42	34	51	40	41	18	27	29
Shannon index (*H'*)					4.96			
Total area sampled (ha)	6	6	6	6	6	6	6	6
Number of individuals			6621	3357	3264	236	177	3087
Stem density (stems ha-1)			1103.5	559.5	544	39.33	29.5	514.5
Basal area of main trunk (m2 ha-1)			54.36	1.64	52.72	0.07	8.01	44.71

5.2 Sampling (1 ≤ dbh < 10cm) on 6 Hectares

The realization of a sampling by plots as done in the present survey is then generally unavoidable. The species individual curves were constructed for the 4 categories of the dbh: 1cm ≤ dbh ≤ 10cm for the bushes and 3 others for the trees (Figure 7). The observation of the slope at the origin of the curve shows a faster growth of the number of species of the lower strata of the woody curve 10 ≤ dbh. The woody curve 70cm ≤ dbh hardly reaches a level of the landing. The curve of the bushes presents a transverse growth that cuts the curve 30 ≤ dbh < 70cm and describes a landing always below the one of the category 10 ≤ dbh < 30cm, in spite of the high number of individuals (3357).

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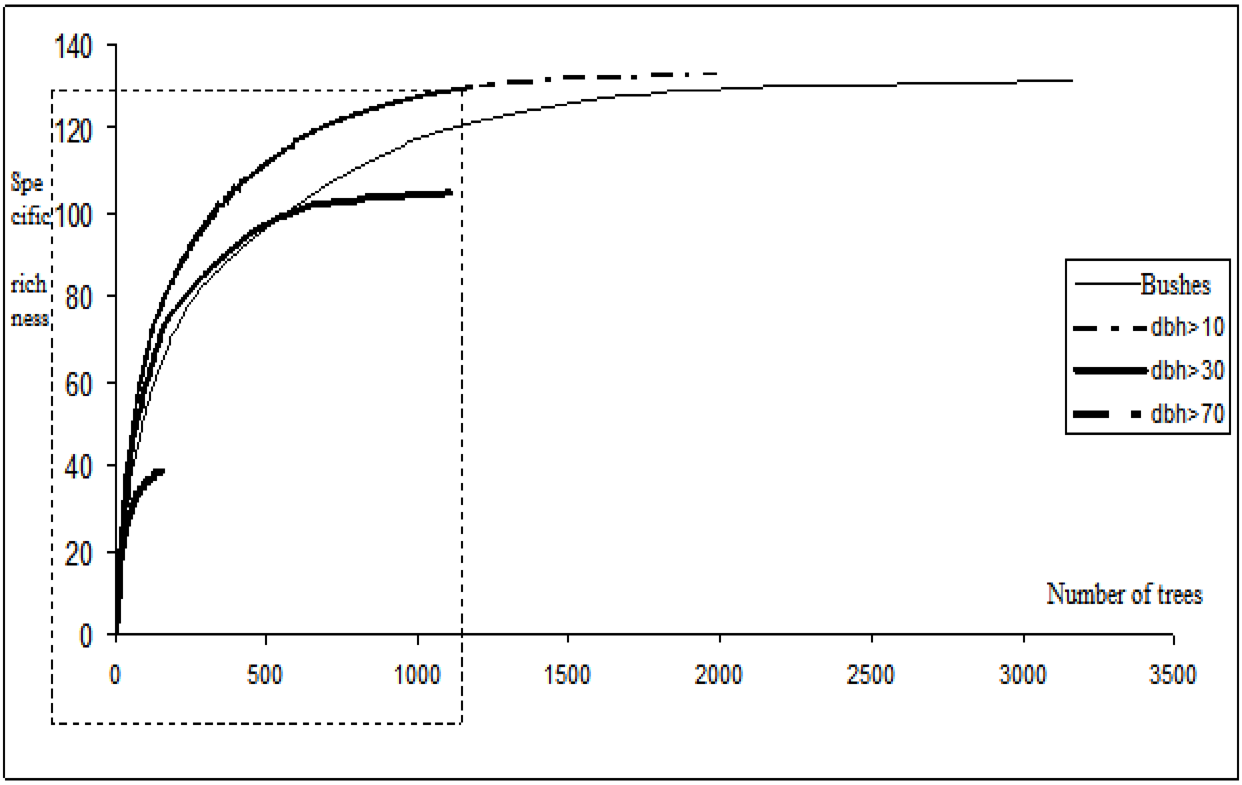

Figure 7. The species individual curves drawn for the bushes (1cm ≤ dbh < 10cm) and for the category of dbh> 10cm, on the entirety of inventories relative to the two categories.

The number of species (1 ≤ dbh < 10cm) taken in the inventory on 6-ha is 40, with 3357 individuals (at least 559.5-ha^{-1}) (Table 1). The basal area is 6.59 m2 (at least 1.6 m^2-ha^{-1}). Among them 25 species don't have any representatives in the category 10cm ≤ dbh. The most abundant are *Treculia acuminata* (77, at least 2% of bushes), *Penianthus longifolius* (at least 0.6%), *Dicranolepis disticha* and *Guarea glomerulata* (at least 0.5% respectively). In the category dbh > 10cm, 49 species do not have any representatives among the bushes, contrary to the 97 others that have at least a representative among the bushes. At least 56% of bushes belong to 5 species: *Garcinia lucida* (at least 38%), *Drypetes parviflora* (at least 5%), *Garcinia mannii*, *Tabernaemontana crassa* and *Beilschmiedia obscura* (at least 4% respectively). The inventory provides information on regeneration of the main forest species, throughout the young plants 1cm ≤ dbh < 10cm and also the gregarious tendency in that forest storey.

5.3 Sampling (10 ≤ dbh) on 6 Hectares

B1. Structure

The number of species (10 ≤ dbh) taken in the inventory on a 0.5-ha plot, varied from 32 to 57 with a mean value of 49.9 species per plot. The basal area is 316.81m^2 (at least 52.8 m^2/ha). Considering tree diameters, the maximum dbh are 132 and 137cm, values attained by 2 individual trees *Terminalia superba* and *Trilepisium madagascariense*. However, such values remain rare if the sampling was made only on 1 ha. In the 6-ha taken in the inventory, 1,247 individual trees occurred in the 10 to 20cm dbh class-size. Altoghether, 99% of trees were less than 100cm dbh (Appendix 1). Distribution in dbh classes showed an inversed J-shaped curve (Figure 8).

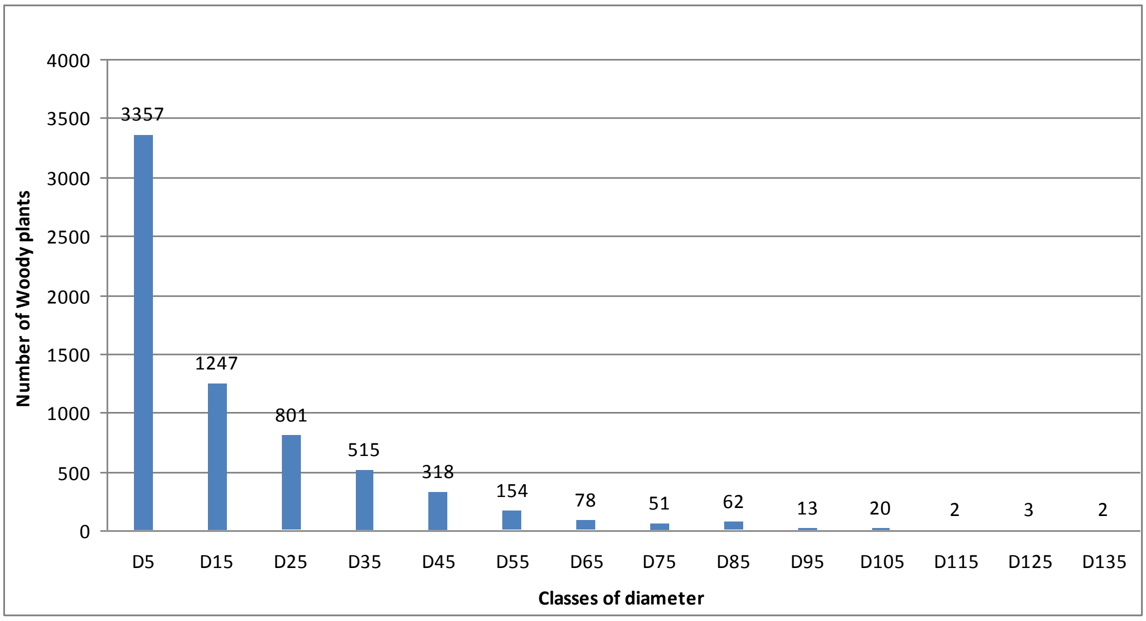

Figure 8. Distribution of trees in 10cm dbh interval size classes. The numbers of recorded individuals are indicated for every size class. On the x-axis, D15 signifies the mean diameter of the class of diameter 10-20cm.

B2. Floristic Composition

Family level – Forty-one families were recoeded in the 6-ha sampling, treating *Caesalpiniaceae*, *Mimosaceae* and *Papilionaceae* as a single family (*Leguminosae*). The ten most important familes for each relative parameter and FIV are listed (Table 3). The value of each relative parameter, for ten families with the highest FIV are represented in Figure 9. The complete results for each family are given in Appendix 3.

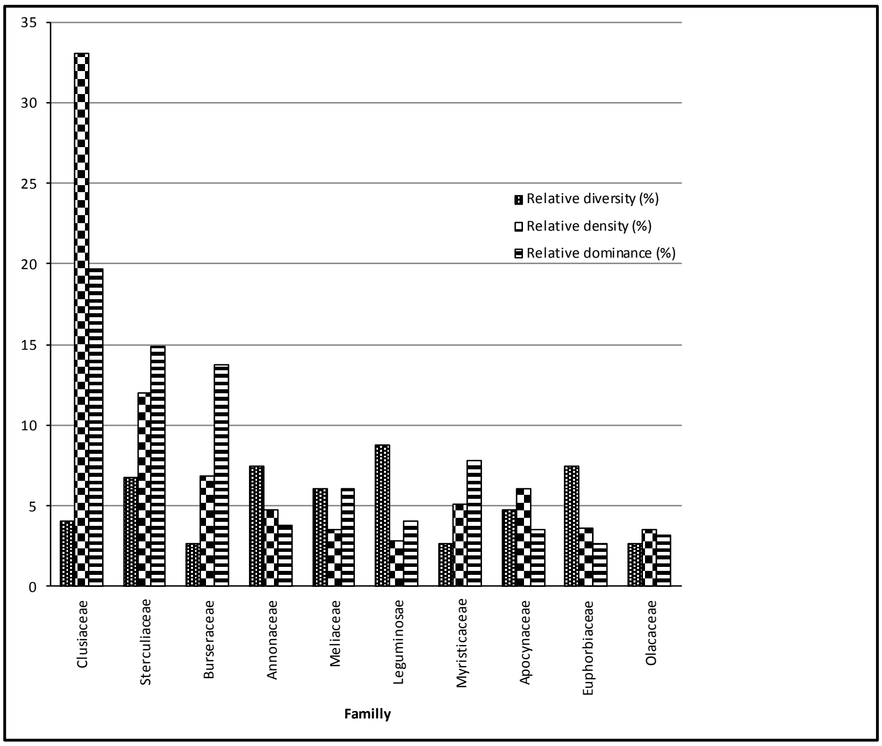

Fig. 9. Relative diversity, relative density and relative dominance of the ten most important families in FIV.

Regarding relative density, the ten must abundant families were

Clusiaceae, Sterculiaceae, Burseraceae, Apocynaceae, Myristicaceae, Annonaceae, Euphorbiaceae, Olacaceae, Meliaceae, Leguminosae. Clusiaceae accounts for 34.83% of all individuals. The density of *Sterculaiceae* exceeds 12%, while those of all the other families do not reach 7%.

Families with highest dominance are *Clusiaceae, Sterculiaceae, Burseraceae, Myristicaceae, Meliaceae, Oleaceae, Leguminosae, Annonaceae, Apocynaceae* and *Olacaceae.* Together they accounted for 81.59% of all trees censored in the sampling. *Clusiaceae, Sterculiaceae* and *Burseraceae* are clearly the must abundant families; together they contributed 53.75% of all trees censored in the sampling.

The ten most species-rich familes are *Leguminosae, Annonaceae, Euphorbiaceae, Sterculiaceae, Meliaceae, Clusiaceae, Apocynaceae, Moraceae, Rubiaceae* and *Ebenaceae*. The relative diversity of *Leguminosae* (13 species) represented 8.8% of the total diversity of the sampling. 20 families are represented by a single species, 6 by two species, 2 by 3 species and 6 by four species

Regarding Family Importance Value (FIV), *Clusiaceae* were the most important family in the sampling, with an FIV of 59.92 (Table 2). They also had the highest relative density and relative dominance values. When comparing FIV and the 3 relative values of the ten most important families, only *Clusiaceae, Sterculiaceae, Leguminosae, Annonaceae, Meliaceae* and *Apocynaceae* appeared among the first ten families for all parameters. *Burseraceae, Myristicaceae* and *Olacaceae* had high density and dominance values but they were presented by only 4 species, while *Euphorbiaceae* had high density and species-rich values and droped to 10th in relative dominance. Considering relative diversity, three families, *Moraceae, Rubiaceae* and *Ebenaceae,* had rather high values and accounted for 11.64% of total species-richnees, but they were represented by a few individuals and dropped to positions 14, 16 and 26 respectively, in relative dominance. Thus, they were not among the 10 families with the highest FIV Table 2).

Table 2. Families with highest values of relative diversity, relative density, relative dominanace, and FIV, in descending order. Families that do not rank among the ten most important in the FIV value appear in italic.

Relative density		Relative dominance		Relative diversity		FIV	
Clusiaceae	34.81	Clusiaceae	20.34	Leguminosae	8.84	Clusiaceae	59.92
Sterculiaceae	12.03	Sterculiaceae	14.94	Annonaceae	7.48	Sterculiaceae	33.77
Burseraceae	6.89	Burseraceae	13.83	Euphorbiaceae	7.48	Burseraceae	23.44
Apocynaceae	6.12	Myristicaceae	7.86	Sterculiaceae	6.80	Annonaceae	16.03
Myristicaceae	5.14	Meliaceae	6.13	Meliaceae	6.12	Meliaceae	15.77
Annonaceae	4.75	Oleaceae	5.10	Apocynaceae	4.76	Leguminosae	15.74
Euphorbiaceae	3.64	Leguminosae	4.08	Clusiaceae	4.76	Myristicaceae	15.72
Olacaceae	3.55	Annonaceae	3.80	Rubiaceae	4.08	Apocynaceae	14.48
Meliaceae	3.52	Apocynaceae	3.59	Moraceae	4.08	Euphorbiaceae	13.80
Leguminosae	2.82	Olacaceae	3.24	Ebenaceae	3.40	Olacaceae	9.51

Species level–146 species were recorded in the sampling. Table 7 lists the ten most important species in each parameter. The value of each parameter for the ten species with the higher IVI is represented in figure 10. Appendix 4 gives the results of all species.

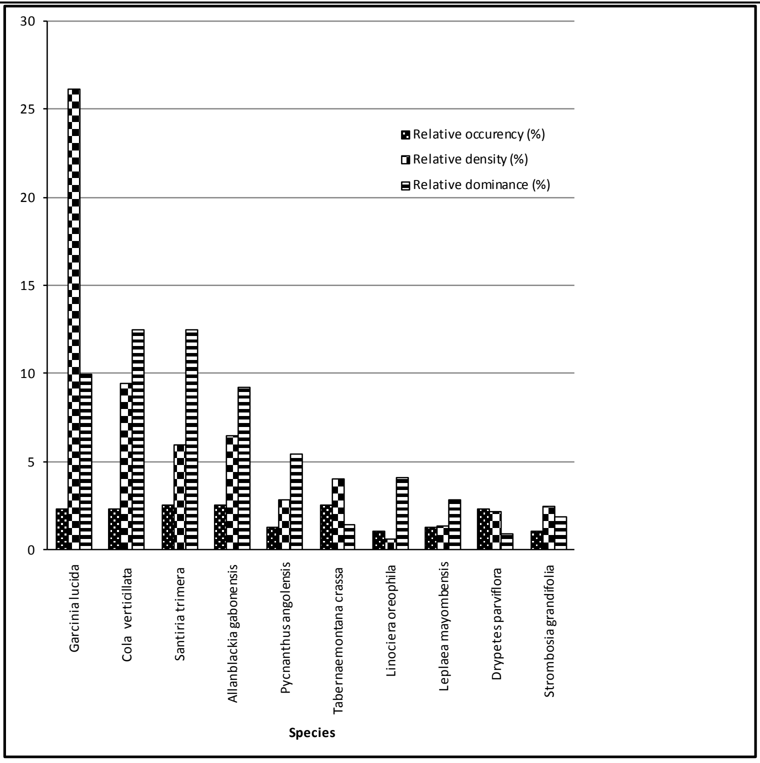

Fig. 10. Relative occurnce, relative density and relative dominance of the ten most important species in IVI.

A very small group of species dominated the sampling: 5 species (3.4% of total number of species) accounted for 52.11% of all trees. The majority of species (63.9%) were represented by less than 5 individuals, 15 species were represented by 2 individuals and 30 by a single individual. Regarding relative dominance about 6 (4%) of the species contributed 53.72% in relative dominance.

Anonidium mannii is 10th in relative dominance and 10th in relative density but dropped to position 13th in relative occurency. Thus it is not among the first ten species with the highest IVI (Table 3).

Table 3. Species with the highest values of relative frequency, relative density, relative dominanace, and IVI in descending order. Underlined: species that do not occur among the ten important in IVI.

Relative occurency [x 100%]		Relative density [x 100%]		Relative dominance [x 100%]		IVI [x 300%]	
Santiria trimera	2.57	Garcinia lucida	26.15	Cola verticillata	12.48	Garcinia lucida	38.49
Allanblackia gabonensis	2.57	Cola verticillata	9.43	Santiria trimera	12.48	Cola verticillata	24.27
Tabernaemontana crassa	2.57	Allanblackia gabonensis	6.52	Garcinia lucida	9.99	Santiria trimera	21.02
Garcinia lucida	2.36	Santiria trimera	5.97	Allanblackia gabonensis	9.23	Allanblackia gabonensis	18.32
Cola verticillata	2.36	Tabernaemontana crassa	4.04	Pycnanthus angolensis	5.46	Pycnanthus angolensis	9.59
Drypetes parviflora	2.36	Pycnanthus angolensis	2.85	Linociera oreophila	4.08	Tabernaemontana crassa	8.01
Beilschmiedia obscura	2.36	Strombosia grandifolia	2.48	Leplaea mayombensis	2.85	Linociera oreophila	5.79
Myrianthus libericus	2.14	Drypetes parviflora	2.14	Terminalia superba	2.15	Leplaea mayombensis	5.51
Gambeya lacourtiana	1.93	Garcinia mannii	1.68	Strombosia grandifolia	1.85	Drypetes parviflora	5.42
Carapa grandifolia	1.93	Anonidium mannii	1.62	Anonidium mannii	1.83	Strombosia grandifolia	5.40

Figure 11 shows the species-area accumulating curve for the sampling. It follows a classical acumulation curve. The slope decreases and the curve reached an asymptote in about 5.5 ha (11 plots). Neverthless in plots, additional species were regularly encountered. In this massif the mesologic variations lay to uncertain inevitable fluctuation and determine a discreetly rich forest. The critical survey (having for aim to distinguish the quality and the shortcomings) reveals the large original and fundamental floristic uniformity of the summits of the hills, at the sub-montane storey.

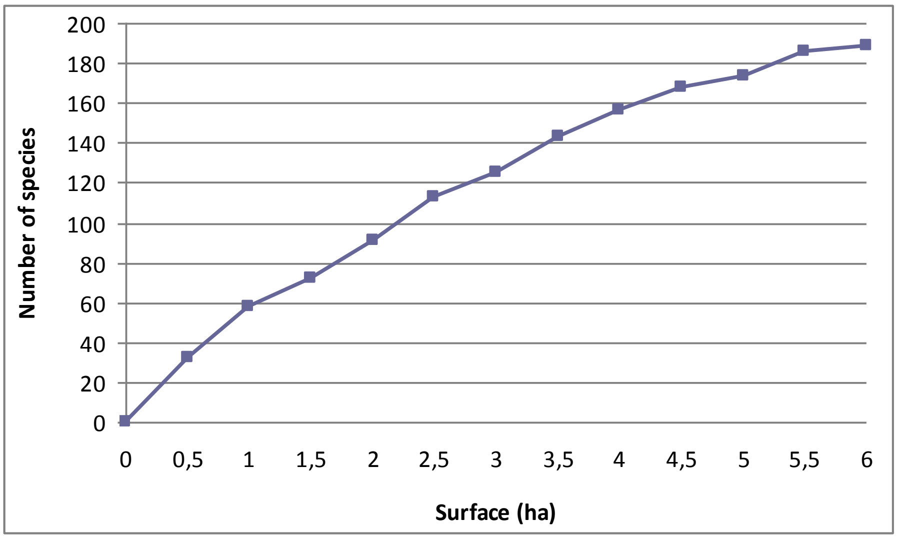

Figure 11. Species-area accumulating curve of the 6-ha sampling in the Mbam Minkom submontane area. Each sub-unit is represented by a 0.5-ha plot. Average: 563/12 = 49.9 species per ha.

Phytogeographic Affinities

Of the 146 dbh > 10 cm species recorded in the study area, 139 were identified to specific level (95.2%), repesenting 96.4% of the number of individuals and 97.4% of basal area. The known distribution of theses species is given in Table 4. The phytogeographic affinities of species recorded falls within 2 majors distribution patterns (Guineo-congolese species and widespread ones).

They revealed that (a) 77.3% were widely distributed in both the major sub-regional centers (upper and lower Guineo-Congolian). The wide spread species were seen throughout the Soudano-Zambezian region (in the savannah) (6.8%), in tropical Africa (6.1%) or shared by many distant domains: Aam (1.3%), Pan (3/146%) and Pal (1.3%). Table 3 shows the proportion of species according to to major distribution patterns, their number and their basal area percentages.

Table 4. Phytogeographic affinities of the identified species of the Mbam Minkom submontane sampling.

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Phytogeographical spectre	Main patterns	Species, 146 (%)		Individuals		Basal area	
		number	%	Number	%	Surface	%
widespread species	Aam	2	1.3	28	0.8	0.98	0.3
	At	9	6.1	32	0.9	4.05	1.2
	G-Sz	10	6.8	124	3.7	11.07	3.4
	Pal	2	1.3	5	0.1	0.45	0.1
	Pan	3	2	10	1.3	1.43	0.4
	Total	27	18.4	199	6	17.98	5.6
Guineo-congolian species	Cg	43	29.4	1706	52.2	122.26	38.6
	G	70	47.9	1242	38	168.08	53.1
	Total	113	77.3	2948	90.2	290.34	91.7
	Indet	6	4.4	117	3.5	8.02	2.5
	total all	146	100	3266	100	316.34	100

Aam (Afro-American), At (Afro-Tropical), Cg (Centro-Guineo-Congolian), G (omni or sub-omni Guineo-congolian), G-Sz (Guineo-Sudano-zambezian), Pal (Paleotropical), Pan (Pantropical)

Altitudinal Variation Affinities

The heights establish the altitudinal preferendum of the species. They are divided into Low and middle altitudes (Bm), Submontane altitude (Sm) and humid Montane altitude (hM). Only the intermediate combination between two successive types of the pressure gradient is generally feasible for species of liaison (Senterre, 2005, Noumi, 2012). In the Mbam Minkom sub-mountane floor, some of the species (6 species; at least 4%) are highlander and at least 14% Submountane; this later repesenting 57.7% of the number of individuals and 56.1% of basal area.

Table 4. Altitudinal variation affinities of the identified species of the Mbam Minkom submontane sampling.

Altutudinal variation types	main patterns	Species, 146 (%)		Individuals, 3266/6ha (%)		Basal area, 316.34/6 ha (%)	
lowland and average altitude species	Bm	83	56.8	939	28.7	110.73	35
	Bm/Sm	30	20.5	287	8.7	18.88	5.9
	Total	113	77.3	1226	37.5	129.61	40.9
Total submountain species	Sm	15	10.2	940	28.9	127.53	40.3
	Sm + hM	6	4.1	945	28.9	50.25	15.8
	Total	21	14.3	1885	57.8	177.78	56.2
mountain species	Mi	6	4.1	36	1.1	0.93	0.3
	Indet	7	4.7	117	3.5	8.02	2.5
	Total all	146	100	3266	100	316.34	100

Bm (lower and middle altitudes), Bm + Sm (low and medium altitudes going up to Sm), Sm (Submountane altitude), Sm + hM (Submountane going up to hM), h M (lower highlander, (strong hygrometry).

Ecosociological Affinities

Regarding phytosociologic aspect, the different taxa are shown in Table 5. A Strong proportion of the species (42.4%) belongs to the rainforests (*Strombosio-Parinarietea sensus larto*). The other species are features of the semi-decideous forests (*Piptadeniastro-Celtidetalia* (33.5%), secondary forests (9.5%) and of swamp planitiary forests (*Mytraginetea*) (6.8%).

Table 5. Altitudinal variation and phytosociologic affinities of the identified species of the Mbam Minkom submontane sampling.

Altitudinal floor	Lowland strata				Submountane floor	lower mountane floor (high hygrometry)		
Phytogeographic affinities				Bm, Bm + Sm	Sm, Sm + Hm	hM	hM	Sm and hM
Phytosociologic classes		*Musango-Terminalietea* Lebrun and Gilbert 1954	*Mitragynetea* SCHMITZ 1963	*Strombosio-Parinarietea* Lebrun and Gilbert 1964 (sensus stricto = 9 species)				
Phytosociologic ordern	*Piptadenio-Celtidetalia* Lebrun and Gilbert 1954			*Gilbertiodendretalia dewevrei* Lebrun and Gilbert 1954	*Garcinietalia* Noumi 1998	*Ficalhoeto-Podocarpetalia* Lebrun and Gilbert 1954	*Polyscietalia fulvae* Lebrun and Gilbert 1954	Oleo-Jasminetalia Lebrun and Gilbert 1954
Species Number	49	14	10	29	19	5	1	3
% species according to total species	33.5	9.5	6.8	19.8	13	3.4	0.6	2

Strombosio–Parinarietea Lebrun and Gilbert 1954 rainforests subdivided into 3 orders: *Ficalhoeto-Podocarpetalia* Lebrun and Gilbert 1954, montane rainforest; *Garcinietalia* Noumi 1998 (Gar), submontane rainforest and *Gilbertiodendretalia dewevrei* Lebrun and Gilbert 1954, equatorial lowland rainforests. *Mitragynetea* Schmitz 1963, edaphic forests link to hydromorphic soils; *Musango-Terminalietea* Lebrun and Gilbert 1954, secondary forests; *Piptadeniastro-Celtidetalia* Lebrun and Gilbert 1954, mesophile forests; *Polyscietalia fulvae* Lebrun and Gilbert 1954, montane secondary forest. *Oleo-Jasminetalia* Lebrun and Gilbert 1954, Sclerophyll montane and submontane forests.

6. Discussion

The comparisons between the data obtained from this survey and those of other rainforests concern the structural parameters as well as floristic, qualitative and quantitative compositions. The goal was to determine the type of forest (submontane/montane) with which the Mbam Minkom forest has the most affinity.

Structure

About species individual curves (Figure 11). At the level of the strata one notes a decrease of the number of individuals as the diameter classes increase, in a sampling of 6 ha: $10 \leq$ dbh < 30 cm (2048 individuals), $30 \leq$ dbh < 70cm (1063), 70cm $\leq$ dbh (153). Condit et al. (1996, 1998) and Senterre (2005) admitted that an effort of sampling of 90-120 individuals is already representative of the plant community of the stratum concerned and constitute the best compromise in any case between homogeneity and representativeness (maximal effort). The information above (reduced to the hectare) is representative of the studied plant community. The shrubs although more abundant, are less varied on the area of same value and on the entirety of the inventory.We deduce from this observation that there is no need to consider the shrubs in the survey of the biodiversity.

Density

We counted a total of 324 vascular plant species among which were 150 herbaceous species, 171 dbh $\geq$ 1cm woody and 146 dbh $\geq$ 10cm woody, on the entire 6 hectares studied. In the dbh $\geq$ 10 cm category we counted 3264 individuals, re-evalued at 544 feet per ha. This density of 544 trees ≥ 10cm dbh is within the range of 167 to 1947 trees per hectare reported by Gentry (1982) for Neotropical forests sampled by different methods. Rollet (1983) estimated that the relative density in tropical forests around the world averages 552 trees/ha (dbh ≥ 10cm). The plots set in high elevation rainforest of Western Cameroon (Noumi, 2012, 2013) and Nigiri Indian (Mohandass and Davidar, 2009) recorded a number of trees (dbh ≥ 10cm) at 763, 1269.2 and 832 trees per hectare, respectively (Table 6). The comparison with woody plant inventories of tropical rainforests sampled in various continents showed that tree density seemed to have a similar range of variation throughout the world with however a tendency toward a rise, in densities in high altitude forests (Table 6).

The numbers of individuals recorded 10 ≤ dbh < 20cm are of 1247 for 6 ha, either 207.8/ha at Mbam Minkom, 267 at Scio (Nusbaumer et al., 2005). The value found at Mbam Minkom and the distribution of the observed diameter classes is typical of a forest in good state of conservation with a good capacity for regeneration (Rollet, 1979). At Mbam Minkom individuals in the 1 ≤ dbh < 10cm range reached a density of 559.5 per ha against 544 for the dbh ≥ 10 cm. The undergrowth is then very congested. The forest shows then 1103.5 individuals/ha and their distribution by diameter size classes confirm the absence of lumbering in the studied zone.

Table 6. Number of trees per hectare (dbh ≥ 10 cm) in Mbam Minkom forest, in lowland and highland rainforests sites in Africa, Madagascar and Neotropic regions.

Sites	Countries	References	Number of trees/ha
Low elevation rainforests sites			
National Park of Odzala (layon Andzoyi)	Congo	Lejoly, 1996	294.7
Lopé (site 1)	Gabon	White, 1992	304
Classified forest of Scio	Côte d'Ivoire	Nusbaumer et al., 2005	413
Bees forest	Gabon	Gesnot, 1994	458
Jenaro Herrera	Peru	Spichiger et al., 1996	482
Forest with *Cleistopholis patens* and *Ficus mucuso*	Benin	Sokpon, 1995	494
Forestry Reserve of Dja (Alat 1.7)	Cameroon	Sonké, 1998	513
Ngovayang forests	Cameroon	Gonmadje et al., 2011	532
Forest of Ngotto	Centrafrican Republic	Lejoly, 1995	549
Yapo (unfloodplain forest),	Côte d'Ivoire	Corthay, 1996	649
Alto Ivon,	Bolivia	Boom, 1986	649
Yasuni (unflooded forest),	Ecuator	Balslev et al., 1987	728
Lowland rainforest in Manongarivo	Madagascar	D'Amico and Gauthier, 2000	728
Andranomintina (plot 1),	Madagascar	Rabevohitra et al., 1996	1223
High elevation rainforests sites			
Mbam minkom sub-mountane forest	**Cameroon**	**Present study**	**544**
Manengouba forest	Cameroon	Noumi, 2013	763
SacredSecrad forest Kouoghap	Cameroon	Noumi, 2012	1269.2
Shola montane evergreen forest	Nilgiri, India	Mohandass and Davidar, 2009	832

The basal area (54.36 m^2 ha^{-1}) is more elevated than the values found in the lowland tropical rainforests sites (Table 7), the highest value being 51.9m2. (Mori et al., 1983). The highest basal areas are found in the highland rainforests of Asia (Mohandass and Davidar, 2009) and Cameroon:

90.36 m^2 ha^{-1} at Kouoghap (Noumi, 2012); 61.69 m^2 ha^{-1} at Manengouba (Noumi, 2013). At high altitude, the rainforests are populated by middle size and mesothermic individuals in the overhead stratum (20-25m) and even less so in the most elevated altitudes (Lebrun & Gilbert, 1954). We observed that this reduction of size is compensated by a renewal of trunk size with the consequence of 27 trees reaching diameters of 120 to 140 cm on an average basal area 4.32m^2 ha^{-1} among others. These large trees are *Terminalia superba, Trilepisium madagascariense, Santiria trimera* and *Lovoa trichilioides*. The same situation is observed in the Kouoghap forest where 28 individuals have diameters between 100 to 140 cm onan average basal area of 12.9 m^2 ha^{-1} covered by *Dracaena arborea* (Willd.) Link, *Vitex grandifolia* Gürke, *Canarium schweinfurthii* Engl., *Syncepalum cerasiferum (*Welw.) T. D. Penn., *Xylopia staudtii* Engl. & Diels, *Lovoa trichilioides* Harms, *Funtumia africana (*Benth.) Stapf, *Piptadeniastrum africanum* (Hook. f.) Brenan (Noumi 2012). In the Manengouba forest 5 individuals reach diameters of 100 to 120 cm on a basal area of 4.6 m^2 ha^{-1} covered by *Polyscias fulva* (Hiern) Harms, *Carapa grandiflora* Sprague, *Schefflera barteri* (Seem.) Harms (Noumi 2013).

Table 7. Basal area per ha (dbh $\geq$ 10cm) in the Mbam Minkom forest, lowland and highland rainforests, in Africa and other tropical rainforests sites.

Site	Country	Reference	basal area (m²)
Low elevation rainforests sites			
Manongarivo	Madagascar	D'Amico and Gauttier,2000	22.4
Jenaro Herrera	Peru	Spichiger et al., 1996	22.6
Andranomintina (plot 2)	Madagascar	Rabevohitra et al., 1996	25.3
Andranomintina (plot 1)	Madagascar	Rabevohitra et al., 1996	27.9
Scio Classified forest	Côte d'Ivoire	Nusbaumer et al., 2005	30.82
Yasuni (unflooded forest)	Ecuator	Balslev et al., 1987	33.7
Dja Forestry Reserve (Alat 1.7)	Cameroon	Sonké, 1998	34.2
Ngovayang forests	Cameroon	Gonmadje et al., 2011	34.6
Yapo classified forest	Côte-d'Ivoire	Corthay, 1996	40.0
Cleistopholis patens and *Ficus mucuso* forest	Benin	Sokpon, 1995	42.3
Bahia	Brazil	Mori et al., 1983	51.9
High elevation rainforests sites			
Shola montane evergreen forest	Nilgiri, India	Mohandass and Davidar, 2009	53.55
Mbam Minkom sub-moutane forest	**Cameroon**	**Present study**	**54.36**
Manengouba forest (Mbouroukou)	Cameroon	Noumi, 2013	61.69
SacredSecrad Forest Kouoghap (Kouoghap 1)	Cameroon	Noumi, 2012	90.36

Floristic Composition

Family level

In the surface sampled, more than 53.7% of all trees were represented by 3 families *Clusiaceae, Sterculiaceae* and *Burseraceae* (Table 3). Similar results were recorded in littoral forests along Madagascar's coast, where more than 50% of total trees were always represented by 4, 5 or 6 families (Rabevohitra et al., 1996).

According to Gentry (1988), family composition of lowland forests of the tropics tends to be similar. He lists 11 families (*Leguminosae, Lauraceae, Annonaceae, Rubiaceae, Moraceae, Myristicaceae, Sapotaceae, Meliaceae, Arecaceae, Euphorbiaceae* and *Bignoniaceae*) that contribute half of the species' richness to 0.1 ha samples in lowland Neotropical forests. A dissimilar result is observed in the submontane and montane forests.The richer species of Mbam Minkom submontane floor are

Clusiaceae, *Sterculiaceae*, *Burseraceae*, *Apocynaceae*, *Myristicaceae*, *Annonaceae*, *Euphorbiaceae*, *Olacaceae*, *Meliaceae* and *Leguminosae*. They contribute 83.27% of the species' richness on a 6-ha area sampled.

The next families *Annonaceae, Apocynaceae, Burseraceae, Clusiaceae, Euphorbiaceae, Leguminosae, Meliaceae, Moraceae, Sterculiaceae* and *Rubiaceae* are the ten most abundant families for relative diversity in the surface sampled (Table 3). Sixteen plant families (40%) were represented by only 1 species and among these, five (12.5% of total families) by only one individual. These families seemed to be much less abundant in the study area. The same scarcity of for example *Alangiaceae*, *Arecaceae* and *Ochnaceae,* in the SACRED FOREST OF Kouoghap secrad forest was recorded with a value of 41.3% (Noumi, 2012).

Table 8. The fifteen most abundant families in the Mbam Minkom submontane forest and 5 forests of altitude (altitude of suvey indicated). For PN Obo only the first 12 abundant families were reported (data available).

P.N. Mt. Alen	Kala Forest	Mbam minkom	FS Kouoghap	Manengouba forest	P.N Obo
Van Reeth (1997)	Madiapevo [40]	Present study	Noumi (2012)	Noumi (2013)	White (1983)
Alt. 350-1200 m	Alt. 1000-1156 m	1000-1265m	Alt. 1400-1550 m	2000---2295 m	Alt. 0-2024 m
Euphorbiaceae	Myristicaceae	Clusiaceae	Rubiaceae	Myrsinaceae	Rubiaceae
Burseraceae	Clusiaceae	Sterculiaceae	Meliaceae	Rubiaceae	Apocynaceae
Leguminosae	Leguminosae	Burseraceae	Moraceae	Euphorbiaceae	Flacourtiaceae
Olacaceae	Annonaceae	Apocynaceae	Bignoniaceae	Araliaceae	Meliaceae
Myristicaceae	Rubiaceae	Myristicaceae	Apocynaceae	Meliaceae	Euphorbiaceae
Meliaceae	Sterculiaceae	Annonaceae	Sapotaceae	Opiliaceae	Sapindaceae
Rubiaceae	Meliaceae	Euphorbiaceae	Leguminosae	Thymelaeaceae	Sapotaceae
Flacourtiaceae	Apocynaceae	Olacaceae	Euphorbiaceae	Cyatheaceae	Clusiaceae
Annonaceae	Burseraceae	Meliaceae	Araliaceae	Rutaceae	Olacaceae
Apocynaceae	Euphorbiaceae	Leguminosae	Clusiaceae	Rosaceae	Ulmaceae
Clusiaceae	Moraceae	Rubiaceae	Annonaceae	Melianthaceae	Annonaceae
Sapindaceae	Bignoniaceae	Sapotaceae	Verbenaceae	Sapindaceae	Burseraceae
Ebenaceae	Irvingiaceae	Sapindaceae	Sterculiaceae	Moraceae	
Ulmaceae	Flcourtiaceae	Cecropiaceae	Burseraceae	Asteraceae	
Sapotaceae	Combretaceae	Anacardiaceae	Olacaceae	Oleaceae	

The comparison of the taxonomic information of the Mbam Minkom forest, with those of others of similar inventories, sampled in Guinean zone (Table 9) enabled the raising of the abundant families of the submontane forest to the level of the low, middle montane altitudinal forests. The studied forest can be characterized on the basis of the two families, distinguished by their fidelity and their abundance: *Clusiaceae* (189.5 individuals/ha for the ligneous dbh $\geq$ 10cm) and *Sterculiaceae* (65.5 individuals/ha) (Table 5). Other families also show a remarkable abundance: *Apocynaceae* (31.5 individuals/ha) and 5 families of old low Guinean forests with Atlantic characters: *Burseraceae* (37.5), *Annonaceae* (36) and *Rubiaceae* (13.5) (Senterre et al., 2004). These families are largely wispread (Table 8), with the highest values FIV in lowland forests of *Leguminosae* declining in the submontane forests and disappearing in the montane forest. Clusiaceae presents the highest values FIV in the the submontane floor, the preferendum ecologic with many of its species, disappearing also in the montane forests. The values FIV of *Rubiacaeae* are high in the submontane floor and highest montane forests, where the family displaced the family Leguminosae (White, 1983; Mohandass and Davidar, 2009, Noumi, 2013).

Table 9. Family Importance Value of the 15 most important plant families in Mbam Minkom and other Cameroonian altitudinal forests.

Kouoghap (Cameroon, 1550 m) (Noumi, 2012)		Kala forest, 1156 m (Cameroon) Madiapevo [40]		Mbam minkom Forest, 1295 m (Present study)		Manengouba forest, 2295 m (Noumi, 2013)	
Family	FIV	Family	FIV	Family	FIV	Family	FIV
Meliaceae	33.38	*Leguminosae*	31.006	Clusiaceae	60.01	Rubiaceae	56.19

Leguminosae	32.63	*Clusiaceae*	27.900	Sterculiaceae	33.85	Euphorbiaceae	55.71
Moraceae	31.81	*Myristicaceae*	26.804	Burseraceae	23.48	Araliaceae	51.03
Sapotaceae	26.83	*Burseraceae*	21.774	Leguminosae	17.28	Myrsinaceae	49.52
Rubiaceae	26.12	*Sterculiaceae*	21.410	Annonaceae	16.81	Meliaceae	16.06
Bignoniaceae	21.16	*Annonaceae*	18.246	Meliaceae	15.82	Moraceae	8.33
Apocynaceae	19.49	*Rubiaceae*	17.967	Myristicaceae	14.86	Rutaceae	7.95
Euphorbiaceae	15.74	*Meliaceae*	17.838	Apocynaceae	14.52	Cyatheaceae	7.40
Verbenaceae	12.51	*Euphorbiaceae*	15.780	Euphorbiaceae	13.86	Opiliaceae	6.66
Annonaceae	11.23	*Apocynaceae*	13.765	Olacaceae	9.54	Sapindaceae	6.19
Burseraceae	9.65	*Irvingiaceae*	8.180	Rubiaceae	7.73	Thymelaeaceae	5.59
Sterculiaceae	9.33	*Moraceae*	8.132	Oleaceae	7.33	Rosaceae	5.14
Araliaceae	7.70	*Cecropiaceae*	7.923	Moraceae	6.25	Melianthaceae	4.26
Agavaceae	6.83	*Flacourtiaceae*	7.433	Sapotaceae	5.45	Asteraceae	3.14
Clusiaceae	6.66	*Sapotaceae*	7.385	Sapindaceae	5.10	Alangiaceae	3.10

Three groups of families take turns on the slopes on the reliefs, humid and rainy, in the following manner:

The first group is formed by the hygromegathermal families for which the relative density and basal area indices decrease with the altitude: example the *Leguminosae*. This family represents the humid tropical low altitude forest altitudes associated with the hot (megathermal) and humid (hygrophile) sector of the lowlands, up to 800 m of altitude, also called "megathermal and hygrophile floor", (Boullet, 2005). This family generally presents the most elevated FIV values. These values decrease in the submontane altitude and the family stops its ascent.

- The second group includes the hygromesothermal families for which relative density and basal area indices increase rapidly after 800 m. This is the case of the *Clusiaceae*. This family represents the tropical humid submontane forest, or «nephelophile forest” (forest of clouds). It corresponds to the cool and very humid sector of the zone of the large horizontal extension of orographic clouds that crowns the crests and vanishes immediately beyond the summits. The altitude is called «mesothermal hygrophile floor", or «mesothermal nephelophile floor ". The submontane forest with *Garcinia* spp. of Mbam Minkom, enrols itself in this climatic potentiality (Noumi, 1998).

- The third group is constituted of the hygro-oligothermal families of which the relative density and basal area indices increase regularly from the low and middle altitudes to the superior altitudes. Thisis characterised by the *Rubiaceae* family representing the cold and humid sector of the high altitudes, above 1900 m (Noumi, 2013), or “oligothermal hygrophile floor” (Boullet, 2005). It already presents an elevated FIV value (11^{th} on FIV) in the Mbam Minkom massif (Table 9).

Specific level

The study of woody plant species (49.9 species per 0.5ha) of the Mbam Minkom massif enabled us to relativize the number of species by hectare, with those of other inventories based on the same principle. But this comparison is not comfortable for several reasons.

- Variations in the forest inventory types (different surfaces, equal surfaces but different length of trails); differences on the physionomic plan; and between altitudinal and lowland forests). It however agrees on comparing values calculated at the same level of sampling. But for lack of the comparable values, the best thing to do is to compare some species-area cumulative curves (Lejoly, 1996; Collin, 1998). We did it on the basis of the ligneous species 10cm ≤ dbh (Figure 12), for several inventories in Africa. The speciesacred Forest of abundance does not increase proportionally with the sampling effort. The category 10cm ≤ dbh shows a phytodiversity of 58 species/ha at Mbam Minkom. It is higher than those of PN Odzala and Manengouba forest, but low in relation to other comparative forest values.

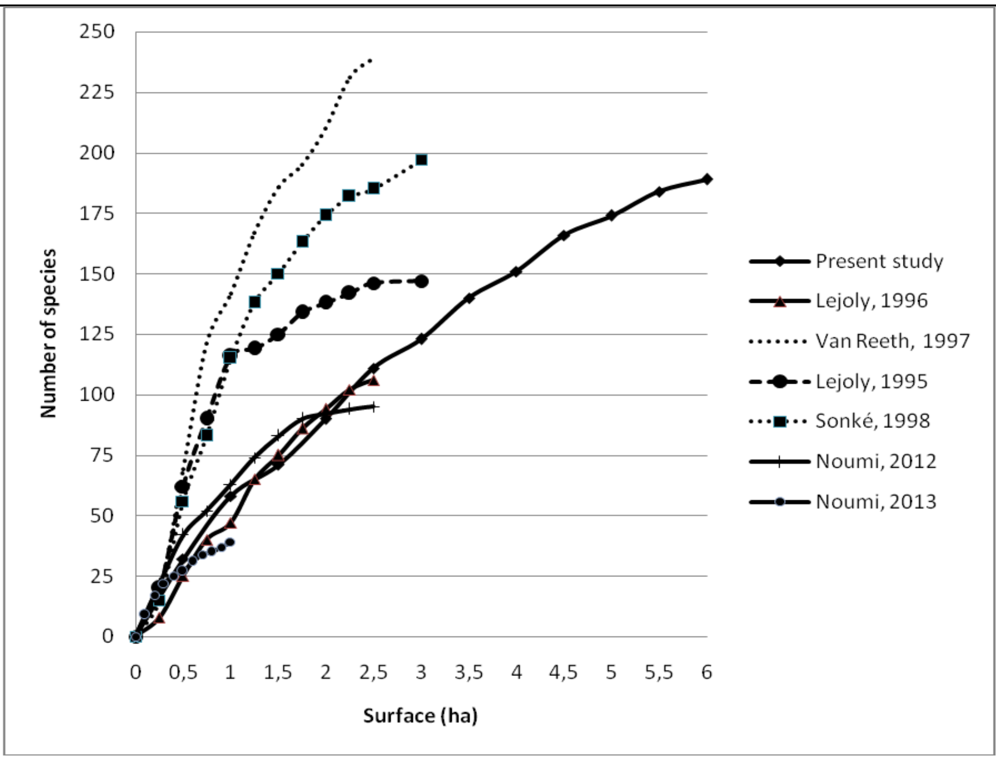

Figure 12. Species/area cumulative curve of the 6-ha sampling in the Mbam Minkom submontane rainforest (for ligneous flora with dbh > 10 cm) in addition to six other species/area cumulative curves of the Atlantic Central Africa forests (Source: Lejoly (1995), Gotto, Bambio LC,1500 m, RCA; Lejoly (1996), PN Odzala, Andzoyi, 400-700 m, Congo; Van Reeth (1997), Monte Alèn, Mont chocolate, 350-1200 m, Equatorial Guinea; Sonké (1998), RF Dja, Alat, 1500-700 m, Cameroon; Noumi (2012), SACRED FOREST OF Kouoghap, R1 sampling 1450-1550 m, Cameroon ; Noumi, (2013), Manengouba, Bouroukou sampling, 2000-2295 m ; Noumi (Present study), Mbam minkom , summit sampling), 1000-1295m).

The diversity index of Shannon (ISH) varies from 3.34 to 4.14 in the forests with gregarious species such as the Lope forest of Gabon (White, 1992), and of 5.24 to 5.46 in the heterogeneous rainforests such as the Dja forest of Cameroon (Sonké & Lejoly, 1998). The observed value (5.45) in the submontane Mbam Minkom forest for all woody species (dbh $\geq$ 10 cm) is therefore relatively elevated, indicating that it is heterogeneous.

Abundance of Taxons

An inventory based on the woody species of the lower stratum (1cm $\leq$ dbh <10cm) enabled the noting of a reduced number of species at the same level of sampling effort than in the 10cm <dbh stratum, and a higher number of woody species (Figure 2A), without having to cover a large surface area (1.64 m^2) (Table 1). It informs in the same way on the main forest species regeneration. Species like *Garcinia polyantha* (146 shrubs/ha), *Garcinia lucida* (61.1), *Drypetes parviflora* (32.5), *Tabernaemontana crassa* (20.3) and *Greenwayodendron suaveolens* (14.6) show a much noticeable abundance of the dbh < 10cm. The demarcation is very similar in the category of the 10cm $\leq$ dbh with *Garcinia lucida* (984 indiviuals/ha), *Tabernaemontana crassa* (18.1), *Drypetes parviflora* (11) and *Greenwayodendron suaveolens* (7.5).

Table 10. Number of species tallied (dbh $\geq$ 10cm) per ha in Mbam Minkom, and other altitudinal rainforests in Africa and other tropical rainforest sites.

Site	Country	Reference	Number of species/ha
Low elevation rainforests sites			

Manongarivo	Madagascar	D'Amico and Gauttier, 2000	90
Scio Classified forest	Côte d'Ivoire	Nusbaumer et al., 2005	89
Dja Forestry Reserve (Alat 1.7)	Cameroon	Sonké, 1998	79
Yapo classified forest	Côte-d'Ivoire	Corthay, 1996	57
P.N Obo	Sao Tomé	White, 1983	40
P.N. Mt. Alen	Equatorial Guinea	Van Reeth, 1997	106
High elevation rainforests sites			
Shola montane evergreen forest	Nilgiri, India	Mohandass and Davidar, 2009	70 (with shrub species)
Mbam minkom sub-moutane forest	Cameroon	Present study	58
Manengouba forest (Mbouroukou)	Cameroon	Noumi, 2013	41
SacredSecrad Forest Kouoghap (Kouoghap 1)	Cameroon	Noumi, 2012	31

Fourty-six species were encoutered in the inventory. The number of species per hectare fluctuates in Cameroon and in the other tropical counties 31 to 106 (Table 10). Generaly high diversity values ares recorded in lowland rainforests, 228 species in one hectare of unflooded forest in the Amanzonian Ecuador (Balsev et al., 1987), and 241 in French Guiana (Mori and Boom, 1987). The diversity value in Mbam Minkom (58 species/ha) seems very low. Lower diversity was also recorded in the high elevation rainforest species of (Table 7), with the lowest in the sacredsecrad forest of Kouoghap where Noumi (2012) found 31 species.

In undisturbed lowland Amanzonian forests of Venezuela, 50% of individuals on average are represented by 20 species (Rollet, 1983), In Monanogrivo, half of the trees are represented by 11 species, 12 species at Andohahela, Madagascar (Rakotomalaza and Messmer, 1999). In the study area more than 50% of individuals are represented by only 5 species due to their gregarism and their development in a biotope where they find their ecological preferandum

Mori et al. (983) considered as rare species those which are found only once in the sample: 20.54% species in the Mbam Minkom forest. At Manongarivo, Madagascar, the percentages of species represented by only one individual was 21.1% (D' Amico and Gautier, 2000), and at Alto Parana (22%) (Spichiger et al., 1992). These data are much closer to the percentage reported in this study. The value is lower than 41% species of the lowland forest of Eastern Brazil (Mori et al., 983), 55% in the unflooded forest and 62% in the floodplain forest of Ecuador (Baslev et al., 1987). Similar values were found in Peru: 55% (Spichiger et al., 1996). A forest inventory in Andohahela, Madagascar, Rakotomalaza and Messmer (1999) recorded a value of 38.8%. The lowest value (13% species) is reported in Kala (Madiapevo, 2008).

The individual/species ratio in the Mbam Minkom sampling is 22.35. Out of the closed value, 22.1 *(*Rabevohitra et al., 1996), the other ratio is much higher 33.4 in the secrad forest of Kouoghap (Noumi, 2012). In other studies it was much lower, 10.57 (Madiapevo, 2008); 8.1 (D'Amico and Gautier, 2000), 6.1 (Rakotomalaza and Messmer, 1999), 7.96 and 8.42 (Corthay, 1996). A series of 1-ha forest inventories samples in the Neotropics recorded the following values: 8.42 in Brazil (Mori et al., 1983), 7.37 in Paraguay (Spichiger et al., 1992), 2.79 in Ecuador (Balslev et al., 1987). The gregariousness of some species such as *Garcinia lucida*, *Cola verticillata* and *Allanblackia gabonensis* in Mbam Minkom forest, is therefore brought to the limelight.

The IVI of *Garcinia lucida* (38.52), the species with the highest value in the surface sampled, falls within the Brazil: 37.7 to 43.5 range of highest IVI recorded by Gibbs et al. (1980). The highest values are recorded in the Manengouba Forest Cameroon: 37.35 (Noumi, 2013), in Alto Parana, Paraguay: 33.4 (Spichiger et al., 1992), in Alto Ivon, Bolivia: 29.58 (Boom, 1986). The other IVI falls within the 12.5 to 28.7 range of values recorded by Mori et al. (1983) and Boom (1996) in the lowland moist forests. Similar values were recorded in the Sacred Forest of Kouoghap, Cameroon: 28.24 (Noumi, 2012), at Kala, Cameroon: 20.71 (Maddpapevo, 2008), at Andohahela, Madagascar: 19.7 (Rakotomalaza and Messmer, 1999), in Yapo, Côte-d'Ivoire: 26.95 (Nusbaumer et al., 2005) and in Yasuni National Park, Ecuador: 27.1 (Balslev et al., 1987). In inventories cited earlier, a species with an IVI value higher than 10 always belongs to one of the ten highest IVIs of the sample.

In the Mbam Minkom Forest as well as in other forests with an elevation above 1000 m, the species (and other main ones) with the highest IVI are sub-mountane: *Garcinia lucida, Clusiaceae*. It is the principal characteristic of the submontane forest storey confered to a phytososiological unit of the order *Garcinietalia* Noumi 1978. This is same with *Cylicomorpha solmsii,* (*Caricaceae*) which has the highest IVI in the Messa forest and the A*llanblackia gabonensis* (*Clusiaceae*) in the Kala forest. In Manengouba forest the highest IVI belongs to *Macaranga occidentalis* (Euphorbiaceae), a montane species.

The floristic composition of the Mbam Minkom forest matches up, according to the considered parameters earlier mentioned, with some lowland forests. However, there are some discrepancies that are explained by the altitude, presence of clouds and mists and the elevation effect of mass, the "massenerhebung " (Van Steenis, 1935-36) that accounts for the uniqueness of the Mbam Minkom massif. Five afromontane species 10cm < dbh *Linociera oreophila, Cephaelis densinervia, Carapa grandifolia* and *Memecylon polyanthomos* were trees that occurred at a 1.8% density.They are charadteristic species of *Ficalhoeto-Podocarpetalia* Lebrun and Gilbert (1954); widely distributed among Cameroonian Afro-highlander archipelagos and the Guineo-Congolian phytogeographic region (Letouzey, 1985). The structure and diversity of the sub-montane Mbam minkom forest were a bit similar to that of the sacred of forest Kouoghap. About 15.75% of the species were common, indicating a common heritage of the two forests which are about 200 km apart. Both the Mbam Minkom and Sacred forest of Kouoghap supported low-diversity forests with high basal area contributed by large trees especially at Kouoghak (Noumi, 2012).

Differences appeared in the dominant species in both regions: a megaphanerophyte, *Syncepalum cerasiferum (*Welw.) T. D. Penn, Sapotaceae which occurred at high densities at Kougap and a mesophanerophyte, *Garcinia lucida* Vesque, *Clusiaceae,* in Mbam Mikom. In both regions occurred a family *Clusiaceae*, which is among the families that characterised the wet evergreen forests of the submontane storey in the Guineo-Congolian region, Madagascar and Neotropical zones (Schmid, 1974; Noumi, 1998).

7. Conclusion

The Mbam Minkom forest (1000-1295 m) harbours highlander indices by the number and the diversity of the orophytes species, 9 against 7 in the sacred forest of Kouoghap. This grid of feature Afro-highlanders could be due to the effect of elevation of the massif of the hills, creating the mesologic factors simulated to those of the highlander floor. The study site shared 34 (15.75%) species with the isolated summit of the Kouoghap forest (1400-1550 m), located in the highlands of West Cameroon at a distance of 200 km west of the study site. This suggests a possible common biogeographical heritage and a finding that supports the rainforest characteristic of Mbam Minkom sub-montane forest. *Leguminosae* and *Sterculiaceae*, two hydromegathermal families of low and middle altitudes of preference, have higher FIV in the submontane forest of Mbam Minkom. *Clusiaceae,* a hydromesothermal family of submontane altitude, shows the the highest FIV value. *Rubiaceae* family, comes in second position (15 species) behind the Orchidaceae (20 species) when the herbaceous species are taken into consideration in the diversities. Thus, it characterizes altitudes superior or equal to 1295m, as hygrophile olgothermal montane altitude. The Mbam Minkom plant formation is thus an ecotone. In this sector with the strong climatic contrasts (West side receiving the humid monsoon in relation to the East side, the south side with the equatorial regime in relation to the north side, tropical) exists in fact a fine succession of climax closely linked to the altitudinal pressure gradient. That succession is marked by a progressive and conjoined lowering of temperatures and vegetation (that undergoes some modifications), right from the low altitude valleys to the summits of the hills.

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Appendix 1. Herbaceae plant species of submontane forest of Mbam minkom massif

TB	Plant species	Families
h	Acantus montanus (Nees) T. Anderson	Acanthaceae
gr	Aframomum melegueta (Roscoe) K. Schum.	Zingiberaceae
gr	Aframomum pruinosum Gagnepain	Zingiberaceae
h	Afrotrilepis pilosa (Boeck) J. Raynal	Cyperaceae
g	Amorphophallus sp	Araceae
g	Anchomanes diformis (Blume) Engl.	Araceae
na	Ancylobotrys scandens (Schum. & Thonn.) Pichon	Apocynaceae
lh	Aneilema aequinoctial (P. Beauv.) Kunth.	Commelinaceae
lh	Aneilema umbrosum (Vahl.) Kunth.	Commelinaceae
ep	Angreacum birrnimense Rolfe	Orchidaceae
na	Anisotes macrophylla (Lind.) Heine	Acanthceae
h	Anubias baryeri Schott	Araceae
na	Aptandra zenkeri Engl.	Olacaceae
na	Ardisia ototomoensis Tatou	Myrsinaceae
h	Asplenium annettii (Jeaup.) Alston	Aspleniaceae
h	Asplenium buettnari Hier. Ex Braure	Aspleniaceae
ep	Asplenium drageanum Ktze	Aspleniaceae
ep	Asplenium geppii Carr.	Aspleniaceae
ep	Asplenium mannii Hook.	Aspleniaceae

ep	Asplenium staudtii Hier	Aspleniaceae
se-ep	Asplenium vagans Bak.	Aspleniaceae
h	Asplenium variabile var. paucijugum (Ballard) Alston	Aspleniaceae
ep	Begonia furfuracea Hook. f.	Begoniaceae
h-ep	Begonia oxanthera Waeb.	Begoniaceae
h-rh	Bolbitis acrostichoides (Afz.) Chirig.	Lomariopsidaceae
h-rh	Bolbitis gemmifera (Hiern.) C. Christ	Lomariopsidaceae
ep	Brachycorythis macrantha Lindl.	Orchidaceae
h	Brrachystaphanus yaoundensis Lindau	Acanthceae
h	Bulbodtylis congolensis De Wild	Cyperaceae
se-ep	Bulbophyllum lupulinum Lindl.	Orchidaceae
na	Caloncoba welwitschii (Oliv.) Gilg.	Flcourtiaceae
se-ep	Calvoa zenkeri Gilg.	Melastomataceae
na	Cephaelis pendoncularis Salisb.	Rubiaceae
l- mp	Cercestis dinklagei Engl.	Araceae
se-ep	Cercestis ivorensis A. Chv.	Araceae
g	Chloriphytum orchiastrum Lindl.	Liliaceae
lh	Commelina capitata Benth.	Commelinaceae
h	Commelinidium mayumbense (French.) Stapf.	Poaceae
se-ep	Corymborki corymbosa Thon.	Orchidaceae
gr	Costus albus	Costaceae
h	Crossandra flva Hook.	Acanthceae
h	Crossandra obarensis Heine	Acanthceae
h	Ctenitis seciridiformis Hook.) Cop.	Aspidiaceae
se-ep	Culcasia barombensis N. E. Br.	Araceae
l-mp	Culcasia dinklagei Engl.	Araceae
lh	Culcasia insularis N. E. Br.	Araceae
lh	Culcasia poissonii 5engl.) N. E. Br.	Araceae
lh	Cyanotis lanata Benth.	Commelinaceae
na	Cyathea camerooniana Hook.	Cyatheaceae
na	Cyathea manniana Hook.	Cyatheaceae
h	Cyclosorus afer (Christ) Ching	Thelypteridaceae
h	Cyperus fertilis Hook.	Cyperaceae
ep	Cyrtorchis rigens Rchb. F.	Orchidaceae
lna	Desmotachys oblongifolia (Engl.) Villiers	Icacinaceae
lna	Desmotachys tenuifolia Oilv.	Icacinaceae
ep	Diaphananthus pellucida Lindl. Schlt.	Orchidaceae
g	Dioscorea dumetorum (Kunth.) P. Paxin	Dioscoreaceae
h	Dissotis Brazzea Long.	Melastomataceae
h	Dissotis irvingiana Hook.	Melastomataceae
na	Dorstenia poinsettifolia Engl	Moraceae
na	Dracaena camarooniana Bak.	Agavaceae
na	Dracaena scoparia Aubr.	Agavaceae
na	Dracaena thallioides Maleog. Ex C. Morren	Agavaceae
se-ep	Epipogium roseum (Don.) Kindl.	Orchidaceae
h	Eragrostis glauvillei C…..	Poaceae
h	Eulophia euglossa (Rchb.) Rchb. F.	Orchidaceae
h	Eulophia schupangas	Orchidaceae
lh	Eureindra formosa Hook. f.	Cucurbitaceae
na	Fagara viridis	Rutaceae
na	Ficus cyathistipula Warb	Moraceae
na	Ficus natalensis Hochst.	Moraceae
h	Gastrodia africanus Kraenzl	Orchidaceae
g	Gloriosa superba Hiern	Liliaceae
h	Habenaria gobonensis (Rchb.) Summer	Orchidaceae
h	Habenaria procera (Sw.) Lindl.	Orchidaceae
h	Halopegia azurea K. Schum.	Marantaceae
h	Heberaria macrantha Lindl.	Orchidaceae
h	Heberaria microceras	Orchidaceae

na	Heisteria parvifolia Sm.	Olacaceae
h	Hetaria heterosepala (Rchb.) Summer	Orchidaceae
h	Hibiscus cf noldeae Bak. F.	Malvaceae
lna	Hibiscus macranthus Hutch. Ex A. Rich.	Malvaceae
h	Impatiens posbrata Farron	Balsaminaceae
h	Kalanchoe crenata (Andrew) Haw.	Crassulaceae
h	Laportea ovalifolia (Schum. & Thonn.) Chev.	Urticaceae
rhna	Lastreopsis efulensis (Bak.) Tardieu	Aspidiaceae
h	Leptaspis cochleata Twaites	Poaceae
na	Lindackeria dentata (Oliv.) Gilg.	Flcourtiaceae
se-ep	Lomariopsis guineensis (Lind.) Alston	Lomariopsidaceae
ep	Lonchitis currori (Hook.) Metten ex Kühm	Debbstaedtiaceae
h-ep	Loxogramme lanceolata Sw. Presl.	Polypodiaceae
h-na	Magrphrynium macrostachyum (Benth.) M-Readh.	Marantaceae
h	Mapania macranta (Bach.) P. Feiffer	Cyperaceae
h-na	Marantachloa leucantha (K. Schum.) M-Readh.	Marantaceae
h-rh	Marattia fraxinea J. Smith	Marrattiacae
se-ep	Microsorium punstatum (L.) Cop.	Polypodiaceae
lh	Mikamia cf cordata B. L. Robin	Asteraceae
h	Mikaniopsis maitlandii C. D. Adams	Asteraceae
lna	Momordica cissoides	Cucurbitaceae
h	Mostuea brunensis Aidr.	Loganiaceae
h-ep	Nephrolepis undulata (Afz. Ex Swar.) J. Smith	Davalliaceae
lna	Neuropeltis acumunata (P. Beauv.) Benth.	Convolvulaceae
na	Neurotheca leoselioides (Spruce ex Prog.) Baill.	Gentianaceae
na	Octolepis casearia Oliv.	Thymeliaceae
na	Olax latifolia Engl.	Olacaceae
h	Olyra latifolia L.	Poaceae
h	Oplimenus histellus (L.) Beav.	Poaceae
na	Palisota bracteata C. B. Cl.	Commelinaceae
na	Palisota schweinfirthii C. B. Cl.	Commelinaceae
na	Pavetta mannioides Hutch. & Dalz.	Rubiaceae
h	Pelea chevaleri R. Schnell	Urticaceae
h	Pellaoa doniana Hook	Adiantaceae
ep	Peperomia stuhlmannii	Piperaceae
h	Phaulopsis falsisepala C. B. Cl.	Acanthceae
lme	Piper guineense Schum. & Thonn.	Piperaceae
h-ep	Platycerium stemaria (P. B.) Desvaux	Polypodiaceae
h	Pollia condensata C. B. Cl.	Commelinaceae
h	Polystachya albescens Rindl.	Orchidaceae
ep	Polystachya alpina Lindl.	Orchidaceae
h	Polystachya colluniflora Kraenzl.	Orchidaceae
ep	Polystachya polychaete	Orchidaceae
ep	Preissiella kamerunensis Gilg.	Melastomataceae
h	Pseudechinolaeana pilantachya (Hutch.. P. Stapf.	Poaceae
lna	Pseuderanthenum tunicatum (Afzl.) M-Readh.	Acanthceae
h	Pteris acanthneura Alston	Adiantaceae
h	Pteris mildbraedii Hiers	Adiantaceae
na	Pterorhachis zenkeri Harms	Meliaceae
gr	Renealmia africana	Zingiberaceae
gr	Renealmia cincinnata (K. Schum.) Bak.	Zingiberaceae
na	Rothmannialibisa N. Hallé	Rubiaceae
na	Salacia pyriformis (Sabine) Steud.	Hippocrateaceae
h-rh	Sanse vieria longiflora var. fernandopoensis N. E. Br.	Agavaceae
h-na	Sarcophrynium prionogponium K. Schum	Marantaceae
g	Scadoxus multiflorus (Martyns) Raf.	Amaryllidaceae
g	Scilla sudanica A. Chev.	Liliaceae
h	Selaginella vogelii Spring	Selaginellaceae
h	Stanfieldiella imperforata C. B. Cl.	Commelinaceae

h	Streptogyne crinata P. Beauv.	Poaceae
na	Talbotiella gentii Hutch. & Green	Caesalpiniaceae
na	Tarenna conferta (Benth.) Hiern	Rubiaceae
na	Tarenna pellidula Hiern	Rubiaceae
rhna	Tectaria camerooniana (Hook.) Alston	Aspidiaceae
rhna	Tectaria fernandiensis (Bak.) C. Christ	Aspidiaceae
rhna	Tectaria magnifica (R. Bon.) C. Christ	Aspidiaceae
na	Thumbergia erecta (Benth.) T. Anderson	Acanthceae
lna	Thumbergia togoensis Lindl.	Acanthceae
na	Tricalysia oligoneura K. Schum.	Rubiaceae
se-ep	Tridactyle tridactylites Schltr.	Orchidaceae
lna	Turraea vogellii	Meliaceae
h	Utrcularia angolensis Welw. Ex Hiern.	Lentibulariaceae
na	Whitfiedia elongata (P. Beauv.) De Wild & T. Anderson	Acanthceae
na	Zenkerella citrina Taub.	Caesalpiniaceae

Apppendix 2. Floristic list of the submontane Mbam minkom forest, with the number of individual by class average of diameter (dbh ≥ 10 cm).

TB	TP	V/Al	PU	Species	Families	Dbh<10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 to 90	90 to 100	100 to 110	110 to 120	120 to 130	130 to 140	Ni dbh <10cm	Ni dbh≥ 10cm
mg	G	Bm	Pip	Terminalia superba Engl. & Diels	Combretaceae							1	2		1	4			1	9	9
me	G	Bm	Mus	Trilepisium madagascariense DC.	Moraceae	2	3	2											1	8	6
mg	G	Sm	Gar	Santiria trimera (Oliv.) Aubr.	Burseraceae	24	25	33	47	29	17	14	5	16	1	6		2		219	195
mg	G-Sz	Bm	Gil	Lovoa trichilioides Harms	Meliaceae	4	1	2	3	1		1		1		1		1		15	11
me	Cg	Sm/hM	Fic	Linociera oreophila Knobl.	Oleaceae				1	1		3	1	6	2	5	2			21	21
mg	G	Sm	Gar	Allanblackia gabonensis (Pellegrin) Bamps	Clusiaceae	76	42	46	49	28	22	11	6	7	1	1				289	213
mg	G	Bm/Sm	Str	Anonidium mannii (Oliv.) Engl. & Diels	Annonaceae	14	11	15	15	3	6	2				1				67	53
me	G	Bm	Gil	Khaya ivorensis A. Chev.	Meliaceae					1		1	2	1		1				6	6
me	Cg	Sm	Gar	Leplaea mayombensis (Pellgr.) STaner	Meliaceae	27	6	10	5	8	6	1	5	2	1	1				72	45
mg	G	Sm/hM	Fic	Syzygium rowlandii Sprague	Myrtaceae	9	1	1		1	2	1			2					17	8
me		Bm/Sm		Caesalpiniaceae sp,	Leguminosae	4	3	10	6	5	2	1	1		1					33	29
me	Cg	Bm	Gil	Cola lateritia K. Schum.	Sterculiaceae	15		3	1	3			1	1	1					25	10
me	Cg	Sm	Gar	Cola verticillata (Thonn.) Stapf ex A. Chev.	Sterculiaceae	18	24	59	101	79	29	6	6	3	1					326	308
me	G	Bm	Pip	Schrebera arborea A. Chev.	Oleaceae					1		2		3	1					7	7
me	Cg	Bm	Mit	Uapaca acuminata (Hutch.) Pax & K. Hoffm.	Euphorbiaceae	16	5	3	7	5	1	1			1					39	23
me	G	Bm	Mus	Pycnanthus angolensis (Welw.) Warb.	Myristicaceae	44	22	15	9	6	13	11	11	4						135	91
me	G	Bm	Pip	Parkia bicolor A. Chev.	Leguminosae			1	1	1	1	1		3						8	8
me	G	Bm	Pip	Alstonia boonei De Wild.	Apocynaceae					2	5	3	3	2						15	15
me	G		Pip	Cola cordifolia (Cav.) R. Br.	Sterculiaceae	5		2	4		3		1	2						17	12
me	Cg	Sm/hM	Gar	Ficus chlamydocarpa	Moraceae									2						2	2
me	G	Bm	Str	Strombosia scheffleri Engl.	Olacaceae	21	4	6	7	3	3			2						46	25
me	Cg	Sm	Gar	Beilschmiedia obscura (Stapf)	Lauraceae	135	13	7	3	1	1			1						161	26

				Engl. & A. chev.																	
me	Pan	Bm	Mus	Ceiba pentandra (L.) Gaertn.	Bombacaceae									1						1	1
me	At	Bm	Gil	Dialium Pachiphyllum Harms	Leguminosae	1				1	2			1						5	4
me	G	Bm/Sm	Pip	Entandrophragma angolensis (Welw.) C. DC.	Meliaceae	1								1						2	1
me	G	Bm	Pip	Klainedoxa gabonensis Pierre & Engl.	Irvingiaceae				1					1						2	2
me	G	Bm	Pip	Nesogordonia papaverifera (A. Chv.) R. Capuron	Sterculiaceae	4		1	1					1						7	3
me	G	Bm	Pip	Trichoscypha patens (Oliv.) Engl.	Anacardiaceae		1	1	1					1						4	4
mi	G	Bm/Sm	Gil	Sloetiopsis usambarensis Engl.	Moraceae	7	1						2							10	3
me	G	Bm	Str	Dacryodes macrophylla (Oliv.) Lam. Aubr. Pellegr.	Burseraceae	7	2	1	4	8	2	1	1							26	19
mi	G	Bm/Sm	Pip	Garcinia kola Heckel	Clusiaceae		1						1							2	2
me	Cg	Bm	Gil	Gossweilerodendron balsamiferum (Verm.) Harms	Leguminosae								1							1	1
me	G	Bm	Pip	Trichilia prieureana A. Juss.	Meliaceae	2		3	7	1	1		1							15	13
me	G	Bm	Mit	Trichilia retusa Oliv.	Meliaceae					2			1							3	3
me	G	Bm	Mus	Ricinodendron heudelotii (Baill.) Pierre ex Pax	Euphorbiaceae					1		3								4	4
me	G	Bm/Sm	Pip	Sorindeia grandifolia Engl.	Anacardiaceae	17	17	7	6	2	1	2								52	35
me	At	Bm	Pip	Zanthoxylum adolfi-fridericii Engl.	Rutaceae							2								2	2
me	At	Bm/Sm	Mus	Albiza adianthifolia (Schum.) W. F. Wight	Leguminosae							1								1	1
me	At	Bm	Gil	Anthonotha macrophylla P. Beauv.	Leguminosae	2		1		1		1								5	3
me	Cg	Bm	Gil	Antrocaryon klaineanum Pierre	Anacardiaceae			1				1								2	2
me	G	Bm	Pip	Blighia welivitschii (Hiern.) Radlk	Sapindaceae	24	4	17	6	5	1	1								58	34
me	G	Bm	Pip	Elaeophorbia drupifera (Thonn.) Stapf	Euphorbiaceae	1			1			1								3	2
me	Cg	Bm	Gil	Greenwelodendron suaveolens (Engl. & Diels.) Verde	Annonaceae	18	39	6	3	3	1	1								71	53
me		Bm/Sm		Indétermineé 5	Ind	3	10	11	5	5	2	1								37	34
me	G-Sz	Bm	Gil	Mammea africana Sabine	Clusiaceae							1								1	1
me	G-S	Bm	Str	Strombosia grandifolia Hook. f. ex	Olacaceae	33	25	25	17	11	2	1								114	81

	z			Benth.																	
me	At	Bm	Mit	Treculia africana Decne	Moraceae	8	4	1	1			1								15	7
me	G	Bm	Mit	Coelocaryon preussii Warb,	Myristicaceae	26	11	12	7	16	4									76	50
me	G	Bm	Pip	Gambeya lacourtiana (de Wild.) Aubr. & Pellegr.	Sapotaceae	11	7	11	7	3	4									43	32
me	G	Bm	Mus	Musanga cecropioides R. Br.	Myristicaceae	9	5	5	6	5	4									34	25
me	G	Bm	Gil	Dacryodes iganga Aubr. & Pellegr.	Burseraceae		1			1	2									4	4
me	G	Bm	Pip	Hymenostegia afzelii (Oliv.) Harms	Leguminosae	5	2	6	4	5	2									24	19
mi	G	Bm	Pip	Antiaris africana Engl.	Moraceae						1									1	1
me	Cg	Bm/Sm	Pip	Dacryodes edulis G. Don) Lam	Burseraceae	2	1	2	3		1									9	7
me	Pal	Bm/Sm	Mus	Ficus *exasperata* Vahl	Moraceae				1		1									2	2
me	G	Bm	Oleo	Grewia coriacea Mast.	Tiliaceae	5	6	4	9	3	1									28	23
me	G	Bm	Pip	Monodora brevipes Benth.	Annonaceae	6	3	2	2	1	1									15	9
me	G	Bm	Mus	Myrianthus arboreus P. Beauv.	Cecropiaceae			1	1		1									3	3
me	G	Sm	Gar	Myrianthus libericus Rendle	Cecropiaceae	68	13	11	10	4	1									107	39
me	G	Bm	Gil	Odyendyea gabonensis Pierre	Simaroubaceae						1									1	1
me	G	Bm	Str	Strombosiopsis tetrandra Engl.	Olacaceae	2		2	3	2	1									10	8
me	Cg	Bm/Sm	Pip	Vitex grandifolia Gürke	Verbenaceae				2	1	1									4	4
mi	Cg	Bm	Mus	Voacanga africana Stapf	Apocynaceae	3	1	1		2	1									8	5
me	G	Bm	Pip	Xylopia aethiopica (Dunal) A. Rich.	Annonaceae		2	1	1	2	1									7	7
me	Cg	Bm	Gil	Xylopia staudii Engl. & Diels	Annonaceae	10	3	5	7	5	1									31	21
me	Cg	Sm/hM	Gar	Garcinia lucida Vesque	Clusiaceae	1291	490	282	62	20										2145	854
me	Cg	Bm/Sm	Pip	Drypetes parviflora (Müll. Arg.) Pax & K. Hoffm	Euphorbiaceae	181	41	18	7	4										251	70
mi	Cg	Sm	Gar	Aulacocalyx jasmiflora Hook.	Rubiaceae	16	10	8	9	3										46	30
mi	Cg	Sm	Gar	Leonardoxa africana (Baill.) Aubr.	Leguminosae	17	6	7	6	3										39	22
me	Cg	Sm	Gar	Aulacocalyx caudata Hook. f.	Rubiaceae	17	14	7	2	2										42	25
mi	Cg	Sm/hM	Gar	Garcinia mannii Oliv.	Clusiaceae	163	36	15	2	2										218	55
me	Pan	Bm	Mit	Symphonia globulifera L. f.	Clusiaceae			4	2	2										8	8
me	G	Bm	Mus	Tabernaemontana crassa Benth.	Apocynaceae	137	92	25	13	2										269	132

me	At	Bm	Pip	Tetrorchidium didymostemon (Baill.) Pax & K. Hoffm.	Euphorbiaceae	15	1			2										18	3
me	Pan	Bm	Pip	Celtis milbraedii Engl.	Ulmaceae	1				1										2	1
me	Cg	Bm/Sm	Gil	Cola pachycarpa K. Schum.	Sterculiaceae	20	13	4		1										38	18
me	G	Bm/Sm	Gil	Desplatsia subericarpa Bocq.	Tiliaceae					1										1	1
me	Cg	Bm	pip	Homalium africanum Hook. F.) Benth.	Samydaceae			1	1	1										3	3
me	G	Bm	Pip	Lecaniodiscus gabonensis Planch.	Sapindaceae	2	1			1										4	2
me	G-Sz	Bm/Sm	Mus	Maesospis mannii Engl.	Rhamnaceae	4	3	1		1										9	5
me	Cg	Bm	Gil	Octolobus zenkeri Engl.	Sterculiaceae	47	15	3		1										66	19
me	G	Bm/Sm	Mit	Plagiosiphon emarginatus (Hutch. & Dalz.) J. Léonard	Leguminosae					1										1	1
me	G	Bm	Pip	Pterocarpus soyauxii Taub.	Leguminosae					1										1	1
me	G	Bm/Sm	Pip	Zanthoxylum macrophylla Engl.	Rutaceae	1	4	2		1										8	7
mi	G	Bm	Gil	Diospyros suaveolens Gürke	Ebenaceae	14	4	4	2											24	10
me	Cg	Bm	Pip	Cordia platythyrsa Bak.	Boraginaceae	1		2	3											6	5
me	G	Bm	Pip	Duboscia macrocarpa Bocq.	Tiliaceae				3											3	3
me	G-Sz	Sm	Gar	Pachystela msolo Engl.	Sapotaceae	14	2	5	3											24	10
me	Cg	Bm	Gil	Antidesma venosum Tul.	Euphorbiaceae	2	3		2											7	5
mi	Aam	Bm	Gil	Christiana africana DC.	Tiliaceae	5	8	2	2											17	12
mi	G	Bm	Mus	Rauvolfia caffra Sond.	Apocynaceae	3	1		2											6	3
me	At	Sm	Oleo	Allophylus africanus P. Beauv.	Sapindaceae	2	2		1											5	3
me	Cg	Bm	Pip	Angylocalyx pynaertii de Wild.	Leguminosae				1											1	1
me	Cg	Bm	Gil	Anisophyllea polyneura Floret	Rhizophoraceae				1											1	1
me		Bm	Gil	Apocynaceae sp,	Apocynaceae	57	34	3	1											95	38
me	G	Bm/Sm	Mit	Bridelia micrantha (Hochst.) Baill.	Euphorbiaceae			2	1											3	3
mi	Aam	Bm/Sm	Str	Carapa procera DC.	Meliaceae	4	9	6	1											20	16
me	G	Bm	Mit	Cleistopholis patens (Benth.) Engl. & Diels	Annonaceae				1											1	1

me	Cg	Bm	Pip	Cola hypochrysea K. Schum.	Sterculiaceae	2	3	1	1											7	5
mi	G	Bm/Sm	Gil	Diospyros preussi Gürke	Ebenaceae	1	2		1											4	3
mi	Cg	Bm	Mit	Englerophytum oubanguiense Aubr. & Pellegr.	Sapotaceae				1											1	1
me	Cg	Bm	Pip	Fernandoa adolfi-fredericii (Gilg. & Mildbr.) Heine	Leguminosae				1											1	1
mi	G-Sz	Bm	Pip	Markhamia lutea (Benth.) K. Schum.	Bignoniaceae		1	1	1											3	3
na	G	hM	Fic	Memecylon polyanthomos Hook. f.	Melastomataceae	46	13	4	1											64	18
mi	G	Bm	Gil	Pleiocarpa bicarpellata Stapf	Apocynaceae		2	3	1											6	6
mi	Cg	Sm	Gar	Raphia regalis Becc.	Arecaceae	2		1	1											4	2
mi		Bm/Sm	Str	Rubiaceae sp,	Rubiaceae	42	6	2	1											51	9
mi		Bm/Sm		Sapindaceae sp,	Sapindaceae	7	3		1											11	4
me	Cg	Bm	Pip	Zanthoxylum heitzii (Aubr. & Pellegr.) Waterman	Rutaceae		8		1											9	9
me	At	Bm/Sm	Pip	Zanthoxylum mildbreadii Engl.	Rutaceae				1											1	1
me	pal	hM	Pol	Alangium chinensis (Lour.) Harms	Alangiaceae		1	2												3	3
mi	Cg	Sm/hM	Gar	Garcinia smeathmannii Oliv.	Clusiaceae	3		4												7	4
me	G	Bm/Sm	Pip	Casearia stipitata Mast.	Samydaceae		2	3												5	5
na	G	Bm/Sm	Str	Cola attiensis var. *bodardii*	Sterculiaceae	60	7	3												70	10
me	Cg	Bm/Sm	Mit	Trichilia rubescens Oliv,	Meliaceae	19	14	3												36	17
me	G	Bm	Pip	Leptonychia echinocarpa K. Schum.	Sterculiaceae	1	1	2												4	3
me	G-Sz	Bm	Gil	Maesobotrya barteri (Baill.) Hutch.	Euphorbiaceae	3	4	2												9	6
mi	G	Bm	Pip	Monodora tenuifolia Benth.	Annonaceae			2												2	2
mi	At	Bm/Sm	Gil	Pachystela brevipes (Bak.) Engl.	Sapotaceae	4	6	2												12	8
me	Cg	Bm	Pip	Piptostigma pilosum Oliv.	Annonaceae	6	3	2												11	5
mi	G	Bm/S	Str	Strombosia pustulata Oliv.	Olacaceae			2												2	2

		m																			
me	Mt	hM	Fic	Carapa grandifolia Sprague	Meliaceae	23	2	1												26	3
me	Cg	Bm	Pip	Cola lepidota K. Schum.	Sterculiaceae		4	1												5	5
me	Cg	Bm	Pip	Desbordesia glaucescens (Engl.) Van Tiegh.	Irvingiaceae			1												1	1
me	Cg	Bm	Mus	Hylodendron gabunense Taub.	Leguminosae	2		1												3	1
mi	Cg	Bm	Pip	Hypodaphnis zenkeri (Engl.) Stapf	Lauraceae	5	2	1												8	3
mi	Cg	Bm/Sm	Pip	Monodora myristica (Gaeertn.) Dunal	Annonaceae	12	1	1												14	2
me	G	Bm	Str	Parinari hypochrysea Mildbr. ex R. Let & F. White	Chrysobalanaceae			1												1	1
mi	G	Bm/Sm	Mus	Rauvolfia vomitoria Afz.	Apocynaceae	1		1												2	1
mi	G	Sm	Gar	Ouratea turnerae (Hook. f.) Huch. & Dalz.	Ochnaceae	29	14													43	14
mi	Cg	hM	Fic	Cephaelis densinervia (K. Krause) Hepper	Rubiaceae	23	12													35	12
mi	G	Sm	Gar	Cyathea cameroonianna Hook.	Cyatheaceae	18	7													25	7
mi	G	Bm/Sm	Oleo	Canthium vulgare (K. Schum.) Bullock	Rubiaceae	3	3													6	3
mi	G-Sz	Bm/Sm	Gil	Diospiros hoyleana F. White	Ebenaceae	2	3													5	3
mi		Bm/Sm	Gil	Diospiros sp.	Ebenaceae	1	2													3	2
mi	G	Bm/Sm	Gil	Diospyros zenkeri (Gürke) F. White	Ebenaceae	3	2													5	2
mi	G	Bm	Gil	Rothmannia hispida (K. Schum.) Fagerlind	Rubiaceae	20	2													22	2
me	G	Bm	Pip	Antidesma membranaceum Müll. Arg.	Euphorbiaceae		1													1	1
mi	Cg	Bm	Pip	Baphiopsis parviflora Benth. ex Bak.	Leguminosae	45	1													46	1
mi	G	Sm/hM	Gar	Eugenia pobeguinii Aubr.	Myrtaceae	2	1													3	1
mi		Bm	Gil	Hexalobus sp,	Annonaceae	8	1													9	1
mi	G	Sm/hM	Pip	Microdesmis puberula Hook. f. ex Planch.	Euphorbiaceae	3	1													4	1
me	Cg	Bm	Pip	Pterocarpus mildbreadii Harms	Leguminosae	2	1													3	1
me	G	Sm	Gar	Uapaca esculenta A. Chev.	Euphorbiaceae	2	1													3	1

mi	G-Sz	Bm	Gil	Uvaria bipindensis Engl. & Diels	Annonaceae	5	1													6	1
mi	G	Bm	Gil	Uvariodendron giganteum (Engl.) R. E. Fries	Annonaceae	13	1													14	1
na				Treculia acuminata Baillon	Moraceae	77														77	0
na				Penianthus longifolius Miers	Menispermaceae	23														23	0
na				Dicranolepis disticha Planchon	Thymeliaceae	20														20	0
na				Guarea glomerulata Harms	Meliaceae	20														20	0
na				Cephaelis mannii (Hook. F.) Hiern.	Rubiaceae	18														18	0
na				Leptonychia multiflora	Sterculiaceae	11														11	0
na				Rinorea dentata O. Ktze	Violaceae	10														10	0
na				Euadenia trifoliolata (Schum & Thonn.) Oliv.	Capparidaceae	8														8	0
na				Rinorea oblongifolia (Ch. W.) Marquand ex Chip.	Violaceae	8														8	0
mi				Cyathea manianna Hook.	Cyatheaceae	6														6	0
na				Rinorea ilicifolia (Welw. ex Oliv.) O. Ktze	Violaceae	6														6	0
na				Ardisia platyphylla (Gilg. & Schellenb.) Taton	Myrsinaceae	4														4	0
na				Ixora talbotii Wernham	Rubiaceae	4														4	0
na				Microdesmis zenkeri Pax	Euphorbiaceae	4														4	0
na				Bertiera sp.	Rubiaceae	3														3	0
na				Leea guineensis G. Don	Leeaceae	3														3	0
mi				Erythroccoca hispida (Pax) Prain	Euphorbiaceae	2														2	0
na				Schumaniophyton magnificum (K. Schum.) Harms	Rutaceae	2														2	0
na				Monodora tenuifolia Benth.	Annonaceae	1														1	0
na				Panda oleosa Pierre	Pandaceae	1														1	0
na				Peddia fisheri Engl.	Thymeliaceae	1														1	0
me				Polyscias fulva (Hiern.) Harms	Araliaceae	1														1	0
na				Staudtia stipitata Warb.	Myristicaceae	1														1	0
mi				Teclea afzelii Engl.	Rutaceae	1														1	0
na				Vitex madiensis Oliv.	Verbenaceae	1														1	0
				Total	Total	3357	12	80	51	31	15	78	51	62	13	20	2	3	2	6621	3264

							47	1	5	8	2										

Appendix 3. Diversity, density, basal area and FVI of the plant families encountered in the 6-ha sampling, in the submountane Mbam minkom Forest, presented by decreasing FIV.

Familly	Number of species	Number of trees	Basal area	Relative diversity (%)	Relative density (%)	Relative dominance (%)	FIV
Clusiaceae	6	1082	62.58	4.08	33.13	19.75	56.96
Sterculiaceae	10	393	47.33	6.80	12.03	14.94	33.77
Burseraceae	4	225	43.81	2.72	6.89	13.83	23.44
Annonaceae	11	155	12.05	7.48	4.75	3.80	16.03
Meliaceae	9	115	19.41	6.12	3.52	6.13	15.77
Leguminosae	13	92	12.94	8.84	2.82	4.08	15.74
Myristicaceae	4	168	24.90	2.72	5.14	7.86	15.72
Apocynaceae	7	200	11.39	4.76	6.12	3.59	14.48
Euphorbiaceae	11	119	8.48	7.48	3.64	2.68	13.80
Olacaceae	4	116	10.27	2.72	3.55	3.24	9.51
Rubiaceae	6	81	3.61	4.08	2.48	1.14	7.70
Oleaceae	2	28	16.16	1.36	0.86	5.10	7.32
Moraceae	6	21	4.74	4.08	0.64	1.50	6.22
Sapotaceae	4	51	3.63	2.72	1.56	1.15	5.43
Sapindaceae	4	43	3.30	2.72	1.32	1.04	5.08
Anacardiaceae	3	41	3.55	2.04	1.26	1.12	4.42
Ebenaceae	5	20	0.71	3.40	0.61	0.23	4.24
Tiliaceae	3	38	2.60	2.04	1.16	0.82	4.03
Rutaceae	4	19	1.33	2.72	0.58	0.42	3.72
Cecropiaceae	2	42	2.99	1.36	1.29	0.94	3.59
Combretaceae	1	9	6.82	0.68	0.28	2.15	3.11
Clusiceae	1	55	1.88	0.68	1.68	0.59	2.96
Lauraceae	2	29	1.91	1.36	0.89	0.60	2.85
(vide)	1	34	2.80	0.68	1.04	0.88	2.61
Myrtaceae	2	9	2.47	1.36	0.28	0.78	2.42

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Samydaceae	2	8	0.49	1.36	0.24	0.15	1.76
Irvingiaceae	2	3	0.71	1.36	0.09	0.22	1.68
Melastomataceae	1	18	0.52	0.68	0.55	0.16	1.40
Ochnaceae	1	14	0.25	0.68	0.43	0.08	1.19
Verbenaceae	1	4	0.59	0.68	0.12	0.19	0.99
Boraginaceae	1	5	0.39	0.68	0.15	0.12	0.96
Cyatheaceae	1	7	0.12	0.68	0.21	0.04	0.93
Rhamnaceae	1	5	0.26	0.68	0.15	0.08	0.92
Bombacaceae	1	1	0.57	0.68	0.03	0.18	0.89
Bignoniaceae	1	3	0.16	0.68	0.09	0.05	0.82
Alangiaceae	1	3	0.12	0.68	0.09	0.04	0.81
Arecaceae	1	2	0.15	0.68	0.06	0.05	0.79
Simaroubaceae	1	1	0.24	0.68	0.03	0.07	0.79
Tilaceae	1	1	0.16	0.68	0.03	0.05	0.76
Ulmaceae	1	1	0.16	0.68	0.03	0.05	0.76
Leguminosae	1	1	0.10	0.68	0.03	0.03	0.74
Rhizophoraceae	1	1	0.10	0.68	0.03	0.03	0.74
Chrysobalanaceae	1	1	0.05	0.68	0.03	0.02	0.73
Annonoceae	1	1	0.02	0.68	0.03	0.01	0.72
Fabceae	1	1	0.02	0.68	0.03	0.01	0.72
Total	147	3266	316.82	100.00	100.00	100.00	300.00

Appendix 4 Ocurrency, density, basal area and IVI of the plant species encountered in the 6-ha sampling in the submountain Mbam minkom Forest, presented by decreasing IVI.

Species	Occurency	Number of trees	Basal area	Relative occurency [x 100%]	Relative Density [x 100%]	Relative dominance [x 100%]	IVI [x 300%]
Santiria trimera (Oliv.) Aubr.	12	195	39.53	2.57	5.97	12.48	21.02
Allanblackia gabonensis (Pellegrin) Bamps	12	213	29.24	2.57	6.52	9.23	18.32
Tabernaemontana crassa Benth.	12	132	4.42	2.57	4.04	1.40	8.01
Cola verticillata (Thonn.) Stapf ex A. Chev.	11	308	39.54	2.36	9.43	12.48	24.27

Garcinia lucida Vesque	11	854	31.65	2.36	26.15	9.99	38.49
Drypetes parviflora (Müll. Arg.) Pax & K. Hoffm	11	70	2.92	2.36	2.14	0.92	5.42
Beilschmiedia obscura (Stapf) Engl. & A. chev.	11	26	1.83	2.36	0.80	0.58	3.73
Myrianthus libericus Rendle	10	39	2.61	2.14	1.19	0.82	4.16
Gambeya lacourtiana (de Wild.) Aubr. & Pellegr.	9	32	2.76	1.93	0.98	0.87	3.78
Grewia coriacea Mast.	9	23	1.88	1.93	0.70	0.59	3.23
Carapa grandifolia Sprague	9	3	0.08	1.93	0.09	0.03	2.05
Garcinia mannii Oliv.	8	55	1.88	1.71	1.68	0.59	3.99
Anonidium mannii (Oliv.) Engl. & Diels	7	53	5.81	1.50	1.62	1.83	4.95
Coelocaryon preussii Warb,	7	50	4.95	1.50	1.53	1.56	4.59
Caesalpiniaceae sp,	7	29	3.87	1.50	0.89	1.22	3.61
Dacryodes macrophylla (Oliv.) Lam. Aubr. Pellegr.	7	19	2.99	1.50	0.58	0.94	3.02
Uapaca acuminata (Hutch.) Pax & K. Hoffm.	7	23	2.98	1.50	0.70	0.94	3.14
Blighia welivitschii (Hiern.) Radlk	7	34	2.85	1.50	1.04	0.90	3.44
Greenwelodendron suaveolens (Engl. & Diels.) Verde	7	53	2.32	1.50	1.62	0.73	3.85
Pycnanthus angolensis (Welw.) Warb.	6	93	17.29	1.28	2.85	5.46	9.59
Leplaea mayombensis (Pellgr.) STaner	6	45	9.03	1.28	1.38	2.85	5.51
Alstonia boonei De Wild.	6	15	4.96	1.28	0.46	1.57	3.31
Musanga cecropioides R. Br.	6	25	2.66	1.28	0.77	0.84	2.89
Parkia bicolor A. Chev.	6	8	2.58	1.28	0.24	0.81	2.34
Sorindeia grandifolia Engl.	6	35	2.44	1.28	1.07	0.77	3.13
Leonardoxa africana (Baill.) Aubr.	6	22	1.50	1.28	0.67	0.47	2.43
Monodora brevipes Benth.	6	9	0.74	1.28	0.28	0.23	1.79
Pachystele msolo Engl.	6	10	0.57	1.28	0.31	0.18	1.77
Trichilia rubescens Oliv,	6	17	0.39	1.28	0.52	0.12	1.93
Linociera oreophila Knobl.	5	21	12.92	1.07	0.64	4.08	5.79
Strombosia grandifolia Hook. f. ex Benth.	5	81	5.86	1.07	2.48	1.85	5.40
Indéterminé 5	5	34	2.80	1.07	1.04	0.88	3.00
Syzygium rowlandii Sprague	5	8	2.45	1.07	0.24	0.77	2.09

Strombosiopsis tetrandra Engl.	5	8	0.94	1.07	0.24	0.30	1.61
Octolobus zenkeri Engl.	5	19	0.57	1.07	0.58	0.18	1.83
Treculia africana Decne	5	7	0.55	1.07	0.21	0.17	1.46
Rubiaceae sp,	5	9	0.30	1.07	0.28	0.09	1.44
Terminalia superba Engl. & Diels	4	9	6.82	0.86	0.28	2.15	3.28
Strombosia scheffleri Engl.	4	25	3.36	0.86	0.77	1.06	2.68
Xylopia staudii Engl. & Diels	4	21	2.00	0.86	0.64	0.63	2.13
Hymenostegia afzelii (Oliv.) Harms	4	19	1.99	0.86	0.58	0.63	2.06
Aulacocalyx jasmiflora Hook.	4	30	1.91	0.86	0.92	0.60	2.38
Aulacocalyx caudata Hook. f.	4	25	1.10	0.86	0.77	0.35	1.97
Symphonia globulifera L. f.	4	8	0.71	0.86	0.24	0.22	1.32
Cola pachycarpa K. Schum.	4	18	0.59	0.86	0.55	0.18	1.59
Memecylon polyanthomos Hook. f.	4	18	0.52	0.86	0.55	0.16	1.57
Maesobotrya barteri (Baill.) Hutch.	4	6	0.17	0.86	0.18	0.05	1.09
Lovoa trichilioides Harms	3	11	3.56	0.64	0.34	1.12	2.10
Cola lateritia K. Schum.	3	10	2.44	0.64	0.31	0.77	1.72
Trilepisium madagascariense DC.	3	6	1.58	0.64	0.18	0.50	1.33
Ricinodendron heudelotii (Baill.) Pierre ex Pax	3	4	1.15	0.64	0.12	0.36	1.13
Xylopia aethiopica (Dunal) A. Rich.	3	7	0.74	0.64	0.21	0.23	1.09
Dacryodes iganga Aubr. & Pellegr.	3	4	0.65	0.64	0.12	0.21	0.97
Diospyros suaveolens Gürke	3	10	0.46	0.64	0.31	0.15	1.09
Cordia platythyrsa Bak.	3	5	0.39	0.64	0.15	0.12	0.92
Zanthoxylum macrophylla Engl.	3	7	0.33	0.64	0.21	0.10	0.96
Cephaelis densinervia (K. Krause) Hepper	3	12	0.21	0.64	0.37	0.07	1.08
Pachystela brevipes (Bak.) Engl.	3	8	0.20	0.64	0.24	0.06	0.95
Bridelia micrantha (Hochst.) Baill.	3	3	0.19	0.64	0.09	0.06	0.80
Piptostigma pilosum Oliv.	3	5	0.15	0.64	0.15	0.05	0.84
Canthium vulgare (K. Schum.) Bullock	3	3	0.05	0.64	0.09	0.02	0.75
Schrebera arborea A. Chev.	2	7	3.23	0.43	0.21	1.02	1.66

Khaya ivorensis A. Chev.	2	6	2.81	0.43	0.18	0.89	1.50
Trichilia prieureana A. Juss.	2	13	1.66	0.43	0.40	0.52	1.35
Apocynaceae sp,	2	38	0.84	0.43	1.16	0.27	1.86
Trichilia retusa Oliv.	2	3	0.76	0.43	0.09	0.24	0.76
Trichoscypha patens (Oliv.) Engl.	2	4	0.73	0.43	0.12	0.23	0.78
Klainedoxa gabonensis Pierre & Engl.	2	2	0.66	0.43	0.06	0.21	0.70
Voacanga africana Stapf	2	5	0.62	0.43	0.15	0.20	0.78
Vitex grandifolia Gürke	2	4	0.59	0.43	0.12	0.19	0.74
Anthonotha macrophylla P. Beauv.	2	3	0.54	0.43	0.09	0.17	0.69
Christiana africana DC.	2	12	0.43	0.43	0.37	0.14	0.93
Duboscia macrocarpa Bocq.	2	3	0.29	0.43	0.09	0.09	0.61
Pleiocarpa bicarpellata Stapf	2	6	0.28	0.43	0.18	0.09	0.70
Maesospis mannii Engl.	2	5	0.26	0.43	0.15	0.08	0.66
Ouratea turnerae (Hook. f.) Huch. & Dalz.	2	14	0.25	0.43	0.43	0.08	0.94
Zanthoxylum heitzii (Aubr. & Pellegr.) Waterman	2	9	0.24	0.43	0.28	0.07	0.78
Garcinia smeathmannii Oliv.	2	4	0.20	0.43	0.12	0.06	0.61
Casearia stipitata Mast.	2	5	0.18	0.43	0.15	0.06	0.64
Markhamia lutea (Benth.) K. Schum.	2	3	0.16	0.43	0.09	0.05	0.57
Sapindaceae sp,	2	4	0.15	0.43	0.12	0.05	0.60
Allophylus africanus P. Beauv.	2	3	0.13	0.43	0.09	0.04	0.56
Diospyros preussi Gürke	2	3	0.13	0.43	0.09	0.04	0.56
Cola lepidota K. Schum.	2	5	0.12	0.43	0.15	0.04	0.62
Alangium chinensis (Lour.) Harms	2	3	0.12	0.43	0.09	0.04	0.56
Hypodaphnis zenkeri (Engl.) Stapf	2	3	0.08	0.43	0.09	0.03	0.55
Rothmannia hispida (K. Schum.) Fagerlind	2	2	0.04	0.43	0.06	0.01	0.50
Cola cordifolia (Cav.) R. Br.	1	12	2.77	0.21	0.37	0.88	1.46
Dialium Pachiphyllum Harms	1	4	1.20	0.21	0.12	0.38	0.72
Ficus chlamydocarpa	1	2	1.13	0.21	0.06	0.36	0.63
Sloetiopsis usambarensis Engl.	1	3	0.90	0.21	0.09	0.28	0.59

Nesogordonia papaverifera (A. Chv.) R. Capuron	1	3	0.71	0.21	0.09	0.22	0.53
Zanthoxylum adolfi-fridericii Engl.	1	2	0.66	0.21	0.06	0.21	0.48
Dacryodes edulis G. Don) Lam	1	7	0.64	0.21	0.21	0.20	0.63
Ceiba pentandra (L.) Gaertn.	1	1	0.57	0.21	0.03	0.18	0.42
Entandrophragma angolensis (Welw.) C. DC.	1	1	0.57	0.21	0.03	0.18	0.42
Carapa procera DC.	1	16	0.55	0.21	0.49	0.17	0.88
Garcinia kola Heckel	1	2	0.46	0.21	0.06	0.15	0.42
Gossweilerodendron balsamiferum (Verm.) Harms	1	1	0.44	0.21	0.03	0.14	0.38
Elaeophorbia drupifera (Thonn.) Stapf	1	2	0.43	0.21	0.06	0.14	0.41
Myrianthus arboreus P. Beauv.	1	3	0.38	0.21	0.09	0.12	0.43
Antrocaryon klaineanum Pierre	1	2	0.38	0.21	0.06	0.12	0.40
Tetrorchidium didymostemon (Baill.) Pax & K. Hoffm.	1	3	0.34	0.21	0.09	0.11	0.41
Ficus exasperata Vahl	1	2	0.33	0.21	0.06	0.11	0.38
Albiza adianthifolia (Schum.) W. F. Wight	1	1	0.33	0.21	0.03	0.10	0.35
Mammea africana Sabine	1	1	0.33	0.21	0.03	0.10	0.35
Homalium africanum Hook. F.) Benth.	1	3	0.30	0.21	0.09	0.10	0.40
Cola attiensis var. bodardii	1	10	0.27	0.21	0.31	0.09	0.61
Antidesma venosum Tul.	1	5	0.25	0.21	0.15	0.08	0.44
Antiaris africana Engl.	1	1	0.24	0.21	0.03	0.07	0.32
Odyendyea gabonensis Pierre	1	1	0.24	0.21	0.03	0.07	0.32
Rauvolfia caffra Sond.	1	3	0.21	0.21	0.09	0.07	0.37
Cola hypochrysea K. Schum.	1	5	0.20	0.21	0.15	0.06	0.43
Lecaniodiscus gabonensis Planch.	1	2	0.18	0.21	0.06	0.06	0.33
Celtis milbraedii Engl.	1	1	0.16	0.21	0.03	0.05	0.29
Desplatsia subericarpa Bocq.	1	1	0.16	0.21	0.03	0.05	0.29
Plagiosiphon emarginatus (Hutch. & Dalz.) J. Léonard	1	1	0.16	0.21	0.03	0.05	0.29
Pterocarpus soyauxii Taub.	1	1	0.16	0.21	0.03	0.05	0.29
Raphia regalis Becc.	1	2	0.15	0.21	0.06	0.05	0.32
Cyathea cameroonianna Hook.	1	7	0.12	0.21	0.21	0.04	0.47

Leptonychia echinocarpa K. Schum.	1	3	0.12	0.21	0.09	0.04	0.34
Monodora tenuifolia Benth.	1	2	0.10	0.21	0.06	0.03	0.31
Strombosia pustulata Oliv.	1	2	0.10	0.21	0.06	0.03	0.31
Angyocalyx pynaertii DE Wild.	1	1	0.10	0.21	0.03	0.03	0.28
Anisophyllea polyneura Floret	1	1	0.10	0.21	0.03	0.03	0.28
Cleistopholis patens (Benth.) Engl. & Diels	1	1	0.10	0.21	0.03	0.03	0.28
Englerophytum oubanguiense Aubr. & Pellegr.	1	1	0.10	0.21	0.03	0.03	0.28
Fernandoa adolfi-fredericii (Gilg. & Mildbr.) Heine	1	1	0.10	0.21	0.03	0.03	0.28
Zanthoxylum mildbreadii Engl.	1	1	0.10	0.21	0.03	0.03	0.28
Monodora myristica (Gaeertn.) Dunal	1	2	0.07	0.21	0.06	0.02	0.30
Diospiros hoyleana F. White	1	3	0.05	0.21	0.09	0.02	0.32
Desbordesia glaucescens (Engl.) Van Tiegh.	1	1	0.05	0.21	0.03	0.02	0.26
Hylodendron gabunense Taub.	1	1	0.05	0.21	0.03	0.02	0.26
Parinari hypochrysea Mildbr. ex R. Let & F. White	1	1	0.05	0.21	0.03	0.02	0.26
Rauvolfia vomitoria Afz.	1	1	0.05	0.21	0.03	0.02	0.26
Diospiros sp.	1	2	0.04	0.21	0.06	0.01	0.29
Diospyros zenkeri (Gürke) F. White	1	2	0.04	0.21	0.06	0.01	0.29
Antidesma membranaceum Müll. Arg.	1	1	0.02	0.21	0.03	0.01	0.25
Baphiopsis parviflora Benth. ex Bak.	1	1	0.02	0.21	0.03	0.01	0.25
Eugenia pobeguinii Aubr.	1	1	0.02	0.21	0.03	0.01	0.25
Hexalobus sp	1	1	0.02	0.21	0.03	0.01	0.25
Microdesmis puberula Hook. f. ex Planch.	1	1	0.02	0.21	0.03	0.01	0.25
Pterocarpus mildbreadii Harms	1	1	0.02	0.21	0.03	0.01	0.25
Uapaca esculenta A. Chev.	1	1	0.02	0.21	0.03	0.01	0.25
Uvaria bipindensis Engl. & Diels	1	1	0.02	0.21	0.03	0.01	0.25
Uvariodendron giganteum (Engl.) R. E. Fries	1	1	0.02	0.21	0.03	0.01	0.25
Total	467	3266	316.82	100.00	100.00	100.00	300.00

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Legend of Appendix 2

TB	TB Biological types (Rankiaer, 1934; Schnell, 1970)	TP	Phytogeographical types (Rankiaer, 1934; Schnell, 1970)	AV	Altitudinal variation (AV (SEnterre, 2005; Noumi, 2012)	PU	Phytosociological unit (PU)
me	mesophanerophyte	Aam	Afro-malagasy	Bm	Lower and middle altitudes	Fic	*Ficalhoeto-Podocarpetalia* (Lebrun and Gilbert, 1954)
mg	megageophyte	At	Afro-tropical	Bm/Sm	Lower and middle altitudes going up in Sm	Gar	*Garcinietalia* (Noumi, 1998)
mi	microphanerophyte	Cg	Centro-guineo-congolian	hM	Lower Montane (higher hygrometry)	Gil	*Gilbertiodendretalia dewevrei* (Lebrun and Gilbert, 1954)
na	nanophanerophyte	G	Omni- ou subomni-guineo-congolian	Sm	Submontane	Mit	Mitragynetea (Schmitz, 1963)
		G-Sz	G-Sz :	Sm/hM	Submontane	Mus	*Musango-Terminalietea*

			Guineo-soudano-zambezian		floor going up in hM		(Lebrun and Gilbert, 1954)
		Pal	Paleotropical	Sm and hM	Submontane floor and hM	Oleo	Oleo-Jasminetalia (Lebrun and Gilbert, 1954)
		Pan	Pantropical			Pip	*Piptadeniastro-Celtidetalia* (Lebrun and Gilbert, 1954)
						Pol	*Polyscietalia fulvae* (Lebrun and Gilbert, 1954)
						Str	*Strombosio-Parinarietea* (Lebrun and Gilbert, 1954)