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Floristic Inventory of Woody Species in the Manengouba Mountain Forest, Cameroon

Emmanuel Noumi

Dept of Biological Science, Higher Teachers' Training College

University of Yaoundé I, P.O.Box 47 Yaoundé, Cameroon

Tel: 237-7797-7371 E-mail: noumikap@yahoo.fr

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Abstract

This study aims to assess the vegetation structure and diversity of woody species in the mountain forest of mount Manengouba, and compare the values obtained with those from other tropical regions of the world.

A quantitative inventory of a 1-ha plot was achieved by plots of rectangles taking into account all trees whose diameter at breast height (DBH) was superior or equal to 10 cm, and the parameters of floristic diversity were calculated using the standard methodology.

A total of 763 trees, belonging to 40 species, were inventoried. The total basal area was 61.6 m^2/ha.. Most of trees had between 10 and 15 m height and diameters between 10 and 20 cm, but an important number of individuals attained even higher values, up to 25 m height and 115 cm of diameter. The 4 most important families in terms of density, diversity and dominance were *Rubiaceae*, *Euphorbiaceae*, *Araliaceae* and *Myrsinaceae*. They represent 70.8% of the Family Importance Value (FIV). The specific composition reveals that a small number of common species dominate the forest, 15% of species represent 54.59% of the Index of Value Importance (IVI). They are *Macaranga occidentalis, Rapanea melanophloeos, Maesa lanceolata, Polyscias fulva*, *Psydrax arnoldianu* and *Rothmannia urcelliformis*. A fraction of species (32.5%) is only represented by 1 individual.

In conclusion, in the Manengouba montane forest the diversity is weak, the density and dominance are in the higher fringes of the values obtained in most forests of tropical regions of the world. The family *Rubiaceae* displaced the family Leguminosae in the Manengouba forest even though the Leguminosae is the most important family in the lower and sub mountain forests of the tropical regions of the world.

Keywords: Cameroon, Manengouba Mountain, Mountain rainforest, Diversity, Woody flora.

1. Introduction

The limit of the guinea-Congolese and Afro highlander regions is situated between 1800-2200 m (Letouzey, 1985). One notes that the Cameroonian mountains, with the specific example of mount Manengouba (2396 m), form an archipelago connected comfortably (in the floristic point of view), to the other archipelago highlanders of oriental Africa and southern Africa (White, 1983). All these archipelagos include preferential taxa, to the echelon of the family or the species.

Many works on the structure and biodiversity have been achieved in forests of low and middle altitudes in African, Malagasy and Neotropical regions (Villanueva, 1991; Spichiger et al., 1992, 1996; Lejoly, 1995; Rabevohitra et al., 1996; Sonke, 1998; Collin, 1998; Rakotomalaza and Messmer, 1999; D'Amigo and Gautier, 2000; Senterre et al., 2004; Senterre, 2005). They enabled the circumscription of quantitative values for the families and the species of these types of forest. The mountain forests haven't had such investigations conducted according to similar methodologies. Will the characteristic values of the structure and diversity parameters determined in the mountain Manengouba forest permit establishment of differences between her and the forests of low and medium African, Malagasy and neotropical altitudes, or to unite them in the same wholes?

This survey was done on the Manengouba mount, towards the side of Mbouroukou, at 2000-2200 m of altitude. Vegetation is disrupted by the surrounding populations. The stem barks of *Prunus africana* are removed for example regularly for medicinal uses, an inconvinence that drags many precocious trees and bushes to mortality. The herds of beef (of the Bororos) that graze in the highlander prairie disrupt vegetation by their stampings. The species introduced (*Persea americana* for example) integrate to the autochthonous flora. This human activity also orders this survey, before a more advanced disruption.

Aims and objectives: The present study was aimed to make a sampling of the Manengouba forest by summaries of plots, taking into account the trees in DBH (Diameter at Breast Height) > 10 cm, to establish their structural and diversity parameters quantitatively, and to characterize the Manengouba forest in relation with the data (already established) of the low and medium altitude forests.

2. Study Area

The Manengouba massif regroups in altitude a set of summits, the most elevated, Eboga peak, culminating to 2396 m (Figure 1). It spreads between 4°48'-5°06 ' of the North latitude and 9°46'-9°55' of the East longitude. Its planimetric surface is of about 16875 ha. Its flanks are occupied by four villages: Mouanguel (North side), Mouandong (Southwesterly side), Mbouroukou (Northeast side) and Bangem on the (West side). The mount is a volcano-tectonic horst (Deruelle et al., 1991) with irregular shapes. The geology of the summit is essentially constituted of the basaltic volcanic formations, giving a ferralitic soil (Kagou, 1998). The summit presents 3 crater lakes: the man's lake, the woman's lake and the child's lake. The forest covered the south side of the summit. The herbaceous is essentially constituted of an uniform carpet of *Sporobolus africanus*, and serves for grazing. Many tributaries that leave from the mount give regular rivers either a profile of dendritic or treelike type. They form Dibombé, Djoubé and Jidé on the north side; Maa, Mom, Nguédi and Nhé on the northeast side, Moum on the east side and Mbé on the northwest side. Sources of mineral water exist to the foot of the Manengouba mount in Bangem, Baré, Ngol and Nsoung. In the absence of the data on the local climate of the Manengouba massif, those of Nkongsamba town (900 m of altitude) situated of the north side of the mount are taken into consideration. The annual average of precipitations is 2742 mm in Nkongsamba (140 km from the Atlantic coast). The level of the rainfalls is influenced negatively by the continentality. The months of December and January are least rainy. The rainfall on the Manengouba mount would be greater to the one of Nkongsamba because of the altitude. The yearly mean temperature is 22.5 °C. The relative humidity rises along the year (above 86%). The population is formed by the Mbo (natives), the Bamiléké (emigrants and planters of coffee, *Coffea robusta*) and of the Bororo (nomads and shepherds of the cows).

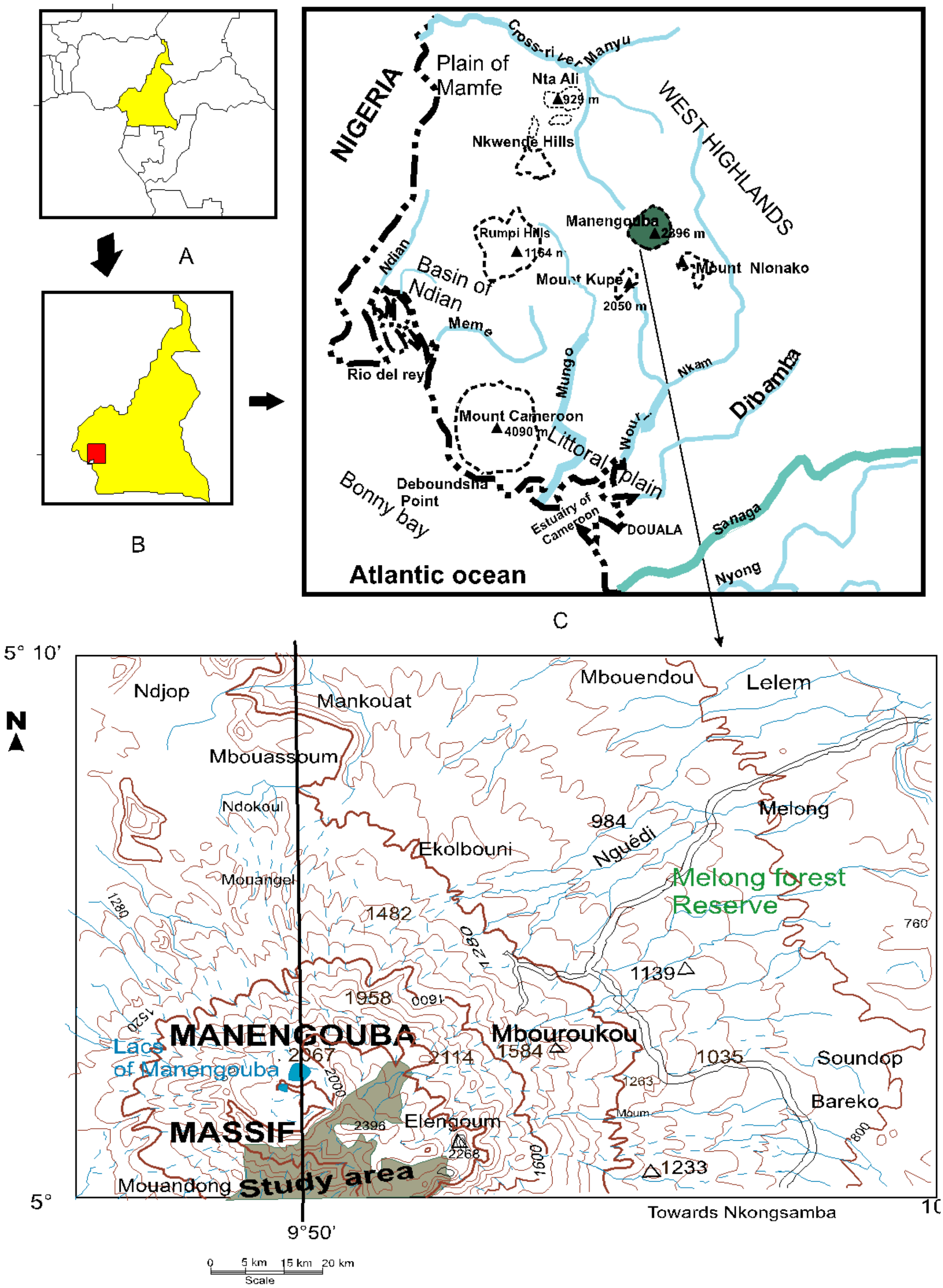

Figure 1. Geographic situation of the Manengouba mountain (2396 m) on the map of Cameroon. A) Situation of Cameroon on the Africa map, in the gulf of guinea (yellow color).

B) Situation of the Cameroonian Afro-highlander archipelagos in the south West region of Cameroun (red square). C) Some higher summits of archipelago, the highest being Mount

Cameroon, in the vicinity of Atlantic Ocean. The rivers of the Atlantic basin are in blue color (source: Yahmed and Houstin, **2006**). D) Situation of Manengouba forest (grey color) around the highest summit called Eboga peak, culminating to 2396 m, on the South, West and North sides. The site of survey is the forest above 2000 m of altitude. Sources: map of Cameroon, 1/200000, sheet NB-32-XI, CGN.

3. Materials and Method

The fieldworks were made in 2008-2010. The studied forest occupies the Southern, Western and northern slopes of the summit of the Manengouba massif. The sites inventoried, at elevations ranging from 2000 to 2200 m aslant in the montane forests, were upper 5 ° N Latitude and strading 9°50’E Longitude) for the plots. Woody plant diversity was assessed in 10 rectangles plots of 0.1 ha dimension, selected on the basis of random sampling of 0.1 ha area. These plots are all identical at the mesological and physionomical point of view. The prospection was made on a rectangular strip of 25 m of width and 40 m of length. A trail of 40 m to the center of rectangle facilitated 12.5 m sampling on one side and the other side of the trail, and so we explore every time all the strip surface.

All trees and lianas with DBH ≥ 10 cm were shortlisted and DBH (Diameter at Breast Height, measured at 1.3 m from the ground level) and height (m) were measured. The plant specimens were collected and determined by comparison with plant herbariums of the Department of Plant Biology of the Higher Teacher Training College and the National Herbarium of Cameroon (YA) in Yaoundé, while using the volumes of the flora of Cameroon (Aubréville et al., 1963-1998), Flora of West Tropical Africa, FWTA (Hutchinson and Dalziel, 1954-1972), and some books (Normand, 1965; Vivien and Faure, 1985). All woody plants ≥10 cm DBH were identified to species Data from all the plots were pooled for analysis.

On the basis of these data, we represented the curves of species-strength accumulation of different categories of DBH and species-area accumulation (Gounot, 1969) and various values were calculated: basal area or surface of the species on the soil, the index value of importance of the families (Family Importance Value, FIV; Mori et al., 1983) and the index value of importance of the species (Importance Index Value, IVI; Cottam and Curtis, 1956). The diversity was evaluated by the following index:

-index of diversity of Shannon and Weaver (1949): $ISH = -\sum Ni/N \ \log_2 \ Ni/N$;

- index of heterogeneity of Simpson (Colinvaux, 1986): D’ = $(Ni/N)^2$;

- equitability of Pielou (1966): EQ = $ISH/\log_2 S$;

Where S is the number of species of the dition; Ni is the number of the species i and N the strength of all species. It is expressed in bits;

4. Results

4.1 Forest Structure

In one hectare sampled, a density of 763 trees DBH ≥ 10 cm was recorded, representing a basal

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area of 61.69 m^2. The floristic list is made up of 40 species all identified (Appendix 1). They are distributed in 35 genus and 20 families. The richest families were the *Euphorbiaceae* and the *Rubiaceae* represented each by 6 species. These taxa drift of 763 recorded trees on 1-ha plot.

Considering tree diameter, 70.77% of individuals occurring within the 10-30 DBH size-class, 25.95 % in the 30-70 cm range. The lower percentage occured in the 70-120 cm range (3.27%). Only 0.26% of trees occured in the maximum DBH size-class (110-120 cm). Altogether, 86.1% of trees are less than 40 cm DBH (Appendix 1). The biggest trees represented by *Schefflera barteri*, *Polyscias fulva* and *Carapa grandiflora* had a DBH of 108, 113 and 117 cm respectively. Twenty-five trees belonging to 6 species had a DBH ≥ 70 cm. The distribution in DBH classes shows an inverse-shaped curve (Figure 2).

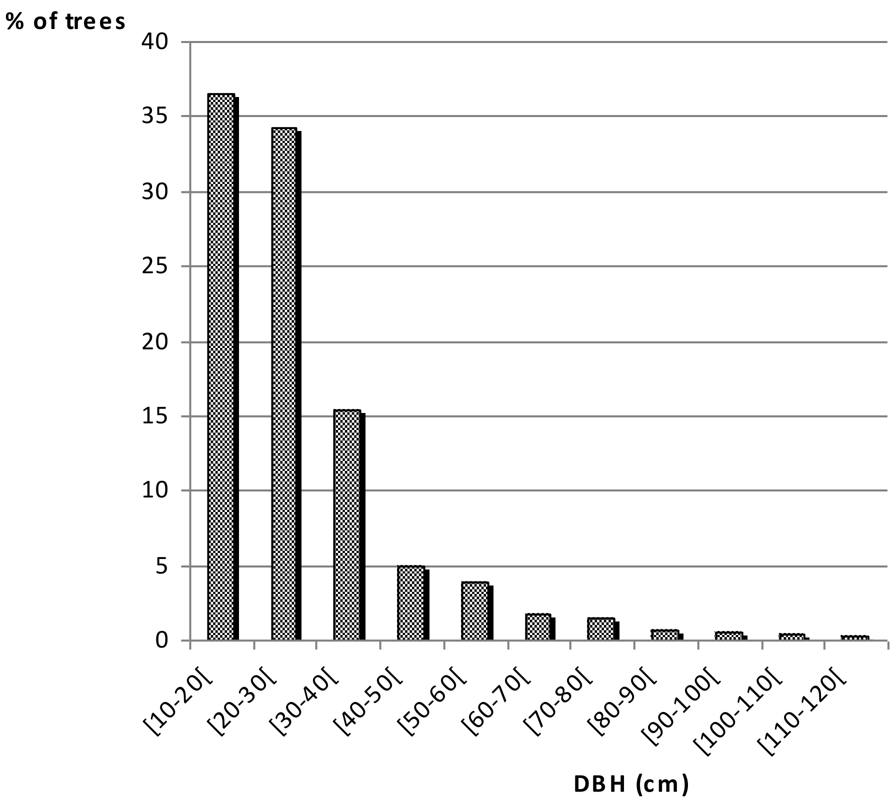

Figure 2. Size classes of all 763 trees (≥ 10 cm dbh), from 40 species.

When one considers the diversities of the 3 strata, the number of recorded species and the different indexes are presented in the Table 1. The lower stratum is always the more diversified.

Table 1. Diversity of 3 strata (RS: specific richness, N: number of ligneous species whose distribution is observed, ISH: Shannon specific diversity index values and EQ: Pielou equitability index values.

Plant strata	diameter classes	RS	N	ISH	EQ
Highest stratum	DBH ≥ 70 cm ,	25	6	2.2	0.85
Middle stratum	30 ≤ DBH < 70	198	21	3.47	0.99
Lower stratum	10 ≤ DBH < 30 cm	530	40	3.81	0.72

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The number of species inventoried by plot of 0.1 ha varies from 8 to 17 with an average of 12.6 species per plot. The species-area accumulation curve for the whole survey is drawn (Figure 6).

On the same level of sampling effort, for 25 individuals observed in each stratum, the results are presented in Table 2. The lower stratum (ligneous with 10 ≤ DBH < 30 cm) is the more diversified with 18 plant species. The species-sampling size accumulation curves are drawn for 3 diameter intervals (Figure 3). The lower stratum shows a fast increasing number of species and describes a landing subparallel to the axis of the abscissas. The woody plants with 10 ≤ DBH < 30 cm present faster growth and also describe a landing. The curve of the emergent stratum stays in the fringe that didn't yet reach the landing.

Table 2. Sampling size and diversity of 25 ligneous by stratum (RS: specific richness, N: number of ligneous species whose distribution is observed, ISH: Shannon specific diversity index values and EQ: Pielou equitability index values).

Plant strata	diameter classes	RS	N	ISH	EQ
Highest stratum	DBH ≥ 70 cm	25	6	2.2	0.85
Middle stratum	30 ≤ DBH < 70	25	12	3.43	0.96
Lower stratum	10 ≤ DBH < 30 cm	25	18	4.42	0.96

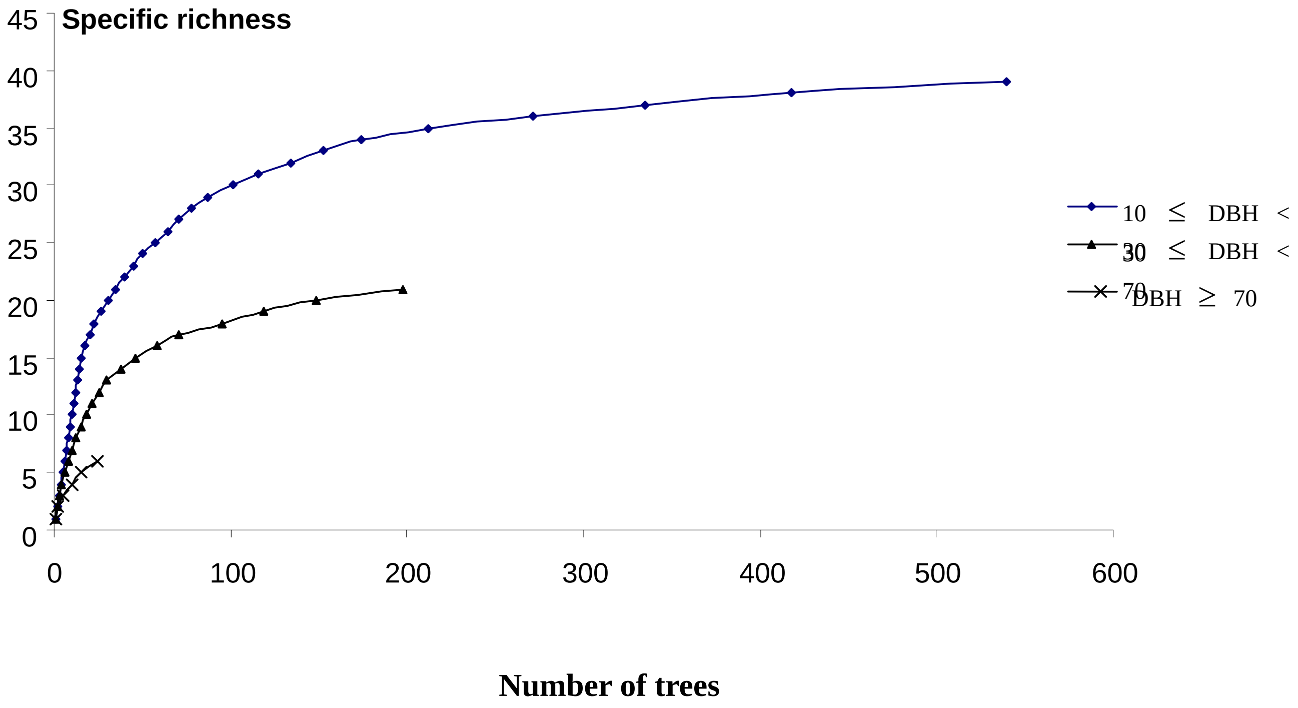

Figure 3. Species strength accumulation curve of 3 categories of DBH (DBH ≥ 70, 30 and 10 cm) on the entirety of the inventory, with respect to each of these categories.

4.2 Phytogeographic and Phytosociologic Affinities

We identified all the 40 species recorded on the plot to the specific level, but the introduced *Persea americana* is not taken into account. The known distribution of the species is given in

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Appendix 1 and reveals that 2 species *(Allophylus bullatus* and *Schefflera mannii)* are endemic to the Cameroonian high mountains archipelago (Letouzey, 1985). Within the tropical region, the occurrence of these species is given (Table 3). The contribution of Manengouba local endemic is 5%. The majority of the species (15 species; 41%) are highlander and 23% submountain. Regarding phytosociologic aspect, the different taxa are in Table 3. Only the intermediate combination between two successive types of the pressure gradient (and no disconnected) are generally feasible for species of liaison (Senterre, 2005). The majority of the species (85%) belong to the rainforests (*Strombosio-Parinarietea*). The other species are features of the secondary mountain forests (*Polyscietalia fulvae*) (7.5%) and of secondary planitiary forests (*Musango-Terminalietea*) (5.65%).

Table 3. Phytogeographic and phytosociologic affinities of the identified species of the Manengouba sampling.

Altitudinal strata	Lowlands stratum		Submountain stratum	lower mountain stratum (high hygrometry)	
Phytogeographic affinities	Bm, Bm + Sm		Sm, Sm + Mi	Mi, Mi + Ms	
		Strombosio-Parinarietea Lebrun & Gilbert 1954			
Phytosociologic groups	*Musango-Terminalietea* 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
Number of species	5	12	7	10	5

Bm (lower and middle altitudes), Bm + Sm (low and medium altitudes going up to Sm), Sm (Submountain altitude), Sm + Mi (Submountain going up in Mi), Mi (lower highlander, (strong hygrometry), Mi + Ms (lower highlander going up in Ms), Ms (superior highlander, weak) hygrometry).

4.3 Floristic Composition

Family level – Three families *Fabaceae, Mimosaceae* and *Caesalpiniaceae* are treating as a single family *(Leguminosae*). So, we recorded twenty families in the sampling. The ten most important families for each relative parameter and FIV are listed in Table 4. The value of each relative parameter for the ten families with highest FIV is represented in Figure 4. The complete results for each family are given in Appendix 2.

Table 4. Families with highest values of relative diversity, relative density, relative dominance and FIV in decreasing order. Families that do not rank among the ten most important in FIV value appear in bold type.

Relative diversity [x 100%]	Relative density [x 100%]	Relative dominance [x 100%]	FIV [x 300%]

Euphorbiaceae	15	*Myrsinaceae*	28.44	*Araliaceae*	29.11	*Rubiaceae*	56.19
Rubiaceae	15	*Rubiaceae*	25.69	*Euphorbiaceae*	25.77	*Euphorbiaceae*	55.71
Araliaceae	10	*Euphorbiaceae*	14.94	*Myrsinaceae*	16.08	*Araliaceae*	51.03
Moraceae	7.5	*Araliaceae*	11.93	*Rubiaceae*	15.50	*Myrsinaceae*	49.52
Myrsinaceae	5	*Meliaceae*	5.24	*Meliaceae*	5.81	*Meliaceae*	16.06
Meliaceae	5	*Cyatheaceae*	1.97	*Opiliaceae*	1.67	*Moraceae*	8.33
Rutaceae	5	*Opiliaceae*	2.49	*Rutaceae*	1.51	*Rutaceae*	7.95
Cyatheaceae	5	*Thymelaeaceae*	2.49	*Rosaceae*	1.33	*Cyatheaceae*	7.40
Sapindaceae	5	*Rutaceae*	1.44	*Melianthaceae*	0.71	*Opiliaceae*	6.66
Opiliaceae	2.5	*Rosaceae*	1.31	*Thymelaeaceae*	0.60	*Sapindaceae*	6.19

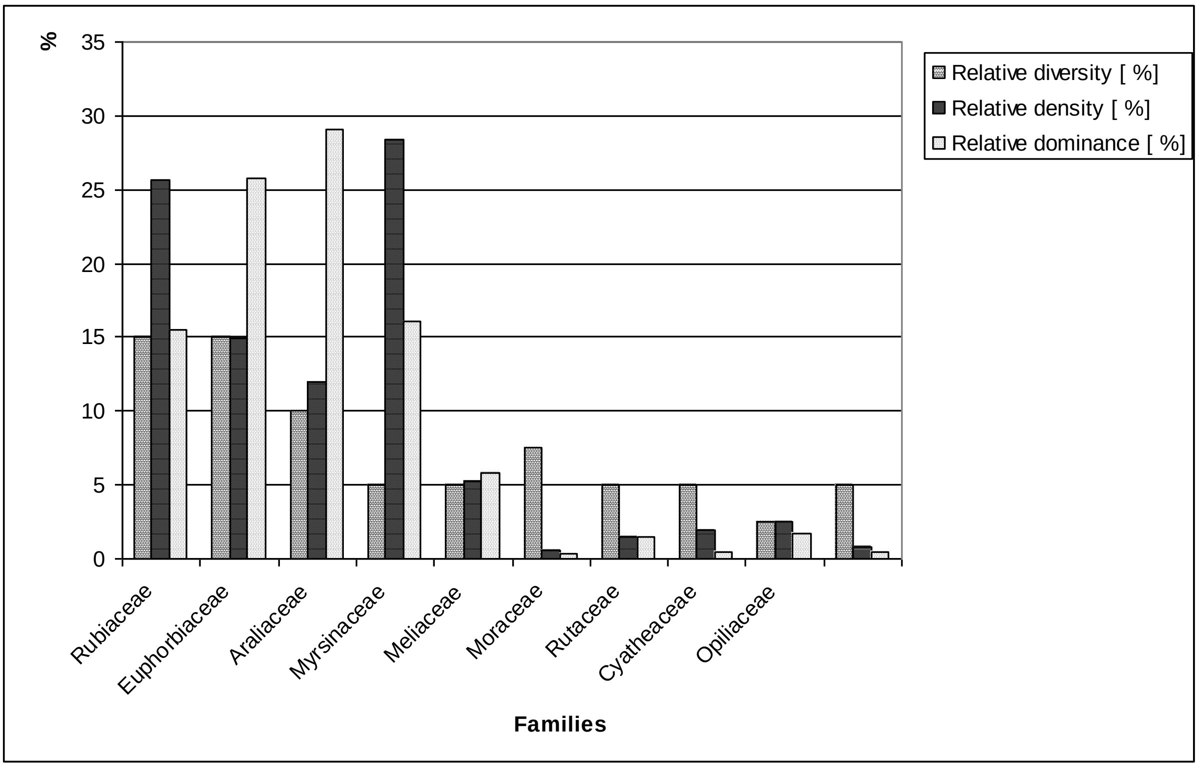

Figure 4. Relative diversity, Relative density and relative dominance of the ten most important families in FIV.

Regarding relative density, the ten most abundant families are *Myrsinaceae, Rubiaceae,Euphorbiaceae, Araliaceae, Meliaceae, Opiliaceae, Thymelaeaceae, Cyatheaceae, Rutaceae* and *Rosaceae.* The density of each other family does not reach 6%. *Myrsinaceae, Rubiaceae, Euphorbiaceae* and *Araliaceae* are clearly the most abundant families. Together they contribute 81% of all trees in the sampling inventory (Table 4).

Families with highest dominance are *Araliaceae, Euphorbiaceae, Myrsinaceae, Rubiaceae, Meliaceae, Opiliaceae, Rutaceae, Rosaceae,,Melianthaceae* and *Thymeliaceae*. *Araliaceae, Euphorbiaceae, Myrsinaceae* and *Rubiaceae* together account for 86.49% of the total basal area. The ten most species-rich families are *Rubiaceae, Euphorbiaceae, Araliaceae, Moraceae,* *Myrsinaceae*, *Rutaceae*, *Cyatheaceae* , *Sapindaceae*, *Meliaceae* and *Opiliaceae*. The relative diversity of *Rubiaceae* (6 species) represents 15% of the total species diversity of the sampling. Eleven families are represented by a single species, 5 by 2 species, 1 by 3 species and 1 by 4 species (Appendix 2).

With regard to Family Importance Value (FIV), Rubiaceae (italic) are the most important family in the sampling with a FIV of 56.19. They also have the highest relative diversity (with *Euphorbiaceae*) and the higher relative density values. When comparing FIV and the 3 relative values of the ten most important families, only *Rubiaceae, Euphorbiaceae, Araliaceae, Myrsinaceae, Meliaceae, Rutaceae Cyatheaceae* and *Opiliaceae* appeared among the first ten families for all parameters. *Sapindaceae* are tenth in FIV due to their relative diversity. *Moraceae* are 4th in relative diversity but they drop to the position 6th in FIV because of their low relative density and dominance. Considering relative dominance, three familes: *Rosaceae, Melianthaceae* and *Thymeliaceae* have some appreciated values and account for 2.64% of the total basal area, but are represented by only one species and a few individuals respectively. Thus the two families are not among the ten families with the highest FIV.

Specific level – We recorded forty species in the sampling. The authors of scientific name appear in appendix 1. Table 5 lists the ten most important species in each relative parameter. The values of each parameter for the ten species with the higher IVI are represented in Figure 5. Appendix 3 gives the results for all species. A small group of species dominates the plot: 5 species (12.5% of the total number of species) account for 63.96% of all trees. The majority of species (47.5) are represented by lest than 5 individuals: 2 species are represented by 2 individuals, but 13 species (32.5%) are represented by a single individual. Regarding relative dominance, less than 10% of the species contribute 54.78% of total basal area. High dominance can be achieved by a great number of small trees or by a few large trees. *Schefflera abyssinica* is 9th in relative density (22 individuals) but drops to 20th position in relative dominance. *Opilia celtidifolia* is 4th in relative frequency, but it is 11th in both relative density and relative dominance.

Table 5. Species with highest values of relative frequency, relative density, relative dominance and IVI in decreasing order. Species that do not rank among the ten most important in IV I value appear in bold characters.

Relative frequency [x 100%]		Relative density [x 100%]		Relative dominance [x 100%]		IV I [x 300%]	
Rapanea melanophloeos	7.52	*Rapanea melanophloeos*	16.25	*Macaranga occidentalis*	20.65	*Macaranga occidentalis*	37.35
Polyscias fulva	7.52	*psydrax arnoldianum*	12.45	*Polyscias fulva*	13.36	*Rapanea melanophloeos*	30.48
Schefflera mannii	6.02	*Maesa lanceolata*	12.19	*Schefflera barteri*	11.39	*Maesa lanceolata*	26.08
Opilia celtidifolia	5.26	*Macaranga occidentalis*	12.19	*Maesa lanceolata*	9.38	*Polyscias fulva*	24.16
psydrax arnoldianum	4.51	*Rothmannia urcelliformis*	10.88	*Rothmannia urcelliformis*	7.66	*psydrax arnoldianum*	23.44

Maesa lanceolata	4.51	*Schefflera barteri*	4.46	*Rapanea melanophloeos*	6.71	*Rothmannia urcelliformis*	22.30
Macaranga occidentalis	4.51	*Carapa grandiflora*	3.54	*psydrax arnoldianum*	6.48	*Schefflera barteri*	18.85
Croton macrostachyus	4.51	*Polyscias fulva*	3.28	*Carapa grandiflora*	4.34	*Carapa grandiflora*	11.64
Rothmannia urcelliformis	3.76	*Schefflera abyssinica*	2.88	*Croton macrostachyus*	3.34	*Schefflera mannii*	10.57
Prunus africana	3.76	*Opilia celtidifolia*	2.49	*Schefflera mannii*	3.24	*Croton macrostachyus*	9.81

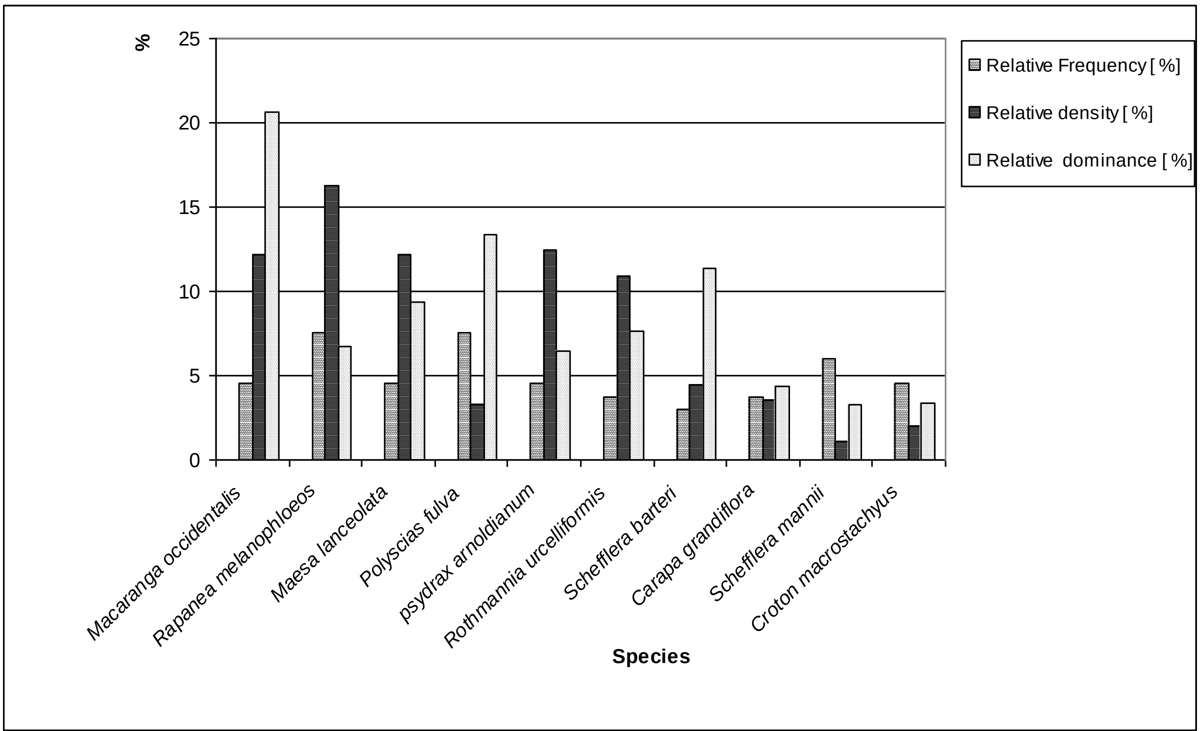

Figure 5. Relative frequency, relative density, and relative dominance of the ten most important species in IVI.

5. Discussion

The comparisons between the data of this survey and those of other dense forests of Africa, Madagascar and Neotropic region are based on the floristic and structural, quantitative and qualitative parameters. The main aim was to determine the parameters that make the differences and those that bring them closer, to highlight the features closed to the Manengouba highlander forest.

5.1 Manengouba Forest Structure

The species-area accumulation curve for the plot is drawn and compared to those of some samplings of central Africa (Figure 6). In any case, the expression of the study area shows quantitatively low data. It follows a classical accumulation curve. In any consecutive quadrat, new species were encountered making it difficult to determine if one ha is satisfactory for a fully representative sample for the forest. In fact it is observable in the accumulation curve. Nevertheless in the other central African forests, new species always occur in spite the altitude and of the inventoried surface. One can presume that 1-ha surface is suitable for the study (D'Amico and Gautier, 2000; Nusbaumer et al., 2005).

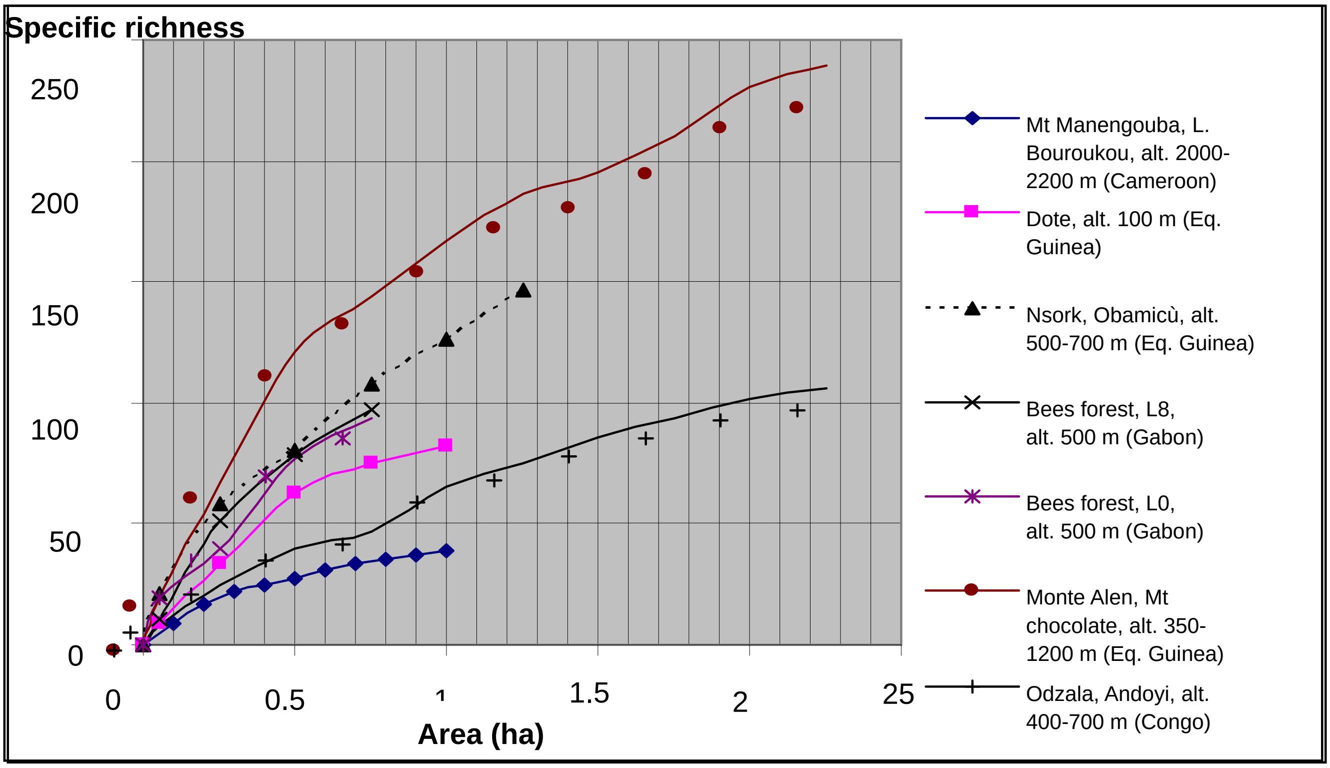

Figure 6. Species-area accumulation curve of the 1-ha plot in the Manengouba highlander forest (each sub-unit is represented by 40 x 25 m = 0.1 ha) and 6 species-area accumulation curves achieved in Atlantic central Africa; Dote (Collin, 1998), Bees forest, L.0 et L.8 (Gesnot, 1994), Monte Alèn (Van Reeth, 1997), Nsork (Senterre, 2005), Odzala, (Van Asbroeck, 1997).

The density of 763 trees $\geq$ 10 cm DBH is within the range of 167 to 1947 individuals per hectare reported by (Gentry, 1982) for Neotropical forests sampled by different methods, and the range of 542 to 1223 trees/ha (DBH $\geq$ 10 cm) (Rabevohitra et al., 1996; Rakotomalaza & Messmer, 1999) recorded in a series of 1-ha plots set low elevation rainforests in the eastern Madagascar. The comparison with inventoried trees of tropical rainforests sampled in various continents shows that tree density seems to have a high similar range of variation in the mountain forests throughout the world (Mohandass and Davidar, 2009) but, no matter the altitude (Table 6).

Table 6. Number of trees per hectare (dbh $\geq$ 10 cm) in Manengouba rainforest and in lowland rainforests sites in Africa, Madagascar and Neotropic regions, by decreasing density.

Sites	Countries	References	Number of trees/ha
Andranomintina (plot 1),	Madagascar	Rabevohitra et al., 1996	1223

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Shola montane evergreen forest	Nilgiri, India	Mohandass and Davidar, 2009	832
Manengouba forest (Mbouroukou)	Cameroon	Present study	763
Yasuni (unflooded forest),	Ecuator	Balslev et al., 1987	728
Lowland rainforest in Manongarivo	Madagascar	D'Amico and Gauthier, 2000	728
Yapo (unfloodplain forest),	Côte d'Ivoire	Corthay, 1996	649
Alto Ivon,	Bolivia	Boom, 1986	649
Forest of Ngotto	Centrafrican Republic	Lejoly, 1995	549
Forestry Reserve of Dja (Alat 1.7)	Cameroon	Sonké, 1998	513
Forest with *Cleistopholis patens* and *Ficus mucuso*	Benin	Sokpon, 1995	494
Oveng	Gabon	Reitsma, 1988	485
Jenaro Herrera	Peru	Spichiger et al., 1996	482
Bees forest	Gabon	Gesnot, 1994	458
Yasuni (floodplain forest),	Ecuator	Balslev et al., 1987	417
Classified forest of Scio	Côte d'Ivoire	Nusbaumer et al., 2005	413
Lopé (site 1)	Gabon	White, 1992	304
National Park of Odzala (layon Andzoyi)	Congo	Lejoly, 1996	294.7

The structure the Menengouba mountain forest is in a high range as the montane Shola forests of the Nilgiris (Mohandass and Davidar, 2009). The basal area (61.69 m^2/ha) is more elevated than the value reported by D'Amico & Gauthier (2000) and those reported by Mori et al. (1983) for five moist lowland neotropical forests (ranging from 21.5-53.0 m^2/ha) sampled by the point centered quarter method (Cottam & Curtis, 1956). Basal areas have also been found in other lowland rainforests of Madagascar sampled using the permanent 1-ha plot method: 34.1 m^2/ha at Andohahela (Rakotomalaza & Messmer, 1999), and a range of 19.0 to 38.9 m^2/ha in ten different eastern lowland forests (Rabevohitra et al., 1996), or in African lowland rainforest of : 19.2 m^2/ha in Cameroon (Lejoly, 1996) ; 42.32 m^2/ha in Benin (Sokpon, 1995) ; 30.82 m^2/ha in Côte-d'Ivoire (Nusbaumer et al., 2005). Many works over the world show lower values of basal area than Manengouba highland forest (Table 7). In this study the value of the basal area and the distribution of the diameter classes observed are typical of a forest in good state of conservation (Rollet, 1979). The forest remains always in the state of growth, due to its mesologic characters (Lebrun and Gilbert, 1954). The individuals of the mountain ombrophile species (*Carapa grandiflora*, *Macaranga occidentalis*, *Polyscias fulva*, *Schefflera barteri* and *Schefflera mannii*) gain dimension.

Table 7. Basal area/ha in the Manengouba forest and lowland rainforests altitudes, in Africa and other areas, in deceasing dominance.

Sites	Countries	References	basal area (m^2)
Manengouba forest (Mbouroukou)	Cameroon	Present study	61.69

Shola montane evergreen forest	Nilgiri, India	Mohandass and Davidar, 2009	53.55
Cleistopholis patens and *Ficus mucuso* forest	Benin	Sokpon, 1995	42.3
Yapo classified forest	Côte-d'Ivoire	Corthay, 1996	40.0
Dja Forestry Reserve (Alat 1.7)	Cameroon	Sonké, 1998	34.2
Yasuni (unflooded forest)	Ecuator	Balslev et al., 1987	33.7
Scio Classified forest	Côte d'Ivoire	Nusbaumer et al., 2005	30.82
Andranomintina (plot 1)	Madagascar	Rabevohitra et al., 1996	27.9
Andranomintina (plot 2)	Madagascar	Rabevohitra et al., 1996	25.3
Jenaro Herrera	Peru	Spichiger et al., 1996	22.6
Manongarivo	Madagascar	D'Amico and Gauttier,2000	22.4

5.2 Floristic Composition

The floristic list is composed of 40 species all identified (Appendix 1) from which are derivates 35 genus and 20 families. The nomenclature follows Lebrun & Stork (1991-1997).

Family level - In the plot sampled, more than 58% of all trees are represented by 3 families. According to Rabevohitra et al. (1996) 4, 5 or 6 families always represent more than 50% of total trees in littoral forests along Madagascar's east coast. Table 8 shows that in Manengouba forest and 3 sub mountain forests inventories in Cameroon, *Apocynaceae, Euphorbiaceae, Leguminosae (capital), Meliaceae* and *Rubiaceae* are frequently among the ten most abundant families. *Araliaceae* is the mountain forest family.

Table 8. The ten most abundant families in Manengouba forest and three Cameroonian submountain forests (available data). Families among the ten most abundant in at least 3 plots appear in bold letters.

Messa forest	Kala forest	Kouoghap Sacral forest (SF)	Manengouba forest
Tagne, 2007	Madiapevo, 2008	Noumi (2012)	Present study
Alt. 900-1015 m	Alt. 1000-1156 m	Alt. 1400-1550 m	2200-2396 m
Sterculiaceae	Myristicaceae	Rubiaceae	Rubiaceae
Moraceae	Clusiaceae	Meliaceae	Euphorbiaceae
Euphorbiaceae	Leguminosae	Moraceae	Araliaceae
Leguminasae	Annonaceae	Bignoniaceae	Moraceae
Meliaceae	Rubiaceae	Apocynaceae	Myrsinaceae
Apocynaceae	Sterculiaceae	Sapotaceae	Meliaceae
Caricaceae	Meliaceae	Leguminosae	Rutaceae
Myristicaceae	Apocynaceae	Euphorbiaceae	Cyatheaceae
Lauraceae	Burseraceae	Araliaceae	Sapindaceae
Ulmaceae	Euphorbiaceae	Clusiaceae	Opiliaceae

Family composition of Lowlads forests of the tropics tend to be similar (Gentry, 1988). This latter listed 11 families (*Leguminosae, Lauraceae, Annonaceae, Rubiaceae, Moraceae,*

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Myristicaceae, Sapotaceae, Meliaceae, Arecaceae, Euphorbiaceae and *Bignoniaceae*) that contribute half of the species' richness to 1-ha samplings in lowland neotropical forests. At least eight of these families are always among the ten richest species in Africa and Asia as well. This is not the case with the Manengouba highlander forest. Only 5 families (*Rubiaceae Euphorbiaceae Araliaceae Moraceae Myrsinaceae*) contribute half of the species' richness to 1-ha plot in the Manengouba forest. The same families, except for *Moraceae*, are the richest species. Five families (*Myrsinaceae, Rubiaceae, Euphorbiaceae, Araliaceae, Meliaceae*) are among the ten most important families for relative density and FIV in the plot sampled here (Table 9). The dominance of *Leguminosae* in the neotropic regions and Africa is equal when only the trees in DBH $\geq$10 cm are considered (Gentry, 1988). The *Leguminosae* is among the first families in FIV in the lowland and submountain forests (Table 9). It no longer has a representative in the highlander Manengouba forest. The same is observed in an inventory of all plants ≥1 cm dbh recorded in 19 sholas of total area 11.5 ha (Mohandass and Davidar, 2009).

It is remarkable that in the Cameroonian highland forests, *Rubiaceae* seem to be more important than in Neotropical (capital) and African lowland forests. At Manengouba it is the first in FIV accumulation values (FIV: 56.19), while it is 4th with an FIV of 21.23 at Manongarivo (D'Amico and Gautier, 2000), 6th with an FIV value of 14.71 at Yasuni (Balslev et al., 1987),10th with an FIV value of 8.3 at Alto Ivon (Boom, 1986), 14th with an FIV value of 7.79 at Jenera Herrera (Spichiger et al., 1996). The scarcity of *Rubiaceae* is observed as recorded in many lowland forests (Table 9). On the one hand in Cameroon, *Rubiaceae* are much more abundant and more species-rich in the highland forests (Tagne, 2007; Madiapevo, 2008; Noumi, 2012),on the other hand at Manengouba *Myrsinaceae* are the much more abundant, the *Rubiaceae* and *Euphorbiaceae* are the most diversified.

Table 9. Family Importance Value of the 15 most important plant families in Manengouba and 3 other Cameroonian highland forests, and 7 lowland tropical forests reported by D'Amico and Gautier (2000) (for Mori et al. 1983, only the first 10 were reported).

SF Kouoghap (Cameroon) Noumi 2012		Kala forest (Cameroon) Madiapevo, 2008		Messa forest Cameroon) Tagne, 2007		Manengouba forest (Cameroon) Present study	
Families	FIV	Families	FIV	Families	FIV	Families	FIV
Meliaceae	33.38	*Leguminosae*	31.00	*Leguminosae*	47.60	*Rubiaceae*	56.19
Leguminosae	32.63	*Clusiaceae*	27.90	*Sterculiaceae*	33.17	*Euphorbiaceae*	55.71
Moraceae	31.81	*Myristicaceae*	26.80	*Moraceae*	28.93	*Araliaceae*	51.03
Sapotaceae	26.83	*Burseraceae*	21.77	*Euphorbiaceae*	26.11	*Myrsinaceae*	49.52
Rubiaceae	26.12	*Sterculiaceae*	21.41	*Meliaceae*	17.26	*Meliaceae*	16.06
Bignoniaceae	21.16	*Annonaceae*	18.24	*Apocynaceae*	13.90	*Moraceae*	8.33
Apocynaceae	19.49	*Rubiaceae*	17.96	*Myristicaceae*	12.59	*Rutaceae*	7.95
Euphorbiaceae	15.74	*Meliaceae*	17.83	*Ulmaceae*	12.26	*Cyatheaceae*	7.40
Verbenaceae	12.51	*Euphorbiaceae*	15.78	*Caricaceae*	10.57	*Opiliaceae*	6.66
Annonaceae	11.23	*Apocynaceae*	13.76	*Rubiaceae*	10.12	*Sapindaceae*	6.19

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Burseraceae	9.65	*Irvingiaceae*	8.18	*Bombacaceae*	7.44	*Thymelaeaceae*	5.59
Sterculiaceae	9.33	*Moraceae*	8.13	*Cecropiaceae*	7.38	*Rosaceae*	5.14
Araliaceae	7.70	*Cecropiaceae*	7.92	*Combretaceae*	7.37	*Melianthaceae*	4.26
Agavaceae	6.83	*Flacourtiaceae*	7.43	*Lauraceae*	7.19	*Asteraceae*	3.14
Clusiaceae	6.66	*Sapotaceae*	7.38	*Olacaceae*	6.85	*Alangiaceae*	3.10
Yapo (Ivory Coast) Corthay, 1996		Manongarivo(Madagascar) D'Amigo & Gautier, 2000		Yasuni (Ecuator) Balslev et al., 1987		Jenera Herrera (Peru) Spichiger et al., 1996	
Famille	FIV	Famille	FIV	Famille	FIV	Famille	FIV
Sapotaceae	34.15	*Clusiaceae*	40.78	*Arecaceae*	55.66	*Leguminasae*	29.07
Leguminosae	32.27	*Euphorbiaceae*	29.09	*Moraceae*	36.48	*Sapotaceae*	28.22
Burseraceae	24.83	*Myrtaceae*	27.17	*Leguminasae*	23.73	*Moraceae*	23.50
Euphorbiaceae	18.88	*Rubiaceae*	21.23	*Bombacaceae*	19.66	*Myristicaceae*	18.84
Meliaceae	18.70	*Myristicaceae*	19.04	*Myristicaceae*	19.59	*Lauraceae*	18.28
Sterculiaceae	18.57	*Lauraceae*	16.32	*Rubiaceae*	14.73	*Chrysobalanaceae*	18.05
Ebenaceae	15.49	*Burseraceae*	13.77	*Meliaceae*	11.62	*Lecithidaceae*	17.38
Clusiaceae	14.85	*Sapotaceae*	10.48	*Euphorbiaceae*	8.15	*Burseraceae*	11.84
Olcaceae	13.51	*Erythroxylaceae*	9.51	*Cecropiaceae*	7.86	*Annonaceae*	10.67
Chrysobalanaceae	12.08	*Annonaceae*	9.37	*Lecythidaceae*	7.54	*Arecaceae*	9.47
Flacourtiaceae	11.91	*Sarcolaenaceae*	8.27	*Lauraceae*	7.37	*Vochysiaceae*	9.43
Combretaceae	8.75	*Asteraceae*	8.22	*Sterculiaceae*	6.72	*Humiraceae*	8.52
Lecythidaceae	6.64	*Leguminosae*	7.71	*Flacourtiaceae*	6.18	*Cecropiaceae*	7.89
Irvingiaceae	6.37	*Ebenaceae*	7.57	*Polygonaceae*	6.07	*Rubiaceae*	7.79
Scytopetalaceae	6.35	*Arecaceae*	7.17	*Sapotaceae*	5.59	*Combretaceae*	7.50
Alto Parana (Paraguay) Spichiger et al., 1992		Alto Ivon (Bolivia) Boom, 1986 (Submountain going up in lower highlander		Bahia (Brazil) Mori et al., 1983			
Famille	FIV	Famille	FIV	Famille	FIV		
Meliaceae	44.4	*Moraceae*	53.3	*Myrtaceae*	52.2		
Lauraceae	42.4	*Myristicaceae*	41.1	*Sapotaceae*	39.4		
Sapotaceae	39.4	*Palmae*	35.7	*Caesalpiniaceae*	28.5		
Leguminosae	31.9	*Leguminosae*	30.1	*Lauraceae*	20.8		
Rutaceae	25.4	*Melastomataceae*	20.1	*Chrysobalanaceae*	15.4		
Moraceae	20.4	*Cecropiaceae*	15.3	*Euphorbiaceae*	12.1		
Boraginaceae	14.7	*Vochysiaceae*	13.9	*Bombacaceae*	11.9		
Arecaceae	11.1	*Annonaceae*	8.7	*Lecythidaceae*	9.5		
Annonaceae	10.1	*Chrysobalanaceae*	8.3	*Melastomataceae*	9.4		
Bignoniaceae	8.2	*Rubiaceae*	8.3	*Moraceae*	9.4		
Solanaceae	4.6	*Lauraceae*	7.2				
Myrtaceae	3.5	*Burseraceae*	6.8				
Sapindaceae	3.2	*Euphorbiaceae*	5.7				
Flacourtiaceae	2.7	*Flacourtiaceae*	5.2				
Euphorbiaceae	2.5	*Myrtaceae*	4.5				

Specific level - In the present study 40 species were encountered. The number of species per hectare seems to be fluctuating in Africa (47-178) (Table 10), in Madagascar: 38-146 (Rakotomalaza and Messmer, 1999; Rabevohitra et al., 1996) and in the néotropical region: 94 at Alto Ivon (Bolivia) (Boom, 1986), 228 in Amazonian Ecuador (Balslev et al., 1987). Lower diversity values were recorded in Côte-d'Ivoire where Corthay (1996) found 76 and 77 species/ha in two plots in the Yapo forest and in Alto Parana where Spichiger et al. (1992) found 60 species. The Manengouba forest (40 species/ha) is characterized by the lowest value of number of species per hectare recorded by different researchers through the African, Madagascar and Neotropical (capital). forests. The selective conditions of the mesologic factors in the mountain effectively limit the number of plant species.

Table 10. Number of species per hectare and Shannon diversity index of Guinean-Congolese rainforests, in decreasing density.

	Countries	References	Number species/ha	Shannon diversity index
Kala forest	Cameroon	Madiapevo, 2008	178	5.19
Messa forest	Cameroon	Tagne, 2007	151	6.24
Dja Forestry Reserve (Djolimpoum L1)	Cameroon	Sonké, 1998	138	5.62
Lopé (site 4)	Gabon	White, 1992	129	4.14
Scio Classified Forest	Côte-d'Ivoire	Nusbaumer et al., 2005	89	5.91
Kouoghap Sacral Forest	Cameroon	Noumi, 2012	79	4.83
Yapo Classified Forest	Côte-d'Ivoire	Corthay, 1996	77	6.19
Ngotto,forest	Centrafrican Republic	Lejoly, 1995	58	5.3
Cleistopholis patens and *Ficus mucuso* forest	Benin	Sokpon, 1995	53	4.76
Odzala National Park (Mbandza 1)	Congo	Lejoly, 1996	47	6.35
Manengouba forest	Cameroon	Present study	40	3.98

According to Rollet (1983) an average of 50% of individuals are represented by 20 species in undisturbed lowland Amazonian forests of Venezuela. In Manongarivo , half of the trees are represented by only 11 species. In Manegouba 53% of trees are represented only by 4 species and 63.9% by 5 species. These plant species are among the ten first in FIV due to their relative density. In high altitude numerous plants are gregarious.

The Shannon diversity index (H') (Shannon and Weaver, 1949) permits a good approach of the diversity on the different plots because it takes into account the number of species and the distribution of abundances. Its calculated values for different Guinean forests are between 4 and 6.5. The Manengouba formation presents a low value (H' = 3.98), which shows a less diversified forest, with gregarious species (Table 10).

Mori *et al*. (1983) consider species found only once in the sample as rare. In a lowland forest of eastern Brazil 41% species were rare, according to this definition. A forest inventory in Andohahela, Madagascar (Rakotomalaza and Messmer, 1999) recorded a value of 38.8%. In our study, the percentage of species represented by only one individual (32.5%) is lower than those reported in the above mentioned studies and is close to the value reported in Messa – 28 % - (Tagne, 2007), but higher than -21.1%- (D'Amico & Gautier, 2000) in Manongarivo; -21.1 % - (D'Amigo and Gautier, 2000), – 22 % - (Spichiger et al., 1992) in Alto Parana and -12,5 % - (Madiapevo, 2008) in Kala.

The ratio of individual/species in the 1-ha plot of Menengouba mountain is 18.65. In other 1-ha plots in Madagascar, recorded values were 6.1 (Rakotomalaza and Messmer, 1999) and 9.17 to 22.1 (Rabevohitra et al., 1996). In Cameroon the individual/species ratios found in the sub mountain forest are -8.03- Tagne (2007) and -10.05 - Madiapevo (2008). A series of 1-hectare forest inventories sampled in the neotropics recorded the following values: 8.42 in Southern Bahia, Brazil (Mori et al., 1983); 2.05 in Jenaro Herrera (Spichiger et al., 1996).

The IVI of *Macaranga occidentalis*, the species with the highest value in the plot, is 37.35. Similar values were recorded in a gallery forest of Mogi-Gua çu, Brazil (Spichiger et al., 1996). where the highest IVIs were 37.7 and 43.5. These values fall to the 12.5-28.7 range of highest IVI recorded by Mori & Boom(1987) in the lowland moist forests (Baslev et al., 1987); to -20.71- (Madiapevo, 2008) at Kala forest and to -16.37- (Tagne, 2007) at Messa forest.

Altitudinal affinities-Comparing floristic composition of Manengouba forest and other highlander rainforests sampled in Cameroon (Letouzey, 1985), 13 (38.46%) species are shared with mountain vegetations: 10 species (*Carapa grandiflora, Schefflera barteri , Schefflera mannii, Rothmannia urcelliformis , Prunus Africana, Bersama abyssinica, Rapanea melanophloeos , Allophylus bullatus , Gnidia glauca* and *Maytenus acuminata*) in the mountain rainforests and 5 species (*Polyscias fulva, Macaranga occidentalis, Maesa lanceolata , Alangium chinense* and *Vernonia blumeoides*) in the secondary mountain forests. It is worth mentioning that among *Leguminosae*, widely abundant in all Guinean-Congolese region (Lowlander formations of divers types and submontain forests) (Letouzey, 1968, 1985), no species was shared between Manengouba highlander rainforest and lower altitude forests.

The *phytogeographic affinities.* According to White (1983) the Cameroonian mountains form an archipelago connected comfortably, at the floristic point of view, to the other African highlanders' archipelagos. The phytogeographic affinities of the mountain species recorded here falls within many distribution patterns.

Size of plant species, 20% of total species (*Alangium chinense, Bersama abyssinica, Carapa grandiflora, Macaranga occidentalis, Polyscias fulva, Rothmannia urcelliformis, Schefflera barteri* and *Vernonia blumeoides*) are widely distributed in Guinean-Congolese region forest; among which *Alangium chinense* has a paleotropical distribution (Jaques-Félix, 1970); 5% of the species (*Prunus africana* and *Rapanea melanophloeos*) are distributed throughout 3 African archipelagos (Cameroonian Afro-highlander archipelago, eastern Africa highlander archipelago and southern Africa highlander archipelago), 5% of the species (*Gnidia glauca* and *Maytenus acuminata*) are shared only with the eastern Africa highlander

Archipelago and 2.5% (*Maesa lanceolata*) with southern Africa highlander Archipelago and 5% (*Allophylus bullatus* and *Schefflera mannii*) are endemic of the Cameroonian highlander archipelago (Letouzey, 1985).

6. Conclusion

Based on the structure and composition at the family level, the Manengouba forest sampled in this study is clearly best classified as dense humid highlander rainforest. In comparison with Cameroonian sub mountain forests and other tropical lowland rainforests in the world, it displays the same relative values for tree densities together with an average number of rare species, a relatively high value for basal area, a relatively lower diversity.

The difference is well marked on the qualitative point of view where the *Leguminosae* family, important in the lower and sub mountain forests, is absent in the Manengouba forest. There, the family of *Rubiaceae* marks the altitudinal steep, by its importance.

Floristic affinities of the species show that more than 13 of species are orophytes among which some are widely distributed in the Guinean-Congolese region, whereas others are shared with the African eastern and southern archipelagos. There is also a clear component of Cameroonian mountains archipelago in which is located the Manengouba rainforest.

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Appendix 2. Density, basal area, diversity and FIV of the plant families encountered in the 1-ha Manengouba plot, presented by decreasing FIV.

N°	Families	Number of species	Number of trees	Basal area [m²]	Relative diversity [x 100 %]	Relative density [x 100 %]	Relative dominance [x 100 %]	FIV [x 300 %]
1	*Rubiaceae*	6	196	9.57	15	25.69	15.50	56.19
2	*Euphorbiaceae*	6	114	15.91	15	14.94	25.77	55.71
3	*Araliaceae*	4	91	17.97	10	11.93	29.11	51.03
4	*Myrsinaceae*	2	217	9.93	5	28.44	16.08	49.52
5	*Meliaceae*	2	40	3.59	5	5.24	5.81	16.06
6	*Moraceae*	3	4	0.19	7.5	0.52	0.31	8.33
7	*Rutaceae*	2	11	0.93	5	1.44	1.51	7.95
8	*Cyatheaceae*	2	15	0.27	5	1.97	0.44	7.40
9	*Opiliaceae*	1	19	1.03	2.5	2.49	1.67	6.66
10	*Sapindaceae*	2	6	0.25	5	0.79	0.40	6.19
11	*Thymelaeaceae*	1	19	0.37	2.5	2.49	0.60	5.59
12	*Rosaceae*	1	10	0.82	2.5	1.31	1.33	5.14
13	*Melianthaceae*	1	8	0.44	2.5	1.05	0.71	4.26
14	*Asteraceae*	1	4	0.07	2.5	0.52	0.11	3.14
15	*Alangiaceae*	1	2	0.21	2.5	0.26	0.34	3.10
16	*Oleaceae*	1	3	0.08	2.5	0.39	0.13	3.02
17	*Capparaceae*	1	1	0.05	2.5	0.13	0.08	2.71
18	*Celastraceae*	1	1	0.02	2.5	0.13	0.03	2.66
19	*Chrysobalanaceae*	1	1	0.02	2.5	0.13	0.03	2.66
20	*Lauraceae*	1	1	0.02	2.5	0.13	0.03	2.66
	Total	40	763	61.74	100	100	100	300

Appendix 3. Density, basal area, frequency and IVI of the species of the Manengouba 1-ha plot, presented by decreasing IVI.

N°	Species	Absolute frequency	Number of trees	Basal area [m²]	Relative Frequency [x 100 %]	Relative density [x 100 %]	Relative Dominance [x 100 %]	IVI [x 300 %]
1	*Macaranga occidentalis*	6	93	12. 75	4.51	12.19	20.65	37.35
2	*Rapanea melanophloeos*	10	124	4.14	7.52	16.25	6.71	30.48
3	*Maesa lanceolata*	6	93	5.79	4.51	12.19	9.38	26.08
4	*Polyscias fulva*	10	25	8.25	7.52	3.28	13.36	24.16
5	*psydrax arnoldianum*	6	95	4	4.51	12.45	6.48	23.44
6	*Rothmannia urcelliformis*	5	83	4.73	3.76	10.88	7.66	22.30
7	*Schefflera barteri*	4	34	7.03	3.01	4.46	11.39	18.85

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8	*Carapa grandiflora*	5	27	2.68	3.76	3.54	4.34	11.64
9	*Schefflera mannii*	8	10	2	6.02	1. 1	3.24	10.57
10	*Croton macrostachyus*	6	15	2.06	4.51	1.97	3.34	9.81
11	*Opilia celtidifolia*	7	19	1.03	5.26	2.49	1.67	9.42
12	*Schefflera abyssinica*	4	22	0.69	3.01	2.88	1.12	7.01
13	*Prunus africana*	5	10	0.82	3.76	1.31	1.33	6.40
14	*Gaertnera paniculata*	4	9	0.65	3.01	1.18	1.05	5.24
15	*Zanthoxylum Xanthoxylo ïdes*	3	8	0.88	2.26	1.05	1.43	4.73
16	*Carapa procera*	2	13	0.91	1.50	1.70	1.47	4.68
17	*Gnidia glauca*	2	19	0.37	1.50	2.49	0.60	4.59
18	*Cremaspora triflora*	4	7	0.12	3.01	0.92	0.19	4.12
19	*Bersama abyssinica*	3	8	0.44	2.26	1.05	0.71	4.02
20	Cyathea manniana	2	14	0.25	1.50	1.83	0.40	3.74
21	*Vernonia blumeoides*	4	4	0.07	3.01	0.52	0.11	3.65
22	*Sclerocroton ellipticus*	2	3	1.01	1.50	0.39	1.64	3.53
23	*Chionanthus mannii* (subsp. *congesta*	4	3	0.08	3.01	0,3 9	0.13	3.53
24	*Teclea afzelii*	3	3	0.05	2.26	0.39	0.08	2.73
25	*Allophylus bullatus*	2	5	0.23	1.50	0.66	0.37	2.53
26	*Alangium chinense*	2	2	0.21	1.50	0.26	0.34	2.11
27	*Ficus elasticoides*	1	2	0.15	0.75	0. 6	0.24	1.26
28	*Bridelia speciosa*	1	1	0.05	0.75	0.13	0.08	0.96
29	*Euadenia trifoliolata*	1	1	0.05	0.75	0.13	0.08	0.96
30	*Rothmannia hispida*	1	1	0.05	0.75	0.13	0.08	0,.6
31	*Antidesma laciniatum* var. *laciniatum*	1	1	0.02	0.75	0.13	0.03	0.92
32	*Bertiera laxa*	1	1	0.02	0.75	0.13	0.03	0.92
33	*Bridelia micrantha*	1	1	0.02	0.75	0.13	0.03	0.92
34	*Cyathea camerooniana*	1	1	0.02	0.75	0.13	0.03	0.92
35	*Dactyladenia lehmbachii*	1	1	0.02	0.75	0.13	0.03	0.92
36	*Ficus sur*	1	1	0.02	0.75	0.13	0.03	0.92
37	*Haplocoelum gallaense*	1	1	0.02	0.75	0.13	0.03	0.92
38	*Maytenus acuminata*	1	1	0.02	0.75	0.13	0.03	0.92
39	*Milicia excelsa*	1	1	0.02	0.75	0.13	0.03	0.92
40	*Persea americana*	1	1	0.02	0.75	0.13	0.03	0.92
	Total	133	763	61.74	100	100	100	300

Appendix 1. Floristic list of the highlander Manengouba forest (Mbouroukou, northeast side) with the number of individuals by class of diameter and woody species frequency, counted on the 1 ha-sampling by 10 plots.

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							Number of individual encountered in 1-ha plot by diameter classes (cm)											
N°	Families	TB	VA	UP	Species	F	[10-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[	[100-110[	[110-120[	Total trees
1	*Araliaceae*				*Polyscias fulva* (Hiern) Harms	10	5	2	1	3	2	2	3	3	2	1	1	25
2	*Meliaceae*	Msph	Mi	Fic	*Carapa grandiflora* Sprague	5	8	10	7			1					1	27
3	*Araliaceae*	Msph	Mi	Fic	*Schefflera barteri* (Seem.) Harms	4	2	3	9	11	3	1	2	1		2		34
4	*Euphorbiaceae*	Msph	Mi	Pol	*Macaranga occidentalis* Müll. Arg.	6	14	24	18	12	18	2	3		2			93
5	*Araliaceae*	Msph	Mi	Fic, End	*Schefflera mannii* (Hook. f.) Harms	8	4	1	1			1	2	1				10
6	*Euphorbiaceae*	Msph	Mi	Str	*Sclerocroton ellipticus* Hochst. ex Krauss	2					1	1	1					3
7	*Meliaceae*	Msph	Bm + Sm	Str	*Carapa procera* DC.	2	7	2	2	1		1						13
8	*Euphorbiaceae*	Msph	Sm	Mus	*Croton macrostachyus* Hochst. ex Del.	6		2	7	3	2	1						15
9	*Rubiaceae*	Mcph	Mi	Gar	*Gaertnera paniculata* Benth.	4	4	3	1			1						9
10	*Myrsinaceae*	Msph	Mi + Ms	Pol	*Maesa lanceolata* Forssk.	6	12	52	28			1						93
11	*Rutaceae*	Msph	Bm + Sm	Mus	*Zanthoxylum Xanthoxyloïdes* (Lam.) Waterman	3		4	2	1		1						8
12	*Rubiaceae*	Mcph	Sm	Fic	*Rothmannia urcelliformis* (Hiern.) Bull. ex Rob.	5	32	27	18	4	2							83
13	*Rosaceae*	Msph	Mi	Fic	*Prunus africana* (Hook. f.) Kalkm.	5	5	2		1	2							10
14	*Opiliaceae*	Msph	Bm + Sm	Gar	*Opilia celtidifolia* (Guill. & Perr.) Endl. ex Walp.	7	5	10	3	1								19
15	*Alangiaceae*	Msph	Mi	Pol	*Alangium chinense* (Lour.) Harms	2		1		1								2
16	*Rubiaceae*	Msph	Sm	Gil	*psydrax arnoldianum* (De Wild. & Th. Dur.) Hepper	6	39	44	12									95
17	*Melianthaceae*	Msph	Mi	Fic	*Bersama abyssinica* Fresen	3	3	2	3									8
18	*Myrsinaceae*	Msph	Mi + Ms	Fic	*Rapanea melanophloeos* (L.) Mez	10	65	57	2									124

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19	*Sapindaceae*	Mcph	Mi	Fic, End	*Allophylus bullatus* Radlk	2	2	2	1									5
20	*Moraceae*	Nnph	Bm	Str	*Ficus elasticoides* De Wild.	1		1	1									2
21	*Araliaceae*	Msph	Mi	Gar	*Schefflera abyssinica* (Hochst. ex A. Rich.) Harms	4	14	7	1									22
22	*Thymelaeaceae*	Mcph	Mi	Fic	*Gnidia glauca* (Fres) Gilg	2	18	1										19
23	*Oleaceae*	Mcph	Mi	Gar	*Chionanthus mannii* (Soler.) Stearn. subsp. *congesta* (Baker) Stearn.	4	2	1										3
24	*Euphrbiaceae*	Msph	Sm + Mi	Gar	*Bridelia speciosa* Müll. Arg.	1		1										1
25	*Capparaceae*	Mcph	Bm	Gar	*Euadenia trifoliolata* (Vahl ex & Thonn.) Oliv.	1		1										1
26	*Rubiaceae*	Mcph	Bm + Sm	Str	*Rothmannia hispida* (K. Schum.) Fagerlind	1		1										1
27	*Cyatheaceae*	Mcph	Bm + Sm	Str	*Cyathea manniana* Hook.	2	14											14
28	*Rubiaceae*	Nnph	Sm + Mi	Str	*Cremaspora triflora* (Thonn.) K. Schum.	4	7											7
29	*Asteraceae*	Mcph	Mi	Pol	*Vernonia blumeoides* Hook. f.	4	4											4
30	*Rutaceae*	Mcph	Bm + Sm	Pip	*Teclea afzelii* Engl.	3	3											3
31	*Euphorbiaceae*	Mcph	Mi	Str	*Antidesma laciniatum* Müll. Arg. var. *laciniatum*	1	1											1
32	*Rubiaceae*	Mcph	Bm + Sm	Str	*Bertiera laxa* Benth.	1	1											1
33	*Euphorbiaceae*	Mcph	Bm + Sm	Str	*Bridelia micrantha* (Hochst.) Baill.	1	1											1
34	*Cyatheaceae*	Mcph	Sm	Gar	*Cyathea camerooniana* Hook.	1	1											1

35	*Chrysobalanaceae*	Nnph	Bm + Sm	Str	*Dactyladenia lehmbachii* (Engl.) Prance & F. White	1	1											1
36	*Moraceae*	Nnph	Bm + Sm	Mus	*Ficus sur* Forssk.	1	1											1
37	*Sapindaceae*	Mcph	Bm + Sm	Mus	*Haplocoelum gallaense* (Engl.) Radlkofer	1	1											1
38	*Celastraceae*	Mcph	Mi	Fic	*Maytenus acuminata* (L. f.) Loes.	1	1											1
39	*Moraceae*	Mcph	Bm	Str	*Milicia excelsa* (Welw.) C. C. Berg	1	1											1
40	*Lauraceae*	Mcph	Cultiv	Mus	*Persea americana* Mill.	1	1											1
41	*Burseraceae*	Mcph	Bm + Sm	Str	*Dacryodes klaineana* (Pierre) H. J. Lam.													
42	*Leguminosae*	Phgr	Mi	Fic	*Milletia pilosa* Hutch. & Daziel													
43	*Convolvulaceae*	Phgr	Bm + Sm	Str	*Neuropeltis acuminata* (P. Beauv.) Benth.													
44	*Rubiaceae*	Nnph	Mi	Fic	*Psychotria peduncularis* (Salisb.) Steyerm. var. *peduncularis*													
45	*Rubiaceae*	Nnph	Sm	Gar	*Psychotria vogeliana* Benth.													
46	*Annonaceae*	Nnph	Sm	Gar	*Uvariodendron fuscum* (Benth.) R. E. Fries													
47	*Asteraceae*	Nnph	Mi	Pol	*Vernonia hymenolepis* A. Rich.													
	Total individuals					133	279	261	117	38	30	13	11	5	4	3	2	763
	Total basal area						4.93	12.81	11.26	6.04	7.13	4.31	4.86	2.84	2.84	2.60	2.08	

Legend of appendix 1.

BT	Biological Types (BT) Raunkiaer, 1934; Schnell, 1970)	AV code	Altitudinal variation (AV) (Senterre, (2005)	PU	Phytosociological Units (PU)
Mcph	Microphanerophyte	Bm	Lower and middle altitudes	Fic	*Ficalhoeto-Podocarpetalia* Lebrun and Gilbert 1954
Msph	Mesophanerophyte	Bm + Sm	Lower and middle altitudes going up in Sm	Gar	*Garcinietalia* Noumi 1998
Nnph	Nanophanerophyte	Mi	Lower highlander (strong hygrometry)	Gil	*Gilbertiodendretalia dewevrei* Lebrun and Gilbert 1954
Phgr	Phanerophyte climbing	Mi + Ms	Lower highlander going up in Ms	Mus	*Musango-Terminalietea* Lebrun and Gilbert 1954
		Ms	Superior highlander (weak hygrometry)	Pip	*Piptadeniastro-Celtidetalia* Lebrun and Gilbert 1954
		Sm	Submountain	Pol	*Polyscietalia fulvae* Lebrun and Gilbert 1954
		Sm + Mi	Submountain going up in Mi	Str	*Strombosio-Parinarietea* Lebrun and Gilbert 1954
			Cultiv. : species cultivated	End	endemic to the Cameroonian high mountains archipelago”,