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Full Length Research Paper

Inventory and distribution of the Annonaceae along elevation gradient on Mount Cameroon

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This work was carried out on Mount Cameroon, South West Region of Cameroon. It focused on producing an inventory and distribution of Annonaceae along the elevation gradient on the mountain. As a matter of fact, how Annonaceae flora change along an elevation gradient has never been studied for Mount Cameroon. The Complete Census Method was used. Twelve sites, located at three elevation categories: low (lowland: sea level to 700 m), mid (submontane: 800 to 1800 m), and high (montane: 2200 to 3500 m) were investigated. At each site, 8 transects of 500 m × 10 m were sampled and all the Annonaceae species enumerated. To supplement the information gathered on measured plots and to generate a complete list of target species, plotless sample method was used. This entailed the collection of materials along footpaths and within particular habitats such as ravines, seasonal streams, and disturbed areas. A total of 49 species in 21 genera including climbers, shrubs and trees were collected and identified from both plot and plotless samples. Low and mid elevations were rich in Annonaceae with 37 species in 17 genera and 31 species in 16 genera, respectively. The family was nearly absent from high elevation with only one species. Sixteen species in 10 genera were restricted to low elevation and 11 species in 8 genera confined to the mid elevation. Only *Uvariodendron connivens* was abundantly found at both low and mid elevations. Three species were frequent and confined to low elevation only. One and five species appeared occasionally and were restricted to low and mid elevations, respectively. 23, 18 and 1 species were rare at low, mid and high elevations respectively. Low elevation showed a higher species diversity (H' = 2.65) than the mid elevation (H' = 0.48). The high elevation with two individuals in a single species was the least diverse (H' = 0.15). The species were more even in their abundance distribution within the low elevation (J = 0.76) than in the mid elevation (J = 0.15).

Key words: Inventory, elevational distribution, Annonaceae, Mount Cameroon.

INTRODUCTION

Of the world's major ecosystems, the tropical forest is the most complex both architecturally and floristically and this complexity is least understood (Locatelli et al., 2008). Lying between 8° to 16°E and 2° to13°N (Amougou et al., 1985), Cameroon is a diversified territory with abundant natural resources. The sustainable exploitation and conservation of these resources is only possible if quailtative and quantitative estimations are made. Letouzey (1985)estimated the flora of Cameroon to be about 75,000 species distributed in about 1,800 genera belonging to 230 families. Annonaceae are among the most represented plant families in Cameroon particularly within Mount Cameroon (Cable and Cheek, 1998). It is one of the groups of primitive families of flowering plants sometimes termed the Annoniflorae, often with indefinite number of free floral parts and spirally arranged stamens.

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It is a large family of the angiosperms with about 2,500 species in 130 genera worldwide. There are 900 species in 40 genera in Africa. 111 species in 24 genera are reported in the Flora of West Tropical Africa (Hutchinson and Dalziel, 1954). 121 species in 29 genera are reported in the Democratic Republic of Congo, 57 species in 16 genera in Central African Republic, 73 species in 24 genera in Angola, and 119 species in 29 genera in Gabon (Le Thomas, 1969). There are 4 species in 3 genera reported in Gambia (Steentoft, 1988) and 92 species in 27 genera recorded in Kenya (Beentje, 1994). In Cameroon, 22 species in 13 genera have been collected and identified in the 'Herbier National Camerounais' (YA). On Mount Cameroon, 37 species in 18 genera have been collected and identified in the Limbe Botanic Garden Herbarium (SCA).

In Africa, most of the Annonaceae genera are confined in the Guinean-Congolian region. A number are monotypic, such as, Meiocarpidium, Balonga, Pseudartabotrys and Exellia. Annonaceae are centred in the lowland rainforests and tend to change with elevation but are generally absent from elevations above 1,500 m (Dassanyayaka and Fosberg, 1985). To test the hypothesis that Annonaceae flora change with elevation, we focused our work on the distribution of the species of this family along three elevation categories on Mount Cameroon: low (lowland: sea level to 700 m), mid (submontane: 800 to 1800 m), and high (montane: 2200 to 3500 m). This work drew its origin on recommendations from previous works on the mountain by Tchouto (1995; 1996), Cable and Cheek (1998) and Ndam (1998) based on: (1) although plant species of Mount Cameroon are described in a comprehensive volume (Cable and Cheek, 1998), there was an urgent need for an account, not merely of the occurrence of species on the mountain, but also of their distribution especially along the elevation gradient for families whose flora tends to change along an elevation gradient such as the Annonaceae; (2) botanical collectors, naturally enough, have concentrated their collection of the lowland species of Annonaceae especially on accessible places generally near forest paths, villages, main roads and towns, and with accessible flowers for much of the year. In addition, climbers have often been omitted. Foresters get off the beaten track, but their main interest is on large commercial trees. Therefore, further inventory was needed to have a full view of an elevational distribution of the family on the mountain; (3) in addition, according to WCMC (1995) and IUCN (1998) some species within the family have been reported to be threatened in Cameroon and especially within Mount Cameroon (Cable and Cheek, 1998).

Therefore, this study aimed to assess the distribution of the Annonaceae species on the mountain by providing frequency of species occurrence, variation of species diversity, individual species abundances and the list of rarity along the three elevation categories.

The objectives were to undertake an inventory of Annonaceae on Mount Cameroon, to augment herbarium specimens and to determine the distribution patterns of the various species along the three elevation categories.

METHODS

Description of the study area

This work was carried out on Mount Cameroon in the South-West Region of Cameroon, on the coastal belt of the Gulf of Guinea (Biafra) (Figure 1). Mount Cameroon is the highest mountain in Central and West Africa, rising up steeply from sea level to 4,095 m at the summit (Cable and Cheek, 1998; Ndam, 1998). This huge volcanic mass has its long axis (about 45 km long and 30 km wide) running SW to NE between 3º57' to 4º27'N and 8º58' to 9º24'E. The main peak is at 4º7'N and 9º10'E (Tchouto, 1996; Fraser et al., 1998).

Mount Cameroon has a humid tropical climate and the climatic pattern is sharply modified by the influence of the topography (Courade, 1972). The main annual rainfall varies between 2,085 mm near Ekona to 9,086 mm at Debundscha (Fraser et al., 1998).

The mean annual temperature is about 25°C and this decreases by 0.6°C per 100 m of ascent, to 4°C at the summit (Boughey, 1955; Barry, 1992). The soil temperature, measured at 10 cm depth, varies from 25°C at 200 m through 20°C at 1,100 m to 15°C at 2,200 m (Payton, 1993). The air humidity remains at 75 to 80% throughout the year on the South Western side of the Mountain due to the marine influence and the incidence of mist and orographic cloud formation. The persistent cloud cover and mist make Mount Cameroon one of the areas that receive the lowest values of annual sunshine hours in West Africa. This starts with 900 to 1,200 h per annum at sea level and decreases with altitude. Between 1,200 to 2,000 m, the mountain is characterized by semi-permanent mists and cloudiness (Payton, 1993). Snow is rare on the summit (4,095 m) of Mount Cameroon, though frost is not uncommon.

At sea level, there is often a gentle breeze at the coast, but generally air movements are slow. Hurricanes are unknown. At the beginning of the wet season however, the opening frontal storms can be violent and this is the main season for natural tree fall.

Mount Cameroon is an active Hawaiian type volcano without a central crater, subject to continued fissure eruptions on the flank of the mountain that result in lava flows and small cinder cones. The mountain is built up by a successive series of eruptions of basaltic lava, tuff and ash and materials that surround and cover to a considerable depth, the base of the mountain. This results in a landscape of steeply sloping (15 to 35°C) rocky ridges conforming to individual lava flows separated by numerous ravines.

The soil types are mainly volcanic and relatively fertile. The lower slopes of the mountain have ancient ferralitic soils on highly weathered substrates. They are much deeper, nutrient-rich andosols, less stony and therefore intensively cultivated. Above 1,000 m, the volcanic lava gives rise to brownish or blackish soils. The surface of the mountain peak is covered by latest lava flows, cinder cones and other pyroclastic materials (Tchouto, 1996; CDC, 1997).

Human factors that affect the mountain come in the form of burning for hunting purposes and farming activities, although above 1,200 m the terrain becomes too rough for farming. At lower levels, the forest has greatly been replaced by shifting cultivation or organized commercial plantations, mainly oil palms, banana and rubber scattered over the Southern slopes of the mountain from sea level to 950 m (Payton, 1993).

Desktop preparation and reconnaissance surveys

The work involved review of the plant specimens found in both the

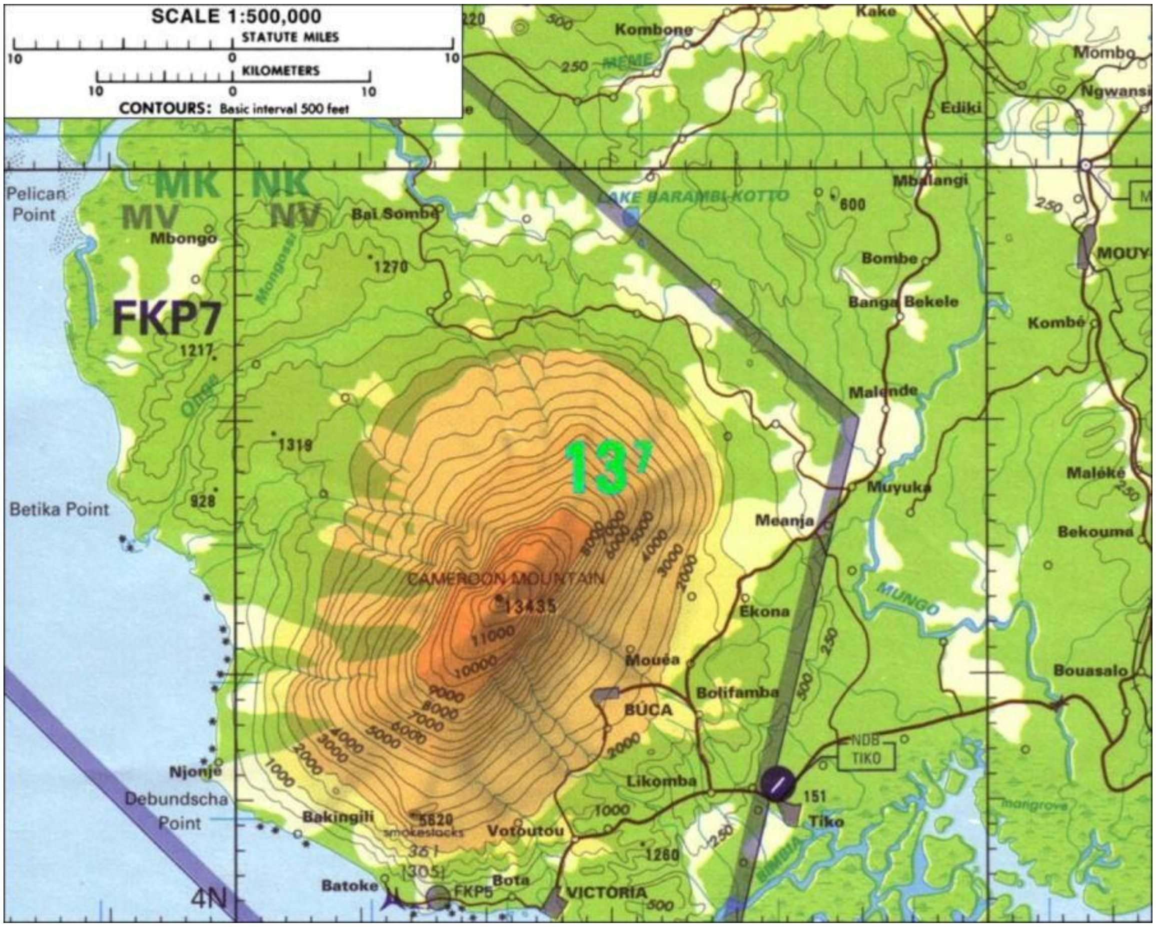

Figure 1. Map of the study area.

Herbier National Camerounais (YA)' and the Limbe Botanic Garden Herbarium (SCA). Reconnaissance surveys aimed to choose representative sites for plant collection on the mountain were done by taking into consideration the elevation category and locations on the mountain. The surveys entailed going through the accessible parts of the vegetation of the mountain. It was also a period to get acquainted with village communities prior to proper field surveys.

Field surveys and collection sites

Since Mount Cameroon is too large for this study in the time available, representative sites were selected for more detailed study after preliminary reconnaissance surveys. 12 sites were selected at three elevation categories (Table 1). The choice of the sites was based on the differences in structure of the vegetation, physiognomy and crown form. Other criteria such as geology, soils, climate and ecological factors (e.g. fire) were also taken into consideration. Field surveys and collections were also made at these sites at the three elevation categories.

Sampling strategy and techniques

Transects were used for a better option for estimation, detection, and distribution of Annonaceae species. They were laid along the altitudinal gradient in each of the three elevations (lowland, submontane and montane). Based on the considerations outlined in Peters (1994 and 1999) and Sunderland (1999), sampling consisted of a series of parallels of 10 m wide established at irregular intervals at a random starting point and were 500 m in length (Ideally, these would have been longer (1 to 2.5 km, Peters, 1994 and 1999) but time constraints dictate the need for more numerous, shorter transects)and were run out along a predetermined bearing using a compass. Distances were corrected for slopes in order to get horizontal distances using:

$$D = d \times \cos\alpha,$$

Where D= horizontal distance of the transect, d= slope distance and α the angle of the slope.

Transects were covered by walking, counting and recording the sample species. Eight transects were established in each of the five sites at low and mid elevations. At high elevation, only two sites were selected and eight transects were established at each of the sites. However, given the fact that the measured plot samples method is inefficient for generating species list and that some species, particularly those with very restricted habitats or those which are scarce, may almost certainly be missed, plotless sample method was used. This method was used to supplement the information gathered on measured plots and to ensure that target species were collected or recorded. It entailed the collection of materials along footpaths and within particular habitats such as ravines, seasonal streams and disturbed areas. These distinctions were very important for evaluating range data in particular as the sample plot method has most statistical meaning for defining

Table 1. Field surveys and collection sites.

Site	Elevation (m)	Elevation category
Bimbia-Bonadikombo	Sea level - 200	Lowland
Njonji	Sea level - 600	Lowland
Bakingili	200 – 700	Lowland
Liwenyi	200	Lowland
Bomana	150	Lowland
Njonji	800 - 1800	Submontane
Bakingili	800 – 1000	Submontane
Mapanja	800 –1800	Submontane
Likombe	700 - 1800	Submontane
Bwassa	800 – 1800	Submontane
Mann’s Spring	2200 – 3500	Montane
P&T Radio Station	2200 – 3500	Montane

associations (allows prediction of distribution) while the plotless method provides the least ambiguous distribution data (that is, it really does or does not occur in the area) (Sheil, 1997).

Data collection

Once transects were laid out, the enumeration team moved slowly along these transects and carefully searching or scanning a 10 m-band (5 m on either side of the central line) for individuals of all target species. The 5 m distances were periodically checked for borderline trees. Each individual of the appropriate species once spotted, checked and identified by the field botanist was recorded in the datasheet. Each individual tree, shrub and liana was recorded. Information on physical characteristics of the habitat, vegetation structure and elevation was also recorded.

Plant collection, treatment and identification

Herbarium specimens were made for species not well represented in the SCA herbarium. In addition, herbarium collections were automatically made in case of doubt in identification in the field and for suspected species for further identification in the herbarium. Adequate samples of all the organs available were collected whenever possible. Plant specimen preparation methods generally followed those of Foreman and Bridson (1989). On returning to the herbarium, specimens were inspected and interleaved with blotters and corrugated sheets before placing them in the dryer. The presses in the dryer were frequently inspected. During inspection, specimens that had dried up were removed from the dryer. Identification was done in the Limbe herbarium (SCA) using already existing herbarium specimens and illustrated flora. Some doubtful specimens were taken to the National Herbarium for identification. Undermined specimens were then piled for future identification at Kew by the family specialist.

Data analysis

The species encountered were compiled according to the three elevation categories. Excel and Statsgraphics software were then used for different analyses. Species diversity and similarity were measured to provide information about rarity and commonness of species at the three different elevation categories. The following equations were used to calculate indexes:

D = 1-S(pi) or H'=S(ni/N)(log$_n$ni/N)

Where D= Simpson’s index; H’= Shannon-wiener index; ni=number of individuals of a species; N=total number of individuals. These index measures accounted for both abundance and evenness of the species present at each elevation category.

J= S(ni/N)(lognni/N)/lognS

Where J= Equitability or evenness and S= number of species. This measures how similar the abundances of different species were at each elevation category.

Cj = a/(a+b+c) or Cn= 2a/(2a+b+c)

Where Cj= Jaccard’s Coefficient, Cn= Sorensen’s coefficient, a= number of species in Samples A and B (joint occurrence), b= number of species in Sample B but not in Sample A, and c= number of species in Sample A but not in Sample B. These measures helped compare the similarity and diversity of sample sets at different elevation categories.

t=χ - µ/Sχ

Where t= student t-test, χ= deviation, µ= mean, and Sχ= standard deviation. This test was used to check the normality of the distribution.

Mann-Whitney test: W= n1 n2+n1(n1+1)/2-R1 and W’= n2 n1+n2(n2+1)/2-R2

Where n1= Number of observations in community 1, n2 = Number of observations in community 2, R1= Sum of rank in community 1, R2= Sum of rank in community 2. This test was used as an alternative to the independent group t-test in case the assumption of normality or equality of variance was not met.

RESULTS

Species encountered

41 species in 20 genera were collected and identified for a total of 96 transects of 10 m × 500 m surveyed from 12 sites at low, mid and high elevation (Table 2). In addition,

Table 2. List of Annonaceae species recorded at three elevation categories.

Species code no.	Species code	Scientific name	Elevation		
			Low	Mid	High
1	ANNICH	*Annickia chloranta* (Oliv.) Setten & P.J.Maas	X	X	
2	ANNOSE	*Annona senegalensis* Persoon			X
3	ANONFL	*Anonidium floribundum* Pellegr	X		
4	ARTAAR	*Artabotrys aurantiacus* Engl.et Diels	X		
5	ARTARH	*Artabotrys rhopalocarpus* Le Thomas	X	X	
6	ARTAVE	*Artabotrys velutinus* Scott-Elliot		X	
7	BOUTPL	*Boutiquea platypetala* (Engl.et Diels) Le Thomas	X	X	
8	FRIEEN	*Friesodelsia enghiana* (Diels) Verdc.	X	X	
9	FRIEGR	*Friesodelsia gracilipes (*Benth.) v.Steenis	X	X	
10	FRIEMO	*Friesodelsia montana* (Engl.et Diels) v. Steenis		X	
11	GREESU	*Greenwayodendron suaveolens* (Engl.et Diels) Verdc.	X	X	
12	ISOLZE	*Isolona zenkeri* Engl	X		
13	MEIOLE	*Meiocarpidum lepidotum* (Oliv.) Engl.et Diels		X	
14	MISCEL	*Mischogyne elliotianum* (Engl.et Diels) R.E.Fries		X	
15	MONAFO	*Monanthotaxis foliosa* (Engl.et Diels) Verdc.		X	
16	MONOBR	*Monodora brevipes* Benth	X		
17	MONOCR	*Monodora crispata* Engl.et Diels	X	X	
18	MONOMY	*Monodora myristica* (Gaertn.) Dunal	X	X	
19	MONOTE	*Monodora tenuifolia* Benth	X	X	
20	PACHST	*Pachypodanthium staudtii* (Engl.et Diels) Engl.et Diels	X		
21	PIPTFA	*Piptostigma fasciculata* (De Wild Boutique)		X	
22	PIPTMU	*Piptostigma multinervum* Engl.et Diels	X	X	
23	PIPTPI	*Piptostigma pilosum* Oliv	X	X	
24	POLYPA	*Polyceratocarpus parviflorus* (Bak.f.) Ghesq	X	X	
25	UVARAN	*Uvaria anonoides* Bak.f.	X	X	
26	UVARBA	*Uvaria baumannii* Engl.et Diels	X		
27	UVARIN	*Uvariastrum insculptum* (Engl.et Diels) Spr.et Hutch.	X		
28	UVARPY	*Uvariastrum pynaertii* De Wild	X		
29	UVARZE	*Uvariastrum zenkeri* Engl.et Diels	X		
30	UVARCON	*Uvariodendron connivens* (Benth.) R.E.Fries	X	X	
31	UVARFU	*Uvariodendron fuscum* (Benth.) R.E.Fr.		X	
32	UVARGI	*Uvariodendron giganteum* (Engl.) R.E.Fries	X		
33	UVARBA	*Uvariopsis barkeriana* (Hutch.et Dalz.) Robyns & Ghesq	X	X	
34	UVARDI	*Uvariopsis dioica* (Diels) Rob. & Ghesq	X	X	
35	UVARK0	*Uvariopsis korupensis* Gereau & Kenfack	X	X	
36	XYLOAC	*Xylopia acutiflora* (Dunal) A. Rich	X	X	
37	XYLOAF	*Xylopia africana* (Benth.) Oliv.		X	
38	XYLOHYP	*Xylopia hypolampra* Mildbr.	X	X	
39	XYLOQU	*Xylopia quintasii* Engl.et Diels	X		
40	XYLORU	*Xylopia rubescens* Oliv.	X		
41	*XYLOST*	*Xylopia staudtii* Engl.et Diels	X		

8 species were collected and identified from plotless samples within particular habitats out of transects such as foothpaths, ravines, seasonal streams, and disturbed areas (Table 3). *Annona muricata* was the only cultivated species collected. The ornamental species recorded were *Greenwayodendron peltata* and *Cananga odorata*.

Distribution

From a total of 41 species obtained from measured plots, 12 (29%), 9 (22%) and 1 (3%) were restricted to low, mid and high elevation respectively while 19 (46%) were shared by both low and mid elevations (Table 2). From

Table 3. List of species found out of transects.

Species code	Scientific name	Elevation		
		Low	Mid	High
CLEIST	*Cleistopholis staudtii* Engl. et Diels	X	X	
FRIEHI	*Friesodelsia hirsuta* (Benth.) v.Steenis		X	
MONAFI	*Monanthotaxis filamentosa* (Diels) Verdc.		X	
PIPTCA	*Piptostigma callophyllum* Mildbr. et Diels	X		
PIPTOY	*Piptostigma oyemensis* Pellegr		X	
UVARHE	*Uvaria heterotricha* Pellegr	X		
UVARMO	*Uvariodendron molundense* (Engl. et Diels) R.E.Fries	X		
XYLOPA	*Xylopia parviflora (A. Rich.)* Benth	X		

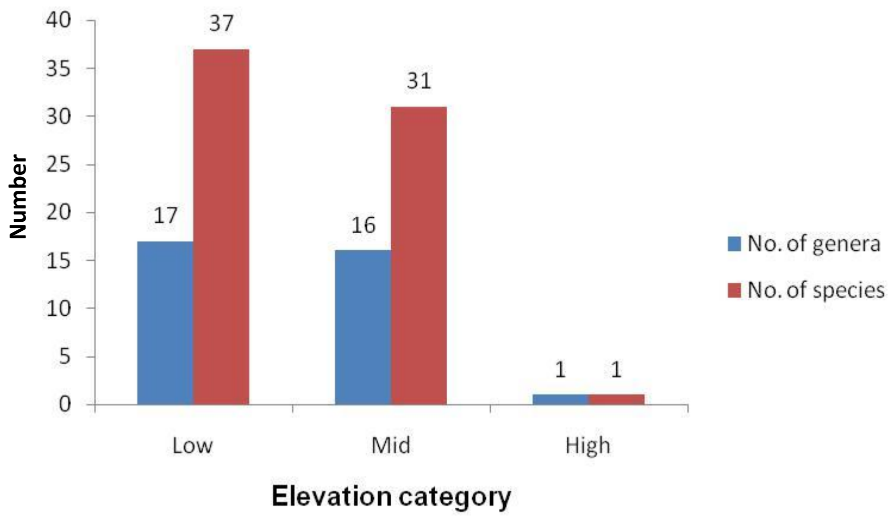

Figure 2. Number of genera and species at three elevation categories.

plotless samples, only *Cleistopholis staudtii* was shared by both low and mid elevation and 4 and 3 species restricted only to low and mid elevations respectively and nothing found at high elevation (Table 3).

The number of genera and species at each elevation category was calculated (Figure 2). Considering that species from plotless samples only served to generate a complete list of species and since their number of individuals was not the main interest here, the eight species from these samples were not more included in the further analysis. The distribution was therefore studied in terms of presence or absence, abundance as well as frequency from measured plot samples (Tables 4 and 5).

Frequency of occurrence of species within the three elevation categories

The frequency of each species was calculated at the three elevation categories using the formulae

$X/Y \times 100$

Where X= number of transects in which species is present, Y= total number of transects in each elevation category (Table 5).

The evaluation of each species in each elevation was made as follows:

1. Species present in 30 - 40 transects that is, 75-100%, meant that the species was abundant
2. Species present in 20 - 29 transects that is, 50-74%, meant that the species was frequent
3. Species present in 10-19 transects that is, 25-49%, meant that the species was occasional

4. Species present in less than 10 transects i.e. <25%, meant that the species was rare.

Code numbers used to represent these were as follows: Abundant= 4; Frequent= 3; Occasional = 2; and Rare = 1.

Table 4. Total number of individuals of each species encountered at each elevation category

Species code no.	Species name	Species code	Total		
			Low	Mid	High
1	*Annickia chloranta*	ANNICH	30	5	0
2	*Annona senegalensis*	ANNOSE	0	0	2
3	*Anonidium floribundum*	ANONFL	1	0	0
4	*Artabotrys aurantiacus*	ARTAAR	1	0	0
5	*Artabotrys rhopalocarpus*	ARTRH	5	4	0
6	*Artabotrys velutinus*	ARTAVE	0	4	0
7	*Boutiquea platypetala*	BOUTPL	1	1	0
8	*Friesodelsia enghiana*	FRIEEN	67	15	0
9	*Friesodelsia gracilipes*	FRIEGR	75	15	0
10	*Friesodelsia Montana*	FRIEMO	0	5	0
11	*Greenwayodendron suav.*	GREESU	3	3	0
12	*Isolona zenkeri*	ISOLZE	1	0	0
13	*Meiocarpidum lepidotum*	MEIOLE	0	2	0
14	*Mischogyne elliotianum*	MISCEL	0	2	0
15	*Monanthotaxis foliosa*	MONAFO	0	2	0
16	*Monodora brevipes*	MONOBR	1	0	0
17	*Monodora crispate*	MONOCR	2	2	0
18	*Monodora myristica*	MONOMY	15	11	0
19	*Monodora tenuifolia*	MONOTE	2	11	0
20	*Pachypodanthium staudtii*	PACHST	2	0	0
21	*Piptostigma fasciculate*	PIPTFA	0	3	0
22	*Piptostigma multinervum*	PIPTMU	1	3	0
23	*Piptostigma pilosum*	PIPTPI	21	5	0
24	*Polyceratocarpus parviflorus*	POLYPA	74	20	0
25	*Uvaria anonoides*	UVARAN	1	2	0
26	*Uvaria baumannii*	UVARBA	4	0	0
27	*Uvariastrum insculptum*	UVARIN	4	0	0
28	*Uvariastrum pynaertii*	UVARPY	2	0	0
29	*Uvariastrum zenkeri*	UVARZE	1	0	0
30	*Uvariodendron connivens*	UVARCON	130	1861	0
31	*Uvariodendron fuscum*	UVARFU	0	14	0
32	*Uvariodendron giganteum*	UVARGI	1	0	0
33	*Uvariopsis barkeriana*	UVARBA	13	5	0
34	*Uvariopsis dioica*	UVARDI	6	5	0
35	*Uvariopsis korupensis*	UVARK0	11	5	0
36	*Xylopia acutiflora*	XYLOAC	4	8	0
37	*Xylopia Africana*	XYLOAF	0	10	0
38	*Xylopia hypolampra*	XYLOHYP	3	5	0
39	*Xylopia quintasii*	XYLOQU	1	0	0
40	*Xylopia rubescens*	XYLORU	1	0	0
41	Xylopia staudtii	XYLOST	1	0	0

From Table 5, only one species (*Uvariodendron connivens*) was found abundant at both low and mid elevations. Three species were frequent and confined to low elevation only. 1 and 5 species appeared occasionally and were restricted to low and mid elevations respectively. 23, 18 and 1 species were rare at low, mid and high elevations respectively (Figure 4).

The diversity index (Table 6) was also assessed. Shannon-Wiener diversity index for the different elevation categories is given in Figure 5.

The similarity measures were also assessed (Table 7). The higher elevation with only 1 species with 2.

Table 5. Frequency of occurrence of each species at each elevation category.

		Low			Mid			High		
Species code	Species code	No. of transects in which species occur out of 40 (X)	Frequency (X/Y) × 100	Frequency code	No. of transects in which species occur out of 40 (X)	Frequency (X/Y) × 100	Frequency code	No. of transects in which species occur out of 16 (X)	Frequency (X/Y) × 100	Frequency code
1	ANNICH	14	35	2	4	10	1	0	0	0
2	ANNOSE	0	0	0	0	0	0	2	12.5	1
3	ANONFL	1	2.5	1	0	0	0	0	0	0
4	ARTAAR	1	2.5	1	0	0	0	0	0	0
5	ARTARH	3	7.5	1	5	12.5	1	0	0	0
6	ARTAVE	0	0	0	3	7.5	1	0	0	0
7	BOUTPL	3	7.5	1	1	2.5	1	0	0	0
8	FRIEEN	25	62.5	3	11	27.5	2	0	0	0
9	FRIEGR	22	55	3	11	27.5	2	0	0	0
10	FRIEMO	0	0	0	4	10	1	0	0	0
11	GREESU	3	7.5	1	5	12.5	1	0	0	0
12	ISOLZE	1	2.5	1	0	0	0	0	0	0
13	MEIOLE	0	0	0	3	7.5	1	0	0	0
14	MISCEL	0	0	0	2	5	1	0	0	0
15	MONAFO	0	0	0	3	7.5	1	0	0	0
16	MONOBR	1	2.5	1	0	0	0	0	0	0
17	MONOCR	2	5	1	2	5	1	0	0	0
18	MONOMY	9	22.5	1	7	17.1	1	0	0	0
19	MONOTE	1	2.5	1	7	7	1	0	0	0
20	PACHST	3	7.5	1	0	0	0	0	0	0
21	PIPTFA	0	0	0	1	1	1	0	0	0
22	PIPTMU	1	2.5	1	3	3	1	0	0	0
23	PIPTPI	9	22.5	1	5	5	1	0	0	0
24	POLYPA	26	65	3	16	16	2	0	0	0
25	UVARAN	1	2.5	1	1	1	1	0	0	0
26	UVARBA	3	7.5	1	0	0	0	0	0	0
27	UVARIN	1	2.5	1	0	0	0	0	0	0
28	UVARPY	1	2.5	1	0	0	0	0	0	0
29	UVARZE	1	2.5	1	0	0	0	0	0	0
30	UVARCON	30	75	4	39	39	4	0	0	0
31	UVARFU	0	0	0	12	12	2	0	0	0
32	UVARGI	1	2.5	0	1	1	0	0	0	0
33	UVARBA	8	20	1	7	7	1	0	0	0

Table 5. Contd.

37	XYLOAF	0	0	0	15	15	2	0	0	0
38	XYLOHYP	1	2.5	1	5	5	1	0	0	0
39	XYLOQU	1	2.5	1	0	0	0	0	0	0
40	XYLORU	1	2.5	1	0	0	0	0	0	0
41	XYLOST	7	17.5	1	0	0	0	0	0	0

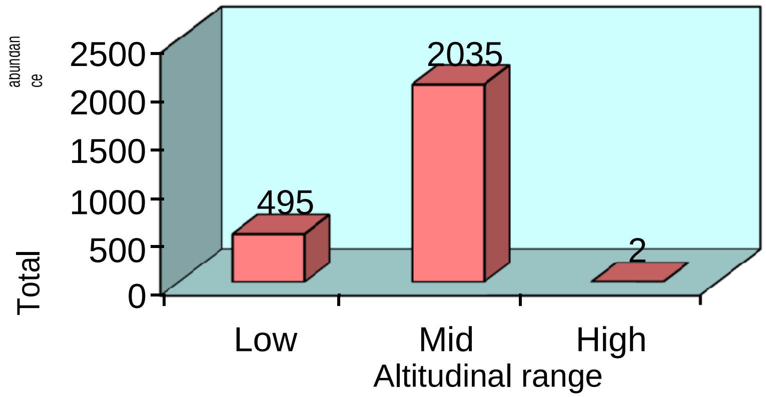

Figure 3. Total number of individuals at each elevation.

individuals was again isolated

To show an example of species richness, Bimbia Bonadikombo and Njonji were randomly selected for low and mid elevations respectively (Figure 6 and 7).

DISCUSSION

The family Annonaceae comprises climbers, shrubs, and trees. During this survey, 41 species in 20 genera were recorded in a total of 96 transects of 10 × 500 m surveyed from 12 sites at low, mid, and high elevations. Table 2 presents the list of all the species encountered in alphabetical order and their corresponding codes. There were 18 species of trees, 4 species of shrubs, 7 species of climbers, 12 species of shrubs/trees. In addition, 8 species were collected and identified from plotless samples within particular habitats out of transects such as foothpaths, ravines, seasonal streams and disturbed areas (Table 3). *A. muricata* was the only cultivated species collected. The ornamental species recorded were *G. peltata* and *C. odorata*. From a total of 41 species from measured plots, 12 (29%), 9 (22%), and 1 (3%) were restricted to low, mid and high elevation respectively while 19 (46%) were shared by both low and mid elevations only (Table 2). From plotless samples, only *Cleistopholis staudtii* was shared by both low and mid elevation and 4 and 3 species restricted only to low and mid elevations categories respectively and nothing found at high elevation (Table 3).

There were almost no significant differences in terms of the number of genera and species at low and mid elevation categories (Figure 2). However, the significant differences were quite clear high elevation category.

The differences in number of genera and species between low and mid elevations on one side and the high elevation on the other side could

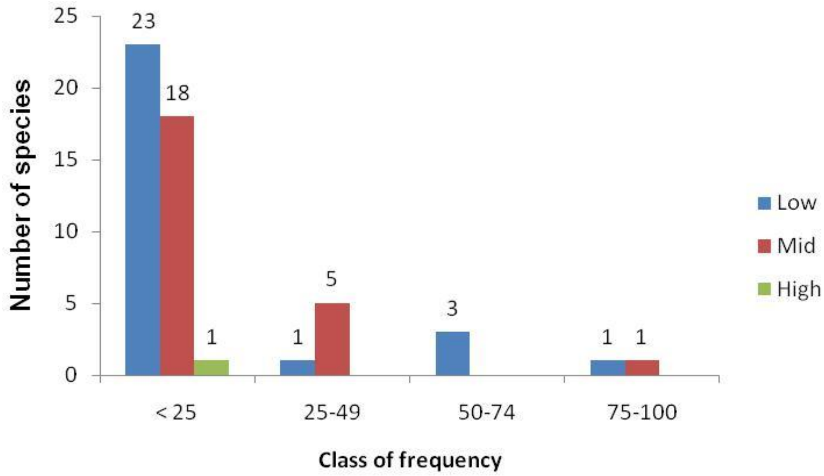

Figure 4. Classes of frequency of species at low and mid elevations.

Table 6. Number of plot (Np), number of individuals/elevation category (N), number of species/elevation category (S), Shannon -Wiener index (H'), Simpson's index (D), reverse of Simpson's index (1/D), Equitability (J), Student test (t-test), Mann-Whitney (w-test).

Elevation category	Np	N	S	H'	D	1/D	J	t-test	w-test
Low	40	494	32	2.65	4.61	0.22	0.76	t=27.85	w = 843.5
Mid	40	2035	27	0.48	1.23	0.81	0.15		p = 0.5094 α = 0.05
High	16	2	1	0.15					

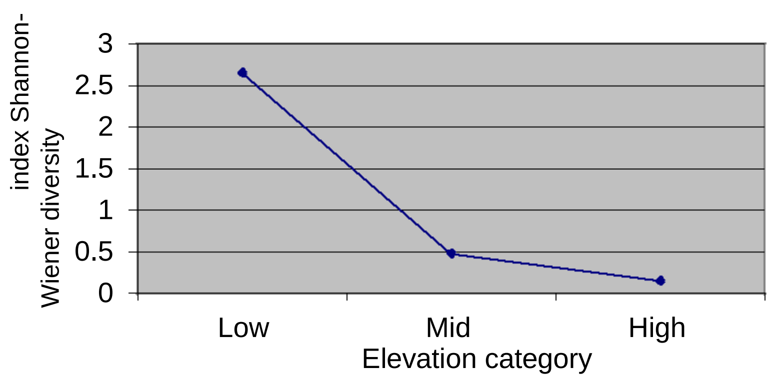

Figure 5. Graph of Shannon-Wiener diversity index for the three elevation categories.

be attributed to the fact that the differences in altitudes had a marked effect on temperature, relative humidity and soil which in turn affects the type of vegetation found on the mountain slope (Payton, 1993). Soils in the lowland forest are nutrient-rich andosols. Andosols are formed from volcanic cinders and weathered basalts from lava flows, which moved towards the lowland in the form of mud. This soil has relatively high natural fertility and good biological and physical properties (Cheek, 1992 and CDC, 1997). With increasing elevation, the humus content of the soil increases due to the slower oxidation rates and the soils are dark in colour. At higher elevations, these soils change rapidly to very young, shallow coarse-textured andosols containing very little water, interspersed with extensive areas of bare recent lava flows and cinder deposits. It has been suggested that recent volcanic activity and immature droughty soils are the major factors limiting tree growth at higher elevation (Hasselo, 1961; Payton, 1993).

Restriction of species distribution to one or two

Table 7. Similarity measures.

Measure	Value
Cj	0.488
Cs	0.656
Cm	0.187
Cmh	0.504

Cj= Jaccard measure (qualitative), Cs = Sorensen measure (qualitative), Cn = Sorensen measure (quantative data), Cmh = Morista-Horn measure (quantitative data).

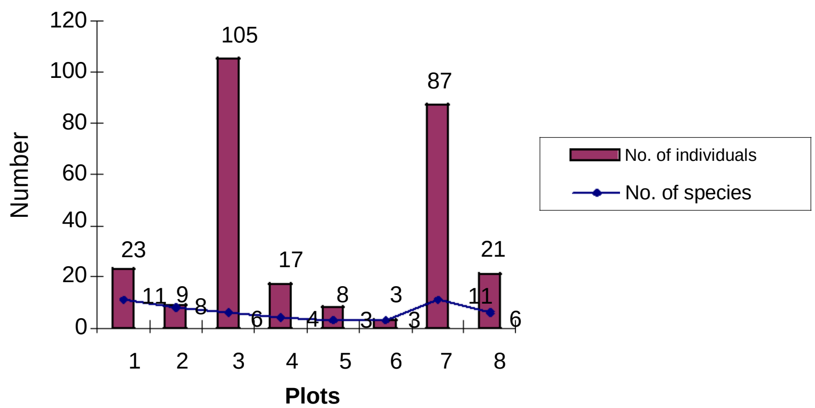

Figure 6. Number of species (S) against number of individuals (N) for all plots in Njonji.

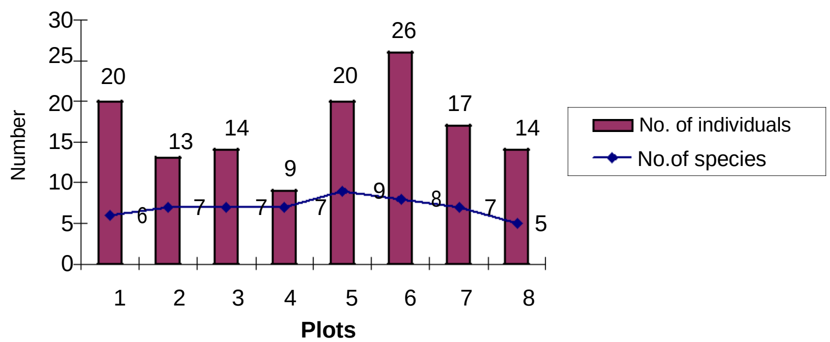

Figure 7. Number of species (S) against number of individuals/site (N) for all plots in Bimbia Bonadikombo.

elevation categories might be simply because dispersal has only just begun and they have not had enough time to expand their range into other habitats. On the other hand, they might be evolutionarily isolated and are particularly useful in indicating antiquity, isolation and diversification of habitats (Rexford, 1978; Tchouto, 1995). Restriction might also be attributed to the lack of dispersers that could carry seeds from one habitat to the other. It might also be because the species are habitat-characteristic or because the viability of their seeds is short. The poor species representation at the high elevation category can be attributed to low sampling size at that elevation category. In fact, only 16 transects were surveyed instead of 40 as in the other elevation categories. Species might also be killed by regular bush fires set by hunters during each dry season at the high elevation.

The abundance of certain species such as *Uvariodendron connivens, Friesodelsia gracilipes, Polyceratocarpus parviflora,* etc might be due to the fact that under climatic constraints, seeds have acquired the capacity to remain dormant during unfavourable periods.

Favourable conditions permit a continuous uninterrupted process of flowering, seed development and dissemination, germination and early seedling growth (Maury-Lechon, 1993). It might also be due to the fact that these species have long flowering and fruiting periods favouring pollination as compared to other species whose reproductive organs do not reach maturity probably because they are washed off by heavy rain at their early stage of development.

Only one species (*Uvariodendron connivens*) was found abundant at both low and mid elevations. Three species were frequent and confined to low elevation only. 1 and 5 species appeared occasionally and were restricted to low and mid elevations respectively. 23, 18 and 1 species were rare at low, mid and high elevations respectively (Figure 4). Rareness of species might be attributed to the fact that they do not flower yearly (intervals are usually irregular) and their seeds, generally fleshy and hydrated, lose their viability when dehydrated, so that they cannot be conserved ("recalcitrant" seeds) (Bras and Maury-Lechon, 1986; Corbineau and Côme, 1988; Tompsett, 1990).

There was an overall trend of decline of species diversity with elevation categories. The Shannon-Wiener index shows that low elevation (H' = 2.65) is more diverse than the mid elevation (H' = 0.48). Similar results were obtained for Simpson's index (Table 6). The higher elevation with two individuals of a single species was therefore the least diverse (H' = 0.15). Species were more even in their abundance distribution within at low elevation (J = 0.76) than at mid elevation (J =0.15). This shows that although the mid elevation contained more individuals; it has a less even species distribution than the low elevation category. Similar results have been obtained by Tchouto (1995) in the proposed Etinde Rainforest Reserve, Sunderland (2000) in Mokoko, Campo and Takamanda forests, and Mboh (2001) in Takamanda, Campo Ma'an, and Ejagham Forest Reserves.

A number of species were prominent in both the low and mid elevations. The Sorensen's Coefficient (Cs = 0.656) shows that low and mid elevations share similarity in species. A similar result was obtained for Jaccard's Coefficient (Cj = 0.488) and Morista-Horn's coefficient (Cmh = 0.504) of similarity measures. Mann-Whitney test also shows that there is no statistically significant difference at the 95% confidence interval between the low and the mid altitudinal elevation categories (Table 6). However, more studies are needed to better understand the pattern behind distribution of species at different elevation categories.

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REFERENCES

Beentje HJ (1994). Kenya Trees, Shrubs, and Lianas, 722p.
Boughey AS (1955). The vegetation of the mountain of Biafra. Proc. Linn. Soc., 165: 144 -150.
Bras P, Maury-Lechon G (1986). Graines forestieres tropicales de type fortement hydraté: la conservation et ses effets, exemple du Symphonia globulifera L.f. de Guyane française. B.T.F. 212: 35-46.
Cable S, Cheek M (1998). The plants of Mount Cameroon: A conservation checklist. Royal Botanic Gardens, Kew, 112p
CDC (1997). Soil surveys and land evaluations for the second development of program of program of the Cameroon Development Corporation. FAO/UNDP/IRAF/ONAREST. Ekona, 7: 113
Cheek M (1992). A botanical inventory of the Mabeta-Moliwe forest. Report on Limbe Botanic Garen Conservation Project, 112p.
Corbineau F, Côme D (1988). Storage of recalcitrant seeds of four tropical species. Seed Sci. Technol., 16: 97-103
Courade G (1972). Regional Atlas. West 1, ORSTOM Cameroon.
Dassanyayaka MD, Fosberg FR (1985). A revised handbook to the Flora of Ceylan vol.5. Smithsonian institution and the Nation Science Foundation. Washington, D.C. pp. 475
Focho DA, Egbe EA, Chuyong GB, Fongod AGN, Fonge BA, Ndam N, Youssoufa BM (2010). An ethnobotanical investigation of the annonaceae on Mount Cameroon. J. Med. Plants Res., 4(20): 2148-2158.
Foreman L, Bridson D (1989). The herbarium handbook. Royal Botanic Garden, Kew, 333p.
Fraser PJ, Hall JB, Healey JR (1998). Climate of the Mount Cameroon region, long and medium term rainfall, temperature and sunshine data. SAFS, University of Wales Bangor, MCP-LBG, Limbe. pp. 56.
Hasselo HN (1961). The soils of the lower eastern slopes of Cameroon mountain and Their suitability for various perennial crops. H. Veemuneen, Wageningen, 67p.
Hutchinson J, Dalziel JM (1954). Flora of West Tropical Africa. 1: I-295.
IUCN (1998). Red date list of threatened species. World Conservation Monitoring Center
Le Thomas A (1969). Les Annonaceae. Flore du Gabon. Muséum National D'histoire Naturelle, 371p.
Letouzey R (1985). Notice of phytographic map of Cameroon at 1/1.500.000. International Institute of Cartography, Toulouse. 6 leaflets, 240p.
Maury-Lechon G (1993). Biological characters and plasticity of juvenile tree stages to restore degraded tropical forests: Programme proposition for genetic resource maintenance, pp. 37-47. In: Lieth H. and Lohmann M. (eds), Restoration of Tropical Forest Ecosystems. Kluwer Academic Publishers, Netherlands, 269p.
Mboh H (2001). Vegetation assessment of Takamanda forest reserve and comparison with Campo Ma'an and Ejagham forest reserves. Mémoire dissertation. Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon, 62p.
Ndam N (1998). Tree regeneration, vegetation dynamics and the maintenance of biodiversity on Mount Cameroon: the relative impact of natural and human disturbance. A Ph.D dissertation. School of Agriculture and Forest Sciences, University of Wales Bangor, U.K., 320p.
Payton RW (1993). Ecology, altitudinal zonation and conservation of tropical rainforest of Mount Cameroon Final Project Report R4600, ODA, London, Mount Cameroon Project, 70p.
Rexford D (1978). Plant geography. Academic Press. New York, San Francisco and London.
Steentoft M (1988). Flowering plants in West Tropical Africa. Cambridge University Press, 344p.
Sunderland TCH (2000). The Taxonomy, Ecology and Utilization of

African Rattan (Palmae & Calomoideae), PhD thesis, University College of London, UK. Pp. 308-320.
Tchouto P (1995). The vegetation of the proposed Etinde Forest Reserve, Mount Cameroon, and its conservation. M.Sc. dissertation, University of Edinburgh. Royal Botanic Garden, Edinburgh, 94p.
Tchouto P (1996). Forest inventory report of the proposed Etinde Rainforest reserve. Mount Cameroon Project, 68p.
Thompsett PB (1990). Predicting the storage life of orthodox tropical forest tree seeds; In: Proc. UIFRO Symp. Seed problems of multipurpose trees and other tropical and subtropical species, ACIAR, Canberra, pp. 93-98.
WCMC (1995). Cameroon-nationally threatened and endemic plant taxa: conservation Status Listing of Plants, 22p.

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