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Species composition, diversity and distribution in a disturbed Takamanda Rainforest, South West, Cameroon

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This study assessed the diversity and distribution of trees and shrubs in a 16 ha disturbed plot in the Takamanda Rainforest. Linear transects (8) were laid in the field which radiated from the centre of the plot. The girth of the trees and shrubs were measured and species identified. A total of 99 species (72 trees and 27 shrubs) belonging to 87 genera and 34 families were recorded. Caesalpinaceae was the most represented tree family (9 species) while Rubiaceae was the most represented among shrubs (9 species). *Baphia nitida* recorded the highest tree density (143.75 individual's ha^{-1}) and lowest tree density (1.56 individual's ha^{-1}) was recorded for *Khaya anthotera.* The highest shrub density (192.19ha^{-1}) was recorded for *Angylocalyx pynatii* while the lowest was (1.56 ha^{-1}) was recorded for *Voacanga africana.* The girth class distribution showed a reverse J-shape distribution, with the highest densities in the lower girth (15-30 and 30-45 cm) classes. This decreases in density with the larger girth (> 75) class. The Importance Value Index (IVI) of trees was highest for *Baphia nitida* (20.06) while the lowest was recorded for *Millettia sanagana* (0.51). For shrubs, *Chytranthus macrobotrys* had highest IVI of 45.05 while the lowest was observed in *V. Africana* (1.24). Diversity index of trees and shrubs were 3.87 and 2.88, respectively. A dominance index of trees was 0.03 and that of shrubs was 0.08. The species evenness for trees (0.90) and shrubs (0.87) showed a slight variation in distribution. Abundance/ frequency ratio (A/F) for tree and shrub was >0.05 and showed a clumped pattern of distribution. Sustainable management of the forest would continue to provide goods and services for communities around the rainforest.

Key words: Diversity index, distribution, abundance/frequency ratio' contagious, importance value index, evenness index.

INTRODUCTION

Tropical rainforest are looked upon as one of the most species-diverse terrestrial ecosystems. They are distinguished from all other terrestrial ecosystems by a very high diversity at many levels (species, life forms, etc). Their immense biodiversity generates a variety of natural resources which helps to sustain livelihoods of both local

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and urban communities (Kumar et al., 2006). Some of these goods enjoyed by forest dwellers include: medicinal plants, fodder, food, fruits, bush meat, construction materials, etc (Ndah et al., 2013a). Forest communities also enjoyed services provided by the forest, some of which include: the regulation of temperature, purification of air, detoxification of soil, thus producing a healthy environment for livelihoods support (Tripathi et al., 2010; Hadis et al., 2009)

Trees, apart from forming the major structural and functional basis of tropical rainforest, are vital as carbon sinks, water sheds, provide shades and homes to many life forms and above all, act as a primary harvester of energy into the ecosystem (Singh, 2002). Trees diversity is vital to tropical forest biodiversity, because tree provide homes and resources to a wide variety of plant and animal species (Huang et al., 2003). Tree species diversity and spatial distribution in tropical forest are greatly influence by biogeography, niche requirement and disturbance (Huang et al., 2003).

Many tropical forests are undergoing severe anthropogenic modifications such as cutting down of forest for plantation establishment, poor farming techniques, poor hunting and trapping practices (Ndah et al., 2012, 2013a, b). Over exploitation of non-timber forest products, etc and sustainable management techniques are required to maintain the biodiversity and productivity of the ecosystems (Reddy and Ugle, 2008).

The Takamanda Rainforest is an area noted for its richness and diversity in plant and animal species which are widely distributed within the different ecological types (Ndah et al., 2012; Sunderland-Groves, 2003). This area harbours some African threatened species that are of paramount conservation interest. Some of these tree species included *Terminalia ivorensis, Pterocarpus soyauxii, Milicia excelsa, Balonella toxisperma, Staudtia stapitata, Afzelia bipindensis* and *Diospyros crassiflora* (Sunderland et al., 2003). Besides the plant species, the forest equally harbours animals of conservation interest. Amongst these are the Nigeria-Cameroon chimpanzee (*Pan troglodytes vellerosus*), drill (*Mandrillus leucophaeus*) and Preuss's guenon (*Cercopithecus preussi*) (Grove and Maisel, 1999). The Cross River gorilla (*Gorilla gorilla diehli*) apart from being endangered is endemic to the area (Grove and Maisel, 1999; Ndah et al., 2012).

This rainforest have been subjected to anthropogenic activities, mainly indiscriminate exploitation of timber (*Pterocarpus soyauxii*, *Terminalia ivorensis*, *Eribroma oblongata*) and gathering of non-timber forest products (*Irvingia* spp., *Garcinia manii*, *Carpolobia* spp.) as well as slash and burn system of agriculture (Ndah et al., 2012, 2013a). Nevertheless, the Takamanda rainforest is part of the Guineo-Congolean forest which harbours some endemic life forms of the world (Lawson, 1996). The control of man's excesses in this ecosystem may support biodiversity conservation.

The aim of this study was to evaluate tree and shrub composition, diversity and distribution pattern in a disturbed Takamanda rainforest. This study gives baseline information on the effects of anthropogenic disturbance on forest species distribution and diversity. This will enable the different stakeholders to take appropriate decisions and measures in sustainable forest management.

MATERIALS AND METHODS

Location of study area

The Takamanda Rainforest which covers a surface area of 67,599 ha is located in the South West Region and this part of Cameroon has been described in details in Ndah et al. (2012). Rainfall in this forest has a range of 2500 to 4000 mm per annum (Egbe Enow Andrew, unpublished data) and gives rise to a diverse floristic composition. The low land forest is dominated by *Afrostyras kamerunensis*, *Klainedoxa gabunensis* and *Irvingia gabonensis*, the montane forest dominated by *Xylopia staudtii*, *Macaranga occidentalis* and *Bridelia grandis*; the grassland dominated by *Hyparrhenia diplondra*, *Setaria ancep* and *Loudetia camerunensis* (Sunderland et al., 2003).

The terrain is undulating in the lowland areas, but rises sharply to an altitude of 1,500 m in the northern part of the rainforest, where slopes are extremely steep. In general, the region has two distinct seasons with most rainfall occurring from April to November, with peak period in July-August and September. The mean annual temperature is about 27°C. Normally, it is cooler in the rainy season than in the dry season (Comiskey et al., 2003). The estimated human population of the area is between 6 and 12 individuals per km^2 (Ndah et al., 2013a).

Vegetation assessment

Eight linear transects 500 m long running north, northeast, east, southeast, south, southwest, west and northwest were established in the disturbed forest radiating from the centre of the site. Radiating transects traversed swamps, plains, ridges, slopes, gulley and valleys. A quadrat size of 20 x 20 m was used for trees, 5 x 5 m for shrubs. Girth was measured at breast height (DBH 1.3 m) using a girth tape. In the case of buttressed trees, the measurements were made above the buttress. All trees in the plot were enumerated and identified with the help of Flora of West Africa (Hutchinson and Dalziel, 1954) and voucher specimens of unidentified species were taken to the Limbe Botanical Garden (SCA) for identification. To determine girth class sizes, only tree species with girth ≥ 15 cm was used for the analysis. For the shrubs girth size of ≥ 1 and ≤ 10 cm were used for the analysis.

Data analysis

Frequency, density, basal area, abundance and importance value index (IVI) of plant species were calculated following Misra (1974) and Mueller-Dombois and Ellenberg (1974). The basal area of each

Table 1. Density, basal area, importance value index (IVI) and abundance frequency ratio (A/F) of trees in the study area.

Specie	Family	Density ha^{-1}	Basal area (cm^2 ha^{-1})	IVI	A/F ratio
Afzelia africana	Mimosaceae	1.56	191.65	0.85	0.49
Albizia adianthifolia	Mimosaceae	7.81	1701.93	4.88	0.81
Albizia zygia	Leguminosae	54.69	2653.36	15.27	1.21
Allanblackia floribunda	Guttiferea	7.81	302.34	2.38	0.81
Alstonia boonei	Apocynaceae	1.56	10780.33	19.69	0.49
Amphimas pterocarpoides	Papilionaceae	18.75	277.90	4.86	0.83
Annickia chlorantha	Annonaceae	15.63	20.43	3.39	0.97
Anthonotha macrophylla	Moraceae	29.69	31.56	6.60	0.92
Antiaris africana	Moraceae	31.25	147.74	7.31	0.88
Baphia nitida	Papilionaceae	143.75	48.99	20.06	3.19
Barteria fistulosa	Passifloraceae	23.44	106.47	5.73	0.81
Bertiera fostulosa	Rubiaceae	3.13	155.24	1.29	0.49
Bridelia micrantha	Euphorbiaceae	10.94	676.34	3.72	0.85
Calpocalyx dinklagei	Caesalpiniaceae	42.19	231.27	7.60	1.64
Canarium schweinfurthii	Burseraceae	1.56	20.87	0.54	0.49
Canthium arnoldianum	Rubiaceae	3.13	225.62	1.41	0.49
Carapa procera	Meliaceae	4.69	41.74	1.59	0.49
Ceiba pentandra	Bombacaceae	4.69	2944.98	6.76	0.49
chumanyophytum sp	Rubiaceae	4.69	18.42	0.87	1.46
Coelocaryon preussii	Myristicaceae	3.13	185.94	1.00	0.97
Cola millenii	Sterculiaceae	31.25	49.99	6.46	1.08
Dacryodes edulis	Burseraceae	6.25	132.82	1.92	0.65
Dialium lopens	Caesalpiniaceae	1.56	155.24	0.78	0.49
Diospyros herienasis	Ebenaceae	1.56	66.71	0.62	0.49
Distemonanthus benthamianus	Caesalpiniaceae	10.94	1360.41	5.28	0.68
Drypetes preussii	Euphorbiaceae	29.69	22.71	6.92	0.84
Eribroma oblongata	Sterculiaceae	1.56	3880.92	7.41	0.49
Eriocoelum macrocarpum	Sapindaceae	1.56	155.24	0.78	0.49
Ficus exaspirata	Moraceae	25.00	401.56	6.42	0.86
Ficus mucoso	Moraceae	4.69	1466.98	3.79	0.73
Funtumia africana	Apocynaceae	26.56	217.98	6.94	0.75
Garcinia staudtii	Guttiferae	3.13	4.91	0.68	0.97
Greenweodendron sp	Annonaceae	3.13	185.94	1.34	0.49
Grewia coriacea	Tiliaceae	1.56	1.92	0.51	0.49
Hannoa klaineana	Simaroubaceae	6.25	240.41	2.11	0.65
Hylodendron gabunense	Caesalpiniaceae	15.63	30.21	3.41	0.97
Hypodaphnis zenkeri	Caesalpiniaceae	3.13	30.66	1.07	0.49
Irvingia gabonensis	Irvingiaceae	6.25	789.77	3.43	0.49
Khaya anthotera	Caesalpiniaceae	1.56	155.24	0.78	0.49
Lannea welwichii	Anacardiaceae	7.81	1500.39	4.52	0.81
Macaranga monandra	Euphorbiaceae	9.38	196.80	3.04	0.58
Maesopsis eminii	Rhamnaceae	4.69	913.59	3.14	0.49
Margaritaria discoidea	Euphorbiaceae	1.56	2767.43	5.43	0.49
Milicia excelsa	Moraceae	3.13	2944.98	6.25	0.49
Millettia mannii	Papilionaceae	6.25	294.68	1.87	0.97
Millettia sanagana	Papilionaceae	1.56	1.92	0.51	0.49

Table 1. Contd.

Musanga cecropioides	Cecropiaceae	15.63	661.61	4.87	0.81
Myrianthus arboreus	Cecropiaceae	32.81	155.48	6.47	1.28
Newbouldia laevis	Bignoniaceae	3.13	76.07	0.81	0.97
Oncuba gloca	Euphorbiaceae	1.56	191.65	0.85	0.49
Pentaclethra macrophylla	Mimosaceae	6.25	124.19	1.90	0.65
Plagiostyles africana	Euphorbiaceae	21.88	545.52	4.99	1.36
Pseudospondias microcarpa	Anacardiaceae	4.69	1295.56	3.14	1.46
Pterocarpus soyauxii	Leguminosae	32.81	342.91	7.14	1.13
Pycnanthus angolensis	Myristicaceae	12.50	603.82	4.10	0.78
Ricinodendron heudelottii	Euphorbiaceae	18.75	6081.92	16.21	0.58
Santiria trimera	Burseraceae	6.25	264.60	1.81	0.97
Scottellia sp.	Flacourticaceae	1.56	460.44	1.32	0.49
Sorindeia grandifolia	Anacardiaceae	1.56	18.42	0.54	0.49
Staudtia kamerunensis	Myristicaceae	3.13	141.74	0.92	0.97
Sterculia tragacantha	Sterculiaceae	75.00	321.66	13.61	1.56
Tabernaemontana crassa	Apocynaceae	1.56	68.99	0.63	0.49
Thorianthus sp	Meliaceae	1.56	78.50	0.65	0.49
Treculia obovoidea	Moraceae	4.69	21.29	1.55	0.49
Trichilia rubescens	Miliaceae	29.69	264.95	7.01	0.92
Trichilia welwitschii	Miliaceae	3.13	931.81	2.67	0.49
Trilepisium madagascariense	Moraceae	10.94	328.53	3.44	0.68
Uapaca guineensis	Euphorbiaceae	1.56	766.60	1.87	0.49
Vitex grandifolia	Vitaceae	1.56	3066.41	5.96	0.49
Xylopia aethiopica	Annonaceae	17.19	321.18	4.43	0.89
Xylopia quintasii	Annonaceae	3.13	8.25	0.69	0.97
Zanthoxylum xylate	Rutaceae	3.13	328.89	1.26	0.97
		945.3125	**56203.49**	**300**	

individual tree species was calculated as Ba = Pi ($^1/_2$ Dbh)^2

The importance value index (IVI) for trees and shrubs were calculated by summing the relative frequency, relative density and relative dominance for trees and shrubs. Importance value index was calculated from the values of relative frequency and relative density.

The species diversity index was calculated following Shannon-Wiener index (1963), where: H' = -Σ (ni/N) ln ni/N and H' = Shannon-Wiener index of general diversity, ni = importance value index of i^{th} species, N = sum of importance value index of all the species.

The species dominance index was calculated by the formula given by Simpson (1949) Cd = Σ (ni/N)^2, ni = importance value index of i^{th} species, N = sum of importance value index of all the species.

The spatial distribution of trees and shrubs was determined following Whitford (1949): WI = abundance/frequency (A/F Ratio). A value <0.025 would imply a regular distribution, values between 0.025-0.05 means a random distribution and a value >0.05 would mean a contagious distribution.

RESULTS

Tree species composition

A total of 99 tree species belonging to 87 genera under 34 families were recorded at the study area (Table 1). Seventy-two (72) tree (height above 10 meters) species were recorded in the study site (Table 1). Most of the species (9) belonged to the family Caesalpiniaceae followed by Moraceae (7 species), Meliaceae and Papilionaceae (6 species each), Annonaceae and Sterculiaceae (4 species each), Anacardiaceae, Apocynaceae, Burseraceae, Euphorbiaceae, Leguminosae, Mimosaceae and Myristicaceae (3 species each), Cecropiaceae, Guttiferae and Pandaceae (2 species each) Bignomiaceae, Bombacaceae, Ebenaceae, Flacourticaceae, Irvingiaceae, Passifloraceae, Rhamnaceae, Rutaceae, Sapindaceae and Simaroubaceae (1 species each) (Table 1).

Table 2. Density, basal area, importance value index (IVI) and abundance frequency ratio (A/F) of shrubs in the study area.

Specie	Family	Density (ha^{-1})	Basal area (cm^2 ha^{-1})	IVI	A/F ratio
Angylocalyx oligophyllus	Papilionaceae	14.06	5.25	4.10	1.19
Angylocalyx pynatii	Papilionaceae	192.19	5.43	37.24	2.16
Carpolobia alba	Polygalaceae	6.25	6.04	3.19	0.53
Carpolobia lutea	Polygalaceae	31.25	7.03	13.50	0.48
Chytranthus macrobotrys	Sapindaceae	4.69	307.49	45.05	0.40
Chytranthus tabotii	Sapindaceae	10.94	45.75	11.65	0.37
Coffea sp.	Rubiaceae	3.13	54.86	9.60	0.26
Crateristermum aristatum	Rubiaceae	4.69	17.63	5.38	0.26
Dracaena camerooniana	Dracaenaceae	9.38	1.55	2.20	1.58
Glyphaea brevis	Tiliaceae	7.81	24.02	5.13	1.32
Heinisa crinita (Afzel	Rubiaceae	4.69	27.67	6.78	0.26
Lasianthera africana	Icacinaceae	40.63	5.07	12.90	0.76
Maesobotrya staudtii	Euphorbiaceae	1.56	11.98	2.64	0.26
Mallotus oppositifolius	Euphorbiaceae	125.00	8.88	27.47	1.62
Massularia acuminata	Rubiaceae	6.25	15.29	5.25	0.35
Microdesmis puberula	Papilionaceae	45.31	5.49	11.26	1.27
Microdesmis zenkeri	Papilionaceae	43.75	4.86	14.05	0.74
Pavetta staudtii Hutch	Rubiaceae	9.38	1.92	5.33	0.32
Penianthus camerounensis	Menispermaceae	1.56	2.11	1.27	0.26
Psychotria biferia	Rubiaceae	1.56	8.45	2.15	0.26
Rauvolfia vomitoria	Apocynaceae	21.88	67.44	19.17	0.41
Rinorea digitata	Violaceae	148.44	4.19	31.39	1.67
Rinorea oblongifolia	Violaceae	14.06	17.25	6.54	0.79
Rothmannia hispida	Rubiaceae	4.69	21.72	5.95	0.26
Rothmannia isuda	Rubiaceae	14.06	12.57	5.12	1.19
Rothmannia sp	Rubiaceae	1.56	24.84	4.44	0.26
Voacanga africana	Apocynaceae	1.56	1.92	1.24	0.26
		770.31	**716.72**	**300**	

Total stem density in the study area was 1716 individuals' ha^{-1} which comprised 945.3 and 770.31 for trees and shrubs, respectively (Table 1). The tree species with the highest stem densities was *Baphia nitida* with 143.75 individuals' ha^{-1} while the lowest was recorded for *Afzelia Africana, Alstonia boonei, Canarium schweinfurthii, Dialium lopens, Diospyros herienasis, Eribroma oblongata, Eriocoelum macrocarpum, Grewia coriacea, Khaya anthotera, Margaritaria discoidea, Millettia sanagana, Oncuba gloca, Scottellia* sp., *Sorindeia grandifolia, Tabernaemontana crassa, Thorianthus* sp., *Uapaca guineensis* and *Vitex grandifolia* with 1.56 individual ha^{-1} (Table 1).

The basal area ranged from 1.92-10780.33 cm^2 ha^{-1} for different species in the study area (Table 1). Total basal area of tree species recorded was 56203.49 cm^2 ha^{-1}. The highest basal area of 10780.33cm^2 ha^{-1} was observed with *A. boonei*. This was closely followed by *Ricinodendron heudelottii* with basal area of 6081.92 cm^2 ha^{-1} (Table 1).

The lowest basal area of 1.92cm^2 ha^{-1} was noted with *Millettia sanagana* and *Grewia coriacea*.

The Importance Value Index (IVI) of tree species ranged from 0.51-20.06 (Table 1). *Baphia nitida* had the highest IVI of 20.06 which was closely followed by *A. boonei* with IVI 19.69. This signified that *B. nitida* and *A. boonei* were the most dominant species of the area while *M. sanagana* and *Sorindeia grandifolia* were the least dominant species in the study area (Table 1).

The abundance frequency ratio (A/F) of each tree and shrub were > 0.05 showing a clumped or contagious pattern of distribution for each species (Table). None of the species showed regular and random patterns of distribution (Tables 1 and 2).

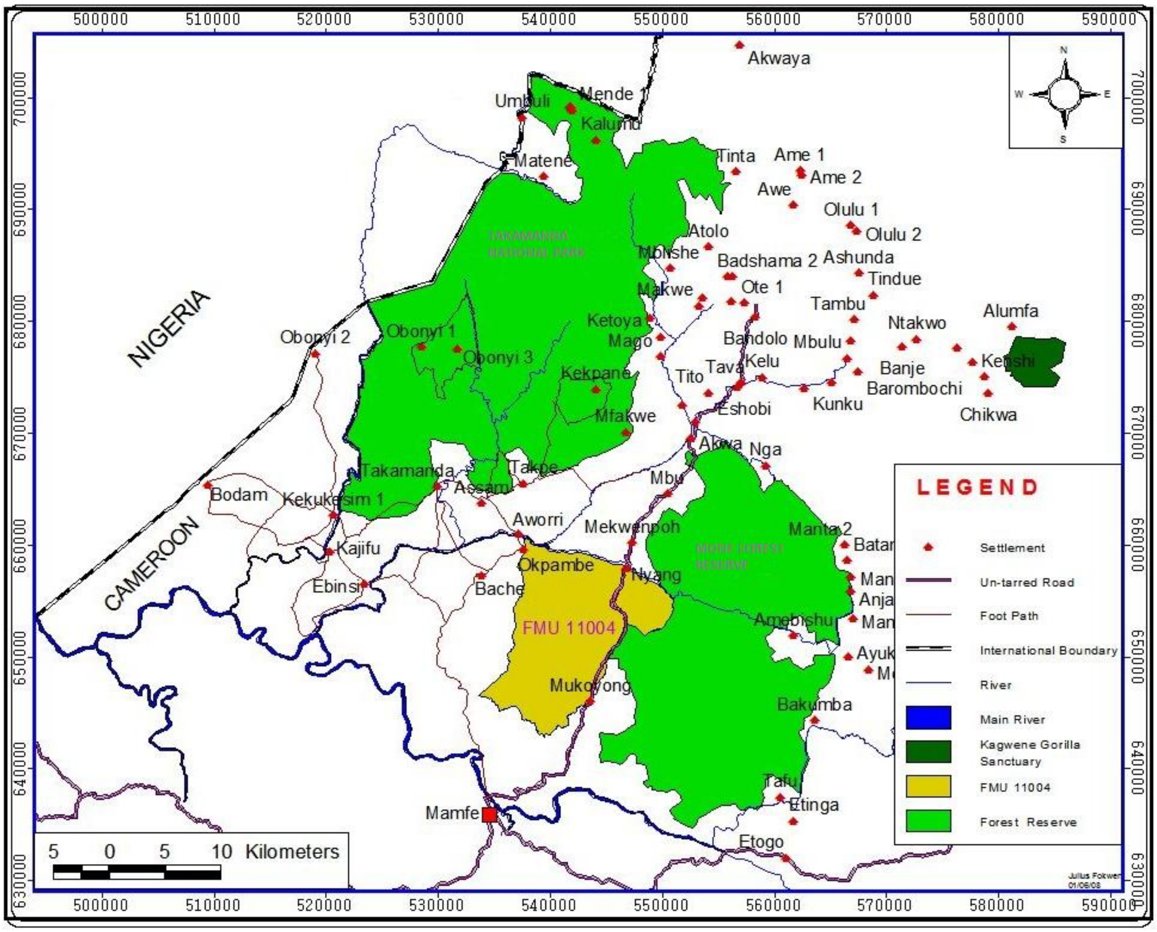

Figure 1. Map of the study area.

Shrub species composition

Twenty- seven (27) species of shrubs were recorded in the study area (Table 2). Most of the shrub species (9) belonged to the family Rubiaceae (Table 2). This was followed by the family Papilionaceae (4 species), Polygalaceae, Sapindaceae, Icacinaceae, Euphorbiaceae, Apocyanaceae and Violaceae (2 species each) and Dracaenaceae, Tiliaceae and Menispermaceae (1 species each) (Table 2). Stem density for shrub ranged from 1.56-192.19 individual ha^{-1} in the study area (Table 2). The total shrub density recorded was 770.31 individuals ha^{-1} (Table 2) with *Angylocalyx pynatii* being the most prevalent with a stem density of 148.44 individual ha^{-1} while the lowest stem density of 1.56 individual ha^{-1} was noted for the following species: *Maesobotrya staudtii, Penianthus camerounensis, Rothmannia* sp. and *Voacanga africana* (Table 2).

The basal area of shrub species varied from 1.55-307.49cm^2 ha^{-1} for the different species. The maximum basal area of 307.49 cm^{2}ha^{-1} was observed for *Chytranthus macrobotrys* while the minimum basal area of 1.55 cm^2 ha^{-1} was observed for *Dracaena camerooniana* (Table 2).

Among the shrubs, *Chytranthus macrobotrys* was the dominant species with the maximum IVI of 45.05 while the minimum IVI 1.24 was obtained for *V. africana* (Table 2).

Size class distribution of species

The class size distribution was recorded for trees with a girth ≥15 cm (Figure 1). The class size distribution of trees showed a reverse J-shaped distribution with decreasing density and with increase in girth (Figure 2). Most of the individual trees have girths from 15 – 30 cm (99 species) while 9 species showed a girth >75 cm (Figure 2).

Shrub density at different girth classes equally showed a reverse J- shaped distribution but with a slight increase in girth classes' ≥40 (Figure 3). The girth classes 1-10 showed the highest number of individuals while the girth class 30 to 40 showed the least number of individual per

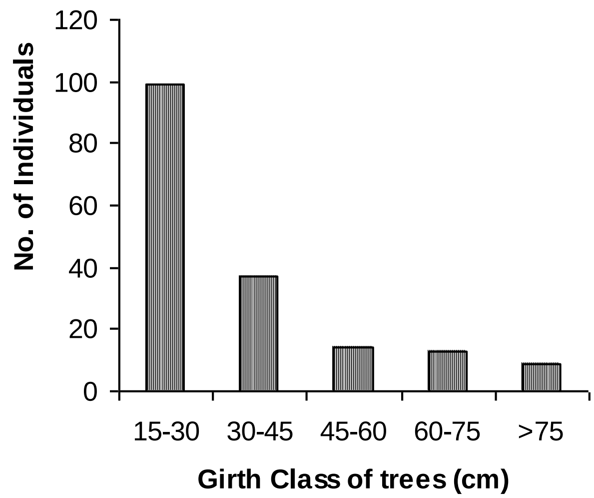

Figure 2. Girth class distribution of tree species in the study area.

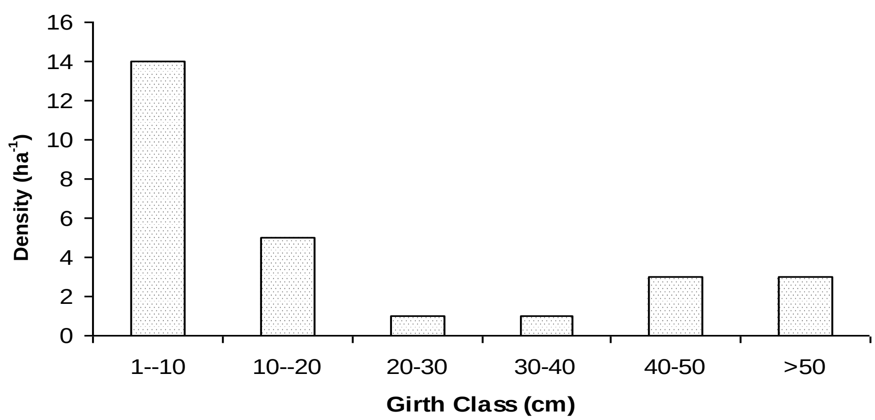

Figure 3. Density of shrubs at different girth classes in the study area.

hectare (Figure 3).

Species diversity

The Shannon – wiener's diversity index of 3.87 and 2.88 were recorded for trees and shrubs respectively (Table 3). The Simpson's dominance for tree species was 0.03 and 0.08 for shrubs (Table 3). Species evenness for trees was 0.90 and 0.87 was for shrubs (Table 3).

DISCUSSION

The Takamanda rainforest is a biodiversity conservation unit typified for its richness, endemism in flora and fauna (Ndah et al., 2012, 2013a, b; Sunderland et al., 2003). The richness in biodiversity makes it a gene bank for most species.

The flora of the Takamanda rainforest is characterized by a variety of tree species. The Caesalpinaceae were observed to be the most prevalent family. This may be due to their fast germination ability, associated with symbiotic properties which have enabled species to easily establish within habitat types. This finding was in line with the works of Deka et al. (2012), on vegetative assessment of tree species and shrubs indicating that legumes were the prominent species recorded in the study area. Moraceae, Meliaceae and Papilionaceae also their ability to produce numerous seeds which was eventually establish at suitable sites. This result was confirmed by Khan et al. (1986) while working on regeneration and survival of

Table 3. Characteristics of trees and shrubs in the study area.

Parameter	Tree	Shrub
Shannon's diversity index (H')	3.87	2.88
Pielou evenness index (J_{sw})	0.90	0.87
Simpson index (Cd)	0.03	0.08
Richness (total number of species)	72	27

tree seedlings in tropical forests. The reasons for the low number of species observed in some families could be attributed to diseases and browsing by herbivores which resulted in poor growth and establishment and perhaps seeds need scarification treatment before germination. Similar results were reported by Coley and Barone (1996) on herbivory and plant defenses on herbivores. The low number of species could also be attributed to anthropogenic activities which affected species growth and production. Similar findings have been reported by Sumina (1994) on plant communities on anthropogenically disturbed sites in Chukotka Peninsula.

In the shrub layer, the Rubiaceae was the most dominant family in the site. The dominance of this family could be as a result of habitat adaptation and favourable environmental conditions which encourage pollination, dispersal and eventual establishment of species. Similar situations were reported by Pausas and Austin (2001) on species richness in relation to environment. Austin et al. (1996) found that edaphic parameter (soil nutrients) played a major role in species richness and establish-ment in an ecosystem. The reasons for the poor establishment of some families which showed lowest species may be attributed to competition for nutrients, limited light by canopy trees and destruction of undergrowth during tree snapped and logged on the forest floor. Egbe et al. (2012) mentioned similar reports in a disturbed and natural regeneration forest in Korup National Park and Coley and Barone (1996) also recorded anthropogenic activities affecting growth and distribution of species.

The stem density of tree species decreased with increase in girth class distribution in the study area. This could result from anthropogenic activities such as the logging of trees for timber, felling of trees for construction and deforestation of forest for plantation crops. This finding is in accordance with the works of Deka et al. (2012) with tree species having high stem densities at lower girth classes.

For shrubs, the highest stem density was smaller as compared to stem density of trees. The low stem densities for shrubs may be as a result of canopy trees which shade most shrubs from sunlight, thus limiting the production of photosyntates for anabolic and catabolic processes. Furthermore, poor root establishment in the soil for nutrient and water uptake which are essential for the increase in girth and linear growth of plants.

The basal areas of tree species were comparatively higher than those of the shrubs due to the presence of large number of young individuals as well as old individuals in the community when compared with shrub species. The higher basal areas of tree species may also be due to the presence of adapted root architecture to absorb nutrients for growth. This finding is similar to the works of Parthasarathy (2001) and Parthasarathy (1999) on changes in forest composition and structure working in three sites of a tropical forest. Most of the shrub species recorded lower basal areas than those of tree species. Perhaps the low basal area could be attributed to poor root establishment for the acquisition of nutrients. Chauhan et al. (2008) reported that poor growth of tree species can be attributed to poor efficiency of some species in absorbing nutrients in the ecosystem.

Generally, species diversity is one of the most important indices used to evaluate an ecosystem. A rich ecosystem with high species diversity has a large value (H') while an ecosystem with low value (H') will have a low species diversity (Sobuj and Rahman, 2011; Deka et al., 2012). The present study site had a high species diversity for both tree and shrub species. Probably, the high species diversity for trees and shrubs could be attributed to the many tributaries and streams that empty rich organic content and mineral resources utilized by the species for growth and production. Giliba et al. (2011) reported similar findings on woodland of Bereku Forest Reserve in Tanzania.

Simpson's dominance index of trees and shrubs varied greatly within the study site. The lower the index value, the lower the dominance of species (Giliba et al., 2011). Misra (1989) reported that the greater the value of index of dominance, the lower the species diversity. This report tallies with findings of this study with high species diversity of trees and shrubs with a corresponding low dominance index value for shrub and trees in the study sites.

The species evenness values for trees and shrubs showed some similarities in the study area. This study showed to an extent some variation in the distribution of species in the study area. Similar remarks were made by Sunderland et al. (2003).

The clumped pattern of distribution of species depicts natural vegetation (Venna et al., 1999). The abundance frequency ratio (A/F) for trees and shrubs was evidence that the area was natural vegetation in which most seedlings were adapted to grow close to the mother plant. These observations were also reported by Deka et al. (2012), Giliba et al. (2011), Sobuj and Rahman (2011), Al-Amin et al. (2004) and Sugar et al. (2004) who mentioned different vegetation types.

Conclusion

This study revealed that the Takamanda Rainforest has high species (shrubs and trees) diversity. Families noted with dominant species in the study area included: trees (Caesalpinaceae, Moraceae, Meliaceae and Paplionaceae) and shrubs (Rubiaceae and Paplionaceae). However, species richness for some timber species and non timber forest products such as *Milicia excelsa*, *Afzelia africana*, *Carpolobia alba* and *Annikia chlorantha* were very poor due to over harvesting for the market and livelihood support. Nevertheless, the presence of many species in the lower girth classes gives the rainforest the potential for regeneration. This indicated that effective conservation and sustainable management of the forest would make it possible for the said forest to continue providing goods and services necessary for communities around the rainforest.

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REFERENCES

Al-Amin M, Alamgir M, Patwary MRA (2004). Composition and Status of Undergrowth of a Deforested Area in Bangladesh, Asian J. Plant Sci. 3 (5):651-654.

Austin MP, Pausas JG, Nicholls AO (1996). Patterns of tree species richness in relation to environment in south-eastern New South Wales. Aust. J. Ecol. 21:154-164.

Chauhan DS, Dhanai CS, Bhupendra S, Chauhan S, Todaria NP, Coley PD, Barone JA (1996). Herbivory and plant defenses in tropical forests Ann. Rev. Ecol. Syst. 27:305-335.

Deka J, Tripathi PO, Khan LM (2012). High Dominance of *Shorea robusta* Gaertn. in Alluvial Plain Kamrup Sal Forest of Assam, N. E. India Int. J. Ecosys. 2(4):67-73.

Egbe EA, Chuyong GB, Fonge BA, Namuene KS (2012). Forest disturbance and natural regeneration in African rainforest at Korup National Park, Cameroon, Int. J. Biodiver. Conserv. 4(11):377-384.

Giliba RA, Boon EK, Musamba EM, Kashindye AM, Shayo PF (2011). Composition, Richness and Diversity in Miombo, J. Biodiver. 2(1):1-7.

Groves J, Maisel F (1999). Report on the large mammal fauna of the Takamada Forest Reserve, South West Region, Cameroon.

Hadi S, Ziegler T, Waltert M, Hodges JK (2009). Treediversity and forest structure in Northern Siberut, Mentawai Island, *Indon,* J. Trop. Ecosys. 50(2):315-327.

Khan ML, Rai JPN, Tripathi RS (1986). Regeneration and survival of tree seedlings and sprouts in tropical deciduous and subtropical forests of Meghalaya, India. For. Ecol. and Manag. 14,293-304.

Kumar A, Marcot BG, Saxena A (2006). Tree species diversity and distribution patterns in tropical forests of Garo Hills, Curr. Sci. 91(10):1370-1381.

Lawson GW (1996). The Guinea-Congo lowland rain forest: An overview. Proceedings of the Royal Soc Edinburgh Section B, Biol. Sci. 104:5-13.

Misra R (1968). Ecology Work Book. Oxford-IBH Publishing Company: Calcutta, India.

Mueller-Dombois D, Ellenberg H (1974). Aims and Methods of Vegetation Ecol. John Wiley & Sons, Inc: New York, USA.

Ndah NR, Asaha S, Mboh H, Yengo T, Egbe AE, Mukete OR, Naah T (2012). Distribution of mammals and hunting practices in Okpambe and Assam areas of the Takamanda Rainforest, South-West Cameroon, J. Soil Sci. Environ. Manag. 3(10): 252-261.

Ndah RN, Egbe EA, Bechem E, Asaha S, Yengo T, Chia LE, Ngaiwi Eyenieh MN (2013a). Ethnobotanical study of commonly used medicinal plants of the Takamanda Rainforest South West, Cameroon, Afr. J. Plant Sci. 7(1):21-34.

Ndah RN, Chia LE, Egbe EA, Bechem E, Yengo T (2013b). Spatial distribution and abundance of selected non-timber forest products in the Takamanda National Park, Cameroon Int. J. Biodiver. Conserv. 5(6):378-388.

Parthasarathy N (1999). Tree diversity and distribution in undisturbed and human impacted sites of tropical wet evergreen forest in Southern Western Ghats, India. Biodiver. Conserv. 8:1365-1381.

Parthasarathy N (2001). Changes in forest composition and structure in three sites of tropical evergreen forest around Sengaltheri, Western Ghats. Curr. Sci. 80: 389–393

Pausas JG, Austin MP (2001). Patterns of plant species richness in relation to different environments: An appraisal J. Veg. Sci. 12:153-166.

Reddy SC, Ugle P (2008). Tree species diversity and distribution patterns in tropical forest of Eastern Ghats, India: a case study J. Life Sci. 5(4):87-93.

Shannon CE, Wienner W (1963). The Mathematical Theory of Communication. University of IIIinois Press: Ur-bana, Illinois.

Simpson EH (1949). Measurement of diversity Nat. 163:688.

Singh JS (2002). The biodiversity crisis: a multifaceted review. Curr. Sci. 82:638-647.

Sobuj NA, Rahman M (2011). Assessment of plant diversity in Khadimnagar National Park of Bangladesh Inter. J. Environ. Sci. 2(1):1-13.

Sumina OI (1994). Plant communities on anthropogenically disturbed sites on Chukotka Peninsula, Russia. J Veg. Sci. 5:885-896.

Sunderland TCH, Besong S, Ayeni JSO (2003). Distribution, Utilization and Sustainability of Non-Timber Forest Products from Takamanda Forest Reserve, Cameroon , in Comiskey et al. (eds.), *Takamanda:* The Biodiversity of an African Rainforest. Washington DC: SI/MAB Series #8. Smithsonian Institution.

Sunderland-Groves JL, Sunderland TCH, Comiskey AL (2003). Takamanda Forest, Cameroon, in Comiskey et al. (eds.), Takamanda: The Biodiversity of an African Rainforest. SI/MAB Publications/Smithsonian Institute.

Tripathi PO, Upadhaya K, Tripathi KS, Pandey HN (2010). Diversity, dominance and population structure of tree species along fragment size gradient of subtropical humid forest of Northeast India, Res. J. Environ. Earth Sci. 2(2):97-105.

Venna RR Snadang DK, Totey GN (1999). Species diversity under plantation raised on a degraded land. Malaysian For. 62:95-106.

Whitford PB (1949). Distribution of woodland plants in relation to succession and clonal growth. Ecology 30:199-208.