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COMPOSITION AND DIVERSITY OF UNDERSTORY PLANTS IN THE TROPICAL RAIN FOREST OF CROSS RIVER NATIONAL PARK (CRNP), NIGERIA

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ABSTRACT

The study assessed the composition and diversity pattern of understory in Oban division of CRNP with a view to established the contribution of the understory to diversity of the area. The study was conducted in four land use types: primary forest (core), secondary forest (buffer), farm fallow and plantation. Ten transects of 2000m length each were systematically located in each land use type. Four sample plots of 50×50m were located on each transect at an interval of 500m. Each plot was subdivided into nine 10× 10m subplots for shrubs enumeration and a 1×1m mili-acre plot was located at the center of each subplot for herb enumeration. Flora species composition, distribution and diversity were estimated across the land use types using diversity indices. Primary forest (core) was used as baseline for comparison. A total of 608 understory species in 82 Families were recorded in the study area. The highest numbers of understory species (454) were recorded in the core. Species richness (D) for shrubs was higher in the core (D =24.0). Similarity and species diversity (H') shrubs, was higher in the core (H'= 4.66) and (H'=3.71) respectively. Herb species composition, Species richness and diversity increased were higher in the farm fallow (D26.23) and (H'=4.577). The highest density/ha for all life forms were recorded in the farm fallow. It is imperative that biodiversity assessment in the area should also give attention to understory composition in the area to enhance their conservation.

Key words: Understory, Species, Composition, Diversity, Conservation

INTRODUCTION

The Guinean forest of West Africa is recognized as a Biodiversity Hotspot (Myer *et al.*, 2000); the forest contains unique biota and supporting about a quarter of the African mammal fauna and with a good number of endemic species across animal and plant. Despite all these attributes, the forest of West Africa is under seriously threatened from human pressure. Many species in the area are threatened with extinction and only small proportion of the area is protected (Norris *et al.*, 2010). Understanding how biodiversity responds to human-induced habitat change is very vital for conservation efforts in the region. Limited scientific work has been conducted on biodiversity in human-modified forest landscapes in West Africa compared with Amazonia or South East Asia (Gardner *et al.*, 2009).

One important component of tropical forest ecosystem that is often neglected in biodiversity assessment is understory. In Nigeria most of biodiversity studies in tropical forest ecosystems are often limited to tree species which are assumed to reflect the forest floristic composition and physical structure (Adekunle and Olagoke 2008, Ihenyen *et al.*, 2009, Jimoh,

et al.,2012, Adeyemi *et al.*, 2013; Aigbe, 2015). Tchouto *et al.* (2006) argued that this forest inventory approach which only tree species are being considered is not sufficient for biodiversity assessment as other life forms especially the understory which contribute to floristic composition and diversity of tropical rainforest (Lu *et al.*, 2011) are often not or under-represented. Tchouto *et al.* (2006) further stated that in Central and West Africa that many plant species of high conservation value such as endemic and rare species are shrub and herbaceous species. Recently it has been acknowledged that understory component of forest ecosystem is receiving some level of considerations during biodiversity assessment (Tchouto *et al.*, 2006).

Oban division of cross river National Park is poorly studied in terms of understory component of forest ecosystems. Therefore, our current knowledge of understory species diversity and distribution patterns in Oban forest ecosystems is limited. This study therefore is an attempt to study understory species diversity and distribution patterns to ascertain the contribution of the understory component to total species diversity of the area.

METHOD

Study area

The Oban Division of CRNP was carved out of Oban group Forest Reserve in 1991. It is located in Cross River State, Nigeria, within latitudes $05^{o}15'$ and $05^{o}25'$N, and longitudes $08^{o}30'$ and $08^{o}45'$E (figure 1). The total area (including buffer zones), is about 3,000km^2. The area of farm fallow and plantation is not specified as they occur in several locations and in varying sizes at the periphery of the park. The park shares a border with Korup National Park, Cameroon, in the east. Annual rainfall ranges between 2,500 and 3,000mm (Oates *et al.*, 2004; Bisong and Mfon, 2006; Jimoh *et al.*, 2012). Relative humidity is about 75-95% in January, but towards the end of the year, it reduces gradually below 70% as a result of harrmattan (Bisong and Mfon, 2006, Jimoh *et al.*, 2012).

Altitude ranges from 100 to over 1,000m above sea level (Oates *et al.*, 2004; Jimoh *et al.*, 2012). The vegetation of the park is characteristically moist tropical rainforest. In the less accessible areas, the forest has had little interference, but elsewhere the vegetation has been much influenced by human activities. Exploitation in the buffer zone has resulted in secondary regrowth. Tree height reaches 50 m to about 65 m and sometimes more (Jimoh *et al.*, 2012). Patches of oil palm/cocoa plantations and farm fallows exist in various locations at the periphery of the park. Schmitt (1996) identified 1,303 species of plants, 141 lichens, and 56 mosses within the park. Seventy-seven of these are endemic to Nigeria. Fauna diversity includes 134 mammals, 318 birds, 42 snakes, and over 1,266 butterflies (Schmitt, 1996).

Some of the typical tree species found in the area include; *Afrormosia elata* (Harms) Van Meeuwen, *Amphimas pterocarpoides* Harms, *Enantia chlorantha* (A DC) van Setten & Maas, *Entandrophragma spp, Hannoa klaineana* Pierre &Engl, *Irvingia Spp* (Aubry-Lecomte) Bail, *Khaya grandifoliola* C.DC. *Lophira alata* Banks exGaertn.f. *Milicia excelsa* (Welw.) C.C. Berg, *Piptadeniastrum africanum* (Hook.f) Brenan, *Piptostigma pilosum Oliv,. Strombosia schefflei Engl. Tabernaemontana spp, Terminalia spp and Treculia spp,*(Jimoh *et al.*, 2012).

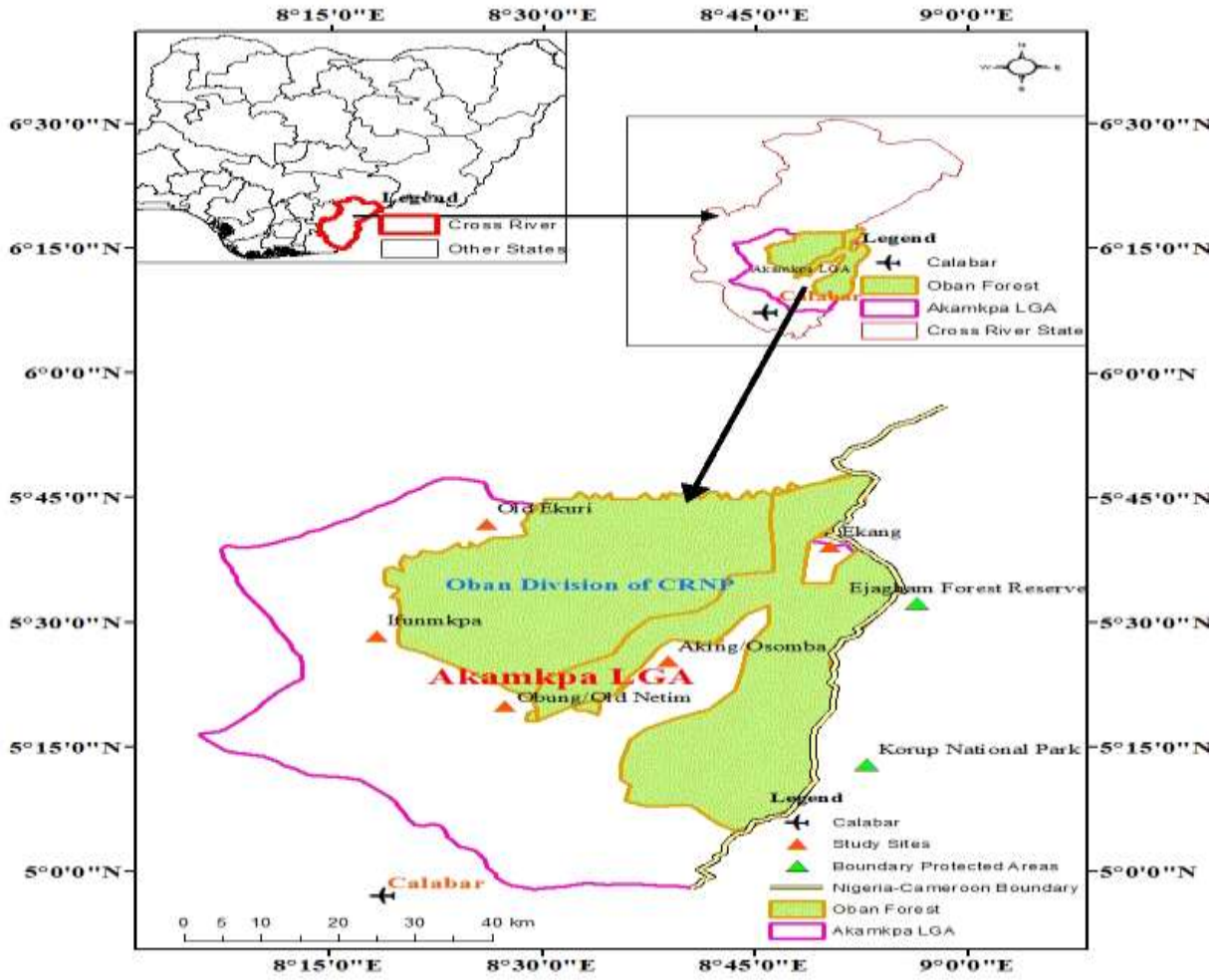

Figure 1. Map of Cross River National Park Showing the Study Locations

Study Design and data collection

Oban Division of CRNP is divided into two corridors, the West and East corridors. With the permission of the management of the park, the study was conducted in all the corridors. Five villages were purposefully selected from these corridors as shown in Figure1 Obung/Old netim (Erokut, Old Ekuri and Ifumkpa in the West and; Aking/Osomba and Ekang in the East).

The study was conducted in the four major land use types in the Oban Division of CRNP namely; primary forest (core), secondary forest (buffer), farm fallow and plantation. Ten transects of 2000m length each were systematically located at an interval of 1-2 Km apart in each land use type. Four 50 m × 50 m (0.25 ha) plots were located alternately at 500 m intervals along each of the transects. Each plot was subdivided into nine 10× 10m subplots for shrubs enumeration and a 1×1m mili-acre plot was located at the center of each subplot for herbs enumeration (Sullivan and Sullivan, 2006). This was replicated in the five sites.

The identification of plants samples was carried out using flora Field guides (Keay, 1989; Akobundu and Agyakwa, 1998; Arbonnier, 2004). A taxonomist was engaged for the identification of the plants on the field. Those that could not be identified on the field were preserved in wooden press and taken to Forestry Research Institute of Nigeria Ibadan Herbarium for proper identification.

Identified species were grouped into species, genera and families. Importance value index (IVI) was calculated for all species by summing

relative frequency and relative density values for all the life forms. IVI was used to identify dominant species in the study area as used by Maingi and Marsh (2006) Adam *et al.* (2007).

Relative frequency

The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

Relative Frequency = Species frequency of individual species x100 **Eq. (1)**
Total of frequency values for all species

Relative density

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

Relative Density = species density of individual species x 100 **Eq. (2)**
Total density for all species

Importance value index (IVI) = relative frequency+ relative density

Floristic composition in the various land use types were estimated using species richness, diversity and evenness. Species richness was computed using Margalef Index Magurran (2004) as follows:

$$D = \frac{(S-1)}{\ln N} \quad \text{.....Eq. (3)}$$

Where, D = species richness index (Margalef Index), S = number of species and N = the total number of individuals.

Species diversity was estimated using Shannon- wiener diversity index as cited Turyahabwe and Tweheyo (2010). Shannon-wiener diversity index equation is stated as:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \quad \text{.....Eq. (4)}$$

Where H′ = species diversity index, pi = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total abundance. ln= natural logarithm.

Species evenness was estimated using Pielou's evenness (equitability) index (Pielou, 1966) as cited by Odiwe *et al.* (2012) as follows:

$$J' = \frac{H}{\text{In S}} \quad \text{.....Eq. (5)}$$

RESULT

A total of 608 species in 82 families were recorded. Out of this number, 273 (44.9 %) were shrub species, while 335 (55.1%) were herb species while (Table 1). The highest number species for shrubs was recorded in the core 211 the least number of shrubs species 92 was recorded in the plantation. Herbs species composition was high in the farm fallow 270 while the least number of 88 species was recorded in the core. Similarly, the highest density of individuals per hectare were recorded in the farm fallow, 1,785/ha and 789,750/ha for shrubs and herbs respectively (Table 1).

Families, presentation shows that shrubs were represented 43 families (35.83%) and herbs 51(42.50%) families. The highest number of families for shrubs was recorded in the core, 40. The highest number of families for herbs was recorded in the farm fallow with 46 families (Table 2). The dominant family was *Rubiaceae* with116 species representing (19.08%) of the total species recorded. This was followed by *Orchidaceae* 48 (7. 98%) and *Acanthaceae* 34 (5.59%).

Table 1. Distribution of flora life forms and individual species occurrence across land use types in Oban division of CRNP

Life forms/ land use		Core	Buffer	Farm fallow	Plantation	Total
Shrubs	Number of species	211	172	112	92	
	Individuals	6,240	5410	6426	3,721	20,797
	Family	40	38	27	27	
	Density/hectare (ind/ha)	1,733.3	1,502.8	1,785	1,033	
Herbs	Number of species	88	139	270	190	
	Individual	5141	5901	28431	15362	54,835
	Family	18	30	46	40	
	Density/hectare	142,805. 6	162,916.7	789, 750	426, 722.2	

Table 2. Ten Families with the highest number of species in the four life forms in Oban Division of CRNP

S/N	Family	Shrubs	Herbs	Total
1	Rubiaceae	98	18	116
2	Orchidaceae	0	48	48
3	Acanthaceae	6	28	34
4	Asteraceae	2	28	30
5	Papilionoideae	19	8	27
6	Araceae	0	21	21
7	Euphorbiaceae	12	7	19
8	Marantaceae	0	17	17
9	Amaranthanceae	0	17	17
10	Zingiberaceae	0	11	11

Importance Value Index for Flora Species

The most populated shrub species in the core and buffer was *Olax gambecola with* densities 94.73 Ind/ha and 72.22 Ind/ha. *Chromolaena odorata* was the most populated shrub species in farm fallow with density of 631.11In/ha and in the plantation 418.61 Ind/ha (Table 3). *Maranochloa mannii* (K.schum) Milne-Redlh was the most populated herb in the core with density of 10,527.75 Ind/ha, Acanthus *montanus* was recorded as the most populated herb with a density of 22,305.56 in the buffer. *Ageratum conyzoides* most populated herb in farm fallow and plantation with the densities of 58,055.56 Ind/ha and 44.027.78 Ind/ha (Table 4).

Olax gambecola was the most dominant shrub species in the core with IVI of 8.14 and buffer 7.74. *Chromolaena odorata* was the most dominant shrub species in the farm fallow with IVI of 39.83 and plantation 47.59 (Table 3). *Acanthus montanus* was the most dominant herb species in the core 13.46 and buffer 21.03. *Ageratum conyzoides* was the most dominant in farm fallow 9.44 while *Commelina benghalensis* was the most dominant in plantation 14.33 (Table 4).

Table 3. Ten most important shrub species based on IVI and density per hactere in Oban division of CRNP

S/No	Species	Core		Buffer		Farm fallow		Plantation	
		D/ha	IVI	D/ha	IVI	D/ha	IVI	D/ha	IVI
1	*Olax gambecola*	94.72	8.14	72.22	7.74	97.50	7.51	93.33	12.97
2	*Carpolobia lutea G.Don*	75.28	7.02	36.67	5.37	17.22	2.50	14.17	3.14
3	*Psychotria psychotrioides* (DC.) Roberty	80.28	6.89	47.22	5.13	16.11	2.57	4.17	1.78
4	*Diospyros bipindensis* Guerke	57.78	5.73	20.83	2.87	0.00	0.00	0.00	0.00
5	*Rothmannia hispida* (K.Schum.) Fagerlind	60.28	5.66	41.39	4.84	8.33	1.11	2.22	0.61
6	*Carpolobia alba G.Don*	29.17	3.87	30.28	4.85	14.17	3.35	7.50	3.88
7	*pavetta Spp*	31.11	2.99	16.67	4.84	0.00	0.16	0.00	0.00
8	*Heisterian parvifolia* Sm.	0.83	0.26	21.39	4.45	10.83	3.42	11.39	5.24
9	*Bertiera fimbriata* (A.Chev.ex.Hutch.Dazl.) Hepper	15.56	1.46	36.94	3.44	0.00	0.00	0.00	0.00
10	*Chromolaena odorata (L.) King & Robinson*	0.00	0.00	0.00	0.00	631.11	39.83	418.61	47.59

Table 4. Ten most important herb species based on IVI and density per hactere in Oban division of CRNP

S/No	Species	Core		Buffer		Farm fallow		Plantation	
		D/ha	IVI	D/ha	IVI	D/ha	IVI	D/ha	IVI
1	*Acanthus montanus (Nees) T. Anders*	10,055	13.46	22,306	21.02	42,750	7.34	26,222	9.36
2	*Marantochloa Purpurea (Ridl.) Milne-Redh*	10,527	11.83	1,278	1.63	2,917	0.58	0.00	0.00
3	*Thalia geniculata*	7,861	11.03	2,028	2.72	194.44	0.08	1,056	0.51
4	*Maranochloa mannii (K.schum) Milne-Redlh*	11,444	10.33	1,250	1.40	0.00	0.00	0.00	0.00
5	*Anubias lanceolata*	5,611	9.28	3,111	3.81	8,000	1.71	4.361	2.07
6	*Culcalsia scandens P. Beauv*	7,555	9.03	1,861	2.20	0.00	0.00	0.00	0.00
7	*Psychotria humilis Hiern*	6,944	8.96	3,917	4.51	0.00	0.00	0.00	0.00
8	*Psychotria nigerica Hepper*	8,055	7.78	444	4.55	1,778	0.55	811.11	0.64
9	*Costus afer*	4,916	7.54	8,333	8.26	3,000	0.86	5,384	1.26
10	*Ageratum conyzoides Linn*		0.00	819.00	8.19	58,056	9.44	44,028	13.10

Flora Species Diversity

The result of the study as presented in table 6 revealed that species richness and Shannon Wiener species diversity index for shrub were higher in the core of the park D =24.03 and H'= 4.66. Farm fallow had the highest values for herb species richness and Shannon Wiener species diversity index D =26.23 and H'= 4.58 respectively. The highest species evenness value for shrubs was recorded in the buffer J´= 0.51, Farm fallow had the highest species evenness value for climbers J´= 0.42. While core the highest species evenness value for J´= 0.37) (Tables 6).

Table 6. Flora species diversity indices across land use types in Oban Division of CRNP

Life Form/	core			Buffer			Farm fallow			Plantation		
	H´	J´	D	H´	J´	D	H´	J´	D	H´	J´	D
Shrubs	4.66	0.5	24.03	4.48	0.51	19.89	3.02	0.18	12.66	2.80	0.18	11.07
Herbs	3.47	0.37	10.18	3.85	0.34	15.89	4.58	0.36	26.23	4.11	0.32	19.61

Note: H´= Species diversity, J´= Species Evenness and D = Species richness

DISCUSSION

The number of understory species recorded across the four land use types in Oban division of CRNP is a reflection of the rich nature of the area which is not only restricted to tree species but also obtainable in the understory component. The findings of this study agreed with earlier conclusions that Oban region is rich and diverse in flora and fauna species (Schmitt, 1996, Oates *et al.*, 2004, Bergl *et al.*, 2007). The understory species recorded in this study was higher than 444 tree species recorded by Schmitt (1996) and 329 tree species recorded by Ikyaagba *et al.*, (in the press) in the study area, this is an indication of the contribution of the understory component to the rich nature of Oban region. This agreed with submissions by Tchouto *et al.*,(2006), Lu *et al.*, (2011) that the understory is an important component and in most cases they contribute more to the richness of the forest ecosystems than the tree component. In Campo-Ma'an rain forest, Cameroon Tchouto *et al.*,(2006) reported that the shrub layer contributed more than 80% of the total number of species recorded in each forest type assessed.

The study has shown that the number stem/ ha was generally higher in farm fallow compared to other land use types, in term of life it was higher in herbs than the shrubs. The number stem/ ha obtained in this study was similar than the values obtained by Lu and Tang (2010) in tropical seasonal rain forest of Xishuangbanna. The high number of species recorded in herbs could be linked to increased conversion of forest to agricultural land which allows for pioneer species of weedy character to invade the area, as a result of opening up of the forest canopy (Fujisaka *et al.,* 1998). Similarly the study recorded a general variation in both species composition and diversity across land use type and among the two life forms.

The decrease in diversity indices from core to plantation suggest that shrubs diversity and composition are negatively affected by disturbances (Sagar *et al.,* 2003; Bobo *et al.,* 2006; Gradstein *et al.,* 2007). This result agrees with other studies which show similar pattern (Fusjisaka *et al;* 1998; Sagar *et al.,* 2003; Schulze *et al;* 2004; Gradstein *et al;* 2007; Mbue *et al* 2009). However, with herbs the composition and indices of diversity increased from core to plantation and was highest in the farm fallow, suggesting that herbs are favoured by land use change as it reduces competition from overstory trees for light or below-ground resources (Ares *et al.,* 2010). This is also in line with the observation by Schulze *et al*., (2004) that, diversity indices do not always decrease with human disturbances, but in some instances such disturbance may stimulate increase in occurrences of other species. The low number of species of herbs recorded in the core of the park which is considered less disturbed is a typical characteristic of a tropical forest (Costa and Magnusson, 2002). This low number of herbs species could be linked to the suppression by tree canopy which only allowed shade loving species to survive (LaFrankie *et al*., 2006). The number of herb species recorded in the core of the park is similar to what is obtainable in other forests. For instance,

Poulsen and Balslev (1991) recorded 96 herbs species in Ecuador and Poulsen and Balslev (1995) listed 87 species in Borneo.

As recorded by Tchouto *et al*. (2006) there was some floristic overlap across land use types for both shrubs and herbs as more than 50% of the species occurred in more than one land use type. The high number shrubs species and Shannon diversity index recorded in the core of the park, could be due to the fact that it is located in the rich Biafran forest type that extends from southeast Nigeria to Gabon and the Mayombe area in Congo and shares with these sites the overall characteristic of lowland evergreen rain forest with some semi-deciduous species (Tchouto *et al*., 2006). Also it may be partly due to the fact there is reduce human disturbance in the core.

The number of shrubs recorded in this study was more than tropical evergreen forest in Anamalais India, with 155 shrub species (Annaselvam and Parthasarathy,1999), and Kolli Hills eastern Ghants, India with 52 shrub species (Chittibabu and Parthasarathy, 2000). Also it is richer than tropical lowland forests of Little Andaman Island in India with 108 species (Rasingam and Parthasarathy, 2009). However, it was similar with the findings of Tchouto *et al*. (2006) and Lu *et al.* (2011), who recorded high number of species in shrub layer in all the strata of the Campo-Ma'an rainforest in Cameroon and Xishuangbanna in South-West China.

Results from the present study and that of Tchouto *et al*. (2006) confirmed that species richness of the understory is usually high and even higher compared to that of the tree layer, indicating that understory deserves more attention during tropical rainforest biodiversity inventories in the future.

CONCLUSION

The study has established that Oban division of Cross River National Park is rich in understory species. This has demonstrated that the understory component of the forest ecosystems can contribute to the total species richness of the tropical rainforest. However, it has been shown that the species richness and diversity as well as composition of the understory in the area are affected by the land use types in the area. Based on the contribution and threat being experienced by the understory, it is suggested that the understory component of the forest of the area should be give full attention during biodiversity assessment in the area and other forest ecosystems in Nigeria.

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