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TREE SPECIES COMPOSITION OF SELECTED RANGES WITH DRILL (*Mandrillus leucophaeus*) PRESENCE IN CROSS RIVER NATIONAL PARK, NIGERIA

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ABSTRACT

This study investigated tree species diversity and richness across four ranges (Aking, Orem, Nsofang and Anape) of the Cross River National Park with Drill presence. Enumeration of tree species was carried out on a total of Eight (8) plots (50 × 50) established in both divisions of the park (Oban; Six (6) plots and Okwangwo; Two (2) plots). A total of 594 trees belonging to 29 families were recorded. The dominant species were Tabernaemontana pachysiphon (8.15%) and Klainedoxa gabonensis 8.15% (Anape), Strombosia pustulata 7.84% (Nsofang), Coula edulis 14.09% and 10.83% (Aking and Orem). The family Olacaceae was most represented in Nsofang, Aking and Orem while Apocynaceae and Irvingiaceae were most dominant for Anape. Simpson' Indices were 0.96 (Anape, Nsofang and Orem) and 0.95 (Aking), which implied high floristic richness. The Shannon-Wiener's Indices (Anape=3.39, Nsofang=3.37, Aking=3.29 and Orem=3.35) and the margalef index were relatively high indicating moderate representation of most of the species. The forest is high in tree diversity and richness and continues to provide food and shelter for the drill and other fauna species. However, the level of habitat alteration from logging and farming in some of the ranges is of concern. The park authority is therefore implored to continuously engage support zone communities while intensifying conservation and protection efforts.

Keywords: Endangered. Species diversity. Tropical rainforest. Floristic richness. Conservation

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INTRODUCTION

The south-eastern part of Nigeria has a biological distinctiveness exceptional to Cross River National Park (CRNP), which is home to one of the oldest tropical rainforests in Africa, and the remaining rainforest in Nigeriaeven with the increasingly evident forest disturbance and fragmentation caused by factors such as illegal logging and land conversion for local agricultural purposes (Ogunjobi *et al*., 2010). Also, the survival of the critically endangered Cross-River gorilla (*Gorilla gorilladiehli*) (Bergl *et al*., 2016), Nigeria–Cameroon chimpanzees (*Pan troglodytes ellioti*)) and the endangered drill (*Mandrillus leucophaeus*) are highly dependent on these remaining forest in which they find refuge. However, the high species diversity of tropical rainforests is partly the reason for the intense pressure under which they have been subjected to by the people (Alao and Shuaibu, 2011). Maintaining the overall biological diversity, productivity and sustainability of the tropical forest ecosystems requires sustainable management techniques, practices and interventions (Reddy and Ugle, 2008), which can only be achieved through genuine information about the status and distribution of tree species. This shapes the support for other life forms as about 80% of the World's terrestrial species live in forests (GFW, 2020) and utilize forest resources thus making vegetation an important factor for the survival of

wild animal species, providing food, cover and protection (Afolayan and Agbelusi, 1997). Therefore, understanding tree composition is a vital instrument in assessing the sustainability of the forest, species conservation, and management of forest ecosystems (Kacholi, 2014).

This paper therefore assessed tree species diversity and richness in areas with drill (*M. leucophaeus*) presence in CRNP to ascertain the level of intactness or degradation of the forest occasioned by anthropogenic activities as the forest continues to harbor diverse primate species especially the endangered *M. leucophaeus* and providing its habitat needs.

MATERIALS AND METHODS

Study Area

The Cross River National Park which is one of the oldest rainforests in Africa and recognised as a biodiversity hotspot consists of primary moist tropical rainforests in the north and central parts, while the southern parts contain mangrove swamps on the coastal zones. It covers a total area of 4000 km² segmented into two non-contiguous divisions (Oban and Okwangwo). The Oban division is centred on coordinates 5°25′00″N8°35′00″E and located in the southern part, covering 3000km² and the Okwangwo division (coordinates 6°17′00″N and 9°14′00″E) made up of the former Boshi, Okwangwo and Boshi Extension Forest Reserves (Ite, 1996) in the northern part covering about 1000 km². The area has marked wet (March–November) and dry (December–February) seasons with up to 4,280 mm of rain falls annually and relative humidity of well over 30% (Birdlife International, 2022).

The Oban Hills Division which forms a single protected ecological zone, shares a long border with Korup National Park in the Republic of Cameroon. The plants species identified in the division is about 1,568 with 77 endemics to Nigeria.These include 1,303 flowering plants, 141 lichens and 56 moss species with over 350 bird species(Birdlife International, 2022). The Okwangwo division is also richly diverse in flora species that are endemic to the area. The recorded numbers of bird species are over 280; this includes the vulnerable grey-necked rock fowl, which breeds in the Mbe Mountains and the golden greenbul (Birdlife International, 2022). There are at least 75 mammal species, including the highly endangered drill, the Cross-River gorilla, African Buffalo, African forest elephant, common chimpanzee, Sclater's guenon and Preuss's red colobus (CRNP, 2008).

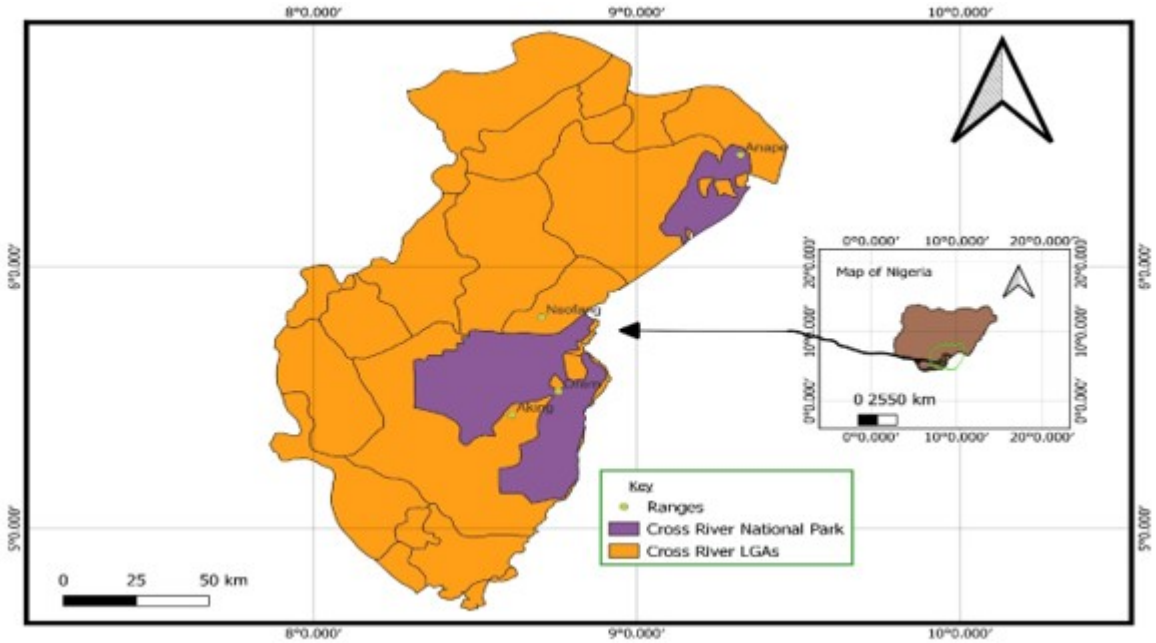

Fig. 1 Map of Cross River National Park showing the selected ranges for the study

Data Collection and Analysis

The study site selection (fig. 1) was based on previous records of drill (*M. leucopheus*) presence in the selected ranges (Anape, Nsofang, Aking and Orem) of the park. Systematic sampling technique was adopted in each of the study sites for plot locations (Adekunle and Olagoke, 2008). Two transects, 2km long with a distance of 1000m apart was established in each of the study location. One (1) sample plot of 50m×50m was laid randomly along each 2km transect. This procedure was replicated in the four ranges, thus summing up to 2 sample plots per 4km-transect, and a total of eight (8) sample plots were used for the study. This involved the enumeration of all tree species above 1m in height and diameter of not less than 10cm, classifying them into the family they belong. The height of each tree was measured to the nearest meter using the Haga Altimeter.

RESULTS

A total number of 594 tree stems of 66 species, belonging to 29 families were enumerated in the 8 plots used for the study (Table 1)). *Coula edulis* (7.74%), *Strombosia pustulata* (6.06%), *Klainedoxa gabonensis* (4.88%), *Garcinia manni* (4.71%) and *Baphianitida* (4.38%) are the most dominant species in the study area (Table 1). The dominant family in the different ranges were Apocynaceae and Irvingiaceae (Anape) (fig. 2a), Olacaceae and Leguminosae (Nsofang) (fig. 2b), Olacaceae and Fabaceae (Aking and Orem) respectively (fig. 2c and 2d). However, for the entire study plots the families Olacaceae (18.4%), Fabaceae (10.9%), Leguminaceae (8.9%), Myristicaceae (7.9%) and Irvingiaceae (6.6%) has the highest frequency of representation accordingly in terms of number of tree stems (Table 5).

Table 1: Tree species in the four ranges of the Park

Species	Life form	Anape	Nsofang	Aking	Orem	Total	% Frequency
Anonidium manni	T	2	1	0	0	3	0.51
Antrocaryon micraster	T	1	4	1	2	8	1.35
Baillonella toxisperma	T	8	3	0	0	11	1.85
Baphia nitida	T	1	6	11	8	25	4.38
Barteria nigritiana	T	0	0	0	1	1	0.17
Blighia sapida	T	1	2	3	3	6	1.52
Brachystegia eurycoma	T	9	1	3	1	14	2.36
Bridelia micrantha	T	0	4	6	3	13	2.19
Calpocalyx cauliflorus	T	1	5	3	3	12	2.02
Canarium schweinfurthii	T	0	2	0	0	2	0.34
Carapa procera	T	4	8	7	4	23	3.87
Carpolobia lutea	T, S	1	0	3	6	10	1.68
Ceiba pentandra	T	8	0	0	3	11	1.85
Chrysophyllumalbidium	T	2	0	0	1	3	0.51
Chrysophyllumwelwitschia	T	1	0	0	0	1	0.17
Cleistopholis patens	T	1	1	1	1	4	0.67
Cola acuminata	T	1	0	0	1	2	0.34
Cola lepidota	T	4	0	0	0	4	0.67
Cola nitida	T	0	1	0	1	2	0.34
Coula edulis	T	0	8	21	17	46	7.74
Dacryodes edulis	T	4	1	2	3	10	1.68
Deplatsiadewevrei	T	1	0	0	0	1	0.17
Diospyros melocarpa	T, S	1	0	0	0	1	0.17
Diospyros mespiliformis	T	0	0	3	0	3	0.51
Diospyros zenkenri	T, S	7	4	6	4	21	3.54
Funtumiaafricana	T	1	0	0	0	1	0.17
Funtumia elastic	T	0	0	1	1	2	0.34
Garcinia cola	T	0	1	0	0	1	0.17
Garcinia manni	T	4	9	2	13	28	4.71
Garcinia smeathmannii	T, S	9	0	0	1	10	1.68
Hildegardiabarteri	T	1	0	0	0	1	0.17

Hylodendrong abunense	T	0	0	1	0	1	0.17
Irvengia gabonensis	T	3	2	4	1	10	1.68
Khaya ivorensis	T	1	2	0	0	3	0.51
Klainedoxa gabonensis	T	11	6	6	6	29	4.88
Lasianthera africana	T	3	0	0	0	3	0.51
Lophira alata	T	0	2	4	3	9	1.52
Lovoa trichiliodes	T	0	0	0	3	3	0.51
Maesobatry abateri	T	7	2	2	2	13	2.19
Microdermis puberula	T, S	2	0	0	1	3	0.51
Milicia excelsa	T	1	0	0	0	1	0.17
Morinda lucida	T, S	0	1	2	0	3	0.51
Musanga cecropiodes	T	0	0	3	0	3	0.51
Nauclea diderrichii	T	0	1	0	0	1	0.17
Octoknema affinis	T	1	0	2	1	4	0.67
Ourateaca lophylla	T, S	2	2	0	1	5	0.84
Ouratea monticola	T	1	0	0	0	1	0.17
Parkia bicolor	T	0	4	4	6	14	2.36
Pentaclethra macrophylla	T	0	6	3	7	16	2.69
Piptandeniastrum africanum	T	0	8	3	6	17	2.86
Pterocarpus osun	T	2	10	3	2	17	2.86
Pycnanthus angolensis	T	0	11	6	6	23	3.87
Rauvolfia vomitoria	T	2	0	0	0	2	0.34
Rothmannia hispida	T, S	2	1	0	0	3	0.51
Staudti stipitate	T	5	6	6	7	24	4.04
Strombosia grandifolia	T, S	5	7	7	4	23	3.87
Strombosia pustulata	T	2	12	11	11	36	6.06
Tabernaemontana pachysiphon	T, S	11	1	3	9	24	4.04
Terminalia ivorensis	T	0	0	3	0	3	0.51
Terminalia superba	T	0	5	0	0	5	0.84
Tetrapleuratetraptera	T	0	0	0	1	1	0.17
Treculia africana	T	0	0	1	0	1	0.17
Uapaca staudtii	T	0	2	1	3	6	1.01
Uapaca togoensis	T	0	1	1	0	2	0.34
Xylopia quintasii	T	1	0	0	0	1	0.17
Total		**135**	**153**	**149**	**157**	**594**	

T=Tree; S =Shrub

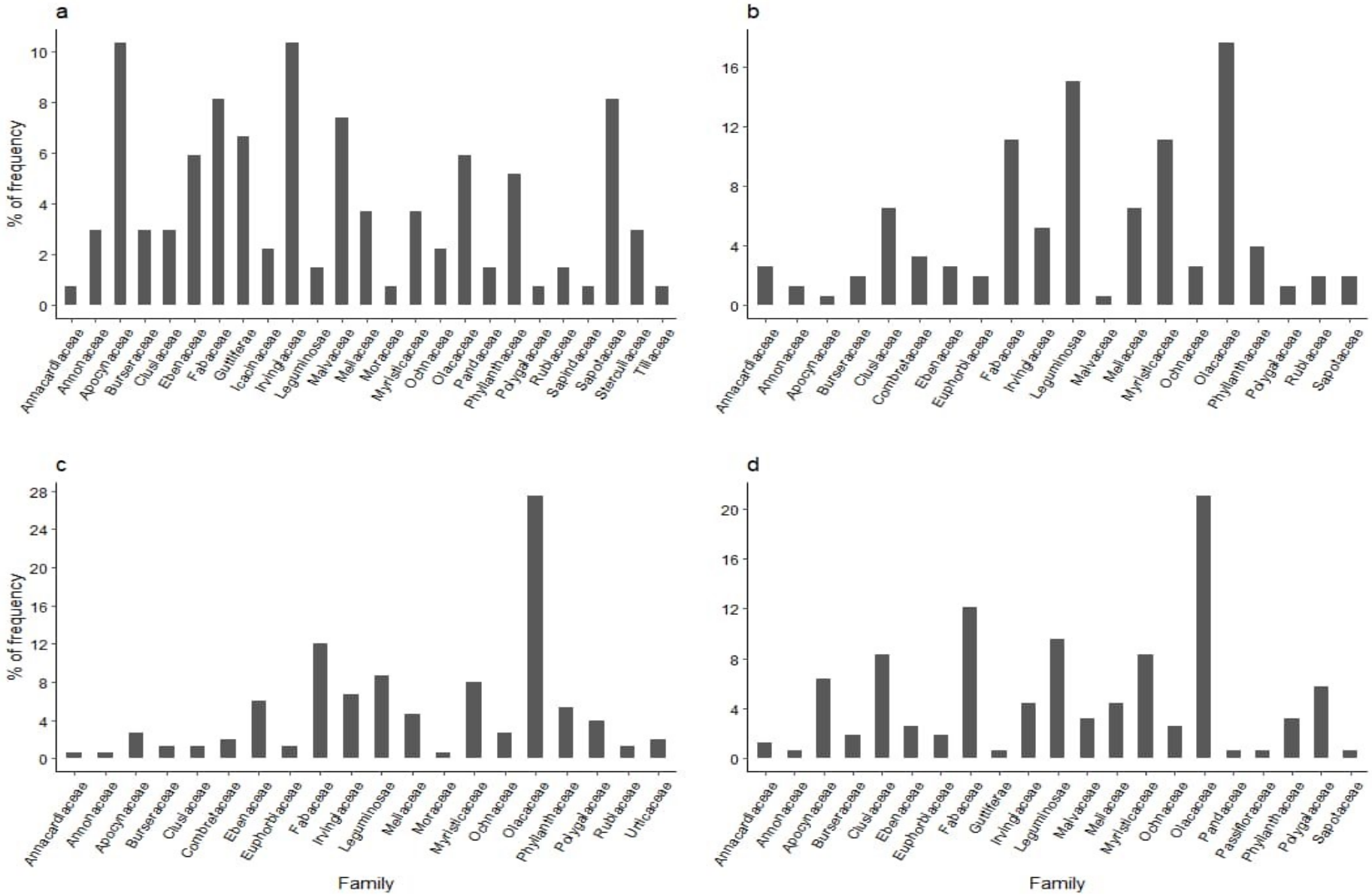

Fig. 2 Family of tree species represented in each range. ***a-Anape, b-Nsofang, c-Aking and d-Orem***

Table 2 Family Distribution of Tree Species in the study area

S/N	Family	Number of Species	Frequency of Trees	Percentage (%)
1	Annacardiaceae	1	8	1.3
2	Annonaceae	3	8	1.3
3	Apocynaceae	4	29	4.9
4	Burseraceae	2	12	2.0
5	Clusiaceae	2	29	4.9
6	Combretaceae	2	8	1.3
7	Ebenaceae	3	25	4.2
8	Euphorbiaceae	2	8	1.3
9	Fabaceae	6	65	10.9
10	Guttiferae	1	10	1.7
11	Icacinaceae	1	3	0.5
12	Irvingiaceae	2	39	6.6
13	Leguminosae	4	53	8.9
14	Malvaceae	4	16	2.7
15	Meliaceae	3	29	4.9
16	Moraceae	2	2	0.3
17	Myristicaceae	2	47	7.9
18	Ochnaceae	2	15	2.5
19	Olacaceae	4	109	18.4
20	Pandaceae	1	3	0.5
21	Passifloraceae	1	1	0.2
22	Phyllanthaceae	2	26	4.4
23	Polygalaceae	2	18	3.0
24	Rubiaceae	3	7	1.2
25	Sapindaceae	1	1	0.2
26	Sapotaceae	3	15	2.5
27	Sterculiaceae	1	4	0.7
28	Tiliaceae	1	1	0.2
29	Urticaceae	1	3	0.5
	Total	66	594	100.0

Height and Diameter Distribution

The height distribution (fig. 3) shows that trees within the height class group of 10.1 – 20.0m have the highest frequency of occurrence in three (Nsofang, Aking and Orem) ranges with Anape range having class group 1.0 – 10.0m occurring the most. The height class group 40.1 – 50.0m had the least occurrence in the four ranges of the park. Overall, the height class group 10.1 – 20.0 had the highest frequency of 271 stems constituting about 45.9%. This was followed by class group 1.0 – 10.0 with 195 stems (33.1%) and the least was class group 40.1 – 50.0 constituting only about 1.2%. The diameter distribution (fig. 4) shows that across all ranges the diameter class of 1.0 – 25.0cm had the highest frequency with diameter class of 100.0 – 125.0 having the least frequency. Also, the overall diameter distribution curve shows that the number of stems in each diameter class was inversely proportional to diameter size with trees within the diameter distribution of 1.0 – 25.0 cm having the highest frequency (300) and constitution 50.8% of the total number of stems. This was followed by class group 25.1-50.0 with 180 stems (30.5%), 50.1 – 75.0 (91) stems (15.4%), 75.1 – 100.0 17 stems (2.9%) and 100.1 – 125.0 2 stems (0.3%) respectively.

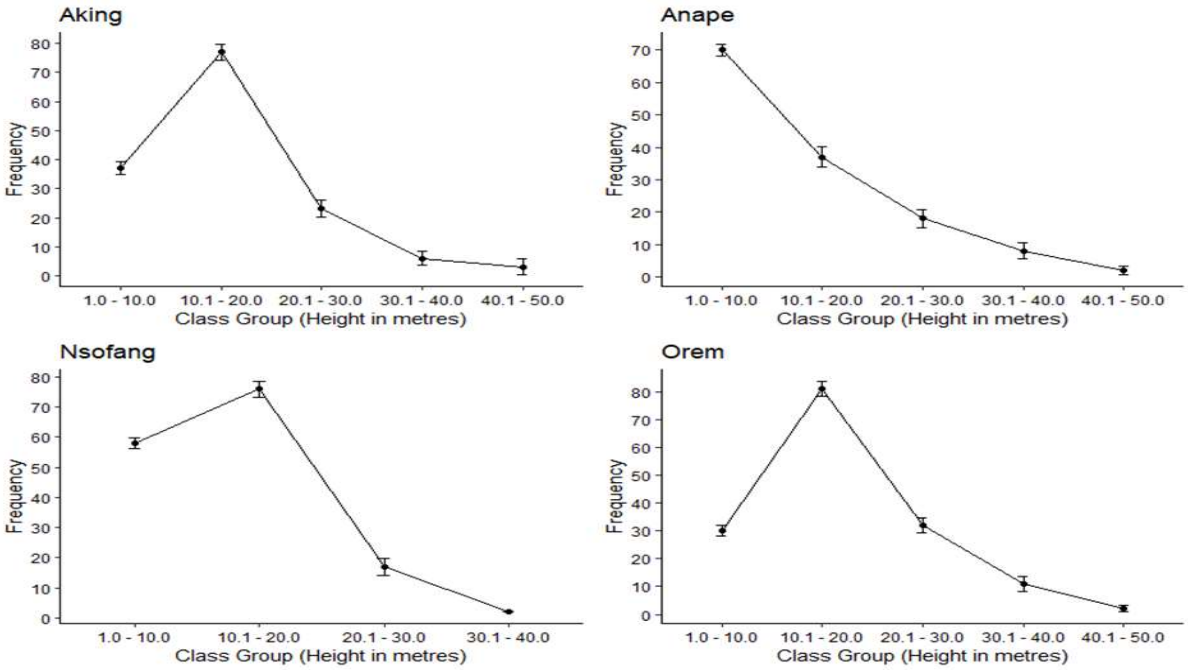

Fig. 3 Height of tree species composition in the four ranges

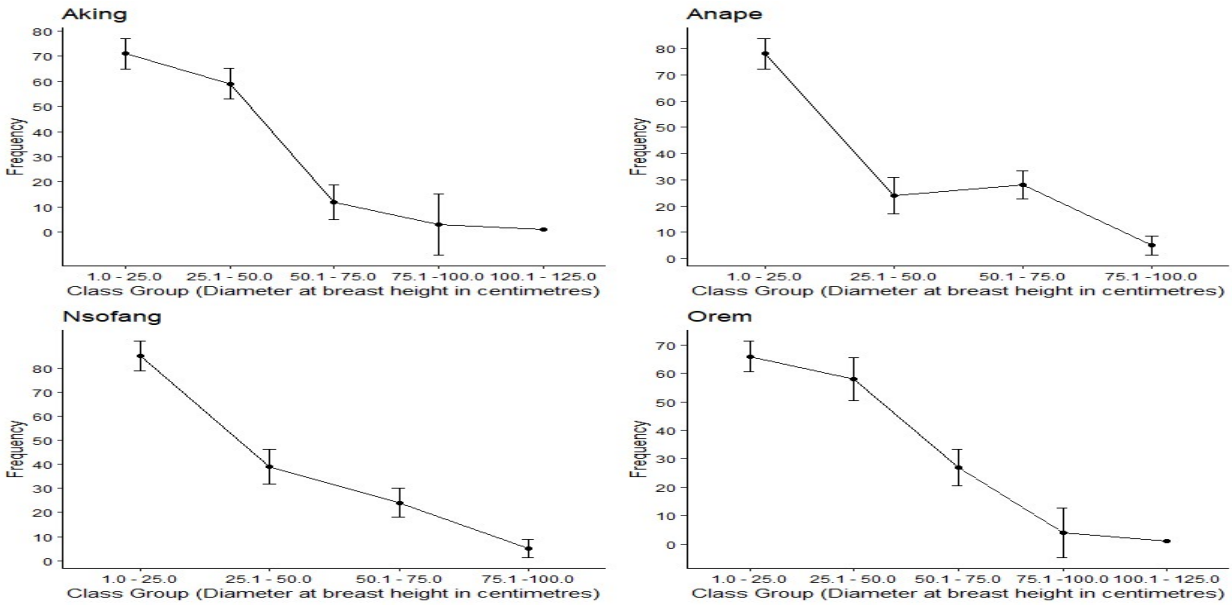

Fig. 4 Diameter at Breast Height (DBH) class group of tree species

The species diversity indices for the four ranges as presented in Table 6 shows that the Shannon-Wiener's Indices (3.29, 3.39, 3.37 and 3.35) were high for the four ranges (Aking, Anape, Nsofang and Orem), which indicate high species diversity. The high values for Simpson's Index (0.95 and 0.96) in the four ranges indicated high species richness in the forest. Also, the species evenness (0.91 and 0.92) was high in each of the range, which means that there was less variation in species diversities in the ranges.

Table 3 Diversity, Richness and Evenness of Tree Species in the Four Ranges of CRNP

Name of Range	No of Tree Species	Occurrence	Shannon Wiener's Index	Evenness	Margalef's Index	Simpson Index
Aking	36	149	3.293933	0.9122148	6.99448	0.9495111
Anape	41	135	3.385959	0.9059012	8.154487	0.9565773
Nsofang	38	153	3.373677	0.9208736	7.355224	0.9586621
Orem	39	157	3.354708	0.909411	7.515457	0.9551329

DISCUSSION

Floristic Composition

The Cross River National Park is a typical tropical rainforest ecosystem (Sunderland *et al.* 2003) which harbors some of African's threatened species (fauna and flora) of paramount conservation relevance. Sunderland *et al.* (2003) noted some of the tree species to include *Terminalia ivorensis*, *Lophiraalata* and *Bailonellatoxisperma* which were also captured in this study. The forest is equally home to fauna species of conservation significance such as the *Mandrillusleucophaeus*, *Cercopithecus preussi* and *Gorilla gorilladiehli* which is also endemic to the area (Ndah*et al.*,2012). The continuous survival of these fauna species is dependent on the forest which makes information on forest composition and structure very critical in forest management (McLennan and Plumptre, 2012). The density and size distribution of these trees are major contributors to the structure of these tropical rainforest. Tree species (66) belonging to 29 families shows species diversity and richness for this forest relative to the number of plots sampled, although it is lower than the 125 tree species belonging to 36 families reported by Adeyemi *et al.* (2015) in Okwangwo forest. This may however be as a result of the lower number of plots used for this study. The forest is characterized by the dominance of the families Olacaceae, Fabaceae, Leguminosae and Myristicaceae. Tree species *Coula edulis*, *Strombosiapustulata*, *Klainedoxagabonensis* and *Garcinia manni*were the most frequently encountered species in the area. The floristic composition has shown tree species diversity and richness in this forest which emphasizes the recognition of tropical rainforest as the most biologically diverse terrestrial ecosystem on earth (Onyekwelu*et al.,*2007; Schmitt *et al.,* 2009) and as the most obvious plant life form in this forest serves as a core receptacle of the genetic diversity of both flora and fauna.

Diameter and Height Distribution of Tree Species

Tree species in the diameter class of 1.0 – 25.0cm dominated the study area. The characterization of the study area by the dominance of trees within this diameter class group of 1.0 – 25.0cm is in tandem with the findings of Jimoh*et al.* (2012), who observed the prominence of tree species in lower diameter classes in Oban Division of Cross River National Park. The diameter distribution followed a pattern that is characteristic of tropical forests which is in agreement with the study by Boakye *et al.* (2015). The distribution pattern possibly suggests an effective regeneration of tree species within the park as highlighted by Oke*et al*. (2017) and also observed by Boakye, *et al.* (2015). In order to maintain its population, there is the need for an abundance of juvenile to recruit into adult size classes (Boakye *et al*.2015). This gives a notion of the structure proposed for a natural forest by Husch et al. (2003). The height class group of 10.1 – 20.0m dominated in three (Nsofang, Aking and Orem) of the four ranges of the park except for Anape that was dominated by the class group of 1.0 – 10.0m. This class difference might be attributed to the fact that Anape is in a separate sector of the park and as such might have slightly different growth parameters. The domination of the study areas by tree species in height group in the lower class and middle class signifies the occurrence of emergent trees which is in tandem with studies by Adekunle *et al.* (2013). The height and diameter distribution give an inclination of the proportion of young to old trees which has implications for the conservation and management of forest (Jimoh*et al*.,2012). Also, according to Zenner, (2000) an important attribute of structure to cogitate is variation in tree height as stands containing a variety of tree heights tend to contain a variety of tree ages and species consequently providing a diversity of micro-habitats for fauna species.

Species Diversities and Richness

Species diversity index encompasses both the number of species in an assemblage and also some measure of their relative abundance (Gottelli and Chao, 2013). In tropical forests, high species richness is a major feature. The Shannon wiener diversity index value according to Magurran (1988) is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5. This study shows that all four ranges (Anape, Nsofang, Aking and Orem) of the park have an index value higher than 3. However, tree species were more diverse in Anape (3.39) and Nsofang (3.37) range of the park. The range with the record of the least diversity of tree species was Aking range (3.29). Although the diversity index was lower than that reported by Cazolla*et al.* (2017) for a protected forest reserve in Ghana (4.35) probably as a result of the low plot sampling intensity of this study but it was however higher than the 2.82 and 3.12 as reported for two out of the three protected areas studied by Onyekwelu*et al.* (2007). This shows that the forest is still fairly intact and has the ability to support the drill and other fauna species. According to Fran *et al*. 2015, all wildlife requires a habitat that is diverse and can support great diversity of fauna species as source of food, cover and breeding space.

CONCLUSION AND RECOMMENDATIONS

This study has shown tree species diversity, richness and similarities in identified areas with drill (*M. leucphaeus*) presence in four ranges, (Anape, Nsofang, Aking and Orem) of Cross River National Park, Nigeria. The high diversity and species richness in the selected areas is an indication of some level of conservation achievement by the park management and other key stakeholders. The forest of CRNP is very rich in biological diversity and harbor many species (flora and fauna) of biological importance including the endangered drill which is endemic to the area in Nigeria. This study show that Anape range is more diverse than other ranges, although somewhat insignificant, the more diverse nature of Anape could be attributed to the fact that logging and farming is a rare occurrence probably due to the sub-mountainous terrain and the level of protection afforded the area as it is also home to the critically endangered Cross River Gorilla (*Gorilla gorilladiehli*). However, the level of habitat alteration from logging and farming was more visible in the other ranges. This may not have contributed much in terms of diversity and number of trees in these ranges but it is a present threat that needs attention. The park authority is therefore implored to continuously engage support zone communities while intensifying conservation and protection efforts in these areas.

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