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Diversity and population density of mammals in Cross River National Park, Cross River State, Nigeria

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ABSTRACT

A survey of mammalian species was conducted in Cross River National Park, (Oban and Okwangwo Divisions) Cross River State, Nigeria, to ascertain species diversity and population density, for a period of six months. A census of mammals was carried out on one transect in each division for a period of six months, January to March and May to July (both dry and rainy season). Shannon-Wiener (H) and Simpson (1-D) diversity indices were used to measure diversity of mammals in each division while Sorensen's similarity index was used to ascertain the similarity of mammals between the two divisions. The similarities in mammalian species were generally high between the two seasons within and between divisions. Oban division had the highest mammalian diversity during rainy season (H = 2.009; 1 – D = 0.810) while Okwangwo division had the highest mammalian diversity during dry season (H = 1.901; 1 – D = 0.819). Oban division had the highest species richness during rainy season (0.618) while Okwangwo division had the highest species evenness in dry season (0.865). The population density of mammalian species in the park was considerably low. Population densities as low as 0.11/sq.km (Bush baby) and 1.33/sq.km (Red flank duiker) were recorded in Oban and Okwangwo respectively. The species with the highest density in Oban division was Mona monkey (58.44/sq.km) followed by the Putty nose monkey (27.67/sq.km). A similar trend occurred in Okwangwo. Management strategies for Cross River National Park should therefore be restructured to curb human activities such as hunting, bush burning and encroachment on the forest ecosystem in order to conserve the rare fauna species and biodiversity

Keywords: Biodiversity Conservation, Cross River National Park, Diversity and Density of Mammals

INTRODUCTION

Mammalian species are widely distributed in most rainforests in tropical Africa and it is of paramount importance to protect these species for the role they are playing in ecosystem structuring and function (Fonkwo, Angwafo and Mbida, 2011). Mammalian fauna of Africa are subject of serious concern to many interest groups (Mendoza, Janis, and Palmqvist, 2005) because Africa contains the last great community of large mammals in the world (Eisennberg, 1990). There is limited information on the rainforest mammalian species beyond the primate communities (Agbelusi, 1994; Oates *et al*., 2008). Mammals are a species group known to be at high risk of extinction globally. In Nigeria, a major problem facing wildlife conservation is the increasing rate of habitat loss or modification due to human activities (Ogunjemite *et al*., 2007). Afolayan *et al.* (2004) observed that about 75% of the original wildlife habitat in Nigeria had been lost. This has affected wildlife resources within these ecological systems leaving only remnant populations of wildlife resources in protected areas including the National Parks. Cross River National park is under threat from large scale forest clearance and industrialization. Most of the areas under conservation have been extensively encroached upon by other land uses and wildlife resources have suffered serious depletion as a result of over-exploitation and gross abuse. More species are becoming endangered daily and the habitats of wildlife continue to dwindle. Increasing human activities around protected area pinpoint to looming degradation and alteration of the component of such areas, especially where adequate measures are not taken to forestall encroachment. Biodiversity, therefore is presently exploited at a much faster rate than ever before with negative implication on sustainable human livelihood (Turner *et al*., 1990). The objectives of this research work are to compute the population density of mammals in Cross River National Park, Cross River State, Nigeria and determine the similarity and diversity indices of mammals in the park

METHODOLOGY

Study Area

The study was conducted in Cross River National Park. The Park has one of the oldest rainforests in Africa, and has been identified as a biodiversity hot spot (Oates, 1999). Cross River National Park is one of the richest areas of tropical rainforest in West Africa. It is surrounded by moist tropical rainforest around the northern and western parts and mangrove swamps in the coastal fringes (Ezealor, 2002). Geographically, The Park covers a total area of about 4000km^2 and segmented into two non-contiguous divisions – the Oban division in the Southern part of the Park, which covers approximately 3000 km^2 and the Okwangwo division in the Northern part of the park that covers approximately 1000 km^2. The park lies within longitude 5^o 5^1 and 6^o 29^1 N and Latitude 8^o 15^1 and 9^o 30^1 E (CRNP Tourist Guide Handbook, 2001).

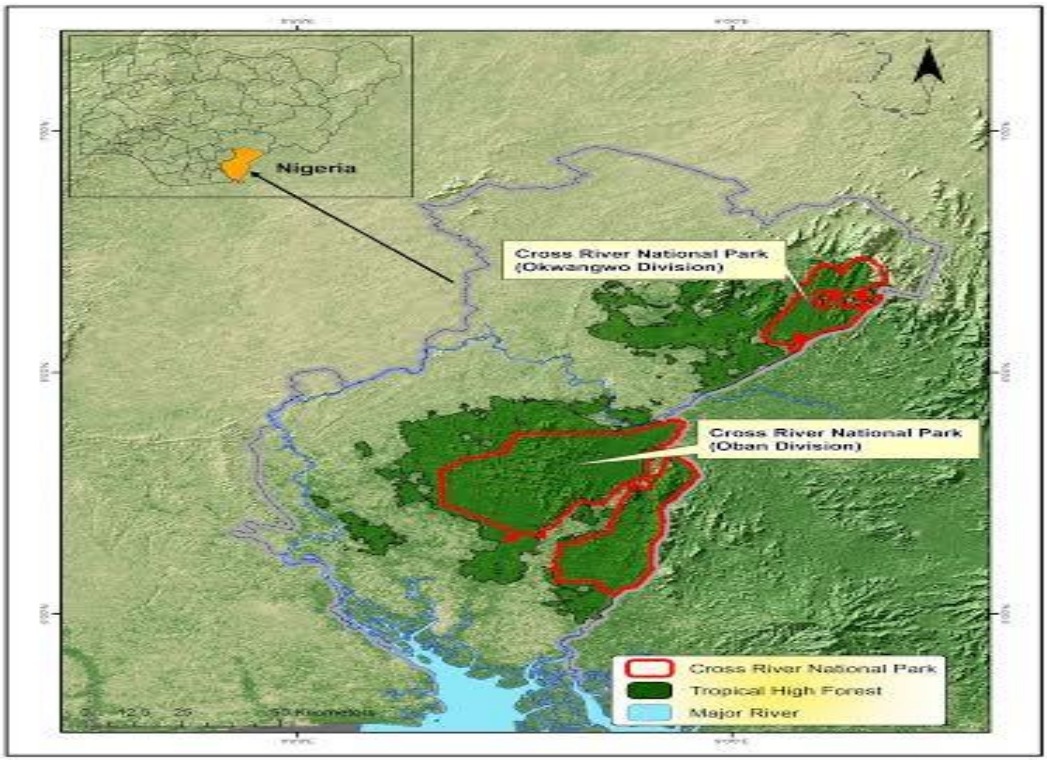

Figure 1: Map of Cross River State showing Cross River National Park.

Sampling Techniques

During the period of the research, a census of mammals was conducted in the park using day time visual counts, nest and dung counts, searching at natural stream, and fresh water marsh during daytime as well as *ad hoc* records of all sightings, tracks, and signs of mammals observed.

Direct observation involving the use of line transects as described by Sutherland (1999) and Bibby and Hill (1998) was used for the survey of mammals. This involved walking along the established 3km transect in Oban division and 1k transect in Okwangwo division on each site making visual observations on both sides of the laid transect- However, averages of the values for Oban were taken (before analysis) to enable comparison with the values from Okwangwo. Incursions were made at 50m interval to either right or left sides of transect and the area criss-crossed in search of mammals up to a distance of 100m from the point of entry in line with Norton-Griffiths (1996). When the target animals (mammals) are sighted the species, number, group size, activity when first sighted and activity after sighting were recorded.

Data Analysis

The densities of abundant species were analyzed for each of the sampled division using the formula:

$$\text{Density} = \frac{\text{Total number of animals}}{\text{Area of Sampling Unit}}$$

Absolute density of mammals was determined using king's census model as described by Bliston (2001) and Hill (1997).

$$D = \frac{n}{2L\bar{r}}$$

where: D = density of animals in Cross-River national park

n = number of animals sited in Cross-River national park

L = transect length
$\bar{r}$ = the average sighting distance

Species Richness Index:
Species richness was determined using Menhinnic's index as described by Jayaraman (1999). The index is as follows:

$$\text{Species Richness Index} = \frac{S}{\sqrt{N}}$$

where:
S = Number of animal species in collection in Cross-River national park
N = Number of individuals of animals collected in Cross-River national park

Species Evenness
The species evenness was determined using Pieliou's evenness index s reported by Mulder *et al.* (2004). The index is stated as:

$$\text{H Max} = -\sum_{i=1} \frac{1}{S} \ln \frac{1}{S}$$

where: H = is the number derived from the shannon's diversity index
S = Total number of animal species in Cross River National Park

Species Diversity of Fauna Resources:
Mammalian species diversity was determined using Shannon-wiener Diversity Index as described by Charles (1989). The index is as follows:

$$H = -\sum_{\tau 1}^{N} pi \ln pi$$

where
H = Shannon index
N = The total number of all individuals of each species in cross- river national park
pi= The relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.
ln = natural logarithm

Simpson diversity index is expressed as:

$$D = \frac{\sum_{i=1}^{q} ni(ni-1)}{N(N-1)}$$

Where:

N = Total number of individuals sighted
ni = Number of individuals of ith mammalian species enumerated for i=1
q = Number of different mammalian species sighted.

Sorenson's similarity index
The Sorensen's similarity index was determined using the formula describe by Margurran (2004) which is as follows:

[2a / (2a + b + c)] x 100
Where:
a = number of species common to both sites
b = number of species present in site1 but absent in site 2
c = number of species present in site 2 but absent in site 1

RESULTS
Results on mammalian species identified in Cross River National Park (Oban and Okwangwo divisions) are presented in Tables 1 and 2. Population census of mammalian species in both Oban and Okwangwo division for dry and rainy season are presented in Tables 3 and 4. Mean density of mammalian species sighted in both divisions are presented in Tables 5 and 6.

Table 1: Mammalian species identified in Oban division

Common names	Scientific names	Means of identification
Blue Duiker	*Philantomba monticola*	Footprints, dungs, trail, feeding activities
Red Flank Duiker	*Cephalophus rufilatus*	Footprint, trail
Buffalo	*Syncerus caffer*	Footprint, dung
Forest Elephant	*Loxodonta africana*	Footprint, dungs, trail
Putty Nose Monkey	*Cercopithecus nictitans*	Sighted
Mona Monkey	*Cercopithecus mona*	Feeding activities
Red River Hog	*Potamochoerus porcus*	Dungs, trail
Cane Rat	*Thryonomys swinderianus*	Sighted
Tree Squirrel	*Paraxerus cepapi*	Footprint
African Giant Squirrel	*Protoxerus stangeri*	Footprint
Porcupine	*Atherurus africanus.*	Footprint, feeding activities, trail
Mongoose	*Herpestes naso*	Footprint, feeding activities, trail
Civet Cat	*Viverra civetta*	Dungs
Tree Pangolin	*Manis tricuspis*	Feeding activities
Galago	*Galago senegalensis*	Sighted
Red Tailed Monkey	*Cercopithecus ascanius*	Sighted

Source: Field Survey (2016).

Table 2: Mammalian species identified in Okwangwo division

Common names	Scientific names	Means of identification
Blue Duiker	*Philantomba monticola*	Footprint, dung
Red Flank Duiker	*Cephalophus rufilatus*	Footprint, dung
Forest Elephant	*Loxodonta africana*	Footprint, dung
Putty Nose Monkey	*Cercopithecus nictitans*	Sighted
Mona Monkey	*Cercopithecus mona*	Feeding activities
Red River Hog	*Potamochoerus porcus*	Footprint
Tree Squirrel	*Paraxerus cepapi*	Footprint, feeding activities
African Giant Squirrel	*Protoxerus stangeri*	Footprint, feeding activities
Porcupine	*Atherurus africanus*	Footprint, feeding activities, trail
Mongoose	*Herpestes naso*	Footprint, feeding activities, trail

Source: Field Survey (2016).

Table 3: Seasonal populations of mammalian species in Oban Division of the Park

Species	Adult counts		Juvenile counts		Total		Average	
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry (No/day)	Rainy (No/day)
Red Flank Duiker	11	4	3	1	14	5	0.93	0.33
Blue Duiker	27	8	46	12	73	20	4.87	1.33
Mona Monkey	150	98	190	88	340	186	22.67	12.40
Putty Nose Monkey	72	45	89	43	161	88	10.73	5.87
Elephant	0	0	0	0	0	0	0.00	0.00
Buffalo	0	2	0	0	0	2	0.00	0.13
Red River Hog	22	9	36	19	58	28	3.87	1.87
Giant Squirrel	34	24	24	27	58	51	3.87	3.40
Tree Squirrel	23	27	28	25	51	52	3.40	3.47
Mongoose	20	13	7	10	27	23	1.80	1.53
Porcupine	11	17	9	10	20	27	1.33	1.80
Cane Rat	4	2	0	2	4	4	0.27	0.27
Red Tailed Monkey	2	4	1	3	3	7	0.20	0.47
Bush Baby	0	1	0	0	0	1	0.00	0.07
Civet Cat	0	0	0	0	0	0	0.00	0.00
Tree Pangolin	8	11	7	8	15	19	1.00	1.27
Total	384	265	440	248	824	513	54.93	34.20

Source: Field Survey (2016).

Table 4: Seasonal populations of mammalian species in Oban Division of the Park

Species	Adult Counts		Juvenile Counts		Total		Average	
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry (No/day)	Rainy (No/day)
Red Flank Duiker	1	2	0	1	1	3	0.07	0.20
Blue Duiker	10	4	18	6	28	10	1.87	0.67
Mona Monkey	37	23	64	48	101	71	6.73	4.73
Putty Nose Monkey	23	9	36	13	59	22	3.93	1.47
Elephant	0	0	0	0	0	0	0.00	0.00
Buffalo	0	0	0	0	0	0	0.00	0.00
Red River Hog	8	0	18	0	26	0	1.73	0.00
Giant Squirrel	11	8	18	16	29	24	1.93	1.60
Tree Squirrel	13	12	14	6	27	18	1.80	1.20
Mongoose	6	7	13	9	19	16	1.27	1.07
Porcupine	5	4	13	8	18	12	1.20	0.80
Cane Rat	0	0	0	0	0	0	0.00	0.00
Red Tailed Monkey	0	0	0	0	0	0	0.00	0.00
Bush Baby	0	0	0	0	0	0	0.00	0.00
Civet Cat	0	0	0	0	0	0	0.00	0.00
Tree Pangolin	0	0	0	0	0	0	0.00	0.00
Total	114	69	194	107	308	176	20.53	11.73

Source: Field Survey (2016).

Density of Mammals sighted in Oban and Okwangwo division

The population density of mammalian species in the park was considerably low.

Table 5: Mean daily siting and density of mammals in Oban division

Species	Dry Season (No/day)	Rainy Season (No/day)	Species Density (No/sq.km)
Red Flank Duiker	0.93	0.33	2.11
Blue Duiker	4.87	1.33	10.33
Mona Monkey	22.67	12.40	58.44
Putty Nose Monkey	10.73	5.87	27.67
Elephant	0.00	0.00	0.00
Buffalo	0.00	0.13	0.22
Red River Hog	3.87	1.87	9.56
Giant Squirrel	3.87	3.40	12.11
Tree Squirrel	3.40	3.47	11.44
Mongoose	1.80	1.53	5.56
Porcupine	1.33	1.80	5.22
Cane Rat	0.27	0.27	0.89
Red Tailed Monkey	0.20	0.47	1.11
Bush Baby	0.00	0.07	0.11
Civet Cat	0.00	0.00	0.00
Pangolin	1.00	1.27	3.78
Total	54.93	34.20	148.56
No. of species	12	14	
Absolute Density	75/sq.km		

Source: Field Survey (2016).

Table 6: Mean daily siting and density of mammals in Oban division Okwangwo division

Species	Dry Season (No./day)	Rainy Season (No./day)	Species Density (No/sq.km)
Red Flank Duiker	0.07	0.20	1.33
Blue Duiker	1.87	0.67	12.67
Mona Monkey	6.73	4.73	57.33
Putty Nose Monkey	3.93	1.47	27.00
Elephant	0.00	0.00	0.00
Buffalo	0.00	0.00	0.00
Red River Hog	1.73	0.00	8.67
Giant Squirrel	1.93	1.60	17.67
Tree Squirrel	1.80	1.20	15.00
Mongoose	1.27	1.07	11.67
Porcupine	1.20	0.80	10.00
Cane Rat	0.00	0.00	0.00
Red Tailed Monkey	0.00	0.00	0.00
Bush Baby	0.00	0.00	0.00
Civet Cat	0.00	0.00	0.00
Pangolin	0.00	0.00	0.00
Total	20.53	11.73	161.33
No. Of species	9	8	
Absolute Density	323/sq.km		

Source: Field Survey (2016).

Similarity, Diversity, Richness and Evenness of Mammalian species in the study area

The result of Sorenson's similarity index is presented in Table 7. The similarities in mammalian species were generally high between the two seasons. However, as expected, similarities in mammalian species between seasons were higher within the divisions of the park than between divisions.

The Diversity, richness, and evenness of mammalian species are presented in table 8. Oban division had the highest mammalian diversity during rainy season (H = 2.009; 1 – D = 0.810) while Okwangwo division had the highest mammalian diversity during dry season (H = 1.901; 1 – D = 0.819). Table 8 also shows that Oban division had the highest species richness during rainy season (0.618) while Okwangwo division had the highest species evenness in dry season (0.865). Test of significance for both Oban and Okwangwo divisions is presented in tables 9 and 10. Table 10 shows that only Putty Nose Monkey and Blue Duiker showed significant difference in population in Oban and Okwangwo divisions. Between seasons only Putty Nose Monkey and Mona showed significant difference in population.

Table 7: Sorensen's similarity indices for the two divisions at different seasons

	OBDS	OBRS	OKWDS	OKWRS
OBDS	*	92.31	90.00	80.00
OBRS		*	78.26	72.73
OKWDS			*	94.12
OKWDS				*

OBDS = Oban Dry Season; OBRS = Oban Rainy Season; OKWDS = Okwangwo Dry Season; OKWRS = Okwangwo Rainy Season

Table 8: Diversity, richness and evenness of mammalian species in Oban and Okwangwo division

	Oban division		Okwangwo division	
Indices	Dry Season	Rainy Season	Dry season	Rainy Season
Shannon-Weiner Diversity Index	1.836	2.009	1.901	1.764
Simpson's Index of Diversity	0.769	0.810	0.819	0.781
Species Richness Index	0.418	0.618	0.513	0.603
Species Evenness Index	0.739	0.761	0.865	0.849

Source: Field Survey (2016).

Table 9: Results for tests of significant differences for mammalian populations in Oban Division (dry versus rainy season)

Species	t-Calculated	t-Critical (t0.05/2)	Conclusion
Red Flank Duiker	2.598	4.303	Not Significant
Blue Duiker	7.350	4.303	Significant
Mona Monkey	2.295	4.303	Not Significant
Putty Nose Monkey	4.459	4.303	Significant
Elephant	0.000	0.000	No Difference
Buffalo	-1.000	4.303	Not Significant
Red River Hog	3.780	4.303	Not Significant
Giant Squirrel	0.734	4.303	Not Significant
Tree Squirrel	-0.077	4.303	Not Significant
Mongoose	0.264	4.303	Not Significant
Porcupine	-0.896	4.303	Not Significant
Cane Rat	0.000	0.000	No Difference
Red Tailed Monkey	-1.000	4.303	Not Significant
Bush Baby	-1.000	4.303	Not Significant
Civet Cat	0.000	0.000	No Difference
Pangolin	-1.512	4.303	Not Significant

Source: Field Survey (2016).

Table 10: Results for tests of significant difference for mammalian populations in Okwangwo division (dry versus rainy season)

Species	t-Calculated	t-Critical (t0.05/2)	Conclusion
Red Flank Duiker	-0.555	4.303	Not Significant
Blue Duiker	3.464	4.303	Not Significant
Mona Monkey	8.660	4.303	Significant
Putty Nose Monkey	8.488	4.303	Significant
Elephant	0.000	0.000	No Difference
Buffalo	0.000	0.000	No Difference
Red River Hog	3.250	4.303	Not Significant
Giant Squirrel	0.500	4.303	Not Significant
Tree Squirrel	1.732	4.303	Not Significant
Mongoose	0.655	4.303	Not Significant
Porcupine	0.480	4.303	Not Significant
Cane Rat	0.000	0.000	No Difference
Red Tailed Monkey	0.000	0.000	No Difference
Bush Baby	0.000	0.000	No Difference
Civet Cat	0.000	0.000	No Difference
Pangolin	0.000	0.000	No Difference

Source: Field work, 2016

DISCUSSION

Mammals sighted in Cross River National Park (Oban division and Okwangwo division) were analysed in terms of species density, species richness, species evenness, species diversity and similarity. A total of 14 mammalian species were sighted in Oban division and 9 in Okwangwo division. However, signs of 5 mammalian species were recorded for Oban division and 1 recorded for Okwangwo division. The signs mostly observed were the footprints. This was closely followed by animal track and lastly animal dungs. Footprint which was the highest dominant sign followed by 'tracks' which was the second highest in both ranges might be due to the fact that these mammals migrate often in the study sites in search for food and water as such imprinting their foot print on the ground. They also follow a trail (pathway) created for easy movement. The number of mammals sighted was low in the divisions probably due to the fact that there were only a few populations of these mammalian species within the park. This could also be as a result of the fact that some of the mammals were sensitive to strange sounds in the forest and easily escaped from the area. Most of the mammals could easily detect the presence of humans from several meters, thus, escaping without being noticed (Dobson, 1998). Unlimited human activities such as hunting, bush burning and farming in the park might have also resulted in few populations of mammalian species sighted. The total number of adults sighted in Oban division during the dry season was 384 while that of the rainy season was 264. The number of sighted juveniles for Oban division during the dry season was 440 while that of rainy season was 248. The number of adults sighted during the dry season in Okwangwo division was 114 while that of the rainy season was 69. The total number of juvenile sighted in Okwangwo division during the dry season

was 194 while during the rainy season was 107. Mona monkey was sighted most while the least sighted was Bush baby although mammals like Civet cat and Elephant were directly not sighted. The mean value of direct count of mammals for Oban division during the dry season was 55 and that of the rainy season was 34.

The mean value of direct count of mammals during the dry season for Okwangwo division was 21 and that of rainy season is 12. This could be as a result of frequent movement of animals in search of water and food during the dry season. The indirect count of mammals during dry season for Oban division is 13 while that of the rainy season was 46. For Okwangwo division, the indirect count for dry season was 26 and that of rainy season was 49. This may be attributed to the fact that during the rainy season the ground is wet and animal prints, tracks and activities can easily be seen because they become more visible unlike dry season when the soil is very dry and it is difficult to identify footprints and tracks. These signs are very important because they confirm the existence of these mammal species in the divisions.

The result of the Sorensen's similarity index implies that Okwangwo division and Oban division are similar. Sorensen's similarity indices for the divisions are based on mammalian species composition. There are few species differences between the two divisions. The similarities are high between the seasons and within the divisions. This can be attributed to the fact that both divisions are located within the same ecological zone, coupled with their closeness – Animals can easily migrate from one division to the other. Ijeomah *et al.* (2011) reported that many Elephants from Kainji lake national park migrated to Niger Republic because of the closeness of the areas.

The population density of mammalian species in the park was considerably low. The result may indicate that population of mammals was affected by some anthropogenic factors. Thus, the distributions of these species appear to have been greatly affected by the presence of humans. The mammalian species with the highest density in Oban division was Mona monkey (58.44/sq.km) followed by the Putty nose monkey (27.67/sq.km) while the mammalian species with the least density was the Bush baby (0.11/sq.km). Mona monkey had the highest population density (57.33/sq.km) in Okwangwo division followed by Putty nose monkey (27.00/sq.km) while the mammalian species with the least population density is Red flank duiker (1.33/sq.km). This result indicates that population of the red flank duiker might have been affected by hunting- it is one of the frequently hunted game species in the park.

A high index of Species richness was recorded for Oban division in rainy season. This may be due to the fact that abundant food (on which the animal depends) is found in the park (matured forest), and that these areas have marked boundaries beyond which hunting and farming are forbidden (Barnes, 2002; Azevedo-Ramos *et al.,* 2006). Oban ranges had the highest mammalian diversity index during rainy season (H = 2.009; 1 – D = 0.810) while Okwangwo division had the highest mammal diversity index during dry season (H = 1.901; 1 – D = 0.819). Oban division had the highest species richness during rainy season (0.618) while Okwangwo division had the highest species evenness in dry season (0.865). Diversity

varies among sites and depends on habitat, altitude etc.

Higher species diversity is generally thought to indicate a more complex and healthier community because a greater variety of species allows for more species interactions, and indicates good environmental conditions (Starzomski *et al.*, 2008). If a community has only a few species or if only a few species are very abundant, species diversity is low (Cuevas-Reyes *et al*., 2003, 2004).

The high species richness in Oban division during rainy season could be attributed to minimal disturbance (Alvard *et al*., 1997; Carpaneto and Fusari, 2000; Ekobo, 2003). Oban division recorded the least species richness (0.418) during dry season. This may be due to human activities. Poaching is more experienced in Oban than Okwangwo division. Similarly, Muchaal and Ngandjui (1999), Davies (2002) and Reinhard *et al*., (2009) reported that high hunting activities in the dry season may be based on the fact that foot prints and tracks of the animals could be followed and traps are laid. There was fluctuation in species richness during wet and dry seasons. This might also be due to frequent distractions from farmland such as noise from chain saws, rapid encroachment into their habitats scare the animals forcing them to migrate to other favourable habitats free from distractions.

The t-test results for Oban division showed significant difference ($p<0.05$) between dry and rainy seasons' population for only Blue duiker and Putty nose monkey. For the other mammalian species in Oban division, there were no significant difference ($p>0.05$). The dry season population of only two mammals (Mona monkey and Putty nose monkey) significantly differ ($p<0.05$) from the rainy season in Okwangwo division while for the rest of the mammalian population, there were no significant difference ($p<0.05$) between dry and rainy seasons. This can be attributed to the fact that the two divisions are similar in terms of ranges of environmental factors or variables ;which are within the tolerable limits of the species in the two seasons– there is hardly cases of significant seasonal drought or disaster (caused by fire or flooding) which may seriously induce large population of animals to migrate.

CONCLUSION

The impacts of human activities on the distribution of animals varied among the mammalian species. The areas of Oban and Okwangwo divisions in Cross River National Park are rich in mammalian species of high ecological interest. The data obtained showed that the mammalian species observed were available all year round, while differences in population count and density observed in some species may be due mainly to recruitment and reproductive cycle, and perhaps poaching which occurred all year round in the study area. Presently, total dependence of local human inhabitants on the forest resources and the use of sophisticated tools for indiscriminate harvesting of the biological resources have left most of the mammals locally endangered with destroyed habitats and food sources. Proper management of the anthropogenic activities in the rainforest may be paramount to preserve or ensure survival of most of the mammalian species which are at the verge of extinction.

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