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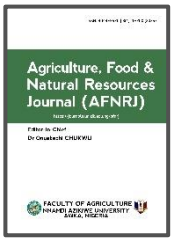

Original Article

Species composition and diversity of some mammals in forest fragments of Gashaka Gumti National Park, Nigeria

OPEN ACCESS

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ABSTRACT

This study investigated the species composition and diversity of some mammalian species using camera traps in Gashaka Gumti National Park, Nigeria. Camera trapping was conducted both in wet and dry seasons in lowland rainforest, forest-savanna mosaic, montane, and gallery forests. Camera density (one per 2km^2) and traps were used to take photos of moving objects without delay between triggers. They were set to snap 3 photos per burst at an interval of 30 seconds. Data were collected from the forest sites for ninety (90) days each in the wet season and dry season, respectively. Images were identified from memory cards using Kingdon's field guide to African mammals. The following parameters were recorded: species name, number and group size, sex structure (male and female), age structure (juvenile and adult), activity at time of snapshot, activity time (day or night), activity area, and weather condition. Results obtained indicated that a total of 31 mammalian species were captured in the four (4) forest sites, belonging to five (5) orders (Ungulata, Carnivora, Primate, Pholidota, and Rodentia). Shannon Weiner Diversity Index analysis indicated a significant difference ($P \leq 0.05$) between dry and wet seasons mammalian species diversity in forest-savanna mosaic. Mammalian species diversity in dry and wet seasons did not differ significantly ($P \geq 0.05$) in lowland rainforest, montane forest, and gallery forest. The existence of endangered species captured through camera trapping is an indicator of the ecological significance of the sites, which has helped to earn the park international recognition.

KEYWORDS: *Biodiversity, Endangered species, Mammals, Traps, Wildlife*

INTRODUCTION

Many wildlife species are experiencing decline in population without fully being assessed (Rija *et al.*, 2020). About 80% population of mammals are declining in tropical forest (Jones *et al.*, 2018 and Rija *et al.*, 2020). The assessment and monitoring of population size and population density by means of affordable and reliable methods are key tools for developing fact-based management in conservation (Williams *et al.*, 2002). The camera trap developed in recent years has proven to be an unaffordable tool and a reliable technique for the assessment of the presence, distribution and abundance of medium and large mammal species particularly the elusive and rare species (Foster & Harmsen, 2012).

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Large and medium sized mammals are important ecological components of forests for their role in seed dispersal, seed predation, habitat modification, regulation of plant species populations, and mediation of forest composition and dynamics (Terborgh et al., 2008). Information on large mammal distribution and abundance is very important to the understanding of their significance in forest ecosystem dynamics. This information is also vital in evaluating conservation hotspots, sites of eco-tourism potential for game-viewing, the nature and extent of human-wildlife conflicts and sustainable harvesting of bush meat by local communities (Kühl *et al.*, 2019).

Gashaka-Gumti National Park (GGNP) Nigeria is the most diverse national park blessed with flourishing population of large mammals with luxuriant tropical forest ecosystems, situated on difficult terrains with little infrastructural development (Adanu *et al.,* 2011). Report of mammalian populations of the park were established for the savanna ecosystems using traditional tracking methods involving direct and indirect observations (Buba, 2013) and even through semi structured questionnaires. However, this study was designed to determine the species composition and diversity of some mammalian species using camera trap in Gashaka Gumti National Park, Nigeria.

MATERIALS AND METHODS

The Study Area

The Location of the study area

Gashaka-Gumti National Park (GGNP) is in a mountainous region of Taraba and Adamawa States in North-eastern Nigeria, adjacent to the international border with Cameroon. It lies on latitude 06°55′ - 08°05′ N and 11°11′ - 12°13′ E and covers 6,731 km² (Figure 1) (Sommer and Ross, 2011). The Park is divided into two sectors (Northern sector and Southern sector). The Northern sector was named after the village of Gumti which is an enclave community, and it stretches far into neighbouring local government areas in Adamawa state.

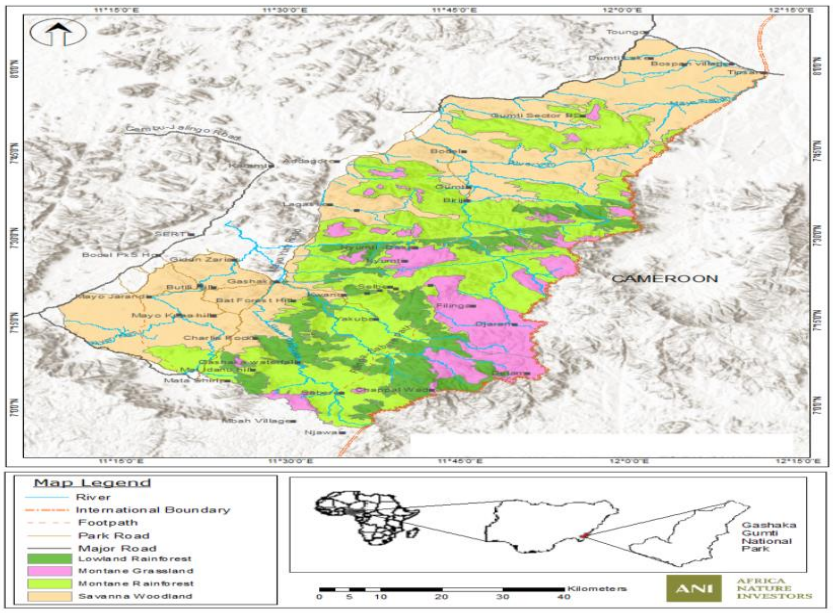

Figure 1: **Figure showing the location and map of Gashaka Gumti National Park**
Source: Africa Nature Investors, (2023)

Data Collection Techniques

The Recon Force Elite HP5 camera trap set was used to take photos of moving objects without delay between consecutive triggers. Each camera and the memory card were given same number. GPS location and elevation of each camera was taken. The camera was set to record time, date, and temperature of each image captured, and cameras were set to snap 3 shots photos per burst at an interval of 30 seconds. The 31 mammalian species in about 462km^2 of forest sites in GGNP compared to the total of 247 mammalian species in about 143,000km^2 FAO (2002). Data were collected from all the forest fragments for ninety (90) days in the wet season and ninety (90) days in the dry season. At the completion of the survey, memory cards were retrieved, and images were identified using Kingdon's field guide to African mammals (2015). The following parameters: species name, group size and number of each species, sex structure (male and female), age structure (juvenile, adult), activity at the time of snapshot, activity time (day, night), activity area, and weather condition were recorded from each camera trap.

Activity period was also classified into four (4) categories namely Norturnal, diurnal, cathemeral, and crespuscular.

Activity budgets were classified following Akosim *et al*. (2005). For activity periods, mammalian species were classified as diurnal if less than ten percent (<10%) of the observations were made in the dark; Nocturnal, if more than ninety percent (<90%) of the observations were made in the dark; Crepuscular, if fifty percent (<50%) of the observations were made one hour before sunrise and one hour after sunset; cathemeral, if the mammalian species have sporadic and random intervals of activity during the day and night.

Data Analysis

1. Data on species composition and diversity of the mammalian species was analysed using:

i. Descriptive statistics such as frequencies and percentages

ii. Shannon Wieners Diversity Index (SDI) was used for the analysis of species diversity. The model is as follows:

$H = -\sum[(pi) * \log(pi)]$ (1)

(Rita and Kumari, 2021)

Where:
H - Shannon diversity index;

p_i - Proportion of individuals of i-th species in a whole community: pi = n / N (2)

n - Individuals of a given type/species; and

N - Total number of individuals in a community,

∑ - Sum symbol; and

Log - Usually the natural logarithm, but the base of the logarithm is arbitrary (10 and 2 based logarithms are also used) and

iii. Shannon evenness index (E) = H^i/H_{max} (3)

Where:

E = Evenness index

H^i = Shannon index

H_{max} = Natural Logarithm of total number of species

E = 0 where the abundance of species is completely disproportional and 1 where all species are equally abundant.

T-test analyses was used to determine if there are significant differences in mammalian species diversity within forest sites.

$$t = \frac{\bar{x} - \mu}{s - \sqrt{\mu}} \quad (4)$$

(Normand, 2018)

Where:

t = Students t-test

$\bar{X}$= mean

μ = theoretical value

s = standard deviation

n = variable set size

One way analysis of variance was used to determine if there are significant differences in mammalian species diversity among the forest sites in both dry and wet season.

$$F = \frac{MST}{MSE} \quad (5)$$

$$MST = \frac{\sum_{i=1}^{k} (T_i^2/n) - G^2/n}{k-1} \quad (6)$$

$$MSE = \frac{\sum_{i=1}^{k} \sum_{j=1}^{n_1} Y_{ij}^2 - \sum_{i=1}^{k} (T_i^2/n_i)}{n-k} \quad (7)$$

(Nomand, 2018)

Where:

F = variance ratio for the overall test

MST = mean square due to treatments/groups (between groups)

MSE = mean square due to error (within groups, residual mean square)

Y_{ij} = observation

T_i = group total

G = grand total of all observations,

n_i = number in group i and n is the total number of observations.

Results

Mammalian Species Composition and Diversity in Forest Ecosystems of Gashaka Gumti National Park (GGNP).

Mammalian Species Composition in Forest Ecosystem of GGNP

The results indicates that a total of thirty-one (31) mammalian species were captured in the four (4) forest ecosystems (Table 1). The distribution of the mammalian species according to the forest types are as follows: lowland rain forest (23), forest-savanna mosaic (18), montane forest (20) and Gallery Forest (26). Table 2 shows that the mammalian species are distributed to ten (10) families in lowland rain forest, nine (9) in forest-savanna mosaic, ten (10) in Montane Forest and twelve (12) in Gallery Forest.

Composition and diversity of some mammalian species

Dry season results of mammalian species Shannon diversity indices and evenness across the sites are presented in Table 3. The results revealed that the Shannon diversity indices and evenness of the mammalian species for the months of January, February, and March ranged from 2.754 to 2.927 in Lowland rainforest, with the highest occurring in February; 2.246 to 2.676 in Montane Forest with the highest occurring in January; 2.754 to 2.835 in Gallery Forest with the highest occurring in January and 2.457 to 2.729 in Forest savanna mosaic with the highest occurring in February. Evenness in the dry season for the four (4) forest sites ranged from 0.7480 to 0.9449.

Evenness in the dry season for the four (4) forest sites ranged from 0.7480 to 0.9449. The wet season results of mammalian species indices and evenness across the sites are presented in Table 4. It shows the indices and evenness of mammalian species for the months of April, May and June. Shannon diversity indices ranged from 2.676 to 2.977 in lowland rain forest. In montane forest the highest occurrence happened in May (2.079 to 2.558), Gallery Forest highest occurrence happened also in May (2.246 to 2.676) while forest-savanna mosaic had highest occurrence in April (2.393 to 2.648). Evenness in the wet season for the four (4) forest sites ranged from 0.7849 to 0.9449.

Mammalian species diversity indices and evenness across the forest sites for the results of Dry and Wet seasons is presented in Table 5. The result indicated that the Shannon Wiener Diversity (SWD) index of mammalian species across the four (4) forest sites was highest in Lowland rainforest (3.053), followed by the Gallery Forest (3.022), Montane Forest (2.820) and Forest Savanna Mosaic (2.745) in descending order.

Table 1: Mammalian species composition as captured by camera in the forest ecosystems of GGNP

S/N	Scientific Name	Common Name	LLF	FSM	MF	GF
1	*Tragelaphus sylvaticus*	Bushbuck	*	*	*	*
2	*Cephalophus silvicultor*	Yellow-backed Duiker	*	*	*	*
3	*Cephalophus rufilatus*	Red-flanked Duiker	*	*	*	*
4	*Philantomba monticola*	Blue Duiker	*	*	*	*
5	*Syncerus caffer*	Forest Buffalo	*	*	-	*
6	*Kobus ellipsiprymnus*	Waterbuck	*	-	-	*
7	*Orycteropus afer*	Aardvark	*	-	-	-
8	*Mungos gambianus*	Gambian Mongoose	*	*	*	*
9	*Caracal aurata*	African Golden Cat	-	-	-	*
10	*Leptailurus serval*	Serval	-	*	-	-
11	*Caracal aurata*	Caracal	-	-	*	-
12	*Genetta genetta*	Common Genet	*	*	*	*
13	*Genetta tigrine*	Blotched Genet	-	-	-	*
14	*Civettictis civetta*	African Civet	*	*	*	*
15	*Hylochoerus meinertzhageni*	Giant Forest Hog	*	*	*	*
16	*Potamochoerus porcus*	Red River Hog	*	*	*	*
17	*Phacochoerus africanus*	Common Warthog	*	-	*	*
18	*Pan troglodytes*	Chimpanzees	-	-	*	*
19	*Cercopithecus mona*	Mona Monkey	*	*	*	*
20	*Cercopithecus nictitans*	Putty Nose Monkey	*	*	*	*
21	*Colobus guereza*	Black and White Columbus Monkey	*	-	-	*
22	*PapioaAnubis*	Baboon	*	*	*	*
23	*Smutsia gigantean*	Giant Pangolin	*	-	-	*
24	*Phataginus tricuspis*	White-bellied tree Pangolin	*	-	*	*
25	*Cricetomys gambianus*	African Giant Poarch Rat	*	-	*	*
26	*Atlantoxerus getulus*	Barbary Ground Squirrel	*	*	*	*
27	*Hystrix cristata*	Crested Porcupine	*	*	*	*
28	*Atherurus africanus*	Brush-tail Porcupine	-	*	*	*
29	*Lupulella adusta*	Side-striped Jakal	-	-	-	*
30	*Crocuta crocuta*	Spotted Hyaena	-	*	-	-
31	*Mellivora capensis*	Honey Badger	*	-	-	-
	Total		**23**	**18**	**20**	**26**

Key: *Lowland Rainforest (LLF); Forest savanna mosaic (FSM); Montane Forest (MF); Gallery Forest (GF); Present *; Absent ⁻*
Source: Field survey, (2024)

Table 2: Families of Mammalian Species Captured by Camera Trapping in the Study Area

S/N	Family	Lowland forest	Forest savanna mosaic	Montane forest	Gallery forest
1	Bovidae	*	*	*	*
2	Bovidae	*	*	*	*
3	Bovidae	*	*	*	*
4	Bovidae	*	*	*	*
5	Bovidae	*	*	-	*
6	Bovidae	*	-	-	*
7	Orycteropdidae	*	-	-	-
8	Herpestidae	*	*	*	*
9	Felidae	-	-	-	*
10	Felidae	-	*	-	-
11	Felidae	-	-	*	-
12	Viverridae	*	*	*	*
13	Viverridae	-	-	-	*
14	Viverridae	*	*	*	*
15	Suidae	*	*	*	*
16	Suidae	*	*	*	*
17	Suidae	*	-	*	*
18	Hominidae	-	-	*	*
19	Cercopithecidae	*	*	*	*
20	Cercopithecidae	*	*	*	*
21	Cercopithecidae	*	-	-	*
22	Cercopithecidae	*	*	*	*
23	Manidae	*	-	-	*
24	Manidae	*	-	*	*
25	Nesomydae	*	-	*	*
26	Sciuridae	*	*	*	*
27	Hystricidae	*	*	*	*
28	Hystricidae	-	*	*	*
29	Canidae	-	-	-	*
30	Hyaenidae	-	*	-	-
31	Mustelidae	*	-	-	-
	Total	**10**	**9**	**10**	**12**

*Key: Present *, Absent –*
Source: Field survey, (2024)

Results of the evenness of mammalian (Table 3) in the four (4) forest ecosystems were as follows; Gallery Forest (0.7899), Montane Forest (0.7624), Forest Savanna Mosaic (0.7437) and Lowland rainforest (0.7624) in descending order. The result revealed that significant difference (P≤0.05) only occurred in Forest Savanna Mosaic between Dry and Wet seasons in mammalian species diversity. Mammalian species diversity did not differ significantly (P≥0.05) between Dry and Wet seasons in Lowland rainforest, Montane Forest, and Gallery Forest. Result of analysis of variance among the forest sites showed that significant difference (P≤0.05) occurred between Lowland rainforest and Montane Forest; Montane Forest and Gallery Forest and Montane Forest and Forest Savanna Mosaic in the Dry season mammalian species diversity indices. In the wet season, mammalian species diversity indices differ significantly (P≤0.05) between Lowland rainforest and Montane Forest; Lowland rainforest and Gallery Forest; Lowland rainforest and Forest Savanna Mosaic as well as between Montane Forest and Forest Savanna Mosaic.

Table 3: Dry season Mammalian species Shannon diversity indices and evenness in the forest ecosystems of GGNP

Site	Lowland rainforest			Montane forest			Gallery forest			Forest savanna mosaic		
Month	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.
Taxa_S	21	24	21	17	16	10	21	19	17	14	17	15
Individuals	130	75	64	38	30	15	49	29	25	55	31	28
Shannon_H	2.75	2.93	2.82	2.68	2.67	2.25	2.85	2.84	2.75	2.46	2.73	2.55
Evenness_e^H/S	0.75	0.78	0.81	0.85	0.89	0.95	0.83	0.89	0.92	0.83	0.90	0.85

Source: *Field survey, (2024)*

Table 4: Wet season Mammalian species Shannon diversity indices and evenness in the forest ecosystems of GGNP

Site	Lowland rainforest			Montane forest			Gallery forest			Forest savanna mosaic		
Wet	Apr.	May	Jun.	Apr.	May	Jun.	Apr.	May	Jun.	Apr.	May	Jun.
Taxa_S	24	24	16	14	14	8	17	16	10	18	16	12
Individuals	123	64	41	36	21	8	38	30	15	49	27	16
Shannon_H	2.96	2.98	2.68	2.55	2.56	2.08	2.68	2.67	2.25	2.65	2.58	2.39
Evenness_e^H/S	0.80	0.82	0.91	0.91	0.92	1	0.85	0.89	0.95	0.78	0.83	0.91

Discussion

Species composition and Diversity of Mammalian species in Forest Ecosystems of GGNP

The finding in camera trapping in this study which reveals the advantage and efficiency of the Camera trapping techniques over traditional tracking techniques in terms of its detectability of secretive, rare, elusive, nocturnal, crepuscular and cathemeral species of animals. This finding compares favourably with the result of the traditional tracking techniques by Buba et al., 2016. Besides, its effective use in difficult terrains and inaccessible forest sites of Gashaka Gumti National Park confers additional advantage to the Camera trapping techniques.

The high detectability of camera trapping techniques of secretive, rare, elusive, nocturnal and Crepuscular mammalian species particularly in difficult terrains and inaccessible forest sites (such as the GGNP forest sites) might have accounted for the increase in detection of mammalian species from nineteen (19) species to thirty-one (31) species in the same forest sites. The 31 mammalian species in about 462km2 of forest sites in GGNP compared to the total of 247 mammalian species in about 143,000km2 FAO (2002) of forest ecosystems in Nigeria is indicative of high diversity of mammalian species in GGNP. The above findings and observations are in tandem with the reports of Tobler et al. (2008) and Buba et al. (2016). Findings on mammalian species diversity across the forest sites for the whole year indicated higher diversity of mammalian species in lowland rainforest and in montane forest sites. The lower diversity of mammalian species in the forest-savanna mosaic may be attributed to volatility in food availability and cover as a result of seasonal changes and susceptibility to human predation. This observation agrees with the report of Buba et al. (2016).

The findings further revealed that the Shannon diversity index recorded in dry and wet seasons differed significantly ($P \leq 0.05$) in montane forest and forest-savanna mosaic. This finding suggests that significant variation might exist in food resources between dry and wet seasons in these sites. However, the dry and wet seasons diversity index did not differ significantly ($P \geq 0.05$) in lowland rainforest and in the Gallery Forest. This perhaps accounted for immigration rather than emigration from the sites. The implication of comparison of dry season Shannon diversity index between the four sites further indicated that the Gallery Forest and the forest-savanna mosaic are less diverse, this could perhaps be as a consequence of less resilience and volatility of the sites in food resources and cover required by some species of mammals. Also, Susceptibility to human predation during dry season as a result of easy access to the sites might be a contributory factor. The findings in the wet season further reveals that the lowland rainforest had a higher diversity in mammalian species followed by the gallery forest, the montane forest and the forest savanna mosaic in that order. This implies the excellent habitat condition that exists in the lowland rainforest during the wet season, which also meets most of the habitat requirements of the mammalian species. The findings and observations are in consonance with the report of Buba et al. (2016).

The essence of this study on mammalian species richness and diversity in the forest ecosystems of GGNP is to determine the extent to which forest sites of GGNP contribute to the conservation value or biodiversity status of the park. The mammalian species richness as determined in the study is thirty-one (31), while the range of Shannon diversity index was 2.079 to 3.053. When these results are compared to the mammalian species highest Shannon diversity index of 2.315 recorded in the forest habitat of borena-sayint national park (Meseret and Solomon, 2014) and 1.44 recorded in Debre-libanos forest (Tameut et al., 2023) which conferred high conservation values on them, it therefore implies that the forest ecosystems of GGNP which is relatively higher in Shannon diversity index could be considered higher in biodiversity status and conservation value. The classification of GGNP as a hotspot for biodiversity conservation is therefore not unexpected.

CONCLUSION AND RECOMMENDATION

In conclusion, the composition and diversity of mammalian species in the study area revealed the high conservation value of the forest ecosystems of Gashaka Gumti National Park. The findings through the use of camera trapping in the forest sites is an indicator of the ecological significance of the sites which has helped to earn the park the international recognition as a hot spot for biodiversity conservation.

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Authors Contributions

Authors PDD managed data collection, interpretation of data, writing of manuscript, material support. Authors YZB managed the literature searches. Author AGT reviewed manuscripts and wrote the first draft of the manuscript. While EMS managed the development of methodology. All authors read and approved the final manuscript.

Ethical Statement

Not applicable

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