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An Analysis of Direct Observation and Camera Trapping in the Survey of Large Mammals in Gashaka Gumti National Park, Nigeria

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A B S T R A C T

Large mammalian species community was surveyed using camera trap and direct observation at Kwano forest of Gashaka-Gumti National Park, Nigeria. Information on large mammalian species composition, richness and abundance were gathered using motion triggered white flash digital trial cameras. A total of 638 independent events with twenty six (26) large mammalian species were photographed during camera trapping, and thirteen (13) animal species were sighted during direct observation method. The large mammals relative abundance index (RAI) ranged from 0.07 (waterbuck) to 10.47 (baboon). The results suggest that the park still holds a good number of large mammals. Human activities of any kind should be prevented, and there should be periodic large mammals monitoring programs using camera traps and drones in and around this sector of GGNP

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INTRODUCTION

The integrity of an ecosystem is often dependent upon the functional assemblages of mammals of different guilds and body sizes (Ripple et al., 2014). They are important ecological components for the proper functioning of an ecosystem as they regulate the structure and function of the ecosystem in which they occur (Ripple, et al. 2015). They play a fundamental role in nutrient cycling through the consumption of plants at one point and excreting them or dying at another location (Akinsorotan, 2017; Doughty et al., 2016), recruitment of plants (Snyder et al., 2006), pollination, monitoring the structure and composition of vegetation, and seed dispersal as a vital process in maintaining the biodiversity of sites (Jordano et al., 2007). The trampling activities of large herbivores are critical in maintaining diverse patches of habitat in many ecosystems (Ripple et al., 2015). They are also important in fulfilling the needs of humans such as cloth, food especially to poor, rural people that are constrained by the availability of animal protein, and demographic and/or socioeconomic factors, and cultural values that contributes to spiritual wellbeing as well as opportunities for recreation (Boesch et al., 2017; Keane et al., 2011). They also provide economic benefits for communities around protected areas as tourists are drawn to where charismatic herbivores exist in large abundance with significant impact in providing income (Tao and Wall, 2009). Despite all these benefits, habitat loss, overexploitation, invasive species, and climate change caused by human activities have severely affected mammals' population (Pacifici et al., 2017). The extinction of animals in protected areas may affect ecosystem processes in ways that we do not yet comprehend (Boddicker et al., 2002). It is therefore imperative, to monitor and document mammalian species in and around protected areas to plan on their future conservation and management activities. The presence or absence of mammals, their abundance, and distribution in different areas can be assessed by various methods (Wilson et al., 1996). Most of the methods developed to survey larger mammals inhabiting open savanna or grassland habitats have been easily applied. In contrast to open habitats, investigating medium and large mammals inhabiting tropical forest habitats is difficult (Andreka et al., 1999). Hence, it is particularly challenging to locate, count, and monitor mammals in tropical forests. This could force researchers to use flexible methods to assess and monitor mammal communities in and around protected areas (Boddicker et al., 2002).

Estimating population sizes and documenting the presence of large and medium-sized mammals in tropical forest are difficult because of the thick forest, high canopies, and nocturnal activities of most animals, and avoidance of human presence. For such animals, researchers have used indirect evidence such as footmarks, droppings, sound, and feeding remains to verify presence (Burton et al., 2015) and to estimate population size by developing indices of abundance of mammals (Tobler et al., 2008; Trolle, 2003). More recently, camera-traps have been used to capture photographs of large mammals as they cross in front of un-manned cameras (Rovero and Marshall, 2009). A camera trap is a cost-effective technique used to monitor secretive mammalian species in forested ecosystems (Burton et al., 2015). It is less invasive, time-consuming, and cheaper than other

methods to survey and estimate mammalian species in inaccessible areas (Burton et al., 2015). Camera traps have been used to quantify the presence and relative abundance of rainforest mammals (Burton et al., 2015; Martins et al., 2007).Cameras have also been used by researchers to estimate population density and relative abundance of wildlife species (Burton et al., 2015; Nielsen and McCollough, 2009). It is also used to assess the feeding ecology and activity patterns of mammals (Frey et al., 2017; Springer et al., 2011).

Gashaka-Gumti National Park (GGNP) is Nigeria's most diverse national park blessed with flourishing population of large mammals (Adanu et al., 2011; Dunn, 1993). However, all of these reports were established through older methods involving the use of direct and indirect observation methods such as direct contacts (Dunn, 1993; Buba, 2013), use of artifacts (burrows, hairs, feaces, nests, footprints, and even through semi structural questionnaires. The former methods for large mammals' survey are sometimes deceitful. It is in view of this that this research surveyed large mammalian community in Kwano forest of Gashaka Gumti National Park using an advanced technological method (Camera traps) and direct observation with saltlick points and animal trails as targeted spots to compare species richness, and species abundance between the two methods.

METHODS

Study Area

Gashaka-Gumti National Park (GGNP) is located in a mountainous region of North-east Nigeria's states of Taraba and Adamawa, adjacent to the international border with Cameroon. It lies on latitude 06°55′ - 08°05′ N and 11°11′ - 12°13′ E, and covers 6731 km² (Fig1).

Terrain in the study area is rugged with altitudes ranging from about 300 – 2400 m, including the northern outcrop of the Cameroonian Highland chain. This southern sector of the GGNP includes a succession of lowland (< 825 m), sub-montane and montane (> 1650 m) strata, rising to 2419 m at Gangirwal, "the mountain of Death," Nigeria's peak on the Chappal Wadi escarpment (Sommer and Ross, 2011).

Gashaka-Gumti National Park is an important water catchment area for Benue River, as abundant rivers flow continuously, even throughout the distinct dry season (Koutsioni and Sommer, 2011).

The ethnic composition of the study area (Gashaka sector) is diverse (Adanu *et al.,* 2011; Nyanganji *et al.,* 2011), although the dominant groups are Fulani cattle herders who speak Fulfulde and farmers who speak mostly Hausa. The predominant religion in the area is Islam, especially amongst the Fulani, although Christian dominations exist, particularly in the town of Serti. People practice subsistence agriculture. Within the park exists 6 Fulani dominated enclaves, mainly in the highlands, where livestock grazing and cultivation are permitted (Buba, 2013).

The study area, Gashaka sector of the park includes a handful of enclaves, particularly in the highlands, where tens of thousands of cattle are grazed by the Fulani clans. The enclaves are legal. More cattle are intermittently brought across

the border from Cameroon. Subsistence farming is also common in the enclaves and the village of Gashaka. Logging is also carried out in the village of Gashaka.

Climate

The climate of Gashaka Gumti National Park fluctuates between a dry and a wet season. Rains are completely absent from mid-November till mid-March, when a dry and dusty wind, the Harmattan, will frequently blow down from the Sahara Desert. Heavy downpours occur between mid-April till mid-October, averaging 1935 mm (Koutsioni and Sommer, 2011). The mean minimum and maximum temperatures are 20.9 °C and 32.2 °C respectively, and the coolest and hottest day are 12 °C and 42 °C respectively (Sommer and Ross, 2011).

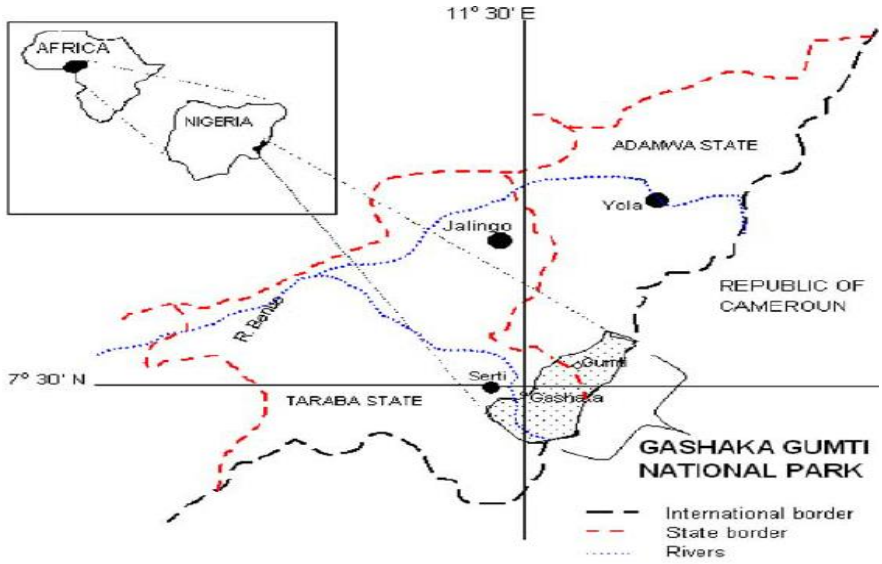

Figure 1: Map, Showing the location of Gashaka Gumti National Park **(Source: Warren, 2004)**

The vegetation cover represents a mosaic of montane grassland, montane forests, savannah-woodland, lowland and gallery forests (Chapman and Chapman, 1999). Montane forests, often misty, grow upwards of 1650 m (Koutsioni and Sommer, 2011). Trees reach a height of 15 – 10 m, with open canopy and abundant epiphytes. Montane grassland is at least partly human-made through grazing and annual burning from the onset of the dry season. Savannah-woodland is dominated by a ground cover of tall coarse grasses, 2-3 m high, and relatively small, disperse and often fire-resistant trees. The lowland rain forest is often stratified, with emergent which may grow up to 40m and include trees with characteristic buttress roots (Koutsioni and Sommer, 2011).

Study Design

A survey of large mammals in the Kwano forest of GGNP was conducted using camera traps and direct observation. Camera trapping was conducted from June to September, 2016.

The study area (26km^2) was first divided into 500m^2 grid cells (Fig2). Geographic waypoints were calculated for the center of each grid cell as potential camera stations. All grid cells where the center point fell directly on, or within 50m of an existing trail to maximize our chance of capturing large mammal images were then selected. Finally, 15 (5 from each habitat type) of these locations

were randomly selected as our final camera trap locations. Camera traps with long life-span battery were installed randomly on identified animal trails, cut trails, transects and salt lick points, and were monitored for 100 days giving a total sampling effort of 1500 (100 days x 15 cameras). Camera traps were positioned so the field of view included an active wildlife trail and then secured to a tree about 2–3 m away from the trail at an average height of 50 cm and left running for 30 days. Since cameras can run automatically over such period, they were not check to avoid unnecessary disturbance.

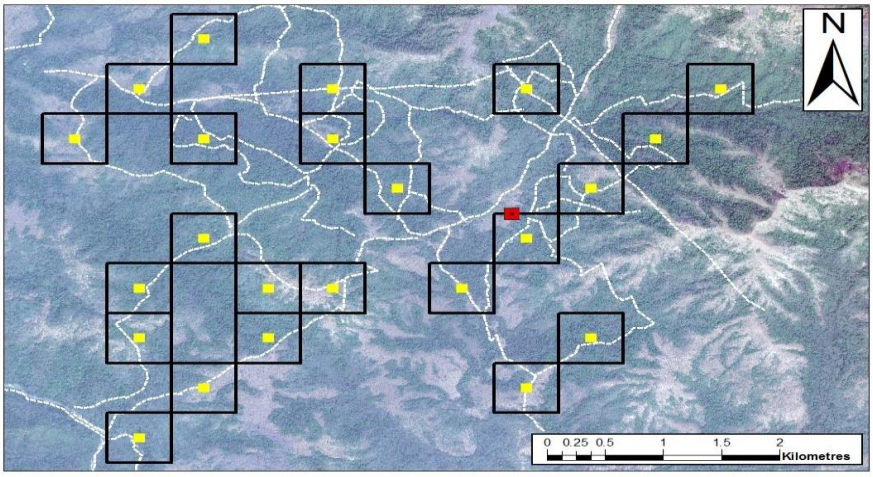

Figure 2. Large mammal camera trap survey design
(**Source: GBP, 2016**)

Key: [Square black outlines = randomly selected 500m2 grid cells, Filled yellow squares = camera trap locations, White dashed lines = existing trails, Filled red square = Kwano research station]. Two existing transects of 4 kilometers each cut across the study area, supplemented by several randomly-cut animal's survey trails named alphabetically, were also used to compliment camera trapping (Fig3).

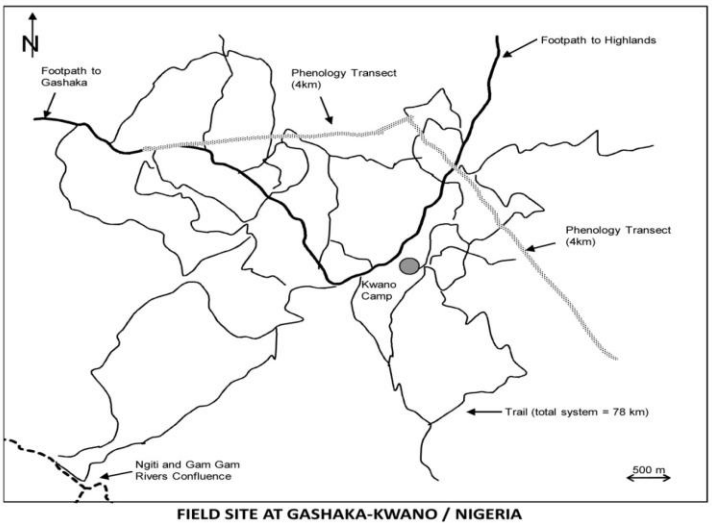

Figure 3. Map showing the animal survey trails and transects cut across the study site **(Source: GBP, 2016)**

Data Collection Techniques

Data was collected in Gashaka-Kwano forest located in the Gashaka sector of Gashaka-Gumti National Park (GGNP). Reconyx 550 Hyper-fire white flash digital trail cameras, set to take photos without delay between consecutive triggers was used. At sampling completion, memory cards were retrieved and images were identified using Kingdon's field guide to African mammals (2015). Records of large mammals were taken from images of the camera traps, and during trails and transects walk, and the Kingdon's guide to African mammals (2015) was used to identify the large mammals in the images and those sighted during the study period.

Another set of data were also collected based on opportunistic contacts with mammals during trail/transect walks for other purposes. Each transect was walked twice a week and records of encountered mammals were carefully taken. Trails were walked randomly on daily basis (morning and evening) and record of sighted mammals was also taken. Generally, the following parameters were recorded for each mammal sighted. These are; date, time, species, number, age-class, poly-specific association and habitat type.

Data Analysis

Standard descriptors of mammal community were derived by filtering the image records for each species of mammal to derive the number of events per hour, hence avoiding that multiple images of the same individual pausing in front of the camera trap were scored as multiple events (Rovero and Marshall, 2009). Species checklist of large mammals was derived from the camera trap. Relative abundance index (RAI) was then computed for individual species as the number of events divided by sampling effort and multiplied by 100 (i.e. events per 100 days of camera trapping):

$$RAI = \frac{Number\ of\ Event}{Sampling\ Effort} \times 100$$

Naïve occupancy of each species was also computed as the number of camera trap sites occupied on sites sampled. Another species checklist and status of large mammals sighted during direct observation was also made. Population abundance (base on frequency of sightings), and distribution of large mammals according to months was also analyzed using descriptive statistics such as mean, frequencies, and percentages, and data was presented on tables, graphs and charts. Activity periods were classified following Gómez *et al.* (2005), with the exception that a crepuscular category was included. Events that occurred one hour before and after sunrise and sunset were defined as crepuscular. Species were classified as diurnal (<10% of observations in the dark), nocturnal (>90% of observations in the dark), mostly diurnal (between 10 and 30% of observations in the dark), mostly nocturnal (between 70 and 90% of observations in the dark) and crepuscular (50% of observations during the crepuscular phase). The rest of the species were classified as cathemeral (organism that has sporadic and random intervals of activity during the day or night in which food is acquired).

RESULTS

Large Mammals' Species Composition and Richness in The Kwano Forest of GGNP

The results of direct observation in Table 1 shows thirteen (13) animal species under three (3) different taxonomic group (Primates, Ungulates and Carnivores) were sighted in the Kwano Forest of GGNP. Most primates such as Olive baboon (*Papio anubis)*, Mona monkeys (*Cercopithecus mona),* Putty-nosed monkeys (*Cercopithecus nictitans)* and Black-and-white Colobus monkey (*Colobus guereza)* were commonly (C) sighted; Tantalus monkeys (*Chlorocebus tantalus*), Bushbuck (*Tragelaphus scriptus*), Red river hog (*Potamochoers porcus),* Waterbuck (*Kubos ellipsiprymnus),* Yellow-backed duiker (*Cephalophus silvicultor),* Red-flanked duiker (*Cephalophus rufilatus*), Blue duiker (*Philantomba monticola)* and African civet (*Civetticus civetta)* were occasionally (O) sighted while Marsh mongoose was rare (R).

Table 1. Checklist and Status of Large Mammal Species Sighted in the Kwano Forest of GGNP

Taxon	Common name	Scientific name	Hausa name	Status
Primates	Olive baboon	*Papio anubis*	Gogo	C
	Putty-nosed Monkey	*Cercopithecus nictitans*	Bakin biri	C
	Mona Monkey	*Cercopithecus mona*	Gimchiki	C
	Black and white Colobus	*Colobus guereza*	Biri mai roro	C
	Tantalus Monkey	*Chlorocebus tantalus*	Kirikaa	O
Ungulates	Bushbuck	*Tragelaphus scriptus*	Mazo	O
	Red river hog	*Potamochoerus porcus*	Jan alade	O
	Waterbuck	*Kobus ellipsiprymnus*	Gwambaza	O
	Yellow-backed duiker	*Cephalophus silvicutor*	Boka	O
	Red-flanked duiker	*Cephalophus rufilatus*	Makurna	O
	Blue duiker	*Philantomba monticola*	-	O
Carnivores	African Civet	*Civetticus civetta*	Tunkun juda	R
	Marsh Mongose	*Atilax paludinosus*		

Key: C = Common, O = Occasional, R = Rare

The results in Table 2 show that the sightings of large mammals still remain high at Kwano Forest of GGNP and these include Olive baboon (n = 21), Putty-nosed monkey (n = 15), Mona monkey (n = 10), Colobus monkey (n = 13), Tantalus monkey (n = 5), Bushbuck (n = 11), Waterbuck (n = 5), Yellow-backed duiker (n = 8), Red-flanked duiker (n = 7) Blue duiker (n = 7), Red river hog (n = 6) and African civet (n = 5).

Table 2. Population Abundance of Large Mammals in Kwano Forest of GGNP

Taxon	Common name	Sightings	Number	Mean	Min	Max	SD
Primates	Olive Baboon	21	318	15.1	1	21	4.8
	Putty-nosed monkey	15	179	11.9	8	15	2.2
	Mona monkey	10	105	10.9	7	13	1.8
	Black-and-white Colobus	13	96	7.4	2	12	3.1
	Tantalus monkey	5	15	3.0	1	6	2.1
Antelopes	Bushbuck	11	15	1.4	1	2	0.5
	Waterbuck	5	7	1.4	1	3	0.9
	Yellow-backed Duiker	8	10	1.3	1	2	0.5
	Red flanked Duiker	7	11	1.6	1	2	0.5
	Blue Duiker	7	10	1.4	1	2	0.5
Pigs	Red river hog	6	21	3.5	1	7	2.3
Carnivores	African Civet	5	8	1.6	1	2	0.5

Species Relative Abundance Index in Kwano Forest of GGNP

The camera trapping results in Table 3 shows a total of twenty-six (26) animal species under seven (7) different taxonomic groups (Primates, Ungulates, Carnivores, Rodents, Pangolins, Aardvark and Potto) in the Kwano Forest. A total of 738 images were obtained with Olive baboon being the highest frequently captured species (n = 157), followed by Yellow-backed duiker (n = 117), Bushbuck (n = 103), Red river hog (n = 68), Crested porcupine (n = 62), Blue duiker (n = 59), African civet (n = 48), Red-flanked duiker (n = 25), Genet (n = 22), Aardvark (n = 20), Chimpanzee (n = 17), Golden cat; Plate I (n = 11), Giant forest hog (n = 8) while Palm civet (n = 4), Tree pangolin, African buffalo were (n = 3), Mona monkey, Marsh mongoose (n = 2), Colobus monkey, Putty-nosed monkey, Tantalus monkey, Waterbuck, Slender mongoose, White-tailed mongoose, Giant pangolin (Plate II) and Common Potto (n = 1) were the least captured species.

Table 3. Checklist and Relative Abundance Index of Mammal Species Camera Trapped in Kwano Forest of GGNP During the Study Period

Taxon	Common name	Latin name	No. of Events	Survey effort	RAI	Naïve occupancy
Primates	Chimpanzee	*Pan troglodytes*	17	1500	1.13	0.47
	Colobus Monkey	*Colobus guereza*	1	1500	0.07	0.07
	Mona Monkey	*Cercopithecus mona*	2	1500	0.13	0.13
	Olive Baboon	*Papio anubis*	157	1500	10.47	1.00
	Putty-nosed Monkey	*Cercopithecus nictitans*	1	1500	0.07	0.07
	Tantalus Monkey	*Chlorocebus tantalus*	1	1500	0.07	0.07
	Common Potto	*Perodicticus potto*	1	1500	0.07	0.07
Ungulates	Bushbuck	*Tragelaphus scriptus*	103	1500	6.87	0.93
	Blue Duiker	*Philantomba monticola*	59	1500	3.93	0.80
	Red-flanked Duiker	*Cephalophus rufilatus*	25	1500	1.67	0.33
	Yellow-backed Duiker	*Cephalophus silvicultor*	117	1500	7.80	0.93
	Waterbuck	*Kobus ellipsiprymnus*	1	1500	0.07	0.07
	African Buffalo	*Syncerus caffer*	3	1500	0.20	0.07
	Red river hog	*Potamochoerus porcus*	68	1500	4.53	0.87
	Giant forest hog	*Hylochoerus meinertzhageni*	8	1500	0.53	0.27
Carnivores	African Civet	*Civettictis civetta*	48	1500	3.2	0.93
	Palm civet	*Nandinia binotata*	4	1500	0.27	0.20
	Golden Cat	*Profelis aurata*	11	1500	1.78	0.33
	Marsh Mongoose	*Atilax paludinosus*	2	1500	0.13	0.07
	Slender Mongoose	*Herpestes sanguineus*	1	1500	0.07	0.07
	White-tailed Mongoose	*Ichneumia albicauda*	1	1500	0.07	0.07
	Genet	*Genetta genetta*	22	1500	1.47	0.60
Rodent	Crested Porcupine	*Hystrix cristata*	62	1500	4.13	0.93
Tubulidentata	Aardvark	*Orycterus afer*	20	1500	1.33	0.73
Philodota	Tree Pangolin	*Phantaginus tricuspis*	3	1500	0.20	0.20
	Giant Pangolin	*Smutsia gigantea*	1	1500	0.07	0.07

Figure 4. African Golden Cat (*Profelis Aurata*) Camera Trapped During the Study

Figure 5. Giant Pangolin (*Smutsia Gigantean)* Camera Trapped During the Study

DISCUSSION

The species richness of large mammals photographed in the study area 26 species as recorded over 1500 trap nights which consist of *Pholidota* (Giant pangolin, Tree pangolin), *Rodentia* (Crested porcupine), *Tubulidentata* (Aardvarks), *Artiodactyla* (Bushbucks, Yellow-backed duiker, Red-flanked duiker, Blue duiker, Waterbuck, African buffalo, Red river hog and Giant forest hog), *Primates* (Chimpanzee, Olive baboon, Colobus monkey, Mona monkey, Tantalus monkey, Putty-nosed monkey, Common potto) and *Carnivora* (African civet, Palm civet, Golden cat, Genet, Marsh mongoose, Slender mongoose, White-tailed mongoose). The presence of several taxa of large mammals in the Kwano forest of GGNP could be an indication of its richness in terms of food availability and abundance as well as excellent habitat conditions. However, this might not be so all over the park as the large number could only be the outcome of effective conservation efforts through uninterrupted surveillance by NGOs staff carrying out research in the forest thereby deterring poaching activities in the study area. The above observations agree with the report of Anthony *et al.* (2007) that excellent habitat conditions that provide abundant food, cover and water in

addition to adequate conservation programmes ensure species richness and abundance in a conservation area. This could also be an indication that the animals have escaped attack from both human and non-human predators due to the rugged nature of the terrain. This observation agrees with the report of Fryxell and Sinclair (1988a) that if a prey species can migrate beyond the range of its main predators, then their populations can escape predator regulation.

The common potto (*Perodicticus potto*) (Plate I) and Giant pangolin (*Smutsia gigantea*) (Plate II) has never been reported in any previous study in the area. This could be as a result of the elusive and nocturnal nature of the animals that makes it difficult to be detected by researchers using other survey techniques in previous studies. The above observation agrees with the report of Tobler *et al.* (2008) that the use of camera trapping for mammal surveys has been found to be one of the most effective methods for studying and inventorying elusive and nocturnal/crepuscular species that are rarely found by other survey techniques. This finding may be an indication that, unwilling to be seen animals are probably yet to be discovered inside GGNP.

CONCLUSION

Our results show that camera-trapping when employed using a large number of camera traps over a sampling period of 100 days can be effective in acquiring baseline data on large terrestrial mammal species richness and composition. The sampling saturation achieved by this study for the Kwano forest of GGNP was relatively high and we obtained numerous (26) records of large terrestrial mammal species, including species that are of management and conservation concern. The use of camera-traps also allowed us to detect mammal species that are rare, cryptic and elusive which otherwise would have been difficult to detect via alternative methods such as direct observation or live trapping. Of particular interest were the Pangolin, Chimpanzee and the Golden Cat which according to the IUCN Red List (2016) are Endangered and Vulnerable respectively. These findings indicate that the Kwano forest and surrounding areas are important habitats for the mammal community. The species photographic rates obtained have provided us with useful information on which species could potentially be monitored with a camera-trapping system in the long run. This information may also be useful as a gauge to monitor the effectiveness of potential conservation management programmes to be established in the GGNP in the near future.

RECOMMENDATIONS

Based on the findings from this study, the following recommendations are proffered.

(1) The park management and NGOs should step up conservation education, employment of the support zone dwellers, and provision of infrastructural and credit facilities and allow for full participation of the support zone dwellers in the management of the park. These will hopefully generate the support of the residents of the support zone towards the conservation project.

(2) There should be a periodic monitoring program to monitor large mammals in the GGNP and surrounding. This will ensure evaluation of the population trend of the animals in the park.
(3) Rangers' posts should be constructed in all the ranges of the park to boost anti-poaching patrols which should be supplemented by Rangers' refresher courses. This is to help the park's protection unit to maintain a viable and gallant team of Rangers to ensure deterrence of poaching activities in the park.

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