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Pattern of Occurrence, Abundance and Threats to the Common Hippopotamus (*Hippopotamus amphibious*) along Oli River, Kainji Lake National Park, Nigeria

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ABSTRACT
This study determined the common hippopotamus occupancy, abundance and threats in Kainji Lake National Park (KLNP), Nigeria. Data obtained through line transect method, point count method and oral interview were analyzed using descriptive statistics, ANOVA and QGIS. Six pools along the Oli river were occupied by Hippopotami during the dry season. The mean population size for hippos during the late dry season was 22±1.35 (84% adults and 16% calves) with a population density of 0.69hippo/km, while the early rainy season mean population size was 4±0.00 (100% adults). The difference in the mean number of hippos was significant at $P<0.05$ across the pools. Hippopotamus in KLNP are threatened by poaching, pollution, uncontrolled burning, and severe weather condition. The number of hippos recorded was low, and may be connected to the varying threat factors impacting the population. There is a potential of future increase, if the threats are greatly reduced or eliminated.

Keywords: Hippopotamus, occupancy, abundance, threats

INTRODUCTION
Conservation of wildlife is in crisis as species are declining worldwide. The major causes of declines in wildlife in developing countries are human population growth, habitat fragmentation, inadequate land use practices and management, lack of economic alternatives, social and political conflicts, and unsustainable use of resources (Kideghesho *et al.*, 2007; Plumptre *et al.*, 2008). Assessment of wildlife populations, distribution and ecology is an important way to determine the sources and impacts of human actions on natural environment and to understand the natural rates of wildlife changes (Balmford *et al*., 2003). Monitoring the distribution, abundance and ecology of large mammals like hippopotamus is a prerequisite for better management because they can detect the ecosystem health (Wanyama *et al*., 2009).

Hippopotami are even-toed ungulates, hoofed mammals in the order Artiodactyla. The name hippopotamus comes from the Greek words 'hippos' and 'potamus' meaning horse and river respectively. Members of the family Hippopotamidae are non-ruminants artiodactyls whose mode of life makes them unique in Africa among the large mammals

(Cerling *et al.,* 2008). The common hippopotamus (*Hippopotamus amphibious)* is a semi-aquatic artiodactyl of sub-Saharan Africa and, historically, was widely distributed throughout the region (Feldhake, 2005; Lewison and Oliver, 2008). Common hippopotamus is the third largest herbivorous African mammal next to African elephant (*Loxodonta africana)* and Rhinoceros (*Diceros bicornis*).

Lewison and Pluhacek (2017) reported that an estimated global population of 115,000 - 130,000 individuals currently occurs in fragmented populations in rivers, lakes and other wetlands of eastern, western and southern Africa. Of the 36 countries where the common hippopotamus is known to occur, 20 have confirmed declining populations, seven (including Nigeria) have populations of unknown status, nine have stable populations and three (Algeria, Egypt and Mauritania) have experienced recent extinctions. Based on the estimated global population, coupled with intensifying threats of poaching for meat and ivory from the large canines and incisors (Lewison, 2007; Williamson, 2004), progressive habitat loss and persecution because of conflicts with people, the hippopotamus was still categorized as Vulnerable on the IUCN Red List in 2016 (Lewison and Pluhacek, 2017). It was found that populations most at risk were those in West Africa, where the distribution was particularly fragmented (Lewison, 2007). Trampling and crop raiding by hippopotami led to early and determined efforts to exterminate them (Herbison and Frame, 2008; Kendall, 2011). As a result, the Convention on International Trade in Endangered species of Wild Fauna and Flora (CITES), has placed hippopotamus in Appendix II where international trade is regulated through issuance of CITES permits and conducting non detriment findings which facilitates setting of sustainable quotas.

Protected areas have been regarded as pillars for global conservation efforts (Craigie *et al*., 2010). Across the world, the number of tourists seeking interactions with wildlife in their natural environment is increasing and there is a significant literature describing the revenues generated from wildlife tourism (Ayodele, 2002; Meduna *et al.,* 2005; Lindsey *et al.,* 2007). Thuiller *et al*., (2006) noted that National Parks are among the key conservation areas for protecting species. Kainji Lake National Park (KLNP) is one of the few protected areas in Nigeria set aside for biodiversity conservation and known to be a frequently visited destinations for nature based tourism. The choice of visiting the park stems from the array of fauna resources of the park; especially the hippopotamus, and the scenic view of the riparian forest around the Oli river, hence the need to estimate density of hippopotami in Kainji Lake National Park. Therefore, a detailed knowledge of the distribution, ecology and threats is needed in order to effectively protect the common hippo in KLNP and provide requisite information for future research on the species within the park and hippopotamus conservation in Nigeria at large.

MATERIALS AND METHODS

Study Area

Kainji Lake National Park is located between latitude $9^0\ 40^1$ and $10^{\ 0}\ 30^1$N and longitude $3\ 50^1$ E and has a total land mass of 5,370.82km^2 (Figure 1). The establishment of KLNP in 1976 marked the first attempt at managing wildlife for recreation in Nigeria. Kainji Lake National Park has a savanna climate. Night temperature can be as low as 7^{o}C near Oli river. The drainage system in the two sectors of Kainji Lake National Park is maintained by the Oli, Menai and Doro Rivers (Borgu sector) and Manyara and Nuwa Zurugi Rivers (Zurguma sector). The two major features of the climate of the park are the division into wet and dry seasons and the

variability from year to year. The wet season extends from May to October. The mean annual rainfall varies from 1,100mm in the eastern part to 1,200mm in the western part. The lowest temperature of the park of about 10^{o}C occurs between December and January, and the highest mean maximum temperature occurs during months of February, March and April and is about 30^{o}C. The trend surface analysis of the mean annual rainfall in Borgu sector indicates a decrease in rainfall from the south to the north and increasing rainfall toward the west and east (Milligan, 1978). KLNP harbours diverse fauna resources, and notable among them are Baboon, Patas monkey, Green monkey, Lion, Buffalo, Grimm's Duiker, Warthog, Red flanked Duiker and Hippo.

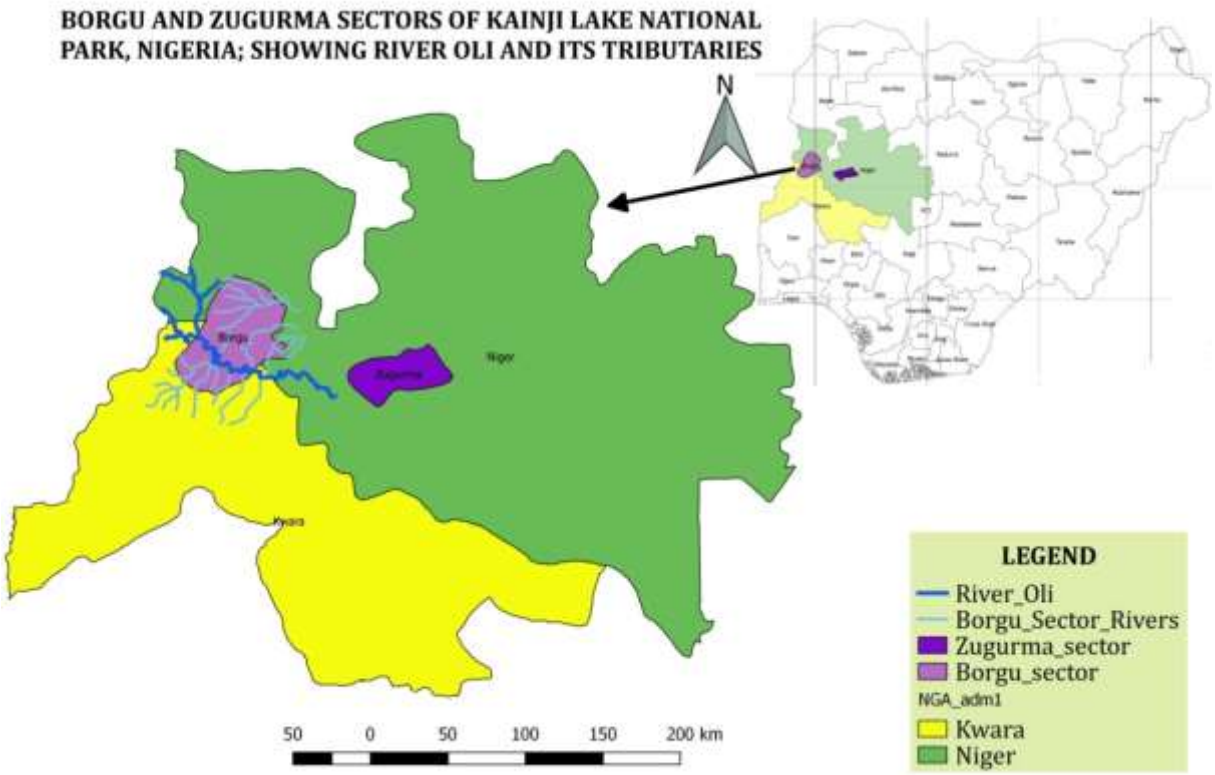

Figure 1: Map of Kainji Lake National Park showing Oli river and its tributories

Data Collection

Determination of hippopotamus distribution along Oli river

The distribution of hippopotamus along Oli river (the only perennial River) was assessed using line transect method as described by Stommer *et al.* (2016). The research team moved along the river bank to document the number of pools and to identify those occupied by hippo, where detailed survey (hippo counting) was carried out. A total of 32km shore length was covered along Oli river and surveyed repeatedly for one week per month. During the survey, the following information were collected: number of pools formed along the river, number of pools occupied by hippo, the size-surface area of the pools, signs of hippo presence such as grazing activity, fecal dropping, footprints and hippo trail. Also recorded were, the presence of human activities such as hunter's camp, spent cartridge, fishermen camp, fishing nets set and

sign/odour of chemicals used in fishing as well as signs of dead fishes on water surface. The GPS coordinates of the pools occupied by hippo was recorded. This was done for a period of five months, from January to May, 2018 covering late dry season and early wet season.

Estimating the population structure and density of hippopotamus

Ground count survey through point count/scanning method as described by kanga *et al*. (2011) was adopted for determination of hippopotamus abundance in the identified hippo pools along Oli river between January to May, on 30 survey days in the year 2018 both during mornings (7-10am) and evenings (3-6pm) surveys. This period was chosen because it spanned the dry season when water levels in the river are lowest and visibility of hippopotamuses in the water is highest. Hippos were counted by scanning each pool at three monitoring points for at least twenty minutes using binoculars. This minimum observation period was used because hippos can stay submerged for up to seven minutes (Leivestad *et al.,* 1973). Upon sighting individuals or groups of hippopotamuses at each hippo pool, the group size, number of adults and number of calves were recorded. Calves were distinguished by their small body size relative to adults.

The mean population size and density of common hippopotamus were calculated using the formula described by Onyango and Plews, (2005) as follows:

a) Mean Population size = Σx/n **……**Equation 1
   Where:
   Σ*x* is the sum of values (number of hippos recorded per count); and
   n is the number of observations
b) Hippopotamus population density was calculated as follows:

D = N/ L**……...**Equation 2
   Where:
   D is density;
   N is the number of hippopotami; and
   L is the shore length.

Identifying threats to hippo in KLNP

The level of threats to the hippopotamus population was assessed by direct field observation and oral interview while secondary data from record of arrest was also collected from the park. Field observation was carried out to determine the presence of anthropogenic activities like hunting, fishing, cattle grazing, farming, late burning etc (Ertiban, 2016). Also presence of human activities such as hunter's camp, spent cartridge, fishermen camp, fishing nets set and sign/odour of chemicals used in fishing as well as signs of dead fishes on water surface was recorded. Oral interview was conducted with the park rangers and secondary data from administrative records (threats recorded, nature of threat, frequency of threat) at the litigation unit was also collected (Chomba, 2013).

Data Analysis

Data analysis was carried out using the statistical package SPSS for Windows, version 20 and were presented with descriptive statistics such as tables and frequencies. ANOVA was used to compare the difference between the abundance of hippos at the different monitoring locations while regression analysis was done to check whether hippo abundance is dependent on pool size (water surface area). GPS points were analyzed and mapped using QGIS.

RESULTS

Spatial Distribution of Hippopotamus along Oli River

A total of 20 pools with water surface area not less than 6,000 square meters was recorded during the study. However, Hippopotami were observed to occupy six pools along the Oli river during the dry season. Hippos were sighted at the pools at kilometers 3, 5, 8, 12 and 28 from the Oli base camp; along the Shehu Shagari track, and were also sighted at the Zaure hippo pool, but during the early rainy season, hippos were only sighted directly at kilometres 5 and 8 in less number. The monitoring locations, GPS coordinates and surface area of each pool are as shown in Table 1.

Table 1: GPS coordinates of the Kainji Lake National Park dry season hippo pools and their surface area

S/N	HIPPO POOL	LATITUDE (°N)	LONGITUDE (°E)	SURFACE AREA (M^2)
1	Km 3	9.90316	3.97343	11,993
2	Km 5	9.91157	3.95355	9,595
3	Km 8	9.90059	3.99532	9,345
4	Km 12	9.8878	4.0121	8,995
5	Km 28	9.91301	3.95542	13,792
6	Zaure	9.90728	3.94138	6,996

Fresh hippo signs (hippo trails, footprints and dung) were observed along the river bank in both seasons. The most recorded signs were the foot prints (53.8%), followed by the hippo trails and dung having 23.1% occurrence each (Plate 1). Figure 2 shows the distribution of hippopotamus along the river.

Plate 1 : Foot prints (left) and fecal droppings (right) of common hippos in KLNP

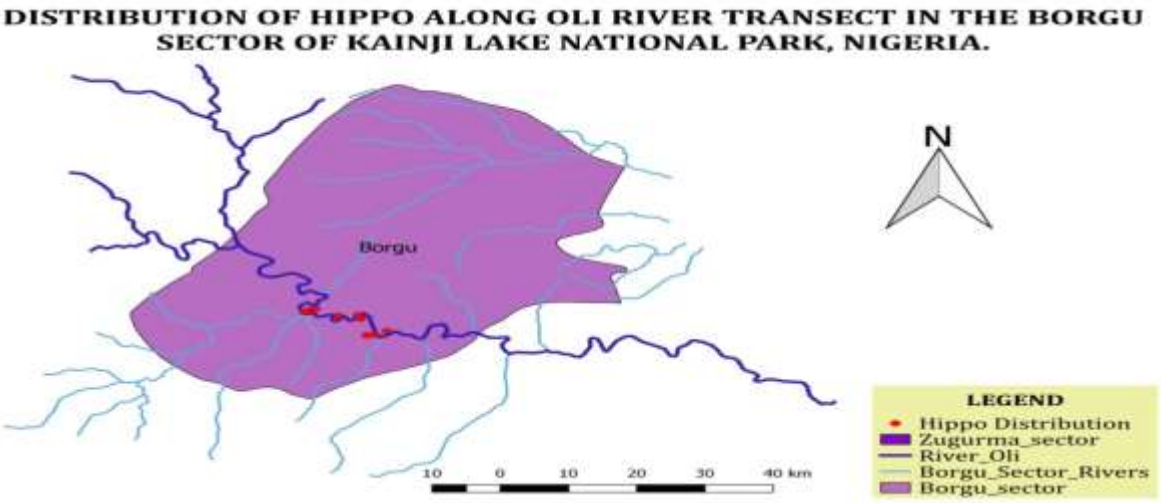

Figure 2: Distribution of common hippo along the Oli river in Kainji Lake National Park, Nigeria

Hippo Abundance and Age Population Structure

The mean population size of the hippos during the late dry season was 22±1.35; comprising 84% adults and 16% calves, while the early rainy season mean population size stood at 4±0.00; comprising 100% adults and no calves, as shown in Table 2 and Figures 3 and 4. The population density during the late dry season was 0.69/km and at the early wet season was 0.13/km.

Table 2: Summary of hippo abundance

LOCATION	Pool size (M^2)	LATE DRY SEASON MEAN ABUNDANCE	EARLY RAINY SEASON MEAN ABUNDANCE
Km 3	11,993	3±0.13	0
Km 5	9,595	3±0.06	2±0.00
Km 8	9,345	2±0.05	2±0.00
Km 12	8,995	5±1.22	0
Km 28	13,792	6±0.53	0
Zaure	6,996	3±0.025	0
TOTAL		22±1.35	4±0.00

The mean hippo abundance at each of the hippo pools statistically and significantly varied across the locations and between seasons (Zeros inflated Negative binomial model, log-likelihood ratio test, test statistic=176.71, n=192, P<0.0001), with the hippo pools at km 5,12 and 28 being more significantly different from the other hippo pools as shown in Tables 3 and 4.

Table 3: Test of Model Effects for hippo abundance in each of the location between the two seasons

Source	**Wald Chi-Square**	**df**	**P-value**
Season	155.14	1	0.00
Location	30.88	5	0.00

Dependent variable: Hippo abundance Model: Season, Location

Table 4: Mean Hippo abundance between locations across seasons

Location	**Wald Chi-Square**	**df**	**P-value**
Km 3	1.39	1	0.24
Km 5	10.22	1	0.00
Km 8	1.86	1	0.17
Km 12	11.61	1	0.00
Km 28	20.79	1	0.00
Zaure	-	-	-

The mean value is statistically different at $P<0.05$

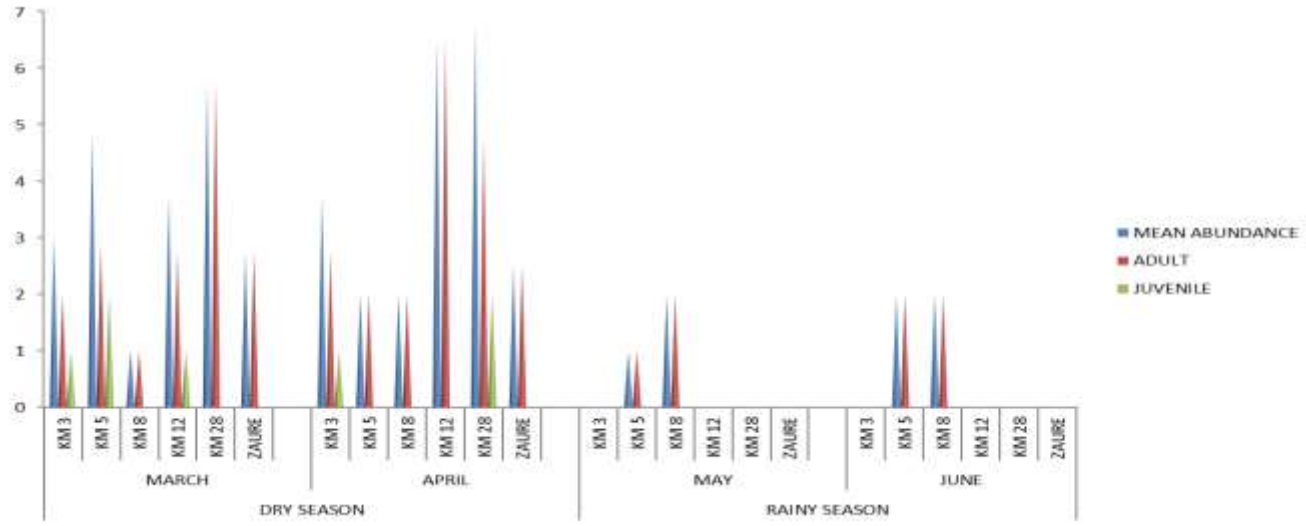

Figure 3: Age population structure (Mean) of hippopotamus at the different pools in Kainji Lake National Park

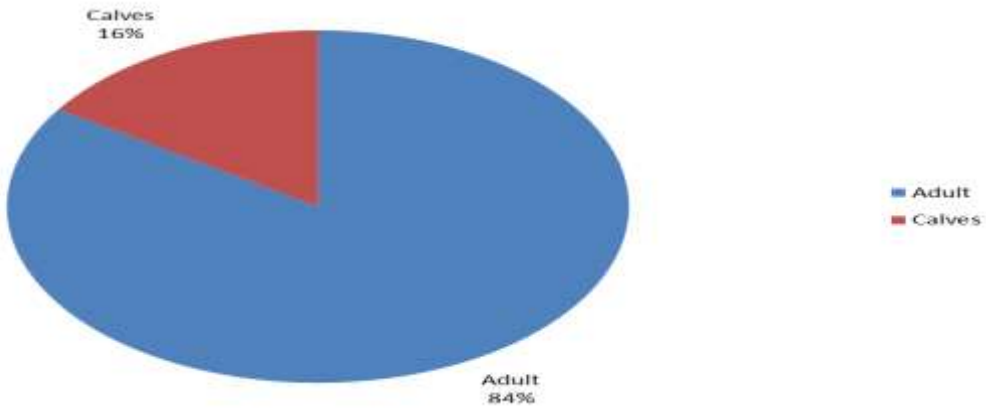

Figure 4: Age structure of hippopotamus recorded along Oli river in KLNP during the study

Plate 2: Common hippos in Oli River, KLNP

Threats to common hippos in KLNP

Direct field observation, administrative records and interviews showed that common hippopotamus in Kainji Lake National Park are faced with threats in form of poaching, pollution, uncontrolled burning and severe weather condition. Records from the park litigation unit and field observation showed

that hippos of the park have been faced with series of poaching activities in the past few years; with the most recent one happening in the course of this study (Plate 6). 75% of hippo deaths were recorded as a result of poaching activities, while the 25% was attributed to an unknown course. Also, presence of human activities such as hunter's camp, spent cartridge, fishermen camp, fishing nets set and sign/odour of chemicals used in fishing as well as signs of dead fishes on water surface were recorded (Table 5). More so, inadequate food materials within the park due to severe weather condition and uncontrolled burning leads to the migration of hippos to larger water bodies and farmlands as well as communities outside the park, which exposes the species to human-wildlife conflicts.

Table 5: Identified hippo threat factors in Kainji Lake National Park

Threat factors	Frequency of Occurrence	Ranking	Means of Identification
Active fishing net	22	1st	Field observation
Gunshots	12	4th	Field observation
Fishermen camp	5	6th	Field observation
Spent Cartridge	14	3rd	Field observation
Poacher's fire	2	8th	Field observation
Hunter's camp	4	7th	Field observtion
Hippo killing	1	9th	
Polluted pools	7	5th	
Sand dunes from erosion	15	2nd	

Plate 3: Poachers activity at marguba range in Kainji Lake National Park

Plate 4: Poachers' fishing net recovered during anti-poaching patrol

Plate 5: Hippo killed outside the park boundary
Source : From social media

DISCUSSION

Spatial Distribution of Hippopotamus along the River bank

When the water level in the rivers within the park becomes very low during the dry season and break into pools, the hippos are forced to occupy only the Oli river to look for the pools that have enough water to meet their daily need, thereby occupying some pools in groups, while some individuals move out of the park in search of deeper waters and fresh food materials. This is in support of Christopher (2012) and other previous studies that reported that hippo species depend highly on water for its daily activities, with dependency on physical requirements like appropriate water level, size and the riparian forest cover. Hippos in Kainji Lake National Park are widely distributed along the Oli river. At both seasons, activities of the hippos are seen along the river and far into the upland areas where they visit for grazing and other activities. Hippo trails, foot prints and dung were the major activities seen in the course of this study. In line with the observation of Stommel *et al.* (2016), the distribution of hippos during the dry season favoured the pools with larger amount of still water or water moving at a low current and parts of the river that have dense riparian forest cover that helps to shield the pools from the excessive heat of the sun; as was observed along the river at km 12 and 28. The upstream part of the river; as it takes it flow from the Republic of Benin had shallow pools during the late dry season and continued to the downstream where the pool size increased and emptied into the lake Kainji. At this time, though their night foraging activities were seen upstream, the hippos of the park populated the downstream where they had enough water for their daytime rest. Minimum inter-individual distances or maximum aggregations were recorded during the dry season, and as the wet season advanced, there was less aggregation as water receded, as supported by Christopher (2012). This dry season aggregation tends to put serious pressure on the quality and quantity of the forage resources available within or close to their habitat, and may expose individuals to conflicts within the group or make them move out of the park in search of food. During the rainy season, the water level in the major river increased and the hippos became free to move from one part of the park to the other, and sometimes, move out of the park along the river channel. The water current at some of the monitoring locations probably became too high for the hippos, making it a little bit difficult to say precisely where the hippos can be found at any particular time, as supported by the earlier report of Christopher (2012) that stated that during the wet season, hippopotami spread out, possibly to avoid deeper and fast moving

waters and increased distances exist between them, unlike during the dry season when they can be easily located at their dry season pools.

Hippo Abundance and Age Population Structure

Hippo abundance varied significantly between seasons and locations. The ratio of hippos sighted between the late dry season and early rainy season stood at about 6:1; informing the most appropriate time to bring visitors in for hippo viewing. Christopher (2012) reported that during the wet season, hippos spend more day time actively feeding, hence a more spread activity budget over the times of the day. This may account for the smaller number of hippos found at the monitoring locations during the early rainy season. It was observed that the hippo pool at Km 28 that was known to accommodate the largest number of hippos during the dry season because of its large pool size became inconvenient for the hippos as the water current increased at the start of the rainy season, and hippos moved out of the location. The presence of the minimum of 22 hippos within the park; with about 16% being the young calves showed that the environmental conditions within their habitat were favourable enough for breeding; requiring that proper management plans be put in place to maintain a healthy population of the species. Consistent with the findings of Stommel *et al.* (2016) and other studies on other hippo populations in Africa, the results of this work indicate that highest mean population was observed at the monitoring location with the highest water surface area during the late dry season.

Threats to common hippos in KLNP

In line with previous studies (Graham, *et al.*, 2002; Lewison and Oliver, 2008) that have suggested that habitat loss and poaching are the biggest threat to hippos, poaching activities for bush meat sales and consumption contributed the biggest threat to the hippos of Kainji Lake National Park as observed in the course of this study; with several threat factors pointing to high hunting pressure. Seasonal changes in water level of the part of the river within the park boundary increased the rate of exposure of the hippos to further threats outside the park. Severe weather condition resulting in increase in temperature and inadequate food materials also adersely affect the species, as hippos were also observed to move out of the park in search of fresh forage resources during the dry season, which also contributed a level of threat to their safety.

CONCLUSION

This study has shown that common hippopotamus is one of the large mammals that can still be readily found in Kainji Lake National Park, all year round, but at more specific locations during the dry season. Evidence of reproduction as shown by the presence of juveniles indicates that they have a population that has the ability to grow sustainably if proper management practices are focused on their safety and perpetuation. The information that this study provides on the abundance and distribution of the hippos of KLNP forms a step in the right direction at documenting the relevant information long required by the IUCN to conserve common hippopotamus within their natural ranges in Nigeria and other part of the sub Sahara Africa. The populations and locations of hippos at specific time of the year that this study has revealed can benefit the ecotourism sector of the park in taking visitors for hippo viewing, as informed by the most appropriate period of the year when visitors can be assured of enjoying the scenic view of this species, since seasonal changes have been confirmed to affect the spatial and temporal activities of the hippos of KLNP.

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