AN ASSESSMENT OF THE TERRESTRIAL LARGE MAMMALS POPULATION ABUNDANCE, CONSERVATION STATUS AND CHALLENGES OF MANAGEMENT IN A WEST AFRICAN PROTECTED AREA

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LIST OF ABBREVIATIONS

ABCG	Africa Biodiversity Collaborative Group
AESR	African Elephant Study Report Agency
AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
AOO	Area of Occupancy
BCTF	Bushmeat Crisis Task Force
BSP	Biodiversity Support Project
CAR	Central African Republic
CARPE	Central African Regional Program for the Environment
CBD	Convention on Biological Diversity
CDS	Conventional Distance Sampling
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Floara
CR	Critically Endangered
DD	Data Deficient
DRC	Democratic Republic of Congo
EN	Endangered
EOO	Extent of Occurrence
FNBR	Nigeria Fifth National Biodiversity Report
GPS	Global Positioning System
IGCP	International Gorilla Conservation Program
IUCN	International Union for Conservation of Nature
LC	Least Concern
LRA	Lord's Resistance Army
NBSAP	National Biodiversity Strategy and Action Plan

NCF	Nigerian Conservation Forum
NESREA	National Environmental Standards and Regulations Enforcement
NGOs	Non-Governmental Organizations
NNPS	Nigerian National Park Service
NT	Near Threatened
OONP	Old Oyo National Park
PAs	Protected Areas
RO	Range Officer
SPSS	Statistical Package for the Social Sciences
VU	Vulnerable
WCS	Wildlife Conservation Society
WHS	World Heritage Sites

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PENILAIAN KELIMPAHAN POPULASI MAMALIA BESAR DARATAN, STATUS PEMULIHARAAN, DAN CABARAN PENGURUSAN DI KAWASAN LINDUNGAN AFRIKA BARAT

ABSTRAK

Penurunan global mamalia besar diakui secara meluas sebagai ancaman utama terhadap ekosistem dunia. Di Afrika Barat dan Tengah, mamalia besar terestrial khususnya terancam akibat perdagangan dan penggunaan. Namun begitu, maklumat kuantitatif dan saintifik mengenai status populasi serta pemuliharaan mamalia besar terestrial dalam kawasan perlindungan di Nigeria masih sangat terhad atau hampir tiada. Kajian ini bertujuan untuk mengurangkan jurang maklumat tersebut. Dalam kajian ini, kelimpahan, status pemuliharaan, taburan populasi bermusim, serta pengaruh faktor pemburuan haram dan vegetasi terhadap mamalia besar terestrial telah dinilai di Taman Negara Old Oyo, Nigeria pada tahun 2022. Data dikumpul menggunakan kaedah pensampelan jarak transek garis, rekod pangkalan data taman, serta tinjauan soal selidik. Sebanyak tiga puluh sembilan (39) transek berjalan telah ditubuhkan secara rawak merentasi enam jajahan pentadbiran taman tersebut. Analisis pensampelan jarak menganggarkan kelimpahan mamalia besar terestrial pada 5,241 ± 2,049 individu, dengan kepadatan 11.96 ± 6.03 individu setiap km². Berdasarkan garis panduan IUCN bagi penilaian status pemuliharaan tempatan, 12 spesies yang direkodkan dikategorikan seperti berikut: satu Rentan (VU), sepuluh Hampir Terancam (NT), dan satu Paling Tidak Membimbangkan (LC). Perbezaan bermusim menunjukkan perubahan taburan spesies, khususnya di jajahan Marguba. Pada musim kering, perubahan ini didapati sangat berkait rapat dengan aktiviti pemburuan haram, manakala pada musim hujan, penyebaran spesies lebih dipengaruhi oleh faktor

vegetasi. Tanda-tanda ancaman pemburuan yang direkodkan sepanjang transek menunjukkan kadar pertemuan yang jauh lebih tinggi pada musim kering berbanding musim hujan, mencerminkan tekanan pemburuan yang lebih serius pada musim kering. Analisis Model Linear Tergeneralis (GLM) turut mengesahkan bahawa faktor pemburuan sangat mempengaruhi taburan spesies merentasi jajahan dan sub-habitat pada musim kering. Sebaliknya, vegetasi (diukur melalui NDVI) merupakan peramal terkuat kepada penyebaran spesies pada musim hujan, menunjukkan tekanan pemburuan yang lebih rendah pada tempoh tersebut. Rekod tangkapan pemburu haram turut menyokong dapatan ini: jumlah tangkapan berkaitan aktiviti memburu dan meragut sentiasa lebih tinggi pada musim kering, mencerminkan kemasukan lebih ramai pemburu serta selari dengan ramalan model GLM. Berdasarkan persepsi kakitangan, cabaran kepada penguatkuasaan undang-undang termasuklah kelemahan pelaksanaan dasar, pemantauan hidupan liar yang lemah, sokongan perundangan serta kehakiman yang terhad, dan kekangan institusi. Ancaman baharu yang timbul ialah cubaan kumpulan penjenayah bersenjata untuk menduduki sebahagian kawasan taman. Usaha rondaan antipemburuan renjer turut terjejas akibat kekurangan senjata, peralatan, motivasi dan sokongan institusi. Secara keseluruhannya, penyelidikan ini memberikan pandangan penting mengenai demografi serta corak taburan bermusim mamalia besar terestrial di Taman Negara Old Oyo, khususnya berhubung faktor pemburuan haram dan dinamik vegetasi. Hasil kajian ini boleh dijadikan asas dalam pembangunan strategi pemuliharaan di peringkat tempatan dan kebangsaan. Memandangkan kekurangan maklumat kuantitatif mengenai populasi mamalia besar Nigeria dalam kawasan perlindungan, usaha pemuliharaan pada masa hadapan akan banyak mendapat manfaat daripada kajian ini. Akhir sekali, penggunaan kategori dan

kriteria IUCN di peringkat tempatan serta kebangsaan adalah penting untuk memastikan pemuliharaan spesies di Nigeria lebih berkesan.

AN ASSESSMENT OF THE TERRESTRIAL LARGE MAMMALS POPULATION ABUNDANCE, CONSERVATION STATUS AND CHALLENGES OF MANAGEMENT IN A WEST AFRICAN PROTECTED AREA

ABSTRACT

The global decline of large mammals is widely acknowledged as a major threat to ecosystems worldwide. In West and Central Africa, terrestrial large mammals are particularly threatened by trade and consumption. However, quantitative and scientific information on the population status and conservation of terrestrial large mammals within protected areas in Nigeria is either scarce or extremely limited. This research seeks to help close that information gap. In this study, the abundance, conservation status, seasonal population distribution, and the influence of poaching and vegetation factors on terrestrial large mammals were assessed in Old Oyo National Park, Nigeria, in 2022. Data were collected using line-transect distance sampling, records from the park's database, and questionnaire surveys. A total of thirty-nine (39) walking transects were randomly established across six administrative ranges of the park. Distance sampling analysis estimated the abundance of terrestrial large mammals at 5,241 ± 2,049 individuals, with a density of 11.96 ± 6.03 individuals per km². Based on IUCN guidelines for local conservation status assessment, the 12 species recorded were classified as follows: one Vulnerable (VU), ten Near Threatened (NT), and one Least Concern (LC). Seasonal variations indicated shifts in species abundance, particularly in the Marguba range. During the dry season, these shifts were strongly associated with poaching, while in the wet season, species dispersal was more strongly predicted by vegetation factors. Poaching threat signs recorded along transects showed a

significantly higher encounter rate in the dry season compared to the wet season, suggesting greater poaching pressure during the dry months. Generalized Linear Model (GLM) analysis confirmed that poaching factors strongly influenced species distribution across ranges and sub-habitats in the dry season. Conversely, vegetation (measured using NDVI) was the strongest predictor of species dispersal in the wet season, indicating lower poaching pressure during that period. Poaching arrest records further supported these findings: higher numbers of arrests related to hunting and grazing were consistently recorded during the dry season, reflecting an influx of poachers and aligning with GLM predictions. Based on staff perceptions, challenges to effective law enforcement include inadequate implementation of policies, weak wildlife monitoring, insufficient legislation and judicial support, and limited institutional capacity. An emerging threat is the occupation of parts of the park by armed bandits. Rangers' anti-poaching efforts are hampered by a lack of adequate weapons, equipment, motivation, and institutional support. Overall, this research provides valuable insights into the demographics and seasonal distribution patterns of terrestrial large mammals in Old Oyo National Park, highlighting the critical roles of poaching and vegetation dynamics. The findings can inform the development of local and national conservation strategies. Given the scarcity of quantitative information on Nigeria's large mammal populations in protected areas, future conservation efforts will benefit greatly from this study. Finally, the application of IUCN categories and criteria at both local and national levels is essential for effective species conservation in Nigeria.

CHAPTER 1

INTRODUCTION

1.1 The Terrestrial Large Mammals

Among the terrestrial vertebrate taxa, large mammals play prominent roles in world ecosystems (Burak and Safak, 2020). Among these roles, large herbivores act as considerable modifiers of primary production, nutrient cycles and soil properties (Ripple et al, 2015) and large carnivores play a major role of shaping and regulating population of species they prey on (Bottelo et al, 2018). Home range sizes of large mammal species are relatively bigger than those of other vertebrates, and hence they require large, uninterrupted ecosystems for feeding and breeding (Fuller et al, 2016) and they take longer period to reach sexual maturity, have longer gestation periods and interbirth intervals and have relatively fewer offspring over their lifespan compared to smaller bodied species (Fuller et al, 2016; Wilkie et al, 2016).Terrestrial mammals range in size from 0.003 to 6,500kg (Biewener, 1989; Newmark, 1996 Skinner and Chimimba, 2005). The threshold size criterion for large mammals had been variously put at adult weight 2-7kg (Anadu, 1987; Pardo et al, 2018; Fetene et al, 2019; Legese et al, 2019; Burak and Safak, 2020; Kassa and Tekalign, 2022).

1.2 Terrestrial Large Mammal of Nigeria

Nigeria has a very rich and diverse mammalian fauna; 274 species are known of existence and it is probably that more species may be found, especially in the montane and forested regions (Ladan, 2018). Wild large mammalian species with International Union for Conservation of Nature (IUCN) global threaten category in Nigeria include; Gorilla *(Gorilla gorilla)*, West African Manatee *(Trichechus*

senegalensis), Chimpanzee *(Pan troglodytes ellioti),* White-thighed Colobus (*Colobus vellerosus (probably extinct in Nigeria)*), Olive Colobus (*Procolobus verus*), White-collared Mangabey (*Cercocebus torquatus*), Preuss's Red Colobus (*Procolobus preussi*), Drill Mandrillus (*I. leucophaeus*), Sclater's Monkey (*Cercopithecus sclateri*), Red-eared Monkey (*Cercopithecus erythrotis*), White-throated Monkey (*Cercopithecus erythrogaster*), African Wild Dog (*Lycaon pictus*), Lion (*Panthera leo*), African Golden Cat (*Caracal aurata*), Western Mountain Reedbuck (*Redunca fulvorufula adamauae*), Western Klipspringer (*Oreotragus oreotragus porteousi*), Western Hartebeest (*Alcelaphus buselaphus major*), Roan Antelope (*Hippotragus equinus*), Ogilby's Duiker (*Cephahlopus ogilbyi*) (Mallon et al, 2015). Occurrence of mammalian species might vary between protected areas within the same country (Risdianto et al, 2016). For example, Lion (*Panthera leo*) is known to exist currently only in Kainji Lake National Park and Yankari Game Reserve (Henschel et al, 2010) and Gorilla *(Gorilla gorilla)* and Chimpanzee *(Pan troglodytes ellioti)* only in Cross River National Park in Nigeria (Mallon et al 2015). Barely all of the National Parks in Nigeria do not have estimate of current population size of wild terrestrial large mammals.

Nigeria has no national red list and criteria for assessing extinction risk of its wildlife species and also application of International Union for Conservation of Nature (IUCN) Guidelines and criteria for regional and national assessment of extinction risk is extremely rare. Therefore, Nigeria largely relies on International Union for Conservation of Nature (IUCN) Global Red List of threatened species for reporting its biodiversity Conservation status which is more of global context (Imarhiagbe et al, 2020). There is general consensus that information about current biodiversity status, basic and applied indigenous research are grossly lacking (National Biodiversity

Report, 2010, 2015) and are extremely important for local and national conservation planning, policy design, priority, strategy and action plan. Presently, local conservation status of many wild terrestrial large mammalian species is not known in most of the Nigerian protected areas.

As far as the available literature consulted no report available on seasonal migration of terrestrial large mammals between protected areas or seasonal distribution within protected area in Nigeria. Ungulates migrate for seasonally changing food quantity, phenology, and accessibility to seasonal critically limiting resources such as water and nutrients, seasonal escape from predators, parasites or insect harassment (Bolger et al, 2008). African wild ungulates intensively compete with livestock (cattle) during dry season and competition free during wet season (Odadi et al, 2011). Macroparasites infection heightened during wet season while stress hormones mainly apex in the dry season among African wild ungulates more especially in zebra (Cizauskas et al, 2015).

Human population growth has been recognized as an indirect driver of wildlife threat which connotes higher demand for wildlife resources. Nigeria is the most populous country in African and has one of the highest growth rates in the world. The population of Nigeria is estimated at 223,804,632 people as at 2023 projected to 377,459,883 by 2050 (United Nations). More than 70% of Nigerians live in rural areas. Nigeria's large population is characterized by high percentages of illiteracy, unemployment and poverty, which act as powerful drivers of increasingly severe demands on the wildlife resources. This increased population is associated with urbanization; Towns are becoming larger, new villages are being established; insecurity prevails, farms and wood cutting activities are extending further and further

from each settlement. New roads and tracks enable farming, hunting and wood cutting to occur in previously undisturbed habitats (Imarhiagbe et al, 2020).

Extirpations of local populations and decline in abundance of terrestrial large mammals is widespread even in species not close to extinction (Johnson et al, 2017; Braby et al, 2021). Wild terrestrial large mammals serve as source of food, cloth, income to many households especially in Africa, Asia and South America where illegal and unsustainable harvesting of wildlife is common (Ripple et al, 2016; Wilkie et al, 2016). It is also use for traditional medicine and cultural celebrations among some ethnic groups in Africa (Dery et al, 2022). Nigeria is one of the West African countries where wildlife are important source of protein, perhaps most especially to larger rural populations within and around protected areas. Anthropogenic pressure might vary between protected areas within the same country (Risdianto et al, 2016). Wildlife in almost all protected areas in Nigeria is under immense threat pressure from anthropogenic activities majorly in form of overexploitation of wildlife, habitat disturbance and destruction, climate change, invasive species and pollution. Unsustainable illegal removal of wildlife resources for livelihood and economy in form of hunting for bushmeat consumption and trade, live wild animal trade and wildlife parts trafficking are most important pressure on wildlife and management challenges of wildlife in Nigerian protected areas.

Protected areas in Nigeria faces various challenges in efforts to conserve wildlife and management within their boundaries. The challenges include wildlife conservation policies implementation, poaching, violent bandits who use the forests as a hideaway, lack of proper wildlife monitoring, lack of funds, lack of support, shortage of personnel, lack of equipment for law enforcement, lack of prosecution of wildlife crime, weak and out-dated laws.

1.3 Terrestrial Large Mammals Species in Old Oyo National Park

Historically, Old Oyo National Park (OONP) refuge many species of terrestrial large mammals. Almost all of the top predators and other mega faunas such as Elephant and Buffalo had historic presence (Akinsoratan, 2017). Very recently, wild terrestrial large mammals recorded from camera trap include; Aardvark (*Orycteropus afer*), African civet (*Civettictis civetta*), Bushbuck (*Tragelaphus scriptus*), Bush pig (*Potamochoerus larvatus*), Cane rat (*Thryonomys*), Caracal (*Caracal caracal*), Crested porcupine (*Hystrix cristata*), Giant pouched rat (*Cricetomys*), Ground pangolin (*Smutsia temminckii*), Kob (*Kobus kob*), Long-snouted mongoose (*Herpestes naso*), Maxwell's duiker (*Philantomba maxwellii*), Olive baboon (*Papio anubis*), Oribi (*Ourebia ourebi*), Patas monkey (*Erythrocebus patas*), Red-flanked duiker (*Cephalophus rufilatus*), Roan antelope (*Hippotragus equinus*), Scrub hare (*Lepus saxatilis*), Side-stripped jackal (*Lupulella adusta*), Striped ground squirrel (*Ictidomys tridecemlineatus*), Tantalus monkey (*Chlorocebus tantalus*), Warthog (*Phacochoerus africanus*), Waterbuck (*Kobus ellipsiprymnus*), Western hartebeest (*Alcelaphus buselaphus*), and from transect survey include; Bushbuck (*Tragelaphus scriptus*), Cane rat (*Thryonomys*), Kob (*Kobus kob*), Maxwell's duiker (Philantomba maxwellii), Olive baboon (*Papio anubis*), Patas monkey (*Erythrocebus patas*), Red Colobus monkey (*Piliocolobus*), Roan antelope (*Hippotragus equinus*), Scrub hare (*Lepus saxatilis*), Striped ground squirrel (*Ictidomys tridecemlineatus*), Warthog (*Phacochoerus africanus*), Western hartebeest (*Alcelaphus buselaphus*), White-throated monkey (*Cercopithecus erythrogaster*). The densitiAes of some of these large mammals studied were Bushbuck 5.97 ±2.06/km^2, Duiker 2.35 ±0.65/km^2, Kob 18.33 ±6.60/km^2, Roan antelope 2.53 ±0.88/km^2, Western hartebeest 3.48 ±0.99/km^2 (Afolayan et al, 1983), 15.47/km^2-Baboon, 4.27/km^2-Bushbuck and Kob

(Akinsoratan, 2017), 0.08/km^2-Western hartebeest (Akinyemi and Kayode, 2010). Presently, no population estimation and national Red List of wild terrestrial large mammals exists for the entire country protected areas (National Parks). Subsequently, from the previous studies in Old Oyo National Park terrestrial large mammal populations indicated serious decline trend.

1.4 Statement of the Problem

Population trends of large terrestrial mammal species decline continue to worsen (David and Franklin, 2013, Ripple et al, 2016, Botelho et al, 2018). Overexploitation in form of hunting for bushmeat consumption and trade (Ripple et al, 2016) and trafficking of wildlife parts (Emslie, 2013; Wittemyer et al, 2014; Dery et al, 2022) has been reported as the major threat and reason for declining of wildlife most especially in Africa, Asia and South America regions of the world.

In Nigeria, bushmeat is a booming commercial activity especially among the communities around national parks and game reserves, as the price per carcass increases with the increase of the distance away from the protected areas (Macdonald et al, 2012), so the trade seemed to be promoted by the increasing penetration of logging roads in to the remote forest and greater access to the modern weapons by the hunters. Live wild animal trade and wildlife parts trafficking are currently in top gear. Other important threats include livestock grazing, forest fire and logging. Challenges of managing wildlife in Nigerian protected areas are numerous. Implementation of wildlife conservation policies in national park is a serious challenging issue due to low budgetary allocation and lack of support. Lack of sufficient wildlife monitoring programme is visible in Nigerian protected areas. Laws that deal with wildlife crime are very weak not deter the perpetuators as such discouraging the morale of the law

enforcement personnel. National Parks as repository of much of Nigeria's wildlife faces serious threats of poaching in recent years, losing not only wildlife but also rangers to poachers (Yager et al, 2018) and to criminal bandits very recently. Improved equipment for the protection activities are dearly needed for the law enforcement rangers to convert wildlife crime within and around protected areas.

The declining trend in the population densities of certain species in Old Oyo National Park is alarming. Reports on density trends and the population status of wild terrestrial large mammals—based on the perceptions of patrol rangers and surrounding community zones (Akinyemi & Kayode, 2010; Akinsoratan, 2017)—have provided some insights into population status. However, these previous studies did not generate population estimates or conservation assessments for large terrestrial mammals using systematic methodologies such as Distance Sampling or IUCN assessment criteria across the entire study area, sub-habitats, and ranges. This study addresses that gap by conducting empirical, field-based population surveys, producing first-hand quantitative data on species abundance and distribution, and reporting local conservation status using IUCN criteria.

Terrestrial large mammals in the study area are likely subjected to greater anthropogenic pressure than in any other national park in Nigeria, due to the higher density of human settlements surrounding it (Akinsoratan, 2017). This situation reflects an increasing human population and demand for wildlife resources, with negative consequences for wildlife populations. Most conservation studies in Nigeria have focused either on species distribution or on general poaching threats in isolation, but have rarely examined how poaching fluctuates seasonally and how it directly influences mammal movements within protected areas. Understanding seasonal poaching pressure and its impact on the distribution of large terrestrial mammals in the

Old Oyo National Park landscape is therefore crucial for effective conservation management. This study addresses that gap by integrating transect surveys, poacher arrest records, and habitat-based distribution analyses to evaluate seasonal patterns of poaching threats and their influence on mammal distribution.

The management of Old Oyo National Park is confronted with many of the broader challenges affecting wildlife management and conservation across Nigeria. These challenges include weak implementation of conservation policies, persistent poaching, the presence of violent bandits using the forests as hideouts, inadequate wildlife monitoring, insufficient funding and institutional support, shortage of trained personnel, lack of enforcement equipment, limited prosecution of wildlife crimes, and outdated or ineffective legislation. Although poaching and conservation challenges are widely acknowledged in Nigerian national parks, research evaluating the effectiveness of anti-poaching patrols, staff perceptions of conservation, and gaps in enforcement and policy remains limited. This study contributes new insights by assessing ranger patrol challenges, identifying policy and enforcement weaknesses, and providing practical recommendations to strengthen conservation strategies.

1.5 Research Objectives

The overall aim of this study was to generate reliable information on the population abundance, conservation status, and seasonal distribution of wild terrestrial large mammals, and to examine the management challenges associated with wildlife protection efforts in Old Oyo National Park. Within this context, the specific objectives of the research were as follows:

i. To estimate the population abundance and assess the local conservation status of terrestrial large mammals in Old Oyo National Park

ii. To examine the seasonal patterns of terrestrial large mammal distribution in relation to poaching and vegetation factors in Old Oyo National Park.

iii. To investigate management efforts and challenges related to wildlife protection and conservation in Old Oyo National Park.

CHAPTER 2

LITERATURE REVIEW

2.1 Terrestrial Large Mammal Population Trends

Information on large mammal population size and distribution is very vital to understand their conservation status, evaluating conservation hotspots, understand eco- tourism potential of the protected area, nature of wildlife human conflicts, monitor extent of exploitation and disturbance (Cousins et al, 2008; Di Minin et al, 2013; Fetene et al, 2019; Okosodo et al, 2021). Mammalian population size and conservation status largely remains unknown in many protected areas (David and Franklin, 2013). Population trends of large terrestrial mammal species with a multitude of ecological roles and services from different levels of the food chain and food web (predators, preys, herbivores and seed dispersal and pollinators agents) continuous to worsen (David and Franklin, 2013, Ripple et al, 2016, Botelho et al, 2018). Twenty five percent of the world's carnivore and ungulate species have moved closer to extinction in the past four decades (Di Marco et al, 2014). Fifty nine percent of the African large mammal's populations were estimated to have been lost within protected areas and most of predators and ungulates have faced continental-scale deterioration in the past 40 years (Di Marco et al, 2014). Assessing wildlife population size and conservation status periodically to figure out trends in extinction (Baillie et al, 2004, Butchart et al, 2005, IUCN 2006) is crucial in wildlife conservation. Less than 6% of the world's identified species that have had their conservation status evaluated so far (IUCN, 2020, Fernández et al., 2022), within which over 41% of amphibians, 26% of mammals, and 14% of birds are threatened among the major vertebrate groups that have undergone thorough assessment of extinction (IUCN, 2019). Hence, a frequent monitoring of

population size is required to track species conservation status and to determine which species population requires urgent conservation attention to prevent its extinction in a particular area.

Terrestrial mammals have worldwide distribution ranges, Africa, Asia, South America, Europe, America and Polar Regions with higher species richness in tropic and subtropics. The population sizes and geographical ranges of the terrestrial large mammals group are facing substantial declines in recent times globally (Ripple et al, 2016). Three hundred and one terrestrial mammal species are threatened with extinction by bushmeat hunting worldwide (Ripple et al, 2016).

2.2 Effect of Seasonality on Terrestrial Large Mammals Ecology

Seasonal climatic changes influence the phenology of plant communities, including deciduous cover, as well as the nature, abundance, and distribution of both plant and animal food resources (Van Schaik & Brockman, 2005). Variation in food availability across seasons is a central theme in animal ecology, and seasonality exerts a particularly significant impact on the ecology of terrestrial large mammals (Van Schaik & Brockman, 2005). These animals exhibit various behavioral and physiological adaptations to cope with changing environmental conditions associated with different seasons (Pereira et al, 2014). Tropical habitats are characterized by seasonal variation in rainfall and sunshine and also tropical climate normally classified according to the duration and intensity of the dry season (Van Schaik and Brockman, 2005). Vertebrate species in season free environments exhibit higher densities than species in environments with long wet seasonality (Santini et al, 2022). There was higher population abundance and species richness in vertebrates during the low water season than high water season in the floodplain forest of Amazon (Costa et al, 2018).

Seasonal variation of ungulate diet in floodplain forest of central Amazon basin was appeared to be affected more by riverine deluges than rainfall and ungulate response varies between species (Bodmer, 1990). Due to higher mortality during the season of scarce resources the surviving individuals will enjoy abundant resources with less competition during the season of availability of resources and in some taxa increased fecundity (Lindstedt and Boyce, 1985). Terrestrial large mammal experiences higher rate of survival during the season of scarce resources favoured by large body size (more energy store) which increase fasting endurance and decreased density-dependant competition (Lindstedt and Boyce, 1985). Smaller individuals need less food therefore are more likely to survive season of food resources scarcity (Van Schaik and Brockman, 2005). Daily movement rate of herbivores decreased with daily temperature decrease during winter and daily movement rate decreased with daily temperature increase during summer (Illius and O'connor, 2000). Ungulates migrate for seasonally changing food quantity, phenology, and accessibility to seasonal critically limiting resources such as water and nutrients, seasonal escape from predators, parasites or insect harassment (Bolger et al, 2008). African wild ungulates intensively compete with livestock during dry season and competition free during wet season (Odadi et al, 2011). Microparasites infection heightened during wet season while stress hormones mainly apex in the dry season among African wild ungulates more especially in zebra (Cizauskas et al, 2015). Reindeer selective grazing behaviour during summer increases food digestibility and daily body weight gain likely influences conception rate and survival during winter (White, 1983).

Seasonal variation in the availability of susceptible prey to being killed or die has conservation implications on carnivores. Seasonal variation can influence carnivore community richness and behaviour. Mammalian carnivores tend to shift

from strict predators to scavengers to maintain regular supply of food during the season when vulnerable prey resources were highly scarce (Pereira et al, 2014). As the carrion carcasses scarce and energy cost to kill prepared adult prey increases, mammalian carnivores take advantage of weaker segment of prey population such as newborn young, heavily pregnant female, male weakened by reproductive activities (Pereira et al, 2014). In northern latitudes death of most of the ungulates occurred during winter months. Transition from winter to spring season in northern latitudes is the worst period for the prey ungulates during which wolves and other carnivores utilized frozen stored carrion of ungulates at no energy cost (Inman et al, 2012; Metz et al, 2012). In Africa death of herbivores other than from predation causes is largely occurred towards the end of the dry season when food resources are limited. The carnivores switched utilizing carcass remains or left by and stolen from other carnivores (Pereira et al, 2014). During wet season lion predates more on zebras and wildebeest than any other prey and generally predators attempt to targeted smaller prey species during the season of lesser susceptibility of herbivores prey being killed (Pereira et al, 2014). Seasonal shift of parasite larvae increases vulnerability of wolf to infections between spring and autumn (Bryan et al, 2012).

The type, quality and distribution of food resources is widely acknowledge as prominent factor explaining the seasonal variation in primates' behaviour (Gursky, 2000; Van Schaik and Brockman, 2005). Primates are organisms that some species seem to increase activity, some decrease it and some others to the extent of hibernation during the period of resources scarcity to escape unfavourable conditions (Van Schaik and Brockman, 2005). Most of the primates showed preference to ripe fruits and exploits their range with the constantly updated information about the distribution of suitable patches (Van Schaik and Brockman, 2005). As predicted by optimal foraging

theory (Stephens & Krebs 1986) when preferred food became scarce, less preferred available would be the alternative option. To cope with reduction of resources availability, primates switch to variously lesser quality food resources, increases their foraging time and distance and in some species, they minimize their group size and maximizes their group dispersal (Gursky, 2000; Van Schaik and Brockman, 2005). In response to seasonal or scarce resources, both frugivores, folivores and inctivores primates modify their behaviour (Gusky, 2000). For example, insectivore primate species spectral tarsiers (*Tarsius spectrum*) were likely to showed more territorial dispute during dry season than wet season and consumed more Orthoptera and Lepidoptera insects when resources abundance was high (wet season) and switch to include Coleoptera and Hymenoptera insects when preferred resource abundance was low (dry season) (Gusky. 2000). Frugivores and folivores primates switch to topographically complex landscapes such as floodplains, uplands, valleys, hillsides and mountain slopes where fruits and foliage abundance were higher (Van Schaik and Brockman, 2005). As predicted by diet breadth models, they could also switch to other foods with lower quality and less travel harvest such as unripe fruits, young and mature leaves, flowers, gum, insects and amphibians (Van Schaik and Brockman, 2005).

Small strepsirrhines are the only primate species that exhibit hibernation as response to the seasonal food resources scarcity as smaller individuals need less food are therefore more likely to survive severity of food resources seasonal scarcity (Van Schaik and Brockman, 2005). In primates timing of reproduction in response to seasonal fluctuations is unclear because they exhibit both intrinsic and geometric birth rates (Janson, 2005; Van Schaik and Brockman, 2005). Species with longer gestation periods were less sensitive to season than species with shorter gestation periods probably because shorter gestation periods are more easily to synchronize reproductive

activity with annual cycles (Heldstab et al, 2021). Birth seasons were shorter with increasing latitude of geographical origin and smaller primate species are more likely to have seasonal reproduction than the larger ones (Heldstab et al, 2021). Folivores species are generally non-seasonal because leaf availability is relatively independent of season (Heldstab et al, 2021). Seasonal variation forced terrestrial large mammals to respond in various ways more especially during unfavourable seasons of harsh conditions and scarcity of food resources.

2.3 Wildlife conservation in Nigeria

Present day National Parks and Game Reserves (protected areas) in Nigeria were originally forest reserves created in the early 1900s (FNBR, 2010). The British colonial administration spearheaded the creation of game reserves to conserve wildlife for protein supplement and also for posterity (FNBR, 2010). Protected area biodiversity conservation (in situ) and (ex situ) conservation approaches are currently the practice in Nigeria. In-situ conversation is feasible where the pressure on the natural ecosystems is high like Nigeria (Ladan, 2018). Presently Nigeria has 7 National Parks namely; Chad Basin, Cross River, Gashaka-Gumti, Kainji Lake, Kamuku, Old Oyo and Okomu, 994 Forest reserve, 32 Game reserve 11 Ramsar Sites; 2 World Heritage Sites, 1 Biosphere Reserve and many Sacred groves (NBSAP, 2015; Ladan, 2018; Anwadike, 2020; Imarhiagbe et al, 2020 Mafiana et al, 2022) in situ conservation of its wildlife and biodiversity resources. Nigeria has a very rich and diverse mammalian fauna; 274 species are known of existence and probably more species may be found, especially in the montane and forested regions (Ladan, 2018). Absolute number of species of animals in Nigeria has been difficult to determine due to local losses and irregular and inadequate local assessment (NFNBR, 2015; Ladan, 2018).

According to the IUCN lobal Red list 2013, Nigeria has a total of 309 threatened species with 26 mammalian taxa second highest group (NFNBR, 2015). Of the 274 species of mammals that have occurrence in Nigeria, African elephant has no definite or probable population estimate in its 22,968 km^2 range area, but has 108 individuals as possible and 667 individuals as speculative national population estimates (Mallon et al, 2015), with some occasional sighting in forested areas. Most of the population estimate of both aquatic and terrestrial vertebrates compiled in (Mallon et al, 2015), were more than 10 years old and almost all of these literatures indicated serious decline in population of mammalian species endemic and non-endemic that are present in Nigeria such as Gorilla *(Gorilla gorilla)*, West African Manatee *(Trichechus senegalensis)*, Chimpanzee *(Pan troglodytes ellioti),* White-throated Colobus (*Colobus vellerosus (probably extinct in Nigeria)*), Olive Colobus (*Procolobus verus*), White-collared Mangabey (*Cercocebus torquatus*), Preuss's Red Colobus (*Procolobus preussi*), Drill Mandrillus (*I. leucophaeus*), Sclater's Monkey (*Cercopithecus sclateri*), Red-eared Monkey (*Cercopithecus erythrotis*), White-throated Monkey (*Cercopithecus erythrogaster*), African Wild Dog (*Lycaon pictus*), Lion (*Panthera leo*), African Golden Cat (*Caracal aurata*), Western Mountain Reedbuck (*Redunca fulvorufula adamauae*), Western Klipspringer (*Oreotragus oreotragus porteousi*), Western Hartebeest (*Alcelaphus buselaphus major*), Roan Antelope (*Hippotragus equinus*), Ogilby's Duiker (*Cephahlopus ogilbyi*).

For both the species ranked threaten and non-threaten in the IUCN global category, (Mallon et al, 2015; Imarhiagbe et al, 2020) raised concern that using global assessment might understate or overstate regional and local situation and there is no adequate national and/or local wild terrestrial large mammals population estimates and conservation status assessment available in Nigeria. Mammalian species especially

large and medium-sized species, are highly valued for their meat and other products and in many parts of Africa (Nigeria inclusive) bushmeat provides a major source of protein for human consumption (Ripple et al, 2016; Wilkie et al, 2016). Shooting and unscrupulous snaring are prevalent throughout the forest areas put enormous pressure particularly on populations of primates and forest antelopes (Mallon et al, 2015).

Nigeria became signatory of the convention on biological diversity (CBD) in 1992 and ratified it in 1994. In 2002 the UN World Summit on Sustainable Development endorsed the target agreed by the Parties to the Convention on Biological Diversity (CBD) 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level. Nigeria developed a policy document (National Biodiversity Strategy and Action Plan) for implementation to achieve (CBD) agreement and attainment of 2010 target. Nigeria has not been able to meet the 2010 target in so many areas, particularly in the reduction of the current rate of wildlife and biodiversity loss and in reversing it (FNBR, 2010). National Biodiversity Strategy and Action Plan (NBSAP) was revised in 2015 with set of 14 national targets to achieve from 2016 to 2020 in line with (CBD) and other environmental conventions agreements.

2.4 Terrestrial Large Mammal population in Nigerian Protected Areas

Despite numerous and various challenges experienced by protected areas (PAs) within and around their boundaries, yet, PAs remained the most effective refuge for management and conservation of wildlife worldwide (Araújo et al, 2007; Cantú-Salazar and Gaston, 2010; Li et al, 2012; Geldmann et al, 2013; Gonzalez-Maya et al, 2015; Barnes et al, 2017; Geldmann et al, 2018). As wildlife populations outside

protected areas decline, poaching pressure is increasing in many parks and reserves (Li et al, 2012; Geldmann et al, 2013; Ripple et al, 2016).

In Nigeria today protected areas are the only places you will find wild animal more especially the iconic members in their natural habitat but information on their population trends were scarcely and sparsely reported (Nicholas, 2004). For example, Kob *Kobus kob* existed in eleven protected areas but currently restricted to ranges within three national parks namely; Kainji Lake, Old Oyo and Gashaka Gumti national parks (Jayeola et al, 2011). Today only in Kainji National Park and Yankari Game Reserve Lion *Panthera leo* known to exist with previous population estimate of 24 individuals 2.97/100 km^2 in Kainji and 15 individuals 2.41/100 km^2 in Yankari (Henschel et al, 2010). Elephant *Loxodonta africana* presence was known in Yankari Game Reserve with previous aerial total count of 348 individuals and other species count were Duiker-5, Oribi-6, Roan entelope-75, Waterbuck-34, Warthog-10 and Western heartebeest-68 individuals (Omondi et al, 2006). Signs of forest elephant *Loxodonta africana cyclotis* activities were recorded in Okomu National Park a forest elephant range which has not been accounted for in the African Elephant Study Report (AESR) (Omoregie et al, 2019). Population size estimate of two duiker species recently reported in Okomu National Park were blue duiker *Philantomba monticola* 47 individual 11.8/km^2 density and Maxwell's duiker *Philantomba maxwellii* 39 individual 9.8/km^2 (Adeyemi et al, 2018) and mona monkey 1441.05± 398.96 individuals 4.47± 1.24 troops/km^2, white throated monkey 856.2± 489.45 individuals 2.66± 1.52 troops/km^2, red-capped mangabey 347.3±142.29 individuals 2.15± 0.88 troops/km^2, putty-nosed monkey 128.84± 81.49 individuals 2.40 ±1.50 troops/km^2, red-flanked duiker 1970.93±412.93 individual 36.66 ± 7.68/km^2, Maxwell duiker 1104 ± 292.65 individuals 20.54 ± 5.44/km^2, yellow-backed duiker 9 ± 2 individuals

0.17±0.36/km^2 previously reported (Akinsorotan et al, 2011). In Cross River National Park two species of duiker population size was previously estimated at a minimum of 16,000 individuals 5.56/km^2 for blue duiker and 1,600 individuals 0.89/km^2 for Ogilby's duiker (Jimoh et al, 2012) and mona monkey density was estimated at 2.5 ± 0.7/km^2 (Yaduma et al, 2017). In Gashaka Gumti National Park it was recently reported that the number of individual sighted for Olive baboon 318, Putty-nosed monkey 179, Mona monkey 105, Black-and-white Columbus 96, Tantalus monkey 15, Bushbuck 15, Waterbuck 7, Yellow-backed-Duiker 10, Red-flanked Duiker 11, Blue Duiker 10, Red river hog 21 and African Civet 8 (Schombi et al, 2023), Chimpanzee density of 0.122±0.027/km^2 (Tyowua et al, 2020) and previous density of mountain Reedbuck stand at 3.5/km^2 (Nicholas, 2004). Most of the information available here were more than ten years and mainly on single species Duiker. Regular update of information on diverse large terrestrial wildlife populations in the protected areas is vital to keep track of the species conservation status, local extinction risk, assess conservation success and ecotourism opportunities of the area for sustainable management.

2.5 Threats to Terrestrial Large Mammal in Nigeria

Nigeria, like many other countries, faces multiple threats to its wildlife. These threats stem from both anthropogenic and natural factors. The following are key threats affecting terrestrial large mammals in Nigeria:

2.5.1 Poaching

An illegal uptake of wildlife is an issue that raised concern generally and unequivocally viewed among ecologist and conservationist as inimical to the persistence of wildlife (Macdonald, 2019). Motives behind poaching range from

household consumption, commercial gain, recreational pursuit, rebellion and exercise of traditional right (Bell et al, 2007) and it involved use of indiscriminate methods which results in to killing of target and non-target species (Rowcliffe et al, 2005; Lindsey et al, 2013).

Between 2006 and 2014 before management collaboration with Wildlife Conservation Society (WCS), Yankari Game Reserve elephant population decline from 350 to 100 individual due to poaching for ivory trade (WCS, 2019). Poaching of other large mammals to supply the lucrative bushmeat trade also threatens to undermine the ecotourism potential for game viewing and reduces natural prey for endangered lion populations in Yankari Game Reserve (WCS, 2019).

In Nigeria, poachers believed that poaching is their heritage right and perceived establishment of protected areas as denial of their right, so they can adopt any tactics to hunt and evade arrest (Paul and Usman, 2020). Between 2012 and 2020, 401 poachers were arrested, 59,091 ware snares and 16,879 bullet cartridges were collected within 4 reserves in Cross River State (Premium Times Nigeria, 2022). At Okwangwo division of Cross River National Park 3 elephants were killed, 50 poachers were arrested, 10,858 ware snare and 3,428 bullet cartridges were collected in nine years, while, at Oban division 111 hunters were arrested for killing pangolin, duiker and monkeys between 2015 and 219 (Premium Times Nigeria, 2022). Poaching seemed to remain persistent due to corruption among park rangers (Paul and Usman, 2020). Similar trend is suspected to be even in the protected areas that were not reported. Poaching was presumed to have link with insecurity as many forested areas in Nigeria today are hideaways of criminal bandits and kidnappers.

Criminal insurgent groups in Africa have a history of been involved in poaching to fund their activities. For instance, in Democratic Republic of Congo (DRC) Lord's Resistance Army (LRA) have been reported to have poaches African Elephants to acquire ivory for illegal trade to fund their activities (Ondoua Ondoua et al, 2017). Janjaweed, bandits and criminal groups of Sudan were reported to been heavily involved in Elephants poaching in Central African Republic (CAR) and (DRC) and are still funding their activities from illegal ivory trade through Kenya (Ondoua Ondoua et al, 2017). Media and government discourse reported Boko Haram insurgent group operating in north eastern Nigeria known for kidnapping and banditry were linked with use of wildlife products from the Chad Basin National Park and Cameroun and Chad boarder parks to sustain their operations (Pennaz et al, 2018). It was also reported that poachers disguised as terrorist exploiting wildlife resources in the west and central Africa (Pennaz et al, 2018). Criminal bandits and kidnappers currently terrorizing north western part of Nigeria are making forested areas including protected areas inaccessible to even law enforcement staff of protected areas. Recently, in March 2021, bandit occupied Kainji Lake National Park attacked patrol rangers and killed one (Personal experience). This incidence forced management to close down the park and the park became inaccessible to even law enforcement rangers. Some informal report speculate that bandits are exporting timber and other wildlife resources to the neighboring Benin Republic.

2.5.2 Bushmeat consumption and trade

Illegal acquisition and exchange of wild meat (bushmeat) in Africa is unsustainable and one of the major drivers of wildlife species depletion (Lindsey et al, 2013, Ripple et al, 2016) and was term bushmeat crisis by (van Vliet and Mbazza,

2011). In West and Central Africa, commercial hunting is outweighing subsistence hunting with chain of trade dealers i.e (hunters-middleman-roadside traders-urban dealers) targeting higher profit in urban areas (Akani et al, 2015; Van Vliet et al, 2019) and herbivores were the most common trophic animal guild traded (Petrozzi et al, 2016).

Historically, hunting wild animals has been a cultural and traditional occupation in Nigerian communities (Anadu, 1987) next to farming and fishing (Akani et al, 2015). High demand for 'bushmeat', trophies and animal parts as ingredients of medicinal and magical concoctions, hunters are assured of a lucrative business (Anadu, 1987). In Nigeria today, bushmeat is a booming commercial activity especially among the communities surrounding the national parks and game reserves as the price per carcass increases with the increase of the distance away from the protected areas (Macdonald et al, 2012) due to higher demand in urban areas and even cities and size of the carcass determined the price not the consumer preference (Luiselli et al, 2017). Nigerians predominantly in the southern parts consume wild animal (bushmeat) unsustainably and more preferably wild large animal resources and in some cases considered as a delicacy. With the exception of primate species some northern communities also do consume bushmeat. Many studies have showed wildlife consumption and trading has long been persistent and severe in southern Nigeria, for example, according to Anadu, 1988. 22 species of mammals and 5 species of reptile were found on sale during bushmeat market survey in then Bendel state. Bushmeat roadside market survey in south western Nigeria still revealed 17 species of mammals smoked meat on sale include white-throated monkey *(Cercopithecus erythrogaster*), a species of high conservation concern in Nigeria (Olayemi et al, 2011). Different bushmeat markets do exist such as hub market (Akani et al, 2015), bushmeat depot

market (Jayeola et al, 2023) for upward trading to the towns and cities with several roadside and locally spread small market for local consumption. Twenty one mammalian species was recorded at largest bushmeat hub market in Niger Delta (Akani et al, 2015). The most popular species in the Nigerian bushmeat markets were grasscutter *(Thryonomys swinderianus)* and duikers (Anadu, 1988, Olayemi et al, 2011; Jayeola et al, 2023) which may implies most available for hunt. Bushmeat consumption is a crucial source of animal protein food resource for poor families in Nigeria particularly in rural areas, but there is a rising appetite for bushmeat consumption among urban residents which increased its demands (WILDAID, 2021). Bushmeat consumption was immediately avoided by the populace during 2014 Ebola crisis (Luiselli et al, 2017), however, three years after Ebola, bushmeat consumption have rebounded in Nigeria, following the rising demand and flourishing illegal wildlife trade, which continued to thrive (WILDAID, 2021). Despite suitable alternatives such as frozen chicken, beef and fish most of the bushmeat consumers in Nigeria intended to continue eating bushmeat mindless about spread of zoonotic diseases including COVID-19 (Meseko et al, 2020; WILDAID, 2021). Grasscutter and antelopes (bushbuck and duikers) are the most consume, however, even the consumers are lamenting serious scarce of the commodity (bushmeat) these days (WILDAID, 2021). This implies serious shrinking in the populations of these wild large animal under bushmeat trading and consumption pressure. To have complete in sight in to the extent of bushmeat consumption and trading in Nigeria, information from the northern part should be provided through research more specifically around protected areas as it is not available. Nigeria has flourishing unregulated bushmeat markets selling even live wild animals (Meseko et al, 2020) increasing close contact between the animals and humans. Recently a lion cub was in intercepted in Abuja by National Environmental

Standards and Regulations Enforcement Agency (NESREA) was attempted to be sold at the sum of N 6,000,000 ($7,500).

2.5.3 Wildlife trafficking

Global illicit wildlife trade has grown rapidly in the last decade (Sas-Rolfes et al, 2019), mainly, because, illicit wildlife transnational trade is the fourth most lucrative illegal business after narcotics, human trafficking, and weapons (Rosen and Smith, 2010; Warchol, 2004). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), hosted by the United Nations Environment Programme, brings together state of nations to combat illegal wildlife trade through uniform regulation (Chalakkal, 2013; Oyende, 2022). Nigeria is a signatory to this convention and have existing laws such as protection of endangered species in international trade regulation 2011 and the endangered species control of international trade and traffic act 2016 as amended (Oyende, 2022).

Yet, Nigeria has emerged as a top source and transit country for illicit trade in ivory and pangolin scales and the reason for Nigeria's leading role in the trade is unknown (Emogor et al, 2021), but smugglers could be attracted by its porous borders, corruption level, transport links to Asia, and poor law enforcement (Omifolaji et al, 2020; Emogor et al, 2021). Between 1997 and 2019, Nigerians are involved in bushmeat, live wildlife trafficking and linked to most of seized ivory and pangolin scales globally (TRAFFIC Bulletin, 2019). The first reported ivory seizure linked to Nigeria confiscated outside Nigeria was in 1996 in Belgium on board to China (TRAFFIC Bulletin, 2019). In 2016 custom official in Nigeria arrested two Chinese nationals first known arrest for attempting to smuggle out of the country raw and processed elephant tusks (CITES I) and pangolin Manis (CITES II) scales (TRAFFIC