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Population Estimate, Feeding Ecology and Habitat Use of White – eared kob (*Kobus kob leucotis*, Lichtenstein and Peters, 1854) and their Interaction with Livestock in Gambella National Park, Southwestern Ethiopia

Department of Zoological Sciences (Ecological and Systematic Zoology Stream)

A Dissertation Presented to the Department of Zoological Sciences of Addis Ababa University in Partial Fulfillment for the Requirements of the Degree of Doctor of Philosophy in Biology (Ecological and Systematic Zoology)

Prepared by: Nhial Tuach Riek

Advisor: Prof. Afework Bekele

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ACRONYMS

AAU: Addis Ababa University

asl: above sea level

BIDNTF: Biodiversity Indicator Development National Task Force

BNP: Boma National Park

CMS: Convention on Migratory Species

EWCA: Ethiopian Wildlife Conservation Authority

GNP: Gambella National Park

GPNRS: Gambella People's National Regional State

IBC: Institute of Biodiversity and Conservation

HoAREC/N: Horn of Africa Regional Environmental Center and Network

TPA: Transboundary Peace Parks

WISP: World Initiative for Sustainable Pastoralism

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DEDICATION

To the loving memory of my Father, Tuach Riek Nyang.

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DECLARATION

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Nhial Tuach “Population Estimate, Feeding Ecology and Habitat Use of White – eared kob (*Kobus kob leucotis*, Lichtenstein and Peters, 1854) and their Interaction with Livestock in Gambella National Park, Southwestern Ethiopia” and submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy in Zoology (Ecological and Systematic Zoology) complies with the regulations of the University and meets the accepted standards with respect to originality and quality

Signed by the Examining Committee

External examiner Signature Date

Internal Examiner..... Signature Date

Advisor Signature Date

Chairperson Signature Date

ABSTRACT

Population Estimate, Feeding Ecology and Habitat Competition Use of White – eared kob (*Kobus kob leucotis*, Lichtenstein and Peters, 1854) and their Interaction with Livestock in Gambella National Park, Southwestern Ethiopia

Nhial Tuach, PhD Dissertation, Addis Ababa University, 2019

*Ethiopia is a land of great natural abundance. However, human activities are causing severe adverse impacts in this country. Pastoral system is one of the traditional land use systems practiced in the rural sides of the country. Ethiopia is known among the East African countries hosting one of the few remaining sites in Africa where significant seasonal migration still occurs at Boma–Gambella Transboundary Park for white – eared kob (*Kobus kob leucotis*). This study was conducted in Gambella National Park, from 2016 to 2018. It is located at latitude of 8⁰N and longitude of 34⁰15'E of the Southwestern Ethiopia. Distance sampling survey using line transect methods were carried out during the dry season (February – April) and wet season (May). Data were collected for eight seasons. Assessment of selected specific food and cover resource from the patches used by the individual within its home range was conducted and numbers of animals were recorded. The plant species samples were collected. A total of GNP 6423 white eared kob (CI = 217.8 – 317.4) during wet season (N = 446, CI = 26.3–121.7) and dry season (N = 5977, CI = 82.59–581.41). This study revealed wetland meadows were the most important utilized habitats of all in habitat types. The dietary proportions indicated *Paspalum scrobiculatum* (9.4%), *Pennisetum setaceum* (9.1%), *Eragrostis multiplosa* (11.7%), *Pennisetum purpureum* (13.4%), and *Sacciolepis africana* ($df = 11, F = 115.6$) $p < 0.001$ ($n = 8408$, mean = 349.78, SD = 258.367, CI = 344.25–355.30) as a major components. A Due consideration should be given to hosting communities and eco–friendly policy from governmental institutions and others important stakeholders in order not to affect the seasonal migration of kob. In this case, both Ethiopia and South Sudan should work in collaboration to conserve this important subspecies.*

Key words: Gambella National Park, livestock, migration, park, wetland, white – eared kob

1. INTRODUCTION

1.1. Background of the study

White – eared kob is native to Ethiopian biogeographic region, which is endowed with vast natural resource. This animal undergoes seasonal migration. Wild animal migration is as important as iconic migrations of East Africa with massive tourist attraction (Nowak, 1991; DuVal, 2000). In spite of the fact that and ecological importance, these natural phenomena, are declining. Their dispersal areas and migratory corridors are being lost due to high human population densities, increasing urbanisation, expanding agriculture and fences. Their loss would contribute to biodiversity decline, and jeopardize tourism and other ecosystem services or what government call 'the hidden treasury of GNP' (Fryxell, 1987; EWCA, 2010; CMS, 2012; Nhial Tuach, 2013; Morjan, 2014; Gatluak Gatkoth. 2015; Gatluak Gatkoth *et al.*, 2015).

Kob (*Kobus kob*), small, stocky African antelope (tribe *Reduncini*, family *Bovidae*) that occurs in large numbers on floodplains of the northern savanna. The kob ranges from Senegal in the west to the Ethiopian border in the east and southward into western Uganda and eastern Democratic Republic of the Congo. There are three distinct subspecies: the western kob (*Kobus k. kob*), the Uganda kob (*K. k. thomasi*), and the white-eared kob (*K. k. leucotis*) of Southwestern Ethiopia and eastern South Sudan (Estes, 1991; Nowak, 1991; DuVal, 2000).

These antelopes prefer perennial grasses in their early stages and need to drink daily (Estes, 1991). Their habitat of green pastures in well-watered areas is threat-ened by agricultural development and, as a result, their distribution is being reduced. Meanwhile the migratory white – eared kob are known transversing vast floodplains of GNP in Ethiopia and Boma National Park (BNP) in South Sudan (Stubblefield, 1995).

Like other large herbivorous mammals, white – eared kob plays a key role in the structure and function of rangelands in a given ecosystem, particularly in absent of carnivores and where native species interact with domestic livestock and exotic or feral herbivores (Garnick *et al.*, 2018). The impacts of mammalian herbivores on rangelands depend on both environmental features such as aridity and history of disturbance and animal features including body size, diet type, and evolutionary origin (Seft *et al.*, 1987).

In Ethiopia, white – eared kob abundance and distribution in most parts of the Park with herd size ranging 150–260, followed by the central and southern parts of the Park, which comprise 50–90 and 23–50 herds of white – eared kob, respectively (Gatluak Gatkoth, 2015). Population size of white – eared kob estimates reported were of 1,000,000 (Watson *et al.*, 1977) and over 800,000 in BNP (Fryxell, 1987). Density estimates range from 500–100 white – eared kob km⁻² (Fryxell, 1987; Morjan, 2014). However, economic inevitable causing impacts nationwide, particularly in Gambella People’s Regional State, which result in a steady growth in construction and infrastructure, investment, flourishing of private sector, urbanization and villagization as well as pastoralist way of life practice in Gambella National Park (GNP) (Nhial Tuach, 2013; Wondwosen Michago, 2017).

Climatic conditions force nomadic settlers of Sahel Africa to immigrate to the Nile valley in search of a permanent watering ground. Nuer people living in Ethio–South Sudan border have similar life styles with Fulani of West Africa practicing pastoral way of life. However, their economies do not only pastoral way of life, but also hunt antelopes and other game animals (Mokhtar, 1981; Nhial Tuach, 2013; Wondwosen Machigo, 2017).

Pastoralism is an important economic and cultural way, which is believed to be one of the compatible environmental systems predominantly in dry and sub-humid lands. Among the authors who worked on the Nuer pastoralists are Evans-Pritchard (1940), Goldsmith *et al.* (2002) and Matthews (2015). Therefore, pastoralism and wildlife migration are land–use

systems in arid lands that enhance biodiversity and support the long-term conservation of important wildlife habitats. However, government policies and strategies are indicted and support pastoralists' settlement program of rural villagization to boost economic (Nhial Tuach, 2013), where only small patches of critical dry season resource ranges left for use. As a result of this, pastoralists, which caused a phenomenon collectively referred to as the 'tragedy of the commons' (Hardin, 1968).

According to McGahey *et al.* (2014), pastoralist knowledge is important basis of rangeland conservation in drylands where access to water is a limiting factor, which determines herd sizes (Fig. 1). Investigation of resource utilization plays an important role to understand the mechanisms that influence community structure in the given ecosystem (Vieira and Port, 2006).

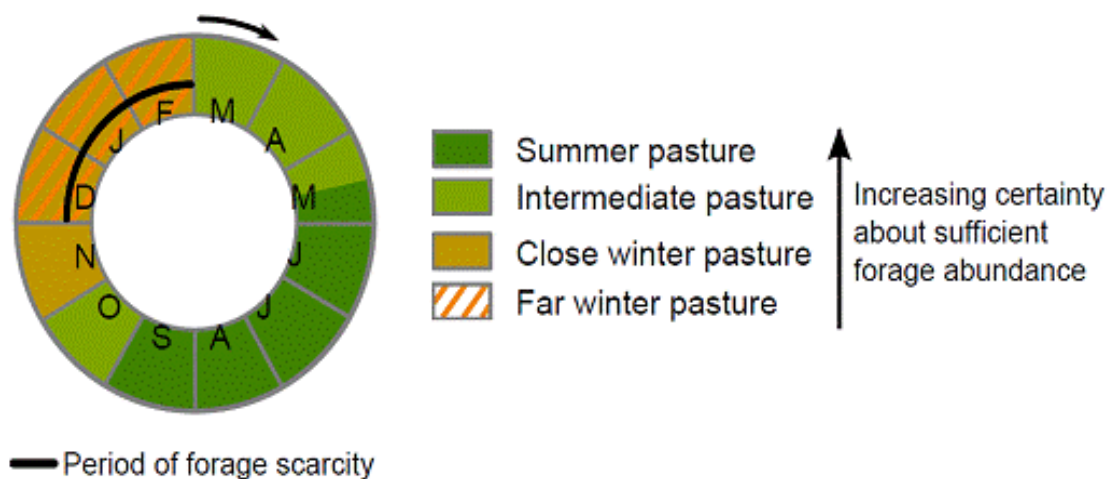


Figure 1. The normative transhumance cycle

Livestock grazing is a major conservation threat facing protected areas in Africa (Anagaw Atickem and Loe, 2013). Long before the presence of European settlers, the abundance of ungulates species was determined largely by the presence of surface water. This was not only for resident populations, which live near permanent water source, but equally and apparently used by migratory herds such as springbok, *Antidorcas marsupialis*, black wildebeest,

Connochaetes gnou, blesbok *Damaliscus pygargus*, quagga *Equus quagga* and eland *Taurotragus oryx*, known to move in response to drought and food availability around Karoo. However, the regularity and impacts of migrations remain unknown, and substantial reductions of large herbivore populations were followed by dominance of livestock because of primary agricultural activity with extensive livestock grazing (Todd, 2006).

The impacts of overgrazing include loss of vegetative cover and soil erosion in the most extreme cases, with negative impacts on wild grassland species as well as inland waterways, which can suffer from sedimentation. Conflict with other grazers tends to be most noticeable during periods of stress such as drought. Additional conflict arises from the transmission of disease from pastoral communities to wildlife. For example, an outbreak of rinderpest in Kenya resulted in its transmission to wild grazers with death rates in the mid-1990s reaching 60% in buffalo and 90% in kudu populations in some areas (Adriansen, 1997; Aboud *et al.*, 2012).

Ethiopia is a member of Partisan of Convention of Migratory Species (CMS), which are of international concern. It has four Transboundary Peace Parks (TPA): Gambella National Park in the west, Altosh National Park in the northwest, Kafta–Sheraro National Park in the north, and Gerral National Park in the Somali National Regional State in the east, at frontiers that borders south Sudan, northeast Sudan, Eritrea and Kenya, respectively (IBC, 2009). Ethiopia is one of the East African countries hosting one of the few remaining sites in Africa where significant seasonal migration still occurs at Boma – Gambella Transboundary Park for white – eared kob (EWCA, 2010). After the wildebeest, this is the second largest mammal migration in Africa; some call it ‘the second Masai–Mara’ (BIDNTF, 2010). This large mammal migration is a kind of culmination of nature’s spectacle across the world that survives only in a few places (Bolger *et al.*, 2008). The similarity in the landscape, climatic and hydrologic features on both sides of the national border of this intact eco–region provide

habitats for not only white-eared kob but also many other wildlife including Nile lechwe, elephant, giraffe, common eland, giant eland, oryx, lion, wild dog, buffalo, topi (locally called *Tiang*), waterbuck, Roan antelope, zebra, bushbuck, Abyssinian reedbuck and warthog (Giessen, 2011). White – eared kob migrates seasonally. However, there are some populations known to stay within the GNP all year round. This is evident from two adult white – eared kob females fitted with satellite collars to study their home ranges roaming around within Gambella, Ethiopia (CMS, 2012; Nhial Tuach, 2013; Gatluak Gatkoth *et al.*, 2015). These natural phenomena occur in four groups of mammals (Bolen and Robinson, 2003), the highest evolved taxonomic group of the animal kingdom (Demeke Datiko and Afework Bekele, 2011), which undergo migration in aggregation such as bats, cetaceans (whales and porpoises), pinnipeds (seals and sea lions) and large hoofed herbivores (Bolen and Robinson, 2003).

Several studies on white – eared kob were carried out such as reproduction, diurnal activity budgets, seasonal changes in body conditions and forage availability and resource use (Fryxell, 1987; Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988; Estes, 1991; Nhial Tuach, 2013; EWCA, 2010; Morjan, 2014; Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015).

Fryxell and Sinclair (1988) presented the significance of evolutionary adaptations of migration. This consists of merits such as enhancing access to shifting patterns of absolute resource abundance, enhancing access to patch of high quality and reducing risk of predation; and demerits that are related to consequences of population dynamics, community structure and long–term persistence of plant–herbivore system.

These adaptations partly determine individual behaviour, and whichever is dominant will depend on the current circumstances and the different time scales on which they function. Adaptations of animals make tradeoffs between competing goals to try and find an optimal

solution that maximizes their fitness. There are three main forms of round-trip migration in mammals: refuge, a movement away from breeding areas to avoid seasonally harsh conditions (e.g: Dusk rat, *Rattus colletti*, migrates from back swamp woodland to avoid flooding during wet season); breeding, a movement between a feeding and a breeding ground (e.g: Humpback Whale, *Megaptera novaeangliae*) migrates seasonally between high latitude feeding ground and low latitude breeding ground (Holdo *et al.*, 2010); and tracking, a continuous movement following predictable changes in food distribution (e.g: wildebeest and white – eared kob). These types of movements have fundamental distinction in terms of the timing of energy intake with respect to reproduction over the course of a year. In refuge migrations, individuals tend to breed at the same time and they have a peak in energy intake. Meanwhile in breeding migrations, individuals acquire energy at one location and store it before reproducing elsewhere, where individuals fund their reproduction either with energy as they acquire it or from energy stored ahead of time. In tracking migrations, individuals are constantly acquiring energy over the course of a year, although often these species still display seasonal reproduction. A number of species with tracking migrations follow prey species that are themselves migratory (Fryxell and Sinclair, 1988; Berger *et al.*, 2004).

Seasonal migration in terrestrial mammalian herbivores exhibits seasonal shifts in accordance with seasonal green-up (Fig. 2). The two key elements that unequivocally give rise to a seasonal migration are rainfall and fertility. Rainfall acts as a seasonal “switch” that controls the availability (and to some extent, the quality) of grass biomass. The length of the growing season is positively correlated with the amount of rainfall received across the ecosystem (Holdo *et al.*, 2010). However, wildebeest and white – eared kob move away from the high rainfall and more productive ranges during the wet season to areas with lower rainfall, reduced productivity, but apparently better quality forages. They return to higher rainfall regions only during the dry season in response to declining food quality and diminishing

supplies of drinking water. Such opposing rainfall and fertility gradients are common features of African savanna ecosystems and play major role in driving ungulate migration. The size of the local neighborhood of habitats that migrants track and move within is as important as the overall spatial distribution of resources and seasonality in determining the migration (Holdo *et al.*, 2010). Migration routes and the timing of movements are highly variable from year to year, prompting to prefer the term “nomadic” rather than “migratory” to describe wildebeest movements. However, factors other than large-scale perception may drive wildebeest to move out of local resource patches and make adaptive “decisions” based on immediate comparisons among sites (Holdo *et al.*, 2010).

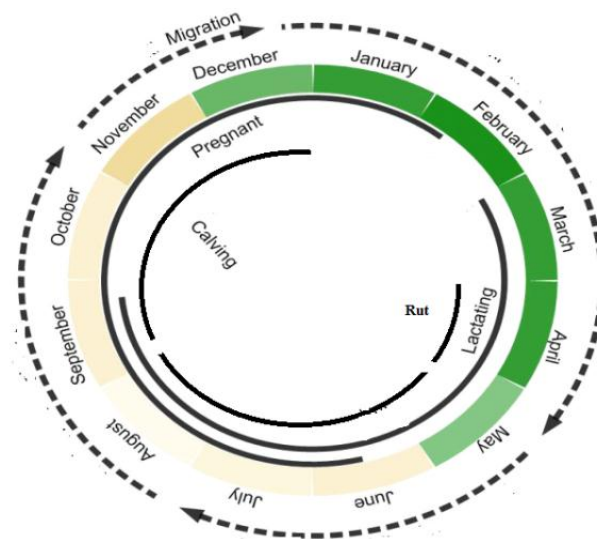


Figure 2. The seasonal migration

One of the few remaining sites in Africa where significant seasonal migration still occurs is the Gambella–Boma Transboundary Park of Ethio–South Sudan border for white eared kob, it is the longest and second largest mammal migration in the world some call it ‘the second Masai-Mara’, which is referred as ‘the hidden treasure of Gambella National Park’ (Nhial Tuach, 2013).

Challenge demands ecologists to link science to planning, decision and policy making,

forecasting ecosystem states, and evaluating ecosystem services and natural capital. Therefore, migration is a transitional shift of resource use in response to changing availability and quality of resource (Fryxell and Sinclair, 1988). This benefits populations with high access to high quality forages. With this mechanism, they reach higher numbers than non-migrants, which are limited by food availability. These patterns of distribution have been reported in comparative studies caribou occupied on boreal forest during winter and return to Tundra in summer in temperate region and tiang, Nile lechwe in Ethiopia and South Sudan and wildebeest, zebra and Thompson's gazelle in Serengeti, Tanzania in East Africa (Fryxell and Sinclair, 1988). Climate change becomes a determinant factor that results in the loss of large mammal species. They are good indicators of changes (Mitchell *et al.*, 2018). Competition and predation patterns require knowledge of processes that link local abundance and regional scale. This pattern of species abundance is accompanied on a larger scale, which the tendency of widespread species also occur in higher densities compared to those restricted in their geographic distribution (Verberk, 2011).

Living in herds in ungulates, like other grouping of organisms such as schools of fish, flocks of birds and packs of wolves as well as social groups have strong effects on individual fitness. These grouping at the same time, have more behaviour and dynamic differences than solitary or isolated individuals (Grimm and Railsback, 2004). Interactions are the mechanisms determining what individuals know about others in the populations. Livestock grazing intensity gradient associated with watering grounds has profound effects on both vegetation and the physical environment (Todd, 2006).

1.2. Research problem

Gambella National Park was established in 1974 with a clear vision to protect its outstanding critical biodiversity and important wetland habitats, and large mammal species including the white – eared kob, the Nile Lechwe and elephants. They are nationally and internationally important species, which government refers to as ‘the hidden treasury of Gambella National Park’ (EWCA, 2010), equally and apparently qualified for management and conservation issues. In recent years, the wildlife populations within and around the Park have been negatively affected by a combination of illegal hunting (Appendix. 1), deforestation and intruding of pastoralists invading important habitats in different parts of the Park (EWCA, 2010). It is one of the largest protected areas in the country, facing problem of habitat fragmentation. Competition for resources between Kob and cattle as well as introduction of diseases such as foot and mouth disease, rabies, anthrax, brucellosis and bovine tuberculosis can be transmitted between livestock and wildlife. This is due to similar use of water resources resulting in high potential interspecific interaction around landscape especially during the dry season (Barasona *et al.*, 2014). A potential contest for water resource was observed during the dry season among white – eared kob populations and Nile Monitor lizard, *Varanus niloticus*, increase leading to death of both species in GNP during the mid-dry season (Appendix 2).

Gambella National Park, at present, is one of the endangered Parks in the country undergoing rapid landscape change and posing threat to migratory white eared Kob, one of the keystone species of conservation concern (Nhial Tuach, 2013). One of the most critical factors for all species is the suitability and availability of habitats. This landscape modification takes place for numerous and often quite different reasons. As a result, high-productivity parts of the Park areas are typically and extensively modified for commercial agricultural expansion (Appendix 3), and other human activities (Nhial Tuach, 2013).

The region's landscape is engulfed by the *tragedy of commons* (Hardin, 1968), in which the management of natural resources lack definitive ownerships and individuals place their own interest. It is subjected to current policy of villagization program and heavy mechanized investment practices as well as different pastoralists from different countries. Wildlife populations, particularly white – eared kob have encountered modern human activities, for instance, settlements and transport infrastructures, which depend on habitat networks as they move.

Competitions for resources have been advocated due to social interactions and diet overlap where proof is uncertain. However; these required a confluence of factors that show diet overlap between white – eared kob and cattle (Appendix 4) (Hosten *et al.*, 2007). Nearly one-third of the world's land area has been converted to cropland and pastures, and an additional one-third is already heavily fragmented, with devastating impacts on wildlife (Kurvits *et al.*, 2011). According to Kurvits *et al.* (2011), wetlands and stopover sites for wildlife during migration are declining and many of these are critical to the long migratory routes.

Population size, species richness and occurrence of rare species are good indicators of conservation status. They are also positively correlated with the size of individual or total extent habitat in the landscape. Therefore, ecological networks connecting ecosystems and meta-population of migratory species are essential (Sodhi and Ehrlich, 2010). These migrants represent perhaps the most vulnerable ecological elements on the planet. They depend entirely on a network of well–functioning ecosystems, stopover sites, where to refuel, reproduce and survive in every station they visit and upon unrestricted travel (Kurvits *et al.*, 2011). As these key resource areas attract human developmental activities, the Park was devastated due to habitat fragmentation. Therefore, for effective biological conservation, it is critical to determine and understand population size and habitat utilization of Kob and the effects of ongoing recession of landscape degradation. Habitat and dietary overlap are often

reported as the primary mechanism by which competition occurs due to displacement used as evidence of competition (Butt and Turner, 2012).

Dietary preferences and niche dimensions of each species are flexible, and depend significantly on season, habitat, food availability, and the presence of other herbivores. This is revealed in East and South African savanna ecosystems, where cattle are the main domestic herbivores that overlap in diet with several wild ungulates, including impala, plains zebra, and wildebeest. Despite different dietary preferences, impala reveal change of feeding habits in the presence of cattle by lowering their food selectivity, decreasing their group size, reducing overall density, and moving to refugia habitat to avoid competition (Foufopoulos, *et al.*, 2003).

Although Gambella landscape covers diverse assemblage of wildlife and unique habitats, its future remain unpredictable to support diversified mammal species and nearly a million white – eared kob across this eco–region. Despite the fact that white – eared kob is listed as a ‘least concern’ species, its populations and habitats are highly susceptible to hunting, loss of habitat, reduction of habitat quality, disruption of the natural flooding regime and cut of migratory corridors (IUCN, 2008). It is not yet known how far this affects the white – eared kob and other migratory species of the region. The road construction is underway and large camps and human settlements have followed in its wake. Access to these large wildlife populations, as well as infrastructural connections to large urban markets, have made these areas vulnerable to poaching and commercial bush meat trade. Due to the topography and hydrology of the area, road construction will also have major adverse effects on the hydrology of the area as the road is a formidable barrier to natural water flow and the flooding regime. A number of small tributary roads leading of the main road, especially toward South of the Park have been recorded during the survey (Nhial Tuach, 2013; Gatluak Gatkuoth, 2015).

Therefore, relevant conservation requires understanding of species' biogeographical patterns, population dynamics, behaviour, community structure as well as health issues. This can be achieved by restoring, maintaining and demarcating the critical habitat of the species (habitat that provides food and other resources for year round periods and breeding sites) beyond the migration event. This exploitative competition could be sending economic ripple to pastoralists as livestock desired outputs such as meat, milk and offspring are decreasing on the ground. As a result, sharing the area with livestock could not be attained in that environmentally sensitive area or agro-ecological zone. This area is also experiencing considerable human activities and threats. The principal development here is the construction of a national road project connecting Ethiopia with South Sudan, via Akobo and then towards Nasir and Malakal (key oil producing areas).

1.3. Significance of the study

This study is essential since no research that has been conducted on white – eared kob in the specific area. There is no enough documented information in ecological and other aspects of white – eared kob in GNP. Therefore, it is relevant to have necessary information available to users in both scientific community as well as host communities living near by the Park area in the region to bridge the gap that hinder conservation in the Park.

2. LITERATURE REVIEW

2.1. Physical description

White – eared kob is one of the large herbivorous animals with unique biological heritage, and mass migration behaviour a characteristic of grassland and boreal forest ecosystems. This is a general consensus accepted by many authors to enhance access to resources (Fryxell, 1987; Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988). White – eared kob feed on *Hyparrhenia* sp., *Brachiaria brizantha*, *Setaria gyanus*, *Chloris gayana*, *Echinochloa* sp., and *Digitaria* sp., (Bindernagel, 1968). Kob antelope resembles the impala but is more robust and dimorphic (Kingdon, 1982; Estes, 1991; Nhial Tuach, 2013). White – eared kob which stand 70 – 100 cm at the shoulder are characterized by white – coloured facial markings and conspicuous eye rings. The S-shaped and ringed horns are found only in males and bend sharply backwards, then curve up. Males of the white – eared kob have distinctive white throat and belly and they are also strikingly different from their closest allies by their deep darker colouration, which makes them similar to the male Nile lechwe (Nhial Tuach, 2013).

White – eared kob usually lives in the flood plains, well watered areas. Adult males are territorial, although the size of their defended ranges varies depending on the habitat and population density. The length of time a male may hold his territory varies from days to months (Fryxell, 1987; Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988). However, seasonal and spatial variations in forage quality, protein content, phosphorus and digestibility are correlated with latitude and elevation. Unlike browsers, migratory grazers do not meet their metabolic needs from forage, and they seek a permanent water supply during the dry season. Distribution patterns of large herbivore populations are balanced against energetic requirements which in turn affect reproductive success through mortality and fecundity (Fryxell, 1987; Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988).

The Sudd in South Sudan and Ethiopia is one of the greatest concentrations of wetlands harbouring migration, one of the most spectacular of natural phenomena that includes movements of thousands of individuals over large spatial scales. Among the most awe-inspiring are ungulate migrations. The paucity of information on ungulate migrations today calls attention to the need for effective conservation (Berger 2004; Bolger *et al.*, 2008).

2.2. Distribution

White – eared kob antelope (*Kobus kob*) has three subspecies of medium-sized mammals. They occur on the northern savannah plains across Equatorial Africa. They are distinguished by geographical distribution and variations in male coat colour (East, 1999). *Kobus kob kob* (Buffon’s kob) is found in West Africa and *K. k. thomasi* (Uganda kob) in Central Africa. They are phenotypically similar, and mature males are brown. Both subspecies are considered conservation-dependant by the World Conservation Union, (IUCN) (East, 1999). *Kobus kob leucotis* (white – eared kob) is found in GNP in western Ethiopia and Boma National Park of the Republic of South Sudan. Mature males are ebony coloured (IUCN/SSC, 2008). The white – eared kob is gregarious, with male and female herds forming big aggregations (Estes, 1991; Balmford, 1992).

2.3. Migratory behaviour

Kobus kob leucotis is the only migratory subspecies, and it is considered near-threatened by IUCN (East, 1999). This adaptation of migration helps *K. k. leucotis* to overcome the constraints imposed by body size and habitat. Predators cannot follow migrating herbivores because they are confined to territories to raise and protect their young. This is evident in all mammal migration systems such as the wildebeest and gazelles in Serengeti and Botswana, caribou (*Rangifer tarandus*) in northern Canada, and the plains bison of the North American prairies (Sinclair, 1983; Fryxell and Sinclair, 1988; Sinclair, 2003). These two features of migration systems allow populations to become greater in number than residents (Sinclair, 2003). Migrating species, therefore, escape from predator regulation even when they are

relatively small, as in gazelles. In addition, migration is an adaptation to access ephemeral, high-quality food resources not available to non-migrants. White – eared kob gather on and move from one pasture to another, coinciding with seasonal changes (Kingdon, 1982).

Migration behaviour maintains positive benefits favoured by natural selection, which provide animals with flexibility in time of environmental uncertainty (Fryxell, 1987). These influence the demographic processes of birth and death playing central role in population dynamics and the survival and reproduction of individuals within the population as agents of natural selection explained by marginal foraging theory.

Seasonal variation has caused shifting habitat utilization of pastoralists with their livestock and migratory antelope in order to exploit essential nutrients in food items located randomly in heterogeneous landscape for maintenance and reproduction. Similar patterns have been reported in wildebeests. As they are regulated by these phenomena, population dynamics of large herbivorous mammals such as white – eared kob and wildebeest increase by increased difference found between recruitment during the wet season and losses from malnutrition and predation during the dry season of the year (Fryxell, 1987; Fryxell *et al.*, 1988).

While births may occur throughout the year, in drought-prone areas there is a peak at the end of the rains (September–December). After birth, the young lie concealed for about 6 weeks, after which they follow their mothers. Kob has gestation period of 7.5-9 months only one young and weaned after 6-7 months. Female kob reaches sexual maturity at 13 months, males around 18 months (DuVal, 2000).

The white – eared kob is most active in the morning and late afternoon. Adult males are territorial, although the size of their defended ranges varies depending on the habitat and population density.

In flooded areas, white – eared kob populations may travel hundreds of kilometers and dry season walks to water points may take 10 km or more (Kingdon, 1982). Demographic components are influenced by factors such as movement, birth and death (Fryxell, 1987; Fryxell and Sinclair, 1988; Smith, 2012).

Distribution patterns of animals during foraging periods reflect their movement. Therefore, behavioral mechanisms determine large–herbivore foraging patterns at intermediate scales of food patches and feeding sites. The number of individuals in the given habitat locations are related to the resource availability (Bezawork Afework *et al.*, 2009). The larger the group, the less cost per member to defend. This could be an anti – predator behaviour. However, factors such as topography, distance to water and temperature are important determinants of forage quality and quantity (Bailey and Provenza, 2008).

2.4. Habitat utilization

Distribution of an organism depends primarily upon the sustainability of the environment for its survival, growth and reproduction (Aramde Fetene, *et. al*, 2011). White - eared kob is found in South Sudan on both sides of the White Nile, and the Gambella region of western Ethiopia (Fig. 3). Individuals or small groups occasionally wander into northern Uganda.

Distribution and abundance of food resources are key determinants shaping the behaviour of the given animal in its environment. This implies that changes in temporal and spatial patterns of resource abundance that shape feeding, behaviour, habitat choice and population cycle of both resources and consumers. Therefore, basic resources necessary for growth and reproduction are processed by affective (non cognitive) system such as morphology and effective (cognitive) system, odour, sight of food and taste (Bailey and Provenza, 2008; Smith, 2012; Nhial Tuach, 2013).

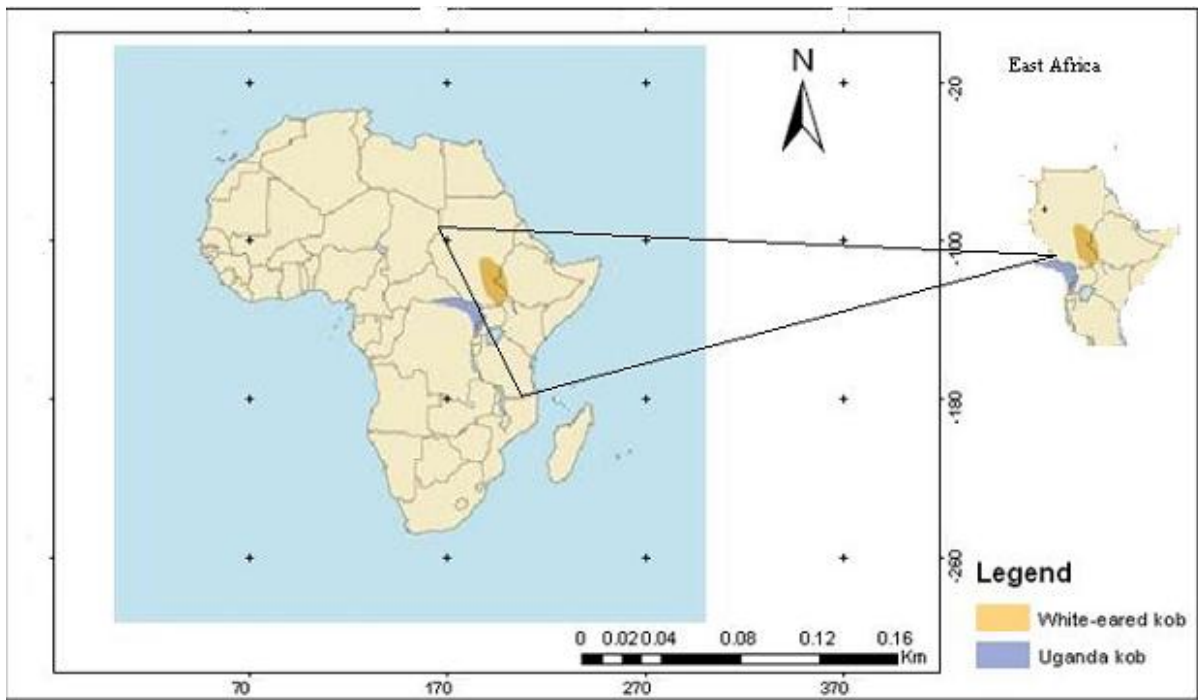


Figure 3. White – eared kob distribution. Source: (Nhial Tuach, 2013)

Variation of populations showed that rainfall is the main determining factor on vegetation productivity. This has pronounced effects on movements when raining, animal populations such as cattle and white – eared kob were observed to turn their movements toward direction of the winds (Fryxell, 1987; Fryxell, *et al.*, 1988). Therefore, adaptations have physiological and morphological alignments to the need of animals. Juvenile mortality rate was related to the immobility or incapacity to escape dangers than food shortage (Fryxell *et al.*, 1987). During the wet season, local communities living at the buffer zones of the Park claimed several attacks by lion and hyaena predators. Fryxell and Sinclair (1988) suggested that temporal regularity of population dynamics indicate the seasonal change in resource availability and nutritional quality and availability of other vital resources that are factors responsible for this shift in population dynamics.

2.5. Feeding ecology

Feeding habits of white – eared kob is affected by seasonal climatic and hydrological events. Therefore, antelopes such as white – eared kob, tiang, zebras and lechwe migrate in response to seasonal changes in resource availability. The subtle links between migration and resources is seasonal movement. Seasonal variation of food quality also becomes more important. For instance, wildebeest in Serengeti – Mara Ecosystem and white – eared kob in Gambella – Boma Ecosystem, the transitional uses of resource, migrate from grassland ecosystem during the wet season to wooded grassland with higher biomass during the dry season (Fryxell and Sinclair, 1988; Fryxell *et al.*, and Sinclair, 1988).

Lion, hyaena, wild dog and domestic dogs are principal predators of white – eared kob. Consequently, resident white – eared kob are distinguished from being less advantageous than migratory ones. Predators remain near den sites, where they care for their immobile young. The risk of predation is reduced in two ways: (1) moving beyond foraging range of predators referred as temporal refugia, and (2) decoupling of predator abundance by making them unable to respond numerically to the temporary supper abundance of migrants.

There are two ecological consequences of seasonal migration. Pastoral communities settle around permanent water supplies leading to vegetation cover removal around settlement and deplete and cause soil erosion and overgrazing (Fryxell and Sinclair, 1988). So far the total population size is more than 800, 000 white – eared kob in Boma National Park, Sudan. Their movement was correlated to dry season to scarcity of food and water (Fryxell and Sinclair, 1988). They concentrate at densities of exceeding 100 km² in low lying meadows adjacent to permanent water holes that produced grass re–growth throughout the dry season (Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988). During the wet season, movement is unrelated to the availability of food and water, but to the quality of food and water. They preferred the northern part of the geographic range of migration during the dry season, the current GNP,

which is prone to surface flooding and the southern range during the wet season which is less prone to surface flooding (Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988; Duval, 2000).

2.6. Activity patterns

Kob is mostly active in morning and evening hours. They form mixed-sex herds of females and young males (< 8 months) that may vary greatly in size over short time periods. Females occupy large, overlapping home ranges, apparently moving in response to food availability. Males' movements are more restricted, and they commonly remain close to lek areas (Balmford 1992).

Herds of non-breeding males may also form. Populations vary widely in density; 8 to 124 kob km⁻² have been reported in suitable habitat (Muhlenberg and Roth 1985). This variation in density affects male mating strategies. Males may move in herds, have single territories, or defend lek territories. Higher populations favor lek mating. Kob on the Ivory Coast, which has low population density, does not lek (Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988; Duval, 2000).

2.7. Human settlement

Anthropogenic activities such as indiscriminate killing and hunting with modern equipment and the new development of road infrastructures and human settlements lead to range restriction, habitat alterations both on sites (grazing, logging, poaching) and off sites (change in hydrology, pollinators, habitat fragmentation) (Fryxell and Sinclair, 1988). Therefore, behavioural mechanisms determine large herbivore foraging patterns at intermediate scales (food patches and feeding sites). Spatial locations and areas of which animals are found explain their distributions. These are influenced by the occurrence of suitable environmental conditions (Bailey and Provenza, 2008; Smith, 2012). Factors such as topography, distance to water and temperature act as constraint within which biotic factors such as forage quality and quantity operate (Bailey and Provenza, 2008). White – eared kob is grouped under large

herbivore. At coarser scales, topography, distance to water and temperature operate parallel to in opposite direction with forage quality and quantity, which trigger migration of animals from one region to another. Grazing bout preceded and followed by non grazing behaviours such as resting and ruminating. Multiple patches within the bout and feeding site reflect coarser spatial scale (such as daily, seasonal and lifetime) and encompass the entire area grazed within bout (Bailey and Provenza, 2008).

Ethiopia, more than 90 million people earn their livelihood from agriculture (crop cultivation and livestock rearing activities). This high population and low urbanization increase the scarcity of other resources, particularly agricultural land. This results in modification of wildlands and habitats. When humans alter ecosystems, large mammals are typically the first species to disappear. They are hunted for meat, hides and horns. They are harassed and killed if they pose a threat. They require expansive habitat and are susceptible to diseases, such as anthrax, rinderpest, and distemper that are spread by domestic animals (Sodhi and Ehrlich, 2010). Shifting cultivation through land clearing commonly performed through slash and burn has contributed a lot to the depletion of this forest. Recent developments have brought in dam and road construction, various settlements and state farms along with extractions of fuel wood, all of which have contributed a lot towards the shrinkage of this unique forest ecosystem. Wildlife–livestock interactions on rangeland grazing grounds remain non directional. Interaction among populations of the same or different species is one of the basic tenets that determines abundance and distribution of organisms (Augustine, *et al.*, 2011).

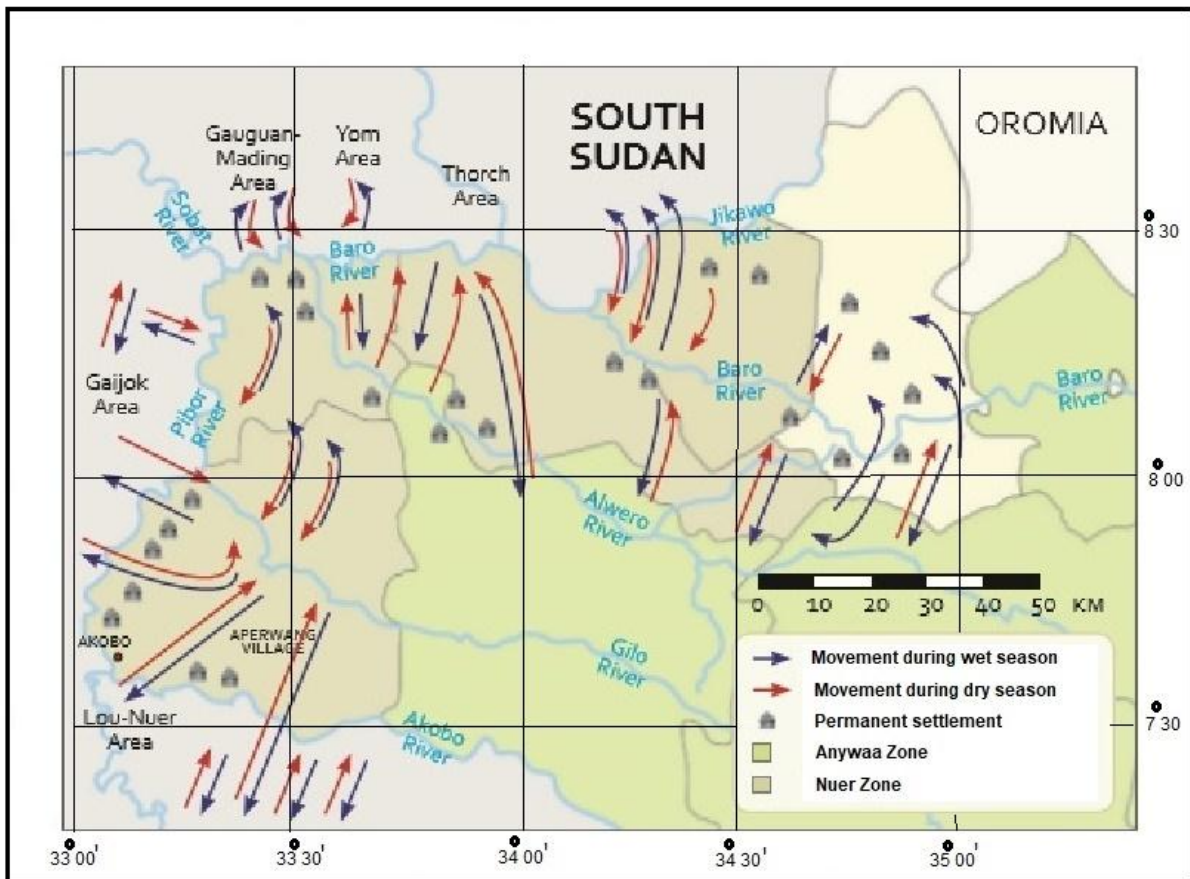


Figure 4. Seasonal movement of Nuer Pastoralists into GNP (Source: Wondwosen Machigo, 2017)

With a few notable exceptions such as Somalia and Djibouti (Barrow *et al.*, 2008), and Mongolia (Boto and Edeme, 2012), pastoralists are usually minorities in their countries occupying marginal land along national borders, and ruled by these political elites often representing an agricultural majority, who live in higher rainfall zones (Randall, 2015). As a result, a new paradigm is expected to be integrated among human society because a full understanding of the environment is crucial for human geography for analyzing human and environmental relations. There are similar orientations between human geography and the new paradigm (Adrainson, 1997).

Human encroachments and land-use changes cause loss of grazing land for wildlife and lead to human-wildlife conflicts. Survival of wildlife in the protected areas is highly correlated

with ecological and environmental integrity of corridors and migratory routes, which facilitated their movements in the landscape (Okello, 2012).

Competition between ungulates and livestock is accompanied by noise (such as noisy bells hung on oxen), bushmeat hotspots and herdsmen, scouting cattle avoid cattle raid during grazing in the field. These factors such as feeding behaviour caused most of the displacement of wildlife (Okello, 2012).

However, Butt and Turner (2012) claimed that wildlife–livestock competition is largely seen as exploitation rather than interference competition. Therefore, ecological interspecific competition follows three conditions: 1) populations of the different species must share resources; (2) these resources must be limited, and; (3) the joint exploitation of the reduced nutritional status of wildlife or domestic livestock caused by exploitation competition could lead to lower recruitment, increased vulnerability to disease and emigration out of competitive areas to other areas of higher forage quality.

3. OBJECTIVES OF THE STUDY

3.1. General Objective

- The general objective of this present study was to investigate populations estimate, habitat association, activity patterns and human – white – eared kob interaction in GNP.

3.2. Specific Objective

- To estimate populations of white – eared kob in the study area
- To determine habitat association and distribution
- To examine Feeding ecology of white – eared kob in the study area
- To assess time allocations and activity patterns white – eared kob and cattle in the specific habitat
- To assess and investigate human–wildlife conflict in the study areas

4. MATERIALS AND METHODS

4.1. Description of the study area

4.1.1. Location

This study was conducted in GNP, in Wanthoa and Akobo Woredas of Nuer Zone Administrative Council, West of Gambella, which is 767 km away from the capital city, Addis Ababa. It is located at latitude of $8^{\circ} 0'0''\text{N}$ and longitude of $34^{\circ}15'0''\text{E}$ of the southwestern Ethiopia (Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015). It is situated between eight administrative districts namely Jikawo, Lare, Wantawo in the north, Akobo in the west, Itang and Abobo in the east, Gog and Jor in the south. Its recent area covered 4,575km².

GNP has important wildlife core areas consisting of mainly wetlands as a critical and sensitive habitat types in the Park (Fig. 5). These include Alewero, middle Gilo and some part of lower Gilo-Pibor swamp with, species of national and international importance such as Nile lechwe, shoe bill stork, tiang and buffalo in Alewero.

African elephants, giraffes, roan antelopes and white – eared kob reside in the middle Gilo and lower Gilo–Pibor swamps and marshy grasslands (Nhial Tuach, 2013; Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015). These habitats in the Park did not have the highest diversity of wild animal species, but make GNP a center where the continent's most important five big game animals reside with exception of rhino, which had gone missing due to anthropogenic related activities. This constituted a total of 1821 km², which comprise 32.04%, buffer zones consisting of 1552 km² (27.31%), low use have 222 km² (3.91%) (Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015).

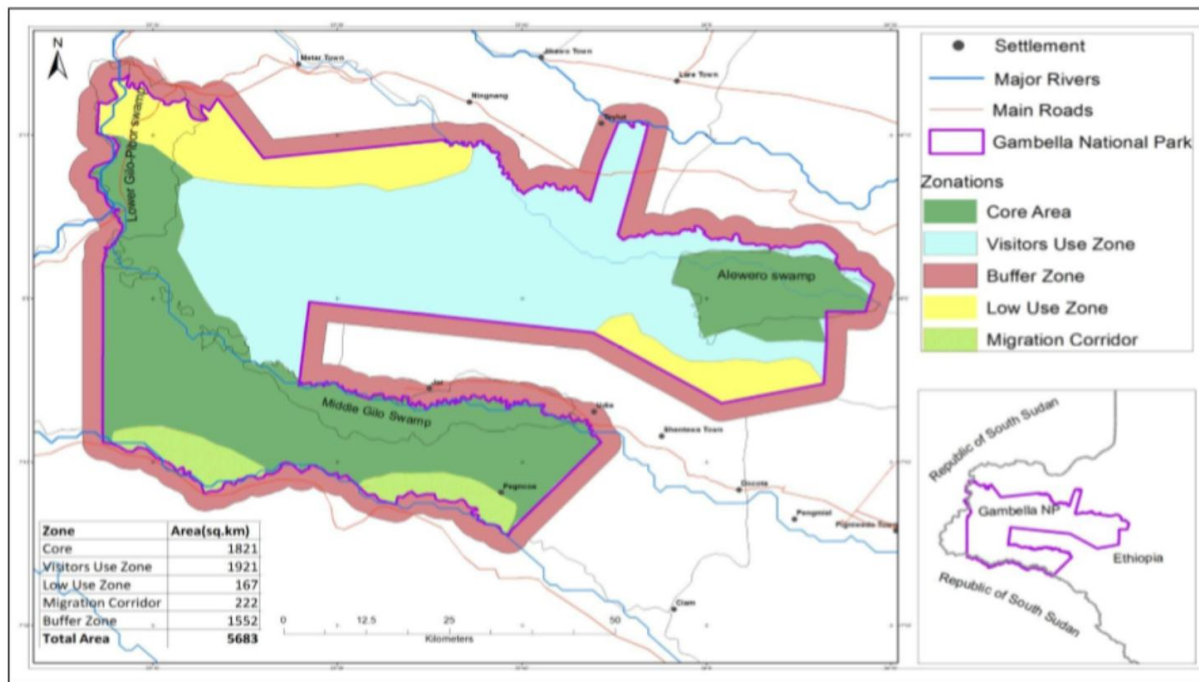


Figure 5. Showing GNP zonation

4.1.2. Topography

The topography of the Gambella Regional State in general has diverse topographic features with altitude ranging from 394 m .a.s.l in western lowland areas to 2300 m a.s.l. in eastern highlands (Gatluak Gatkoth, 2015). The land mass of the region is extensive flat plain that is surrounded by chains of mountain ranges, which form drainage system in the North and South eastern part of the region. The Park is located in the flat plain with average altitude of 500 m a.s.l (Goldsmith *et al.*, 2002; Nhial Tuach, 2013; Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015; Ketema Tilahun, 2015).

4.1.3. Geology

The Park and surrounding areas are primarily a flat plain with little relief, surrounded by highland areas that provide catchments for the rivers in this landscape. Much of the landscape, particularly in the west at the border of Republic of South Sudan is seasonally flooded. The natural vegetation around the Park varies widely. Predominant vegetation type in the area is open woodland, crisscrossed with riverine vegetation along the drainage channels. Most of the woodlands are fire-adapted vegetation in the study area (Fig. 6) (Goldsmith *et al.*, 2002; Nhial Tuach, 2013).

4.1.4. Soil.

GPNRS possesses hot weather, richly endowed with high quality soils, abundant water supplies as part of the White Nile watershed. Black- cotton soil is the only type of soil in this study area. It is nutrient rich soil with high clay content making it highly adhesive (muddy) in the rainy (wet) season to rocky- hard and cracked during the dry season. After the rain, it dries easily (Fryxell, 1985; EWCA, 2010; Nhial Tuach, 2013).

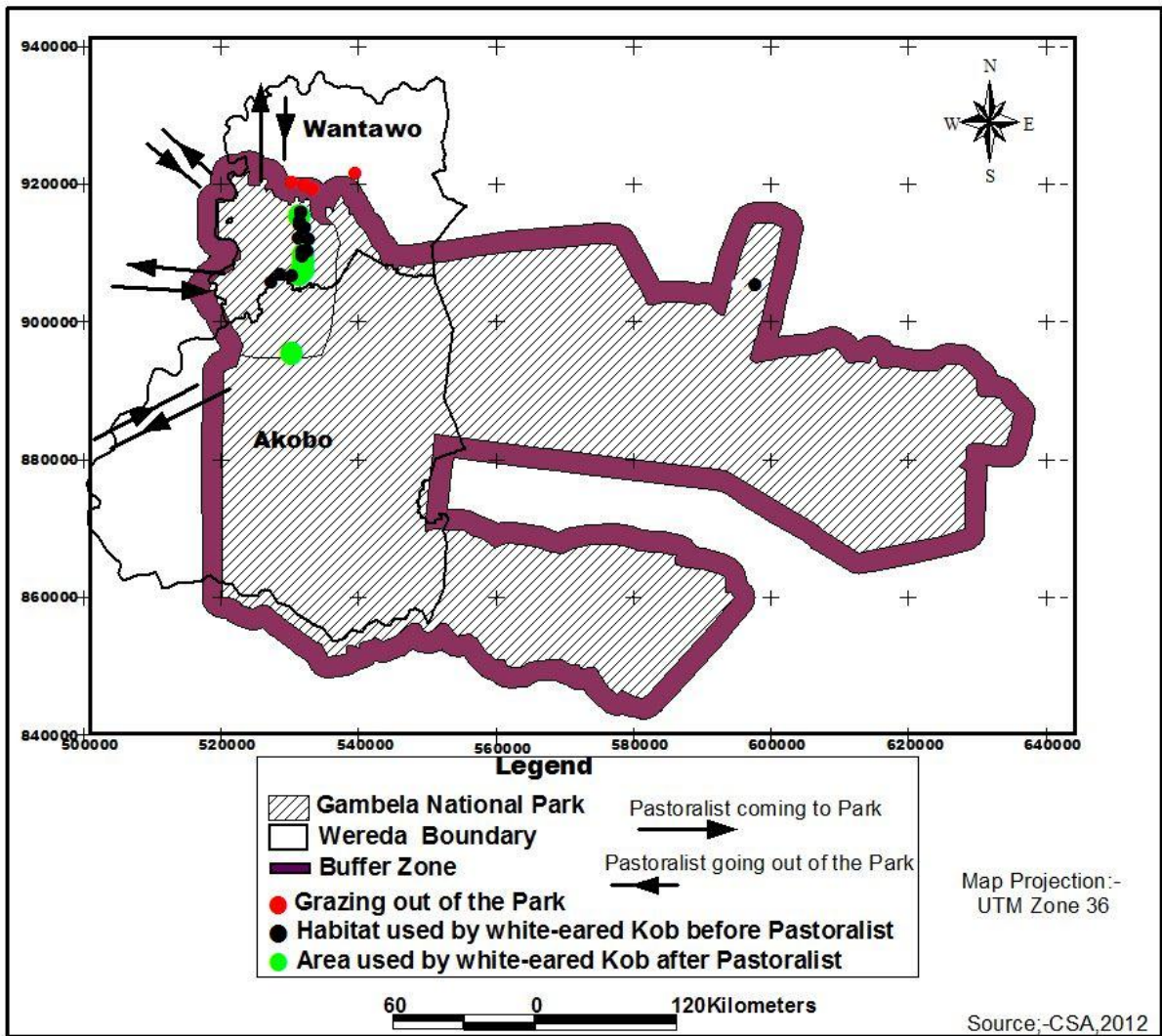


Figure 6 Map of the study Area

4.1.5. Climate

4.1.5.1. Temperature

The hottest months in the GNP are January, February, March and April with temperature ranging from 39⁰C to 43⁰C and high rainfall during the wet season from May to October. The mean annual temperature is 27⁰C but the mean monthly temperature varies significantly. The absolute maximum temperature of 45⁰C has been recorded in mid March while the absolute minimum temperature of 10.3⁰C has been recorded in December following the onset of winter season (Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015).

4.1.5.2. Rainfall

The average the rainfall in the area is 450 mm. Average daily temperatures ranging from 36⁰C to 43⁰C. The wettest season lasts for 7 months (May to November) and the wettest month of the year reaches its peak in June. Dry season lasts for 5 months (November to April) and February is the highest peak of the dry season of the year. The mean annual rainfall of the park is 1400 mm (Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015).

4.1.6. Fauna

GNP to protect its outstanding biodiversity and important wetland habitats, and to care for large mammal species in the area. It is situated in the Guinea–Sudan savanna of western Ethiopia. It possesses an enormous diversity of ecosystems and wildlife species (Ketema Tilahun, 2015). In particular, it is renowned for its diverse assemblage of large mammals like elephant (*Loxodonta africana*), leopard (*Panthera pardus*), spotted hyaena (*Crocut crocuta*), warthog (*Phacochoerus aethiopicus*), buffalo (*Syncerus cafer*), lion (*Panthera leo*) and other numerous species of ungulates. GNP has been officially gazette (EWCA, 2010; Nhial Tuach, 2013; Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015).

4.1.7. Flora

The floral components in GNP consist of mixed different plant species. These include *Combretum–Terminalia* woodland, *Terminalia* woodland, *Tamarindus–Terminalia* woodland located in the eastern part of the Park and the *Balanites-Acacia* woodland, *Acacia* woodland, *Ziziphus–Acacia* wooded grassland, *Orzya–Ziziphus* savannah grassland and *Hyparrhenia–Orzya* open grassland situated in the west, northwest and central part of the Park. The *Cyperus–Perpyrmuo-Orzya* seasonal swamp, *Orzya–Hyparrhenia* permanent swamp and *Orzya* permanent swamps are also other major vegetation community types found in wetlands

habitats (EWCA, 2010; Nhial Tuach, 2013; Gatluak Gatkoth, 2015; Gatluak Gatkoth *et al.*, 2015; Ketema Tilahun, 2015).

4.2. Research Designs and Methods

This study used both quantitative and qualitative designs. Primary and secondary information concerning these study species were also gathered from the field and literature. The approach was undertaken using both existing sources of information and primary data collected during the initial field investigation. Methodology consists of two phased approach in which scoping assessment during the dry season and wet seasons.

4.3. Materials

For this study, GPS, binoculars, mega pixel digital camera, measuring tape, data sheet, field guide map and video camera, study map, data sheets were used during the study period.

4.4. Methods

During pilot study survey habitat classification for white – eared kob was carried out for one week to familiarize the place and identify the site for detailed study in GNP (Appendix 5). Camping sites, logistic support and recruitment of field workers were set up as well as collection of all necessary data from GNP town sites, Nyinenyang and Matar were carried out. Similarly, non–governmental organizations and local inhabitants were also contacted to provide baseline information (Appendix 6).

4.4.1. Population estimates

Distance sampling survey using line transect method was repeatedly carried out during the dry season and wet season (Elzinga *et al.*, 2001; Hedley *et al.*, 2004; Garton *et al.*, 2004; Skalski *et al.*, 2005). Independent transect lines were randomly laid in the study area. . Prior to detection of White – eared kob, time, GPS location, group size, group spread, animal–observer distance, animal distance or perpendicular distance (PD). Animal disruption was

minimized by employing silent detection methods (Demeke Datiko and Afework Bekele, 2011; Selvan *et al.*, 2013). Experimental observation and measurements on environmental, independent variables, such as biotic factors (members of social group, vegetative characteristics and herbivore–plant relationships) and abiotic factors (temperature, wind and rainfall) were taken repeatedly (Fryxell and Sinclair, 1988; Stubblefield, 1995; Gould, 2002). Distance sampling methods were used to estimate population during the wet and dry seasons (Burnham *et al.* 1984). Transect surveys were conducted during August 2016 to August 2018. Sex and age categories were identified in the field by using characteristics such as the relative body size, external genitalia and furry hair. The categories included adult male and female, sub-adult male and female, unidentified juvenile sex. Total number of individuals in a group was counted to identify the group size. Individuals were grouped into one when the distance between them fall less than 50 m following Befekadu Refera and Afework Bekele (2004), Yishak Doku *et al.* (2007) and Mesele Yihune and Afework Bekele (2012).

4.4.2. Habitat association

Prior to white – eared kob sighting in the study area, habitat type was recorded to identify habitat associations. Numbers of individuals sighted were taken as scores with respect to habitat types and compared their frequencies to the relative availability of vegetation types. Present of plant morphological characteristics or vegetation structure available in the site, and GPS positions were also recorded. Integration of information helps to accurately reflect species habitat associations (Mesele Yihune and Afework Bekele, 2014). Repeated counting of the same herd or cluster was avoided using recognizable features such as cluster size, herd composition and distinct individuals with body deformities such as broken leg, cut tail or ear

(Demeke Datiko and Afework Bekele, 2011; Selvan *et al.*, 2013; Mesele Yihune and Afework Bekele, 2012).

The study area was divided into three major habitat types namely, bushland, tall grassland and wetland base on vegetative different in the study area (Gatluak Gatkoth *et al.*, 2015). and feeding habits were recorded. The survey was started from 06:00 h to 12:00 h in the morning and from 14:00 h to 18:00 h to gather both dry and wet season data (Nhial Tuach, 2013). The use of habitat patches within a home range where resources were available was delineated from daily based observations carried out during the study period. Sampling habitat elements and resources in grazing bouts were executed and recorded (McComb *et al.*, 2010; Mesele Yihune and Afework Bekele, 2012; Mesele Yihune and Afework Bekele, 2014).

Repeated standard observations were used to collect data on foraging behavior, time spent for foraging was also recorded using focal sampling. Focal sampling consisted of watching an individual for a fixed period (10 min) with unaided eye or binocular according to the size and the distance of the animal from the observer and recording the activities such as the type of food items consumed and amount of time spent for foraging (Fryxell and Sinclair, 1988; Gould, 2002; Mesele Yihune and Afework Bekele, 2012; Mesele Yihune and Afework Bekele, 2014).

Assessment of selected food resources from the patches used by the individual within its home range was conducted and numbers of animals were recorded. The method of Norton-Griffiths (1978) was used to describe the dry season distribution and the vegetation type utilized by the study species. Prior to foraging, White – eared kob, was observed and the most clearly visible animal was selected as focal animal. This focal animal was changed if it fails to select feed within 60 seconds (Breebaart *et al.*, 2002). Stems and leaves of plant species after herds abandoned the grazing field were collected. These plant species were identified and given vernacular names. The samples were collected after identification by the local

people and brought to Addis Ababa University Herbarium for identification at the species level. These plant specimens were collected from all the bites found in the study area for taxonomic identification.

4.4.3. Activity patterns

Diurnal activity budgets of adult White – eared kobs and cattle were estimated on feeding bout following Fryxell (1987). Focal–animal sampling and scan sampling techniques were employed. Data were collected on foraging behaviour, competition, interaction and habitat and micro–habitat use was carried out within 40 m radius for every 10–15 minutes (Underwood, 2005; Morrison, 2006). Focal individuals randomly selected were stratified into age and sex of particular individual with dominant activity in the group under observation (Aberham Megaze *et al.*, 2012; Mesele Yihune and Afework Bekele, 2012).

Field survey of niche overlaps were carried out in the field reflecting similarity in resource use. The species interactions in the community were measured based on the utility of resources such as food, space or other resources during the study periods. Location, resource state, number of individual and abundance of resource state were also recorded in the field (Barasona *et al.*, 2014).

Interspecific crowding of niche overlap quantification for two species (white – eared kob and cattle) were made to evaluate resource state and diet categories in order to measure directional overlap or crowding of species 1 on 2 with respect to their corresponding sites (Hurlbert, 1978; Bart, 2004; Morris, 2006; Smith, 2012; Kinga, 2018).

4.4.4. Human–white eared kob conflict

Fieldwork was done between February 2016 and March 2018. Data collection was initiated in the villages. Information was obtained through participant observation and interviews.

Record forms allowed recording animals hunted, biomass extracted, distance intervals to hunting sites, habitat types and seasonality of wildlife harvests (Mesele Yihune, 2006; NCD, 2008; Santos-Fita *et al.*, 2012). The baseline survey was employed in the study area using field investigation techniques through direct observation in GNP. This is to estimate the population levels of animals' death. The information was collected based on the presence of animals within a given transect. Therefore, visual recognition of scats and of the actual animals was used to estimate the population at specific point. The length of each transect was placed at 500 m following (JICA, 2002; Mesele Yihune, 2006; Paton *et al.*, 2017).

4.5. Data analysis

Data analyzed using SPSS v.23 and Microsoft Office Excel 2007 to calculate various sizes of dimensions (average length, width, radius and associated areas) as per standard mathematical formulae. Further, statistical tests between variables (parametric tests) and dependence of sightings and animal numbers on habitats (enumerative statistical tools) were done.

Densities of white – eared kob were estimated using the effective distance method as:

$$TW = 2xESD$$

Where TW = Transect Width, ESD Effective Sighting Distance and TL = transect length

$$\text{Total Area Sampled (A in km}^2\text{)} = TLxTW$$

A = Total extent of habitat of the present study (in km²)

Density Estimate (Groups) = Total number of groups seen (ni) divided by total area sampled

$$\text{Mean Group Size (si)} = \frac{xi}{ni}$$

Density Estimate (Individuals) = Density (herds) x Mean Group Size

N = D x A, where, N = total population size and D = Population density (individual per km²)

Niche breadth was obtained by calculating different habitat types. The measurement for the average number of white – eared kob was located within distance of randomly chosen cattle herds divided by density of White –eared kob.

$$B_A = \frac{B - 1}{n - 1} \quad \text{where } B = \frac{1}{\sum p_j^2}$$

Where B is Levin's measure of niche breadth, p_j the proportion of the observations found in resource state j . Maximum B is obtained when the observation percentages are similar in each resource state and minimal if all observations occur only in one resource state. B was standardised to B_A , ranging from 0 to 1, based on the following equation of Hurlbert (1978):

$B_A = B-1/n-1$ where n is the number of resource states. Overlap in resource use was assessed by using Pianka's niche overlap index (Pianka, 1973):

$$O_{jk} = \frac{\sum p_{ij} p_{ik}}{\sqrt{\sum p_{ij}^2 \sum p_{ik}^2}}$$

O_{jk} is the index of niche overlap between white – eared kob and cattle; p_{ij} is the white – eared kob proportionate use of the resource unit j (calculated as: percentage of the observations that were in habitat j , as a proportion of the total observations across all habitat types); p_{ik} is the cattle proportionate use of resource unit j ; n is the total number of habitat types. This is a symmetrical measure that ranges from 0 when no habitat is used in common to 1 when there is complete habitat overlap.

5. RESULTS

Results of this study are presented in five sections. These are: (1) estimation of population density of White – eared kob, (2) habitat association of white – eared kob and livestock, (3) activity patterns, (4) feeding ecology of white – eared kob and livestock in the study area, and (5) human–white – eared kob conflict.

5.1. Population estimates

A total of 6423 white – eared kob populations comprising 93.1% during the dry season (February–April) and 6.9% in the wet season (May) was counted from the survey in the study area in the GNP (CI = 217.8 – 317.4) (Table 1). The common population variance between wet and dry seasons was tested using F – test. The ratios between two variances ($F_{cal} = 5.80$ and $F_{tab} = 2.81$) to constant variance differ significantly ($t_{0.05}(v) = 17.79$). Therefore, null hypothesis was rejected. The result of temporal distribution of white – eared kob populations varied significantly during wet season ($N = 446$, CI = 26.3–121.7) and dry season ($N = 5977$, CI = 82.59–581.41).

Table 1. Seasonal population estimate of white – eared kob in the study areas

Season	Observations	Sample size	Mean \pm SE
Wet	446	6	74 \pm 47.7
Dry	5977	18	332 \pm 249.41
Mean \pm SE	6423	24	267.6 \pm 49.8

Population estimate of white – eared kob based on age comprise of 73.7% adults (35.2 % males 64.78% females) and 13.1% sub–adults (41.8% males and 58.2% females) and 13.2% juveniles (sex was undetermined) in Muon site (Table 2).

However, Kankan possessed 66.3% adults (36% males and 64% females), 21.24% sub–adults (61.8% males and 38.2% females) and 12.48% juveniles.

The result has shown significance difference ($df = 2, 17, F = 9.163$ and $p < 0.05$), but sub–adults and juvenile were insignificant.

Table 2. Population estimate of white – eared kob based on age–sex structure

Study site	N	Age - sex structure					Mean \pm 1.96*SE
		Male	Female	Male	Female	Juvenile	
Muon	3651	948	1744	200	278	481	202.83 \pm 111.5
	Mean	316	581.3	66.67	92.67	80.2	
	SE	264.6	306	39.17	48.81	29.96	
Kankan	2772	662	1175	364	225	150	154 \pm 70.9
	Mean	220.6 7	391.67	121.3	75	57.7	
	SE	90	224.73	78.05	27.84	41.6	

Based on age–sex ratios (Table 3), White–eared kob populations revealed male (M): female (F) ratios in each age group. The ratio ratios were 0.5 in adults and 0.7 for sub–adults and juveniles in Muon study site. However, Kankan revealed sub–adult male survival was 1.6 times higher than females. The ratio of both adult female to juveniles showed that females survive 3.6 times and 3.4 times higher than juveniles in Muon and Kankan, respectively.

Table 3. Population estimate of white – eared kob based on age: sex ratio

Study site	Sex-age		
	Adult (M:F)	Sub-adult(M:F)	Adult female : Juvenile
Muon	0.5	0.7	3.6
Kankan	0.6	1.6	3.4

The population density of white – eared kob consisting 26 White–eared kob km⁻² was estimated from 64 line transects surveyed in the study area. In Muon, the largest groups of herds recorded were Laknom and Ganbor consisting 76 and 45 with mean group density (28 White–eared kob km⁻² and 27 White–eared kob km⁻²) and density (74.86 White–eared kob km⁻² and 48.26 White–eared kob km⁻²), respectively.

In Kankan, population density of White–eared kob between Dualbab (6.7 White–eared kob km⁻²), Malow (9.23 White–eared kob km⁻²) and Pulit–Lit (18.24 white – eared kob km⁻²) were recorded (Table 4).

Table 4. Population density estimate of white – eared kob in the study areas in GNP.

Study site	Block (stratum)	Total Transect	Area sampled (km ²)	Herd size	Group density	Individual	Mean group size	Density
	Ganboor	8	16.23	45	2.77	1215	27	74.86
Muon	Laknom	10	44.09	76	1.72	2128	28	48.26
	Jiek	12	72	14	0.19	308	22	4.28
Kankan	Malow	10	87.23	35	0.40	805	23	9.23
	Pul-Lit	14	90.3	61	0.68	1647	27	18.24
	Dualbab	10	48.04	16	0.33	320	20	6.66
	Total	64	357.89	247		6423	26	

5.2. Habitat association

Population size of white – eared kob was estimated in the study area (Table 5). This was conducted for two different study sites (Muon and Kankan), which were stratified into 3 blocks each. They differ in coverage, tall grassland (31.4%), wetland meadow (58.8%) and bushland (9.8%), occupied by white – eared kob populations.

Table 5. Population estimate of white – eared kob in Muon and Kankan study sites

Study site	Habitat type	N	Mean \pm SE
	Tall Grassland	1215	303.75 \pm 178.3
Muon	Wetland	2128	532 \pm 274.26
	Bushland	308	77 \pm 11.76
	Total	3651	304.25 \pm 286.7
Kankan	Tall Grassland	805	201.25 \pm 82.9
	Wetland	1647	411.75 \pm 174.44
	Bushland	320	80 \pm 37.44
	Total	2772	231 \pm 196.6

The Muon study site, 56.8% of white – eared kob populations were sampled, which differ in proportions, bushland (4.8%), tall grassland (18.9%), and wetland meadow (33.1%). White – eared kob populations were more in wetland meadow (58.3%) than in tall grassland (33.3%) and in bushland (8.4%) $N = 3651$ ($df = 3$, $F = 2748.52$, $p < 0.001$).

The Kankan study site consists of 43.2% of sampled white – eared kob populations with relative abundance comprising of tall grassland (12.5%), wetland meadow (25.6%) and bushland (5.0%) in the whole study area. Within Kankan, populations among habitat types

were 29.0%, 59.4% and 11.5% in tall grassland, wetland meadow and bushland habitat types, respectively. The results statistically differ significantly ($df = 3$, $F = 18040.6$, $p < 0.001$).

5.3. Feeding ecology

In the study area, food resources in Muon and Kankan consist of 49.9% and 51.1%, respectively. Proportion of food resources utilized by each species indicated 44.4% white – eared kob and 55.6% cattle Pearson’s Chi–square ($df = 11$, $\chi^2 = 1105.945$ and $p < 0.001$) and ($df = 11$, $F = 117.364$ and $p < 0.001$).

A total of 12 different plant entities used by white - eared kob and cattle were identified from various grazing fields in the study area in GNP (Table 6). During the dry season, *Panicum maximum* (7.9%), *Hyparrhenia conifis* (8.1%), *Eragrostis multiplosa* (11.7%), *Pennisetum purpurum* (13.4%), and *Sacciolepis africana* (21.7%) were observed major food items highly utilized and varied in both Muon and Kankan with Pearson’s Chi – square ($\chi^2 = 705.301$, $df = 11,1$ and $p < 0.001$) for white – eared kob. Dietary proportions consisted of *Oryza longistaminata* (6 %1), *Panicum maximum* (7.9%), *Hyparrhenia conifis* (8.1%), *Paspalum scrobiculatum* (9.4%), *Pennisetum setaceum* (9.1%), *Eragrostis multiplosa* (11.7%), *Pennisetum purpurum* (13.4%), and *Sacciolepis africana* (21.7%). There were significant differences among these plant species grazed ($df = 11$, $F = 115.6$, $p < 0.001$) ($N = 8408$, mean = 349.78, $SD = 258.367$, $CI = 344.25–355.30$).

Table 6. Plant species fed by cattle and white – eared kob in the study area in GNP

(vernacular are names in bracket)

Plant species	Population size	
	Mean \pm SD	95% C I Mean
<i>Tetrapogon villosa</i> (Thir)	49.15 \pm 15.63	46.48 - 51.82
<i>Paspalum scrobiculatum</i> (Gok)	211.92 \pm 41.631	209.02 - 214.82
<i>Eragrostis multiplosa</i> (Lum)	312.24 \pm 141.194	303.39 - 321.1
<i>Panicum maximum</i> (Gaw)	233.18 \pm 121.438	223.95 - 242.42
<i>Sacciolepis africana</i> (Buor)	613.71 \pm 282.214	600.76 - 626.66
<i>Hyparrhenia conifis</i> (Reel)	203.5 \pm 87.345	196.91 - 210.09
<i>Penniseteum purpureum</i> (Nguenyng)	449.91 \pm 224.001	436.81 - 463.02
<i>Pennisetum setaceum</i> (Chiomier)	482.88 \pm 223.642	467.05 - 498.71
<i>Cynodon dactylon</i> (Muoth)	102.96 \pm 52.959	96.92 – 109
<i>Oryza longistaminata</i> (Pon)	148.98 \pm 47.085	144.9 - 153.06
<i>Echinochloa colona</i> (Guot)	115.85 \pm 37.086	111.62 - 120.07
<i>Digitaria</i> species (Yiw)	82.39 \pm 8.467	81.46 - 83.31
Total	349.78 \pm 258.36	344.25 -355.3

In Kankan, proportions of cattle occupations of habitat types were represented as 16.69%, 50.67% and 32.64% in tall grassland, wetland and bushland habitats, respectively.

Results of diet indicated much higher niche overlap than expected as a chance in all months and habitat types except in May and bushland habitats for white – eared kob and cattle in the study area as presented in Table 7.

Table 7. Temporal and spatial indices of white – eared kob and cattle

Months and habitat type	Animals	Pianka's Overlap Index
February	White – eared kob	0.56
	Cattle	0.6
March	White – eared kob	0.665
	Cattle	0.79
April	White – eared kob	0.513
	Cattle	0.725
May	White – eared kob	0.436
	Cattle	0.725
Tall grassland	White – eared kob	0.941
	Cattle	0.886
Wetland meadow	White – eared kob	0.47
	Cattle	0.755
Bushland	White – eared kob	0.337
	Cattle	0.458

5.4. Activity patterns

Time allocation varies among white – eared kob (39.4%) and cattle (60.6). The observations indicated for foraging (46.5%), socializing (58.4%), resting (32.4%), walking (40.7%), and others (24.3%) in the case of white – eared kob (Fig. 7). For cattle time allocation for foraging was 53.5%, socializing (41.6%), resting (67.6%), walking (59.3%), and others (75.7%). The results revealed that males and females differ significantly in time allocation and activity patterns of kob and cattle populations ($\chi^2 = 2439.525$, $df = 4$, $p < 0.001$) ($df = 1$, 43055, $F = 2613.654$, $p < 0.001$).

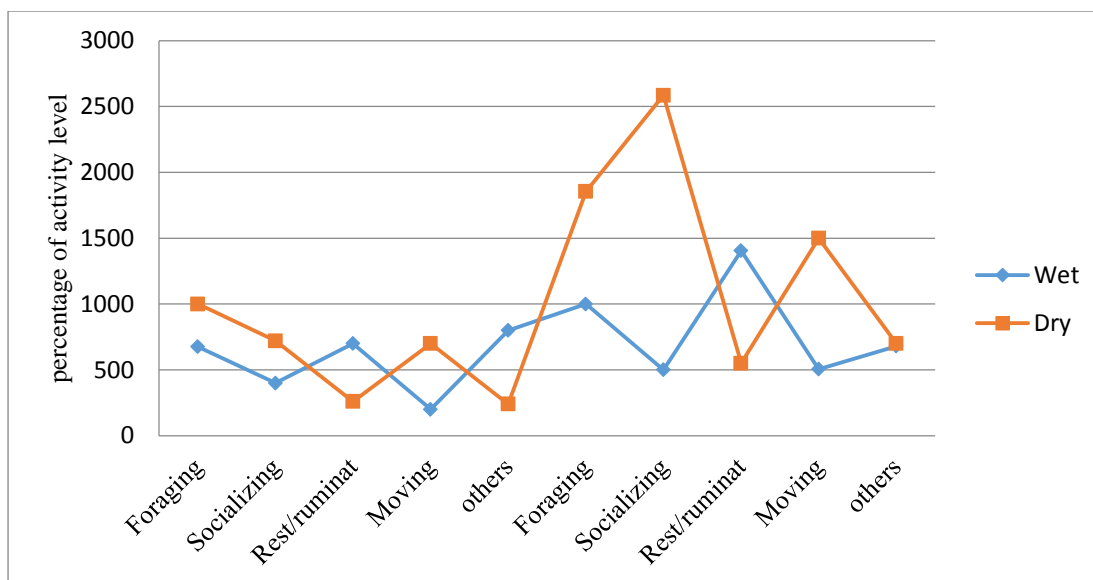


Figure 7. Seasonal activity budget of white eared kob

White – eared kob and cattle with respect to their habitat associations varied considerably. Cattle population utilized 60.5% and white – eared kob utilized 39.5% in all habitat type in the whole study area. For cattle populations, abundance varied 54.2% (tall grassland), 50.9% (wetland meadow) and 85% in the bushland. Records of white – eared kob show 45.8% (tall grassland), 49.1% (wetland meadow) and bushland (15%).

Activity patterns for male white – eared kob was 33.5% and for females it was 66.5% ($n = 16975$). These behavioural activity patterns ($n = 16975$) include foraging (26.7%), socializing

(24.8%) resting/ruminating (17.2%), moving/walking (17.1%) and others (14.3%). The variation was significant ($df=1, 16974; F = 20407.071; p < 0.001$).

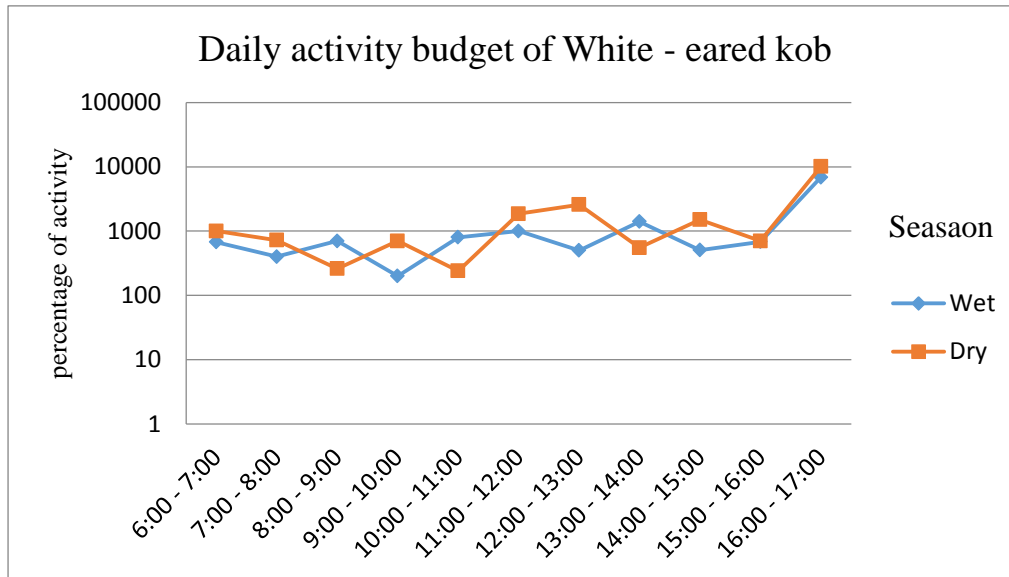


Figure 8. Daily activity budget of white - eared Kob

In cattle, the behavioral record were foraging (20%), socializing (11.5%), resting (23.4%), walking (16.2%) and others (28.9%) ($n = 26081$). These results showed that there was a significant difference ($\chi^2 = 4358.315; df = 4; p < 0.001$) and the ANOVA ($df = 4, 43055; F = 3925.051, p < 0.001$).

The highest to the lowest numbers of cattle were recorded in bushland (85%), tall grassland (54.2%), and wetland meadow (50.9%). Habitats utilized by white – eared kob were 45.8% in tall grassland, 49.1% in wetland and 15.0% for bushland. Therefore, study sites of white – eared kob and cattle for each ecological habitat when combined using ($\chi^2 = 79.258; df = 16269; p < 0.001$) differed significantly.

Table 8. Estimates of white – eared kob and cattle populations based on habitat types in the

Animal	Site	Habitat type	N	Mean \pm SE	95% CI	
Cattle	Muon	Tall grassland	860	215 \pm 104.45	110.55 - 319.45	
		Wetland	2693	673.25 \pm 221.48	451.77–894.73	
		Bushland	2460	615 \pm 230.85	384.15–845.85	
		Total	6013	501 \pm 302.82	198.18–803.82	
	Kankan	Tall grassland	1527	381.75 \pm 196.82	184.93–578.57	
		Wetland	1219	304.75 \pm 232.92	71.83–537.67	
		Bushland	1088	272 \pm 125	147–397	
		Total	3834	282 \pm 89.1	192.9–371.1	
	<hr/> White – eared kob					
		Muon	Tall grassland	1215	303.75 \pm 178.3	125.45–482.05
			Wetland	2128	532 \pm 274.26	257.74–806.26
			Bushland	308	77 \pm 11.76	65.24–88.76
Total			3651	304.25 \pm 286.7	17.55–590.95	
Kankan		Tall grassland	805	201.25 \pm 82.9	118.35–284.15	
		Wetland	1647	411.75 \pm 174.44	237.31–586.19	
		Bushland	320	80 \pm 37.44	42.56–117.44	
		Total	2772	231 \pm 196.6	34.4–427.6	

Within the habitat types for cattle, only 24.2%, 39.7%, and 36.0% were recorded representing tall grassland, wetland and bushland use specifically. A total of 16270 individuals consisting of 39.5% white – eared kob ($n = 6423$, mean = 480.69, $sem = 3.702$, CI = 473.43 – 487.94) and 60.9% cattle ($n = 9847$, mean = 590.91, $sem = 2.565$, CI = 585.88–595.94) were recorded from the two study sites, Muon and Kankan, during the study period.

Seasonal distribution of cattle populations were 21.94% in winter and 78.06% in spring whereas that of white – eared kob were 28.26% in winter and 71.74% in spring.

Among the seasons of the study period, 21.9%, 20.7%, 27.5% and 29.8% were specific coverage of cattle populations in February, March April and May, respectively. Among the months of study periods, 28.3%, 44.2%, 20.6% and 6.9% were specific to white – eared kob populations during February, March April and May, respectively. Habitat types of the study area for each month February, March April and May). Contingency table showed that there was significant difference among habitats ($\chi^2 = 1827.391$, $df = 3$, $p < 0.001$). Statistical estimation of habitat types among tall grassland, wetland meadow and bushland showed that populations differed significantly ($df = 2$; $F = 1457.395$, $p < 0.001$).

The results differed significantly ($df = 1$, 16269; $F = 195.931$, $p < 0.001$).

5.5. Human impact on white – eared kob

This study identified three different threats causing death as dog, gunshot and vehicles each was 36.6%, 24.5% and 38.9%, respectively in the study area in GNP. From two study sites, Muon site has 75.3% of death of white – eared kob in the study area in GNP. Among these, dog caused 45% followed by 19.8% gunshots and 34.7% by vehicles death on road.

Meanwhile in Kankan 24.7% of White – eared kob death threats consist of 9.4% dog, 38.8% gunshots and 32.8% from vehicle accidents. Therefore, deaths in white – eared kob populations varied considerably among the groups with Pearson's Chi – Square ($\chi^2 = 202.881$, $df = 2$, 1; and $p < 0.001$).

Among sex and age structures 48.1% adults (13.7% males and 34.4% females), 21.8% sub – adult and 30.1% juveniles (not identified in sex). The results indicated a significant differences ($\chi^2 = 476.187$, $df = 6$, 1; and $p < 0.05$).

6. DISCUSSION

6.1. Population Estimates

Obtaining clear information on distribution and abundance of wildlife is essential for conservations and management related activities (Southwood and Henderson, 2000). The present study was carried in GNP, where populations of white – eared kob movement patterns were influenced by forage availability and quality, which trigger mass migrations as in many other grassland ecosystems in East Africa (Appendix 7).

Migration is associated with changes in spatial patterns of rainfall, which affects the availability of food and nutrient quality. Similar observations were in Bison, wildebeest and White-eared kob (Fryxell, 1987; Fryxell and Sinclair, 1988). Such movements from one place to another result from lack of forage (Fryxell, 1987). Results indicated that populations of white – eared kob were maximum than in Kankan. This might be due to the importance of the areas containing many suitable and critical sites and influx of new migrants to the core areas. Similar findings were also reported in the study of white – eared kob in the same eco-region (Fryxell, 1987; Fryxell *et al.*, 1988).

Important habitats for white – eared kob were located adjacent to human-inhabited residential and pastoral communities (Appendix 8). More herds of white – eared kob were recorded during morning time. These habitats contain watering and grazing grounds. Thus, geographic distribution, population size and abundance are good indicators of hospitality of an area, which plays a major role in animal fitness by providing all requirements for survival, reproduction and maintenance (Smith, 2012). Wild animals used the habitat after livestock abandoned the site during night. This mechanism would suggest that wild animals were avoiding disturbances during the day time hours and reoccupy in the absent of disturbance.

The locations were used by heavy trucks and other vehicles. This may be noisy for the animals while passing through their habitats.

Generally, White-eared kob avoids human activities as a result, the abundance decreased toward human settlements. It is only sub-species confined to Ethiopia and South Sudan. The age-sex ratio was biased toward males in the present study. Female white-eared kobs were encountered more frequently followed by males. In this study, higher proportion of adult females observed may be the result of poaching targets (Stubblefield, 1995). More males in the study area were associated with the rutting time. This resulted in ideal clump distribution of males onto areas of high estrous female dispersion (Nhial Tuach, 2013).

6.2. Habitat association

Populations of white-eared kob were highly associated with areas where necessary resources are available. The study revealed wetland meadows were the habitat mostly utilized by White-eared kob. The availability of palatable green pastures in the vicinity of water-holes in this type of habitat would make it conducive and more selective for white-eared kob. This coincides with the findings that short grasses are more preferred because they are digestible, possess high concentration of calcium and protein and higher ratio of leaf to stem tissue than tall grasslands (Fryxell *et al.*, 1988). White-eared kob populations were mostly found in association with open grasslands habitats. They prefer wetland meadow alongside savannas grasslands and also grassy floodplains. Physiological, energetic, physical and biotic factors are important in selecting an animal's habitat (Smith, 2012). A potential contest for water resources during the dry season within groups of white – eared kob populations increased intensity of intraspecific competition. This was observed in the study area where they drove away Nile Monitor Lizards in deep and large water pond during the mid-dry season. Migratory species are declining as their population size and geographical distribution ranges

are shrinking worldwide. These happen due to disrupting migratory corridors and routes, caused by negative anthropogenic activities such as settlements, physical infrastructures, agriculture and wars (Fryxell, 1987; Fryxell and Sinclair, 1988). Distribution patterns of organisms occur along spatial and temporal scale differences. However, during progressive dry season, white – eared kob shifted their habitat utilization (Bailey and Provenza, 2008).

Of the two habitats utilized by white–eared kob, majority (86.3%) occurred in wetland meadows. This study agrees with the findings of Fryxell (1987) and Fryxell, *et al.* (1988), where animals gather in areas with plenty of green grasses. Wetland meadow is the only habitat where flood water remains for long period of time during the dry season and white – eared kob concentrate, where their density reached more than 500 individuals per km² (Fryxell, 1987; Kinga *et al.*, 2018). This study also has found similar findings that high kob concentration were commonly located in *Hyparrhenia-Themeda* grassland (Stubblefield, 1995).

6.3. Feeding ecology

The observed interaction between cattle and white – eared kob in wetland meadows and tall grassland habitats determine optimal patterns of diet choice. Habitat destruction is one of the key threats to white – eared kob (Appendix 9), reducing habitat quality due to invasive species and growing livestock numbers, disruption of the natural flooding regime and barriers to migration (resulting from fencing and infrastructure development). Spatio–temporal overlaps and herdsmen accompanying cattle herds, it caused spatial relationship repulsion increasing as distance decreased (Kinga *et al.*, 2018).

Both cattle and white – eared kob preferred flat areas and open country close to permanent water logging (Estes, 1991). White – eared kob is a medium sized mammal, which requires food with a higher content of protein than larger ruminants to maintain, growth and reproduction. Therefore, they require forage having a minimum of 9% crude protein, unlike

Hyparrhenia rufa (Appendix 10) which has 2% of crude protein (Fryxell, 1987; Fryxell *et al.*, 1988). However, white – eared kob use it burned and newly regenerated plants (Fryxell, 1987; Fryxell *et al.*, 1988; Tyrrell *et al.*, 2017). They prefer open floodplain grassland habitat associated with permanent water sources. Bezawork Afework *et al.* (2009) also found forages to be abundant in swamplands during the dry season.

During the rainy season, white – eared kob preferred short grasses. As they are dependent on water, white – eared kob lives in the savannah and floodplain. Therefore, availability of water served as one of the determinant factors causing population dynamics. It was found that 75% of populations of white – eared kob live within 10 km during the dry season (Morjan, 2014). White – eared kob preferred grasses from meadows, which contained 17% of the vegetation similarity in the study area of grassland meadow (Fryxell, 1987). Migrants move from locations where food quality and quantity is poor or inaccessible to places where it is more abundant, nutritious and more available. They seek for young grass, because it is most digestible and high in protein content (Harris *et al.*, 2009). The quality and quantity of grass depends on the availability of water, which varies in time, amount and distribution across the ranges of white – eared kob (Williamson *et al.*, 1988). Animals track the seasonal and shifting distribution of their forage ('green flushes') and therefore become migratory (Fryxell and Sinclair, 1988; Boone *et al.*, 2006; Mueller *et al.*, 2008; Harris *et al.*, 2009). Many migratory species are good indicators of response to changes in resource availability. Rapid, long distance movements are characteristic of large herbivores that evolved in grassland ecosystems. Migration during the dry season by white – eared kob is to access green grass and water resources (Fryxell, 1987; Fryxell and Sinclair, 1988).

Among the variety of plants fed in the study area, there was niche overlap except in the month of May (0.436 in white – eared kob and 0.451 in cattle). This is because palatable forages and availability increased in May, which result into lowest indices prior to the onset

of rainy season. This indicated similarity in the resources utilized.

Competition for food between large herbivores can be manifested by factors (Helm, 2006), the most important of which are diet similarity, consumption equivalence, range overlap, timing of forage use, forage height, quantity and quality and density of competing species. Competition between white – eared kob and cattle greatest on dry season ranges. Grazing land management, especially in drought-prone areas, is a complex process requiring a balance between the use of water and food. Therefore, pastoralists have unique knowledge of how to balance between conservation and sustainable use and how to achieve and maintain it. In addition to seasonal and annual changes in use patterns, pastoralists are also able to quickly respond to perturbations because of their close historical connections with traditional biodiversity conservation practices. This is often reflected in local management practices, which largely emphasize long time horizons in decision-making in order to maintain culturally important elements of the ecosystem. For example, in Rajasthan (India), Raika and Rabari pastoral people use local decision-making processes to sustainably manage mixed livestock herds to produce meat and milk (Blench, 2000), where traditional pastoral livelihoods and management practices are replaced or restricted. However, the degradation of critical ecosystem services often follows (McGahey *et al.*, 2014).

Many pastoral systems are good examples for the application of ecosystem approaches. It recognizes that humans with their cultural diversity are an integral component of ecosystems. Through ecosystem approaches, production and economic considerations are balanced with conservation and the maintenance. The ecosystem approach also recognizes the importance of involving all stakeholders in decision-making and of decentralizing management to the lowest level possible (McGahey *et al.*, 2014).

The body conditions of white – eared kob indicate nature and severity of season's carrying capacity to support individual white – eared kob (Fryxell, 1987; Fryxell and Sinclair, 1988; Fryxell *et al.*, 1988).

6.4. Activity patterns

Movement and foraging behaviour also play important roles for the existence of a species because individuals can allow to reproductive age and survive. White – eared kob is gregarious and polygamous forming loosely structured herds which vary in size and composition on a daily basis (Stubblefield, 1995). Fryxell (1987) also reported that males are better than females in their functional response and diet breadth constrained energy and nutrient gains in a given habitat. Populations of animals are related to environmental demands and supply of food for individual organisms. Changes in environmental drivers within a given year are responsible for causing different weather patterns and seasons of which annual cycles produce climatic patterns (Barboza *et al.*, 2009).

White – eared kob females are at the front of the daily movements to water sources. However, in larger herds, females take their signals from other females. Males are also present in the migratory herds and follow the females. All-male herds may number in the hundreds and accompany females during the dry season migration (Estes, 1991). White – eared kob, like other animals, require essential elements such as sodium, calcium, magnesium and essential nutrients influencing the distribution, behaviour, growth and reproduction (Smith, 2012).

6.5. Human impacts on white – eared kob

This study identified 75.7% of deaths in Muon site (A); meanwhile Kankan caused only 24.3%. White – eared kob serve as food to local communities exploited by hunting using different means of capturing mechanisms including hunting dog, fire gun, and sword (Fryxell, 1987; Fryxell *et al.*, 1988; Morjan, 2014). Mortality rate of juveniles was related to

the immobility or incapacity to escape dangers than food shortage (Fryxell *et al.*, 1987). However, during the wet season, local communities living in the buffer zone of the Park claimed several attacks by lion and hyaenas.

Mortality of calves and adults increases during the dry season where human-induced mortality rates caused the most severe due to over hunting (Morjan, 2014). Hunting for bush meat, wildlife diseases, as well as entanglement in snares targeting non-preferred individuals are considered to be direct threats to white – eared kob (Appendix 11). It is suspected that the continuing uncontrolled hunting of white – eared kob is likely to threaten them. Despite legal protection, white – eared kob populations are still being hunted throughout their range for meat and skin. Many of the hunters are from communities residing within and surrounding the GNP. Recently the influx of refugees from South Sudan (more than 100,000) has aggravated the bush meat off-take (EWCA, 2013). Despite the fact that predation and hunting kill their prey, predations have been found to have greater negative influence on white – eared kob than hunting in the present study area. Predators select young and weaker individuals because they are caught easily (Barboza *et al.*, 2009).

Results of mortality rate observed among demographic groups were 30.3% in juveniles and 28.2% in males, 21.5% in sub-adults and 20.0% in females in the study area (Appendix 12). Males engaged by females were subjected to fight with intruding ones, which incurred injuries during the rutting month of their life cycle (Fryxell, 1987; Fryxell *et al.*, 1988; Morjan 2014).

However, death of animals during the dry season may happen as a result of anthropogenic – ungulate trophic mismatch, a situation where migratory animals move by using correlative cues to anticipate seasonal food availability. However, due to climatic conditions, habitats may result in supply and mismatch of demands lead to the trophic mismatch (Fryxell, 1987; Fryxell *et al.*, 1988; Barboza *et al.*, 2009). Demographic studies of both wildebeest and white

– eared kob documented that most deaths were caused by malnutrition or shortage of food (Fryxell, 1987; Fryxell *et al.*, 1988). Frequency of carcasses of both calves and females decline as the distance from routes used by vehicles increase. This may be related to visibility of wildlife in the grassland habitats (Fryxell, 1987; Fryxell *et al.*, 1988).

Fryxell (1987) found that sensitivity to the duration of the dry season that mortality not only affected by the number of individuals competing for scarce resources, but also the length of time individuals are dependent upon sub-maintenance supplies. Because the longer an individual utilized its body reserve to meet nutritional deficit, the lower these body reserves become and the more they are to face potential mortality causing agents. The consequence of direct relationship between food and mortality rates cause populations prone to fluctuation over time. Poaching intensity have been reported the strongest pressures (Appendix 13). Number of poachers seen hunting kob with an automatic rifle and using dogs to work out game. Excessive burning by poachers trying to encourage new grass growth and improve visibility, and encroaching cattle, contribute to the destruction of kob habitat (Stubblefield, 1994).

7. CONCLUSION AND RECOMMENDATIONS

7.1. Conclusion

White – eared kob like other wildlife, serve as good indicators, informing managers about ongoing conditions in their habitats. Obtaining clear information on distribution and abundance of wildlife is essential for conservations and management related activities. A basic understanding is needed in the case of stakeholders to move forward in relation to wildlife conservation activities. Migration of animals is typically an adaptive response to spatio-temporal variation in resources required by individuals to detect and respond to long-range environmental gradients. White – eared kob movements from one place to another result from lack of forage. These study finding indicated that populations of white – eared kob were maximum than in Kankan due to the importance of the areas located in Muon study site. Important habitats for white – eared kob were seen occupied by human settlers. White-eared kob avoids human activities as a result, the abundance decreased toward human settlements. It is only sub–species confined to Ethiopia and South Sudan. The age-sex ratio was biased toward males in the present study. Female white-eared kobs were encountered more frequently followed by males. More males were aggressive during rutting period in April showed their association females.

The study revealed wetland meadows were the habitat mostly utilized by White–eared kob. The availability of palatable green pastures in the vicinity of water–holes in this type of habitat would make it conducive and more selective for White–eared kob. These special habitats need special protection if white – eared kob is to be under good custody.

Competition for food between white – eared kob and cattle was manifested by sharing, limiting resources in the study area. This is revealed by diet similarity, consumption equivalence, range overlap, timing of forage use, forage height, quantity and quality and

density of competing species. Competition between white – eared kob and cattle greatest on dry season ranges. This study identified 75.7% of deaths in Muon site meanwhile Kankan caused only 24.3%. White – eared kob serves as food to local communities exploited by hunting using different means of capturing mechanisms. These include hunting dog, fire gun, and sword. Mortality rate of juveniles was related to the immobility or incapacity to escape dangers than food shortage.

Re – allocation of people from wildlife dispersal areas might be a solution to avoid human-wildlife conflict. However; this needs consultations with stakeholders in the area. Complete loss of wildlife dispersal areas and migratory corridors will reduce protected areas to ecological islands where sustainable conservation of the species may not be possible. Therefore, land-use plans should be pursued that are both profitable and sustainable for communities and wildlife conservation in the context of the large migratory ungulates of Africa.

7.2. Recommendations

White – eared kob populations seasonally migrate to GNP looking for basic resources such as shelters, food, and water are obtained in the study area in GNP. Therefore, this research paper recommended the following points for conservation of this subspecies of antelope, white – eared kob. In order to maintain current population levels of white – eared kob:

- Grassland habitats located near rivers should be left undeveloped for grazing and access to water
- Hunting practices should target only bachelor males rather than the easily-obtained to avoid bio-catch or non-target individuals – juveniles
- Female white – eared kobs should not be harvested, as they are likely to be in estrous or caring for young
- Scientific based knowledge of behavioural interaction, time of day and important
- Avoiding tragedy of common through passing and enforcing laws by standardized ways of ensuring local people do not harm society as a whole while acting in their self interest
- Sensitizing local communities to actively participated in conservation initiatives
- Ethiopia and South Sudan should work in collaborations to conserve this large population of white – eared kob
- Strengthen collaboration between range states, sharing of lessons learnt, methods, capacity building tools, joint meetings to facilitate closer collaboration of law enforcement personnel from the two range states
- Application of same and technically coherent monitoring methodology based on best scientific knowledge across range states
- Removal of barriers to migration (e.g. Road, fence), which are currently restricting the transboundary movement of the animals

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List of Appendices



Appendix 1. Local people inside GNP with remains of killed white – eared kob (Nhial

Tuach, 2017)



(a) Nile Monitor lizard forced out and recolonize pond after white – eared kob,



(b) Dead Nile monitor lizard and white –eared kob in GNP (Nhial Tuach, 2018).

Appendix 2. Impact of contested water resource between white – eared kob and Nile

Monitor lizard in March 2018: (a) Nile Monitor lizard forced out and recolonize pond after white – eared kob, (b) both found dead in the habitat after driven out by herds of white –eared kob in GNP (Nhial Tuach, 2018).



Appendix 3. Part of the GNP taken by Karuturi Agro – industry (Nhial Tuach, 2017)



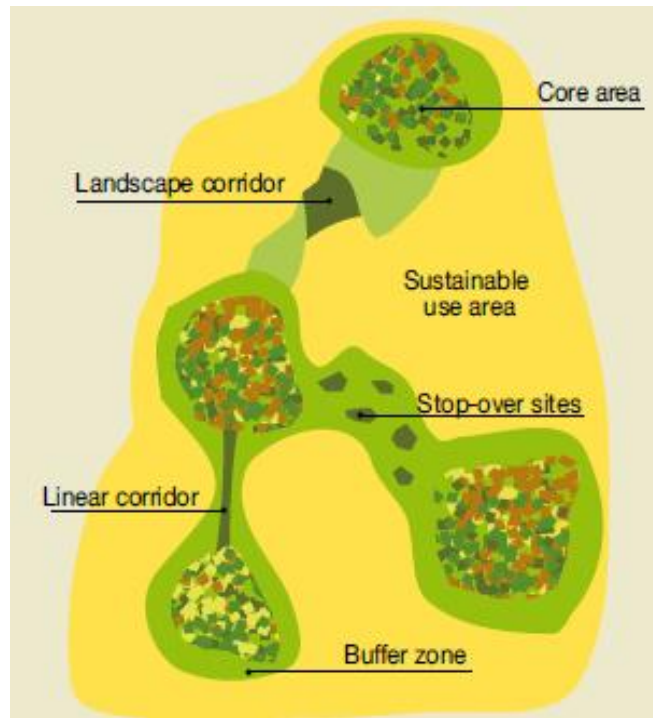
Appendix 4. Falata Pastoralists in GNP (Nhial Tuach, 2018)



Appendix 5. Researcher with GNP wildlife scouts (Henok, 2018)



Appendix 6. Advisor's field validation visit. From left to right Prof. Afework Bekele (Advisor), Nhial Tuach (Researcher) and Koang Tut (Driver) in GNP Corridor invaded by Foreigner Falata pastoralists



Appendix 7. Spatial configuration of an ecological network in the landscape (Source: Nhial Tuach, 2013).



Appendix 8. Cattle grazing in GNP



Appendix 9. Road construction in the GNP (Nhial Tuach, 2018).



Appendix 10. Wet season elephant grass (Photo: Nhial Tuach, 2018)



Appendix 11. Poaching activities in the GNP



Appendix 12. Juveniles caught by dogs



Appendix 13. Local market of white – eared kob bushmeat in Wanthoa Woreda of Gambella

People's National Regional State (Nhial Tuach, 2018)