COLLEGE OF NATURAL SCIENCE

DEPARTMENT OF BIOLOGY

THE DIVERSITY, DISTRIBUTION AND RELATIVE ABUNDANCE OF MEDIUM AND LARGE-SIZED MAMMALS IN GAMBELLA NATIONAL PARK, NUER ZONE WESTERN ETHIOPIA

A Thesis Submitted to the Department of Biology, College of Natural Sciences, Jimma University in Partial Fulfilment for The Requirement of the Degree of Master of Science

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The Diversity, Distribution and Relative abundance of Medium and Large Sized Mammals in Gambella national Parks Nuer zone, Western Ethiopia

By

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A Thesis submitted to the Department of Biology, College of Natural Sciences and School of graduate studies, Jimma University in partial fulfillment for the requirement for the degree of Master of Science in Biology (Ecological and Systematic Zoology)

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Acronyms/Abbreviations

CSA……. Central Statistical Agency

GNP---------Gambella National Park

GPNRS----- Gambella People's National Regional State

GPS -------Global Positioning System

GRSBOLR-----Gambella Regional State Bureau of Land Resources

GFAP----------Gambella Forestry Action Program

ITCZ: ----------Inter-Tropical Convergence Zone

SPSS----Statistical package for social science

SCG---------- Strategy Conservation of Gambella

WBISPP------ Woody Biomass Inventory and Strategic Planning Project

Abstract

Mammal inventories are essential to effectively direct conservation strategies and management practices. A study on the diversity and relative abundance of large and medium-sized mammals was conducted in Gambella National Park, Nuer zone (Makuey, Wanthoa and Akobo), Western Ethiopia, from February- June, 2020. The method of line transects was employed to collect data in three habitat types (riverine forest, wetland and grassland with scattered trees) identified in the study area. A total of 25 mammalian species of medium and large-sized mammals were recorded during the whole study period. The park harbors a number of larger mammals such as the White Eared kob, African elephant, African Buffalo, and Topi antelope. The highest mammalian diversity was recorded in the Riverine forest habitat. A few species that were rare or absent in the Riverine forest habitat in the other two habitat types (grassland with scattered trees and Wetland habitats). The highest diversity was recorded from riverine forest (H'=2.944), the second was recorded in grassland (H'=1.864) during dry season and the least was recorded in wetland (H'=1.366). During wet season the highest diversity was recorded from riverine forest (H' = 1.835) and the least in grassland (H'=1.790). The most common mammals in the study area during both seasons were white eared kob (Kobus kob) Africa buffalo (Syncerus caffer) and olive baboon (Papio anubis). The most abundant species in both seasons were white eared kob (Kobus kob) 200(56.49%) Topi antelope 24(6.77%) olive baboon (Papio anubis) 20 (5.64%) and vervet monkey respectively 20(5.64%). During the wet season were white eared kob (Kobus kob)100(65.35%) African buffalo (Syncerus caffer) 20(13.07%). During dry season the least abundant were spotted hyena (corcuta corcuta) and leopard (Panthera pardus) (0.56%). Among the three habitat types the highest Simpson's index (SI) similarity of mammalian species was obtained from grassland and riverine forest both during the dry (0.86) and wet season (0.83), while less similarity was obtained from species of grassland and wetland during dry (0.34) and wet season (0.32) respectively. Despite the study area is home for different species of mammals, livestock grazing and human encroachments are evident in the area, putting strain on the flora and fauna. Hence, conservation measures should be taken to ensure long term conservation of the area.

***Keywords:**, Diversity, Gambella, ,habitat type, Mammals, National Park, , relative abundance*

CHAPTER ONE

INTRODUCTION

1.1. Background of Study

Mammals are the most important components of biodiversity in the world. Functional structures of mammals are determined by the composition of useful traits (feeding type, body mass, activity patterns and gregariousness). Such structures often vary along environmental gradients like resource availability (Hashim and Mahgoub., 2007).

Commonly, mammals are divided into small, medium and large based on body weight. Medium sized mammals are mammals between 2kg and 7kg such as small carnivores, small primates, large rodents, hyraxes, and pangolins while the species with more than 7kg are considered to be large size mammals these includes most diurnal primates, most carnivores larger than a fox or house cat, all perissodactyls and artiodactyls (Emmons and Feer, 1997).

They are very sensitive and intolerant to disturbance and indicators of the healthiness and integrity of ecosystem (Atnafu, 2018). Large sized mammals have long been recognized as animals that interact in particularly complex and powerful fashions with their habitat (Laws. 1970). They are also basic elements in many ecosystems. Large carnivores regularly shape the quantity distribution, and behavior of prey animals (Berger *et al*., 2001). Large herbivores function as ecological engineers by altering the structure and species composition vegetation (Dinerstein, 2003). In addition, mammals greatly influence the environment beyond direct species interaction such as through cascading tropic effects (Berger *et al.,* 2001). Large-sized mammals also act as umbrella species because of their large area home range requirements and contribute to the conservation of other species.

Ethiopia is one of the African countries known for high mammal species richness (Zerihun *et al*., 2012b), and possesses more than 320 species mammals of which 36 species are endemic to the country. Most populations of medium and large mammals are severely depleted in the country including protected areas due to growth of human population, habitat loss, fragmentation, weak management of the protected areas and deforestation (USAID, 2008; Rabira *et al*., 2015).

The Gambella National Park, one of the National Parks of Ethiopia, is used to be one of the richest biome, since it is the confluence point of Congolian-Sudanese and Somali-Masai biomes, which

make the area very rich in terms of bio-diversity. Wild animals such as White-eared Kob, Nile Lechwe, Elephant, African Buffalo, Lion, Leopard and Roan antelope are important species of the area as far as large game distribution in Ethiopian is concerned, some of these species are regionally endemic (Mac Kinnon et al., 1986). The region is also blessed with a variety of wild animals including birds. As noted by (Selkhozpromexport, 1989), the Gambella plain is one of the few places not only in Ethiopia and the African continent, but also in the whole world where the original and rich fauna and flora have not been altered by human activities. The previous works of Gambella national parks were 69 species of mammalian and 327 species of birds were reported to occur in the region by (Hillman, 1993); (Selkhozpromexport, 1989) (EWNHS., 1996). Extensive areas of swamp habitats, grassland and savanna woodlands support unique varieties of faunastic populations that were rare, endangered and globally threatened. Larger mammalian species such as White-eared kob (*Kobus kob*), Nile Lechwe *(Kobus megaceros*) Buffalo (*Syncerus caffer*), Elephants *(Loxodonta Africana),* and Roan Antelope *(Hippotragus equinus)* were important species of the area (IUCN., 2008)

The success of any live natural resource management program greatly depends on appropriate planning. Hence, the formulation of management plan should be seen as essential prerequisite for initiating sustainable management of wildlife or other live natural resources. It is with this background that the Gambella National Regional State has decided to undertake studies, which include assessment of wildlife resources in the park with the ultimate goal to prepare a management plan that can lead towards the conservation, development and sustainable utilization of the resources in the park.

Therefore, this study was aimed to assess the species diversity and relative abundant of medium and large sized mammals that inhabit in the Gambella national park, in different environmental situations, covering both well preserved areas, and areas potentially affected by the advancement of human activities.

1.2. Statement of problem

Large and medium–sized mammals are particularly sensitive to habitat changes, and they are common victims of poaching and illegal trading (Michalski& Peres, 2005; Laurence *et al.*, 2006). The functional significance of these species lies in their ecological roles, such as seed dispersal and predation on numerous plant species. These functional roles may change the structure and

composition of the ecosystem. Moreover, these species influence the community structure and complexity on the tropic levels in which they are involved, due to their regulatory role as preys and predators (Roemer *et al.,* 2009). The loss of these organisms could have devastating effects because they contribute in many ways to the functioning of the natural ecosystem (Alonso; et al., 2001; Bolaños & Naranjo., 2001). Given the importance of these species, studies identifying and predicting the environmental changes that may affect their diversity are essential, and in such studies, relative abundance and species diversity are usually used as indicators (Carrillo *et al.,* 2000).

Information on local fauna is essential for future conservation strategies and provide basic information for more complex ecological and biogeographical studies (Botelho *et al*., 2012), and which is the first step for conservation action (Botelho *et al.,* 2012) (Fornitano *et al*., 2015). Investigations on diversity and abundance of medium and large provide information of the status of populations for appropriate conservation actions (Galetti *et al*., 2009); (Rabira *et al.,* 2015); (Yosef, 2015). Hence, lack of survey may hinder preparation of appropriate management plan in the protected areas (Fornitano *et al.,* 2015). The fauna of Ethiopia is not well investigated (Dawit and Afework, 2008; Alemneh 2015 b; Dereje *et al.,* 2015). There is little quantitative information about how the tropical forest mammals change (Ahumada *et al.*, 2011).

Similarly, knowledge on diversity, abundance and habitat association of mammals is very essential for the development of sound management plan of Gambella national park. Even though the mammals of the area were studied in the past for example (Stephens *et al*, 2001), there is no up-to-date information on diversity, and abundance of Medium and large-sized mammals in the area. Thus the present study was aimed to fill the gap by gathering current information on the diversity and relative abundance of medium and large sized mammalian in Gambella National Park Nuer Zone, Gambella National Regional State, western Gambella in the area of Makuey, Wanthoa and Akobo Woreda.

1.3. Objectives

1.3.1 General objective

The general objective of this study was to assess the diversity and relative abundance of medium and large-sized mammals in Gambella National Park, Nuer zone, Western Ethiopia

1.3.2 Specific objectives

The specific objectives of the study are: -

- Identify the medium and large-sized mammalian species in the study area
- Analyze habitat association of medium and large sized mammals in the study area
- Determine relative abundance of medium and large sized mammal species in various habitats of the study area
- To assess the threat of mammalian in Gambella national parks.

1.5. Significance of the study

The result of the proposed research work has a great importance in scientific documentation and provides the current detail information about the diversity, and relative abundance of medium and large sized mammals in Gambella national park, Nuer zone, and Western part of Gambella Regional state, western Ethiopia. This is important for the future development and sound management plan of Gambella national park.

CHAPTER TWO

2. Literature Review

2.1 Mammalian Diversity

On a global scale, (Wilson & Reeder.,2005) estimated some 5416 mammalian species, of which a large number were small mammals. This group includes some of the most secretive, hard to survey, and hence still poorly known species. Large mammals" include most diurnal primates, most carnivores larger than a fox or house cat, all perissodactyls (horses, rhinos, tapirs) and artiodactyls (including the relatively small duikers. Among mammals living today, 0.1% of them is egg laying and 99% are placental. They live on land, water bodies and air (Solomon Yirga., 2008).

There are different factors, both abiotic and biotic that can determine the composition and abundance of mammals. Water resource availability, for example, can be a limiting factor for mammalian species because temporal environmental variation influences the structure and species composition (i.e., which species may occur) of a community (O'Connell, 1989; Goulart *et al*., 2009; Ferreguetti *et al.*, 2017). Ecological studies on mammals confirmed the importance of the group in protected areas, as they act on seed dispersal, herbivore control and nutrient cy-cling, especially larger mammals (Wilson & Reeder, 2005; Galetti *et al.*, 2015).

One of the most interesting appearances of tropical Africa is the richness and diversity of its mammalian fauna (Delany and Happold, 1979). This fauna holds species as varied as enormous elephants, tiny pygmy mice, scaly pangolins, amphibious hippopotamuses, flying squirrels, naked burrowing rodents, and termite-eating aardvarks.

Ethiopia is endowed with immense ecological diversity and huge wealth of biological resources attributed mainly to its geographical position, range of altitude, rainfall pattern and soil variability. The Ethiopian mammal fauna consists of 311 species belonging to 144 genera, 43 families and 14 orders (Lavrenchenko and Afework Bekele, 2017)). Fifty-five mammalian species (17.7% of the total) are at present considered to be endemic to Ethiopia. Among them are 36 rodents, 10 shrews, 3 bats, 2 primates, 2 artiodactyls, 1 carnivore and 1 hare. The IUCN Red List includes 32 Ethiopian threatened (i.e., falling into one of the three categories of Critically Endangered, Endangered and Vulnerable) mammalian species. Among them, 19 are larger mammals and only 13 are small mammals (rodents, shrews and bats). (Lavrenchenko et al., 2014; 2016).

Although mammals share several features in common; they also contain a vast diversity of forms. Topographic diversity and climate are the most significant predictors of mammalian species diversity (Melaku, 2011) in which heterogeneous habitats support different species of mammals (Vaughan et al. 2000). Mammals have evolved to exploit a large variety of ecological niches and have evolved numerous adaptations to take advantage of different lifestyles (Flynn et al., 2005). They are diversified both structurally as well as functionally (Yonas and Fikresilasie, 2015).

Mammals inhabit every terrestrial biome, from deserts through tropical rainforests to polar icecaps. Many mammals are aquatic, living near lakes, streams or the coastlines of Oceans. Locomotion styles are also diverse. Social behavior varies considerably as well. Some mammals live in groups of tens, hundreds, thousands or even more individuals. Other mammals are generally solitary except when mating or raising young. Activity patterns among mammals also cover the full range of possibilities. Mammals may be nocturnal, diurnal or crepuscular (Reichholf, 1990).

Mammalian species play crucial roles in ecosystem dynamics. A reduction in the abundance or local extinction of these species would have consequences for forest dynamics and succession due to ecological roles such as seed dispersal capacity and roles in tropic cascades (Camargo and Mendoza, 2016; Dirzo and Miranda, 1990); (Estes et al 2011).Hence, diversity, and relative abundance of medium and large mammals' conditions of a particular ecosystem is the first step for conservation action and provide information to establish appropriate conservation strategies. Understanding of which and how mammalian species persist in disturbed fragments may also indicate the minimum requirements of the species and might contribute to their conservation. (Bernardo; 2013)

2.2. Habitat and distribution of mammals

The distribution of a species represents the sum of many local populations and the distribution of a particular species or group of populations. Distribution of mammals occurs in two levels namely geographical distribution and the local distribution (Vaughan et al., 2000**).** Structurally complex habitats may provide more niches and diverse ways of exploiting environmental resources and thus increase species diversity (Bazzaz., 1975). Different species of mammals have evolved to live in nearly all terrestrial and aquatic habitats on the planet.

Many species are arboreal, spending most or all of their time in the forest canopy. One group (bats) has even evolved powered flight, which represents only the third time that this ability has evolved in vertebrates (the other two groups being birds and extinct Pterosaurs). Many mammals are partially aquatic, living near lakes, streams, or the coastlines of oceans (e.g., seals, sea lions, walruses, otters, musk rats and many others) (McCoy and Bell., 1991). Whales and dolphins (cetacean) are fully aquatic, and can be found in all oceans of the world and some rivers. Whales can be found in polar, temperate, and tropical waters, both near shore and in the open ocean, and from the water's surface to depths of over 1 kilometer (Hashim and Mahgoub., 2007).

Large sized mammals perform important ecological functions and are good indicators of the habitat value because they do not typically rely on specific single habitat as many small mammals do (NLFC., 2005). Large mammals, particularly those in well-protected National Parks are generally easy to observe, sometimes on foot, but usually from a vehicle or hide. Outside protected areas, they can only be seen at some distance. Many mammals were detected indirectly, most commonly by their tracks, diggings, excreta and feeding site. Mammals are mobile and often choose specific habitats and supply to ecological processes such as seed dispersal predation and pollination (Kingdon. 1997).

2.3 Survey of medium and large sized mammal

Medium and large sized mammals consist of a wide variety of species from different tropic levels, from herbivores (e.g., lagomorphs), to top carnivores (e.g., weasels, mountain lions). The diversity and abundance of medium and large sized mammals can be monitored by different techniques. Among these techniques the oldest method used to survey medium and large sized mammals are the identification of foot print in the ground (Martin et al., 2000); (Rudran et al., 1996).

Two of the most commonly applied methods to survey medium and large sized mammals are track plot recording and camera trapping (Scheibe *et al.*, 2008). Both methods permit the estimation of the presence and /or abundance (Wemmer *et al.*, 1996; Cutler and Swann, 1999; Srbek-Araujo and Chiarello., 2005). In addition, terrestrial visual encounter is the core survey for medium and large sized mammals (Janelle et al.,2002; Reif and Tornberg., 2006).

2.4. Threats of mammals

The abundance of organisms is influenced by the interplay of abiotic and biotic factors to varying degree. This is because each species may get favorable site from the combination of environmental variables that most closely corresponds to its requirements (Brown, 1984). Mammals face various threats to their continued existence including habitat degradation and destruction, overexploitation, loss of genetic diversity, endangerment and extinction. The decline of mammals was dramatically accelerated by human activities that shoot, trap, and poison animals and burn forests (Miller et al., 2000). Increasing human population and the associated impacts such as habitat loss and hunting are the underlying factors for the decline of mammalian species. They are considered as species threatening factors and vary in intensity across the surface of the earth. Species that inhabit more heavily impacted regions are expecting to have a higher risk of extinction (Cardillo et al., 2004).

Different activities of humans have its own impacts on wildlife by modifying the behavior of animals and their distribution. The disturbance of behavioral patterns can affect their social structure, which is a key component in the evolution and dynamics of species. Thus, its disruption by human disturbance can have a major consequence on future populations even if the disturbance does not directly affect the survival and reproduction of mammals (Manor and Saltz, 2003; Cardillo et al., 2004). Increasing global human population have been associated with extensive habitat disturbances related to changes in land cover, agriculture, uncontrolled resource extraction, and extensive fragmentation of the remaining forests. Habitat loss and modification are also considered among the leading threats to all species globally; especially mammals (Miller et al., 2000).

Mammalian species diversity and abundance tend to decrease with increasing human disturbances of the landscape (Chiarello, 2008; Laurence et al., 2008; Lopes and Ferrari, 2008). Environmental pollutants also directly or indirectly affect mammals. Aquatic pollution has adversely affected semi-aquatic mammals such as the river otter and water shrew, either by direct toxicity or by

reducing their food resources (Kathpal., 1994). Pollutants also have adversely affected marine mammals including sea otters, seals, and whales. This is particularly the case in estuaries and shallow coastal waters where pollutants are present in higher concentrations than in the open ocean (Miller et al., 2000).

Humans have a long history of both deliberately and accidently introducing exotic species. The long history of negative impacts that introduced exotics have had on native species and habitats dictates that extreme caution should be exercised before any exotic species is introduced (Atkinson., 2001). There are many examples of negative impacts that exotics have had on native species (Meseret, 2010). Exotic species may contribute to the decline and extinction of native species in several ways. They may carry diseases to which native organisms have no defenses. Exotics may also out compete native species for habitat, food, and nesting sites, or may become predators on native species. Feeding activities of exotic herbivores may deplete food resources and otherwise disturb habitats to the extent that native species can no longer survive (Veitch, 2001).

In addition, illegal or traditional exploitation of wildlife within conservation area for both subsistence and economic gain is common. For example, as reported by Williams et al.,1990), the decline of black rhinos and elephants in many African countries is due to overexploitation. If this trend continues, one can expect the complete collapse of the core wildlife area. Besides, indirect negative effects of human activities through habitat disturbances, humans in many poor areas of the world rely to an ever increasing extent on hunting and poaching of mammals for food or trade. For example, the multibillion-dollar trade in bush meat, i.e., the meat of terrestrial wild animals, hunted and for subsistence or for commercial purposes, is an important contribution to the economy of the developing Country. Hunting for bush meat is considered as one of the most important threats to the survival of tropical mammals (Brashares et al., 2004). Similarly, poaching has been shown to reduce substantially the abundance of mammal populations in high demand (Wright et al., 2001)

CHAPTER THREE

3. Study Area and Methodology

3.1. Description of the Study Area

Gambella National Park (GNP) is one of the national parks found in western part of Ethiopia about 776km by road from Addis Ababa, 110 km from Gambella to Nuer zone. The Park is located in the central part, mainly in the lowland plain of the GPNRS among three Woreda namely: Makuey, Wanthoa and Akobo that surround the national park in the region. The park has neither demarcated nor legally established boundaries. Thus, information on the location and extent of the park vary. According to EWCO (1993. Similarly, the map produced by GFAP (1999) and WBISPP (2000) depicts that the park is located in the central lowland plain of the region and falls in six Woredas, namely Gambella, Abobo, Gog, Jor, Itang and Nuer zones. This is further supported by the SCG (2000). There is, therefore, much similarities among the above four studies as regards to the location of the park. However, in all cases, the park is situated within Baro and Gilo rivers, with its northern and southern boundaries running along the major channels of the two rivers, respectively.

During its early inception of establishment, the park was one of the extensive conservation areas in the country with size coverage of 5061 km2. The park now comprises about 14.9% of the region's total land area. The responsibility for management and administration of the park was originally given to Ethiopian Wildlife Conservation Organization (EWCO), the government authority in charge of wildlife in Ethiopia.

Thus, since the time of its establishment up to the first half of 1996, the management of the park has been run by EWCO. The organization (EWCO) has made considerable efforts to conserve the park. Unfortunately, due to several constraints including lack of appropriate policy framework, shortage of manpower and financial resources, EWCO has been unable to properly manage or undertake proper investment in the park

Until the mid-1980s, the park was a relatively free area from human interference, and had abundant wildlife populations. But following the 1984/85 famine in the northern highlands of the country, the government moved a considerable size of people and settled them in the eastern parts of the park. At the same time, refugees from South Sudan were also allowed to settle in the park area. These activities have resulted in considerable habitat destruction and intensive poaching.

Most part of Gambella is flat and its climate is hot and humid. Annual rainfall averages about 600 mm while the mean minimum and maximum temperatures are approximately 21.10C and 35.9oC respectively (http://www.ethiopar.net) here is the map of the studied Areain (figure :1)

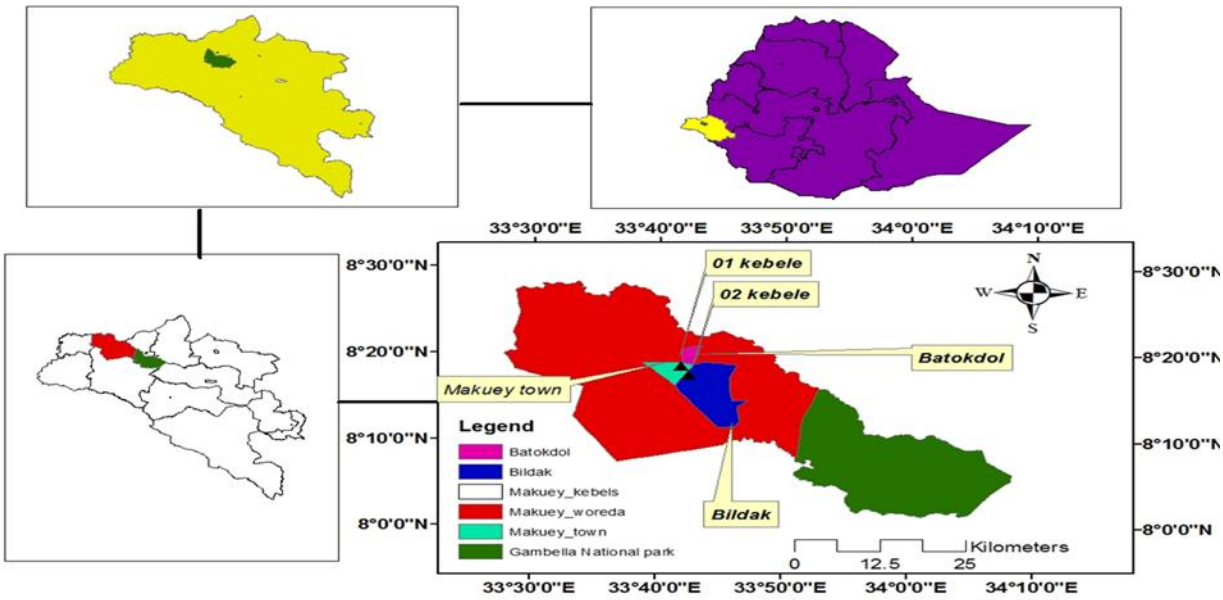

Figure 1: Map of study area

3.1.2. The habitat types of the study area

Three habitat types were recognized in the study area, the grassland, wetland, and riverine forest.

3.1.2.1. Grassland

The Woreda where the park located have a vast areas of savannahs grassland that covering about 34%. The general landscape is flat but it has area of raised ground that supports deciduous woodlands and grasslands. Extensive areas covered by grasslands are inundated by water forming valuable seasonal wetlands in the rainy season. There are however extensive areas of permanently inundated wetlands especially near rivers. Grasses have lush growth and there are species which can reach 2-3 meters in height (Tesfaye et al., 2001) in wooded grasslands of the western Gambella. Dominant vegetation community was savanna grassland region, these types of vegetation occurs in Gambella national park in study area and open grassland it was characterized by a tallness stratum that burns annually, and a canopy layer of trees that can both tolerate burning

and temporary flooding in (figure 2 a, b) below show the grassland during both season. This vegetation is suffered from frequent occurrence of flood and fire (Friis et al., 2010).

Figure 2*: a. Grassland in wet season b. grassland in dry season*

3.1.2.2. Riverine forest

Riverine forest occurs along the narrow strip of the river banks in the study area. Rivers Including Jiek, Kankan and lume are within the national park along which the riverine forests are located. This habitat is characterized by mixed vegetation type composed of large trees and herbaceous species in (figure 3). This type of vegetation is highly variable in structure and density, and the floristic composition dependent on altitude and geographical location. As described by Friis et al. (2010).

Figure 3*: Riverine forest in the study area (photo by Tet Yien, 2020)*

3.1.2.3. Wetland

The western Ethiopia is characterized by different types of wetlands that are crucial for multiple purposes 50%was a total land covered by the wet land. Among these, Baro River wetland has an importance in biodiversity conservation. Baro River is one of the important bird areas of Ethiopia.

It holds huge numbers of water birds such as storks, pelicans, herons and egrets, shoebill (EWNHS, 1996a) that can be seen in (figure 4). In addition to its avian diversity, Baro River is represented by a great diversity of Nilo-Sudanic and East African forms of fish species (Michael, 2012).

The wetland of Baro-Gambella in western Ethiopia also supports hundreds of hippos with different life features (Unbushe,2013).

Figure 4*: wet season in study area.*

3.1.3. Climate and Topography of the study area

Among the three climatic zones of Ethiopia (NMSA, 1996) namely: dry climate, tropical rainy climate and temperate rainy climate, the tropical rainy climate occurs in the Gambella Region. The escarpments of eastern Gambella face the humid air currents coming from the Atlantic Ocean and receive high rainfall compared to the lowlands in western Gambella. A single maximum rainfall that runs from February/ March to October/November characterizes the rainfall in this region. The second highest mean maximum temperature for the country was recorded in the lowlands of Gambella (21—42°C, next only to that of the Afar Depression 40°C ((NMSA, 1996).

There are two seasons in the Nuer zone and based on the movement of Inter-Tropical Convergence Zone (ITCZ), the amount of rainfall and the rainfall timing. The two seasons are Kiremt (summer), which is the main rainy season (June-October), Bega (spring), which is the dry season (November-May). The terrain in Nuer zone Woreda consists of marshes and grasslands area; the elevations range from 390 to 412 m. a. s. l. According to the Atlas of the Ethiopian Rural Economy published by the Central Statistical Agency (CSA), around 10% and 90% of the Woreda is forest and Grass land respectively. The Several areas in Woreda become flooded during the rainy season (summer), this force the people to migrate to the medium highlands areas with their cattle until the waters recede. (GRSBoLR. 2011)

3.2 Methodology

3.2.1. The study design and materials

Direct observation was made with the aid of binoculars, while evidence of sound tracks, feeds, beds, calls were considered indirect observation. Digital camera CDMA, GPS, was used. Indirect evidences are very useful when surveying animals that are naturally rare, elusive, found at low densities and difficult to capture repeatedly.

3.2.2. Preliminary survey

Before starting the main research work, preliminary survey about the study area was conducted during August, 2019 in the Nuer zone (Wanthoa, and Akobo Woreda for seven days. All the relevant information about study area such as the size of the study area, climatic condition, habitat types, and topography of the study sites was gathered from observation and from the concerned bodies. Representative sampling sites were selected from each habitat type. The sampled areas were made to cover at least 20 to 25 % of the study area (Bibby *et al.*, 1992**).**

Faunal survey was conducted from March to August, 2020 using the method of line transect. During this period random transect lines was established and the locations was marked using Global Positioning System (GPS).

3.2.3. Data collection

Data to study the diversity and relative abundance of medium and large-sized mammals were collected through direct and indirect observation by line transect method in study sites. Direct observation was conducted with naked eyes or aided by binoculars (7x50 mm). During observation, the number of individuals of each species, sex, age, time and habitat types were recorded. Body size, pelage color, presence or absences of horn were used to determine sex (Kingdon, 1997, 2014, Yirga, 2008).

3.2.3 1. Transect survey

Indirect evidences such as fecal droppings, calls, marks and prints, quills, holes, feeding signs were used to record the presence of mammals in established transect lines (Wilson, 1996). All the observed mammals were identified to species level by using the taxonomic characters listed in (Kingdon .2004; Yalden and Largen 1992). In the direct observations, animals were observed directly while walking along transect lines. Indigenous people were also being consulted for vernacular name. Photographic pictures of some mammals and their indirect evidence (footprints, droppings) were taken for further confirmation. Documentary film, which shows the present status of the different habitats and the associated wild animals, was recorded during this study period.

Standardized arrays of random sampling decrease detection of the number of animals and incidence of rare species (Kunin and Gaston, 1993). So, in addition to the standardized arrays of transects (blocks), the inventory also included non-standardized arrays of blocks in nonrandom locations. This exploration of habitats uses to find out the presence or absence and the distribution patterns of particularly rare mammals of the park.

Two rounds of observations of large and medium-sized mammals were carried out during field study period from March –June, 2020. And the second round was carry out in July to August,2020.

When mammals were sighted, species type, the number and GPS location were recorded at each transect line. Survey was conducted twice when the animals are mostly active: in the morning (06:00 to 10:00 am) and late afternoon (16:00 to 18:30 pm) in each transects (Rebira, Tsegaye and Tadesse, 2015).

3.2.3.2. Line transects survey

A total of six blocks (two for wet land, two for riverine forest and two for grassland) each with varying size, representing each habitat was set randomly in the study site. The selected blocks covered about 20% of the total study area. In the study of diversity and relative abundance of medium and large sized mammals the randomly selected blocks for actual study should cover at least 20 to 25% of the study area (Bibby et al., 1992).

A total of 36 line transect were established representing each habitat; 20 line transect for grassland habitats (Mon, Malou, Panyuan and Kankane, five line transect for each). Ten line transects were

established for the Riverine forest (Pior and Makuey, with 5 line transect each) and 6 for the wetland (Bar jack and Pulit each with line 3 transect). The number of line transect in each habitat type was determined based on the size of the blocks. The distance between transects varied based on the Visibility of the habitat. As the result, in grassland transect length was 3 km with width of 200 m, riverine forest 2.5 km length and 100 m width and for the wetland, the length of transect was 3.5 km length with 50 m width.

3.2.3.3 Indirect Evident

Indirect observations of medium and large mammals were conducted along selected transects (trails, footpaths and other access routes). Identification and recording of mammalian species were made through direct observation with the naked eye and aided with binoculars. On the other hand, signs of large and medium sized mammals along transects was observed indirectly in both season. The signs included fresh tracks, faeces, feeding, digging, territorial markings, footprints, animal parts, and other tangible evidences indicating that mammalian species were present. Indirect evidences are very useful when surveying animals that are naturally rare, elusive, found at low densities and difficult to capture repeatedly (Meseret and Solomon, 2010).

Field observation of mammalian species identification was based on visible morphological characters of each of the mammalian species such as body size, coloration, proportion and structure of various organs like tail, ears and also from personal experiences. To have clear pictures of each mammalian species, observer noises were minimized and to avoid being smelled by the animals, observation were made by moving against the direction of wind as far as possible.

3.2.5. Method of Data analyses

Species diversity of medium mammals and large mammals was calculated using the Shannon-Weaver index of diversity, H'=- N PilnPi where Pi is the proportion of the ith species in the habitat (Shannon and Weaver, 1949). Where ni= number of individuals of each species

and

N = total number of individuals for the site, and

ln = the natural log of the number

H'= is influenced both by number of species as well as by the evenness with which mammals are distributed with those species. Equal H values may thus be obtained if one habitat contains fewer and evenly distributed species of mammals.

The evenness of Mammalian species refers how close in numbers each in a habitat and was Calculated as J= ′ Where, J = evenness H' = is Shannon-Wiener index of diversity H maximum = is maximum diversity index Hmax= ln(s) and s is the number of species.

Simpson similarity index (SI) was computed to assess the similarity among and between three habitats with reference to the composition of species.

SI= 3C/I+II+III

Where: SI= Simpson's similarity index,

C= the number of common species to all three habitats

I= the number of species in habitat one

II= the number of species in habitat two

III = the number of species in habitat three

The relative abundance index of species (RAI) was calculated by dividing the number of records of each species by the total number of records of all species.

Causal records of mammals including animals seen on non-random basis were not considered in the calculation of contact frequencies, but they were incorporated to indicate their distribution and for comment on the species account.

The location point of each mammal species can be differentiated from the direct observation and also from identifiable signs (dropping, track, dung) in the park. The location points (data) were recorded by GPS for each mammal species during the field work. These data were used to produce separate distribution maps for a group of mammalian species in the park.

According to Wemmer *et al*. (1996), mammals can be categorized as common (fairly well distributed and sighted and/ or evidence recorded once a day), uncommon (fairly well distributed and sighted and/or evidence were recorded once a week), occasional (restricted distribution and

sighted and/ or evidence recorded infrequently), and rare (very few evidences recorded and/or single recorded during the whole survey periods). In the present study mammals' categorization were done based on this criterion.

3.2.6. Ethical Consideration

This particular study, by its kind, has no identified harm to the park and surrounding communities. However, ethical approval was obtained from institutional review board (IRB), Jimma University. Prior to the study official permission was also be obtained from GNP administration. The objective of the study with methods was explained to all responsible bodies. Verbal consent was obtained during individual interview to assess their perspective. The response of each study participants confidentially was kept and the research findings presented are purely the result of collected data analysis. There were no intentionally unacknowledged issues of others' works incorporated the thesis.

CHAPTER FOUR

4. RESULTS

4.1 The Diversity of mammalian species

From a total of 511 individuals of medium and large-sized mammals counted during the study period, 25 species grouped into seven orders and thirteen families were identified in the study area (Table 1). Among these mammalian species, four species; namely Crested Porcupine (*Hystrix cristata),* Vervet monkey *(Chlorocebus aethiopis*), Stark's hare (*Lepus starcki*) and white tailed mongoose *(Icheumia albicauda*) were the medium sized mammals, while the remaining 21 species were large sized mammals. Order primate, Felidea, Bovidea, Lagomorpha, Carnivora, Suidae and Artiodactyl compose the largest number of species.

Out of the 25 species of mammals recorded from the present study area, the Nile Lechwe and white-eared kob were two endangered antelope species that were identified by direct evidence. The presence of seven mammalian species such as crested porcupine (*Hystrix cristata*), aardvark (*Orycteropus afer*), African buffalo (*Syncerus caffer*), spotted hyena (*Crocuta crocuta*), leopard *(Panthera pardus*) and lion (*Panthera leo*) were identified both by direct and indirect evidences of identification (Table 1).

Table 1: The Medium and large sized mammals identified during dry and wet seasons from Gambella national parks , 2020

Local name	Common name	Scientific name	Order	Family
Gok	Vervet monkey	*Cercopithecus aethiops*	Primate	Cercopithecidae
Rumcuduar	Porcupine	*Hystrix cristata*	Rodentia	Hystricidae
Thiil	White eared kob	*Kobus kob*	Artiodactyla	Bovidea
Buok	Nile lechwe	*Kobusmer gereasa*	Artiodactyla	Bovidae

Gokrial	Colobus monkey	*Colobus guereza*	Primate	Cercopithecidae
Peer	Grey duiker	*Sylvicapra grimmia*	Artiodactyla	Bovidea
-	Bush pig	*Potamochoerus larvatus*	Artiodactyla	Bovidea
Pelpel	Stark‟s hare	*Lepus starcki*	Lagomorpha	Leporidea cercopitheci
Deer/kuul	Warthog	*Phacochoerus africanus*	Artiodactyla	Suidea
Yak	Spotted hyena	*Crocuta crocuta*	Carnivore	Hyaenidea
Mok	African buffalo	*Syncerus caffer*	Artidactyla	Bovidae
Lony	Lion	*Panthera leo*	Carnivore	Felidae
Kuac	Leopards	*Panthera pardus*	Carnivore	Felidea
Thiang	Topi antelope	*Damaliscus lunatus*	Artiodactyla	Bovidea
-	Common bushbuck	*Traglaphus scriptus*	Artiodactyla	Bovidea
-	Aardvark	*Orycteropus afer*	Oryctestidae	Tubulidntata
Guor	Elephant	*(Loxodonta africana*	Artiodactyla	Bovidea

Gook low	Olive baboon	*Papio anubis*	Primate	Cercopithecidae
	Roan antelope	*Hippotragus equinus*	Artiodactyla	Bovidae
Lual duot	Hart beast	*Alcelaphus*	Artiodactyla	Bovidae
Guec	Giraffe	*Giraffa camelopardis*	Artiodactyla	Giraffidae
Diel	Waterbuck	*Kobus ellipsiprymnus*	Artidactyla	Bovidae
-	Reedbuck	*Redunca redunca*	Artiodactyla	Bovidae
Keew	Gazelle	*Eudorcas thomsonii*	Artiodactyla	Bovidae
Total	‘	‘	‘	25

4.1.2. Richness and evenness of mammals in three types of habitat

The diversity of medium and large sized mammals in Gambella National Parks in the three habitat types during dry and wet seasons are shown in (Table 2). The highest diversity of mammals was recorded in the riverine forest (H’=2.944) during the dry season. The second diversified habitat was grassland (H‟=1.864) and the least diversified habitat was grassland (H‟=1.366) in the same season. The calculated species evenness was J=0.384, J=0.097 and J=0.070, for the, riverine forest, wetland, and grassland respectively during this season (Table-2).

During wet season the highest diversity was seen in riverine forest (H‟=1.835). The second diversified habitat was grassland (H‟=1.79 and the least diversified habitat was wetland (H‟=0) in the same season. The calculated species evenness was J=0.200, J=0.047 and J=0 for grassland, riverine forest and wetland respectively during this season (Table 2).

Table 2: Richness, evenness (J) and abundance for medium and large sized mammal species in the three different habitat types in the study area during dry and wet seasons

Habitat type	Number of species		Abundance		Diversity(H')		Evenness (J)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Grassland	9	6	58	125	1.864	1.790	0.070	0.200
Riverine forest	19	8	241	30	2.944	1.835	0.384	0.047
Wetland	5	0	61	0	1.366	0	0.097	-0

4.1.3. Mammals observed in the different habitat types

Out of the 25 species of mammals recorded from the present study area, the species identified and recorded only by indirect observation was crested porcupine (Hystrix cristata) spotted hyena (Carcuta carcuta) and Lion (Panthera leo). Presence of this species in the study area was identified by faeces and spine. Five species of mammals, bush pig (Potamochoerus larvatus), white Eared kob *(*Kobus kob), leopard *(*Panthera pardus), and spotted hyena *(*Carcuta carcuta) were identified both by direct and indirect method of identification and the remaining twenty mammalian species were identified by direct observations.

By direct observation twenty-two (22) species of mammals were observed from the three habitat of the forest, while three (3) species was recorded by indirect evidences using track, foot print and spine. The largest number of species (twenty-two species) was recorded from the riverine forest followed by the grassland and wetland respectively (Table 3).

Table 3: The distribution and means of identification of mammals in the three habitat of Gambella national parks priority area during the dry and wet seasons; √ stands for the presence of animal in study area - stands for the absence of animal in the park

				Habitat types					
s/no	Common name	Mode of identification		Grassland		Riverine forest		Wetland	
		Sign	Present /absent	Dry	We t	Dry	Wet	Dry	Wet
1	Buffalo	Visual	Common			✓			
2	Elephant	Visual /foot print	Common					✓	
3	Topi antelope	Visual	Common	✓				✓	
4	White eared kob	Visual	Common	✓	✓	✓	✓		
5	Gazelle	Visual	Common			✓			
6	Grey duiker	Visual	Common			✓			
7	Nile lechwec	Visual	Common			✓			
8	Hyena	Sound/ Feaces	Common	✓	✓	✓	✓	✓	
9	Lion	Sound &feaces	Common	✓	✓	✓	✓	✓	
10	Aardvark	Visual /faeces	Rare	✓	✓	✓	✓	✓	
11	Olive baboon	Visual	Common	✓	✓	✓	✓	✓	
12	Bush pig	Visual/ Faeces	Common	✓	✓	✓	✓	✓	
13	Reedbuck	Visual	Common		✓	✓	✓	✓	
14	Bush buck	Visual	Rare	✓	✓	✓	✓	✓	
15	Water buck	Visual	Rare		✓	✓	✓	✓	
16	Mantled guereza	Visual	Common		✓	✓	✓	✓	
17	Hart beast	Visual	Common	✓	✓	✓	✓		
18	Roan antelope	Visual	Common	✓	✓	✓	✓		
19	Warthog	Visual	Common			✓			

20	Leopard	track/Foot print	Rare				✓			
21	Porcupine	spine	Common	✓		✓				
22	Stark hare	Visual	Common	✓		✓				
23	White-tailed mongoose	Visual	Common				✓			
24	Vervet monkey	Visual	Common			✓				
25	Giraffe	Visual	Common			✓				

4.1.4. Relative abundance

The total number of mammals counted during dry season was 356 the most abundant species during this season was white eared kob (Kobus kob) (56.49%) followed by topi antelope (Damaliscus) (6.77%), olive baboon (*Papio Anubis*) (5.64%), and vervet monkey (*Cercopithecus aethiops)* (5.64%) buffalo (Syncerus caffer)(4.23%),gazelle (eudorcas thomsonii) (3.10%)warthog (Phacochoerus africanus*)* and mantled guereza (2.82%) which composed (2.82%) were the third and fourth most abundant species in the study area, respectively. Common bush buck (Traglaphus scriptus) (1.69%), Roan antelope (hippotragus equinnus (1.41%) and hartebeest (alcelapus) (1.41%) were the least abundant species during dry season in the study area.

The total number of mammals counted during wet season was 155 during this season, the most abundant species was white –eared- kob (*Kobus Kob*) (65.35%) followed by buffalo (*Syncerus caffer)* (13.07%), olive baboon (*Papio Anubis),*20(6.53%) White tailed moogose (*Ichneumia albicauda),*3.92%, porcupine and water buck have (3.26, &3.26%) and mantled guereza (*Kolobus guereza)*2.55%)and elephant (*loxondonta Africana)2.61%*were least in the study area (Table 4)

During the whole study period, 511 individuals of medium and large sized mammals were recorded in dry and wet seasons from the selected sites of Gambella national park (Table 4) Seasonal variations were observed in species composition and individual number of mammals among different habitats. The highest number of species was recorded in the riverine forest during the dry season. Grassland had also considerably high number of species during both dry and wet season, whereas wetland contains the least number of species during the dry season. Among the 356

individual of medium and large sized mammals recorded during the dry season, the most abundant species was White –Eared -kob, 200(56.49%) and the second was topi antelope 24(6.77%), vervet monkey the third abundant species was 20(5.64%) followed by olive baboon 20(5.64 %). The fifth was Gazelle, Warthog, Olive baboon, and, Colobus monkey each with 11(3.10%). During wet season, out of the total 153 mammals recorded, the most abundance was white eared kob 100(65.35%) second were buffalo 20(13.07%)and olive baboon 10(6.53%) followed by White-tailed mongoose 6 (3. 92%).firth was Porcupine and water buck 5 (3.26%). Elephant and mantled gureza, 4 (2.64%) were the sixth and Bush pigs each with 1 (0.65%) individuals the spotted hyena was the least abundant with individual in (table 5).

Table 4: Total number of medium and large sized mammal species recorded in the study area and their relative abundance during wet and dry season

		Habitat types						Total number of individual		Relative abundant in %	
		Grass land		Riverine forest		Wetland					
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
1	Buffalo	-	15	10	5	5	-	15	20	4.23	13.07
2	White eared kob	-	100	150	-	50	-	200	100	56.49	65.35
3	Topi antelope	15	-	9	-	-	-	24	-	6.77	-
4	Water buck	-	5	-	-	-	-	-	5	-	3.26
5	Elephant						4	-	4	-	2.61
6	Roan antelope	5	-	-	1	-	-	5	1	1.41	0.65
7	Bush pigs	-	-	2	1	-	-	2	1	0.56	0.65

8	Colobus monkey	-	-	10	4	-	-	10	4	2.82	2.61
9	Reedbuck	-	-	2	-	--	-	2	-	0.56	-
10	Bushbuck	5	-	1	-	-	-	6	-	1.69	
11	Grey duiker	-	-	3	-	-	-	3	-	0.84	
12	Gazelle	11	-	-	-	-	-	11		3.10	
13	Nile lecwe	-	-	2	-	--	-	2		0.56	
14	Warthog	7	-	3	-	--	-	10		2.82	
15	Leopard	-	-	3	-	-	-	3		0.84	
16	Lion	-	--	2	-	-	-	2		0.56	
17	Spotted hyena	-	-	1	-	1	-	2		0.56	-
18	Giraffe	-	-	2	-	-	-	2		0.56	
19	Olive baboon	-	-	20	10	-	-	20	10	5.64	6.53
20	Porcupine	-	1	-	4	-	-	-	5	-	3.26
21	Stark hare	1	-	2	-	--	-	3		0.84	
22	White tailed moogose	-	3	2	3	1	-	3	6	0.84	3.92
23	Aardvark	2	1	-	2	-	-	4	1	1.12	0.65
24	Vervet monkey	5	-	15	-	-	-	20	-	5.64	-
25	Hartebeest	3	-	2	-	-	-	5	-	1.41	=
	Total	54	125	241	30	61	0	356	155		

4.1.5. Species similarity

The Simpson's similarity index (SI) of mammals among the three habitats of the study area during dry season was (SI = 0.33) and wet (SI = 0.18). This indicated that 30% of the species during the dry season and 18% during the wet season were common for the three habitats.

Among the three habitat types the highest Simpson's index similarity of mammalian species was obtained from grassland in both the dry season (SI =0.86) and wet seasons (SI = 0.34) followed by riverine forest and wetland in both dry (SI = 0.83) and wet (SI = 0.32) seasons. However, less similarity was obtained from species of wetland and grassland during wet (SI=0.34) and wet (SI =0.32) respectively in the (Table 5)

Table 5**:** Species similarity among the three habitats during the dry and wet seasons

Habitat types						
	Grassland		**Riverine forest**		**Wetland**	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Grassland	**0.86**	**0.34**	**-**		**0.32**	**-**
Riverine forest	**-**	**-**	**0.59**	**0.83**	**-**	
Wetland	**-**	**-**	**-**	**-**	**-**	**-**

4.2. Threats of mammals in Gambella national park

4.2.1. Major Threats on Vegetation

The major causes of destruction on the vegetation of the park in particular and that of the region in general can be summarized as follows:

1 **Destruction of Forests from uncontrolled expansion of small-scale agriculture in catchments**. In the region, strictly speaking, there is no practically protected area to minimize large-scale human interference. As a result, logging is a serious problem in Godere forest where *Cordia africana* Lam., for instance, is selectively logged for timber. Unless measures are taken soon, logging, expansion for coffee plantation and shifting cultivation will spread and result in severe soil erosion and climatic changes, at least in southwestern Ethiopia.

2 **Destruction of woodlands and lowland forests by refugees**. Vegetation of the Gambella plain has been degraded (EnsermuKelbessa *et al*., 1992), due to resettlement programs and concentration of refugee from southern Sudan. Establishment of Abobo State Farm also removed significant proportion of the natural vegetation. This is a serious issue around Fugnido, Kule and Dimma Refugee camps. Tree planting within the refugee camps helps in arresting forest and woodland destruction. The new Alwero Dam is now ready for use and more than 10 thousand hectare of natural vegetation were cleared used for agricultural field purpose in the parks /were converted into agricultural field.

4.3. Threats of Wildlife in the Park

4.3.1. Bush fire

Information obtained from the local people indicated that before the start of the wet season peoples traditionally set fire deliberately every year in some parts of the controlled hunting area to get fresh grass growth and to make open the giant grass. Sometimes fire unintentionally escapes during the charcoal production and fire that escape from surrounding farmers during land preparation for agriculture. This practice greatly affects the proper functioning of the ecosystems and could destroy a lot of wild fauna and flora of the controlled hunting area.

4.3.2. Encroachment

The local community exploits the resource from the national park. The increasing population leads to increasing demand for agricultural land and forest products, thus, the major threat in Gambella national park is the expansion of agriculture and illegal type of hunting, forcing the people to clear woodland/ natural forest for settlement and expansion of farmland. These cause strong impacts on the wildlife of the study area. Wild animals were highly restricted in some parts of the park because of human and livestock encroachment. The settlement and other human activities in the eastern parts of the park (following the road from Gambella to Nuer zone) have hindered the natural movement of the wild animals, especially mammals from east to west and vice versa. The increasing population in this specific part of the park has led to increased deforestation for agricultural purpose, road construction and other development activities.

4.3.3. Livestock grazing

Since the national park lacks natural buffer zone, high number of grazing cattle and other domestic animals make a devastating effect on the edges of the national park. During over grazing, there has been cattle raider that come from north Sudan for grazing purpose and these people affect the wild life in study area (figure 5) because they poison the grass with chemical and this brought the loss of wildlife in the area, deterioration of vegetation close to the edge that might influence the wildlife of the national park.

Figure 5*: livestock grazing in wanthoa woreda*

Chapter Five

5. Discussion

The topography, climate and diverse vegetation types of the GNP have provided habitats for a diverse species of mammals. The 25 species of large and medium sized mammals recorded in the park for the recent study demonstrate the importance of the study area as an area to be protected for the conservation of important mammalian fauna of Ethiopia. However, the result is very useful to get some insight in prioritizing the important wildlife potential areas for the purposes of formulating the envisaged management program. For instance, the wildlife concentration is relatively high in Jor areas. Further threatened species like the Nile Lech are also dominant in the same area. They are widely distributed following Gillo River between Gog and the point where Gillo joins Akobo River; and further crossing Gillo to southwest directions towards Akobo River. It can be concluded that the population of wildlife is relatively higher in the southwestern parts of the park. Therefore, these areas require special concern and immediate conservation measures, in regards for protection.

Though, the size of the protected areas were different, similar studies have been carried out in different parts of Ethiopia that have used similar line transect techniques. For example, Girma Mengesha and Afework Bekele (2008) recorded 20 species of large mammals in Alatish National Park, Meseret Chane (2010) recorded 23 species of mammals in Borena-Sayint national park, Gebrecherkos Woldegeorgis (2010) identified 16 species of large mammas from Yayo coffee forest biosphere reserve, Zerihun Girma et al. (2012) identified 19 species of large mammals in and around Wondo Genet forest patch and in Dati Wolel National Park, Rabira Gonfa (2013) recorded 28 species of medium and large sized mammals. The number of medium and large sized mammals recorded in Gambella national park area was relatively smaller than some well-known wildlife protected areas of Ethiopia. For example, in Dati Wolel National Park 28 species were identified (Rabira Gonfa, 2013), Nechisar National Park 37 species, Mago National Park 38 species and Omo National Park 40 species of mammals were recorded (Gebrecherkos Woldegeorgis, 2010). In the recent study 25 species in Gambella national park indicates the need for a long term study of the area by extending the study period and the sampling area to find out if there are additional mammal species.

The diversity results showed that the highest mammal species diversity was recorded from riverine forests (Malou and Muon) during the dry season followed by grassland (Malou and Muon) that had considerably similar species diversity during both seasons. The highest species evenness was obtained in riverine forest during wet season and grassland during dry season. However, among the three habitats the lowest species diversity and evenness were obtained from wetland habitats (Malou, Muon, and Dualdap). The highest mammalian species diversity in the riverine forests and grassland during the dry season in the study area might be because of the availability of food, water and cover for protection from predation and high temperature compared to wetland. Studies by Shiferaw Ayele (2008) and Dawud Yimer (2008) revealed that species diversity often high in areas where there are sufficient food and water sources.

The presence of bigger rivers within riverine forest, small rivers and streams in the grassland that flow throughout the year might be preferred by mammals. During the dry season, the riverine forests and wetland were relatively less disturbed by human activities such as burning practice and harvesting of grass compared to wetland. This could also have contributed to the higher mammal species diversity during the dry season in both habitats. There is shortage of water and food in the grassland in the study area during the dry season. Shortage of food and water during the dry season reduced the diversity and evenness of mammalian species in the grassland. Bailey (1984), Balakrishnan and Easa (1986) noted that the extent to which a given species possesses a preferred habitat is based on the requirement for resources.

In addition to the availability of adequate food and water sources during the dry season the differences in diversity of mammal species in three the study sites might be due to stress imposed by the environmental factors such as variation in temperature. Climate can affect the distribution of wildlife and their habitat condition. Bailey (1984) point out that mammals respond to climate induced nutritional and structural change in vegetation by the selection of appropriate habitat for survival and reproduction.

Variation in the relative abundance of medium and large sized mammal species in the present study area was observed among species. White- eared kob (Kobus kob) was the most abundant species in the study area. This mammal species was widely spread in all selected habitat types of the study area. A few of the mammalian species recorded in the study area showed no significant difference in composition and abundance between the different vegetation types and seasons.

Almost 41% of the large mammals (olive baboon, African buffalo, warthog, bush Pig, porcupine, spotted hyena, lion, aardvark, leopard, and hartebeest), were found in all the 3 habitat types in varying frequencies. These are mammalian species that have relatively wide habitat range. On the other hand, a few species of mammal (vervet monkey, white tailed mongoose) were recorded only in the riverine forest habitats and most of them were recorded. These are mammalian species that are adapted to such habitats and the present record is in line with previous observations ((Duckworth, *et al* 1992; Kirubel Tesfaye, 1985). Kingdom (1971) also stated consistent distribution and habitat association for most of these mammalian species.

The distribution of mammals in the different habitat types might indicate habitat selection of the different species of mammals based on their ecological preferences and evolutionary adaptation. The diversity results showed that the greatest mammal diversity was concentrated within the riverine forest, with the least diversity being registered at grassland with scattered tree habitat. The riverine forest habitat is rich in the species richness and evenness; this is probably related to the habitat complexity and stability as compared to other habitat types. Foliage diversity of the forest increases species diversity. Besides, most part of the riverine forest habitat was located within the center of the park and so the human impact is also minimal. The primate group, apart from savanna baboons showed a high preference for riverine, related to the animals' arboreal habits and feeding preferences since both occur in the forest trees. The large grazer and browser groups displayed a strong association with grassland and riverine forest habitat in both seasons. This is in line with the observation of Duckworth, *et al*. (1992); Kingdon, (1971). Vegetation provides food, shelter and cover to mammals. The structure and composition of vegetation, therefore, determine the abundance, and diversity of mammalian community residing in it.

Among the bulk feeders, the African buffaloes showed preference to all major habitat types. Kingdon (1982a) stated that animals harbor in all habitats, where water and grass are not a limiting factor. The carnivore species recorded during the current study may reasonably indicate GNP is rich in the diversity of wildlife. (Kingdon 1977) stated that abundance of predator species in an area is one of a good sign of ecological richness and diversity.

Olive baboon *(Papio anubis*) was the third most abundant species in the study area during both seasons. The species was known to be widely distributed to a variety of habitats in the study area. This might be associated to the foraging behavior that it is to feed on different food items (Johnson

et al., 2012). From the three habitat types the highest density of *P. Anubis* was observed in riverine forests in the study area during the dry season. The increased density during the dry season might be due to slight increase in visibility of the area. During wet season because of the presence of rain growth of vegetation might have provided tick cover for the animals which makes observing of them difficult. In addition to the presence of variety of food in these habitats like other primates, P. anubis requires forested areas with tall trees as suitable habitat. Kingdon (2003) noted that primate particularly families of colobidae and cercopithecidae need forested areas with tall trees. Vervet monkey (*Chlorocebus Aethiopis*) and Colobus monkey (*Colobus Abyssinicus*) were the third and fourth abundant species of the study area.

Both species were restricted to the riverine forests and woodland during both seasons and *C. Abyssinicus* was totally absent in the grassland. Studies by Girma Mengesha and Afework Bekele (2008) have revealed that higher number of *C. Aethiopis* was found from riverine woodland of Alatish National Park and Gebrecherkos Woldegeorgis (2010) observed more number of *C. Abyssinicus* in riverine forest. The higher abundance of these species from riverine forest and was probably associated to the availability of sufficient fruits and leaves and the need of forests with tall trees that serve as cover and their best habitat. Since forest habitat was relatively less disturbed, it might have also contributed as refuge for the shy behavior of Colobus monkey. Aramde Fetene et al. (2011) have noted that Colobus monkey selected riverine and large trees as their best habitats. Higher density of *C. Aethiopis* and *C. Abyssinicus* were observed during dry season than wet season in the study area. The possible explanation for this might be similar to *P. Anubis* which is associated to vegetation outgrowth which made sighting of them difficult during the wet season.

The least abundant medium and large sized mammal species recorded from the study area were Leopard (*P*. pardus), Lion *(P. Leo),* spotted hyena. Different factors might be attributed to the lower number of these mammalian species in the study area. For example, information obtained from the park scout indicated that there were more individual number of lion and leopard in the study area before few years. Even the lions occasionally came in groups to the resident area and disturb the local community by killing their livestock. Because of livestock damage posed by lion majority of local community had hostile attitudes toward this animal. The consequence of this condition resulted in human-lion conflict in the area and many lions were killed by the local community from time to time. Lions were destroyed intentionally by either direct or indirect

methods (Marchini and Macdonald.,2012). The commonly used methods include shooting them with gun and luring lions. The remaining individual lion left the reserved area and migrate to other places where sufficient food is available. Similar observations were made in different parts of Africa that lions were killed by peoples in response to attacks on livestock.

Conflict with humans over livestock depredation is the single most important factor causing the decline in African lion populations (Packer et al. 2005). Ogutu et al. (2005) reported that 87 lions were killed in South east Kenya by Masaimorans (warriors) since 1998 in response to attack on their livestock. In Mozambique lion-human conflict and lion mortality is observed because of the attack of livestock by lions (Anderson and Pariela, 2005). In Tanzania, Packer et al. (2005) documented over 125 lion killings between 2000-2005 by the local people using poison or spears. The leopards' density is low as it is mainly hunted for its skin both for commercial and cultural purposes. It is also listed as threatened species in the IUCN Conservation Monitoring Centre 1990 and1988 Red data classification list. The other reason for the reduced individual number of lions and leopard might be associated to the presence of few individual numbers of natural preys such as bushbuck, reedbuck and Hartebeest in the present study area that served as source food for these animals. Nocturnal mammals need densely forested habitats and cover that could make the sighting of them difficult (Zerihun Girma et al., 2012).

Human activities such as burning of grass during dry season every year, harvesting of grass, cutting of trees for construction, illegal settlement, livestock encroachment and illegal hunting activities could limit the individual number mammalian species in the study area. The abundance of mammalian species in ecosystems is closely related to the physical stability of the habitat (Ananthakrishnan, 1988). Habitat modification and destruction by human activity affects the essential requirements of mammals which in turn affected mammalian diversity and makes the area to have fewer mammals. The habitat of medium and large sized mammals among the different habitats of the study area during both seasons shows significant difference. Habitat determined in terms of their food, water cover requirement. Similarly, studies carried out in different parts of Ethiopia have also noted that mammalian and their habitat were often correlated mainly with the availability of water, food and protection (Mohamed Yaba *et al.,* 2011; Zerihun Girma *et al*., 2012).

Seasonal variations were observed in species number of medium and large sized mammals among different habitats in the study area based on the preferences for habitats that provide sufficient resources for survival. The highest number of mammalian species was recorded in the riverine forest during the dry season followed by grassland during the same season, but the least number of mammalian species was recorded in wetland during the dry season. The explanation for the highest species number recorded in the riverine forest and grassland during the dry season was might be due to movement of mammals from grassland toward those habitats which are relatively protected part of the area in search of food and cover. During the dry season the grassland was relatively dry, as a result water and palatable grasses were reduced in the area. Hence mammals could be forced to move towards riverine forests and grassland were sufficient food and water sources area available. Studies by Zerihun Girma et al. (2012) have shown similar observations. The distributions of mammalian species were not consistent throughout its geographical ranges. This is governed primarily by the presence or absence of suitable habitats for species.

Mammalian species like African buffalo, white eared kob, and topi antelope were relatively observed and recorded in all habitats of the study area. Their distribution in all habitat types indicates their adaptation to a variety of habitat types. The ecological preference and evolutionary adaptation of mammalian species plays a role in their distribution in different habitat types (Bailey, 1984). Some primates like olive baboon and verve monkey because of their arboreal life and the availability of a variety of plant species used for food and water they were largely associated to the riverine forest habitats. This finding was in line with Meseret Chane (2010) who reported high number of primate species in riverine forest of Borena Sayint National park.

Regarding species similarity among the habitats types of the study area, the highest species similarity was obtained from riverine forest during both dry and wet seasons, followed by grassland and wetland in both seasons. However, less similarity was obtained from species of grassland and riverine forest during both seasons. The highest species similarity from riverine forest might be due to the presence of similar resource suitable for mammals in both habitats and the presence of cover for protection. This result is different from the findings of Girma Mengesha and Afework Bekele (2008) and Rabira Gonfa (2013) who have recorded high mammalian species similarity in woodland and grassland habitat.

The highest species similarity for seasons of medium and large sized mammals was obtained from the grassland and riverine forest (0.86 and 0.83). This might be due to the less disturbance of the two habitats by human and livestock. The least species similarity was obtained from Grassland and wetland (0.34 & 0.32). This result is different from the findings of Girma Mengesha and Afework Bekele (2008) and Rabira Gonfa (2013) who have recorded high mammalian species similarity in grassland habitat.

The change in the vegetation structure and composition coupled with the entire loss of habitat due to human encroachment are the major threat for wild animals. Before any kind of management measures to reduce habitat alterations are considered, reasons of habitat loss and change should be clearly addressed.

The loss of wildlife habitat in the region is mainly caused as a result of the unwise use of the natural resources. This include tree cutting for fuel and construction, land clearing for farmland, uncontrolled fire and illegal settlements. They were the major threat of Gambella national parks.

Therefore, it is mandatory to conserve the natural habitats by implementing community-based conservation strategies and create awareness among the local community towards biodiversity conservation. Around, 20 large and 5 species of medium mammals were recorded by this survey in the area. Many of these would be lost to the region if the habitat destruction continues.

Similarly, earlier studies in different parts of Ethiopia revealed that mammalian species diversity is often high in areas where there are sufficient food resources and volume of habitat and available water sources (Dawud and Solomon, 2013). On the other hand, less diversity of mammalian species in plantation habitats during both seasons was probably related to the presence of more anthropogenic impact than the natural forest. The riverine forest is relatively far from human settlements so that human impact was minimal.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The present ecological survey revealed that the park supports an impressive variety of larger mammalian species; comparable with very well-known wildlife protected areas in the country. Among these varieties of mammalian fauna, some species which originally had wide ranges are now under greater conservational problems everywhere from habitat loss, deforestation; settlement, poaching, and lack of conservation attention, at present appear to have healthy population in GNP. Some of these mammals include the African elephant, white –eared kob, African buffalo, lion, and leopard. Particularly, the site appears the most suitable habitat for the African elephant as compared to other wildlife protected area in the country.

During the present study 25 species of medium and large sized mammalian species belong to 7 orders and 13 families were identified. Among these mammalian species 5 species such as Crested Porcupine, Vervet monkey, Stark's hare (Lepus starcki), and white tailed mongoose were the medium sized mammals, whereas the remaining 18 species observed were large sized mammals. The mammalian species were found in some study the shore of Baro river Akobo, Gilo River and moved toward Akobo River (southwestern direction).

Direct and indirect evidences were employed to identify mammalian species. The mammalian fauna in Gambella national park were identified and documented in this study so that interested bodies can have base-line information on diversity, and relative abundance of medium and large sized mammalian species for future conservation and management plane. White –eared kob, African buffalo, and Vervet monkey were the most abundant mammalian species in Gambella controlled hunting.

Regardless of its potential to various species of fauna and flora, the negative impacts of various human induced activities are the major threats for future development of the wildlife resources in Gambella national park. The major threats to biodiversity were poaching, burning, deforestation and logging of tree, livestock encroachment, expansion for agriculture and settlement and honey production. Fire is set by the local people deliberately during dry season to make open the giant grass and when they produce charcoal or unintentionally during collection of wild honey. There is chopping down of giant trees for timber production, for commercial purpose. Poaching also is a

serious threat to the wildlife of the protected area. Buffalo, white eared kob, Bushbuck, bush pig, common duiker and warthog are poached for their meat by the local community.

6.2 Recommendations

To ensure the long-term conservation of wild life of the particular and the natural ecosystem of the park as a whole. It is, therefore, wise to take immediate measures to counter the problems and make sure the future of wildlife in the park.

As mentioned above Gambella national Parks has potential to provide suitable habitats to a number of wild mammals and a various species of birds. However, regardless of its potential to various species of fauna and flora its management system is poor. Therefore, in order to ensure effective conservation of biodiversity and management practices in the national park of the following recommendations are suggested:

- Establishing broad-based wildlife conservation education program. Awareness creation at all levels about the benefits of the reserved area should provide to the local community to maintain its biodiversity in general and mammal species in particular.
- The absence of similar studies in the area was a major gap to fill in addressing the assessment of medium and large sized mammalian diversity. Further research should be conducted to get detailed information about the mammalian diversity of the area.
- The regional Government should look forward to scale up conservation efforts of the reserved area together with the other stake holders.
- Implementing and strengthening proper law enforcement actions. Extensive conservation measures have to be implemented through continual support of the regional, zone and woreda administration and other concerned stake holders.
- Clear demarcation and natural system are essential to minimize the exploration of wildlife of the area.
- Illegal settlement and illegal activities of the local community in the national parks should be controlled.
- The reserved area is far from the main road to implement day to day wildlife conservation activities. Therefore, roads and camps should be constructed by concerned bodies.

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Appendix

Details of the result of wildlife census

Figure 7; Buffalo in the study area

Figure 8 Africa buffalo (photo by Tet Yien ,2020)

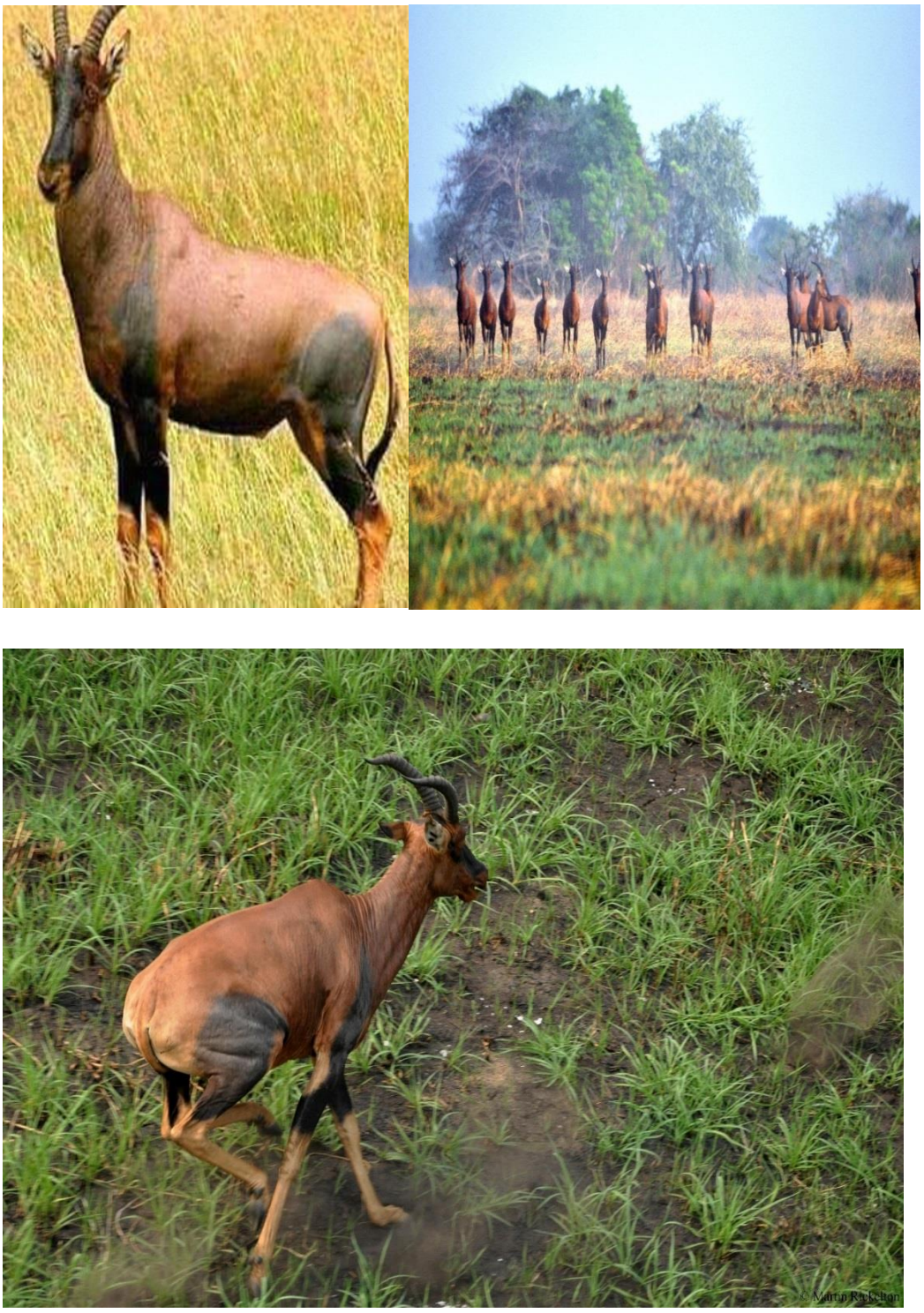

Figure 9, Topi antelope (by Tet Yien ,2020)

Figure 10: Elephant, in Jiek wetland (Photo by Tet Yien,2020)

Figures 11, white –eared- kob (*Kobus kob)* Malou riverine (photo by Tet Yien,2020)

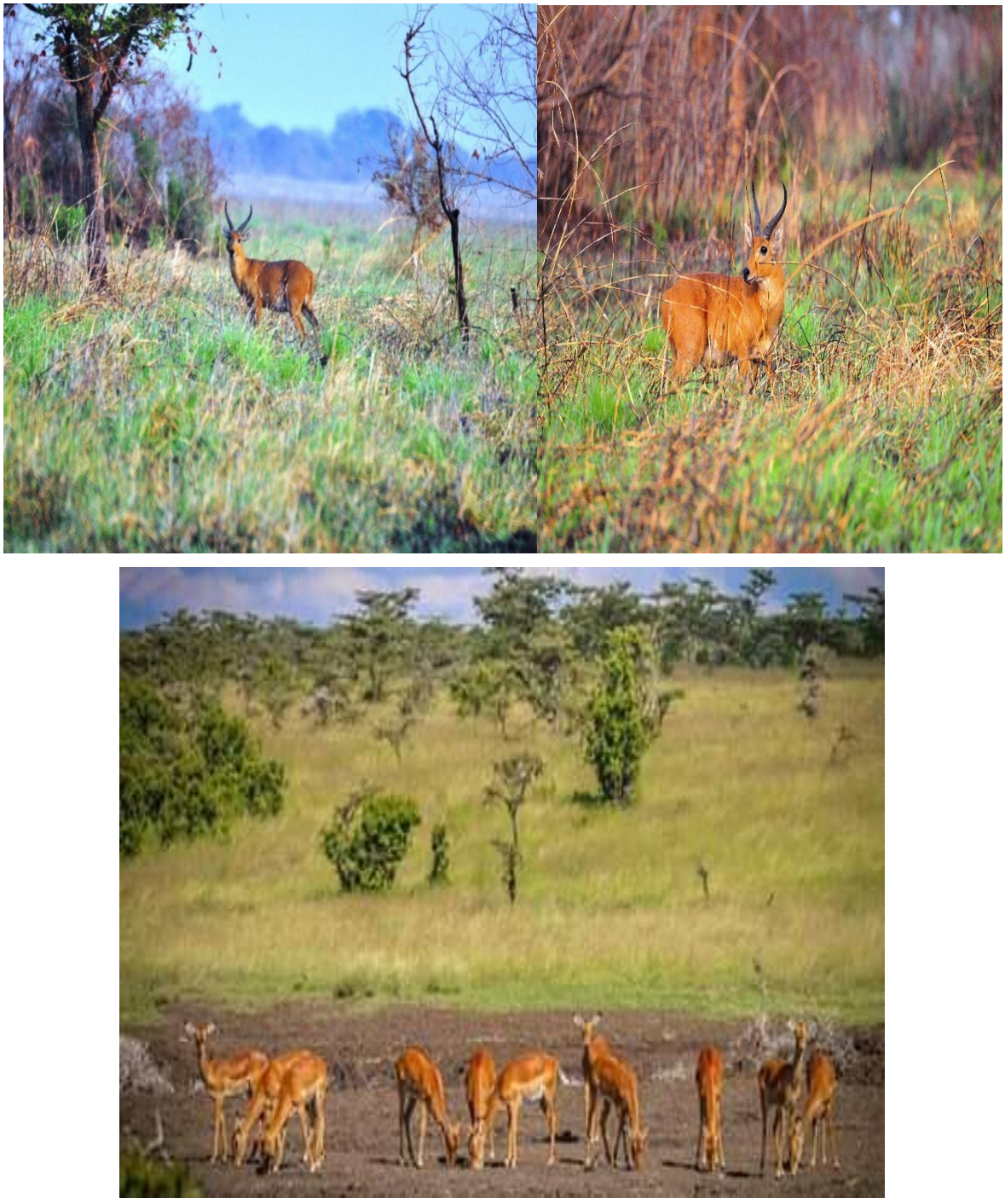

Figure *12;* Gazelles in the study area (photo by Tet Yien)

figure 13; Roan antelope (H. equenus) in the study area

Figure 14; Cattle in the field study area

Figure 15; olive baboon (p anubis) in pior riverine forest (photo by Tet Yien,2020)

Figure 16, Giraffe around the Jiek riverine forest (photo by Tet Yien ,2020)

Figure 17, Tet Y, In the field area

Figure 18, the foot prints and cattle grazing in the study area

Figure 19, Warthog in the riverine forest

Figure 20, Tet Yien ,in the Barjack wetland toward kankane

Figure *21*, Tet Yien After Coming from Dualdap Grassland Forest,2020

Figure 22; Tet Yien, with park scout in study area