Jimma University

College of Natural sciences

Department of Biolog

The Diversity, Distribution and Relative abundance of Medium and Large sized Mammals in Kuni Muktar Mountain Nyala Sanctuary West Hararghe Zone, Eastern Ethiopia.

By

Tariku Nemomsa

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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Advisor: Tsegaye Gadisa (PhD)

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Acronyms

EMA: Ethiopian Mapping Agency

EPA: Environmental Protection Agency

EWCO: Ethiopian Wildlife Conservation Organization

GPS: Global Positioning System

IBC: Institute for Biodiversity Conservation

NLFC: National Life Finance Cooperation

SPSS: Statistical Package for Social Sciences

Abstract

The present study was carried out to investigate medium and large sized mammalian species diversity, distribution and relative abundance in Kuni Muktar Mountain Nyala Sanctuary, Eastern Ethiopia. This study was conducted during January2014-July 2014. The study area was classified into habitat types natural forest, riverine forest and grassland based on the vegetation types. Each habitat type was classified into eight blocks. Representative samples were taken from each habitat type. Line transect method was employed for all three habitat types. During the survey period a total of 16 species were recorded, of which 12 were during dry season and 16 were during wet season. They belonged to six mammalian Orders (Rodentia, Hyracoidea, Tubulidentata, Primates, Artiodactyla and Carnivora) and ten Families were recorded. The diversity of medium and large sized mammals varied among the three different habitat types. The species were correlated with habitat types. The highest diversity index with Shannon-Wiener Index recorded from natural forest (H'=1.849) and the least diversity was recorded in riverine forest with (H'= 1.474) during dry season. During wet season the highest diversity was from grassland (H' = 2.152) and the least in riverine forest (H'= 1.995). The most common medium and large sized mammals in the study area during both season were warthog (Phacochoerus africanus), common bushbuck (Traglaphus scriptus), Menelik bushbuck (Traglaphus meneliki) and olive baboon (Papio anubis). In terms of relative abundance, the most abundant species in both seasons were olive baboon (Papio anubis), during dry season (37.23%) and during wet season (32.5%). During dry season the least abundant were crested Porcupine (*Hystrix cristata*) and leopard (Panthera *pardus*) (1.095%).*The least abundant during wet season were aardvark (Orycteropus afer) (0.83%). Among the three habitat type, Simpson's similarity index showed that the highest similarity was between natural and grassland (SI = 0.84) and the least similarity was between grassland and riverine forest(SI=0.59) during dry season. During wet season the highest similarity was between grassland and riverine forest (SI =0.135) and the least similarity was between natural forest and riverine forest (SI=0.093).*

Key words: *Mammals, diversity, relative abundance and Kuni Muktar Mountain Nyala Sanctuary*

1. INTRODUCTION

1.1. Background of the study

Ethiopia is one of the most physically and biologically diverse countries in the world (Dawit Kassa and Afework Bekele, 2008). Its topography varies from vast plains to high mountains having an altitudinal range of 116m below sea level, and the highest peak of 4620m a. s. l (Shibru Tedla, 1995). Such wide variation in altitudinal ranges, and geographical position results in the presence of diverse biological resources in Ethiopia (Shibru Tedla, 1995).

There are five climatic zones in Ethiopia, defined by altitude and temperature. The hot, arid zone covers the desert lowlands below 500 m, where the average annual rainfall is less than 400 mm and average annual temperatures range between 28°C and 34°C or higher. The warm to hot, semi-arid zone includes those areas with an altitude of 500–1,500 m altitude. Average annual rainfall is around 600 mm and the average annual temperature ranges from 20 to 28°C. The warm to cool, semi-humid zone covers the temperate highlands between 1,500 and 2,500 m altitude. Average annual temperatures vary between 16°C and 20°C, and annual rainfall is generally around 1,200 mm, reaching 2,400 mm in the southwest. The cool to cold humid zone includes the temperate highlands between 2,500 and 3,200 m altitude, where average temperatures range between 10°C and 16°C, with an annual rainfall of 1,000 mm and up to 2,000 mm in higher areas. The cold, moist temperate zone covers the afro-alpine areas on the highest plateaus between 3,200 and 3,500 m; average temperatures are below 10°C and annual rainfall averages less than 800 mm (EPA, 1998 and IBC, 2005).

Ethiopia is rich in its faunal diversity. Its faunal diversity is not evenly distributed in the country. The larger mammals are mainly concentrated in the south and southwest border and adjacent areas of the country. There are also plain game animals along the stretch of the Great Rift Valley System. Mountain massifs in the north are also home to many endemic species. More than 284 species of mammals, 861 species of birds, 201 species of reptiles, and 63 species of amphibians are recorded so far (Dawit Kassa and Afework Bekele, 2008). Among these 31 mammals, 16 birds, 9 reptiles and 25 amphibians are endemic to the country (Manyingerew Shenkut *et al*., 2006; Dawit Kassa and Afework Bekele, 2008). Among the mammalian species in the

country, about 60% is medium and large sized mammals and the remaining are small mammals (Yalden and Largen, 1992).

One common way of classifying mammals is based on their size though it does not show their taxonomic relationships. Medium sized mammals are mammal weighing between 2 kg-7kg such as small carnivores, small primates, large rodents, hyraxes, and those mammalian species with more than 7 kg are considered to be large sized mammals (Emmons and Feer, 1997). These includes most diurnal primates, most carnivores larger than a fox or house cat, all perissodactyls (horses, rhinos, tapirs) and artiodactyls that includes most herbivores. The medium and large sized mammalian species are usually found in and around the arid part of the country for many years (Hillman, 1993).

The natural ecosystems of Ethiopia are being changed due to anthropogenic effects and natural factors. The vegetation has been used for fuel wood, construction and other purposes. Due to this reason, wildlife resources of the country are largely restricted to a few protected areas that account only 2.9% of the country's land area (Hillman, 1993). Kuni Muktar Mountain Nyala Sanctuary is one of the Sanctuaries of the country having remnant biodiversity with important natural forest, high altitude and its fauna, but with limited biological information. The area provides a unique ecosystem with diverse wildlife resources in general and the medium and large sized mammals in particular. As systematic ecological study should be carried out in order to have information on the diversity, distribution and relative abundance of the medium and large sized mammals in the area to design appropriate conservation strategies. Kuni Muktar Mountain Nyala is one of the wildlife Sanctuaries in Ethiopia which established to Protect Mountain Nyala and remaining highland forest by the Ethiopian Wildlife Conservation Organization (EWCO) in 1997 (Vigano, 2008). It is bounded by Oda Bultum Woreda to the West, Chiro Woreda to the East and north and to the South Gemechis Woreda. The largest portion of the Sanctuary is in Gemechis Woreda. This study was aimed to obtain primary information on the diversity, distribution and relative abundance of medium and large sized mammals in Kuni Muktar Mountain Nyala Sanctuary.

1.2. Statement of the problem

Kuni Muktar Mountain Nyala Sanctuary was known to have higher mammalian diversity. However, there is an alarming accelerated reduction on the number of these mammalian

Species, as result of anthropogenic activities, such as hunting by resident people, habitat destruction for agricultural expansion, pressure by domestic animals and heavy encroachment by human. The knowledge on mammalian diversity, distribution and relative abundance was very essential for the development of sound management plan for a given protected area.

In Kuni Muktar Mountain Nyala Sanctuary nothing is done on distribution, relative abundance and habitat association of Medium and large sized mammalian. Thus, the present study was aimed to fill the gap by gathering basic information on the diversity, distribution and relative abundance of medium and large sized mammalian in Kuni Muktar Mountain Nyala Sanctuary West Hararghe Zone, Eastern Ethiopia.

1.3. Objectives of the study

1.3.1. General Objective

- The general objective of this study was to assess the diversity, distribution and relative abundance of medium and large sized mammals in Kuni Muktar Mountain Nyala Sanctuary ,West Hararghe Zone, Eastern Ethiopia

1.3.2. Specific Objective

- To identify the medium and large sized mammalian species in the study area.
- To determine relative abundance of medium and large sized mammal species in various habitats of the study area.
- To determine the habitat preference of medium and large sized Mammals in the study area.

1.4. Significance of the study

The research work have a great importance in scientific documentation and provide detail information about the diversity, distribution and relative abundance of medium and large sized mammals in Kuni Muktar Mountain Nyala Sanctuary, West Hararghe Zone, Eastern Ethiopia which is important for the future development and sound management plan of Sanctuary. In addition, the information collected during this study was also serve as a baseline for other researchers interested to carry out additional studies in this Sanctuary.

2. Literature Review

2.1. Mammalian Diversity

According to Ojeda *et al*. (2000) mammals are one of 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).

According to Delnay and Happold (1979), one of the most interesting appearances of tropical Africa is the richest and diversity of its mammalian fauna. 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. Over 1,150 species of mammals are recorded from Africa, belonging to 13 Orders and 50 Families.

Mammals inhabit every terrestrial biome, from deserts through tropical rainforests to polar icecaps. Many mammals are partially 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). Although mammals share several features in common, they also contain a vast diversity of forms. 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). 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).

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 of the surrounding vegetation (Dinerstein, 2003). In addition,

both set of mammals greatly influence the environment beyond direct species interaction such as through cascading trophic effects (Berger *et al*., 2001).

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. Mammals inhabit every terrestrial biome, from deserts to tropical rainforests to polar icecaps. 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). In most habitats, plant communities determine the physical structure of environment and therefore have a considerable influence on the distribution and interactions of animal species (McCoy and Bell, 1991). According to Berger *et al*. (2001) large mammals are fundamental elements in many ecosystems. Large carnivores frequently shape the number, distribution, and behavior of prey animals.

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 are 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 trophic 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 survey is the core survey for medium and large sized mammals (Jannelle *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 degrees. 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 distraction, 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 expected 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 consequences 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; Laurance *et al*., 2008; Lopes and Ferrari, 2008).

Mammals are also directly or indirectly affected by environmental pollutants. 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). Marine mammals including sea otters, seals, and whales also have been adversely affected by pollutants. 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 Chane, 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 not evolved 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 areas for both subsistence and economic gain is common. For example, as reported by Leader-

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).

In general, humans either directly or indirectly influence the survival of mammals or are responsible for the extinction of many mammalian species. Despite the availability of diverse ecosystems in different regions of Ethiopia, the ecology of most mammalian species is only little known. Among the known wildlife areas in Ethiopia, Kuni Muktar Mountain Nyala is one of the conservation areas where the distribution, relative abundance and habitat preference of mammals are very poorly known. The present study, therefore, attempts to fill this identified gap.

3. The Study area and methods

3.1. Geographic location of the study area

Kuni Muktar Mountain Nyala sanctuary is found in the Oromia Regional State, west Hararghe Zone, Eastern Ethiopia. The area lies between $8^0$59'02" and $9^0$01'12"North latitude and between $40^0$49'32" and $40^0$52'26"East longitude (Fig 1). The Sanctuary covers an area of 104.3km^2. The elevation of the Sanctuary ranges between 1900masl and 3310masl.

Kuni Muktar Mountain Nyala sanctuary is located about 345 km east of Addis Ababa, 18 Kms south of Chiro (Zonal capital). Kuni Muktar Mountain Nyala is one of the wildlife Sanctuaries in Ethiopia which established to Protect Mountain Nyala and remaining highland forest by the Ethiopian Wildlife Conservation Organization (EWCO) and in 1997 (Vigano, 2008). It is bounded by Oda Bultum Woreda to the West, Chiro Woreda to the East and north and to the South Gemechis Woreda. The largest portion of the Sanctuary is in Gemechis Woreda.

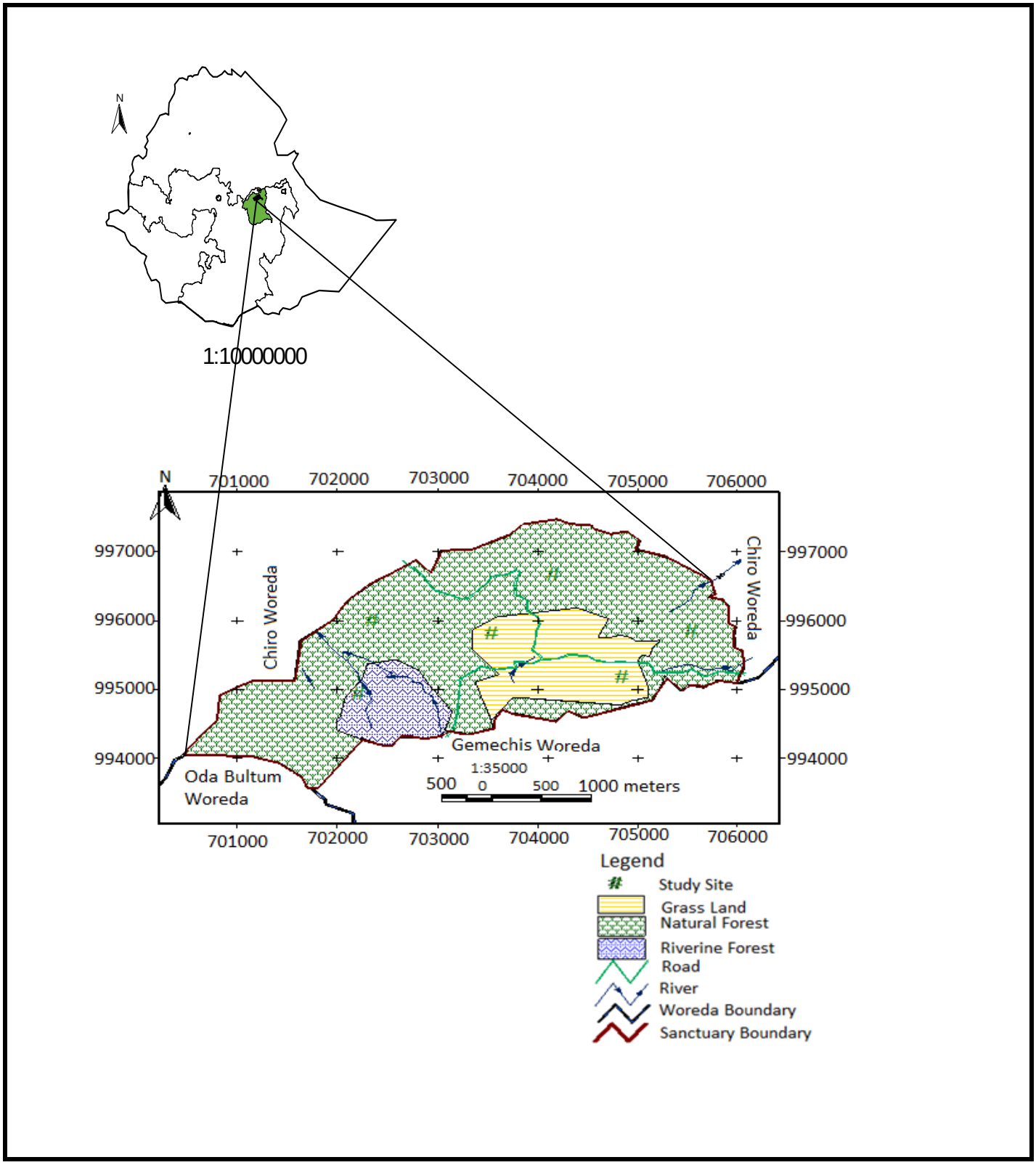

Figure 1. Map of the study area.

3.2. The habitat types of the study area

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

3.2.1. Grassland

The grassland habitat approximately covers about 17% of the total area of the study area.The dominant grass species in the grassland habitat are *Cenchrus pennisetiformis, Cyndonda ctylon and Hyparrhenia multiplex.* The scattered trees that occur in this habitat are *Olea africana*, *Podocarpus gracilior*, and *Juniperus procera* (plate. 1*)*

plate 1. Grassland during A) dry season B) wet season
(Photo by: Tariku Nemomsa, 2014)

3.2.2. Natural forest

The largest portion (over 75%) of the study area is covered by the Natural forest (plate 2). Plant species such as *Podocarpus gracilior, Hagenia abyssinic, Olea africana*, *Rubus apetalus*,and *Cypresuss lusitanica* (Vigano, 2008).

plate 2. Natural forest during A) dry season B) wet season
(Photo by: Tariku Nemomsa, 2014)

3.2.3. Riverine forest

Riverine forest occurs along the narrow strip of the river banks in the study area. Rivers including Chirma Sheka, Sororo and Chiro kela are within the Sanctuary along which the riverine forests are located. This habitat is characterized by mixed vegetation type composed of large tree and herbaceous species. The dominant plant species in this habitat are *Cypresuss lusitanica* and *arizonica*, and less extensively, *Podocarpus gracilior*, *Hagenia abyssinica* and *Olea africana*(Vigano, 2008). This habitat approximately covers 8% of the study area (plate 3).

plate 3. Riverine forest during A) dry season B) wet season

(Photo by: Tariku Nemomsa, January, 2014)

3.3. Geology and soil

There are four types of Soils in the Sanctuary Leptosols, Cambisols, Vertisols and Regosols. An anthropogenic process due to forest clearing has led to continuous removal of soil materials that strongly affected the micro-climate and soil development of the area (Eyelachew, 1999).

3.4. Water

The present study area is within Wabi-Shebele sub water shade and Rift valley drainage system. Rivers such as Chiro Kela and Jelo perennial drained towards the Rift system while rivers like lega Arabo and Lega ferenji draining towards Wabi Shebelle drainage system (EMA, 1999).

3.5. Climate of the study area

The five years meteorology data (for temperature and rain fall) was collected from Chiro Meteorological station.

Accordingly, the mean monthly maximum temperature of the area ranged between 24^{O}C and 29.5^{O}C and the mean minimum between 8.5^{O}C and 15^{O}C (Fig. 2).

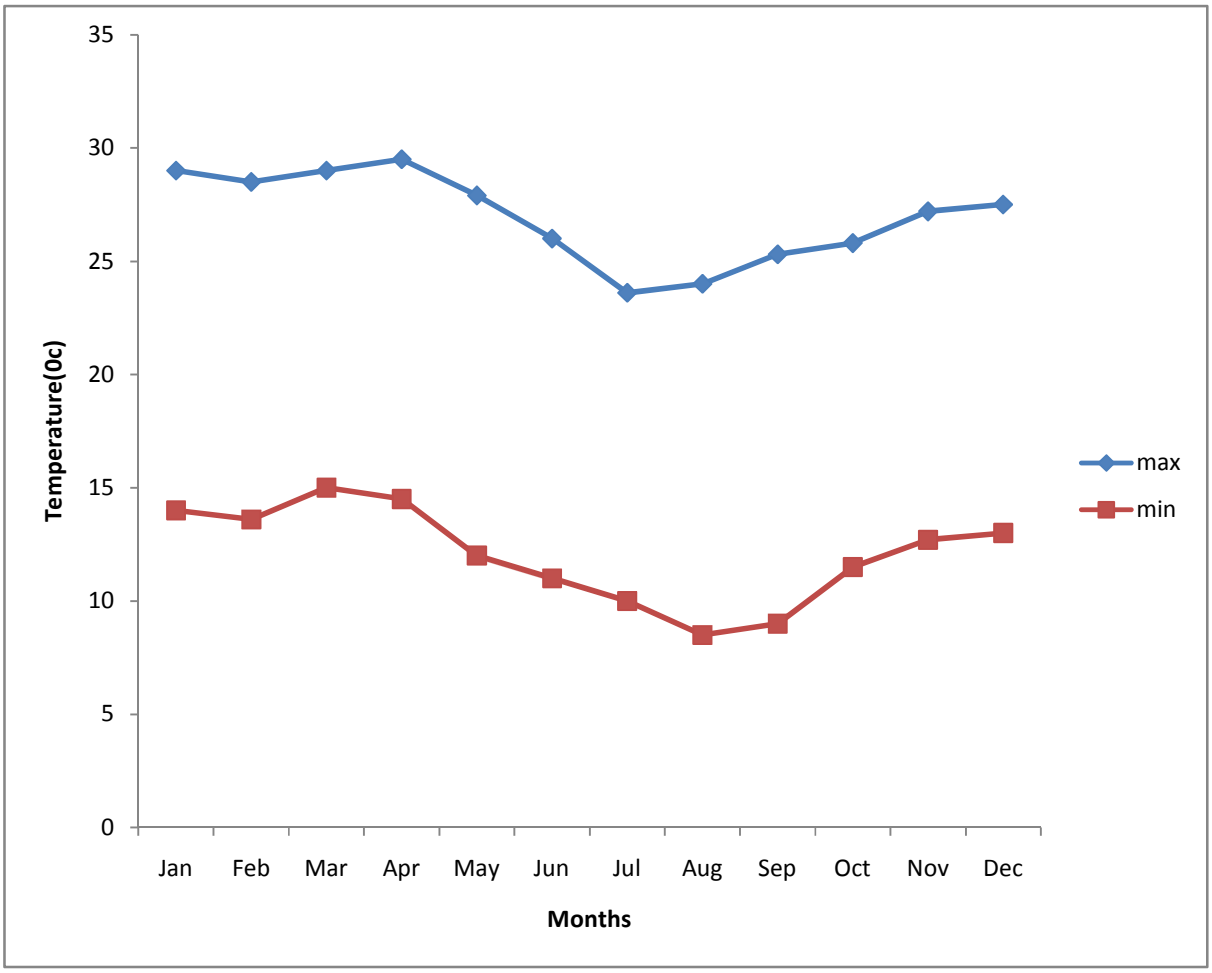

Figure 2. Average temperature record of the study area.

Kuni Muktar Mountain Nyala Sanctuary area has a unimodal, having one long rainy season. The mean annual rainfall in the study area is 979.5mm (ranging between854mm and 1207mm) (Fig 3). The area receives the highest rainfall between June - September and the lowest rainfall during the dry season especially in months of between January - April.

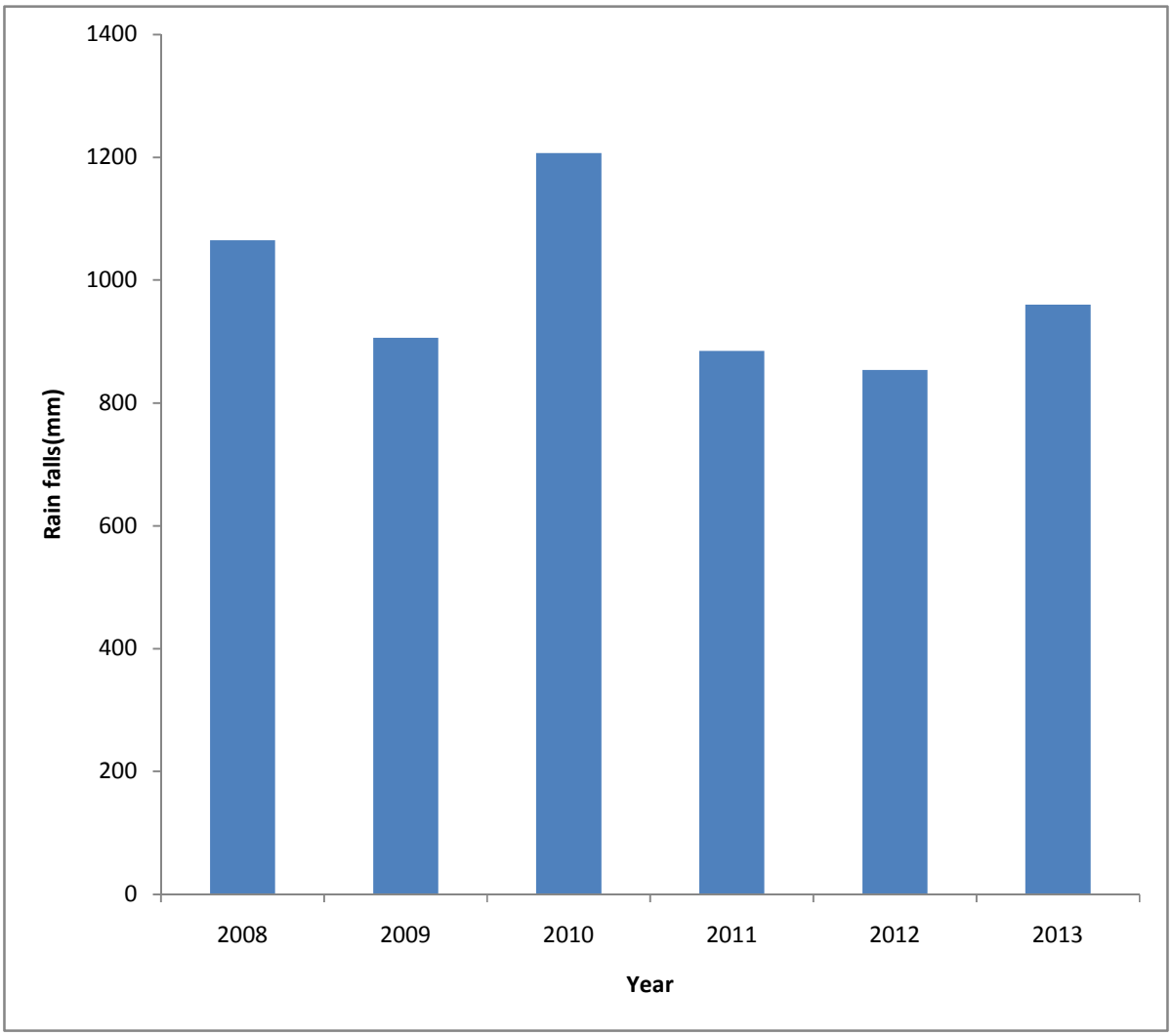

Figure 3.A six year annual rainfall record of the study area.

3.6. Methods

3.6.1. Preliminary survey

Prior to the actual research, a preliminary survey was conducted in the study area to gather information about the study area such as climatic condition, topography, and to estimate the size of the study area. The three habitat types were determined during the survey as the natural forest, grassland and riverine forest habitat types.

Based on the extent of the area eight study blocks were established. Accordingly, five blocks from natural forest (two blocks each for Gara arabo and Bandir, one block for Arer), and two blocks from grassland (dirre Arri and Gutema) and one block from riverine forest (Chirma Sheka) were established on random basis.

3.6.2. Survey of medium and large sized mammals

Inventory of the medium and large sized mammalian species occurring in Kuni Muktar Mountain Nyala Sanctuary was done using line transect method. A total of 23 transect lines were systematically established in the present study area. Out of these, 15 transect lines for natural forest, 5 transect lines for grassland and 3 transect lines for riverine forest was established. The width of transect varied based on the Visibility, As the result, in the natural forest transects length of 2.5 km with a width of 50m, in riverine forest habitat 1.5km with a width of 50 m and in grassland transects length of 2 km and a width of 200m were used.

During observations of medium and large sized mammals, species name, numbers of individuals of each species observed, time, location and vegetation types were recorded. Each count in the same blocks was completed in one day with the help of three experienced scouts to avoid double counting. Observation of medium and large sized mammals was made by with naked eye or aided by binoculars (10 x 42mm). Identification of medium and large sized mammals was carried out based on standard publications (Blower, 1969; Kingdon, 1997; Peres, 1999; Solomon Yirga,2008). Indirect evidences such as tracks, holes, spines, dung/pellets, feeding sites and calls of animals were also used to confirm the presence of mammals in the study area. The location of observed mammal habitat was determined using GPS and marked on a topographic map and distance between each transects line and other biological and

physical parameters were recorded. Filed observation were carried out during (6:00 – 10:00 h) in the morning and (16:00 – 18:00 h) in the late afternoon, when most diurnal mammals were active in the study area.

Mammals can be grouped as common (if probability of seeing is 100% every time of the visit or evidence recorded once a day), uncommon (if probability of seeing is more than 50% and/or evidence recorded once a week), and rare (if probability of seeing is less than 50% or single recorded during the whole survey periods) (Hillman, 1993). In the present study, mammalian species were categorized based on the above criteria.

3.6.3. Data Analysis

Species diversity of medium and large sized mammals was calculated using the Shannon-Wiener Index (H') of diversity (Shannon and Weiner, 1949).

$H' = -\sum [(\frac{ni}{N}) \times \ln (\frac{ni}{N})]$

Where ni= number of individuals of each species (the ith species) and N = total number of individuals for the site, and ln = the natural log of the number.

Evenness of mammals in the study area, was calculated using the equation of (Begon *et al.*,1996).

$$J = \frac{H'}{Hmax}$$

Where Hmax= ln(s) and s is the number of species.

Chi-square (χ^2) was used to calculate to show any difference in species number among habitats and species number between seasons in the study area.

$$\text{Abundance} = \frac{\text{Total number of individuals of species}}{\text{Total number of sample block}}$$ (Brown, 1984).

SPSS computer Programme was used for Chi-square(χ^2) analysis to test the association of mammal species and their habitats (Flower and Cohen, 1990).Simpson similarity index (SI) was

computed to assess the similarity between the habitats with reference to the composition of mammals observed.

$$SI = \frac{nc}{I + II + III}$$

Where: SI= Simpson's similarity index, C= the number of common species to all habitats, n=the number of 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.

4. Results

4.1. Diversity of medium and large sized mammals

A total of 634 individuals of medium and large sized mammals were observed and recorded during the two seasons survey in Kuni Muktar mountain Nyala Sanctuary. During the dry season, 12 species of medium and large sized mammals were observed. Among the recorded mammals, three species crested porcupine (*Hystrix cristata*), vervet monkey (*Chlorocebus aethiops)* and Slender mongoose (*Herpestes senguineus)* were considered medium sized and the remaining (9 species) were large sized mammals. During wet season, 16 species mammals were observed, of which four species crested porcupine (*Hystrix cristata*), vervet monkey (*Chlorocebus aethiops),* bush hyrax (Hetro *hyrax brucei*) and slender mongoose (*Herpestes senguineus)* were considered medium sized and the remaining (12 species) were large sized mammals. The mammalian species recorded from this study area belongs to16 species, 10 families and 6 mammalian orders (Rodentia, Hyracoidea, Tubulidentata, Primates, Artiodactyla and Carnivora).

The highest number of mammalian species was recorded for the family Bovidea which contained four species, followed by Cercopitheci with three species and Suidae that contained two species. The least number of species was recorded for the family Hystricidae, Felidae, Hyrpestidae, Procaviidae, Oryctestidae, Canidae and Hyaenidae which contained only one species each. Among the recorded mammalian species, order Artiodactyla was the most dominant with two families and six species (Table 1).

Table 1.Medium and large sized mammals identified in Kuni Muktar Mountain Nyala sanctuary during dry and wet seasons

Order	Family	Common Name	Scientific Name	Local Name
Rodentia	Hystricidae	Crested Porcupine	*Hystrix cristata*	Xade
∗Hyracoidea	Procaviidae	Bush hyrax	*Hetro hyrax brucei*	Osole Holka
∗Tubulidentata	Oryctestidae	Aardvark	*Orycteropus afer*	Waldigesa
Primate	Cercopitheci	Vervet monkey	*Chlorocebus aethiops*	Qalame
Primate	Cercopitheci	Olive baboon	*Papio anubis*	Jaldessa
∗Primate	Cercopitheci	Colobus monkey	*Colobus abyssinicus*	Weni
Artidactyla	Bovidae	Common duiker	*Sylvicapra grimmia*	Kurupho
Artidactyla	Bovidae	Common bushbuck	*Traglaphus scriptus*	Bosonu
Artidactyla	Bovidae	Menelik bushbuck	*Traglaphus meneliki*	Borofa
Artidactyla	Bovidae	Mountain Nyala	*Tragelaphus buxtoni*	Gadamsa
Artidactyla	Suidae	Bush pig	*Potamochoerus larvatus*	Boye
Artidactyla	Suidae	Warthog	*Phacochoerus africanus*	Karkarro
Carnivora	Hyrpestidae	Slender mongoose	*Herpestes senguineus*	Curree
∗Carnivora	Canidae	Common jackal	*Canis aureus*	Jedala
Carnivora	Felidae	Leopard	*Panthera pardus*	Qeransa
Carnivora	Hyaenidae	Spotted hyena	*Carcuta carcuta*	Warabesa

∗ = mammals observed only during wet season.

Photographs of mammalian species taken during the field study

plate 4. Warthogs (*Phacochoerus africanus)* In the study Area (By: Tariku Nemomsa, January, 2014).

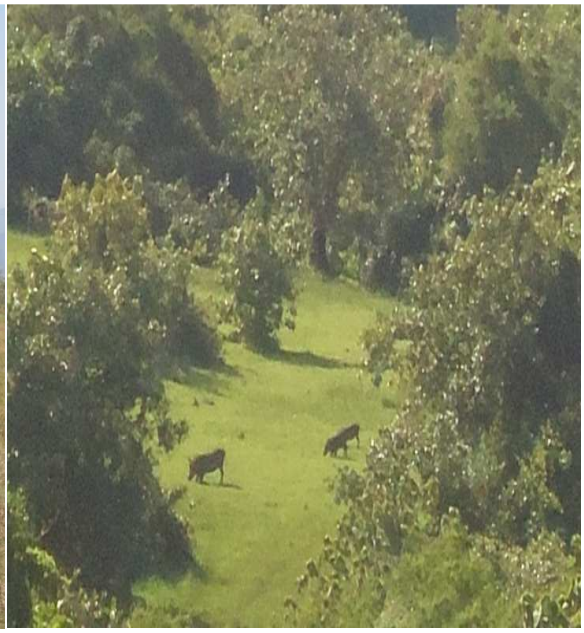

plate 5. Warthogs (*Phacochoerus africanus)* in the study Area (By: Tariku Nemomsa, June, 2014).

Plate 6. Mountain nyala (*Tragelaphus buxtoni)* in the study Area(Photo By: Tariku Nemomsa, June, 2014).

plate 7. Common bush bucks(Traglaphus scriptus) in the study area(January, 2014).

plate 8. Common bush bucks(Traglaphus scriptus) in the study area(June, 2014)

(Photo: Tariku Nemomsa, 2014).

plate 9. Olive baboon *(Papio anubis)* in the study area (By: Tariku Nemomsa, January, 2014).

plate 10. Olive baboon *(Papio anubis)* in the Study area (By: Tariku Nemomsa, June, 2014).

4.1.1. Mammals observed in the different habitat types

Out of the 16 species of mammals recorded from the present study area, the species identified and recorded only by indirect observation was crested porcupine (*Hystrix cristata*). Presence of this species in the study area was identified by faeces and spine. Five species of mammals, bush pig (*Potamochoerus larvatus)*, mountain nyala (*Tragelaphus buxtoni)*, leopard (*Panthera pardus*), aardvark (*Orycteropus afer)* and spotted hyena (*Carcuta carcuta)* were identified both by direct and indirect method of identification and the remaining ten mammalian species were identified by direct observations. Distribution of these mammalian species is shown in table 2.

Table -2. Distribution of medium and large sized mammals along the study habitats observed in the study area during dry and wet season

No	Common Name	Identification Method	Habitat type					
			Grassland		Natural forest		Riverine forest	
			Dry	Wet	Dry	Wet	Dry	Wet
1	Crested porcupine	Faeces /spine	0	✓	✓	✓	✓	✓
2	Bush hyrax	Visual	0	0	0	✓	0	✓
3	Aardvark	Hole/visual	0	✓	0	✓	0	0
4	Vervet monkey	Visual	0	✓	✓	✓	✓	✓
5	Olive baboon	Visual	✓	✓	✓	✓	✓	✓
6	Colobus monkey	Visual	0	0	0	0	0	✓
7	Common duiker	Visual	✓	✓	✓	✓	0	0
8	Common bush buck	Visual	✓	✓	✓	✓	✓	✓
9	Menelik bush buck	Visual	✓	✓	✓	✓	✓	✓
10	Mountain Nyala	Visual/ Faeces	✓	✓	✓	✓	✓	✓
11	Bush pig	Visual/ Faeces	0	✓	0	✓	✓	✓
12	Warthog	Visual	✓	✓	✓	✓	✓	✓
13	Slender mongoose	Visual	✓	✓	✓	✓	0	✓
14	Common jackal	Visual	0	✓	0	✓	0	✓
15	Leopard	Visual/ Faeces	✓	✓	✓	✓	0	0
16	Spotted hyena	Visual/Faeces	0	✓	✓	✓	✓	✓

✓ = Stands for the presence of animal in a habitat

0 = Stands for the absence of animals in a habitat

4.1.2. Diversity indices of medium and large sized mammals

The diversity indices of medium and large sized mammals in Kuni Muktar Mountain Nyala Sanctuary in the three habitat types during dry and wet seasons shown in Table 3.

Table 3. Diversity indices (H'), 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**		**Evenness**	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Grassland	8	14	26.5	46	1.687	2.152	0.812	0.815
Natural forest	11	15	29.4	36.8	1.849	2.014	0.771	0.744
Riverine forest	9	13	74	84	1.474	1.995	0.671	0.778
χ^2 test	0.071							

4.2. Relative abundance

4.2.1. Number of mammalian species in the three habitat types of the study area

During the dry season the highest number of mammalian species was recorded in natural forest with eleven species followed by riverine forest which contained nine species. The least number of mammalian species was recorded in grassland with eight species. During the wet season the highest number of mammalian species was recorded in natural forest 15 species, followed by grassland which contained 14 species. The least number of mammalian species was recorded in riverine forest with 13 species (Fig 4).

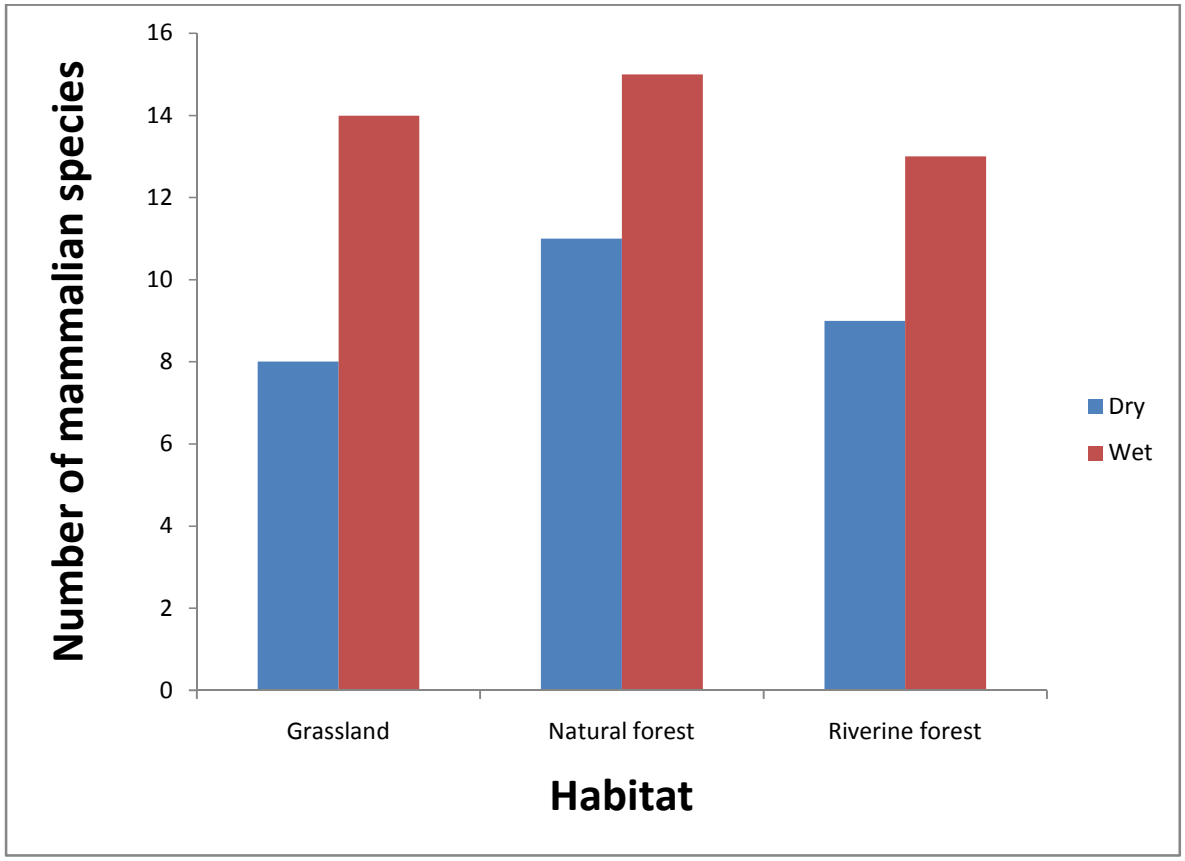

Figure 4. Number of mammalian species in different habitat types during both seasons

The total number of mammals counted during dry season was 274, the most abundant species during this season was olive baboon (*Papio anubis)* (37.23 %) followed by vervet monkey (*Chlorocebus aethiops*) (21.17%), warthog (*Phacochoerus africanus*) (14.96 %), and common bush buck (*Traglaphus scriptus*) (9.85%) were the third and fourth most abundant species in the study area, respectively. Crested porcupine (*Hystrix cristata*) (1.095%) and leopard (*Panthera pardus*) (1.095%) were the least abundant species during dry season in the study area.

The total number of mammals counted during wet season was 360, during this season, the most abundant species was olive baboon *(Papio anubis)* (32.5 %) followed by vervet monkey (*Chlorocebus aethiops*) (19.17%), warthog (*Phacochoerus africanus*) (12.22%) and common bush buck (*Traglaphus scriptus*) (7.22%) in the study area respectively. Aardvark (*Orycteropus afer*) (0.83) was the least abundant species in the study area (Table 4).

In terms of individuals among the three habitat types in the study area, during dry season, the highest number of individuals of medium and large sized mammals were recorded from natural forest 147±20.26(53.65%), followed by riverine forest 74±12.123 (27%) and grassland had the least 53±6.456(19.34%) number of individual species recorded. During the wet season, the highest number of individuals of medium and large sized mammals were recorded from natural forest 184±18.637(51.11%), followed by grassland 92±7.356(25.56%) and riverine forest had the least 84±8.079 (23.33%) number of individual species recorded (Table 4).

Table 4. Total numbers of medium and large sized mammalian species in each habitat type and their Relative Abundance during both seasons

Common name	**Habitat type**						**Total No of individual**		**Relative Abundance (%)**	
	Grass land		Natural forest		Riverine forest					
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	wet
Crested Porcupine	-	2	2	3	1	1	3	6	1.1	1.67
Bush hyrax	-	-	-	3	-	2	-	5	-	1.39
Aardvark	-	1	-	2	-	-	-	3	-	0.83
Vervet monkey	-	14	21	29	37	26	58	69	21.2	19.2
Olive baboon	12	26	71	73	19	18	102	117	37.2	32.5
Colobus monkey	-	-	-	-	-	16	-	16	-	4.44
Common duiker	2	4	3	4	-	-	5	8	1.82	2.22
Common bush buck	10	8	13	15	4	3	27	26	9.85	7.22
Menelik bush buck	5	3	4	6	1	2	10	11	3.65	3.06
Mountain Nyala	2	4	6	10	3	3	11	17	4.01	4.72
Bush pig	-	2	-	5	4	3	4	10	1.46	2.78
Warthog	19	17	18	22	4	5	41	44	14.96	12.2
Slender mongoose	2	2	4	3	-	1	6	6	2.19	1.67
Common jackal	-	3	-	2	-	2	-	7	-	1.94
Leopard	1	4	2	2	-	-	3	6	1.1	1.67
Spotted hyena	-	2	3	5	1	2	4	9	1.46	2.5
Mean ± SD	53± 6.46	92± 7.36	147± 20.26	184± 18.64	74± 12.12	84± 8.079	274	360	274	360
Percentage (%)	19.3	25.56	53.65	51.11	27	23.33	100	100	100	100
Number of Species	8	14	11	15	9	13	12	16	12	16

4.2.2. Occurrences of mammals

From a total 16 species of mammals recorded in Kuni Muktar Mountain Nyala Sanctuary 6 species (37.5%) were common, 4 species (25%) were rare, 6 species (37.5%) were uncommon(table 5).

Table 5. Occurrence of medium and large sized mammals in the study area

No	Common Name	Scientific Name	Category
1	Warthog	*Phacochoerus africanus*	Common
2	Common bush buck	*Traglaphus scriptus*	Common
3	Olive baboon	*Papio anubis*	Common
4	Common duiker	*Sylvicapra grimmia*	Un Common
5	Crested Porcupine	*Hystrix cristata*	Uncommon
6	Bush hyrax	*Hetro hyrax brucei*	Uncommon
7	Aardvark	*Orycteropus afer*	Rare
8	Menelik bush buck	*Traglaphus scriptus meneliki*	Common
9	Mountain Nyala	*Tragelaphus buxtoni*	Common
10	Vervet monkey	*Chlorocebus aethiops*	Common
11	Colobus monkey	*Colobus abyssinicus*	Rare
12	Slender mongoose	*Herpestes senguineus*	Un Common
13	Bush pig	*Potamochoerus larvatus*	Rare
14	Leopard	*Panthera pardus*	Rare
15	Common jackal	*Canis aureus*	Uncommon
16	Spotted hyena	*Carcuta carcuta*	Un Common

4.3. Habitat preference

4.3.1. Species similarity among the three habitat types

Habitat preference of medium and large sized mammals in Kuni Muktar Mountain Nyala is shown in Table 4. During dry season the habitat preference of medium and large sized mammals among the three different habitats of the study area was statistically not significant at $p > 0.05$ level of significance ($x^2 = 7.488$, df =2 P=0.624) and Simpson similarity index (SI) of medium and large mammal species among three habitats in the study area was 0.54.

Among the three habitat types, during dry season more similarity of mammalian species was obtained between natural forest and grassland (SI=0.84) followed by natural forest and riverine forest (SI=0.8). However, less similarity was obtained between species of grassland and riverine forest (SI= 0.59) (Table 6).

During wet season the habitat preference of medium and large sized mammals among the three different habitats of the study area was statistically not significant $P > 0.05$ level of significance ($x^2 = 8.91$, df =2 P=0.083) and Simpson similarity index (SI) of medium and large mammal species among three habitats in the study area was 0.79.

Among the three habitat types, more similarity of mammalian species was obtained from riverine forest and grassland (SI=0.135) followed by natural forest and grassland (SI=0.104). However, less similarity was obtained from species of natural forest and riverine forest (SI= 0.093) (Table 6).

Table 6. Similarity of medium and large sized mammal species between habitats during dry and wet seasons

Habitat	**Simpson Similarity Index (SI)**					
	Grassland		Natural forest		Riverine forest	
	dry	wet	dry	wet	dry	wet
Grassland	_	_	_	_	_	_
Natural forest	0.84	0.104	_	_	_	_
Riverine forest	0.59	0.135	0.8	0.093	_	_

4.4. Threats of mammals in Kuni Muktar Mountain Nyala Sanctuary

4.4.1. Grass collection

Grass collection is one of the serious threats of wildlife in the Sanctuary. The local people cut grass to feed their cattle, sell in the market and thatching houses. This might cause scarcity of grass for herbivores and disturb the natural behavior of wildlife in the Sanctuary.

Plate 11. Illegal collection of grass in the study area (Photo: Tariku Nemomsa, January, 2014).

4.4.2. Encroachment

The local community exploits the resource from the sanctuary. Forest exploitation inside the Sanctuary and traditional farming activities close to the Sanctuary might cause strong impacts on the wildlife of the area. Wild animals were highly restricted in some parts of the Sanctuary because of human and livestock encroachment.

4.4.3. Livestock grazing

Since the Sanctuary lacks natural buffer zone, high number of grazing cattle and other domestic animals make a devastating effect on the edges of the Sanctuary. During over grazing, there has been deterioration of vegetation close to the edge that might influence the wildlife of the Sanctuary.

Plate 12. Livestock grazing inside the Sanctuary during the dry season (Photo: Tariku Nemomsa, January, 2014).

5. Discussion

A total of sixteen species of medium and large sized mammals were recorded during the present study, four of them were medium sized and twelve of them were large sized mammals. This may not represent all the species present in the study area, but it gives update accounts of some of the medium and large sized mammal species present in the study sites. The present study recorded 16 mammalian species in Kuni Muktar Mountain Nyala Sanctuary. More exploration, with extended survey time may revealed more mammalian species in the area. This underlines the area could be one of the wildlife Sanctuaries with high mammalian diversity in Ethiopia.

The distributions of medium and large sized mammalian species are not consistent throughout its geographical ranges. Rather, it is a mosaic and it is governed primarily by the presence or absence of suitable habitats for species. In the present study area due to the availability of food and cover, some primates like Columbus monkey (Colubus abyssinics) and vervet monkey (*Chlorocebus aethiops)* were largely associated to the riverine forest. This finding is in line with Meseret Chane (2010) who reported high number of primate species in riverine forest of Borena-Sayint National park. The extent to which a given species occupy a preferred habitat is based on the requirements of specific resources (Vaughan *et al*., 2000).Likewise, the distribution and abundance of medium and large sized mammal species of the present study area was not uniform. The high number of primates is due to the fact that diet of the mammals differed considerably between sites based at least on the abundance of different tree species in the sites (Gebrecherkos Woldegeorgis, 2010).

Among the three habitats of the study area, the highest diversity index (H'=1.849) of medium and large sized mammals was recorded in the natural forest, followed by grassland (H'=1.687). The highest evenness (J=0.812) of medium and large sized mammals was recorded in the grassland, followed by natural forest (J=0.772) during dry season. During wet season, the highest diversity index (H'=2.152) of medium and large sized mammals were recorded in the grassland, followed by natural forest (H'=2.014). The highest evenness (J=0.815) of medium and large sized mammals were recorded in the grassland, followed by riverine forest (J= 0.778). One explanation for this may be the natural forest and riverine forests contain wider variety of plant species, compared to grassland. This might have created a wider variety of niches for more

diverse species of mammals. This result is in line with the investigation of Meseret Chane (2010) who obtained high diversity index and evenness of medium and large sized mammals from natural forest and riverine forest in Borena- Sayint National Park. Diversity of mammalian species in an area depends primarily on the availability of mixed plant species, which constitute their major food resources (Mathew and Rahamatthulla, 1993). Therefore, heterogeneity of plant species in natural forest and riverine forest in the study area could be the main reason for more mammalian diversity index. Homogenous conditions yield lower diversity while heterogeneous condition yield higher diversity (Alatolo, 1981;Conroy and Nichols, 1996; Tariku Mekonnin *et al.,* 2011), In addition to heterogeneity of habitat, diversity index of mammalian species depends on the existence of food, water and cover.

In addition to the presence of sufficient food and water sources, differences in diversity of mammalian species in the three habitat types of the present study area might be due to habitat heterogeneity. Goodman (1975) reported the positive relationship between species diversity and community stability. A pressure forced by environmental factors such as difference in temperature has resulted in declining mammalian diversity (Gebrecherkos Woldegeorgis, 2010).

The abundance of mammalian species is based on the preferences for habitats that provide resources. With respect to habitat selection, more mammalian species were observed in the natural forest during both season and least was observed in the grassland during dry season and during wet season in the riverine forest. The mammalian species used the dense habitats not only as source of food but also as cover from strong sunlight and predation. The frequency of observation of medium and large sized mammalian species in the riverine forest was low because they were observed in this site only when they needed to drinking water (Aramde Fetene *et al*., 2011). Some species such as bush hyrax, colobus monkey, aardvark and common jackal were not observed in the study area during dry season. Bush hyrax, colobus monkey and common jackal were might be due to their shyness and out of the study site, aardvark was might be due to nocturnal behavior and out of the study site.

The abundance of medium and large sized mammal species in the present study area also varied between species. For example, olive baboon (*papio anubis)(*37.23%) during dry

season and (32.5%) during wet season was the most abundant species in the study area. This mammalian species was sparse in most of the natural forest and riverine forest. Their population was concentrated in the natural forest high lands. The high abundance olive baboon in the study area might be due to availability and suitability of habitat and absence of predators for this species when compared to the other mammalian species. They were found in the natural forest close to riverine forest where they fed during the day time.

Vervet monkey (*Chlorocebus aethiops)* was the second abundant mammal species (21.17%) during dry season and (19.17%) during wet season of the study area. Abundance of this species in the study area might be associated with vegetation cover, and availability of food and water. This result agrees with the findings of Girma Mengesha and Afework Bekele (2008) who recorded high number of vervet monkey (Chlorocebus aethiops) from Alatish National Park. Vervet monkey are abundant in the area with sufficient food and water (Enstam and Isbell, 2007; McDougal *et al.,* 2010).

Warthog (*Phacochoerus africanus*) was the third abundant species (14.96%) during dry season and (12.22%) during wet season of the study area. This species is relatively more abundant during wet season than dry season. This result is similar with the investigation of Mesela Admassu (2007), who obtained high population of warthog during the wet season than the dry season. This is because during the dry season resources required for survival of the species are not available in sufficient amount. In addition the conflict between the animals and the local people is not much intense during the wet season. But during the dry season, especially during harvesting period, the local people hunt warthogs for their meat and against crop damage continuously.

Common bushbuck (*Traglaphus scriptus*), was the fourth abundant species (9.85%) during dry season and (7.22%) during wet season of the study area. This species is mostly seen in the natural forest and grasslands. They feed on small shrubs and grasses and usually occur near water source (Meseret Chane, 2010).The species was frequently seen during the day and near to the periphery at night in all habitat types during both seasons. This might prevent the species from nocturnal predators. Common predator of bushbuck in the study area was leopard.

The least abundant medium and large sized mammal species recorded from the study area during dry season was crested porcupine and leopard (1.095%) and during wet season were aardvark (0.83%). The low number of this mammal in the study area is an indication of unfavorable environmental conditions and could be due to their nocturnal behavior. Nocturnal mammals need densely forested habitats and cover that could make the sighting of them difficult (Girma Timer, 2005).

The low number of some of the mammals in the area might be attributed to factors that are known to limit abundance of mammals in an area such as destruction of habitat, poaching and livestock grazing. Ananthakrishnan (1988) concluded that abundance of mammalian species in ecosystems are closely related to the physical stability of the habitat. As human activities change habitats a lot, a disturbed habitat affects mammalian diversity and makes the area to have fewer mammals. Undisturbed sites have more mammals than in disturbed sites because there are more situates for them to live (Mathooko and Kariuki, 2000).

Water and pasture conditions or the combinations of both might be determining habitat association of medium and large sized mammal populations in their natural habitats. Habitat preference of medium and large sized mammals is determined in terms of their Cover, water and food requirements. Similarly, studies carried out in different parts of the world have also noted that mammalian distribution and their habitat association are often correlated mainly with the availability of water, food and protection (Conroy and Nichols, 1996; Girma Timer, 2005; Mohamed Yaba *et al*., 2011; Zerihun Girma *et al*., 2012).

In the present study area, the highest numbers of species were recorded in natural forest and grassland. The occurrence of more species of medium and large sized mammal in natural forest is probably due to the movement of these species from the peripheral part of the study area towards the inner in search of food and cover.

The presence of more number of medium and large sized mammals in grassland habitat of the study area might be due to the availability of food and other resources to meet their requirements. Occurrence of mammal species to specific habitat type is connected with availability of food sources (Meseret Chane, 2010). Girma Mengesha and Afework Bekele (2008) recorded high number of mammal species from grassland in Alatish National Park.

Mammalian species in different habitat types are attributed to the behavior of animals (Martin, 1998; Aramde Fetene *et al*., 2011).

The mammalian species like common bushbuck (*Traglaphus scriptus*), Menelik bushbuck (*Traglaphus meneliki)*, warthog (Phacochoerus africanus), olive baboon (*Papio anubis*) and mountain nyala (*Tragelaphus buxtoni)* were observed and recorded in all habitats in the present study area.

Distribution of them in all habitats indicates their adaptation to a variety of habitat types. However, the prevalence of olive baboon and common bush buck was common in the habitats of natural forest and grassland. This is due to feeding habits and behavior of them. Smith (1992) pointed out that, differences in the diversity and evenness of mammals are governed partly by differences in their feeding habits. The ecological preference and evolutionary adaptation of mammalian species play a role in their distribution in different habitat types (Bailey, 1984).

6. Conclusion and Recommendation

6. 1. Conclusion

The present study identified and documented mammalian species of Kuni Muktar Mountain Nyala and gave baseline information about their presence. During data collection period, twelve species of medium and large sized mammals were identified during dry season and sixteen species of medium and large sized mammals were identified during wet season. The mammalian species recorded from this study area belong to six mammalian Orders and ten families.

The distribution, relative abundance and diversity of mammal species in the Sanctuary varied because of vegetation, water and other biotic and abiotic factor. For example, warthog, common bushbuck, Meneliki bushbuck and olive baboon were frequently seen in the Sanctuary. In the present study, there was little variation in species diversity among the different habitat types.

However, the abundance of medium and large sized mammals showed marked difference among habitats. This could be related to the difference in habitat preference of medium and large sized mammals depending on the availability of cover, food, water and level of disturbance. The present ecological survey revealed that the sanctuary supports a variety of medium and large sized mammal species in different vegetation types of the area.

The number of large mammal species occurred in the present study has a scenic topographic features and harbored endemic fauna like, mountain Nyala, critically endangered Menelik bushbuck. These two species mountain Nyala and Menelik bushbuck are endemic to Ethiopia. So, the sanctuary needs strong attention from Federal and regional government to implement proper wildlife management.

6.2. Recommendation

To ensure the long-term conservation of wild life of the Sanctuary, the following recommendations are suggested:

- The National and Regional government should introduce appropriate strategies to conserve wildlife of the Sanctuary.
- Clear demarcation and natural buffer zones are essential to minimize the exploration of wildlife of the area.
- Developing habitat management strategies, such as manipulation of the vegetation to make it more suitable for the species.
- Illegal activities of the local community in the Sanctuary should be controlled.
- Meteorological station should set up at in or around the Sanctuary to obtain accurate meteorological data of the Sanctuary.
- Regular assessment and monitoring of fauna and flora of the Sanctuary is essential.
- Controlling or eliminating feral animals (domestic animals that have run wild animals) as they may kill, compete, or interbreed with wild animals.
- Actively protecting endangered species through improving patrols, controlling illegal hunting and trapping adopting special intensive anti- poaching measures.
- Effective conservation measure should be carried out through an extension work to create public awareness among the local community.
- The local people should develop their awareness on conservation of wildlife, so that they appreciate the benefits of natural resources.
- The sharing of benefits with the communities living adjacent to the Sanctuary will reduce conflict between wildlife managers and local communities.
- It is important to integrate the use of full indigenous knowledge and modern conservation systems to develop a deeper understanding of the species and their ecosystems.
- The Sanctuary management staff should have good facilities with the appropriate manpower, equipment and budget.

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Appendices

Appendix **1**

Field data sheet used for surveying medium and large size mammals

Study area----------Study site----------Date----------Observer----------

No	Species Name	Number of individuals	Habitat type	Time	Method of identification

Appendix 2. Row data of mammalian species recorded throughout the study period from different study site during dry and wet season.

Species	Habitat											
	Natural forest						Grassland				Riverine forest	
	Gara Arabo		Bandir		Arer		Gutema		Dirre Arri		Ch/sheka	
	Dry	wet	Dry	wet	Dry	wet	Dry	wet	Dry	wet	Dry	wet
Crested Porcupine	-	-	-	2	-	1	-	1	1	3	-	1
	-	-	3	2	-	2	-	2	1	2	1	2
	2	-	2	1	-	-	-	2	-	1	1	-
	2	2	-	-	-	3	-	-	-	-	2	2
Bush hyrax	-	-	-	2	-	-	-	-	-	-	-	-
	-	2	-	-	-	-	-	-	-	-	-	3
	-	3	-	2	-	3	-	-	-	-	-	2
	-	-	-	-	-	-	-	-	-	-	-	3
Vervet monkey	-	-	-	18	26	-	-	22	-	-	35	21
	-	-	23	-	-	25	-		-	16	28	29
	14	19	-	-	-	28	-	18	-	-	44	22
	-	22	20	20	-	-	-		-	-	41	32
Olive baboon	38	36	-	-	34	24	-	14	-	-	26	27
	31	34	37	42	-	22	47		-	37	-	20
	-	38	36	36	28	-	-	28	-	-	21	-
	46	34	-	-	35	26	-	25	-	-	27	26
Common duiker	-	3	-	2	2	2	-	3	1	2	-	-
	2	3	3	-	-	-	2	4	2	2	-	-
	1	-	2	3	-	1	-		-	3	-	-
	-	2	-	-	1	-	3	3	-	5	-	-

Colobus monkey	-	-	-	-	-	-	-	-	-	-	-	19
	-	-	-	-	-	-	-	-	-	-	-	24
	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	22
Common bush buck	6	5	4	5	-	5	5	3	6	3	5	-
	4	5	5	7	3	9	3	4	5	4	4	6
	5	3	-	-	7	6	4	7	7	4	-	7
	7	4	6	6	5	6	4	5	6	2	6	-
Menelik bush buck	-	2	2	3	-	-	2	2	3	3	-	4
	-	2	4	2	2	4	3	-	-	-	2	3
	3	-	2	3	1	-	-	3	4	3	-	2
	2	5	-	-	-	5	3	-	4	-	3	-
Mountain Nyala	5	-	-	4	3	3	-	3	-	3	1	5
	-	6	5	4	-	-	2	-	4	5	3	3
	4	5	-	3	-	5	-	-	-	2	5	-
	4	3	-	2	4	4	-	4	3	-	3	4
Bush pig	-	-	-	-	-	-	-	-	-	2	4	3
	-	3	-	-	-	5	-	3	-	-	5	-
	-	5	-	2	-	-	-	-	-	-	2	5
	-	-	-	-	-	4	-	-	-	4	4	3
Warthog	7	11	12	6	6	8	8	9	9	8	6	-
	5	7	7	5	-	5	10	9	8	10	6	4
	6	9	4	7	5	6	11	7	9	9	-	9
	7	5	9	9	6	10	10	8	11	8	5	7
Slender mongoose	3	2	2		-		-	-	-		-	-
	2		-	2	3	2	-	2	-	-	-	2
	-	1	-	-	2	3	3	2	-	3	-	-
	2	2	2	2	-	-	3	-	3	3	-	2

Leopard	-	1	1	-	-	-	-	-	2	2	-	-
	1	-	2	2	-	-	-	2	-	-	-	-
	-	-	-	2	-	-	-	3	1	2	-	-
	2	-	-	-	-	-	-	3	1	3	-	-
Spotted hyena	3	1	-	2	-	-	-	-	-	2	1	3
	-	3	2	3	3	4	-	3	-	-	2	-
	2	-	-	3	-	-	2	-	-	2	-	2
	-	2	-	-	2	2	-	2	-	-	2	5
Common jackal	-	-	-	-	-	-	-	2	-	-	-	-
	-	-	-	-	-	-	-	2	-	-	-	3
	-	-	-	-	-	-	-	3	-	3	-	2
	-	-	-	-	-	-	-	2	-	-	-	3
Aardvark	-	2	-	-	-	-	-	2	-	-	-	-
	-	1`	-	2	-	-	-	-	-	2	-	-
	-	-	-	-	-	2	-	2	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-

DECLARATION

I undersigned, declare that this thesis is my original work and has not been presented for degree in any other University, and that all sources of materials used for the thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M. Sc. Degree at Jimma University and is deposited at the University library to be made available to borrowers under rules of the library. I declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of the source is made.

Name: **Tariku Nemomsa**

Signature----------

Date----------