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Diversity, Relative Abundance and Distribution of Medium and Large Sized Mammals of Goji and Nopha, Becho District, South Western Ethiopia

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List of Abbreviation and Acronyms

m.a.s.l…….....meter above sea level

ANRS…….....Agricultural and Natural Resources

H' …….....Shannon – Wiener diversity Index

Pi…….....The proportion of each species in the sample

lnpi…….....Natural logarithm of the proportion

E…….....Shannon Wiener evenness index

RAI…….....Relative Abundance Index

Spp. …….....Species

Abstract

This study was conducted to survey and determine the diversity, relative abundance, distribution of medium and large size mammals in Nopha and Goji forests from February 2020 - September 2020. Preliminary survey was conducted and two habitat type:-, dense forest and woodland habitats were identified. A line transect survey method was implemented to record the mammalian diversity. Representative sample blocks were taken from each habitat type. Line transect method was employed for the two habitat types and species identification and counting of individuals were made along each transect. In addition to direct observation, indirect methods such as scat/dropping, spines and calls were also used for identification of mammals. A total of 22 mammal species belonging to 7 orders and 13 families were recorded from the study area during both seasons. Among these, four species: Vervet monkey (Chlorocebus aethiopis), Stark's hare (Lepus starcki), Bush hyrax (Heterohyrax brucei) and White tailed mangoose (Icheumia albicauda) were medium-sized and the remaining 18 species were large-sized mammals. Order Carnivora has the highest number of species with nine species followed by Primates and Artiodactyla with five and four species respectively. Order Tubulindentata, Lagomorpha, Hyracoidea and Rodentia were represented by one species each. Among the 22 species of mammals, Vervet monkey (Chlorocebus aethiops) was the dominant mammalian species followed by Olive baboon (Papio anubis) and Colobus monkey(Colobus guereza) and Lion (pantherleo), leopard (panthera pardus) and white tailed mongoose (Icheumia albicauda) were the least abundant species. Dense forest habitats had the highest mammalian species diversity during the dry season with the diversity index (H') 2.497and the least diversified habitat was woodland (H"=1.625) in the same season. The abundant mammal species in the study area were Vervet monkey (C. aethiopis) (22.61%) , Olive baboon (P. anubis) (21.55%) and Colobus monkey (C. guereza) (17.31%) were the most abundant species, whereas leopard (Panthera pardus) and lion (Panthera leo) were fewer than 1% of the total observation. Among the two habitat types the highest Simpson's index (SI) similarity of mammalian species was obtained from dense forest and woodland both during the dry (0.86) and wet season (0.76) respectively. Despite the study area provided habitats for various species of mammals, human influence such as intensive deforestation for agricultural expansion, charcoal production, fuel wood collection, and grazing by livestock resulted in alteration of the natural forest in the study area. This finding showed that attention should be given to the varieties of mammal species to avoid any aspect of human pressures.

Keywords; Abundance, Distribution, Diversity, Goji, Mammals, Nopha

1. Introduction

1.1 Background

Mammals are one of the most important components of biodiversity in the world (Yalden, 1983). They can be divided into small, medium and large based on body weight. Medium sized mammals are mammals whose body weight varies from 2kg to 7kg such as small carnivores, small primates, large rodents, hyraxes, and pangolins. While Species with more than 7kg are considered to be large sized mammals and these include most diurnal primates, most carnivores larger than a fox or house cat, all perissodactyls and artiodactyls (Emmons and Feer, 1997).

Functional structures of medium and large-sized mammals are determined by the composition of functional traits (feeding type, body mass, activity patterns and gregariousness). Such structures often vary along environmental gradients such as disturbance and resource availability (Hashim and Mahgoub, 2007). Medium and large sized mammals are very important for the proper functioning of ecosystems. They are responsible for plant pollination,seed dispersal, nutrient recycling and balancing populations through predator-prey interaction (Janson *et al*., 1981). In addition, they have enormous effects on the structure and composition of vegetation (Sinclair and Arcese, 1995). Large mammals have long been recognized as animals that interact in particularly complex and powerful fashions with their habitat (Berger, 2001). They are also fundamental elements in many ecosystems. Large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation (Hashim *et al*., 2007).

Mammals are the most diverse and successful group of animals having approximately 5, 416 extant species on the globe (Geleta and Bekele, 2016; Real *et al*, 2014). About 320 species of mammals exist in Ethiopia of which 55 are endemic (Lavrenchenko and Bekele, 2017). Mammals are threatened by various factors. Habitat destruction has also caused some large sized predatory species to venture in to human settlement areas, and pose risks to humans and themselves. Cardillo *et al.*, (2005) have predicted more rapid loss of large mammals of the world in the near future. The reduction of small and medium – sized mammals may be less evident but equal to or greater than those of large sized.

Mammals' inventories are tremendously vital to improve our understanding of their geographical distribution, habitat used and their status (Melo *et.al,* 2012). The ecological relevance of mammals, shortage of ecological data and increased human threats make the matter very

essential and necessary to evaluate their current conservation status (Wuver , 2006; Eduardo , 2009). The absence and rarity of these mammals in a given ecosystem have severe consequence in the structure, composition and diversity of forests. Hence, surveys of mammalian diversity, abundance and habitat conditions of a particular ecosystem is the first step for conservation action and provide information to design 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 (Bernando and Melo , 2013).

Mammals of Ethiopia are under progressive studies, but the diversity and conservation status of mammalian species outside protected areas are poorly known (Atinafu and Yihune, 2018). Mammal inventories are essential tools to efficiently forward conservation strategies and management practices (Legese *et al.,* 2019).

Nopha and Goji forests are among the current priority area and are among the few remaining montane forest in the south west Ethiopia. These forests are degraded for managed coffee plantation and timber production by local in habitats. This ecosystem was hypothesized to contain some medium and large-sized mammal species in its forest patch. Like most of unprotected areas of the country, there is no information available about the mammal species diversity, abundance and the distribution in these forest patches. Therefore, the aim of this study was to survey the species composition of medium and large sized mammals and the prevailing anthropogenic threats to wildlife in this forest patches of Goji and Nopha, Becho district, south western Ethiopia.

1.2 Statement of the Problem

Knowledge on diversity, distribution and relative abundance of mammals are very essential for the development of effective land management plan (Stephens *et al*., 2001). Mammals of Ethiopia in protected areas had better access for repeated studies, but the diversity and conservation status of mammalian species outside protected areas are poorly known. However, there is scarce information on diversity, relative abundance and distribution of medium and large mammals in the study area. Therefore, the present study was proposed to fill this gap by collecting current information on the diversity, relative abundance and distribution of medium and large sized mammals in Nopha and Goji forests, Becho District Ilu Ababor Zone, South Western Ethiopia.

1.3. Research Questions

This research will try to address the following research questions:

- What mammalian species are found in the two forests, and what are their status?
- What is the relative abundance of each species in both forests?
- Is there habitat preference in distribution, diversity and abundance of mammalian species between the two forests?
- What are the actual and potential threats for the mammals in these forests?

1.4. Objectives of the study

1.4.1. General objective

The general objective of this study was to assess the diversity, relative abundance and distribution of medium and large sized mammals in Goji and Nopha, in Ilu Ababor zone, South Western Ethiopia.

1.4.2. Specific Objectives

- ✓ To record the diversity of medium and large sized mammals in two forests.
- ✓ To assess the habitat preference of the mammals in the two forests.
- ✓ To compare the variation, in diversity and relative abundance of mammalian species in the two forests.
- ✓ To investigates and identify threats to mammalian species in these forests and recommend management and conservation measures.

1.5. Significance of the Study

The destruction of vegetation and environmental degradations is becoming issues of national and global concern in recent years. This is because of declining vegetation cover and depletion of natural resources were closely associated with drought and food shortages that have become major threat affecting wild life.

Identifying the diversity and the relative abundance of mammalian species is very crucial for the conservation of the species and their habitat. Therefore, the investigation of this study helps to record baseline data for species diversity and other parameters of large sized mammals of the area. The study results also basic data for the management and conservation of medium and large mammals in Goji and Nopha forests for Oromia forest and wildlife enterprise and Becho woreda environment forest and climate change authority.

1.6. Scope and Limitation of the Study

Though the survey of species diversity, distribution and relative abundance of medium and large sized mammals should cover all the patchy forests in the woredas. Only Goji and Nopha forests were purposively selected for logistic, time and resources problem. Furthermore, because of time limitations and resource constraints, the study addressed the randomly selected transect lines and target respondents on additional information in the study area.

2. Literature Review

2. 1. The ecological roles of mammals

Mammals are very important for the proper functioning of ecosystems. They are responsible for pollinating plants (Janson *et al.*,1981), seed dispersal, balance populations via predator-prey interaction (Nowak, 1991) and have enormous effects on the structure and composition of vegetation (McInnes *et al*., 1992; Sinclair and Arcese, 1995), plant productivity and nutrient cycling (Pastor *et al*., 1993). The absence and rarity of mammals in a given ecosystem have severe consequences in the structure, composition and diversity of forests. The loss of mammalian diversity could change ecosystems in ways that we do not recognize and understand the changes (Chapman and Onderdonk, 1998).

The use of animals by humans for food (Alves *et al*., 2010; Alves, 2012), tools manufacturing, medicines production and magical-religious practices dates to the early history of human (Frazier, 2007). Mammals and birds are the preferred groups of animals selected by hunters for food. Mammals have long been recognized as animals that interact in particularly complex and powerful fashions with their habitat (Laws, 1970). Large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation.

The functional roles may change the structure and composition of ecosystems. 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, 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). 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).

Small mammals, particularly rodents are essential components of all terrestrial ecosystems. They play important part in natural communities, and provide the main supply of living food for many of the predatory mammals, birds and reptiles (Davies, 2002). They are also useful in the study of environmental gradient (Mena and Vazque-Dominguez, 2005), and good indicators of habitat change. Some of them are considered as pioneer species of ecosystem succession (Davies, 2002). Rodents play important structural roles in different ecosystem services by pruning or eliminating

vegetation types, aerating soil through their digging and burrowing activities, spreading seeds, pollen and competing with other animals (Kingdon, 1997). They are also valued as vital food sources in many regions of Africa. For example, they comprise an important component of the diet of the Gumuz- indigenous people in Ethiopia (Tadesse, 2005). In addition, rodents serve as model organisms for studying the effect of tropical forest fragmentation.

Large and medium–sized mammals are particularly sensitive to habitat changes, and they are common victims of poaching and illegal trading (Laurance *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 trophic 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). 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).

Large mammals are fundamental elements in many ecosystems (Berger *et al*., 2001). Large carnivores frequently shape the number, distribution, and behavior of prey animals. Large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation (Dinerstein, 2003). Furthermore, both set of mammals profoundly influence the environment beyond direct species interaction such as through cascading trophic effects (Berger *et al*., 2001). 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).

2.2. Mammalian diversity

Mammals are highly diverse. Mammaliogists commonly group mammals as small or large based on body weight or size. The extant land placental mammals range from the six ton elephant to mice, shrews and bats weighting a few grams (Nowak, 1991; Wirminghaus and Perrin, 1993). The body size of mammals, generally, correlates with territory, amount of food intake and reproductive potential. Large mammals in general require larger territory, consume large

quantity of food per individual and have relatively lower reproductive potential as compared to the smaller mammals.

Mammals are one of the most important components of biodiversity in the world (Yalden, 1983). They can be divided into small, medium and large based on body weight. Medium sized mammals are mammals whose body weight varies from 2kg to 7kg such as small carnivores, small primates, large rodents, hyraxes, and pangolins. While Species with more than 7kg are considered to be large sized mammals and these include most diurnal primates, most carnivores larger than a fox or house cat, all perissodactyls and artiodactyls (Emmons and Feer, 1997).Large sized mammals (elephant, rhino, ungulates, carnivores and most primates) have low reproductive rates and compete directly with humans for resources. Most medium sized mammals have variable size, moderate reproductive rate and limited competition with humans for resources. Smaller mammals (rodents, shrews and bats) have high metabolic and reproductive rates, and are difficult to hunt compared to large mammals. They show positive response (population increment) to most human influences, unlike large mammals. They range in size from African pigmy mice (Musminutoides) to whales (Mugatha, 2002).

According to a Delnay and Happold (1979), one of the most interesting appearances of tropical Africa is the riches 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. Out of the 900 genera of placental mammals in the world, 20% occur in East Africa (Kingdon, 1971). Simpson (1945) classified 26 orders of placental mammals, ten of which have become extinct. Out of the remaining 14 orders of placental mammals, 12 are represented in East Africa in 47 families with over 360 species.

Mammals inhabit every terrestrial biome from deserts through tropical rainforests to polar icecaps. Many species are arboreal, spending most or all of their life time in the forest canopy. 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 are egg laying and 99% are placental. They live on land, water bodies and air (Solomon, 2008).

2.3. Distribution of Mammals

The geographical distribution of mammals is world-wide. They occupy all continents, from far beyond the Arctic Circle in the north to the southern most parts of continents and large islands in the south covering most habitats of the earth. Some orders and families that are absent in one continent occur in the other. Family Leporidae, Mustllidae, Cotiedae and Felidae are native to all continents except Antarctica and Australia. Aardvark occurs only in Africa. Insectivores are absent from Australia and South America. Since the distribution and abundance of animal population is the result of their past colonization history and ongoing interactions with their respective environment, the reason for restricted or wider distribution of any given species needs to be viewed accordingly.

Ethiopia has high level of biodiversity and endemism because of the diverse habitats, altitude and climate that vary from desert to tropical and Afroalpine habitats. Ethiopian high faunal biodiversity reflects the existence of a large number of species of mammals and other higher vertebrates. The expansion of human settlement and agriculture causes many wildlife species to become smaller in population. In the face of global change and ensuing modifications of biodiversity patterns, research on species distribution is a prime focus in ecology and conservation. Large scale land conversion, resource exploitation, industrial, agricultural and climate change are posing considerable pressure on species (Foley *et al*., 2005). The question of how this impact will modify community assemblages, species interactions and eventually ecosystems and their services requires first and foremost a solid understanding of the mechanisms determining species distribution and biodiversity patterns (Gaston, 2000). The distribution of species and biodiversity is determined by a large number of abiotic and biotic factors, of which usually only a few are well established for any given species (Guisan, 2006). Much research effort has been devoted to identifying the factors for individual species and

patterns of biodiversity including geophysical conditions, geographical features, the productivity, quality and heterogeneity of habitats, predation, disease, demographic effects, human impact and species interactions (Guisan, 2006).

Consequently, depending on the taxa of interest these effects then lead to both positive and negative relationships between biodiversity and human impact. The habitat of the animals is the area where the animal preferably occurs and where all its life necessities are fulfilled. Wildlife resources including mammals of the country are now largely restricted to a few protected areas (Tewodros and Afework, 2014).

2.4. Major threats of Biodiversity

2.4.1. Habitat Destruction

The three forms of habitat destruction were degradation, fragmentation and outright loss. While habitat degradation is "the process by which habitat quality for a given species is diminished", fragmentation "is the process by which a natural landscape is broken up into small parcels of natural ecosystems, isolated from one another in a matrix of lands dominated by human activities". Outright loss of habitats occurs when habitat quality is so low such that the environment is no longer usable by a given species. Habitat destruction refers to a factor that has negative impacts on species richness, population abundance (Laurence *et al*., 2002), and genetic diversity. In addition, habitat destruction is factor that impacts both biodiversity and human directly by decreasing production of ecosystem goods and services such as pollination. Habitat destruction is the process by which natural habitat is destroyed to such an extent that it no longer is capable of supporting the species and ecological communities that naturally occur there. It often results in the extinction of species and, as a res Habitat fragmentation is splitting of natural habitats and ecosystems into smaller, more isolated patches driven by many different factors like disturbance, pollution, settlement, infrastructure, and deforestation (Leykun, 2000). It is the main process responsible for biodiversity loss and threat in tropical forests leading to isolation. Conversion to agricultural land use results in a loss of habitat, reduction in patch size, and an increase in distance between patches and new habitat formation (Olifiers *et al*., 2005). Habitat loss has pervasive and disruptive impacts on the biodiversity and its magnitude of the ecological impacts can be exacerbated by habitat fragmentation.

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The impacts can also occur in introduction of exotic species, invasion by competitors, alteration of microclimatic conditions, crop cultivation, pasture and human residence near the fragmented forest habitat also highly determine the species composition and abundance of mammals (Olifiers *et al*., 2005). Species composition and abundance change as fragmentation occurs in landscapes by losing those species that require large areas. This increases the probability of extinction. The rate of species extinction in an isolated patch is inversely related to the size because it less likely provides food, cover, and other resources necessary to support the native wildlife community. The physical changes in the extent and connectivity of suitable habitat conditions affect many processes that influence the behavior and spatial habitat use patterns and intra- and interspecific interactions that influence population persistence and community structure and dynamics (Wilson, 1996).

2.4.2. Deforestation

Deforestation resulting land degradation is the global threats for many wild animals with its natural habitat and affects the wild animal's life style in their preferred habitats. The human population around most protected areas over the years has been changing in terms of its size, density and livelihood strategies (Masanja,2014). Uncontrolled logging, illegal charcoal production and fuel wood collection are some of the major causes of deforestation that directly influence large mammal's habitat. Moreover, such activities impose to decline the scenic beauty of the protected area.

2.4.3. Hunting

Hunters usually target larger prey (MacArthur and Pianka 1966), although when the preferred species are exhausted the range of hunted species increases as hunters are forced to target less valuable prey (Peres, 2003). Hunting pressure, nevertheless, may be moderated by taboos and

prey preferences (Colding, 1998). In this sense, the different cultural aspects of each human population can affect wildlife on different scales. It is necessary to know the species chosen or avoided (and why), hunting techniques used, number of animals harvested, and motivation or purpose for hunting in order to both determine the impact of this activity, and promote conservation and sustainable management (Trinca and Ferrari 2006).

2.4.4. Poverty

Poverty is defined as a state of deprivation associated with lack of incomes and assets, physical weakness, isolation, vulnerability and powerlessness. It is considered a rural phenomenon over the world where more population live below the food poverty line and basic needs poverty line (UNDP, 2003). Expansion into new lands - including sensitive areas for wildlife becomes the most feasible strategy to this end. Essentially, land shortage around national parks can be ascribed to poor agricultural practices. Fuel wood is the main source of energy for cooking and heating in Ethiopia. Fuel wood demand expands exponentially with population growth (Mwalyosi, 1992). This demand exacerbates destruction of the critical wildlife habitats. While electricity could serve as an alternative source of energy, until recently most areas lacked access to this service. Further, even in areas with the service high installation and service costs render its affordability practically impossible to majority of the households (Wako, 2009).

3. Materials and Methods

3.1 Description of the Study Area

This study was conducted in two forest priority areas, Goji and Nopha, in Becho District, Ilu Ababor zone, Southwest Ethiopia. Becho woreda is found at 621km Southwest of Addis Ababa and located between $8^0$43’12” to $8^0$55’40”N latitude and $35^0$44’09” to $35^0$50’52”E longitudes (Fig. 1). The district has 17 kebeles. Nopha is located in three kebeles (Gudina sor, Gabisa sor and Lalisa sor) and Goji is located in 3 kebeles (Agaro, Gorbi and Sacho). Nopha forest is located in the West part and Goji forest is located in East part of the woreda. Among the 17 rural kebeles of the woreda, the study area covers six kebeles with the total land coverage of 28,072 hectares. Gudina sor, Gabisa sor, and lalisa sor covers total land coverage 19,293 hectares and from these 3774 hectares used for settlement, agriculture and grazing area. Gorbi, Agaro and Sacho had a total land coverage 8,779 hectares and 5057 hectares used for settlement, agriculture and grazing area (Becho Woreda Land Administration office, 2019).

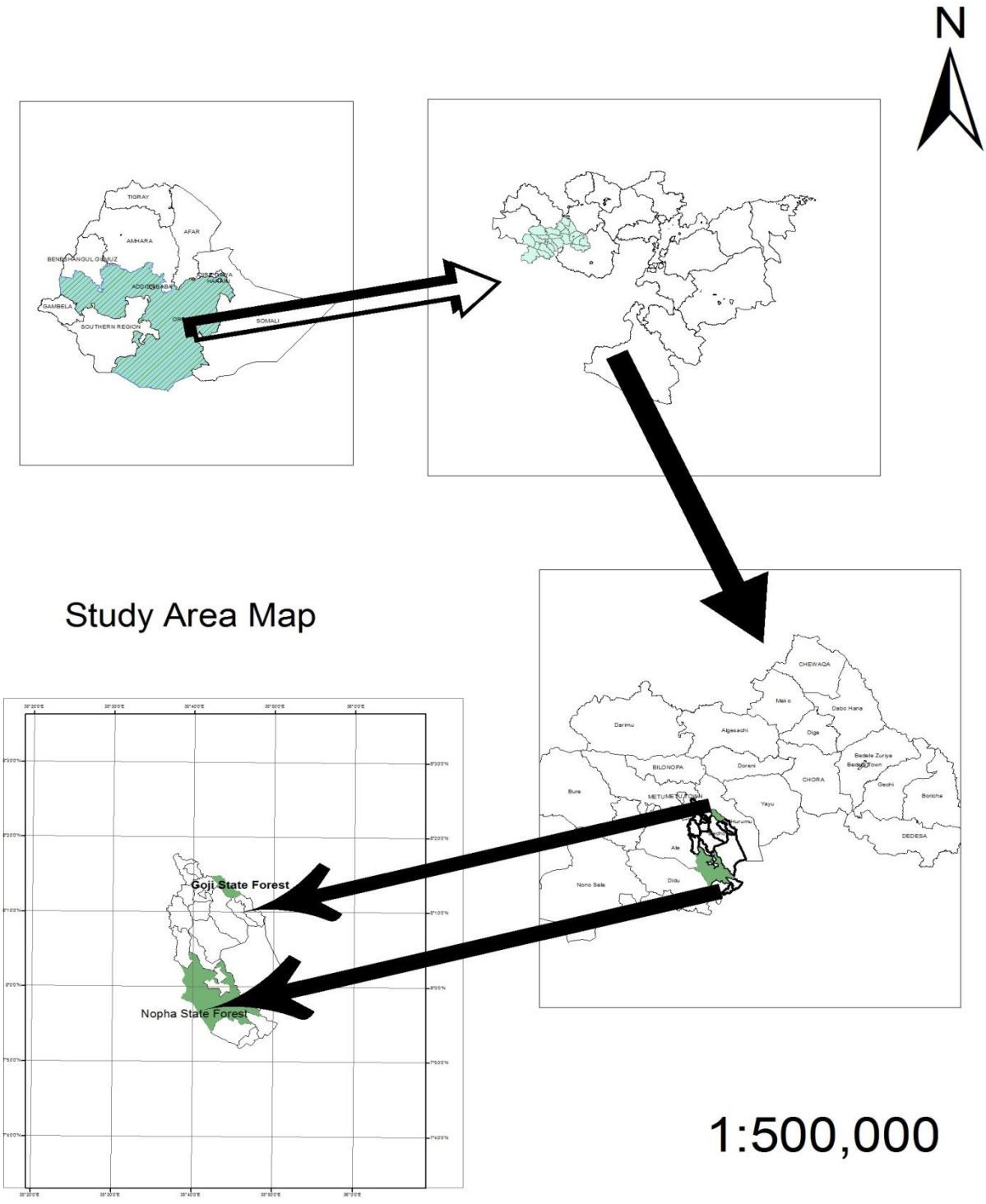

Figure 1: Map of the study area

The study areas are classified in to two climate zone (Dega and Woyna-dega). Its altitude ranges from 1760 to 2120 m.a.s.l. The study area receives the highest rain fall that extends from March to October accompanied with short dry season from November to February. The average annual rainfall ranges from 1,710 to 2,200 mm and the average temperature of the study area ranges from 17^0 to 27^0,(National Methodology Agency Becho station 2019-2020).

3.2. Vegetation types

The vegetation of the study area can be categorized in to two major habitat type namely dense forest and woodland forests.

3.2.1. Dense Forest

The habitat is characterized by large trees species. The dominant plant species in this habitat include Ficus capensis, Millettia ferruginea, Croton macrostachyus, Albiza gummifera, , Cordia Africana, Ekebergia capensis and Prunus africana,

Figure 2: Dense forest in the study area (photo by Temesgen Fikadu, July 2020)

3.2.2. Woodland

This habitat is characterized by small to moderate-sized tree species. Based on the types of dominant species the Woodland area can be characterized by small to moderate sized tree species with broad leaves, often deciduous. The dominant plant species found are Albiza gummifera, Acacia spp., Ehretia cymosa, Maesa lanceolata, Cordia africana, and Croton macrostachyus(figure 3).

Figure 3: Woodlands in the study area(photo by Temesgen Fikadu, July 2020)

3. 3. Preliminary Survey

Preliminary survey was conducted in two forests before the actual study for 6 days, On January 1-6 in 2020. Based on the types of vegetation structure and canopy forms, the study area was classified into two habitat types. These habitats include dense forest and woodland.

3.4. Research Sampling Design and Data Collection

3.4.1 Sampling Design

Preliminary survey was conducted in the first field work. During this survey the study area was sub divided into two habitats dense forest and woodland. In each habitat type stratified random sampling techniques sampling was employed. If a species is relatively large and conspicuous, one of the best methods for estimating abundance is the line transect. Line transects are best used for visible mammals in open habitats and it can be used to estimate the abundance indices of mammal, such as dung piles and burrows (Sutherland, 2006). The length and width of transect lines in Goji forest were 2km and 200m respectively and for Nopha forest the length and width were 4.5km and 220m respectively. In each habitat 32 transect lines were established in stratified randomly selected area and 20 transect lines were used permanently by lottery. The minimum distance between any two transects was 2 km.

3.4.2 Data Collection

The investigations of medium and large-sized mammals in the study area were conducted by direct observation by naked eyes or using binocular by walking along selected transect lines recording animals observed both from the left and right side of the transect lines. Some individuals to the side of the path being walk escape detection by the observer and the critical assumption is that all animals on the path are seen (Sutherland, 2006). For nocturnal and naturally rare animals, indirect indicators such as animals' dropping, tracks, hair, vocal sound, quill, died animal and other indicators in the transect line was used for of the presence of species. Indirect detection indices such as scats, hair samples, tracks, dense or burrows and scratches are very useful when surveying animals such as carnivores that are naturally rare, elusive, found at low densities and difficult to capture repeatedly (Meseret and Solomon, 2010).

The data collection was conducted for two seasons, dry and wet seasons to get relatively representative data. For the dry season, data was collected from February – April, 2020 and for the wet season from July – September, 2020. When mammals were sighted, the type of species, the number of individuals of each species were recorded at each transect lines. Each transects were surveyed twice a month for three months in each season. Two data collectors were assigned per transect, one walks along a straight path and records the individuals seen. The other individual to the left side of the path being walked escape detection. All transects in a given

habitat type was surveyed between 06:00 am and 10:00 am in the morning and between 16:00 pm and 18:00 pm in late afternoon, when most mammals were active in the study area (Rebira *et al*., 2015).

All mammals observed along the transect lines were identified, counted, sexed and age categorized. Body size, pelage color, presence or absence of horn were used to determine sex and age (Bekele and Yalden, 2014). Mammals of Ethiopia and mammals of Eritrea and Ethiopia (Bekele and Yalden, 2014), was used for mammalian identification

Indigenous people were also consulted for vernacular name, calls and sign identification.

During this study, using body weight as a basic feature, (Emmons and Feer, 1997) mammals in the study area were categorized in to medium sized from 2kg and large sized those over 7 kg. According to this classification mammal such as small carnivores and primates, large rodents, hyraxes and pangolins are grouped under medium and most diurnal primates, carnivores larger than a fox or house cats, all perissodactyla and artiodactyls categorized under large sized mammals

3. 5. Data Analysis

The analysis of obtained data was carried out using appropriate statistical test methods. Species diversity of medium and large sized mammals was calculated using the Shannon – wiener Index (H') (Shannon and Wiener, 1949).

$H' = -\sum Pi \ lnPi$

Pi = is the proportion of individuals of species in a sample (Krebs, 1999)

Species evenness, which represents the distributional patterns of mammals, was evaluated using Shannon – wiener evenness index (E). E = H' / Hmax where, H' is Shannon – wiener diversity index and Hmax = lns is the natural logarithm of total number of species in each habitat.

Species similarity between seasons and among the different habitats were determined using Simpson's similarity index (SI) (SI= 2C/A+B,) where C is common species in the habitats A and B. A is the number of species observed in habitat A and B is the number of species observed in habitat B (Simpson, 1949). Abundance of mammals was calculated as, Abundance = total number of individual species/ sample blocks (Brown, 1984). The chi-square (($\chi 2$) statistical test method was used to carry out the analysis of seasonal abundance of mammals among different habitats. The mammalian species were classified as common if the probability of seeing is 100%

in every time of the observation or evidence recorded once a day, uncommon if the probability of seeing is more than 50% and/or evidence recorded once a week and rare if the probability of seeing is less than 50% and/or single recorded during the whole survey periods (Hillman, 1993).

4. Results

4.1. Species composition

During this survey in Nopha forest a total of 679 (396 and 283 during dry and wet season, respectively) individual mammals distributed in 21 species, 12 families and 7 orders were recorded. Among these, only four species: Vervet monkey (*Chlorocebus aethiopis*), Stark's hare (*Lepus starcki*), Rock hyrax (*Procavia capensis*) and White tailed mangoose (*Icheumia albicauda*) were medium-sized and the remaining 17 species were large-sized mammals. Order Carnivora with eight species were the most diverse order followed by Primates and Artiodactyla with five and four species respectively. Order Tubulindentata, Lagomorpha, Hyracoidea and Rodentia were represented by one species each (Table 1).

Table 1: Medium and large-sized mammals recorded in Nopha forest patches.

Order	Family	Scientific name	Common name	Local name	Record evidence
Carnivora	Felidae	*Felis servestris*	African wild cat	Adala	Visual
		Felis serval	Serval cat	Muno	Visual
		Panthera leo	Lion	Lencha	Visual/sound
		Panthera pardus	Leopard	Kerensa	Visual/scat
	Canidae	*Canis mesamolas*	Black backed jackal	Jedala	Visual
	Hyeaniadae	*Hynae hynae*	Stripped hyena	Warabesa	Visual/foot print
	Hyrpestidae	*Icheumia albicauda*	Whitetailed mongoose	Fochi	Visual
	Mustelidae	*Mellivora capensis*	Honey badger	Hama	Visual
Primates	Cercopitheci	*Papio anubis*	Olive baboon	Jeldesa	Visual
		Colobus guereza	Colobus monkey	Weni	Visual
		Chlorocebus aethiopis	Vervet monkey	Qamale	Visual

		Certhopithucus neglectus	De Brazza's monkey	Wona	Visual
		Certhopithucus mitis	Blue monkey	Chana	Visual
Artiodactyla	Suidae	*Potamochoerus larvatus*	Bush pig	Boye	Visual/faeces
		Phacochoerus africanus	Warthog	Karkaro	Visual
	Bovidae	*Traglaphus scripis*	Common Bush buck	Bosonu	Visual
		Sylvicapra grimmia	Grey duiker	Kuruphe	Visual
Hyracoidea	Procaviidae	*Procavia capensis*	Rock hyrax	osole	Visual
Lagomorpha	Leporidae	*Lepus starcki*	Stark's hare	Ileti	Visual
Rodentia	Hystricidae	*Hystrix cristata*	Crested porcupine	Xade	Visual/Spine
Tubulidentata	Orycteropodiadae	*Orycteropus afer*	Aardvark	Waldigesa	Burrow

In Goji forest patches a total of 339 (184 and 155 during dry and wet season respectively) individual mammals distributed in 15 species, 9 families and belonging to 5 orders were recorded. Order Carnivora with seven species were the most diverse order followed by Primates and Artiodactyla had three species each respectively. Order Tubulindentata and Rodentia were represented by one species each (Table 2).

Table 2: Medium and large-sized mammals recorded in Goji forest patches.

Order	Family	Scientific name	Common name	Local name	Record evidence
Carnivora	Felidae	*Felis servestris*	AfricanWild cat	Adala	Visual
		Felis serval	Serval cat	Muno	Visual
		Panthera leo	Lion	Lencha	Visual/ sound
		Panthera pardus	Leopard	Kerensa	Visual/scat

	Canidae	*Canis mesamolas*	Black backed jackal	Jedala	Visual
	Hyeaniadae	*Hynae hynae*	Stripped hyena	Warabesa	Visual/foot print
	Viverridae	*Civetticitis civetta*	African civet	Tirigni	Visual/scat
Primates	Cercopitheci	*Papio anubis*	Olive baboon	Jeldesa	Visual
		Colobus guereza	Colobus monkey	Weni	Visual
		Chlorecebus aethiopis	Vervet monkey	Qamale	Visual
Artiodactyla	Suidae	*Potamochoerus larvatus*	Bush pig	Boye	Visual/faeces
	Bovidae	*Traglaphus scripis*	CommonBush buck	Bosonu	Visual
		Sylvicapra grimmia	Common duiker	Kuruphe	Visual
Rodentia	Hystricidae	*Hystrix cristata*	Crested porcupine	Xade	visual/spine
Tubulidentata	Orycteropodiadae	*Orycteropus afer*	Aardvark	Waldigesa	burrow

4.2 Diversity indices and Evenness of medium and large sized mammals

During dry season the highest diversity of mammals was recorded in Nopha forest (H‟ = 2.497) and the least diversified habitat was Goji forest (H‟= 1.625) in the same season. The calculated species evenness Nopha forest was J=0.833, J=0.791 and Goji forest J=0.785 , J= 0.739 during dry season (Table 3).

During wet season the highest diversity was recorded in Nopha forest (H‟= 2.286) and the least diversified habitat was Goji forest (H‟=1.790) in the wet season. The calculated species evenness Nopha forest was J=0.806 and Goji forest J=0.793, J = 0.840 , J=0.814) during wet season (Table 3).

Table 3. Diversity indices of medium and large sized mammals in different habitat types during dry and wet seasons

Habitat type	No.of Species		Number of individual		H'		H 'max		Eveness(J)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Noph forest										
Dense forest	20	17	233	161	2.497	2.286	2.995	2.833	0.833	0.806
Wood land	14	15	163	122	2.089	2.150	2.639	2.708	0.791	0.793
Goji forest										
Dense forest	12	12	127	83	1.952	2.088	2.484	2.484	0.785	0.840
Woodland	9	9	57	72	1.625	1.790	2.197	2.197	0.739	0.814

4.3. Relative Abundance

Among the 21 species of mammals recorded in Nopha forest Vervet monkey (*C. aethiopis) (*22.61% *and 18.39%* during wet and dry) and Olive baboon (*P. anubis*) (21.55% wet and 21.96% dry season) was the most abundant species. Colobus monkey (*C. guereza*) (with 17.31% and 15.65%) and common Bush buck (T. scripis) (with 8.12% and 7.07%) were the next abundant species. Lion (*Panthera leo*) (with 0.7% and 0.25%), Leopard (*Panthera pardus*) (0.35% and 0.75%), Warthog (*Phacochoerus africanus*) (1.06% and 0.25%) and White tailed mangoose(*Icheumia albicauda) (*0.35% and 1.01%) during wet and dry season were the least abundant species in Nopha forest(Table 4).

Table 4. Relative abundance of medium and large sized mammalian species recorded in the Nopha forest during wet and dry seasons

Scientific name	Common Name	Nopha Forest Patches						Relative Abundance %	
		Dense		Woodland		Total			
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Papio anubis	Olive baboon	35	49	26	38	61	87	21.55	21.96
Colobus guereza	Colobus monkey	30	32	19	30	49	62	17.31	15.65
Chlorecebus aethiopis	Vervet monkey	29	34	35	41	64	75	22.61	18.93
Certhopithucus mitis	Blue monkey	6	13	2	7	8	20	2.82	5.05
Certhopithucus neglectus	De brazze's monkey	4	8	3	2	7	10	2.47	2.52
Canis mesamolas	Black backed jackal	3	5	3	3	6	8	2.12	2.02
Felis serval	Serval cat	0	3	2	4	2	7	0.70	1.76
Panthera leo	Lion	2	1	0	0	2	1	0.70	0.25
Panthera pardus	Leopard	1	3	0	0	1	3	0.35	0.75
Hynae hynae	Stripped hyena	7	9	3	3	10	12	3.53	3.03
Icheumia albicauda	White tailed mongoose	0	2	1	2	1	4	0.35	1.01
Mellivora capensis	Honey badger	4	6	0	0	4	6	1.41	1.51
Felis servestris	AfricanWild cat	1	2	3	0	4	2	1.41	0.50
Potamochoerus larvatus	Bush pig	10	19	7	10	17	29	6.01	7.32
Phacochoerus africanus	Warthog	3	1	0	0	3	1	1.06	0.25
Traglaphus scripis	Common Bush buck	16	21	7	7	23	28	8.12	7.07
Sylvicapra grimmia	Grey duiker	7	13	6	11	13	24	4.59	6.06
Procavia capensis	Rock hyrax	0	3	3	4	3	7	1.06	1.76

Lepus starcki	Stark hare	2	6	0	0	2	6	0.70	1.51
Hystrix cristata	Crested Porcupine	1	3	2	1	3	4	1.06	1.01
Total		161	233	122	163	**283**	**396**	100	100

In Goji forest patches 15 species mammals were recorded. Among these species of mammals, Olive baboon (*Papio anubis*) was the dominant mammalian species with (23.22% and 29.43%) during wet and dry season respectively. Vervet monkey (*Chlorocebus aethiops*) was the second abundant mammal with (24.51% and 26.63%), while Colobus monkey (*colobus guereza*) with (18.06% and 17.39%), Common Bush buck (*Traglaphus scripis)* with (7.09% and 7.60%) and Grey duicker with (9.03% and 5.43%) during wet and dry season were respectively the next abundant species. Lion (*panther leo*) (1.29% and 0%), Serval cat (*Felis serval)* (0.64% and 0.54%), leopard(*Panthera pardus*) (1.29% and 0.54%) and African wild cat (*Felis servestris*) (0.64% and 1.08%) were least abundant species during wet and dry season respectively (Table 5).

Table 5. Relative abundance of medium and large sized mammalian species recorded in the Goji forest during wet and dry seasons

Scientific name	Common Name	Goji Forest Patches						Relative Abundance %	
		Dense		Woodland		Total			
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Papio anubis	Olive baboon	21	34	15	20	36	54	23.22	29.34
Colobus abyssinicus	Colobus monkey	16	23	12	9	28	32	18.06	17.39
Chlorecebus aethiopis	Vervet Monkey	12	31	26	18	38	49	24.51	26.63
Canis mesamolas	Black backed jackal	1	3	0	1	1	4	0.64	2.17
Felis serval	Serval cat	0	1	1	0	1	1	0.64	0.54
Panthera leo	Lion	2	0	0	0	2	0	1.29	0

Panthera pardus	Leopard	2	1	0	0	2	1	1.29	0.54
Hynae hynae	Stripped hyena	7	6	3	2	10	8	6.45	4.34
Felis servestris	AfricanWild cat	1	1	0	1	1	2	0.64	1.08
Potamochoerus larvates	Bush pig	4	5	4	1	8	6	5.16	3.26
Traglaphus scripis	Common Bush buck	7	12	4	2	11	14	7.09	7.60
Syvicapra grimmia	Grey duiker	9	7	5	3	14	10	9.03	5.43
Hystrix cristata	Crested Porcupine	1	3	2	0	3	3	1.93	1.63
Total		83	127	72	57	**155**	**184**	100	100

In Nopha forest Seasonal variations were observed in the mammalian species composition and number of individuals between habitats and seasons. The highest number of individuals of medium and large sized mammals were recorded from dense forest habitat (233), followed by woodland (163) during dry season (Table 6). More number of individuals was observed in dense forest (161) than woodland (122) during wet season (Table 6). Within habitat, the seasonal abundance of mammals was significantly vary for all habitats (dense forest: $\chi 2 = 1.5$, 1 df , $P< 0,05$; Woodland: $\chi 2= 1.65$, 1 df, $P<.0.05$

Table 6. Seasonal abundance (number of individuals counted) and distribution of mammals among different habitats and their relative abundance during wet and dry season in Nopha Forest

Scientific name	Common Name	Habitat types							
		Dense forest				Woodland			
		Wet	RA %	Dry	RA %	Wet	RA %	Dry	RA %
Papio anubis	Olive baboon	35	21.7	49	21.0	26	21.3	38	23.3
Colobus guereza	Colobus monkey	30	18.6	32	13.7	19	15.6	30	18.4
Chlorecebus aethiopis	Vervet monkey	29	18.0	34	14.6	35	28.7	41	25.2
Certhopithucus mitis	Blue monkey	6	3.7	13	5.6	2	1.6	7	4.3

Certhopithucus neglectus	De brazze's monkey	4	2.5	8	3.4	3	2.5	2	1.2
Canis mesamolas	Black backed jackal	3	1.9	5	2.1	3	2.5	3	1.8
Felis serval	Serval cat	-		3	1.3	2	1.6	4	2.5
Panthera leo	Lion	2	1.2	1	0.4	-		-	
Panthera pardus	Leopard	3	1.9	1	0.4	-		-	
Hynae hynae	Stripped hyena	7	4.3	9	3.9	3	2.5	3	1.8
Icheumia albicauda	White tailed mongoose	-		2	0.9	1	0.8	2	1.2
Mellivora capensis	Honey badger	4	2.5	6	2.6	-		-	
Felis servestris	AfricanWild cat	1	0.6	2	0.9	3	2.5	-	
Potamochoerus larvatus	Bush pig	10	6.2	19	8.2	7	5.7	10	6.1
Phacochoerus africanus	Warthog	1	0.6	3	1.3	-		-	
Traglaphus scripis	Common Bush buck	16	9.9	21	9.0	7	5.7	7	4.3
Sylvicapra grimmia	Grey duiker	7	4.3	13	5.6	6	4.9	11	6.7
Procavia capensis	Bush hyrax	-		3	1.3	3	2.5	4	2.5
Lepus starcki	Stark hare	2	1.2	6	2.6	-		-	
Hystrix cristata	Crested Porcupine	1	0.6	3	1.3	2	1.6	1	0.6
Total		161	100	233	100	122	100	163	100

In Goji forest Seasonal variations were observed in the mammalian species composition and number of individuals between habitats and seasons. The highest number of individuals of medium and large sized mammals were recorded from dense forest habitat (127) during dry season, followed by woodland (72) during wet season (Table 7). More number of individuals was observed in dense forest (83) during wet season than woodland (57) during dry season (Table 7). Within habitat, the seasonal abundance of mammals was significantly vary for all habitats (dense forest: $\chi 2 = 1.4$, 1 df, $P < 0.05$; Woodland: $\chi 2 = 1.3$, 1 df, $P < 0.05$

Table 7. Seasonal abundance (number of individuals counted) and distribution of mammals among different habitats and their relative abundance during wet and dry season in Goji Forest

Scientific name	Common Name	Habitat types							
		Dense				Woodland			
		Wet	RA %	Dry	RA %	Wet	RA %	Dry	RA%
Papio anubis	Olive baboon	21	25.3	34	26.8	15	20.8	20	35.1
Colobus abyssinicus	Colobus monkey	16	19.3	23	18.1	12	16.6	9	15.8
Chlorecebus aethiopis	Vervet Monkey	12	14.5	31	24.4	26	36.1	18	31.6
Canis mesamolas	Black backed jackal	1	1.2	3	2.4	-		1	1.8
Felis serval	Serval cat	-		1	0.8	1	1.4	-	
Panthera leo	Lion	2	2.4	-		-		-	
Panthera pardus	Leopard	2	2.4	1	0.8	-		-	
Crocuta crocuta	Spotted hyena	7	8.4	6	4.7	3	4.2	2	3.5
Felis servestris	AfricanWild cat	1	1.2	1	0.8	-		1	1.8
Potamochoerus larvates	Bush pig	4	4.8	5	3.9	4	5.6	1	1.8
Traglaphus scripis	Common Bush buck	7	8.4	12	9.4	4	5.6	2	3.5
Syvicapra grimmia	Grey duiker	9	10.8	7	5.5	5	6.9	3	5.3
Hystrix cristata	Crested Porcupine	1	1.2	3	2.4	2	2.8	-	
Total		83	100	127	100	72	100	57	100

4.4 Distribution of Mammals observed in the different habitat types

All 21 species of mammals recorded from Nopha forest were identified by direct Observation and indirect method. The distribution of mammalian species in the two habitat types and seasons were different. Lion (*Panthera leo),* Leopard (*Panthera pardus),* Honey badger (*Mellivora capensis),* Wathorg (*Phacochoerus africanus) and* Stark hare (*Lepus starcki)* were recorded only in dense forest habitat in both season. Serval cat (*Felis serval),*

White tailed mangoose *(Icheumia albicauda),* Bush hyrax *(Procavia capensis)* were recorded in dense forest during dry season and African wild cat (*Felis servestris)* was recorded in woodland during wet season (Table 8).

Olive baboon, Colobus monkey, Vervet monkey, Blue monkey, De brazze's monkey, Blacked jakal, Stripped hyena, Bush pig, Common Bush buck, Grey duicker and Crested porcupine were recorded in all habitat in both wet and dry season. All species were recorded by direct observation and indirect methods. Aardvark was recorded by indirect method via holes (burrow) (Table 8).

Table 8. Distribution of medium and large sized mammals along the study habitats observed in Nopha forest.

Scientific name	Common Name	Habitat types			
		Dense forest		Woodland	
		Wet	Dry	Wet	Dry
Papio anubis	Olive baboon	✓	✓	✓	✓
Colobus guereza	Colobus monkey	✓	✓	✓	✓
Chlorecebus aethiopis	Vervet monkey	✓	✓	✓	✓
Certhopithucus mitis	Blue monkey	✓	✓	✓	✓
Certhopithucus neglectus	De brazze's monkey	✓	✓	✓	✓
Canis mesamolas	Black backed jackal	✓	✓	✓	✓
Felis serval	Serval cat	-	✓	✓	✓
Panthera leo	Lion	✓	✓	-	-
Panthera pardus	Leopard	✓	✓	-	-
Hynae hynae	Stripped hyena	✓	✓	✓	✓
Icheumia albicauda	White tailed mongoose	-	✓	✓	✓
Mellivora capensis	Honey badger	✓	✓	-	-
Felis servestris	AfricanWild cat	✓	✓	✓	-
Potamochoerus larvatus	Bush pig	✓	✓	✓	✓
Phacochoerus africanus	Warthog	✓	✓	-	-

Traglaphus scripis	Common Bush buck	✓	✓	✓	✓
Sylvicapra grimmia	Grey duiker	✓	✓	✓	✓
Procavia capensis	Bush hyrax	-	✓	✓	✓
Lepus starcki	Stark hare	✓	✓	-	-
Hystrix cristata	Crested Porcupine	✓	✓	✓	✓

- ✓ Stand for thepresence of animal in habitat
- \- Stands for absence of animal in habitat.

All 15 species of mammals recorded from Goji forest were identified by direct observation and indirect method. The distribution of mammalian species in the two habitat types and seasons were different. Lion (*Panthera leo) and* Leopard (*Panthera pardus)* recorded in dense forest. Lion recorded in wet season and Leopard during wet and dry season. Serval cat recorded in dense forest and woodland during dry and wet season respectively. Black backed jackal and African wild cat recorded in woodland during dry season and Crested porcupine recorded in dense forest in both season and woodland during wet season. (Table 9).

Vervet monkey, Olive baboon, Colobus monkey, Stripped hyena, Bush pig, Common Bush buck and Grey duicker were recorded in all habitats in both wet and dry season. All species were recorded by direct observation and indirect methods. Aardvark and African civet were identified by indirect method via holes (burrow) and scat respectively (Table 9).

Table9. Distribution of medium and large sized mammals along the study habitats observed in Goji forest.

Scientific name	Common Name	Habitat types			
		Dense		Woodland	
		Wet	Dry	Wet	Dry
Papio anubis	Olive baboon	✓	✓	✓	✓
Colobus abyssinicus	Colobus monkey	✓	✓	✓	✓
Chlorecebus aethiopis	Vervet Monkey	✓	✓	✓	✓

Canis mesamolas	Black backed jackal	✓	✓	-	✓
Felis serval	Serval cat	-	✓	✓	-
Panthera leo	Lion	✓	-	-	-
Panthera pardus	Leopard	✓	✓	-	-
Crocuta crocuta	Stripped hyena	✓	✓	✓	✓
Felis servestris	AfricanWild cat	✓	✓	-	✓
Potamochoerus larvates	Bush pig	✓	✓	✓	✓
Traglaphus scripis	Common Bush buck	✓	✓	✓	✓
Syvicapra grimmia	Grey duiker	✓	✓	✓	✓
Hystrix cristata	Crested Porcupine	✓	✓	✓	-

✓ Stand for the presence of animal in habitat

- Stands for absence of animal in habitat.

4.5 Occurrences of mammals

Based on occurrence in Nopha forest the medium and large sized mammals were grouped in to common, uncommon and rare (Table 10). Out of the 20 mammalian species recorded in the ,Nopha forest 35%(7spp.) were common, 15% (3spp.) were uncommon and 50% (10 spp.) were rare.

Table10. Occurrence of medium and large sized mammals in the Nopha forest.

Common	Uncommon	Rare
Olive baboon (*P.anubis)*	De brazze's monkey*(Certhopithucus neglectus)*	Warthog(*P.africanus)*
Colobus monkey(*Colobus guereza)*	Stripped hyena(*Hynae hynae*)	Lion(*Panthera leo)*
Vervet monkey(*C. aethiopis*)	Black blacked jackal(*C. mesamolas)*	Leopard(*panther pardus)*
Blue monkey(*Certhopithucus mitis)*		White tailed mangoose(*I.albicuada)*
Grey Duiker(*S. grimmia*)		Honey badger(*M.capensis)*

Bush pig*(P. larvatus)*		African wild cat(*F.servestris)*
Common Bush buck (T. scripis)		Rock hyrax(*P.carpensis*)
		Stark hare(*L.starcki)*
		Crested porcupine*(H.cristata)*
		Serval cat(*Felis serval*)

Based on occurrence in Goji forest the medium and large sized mammals were grouped in to common, uncommon and rare (Table 11). Out of the 15 mammalian species recorded in the Goji forest 30.76% (4 spp.) were common, 23.07% (3 spp.) were uncommon and 46.15% (6 spp.) were rare.

Table 11. Occurrence of medium and large sized mammals in the Goji forest.

Common	Uncommon	Rare
Olive baboon (*P.anubis)*	Bush pig(*P.larvatus)*	Black blacked jackal(*C. mesamolas)*
Colobus monkey(*C. guereza)*	Stripped hyena(*Hynae hynae*)	Serval cat*(F.serval)*
Vervet monkey(*C. aethiopis*)	Grey Duiker(*S. grimmia*)	Lion(*Panthera leo)*
Common Bush buck (*T.scripis*)		Leopard(*panther pardus)*
		African wild cat(*F.servestris)*
		Crested porcupine*(H.cristata)*

4.6. Species similarity based on habitat type

During the wet season in Nopha between dense forest and woodland habitat (SI= 0.82) which have similar number of species (Table 12).

Table 12. Similarity of medium and large sized mammal species between habitats during wet and dry season in Nopha forest

Habitat types			
Dense forest		Woodland	
Wet	Dry	wet	Dry
0.75	0.82	0.75	0.82

During the wet season in Goji forest between dense forest and woodland habitat (SI= 0.86) which have similar number of species (Table 13).

Table 13. Similarity of medium and large sized mammal species between habitats during wet and dry season in Goji forest

Habitat types			
Dense forest		Woodland	
Wet	Dry	wet	Dry
0.76	0.86	0.76	0.86

Among the two habitat types for combined season, more similarity of mammalian species in Nopha forest was obtained from dense forest and woodland(SI = 1) that have equal number of species and the two habitat types for combined seasons , similarity of mammalian species in Goji forest(SI= 0.96) between habitats.

5. Discussion

The 22 species records of mammals during the present study gives a good picture of the mammal resources in Becho forest fragment on both forest patches. In Nopha forest patches 21 species were recorded and 15 species from Goji forest patches. The mammalian diversity of the Nopha forest patches is comparable to the Dereje *et. al*. 2015 from Baroye controlled hunting area in southwest Ethiopia were recorded 23 species of medium and large sized mammals. Taye *et .al*. 2020, also recorded 26 species from Nono sale Forest priority area in southwest Ethiopia. Woldegeorgis and Wube (2012) recorded 14 species from Yayu Forest. The mammalian diversity of the current study is more diversified as compared to Yayu forest and the number of medium and large sized mammal record in Nopha and Goji forest were relatively smaller than known wild life protected area of Ethiopia. For example, in Dati Wolel National Park 28 species were identified (Rabira *et.al*, , 2015).

The highest mammal species diversity was recorded from Nopha dense forest in both season followed by Nopha woodland during wet season and the lowest diversity was from Goji woodland in both season. The highest species evenness was obtained in Goji dense forest during wet season followed by Nopha dense forest during dry season and the lowest evenness from Goji woodland in dry season. The highest mammalian species in dense forest during dry and wet season might be because of the availability of food, water and protection predation. Studies by Shiferaw Ayele (2008) and Dawud Yimer (2008) species diversity often high in areas where sufficient food and water were the reason for higher mammalian diversity.

Variation in the relative abundance of medium and large sized mammal species in the present study area was different between species to species. The three primates were the most abundant in the study area. In both Nopha and Goji dense forest Vervet monkey (C. aethiopis) was the most abundant species during dry season. This was due to the availability of the habitat for the species. The lower abundance of species associated with shortage of fresh grass, food and water leading to movement of mammals to available area.

Olive baboon (*P. anubis*) and Colobus monkey (C. gueraza) were the second and third most abundant species in Goji woodland and Nopha dense forest both dry seasons respectively. The higher abundance of these species from dense forest and wood land was

related to the availability of sufficient fruits, leaves and need of forest with tall trees that used as cover. Aramde Fetene *et al*. (2011) have noted that Colobus monkey select riverine and large trees as their best habitats.

The least abundance of medium and large sized mammal species recorded from the study area were White tailed mangoose (*I. albicauda*), Black backed jackal (C. *mesamolas*), Warthog (*P. africanus*), Lion (*P. leo*), Leopard (*P. pardus*), Serval cat (*F. servestris*), Honey badger (*M. capensis*), Rock hyrax (*P. capensis),* Stark hare (*L. starcki*) and Crested porcupine (*H. cristata*). Species like White tailed mangoose, Honey badger, De Brazza's monkey, Blue monkey, Warthog, Rock hyrax and Stark's hare were found only in Nopha forest. The lower mammalian species might be related to different factors. As information obtained from the local community, fore example Honey badger destroyed the traditional honey production in the study area and due to this people's kills and the species migrate to the other place. The local communities in the study area also said that Lion also came in groups and disturb the local community by killing their livestock. Due to this Lions killed by the local community and destroyed. The remaining individuals left migrate to the other places where sufficient food is available. Conflict with human over livestock depredation is the single most important factor causing the decline in African Lion populations (Packer *et. al*.2005).

Mammals in the study area were not distributed uniformly among the two habitats. Mammalian species like Olive baboon, Vervet monkey, Colobus monkey, Stripped hyena, Bush pig and Common Bush buck were relatively observed and recorded in all habitats of the study area.

Regarding species similarity among the habitat types of the study area the highest species similarity was (SI = 0.86) during dry season. The less similarity was (SI = 0.75) during wet season in both habitats. The highest species might due to similar resources suitable for mammals in both habitats and the presence of cover protection.

Changes in habitat and landscape characteristics due to land use change can have also a significant effect on species presence, abundance and distribution. Currently, fragmentation and habitat destruction are the two main driving factors of mammalian populations' decline(Link A, 2010).

According to Turner, 1996 small fragments often have fewer species recorded for the same effort of observation than large fragments or areas of continuous forest. This is due to the deleterious effects of human disturbance during and after deforestation, the reduction of population sizes, the reduction of immigration rates, the increases of forest edge effects, changes in community structure and the immigration of exotic species.

Mammals of Goji Forest is highly affected by several human induced factors such as forest clearing for farming, managed coffee plantation, fuel wood exploitation, charcoal production, and extraction of construction materials from the areas. This holds true for any human altered natural environment. Anthropogenic activities affect the interactions, distribution and diversity of species through habitat loss and modifications (Geleta and Bekele, 2016).

6. Conclusion and Recommendation

6.1. Conclusion

Nopa and Goji forest has potential to provide habitats to a number of medium and large sized mammalian species. During this survey individual mammals distributed in 22 species, 13 families and 7 orders were identified. Among these mammalian species 4 species such as Vervet monkey , Stark's hare (Lepus starcki), Rock hyrax and white tailed mongoose were the medium sized mammals, whereas the remaining 18 species observed were large sized mammals.

Direct and indirect evidences were used to identify mammalian species. The mammalian species were identified and documented in this study so that interested bodies can have base-line information on diversity, relative abundance and distribution, of medium and large sized mammalian species for future conservation and management plane. Diversity, relative abundance and distribution of mammalian species in the study area showed marked difference among habitat types in relation to the difference in habitat preference of the species on the availability of food, water and cover. Vervet monkey, Olive baboon, and Colobus monkey were the most abundant mammalian species in Nopha and Goji ferests.

Notable previous history of human influence such as intensive deforestation for agricultural expansion, charcoal production, fuel wood collection, and grazing by livestock resulted in alteration of the natural forest in the study area. This finding showed that attention should be given to the varieties of mammal species to avoid any aspect of human pressures especially on Goji forest patches. Most of the mammals in the Goji forest patches are either disturbance tolerant or developed specific adaption to the prevailing conditions. The presences of disturbance tolerant and adaptive mammals in the study area suggest that this ecosystem is severely threatened and its resources are also severely depleted.

6.2. Recommendation

The present study provides baseline information about mammals of Nopha and Goji forest patches:

- ✓ To protect mammalian diversity and Ecosystem, all stake holders start educating the rural communities.
- ✓ Very rare mammalian species like Lion and Leopard need special attention.
- ✓ Create awareness about the environmental benefits and economical gain conserving the natural forest, mammalian diversity and other biodiversity.
- ✓ Reforestation of deforested area on by planting trees that helps to secure mammalian diversity and distribution and improve food availability
- ✓ All concerned body should have to work to safe ecosystem..
- ✓ Program should be carried out to increase the awareness of the people so that they stop their illegal activities and work in conjunction with zonal and woreda authorities.
- ✓ Knowledge-based conservation of mammals and management initiatives must be given in the area.

6. References

Alonso, A., Dallameier, F.& Campbell, P. (2001). Urubamba: The biodiversity of Peruviarainforest.Smithsonian Institution, Washington, D.C

Alves, R. R. N. (2012), Relationships between fauna and people and the role of ethno zoology in animal conservation. Ethno biology and Conservation 1:1-69.

Alves, R. R. N., Oliveira, M. D. G. G., Barbosa, R. R. D. and Lopez, L. C. S. (2010). An ethno zoological survey of medicinal animals commercialized in the markets of Campina Grande, NE Brazil. Human Ecology Review 17:11-17.

Aramde Fetene., Girma Mengesha and Tsegaye Bekele.(2011). Spatial distribution and habitat preference of selected large mammalian species in the Nech Sar National Park (NSNP), Ethiopia. Nat. Sci. 9: 80-90.

Atinafu, G., & Yihune, M. (2018).Species composition and relative abun-dance of medium and largemammals in Mengaza communal forest, East Gojjam, Ethiopia. Journal of Ecology and the Natural Environment, 10(2), 34–40. https ://doi.org/10.5897/JENE2017.0667.

Becho Woreda Administration office (2019). Land management profile of Becho Woreda. Becho.

Bekele, A., Yalden DW (2014). The mammals of Ethiopia and Eritrea.Addis Ababa University Press, Addis Ababa, Ethiopia.p. 391.

Berger, P.B.Stacey, L. Bellis and P.Johnson.(2001).“A mammalian predator–prey imbalance: grizzly bear and wolf extinction affect avian neotropical migrants.” Ecol.Appl.,vol., 11, pp.947–960.

Bernardo, P. V. S., & Melo, F. R. (2013). Assemblage of medium and large size mammals in an urban Semi deciduous Seasonal Forest frag- ment in Cerrado biome. Biota Neotropica, 13(2), 76–80.https ://doi.org/10.1590/S1676-06032 01300 0200008.

Brown, J. (1984). The relationship between Abundance and distribution of species. Am.Nat.124:255-279.

Cardillo, M., Mace, G.M., Jones, K.E., Bielby, J., Bininda-Emonds, O.R.P., Sechrest, W., Orme, C.D.L.and Purvis, A. (2005). Multiple Causes of High Extinction Risk in Large Mammal Species. Science press. www.sciencexpress.org/pp. 1-7.

Carrillo, E.,Wong, G. &Cuarón, A. (2000). Monitor- Monitoring mammal populations in Costa Rican protected areas under different hunting restrictions. Conservation Biology, **14**(6): 1580–1591.

Chapman,C and Onderdonk, D.A. (1998). Forest without primates: primates/plants codependency. Am. J. Primatol. 47:127-141

Colding, J. 1998. Analysis of hunting options by the use of general food taboos. – Ecol. Modell.110: 5 – 17.

Davies, G. (2002). *African Forest Biodiversity:* A field survey manual for vertebrates. Earth watch, Cambridge. Pp. 114–142.

Dawud Yimer(2008). Mammalian diversity in Mazie National Park, Ethiopia.M.Sc.Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Delany,M.and Happold, D. (1979). Ecology of African Mammals. Longman Inc, NewYork pp. 434.

Dereje, N., Gadisa, T. and Habtamu A. (2015). The Diversity, Distribution and Relative Abundance of Medium and Large- sized Mammals in Baroye Controlled HuntingArea, Illubabor ZoneSouthwestern Ethiopia," International Journal of molecular and Biodiversity. 5, 1-9.

Dinerstein, E. (2003). The Return of the Unicorns. Columbia University Press, New York

Eduardo A, Pasamani M. Mammals of medium and large size in Santa Rita do sapucai, Minas Gerais, South Western Brazil , check list 2009;5:399-404.

Emmons, L. and Feer F. (1997). Neotropical Rainforest Mammals. Chicago. University of Chicago Press. 380PP.

Flynn, J. Finarelli, J. Zehr, S. Hsu, J. and Nedbal, M. (2005). Molecular phylogeny of the Carnivora (Mammalia): assessing the impact of increased sampling on resolving enigmatic relationships. Syst. Biol. 54: 317-337.

Foley,J.A.,C.Monfreda, N.Ramankutty&D.Zaks.(2005).Global Consequences of land use. Science 309 :570-574.

Frazier (2007), Sustainable use of wildlife: the view from archaeozoology. Journal for Nature Conservation 15(3):163-173.

Gaston (2000), Ecosystems and their services require first and foremost a solid understanding of the mechanisms determining species distribution and biodiversity patterns.

Geleta, M., & Bekele, A. (2016). Survey of medium and large-sized mam- mals in Wacha Protected Forest, Western Ethiopia. Scholarly Journal of Agricultural Science, 6(3), 71–79.

Guisan (2006), the distribution of species and biodiversity is determined by a large number of abiotic and biotic factors, of which usually only a few are well established for any given species.

Hashim and Mahgoub (2007), "Abundance, habitat preference and distribution of small mammal in Dinder National Park, Sudan."

Hillman, J. (1993). Ethiopia: Compendium of Wildlife Conservation Information. Vol.1. Ethiopian Wildlife Conservation Organization, Addis Ababa, 454pp.

Janson (1981), seed dispersal (Levey et al., 1994), Particularly Medium and large sized Mammals are very important for the proper functioning of ecosystems. They are responsible for plants pollination (balance populations through predator-prey interaction (Nowak, 1991).

Janson, C.H., Terborgh, J.W. and Emmons, L.H. (1981). Non - flying mammals as pollinating agents in the Amazonian Forest. Biotropica. 13:1-6.

Kigdon, J.C. (1971). East African Mammals. An Atlas of Evolution. VoU (Primates). Academic Press, London.446pp.

Kingdon, J. (1997). The Kingdom Field Guide to African Mammals. Academic Press, London,488pp.

Laurance, W. F., Croes, B. M., Tchignoumba, L., Lahm, S., Alonso, A., Lee, M. E., Campbell, P. and Ondzeano, C.(2006) Impacts of roads and hunting en Central Africa Rainforest mammals. Conservation Biology, **20**(4): 1251–1261.

Lavrenchenko, A. L.,& Bekele, A. (2017). Diversity and conservation of Ethiopian mammals:What have we learned in 30 years? Ethiopian Journal of Biological Science, 16, 1–20.

Laws, R.M.(1970). Elephant as agents of habitat and landscape change in East Africa. Oikos 21: 1-15.

Legese, K., Bekele, A., & Kiros, S. (2019). A survey of large and medium-sized mammals in Wabe forest fragments, Gurage zone, Ethiopia. International Journal of Avian & Wildlife Biology, 4(2), 32–38

Leykun Abune. (2000). The challenges of conserving Ethiopian wildlife: overview. Walia 21:56-62.

Link A., Luna A, Alfonso F, et.al. Initialneffects fragmentation on the diversity of three Neotropical primate species in to lowland forests of Colombia. Endangered spp Res. 2010; 13: 41- 50.

MacArthur,R. and Pianka, E. 1966. On optimal use of patchy environment. – Am. Nat. 100: 603 – 609.

Masanja, D.F.(2014), the human population around most protected areas over the years has been changing in terms of its size, density and livelihood strategies.

McInnes, P. F., Naiman, R. J., Pastor, J. and Cohen, Y. (1992). Effects of moose browsing on vegetation and litter of the boreal forest, Isle Royale, Michigan, USA. Ecology 73:2059- 2075.

Melo GL, Sponchiado J, Caceres NC. Use of camera traps in natural trails and shelter for the mammalian survey in the Atlantic Forest. Serie zool. 2012; 102:88-94.

Mena ,J. and Vazque-Dominguez, E. (2005).Species turnover on elevational gradients in small rodents.*Glob. Ecol. Biogeo*. **14:** 539-541.

Meseret Chanie and Solomon Yirga, (2010).Diversity of Medium and Large-sized Mammals in Borena-Sayint National Park, South Wollo, Ethiopia.*International Journal of Sciences*:Basic and Applied Research

Mugatha, M. (2002). Influences of Land-use Patterns on Diversity, Distribution and Abundance of Small Mammals in Gachoka Division, Mbeere Distrect, Kenya. Land use Change, Nairobi, 46pp.

Mwalyosi, (1992); Fuel wood demand expands exponentially with population growth.

National Methodology Agency,(2019-2020). Becho Woredda, Becho station.

NLFC.New hall Land and Farming Company.Assesment and Survey of Mammals within the Newhall Ranch Specific Plane Area. California: Impact Science, Inc., 2005, pp1-57. Nowak, R. (1991).Walker's Mammals of the World.5thedn. Johns Hopkins University Press, Baltimor, Maryland.

Olifiers, N. Gentile, R. and Fiszon, T. T. (2005)"Relation between small-mammal species composition and anthropic variables in the Brazilian Atlantic Forest," Brazilian Journal of Biology, vol. 65, no. 3, pp. 495-501.

Packer, C., Ikanda, D., Kissui, B. and Kushnir, H.(2005). Lion Attacks on Humans inTanzania: understanding the timing and distributionof attacks on rural communities will help to prevent them. Nature 436: 927-928.

Peres, C. et al. 2003. Vertebrate responses to surface wildfires in a central Amazonian forest. – Oryx 37: 97 – 109.

Reale, R., Fonseca, R. C. B., & Uieda, W. (2014). Medium and large-sized mammals in a private reserve of natural heritage in the municipal-ity of Jaú, São Paulo, Brazil. Check List,10(5), 997–1004. https ://doi.org/10.15560/ 10.5.997

Rebira Gonfa, Tsegaye Gadisa, Tadesse Habtamu. (2015). the diversity, abundance and Habitat associations of medium and large-sized mammals in Dati Wolel National Park, Western Ethiopia. *Intl J Biodiv Conserv*.7:112−118.

Reichholf, J. (1990). Mammals in the Balance of Nature. Academic Press, New York.

Roemer, G. W., Gompper, E. & Van Valkenburgh, B. (2009).The ecological role of the Mammalian meso carnivore. Biological Science, **59**(2): 165–173.

Shannon E, Weiner N. The Mathematical Theory of Communication. University of Illinois press:1949.

Shiferaw Ayele (2008). Species diversity, distribution, habitat association and similarity of bird and large mammal fauna in Kore community area,southern Ethiopia, M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Simpson EH, (1949). Measurement of diversity. Nature, 163:688.Sinclair, A.R.E. and Arcese, P. (1995). Serengeti II: Dynamics, Management and Conservation of an Ecosystem. University of Chicago Press, Chicago.

Solomon Yirga and Meseret Chane, (2014).Diversity of Medium and Large-sized Mammals in Borena-Sayint National Park, South Wollo, Ethiopia.*International Journal of Sciences*:Basic and Applied Research (IJSBAR).

Solomon Yirga. (2008). “Atibiwochu”. Ethiopian Wildlife and Natural History Society, Stehpens, P.A, C.A, D sa, C. Sillero-zubiri and N. leader- Williams, 2001. Impact of livestock and settlement on the large mammalian wild life of the Bale Mountains National park, South western Ethiopia. Biol. Conserv., 100; 307-322.

Sutherland, W,J.(2006). Ecological census Techniques: a Hand book Cambridge University press, Cambridge .pp.432.

Tadesse Habitamu (2005).The Study of Diversity, Distribution Relative Abundance and Habitat Association of Small Mammals in Alatish Proposed National Park, North Ethiopia.M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Tefera, M. (2011). Wildlife in Ethiopia: Endemic large mammals.World Journal of Zoology, 6(2), 108–116.

Tewodros and Afework (2014), Attitude and perceptions of local residents toward the Protected Area Ethiopia Ecosystem Echography4 (1): 1-5.

Trinca, C. and Ferrari, S. 2006. Ca ç a em assentamento rural na Amaz ô nia mato-grossense. – In: Jacobi, P. R. and Ferreira, L. C. (eds), Di á logos em ambiente e sociedade no Brasil. Annablume Editora, pp. 155 – 167 (in Brazilian Portuguese).

Turner M. species loss in fragments of tropical rain forest : a review of the evidence. T Appl Ecol.1996;33:200- 209.

United Nation Development Programme(2003); population live below the food poverty line and basic needs poverty line.

Wako, D. J. (2009), high installation and service costs render its affordability practically impossible to majority of the households.

Wilson, D. E., Cole, F. R., Nichols, J. D., Rudran,R. and Foster, M. S. (1996). Measuring and Monitoring Biological Diversity. Standard methods for mammals. Smithsonian Institute Press, Washington, DC.

Woldegeorgis, G., & Wube, T. (2012). A survey on mammals of the Yayu forest in Southwes Ethiopia. Ethiopian Journal of Science, 35, 135–138.

Wuver A, Attuquayetio D. The impact of human Activities on Biodiversity Conservation in a Coastal wetland in Ghana. WAJAE.2006; 9;1-14.

Yalden, D.W. (1983). The extent of high ground in Ethiopia compared to the rest of Africa. *Sinet:Ethiop. J. Sci.* **6:** 35-39.

Yirga S (2008). ''Antibiworchu''. Ethiopian wildlife and Natural History society , Addis Ababa.