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Diversity, relative abundance, and habitat association of medium and large mammals in Tankara forest, east Wollega Ethiopia

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BAHIR DAIR UNIVERSITY

COLLEGE OF SCIENCE

DEPARTMENT OF BIOLOGY

**Diversity, relative abundance, and habitat association of medium and large sized mammals
in Tankara forest, east Wollega Zone, Oromia Region, Ethiopia**

A Thesis submitted to Department of Biology, College of Science, Bahir Dar University, in
partial fulfillment of the requirements for the Degree of Master of Science in Biology

By

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Advisor: Dr. Dessalegn Ejigu

February 2021

Bahir Dar, Ethiopia

Declaration

This is to certify that the thesis entitled “diversity, relative abundance, and habitat association of medium and large sized mammals in Tankara forest, East Wollega Zone, Oromia Region, Ethiopia” submitted in partial fulfillment of the requirements for the degree of Master of Science in Biology is a record of original work carried out by me and has never submitted to this or any other institution to get any other degree or certificate. The assistance and help I received during the course of this investigation have been duly acknowledged.

Meserat Ayana Yadeta

February 2021

Bahir Dar University

Approval of thesis for defense

I hereby certify that I have supervised, read, and evaluated this thesis entitled “diversity, relative abundance, and habitat association of medium and large sized mammals in Tankara forest, East Wollega Zone, Oromia Region, Ethiopia” by Meserat Ayana Yadeta prepared under my guidance.

Advisor name _____ Signature _____ Date _____

February 2021

Bahir Dar, Ethiopia

Approval of thesis for defense result

As members of the board of examiners, we examined this thesis entitled “diversity, relative abundance, and habitat association of medium and large sized mammals in Tankara forest, East Wollega Zone, Oromia Region, Ethiopia” by Merseret Ayana Yadeta. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Science in biology.

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ABSTRACT

Study on diversity, relative abundance, and habitat association of medium and larger sized mammals was conducted in Tankara forest, western Ethiopia, from January 2019 up to June 2020. In this area mammals were directly relevant to local community as source of food, recreational values, source of economy and spirituals values (kallicha). Four habitat types (montane forest, riverine forest, shrubland, and grassland) were identified and sampled. Line transect method was implemented to record medium and large sized mammalian diversity. Accordingly, 6 line transects were used in data collection throughout the study area. Among these lines transects, two from montane, one from riverine, two from shrubland, and one from grassland. Direct and indirect observations were used for surveying of mammals. A total of 24 medium and large sized mammals were identified and recorded in the study area. Riverine forest was the habitat relatively with the most species diversity ($H=2.669$), and evenness ($J=0.851$) followed by montane forest ($H=2.377$) and evenness ($J=0.793$) and grassland habitat was considered as the habitat with the lowest diversity ($H=2.162$) and evenness ($J=0.902$). The relative abundance of different mammalian species varies in the study area. As a result, guereza (*Colobus guereza*) with 20.42%, grivet monkey (*Chlorcebus aethiops*) with 17.5%, Olive baboon (*Papio anubis*) with 12.5% were relatively the most abundant species Whereas *Klipspringer* (*Oreotagus oreotagus*) with 0.83%, honey badger (*Mellivora capensis*) with 0.83% were the least abundant species in study area. The highest species similarity ($SI=0.883$) of medium and large mammalian was recorded in riverine forest and montane forests habitats of Tankara forest, while the least species similarity ($SI=0.516$) of medium and large mammalian was recorded in grassland and shrubland. Many mammalian species were highly disturbed in Tankara forest due to anthropogenic factors. Therefore, all habitats of study area should be free from any human activities. The present study was provided awareness for the local community members about the significance of mammals and the actual benefits they provide if sustainable conservation strategies will be implemented in the study area.

Key-word: Diversity, habitat association, mammals, relative abundance, Tankara forest.

1. INTRODUCTION

1.1. Background of the study

Mammals are highly versatile and most familiar groups among vertebrates that include some of the world's fastest runners, deepest divers, and most agile fliers (Ceballos *et al.*, 2006). They are quite diverse in both structures and function (Afework Bekele and Yalden, 2013) and are the most studied vertebrate taxa (Indris Abdu *et al.*, 2019). Researchers identified and recorded 6495 mammalian species were identified over the worldwide. Out of these, 96 were recently extinct mammalian species and 6399 extant mammalian species (Cannor J Burgin *et al.*, 2018). Out of the total of 6399 mammalian species founding over worldwide, 1100 are founding in Africa in (Cannor J Burgin *et al.*, 2018). Out of the total of 1100 mammalian species founding in Africa, 320 Ethiopia where more than 60% of them are medium to large sized (Afework Bekele and Yalden, 2013).

Ethiopia is a country with a unique topography (altitudinal variation) and climate resulting in high biological diversity of wildlife resource (Vreugdenhil *et al.*, 2012). It possesses unique and characteristic fauna with a high level of endemism (Girma Mengesha, 2005).The altitudinal variations within Ethiopia produce a range of climate, which affect every aspect of life in the country including plant and animal distributions, the concentration of people and the types of agriculture (Chala Adugna and Afework Bekele, 2019) while Temperature, rainfall and vegetation play major roles in determining the distribution of fauna including that of endemic mammals (Indris Abdu *et al.*, 2018).

Mammals have highly developed nervous system and endothermic features which enable them become active under wide environmental conditions and can help them which occupy every environment on earth (Yassin, 2005). Mammals live on terrestrial land and in water bodies with great diversity (Solomon Yirga, 2008). They are the most varied and adaptable animals which survive in the broadest range of habitat from oceans to poles and from desert to forest (Yassin, 2005). Mammals are biologically differentiated group in the animal kingdom (Gary *et al.*, 2009) and they are exceedingly diverse in size, shape, form and function to carry out different roles of ecosystems (Mosisa Geleta and Aferwork Bekele, 2016).

Mammals play a great role in different functioning of the health ecosystems such as performing important tasks as food, recreation, medicine, cloth and as pollinators, seed dispersers, predators (Chala Adugna and Afework Bekele, 2019). They are the most important in maintaining the balance of populations and communities associated with them in an ecosystem (Alexandre *et al.*, 2013).

In many forests there is strong relationship between habitat types and mammalian species types in a given ecosystem (Galleti *et al.*, 2009). Medium and large mammals are particularly sensitive to habitat changes and are good indicators of the environmental health (Rabira Gonfa *et al.*, 2015). The structural complex habitats may provide more niches and divers ways of exploiting environmental resources and thus increases species diversity (Meseret Chane, 2010)

The distribution and diversity of mammals are determined by a large number of abiotic and biotic factors of which usually only a few are well established for any given species (Gutema Jira, 2015; Araujo and Guisan, 2006). Land area covered with high forest has been reduced by human activities (Mohammed Kaso and Afework, 2017). As a result of these factors some mammals are being lost even before their existence has been documented (Chala Adugna and Afework Bekele 2019). Like to other parts of Ethiopia, the medium and large mammals in Tankara forest are rapidly lost as result of natural and anthropogenic factors before their existence has been identified. This reduction of medium and large mammals in the study area affects biodiversity of the ecosystem in that area and difficult to see them almost everywhere in forest (Rabira Gonfa *et al.*, 2015). Medium mammals are mammals have weight between 2 and 7kg where as large mammals are mammals that have weight more than 7kg (Kabeta Legese and Afework Bekele, 2019).

The ecological relevance of mammals, shortage of ecological data and increased human threats make the reason essential and necessary evaluate their current conservation status (Kabeta Legese and Afework Bekele, 2019). The inventories of medium and large sized mammals are tremendously vital to improve our understanding of their geographical distribution, relative abundance, diversity and habitat association (Getachew Atnafu and Mesele Yihune, 2017).

1.2. Statements of the problem

Mammals in many forests of Ethiopia are negatively affected by both natural and human activities including chemical contamination, overgrazing, illegal settlement, habitat destruction, hunting, lead them to be extinct (Mohammed Kaso and Afework Bekekle, 2017). Increased anthropogenic threats, poor management system, and limited finances are major challenges to achieve conservation goals of forest (Guta Diriba *et al.*, 2020). Knowledge on the diversity, relative abundance and distribution of medium and large sized mammals in the forest is very limited (Belete Tilahun and Melese Merewa, 2016).

Now days numerous anthropogenic factors such as production of timber, charcoal, building house and land farming have promoted habitat loss and the decline and loss of mammalian biodiversity. As a result of forest destruction by local people, more numbers of medium and large mammals rapidly loss of the world in the near future of (Rabira Gonfa *et al.*, 2015). Most population of medium and large sized mammals is severely decreased and difficult to see almost everywhere in the country (Galetti *et al.*, 2009). Out of the forests found In Haro Limu woreda Tankara forest and its wild life were the most affected by human activities due to kallicha/ spiritual activity was carried inside and outside forest. Tankara forest is exposed fuel wood, charcoal production, timber production and hunting of mammals due to the study area is nearest to Haro Town. Because of these factors, natural environment of study area and its wild life was affected. Sustainable ecosystem management requires regular inventory and monitoring of medium and large sized mammals in the study area. However, no scientific data on the diversity, abundance habitat association of medium and large mammals in study area. As a result, the present research aims to study diversity, relative abundance, and habitat association of medium and large sized mammals in the Tankara forest. .

1.3. Objectives of the study

1.3.1 General objective

- The main objective of this study was to investigate diversity, relative abundance, and habitat association of medium and large sized mammals in the Tankara forest.

1.3.2. Specific objectives

The specific objectives of the study were:-

- To determine the diversity of medium and large sized mammals in the Tankara forest
- To determine the relative abundance of medium and large sized of mammals in the study area.
- To examine the distribution of medium and large sized mammals in different habitats of the study area
- To assess the habitat association of medium and large sized of mammals in Tankara forest.
- To identify medium and large mammals in different habitats of study area.

1.4. Research questions

- ❖ What is the diversity of medium and large sized of mammals in Tankara forest?
- ❖ Which kinds of medium and large sized mammals are more abundant in the study area?
- ❖ How do medium and large sized mammals distribute in Tankara forest?

- ❖ How is the habitat association of medium and large sized mammals in Tankara forest?

1.5. Significance of the study

This study may be used to different individuals in order to give valuable information about the diversity, relative abundance, distribution, and habitat association of medium and large sized mammals in Tankara forest. In addition, the results obtained from this study may serve as a source of information for biologists, especially ecologists, who have interest to do scientific research on medium and large sized mammals in the study area. The study result may also use to inform the Ethiopian biodiversity institute and the Oromia Regional State to take different measurements to minimize habitat loss as a result of different anthropogenic effects in the study area. With better understanding of medium and large sized mammals' diversity, relative abundance, distribution and habitat association it might be possible to draw sound conservation strategies.

The assessment of diversity, estimation of relative abundance and habitat association of mammals with respect to species richness leads to investigating biodiversity continue to be a

central theme of ecological, systematic, and evolutionary biology, and it is also critical to the fields of conservation biology and resource management Meseret Chane (2010). Monitoring of mammals requires conservation actions and species recovery and protection, management, creation and restoration of habitats and management action to be effective (Campbel *et al.*, 2002). Monitoring is also important in order to manage mammalian species for conservation decisions. This requires species- specific knowledge of its biology, ecology, range, taxonomy, population and habitat status (Baillie *et al.*, 2004). Information regarding biological system is also important for biodiversity, for the maintenance of genetic diversity, and to identify threats to species conservation.

2. LITERATURE REVIEW

Mammals are an important ecological constituent in different ecosystems that provide vital services to human beings (Mosisa Geletat and Afework Bekele, 2016) and they act as umbrella because of their large area home range requirements and contribute to the conservation of other species (Kabeta legese *et al.*, 2019). According to the idea of Guta Diriba (2020), many mammals' species act as flagships of public awareness on conservation value of biodiversity. Mammals also important as source of food, seed dispersion of plant, regulate plant diversity through providing raw materials, regulate potential pest through herbivores and control other animals through predation.

It is also essential to monitor factors such as habitat destruction, fragmentation and degradation and to avoid the degradation or ecosystem services provided by the natural ecosystem (Baillie *et al.*, 2004). Villagra *et al.* (2009) described that the diversity of organisms in an ecosystem provides essential food, medicine, industrial and household materials for the nation. Almost 40% of the modern drugs in the developed world are derived from plant and animal products (McGeocha *et al.*, 2008). According to the idea of Galetti *et al.* (2009), knowledge of mammalian species diversity records, relative abundance, and habitat association are the basics for the status determination and to propose appropriate conservation measures. Guta Diriba *et al.* (2020) described that the understanding the number of mammalian species persist in different habitats may indicate the requirements of species and might contribute to their conservation.

2.1. Diversity of mammalian species

Mammals are the most successful groups of animals that include some of the world's fastest runners, deepest divers, and most agile fliers, having colonized most of the Earth's habitats (Villagra *et al.*, 2009). The diversity of animals depends upon the existence of diverse habitats, ecosystem and other environmental variables that created favorable conditions for the evolution and persistence of species (Guta Diriba *et al.*, 2020). The diversity and demographic conditions of mammalian species occur due to habitat variation. This indicated that the more habitat variables available in a given area, the more diverse the mammalian fauna would be (Indris Abdu *et al.*, 2018). The individual and interactive effects of anthropogenic and ecological factors shape the patterns of species richness and diversity within habitat types (Guta Diriba, 2020).

According to Juliet and Don (2002), mammals are exceedingly diverse in size, shape, form, and function. These differences are determined by structure and composition of vegetation because vegetation provides food, shelter and make comfortable home to wildlife (Gray *et al.*, 2009). The species diversity of medium and large sized mammals is reducing due to human disturbance and low quality of habitats (Getachew Atnafu and Mesele Yihune, 2017).

Several mammalian species have shown declining trends both in population size and ranges of occurrence due to habitat loss, fragmentations, and hunting (Guta Diriba *et al.*, 2020). These factors are reducing mammalian species diversity in a given ecosystem. In some countries basically hunters depend on mammalian species for much of their food, increasing economy and they hunt mammals in their surrounding area, and contribute for reduction of mammalian species diversity (Girma Timer, 2005).

The diversity of mammalian species is affected by different factors such as destruction of habitat, over exploitation, loss of genetic diversity, endangerment and extinction of other species (Vaughan *et al.*, 2000). Expanding of human settlements, illegal hunting, and habitat destruction have negative impact on mammalian communities especially in un protected areas (Mahammed Kaso and Afework Bekele, 2017). According to the work of Guta Diriba, (2020) seasons has little influence on species richness, diversity, and composition but habitat type has significant influence.

2.2. Relative abundance of mammalian species

Mammalian richness described as the total number of mammals occurring in habitats whereas relative abundance of mammals refers to the relative representation of a mammalian species in a particular community (Emanuel, 2016). It means that relative abundance refers to the evenness of distribution of individuals among species in a community. Mammals' abundance refers to the relative representation of mammalian species in a particular community, and it is the number of individual per species (Rovero *et al.*, 2010).

Seasonal variation causes for species composition and abundance of large wild mammals among different habitats (Zarihun Girma *et al.*, 2012). Relative abundance of mammals is naturally associated with preference towards a given habitat that provides in terms of food, breeding sites,

shelter and free space (Yassin, 2005). The geographical location, habitat diversity, climatic variability and quality of habitat are the main factors in determining species diversity and relative abundance of mammals in the area (Eshetu Moges *et al.*, 2017). Management and conservation of mammals require unbiased information about population size and about how species richness and abundance is shaped by environmental factors and human activity (Meseret Chane, 2010).

2.3. **Habitat association of mammals**

Habitats with large areas usually have diverse micro habitats and more heterogeneous vegetation structures that provide different resources for species with different feeding and microhabitat requirements (Guta Diriba *et al.*, 2020). Mammals are not uniformly distributed in different seasons and habitat types (Belete Tilahun, 2016). Ultimately this is because each species has its own unique range, largely a product of the interaction between existing ecological conditions and the species' evolutionary history. However, many species share broadly similar but usually not identical distribution patterns. Some mammals are easily seen, while many species are highly secretive often hidden from view (Ruetter, *et al.*, 2003). Most population of the medium and large sized mammals is severely depleted and difficult to see almost anywhere in the country (Rabira Gonfa *et al.*, 2015).

The distributions of many mammalian species have been altered considerably by natural factors and recent human activities including farming, warring, and hunting and of course poaching (Anton and Turner, 2004). Distribution of mammals occurs in two levels namely geographical distribution and the local distribution (Girma Mengesha, 2005). Local distribution of species represents the sum of many local populations and the distribution of a particular species or group of populations (Vaughan *et al.*, 2000). This distribution of species is determined by climate, availability of suitable resource, barriers of dispersal and interspecific interaction with those organisms sharing the same area (Girma Timber, 2005 and Rabira Gonfa. *et al.*, 2015). On the other hand, home ranges, territories and microhabitats are indicators of the distribution of individuals within an area of convenient habitats (Mahammed Kaso and Afewok Bekele, 2017). These are governed by access to important resources such as food, living space, and availability of water. Furthermore, the boundaries of species range fluctuate depending on habitat changes, competition, predation, hunting habit, climatic changes of ecosystem (Ahumada, 2011).

Structurally complex habitats may provide more niches and diverse ways of exploiting environmental resources and thus increase species diversity (Girma Mengesha, 2005). 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 (Girma Timber., 2005). According to the study of Mohammed Kaso and Afework Bekele, (2017) forest serves as a habitat for livestock and refuges for medium and large sized mammals.

Mammals are one of the most important components of biodiversity in the world and indicators of environmental health (Ojeda *et al.*, 2000). Functional structures of mammals are determined by the composition of functional characteristics that may provide more niches and help in ways of exploiting environmental resources (Meseret Chane, 2010). Such structures often vary along environmental gradients such as disturbance and resource availability (Gebrecherkos Woldegeorgis and Tilaye Wube, 2012). The presence of mammalian species and their distribution among the available habitats in a given area are affected by ecological factors such as habitat quality and suitability (Gutaa Diriba, 2020).

Mammals are the fundamental elements in many ecosystems. Large carnivores frequently shape the number, distribution, and behavior of prey animals (Berger *et al.*, 2001). Large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation (Reeder *et al.*, 2007).

Mammals profoundly influence the environment beyond direct species interaction such as through cascading trophic effects (Berger *et al.*, 2001). Large 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 (Meseret Chane, 2010). Medium and large sized mammals are intolerant for human interference and remain the best indicators for most isolated health habitats (Coster *et al.*, 2014; Galetti *et al.*, 2009; Mohammed Kaso and Afework Bekele, 2017).

Large mammals, particularly those in well-protected National Parks are generally easy to observe, sometimes on foot, but usually from a vehicle (Gudeta Nugussie, 2009). Outside protected areas, they can only be seen at some distance. Many mammals are encountered

indirectly, most commonly by their tracks, diggings, excreta and feeding site. The most common strategy for estimating the potential geographic distribution of a species is to characterize the environmental conditions that are suitable for that species (Mugatha, 2002). The spatial distribution of environments that are suitable for a species can then be estimated across a given area.

The distribution of species and biodiversity is determined by a large number of abiotic and biotic factors, that include individual species and patterns of biodiversity, climate and other geophysical conditions, geographical features, the productivity, quality and heterogeneity of habitats, predation, disease, demographic effects, human impact and species interactions with the environment. For instance, in human dominated landscapes the productivity and structural heterogeneity is heavily modified compared to less human impacted environments. Consequently, certain species are no longer able to persist, if they cannot meet their energy requirements (Yamaura *et al.*, 2011). The physical environment is a tremendously complex functional unit within which animals live, feed, reproduce and die. The role of an organism in a community depends on the interactions of organisms with other members of the community and with the physical environment (Vaughan *et al.*, 2000).

In most cases environmental condition and situations determine the mammalian species distribution, richness and abundance. These factors may affect the mammalian's processes of speciation; environmental stability, climatic refuge; productivity, heterogeneity of habitat; natural long-term habitat fragmentation or contraction. At the species level, differences in biology and ecology may occur at the community level. The mammalian species live in narrow habitat niches and small geographical ranges are highly associated with high local species abundance (Meseret Chane, 2010).

Habitat loss or fragmentation can be the result of natural processes, however now a days they are more likely to have occurred because of degradation and destruction of forest by humans. Human disturbance of tropical forests is widely cited as a major threat for mammals and other faunal communities and species (Yassin, 2005). According to work of Kabeta Legese *et al.* (2019), human activities have greatly influenced the diversity and abundance of mammals in an ecosystem.

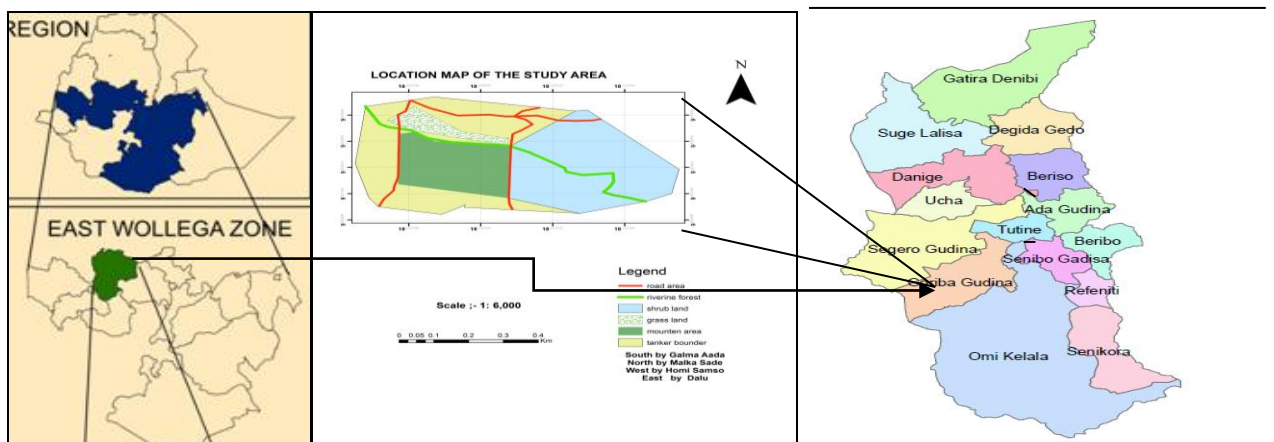
3. MATERIALS AND METHODS

3.1. Materials

Materials used during the study time were digital camera, laptop computer, GPS, note book, pen, guide book, motor cycle to travel around and within Tankara forest.

3.2. Description of the study area

The study was conducted in Tankara forest of Haro Limu District, East Wollega Zone, Oromia Region, western Ethiopia which is located 515 km from Addis Ababa, and 183km from Nekemt. The study area /Tankara Forest/ is found at specific village in Gorba Gudina kebele that is about 20 km from Haro city in the south direction. Haro limmu district is bounded by Ebantu district in the north, Limmu Galila district in the east, Sassiga district in the south, and Yaso district in the west direction. There are 17 kebeles, and 2 administrative towns in Haro Limu the district with total area of 123589.541 ha .The study area /Tankara Forest/ is found at specific village in Gorba Gudina kebele that is about 20km from Haro city in the south direction. The boundaries of Gorba Gudina, Tutine kebele Eastern, Homi kalala kebele Southern, Dami Silase kebele eastern and Sagiro Gudina kebele western direction. The study area is located between 8°28'00'' to 8°47'00'' N latitudes, and between 38°17.5'00'' to 38°29'00'' E longitudes, and its altitude ranging between 1000m- 2232m m.a.s.l. The area covers over 35 ha



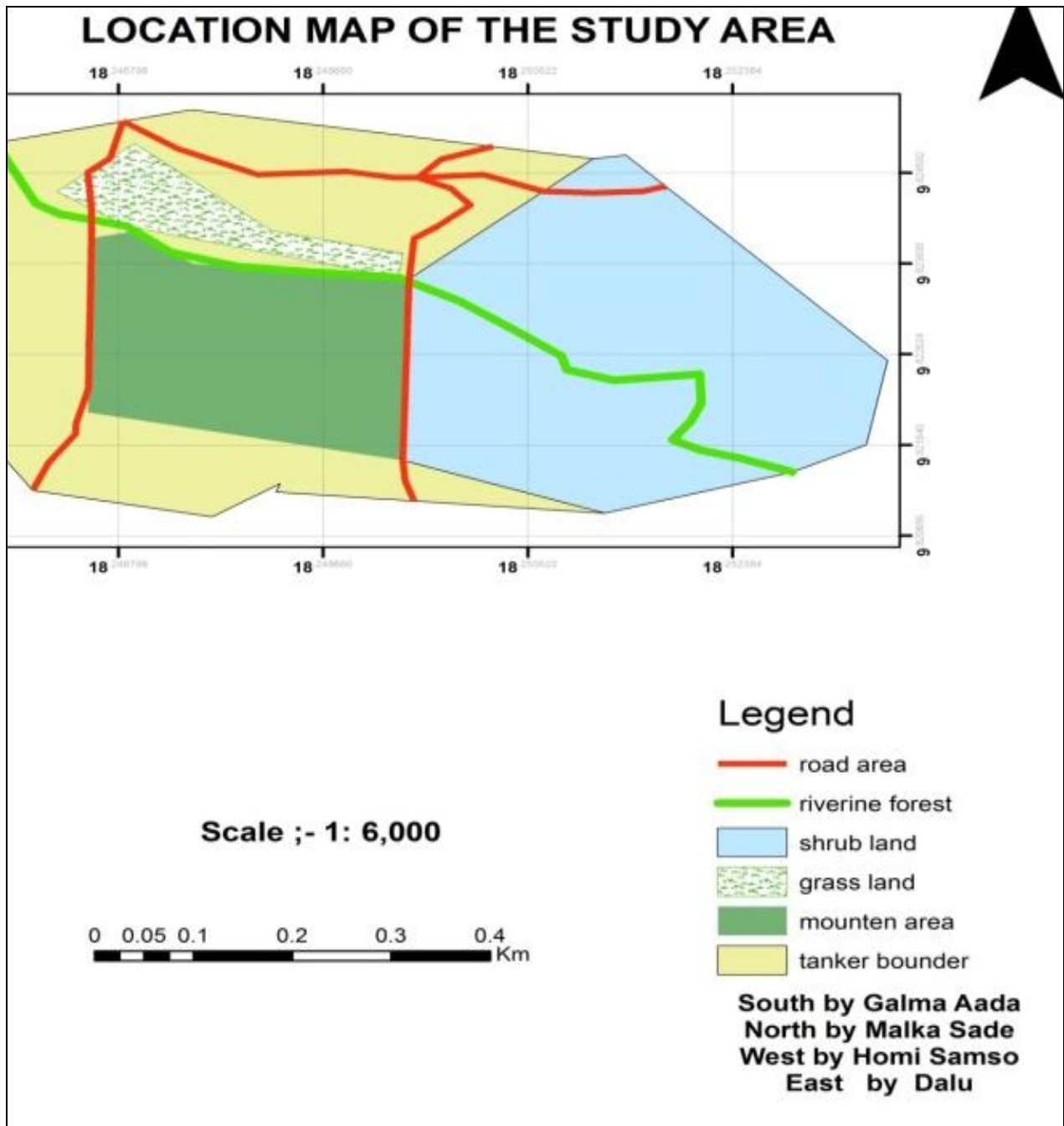


Figure 1. Location map of study area

3.2.1. Topography, climate and soil

The agro ecological zone of study area contains flat, gentle slope and steep slope. The study area contains fertile soil 47%, Nit soil 38% and sandy soil 15%. The agro climate of study varies with more distribution of rain falls between March to May and August to September. The total amount of annual rainfall in the study area varies between 1200 mm and 2400 mm. The highest annual rainfall was 2400 mm and the lowest rainfall was 1200 mm (Haro Limmu Agricultural and Rural Development Office).

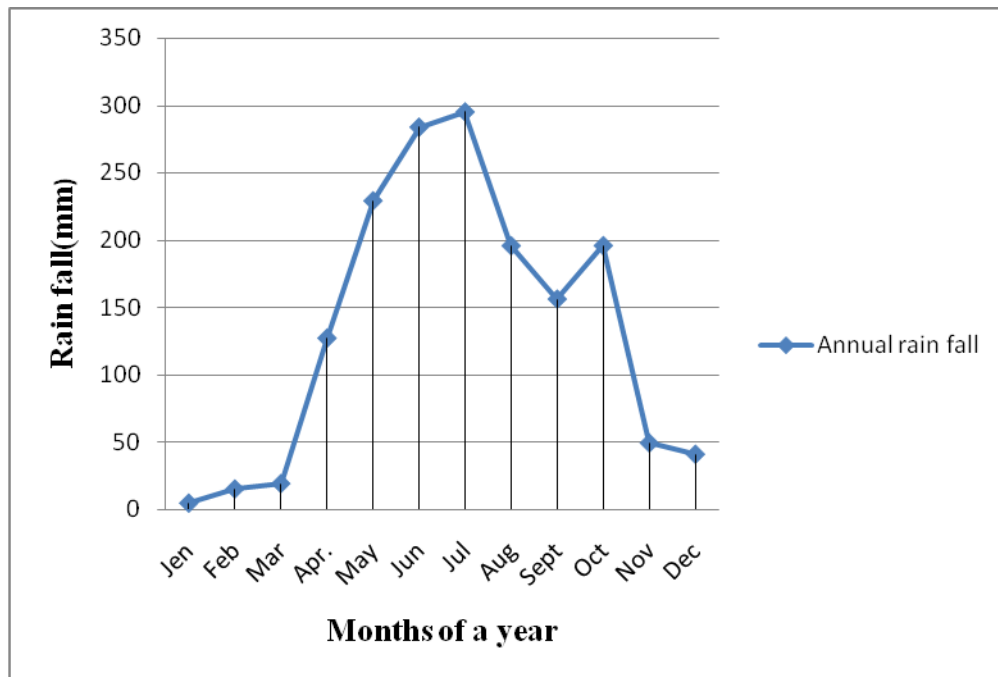


Figure 2. Annual rain falls of a year (Haro Limu metrology station 2019).

The study area indicates variability in its temperature. The maximum and minimum average temperature of the study area were 29C° 11.5C° respectively. The maximum monthly temperature was 35.8C° recorded in May and minimum monthly temperature was 11C° in August. The maximum and minimum averages of annual temperature were 24.25C° and 14C°, respectively (Haro Limmu Agricultural and Rural Development Office).

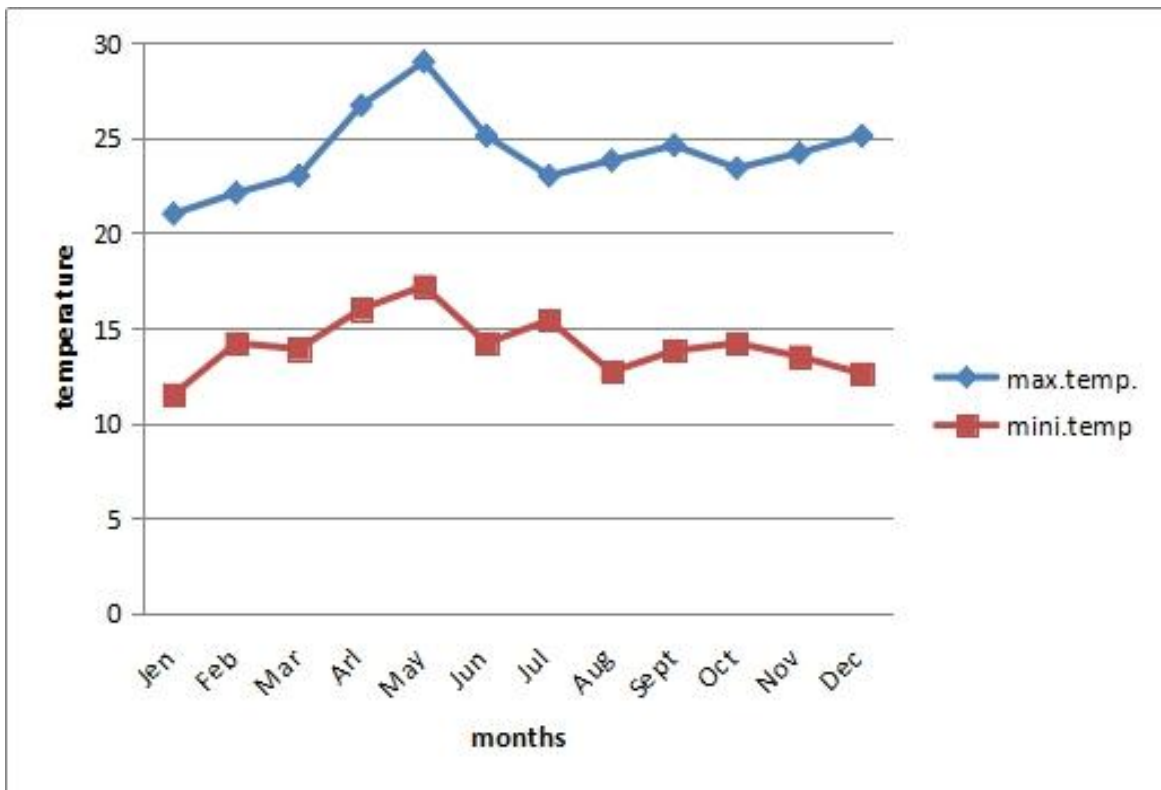


Figure 3. Annual maximum and minimum averages temperature (Haro Limu metrology station 2019)

3.2.2. Water resources

Before 20 years, the study area was known in water source potential but currently it is under severe depletion, due to land degradation caused by soil erosion, steep slope cultivation, deforestation for expansion of agriculture and plantation of Eucalyptus tree on farm land and, along river and stream bank at the middle altitude area also cause water depletion. During the dry season, some streams and wells are dry out or the volume of the water reduces significantly due to clearance of vegetation cover at upstream areas of water shed. This indicates that surface runoff and soil erosion is increased and reducing the annual recharge of the ground water (source: Haro Limu water resource development and energy office).

3.2.3. Habitat categories

The vegetation type of the study area can be classified into four habitat types. These are montane forest, riverine forest, scrublands, and grassland with scatter trees.

Montane forest habitat is a vegetation type that is found on the slope of mountains/inclined area. Under normal condition the distribution of tree of in this habitat relatively uniform. The dominant trees species are *Podocarpus juniperus* and broad leaved tree species. This habitat dominated by trees and characterized by the crown cover of 50% (Haro Limmu Agricultural and Rural Development Office, 2019). It covers around 8 hectares of study area.

The riverine habitat occurs along the course of Tankara River. This habitat characterized by mixed vegetation of large trees species and herbaceous species. The dominant plant species are *Ficus, phonex, costa, Albizia grandibracteata, Chionantus mildobradii, Grewia ferruginea*.

Scrubland means (shrubland, brushland) is a plant community characterized by vegetation dominated by shrubs, often including grasses, herbs and forbs. Most of vegetations in scrubland are much branched woody plant less than 8m high and usually with many stems. Grassland contains different scattered trees where local peoples use for cattle grazing

3.2.4. Mammals

The study area is known for its mammal's species living in the area before some 20 years ago, where remnant mammals' species in the Tankara forest is expected to be existed. But currently, the area is under severe pressure of deforestation, hunting and land degradation, because of population increase which resulted forestland converted into farmlands especially in untouched lowland areas of the zone. Such population increase declined the mammalian diversity and abundance at the lowland areas, which forced the continue extinction of mammalian species in steep slopes, often involving the clearance of native upland vegetation (source: Haro Limu resource and development livestock office).



Montane forest habitat



Riverine forest habitat



Shrubland habitat



Grassland habitat

Figure 4. Habitats of study area

3.3. Data collection methods

3.3.1. Design of the study

During preliminary survey, the study area was stratified into four main habitat types; riverine forest (RF) =4ha, montane forest (MF) =12 ha, shrubland (SL) =16 ha, and grassland habitat (GL) =3 ha with a total area of 35 ha. Each of these habitats was then classified into different transect line with length and width according to its habitat differences.

Table 1. Area of study and transect line

Habitat type	Area (hectare)	Number of transect lines	Length and width
Montane forest	12ha	2	1.2 km x 600 m
Riverine forest	4ha	1	0.4 km x 400 m
Shrubland	16 ha	2	1.6 k x 800 m
GrassLand	3ha	1	0.3 km x 300 m
Total	35ha	6	3.5 km x 2100 m

3.3.2. Sampling design

The study was conducted in study area along each transect of all habitats once a month had acquainted with the mammals' species and environment. The four habitats of unequally sized samples taken from the study area based upon vegetation types and topography of the forest. Six transects lines were established, being (2 transect lines for montaine, 1transect line for riverine, 2 transect lines for shrubland, and 1 transect lines for grassland).

The number of transect lines and length in each habitat varied depending on visibility of medium and large sized mammals, favorability of moving on foot and area cover of each habitat. In montaine habitat, the transect length was 1.2 km and its width 600 m, in riverine forest transect length was 0.4 km and width 400 m, in shrub-land habitat transect length was 1.6 km and with 800 m, in grass-land the transect length was 0.3 km and width 300 m.

Data collection was conducted once a month for a total of 6 months during both the dry seasons (January, February and March 2020) and the wet seasons (April, May and June, 2020) to assess

the diversity, relative abundance, distribution, and habitat association of medium and large sized mammals of Tankara forest. The study was conducted along transect of each habitat type at the same time during early in the morning from 6:00 - 8: 00 am and in the afternoon from 4: 00 - 6: 00pm when most diurnal medium and large mammals were more active in the study area (Kabeta Legese, 2019). Each transect line of each habitat type was visited once for a month at different days and at the same period (early morning and evening). During data collection the researcher and two assistants person were walking on foot along transect line established and directly count all the individuals of medium and large mammals sighted with their respect species using naked eye and digital camera. Researcher and two field assistants also walk I a transect line and record indirect evidence of the animals signs in each sampled area and identified. The most diurnal mammals were identified and recorded during dim light when they were moved searching their food and the place where they are hidden themselves (Girma Timer, 2005).

Identification and recording of medium and large sized mammals was made through direct observation with naked eye on foot along randomly spaced transects. During transect's walk, the observer looked both on left and right side and recorded the species seen, their numbers, habitat types with naked eye (full body, feces, bones and horns) and using digital camera (Indris Abdu *et al.*, 2019) and indirect observation methods (scratch sign, laid area, digging land, vocal sound, dead bodies, quills and drop of hairs dung) from each block of habitat (Cortes *et al.*, 2014). For the identification and to gather information on population trends of medium and large sized mammals in all blocks of each habitat, 25 local people were interviewed from 9 groups local community (5 elders, 3 kebele leaders, 3 office employers, 3 farmers, 3 charcoal producers, 2 kalicha leaders, 2 fuel wood exploiters, 2 timbers producers and 2 hunters about the mammals, their local name and for indirect signs of species in study area. Interview participants were taken from different groups of local people those used the forest for different purpose depending on persons who was more experienced with mammalian species within the forest. The interviewees gave their oral response according to the interview questions prepared concerning tankara forest and its wild life (appendix 11). The vernacular (local) names of all mammals' species; numbers of individual mammals' species were carefully recorded. Photos of some mammals and their dead were taken by digital camera.

3.4. Data Analysis

Data were analyzed using descriptive statistics and species diversity index. Species diversity of medium and large mammals of the study area was calculated using the Shannon-Wiener index of diversity formula $(H') = -\sum (P_i \ln P_i)$ where H' is Shannon-Weaver index of diversity, P_i is the proportion of individuals of a particular species in a sample and \ln is natural logarithm (Shannon and weaver, 1949). The mammalian species was calculated by Shannon evenness as $J' = H' / H'_{\max}$ where H' is Shannon-Weiner index of diversity, $H'_{\max} = \ln(S)$ and S is number of species in community. the species similarity between habitats was computed by simpsons similarity index by using formula $SI = 2C / (A+B)$ Where: C = the number of common species to the habitats $A+B$, A = the number of species in habitat A, B = the number of species in habitat B. C =the number of species in habitat C and D =the number of species in habitat four. The abundance of medium and large sized mammalian species in various habitats was calculated by dividing the total number of individuals of species by sampled habitat $Abundance = \text{total number of individuals species} / \text{sampled habitat}$ (Rabira G. *et al.*, 2015). Species Relative abundance, of a particular species in a given community was calculated by

$$\text{Relative abundance} = \frac{\text{the number of individual each species}}{\text{the total number of individuals in community}} \times 100$$

Chi-square test was used to compare differences in abundance of mammal species between habitats and the overall significant difference in abundance of mammal species in the study area, and Chi- square test also used to analysis to the association of medium and large sized mammals in habitats of Tankara forest. The location point (UTM) of each mammal (group or individual) at each vegetation types was identified and recorded using hand held GPS in the field.

In order to know the attitude of the local people in relation to the medium and large sized mammals of Tankara forest, interviews were undertaken to local the people living surrounding of study area. The method used for assessing about the views of the local people towards of mammalian species was based on interview questions prepared (appendix 2) for the study.

4. RESULTS

4.1. Diversity of medium and large sized mammals

During the study period a total of 480 individuals of medium and large sized mammals were identified and recorded. Among these, 205 were recorded during the dry season, and 275 during the wet season. The individuals recorded from the present study area were grouped in to 24 species, belonging to 13 families and 7 orders. Out of these species, Carnivora was the most diversified containing six families and 11 species, and this followed by Artidactyla, Hyracoidean, Tubulidentata, lagomorpha and Rodentia were the least diversified orders and less distributed mammals in the study area (Table 2).

Among 24 species of medium and large sized mammals recorded from present study area, 33.33% (8 species): genet (*Genetta genetta*), africa wild cat (*Felis servatris*), white tailed mongoose (*Icheumia albicaude*), honey badger (*Mellivora capensis*), bush hyrax (*Hetrohyrax brucei*), rock hyrax (*Procavia capensis*), stark's hare (*Lepus starcki*), and crested porcupine (*Hystrix cristata*) were identified as medium sized mammals while the other (66.66%) (16 species): caracal (*Caracal caracal*), serval cat (*Felis serval*), spotted hyena (*Crocuta crocuta*), common bushbuck (*Tragelaphus scriptus*), bush pig (*Potamochoerus larvatus*), warthog (*Phacochoerus africanus*), klipspringer (*Oreotagus oreotagus*), common duiker (*Sylvicapra grimmia*), african civet (*Civetta civetta*), aardvark (*Orycteropus afer*), guereza (*Colobus guereza*), olive baboon (*Papio anubis*), golden jackal (*Canis aureus*), leopard (*Panthera pardus*), grivet monkey (*Chlorcebus aethiops*), and blue monkey (*Cercopithecus mitis*) were identified and recorded as large mammals (Table 2).

Table 2. Medium and large sized mammals identified

Order	Family	Scientific names	common name	Local name
carnivora	Felidae	<i>Panthera pardus</i>	Leopard	Iyyaa
		<i>Caracal caracal</i>	Caracal	Adala
		<i>Felis serval</i>	Serval cat	Dero
		<i>Felis servatris</i>	Wild cat	Adure laga
	Canidae	<i>Canis aureus</i>	golden jackal	Jeedala
	Hyaeidae	<i>Crocuta crocuta</i>	Spotted hyaena	Warabesa
	Hyrpestidae	<i>Icheumia albicaude</i>	Whitetailed mongoose	Focifochoi
	Mustelidae	<i>Mellivora capensis</i>	Honey badger	Hama
	Viverridae	<i>Civetta civetta</i>	African civet	Tirigni
		<i>Genetta genetta</i>	Genet	Hamakesa
Artidactyla	Bovidae	<i>Tragelaphus scriptus</i>	Common bushbuck	Bosonu
		<i>Ourebia ourebi</i>	Oribi	Kurupe
		<i>Oreotagus oreotagus</i>	Klipspringer	Borte
	Suidae	<i>Potamocheirus larvatus</i>	Bush pig	Boye
		<i>Phacochoerus africanus</i>	Warthog	Karkaro
primate	Cercopithecidae	<i>Cercopithecus mitis</i>	Blue monkey	Canoo
		<i>Chlorcebus aethiops</i>	Grive monkey	Kamala
		<i>Colobus guereza</i>	guereza	Weni
		<i>Papio anubis</i>	Olive baboon	Jaldesa
Hyracoidean	Procaviidae	<i>Hetrohyrax brucei</i>	Bushhyrax	Osoleholka
		<i>Procaviaca pensis</i>	Rock hyrax	Osoledaga
Tubulidentata	Oryctestidae	<i>Oryctero pusafer</i>	Aardvark	Waldigesa
Lagomorpha	Leporidae	<i>Lepus starcki</i>	Stark's hare	Hilet
Rodentia	Hystriidae	<i>Hystrix cristata</i>	Crested porcupine	Xade

The majority of medium and large sized mammals recorded from Tankara forest 83% (20 species): Genet (*Genetta genetta*), grivet monkey (*Chlorcebus aethiops*), blue monkey (*Cercopithecus mitis*), olive baboon (*Papio anubis*), guereza (*Colobus guereza*), common duiker (*Sylvicapra grimmia*), klipspringer (*Oreotagus oreotagus*), warthog (*Phacochoerus africanus*), bush pig (*Potamochoerus larvatus*), common bushbuck (*Tragelaphus scriptus*), spotted hyena (*Crocuta crocuta*), leopard (*Panthera pardus*), Africa wild cat (*Felis servatris*), serval cat (*Felis serval*), golden jackal (*Canis aureus*), white-tailed mongoose (*Icheumia albicaude*), bush hyrax (*Hetrohyrax brucei*), rock hyrax (*Procavia capensis*), stark's hare (*Lepus starcki*), and caracal (*Caracal caracal*) were directly identified and recorded using the naked eyes (direct visualization)

Least species of medium and large mammals 16.66% (4 species); crested porcupine (*Hystrix cristata*), honey badger (*Mellivora capensis*), African civet (*Civetta civetta*), and aardvark (*Orycteropus afer*) were identified using indirect evidence (Table 3).

Focal group discussion with the local people showed that about 29.16% of the respondents indicated that the population trends of medium and large mammals' in Tankara remained stable whereas about 70.83% of respondents showed that the population trends of medium and large mammals' population gradually decreased (Table 3).

Table 3. Population trends of the medium and large mammals in study area

Local name	Common name	Scientific name	ways recorded	Population trend
Iyyaa	Leopard	<i>Panthera pardus</i>	Sign/vocal	Decreasing
Adure laga	Africa wild cat	<i>Felis serval</i>	Visual	Decreasing
Dero	Serval cat	<i>Felis servatris</i>	Visual	Decreasing
Warebesa	Spotted hyena	<i>Crocuta crocuta</i>	Visual	Decrease
Jedala	golden jackal	<i>Canis aureus</i>	Visual	Decreasing
Focifochi	White tailed Mongoose	<i>Icheumia albicaude</i>	Visual	Stable
Hama	Honey badger	<i>Mellivora capensis</i>	Dead body	Decreasing
Tirigni	African civet	<i>Civetta civetta</i>	Defecation	Decreasing
Bosonu	Common Bushbuck	<i>Tragelaphus scriptus</i>	Visual	Decreasing
Boye	Bush pig	<i>Potamocheirus larvatus</i>	Visual	Decreasing
Kamale	Grivet monkey	<i>Chlorcebus aethiops</i>	Visual	Decrease
Weni	guereza	<i>Colobus guereza</i>	Visual	Stable
Jaldesa	Olive baboon	<i>Papio Anubis</i>	Visual	Decrease
Canoo	Blue monkey	<i>Cercopithecus mitis</i>	Visual	Stable
Osoleholka	Bush hyrax	<i>Hetrohyrax brucei</i>	Visual	Stable
Osoledaga	Rock hyrax	<i>Procavia capensis</i>	Visual	Stable
Waldigesa	Aardvark	<i>Orycteropus afer</i>	Sign/holes/	Decreasing
Hilet	Star's hare	<i>Lepus starcki</i>	Visual	Stable
Xade	Crested porcupine	<i>Hystrix cristata</i>	Sign/spines	Decreasing
Dalgambasa	Caracal	<i>Caracal caracal</i>	Visual	Stable
Karkaro	Warthog	<i>Phacochoerus africanus</i>	Visual	Decreasing
Borte	Klipspringer	<i>Oreotagus oreotagus</i>	Visual	Decreasing
hamakesa	Genet	<i>Genetta genetta</i>	Visual	Decreasing
Kurupe	Common duiker	<i>Sylvicapra grimmia</i>	Visual	Decreasing

The species diversity of medium and large mammals varied between the four habitats type of the study area at seasonal variation. The highest species diversity of medium and large mammals

among the four habitat types was recorded in riverine forest during the dry seasons ($H' = 2.708$) and least species diversity ($H = 1.934$) was recorded in grassland during the dry season. The species diversity recorded from riverine forest ($H' = 2.708$) during the dry season and ($H' = 2.594$) during the wet season. In montane forest habitat, Shannon diversity index was similar during both the dry and wet seasons. This means that the species diversity was ($H' = 2.398$) and ($H' = 2.331$) during the dry and wet seasons respectively. Species diversity index of mammals recorded in shrubland was ($H' = 2.283$) during the wet season and ($H = 2.290$) during the dry season. The species diversity indexes of mammals in Grassland habitat was ($H' = 2.234$) and ($H' = 1.934$), during the wet and dry season respectively (Table: 4).

Seasonal variation was observed on the evenness of mammalian species among the four habitats. The highest species evenness index ($J = 0.93$) was recorded from grassland habitat during the dry season and least species evenness index ($J = 0.792$) of mammals was recorded from montane forest during the wet season. The species evenness of shrubland habitat was ($J = 0.821$) during the wet season and ($J = 0.867$) during the dry season. In riverine forest habitat, species evenness was recorded (0.827) during the wet and (0.864) during the dry seasons (Table: 4). The highest species richness was recorded in riverine forest during both seasons and the least species richness was recorded in grassland during the dry season (Table 4).

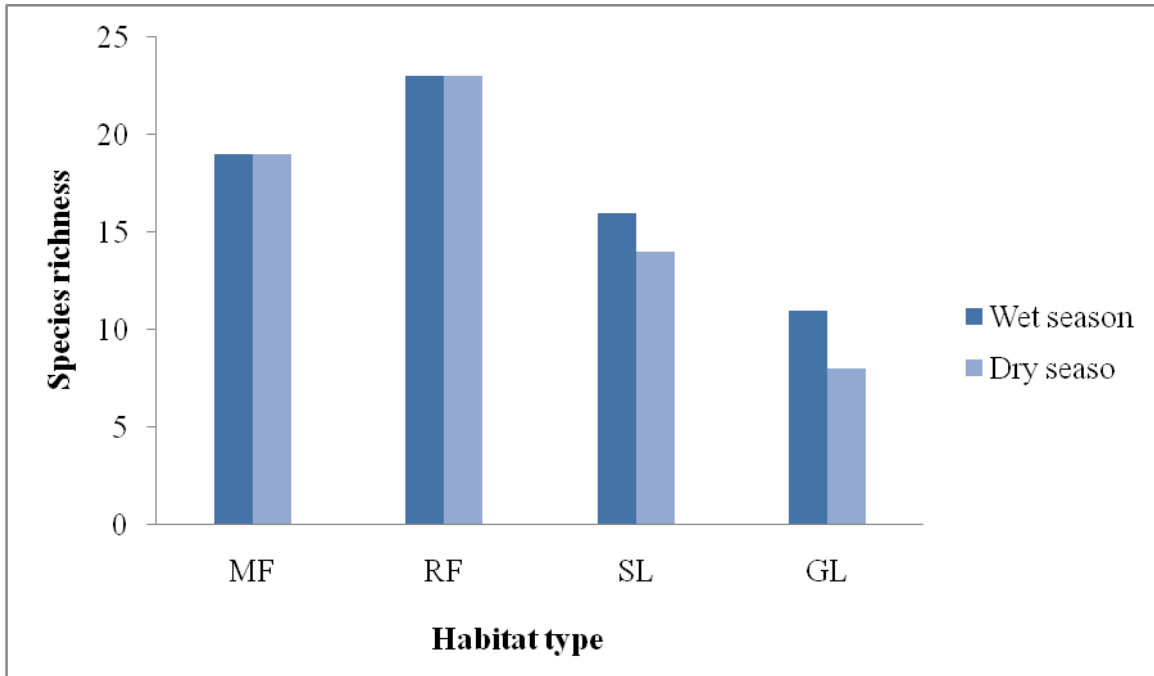
Table 4 . Diversity of medium and large of mammals identified during dry and wet seasons of study area.

Study area	Season	Number of species (S)	Total abundance	ln(S)	H'	D	E
Montaine forest	Wet	19	93	2.944	2.331	0.130	0.792
	Dry	19	60	2.944	2.398	0.113	0.815
Riverine forest	Wet	23	91	3.135	2.594	0.101	0.827
	Dry	23	80	3.135	2.708	0.082	0.864
Shrubland	Wet	16	71	2.773	2.283	0.132	0.821
	Dry	14	49	2.639	2.290	0.112	0.867
Grassland	Wet	11	20	2.398	2.234	0.116	0.93
	Dry	8	16	2.079	1.934	0.079	0.93
	Total	24	480				

Key: H=Shannon wiener diversity index, D =Simpson diversity index E=species evenness

The highest average of species diversity index of medium and large mammals of both seasons was recorded in riverine forest ($H'=0.367$) followed by montane forest ($H'=0.364$) and the highest average of species evenness of both seasons was recorded in shrubland ($E=128$) followed by riverine forest ($E=117$) whereas the least average of species diversity index ($H=0.194$) and least average of species evenness ($J=0.086$) was recorded in grassland along with the four habitat types in study area (appendix. 4).

The highest species richness (23 species) was recorded in riverine forest during both wet and dry seasons followed by montane forest (19 species) during both wet and dry seasons. Shrubland habitat comprised (16 species) during wet season and (14 species) during dry season. The least species richness (11 species and 8 species) was recorded from grassland habitat during wet and dry seasons respectively (Fig. 4). There was the variation of species richness within habitats of the present study area between wet and dry seasons. In the current study area the species richness of mammalian species during wet season was greater than the species richness of mammalian species recorded during dry season (Fig. 4).



Key: MF=montane forest, RF=riverine forest, SL = shrubland and GL=grassland

Figure 5. Medium and large sized mammal species richness in different habitat types

The results of Simpson similarity index among the four habitat types, showed that the highest species similarity (SI=0.857) of medium and large sized mammals was recorded between riverine forest and montane forest during both the dry and wet seasons and followed by between riverine forest and shrubland during wet season (SI=0.769) and during dry season (SI= 0.702), respectively. The least species similarity index (SI=0.37) was recorded between montane forest and grassland during the dry season. Montane forest and shrubland possessed species similarity index (SI= 0.686) during wet season and (SI= 0.727) during dry season in current study area. During the dry season, species similarity index between riverine forest and grassland recorded was (SI=0.452) and during wet season was (SI =0.558). Shrubland and grassland possessed species similarity index (SI=0.666) and (SI=0.455) during wet and dry seasons respectively (Table 5).

Table 5: Species similarity of mammals among the four habitats types during both dry and wet season.

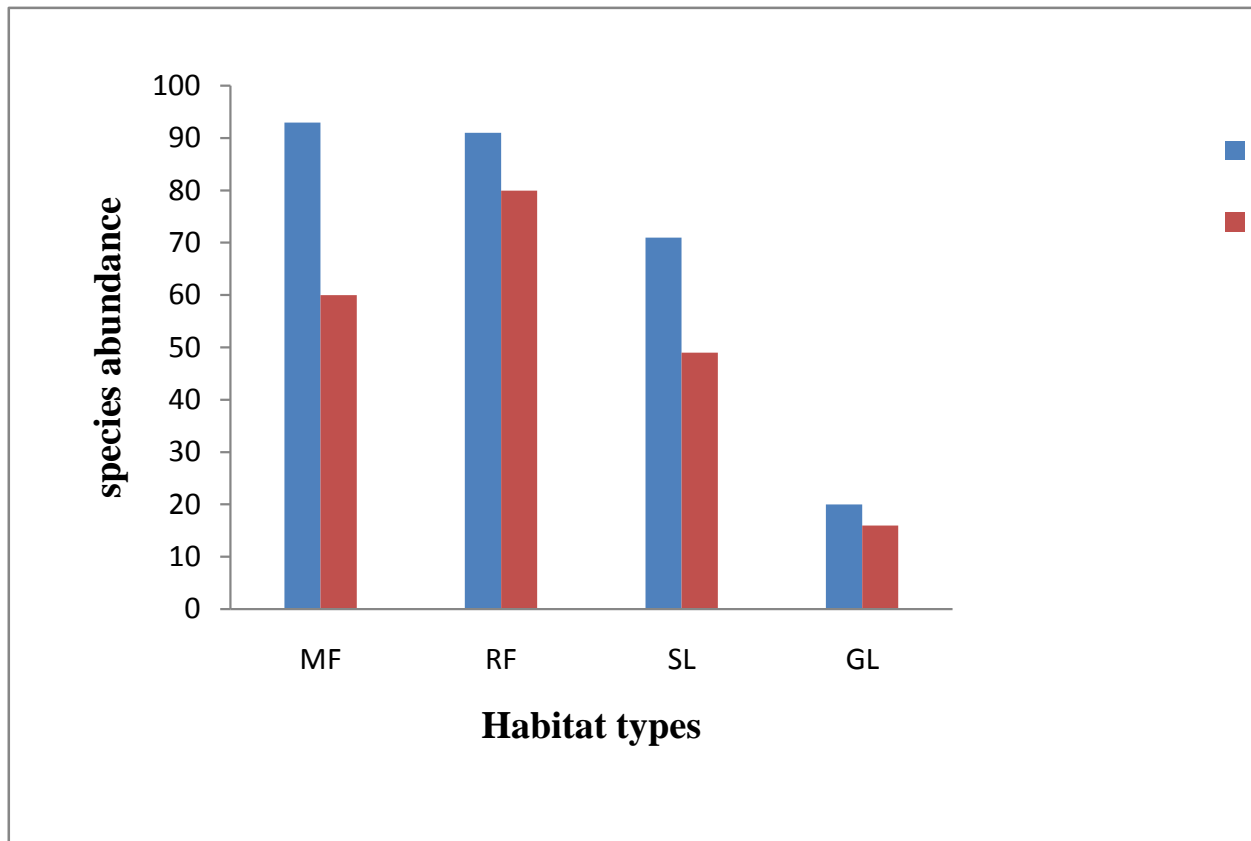
Habitat	season	Montane forest	Riverine forest	Shrubs land	Grass land
Montane forest	wet	1	0.857	0.686	0.466
	Dry	1	0.857	0.727	0.37
Riverine forest	wet	0.857	1	0.769	0.588
	Dry	0.857	1	0.702	0.452
Shrubland	wet	0.686	0.769	1	0.666
	Dry	0.727	0.702	1	0.455
Grassland	wet	0.466	0.588	0.666	1
	Dry	0.37	0.452	0.455	1

According to explained in (appendix 8) the highest mammalian species similarity index (SI=0.883) was recorded between riverine forest and montane forests followed by between montane forest and shrubland (SI=0.777) in study area. Species similarity between riverine forest and shrubland and species between shrubland and grassland (SI=0.769) and (SI=0.666) respectively. The least species similarity (SI=0.516) of medium and large sized mammals was recorded between grassland and montane habitats simultaneously during both seasons (appendix 8).

The seasonal variation in abundance (numbers) of individuals of medium and large mammals among different habitats was significantly different in the present study area. During the study a total of 480 individuals of medium and large mammals were identified and recorded. Among these, 205 individuals were recorded during dry season and 275 individuals during wet season (Appendix 2 and appendix 3).

Riverine habitat of the study area possessed 91 individuals /total abundance/' mammals during wet season and 80 individuals during the dry season. The 93 individuals (observations) of mammals were recorded during the wet season and 60 individuals' (observations) of mammals were recorded during the dry season in montane habitat of study area. In shrubland 71

individuals (total abundance) of mammals were identified during the wet season and 49 individuals were identified during the dry season. 20 individuals of mammals were recorded during the wet season and 16 individuals of mammals were recorded during the dry season in grassland habitat of study area (Fig. 5). This result showed that the number of medium and large sized mammals within habitats varied between seasons.



Key: MF=montane forest, RF=riverine forest, SL=shrubs land and GL=grass laand

Figure 6: total abundance of medium and large mammals versus vegetation types

Seasonal variation was observed in the relative abundance (RA) of medium and large sized mammals identified from the study area. Relatively more number of individuals was observed during the wet season than the dry season. Accordingly, during dry season, a total of 205 numbers of individuals and 275 numbers of individuals recorded during wet season. During dry season relatively the most abundance species recorded were guereza (*Colobus guereza*) that contributed about (RA=18.54%, 38 individuals) of total number of individuals (205) recorded, followed by grivet monkey (*Chlorcebus aethiops*) with RA=16.59% (34 individuals), olive

baboon (*Papio anubis*) RA=12.2% (25 individuals) and blue monkey (*Cercopithecus mitis*) (RA=7.32%, 15 individuals). Among a total of 205 mammals recorded during dry season, five species; wild cat (*Felis servatris*), honey badger (*Mellivora capensis*), klipspringer (*Oreotagus oreotagus*), african civet (*Civetta civetta*), warthog (*Phacochoerus africanus*) with (RA=0.97 %, 2 individuals) were relatively the least abundant mammals in present study area. The relative abundance of medium and large mammals was varied from (RA=0.97 %, 2 individual) to (RA=18.54% 38 individuals) during dry season (appendix 5).

Four mammals guereza (*Colobus guereza*) (RA=21.82%, 60 individuals), grivet monkey (*Chlorcebus aethiops*) (RA=18.18%, 50 individuals), olive monkey (*Papio anubis*) (RA=12.73%, 35 individuals) and blue monkey (*Cercopithecus mitis*) (RA=6.18%, 17 individuals) were relatively the most abundant species recorded during wet season of total number of individuals (275) recorded, whereas five mammalian species; klipspringer (*Oreotagus oreotagus*), honey badger (*Mellivora capensis*), rock hyrax (*Procavia capensis*) with (RA=0.7%, 2 individuals) and bush hyrax (*Hetrohyrax brucei*), genet (*Geneta abysinnica*) with RA=1.1% (3 individuals) were the least abundant medium and large mammals recorded during wet season in current study area. During wet season, the relative abundance of medium and large sized mammals was varied from RA=0.7% (2 individuals) to RA=21.82% with 60 individuals (appendix 5).

The relatively most abundant mammalian species guereza (*Colobus guereza*), grivet monkey (*Chlorcebus aethiops*), olive baboon (*Papio anubis*) and blue monkey (*Cercopithecus mitis*) contributed between 7.32% to 18.54% during the dry season and 6.18% to 21.82% in the wet season where as the relatively least abundant mammalian species contributed between RA=0.97% to 1.46% during dry season and RA=0.7% to 1.1% during wet season (appendix 5). However the average value of between dry and wet seasons revealed guereza (*Colobus guereza*) was relatively the most abundant species contributed 20.42% (49 individuals) and grivet monkey (*Chlorcebus aethiops*) was the second relatively abundant species with RA=17.5% (42 individuals) whereas olive baboon with RA=12.5% (30 individuals) and blue monkey (*Cercopithecus mitis*) with RA=6.67% (16 individuals) were the third and fourth relatively abundant species respectively recorded in study area. Wild cat (*Felis servatris*), African civet (*Civetta civetta*), genet (*Geneta genettas*), warthog (*Phacochoerus africanus*), and rock hyrax

(*Procavia capensis*) with RA=1.25% (3 individuals each) were relatively the least abundant species of Tankara forest (appendix 5).

4.2. Habitat association of medium and large sized mammals in Tankara forest

The mammalian species in different habitat types indicated the existence of great difference in species evenness and richness between the different habitats within the study area. Among 24 mammalian species, 25% serval cat (*Felis serval*), golden jackal (*Canis aureus*), common duiker (*Sylvicapra grimmia*), common bush buck (*Tragelaphus scriptus*), white tailed mongoose (*Icheumia albicaude*) and armadillo (*Orycteropus afer*) were associated in all the four habitat types and 41.6% caracal (*Caracal caracal*), wild cat (*Felis servatris*), spotted hyena (*Crocuta crocuta*), honey badger (*Mellivora capensis*), grivet monkey (*Chlorcebus aethiops*), olive baboon (*Papio anubis*), guereza (*Colobus guereza*), bush hyrax (*Hetrohyrax brucei*), stark's hare (*Lepus starcki*), crested porcupine (*Hystrix cristata*) were occurred in three habitats of Tankara forest and 33.3% species leopard (*Panthera pardus*), African civet (*Civetta civetta*), genet (*Geneta geneta*), bush pig (*Potamocheirus larvatus*), warthog (*Phacochoerus africanus*), blue monkey (*Cercopithecus mitis*), rock hyrax (*Procavia capensis*), and klipspringer (*Oreotagus oreotagus*) were occurred in two habitat types of study area (appendix 2).

Among the medium and large sized mammals recorded, guereza (*Colobus guereza*) was widely distributed in three habitat types; montane forest (36 individuals), riverine forest (34 individuals) and shrubland habitats (28 individuals) and followed by grivet monkey (*Chlorcebus aethiops*); montane forest (30 individuals), riverine forest (29 individuals) and shrubland habitats (28 individuals), and olive baboon (*Papio anubis*); montane forest (21 individuals), riverine forest (21 individuals) and shrubland habitats (18 individuals) in the present study area. More number of individuals of medium and large mammalian species was recorded in riverine forest (171=35.63%) and montane forest (153=31.88%) whereas least number of individuals was recorded in shrubland (120=25%) grass land (36=0.57% habitats. Relatively more number of individuals was observed during the wet season than the dry season. However common jackal, caracal, bush hyrax and rock hyrax were recorded more during dry season (appendix 2).

According to (appendix 7) the chi square test showed the number of valid cases used for analysis. Only cases with no missing values for both types of species and types of habitat can be

used in the test. According to (appendix 7) asymptotic Significance (2-sided) column (0.0000) with 220.487^a Chi square statistic appeared in the value column of the chi square test table immediately to the right of chi square table test. According to (appendix 9) the value of the chi square statistic is 220.487. The p value of appeared in the same row in the asymptotic significances (2-sided column (0.000)). The result was significant the p value was less than the standard alpha value. The result was significant, the data suggested that the variables were type of species and habitat types were associated with each other.

Table 6. Results of chi square Tests.re

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	220.487 ^a	69	.000
Likelihood Ratio	221.744	69	.000
N of Valid Cases	480		
a. 72 cells (75.0%) have expected count less than 5. The minimum expected count is .30.			

Since the p-value is less than our chosen significance level ($\alpha = 0.05$), we reject the null Hypothesis. Hence, we conclude that there is association between types of species and types of habitat. Therefore, based on the results, we e concluded the following. There is association between types of species and types of habitat since ($p = 0.000 < \alpha = 0.05$).

4.3. Results of local people opinion assessment

During the study period' discussion held with local people and district officials on their knowledge and attitudes towards the Tankara forest and mammals, habitat conservation and threats to the study habitat were conducted to 25 targeted person in the study area. The study participants were 5 elders, 3 Gorba Gudina kebele leaders, 2 fuel wood exploiters, 2 timber producers, 3 charcoal producers, 2 leaders of spiritual activity (kallicha) in and around forest, 3 employers from Haro limu worda forestry office, 2 hunters in an area and 3 farmers of study

area gave their idea. All of them were males and had knowledge of the medium and large mammals living in the current study area. According to the views of participants' overgrazing, deforestation and cultivation were the major threats of the study area.

Interview participants stated that local people engaged in use of forest for different purpose as the result of lack of job opportunity and survive their life in case of poverty. For instant; fuel wood exploiters sold 50 ETB per donkey, timber producers sold 220-250 ETB one timber with 50 cm, charcoal producers sold 300 ETB 100 kg charcoal. Most participants argued that excessive fire wood exploitation, charcoal production, timber production, farming land and over grazing reducing mammalian diversity in study area. They showed positive attitudes for the conservation of the area if Oromia regional state government makes job opportunity.

The local people living surrounding the Tankara forest practiced illegal hunting of mammals for food, skins and to reduce predation. The local people /hunter/ kills number of leopard for its skins, common duiker and common bush buck for food. They hunt spotted hyena and common jackal to reduce their harm on their cattle and flocks in the study area. During the study period many unknown and 9 known dead bodies of medium and large mammals were observed in different habitats of the study area. According to the local people response, most of these mammals were killed by the surrounding local people for food. Among the 9 known of carcasses observed in study area, 1 carcass of honey badger observed in shrubland, 2 carcasses of bush buck were observed in montane habitat and 1 carcass of bush buck was observed in riverine forest, 2 carcasses of crested porcupine were observed in shrubland and 1 carcass of crested porcupine was observed in riverine forest. 1 carcass of common duiker was observed in shrubland habitat and 1 carcass of common duiker was observed in mantane habitat of Tankara forest.

The local people living surrounding the Tankara forest also used the forest for house building. These destruction of Tankara forest resulted in destruction of medium and large sized mammals in study area. Local people regularly bring many cattle to the Tankara forest for gazing and drinking water. This over grazing caused for destruction of forest and reduction of mammalian species in study area.

5. DISCUSSION

5.1. Diversity and relative abundance

The present study area comprised different topography, climate and vegetation types that have provided habitats for a diverse medium and large species of mammals. During the present preliminary survey of medium and large mammals from Tankara forest, a total of 24 species were identified from 480 total observational records. These mammalian species were grouped into seven orders and thirteen families. Similarly, Mohammed Kaso and Afework Bekele (2017) recorded 22 species in fragmented remnant forest around Asella town by direct and indirect evidence. A total of 24 species of medium and large sized mammals recorded from Tankara forest during the present study was relatively high compared to other study areas of the country. For examples; 12 species of medium and large mammals were recorded from Mengaza communal forest by Getachew Atnafu and Mesele Yihune (2012), 12 species of mammals were recorded from Wabe forest fragments by Kabeta Legese *et al.* (2019), 14 species of medium and large sized mammalian species were recorded in Yayu forest by Gebrecherkos Woldegeorgis (2012), 18 species in and around Wondo Genet forest patch by Zerihun Girma *et al.* (2012), 22 species from fragmented remnant forest around Asella town (Mohammed Kaso and Afework Bekele, 2017) and 23 species from Baroye control hunting area (Dereje *et al.*, 2015). 13 species of large mammals recorded from Ishaqibin community conservancy, Kenya (Muchai *et al.*, 2008). This higher mammalian diversity recorded from the present study area might be resulted from good vegetation coverage and availability resources. The majority of mammalian species in present study area were identified by direct observations. The same result was reported by Mosisa Geleta and Afework Bekele (2016) from watch protected forest. This detection of mammals through naked eye is due to the openness of the habitats which might have resulted from habitat loss and fragmentation. The least species of medium and large mammals were identified by using indirect evidence due to their nocturnal activity, high secretive behavior, illusive behavior, shy behavior and human disturbance in the current study area contributed for not direct sighting. This result was similar to the work of Kabeta Legese *et al.* (2019), from Wabe forest fragments and Zerihun Girma *et al.* (2012) from Loka Abaya National Park.

On the other hand, the total of 24 number of medium and large mammalian species recorded in the present study area was relatively low compared to the 28 species recorded from Dhati Wolel

National park (Rabira Gonfa *et al.*, 2015). This lower mammalian diversity recorded from the present study area might be associated to limited survey period, variation in the size of study area, severe habitat loss and fragmentation by various anthropogenic activities. Similarly, Indris Abdu *et al.* (2018), reported that declining of medium and large sized mammals due to habitat fragmentation, over exploitation and requirements of large areas,

Among the 24 species recorded from current study area, the majority of species 66.66% (16 species) identified as large sized mammals and least of species 33.33% (8) identified as medium sized mammals. This result was similar with studies of Rabira Gonfa *et al.* (2015) in Dati Wolel National park. This might be due to large mammals require large home range and easily to be detected when move in large area and many medium sized mammals were difficult to detect their presence in different habitats because of their size relatively small hidden in vegetation and their habit of moving during nocturnal time.

Among the four habitat types, different number of medium and large mammalian species was recorded in the present study area. For instance, highest number of species (23 species) was recorded in riverine forest habitat during dry and wet seasons and followed by montane forest having 19 numbers of species during both dry and wet seasons and least number of species was recorded (8 species and 11 species) in grassland during dry and wet seasons respectively. This finding was contrast with the work of Chala Adugna and Afework Bekele least number of medium and large mammalian species (9 species richness) was recorded from riverine habitat of Labu national protected forest and with work of Diriba Guta *et al.* (20120) from the Loka Abaya National park and similarly with finding of Mohamed Kaso and Afework Bekele, (2017) from fragmented remnant forests around Asella Town. This highest species richness in these two habitats might be due to high quality of food and movement of medium and large mammals from peripheral parts of the study (grassland and shrubland) to relatively protected areas as results of their dense vegetation. In shrubland habitat of the current study area, 16 mammalian species were recorded while in shrubland habitat in mix Ethiopia 18 mammalian species were recorded by (Shiferaw Ayele, 2008). In grassland habitat of the current study area, 11 mammalian species were recorded while in shrub land habitat of fragmented remnant forest around Asella town 9 mammalian species were recorded by (Mohammed Kaso and Afework Bekele, 2016). The number of species recorded in different habitat types of study area varied with seasons might be

due to local migration of some of the species between habitats based on the availability of food, vegetation type, and human activities in study area (Cortes *et al.*, 2014).

From a total of 24 medium and large mammals recorded, primates were the most abundant and widely distributed species in three habitats (montane forest, riverine forest and shrubs land habitat) of the present study area. This might be due to their ability to extract food items and adapted to feed on variety of vegetations. Artidactyla was the second abundant species recorded and identified in the current study area. This might be due to they obtained sufficient grasses, leaves and high nutritive value that support them. Similar finding was reported by Indris Abdu *et al.* (2018) in Birbir protected forest western Ethiopia. Carnivores occurred in least abundance due to they were highly secretive and difficult to observe in present study areas using traditional methods. Similarly, least abundance of carnivores also reported in Dati Wolel National park (Rabira Gonfa *et al.*, 2015).

Rabira Gonfa *et al.* (2015), showed that the positive correlation between habitat heterogeneity and mammalian species diversity. Among the four habitats in the present of study area, the highest species diversity recorded in riverine forest habitat during the both dry and wet seasons might be due to the availability of sufficient resources with more stable community of in this habitat and least diversity index recorded in grassland during dry season. The highest species evenness of medium and large mammals recorded in grass land and least species evenness recorded in montaine forest during the wet season. This finding was similar with find of Meseret Chane (2010), in Borena Sayint National park and contradicts with studies of Indris Abdu *et al.* (2018), reported highest diversity index in grassland habitat both in seasons and highest species evenness during dry season. The least diversity index in grassland and least species evenness in riverine forest of current study area might be due to its small size area relative to other habitats. Indris Abdu *et al.* (2018) showed the diversity of species was highly affected by size of area. Similarly other studies in different parts of Ethiopia revealed that mammalian species diversity is often high in areas where there are sufficient food recourse and area of habitat and availability of water sources. On other hand, less diversity of medium and large mammalian species in habitats during both the seasons was probable related to the presence of more anthropogenic impact (Zerihun Girma *et al.*, 2012).

Among the four habitat types in the study area, the highest species similarity of medium and large sized mammals was observed between montane forest and riverine forest during both seasons. This result agrees with species similarity recorded between montane forest and riverine forest of Borena saint national park (Meseret and Solomon, 2014) and between montane forest and riverine forest of Baroye control hunting area (Dereje *et al.*, 2015). However, it contradicts with that least species similarity recorded montane forest and riverine forest of Dhati wolel national park (Rabira *et al.*, 2015). The difference in species similarity between habitats of different study areas might be ecological variations and vegetation structures in those habitats. The highest species similarity between montane and riverine forests in the presence study area during both seasons might be because of resources availability of two habitats relatively similar. The least species similarity of medium and large sized mammals was recorded between grassland and montane habitats during both seasons. This result contradicts with the least species similarity was recorded in Birbir protected forest (Indiris Abdu *et al.*, 2018). The least species similarity recorded between grassland and montane forest in the present study area might be result from the difference in resources and habitat conditions of these two habitats.

There was variation in the overall the number of individuals of medium and large mammals recorded among the four habitats of the study area. The highest number of individuals of mammals recorded from riverine 35.63% (171) and montane forest 31.86% (153) during the both wet and dry seasons. This might be resulted from availability of food, water, and vegetation cover. Least number of individuals of mammals was recorded from grass land (36) due to less refuge of mammals in this habitat. This result contrast with the high number of individuals of mammals recorded from grassland and least number of individuals of mammals recorded from riverine forest (Indiris Abdu *et al.*, 2018).

In grassland habitat of Tankara forest 36 numbers of individuals of mammals were recorded where as in grassland of Dhati Wolel National park 834 numbers of individuals of mammalian species were recorded by Rabira Gonfa *et al.*(2015). In reverine habitat of Tankara forest about 35.63% (171) numbers of individuals were recorded while in riverine forest of Dhati Wolel National park about 319 numbers of individuals of mammalian species were recorded (Rabira Gonfa *et al.*, 2015). In montane habitat of the current study area, 31.86% (153) number of individuals of mammals was recorded. This high number of observation might be due to the

availability of food, water and vegetation coverage, and the least numbers of individuals of mammals were occurred in shrubland habitat 25% (120) and grassland habitat 7.5% (36) due to less refuges and vegetation cover. Similar result was reported by Indiris Abdu *et al.* (2018), from birbir protected forest that lower number of individuals of mammals recorded in grassland during dry season.

Seasonal variation was observed in the number of individuals recorded in the present study. The high total number of individuals of mammals recorded during the wet season (275) surpassed the number of individuals recorded during the dry season (205). This might be because of high availability of resources and dense vegetation coverage during wet season and due to scarcity of resources and less dense vegetation coverage during dry season. This finding similar with work of Mohammed Kaso and Afework Bekele, (2017) from fragment remnant forest around Asella and contradicts with the result reported by Zarihun *et al.* (2012), in Wondo Genet forest patch and Indiris Abdu *et al.* (2018), in Birbir protected forest.

Number of individuals of medium and large mammals recorded during wet season in montane and riverine forest significantly greater than recorded during dry season. This might be because of availability resources and dense vegetation coverage during wet season and due to less dense vegetation coverage during dry season. In addition human activities such as collecting fire wood, charcoal production and spiritual activities high during dry seasons than wet season in present study area and most mammals migrate to other area, thus reducing the sighting of medium and large sized mammals during dry season.

Eshetu Moges *et al.* (2017) had reported species richness of mammals may not vary with respect to seasons rather abundance and population size significantly vary in different seasons due to variation in food and water availability. However species richness was varied with respect of seasonal variation in shrubland and grassland where as species richness may not varied in riverine and montane forests of the present study area. High abundance of medium and large mammals was recorded from montane forest and riverine forest than grassland and shrubland might be due to dense vegetation coverage, availability of food, and water in montane and riverine forests. Similarly Eshetu Moges *et al.* (2017) reported that resources availability, habitat quality, and geographic location can determine the variation in abundance and diversity of

medium and large sized mammals between habitats of Gonde Teklehimanot and Aresema monasteries.

The reason for the higher abundance of mammalian species was recorded in the montane and riverine forest habitats during the wet season probably related to the availability of food and water for most of the medium and large mammalian species. This site also has minimal security problems as compared to other shrubland and grassland habitats because less coverage of mammalian species. During the dry season, most individuals of medium and large mammals' population migrate locally to the other area in order to find good shelter, availability of food and vegetation coverage.

Among 24 medium and large mammals species recorded from the present study area, guereza was recorded as relatively the most abundant mammalian species comprising about 20.416% of the total individuals recorded throughout the study. High abundance guereza also reported from Birbir protected forest by (Indiris Abdu *et al.*, 2018). In the present study it was frequently recorded from montane forest, riverine forest and shrubland during both wet and dry seasons. guereza, grivet monkey, olive baboon and blue monkey were the most abundant mammals recorded in the current study area. Similar study was reported by Kabeta Legese *et al.* (2019), from Wabe forest fragments. This most abundance of primates might be because of their high reproductive successes, diversified foraging behavior and high tolerance level to human disturbances. Wild cat (*Felis servatris*), honey badger (*Mellivora capensis*), african civet (*Civetta civetta*), klipspringer (*Oreotagus oreotagus*), and warthog (*Phacochoerus africanus*) with RA=0.9% (2 individuals) were the least relatively abundant of medium and large sized mammals recorded during the present study area. The possible reason least observation of these mammals in the current study area might be associated to their nocturnal, solitary, and secretive behavior; So that their presence was not easily documented. This result also reported in Birbir protected forest by (Indiris Abdu *et al.*, 2018).

In view of the human activities resulting in the natural habitat modification and the fact that larger mammals are sensitive to natural habitat disturbance it is probable that these species declined in number. According to reported by local community during oral interview conducted, the majority of 24 medium and large mammals (65.5%) in the present study area were gradually

declined in population trends. This finding was similar with the finding of Kabeta Legese *et al.* (2019), from Wabe forest fragments. The possible reason for declining of these species diversity in the present study area might be due to various anthropogenic activities in their natural habitats, disease, habitat fragmentation, the requirement of large area and high sensitivity to human disturbance where as about 37.5% of medium and large mammalian species population trends in Tankara forest remained stable due to they are not serve as food and they are not hunted by local people because of they are neither benefit nor harm crops of the local people.

Another point obtained from interviewed local people; they have knowledge and positive attitude towards the Tankara forest and mammals. They have also showed willingness to participate in conservation of this ecosystem and the mammals it hosts if the government is conserve the area and support them by compensating economy deficiency. Similarly, Kabeta Legese *et al.* (2019) reported a positive attitude of local people towards the mammals in Wabe forest fragments in Gurage zone.

Further survey on the mammalian ecology to investigate critical environmental factors that influence the diversity patterns is necessary for the implementation of appropriate conservation strategies to safeguard this healthy mammalian biodiversity. The interviewed local people have knowledge and positive attitudes towards the mammals. They have also indicated willingness to participate in the conservation ecosystem and the mammals it hosts if the government is conserve the study area.

5.2. Distribution and habitat association

The distribution of medium and large mammals in all habitat types of study area was not uniform due to different resource availability and vegetation coverage in current study area (Indris Abdu *et al.* 2018). Habitat in terms of mammals refers to the vegetation composition, floristic and structure of the area as a product of various factors such as climate, geology and soil. The habitat of animals is the area where animals survive and all its life necessities are fulfilled, consequently medium and large sized mammals' diversity in the present study area was highly associated with habitat type.

The distribution of medium and large sized mammals in the different habitat types of the area might indicate habitat selection of the different species of mammals based on due to ecological preference and evolutionary adaptation (Indris Abdu *et al.*, 2018). Distribution and habitat association of mammals were determined mainly in terms of resources availability in study area. The distribution of mammals in study area was not uniform across the four habitat types. In present study area, majority of primates were associated to montane forest, riverine forest and artiodactyls were associated to shrubs land. This might be related to the quality forging behavior of species. The association of medium and large sized mammals in different habitats of the present study area might be attributed the availability of resources and suitability of vegetation structures for various purposes. The frequency of species encountered in the sampling blocks showed that only three species (serval cat, bush buck, common duiker) were common or widespread in the different major vegetation types of the forest. They were sufficiently recorded in each vegetation types.

The distribution of medium and large mammals in the different habitat types might be based on availability of vegetation type, food, shelter, and water (Kabeta Legese *et al.*, 2019). The riverine forest and montane forest habitats are rich in the species richness and evenness; this is probably related to the habitat complexity and stability as compared to other habitat types. Foliage diversity of the forest increases species diversity. Besides, most part of the riverine forest habitat was located within the center of the forest and so the human impact is also minimal. Whereas the habitat complexity and stability of the shrubland and grassland with scattered tree habitat were lower mainly as a result of the low floral diversity.

In present study area high number of medium and large mammalian species was recorded during wet season than dry season due to more vegetation coverage. However, high number of medium and large mammalian species was recorded during dry season than wet season in and around Wondo Genet forest patch by Zarihun Girma *et al.*, (2012). Primates were highly abundant whereas carnivores and artiodactyls least abundant compared to other might be due to their high ecological adaptation.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The present ecological survey revealed that the Tankara forest supports an impressive variety of medium and large sized mammalian species. In the present study area, 24 species of medium and large sized mammals were identified and this revealed the importance of Tankara forest for biodiversity conservation. High species diversity, evenness and richness were recorded in riverine and montane habitats, whereas less species diversity, evenness and richness were recorded in shrubs and grass land habitats. the majority of the current study documented 24 species of medium and large sized were under greater conservational problems due to habitat loss, deforestation, Settlement, poaching, and lack of conservation attention from local communities. The different topography, climate and vegetation coverage of the present study area provided suitable habitats for survival of medium and large sized mammals. According to discussions made with the local communities, leader of Kalicha and Gorba Gudina kebeles; poaching, cultivation, over grazing and cutting trees were the major prevailing threat of biodiversity conservation in the area have led decline in number of mammalian species in the present study area. The present study was provided awareness for the local community members about the significance of mammals and the actual benefits they provide if sustainable conservation strategies will be implemented in the study area.

6.2. Recommendations

- ❖ The human activities such as hunting, cultivation, timber production and livestock grazing would have a greater impact on the diversity, abundance and distribution of medium and large sized mammals in the study area. It is therefore wise to take immediate measures to minimize the problems and make sure the future of mammalian species.
- ❖ Thus, more attention should be required from the Haro Limu woreda forestry office and east wolega zone forestry office to begin functional conservational activities in Tankara forest by integrating local peoples around the forest.
- ❖ It is very important to develop and conserve Tankara forest to safeguard the diverse habitats and its prestigious wildlife resources.

- ❖ Specific and detailed research on the different resources of the Tankara forest is essential for the long term management plan of the animal and plant life of the forest.

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8. APPENDICES

Appendix 1. Medium and large mammalian species identified in Tankara forest during study time.

No	Common name of mammals	Scientific name of mammals
1	Leopard	<i>Pantherapardus</i>
2	Caracal	<i>Caracal caracal</i>
3	Serval cat	<i>Felis serval</i>
4	Wild cat	<i>Felis servatris</i>
5	golden jackal	<i>Canis aureus</i>
6	Spotted hyaena	<i>Crocuta crocuta</i>
7	Whitetailed mongoose	<i>Icheumia albicaude</i>
8	Honey badger	<i>Mellivora capensis</i>
9	African civet	<i>Civetta civetta</i>
10	Genet	<i>Genetta genetta</i>
11	Common bushbuck	<i>Tragelaphus scriptus</i>
12	Common duiker	<i>Sylvicapra grimmia</i>
13	Klipspringer	<i>Oreotagus oreotagus</i>
14	Bush pig	<i>Potamocheirus larvatus</i>
15	Warthog	<i>Phacochoerus africanus</i>
16	Blue monkey	<i>Cercopithecus mitis</i>
17	Grive monkey	<i>Chlorcebus aethiops</i>
18	guereza	<i>Colobus guereza</i>
19	Olive baboon	<i>Papio anubis</i>
20	Bushhyrax	<i>Hetrohyrax brucei</i>
21	Rock hyrax	<i>Procavia capensis</i>
22	Aardvark	<i>Orycteropus afer</i>
23	Stark's hare	<i>Lepus starcki</i>
24	Crested porcupine	<i>Hystrix cristata</i>

Appendix 2: Abundance of medium and large sized mammals in different habitat types

No	Common names	Type of habitats				Total
		MF	RF	BL	GL	
1	Leopard	5	7	0	0	12
2	Caracal	0	3	5	8	16
3	Serval cat	3	5	4	8	20
4	Wild cat	0	3	1	2	6
5	Golden jackal	1	4	2	3	10
6	Spotted hyaena	5	4	3	0	12
7	White tailed mongoose	2	4	4	2	12
8	Honey badger	1	2	1	0	4
9	African civet	3	3	0	0	6
10	Genet	0	3	0	3	6
11	Common bushbuck	3	7	9	1	20
12	Common duiker	2	2	5	1	10
13	Klipspringer	0	2	2	0	4
14	Bush pig	9	7	0	0	16
15	Warthog	4	2	0	0	6
16	Blue monkey	17	15	0	0	32
17	Grive monkey	30	29	25	0	84
18	Guereza	36	34	28	0	98
19	Olive baboon	21	21	18	0	60
20	Bushhyrax	2	4	0	2	8
21	Rock hyrax	2	4	0	0	6
22	Aardvark	2	3	5	2	12
23	Stark's hare	3	0	3	4	10
24	Crested porcupine	2	3	5	0	10
Total		153	171	120	36	480

Key: MF=montane forest, RF= riverine forest, SL= shrubland, GL=grasslandAppendix

Appendix 3. Abundance of medium and large sized mammals in the wet and dry during both seasons

No	Common name	Different types of habitat								Total
		MF		RF		SL		GL		
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	
1	Leopard	3	2	3	4	0	0	0	0	12
2	Caracal	0	0	2	1	3	2	4	4	16
3	Serval cat	2	1	2	3	2	2	4	4	20
4	Wild cat	0	0	1	2	0	1	1	1	6
5	golden jackal	1	0	3	1	1	1	2	1	10
6	Spotted hyaena	3	2	2	2	1	2	0	0	12
7	Whitetailed mongoose	1	1	2	2	2	2	0	2	12
8	Honey badger	0	1	1	1	0	1	0	0	4
9	African civet	2	1	1	2	0	0	0	0	6
10	Genet	0	0	2	1	0	0	1	2	6
11	Common bushbuck	2	1	3	4	4	5	0	1	20
12	common duiker	1	1	1	1	2	3	0	1	10
13	Klipspringer	0	0	1	1	1	1	0	0	4
14	Bush pig	5	4	3	4	0	0	0	0	16
15	Warthog	3	1	1	1	0	0	0	0	6
16	Blue monkey	9	8	7	8	0	0	0	0	32
17	Grive monkey	20	10	14	15	10	15	0	0	84
18	Guereza	22	14	14	20	10	18	0	0	98
19	Olive baboon	13	8	9	12	8	10	0	0	60
20	Bushhyrax	1	1	3	1	0	0	1	1	8
21	Rock hyrax	1	1	3	1	0	0	0	0	6
22	Aardvark	1	1	1	2	2	3	1	1	12
23	Stark's hare	2	1	0	0	1	2	2	2	10
24	Crested porcupine	1	1	1	2	2	3	0	0	10
Total		93	60	80	91	49	71	16	20	480

MF=montane forest,RF=Riverine forest, SL=shrubland, GL= grassland

Appendix 4. Averages of total abundance of mammalian species among four habitats during both dry and wet seasons together.

Study area	Number of species	Total abundance	H'	Hmax	E
Montane forest	19	76.5	0.364	2.944	0.124
Riverine forest	23	85.5	0.367	3.135	0.117
shrubland	15	60	0.346	2.708	0.128
grassland	10	18	0.194	2.251	0.086
total	24		–	–	–
	240				

Key: H'=species diversity index, E=species evenness

Appendix 5: the relative abundance of the medium and large sized mammalian species in four habitat types during wet and dry seasons of Tankara forest.

No	Common name	Dry season		Wet season		Average	
		No	RA	No	RA		RA
1	Leopard	5	2.44	7	2.55	6	2.5
2	Caracal	9	4.39	7	2.55	8	3.33
3	Serval cat	9	4.39	11	4	10	4.17
4	Wild cat	2	0.01	4	1.45	3	1.25
5	golden jackal	6	2.93	4	1.45	5	2.08
6	Spotted hyena	5	2.44	7	2.55	6	2.5
7	White tailed mongoose	5	2.44	7	2.55	6	2.5
8	Honey badger	2	0.01	2	0.7	2	2.08
9	African civet	2	0.01	4	1.45	3	1.25
10	Genet	3	1.46	3	1.1	3	1.25
11	Common bushbuck	8	3.9	12	4.36	10	4.17

12	Common duiker	4	1.95	6	2.18	5	2.08
13	Klipspringer	2	0.01	2	0.7	2	2.08
14	Bush pig	7	3.41	9	3.27	8	3.33
15	Warthog	2	0.01	4	1.45	3	1.25
16	Blue monkey	15	7.32	17	6.18	16	6.67
17	Grivet monkey	34	16.59	50	18.18	42	17.5
18	Guereza	38	18.54	60	21.82	49	20.42
19	Olive baboon	25	12.2	35	12.73	30	12.5
20	Bush hyrax	5	2.44	3	1.1	4	1.67
21	Rock hyrax	4	1.95	2	0.7	3	1.25
22	Aardvark	5	2.44	7	2.55	6	2.5
23	Stark's hare	4	1.95	6	2.18	5	2.08
24	Crested porcupine	4	1.95	6	2.18	5	2.08
Tot		205	100	275	100	240	100

Key: No=number of individuals, RA=Relative abundance

Appendix 6. Species similarity of medium and large mammals among four habitats during the simultaneously seasons

Habitats	Montane forest	Riverine forest	Scrubsland	Grassland
Montaneforest	1	0.883	0.777	0.516
Riverine forest	0.883	1	0.769	0.588
Scrubsland	0.777	0.769	1	0.666
Grassland	0.516	0.588	0.666	1

Appendix 7: Chi square shows distribution of mammals among habitat type

NO	Species type	Habitat types with chi squares				Chi squares
		MF	RF	SL	GL	
1	Leopard	0.36	1.7	3	0.9	5.96
2	Caracal	4.1	1.28	1	37.5	43.91
3	Serval cat	1.78	0.63	1	28.16	31.57
4	Wild cat	1.91	0.34	0.25	5.3	7.83
5	Common jackal	1.5	0.05	0.25	6.75	8.55
6	Spotted hyaena	0.36	0.01	0	0.9	1.27
7	White tailed mongoose	0.87	0.01	1	1.3	3.22
8	Honey badger	0.06	0.23	0	0.3	0.59
9	African civet	0.61	0.34	1.5	0.45	2.9
10	Genet	1.91	0.34	1.5	14.45	18.2
11	Common bushbuck	1.78	0	3.2	0.16	5.14
12	Oribi	0.44	0.68	2.5	0.08	3.7
13	Klips springer	1.27	0.23	1	0.3	2.8
14	Bush pig	2.98	0.29	4	1.2	8.47
15	Warthog	2.28	0	1.5	0.45	4.23
16	Blue monkey	4.53	1.13	8	2.4	16.06
17	Grive monkey	0.38	0.02	0.78	6.3	7.48
18	Colobus monkey	0.72	0.02	0.5	7.35	8.59
19	Olive baboon	0.18	0	0.6	4.5	5.28
20	Bushhyrax	0.11	0.46	2	3.26	5.83
21	Rock hyrax	0	1.62	1.5	0.45	3.57
22	Aardvark	0.87	0.38	1.33	1.3	3.92
23	Stark's hare	0.01	3.56	0.25	14.08	17.9
24	Crested porcupine	0.44	0.08	2.5	0.75	3.77
Total		X=29.26	X=12.9	X=39.8	X=138.44	x=220.48
			5	3		

Key: MF=montane forest,RF=Riverine forest, SL=shrubland, GL= grassland

Appendix 8: Interview questions

Interview Research questions prepared for more experienced persons with medium and large mammalian species in tankara forest.

Research questions

- ❖ What is the diversity of medium and large sized of mammals in Tankara forest?
- ❖ Which kinds of medium and large sized mammals are more and less relative abundance in the study area?
- ❖ How do medium and large sized mammals are distributed in Tankara forest?
- ❖ What is the habitat association of medium and large sized mammals in tankara forest?

Interview Research questions prepared for more experienced persons with medium and large sized mammalian species in tankara forest.

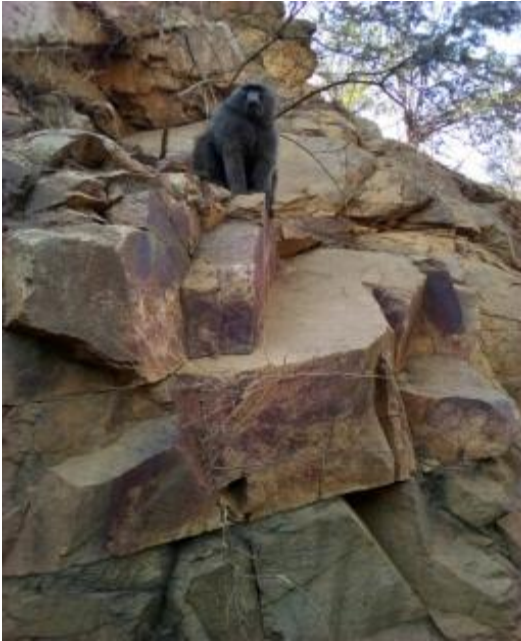
My name is **Meseret Ayana** 4th year **post graduate student at BahirDair University College of science biology department**. I am a creator of this interview questions to estimate and determine the diversity, relative abundance, distribution and habitat association of medium and large sized mammals in tankara forest.

The purpose of this interview question is collecting data about the diversity, relative abundance, distribution and habitat association of medium and large sized mammals in tankara forest. This interview question was 10 opened questions about your recent experience and knowledge with the diversity, relative abundance, distribution and habitat association of medium and large sized mammals in tankara forest. I attempted respondents valuable information and understanding about the diversity, relative abundance, distribution, and habitat association of large and medium sized of mammals and take different measurements to minimize habitat loss and make conservation strategies in Tankara forest

1. **How long have you been around area?** _____
2. Is there any conflict now day with tankara forest? If there is please specify the reason.

3. What are kinds of medium and large sized mammals present in tankara forest?
4. What are the major factors determined the diversity and distribution of medium and large mammals in Tankara forest?
5. All selected habitats have the same diversity, distribution and relative abundance of medium and large sized mammals in the study area?
6. Do you think all kinds of medium and large sized mammals are the same abundant in the Tankara forest?
7. Do you think the practice of hunting, timber production, and charcoal production fire wood collecting proceesed in Tankara forest?
8. What was the trend of numbers of medium and large of mammals' species for 10-15yrs? decreasing increasing or stable?. If decreasing specify the reasons for decline
9. Which habitat types of tankara forest contains high and least species diversity, species evenness, species similarity, and species abundance?
10. What are the best mechanisms for managing of medium and large mammal species in tankara fore

Appendix 9. Some mammals and signs



Olive baboon



guereza



Rock hyrax



tree hyrax



Vomiting of spotted hyena



dead honey badger



Dead body of crested porcupine



bush pig



(Hunting of mammals) Death bush buck



death common duiker



Dig of aardvark



cut down of trees

Appendix 10. Interview held with local people



Discussion held with local persons