JIMMA UNIVERSITY,

COLLEGE OF NATURAL SCIENCES,

DEPARTMENT OF BIOLOGY

DIVERSITY AND HABITAT PREFERENCE OF MAMMALS IN FRAGMENTED SEMI-NATURAL FOREST AROUND JIMMA INSTITUTE OF TECHNOLOGY CAMPUS, JIMMA, SOUTHWEST ETHIOPIA

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A THESIS SUBMITTED TO DEPARTMENT OF BIOLOGY, COLLAGE OF NATURAL SCIENCES, JIMMA UNIVERSITY, FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY (Ecological and Systematic Zoology)

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Jimma, Ethiopia.

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Jimma, Ethiopia.

Declaration

I, hereby declare that this MSc thesis is my original work and has not been presented for any degree in any other University, and all sources of material used for this thesis has been duly acknowledged.

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Date of submission _______________

Thesis has been submitted for examination with my approval as University advisor.

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ACRONYMS

CT	Camera Traps
EL	Ear Length
EMA	Ethiopian Metrological Agency
FAO	Food and Agriculture Organization
HB	Head and Body length
HF	Hind Foot length
IUCN	International Union for Conservation of Nature
JIT	Jimma Institute of Technology
LC	Least concern
NLFC	Newhall Land and Farming Company
RA	Relative Abundance
TL	Tail Length

ABSTRACT

Knowledge of the faunal diversity, abundance and distribution of mammals are basics for the status determination and proposing appropriate conservation measures. This study was aimed to determine diversity, habitat preference and relative abundances of mammals in the semi-natural forest of JIT campus. The study was carried out from December 2018 to August, 2019. The area lacks any scientific documentation regarding its faunal diversity and relative abundance. The stated area was classified into three habitat types (farmland, wetland and forest area). To identify the species diversity and abundance of small mammals, both local and Sherman live traps were used to capture the animals. To generate data for medium and large mammals, a line transect survey method was implemented for all the three habitat types. Data for nocturnal mammals obtained from sensor cameras. A total of 19 species of mammals grouped into six orders and 12 families were recorded from the area. Among the identified mammals, four were small mammals and the rest 15 were from the medium and large mammal category. The highest species diversity of small mammals was recorded in forest habitat during dry season (H' = 1.4), while no species of small mammals were sampled from wetland during the wet season (H' = 0). Mus musculus was the most abundant specie (43.13%) recorded from all habitats during both seasons, while H. gambianus was the rarest species (13%). Regarding medium and large sized mammals, the highest diversity was recorded in the forest area during the wet season (H' = 2.52) whereas the least diversity was sampled from the wetland (H' = 1.4) during the same season. Chlorocebus aethiopis was the most abundant mammal (26.21%) in each habitat, whereas Canis aures was the least abundant species (1.4%). Variation in diversity and abundance of mammals is depends on the tolerance capacity of the animals to survive in highly human disturbed areas, and availability of different types of foods and plant species in the area. The availability of food, water and shelter is in turn depends on seasonal variations. Despite the study area provided habitats for various species of mammals, the high level of human disturbance putting extreme negative effects on the faunal composition of the area. Hence, there is a need for urgent conservation measures to save the biodiversity of the area.

Key words*: Habitat preference, Mammals, relative abundance, species distribution*

1. INTRODUCTION

1.1 Background

Ethiopia is a country of geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges and rolling plains. It is often known as “the roof of Africa” due to its mountainous nature (Nievergelt, 1981). The altitudinal variation within the country produces a range of climate, which affects every aspect of life in the country. Plant and animal distribution and the concentration of people and the types of agriculture varied with altitudinal variations. Temperature, rainfall and vegetation play major roles in determining the distribution of fauna including that of endemic mammals (Yalden and Largen, 1992). The flora of Ethiopia is very diverse with an estimated number between 6,500 and 7000 species of higher plants, of which 15 percent is endemic (Solomon and Meseret, 2014).

Ethiopia is among countries with rich faunal diversity in Africa and has great attractions of wildlife heritage. Over 320 species of mammals are recorded from Ethiopia of which 36 species are endemic, and about 60% are medium and large sized mammals (Afework and Yalden, 2014). The highest level of endemicity in the fauna of Ethiopia appears to be related with highlands (above 3000m) in the country (Yalden, 1983). Endemism even occurs at the level of genera. There are six endemic genera of mammals recorded so far of which four are monotypic (*Megadendromus*, *Muriculus*, *Nilopegamys*, and *Theropithecus*) and the other endemic genera are *Desmomys* and *Stenocephalemys* (Vreugdenhil *et al*., 2012).

One common way of classifying mammals is based on their size even though it does not show their taxonomic relationships. Small sized mammals are mammals weighing below 2 kg such as rodents, bats and insectivores. Medium sized mammals are mammal weighing between 2 and 7 kg such as small carnivores, small primates, large rodents, hyraxes, and those mammalian species with more than 7 kg are considered to be large sized mammals. These include most diurnal primates, most carnivores larger than a fox or house cat, all perissodactyls (horses, rhinos, tapirs) and artiodactyls that includes most herbivores (Emmons and Feer, 1997).

To protect and conserve these diverse and important biological resources such as endemic animals, 12 National Parks, 11 Wildlife Reserves, 3 Sanctuaries, 18 Controlled Hunting Areas and 69 Important Bird Areas have been established as refuge in Ethiopia (Zewdu and

Yemesrach, 2005). These areas are not only act as biodiversity "banks" but also have a direct economic benefit; bringing in revenues from tourism.

For several years, the natural ecosystems of the world have been altered due to anthropogenic effect and natural factors. Many habitats of mammals are undergoing degradation due to high human activities for several purposes. Most of the forest lands have been converted into agricultural and pastoral lands (Stoddart, 1984). Agricultural development often pays little attention to biodiversity and wildlife; it concentrates more on livestock and crop production despite its devastating impacts on the environment. Agriculture impacts both small and large mammals through fragmentation of habitats which may lead to edge effects (Rosenzweig, 2003; Primack, 2010), changes habitat quality in terms of cover and food due to overgrazing, and introduction of new crops or invasive species which may be of poor nutrition to mammals (Palakova *et al.,* 2011). As a result, wildlife resources are largely restricted to protected areas, where they are relatively well preserved; but the records and conservation status are still poorly known outside these areas (Young, 2012).

Urbanization exposes wildlife to new challenging conditions and environmental pressures (Santini *et al.,* 2019). Wildlife-human interactions are increasing in prevalence as urban sprawl continues to encroach into rural areas. Once considered to be unsuitable habitat for most wildlife species, urban/suburban areas now host an array of wildlife populations, many of which were previously restricted to rural or pristine habitats (Stephen *et al.,* 2006). The presence of some wildlife species in close proximity to dense human populations can create conflict, forcing resource managers to address issues relating to urban wildlife. However, evidence suggests that wildlife residing in urban areas may not exhibit the same life history traits as their rural counterparts because of adaptation to human-induced stresses (Jung & Kalko, 2011). Population control or mitigation efforts aimed at urban wildlife require detailed knowledge of the habits of wildlife populations in urban areas.

Information on diversity and abundance of mammals is central to understanding ecological processes including population dynamics, demography, and the community structure of mammals. Such information has significance in conservation that it can pinpoint areas of high diversity of mammals and help managers understand effects of habitat fragmentation, loss of top predators and exploitation of mammalian fauna for the welfare of human kind (O'Connell, 1989).

Even though Ethiopia possesses many mammalian fauna, limited studies have been carried out in different parts of the country with focus on large intact and protected habitats (Zewdu and Yemesrach, 2005; Solomon, 2008). However, there is no sufficient study on small fragmented habitats, particularly those adjacent to cities and towns that could serve as population stock source with significant economical, ecological, social, and cultural values (Mohammed and Afework, 2017). Thus, it is crucial to document their diversity, patterns of species richness, and community compositions in different fragmented forests in order to facilitate sound decisions regarding their conservation. Fragmented semi-natural forest of JIT campus is one of such areas without documented biological information about the composition of mammalian fauna of the area. Thus, the present study was aimed at investigating the status of species diversity, relative abundance and habitat preference of wild mammals in the area.

1.2 Statement of the problem

Due to the expansion of human settlement and agricultural land expansion, many wildlife species have become increasingly harmed. As a result, the wildlife populations are forced to occupy fragmented habitat areas (Girma *et al.*, 2012) that are often found in town forest remnants and grave yards. However, the significance of such small fragments of wildlife habitats in maintaining diverse groups of wildlife species is poorly understood. Jimma Institute of Technology campus fragmented forest is one of such habitats that lack any scientific information concerning its faunal diversity. Therefore, the present study was aimed to fill this gap by collecting data on the diversity, habitat preference and relative abundance of mammals in the stated fragmented forest of JIT campus, Jimma, South West Ethiopia.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study was to determine the diversity, relative abundance and habitat preference of mammalian fauna in fragmented forest of Jimma Institute of Technology campus, in Jimma area.

1.3.2. Specific objectives

The specific objectives of this study were:

- To record the species diversity of mammals in the study area.
- To identify the relative abundance of mammalian species in two seasons in all habitats of the study area.
- To investigate the habitat preference of mammalian species in the study area.

1.4 Significance of the Study

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

Identifying the diversity, relative abundance and habitat preference of mammalian species is very important to conserve and manage wild mammals properly. Therefore, the findings of the present study would document and provide detail scientific information of mammalian species in JIT campus fragmented forest, which is important for the future development of sound management plan for the area. It also play significant role to assess potential to establish city zoo or reserving wildlife areas in the towns. In addition the information collected will serve as a base line for other researchers interested to carry out additional studies in this area.

2. LITERATURE REVIEW

2.1 Biodiversity

Biodiversity is the total variety of life on the earth. It includes all genes, populations, species and ecosystems and ecological processes of which they are part (Burley, 2002). At ecosystem level, biodiversity underpins the ecological processes which are vital to human life, for example, in influencing global climate patterns, in mediating carbon cycle, in safeguarding watersheds, and in stabilizing soils to prevent desertification (Tillman *et al.*, 1999). At species level, components of biodiversity in the form of domesticated and wild animals, plants and microorganisms provide a vast array of goods and services, which are essential for the survival of humanity, as well as having of enormous economic value (Stattersfield *et al*., 1998). Villagra *et al*., (2009) stated 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). In addition to food, medicine, fuel wood and construction materials, biological resources provide wildlife habitat and recreational opportunities. They also act as important biotic checks to pests, and serve to act against global climate change (Scholes *et al.*, 2006).

According to Stattersfield *et al*. (1998), one of the most important attributes of biodiversity is that it is not evenly distributed. 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.

The distribution of species is determined by climate, availability of suitable resource, barriers of dispersal and interspecific interaction with those organisms sharing the same area. Distribution of mammals occurs in two levels namely geographical distribution and the local distribution. The 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). Structurally complex habitats may provide more niches and divers ways of exploiting environmental resources and thus increase species diversity (Bazzaz, 1975). In most habitats, plant communities determine the physical structure of environment and therefore have a considerable influence on the diversity, distribution and interactions of animal species (McCoy and Bell, 1991).

Biodiversity can be affected by different conditions. Naturally occurring phenomena such as fire, volcanic eruption and floods can adversely affect community and there by diversity. The major is humanitarian activities like habitat destruction, hunting, fishing, introducing invasive species, fuel wood gathering and agriculture can be mentioned (FAO, 2001).

2.2 Mammalian Diversity

Although mammals share several features in common, they also contain a vast diversity of forms. They have evolved to exploit a large variety of ecological niches and have numerous adaptations to take advantage of different life styles (Flym *et al.*, 2005). They comprise attractive class of animals that display tremendous morphological, physiological and reproductive diversity (Griffiths, 1984). They range in size from African pigmy mice *(Musminutoides*) (weigh as little as less than 2kg) to blue whale which weighs over 160 tones (Mugatha, 2002). Monotremes, marsupials, and eutherian mammals can be distinguished by variety of characteristics but they have different modes of reproduction that most clearly lead to their classification (Flym *et al.*, 2005).

According to Wilson and Reeder (2005), more than 5400species of mammals exist today which are placed under 29 orders. However, systematists do not yet agree on the exact number or on how some orders and families are related to others. Over 1,150 species of mammals are recorded from Africa, belonging to 13 Orders and 50 Families (Kingdon, 2004).

Mammals inhabit every terrestrial biome, from deserts through tropical rainforests to polar icecaps. Many species are arboreal, spending most or all of their life time in the forest canopy. Many mammals are partially aquatic, living near lakes, streams or the coastlines of oceans. Social behaviour varies considerably; some mammals live in groups of tens, hundreds, thousands or even more individuals. Other mammals are solitary except when mating or raising young. Activity patterns among mammals also cover the full range of possibilities. Mammals may be nocturnal, diurnal or crepuscular (Reichholf, 1990). Among mammals living today, 0.1% of them are eggs laying and 99% are placental, and found on all continents, occurring from the arctic in the north hemisphere to the southern tips of the continents and large islands in the southern hemisphere (Nowak, 1991).

2.3. Habitat and distribution of mammals

The distribution of species is explained as the sum of many local populations and the distribution of a particular species or group of populations. The habitat associations of large mammals are determined in terms of their basic requirements such as food, water and other conditions or factors (Oubert, 1976). Environmental influence has molded the distribution patterns of mammals within the area and on the continent as a whole (Kingdon, 1971). According to Balakrishinan and Easa (1986), habitats in terms of mammals are related to the vegetation composition, floristic and structure of the area. Therefore, the structure and composition of vegetation, determine the distribution, abundance, and diversity of mammalian community residing in it. Complex habitats may provide more niches and diverse ways of exploiting environmental resources and thus increase species diversity (Bazzaz, 1975).

Climate has direct influence on the distribution and abundance of mammals, especially, in those areas where seasonal contrasts are prominent. In such areas during the dry season, bush fire scorch large area, and large area appears devoid of green growth that directly or indirectly sustains all mammals (Inglis, 1976). To counterbalance these climatic effect, most mammals change food habits (moving to new pasture), herds assemble or disperse and in many species, breeding rhythms are clearly associated to the seasons. Climate determines vegetation, which in turn affects the distribution and abundance of larger mammals (Gaston, 2000).

Altitude wise distribution of animals including mammals is reported to follow different patterns in different parts of the world. In the case of groups of terrestrial organisms, diversity has been found to decrease with increasing altitude (Stevens, 1992).

2.4 The ecological roles of mammals

Mammals are an important ecological constituent of terrestrial ecosystems. Small mammals, particularly rodents are essential components of all terrestrial ecosystems. They play important part in natural communities, and provide the main supply of living food for many of the predatory mammals, birds and reptiles (Davies, 2002). They are also useful in the study of environmental gradient (Mena and Vazque-Dominguez, 2005), and good indicators of habitat change. Some of them are considered as pioneer species of ecosystem succession (Davies, 2002). Rodents play important structural roles in different ecosystem services by pruning or eliminating vegetation types, aerating soil through their digging and burrowing activities, spreading seeds, pollen and competing with other animals (Kingdon, 1997). They are also valued as vital food sources in many regions of Africa. For example, they comprise an important component of the diet of the Gumuz indigenous people in Ethiopia (Tadesse, 2005). In addition, rodents serve as model organisms for studying the effect of tropical forest fragmentation (Lambert *et al.*, 2003).

Medium and large −sized mammals are very sensitive and intolerant to disturbance and indicators of the healthiness and integrity of ecosystem (Carvalho *et al.*, 2014). The functional significance of these species lies in their ecological roles, such as seed dispersal and predation on numerous plant species. These functional roles may change the structure and composition of the ecosystem. Moreover, these species influence the community structure and complexity on the trophic levels in which they are involved, due to their regulatory role as preys and predators (Roemer *et al*., 2009).

Large carnivores frequently shape the number, distribution, and behaviour of prey animals. Large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation (Dinerstein, 2003). Furthermore, both set of mammals profoundly influence the environment beyond direct species interaction such as through cascading trophic effects (Berger *et al*., 2001). Large sized mammals perform important ecological functions and are good indicators of the habitat value because they do not typically rely on specific single habitat as many small mammals do (NLFC, 2005). Many mammals (mainly herbivores) serve as human food sources in different countries.

The loss of these organisms could have devastating effects because they contribute in many ways to the functioning of the natural ecosystem (Alonso *et al*., 2001). Given the importance of these species, studies identifying and predicting the environmental changes that may affect their diversity are essential, and in such studies, relative abundance and species diversity are usually used as indicators (Carrillo *et al*., 2000).

2.5 Mammals as pests

In developing countries rodent infestation poses a serious threat for reduction of income and widespread of food shortage by causing substantial damage to food and cash crops worldwide. They are serious pests, and farmers often list rodents as one of their most significant crop pests (Stenseth *et al*., 2001). Rodents cause direct damage to various crops or commodities by gnawing and feeding, and indirect damage by spoiling and contamination. They damage and destroy 30% of the crops in both pre-harvest and post-harvest conditions, being major agricultural pests globally. Rodents cause 5-10% pre-harvest and up to 20% post-harvest rice loss in Asia (Singlten, 2001). Singlton *et al*. (2003) reported that in Asia alone, the amount of rice eaten by rodents in rice fields each year would provide enough to feed 200 million Asians for a year. In 1999-2000-harvest season, rats in Australian cane fields destroyed approximately 825,000 tons of sugarcane valued at US $ 50 million (Smith *et al*., 2003).

Out of the 84 species of rodents in Ethiopia, 11 species are identified as agricultural pest; and they consume or destroy up to 20% cereal crops in some years in Ethiopia (Afework and Leirs, 1997). Among these rodents, *Mastomys natalensis* (Multimammate rats) are important pests in agriculture and the most successful seed and cereal feeders (Workneh *et al.*, 2006). Afework and Leris H. (2003) have also estimated yield loss at harvesting stage of maize as 26.4% in Ziway farm. Similarly, during the serious outbreaks of rodents, some areas in Kenya experiencing up to 90% maize harvest loss (Odhiambo & Oguge, 2003). Rodents are also involved in the transmission of more than 20 types of pathogens including plague, leptospirosis, boutonneus fever, marine typhus, brucellosis, Rift Valley fever, etc (Nowak, 1991; Fiedler, 1994).

Some medium and large sized mammals cause damage to agricultural crops, pasture, and forest nursery. Others are involved in disease transmission or hosts of diseases (Girma, 2012).

2.6 Threats to mammals

It is unfortunate that the survival of mammalian fauna is faced with natural and anthropogenic problems. They are threatened in most by many kinds of influences. The exact number of the species that are endangered is not known (Cuaron, 2008). However, the recent and seemingly sudden declines in many mammalian populations throughout world suggest that more species and populations are in precarious state (Cardillo *et al*., 2004).

Different activities of humans have its own impacts on wildlife by modifying the behavior of animals and their distribution. The disturbances of behavioral patterns can affect their social structure. Social structure is a key component in evolution and dynamics of species. Thus, its disruption by human disturbance can have major consequences on future populations even if the disturbance does not directly affect the survival and reproduction of mammals (Cardillo *et al*., 2004). Human induced habitat loss and associated forest fragmentation are the leading cause of mammalian extinction across the tropics (Wilkie, 2008). Growth of human population have been associated with extensive habitat disturbance related to changes in land cover, expansion of agricultural practices, settlements, uncontrolled resources extraction, introduction of exotic species and extensive fragmentation of the remaining forests. All these anthropogenic problems influence both the original plant communities and the heterogeneity and complexity of the entire ecosystem. This, in turn, influences the availability of resources, and affects the birth and death rates of several species, thus affecting vertebrate diversity (Murcia, 1995; Zarza, 2001). Human actions are causing a biodiversity crisis, with species extinction rates up to 1000 times higher than what normally used to be (Wilson, 2005).

Large and medium–sized mammals are particularly sensitive to habitat changes, and they are common victims of poaching and illegal trading (Michalski & Peres, 2006; Laurance *et al.*, 2008). Illegal trapping and other demands for wild mammals are problems throughout the world. Many species are sought for their use as valuable products for example, elephants for their ivory (Cardillo *et al*., 2004). Mammals are also trapped or taken from wild populations to be sold or breed in the pet trade (Brashares *et al*., 2004). The worldwide demand for pets drives illegal trade of mammals, especially rare species. Sadly enough, wildlife trafficking is thought be one of the most profitable illegal trades in the world (Cardillo *et al*., 2004).

2.7 Mammals of Urban Ecosystem

Once considered to be suitable habitat for a small subset of wildlife species, urban ecosystems are now used by a wide array of wildlife that had previously been associated with rural landscapes or undeveloped wilderness (Stephen *et al.*, 2006). Wildlife in urban areas is exposed to novel environmental pressures including high vehicular and pedestrian traffic, large-scale occurrence of impervious surfaces, chemical, acoustic, and light pollution (Grimm *et al*., 2008). Wildlife can either avoid or adapt by different degrees to urban areas (a process called synurbization). This translates into an overall impoverishment in the diversity of animal communities along urbanization gradients (Hamer, 2011), delineating a picture of a few ‘winners’, well adapted to urban environments, versus many ‘losers’ whose populations decline and eventually go locally extinct (Grimm *et al.,* 2008). A number of processes underlie the biodiversity loss due to urbanization, mostly related to species’ lack of adaptations for exploiting the novel resources and avoiding risks of the urban environment (Croci *et al*., 2008). Phenotypic plasticity, behavioural flexibility, dispersal abilities and niche generalization seem to have an important role for many mammal taxa to cope with challenges posed by human modified habitats (Evans *et al*., 2011; Fristoe *et al*., 2017). Probably the most common example of behavioral modifications of urban wildlife due to anthropogenic stress is temporal variation in activity patterns. Human activity in urban areas tends to be greatest during daylight hours, causing some species to switch their activity to crepuscular periods, or in some cases to become strictly nocturnal (Tigas *et al*., 2002; Riley *et al*., 2003)

Wildlife-human conflicts are rapidly growing in frequency, both as wildlife population increase in number and suburban landscapes continue to sprawl from the urban epicenter. In many cases, the presence of mammals in urban areas brings conflicts with people including zoonotic risks, damage to structures or goods, traffic accidents, direct attacks to humans or domestic animals, or negative consequences of digging, garbage raiding or defecating (Bateman & Fleming, 2012).

3. METHODOLOGY

3.1 The study area

3.1.1 Description of the study area

Fragmented forest of Jimma Institute of Technology campus is located at the outskirt of Jimma town towards the South-western end of the town. Jimma Institute of Technology was established in 1997 as the expansion of Jimma University on over 300 hectare. The study area covers approximately 260 hectares and characterized by three vegetation zones; the semi-natural forest (about 100 hectare), farmland (45 hectare) and wetland (115 hectare) (Figure 1).

The area is dominated by various indigenous and exotic plant species. The largest portion of the study area is covered by wetland (44.2%) with small seasonal stagnant water. It is common grazing area for livestock and wild mammals. The semi-natural forest covers the second largest portion (38.5%), and the rest (17.3%) of the study area is occupied by farmland for various agricultural activities. The forest habitat is characterized by mixed vegetation type composed of shrubs and woody species dominated by *Psidium guajava* and *Eucalyptus cretata* species.

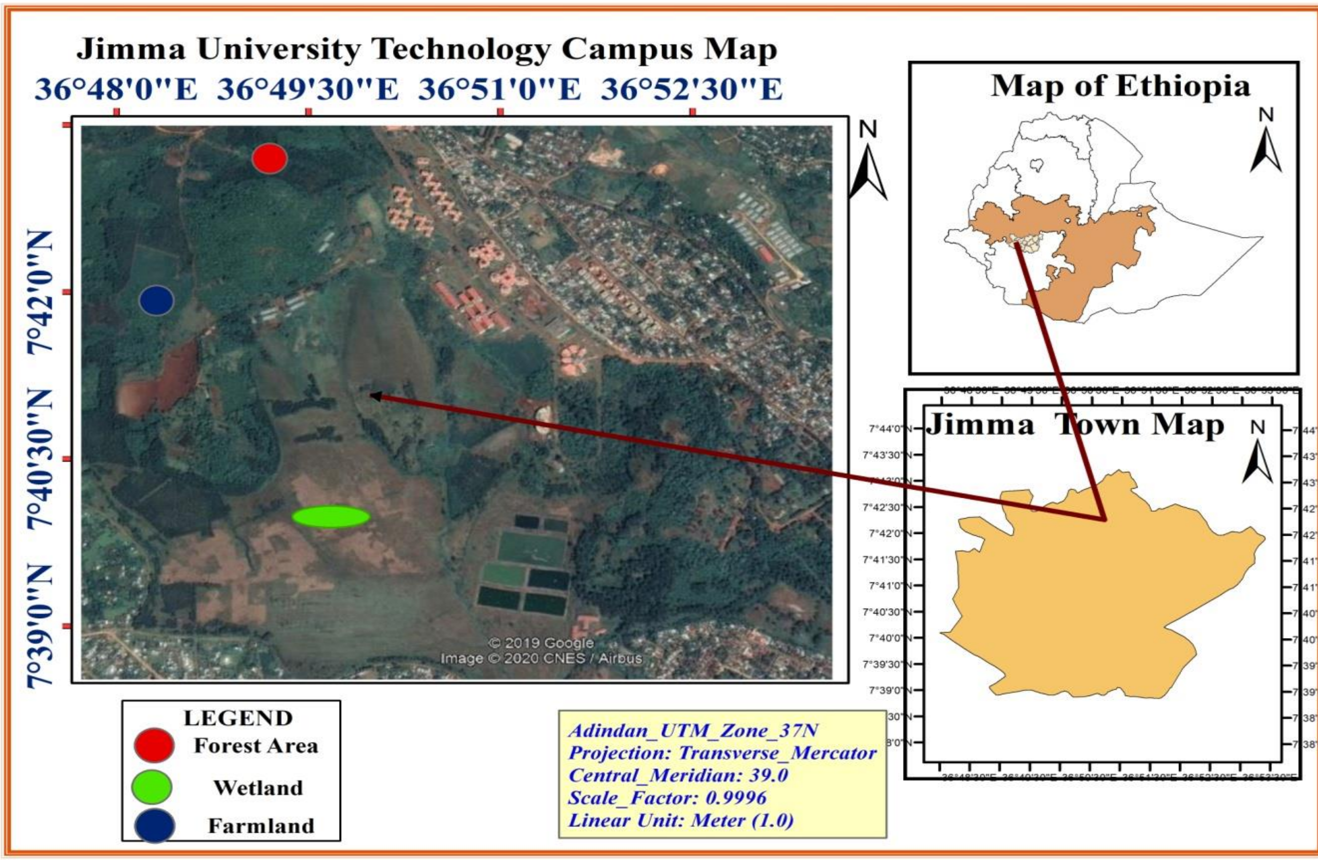

Figure 1. Map of the study area

3.1.2 Climate

Data used for the description of rainfall and temperature record of the study area was collected from EMA, West Oromia branch, (2019). According to the five years (2014 - 2018) rainfall summary, the mean annual rainfall in the area ranges between 1429 and 1935 mm (Figure 2). The rainfall in the area is uni-modal (having one long rain season) between May and September with a peak in August (with mean monthly rainfall of 1221.5mm). A marked dry season ranges from December to February.

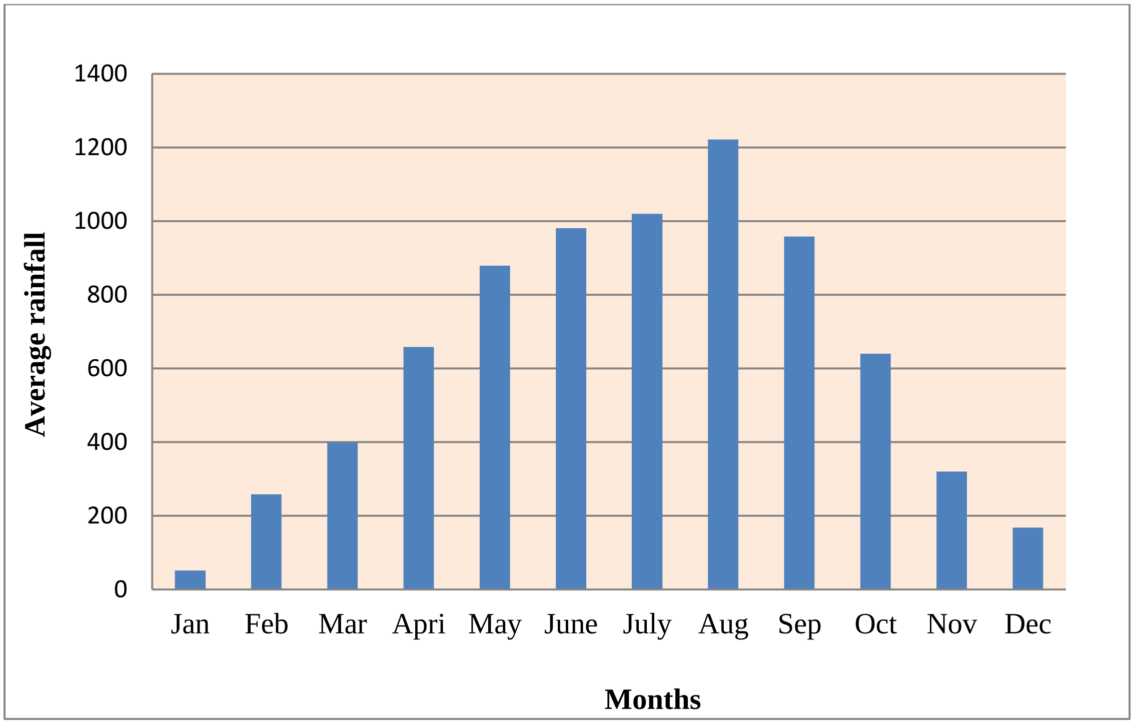

Figure 2. The mean monthly rainfall of the study area (2014 -2018) (EMA, 2019)

The study area is characterized by moderately warm temperature with a mean annual maximum 27.8°C and minimum 12.1°C. The daily temperature range is widest during the dry season, (from 10.5 °C – 29.6°C) and narrowest during the wet season (13.9 °C – 26.5 °C). The hottest months are February and March, (average temperature about 30.1 °C and 30.2 °C respectively), and the average coldest temperature is recorded in January (6.8°C) (EMA, 2019) (Fig. 3).

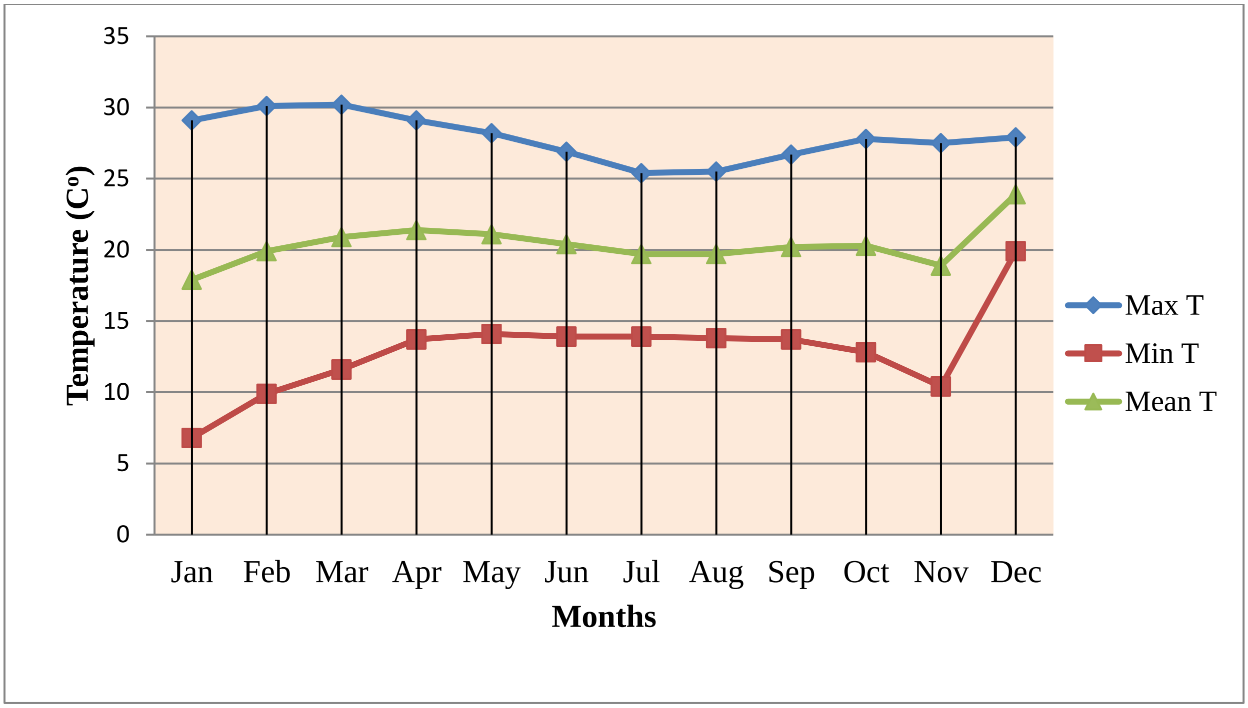

Figure 3. Mean monthly maximum and minimum temperature of the study area (EMA, 2019)

3.2 Methods

3.2.1 Materials

Materials such as data sheets, digital cameras, note books, tape measure, pesola spring balance, both local and Sherman live traps, sensor cameras, binocular and personal computer were used for the purpose of data collection.

3.2.2 Preliminary survey

Prior to the actual research, a preliminary survey was conducted in November 2018 in the study area to gather all the relevant information such as vegetation cover, habitat type and size of the study area.

3.2.3 The study design and data collection methods

Based on its vegetation cover, the study area was divided in to three habitat types (Wetland, farmland and forest area) during the preliminary survey. For small mammals, live trap procedure was used to capture animals. Data for medium and large sized mammals were collected by using line transect survey and sensor cameras. Data were collected from February to April, 2019 for the dry season and from June to August, 2019 for the wet season. A total of 94 study days were used in the study site to conduct preliminary survey and to collect the actual data from each habitat.

3.2.3.1 Data for small mammals

Data to record the diversity, abundance and habitat preference of small mammals of the area were collected using live traps. The traps were placed on a randomly set line transect at different trap sites. Transects were used to locate the traps easily. The number of line transects used was determined by the size of the habitats. Three line transects were used for both wetland and forest area each, whereas two transects were used for farmland. The length of each transects and distance between each transects were 120 m and 80 m respectively. A total of 36 live-traps (22 Sherman and 14 local traps) were used to capture the mammals. Each transects had12 live-traps which were placed at equal interval of 10 m (Perrin *et al.,* 1992) and was set for three consecutive days so as to cover the different vegetation zones. Trapping was conducted in February 2019 during the first data collection period and in July 2019 during the second data collection period. Each trap was baited with a mixture of peanut butter and corn flour. Trapping was preceded by a pre-baiting period to allow animals to familiarize with the traps. Traps were checked twice a day, early in the morning (07: 00 – 08: 30 am) and late in the afternoon (around 04: 30 – 06: 00) (Mohammed and Afework, 2017).

Standard biological measurements, such as sex, weight, head and body length (HB), tail length (TL), ear length (EL) and hind foot length (HF) were assessed (Afework, 1996). Rodent species were identified on the basis of morphological characteristics, such as ear, hind foot and tail length as well as fur texture and colour (Alpine *et al*., 2003).

3.2.3.2 Data for medium and large size mammals

Transect survey

A total of eight transects (three for wetland, three for semi-natural forest and two for farmland), representing each habitat were established and permanently used for both seasons. Based on the extent of the habitat, the length of transects vary, 1km for wetland and forest area, and 800m for farmland. There was 400m distance between any two transects for wetland and forest area and 300m for farmland.

Surveys were conducted twice a day when the animals were mostly active; in the morning (06:00 to 10:00 am) and late afternoon (04:00 to 06:30 pm) in each transects (Kabeta *et al.*, 2019). Two rounds of observation of mammals were made in March and April 2019 and also in July and August 2019 in the study site for dry and wet seasons respectively. Along transects, any large and medium sized mammal species observed and the number of animals seen was recorded. Mammalian species identification was made through direct observation with the naked eye and sometimes aided with binoculars. To have clear pictures of each mammalian species, observer noises were minimized and to avoid being smelled by the animals, observation was made by moving against the direction of wind as far as possible.

Camera traps

Nocturnal and cryptic medium and large sized mammals were recorded using sensor cameras triggered by body heat and motion of animals passing by (Rovero *et al*., 2014). Seven wildlife sensor cameras (Bushnell Trophy Cam. Model #S.119537C, 2013, USA) were set with high potential for detecting mammals in each habitat type (Jansen *et al.*, 2014). Cameras were also placed facing microhabitats of interest such as burrows, caves, edges of farmland and waste disposal areas as potential attractants. To maximize the capture success for both medium and large animals, cameras were set following procedure in Jansen *et al.* (2014) and Srbek-Araujo & Chiarello (2005). Accordingly, cameras were programmed to operate at night and to take sequential videos for 30 seconds with one second interval between successive captures. At each habitat type, cameras were installed for 10 days and checked daily for recorded data and battery replacement. This activity was done in February, 2019 for dry season and in August, 2019 for wet season.

3.5 Data analysis

Species diversity of mammals was calculated using the Shannon-Wiener diversity index (H') (Shannon and Wiener, 1949).

$$H' = -\Sigma\ [\{ni/N\} \times \ln[\{ni/N\}]$$

Where *ni*= number of individuals of each species (the i^{th} species) and

N = total number of individuals for the site, and *ln* = the natural log of the number

Species evenness, which represents the distributional patterns of mammals along the different habitats, was calculated using the equation of Begon *et al*., (1996).

$$J = H'/H_{max}$$

Where H' is Shannon-Wiener diversity index, Hmax = ln(S) and S is the number of species.
Simpson similarity index (SI) was computed to assess the similarity between the habitats with reference to the composition of mammals observed.

$$SI = nC/I + II + III$$

Where SI= Simpson's similarity index, C = the number of common species to all habitats, n= the number of habitats, I = the number of species in habitat one, II = the number of species in habitat two, III = the number of species in habitat three.
The relative abundance index of species was calculated by dividing the number of records of each species by the total number of records of all species.

Percentage of occurrence was calculated to determine whether the mammals were common, uncommon and rare. The observed mammals were categorized as common, if they were seen during all of the surveys (probability of seeing is 100% every time of the visit), uncommon if probability of seeing is more than 50% and rare if probability of seeing is less than 50% (Hillman, 1993; Rebira *et al*., 2015).

Trap success of small mammals was calculated to express the total number of animal trapped per total trap-nights according to Ofori *et al.* (2013). Thus,

$$Ts = Nc \times 100/Tn$$

Where: *Ts* = trap-success, *Nc* = total number of captures and *Tn* = total number of trap-nights.

4. RESULTS

4.1 Small mammals

4.1.1 Species composition of small mammals

During the present study, a total of 160 individuals of small mammals were recorded in 576 trap nights from the three habitat types in two trapping seasons. All the identified small mammals were categorized under a single order (Rodentia), two families (Muridae and Sciuridae) and four species. Among these mammals, 51.25% individuals were recorded in the dry season and the rest 48.75% were recorded in the wet season. All the species are categorized as 'least concern' by IUCN. Three species were identified by live traps (Figure 4), and the rest one species was sighted directly during the study period (Table 1).

Table 1. Species diversity of small mammals recorded from the study area

No	Scientific name	Order	Family	Identification Methods	IUCN status
1	*Rattus rattus*	Rodentia	Muridae	Live trap	LC
2	*Mastomys natalensis*	Rodentia	Muridae	Live trap	LC
3	*Mus musculus*.	Rodentia	Muridae	Live trap	LC
4	*Heliosciurus gambianus*	Rodentia	Sciuridae	Visual	LC

Mastomys natalensis

Rattus rattus

Mus muscallus

Figure 4. The three species of rodents trapped from the study area.

Of the total small mammals recorded for the area, *Mus musculus* had the highest number of individuals (n = 69), followed by *Rattus rattus* (n = 66) in both seasons each. *Mastomys natalensis* took the third position with 16 individuals. However, *H. gambianus* were rarely recorded with only 9 individuals. The highest number of individuals mammals was recorded from farmland (n = 100) (43 in dry, 57 in wet seasons), followed by forest area with 38 (17 in dry, 21 in wet season). Wetland was the habitat in which the least number of individuals of small mammals (n = 22) were obtained only in dry season (Table 2).

Regarding the number of species, farmland and forest area had four species each in both seasons, while three species were recorded in wetland in dry season, but no species was obtained in wetland in the wet season (Table 2).

Table 2. The small mammalian species recorded during the study period from the three habitats

No	**Species**	**Total records in each habitat type**						**Total**		**Overall total**
		Wetland		**Farmland**		**Forest area**				
		Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	
1	*Rattus rattus*	9	0	18	23	7	9	34	32	**66**
2	*Mastomys natalensis*	2	0	4	6	2	2	8	8	**16**
3	*Mus musculus*	11	0	19	24	6	9	36	33	**69**
4	*H. gambianus*	0	0	2	4	2	1	4	5	**9**
Total No. of individual		**22**	**0**	**43**	**57**	**17**	**21**	**82**	**78**	**160**
Total No. of species/ habitat		**3**	**0**	**4**	**4**	**4**	**4**			

4.1.2 Species diversity and distribution of small mammals

The species diversity and distribution of small mammals in the study area were varied among habitat types and between seasons. The highest species diversity was recorded from forest area during dry season (H' = 1.24), followed by farmland in wet season (H' = 1.15). However, the least species diversity was recorded in wetland (the diversity indices were 0 and 1.1 in wet and dry seasons respectively). The two habitats, farmland and forest area had similar species evenness in both seasons (J = 1.00). Wetland was also the least habitat in species evenness (J = 0) in wet season (Table 3).

Table 3. Species diversity (H') and evenness (J) of small mammals in the study area

Habitat types	Number of species		Number of individuals		SWI (H')		H 'max		Evenness (J)	
	Dry	***Wet***	***Dry***	***Wet***	***Dry***	***Wet***	***Dry***	***Wet***	***Dry***	***Wet***
Wetland	3	0	22	0	0.24	0	1.1	0	0.22	0
Farmland	4	4	43	57	1.09	1.15	1.39	1.39	1.00	1.00
Forest	4	4	17	21	1.24	1.09	1.39	1.39	1.00	1.00

Among the three habitat types, the highest species similarity of small mammals was recorded between farmland and forest area both during the dry and wet seasons (SI = 1.00). The species similarity was similar between wetland and farmland, and also between wetland and forest area during the dry seasons with the SI value of 0.86 each. However, no species similarity was observed between wetland and the rest two habitats in wet season.

4.1.4 Relative abundance and habitat preference of small mammals

Mus musculus contributed the largest number of individuals constituting 22.5% of the total catch, followed by *R. rattus* (21.25%) during the dry season each, while *H. gambianus* was the least abundant (2.5%) in the same season. There was a slight difference in relative abundance between *R. rattus* and *Mus musculus* during wet season (20% and 20.63% respectively). *H. gambianus* was also the least abundant species recorded during wet season (3.13%).

Most of the small mammals were recorded from farmland habitat in both seasons (62.5%). The forest habitat had the second highest number of species (23.72%). However, records in wetland show that this habitat is the poorest in terms of both species number and number of individuals that support only 13.75% of small mammals (Table 4).

Table 4. Seasonal variations in relative abundance and habitat preference of small mammals

No	Species	Seasons	Habitat types			Total	RA (%)
			Wetland	**Farmland**	**Forest**		
1	*R. rattus*	Dry	9	18	7	34	**21.25**
		Wet	0	23	9	32	**20**
2	*M. natalensis*	Dry	2	4	2	8	**5**
		Wet	0	6	2	8	**5**
3	*M. musculus*	Dry	11	19	6	36	**22.5**
		Wet	0	24	9	33	**20.63**
4	*H. gambianus*	Dry	0	2	2	4	**2.5**
		Wet	0	4	1	5	**3.13**
Total			**22**	**100**	**38**	**160**	

4.1.5 Trap success in habitat types and seasons

The mean trap success in the study area in 576 trap nights was 26.22%, with the highest trap success in the farmland during wet season (55.2%). This was followed by wetland where 22.92% trap success was recorded. However, the least trap success (15.63%) was recorded in forest area. Trap success throughout the study period indicated that 78 individuals were trapped during the dry season with 51.66% trap success, and 73 individuals were trapped in the wet season with 18.23% trap success (Table 5).

Table 5. Seasonal trap success of small mammals in different habitat types (excluding H. gambianus)

Habitat type	**Season**	**Trap nights**	**Total catch**	**Trap success (%)**
Wetland	Dry	96	22	22.92
	Wet	96	0	0
Farmland	Dry	96	41	42.7
	Wet	96	53	55.2
Forest area	Dry	96	15	15.63
	Wet	96	20	20.83
Overall		**576**	**151**	**26.22**

4.1.6 Sex ratio distribution

Regarding the sex of trapped small mammals, variations were observed among habitats and between seasons. More male individuals were trapped in the dry season (29.8%) than in the wet season (27.15%), while the number of trapped females was almost similar in both dry and wet seasons (21.85% and 21.19% respectively). However, the overall sum of trapped individuals indicated that 56.95 % were male and 43.05% were females. The overall sex ratio in the study area was 1:1.3.

4.2 Medium and large sized mammals

4.2.1 Species diversity

During the present investigation, a total of 15 medium and large mammals (two medium and 13 large sized mammals) were identified during both seasons in the study area. The mammalian species recorded belong to six orders (Lagomorpha, Primate, Artiodactyla, Carnivora, Hyracoidea and Rodentia) and 10 families. The order Carnivora constituted the highest number of species (five species), followed by Artiodactyla with four mammal species, and primates with three species. The orders Lagomorpha, Hyracoidea and Rodentia were represented by only one species each.

Among the mammalian species identified in the present study area, seven species (46.7%) were sighted directly during the study period and eight species (53.3%) were recorded by camera traps (Table 6).

Table 6. Medium and large mammalian species recorded from the study area

Order	**Family**	**Scientific Name**	**Common Name**	**Identification Method**	**IUCN status record**
Lagomorpha	Leporidae	*Lepus habessinicus*	Abyssinia hare	Visual	LC
Primate	Cercopitheci dae	*Colobus guereza*	Colobus monkey	Visual	LC
		Papio Anubis	Olive baboon	Visual	LC
		Chlorocebus aethiopis	Vervet monkey	Visual	LC
Artiodactyla	Bovidae	*Redunca redunca*	Bohor Reedbuck	Visual	LC
		Sylvicapra grimmia	Common duiker	Visual	LC
	Suidae	*Phacochoerus africanus*	Common warthog	CT	LC
		Potamochoerus larvatus	Bush pig	CT	LC
Carnivora	Viverridae	*Genetta genetta*	Common genet	CT	LC
		Civetticitis civetta	African civets	CT	LC
	Canidae	*Canis aures*	Common jackal	CT	LC
	Hyaenidae	*Corcuta corcuta*	Spotted hyena	CT	LC
	Hyrpestidae	*Herpestes sanguineus*	Slender Mongoose	CT	LC
Hyracoidea	Procaviidae	*Hetro hyrax brucei*	Bush hyrax	Visual	LC
Rodentia	Hystricidae	*Hystrix cristata*	Crested porcupine	CT	LC

CT = camera trap   LC = Least concern

During this study, variations were observed in individual numbers of medium and large sized mammalian species among the three habitats and between seasons. A total of 641 individuals of medium and large mammals were recorded from the study area (352 in the dry season and 289in wet season). Forest area contained 164 individuals, which was the highest in number of mammals during the dry season followed by farmland with 150 individuals during the dry seasons. The least record was obtained from wetland (27 individuals of mammals were recorded) during the wet season. For combined season, 256 and 295 individuals of mammals were recorded from farmland and forest area respectively, and again the least number of mammals (98 individuals) were obtained from wetland (Figure 5).

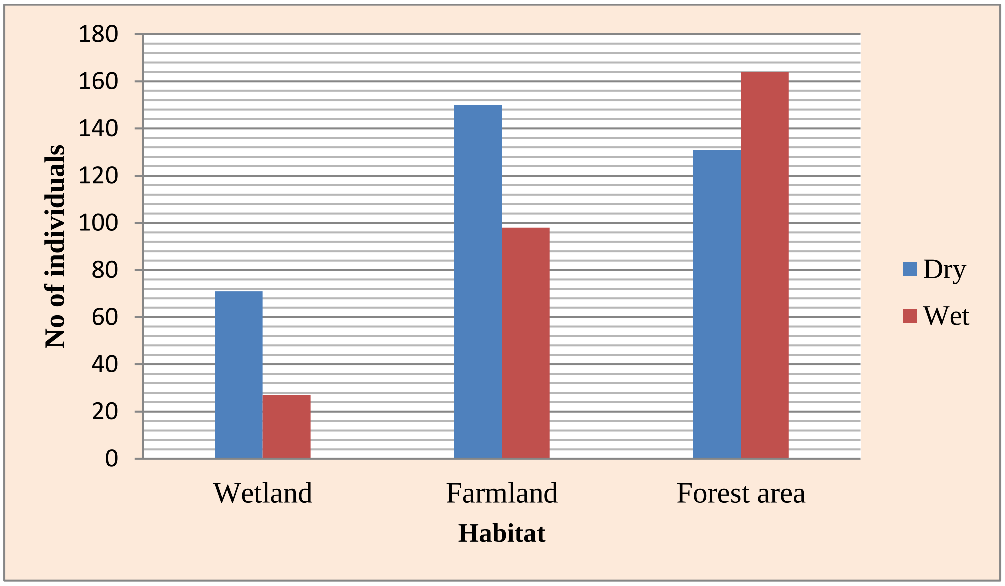

Figure 5. Abundance of medium and large sized mammals in the study area

In terms of species composition, the highest number of medium and large mammalian species (15 species) was recorded from forest area during both seasons, and from farmland in wet season. Farmland took the second position in supporting 14 species during dry season, and with 10 and 5 species, the least number of species was from wetland for dry and wet season, respectively (Figure 6).

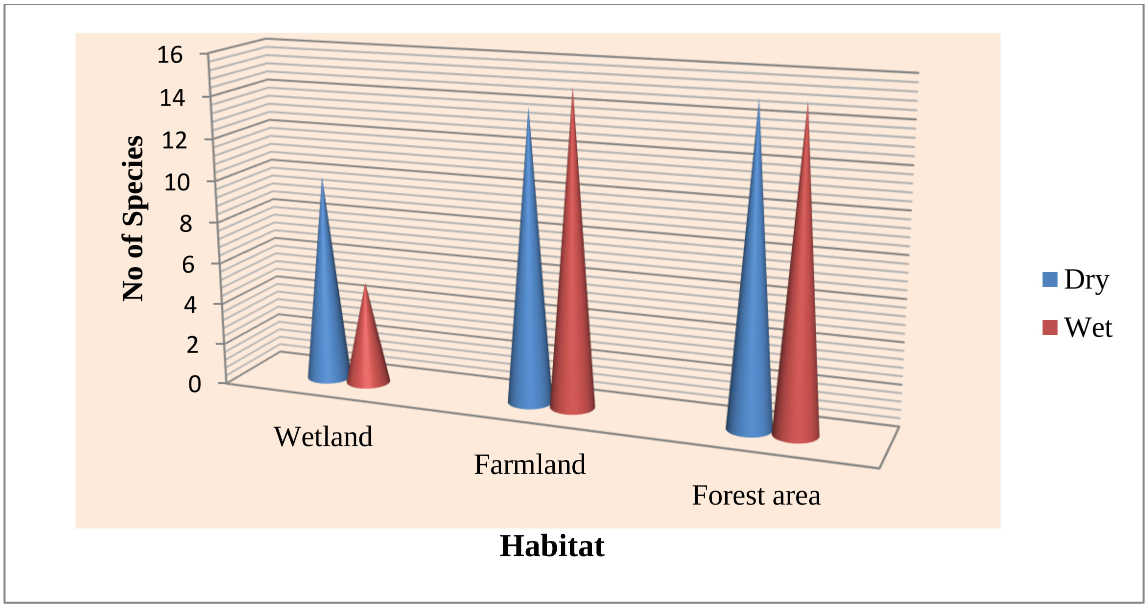

Figure 6. Seasonal variation in species diversity of medium and large mammals

4.2.2 Species diversity of medium and large sized mammals

Among the three habitat types, forest area supported the greatest diversity of medium and large mammals (H' = 2.52 with evenness J = 0.93) during the wet season. The second diversified habitat was farmland with H' = 2.29 and J = 0.85 in the dry season, while the least diversity was recorded from wetland (H' = 1.4, and J = 0.87) during the wet season (Table 7).

Table 7. Species diversity (H') and evenness (J) of medium and large sized mammals in the study area

Habitat types	**Number of species**		**Number of individuals**		**SWI (H')**		**H 'max**		**Evenness (J)**	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Wetland	10	5	71	27	2.1	1.4	2.3	1.61	0.91	0.87
Farmland	14	15	150	98	2.29	2.25	2.71	2.71	0.85	0.83
Forest area	15	15	131	164	2.02	2.52	2.64	2.71	0.77	0.93

4.2.3 Relative abundance and habitat preference of medium and large mammals

From the total of 352 individuals of mammalian species recorded in the study area in dry season, the most abundant species was Vervet monkey (*Chlorocebus aethiopis)* (30.68%). This species also took the first position in abundance during wet season (20.76%). The second abundant species was Olive baboon (*Papio anubis).* Like that of Vervet monkey, Olive baboon was also recorded frequently during both seasons in the study area (17.9% and 17.98% during dry and wet seasons respectively). Warthogs (*P. africanus*) were the third most abundant species (9.09%) in dry season. However, Spotted hyena (*C. carcuta*) and Common jackal (*C. aures*) were the least abundant mammals with less than 2% share each (Table 8).

Table 8. Relative abundance of medium and large sized mammals recorded during dry and wet seasons

No	Species Name	Total No. of individuals recorded		RA for each season (%)		RA For combined season (%)
		Dry	***Wet***	***Dry***	***Wet***	
1	Abyssinia hare (*L. habessinicus)*	10	3	2.84	1.04	2.03
2	Colobus monkey (*C. abyssinicus*)	19	21	5.4	7.27	6.24
3	Olive baboon (*P. anubis*)	63	52	17.9	17.98	17.94
4	Vervet monkey(*C. aethiopis)*	108	60	30.68	20.76	26.21
5	Bohor Reedbuck *(R. redunca)*	14	13	3.98	4.5	4.21
6	African civets (*C. civetta*)	26	24	7.39	8.31	7.8
7	Warthog (*P. africanus*)	32	24	9.09	8.31	8.74
8	Spotted hyena (*C. carcuta*)	5	6	1.42	2.08	1.72
9	Common genet (*G. genetta)*	18	17	5.11	5.88	5.46
10	Common jackal (*C. aures*)	5	4	1.42	1.38	1.4
11	Common duiker (*S. grimmia*)	11	21	3.13	7.27	4.99
12	Bush pig (*P. larvatus)*	8	11	2.27	3.81	2.96
13	Crested porcupine (*Hystrix cristata)*	9	12	2.56	4.15	3.28
14	Bush hyrax (*Hetro hyrax brucei)*	10	9	2.84	3.11	2.96
15	Slender Mongoose *(H. senguineus)*	14	12	3.97	4.15	4.06
	Total	**352**	**289**	100	100	100

4.2.4 Species similarity of medium and large mammals among the three habitat types

Among the three habitat types, the highest mammalian species similarity was observed between farmland and forest area during the wet season (SI = 1.0), followed by the species between the same habitats during dry season (SI = 0.97). However, the less similarity of mammalian species was observed between wetland and forest area, and also between wetland and farmland during wet season with the SI value of 0.5 each (Table 9).

Table 9. Similarity of medium and large mammalian species between habitats during wet and dry seasons

Habitat	Wetland		Farmland		Forest area	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Wetland	-	-	0.75	0.5	0.8	0.5
Farmland	-	-	-	-	0.97	1.0
Forest area	-	-	-	-	-	-

4.2.5 Occurrences of mammals

Based on occurrence, the medium and large sized mammals were grouped in to common, uncommon and rare species. Of the total mammalian species recorded during the study period, 3 species (20 %) were common, 7 species (46.7 %) were uncommon, and 5 species (33.3%) were rare (Table 10).

Table 10. Occurrence of medium and large sized mammals in the study area

No	Common	Uncommon	Rare
1	Colobus monkey	African civets	Abyssinia hare
2	Vervet monkey	Warthog	Spotted hyena
3	Olive baboon	Common genet	Common jackal
4		Crested porcupine	Bush pig
5		Bohor Reedbuck	Bush hyrax
6		Slender Mongoose	
7		Common duiker	
Total	3	7	5
% of occurrence	**20 %**	**46.7 %**	**33.3%**

5. DISCUSSION

In the present study, a total of four species of small mammals were identified from fragmented forest remnant of JIT campus. The species recorded were; *Rattus rattus, Mastomys natalensis, Mus musculus and H. gambianus.* The recorded species were not unique and are common to reported fauna from related habitats in the country. The recorded diversity and abundance, however, was relatively less as compared to most other areas elsewhere, for instance, Demelash, (2015) recorded 10 species of rodents from Natural and Coffee Forest habitats of Afalo, Gera Area; Mohammed *et al*. (2010) reported 17 specie from Chilalo–Galama Mountain range. Such greater variation in species composition might be due to relatively small size and high human interference of the present study area. However, it is comparable with other reports elsewhere in the country; for instance, Afework & Leirs (1997); Ejigu and Afework (2008) reported 5 species of rodents each from maize fields in central Ethiopia and from Bir Farm Development area respectively.

The present study revealed that variation in species composition of small mammal among the three habitats was not significant. Except wetland, where three species were obtained in dry season, the rest two habitats (farmland and forest area) contained four mammal species each during both the dry and wet seasons, but with greatly varied individual number and abundance. Such similarity in species diversity might be due to the close proximity of the two habitats as the animals move freely from habitat to the other.

Seasonality might cause the dynamic changes which occur in the habitats such as cover and food availability (Oguge, 1995). This study also revealed such seasonal variations in composition and abundance of species in the study area. More individuals of small mammals were recorded during the dry season (51.25%) than during the wet season (48.75%). This is comparable with finding of Tadesse and Afework, (2008); Demeke and Afework, (2012) who have reported more individual during dry season. *Rattus rattus* and *Mus musculus* were the most abundant and widely distributed species of small mammal in the present study area (43.13 % and 41.25% respectively), which was recorded from all habitats types. Such high diversity might be due to the ability of these species to tolerate the highly disturbed and degraded habitats with several microhabitats and diverse resources (Clausnitzer & Kityo, 2001). The least abundant small mammalian species recorded from the study area was *H. gambianus* during both dry and wet seasons (2.5% and 3.13% respectively). Different factors might be attributed to the lower number of this species. For example, the less visibility and shy behavior of the animal might contributed to its less abundance.

The distribution of small mammals over the present study area was varied with habitats and seasons. Except *H. gambianus,* which was absent from wetland habitat, the rest three species *(R. rattus, M. natalensis and M. musculus)* were common for all the three habitats. The lowest composition and abundance of small mammals was recorded in wetland. This might be due to flooding of the area during the wet season, thereby reducing the suitability for the survival of the small mammals.

The variation in trap success among different habitat types was significant in the present study area. Trap success during the dry season was relatively higher (51.67%) than in wet season (48.34%). Regarding their habitats, the highest trap success was recorded in farmland (48.95%), and the least trap success was obtained from wetland (18.23%). Such larger variations in trap success might be due to the presence of crop remnants and stored grains in farmland that attract large number of small mammals, and the less suitable conditions in the wetland habitat that support small mammals. The present trap success was low as compared to the study by Tadesse and Afework (2008), who recorded with trap success of 36.8% from Alatish National Park and Mohammed *et al.* (2010), who recorded 44.1% from Chilalo Galama Mountain range. However, it was high as compared to the study by Demelash (2015), who obtained 21.48% trap success from Natural and Coffee Forest Habitats of Afalo Area, and also Getahun and Afework (2015), who obtained 15.8% from Arditsy Forest.

The present study also showed male biased sex ratio (male: female), which was 86:65. The sex ratio difference was also observed between seasons (29.8: 21.85% for dry and 27.15:21.19% for wet season). The possible reason for this fact is that males traveled over greater distances (Getahun and Afework, 2015). Such assumptions are consistent with those made by Hansson (1978), making them more likely to be trapped, as well as results from Tilahun *et al*. (2012) who have recorded higher capture frequency of males.

Regarding medium and large mammalian species, a total 15 species were identified during the present study period. Two of them were medium sized, and 13 were large sized mammals. The number of species recorded from JIT campus fragmented forest was less compared to the number of mammalian species recorded with a similar study in other areas. For example, Mohammed and Afework (2017) recorded 22 species of mammals from fragmented remnant forests around Asella Town. However, it is higher than the finding of Kabeta *et al*. (2019) who have reported 12 species from Wabe forest fragments, Gurage zone.

The results of faunal composition in different habitat types of the present study area indicated that the forest area contained the highest diversity of mammalian species during the wet season (H' = 2.52). The main reason is probably the availability of sufficient food and shelter for protection from predation. Studies by Dawud (2008) revealed that species diversity often high in areas where there are sufficient food and water sources. However, the lowest species diversity was obtained from wetland during wet seasons (H'= 1.4). The possible reason might be due to factors such as high human disturbance and less suitability of the area during wet season. Even, during dry season, wetland supports only grazers, so that mammals with other feeding behaviour are excluded from the area. Matias *et al*. (2011) showed the negative correlation between habitat homogeneity and animal species diversity.

Variation in the relative abundance of mammalian species in the present study area was observed between species to species and among habitats. Vervet monkey (*C. aethiopis)* was the most abundant species of mammals in the study area during both seasons (30.68% in dry and 20.76% in wet season). This mammal species was widely distributed in all habitat types of the study area; although it appeared to be more concentrated in farmland during dry season after the crops were harvested. Vervet monkeys were also frequently observed around peripheral area of the study area including building areas of the campus. Occasionally, they came in groups to the resident areas and disturb the local community. Rebira *et al.* (2015) reported similar abundance of primates from Dati Wolel National Park. Solomon and Meseret (2014) also reported similar finding from Borena-Sayint National Park. The existence of this animal in various habitats is perhaps due to the high reproductive successes, diversified foraging behavior and high tolerance level to human induced stresses (Dereje *et al.,* 2015).

Olive baboon (*Papio anubis*) was the second most abundant species in the study area during both seasons (17.9% in dry and 17.98% in wet season). The species was known to be widely distributed in forest area. The possible explanations for this could be the less suitability of wetland and the occupancy of farmland with crops during wet season; thus the only option is concentrating in forest area. In addition, the availability of different vegetation species in forest area contributed to the higher abundance of these species.

Regarding species similarity medium and large mammals among the three habitat types, the highest species similarity was obtained between farmland and forest area with the value of SI = 1.0 during wet season. This indicated that 100% of the recorded mammalian species of the study area were common to the two habitats. High species similarity might be due to the presence of similar resource suitable for mammals and the proximity of the two habitats, as mammals could move freely from one habitat to the other. The least species similarity was recorded between wetland and the rest two habitats during wet season (SI = 0.5 in both cases). Such less species similarity might be due to less suitability of wetland habitat during the wet season as it is flooded by temporary stagnant water. However, all the three habitats were contained 10 species in common even though the numbers of individuals were varied greatly.

The effects of anthropogenic activities on mammalian species of fragmented forest of JIT campus were substantial. Unfortunately, most of the human induced effects on the wild mammals of the area were practiced by the employees of the University rather than local community. The top most serious threats to the wildlife of the area were poaching. A number of local traps were set at different sites, particularly at the boundary of farmland and forest area. Bohor Reedbucks, bush pigs, common duikers and warthogs were poached for their meat. Vervet monkey, crested porcupine and olive baboons were poached for their destructive effects on crops, which both contribute to the disappearance and population decline of these mammals.

Domestic animals like dog and livestock were the major factors adversely affecting the wild mammals of the study area. The disposal of leftover foods and dead animals in the area by the University itself facilitates the occurrence of large number of dogs from the local areas. The presence of dogs might greatly influence the existence of wild animals. According to Doherty *et al.* (2017), the interaction between dogs and wildlife include predation, disturbance, disease transmission, competition, and hybridization. Livestock were also seen in all the habitats competing for food with mammalian species particularly ungulates. In general, if these threats continue, there might be no more chance to see the present floras and faunas of the study area.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The major purpose of the present study was to develop basic information on the mammalian diversity, relative abundance and habitat preference in JIT campus fragmented forest. The study area harbors a total of 19 species of mammals, despite being small fragmented area. The diversity, habitat preference and relative abundance of mammal species in the study area showed marked difference among habitats and between seasons during the study time. Such variations could be related to the difference in habitat preference of mammals and variations in the availability of water, food, vegetation cover and level of disturbance.

Most of the mammals in the study area are either disturbance tolerant or developed specific adaption to the prevailing conditions. The presences of disturbance tolerant and adaptive mammals in the study area suggest that this area is severely threatened and its resources are also severely depleted. Mammals such as Vervet monkey and Olive baboon were frequently observed in all habitats during both seasons. This indicated that their diversified foraging behavior and high tolerance level of the animals to human disturbances.

6.2 Recommendation

JIT campus fragmented forest is under intense anthropogenic pressure and requires management interventions to maintain the overall biodiversity, productivity, and sustainability of the area. Thus, the following recommendations are suggested to ensure the sustainability of fauna of the area.

- Mammals of the current study area are under high human induced pressures and require special attention and management interventions to sustain their existence.
- Effective conservation measure should be carried out through an extension work to create awareness among the local community and the staff members of the University itself.
- There are many roads crossing the area which connect the nearby farming areas, but might strongly influence the existence of the wild animals unless properly managed.
- Additional detailed study of long duration on the diversity and other ecological aspects of the area should be conducted to get detailed information of the area.

- The boundary of the University should be clearly demarcated and guarded from the interference of local community and domestic animals to minimize the pressure on wild mammals.
- The weak level of protection of mammals and their habitats should be improved through local community awareness, constructing, and maintaining fence, employing enough number of guards and controlling any illegal activities of local communities.
- Service giving facilities and infrastructures must be constructed in the way that they do not disturb biodiversity and animals habitats.

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APPENDICES

Appendix 1. Field data sheet used for recording the standard morphometric measurement of small mammals

Date ________________ Location ____________ Observe __________

Animal code	Sex	Weight	Head & body length (HB)	Tail length (TL)	Ear length (EL)	Hind foot length	Approximate age			Pelage color	Reproductive condition			
											Male		Female	
											Position of testis		Vaginal condition	
							Juvenile	Sub-adult	Adult		Scrotal	Abdominal	Closed	Perforated

Appendix 2. Field data sheet used for surveying medium and large size mammals

Study Area ______________Study site _____________ Date __________ Observer ________

No	Species	No, of individual	Habitat type	Time	Method of identification

Appendix 3. Row data of mammalian species recorded throughout the study period from different study site

No	Species	Total records in each habitat type						Total
		Wetland		Farmland		Forest area		
		Dry	Wet	Dry	Wet	Dry	Wet	
1	Abyssinia hare (*L. habessinicus)*	6	0	1	2	3	1	13
2	Colobus monkey (*Colobus guereza*)	0	0	6	8	13	13	40
3	Olive baboon (*Papio anubis*)	11	0	40	6	12	46	115
4	Vervet monkey (*Chlorocebus aethiopis)*	16	10	48	11	44	39	168
5	Bohor reedbuck *(Redunca redunca)*	8	4	3	5	3	4	27
6	African civets (*Civetticitis civetta*)	2	0	13	15	11	9	50
7	Warthog (*Phacochoeru africanus*)	13	2	11	14	8	8	56
8	Spotted hyena (*Carcuta carcuta*)	0	0	2	5	3	1	11
9	Common genet (*Genetta genetta***)**	4	0	7	8	7	9	35
10	Common jackal (*Canis aureus*)	2	0	1	1	2	3	9
11	Common duiker (*Sylvicapra grimmia*)	5	9	0	2	6	10	32
12	Bush pig (*Potamochoerus larvatus)*	0	0	5	8	3	3	19
13	Crested porcupine (*Hystrix cristata)*	0	0	3	6	6	6	21
14	Bush hyrax (*Hetro hyrax brucei)*	0	0	4	3	6	6	19
15	Slender mongoose *(I. albicauda)*	4	2	6	4	4	6	26
	Total number of individual per habitat	**71**	**27**	**150**	**98**	**131**	**164**	**641**
	Total number of species per habitat	10	5	14	15	15	15	

Appendix 4. Some of medium and large sized mammals recorded during the study period

Warthog

Slender mongoose

Bush pig

Common genet

Spotted hyena

Common duiker

Crested porcupine

African civet

Common jackal


Bush hyrax

Appendix 5. Photographs show various activities during the study period.

Setting local traps to capture small mammals

Conducting line transect survey in forest area

Taking morphometric measurements of trapped animals

Fixing camera traps to record nocturnal mammals