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**Species Richness, Abundance and Habitat Association of
Rodents in Yerer Mountain Forest Area, Central Ethiopia**

By

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TABLE OF CONTENTS

Contents	Page
ACKNOWLEDGMENTS	iii
LIST OF TABLES.....	iv
LIST OF FIGURES	v
ABSTRACT	vi
1. INTRODUCTION AND OBJECTIVES.....	1
1.1. Introduction.....	1
1.2. Objectives	8
1.1.1. General Objective	8
1.1.2. Specific Objectives	8
2. THE STUDY AREA AND METHODS	9
2.1.Geographic location.....	9
2.1.1. Climate.....	10
2.1.2. Flora and Fauna	11
2.1.3. Description of study sites.....	12
2.1.3.1.Forest	12
2.1.3.2.Bushland	13
2.1.3.3. Farmland.....	14
2.1.3.4. Grassland	15

2.2. Materials and Methods	16
2.2.1. Materials	16
2.2.2. Preliminary Survey	16
2.2.3. Sampling Design.....	16
2.2.4. Data Collection	17
2.2.4.1.Sherman live-trapping	17
2.2.4.2.Snap-trapping.....	18
2.2.5. Stomach content analysis.....	19
2.2.6. Data analysis.....	20
3. RESULTS	21
4. DISCUSSION.....	38
4.1. Conclusion and Recommendations.....	44
4.1.1. Conclusion	44
4.1.2. Recommendations.....	44
5. REFERENCES	46

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LIST OF TABLES

Table 1. Species abundance of rodents and insectivore in Yerer Mountain Forest Area...	22
Table 2. Species composition and relative abundance of live-trapped rodent and insectivore species	23
Table.3. Distribution and abundance of live-trapped rodents from different habitats.....	24
Table 4. Species richness and diversity of live-trapped rodents in the different habitats ..	27
Table 5. Seasonal species composition and abundance of live-trapped rodents from different habitats	28
Table 6. Sex ratio and age structure of live-trapped rodents during the wet and dry seasons	29
Table 7. Age groups of live-trapped rodents during different trapping sessions.....	30
Table 8. Sex and age distribution and trap success of live-trapped rodents	31
Table 9. Seasonal trap success of rodents from the different habitats types	32
Table 10. Density of rodents (No. of individuals per hectare) in the different habitats	33
Table 11. Biomass (g/hectare) of live-trapped rodents from the different habitats during the wet and dry season	34
Table 12. Weight and body measurements of snap-trapped rodents	35
Table 13. The number of pregnant females and embryo count for the snap-trapped species during the wet and dry seasons	36
Table 14. Seasonal mean percentage of stomach contents composition	37

LIST OF FIGURES

Figure 1. Map of the study area	9
Figure 2. Monthly average rainfall of Yerer Mountain Forest Area (2000-2010)	10
Figure 3. Average maximum and minimum temperature of the study area (2000-2010)	11
Figure 4. Photo of the forest habitat	12
Figure 5. Photo of the bushland habitat	13
Figure 6. Photo of the farmland habitat	14
Figure 7. Photo of the grassland habitat	15
Figure 8. Schematic representation of Sherman live-trapping grid.....	18
Figure 9. Species distribution in different habitat types	25
Figure 10. Seasonal species diversity of rodents in different habitat types.....	28
Figure 11. Population estimates during the different trapping sessions	32

ABSTRACT

An ecological study on the species richness, abundance and habitat association of rodents was carried out in the farmland, bushland, forest and grassland habitats of Yerer Mountain Forest Area from July 2010 to March 2011. By using Sherman live-trap and snap-traps, six species of rodents and one species of shrew were identified within 3312 trap nights. The identified species were: *Lophuromys flavopunctatus* (31.6%), *Stenocephalemys albipes* (18.0%), *Arvicanthis dembeensis* (16.4%), *Arvicanthis abyssinicus* (17.6%), *Mus Mahomet* (13.7%), *Dendromys mystacalis* (2.2%) and the shrew species *Crocidura fumosa* (0.5%). The variation in the species richness among the habitats was minimal. But there was significant variation in their relative abundance during wet and dry seasons. Seasonal species composition within each habitat was not significant. *C. fumosa* and *D. mystacalis* were the only species captured from the farmland and grassland habitats, during the wet and dry seasons, respectively. Except for *A. abyssinicus*, *C. fumosa* and *D. mystacalis* all the remaining species of rodents were trapped from more than one habitat. *M. Mahomet* was common to all habitat types during both seasons. High mean trap success (23.5%) and biomass (4151g/hectare) was obtained from the farmland habitat. The proportion of adult, sub-adult and young individuals showed variation between species and season. Number of pregnant females and embryo count showed seasonal variation. Stomach content analysis showed high proportion of plant matter in all samples. The study recommended the importance of further ecotourism based investigations on Yerer Mountain.

Key words: Biomass, Habitat association, rodents, species abundance and richness, trap success, Yerer Mountain

1. INTRODUCTION AND OBJECTIVES

1.1. Introduction

East Africa encompasses a widely varied topography, from coral strands to snow-capped mountains, rain forests to deserts, and from tropical to temperate regions (Smythe, 1986). Ethiopia is one of the East African countries with diverse physical and biological features (Leykun Abune, 2000). Its relief includes an altitudinal range of 110 metre below sea level at Kobar Sink in the Afar depression, to a peak of 4620 m asl at Ras Dejen in the Siemen Mountains (Shibiru Tedla, 1995). The extensive highlands and plateaus are the most distinguishing features that makes Ethiopia unique from other African nations. The high plateaux of Ethiopia are very extensive with many high peaks (Happold and Happold, 1989). Among all nations of Africa, highest average altitude is known to occur in this country (Fadda and Corti, 2000). During the Tertiary Period, the intrusion of lava resulted in the formation of the great height of Ethiopian plateau and the deposition of thick layer of basal (up to 3000 m deep) on the underlying marine cretaceous rocks (Yalden and Largen, 1992). The highlands are divided by the Great Rift Valley as it traverses the country from north to south. These highlands exceed 2500 m asl covering about 40% of the total land surface of the country (Afework Bekele and Corti, 1997).

The complex topography of Ethiopia coupled with environmental heterogeneity provides suitable habitats for a wide range of life-forms. The presence of such factors along the altitudinal variations in Ethiopia, produce wide range of climate. This can affect the distribution of flora and fauna, concentrations of people, type of agricultural practice, and the potential of evapotranspiration (Yalden and Largen, 1992). The highlands of Ethiopia are identified as areas of plant and animal endemism. More than 7000 species of higher plants, 284 species of mammals, 861 species of birds, 201 species of reptiles, 64 species of amphibians and more than 140 species of fresh water fish are identified from Ethiopia

(Yalden and Largen, 1992; Manyingerew Shenkut *et al.*, 2006; Dawit Kassa and Afework Bekele, 2008).

Mammals are quite diverse both structurally as well as functionally. There are more than 5,000 extant mammalian species recognized throughout the world (Feldhamer *et al.*, 2007). Of all the mammalian orders, Rodentia constitute the largest number of species (Kingdon, 1997; Vaughan *et al.*, 2000). Rodents account 44% of all the living mammalian species (Wolff and Sherman, 2007), with more than 2,000 species within 32 extant families (Feldhamer *et al.*, 2007). In Africa, there are about 14 families, 89 genera and 290 species of rodents. They are the most ubiquitous and abundant among the mammals (Sewnet Mengistu and Afework Bekele, 2003). East Africa has a wide variety of rodents. Most of them are endemic and account for about 28% of the total East African mammal fauna (Delany 1986; Kingdon, 1997).

Small mammals account 40% of all the mammals of Ethiopia (Yalden and Largen, 1992). Among the 284 species of mammals of Ethiopia, 31 are endemic, of which rodents hold 50% of the endemics (Afework Bekele and Corti, 1997). Rodent fauna of Ethiopia consists of 84 species and constituting almost 25% of the total mammalian fauna of the country (Yalden and Largen, 1992). Out of these rodent species, 15 (21%) are regarded as endemic to Ethiopia (Afework Bekele and Corti, 1997).

The Order Rodentia represents the most successful group in the class Mammalia (Honeycutt *et al.*, 2007). They inhabit all continents except Antarctica, and they occur in terrestrial, subterranean, arboreal, and semiaquatic habitats. They are distributed from the high Arctic tundra to equatorial rain forests, temperate bogs and swamps to hot, arid deserts and rocky mountain tops to sandy canyon bottoms (Feldhamer *et al.*, 2007; Wolff and Sherman, 2007). Rodents are found in all biomes, and many species often live in close association with humans. The species richness of this order is the result of succession of radiation, adaptation and diversification (Mason and Littin, 2003; Auffray *et al.*, 2009). The phylogeny of Rodentia has been a battlefield among and between molecular and morphological scientists (Huchon *et al.*, 2000). Despite confusion and lack of agreement in rodent classification,

there are three generally accepted major divisions in the order Rodentia. The grouping was based on the basis of skull structure and jaw musculature, specifically based on the origin of the masseter muscles (Kingdon, 1997; Vaughan *et al.*, 2000; Feldhamer *et al.*, 2007).

Among all the families of Rodentia, Muridae has a worldwide distribution and represents the most diverse group of rodents. They constitute almost 66% of the extant species of rodents (Vaughan *et al.*, 2000), containing 1,326 species of 17 subfamilies (Feldhamer *et al.*, 2007; Honeycutt *et al.*, 2007). Muridae comprises the highest percentage (84%) as compared to the nine families of rodents, which are found in Ethiopia (Afework Bekele and Corti, 1997).

Rodents reveal a variety of body shapes, from cylindrical to spherical and exhibit diverse locomotor adaptations, such as, cursorial, swimming, fossorial, jumping and gliding. Although the majority of rodents are small, they have variable body size, from less than 10 g to more than 66 kg (Wolff and Sherman, 2007). The tiny pygmy mouse (*Mus minutoides*) and capybara (*Hydrochaeris hydrochaeris*) are the smallest (5 g) and largest (50 kg) known living rodent species, respectively. However, rodents have been much bigger in the past. For instance, the giant fossil rodent from the Plio–Pleistocene of Uruguay, *Josephoartigasia monesi* was estimated to have weighed 1211 kg on average, and possibly as much as 2584 kg (Millien, 2008). But, the value seems overestimated and lies outside the range of size of any previously described rodent species. Generally, rodents show less overall variation in their body plan as compared to other members of the mammalian orders (Macdonald, 1984; Kingdon, 1997).

Despite the number of species and their widespread distribution and diversity, rodents are known to share many uniform morphological features. A prominent feature of all rodents is the presence of a single pair of large gnawing teeth on the upper and lower jaws. These incisor teeth grow persistently throughout the animal's life (hypsodont) and have to be continually worn down by gnawing. The name “rodent” derives from the Latin word *rodere*, which means “to gnaw” (Macdonald, 1984; Kingdon, 1997; Nowak, 1999; Feldhamer *et al.*, 2007; Wolff and Sherman, 2007).

Small mammals are important components of most natural ecosystems in East Africa. Although, most rodents are nocturnal, diverse groups can be observed under different ecological niches, like gliding from tree to tree (flying squirrels), living in an underground network of burrows (mole-rat) and even few are semi-aquatic (muskrats, beavers). Species with similar ecological niches may coexist within the same habitat as a result of niche segregation process. For this reason, habitats with more ecological niches may contain more species (Moreno-Rueda and Pizarro, 2010). Among others, rodent community structure and species richness have been related to habitat structure and complexity, area productivity, predation, trampling and grazing, surrounding landscape and the distance between similar habitats, succession of the vegetation and the presence of exotics (Avenant and Cavallini, 2007). The various characteristics of soil, like soil structure, fertility and texture can directly or indirectly influence the distribution and abundance of small mammals (Massawe *et al.*, 2008). Habitat structure and soil properties are major factors influencing selection of burrow sites by semi-fossorial rodents such as the ground squirrels (Desy, 1998).

The habitat of rodents is highly diversified as expected from high diversity (Demeke Datiko *et al.*, 2007). Habitat preferences of rodents and shrews in Africa are determined primarily by the type of cover and vegetation availability (Iyawe, 1988; Monadjem, 1997). Habitats with high diversity of plant species can support many diverse groups of mammal species (Gubista, 1999). An increase in habitat heterogeneity leads to an increase in species diversity (Cramer and Willig, 2002). In addition, vegetation density affects the microclimate and also provides protection for small mammals against predators. In contrast, mammal diversity tends to be lower in open habitats, where resources are limited (Silva *et al.*, 2005). Changes in landscape use and management can lead to a reduction in suitable habitats for small mammals (Scott *et al.*, 2008). Additionally, vegetation modification by larger herbivores restricts the habitat available to rodents as grazing and trampling reduces the vegetation cover. A decrease of vegetation cover leads to exposure of rodents to predators and, therefore, increases the predation risk (Goheen *et al.*, 2004; Hagenah *et al.*, 2009). Hence, landscape mosaic and characteristics, as well as habitat type availability, are potentially influential in determining species presence and persistence (Kupfer *et al.*, 2006).

The dynamics of population in many small mammals is the result of the combined effects of feedback structure (ecological interactions within and between populations), limiting factors (food, or predator), climatic factors (rainfall), and stochastic forces (Andreo *et al.*, 2008). Basically, rodent population exhibits a great seasonal and year to year variation. Their distribution pattern and relative abundance vary seasonally based on availability of food and vegetation cover (Serekebirhan Takele *et al.*, 2011). The seasonal distribution and quantity of rainfall are considered as major climatic variable in determining population dynamics of rodents in East Africa (Delany and Monro, 1985).

Reproduction plays a major role in the recruitment of diverse species of rodent population density (Workneh Gebresilassie *et al.*, 2006). Rodents are usually small-bodied animals with a fast life history and short life span. These characteristics enable a rapid population response to short term variation, including seasonal fluctuations in climatic conditions and food availability (Vessey and Vessey, 2007). There are speculations in the rodent population dynamics regarding their reproduction pattern. For instance, according to Krebs *et al.* (2007), urinary chemosignals may accelerate or delay sexual maturation in rodents and, in some cases, alter female patterns of reproduction. These indirectly affect the population growth. Diet quality is the most important factor that regulates the commencement of breeding in rodents (Jackson and Vanaarde, 2004). The onset of the rainy season is swiftly followed by the appearance of good ground cover and quality diet leading to increased rate of reproduction. Population outbreak of many species of rodents occurs when prolonged rainfall allows better survival of the young. The driving factors for rodent outbreak could be climatic fluctuations and environmental variations (Afework Bekele and Leirs, 1997).

Small mammals play a fundamental role in ecosystem functioning as they constitute the prey base for many predators (Schmidt *et al.*, 2002) and may potentially influence vegetation composition through selective foraging (Brown and Heske, 1990). Some species of rodents are common and often major players (keystone species) in their communities. Species of *Microtus*, *Peromyscus*, *Apodemus*, *Mus* and *Rattus* are good examples of such types of rodent species. Rodents are also described as indicators of ecosystem integrity in smaller

areas (Avenant and Cavallini, 2007). This is due to their survival adaptability and higher specialization capability to such type of habitats. Common species may have significant top-down effects on vegetation, as well as bottom-up impacts as substantial contributors to higher trophic levels (Lidicker, 2007). In most ecosystems, rodents function as a primary link between primary producers and secondary consumers (Avenant and Cavallini, 2007).

Rodents are not only essential components in the functioning of their communities; they are also known to provide wealth opportunities for evolutionary, ecological and behavioural investigations (Lidicker, 2007). They are also known to present tremendous social and cultural values in some parts of the world. For example, they are identified as important component of feeding culture of Gumuz indigenous people in the northwestern Ethiopia (Tadesse Habtamu and Afework Bekele, 2008). Over ten species of small mammals are known to consume by this ethnic group.

With their higher rate of reproduction and ability to inhabit different type of habitats, rodents present both positive as well as negative impacts on their environment. For instance, they play great ecological role by pruning or eliminating vegetation types, spreading seeds, competing with other animals and helping to spread diseases (Macdonald, 1984; Kingdon, 1997). On the other hand, many species impact human welfare as agricultural pests, carriers of zoonoses, pilferers of stored food, and damaging alien invaders of natural communities (Lidicker, 2007). Most of the agricultural pest rodent species belong to the family Muridae. Periodic population explosions of pest species are a particular hazard for rural farmers in many parts of Africa (Kingdon, 1997). Species of *Arvicanthis* (grassland rats) and *Mastomys* (Multimammate mice) are the most important agricultural pests in Africa (Workneh Gebresilassie *et al.*, 2006). These rodent species are widely distributed in the tropical parts of Africa. According to Afework Bekele and Leirs (1997), *Arvicanthis* spp. and *Mastomys* spp. are major pests to maize croplands of Ethiopia. Out of the 84 rodent species found in Ethiopia, 11 species are major agricultural pests (Afework Bekele and Leirs, 1997; Demeke Datiko *et al.*, 2007).

Several new species of rodents have been discovered from different parts of the world. The results of many studies have revealed the need for further exploration on small mammals distribution and diversity. In Ethiopia, several studies have been conducted on rodent diversity in different part of the country at different times (Yalden *et al.*, 1976; Yalden, 1988; Afework Bekele, 1996a,b; Workneh Gebresilassie, *et al.*, 2006; Manyingerew Shenkut, *et al.*, 2006; Serekebirhan Takele, 2006; Demeke Datiko, *et al.*, 2007; Afework Bekele and Leirs, 1997; Dawit Kassa and Afework Bekele, 2008; Tadesse Habtamu and Afework Bekele, 2008; Mohammed Kasso, 2008; Tilahun Chekol, 2009; Ayenew Gezie, 2009; Mossisa Geleta, 2010). But still more studies are needed to be carried out on the small mammals of Ethiopia.

The present study in Yerer Mountain Forest Area was conducted to address rodent species richness and composition and their association with different types of habitats. The finding of this study adds important information on the diversity and distribution of rodents in the central part of Ethiopia.

1.2. Objectives

1.2.1. General Objective

The general objective of the present study is to investigate the species richness, abundance and habitat associations of rodents in the Yerer Mountain Forest Area.

1.2.2. Specific Objectives

- To describe the species richness and abundance of rodents.
- To determine the distribution of rodents in different habitats.
- To determine the species composition of rodents in the area.
- To describe the habitat association of rodents.

2. THE STUDY AREA AND METHODS

2.1. Geographic location of the study area

The study was conducted in the Yerer Mountain forest area, which is located in the Oromia Regional State, East Shewa Zone. Yerer Mountain is situated at about 40 km southeast of Addis Ababa and 17 km north of Debre-Zeit. The study area was located between 8°52'00'' to 8°55'00'' N latitude and 38°58'30'' to 38°59'30'' E longitude (Fig. 1). The altitude of this mountain ranges from 2000 m at the southeast slope to the highest peak at 3100 m asl. There are five peaks which rise above 2900 metres. The mountain covers a total area of 6000 hectares of which 3500 hectares are designated as a forest land, under the management of Oromia Forest and Wildlife Enterprise (OFWE).

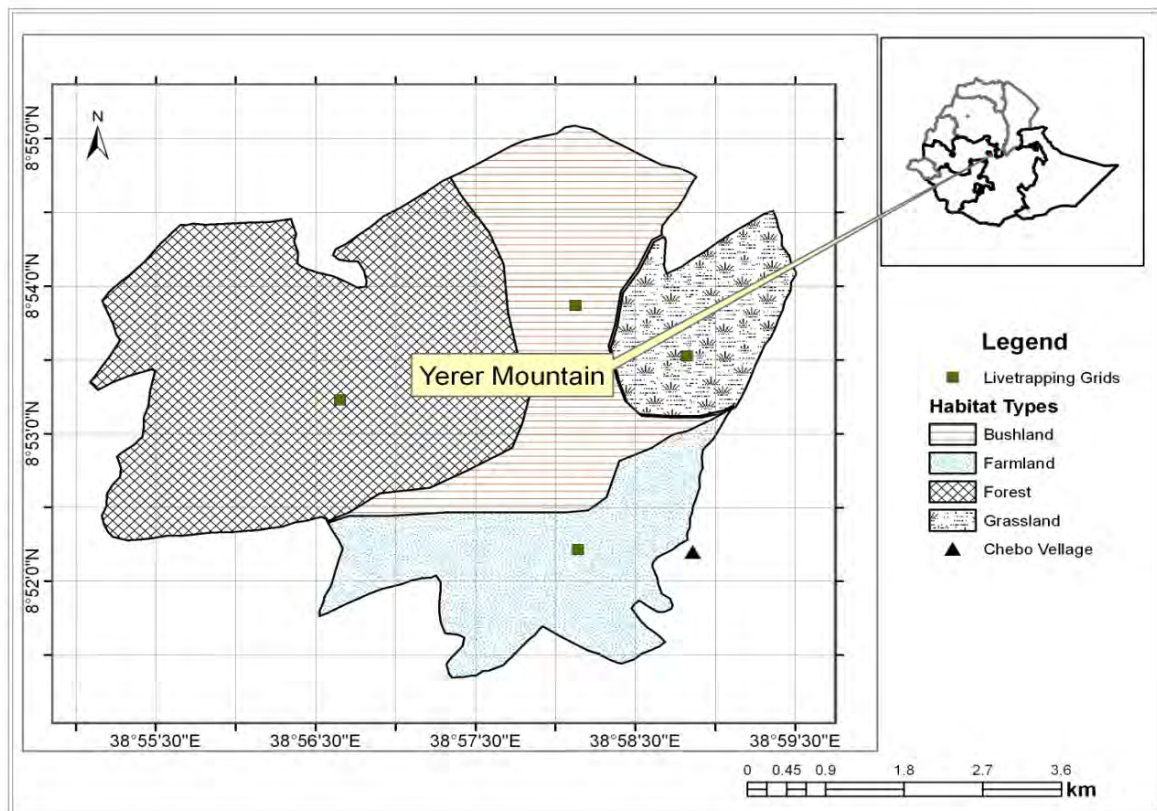


Figure 1. Map of the study area.

2.1.1. Climate

The climatic condition of the study area can be classified in the ‘Woina dega’ agro climatic zone. It is characterized by a unimodal rainfall having long rainy season. The area receives the highest rainfall during the wet season from June to September. Short rains occur at any months of the dry season, especially during March, April and May (Fig. 2). On an average, the area receives more than 1000 mm annual rainfall. The average minimum and maximum temperatures are 10°C and 26°C, respectively (Fig. 3).

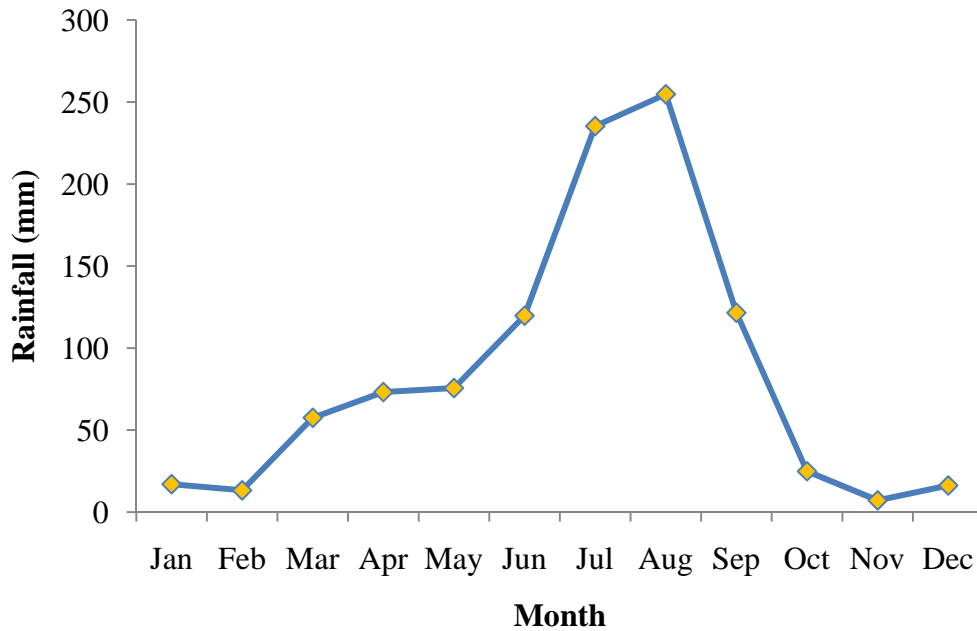


Figure 2. Monthly average rainfall of Yerer Mountain Forest Area (2000 to 2010)
(Source:Ethiopian National Meteorology Agency).

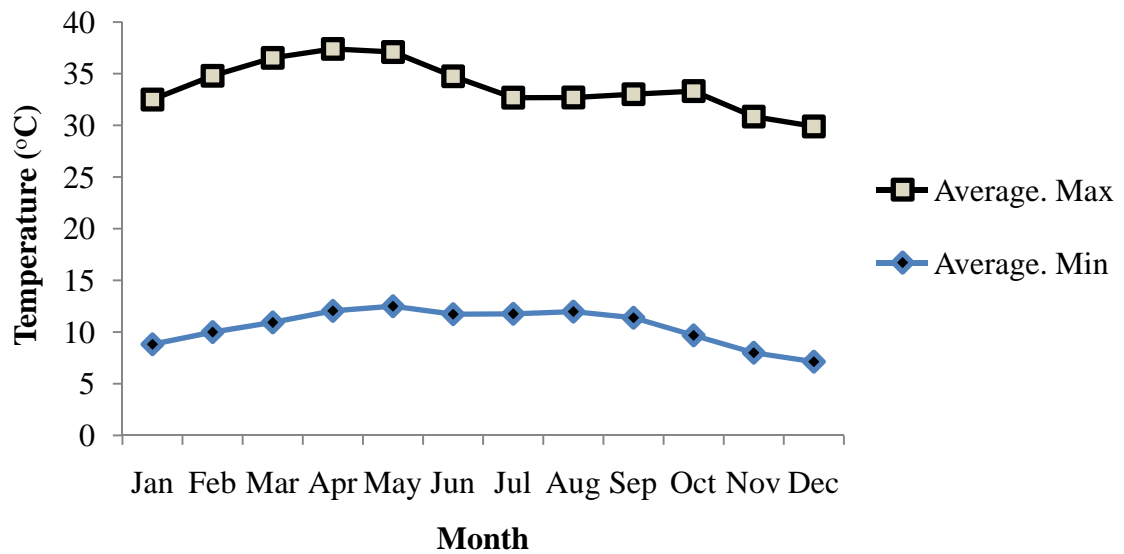


Figure 3. Average maximum and minimum temperature of the study area (2000 to 2010) (Source: Ethiopian National Meteorology Agency).

2.1.2. Flora and Fauna

The vegetation of Yerer Mountain is characterized by both natural forest and man-made plantations. The natural vegetation is dominated by tree species of *Juniperus procera* and diverse species of bushes, shrubs and herbs. Depending on the different environmental gradients like soil, altitude and other climatic factors, the species diversity of the natural vegetation varies from place to place. The upper part of the mountain is highly dominated by bushes and shrubs. The most common species of shrubs are *Carisa edulis*, *Alophylus abyssinicus*, *Maytenus arbutifolia*, *M. unduta*, *Erica arborea*, *Buddleja polystachya*, *Nuxi congesta*, *Entada abyssinica*, *Rosa abyssinica*, *Grewia ferruginea*, *G. villosa* and *Hypericum revolutum*. The man-made plantation is dominated by exotic species such as *Eucalyptus globulus*, *E. camaldulensis* and *Cuppressus lustranica*.

The different types of habitats produced by the natural forest as well as by the plantations support diverse groups of bird species and fewer larger mammals. The most conspicuous large mammals in the area are Klipspringer (*Oreotragus oreotragus*), Menelik's bushbuck (*Tragelaphus scriptus meneliki*), Bush duiker (*Sylvicapra grimmia*), Anubis baboon (*Papio Anubis*), Warthog (*Phacochoerus aethiopicus*) and spotted hyeana (*Crocuta crocuta*).

2.1.3. Description of study sites

2.1.3.1. Forest

The randomly selected study site of forest habitat is located within altitudinal ranges of 2440-2487 m asl. It is locally named as 'Dance' or 'Mekina-menged' (because of its proximity to the car track). It is dominated by tree species *Juniperus procera* with short plant species such as *Alophylus abyssinicus*, *Grewia ferruginea*, *Entada abyssinica* and *Erica arborea* (Fig. 4).



Figure 4. Photo of the forest habitat within the study area (Photo: Yonas Terefe, March, 2011).

2.1.3.2. Bushland

Bushland is the other habitat type selected for this study. It is the main characteristic feature on the northeastern slope of Mountain Yerer. Its altitudes range from 2245 to 2406 m asl. This site consists of deciduous and evergreen bushy plant species with a mixture of various herbaceous plants, scattered woody trees and grass (Fig. 5). This site possesses good ground cover during the wet season. Seasonal agricultural expansion has reduced the extent of area of this vegetation cover. Cleared ground was observed at the edges of this habitat during the period of preliminary survey.



Figure 5. Photo of the bushland habitat within the study area (Photo: Yonas Terefe, August, 2010).

2.1.3.3. Farmland

This study site is situated at the bottom of the southern slope of the mountain near Chebbo Village. At an altitude of 2171 m asl. Few short evergreen plant species were observed growing near the edges of a ploughing ground. This shows the area was previously covered by such types of plant species. The most dominant crop species in this site include wheat, teff, bean and barley (Fig. 6).



Figure 6. Photo of the farmland habitat (new growing shoots of wheat) within the study area (Photo: Yonas Terefe, August, 2010).

2.1.3.4. Grassland

The area near the highest peak of the mountain has good cover of grass as well as scattered *Erica* scrubs. The study site for this habitat type was set at almost 1 km far from the forest habitat. Its altitude is within the ranges of 2547 to 2573 m asl. It is commonly named as ‘Amora-Gedel’ by the nearby villagers (Fig. 7).



Figure 7. Photo of the grassland habitat (with scattered *Erica* scrubs) within the study area (Photo: Yonas Terefe, March, 2010).

2.2. Materials and Methods

2.2.1. Materials

The following equipment and materials were used for the present study: Sherman live traps, snap traps, peanut butter, coloured plastic tag, Pesola spring balance, gloves, polythene bag, GPS, data sheets, field guides, dissecting kit, digital camera, ruler and metre. A light microscope was used for stomach content identification. 70% ethyl alcohol was used as a preservative for the stomach samples.

2.2.2. Preliminary Survey

Before starting the main research work, a preliminary survey was conducted during the last week of July, 2010. During this period, relevant information about the study area (climatic condition, topography and approximate size of the area) was gathered and selection of the study habitats was made.

2.2.3. Sampling Design

Based on the topography and vegetation type, the study area was classified into, forest (FO), bushland (BL), farmland (FL) and grassland (GL) habitats. The representative grids were established randomly among the vegetation type based upon possible representation of different habitats as well as easy accessibility. Each grid was given a code number as, 01, 02, 03, and 04 for farmland, bushland, forest and grassland habitats, respectively. Each sampling site constituted an area of 4900 m² (70 x 70 m). For both wet and dry seasons, the same sampling grids were used. All live trapping grids were separated at about 500 m apart to reduce overlapping of captures. For the analysis of stomach content and embryo count, 20 snap-traps were used during both wet and dry seasons.

2.2.4. Data Collection

Data collection was accomplished between August 2010 and March 2011, which included both wet and dry seasons. Data collection was made in four trapping sessions (data collection periods) and each session was given a Roman number I, II, III and IV. The wet season data was collected from August 2010 to October 2010 consisting of session I and II. The dry season included III and IV data collection periods (November 2010 to March 2011). During both seasons, data collection was performed by using Sherman live-traps and snap-traps. Additionally, data were gathered by direct observations in the study sites.

2.2.4.1. Sherman live-trapping

Sherman live traps ($7.6 \times 8.9 \times 22.9$ cm) were used to trap live rodents from each of the four habitat types (farmland, bushland, forest and grassland). In each trapping grid, a total of 49 Sherman live-traps were set at an interval of 10 m, into horizontal and vertical directions forming a 70 x 70 m square with six rows and six columns (Fig. 8). To locate the traps easily, each trap location was marked with a yellow coloured plastic tags on a branch of the nearby tree. The traps were baited with peanut butter and checked twice a day at early morning (between 07:00 and 09:00 a.m.) and late afternoon (between 05:00 and 06.00 p.m.) for three consecutive nights. However, the time for checking varied depending on trap success, habitat type, weather conditions, topography, diet replenishment and identification of captured rodents. Peanut butter was replenished each day to increase the trapping success. Traps were covered by hay and plant leaves during the dry season. This provided protection against environmental constraints like, strong heat and extreme cold. Each trapped animal was removed from the traps and placed inside a transparent polythene bag, weighed by using 200 g Pesola spring balance and identified to the species level. Additional data like sex, approximate age and reproductive conditions were also recorded. According to Afework Bekele (1996a), the approximate age (juvenile, sub-adult, adult) were determined based on the weight and pelage colour. Reproductive conditions in males were noted by the size and position of testicles (scrotal or abdominal) and the reproductive conditions of females (closed or perforated vagina) were determined by their enlarged nipples, large swollen

abdomen and body weight (Barnett and Dutton, 1995; Afework Bekele, 1996a; Mahlaba and Perrin, 2003). Finally, the trapped rodent was released at the point of capture after toe clipping.

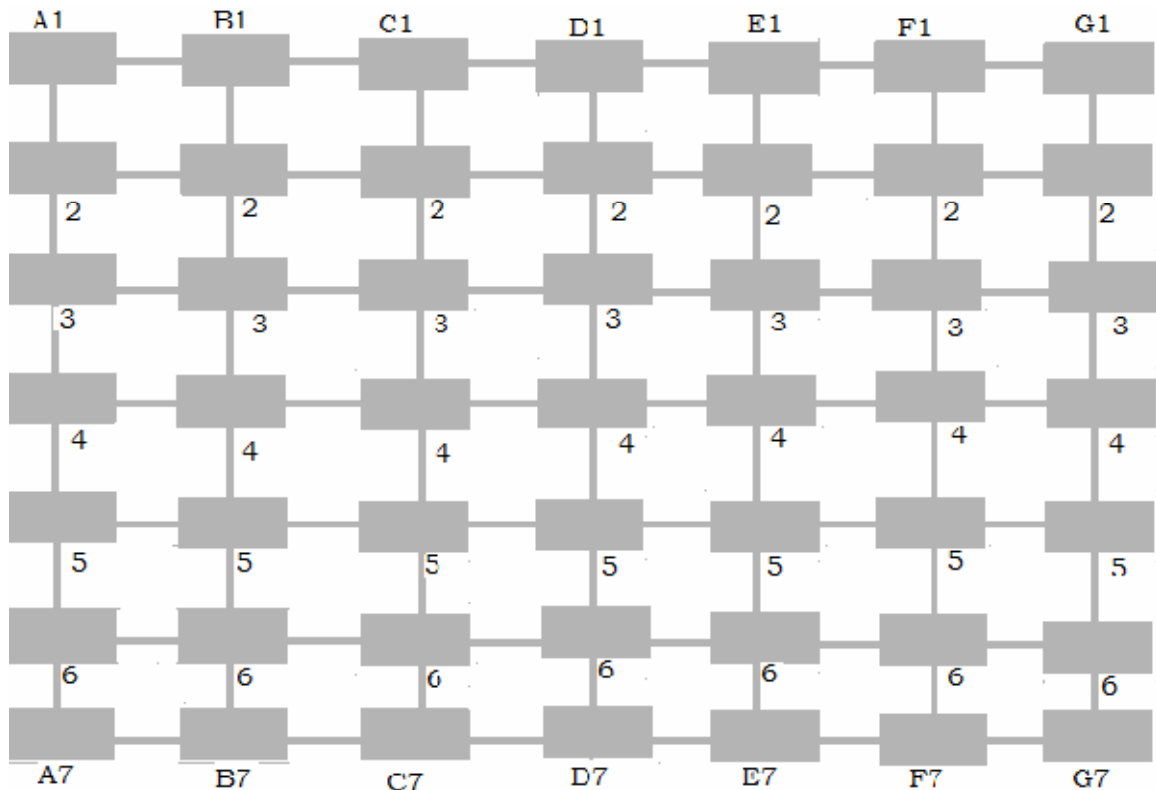


Figure 8. Schematic representation of Sherman live-trapping grid.

2.2.4.2. Snap-trapping

A total of 20 snap-traps were used for further exploration of the remaining habitats outside of the live-trapping grids. In each session, based on the habitat type and topography, the traps were set at different directions of the live-trapping grids. When unique habitat was observed, additional snap-trap was used. The snap-traps were used both for the wet and dry season data collection periods. The traps were set at more than 200 m away from the live-trapping grids. Depending on the habitat type, from two to four parallel lines with an interval

of 50 m were made and the snap-traps within each lines were set at 20 m interval. Similar to the live-trapping, all snap-traps were baited with peanut butter and checked twice a day for three consecutive days. After removing the trapped rodents from the traps, the following data were taken: weight, sex, relative age, reproductive condition and standard body measurements (head-body length, tail length, hind foot and ear length). During both wet and dry season, a representative individual from each habitat was dissected for stomach content analysis as well as pregnant females for embryo count. Skin and skull voucher specimen were prepared for further identification. All specimens were deposited to the Zoological National History Museum of Addis Ababa University.

2.2.5. Stomach content analysis

Stomach content analysis was performed following the method used by Workneh Gebresilassie *et al.* (2004) and Demeke Datiko *et al.* (2007). Stomach samples from the dissected animals were removed and preserved in glass containers, each with 70% alcohol. All stomach contents were brought to Zoological Sciences Unit Laboratory of Addis Ababa University for microscopic examination of the diets. The contents were kept in open air for 24 hr to dry and weighed by using digital balance. The dried samples were washed by distilled water to remove fine particles. For each sample, four slides were prepared and the identification as well as proportion of the different food items were observed using compound light microscope. The food items were grouped into plant matter (leaves, stems, roots, and seed) and animal matter (arthropods). Stomach content analysis was made through calculating the mean percentage proportion of food fragments per slides.

2.1.6. Data analysis

Comparison of species richness, distribution and habitat association of species in the study area, were made by using Chi-square test and SPSS Version 17.0 statistical program. Shannon-Weaver Index was used for calculating the rodent species diversity in the different habitat types. Habitat similarity was computed by using Simpson's Similarity Index. Lincoln-Petersen Index was used to infer the population estimates for the different trapping sessions. The total number of trapped individuals and the overall trap night were used to compute trap success. The number of rodents alive per hectare was used to estimate density of rodents for the different habitats. The mean weight of each species was used to infer the study areas biomass.

3. RESULTS

The results of this study are presented in three separate sections. The first section deals with the overall species composition and relative abundance of small mammals. The second deals with the results obtained from Sherman live-trapping. These results deal with: species composition, relative abundance, distribution and habitat association, species richness and diversity, seasonal variation, sex ratio and age structure, trapping success, population estimate, density and biomass. The last section deals with the results obtained from snap trapping. This section included: species composition, relative abundance and distribution, body measurements, reproductive condition and stomach contents.

During both wet and dry seasons, a total of 7 species of rodents were recorded from Yerer Mountain Forest area. From a total of 3312 trap nights, 402 individuals of small mammals were captured (Table 1). All the captured species belonged to two mammalian Orders (Rodentia and Insectivora). Out of these, 400 (99.5%) individuals represented 6 species of the family Muridae and whereas the remaining 2 (0.5%) belonged to one shrew species (family Soricidae). The trapped small mammal species were: *Lophuromys flavopunctatus*, *Stenocephalemys albipes*, *Arvicanthis dembeensis*, *Arvicanthis abyssinicus*, *Mus Mahomet*, *Dendromys mystacalis* belonging to family Muridae, and *Crocidura fumosa* belonging to family Soricidae.

The most abundant species was *L. flavopunctatus* (31.6%) followed by *S. albipes* (18.0%). *Arvicanthis abyssinicus* (17.6%) and *A. dembeensis* (16.4%) were the third and fourth most abundant species, respectively. *Mus Mahomet* and *D. mystacalis* constituted 13.7% and 2.2% of the total species composition of the study area, respectively. *Crocidura fumosa* (0.5%) was the least abundant species in the study area.

Table 1. Species abundance of rodents and insectivores in Yerer Mountain Forest Area.

Species	Total Catch	Abundance (%)
<i>Lophuromys flavopunctatus</i>	127	31.6
<i>Arvicanthis dembeensis</i>	66	16.4
<i>Arvicanthis abyssinicus</i>	71	17.6
<i>Stenocephalemy albipes</i>	72	18.0
<i>Mus mahomet</i>	55	13.7
<i>Dendromys mystacalis</i>	9	2.2
<i>Crocidura fumosa</i>	2	0.5
Total (7)	402	100

From all selected habitats, and within 2352 trap nights, a total of 307 captures and 87 recaptures were made by Sherman live-traps (Table 2). All species identified by the present study were live-trapped. Out of all live trapped rodents, *L. flavopunctatus* accounted for the highest relative abundance (33.6%). The relative abundance of other species was: *A. abyssinicus* (20.2%), *S. albipes* (14.1%), *M. Mahomet* (15.9%), *A. dembeensis* (13.0%), *D. mystacalis* (2.6%), and *C. fumosa* (0.6%).

Table 2. Species composition and relative abundance of live-trapped rodent and insectivore species. The numbers in bracket shows recaptures.

Species	Individuals captured	Abundance (%)
<i>L. flavopunctatus</i>	103 (27)	33.6
<i>A. dembeensis</i>	40 (14)	13.0
<i>A. abyssinicus</i>	62 (21)	20.2
<i>S. albipes</i>	43 (14)	14.1
<i>D. mystacalis</i>	8 (3)	2.6
<i>M. Mahomet</i>	49 (8)	15.9
<i>C. fumosa</i>	2	0.6
Total	307 (87)	100

The numbers of species captured from the four habitat types varied from two species of forest habitat to five species from farmland habitat. From the bushland and grassland habitats, a total of four species were identified. The farmland constituted the highest number (138) and relative abundance (45.0%) of live-trapped individuals. The abundance of rodents in the bushland, forest, and grassland habitats was 62 (20.2%), 21 (6.8%), and 86 (28.0%), respectively (Table 3). There was a significant difference in the abundance of species between the four habitat types ($\chi^2= 93.3$, $df= 3$, $P< 0.05$).

Table 3. Distribution and abundance of live-trapped rodents from different habitats.

Species	Habitat types				Total capture
	FL	BL	FO	GL	
<i>L. flavopunctatus</i>	19	42	-	42	103
<i>A. dembeensis</i>	38	2	-	-	40
<i>A. abyssinicus</i>	62	-	-	-	62
<i>S. albipes</i>	-	14	19	11	43
<i>D. mystacalis</i>	-	-	-	8	8
<i>M. Mahomet</i>	17	5	2	25	49
<i>C. fumosa</i>	2	-	-	-	2
Total	138	62	21	86	307
Percentage (%)	45.0	20.2	6.8	28.0	100
No. of species	5	4	2	4	7

(FL= farmland, GL= grassland, BL= bushland, FO= forest, (-) = shows absence of trapped individuals).

Species distribution of rodents varied along with habitat types. *Mus Mahomet* (15.9%) was the most widely distributed rodent species along all habitat types (Fig. 9). *Lophuromys flavopunctatus* was the other most widespread and abundant species in most habitats. This species comprised 33.6% of the total captures. *Stenocephalemys albipes* was not captured from the farmland habitat, but was common to other habitat types. *Arvicanthis abyssinicus* and *C. fumosa* were the two species only captured from the farmland. *Arvicanthis dembeensis* was the other most abundant species captured from farmland as well as bushland habitats. *Dendromys mystacalis* was the least distributed and least abundant species of

rodent followed by *C. fumosa*. *Dendromys mystacalis* was recorded only from the grassland habitat.

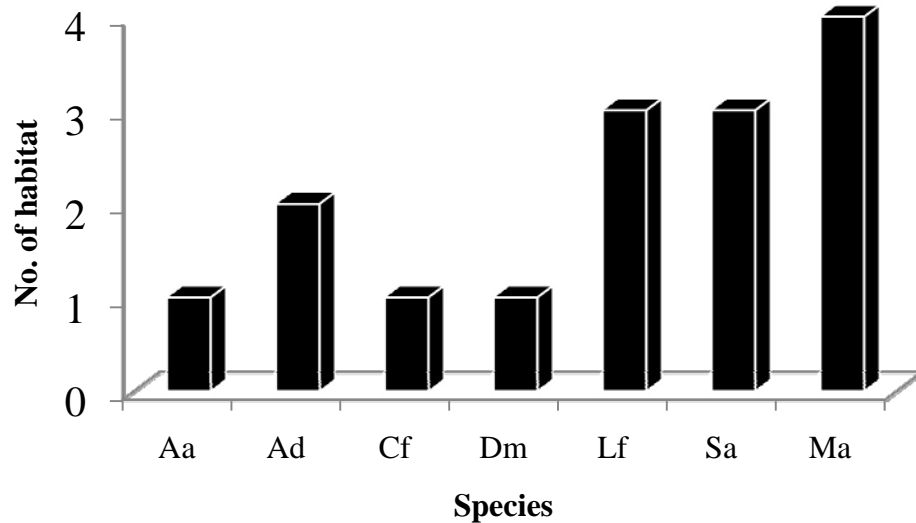


Figure 9. Species distribution in different habitat types (Aa= *Arvicanthis abyssinicus*, Ad= *A. dembeensis*, Cf= *C. fumosa*, Dm= *D. mystacalis*, Lf= *L. flavopuncatus*, Sa= *S. albipes*, Mm= *M. Mahomet*).

Species richness and diversity between the different habitats showed variation, but not significant ($\chi^2=1.5$, $df= 3$, $P > 0.05$). Among the four habitat types, the farmland habitat constituted the highest species richness, with five species (Table 4). The least species richness was registered from the forest habitat. Bushland and grassland habitats showed similar species richness, both with four species. The farmland habitat was the most diversified habitat with Shannon-Weaver Index (H') of 1.382 and Simpson's Similarity Index (SI) of 0.706. The second diversified habitat was grassland with H' and SI value of 1.254 and 0.659, respectively. Bushland habitat was the third diversified habitat ($H'= 0.983$ and $SI= 0.487$), followed by the forest habitat ($H'= 0.228$ and $SI= 0.199$).

Table 4. Species richness and diversity of live-trapped rodents in different habitats.

Habitat	No. of species	No. of captures	H'	SI
Farmland	5	138	1.382	0.706
Bushland	4	62	0.983	0.487
Forest	2	21	0.228	0.199
Grassland	4	86	1.254	0.659

(H' = Shannon-Weaver-Index, SI= Simpson's Similarity Index)

The seasonal species composition and distribution of live-trapped rodents among the different habitats are given in Table 5. Except for *D. mystacalis* and *C. fumosa*, all the remaining species of rodents were trapped during both wet and dry seasons. *Dendromys mystacalis* was trapped only during the dry season from the grassland habitat, whereas, *C. fumosa* was trapped only from the farmland habitat during the wet season. Out of the total captured individuals (307), 152 (49.5%) individuals were trapped during the wet season and 155 (50.5%) during the dry season. The difference in species composition between habitats during wet and dry seasons was not statistically significant ($\chi^2=2.3$, df= 2, $P > 0.05$ and $\chi^2=3.6$, df= 2, $P > 0.05$, respectively).

The highest (138) as well as the lowest (21) numbers of individuals were recorded during both seasons from the farmland and forest habitats, respectively. During the dry season, the total number of trapped individuals increased from 35 to 51 in the grassland habitat. Conversely, the total number of rodents captured from the bushland habitat declined from 40 to 22. The difference between abundance of rodents between habitats during wet and dry seasons was statistically significant ($\chi^2= 34.7$, df= 3, $P < 0.05$ and $\chi^2= 76.1$, df= 3, $P < 0.05$, respectively).

Table 5. Seasonal species composition and abundance of live-trapped rodents from different habitats.

Species	Habitat types and seasons								Total
	Farmland		Bushland		Forest		Grassland		
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	
<i>L. f</i>	14	5	27	15	-	-	19	23	103
<i>A. d</i>	36	2	-	2	-	-	-	-	40
<i>A. a</i>	3	59	-	-	-	-	-	-	62
<i>S. a</i>	-	-	10	3	13	6	5	6	43
<i>M. m</i>	8	9	3	2	1	1	11	14	49
<i>D. m</i>	-	-	-	-	-	-	-	8	8
<i>C. f</i>	2	-	-	-	-	-	-	-	2
Total	63	75	40	22	14	7	35	51	307
Total/season	138		62		21		86		
Percent	45.0		20.2		6.8		28.0		100
No. of species	5	4	3	4	2	2	3	4	7

(*L. f* = *L. flavopunctatus*, *A. d* = *A. dembeensis*, *A. a* = *A. abyssinicus*, *S. a* = *S. albipes*, *M. m* = *M. Mahomet*, *D. m* = *D. mystacalis*, *C. f* = *C. fumosa*, (-) = shows absence of trapped individuals).

The highest number of species from the farmland habitat was registered during the wet season, whereas, the least number of species was registered from the forest habitat during both wet and dry season. The other two habitats (bushland and grassland) harboured similar number of species during both seasons (Fig. 10).

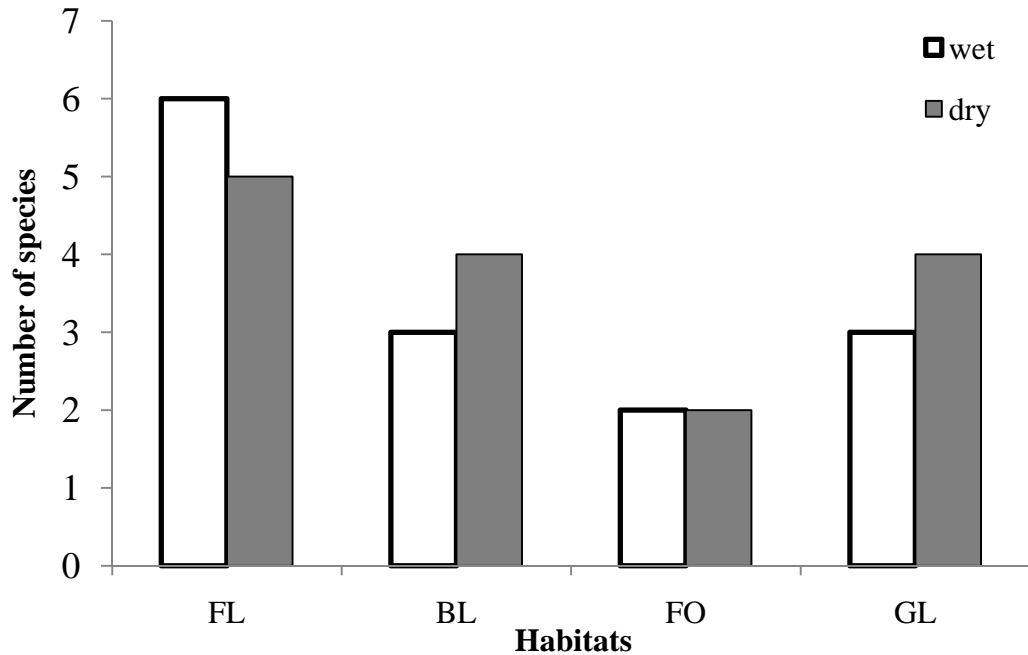


Figure 10. Seasonal species diversity of rodents in different habitat types (FL= farmland, BL= bushland, FO= forest, GL= grassland).

The sex ratio of trapped rodents from different habitats during the wet and dry seasons is given in Table 6. Out of the overall individuals captured by live-trap, females comprised 103 (33.5%) and males 204 (66.5%). The sex ratio of males captured from the different habitats was higher than females during wet as well as dry seasons. The ratio for males was also higher within each species during all trapping sessions. The difference in sex ratio of females and males was statistically significant ($\chi^2= 33.2$, $df= 1$, $P < 0.01$).

Table 6. Sex ratio and age structure of live-trapped rodents during the wet and dry seasons.

Habitat	Season	Number of individuals trapped															
		<i>L.f</i>		<i>A.d</i>		<i>A.a</i>		<i>S.a</i>		<i>M.m</i>		<i>D.m</i>		<i>C.f</i>		Total	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
FL	Wet	9	5	19	17	2	1	-	-	4	4	-	-	2	-	36	27
	Dry	4	1	2	-	35	24	-	-	7	2	-	-	-	-	48	27
BL	Wet	17	10	-	-	-	-	8	2	2	1	-	-	-	-	27	13
	Dry	11	4	2	-	-	-	3	-	2	-	-	-	-	18	4	
FO	Wet	-	-	-	-	-	-	8	5	1	-	-	-	-	9	5	
	Dry	-	-	-	-	-	-	5	1	1	-	-	-	-	6	1	
GL	Wet	12	7	-	-	-	-	3	2	7	4	-	-	-	22	13	
	Dry	18	5	-	-	-	-	6	-	9	5	5	3	-	38	13	
Total		71	32	23	17	37	25	33	10	33	16	5	3	2	-	204	103
(%)		23.1	10.4	7.5	5.5	12.0	8.1	10.8	3.3	10.8	5.2	1.6	1.0	0.7	-	66.5	33.5

(FL= farmland, BL= bushland, FO= forest, GL= grassland, *L. f* = *L. flavopunctatus*, *A. d* = *A. dembeensis*, *A. a* = *A. abyssinicus*, *S. a* = *S. albipes*, *M. m* = *M. Mahomet*, *D. m* = *D. mystacalis*, *C. f* = *C. fumosa*, (-) = shows absence of trapped individuals

Various age groups of rodents from the four trapping session is given in Table 7. A total of 191 (62.2%) adults, 90 (29.3%) sub-adults and 26 (8.5%) juveniles were captured from all trapping sessions. Adult individuals comprised the highest proportion during both wet and dry seasons. There was no seasonal variation in the total capture of adult individuals ($\chi^2=0.26$, $df=1$, $P > 0.05$). But, sub-adult as well as young individuals showed seasonal variation in their total capture ($\chi^2=8.5$, $df=1$, $P < 0.05$ and $\chi^2=11.6$, $df=1$, $P < 0.05$, respectively). Out of the total juvenile rodents, 21 (6.8%) was captured during the wet season.

Table 7. Age groups of live-trapped rodents during different trapping sessions.

Season/Session	Age group			Total
	Adults	Sub-adults	Juveniles	
Wet-I	43	20	9	72
Wet-II	49	17	13	79
Dry-III	51	28	3	82
Dry-IV	48	25	1	74
Total (%)	191 (62.2)	90 (29.3)	26 (8.5)	307

The proportion of age groups varied from species to species as well as from season to season. With the exception of *C. fumosa* and *D. mystacalis*, all age groups (adult, sub-adult and young) were represented in the remaining other live-trapped rodent species (Table 8). A maximum of 5.1% and a minimum of 0.3% trap success were recorded for adult males and juvenile females, respectively. Out of the 56 live trapped adult females, 10 pregnant and 6 lactating females were recorded for the different species. The success of capturing pregnant females was higher for *L. flavopunctatus*.

Table 8. Sex and age distribution and trap success of live-trapped rodents.

Species	Age group								Total
	Ma	Fa	Msa	Fsa	Mj	Fj	P	L	
<i>L. flavopunctatus</i>	41	17	19	7	11	2	4	2	103
<i>A. dembeensis</i>	18	9	5	5	-	1	2	-	40
<i>A. abyssinicus</i>	13	10	16	9	6	4	1	3	62
<i>S. albipes</i>	18	5	13	3	2	-	1	1	43
<i>D. mystacalis</i>	3	5	-	-	-	-	-	-	8
<i>M. Mahomet</i>	24	10	9	4	-	-	2	-	49
<i>C. fumosa</i>	2	-	-	-	-	-	-	-	2
Total	119	56	62	28	19	7	10	6	307
Trap success (%)	5.1	2.4	2.6	1.2	0.8	0.3	0.4	0.3	13.1

(Ma= Adult males, Fa= Adult females, P= Pregnant females L= lactating females, Msa= Subadult males, Fsa= Subadult females, Mj= Juvenile males, Fj= Juvenile females, (-) = shows absence of trapped individuals)

The success of trapping different species varied between habitats as well as seasons (Table 9). Farmland habitat had the highest mean trapping success (23.5%) followed by the grassland habitat with a mean trap success of 14.6%. The lowest mean trap success (3.2%) was recorded from the forest habitat during the wet and dry seasons. The mean trap success in the bushland habitat was 10.5%. There was statistical variation in the trap success between the different habitat types during the two seasons ($\chi^2= 17.2$, $df= 3$, $P < 0.05$).

Table 9. Seasonal trap success of rodents from the different habitats types.

Habitat types	Season	Trap night	Total catch	Success (%)
Farmland	Wet	294	63	21.4
	Dry	294	75	25.5
Bushland	Wet	294	40	13.6
	Dry	294	22	7.5
Forest	Wet	294	14	4.8
	Dry	294	7	2.4
Grassland	Wet	294	35	11.9
	Dry	294	51	17.3

The population estimate of live-trapped rodents during the different trapping sessions is given in Figure 11. Relatively, the highest population estimate was obtained during the second trapping session of the wet season, whereas, the lowest estimate was obtained during the dry season (session IV). There was no significance difference in the population estimate between the different trapping sessions ($\chi^2 = 7.9$, $df = 3$, $P > 0.05$).

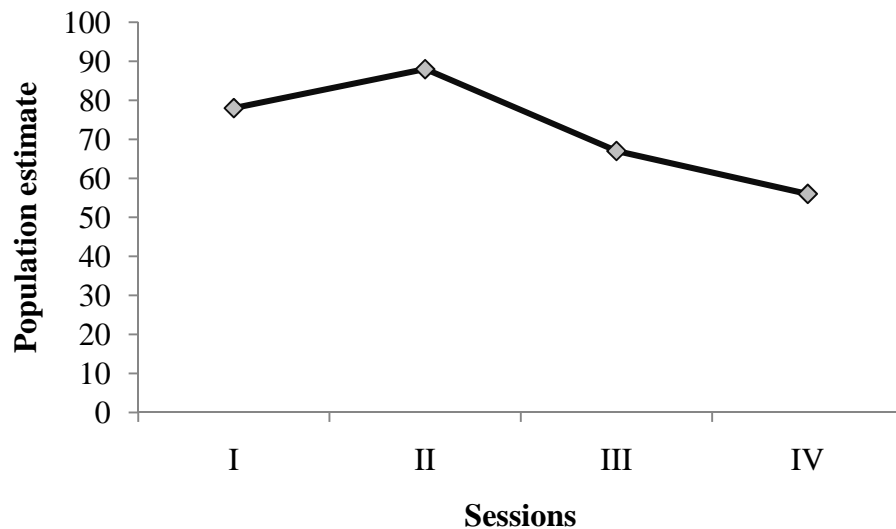


Figure 11. Population estimates during the different trapping sessions.

The overall population density of rodents in the study area was 475/ha (Table 10). The highest density of rodent and shrew species was recorded from the farmland, with 227 individuals per hectare. The population density declined from the grassland habitat (130/ha) to forest habitat (32/ha). Among the other species of rodents, the overall density of *L. flavopunctatus* in the study area was the highest (132/ha). The total population density for *A. abyssinicus*, *M. Mahomet*, *S. albipes*, *A. dembeensis*, *D. mystacalis* and *C. Fumosa* was 105/ha, 86/ha, 69/ha, 69/ha, 12/ha and 2/ha, respectively.

Table 10. Density of rodents (individuals per hectare) in the different habitats.

Species	Habitat types				Total
	FL	BL	FO	GL	
<i>L.f</i>	30	51	-	51	132
<i>A.d</i>	67	2	-	-	69
<i>A.a</i>	105	-	-	-	105
<i>S.a</i>	-	26	28	15	69
<i>D.m</i>	-	-	-	12	12
<i>M.m</i>	23	7	4	52	86
<i>C.f</i>	2	-	-	-	2
Total	227	86	32	130	475

(FL = farmland, BL= bushland, FO= forest, GL= grassland, *L.f*= *L. flavopunctatus*, *A.d*= *A. dembeensis*, *A.a*= *A. abyssinicus*, *S.a*= *S. albipes*, *M.m*= *M. Mahomet*, *D.m*= *D. mystacalis*, *C.f*= *C. fumosa*, (-) = shows absence of trapped individuals).

During the entire study period, a mean of 8341 g/hectare biomass of live trapped rodents was recorded from all habitat types (Table 11). A mean biomass of 1269 and 1114 g/hectare of rodents was collected during the wet and dry seasons, respectively. The highest biomass record was obtained from the farmland habitat (4151 g/hectare), which accounted to 49.8% of the total biomass record. Whereas, the lowest biomass recorded was obtained from the forest habitat (513 g/hectare). The second habitat with highest biomass record was grassland (1843 g/hectare), followed by bushland habitat with 1834 g/hectare. Out of the overall live-trapped species of rodents, the maximum biomass was recorded for *L. flavopunctatus* (3384 g/hectare) and the lowest was for *C. fumosa* (20 g/hectare).

Table 11. Biomass (g/hectare) of live-trapped rodents from the different habitats during the wet and dry seasons. Number in brackets show individuals captured.

Species	Mean body weight (g)	Season	Habitat types				Mean biomass
			FL	BL	FO	GL	
<i>L.f</i>	65.7	Wet	920 (14)	1774 (27)	-	1248 (19)	3384
		Dry	329 (5)	986 (15)	-	1511 (23)	
<i>A.d</i>	85.4	Wet	3074 (36)	-	-	-	1708
		Dry	171 (2)	171 (2)	-	-	
<i>A.a</i>	58.1	Wet	174 (3)	-	-	-	1801
		Dry	3428 (59)	-	-	-	
<i>S.a</i>	52.8	Wet	-	528 (10)	687 (13)	264 (5)	1136
		Dry	-	158 (3)	318 (6)	317 (6)	
<i>M.m</i>	10	Wet	80 (8)	30 (3)	10 (1)	110 (11)	245
		Dry	90 (9)	20 (2)	10 (1)	140 (14)	
<i>D.m</i>	12	Wet	-	-	-	-	48
		Dry	-	-	-	96 (8)	
<i>C.f</i>	20	Wet	40 (2)	-	-	-	20
		Dry	-	-	-	-	
Mean total (%)			4151(49.8)	1834 (22.0)	513 (6.1)	1843 (22.1)	8341

(FL= farmland, BL= bushland, FO= forest, GL= grassland, *L. f* = *L. flavopunctatus*, *A. d* = *A. dembeensis*, *A. a* = *A. abyssinicus*, *S. a* = *S. albipes*, *M. m* = *M. Mahomet*, *D. m* = *D. mystacalis*, *C. f* = *C. fumosa*, (-) = shows absence of trapped individuals).

The mean body weight and body measurements of six snap-trapped rodent species are given in Table 14. The highest mean body weight was recorded for *A. dembeensis* (91.8 g) followed by *L. flavopunctatus* (66.1 g). The least was for *M. Mahomet* (9.7 g).

Table 12. Weight and body measurements of snap-trapped rodents

Species	Total catch	Body measurements (Mean \pm SD)				
		Wt (g)	HB (cm)	TL (cm)	FL (cm)	ER (cm)
<i>L.f</i>	24	66.1 \pm 17.65	12.3 \pm 1.13	5.8 \pm 0.36	2.1 \pm 0.12	1.1 \pm 0.37
<i>A.d</i>	26	91.8 \pm 29.02	14.3 \pm 0.8	9.2 \pm 0.67	2.6 \pm 0.25	1.3 \pm 0.23
<i>A.a</i>	9	60.3 \pm 25.7	13.6 \pm 1.20	9.1 \pm 0.74	2.7 \pm 0.19	1.4 \pm 0.19
<i>S.a</i>	29	56.8 \pm 14.61	12.7 \pm 1.15	15.6 \pm 0.98	2.7 \pm 0.31	1.8 \pm 0.28
<i>M.m</i>	6	9.7 \pm 2.52	5.9 \pm 0.86	5.5 \pm 1.46	1.3 \pm 0.26	0.7 \pm 0.22
<i>D.m</i>	1	12.0 \pm 0	5.0 \pm 0	8.0 \pm 0	1.5 \pm 0	1.0 \pm 0

(Wt= weight, HB= head-body, TL= tail length, FL= foot length, ER= ear length, *L. f* = *L. flavopunctatus*, *A. d* = *A. dembeensis*, *A. a* = *A. abyssinicus*, *S. a* = *S. albipes*, *M. m* = *M. Mahomet*, *D. m* = *D. mystacalis*).

The overall number of pregnant female rodents and embryo count for each species during the wet and dry seasons are given in Table 15. A total of 15 pregnant females were trapped during all trapping period. Except for *D. mystacalis*, pregnant females were captured for the remaining five snap-trapped species. The maximum and minimum number of pregnant females was recorded for *A. dembeensis* and *M. mahomet*, respectively. There was seasonal difference in the total number of snap-trapped pregnant females ($\chi^2 = 0.6$, df= 1, P < 0.05). The number of embryos of pregnant females also showed seasonal variation among species as well as within the same species. For most species, the left horn embryo implantation was higher than the right one.

Table 13. The number of pregnant females and embryo count for the snap-trapped species during the wet and dry seasons ((-) indicates absence).

Species	Season	No. of Pregnant females trapped	No. of embryos recorded
<i>L. flavopunctatus</i>	Wet	2	3-4
	Dry	1	3
<i>A. dembeensis</i>	Wet	5	3-7
	Dry	1	4
<i>A. abyssinicus</i>	Wet	-	-
	Dry	3	4-7
<i>S. albipes</i>	Wet	1	7
	Dry	1	4
<i>M. mahomet</i>	Wet	1	7
	Dry	-	-

The mean percentages of stomach content of snap trapped rodents during the wet and dry seasons given in Table 16. The percentage frequency of plant matters in the stomach was higher than animal matters in all species. The stomach contents of *L. flavopunctatus* and *S. albipes* contained relatively higher frequency of animal matter. Percentages of seed and stem in most stomach contents were higher during the dry season. The percentage of leaves in all stomach contents was higher during the wet season. Higher percentage of animal matter was recorded during the wet season. The percentage of unknown materials was higher in the stomach samples collected during the dry season.

Table 14. Seasonal mean percentage of stomach content composition.

Species	Season	No. of individuals	Plant matters (%)				Animal matters (%)		
			S	St	L	R	W	A	UN
<i>L.f</i>	Wet	4	5.9	13.1	48.6	9.5	6.2	8.5	8.2
	Dry	4	16.7	25.4	29.3	11.9	0	4.1	12.6
<i>A.d</i>	Wet	8	17.1	23.8	45.1	8.2	0	0.9	4.9
	Dry	3	12.3	27.3	29.9	15.2	0	0	15.3
<i>A.a</i>	Wet	2	16.4	10.6	65.4	1.8	0	0	5.8
	Dry	4	22.5	19.3	38.8	6.1	0	1.9	11.4
<i>S.a</i>	Wet	6	5.6	14.7	22.9	15.6	9.7	16.3	15.2
	Dry	6	9.6	25.9	23.9	20.4	0	9.5	10.7
<i>M.m</i>	Wet	2	21.4	23.8	26.3	12.4	1.4	2.5	12.2
	Dry	1	32.4	26.2	19.1	8.8	0	2.2	11.3

(S= seed, St= stem, L= leaf, W= worm, A= arthropods, UN= unknown materials and bait, *L.f*= *L. flavopunctatus*, *A.d*= *A. dembeensis*, *A.a*= *A. abyssinicus*, *S.a*= *S. albipes*, *M.m*= *M. Mahomet*).

4. DISCUSSION

In the present study, a total of six species of rodents and one shrew species were recorded from the Yerer Mountain forest area. In this investigation, *L. flavopunctatus* was the most abundant and widely distributed rodent species following *M. mahomet*. Similarly, other investigators have revealed its wide distribution over most habitat types in different parts of Ethiopia (Yalden *et al.*, 1976; Yalden and Largen, 1992). Similar result was recorded by Mohammed Kasso (2008) from Mount Chilalo and Galama range of Arsi in the southern Ethiopia. According to Clausnitzer and Kityo (2001), *L. flavopunctatus* is the most common along montane and highland habitats of East Africa. In the present study, highest number of individuals of this species was recorded from the mountain bushland and grassland (with scattered *Erica* scrubs) habitats. In line with Delany (1986) and Clausnitzer *et al.* (2003), its wide distribution along such habitat types might be related to its insectivore feeding habit. Such feeding behaviour with the availability of good vegetation cover might be the reason for its dominance in the bushland as well as grassland habitats of the present study area.

Stenocephalemys albipes is the most abundant and widespread endemic rodent species of Ethiopia. It is commonly found within forest habitats and nearby areas (Yalden and Largen, 1992; Afework Bekele, 1995). In the present study also most individuals of *S. albipes* were captured from the forest habitat. This is comparable with the findings of Afework Bekele (1996b), Tadesse Habtamu and Afework Bekele (2008) and Mohammed Kasso *et al.* (2010), who have recorded good number of *S. albipes* from the Menagesha-Suba State Forest, Alatish National Park and Mount Chilalo-Galama Mountain Ranges, respectively.

Arvicanthis abyssinicus was the third most abundant species in the current study area. It is most commonly adapted to mountainous areas within an altitudinal ranges of 2000 and 3000 m asl (Corti *et al.*, 1996). In this study, more individuals of this species were captured exclusively from the farmland habitat. Similar results were obtained by Tilaye Wube (2005) and Ayenew Gezie (2009) from Entoto Mountain (Central Ethiopia) and Meklite Forest and associated areas (Eastern Gojjam zone), respectively. In contrast, Manyingerew Shenkut *et*

al. (2006) have reported more number of individuals of *A. abyssinicus* outside farmland habitats. The other *Arvicanthis* species from the present study area was *A. dembeensis*. In Ethiopia, its distribution ranges from sea level to 2000 m asl (Yalden *et al.*, 1976). It was trapped from farmland and bushland habitats of the current study area.

Mus mahomet was the most common species in all habitat types. It is one of the endemic rodents of Ethiopia (Yalden and Largen, 1992). It was the most abundant species in the farmland as well as grassland habitats, following *Arvicanthis* and *L. flavopunctatus*, respectively. Manyingerew Shenkut *et al.* (2006) also reported its abundance in the farmland of Alleltu Woreda of Oromia Region. The record obtained from Maynugus Irrigation Field (Workneh Gebresilassie *et al.*, 2005) is the lowest compared to the present result.

Crocidura fumosa was the only shrew species captured exclusively from the farmland habitat during the second session of the wet season. It is a highland species, which is common in the moorland habitats (Yalden, 1988). Similarly, Daniel Bayessa (2010) has captured this species during the two wet trapping sessions from montane and transitional forests habitats. Mohammod Kasso (2008) has also recorded *C. fumosa* from Afroalpine habitat of Mount Chilalo and Galama Mountain Range. *Dendromys mystacalis* was the other least abundant rodent species identified in this investigation. It was exclusively captured from the grassland habitat. Dieterlen (2009) has discussed the presence of good number of this species in different parts of Ethiopia.

Species richness of the present investigation was seven, which was comparable with the finding of Yalden (1988), Afework Bekele (1996a) and Dawit Kassa and Afework Bekele (2008), who have recorded seven species of rodents from Bale Mountains, six species from Menagesha-Suba State Forest and seven species from Wondo Genet, respectively. However, the species richness of the present study area was lowest as compared to other findings. For instance, Demeke Datiko *et al.* (2007), Tadesse Habtamu and Afework Bekele (2008) and Mohammed Kasso *et al.* (2010) have recorded 14, 23 and 17 species of rodents from Arbaminch forest and farmlands, Alatish National Park and Mount Chilalo and Galama Mountain Ranges, respectively. Although similar to the finding of Suárez-Gracida and

Álvarez-Castañeda (2009), these variations might be due to the presence of varying degrees of physical and biotic factors in such areas. Generally, the presence and absence of rodent species in the different habitats might have depended upon the microclimate, altitude and vegetation types of the areas.

Habitat heterogeneity is the major driving feature for the difference in species richness and diversity of rodents (Cramer and Willig, 2002). According to Martin (1998), habitat selection has an adaptive basis. Habitat association provides a useful way to determine species richness and diversity from a given area. In this study, there were few differences in species richness between habitats. In contrast, the relative abundance of small mammals showed far more marked significant variation across habitats, with many more individuals being caught from the farmland habitat. Similarly, Massawe *et al.* (2005) and Fitzherbert *et al.* (2006) have recorded high number of rodents from inter-cropped fields of Morogoro and cultivated landscapes and open woodland of Katavi ecosystem, respectively in Tanzania. Other findings from Ethiopia (Tadesse Habtamu and Afework Bekele, 2008; Mohammed Kasso *et al.*, 2010; Daniel Bayessa, 2010; Mossisa Geleta, 2010), have reinforced the current result on the difference in relative abundance of small mammals between different habitats. The availability and quality of food, shelter resources and rainfall might be main factors determining the difference in habitats in the species composition in the present study area.

In this investigation, two *Arvicanthis* spp., *A. dembeensis* and *A. abyssinicus* have showed strong association with the farmland habitat. The first one is most commonly recorded from maize farmlands by various studies (Afework Bekele and Leirs, 1997; Workneh Gebresilassie *et al.*, 2005 and Demeke Datiko *et al.*, 2007). *Arvicanthis dembeensis* and *A. abyssinicus* have been variously described as major pest to farmlands in Ethiopia. The large number of *Arvicanthis* species in the farmland of Yerer Mountain Area might be due to the good ground cover and the presence of shelter and food near the edges of most farmlands.

Stenocephalemys alpiibes, *L. flavopunctatus* and *M. mahomet* were common to the bushlands as well as the grassland habitats. Although *S. alpiibes* is a forest dweller, its presence in these habitats might be related to its ability to move out of forest and possibly having the ability to exploit different environment. Happold (1975) noticed occasional movement of *Stenocephalemys* into grasslands from adjacent forest and secondary vegetation habitats. He also stated that shrubs probably may act as corridors along which the animals move into the forest regions. The occurrence of *L. flavopunctatus* and *M. mahomet* in bushland and grassland habitats of the present study area might be due to the presence of better ground cover between the two habitat types.

The overall species abundance in the current study area did not show seasonal variation. However, the abundance of each species within the different habitats showed seasonal variations. For instance, the total number of *A. dembeensis* in the farmland was high during the wet season. But, it was outnumbered by its close relative *A. abyssinicus* during the dry season. Other species, such as *C. fumosa* and *D. mystacalis* were captured during one of the two seasons. During the dry season, grassland and farmland habitats showed increase in the total number of individuals captured; whereas the bushland as well as the forest habitats had less capture. Such seasonal fluctuation was frequently related to the abundance of vegetation cover, availability of food and water. According to Sidorowicz (1960), different weather conditions can influence the mass appearance of rodents. For example, rainfall can influence different aspects of a given ecosystem. For many species of rodents, breeding often appears to take place during the rainy season (Teylor and Green, 1976). Food shortage and reduced ground cover might be the main reasons for the declined number of rodents in the bushland and forest habitats (Delany, 1964). During the wet season, farmers move their livestock into the mountain vegetation areas to protect their farmland. Cattle were observed grazing in the grassland habitat. Such effect was absent after harvest. The absence of such adverse effects and the presence of good ground cover during the dry season, might have favoured rodents to reproduce, leading to higher trap success.

In this study, trap success between habitats showed seasonal variation. The highest trap success was obtained from the farmland habitat during both seasons. Forest habitat was with the least trap success during both seasons. A mean trap success of 12.7% was recorded from the present study area. This was relatively lower than the previous findings from different parts of Ethiopia. For instance, Afework Bekele (1996a) has obtained 9.1% from Menagesha-Suba State Forest; Serekebirhan Takele (2006) has recorded 13.8% from Wonji Sugarcane Area; Demeke Datiko *et al.* (2007) have obtained 17.6% from Arbaminch Forest and Farmlands; Mohammed Kasso (2008) recorded 44.1% from Chilalo–Galama Mountain range; Tadesse Habtamu and Afework Bekele (2008) have obtained 38.6% from Alatish National Park; and Mossisa Geleta (2010) obtained 13.5% from Komto Protected Forest. Climatic factors, vegetation type, availability of food, and human interference might have contributed to the less trap success of rodents from the present study area.

There was significant variation in the success of trapping of the different age groups in the current investigation. In both seasons, adult individuals comprised the highest percentage of trap success in all habitat types. Several other studies have revealed similar results with the present record on the seasonal variation of different age groups of rodents (Demeke Datiko *et al.*, 2007; Tilahun Chekol, 2009; Mossisa Geleta, 2010). Quality food resource and shelter within habitats play crucial role on the onset of breeding in many small mammal species. The highest trap success for the males could be associated with their high rate of mobility. Trapping success for females was less during both seasons. This might be related with their reproductive behaviour. Odhiambo and Oguge (2003) have explained that males make wider field excursions than females, which usually care for the litters. This might have limited the mobility of females and, hence lowering their trap success. Higher trap success for juveniles during the wet season could be due to the higher rate of breeding in the wet season.

In the present study, the population estimate made to the different data collection periods showed insignificant variation. But, the highest and lowest population record during the second session of the wet season and last session of dry season, respectively, might be related to the pattern of rainfall. Rainfall had crucial role to the breeding of many species of rodents (Teylor and Green, 1976). The highest biomass (1269 g/hectare) of rodents from the present study area was obtained during the wet season. The total biomass recorded varied among habitats. The highest biomass record was obtained from the farmland habitat; whereas the forest habitat was with the lowest biomass record (see Table 11). The high biomass record from the farmland habitat could be related to the highest trap success of *Arvicanthis* spp. during both seasons. In consistent with, Workneh Gebresilassie *et al.* (2005) and Ayenew Gezie (2009), the presence of sufficient food supply in the farmlands could have contributed for better biomass record of rodents from the present study area.

The highest embryo count among the rodents was recorded during the wet season. During the dry season, less number of pregnant females was obtained for *L. flavopunctatus*, *S. albipes* and *A. abyssinicus*. According to Boutin (1990), the presence of good quality and quantity of food in a given habitat may have significant effect on the time of reproduction, litter size and body growth rate of rodents.

There was seasonal variation in the proportion of plant and animal matter obtained from the stomach contents of each species (see Table 16). This shows omnivores and opportunistic feeding behaviour of the trapped individuals. Similarly, Taylor and Green, (1976) and Mohammed Kasso *et al.* (2010) have obtained comparable result from their stomach content analysis.

4.1. Conclusion and Recommendations

4.1.1. Conclusion

The data collected during the present study provided valuable information on the species richness, abundance and habitat association of rodents in Yerer Mountain Forest Area. During the overall data collection period, six species of rodents and one species of shrew were identified. Species richness and abundance among different habitats varied depending on the vegetation complex, altitudinal variation and other biotic and abiotic factors. In the present study, there was little variation in species richness among the different habitat types. However, the relative abundance of rodents showed marked difference among habitats. This could be related to the difference in habitat preference of rodents depending on the availability of good ground cover, vegetation complex, altitude and level of disturbance. There was no seasonal variation on the total live-trapped rodents. This could be mainly attributed to population fluctuation in some species and capturing of some species only one of the two seasons.

4.1.2. Recommendations

Based on the study result and the observations made during the study period the following recommendations are made:

- ❖ Rodents are mostly thought as good indicators of habitat quality. The less species richness to the forest habitat was due to the presence of high habitat manipulation through extracting trees for the purpose of fuel wood, house construction and livestock grazing (mainly during the wet season). Therefore, such type of habitat disturbances should be restricted by introducing community based habitat controlling systems.
- ❖ The area needs further extensive studies on its plant, bird and small mammal species diversity and with relation to different physical and biological factors.

- ❖ Seasonally clearing of the bushland area for the purpose of extending farmlands will cause extinction of diverse plant as well as animal species of the area. So strong control measures should be taken.

- ❖ Yerer Mountain has historical significance. It consists of many caves on different mountain sides. Further investigation is essential to use the area as an eco-tourism center.

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