ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF BIOLOGY

Ecological and Systematic Zoology Stream

Species Richness, Abundance and Habitat Preference of Rodents in Komto Protected Forest, Western Ethiopia

By

Mosissa Geleta

A Thesis Submitted to the School of Graduate Studies of the Addis Ababa University in Partial Fulfilment of the Requirments for the Degree of Master of Science in Biology

Advisor: Prof. Afework Bek

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ABSTRACT

A study on the species richness, abundance and habitat preference of rodents of Komto Protected Forest was carried out from July, 2009 to Feburary, 2010 encompassing both wet and dry seasons. The study was carried out using Sherman live and snap traps in maize farm, grassland, bushland and forest habitats. A total of 312 individual rodents (live traps) and 66 rodents (snap traps) were captured over 2352 and 1200 trap nights, respectively. The species composition and their relative abundance includes: *S. albipes* (48.4%), *L. flavopunctatus* (27.6%), *L. striatus* (10.3%), *P. harringtoni* (7.7%), *R. rattus* (5.1%) and *M. mahomet* (0.9%). In addition, a species of *C. flavescens* was also captured. Most of the rodent species prefer grassland and maize farm to bushland and forest. Bushland and forest habitats provided more number of individual rodents with few species. Males comprised 52.9% and females 47.1% of the total capture. Among the total rodents captured, adults, subadults and juveniles comprised 60.6 %, 28.8% and 10.6%, respectively. Active burrows were not recorded in all habitats during the wet season and in the grassland and forest habitats during both seasons. Population size was estimated by Minimum Number Alive method showed variation from 42 in Fubrary to 101 in September. High population density (309/ha) and biomass (8,048 g/ha) was recorded for *S. albipes* and lowest for *M. mahomet* (6/ha) and 29 g/ha, respectively. Seasonally, maximum biomass was obtained in September (5563 g/ha) and the lowest was in February (2,342 g/ha).

Key words: Abundance, habitat preference, Komto Protected Forest, rodents, species richness

1. INTRODUCTION

Ethiopia is known for its physical and biological diversity (Corti *et al.,* 1999; Leykun Abune, 2000) and high degree of endemicity in both fauna and flora (Yalden and Largen, 1992). The topographic feature of East Africa contains an isolated chain of mountains and plateau stretching from Ethiopia in the north to the Drakensberg Mountains in the south. The high plateau of Ethiopia covers large areas over 2,000 m asl with many peaks over 4,000 m asl (Happold and Happold, 1989; Clausnitzer and Kityo, 2001). The Ethiopian relief includes a range of altitudes from below sea level to high peak of 4,620 m asl (Shibiru Tedla, 1995; Tesfaye Hundessa, 1996; Afework Bekele and Corti, 1997). About 40% of the country consists of extensive highlands above 2,500 m asl. The highland of the country constitutes less than 50% of the total area and harbours about 74% human population (Afework Bekele and Corti, 1997).

Ethiopia is distinguished from all other African countries by its altitudinal variation. The highlands of the Ethiopian plateau are formed as a result of influx of molten rocks between strata during Tertiary Period. Diverse topographic features of Ethiopia produced a range of climate, which affects the distribution of both plants and animals (Yalden and Largen, 1992). Ethiopia has varieties of different species of animals and plants. The country is known in having diverse faunal community. There are about 284 species of mammals, 861 species of birds, 201 species of reptiles, 63 species of amphibians and 145 species of fresh water fishes (Dawit Kassa and Afework Bekele, 2008).

Mammals are evolutionarily the most successful groups of animals with the possible exception of insects (Stanbury, 1972). Among mammals, the order Rodentia represents the most diverse (Kingdon, 1997; Vaughan *et al.*, 2000; Auffray *et al.*, 2009). Approximately, 44% of all mammals are rodents with about 30 extant families (Casanovas-Vilar, 2007; Wolff, 2007), 468 genera and about 2,052 species (Nowak, 1999). The number of families and species of rodents varies according to the opinion of authors (Batzli *et al.*, 1977). More than 10% of the total mammalian biomass was represented by the order Rodentia (Avenant and Cavallini, 2007). Small rodents of Africa are the most ubiquitous and numerous among mammals (Delany, 1986). There are about 14 families, 89 genera and 381 species of rodents in Africa (Singleton *et al.*, 2007).

In Ethiopia, there are 84 species of rodents that account for 30% of all mammalian species of the country (Afework Bekele and Leirs, 1997). There are 15 endemic rodents in Ethiopia (Afework Bekele, 1996a) constituting 21% of the total rodents in the country (Afework Bekele and Corti, 1997). Among the nine families of rodents in Ethiopia, the family Muridae comprises 57 species. They make up 84% of the total rodents and 93% of the total endemic rodents in the country. Endemic rodents accounted for about 50% of the endemic mammals in Ethiopia (Afework Bekele and Corti, 1997).

Rodents are the most successful mammals with the exception of man (Stanbury, 1972) and cosmopolitan in distribution (Vaughan *et al.,* 2000). They show a great diversity in their morphology, ecology and behaviour (Delany and Happold, 1979). The species richness of this order is the result of succession of radiation, adaptation and diversification (Mason and Littin, 2003). Their rapid breeding rate (Stanbury, 1972) and quick response to the environmental changes enable them to have diversified species richness. Their small body size, relatively fast life history and behavioural plasticity make their response fast to the environment and resource variations. For instance, the house mouse (*Mus musculus*), the black rat (*Rattus rattus*) and the water rat (*Rattus norvegicus*) have worldwide distribution because of their association with humans and their adaptation to human habitats (Auffray *et al*., 2009). The population of rodents is known to respond to habitat quality such as climate, food, vegetation cover and rainfall. This response of rodents to the ongoing global climatic change depends on their dispersal ability and acclimatization (Mahlaba and Perrin, 2003; Auffray *et al*., 2009). Rodents respond quickly to disturbances and they are sufficiently mobile to disperse leaving unsuitable sites (Leis *et al.,* 2008).

Habitat factors that provide shelter and food are crucial for reproduction, survival and habitat selection of small mammals (Hansson, 1997). According to Doonan and Slade (1995), food supply is the most important factor that influences the biomass of small mammals. Rodent population exhibits a great seasonal and year to year variation. The specific underlying mechanism for such population changes are less understood. However, climate, food, disease and reproductive behaviours are involved in population changes of rodents (Mununa, 1996). Predators and cattle ranching also affect rodent population through habitat simplification (Tabeni and Ojeda, 2005).

Reproduction is highly energy consuming. Therefore, it requires coinciding with the time of the year that the habitat is rewarding (Shanas and Haim, 2004). Diet is extremely important to determine evolutionary life history strategies and ecological role of animals. Furthermore, it is used to understand the relationships between species and between species and its environments (Kronfeld and Dayan, 1998). Diet quality is the most important factor that regulates the onset of rodent breeding (Jackson and Vanaarde, 2004). Food produces a significant change in life history traits such as initiation of time of reproduction, litter size, body condition and growth rate (Boutin, 1990). Breeding in rodents begins some weeks after the onset of rainy season (Hubert, 1978), but varies with rainfall with increased rate at the end of the rainy season when resources are plenty (Workneh Gebresilassie *et al.*, 2006). In addition, temperature and social environments influence the reproductive performance of rodents (Batzli *et al.*, 1977).

Rodents are small bodied and the most diversified order of mammals (Casanova-Vilar, 2007; Auffray *et al.*, 2009). Their body mass ranges from 5 g to 70 kg in weight and from 80 to 350 mm in length with the exception of large bodied *Hydrochaerus hydrochaerus* and the family Castoridae. There are even larger fossil rodents such as the Pliocene extinct Parvorder Caviomorph and genus *Telicomys* which was as large as rhinoceros (Casanova-Vilar, 2007). Although they show considerable diversity in morphology, habitat utilization, behaviour, life strategies and distribution, they have less overall variation in body form as compared to several mammalian orders (Macdonald, 1984). Rodents are good subjects for study because of their great ecological, economical, medical and short lifespan (Delany, 1986; Kingdon, 1997; Dandrea *et al.,* 2007). Furthermore, they are useful indicators of environmental health (Duckwitz, 2001; Moro and Gadal, 2007; Mulungu *et al.*, 2008) and play an essential role as prey for reptilian, avian and mammalian predators (Kingdon, 1997; Conrey and Mills, 2001; Mulungu *et al.*, 2008; Scott *et al.,* 2008). Rodents are primary consumers of seeds and herbs (Austrheim *et al.,* 2007; Mulungu *et al.*, 2008). Rodents consume plant materials such as cereals, grasses, tubers, seeds, roots and fruits. However, they are opportunistic feeders capable of changing their diet based on the availability of food from season to season (Workneh Gebresilassie *et al.*, 2004). Rodents play an important structural role in the ecosystem by pruning vegetation, aerating soil through their burrowing activities, by mixing up soil components and spreading pollens (Kingdon, 1997). They play a crucial role in seed and fungal spore dispersal allowing them to colonize new habitats (Conrey and Mills, 2001; Duckwitz, 2001; Pearson *et al.*, 2001) and habitat modifications. Rodents are also important as predators of invertebrates and link between primary producers and secondary consumers (Avenant and Cavallini, 2007).

Rodents are used important source of food in many parts of Africa. They make up the most important component of the diet of the Gumuz indigenous people in Ethiopia (Tadesse Habtamu and Afework Bekele, 2008). There are about 71 rodent genera, representing more than 89 species that are consumed by man. Rodents are preferred as a delicious food source in several countries of Africa because of rich of protein content in their flesh (Fiedler, 1990).

The distribution and abundance of organisms are influenced by the interplay of abiotic and biotic factors to varying degrees (Brown, 1984; Desy, 1998; Russell and Clout, 2004; Suarez-Gracida and Alvarez-Castaneda, 2009). This is because each species may get favourable site from the combination of environmental variables that most closely corresponds to its requirements (Brown, 1984). Several habitat variables such as foliage height, vegetation cover (Rosenzweig and Winakur, 1969; Maccracken *et al.*, 1985; Barnett *et al.*, 2000), soil structures and soil types (Leis *et al.*, 2008; Massawe *et al*, 2008) are some of several factors that affect rodent abundance in a given habitat. Furthermore, the distribution, species richness and abundance of small mammals can also be affected by human disturbances such as deforestation, burning, grazing and trampling by cattle (Juch, 2000). Any kind of primary habitat modification has a serious effect on the species composition, diversity and total biomass of small mammals (Delany, 1971). Grazing decreases ground vegetation cover such as grass, herbs and shrubs causing higher exposure of soil surface and reduction in food availability (Juch, 2000).

Rodent community structure and species richness have been related to habitat structure and complexity, area of productivity, predation and succession of the vegetation (Avenant and Cavallini, 2007). Hence, relating habitat structure to faunal communities has been an important issue in ecology (Williams and Marsh, 1988). Different animals are adapted to respond to different categories of habitat structures. Small mammal communities often respond rapidly to changes in habitat structures such as plant composition and ground cover (Leis *et al.*, 2008). Mammal diversity tends to be lower in open habitats, where cover, food and resources are reduced (Silva *et al.,* 2005). This lowers fecundity and increases predation risk (Grant *et al.,* 1982). Habitats with increased structural heterogeneity positively influence small mammal abundance and richness (Ecke *et al.*, 2002). But, ecological disturbance of habitat is associated with decreased rodent species richness (Avenant and Cavallini, 2007). Habitat heterogeneity could enhance diversity as it can support distinct populations thereby allowing specialization. In contrast, diversity is low in fragmented habitats and habitats with low area coverage because of lack of specialization and competition among generalists. Habitat associations provide a useful way to determine how different species respond to environmental heterogeneity (Cramer and Willig, 2002).

The current understanding on habitat preference of rodents and insectivores in Africa is minimal. This is because limited research was conducted in different areas. Moreover, the findings are confounded to restricted geographical regions (Fitzherbert *et al.*, 2006). Habitat selection of small mammals has an adaptive basis. This is because individuals preferring high quality habitat have a reproductive advantage over conspecifics in low quality habitats. This ultimately would lead to particular species being more abundant in some habitats than in others (Cramer and Willig, 2002). Their habitat preference is determined primarily by the type of vegetation cover available (Parmenter and MacMahon, 1983; Iyawe, 1988; Monadjem, 1997). But, as revealed by Suarez-Gracida and Alvarez-Castaneda (2009), isolated environmental factors were not adequate to distinguish rodent abundance, species composition and habitat preference. Assessing habitat preference of rodent is critical as it provides information to develop agricultural pest management guidelines (Johnson, 1995).

Properties of soil are very important in rodent population ecology (Rhodes and Richmond, 1983; Desy, 1998; Massawe *et al.*, 2008). Even though, the properties of soil play a great role in small mammal ecology, several ecologists neglect the role of soil properties (Gibson *et al.*, 1990). However, as revealed by Grant and French (1980), the study of small mammal ecology is incomplete without considering the role of soil in structuring small mammal populations. Soil properties that mostly affect the distribution and abundance of animals include soil texture, moisture, aeration and soil types *(http://southwest.library.arizona.edu/azso/body.1_div.5.html).* Soil type and soil fertility are the two principal factors that influence vegetation characteristics (Leis *et al.*, 2008; Massawe *et al.*, 2008). Soil directly affects the distribution of fossorial mammals by providing shelter and indirectly by affecting the distribution of plants. Also various chemical contents of the soil indirectly affects small mammals by affecting the distribution of plants

(Hardy, 1945). Hence, soil conditions should be coupled with vegetation characteristics in the study of small mammal communities (Leis *et al.*, 2008). Soil properties do not influence animals independently but act together with vegetation cover. Furthermore, soil is a primary factor in influencing selection of burrow sites by semi-fossorial rodents (Desy, 1998). Soil hardness is the most important factor affecting burrowing efficiency of subterranean rodents (Luna and Antinuchi, 2006). They exhibit a preference for drier and well drained soils that presumably facilitate easy burrowing (Desy, 1998). When ground cover is lacking, terrestrial rodents migrate to other habitats or prefer easy burrowing sites to overcome the cost of burrowing and the risk of predation. Therefore, constructing a burrow system could be essential for individuals in open and more exposed habitat patches (Ebensperger, 1998; Carter and Ebensperger, 2005).

In Ethiopia, limited areas were extensively surveyed for the diversity of small mammals (Yalden and Largen, 1992). Several studies that have been conducted in the recent years were restricted to the northern, southwestern, southeastern highlands and central parts of Ethiopia (Yalden, 1988a, b; Sillero-Zubiri *et al.*, 1995; Afework Bekele, 1996a, b; Afework Bekele and Leirs, 1997; Tilaye Wube, 2005; Workneh Gebresilassie *et al.*, 2006; Tsegaye Gadisa and Afework Bekele, 2006; Demeke Datiko *et al.*, 2007; Mohammed Kasso 2008; Tadesse Habtamu and Afework Bekele, 2008). Therefore, there is a need for further survey on small mammals in different part of the country where the diversity of small mammals was not sufficiently investigated so as to balance the information on small mammals of the country. The western part of Ethiopia in general and the eastern and western part of Wollega in particular have several remnant wilderness areas with diverse fauna and flora. Huge natural resources are unexplored and untapped while the diverse wildlife and potential of ecotourism are yet to be discovered in this part of the country. However, as a result of an increased population pressure, people migrate towards the forest blocks seeking fertile farmlands. This is followed by clearing of forest, which in turn affects the diversity of the fauna. So far, relative to the other regions of the country, studies on mammals of this region is neglected. Hence, its faunal community is poorly known. Specially, the faunal and floral communities of the remnant forest blocks around the Dabus and Didessa valleys, Jorgo, Tullu Lafto and Chato forests and Dati controlled hunting area, in Wollega are poorly studied. This might be because of the remoteness of the area as well as the inconvenience and inaccessibility to reach the region. At the same time, the area might be considered as biodiversity cold spot region and gets less attention by conservationists and ecologists. The present study, therefore, aims to fill the gap on species composition and habitat preference of small mammals of a part of this region. Furthermore, it may serve as cue to draw the attention of researchers who would like to conduct further investigation on the biodiversity of this region. Most of the previous studies emphasized on the activity pattern, population dynamics, feeding ecology, abundance and habitat association of rodents neglecting soil types from ecological variables. However, the present investigation is an attempt to consider dominant plant species composition, dominant understory species, soil texture and soil types to assess abundance and habitat preference of rodents.

2. OBJECTIVES

2. 1. General objective

The main objective of the present study is to gather information on species composition, abundance and habitat preferences of rodents in Komto Protected Forest.

2. 2. Specific objectives

The specific objectives of this study are the following:

- To describe rodent species richness in the study area.
- To determine abundance of rodents in different habitats.
- To determine the distribution of rodents in different habitat types.
- To describe the habitat preference of rodents in the study area.
- To describe the effect of soil types on rodent population in the study area.

3. THE STUDY AREA

3. 1. Location

The present investigation was carried out in Komto Protected Forest in the Oromia Regional State of East Wollega Administrative Zone. It is located about 330 km west of Addis Ababa along Addis - Ababa Assosa road and 12 km east of Nekemte, the capital town of east Wollega Administrative Zone. The study area is situated at 9º 05’ 10” – 9º 06’ 35” N latitude and 036º 36’ 47” – 036º 38’ 10” E longitude with an elevation ranging from 2,135 to 2,482 m asl (Fig. 1). This forest was proposed as one of the National Forest Priority Area in Ethiopia in 1976 and established as protected area in 1991 with an estimated total area of 9,100 ha including natural forests, plantations, disturbed and encroached areas (Personal Communication with Guto Wayu Woreda Agricultural Office). The settlers from the forest area were subjected to leave the forest when it was established as a protected area. However, a year later, following the fall of the Dergaue regime, they returned to settle in and around the forest area. At present, because of encroachments (Plate 1), agricultural expansion and logging of trees for charcoal (Plate 2) and timber production (Plate 3), the area of the forest has been reduced. The greatest portion of fuel wood and charcoal consumption of Nekemte town is obtained from Komto Protected Forest. Although guards were employed, it is still seriously logged at night for timber and charcoal production.

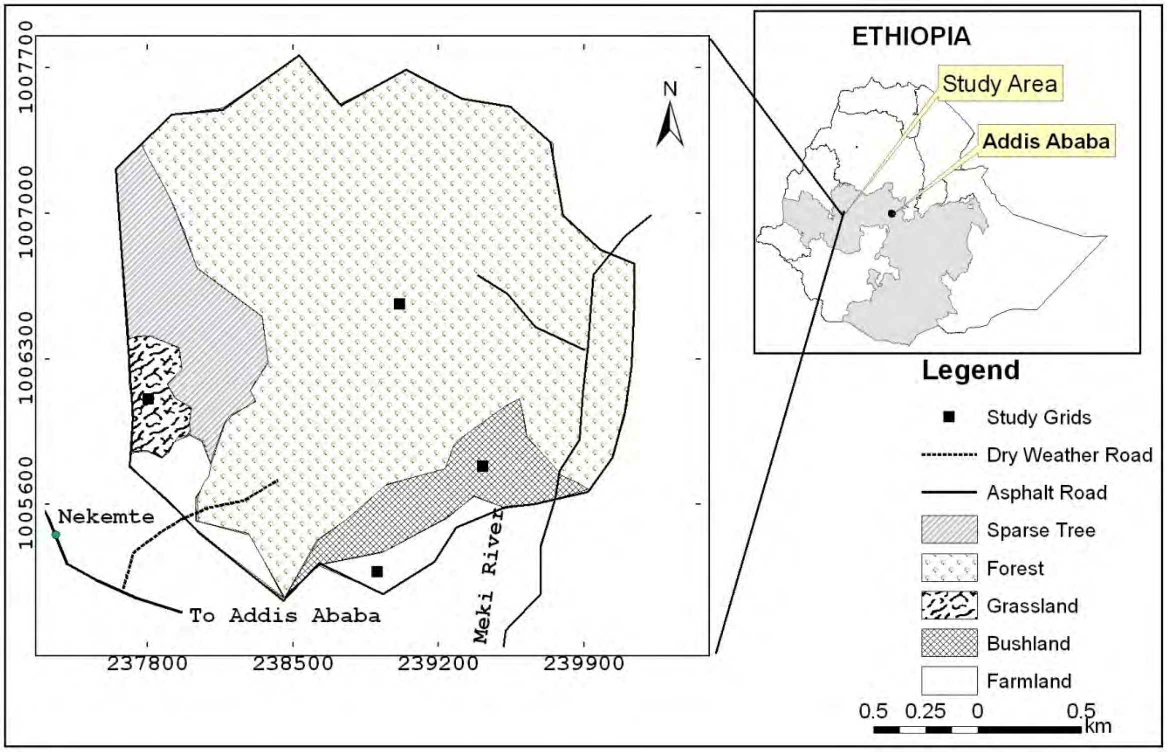

Figure 1. Map of the study area

3. 2. Climate and soil

The study area is characterized by warm temperate (Woina Dega) climatic condition and receives a unimodal annual rainfall. Meteorological data of the study area was obtained from Nekemte Meteorological Station, which is about 12 km away from the study area. The rainy season is longer and mostly extends from April to October with maximum rain between June to August (Fig. 2). The mean annual rainfall the area obtained from 1998 to 2007 was 2,031 mm. The mean minimal temperature registered for most of the months was (12.2ºC) and the mean maximum temperature was 27.9ºC in February and March (Fig. 3).

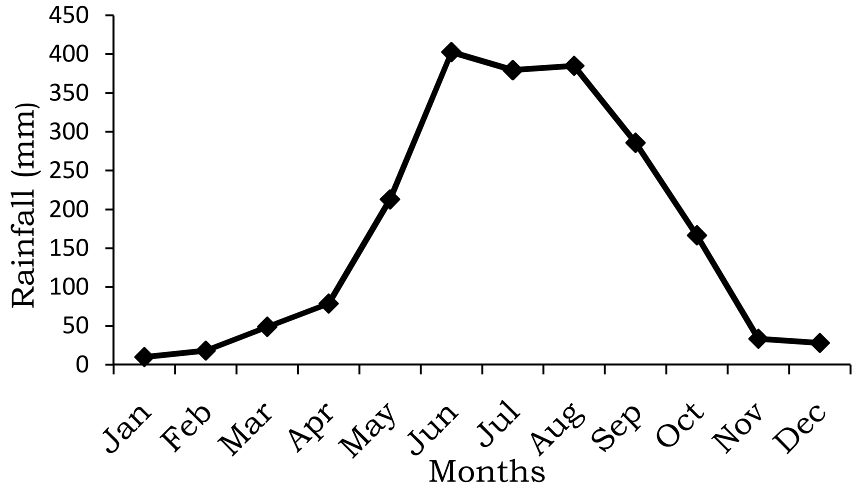

Figure 2. Monthly average rainfall of Nekemte and its surroundings (1998 to 2007).

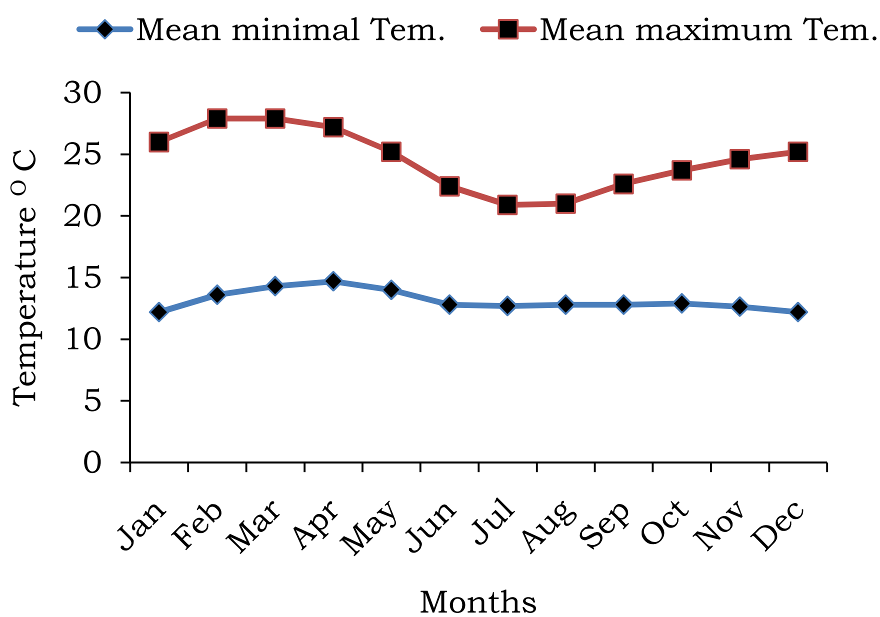

Figure 3. Monthly mean minimum and maximum temperature of Nekemte and its surroundings (1998 to 2007

As described by Demel Teketay (2002), the soil types of the western part of Ethiopia and southwestern Wollega are generally dry vertisols and inceptisols. The major soil types and spatial coverage of soil type in Wayu Tuka Woreda includes clay loam (17371.68 ha), sandy (10133.49 ha) and clay (1447.64 ha), which are suitable for agriculture (Wayu Tuka Woreda Agricultural and Rural Development Office, 2008).

3. 3. Fauna

Komto Protected Forest is home of varieties of mammals including blue monkey, Menelik's bushbuck, bush duicker, spotted hyaena, common jackal, aardvark, olive baboon, Starck's hare and colobus and vervet monkeys.

3. 4. Vegetation

The vegetation type of the eastern highlands of Wollega includes broad leaved and evergreen forests. Some of the common and important tree species include: *Pouteria adolfi-friedrici*, *Syzigium guineense* ssp. *afromontanum*, *Apodytes dimidiate*, *Prunus Africana*, *Albizia gummifera*, *Albizia schimperiana, Croton macrostachyus, Cassipourea malosana, Ekebergia capensis, Euphorbia ampliphylla* and *Ficus sur* (Demel Teketay, 2002). Similarly, Komto Protected Forest is characterized by moist evergreen afromontane forest and the trees form a closed canopy. The vegetation type of the study area consists of natural and man-made forests. The species composition of man-made forest or planted forest includes *Cupressus lusitanica* and *Pinus radiata.* The study habitats were classified as forest, bushland, grassland and farmland. The four habitats were randomly selected from the study area to compare rodent species composition, abundance and their habitat preferences. The largest part of plantation was removed for commercial purpose during the dry season of 2009 and has not included in the study grids.

Extensive agricultural expansion was observed in the peripheral parts of the forest as as result of several settlments. The types of crops that are commonly cultivated around the study area are teff, wheat, maize, barley and sorghum. Out of all farmlands, maize farm was selected because of its large area coverage to set trapping grid (Plate 4A). The grassland is dominated by *Hyparrhenia hirta* grass species with *Medicago polymorpha, Medicago sativa, Cynodon aethiopicus* and other herbs forming dominant understory species (Plate 4B). However, there are short and sparsely distributed shrub species in and around the edge of the grassland habitat. The bushland habitat mainly consists of *Hypoestes forskaolii*, deciduous shrubs, herbs and short vegetation types. The area is mostly covered with secondary vegetation (Plate 5C). There are distantly located large *Croton macrostachus* and *Ekebergia capensis* trees in the grid and few and narrow riverine forests only on one side of the grid. The forest of the study site is mainly dominated by large tree species that have an average height of over 30 m, forming few open canopies with thick ground vegetation cover (Plate 5D). The ground cover is dominated by *Hypoestes forskaolii* and few seedlings of dominant tree species. Habitat description of the four study grids is given in Table 1.

4. MATERIALS AND METHODS

4. 1. Materials

Materials used during the present investigation were: Sherman live traps, snap traps, peanut butter, polyethene bag, Pesola spring balance, ruler, dissecting kit, GPS, hydrometer, hydrometer jar, stirrer, field guides, data sheet, gloves, digital camera, 0.25 mm sieve, yellow plastic tag, petridish and preservative bottles. Dissecting and compound light microscopes were used for stomach content analysis and 70% ethyl alcohol was used to preserve the stomach contents.

4. 2. Methods

4. 2. 1. Preliminary survey

Preliminary survey about the study area was conducted during July, 2009. During this period, all relevant information about the study area such as the size of the study area, habitat types, study sites, climatic conditions, cultivated crops and other environmental conditions were thoroughly assessed.

4. 2. 2. Sampling design

Based on the preliminary survey of the study area, different habitat types were identified as forest (F), bushland (Bl), grassland (Gl) and maize farm (Mf). The study sites were selected randomly from each habitat type. A permanent grid was established in each of the representative habitat types during both wet and dry seasons. Maize farm, grassland, bushland and forest represented grid number 1, 2, 3 and 4, respectively. The sampling grids each consisted 70 x 70 m area with 49 trap stations. All live trapping grids were spaced at more than 400 m apart to ensure independent captures. Trap stations were marked with yellow plastic tag, on the visible part of a branch of a tree near or above the traps, except in the grassland grid in which the tallest grasses were tied at each trapping station.

4. 2. 3. Data collection

Data on the species richness, abundance and habitat preference of rodents were collected from the representative habitats from July, 2009 to September, 2009 for the wet season and from December, 2009 to February, 2010 for the dry season. During data collection, both Sherman live traps and snap traps were used to collect rodents. Data collection was conducted in four trapping sessions with two trap sessions per season covering both wet and dry seasons.

Some of the environmental variables that could influence the abundance and habitat preference of rodents were considered. These include: dominant plant species composition, dominant understory species and structure of the habitat floor, soil texture and soil types. In addition to environmental variables that are considered in this study, the whole study grids were thoroughly surveyed for other activities of rodents such as burrows and burrowing systems during both seasons. The environmental variables were collected after the traps were removed from each grid to minimize disturbance to animals. Detailed habitat description for each sampling grids is given in Table 1. Environmental variables including vegetation parameters were used to associate and compare rodents' abundance and habitat preference among habitat types. Except for soil texture, vegetation parameters were described qualitatively following vegetation inventory and description methods of Whites and Edwards (2000). Dominant plant species composition and understory species were collected from each grid and identified at the National Herbarium of Addis Ababa University.

Table 1. Habitat description of the trapping grids

Habitats	Dominant plants and understory species	Description	
		Wet season	Dry season
Maize farm	Zea mays, *Guizotia scabra, Bidens camporum, Digitaria velutina, Setaria megaphyla*	Ground is covered with weeds (grass and herbs). The maize plants gave ground cover. There are grass covers at the edge.	Harvested, dried, falling and slightly decomposed maize plants covered the ground. Dry grasses are distributed sparsely. Limited ground cover but remnant grasses at the edge. Ground cover was generally poor.
Grassland	*Hyparrhenia hirta, Medicago polymorpha, Medicago sativa, Cynodon aethiopicus, Pennisetum thumbergi, Digitaria velutina*	Grasses (30 to 50 cm long) and very dense understory covers. Areal cover contains grasses and several other herbs. All land covered except few piled soil from burrow sites of mole rats. Understory cover is very thick and dense.	Grasses were about 2 m high and thick. There is no variation in ground cover from wet season except that all the grasses and other understory species are dried up especially at the last trapping session.
Bushland	*Vernonia auriculifera, Hypoestes forskaolii, Medicago sativa, Cynodon aethiopicus, Medicago polymorpha*	Fairly distributed bushes of about 1.5 to 2 m long, wood and leaf debris on the floor. Large *Ekebergia capensis* and *Croton macrostachus* in the grid. Ground is mostly covered with few grasses. Several herb species make close understory cover under *Hypoestes forskaolii* species. Generally ground cover was moderate.	Slightly shed bushes, dried grass species and other understory covers are reduced as the result of intermittent trampling of cattle. Grass patches at the floor of the bushes and sparsed *Hypoestes forskaolii.* Generally ground cover was sparse.
Forest	*Hypoestes forskaolii, Urtica simensis, Girardinia diversifolia*	Long tree species above 30 m high form closed canopy. Other trees of about 5 m high forming secondary layer under the tall trees. Ground covered by *Hypoestes forskaolii* and young seedlings of dominant trees. It also contains leaf and epiphyte debris. The floor is moist and damp. Understory cover is moderate.	The densities of *Hypoestes forskaolii* species decreased. Understory cover was sparse. But tall tree species that form secondary forest layer serve as a good ground cover and shade from a distance. There were no grasses. Ground cover was better than bushland and maize farm.

After physical examination of soil in each grid, about 0.5 kg of 8 soil samples were taken randomly and diagonally across the two opposite angles of each grid at the depth of 30 cm. Thirty two soil samples were collected and packed in plastic bags for further soil texture analysis at Nekemte Soil Research Laboratory Centre. Soil samples from the same grid were mixed thoroughly in the laboratory. About one kilogram of soil sample was taken from each grid for laboratory processing. Soil particle size analysis and their percentages were obtained by using the hydrometer method. Soil types were characterized by using soil texture triangle (Gee and Bauder, 1986; Desy, 1998; National Soil Research Centre Ethiopian Agricultural Research Organization, 2000).

4. 2. 3.1. Live traps

To determine the species richness, abundance and habitat preferences of rodents, Sherman live traps were used. In all grids and trapping sessions, 49 Sherman live traps were used for three consecutive nights and 147 trap nights per grid. Traps were baited with peanut butter and checked twice a day, early in the morning hours (07:00-08:00 h) and late in the afternoon hours (17:00-18:00 h). Traps were cleaned and rebaited when checked if consumed, dried, lose odour and sprung by wind, rain and non-targeted animals. Traps that were shut overnight without capturing anything are reset while checking. To avoid extreme heat or cold, traps were covered with grass and leaves. A single trap was placed at each trap station and labelled with the different number. Rodents were removed from the traps, placed in transparent polyethene bag and weighed to the nearest gram using 100 g Pesola spring balance. Trapped rodents were identified to species level, sexed and approximate age was determined (Adult, subadult and juvenile). In males, reproductive conditions were determined by the position of testicles (scrotal or abdominal) and the size of the testicles. Reproductive conditions in females were determined by the size of nipples, perforation or imperforation of vagina, distended abdomen and body weight (Barnett and Dutton, 1995; Afework Bekele, 1996a; Mahlaba and Perrin, 2003). Lactating females were identified by the presence of halos around the nipples. Juveniles were identified by their low body weight, soft fur and by small cartilages left between their digits (Barnett and Dutton, 1995). As stated by Afework Bekele (1996a), juvenile females were identified as non-perforated vagina and invisible nipples and juvenile males were identified with abdominal testes. Trapped rodents were marked by toe clipping and released at the point of capture. For each capture in each grid, grid number, trap number, time and date of capture were recorded.

4. 2. 3. 2. Snap traps

Twenty five snap traps were used along with Sherman live traps to collect data on morphological measurements (Weight, head-body length, tail length, hind foot and ear length) and for stomach content analysis, both during the wet and dry seasons. Only adult rodents were considered for standard morphological body measurements. All the standard morphological measurements were measured to the nearest cm except body weight. Each snap trap was spaced at about 10 m interval along five transect lines in all habitat types. Trap lines were also separated by about 10 m from each other and about 200 m away from live trapping grids. Snap traps were baited with peanut butter and set in different habitat types for three consecutive nights. Traps were checked twice a day after Sherman live traps were checked. Snap traps were shifted randomly during each trapping sessions in order to assess rodent species that might exist in the habitats. Trapped rodents were dissected and the number of embryos in the left and right uterine horns of pregnant females was counted. The skin and skull voucher of representative snap-trapped rodents were prepared and brought to the Zoological National History Museum of Addis Ababa University, where the final identification of specimens was confirmed.

4. 2. 4. Diet

Diet analysis was done following the methods of Ellis *et al.* (1998); Kronfeld and Dayan (1998); Vieira, 2003; Workneh Gebresilassie *et al.* (2004) and Demeke Datiko *et al.* (2007). Snap trapped rodents were removed from the traps, identified to the species level and sexed in each habitat type. Fifty representative snap trapped rodents were dissected for stomach content analysis. The stomach contents were spread onto a petridish and mixed thoroughly. Then, the contents were added into 0.25 mm sieve and washed with a jet of water to remove finely chewed or digested food and fine particles for proper identification.

The stomach contents were dried in open air for a day. A preliminary examination was carried out to identify the most common types of food items. Four slides were prepared for each sample and the contents were put on a glass slide to observe the type and proportion of food items under dissecting and compound light microscopes. Each food fragment was counted from the entire slide, summed up and converted to the mean percentage for each sample.

4. 2. 5. Data analysis

Relative abundance was calculated as catch per unit effort excluding recaptures. The term “trap night” was used to describe one trap that was set for 24 h and trap success was the number of small mammals captured/100 trap nights. Density of rodents was estimated for each habitat as the number of rodents alive per hectare and biomass was calculated using the mean weight of each species and the population estimates per hectare. Species richness is determined by the number of species captured at each grid (Avenant and Cavallini, 2007; Caro, 2001). Habitat preferences of rodents were inferred by comparing the number of captured rodents in each habitat following Happold and Happold (1989, 1991). The more frequent captures in a particular trap is an indicative of a preference of species for that habitat (Martin and Dickinson, 1985). Populations of rodents during the different trapping session were estimated by the Minimum Number Alive (MNA) method. The Shannon Weaver diversity Index (H’), Simpsons Similarity Index (SI), Chi-square test and SPSS version 13.0 computer programs were used to analyze the data.

5. RESULTS

The findings of this study are presented in four separate sections. The first section consists of the results of soil analysis and the number of burrows recorded in each habitat and season. The total species composition of small mammals identified from the study area is presented in the second section. The third part deals with the results obtained from Sherman live trapped rodents. These include: species composition, abundance, habitat preference, seasonal variation, population structure, trap success, population estimates, reproductive pattern, density and biomass. The last section deals with data collected by snap traps, which includes species composition, body measurements, embryo size and diet analysis.

5.1. Physical properties of soil and rodent burrows

The physical properties of soil for each habitat or trapping grid showed that, the soil type of grassland, bushland and forest habitats is loamy soil with similar percentage of soil particles. But the soil type of maize farm was sandy clay loam in which sand particles make the largest portion of the soil (Table 2).

Table 2. Physical properties of soil types from sampling grids

Grid No.	Particle size analysis (%)			Soil texture
	Clay	Sand	Silt	(Soil types)
1	28	53	19	Sand clay loam
2	18	35	47	Loam
3	22	37	41	Loam
4	22	35	43	Loam

Burrows of rodents were mostly surveyed in all habitats following their tracks during both seasons (Table 3). There were no burrows in maize farm during the wet season and in the grassland and forest habitats during both seasons. However, eleven active burrows during the dry season were recorded in the maize farm. Similarly, three abandoned and five active burrows were recorded in the bushland during the wet and dry season, respectively. The difference in the number of burrows between habitats and seasons was significant (P<0.005).

Table 3. Number of rodent burrows recorded for different habitats and seasons (**-**=No burrows,*****= abandoned burrows, **+**= active burrows)

Habitat types	Number of burrows per season		Total
	Wet	Dry	
Maize farm	-	11^{+}	11
Grassland	-	-	-
Bushland	3*	5^{+}	8
Forest	-	-	-
Total	3	16	19

5. 2. Overall species composition and abundance of small mammals

A total of 391 small mammals were captured in 3552 trap nights (Table 4). All trapped small mammals belonged to the order Rodentia and Insectivora. All rodent species were members of the family Muridae, whereas a species of shrew represented the family Soricidae. The rodent species were *Stenocephalemys albipes*, *Lophuromys flavopunctatus, Rattus rattus*, *Pelomys harringtoni, Lemniscomys striatus* and *Mus mahomet*. The captured shrew species was *Crocidura flavescens*. They were trapped both by

Sherman and snap traps in all habitats during both dry and wet seasons. The relative abundance of small mammals was: *S. albipes* (45.0%), *L. flavopunctatus* (26.4%), *R. rattus* (6.4%), *P. harringtoni* (8.0%), *L. striatus* (10.2%), *M. mahomet* (0.8), *C. flavescens* (2.0%) and unidentified rodents due to ant damages (1.3%). The rodent species accounted for 98% of the total small mammal capture. The remaining 2% was represented by the species of insectivore.

Table 4. Species composition, total catch and abundance of small mammals from Komto Protected Forest (***** Observed not captured)

Species	Total Catch	Abundance (%)
Stenocephalemys albipes (Rüppell 1842)	176	45.0
Lophuromys flavopunctatusI (Thomas 1904)	103	26.4
Lemniscomys striatus (Linnaeus 1758)	40	10.2
Pelomys harringtoni (Thomas 1903)	31	8.0
Rattus rattus (Linnaeus 1758)	25	6.4
Mus mahomet (Rhoads 1896)	3	0.8
Crocidura flavescens (Geoffroy 1825)	8	2.0
Damaged rodents	5	1.3
Tachyrctes splendens (Rüppell 1835)	*	*
Hystrix cristata (Linnaeus 1758)	*	*
Paraxerus ochraceus (Huet 1880)	*	*
Total 10	391	100

Five individual rodents (1.3%) were completely damaged by foraging ants during the wet season in the forest habitat. Therefore, they were not sexed. In addition, they were not known whether they are new captures or recaptures and, hence, hereafter, they are excluded. The presence of other three species of rodents (*Tachyrctes splendens*, *Hystrix cristata* and *Paraxerus ochraceus* was confirmed from the study area. The presence of *H. cristata* was confirmed by droppings and shaded spine quills in the forest whereas *T. splendens* (mole rat) was observed directly by digging the burrowing sites. Furthermore, the burrowing sites and pilled soil especially from the bushland and grassland areas were evident for the existence of mole rats. *Paraxerus ochraceus* were also observed directly by eye near and on the branches of largest and oldest trees.

5.3. Sherman live-trapped rodents

5. 3. 1. Species composition and abundance

A total of 395 captures of 312 individual rodents were trapped in 2352 trap nights from the four selected habitat types. Rodent species recorded by Sherman live traps were *S. albipes, L. flavopunctatus, R. rattus, P. harringtoni, L. striatus* and *M. mahomet* (Table 5). *S. albipes* was the most abundant species (48.4%) whereas *M. mahomet* (0.9%) was the least from the study area. The relative abundance of the other rodents species were *L. flavopunctatus* (27.6%), *L. striatus* (10.3%), *P. harringtoni* (7.7%), and *R. rattus* (5.1%).

Table 5. Species composition, total catch and abundance of live-trapped rodents (Numbers in parenthesis indicate recaptures)

Species		Total Catch	Abundance (%)
S. albipes		151(39)	48.4
L. flavopunctatus		86(21)	27.6
L. striatus		32(7)	10.3
P. harringtoni		24(6)	7.7
R. rattus		16(5)	5.1
M. mahomet		3	0.9
Total	6	312(78)	100

5. 3. 2. Distribution, abundance and species richness

The distribution of rodent species varied in different habitats of the study area (Figure 4). *S. albipes* was the most abundant (48.4%) and widely distributed species followed by *L. flavopunctatus,* which comprised 27.6% of the total rodent catch. However, the number of *L. flavopunctatus* in maize farm was very low and captured only during the dry season. *R. rattus* was exclusively captured from the maize farm. The rodent species that were confined only to two habitats (maize farm and grassland) were *L. striatus* and *M. mahomet. P. harringtoni* was captured only from grassland and forest habitats.

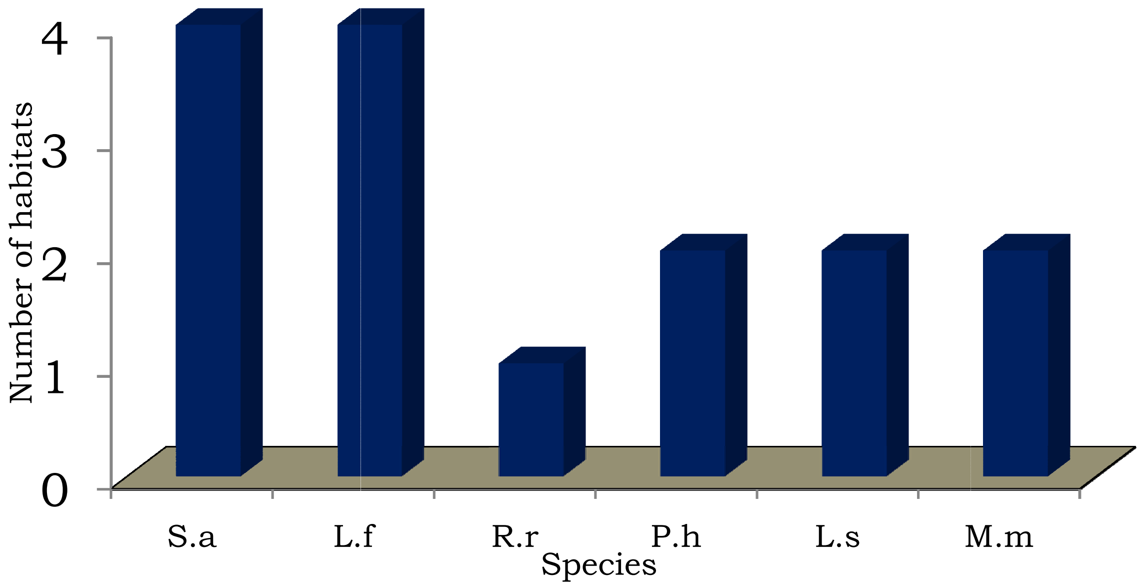

Figure 4. Species distribution of live-trapped rodents in the number of habitats (S.a= *S. albipes,* L.f= *L. flavopunctatus,* R.r= *R. rattus,* P.h= *P. harringtoni,* L.s= *L. striatus,* M.m= *M. mahomet)*

The population of rodents per habitat is given in Figure 5. The highest number of individual rodents was trapped from bushland habitats (30.1%). However, there were only two species present in this habitat. The second highest individual capture was obtained from forest habitat (27.2%) encompassing three species of rodents. The lowest individual captures but with the highest number of species was from grassland (23.1%) and maize farm (19.6%).

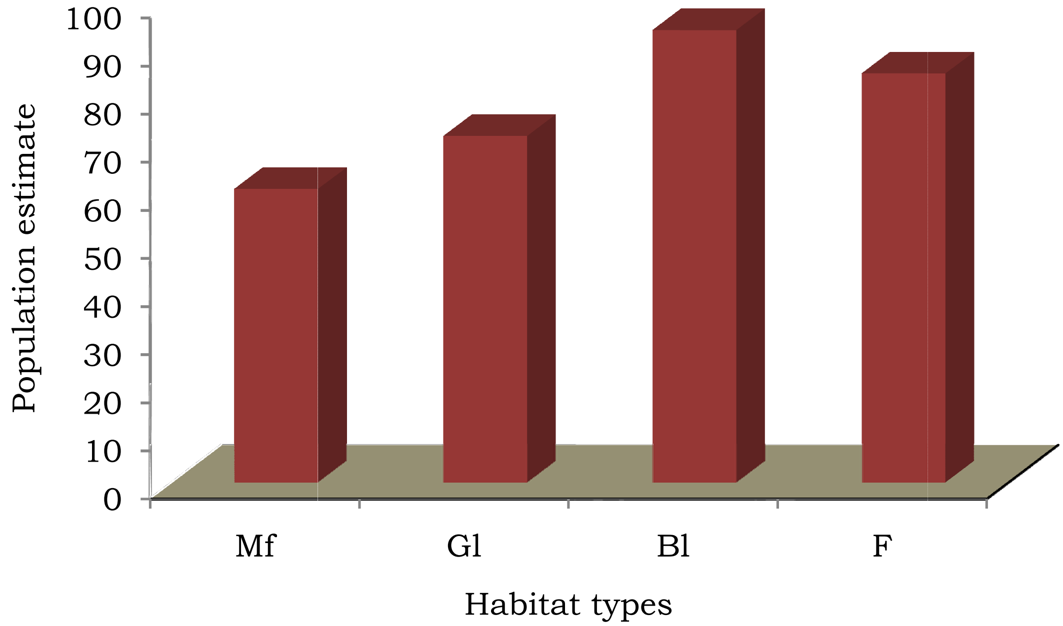

Figure 5. Population estimate of rodents per habitat (Mf= Maize farm, Gl= Grassland, Bl= Bushland, F= Forest)

Species richness varied across habitats from minimum of 2 species in bushland to a maximum of five species in the grassland and maize farm habitats. Simpson's Similarity Index (SI) showed less than 50% similarity between the habitat types (27.0%) with reference to the species composition. The Shannon Weaver diversity Index (H') showed high species diversity in the grassland and maize farm (Table 6).

Table 6. Species richness and diversity of rodents for each habitat (Mf= Maize farm, Gl= Grassland, Bl= Bushland, F= Forest)

Character	Habitat types			
	Mf	Gl	Bl	F
No. of trap nights	588	588	588	588
No. of captures	61	72	94	85
Species richness	5	5	2	3
Diversity Index(H')	1.251	1.396	0.464	0.837

5. 3. 3. Habitat preference of rodents

The distribution and percentage habitat preference of each rodent species are given in Table 7. *S. albipes* (43.7%) highly preferred bushland but *L. flavopunctatus* (38.4%) and *P. harringtoni* (62.5%) prefers forest habitat. *R. rattus* (100%) (exclusively) and *M. mahomet* (66.7%) preferred maize farm whereas *L. striatus* (62.5%) preferred grassland habitat. There was a significant difference in the number of *S. albipes*, *L. flavopunctatus, P. harringtoni*, *L. striatus,* and *R .rattus* captures among habitats (P <0.005) but the captures of *M. mahomet* was insignificant (P>0.005).

Table 7. Habitat preference of rodent species in different habitats (figures in bracket shows % of occurrence)

	Species					
Habitat types	S. a	L. f	P. h	R. r	L.s	M. m
Maize farm	29(19.2)	2(2.3)	-	16(100)	12(37.5)	2(66.7)
Grassland	19(12.6)	23(26.7)	9(37.5)	-	20(62.5)	1(33.3)
Bushland	66(43.7)	28(32.6)	-	-	-	-
Forest	37(24.5)	33(38.4)	15(62.5)	-	-	-

S. a= *S. albipes,* L. f= *L. flavopunctatus,* R. r= *R. rattus,* P. h= *P. harringtoni,* L.s= *L. striatus,* M. m= *M. mahomet*

P. harringtoni and *R. rattus* were the only species which were not trapped from maize farm and grassland, respectively. *S. albipes and L. flavopunctatus* were the commonest species trapped from all habitats. Maize farm and grassland had the highest number of species and bushland was the lowest. Comparison of the species composition among different habitat types was statistically not significant ($P > 0.05$) (Figure 6).

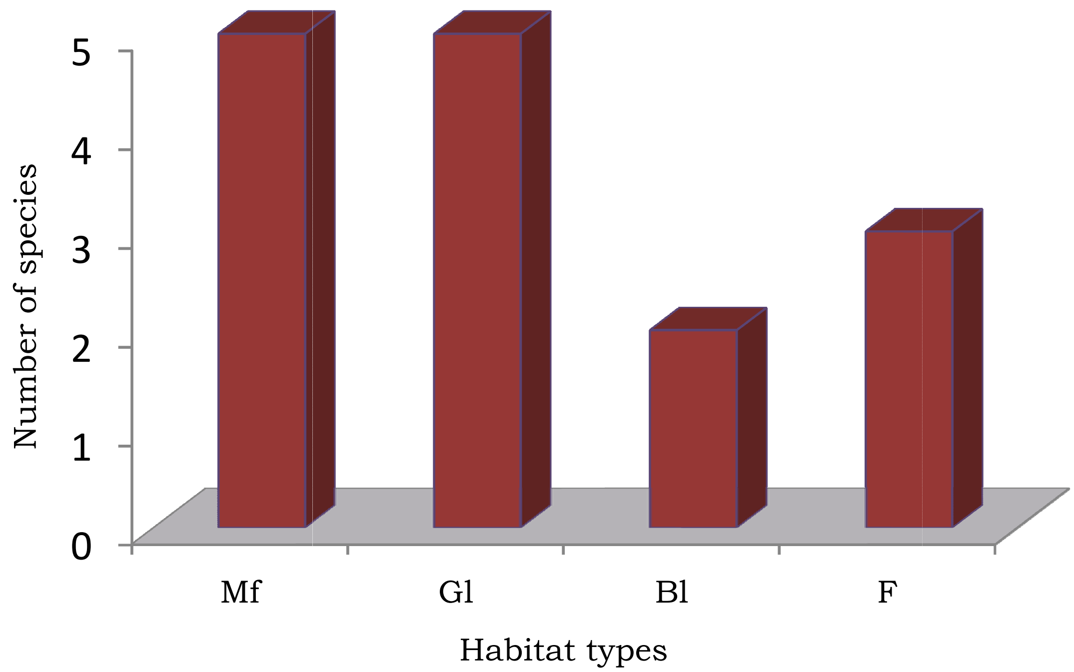

Figure 6. Rodent species diversity across the four habitats (Mf= Maize farm, Gl= Grassland, Bl= Bushland, F= Forest)

During the wet season, the number of *S. albipes* captured in the bushland was greater than captures made in other habitats. Their number increased in all habitats during the wet season except in maize farm. *S. albipes* showed similar preference for maize farm during both seasons. However, it showed high preference for bushland (30.5%) during the wet season and less preference for grassland (3.3%) during the dry season. Except in the maize farm, more number of rodents was captured during the wet season than the dry season. However, the difference in the abundance of rodents within habitats during the different seasons was not significant in the maize farm ($P<0.05$) but varied significantly in the other habitats ($P <0.005$).

During the dry season, *L. flavopunctatus* showed similar preference for bushland (15.1%) and forest (14.0%) habitats and least for maize farm (2.3%). Also, it has similar preference for bushland (17.4%) and grassland (19.8%) during the wet season with increased preference for forest habitat (24.4%). The species totally neglected maize farm during the wet season. *P. harringtoni* has utilized forest habitat more often than other habitats during the wet season (41.7%) followed by grassland (25.0%). *L. striatus* was caught frequently in grassland (43.8%) followed by maize farm (21.9%) during the wet season. Though *R. rattus* was exclusively trapped from maize farm, it showed high preference for maize farm (62.5%) during the dry season. Similarly, 66.7% of *M. mahomet* was caught from the maize farm during the dry season and the remaining 33.3% was from grassland during the wet season.

5. 3. 4. Seasonal variation and sex ratio

Altogether there were six species of rodents trapped. There was no variation in the number of species captured during the wet and dry seasons. *M. mahomet* was captured only in September and December. However, more number of rodents was captured during the wet season than the dry season (Table 8). The overall abundance of rodents between wet and dry seasons was 196 (62.8%) and 116 (37.2%), respectively. The difference in the abundance of rodents between seasons was significant ($P<0.01$).

The sex ratio of different rodent species trapped during the trapping sessions is given in Table 8. Among the 312 live-trapped individuals, males comprised 165 (52.9%), and females 147(47.1%). There were more number of males than females. However, the difference in the number of male and female was not significant ($P>0.05$).

Table 8. Seasonal variation and sex distribution of live-trapped rodents (S.a= *S. albipes,* L.f= *L. flavopunctatus,* R.r= *R. rattus,* P.h= *P. harringtoni,* L.s= *L. striatus,* M.m= *M. mahomet*, M= Male, F= Female)

Species	Number of individuals trapped									
	July, 2009		Sep, 2009		Dec, 2009		Feb, 2009		Total	
	M	F	M	F	M	F	M	F	M	F
S. a	23	22	26	28	15	19	10	8	74	77
L. f	14	12	16	11	10	8	6	9	46	40
R. r	1	1	2	2	6	2	2	-	11	5
P. h	5	4	5	2	3	2	1	2	14	10
L. s	7	6	5	3	3	4	3	1	18	14
M. m	-	-	-	1	2	-	-	-	2	1
Total	50	45	54	47	39	35	22	20	165	147

5. 3. 5. Population structure

Out of 312 individuals trapped, 60.6 % were adults. Subadults and juveniles made 28.8% and 10.6%, respectively (Table 9). More number of adults, subadults and juveniles were captured during the wet season than during the dry season. There was significant variation among the three age classes of rodents during different trapping sessions (P<0.001). However, juveniles of *R. rattus*, *P. harringtoni* and *M. mahomet* were not trapped. Variation in the number of juveniles captured during the wet and dry season was statistically significant (P<0.01). The difference in the total capture of juveniles during the different trapping sessions also varied significantly (P<0.05).

Table 9. Age groups of live-trapped rodents during different trapping sessions

Seasons	Individuals trapped			Total
	Adults	Subadults	Juveniles	
Wet (July,2009)	59	29	7	95
Wet (Sep., 2009)	54	31	16	101
Dry (Dec.,2009)	48	19	7	74
Dry (Feb., 2010)	28	11	3	42
Total	189	90	33	312

5. 3. 6. Distribution of rodents and trap success

The distribution and trapping success of live-trapped rodents in different habitats are given in Table 10. The highest number of rodents trapped from bushland and the lowest was from maize farm. Trap success was high for bushland (16.0%) and low for maize farm (10.4%). The difference in the total number of capture and trap success was significant between habitat types ($P<0.05$).

Table 10. Distribution and trap success of live-trapped rodents in different habitats.

Habitat types	Total catch	Trap nights	Trap success (%)
Maize farm	61	588	10.4
Grassland	72	588	12.2
Bushland	94	588	16.0
Forest	85	588	14.5

Rodent catch and trap success during the wet and dry seasons in each habitat are given in Table 11. Mean trap success during the wet and dry seasons was 16.7 % and 9.9%, respectively. High number of rodents was captured during the wet season from bushland with 20.7% trap success, followed by forest (19.4%) and grassland (17.7%). The lowest trap success was recorded in grassland during the dry season with trap success of 6.8%.

Table 11. Total catch, trap nights and trap success during the wet and dry season in different habitats (Wet=July and September, Dry= December and February)

Habitat types	Season	Total catch	Trap nights	Trap success (%)
Maize farm	Wet	26	294	8.8
	Dry	35	294	11.9
Grassland	Wet	52	294	17.7
	Dry	20	294	6.8
Bushland	Wet	61	294	20.7
	Dry	33	294	11.2
Forest	Wet	57	294	19.4
	Dry	28	294	9.5

5. 3. 7. Population estimates

The population estimates of all live-trapped rodent species during the different trapping sessions are given in Figure 7. The highest population was recorded in September, 2009 and the lowest in February, 2010. The difference in the total number of population size between all trapping sessions was statistically significant ($P<0.005$). The highest population estimates was obtained for *S. albipes,* whereas the lowest was for *M. mahomet*.

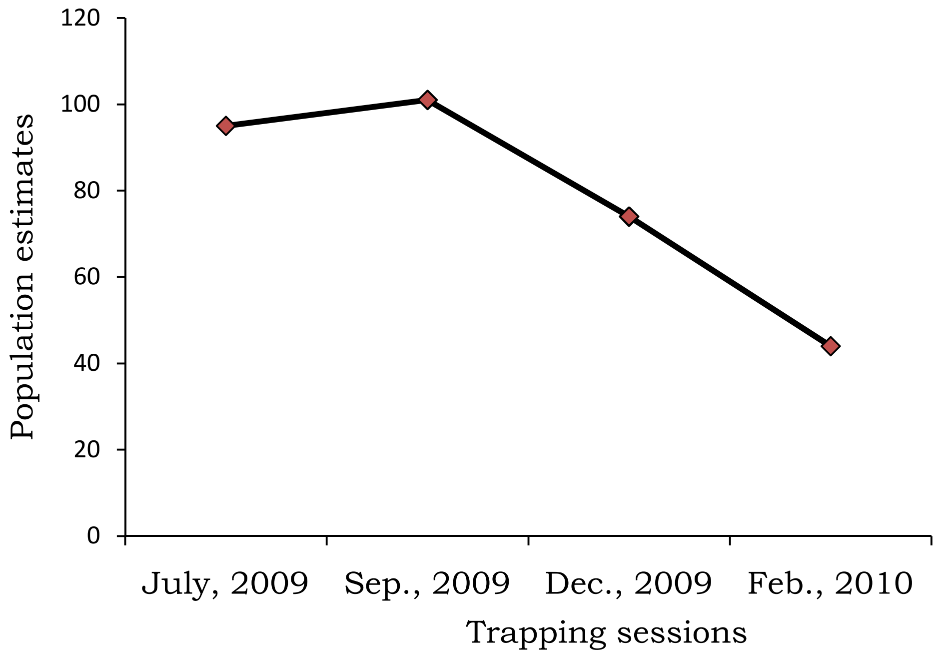

Figure 7. Population estimates of live-trapped rodents during different trapping sessions

5. 3. 8. Reproductive pattern

Reproductive conditions of 312 live-trapped individuals of rodents are given in Table 12. Out of them, adult males comprised 92 (29.5%), followed by adult females (non-pregnant or non-lactating) 75 (24.0%) and the least was of juvenile females (3.8%) followed by juvenile males (6.7%). Adult females (no-pregnant or non-lactating) constitutes for 3.2 % trapping success whereas pregnant or lactating females has 0.9%. Abundance between pregnant or lactating females and non-pregnant or non-lactating females showed significant variation ($P<0.005$). Pregnant or lactating females, juvenile males and juvenile females have had lowest trap success (0.9%, 0.9% and 0.5%, respectively). Trap success increased with age in both sexes and the trap success of each male reproductive group was greater than their female counter age groups (Table 12). The overall variation in the number and trap success between the different reproductive groups of rodents was significant ($P<0.001$). Among the captured pregnant or lactating females and juveniles, *S. albipes* comprised the largest group. Juveniles of *S. albipes* comprised 87.9% among the captured juveniles and pregnant or lactating females comprised 54.5% of the total pregnant or lactating females. Only adult males and females of *M. mahomet* were captured. Similarly, there were no captured juveniles for *R. rattus* and *P. harringtoni* during the present study.

Table 12. Age, sex groups and trap success of live-trapped rodents from the study area (Am= Adult males, Af= Adult females, P/Lf= Pregnant or lactating females, Sam= Subadult males, Saf= Subadult females, Jm= Juvenile males, Jf= Juvenile females)

	Trap success							
Species	Am	Af	P/Lf	Sam	Saf	Jm	Jf	Total
S. albipes	33	36	12	23	18	18	11	151
L. flavopunctatus	30	23	4	15	13	1	-	86
R. rattus	7	2	2	4	1	-	-	16
P. harringtoni	8	4	3	6	3	-	-	24
L. striatus	12	9	1	4	3	2	1	32
M. mahomet	2	1	-	-	-	-	-	3
Total	92	75	22	52	38	21	12	312
Abundance (%)	29.5	24.0	7.1	16.7	12.2	6.7	3.8	100
Trap success (%)	3.9	3.2	0.9	2.2	1.6	0.9	0.5	13.3

(-) indicates no captures

5. 3.9. Density and biomass

The total density of rodents obtained during the study period from all habitats was 637/ha (Table 13). Maximum density was recorded in the bushland (192/ha) and the minimum was in the maize farm (124/ha). *S. albipes* has the highest density (309/ha) and *M. mahomet* the lowest (6/ha).

Table 13. Density of rodent species (Number of individuals/ha) in each habitat types

	Species						Total
Habitat types	S.a	L.f	L.s	P.h	R.r	M.m	
Maize farm	59	4	24	-	33	4	124
Grassland	39	47	41	18	-	2	147
Bushland	135	57	-	-	-	-	192
Forest	76	67	-	31	-	-	174
Total	309	175	65	49	33	6	637

S.a= *S. albipes,* L.f= *L. flavopunctatus,* R.r= *R. rattus,* P.h= *P. harringtoni,* L.s= *L. striatus,* M.m= *M. mahomet*

A total of 17,223 g biomass was obtained for rodents during the entire trapping sessions. The highest biomass was recorded from bushland (5,100 g/ha) and forest (4,994 g/ha) habitats and the lowest was from the maize farm (3,280 g/ha) (Table 14). Out of all rodent species, the maximum biomass was recorded for *S. albipes* (8,048 g/ha) and the lowest was for *M. mahomet* (29 g/ha). The highest biomass was recorded during September (5,563 g/ha) and the lowest was in February (2,342 g/ha) (Table 16).

Table 14. Biomass (g/ha) of each rodent species in each habitat types (Figures in brackets indicate number of individuals)

Habitat types	Biomass (g) of each species						
	S.a	L.f	L.s	P.h	R.r	M.m	Total
Mf	1545(29)	113(2)	499(12)	-	1104(16)	19(2)	3280
Gl	1013(19)	1300(23)	832(20)	694(9)	-	10(1)	3849
Bl	3518(66)	1582(28)	-	-	-	-	5100
F	1972(37)	1865(33)	-	1157(15)	-	-	4994

S.a= *S. albipes,* L.f= *L. flavopunctatus,* R.r= *R. rattus,* P.h= *P. harringtoni,* L.s= *L. striatus,* M.m= *M. Mahomet,* Mf= Maize farm, Gl= Grassland, Bl= Bushland, F= Forest)

Table 15. Biomass (g/ha) of each rodent species during different trapping sessions (Figures in brackets indicate number of rodents)

Species	Mean body weight	Trapping sessions			
		July,2009	Sep.,2009	Dec., 2009	Feb., 2010
S. a	53.3	2399(45)	2878(54)	1812(34)	959(18)
L. f	56.5	1469(26)	1526(27)	1017(18)	848(15)
L. s	41.6	541(13)	333(8)	291(7)	166(4)
P. h	77.1	694(9)	540(7)	386(5)	231(3)
R. r	69	138(2)	276(4)	552(8)	138(2)
M. m	9.7	-	10(1)	19(2)	-
Total		5241	5563	4077	2342

S.a= *S. albipes,* L.f= *L. flavopunctatus,* R.r= *R. rattus,* P.h= *P. harringtoni,* L.s= *L. striatus,* M.m= *M. mahomet*

5. 4. Snap-trapped rodents

5. 4. 1. Species composition and abundance

A total of 68 small mammals were captured in 1200 trap nights from the four different habitats. Out of these, 66 of were rodents representing five species and two were insectivores (*C. flavescens*). The relative abundance of each captured species was *S. albipes* (36.8%), *L. flavopunctatus* (25.0%), *R. rattus* (13.2%), *L. striatus* (11.8), *P. harringtoni* (10.3%) and *C. flavescens* (2.9%). The most abundant species from all snap trapped rodents was *S. albipes*. It accounted for 37.9% of the total trapped rodents. *L. flavopunctatus* was the second abundant species, which accounted for 25.8% of the rodent catch. *P. harringtoni* (10.6%) was the least, followed by *L. striatus* (12.1%) and *R. rattus* (13.6%).

5.4.2. Body measurements

The mean standard morphological body measurements for 5 snap trapped rodents are given in Table 16. Only adult individuals were included during body measurements to avoid under estimation. Variation in the mean body weight among species and between seasons was statistically significant (P<0.1). However, there was no significant difference in the external body measurements among species and seasons (P>0.1).

Table 16. Rodents caught by snap traps with standard morphological measurements (Mean + SD).

Species	Season	No.	Body measurements				
			BW(g)	HB(cm)	TL(cm)	HF(cm)	ER (cm)
S. a	Wet	8	65.1±10.8	12.3±0.9	15.2±1.4	2.6±0.4	2.0±0.4
	Dry	5	53.6±7.7	13.0±0.7	14.5±1.5	2.8±0.3	2.3±0.5
L. f	Wet	6	69.0±11.6	11.9±0.7	6.3±0.9	2.4±0.4	1.9±0.2
	Dry	4	58.6±12.6	11.0±0.8	6.0±0.5	2.3±0.2	1.8±0.2
R. r	Wet	3	73.3±8.5	15.8±2.3	17.5±1.2	3.5±0.4	2.3±0.2
	Dry	4	63.5±4.2	16.3±1.7	18.3±0.9	3.7±0.3	2.5±0.3
P. h	Wet	4	84.8±5.2	12.7±0.8	12.8±0.6	2.3±0.2	1.8±0.2
	Dry	2	76.5±2.5	13.0±0.5	13.3±0.3	2.5±0.1	1.9±0.1
L. s	Wet	3	44.3±4.0	10.6±0.8	11.0±0.4	2.1±0.3	1.8±0.2
	Dry	2	35.5±0.5	9.3±0.3	10.3±0.2	2.1±0.1	1.7±0.2

BW=body weight, HB= head body length, TL= tail length, HF= hind foot length, ER= ear length, S.a= *S. albipes,* L.f= *L. flavopunctatus*, R.r= *R. rattus*, P.h= *P. harringtoni*, L.s= *L. striatus*

5. 4. 3. Embryo counts

A total of 19 pregnant rodents were captured during snap trapping (Table 17). They comprised 28.8% of the total rodents and 27.9% of small mammal catch. Most of these pregnant females belonged to *S. albipes* and captured during the second trapping session (September, 2009). Maximum number of embryos was counted from *S. albipes* and least from *L. striatus*. The number of embryos in the left and right uterine horn varied within species. For instance, in *L. striatus,* both the left and the right uterine horn had equal number of embryos. However, the number of embryos in the left uterine horn mostly exceeded that of the right horn in all other species. Moreover, the number of embryos in each uterine horn of *S. albipes* and *R. rattus* was reduced during the dry season.

Table 17. Number of embryos and pregnant females snap-trapped during wet and dry seasons

Species	Season	No. Pregnant females trapped	No. of embryos recorded
S. albipes	Wet	7	5-6
	Dry	2	5
L. flavopunctatus	Wet	3	4
	Dry	-	-
R. rattus	Wet	2	3-5
	Dry	1	4
P. harringtoni	Wet	3	3-4
	Dry	-	-
L. striatus	Wet	1	2
	Dry	-	-

5. 4.4. Stomach contents

Dietary information was obtained from 50 stomach contents removed from the five rodent species. Data on food items obtained from the rodent species are presented in Table 18. Observed food items were categorized as monocot seeds, dicot seeds, leaves, stems or roots, worms and arthropods. During the present study, plant materials were the dominant food items identified from all rodent species. Variation was observed in the consumption of monocot seeds (MS), dicot seeds (DS), leaves (L), stems or roots (S/R), worms (W) and arthropods (A) among the species and seasons. There was no seasonal variation in the types of food items consumed. However, there was a significant variation in the proportion of food items consumed by the species between seasons ($P<0.05$). The rate of consumption of worms and arthropods was more during the wet season than during the dry season. *R. rattus* usually preferred plant matters to animal matters. Monocot and dicot seeds were mostly consumed by *R. rattus*. *S. albipes* mostly preferred monocot seeds, dicot seeds and leaves. However, considerable amount of arthropods were consumed during the wet season. *P. harringtoni* mostly consumed monocot seeds, leaves and stems or roots. Worms were not observed in the stomach of *P. harringtoni* during both seasons and in *R. rattus* during the dry season. Unlike other rodents, few hairs were observed in the stomach of *L. flavopunctatus,* only during the dry season and in *L. striatus* and *P. harringtoni* during both seasons.

Table 18. Percentage frequency of food items in five rodent species (* indicate observed hairs, and number in bracket represents stomach checked)

		Plant matters (%)				Animal matters (%)			
Species	Season	DS	MS	L	S/R	W	A	H	U
S. a	Wet(8)	18.2	22.0	16.1	11.5	7.7	14.9	-	9.6
	Dry(8)	24.4	17.3	19.0	13.9	5.2	9.1	-	11.1
L. f	Wet(6)	6.2	5.6	3.1	5.8	3.2	68.9	-	7.2
	Dry(6)	9.6	6.3	7.2	8.2	3.0	55.6	*	10.1
L. s	Wet(3)	16.4	18.0	25.3	-	13.8	20.7	*	5.8
	Dry(3)	18.5	14.3	28.8	6.1	8.5	16.2	*	7.6
P. h	Wet(4)	15.6	29.0	19.9	20.6	-	2.1	*	12.8
	Dry(3)	17.6	26.0	24.1	23.3	-	1.3	*	7.7
R. r	Wet(5)	21.4	33.3	15.3	12.4	2.1	3.3	-	12.2
	Dry (4)	28.6	28.0	17.1	13.8	-	2.2	-	10.3

DS= dicot seeds, MS= monocot seeds, L= leaves, S/R= stems or roots, W= worms, A= arthropods, H= hairs, U= unrecognized matters, S.a= *S. albipes,* L.f= *L. flavopunctatus*, R.r= *R. rattus*, P.h= *P. harringtoni*, L.s= *L. striatus*

6. DISCUSSION

6. 1. Species composition and distribution

During the present investigation, six species of rodents and one species of insectivore were recorded. The absence of *Mastomys natalensis* from the present investigation are was unexpected, as it is the most widespread rodent species in Ethiopia. Massawe *et al.* (2008) and Makundi *et al.* (2007) stated that this species is commonly distributed in Sub-Saharan Africa. Studies in Tanzania and elsewhere in Eastern Africa suggested that they have broad tolerance (Makundi *et al.*, 2007). Several other studies carried out in different parts of Ethiopia have confirmed its wide occurrence in the country (Afework Bekele and Leirs, 1997; Demeke Datiko *et al.*, 2007; Tadesse Habtamu and Afework Bekele, 2008). Although not captured, the presence of *Arvicanthis* species was suspected in the study area. This is because few nests constructed of grass in the grassland were observed during the wet season. As revealed by Hubert (1978), *Arvicanthis* species were active all the time and construct nests from dry grasses especially at the base of bushes and high grasses. Nest construction during the wet season may be an adaptation against flooding rather than constructing burrows during the wet season. However, the absence of both species might be associated to a prolonged agricultural practice and application of rodenticides as a rodent pest control. In addition, human disturbance and intensive livestock grazing reduces ground cover, food and hence their population number.

During the present study, *S. albipes* was the most abundant contributing 48.4% of the total rodents captured. Similarly, Afework Bekele (1996a, b) in the Menagesha State Forest and Yalden (1988b) in the southern Ethiopia found that *S. albipes* made the largest proportion of their captures. As reported by Yalden (1988b); Afework Bekele (1996a, b); Afework Bekele and Corti (1997), *S. albipes* was identified as one of the endemic species of rodents in Ethiopia. It is the most widespread and abundant Ethiopian rodent occurring in association with forests at altitudinal ranges of 1500-3300 m asl (Yalden and Largen, 1992).

L. flavopunctatus was the second most abundant and widely occurring species. This agrees well with the findings of Yalden (1988a) in the Harena Forest, Bale Mountains National Park and in the Wondo Genet, Ethiopia, by Dawit Kassa and Afework Bekele (2008). *L. flavopunctatus* is the most widespread and numerous rodents in the moist area of East Africa. The species inhabits a range of different habitats with high preference for montane forest (Clausnitzer *et al.*, 2003). Yalden and Largen (1992) reported that the species was widely distributed in Ethiopia inhabiting both scrub and forest habitats. In the present study, the species has a generalized distribution encountering in all habitats. The findings of earlier studies have shown similar pattern of generalization throughout different habitats, especially in the moist montane forest (Delany, 1971; Juch, 2000). This might be attributed to the diverse feeding habit of the species (Hanney, 1964). Since invertebrates made the dominant diet of *L. flavopunctatus*, it may prefer habitats that are hospitable to worms and arthropods such as damp, rotten woody and leafy debris.

L. striatus was the third abundant species and trapped from maize farm and grassland habitats. This was in line with the findings of Iyawe (1988) in Nigeria, in which the species was typical of savanna grassland and to a lesser extent of scrub. It also occurred in both active and abandoned farmlands. Furthermore, Jeffrey (1977) noted that the species was absent in forest habitats but common in the fields and farmlands. This contradicts with the findings of Demeke Datiko *et al.* (2007) in which the species was trapped from deciduous bushlands of Arbaminch. As noted by Caro (2001), *L. striatus* is common where herbal ground cover is high. Similarly, during the present study, herbal ground cover was high in the grassland habitats during both seasons, but present in maize farm only during the second and third trapping sessions.

P. harringtoni is a widespread species on the Ethiopian plateux at altitude between 1800-2800 m asl and remains poorly known. This species might be arboreal and frequented forest habitats (Yalden and Largen, 1992). Likewise, in the present study, 62.5% of the species was captured from forest habitat at altitude of 2260 m asl and 37.5% from grassland at altitude of 2235 m asl. This species was also snap-trapped from bushland. The capture of this species from the grassland may be an indication of its visit to the grassland habitats. The presence of *P. harringtoni* was reported by Afework Bekele (1996a) from Menagesha State Forest, Ejigu Alemayehu (2008) from Birsheleko and nearby natural habitats and Eshetu Moges (2008) from Donkoro Forest. However, trap success was very low in the present as well as in the previous studies.

R. rattus was the only rodent species that was exclusively trapped from maize farm. It was a global commensal rodent that frequents around human settlement areas, farmlands, and feeds in both fields and houses (Singleton *et al.*, 2007). As revealed by Afework Bekele (1996b), it was a plentiful species in areas of human habitation. This might be associated with the adaptability of the species to the modified and anthropogenic habitats (Auffray *et al.*, 2009). The species might make a visit to farmlands and back to human habitations based upon the availability of food and ground cover.

As reported by Douangboupha *et al.* (2009), in the late harvesting periods, the abundance of rats decreased in the fields and increased in the village areas because of lack of food and covers.

M. mahomet was the least abundant rodent species in the present study area and is considered as a rare species. It was trapped only by live traps in September, 2009 and December, 2009 from grassland and maize farm. This contradicts with the findings of Afework Bekele (1996a) and Manyingerew Shenkut *et al.* (2006) in which the species made the second abundant rodent capture. Moreover, it was captured from bushy vegetation and open forests with grassy patches (Afework Bekele, 1996b). According to Yalden and Largen (1992), this species was taxonomically, the least certain of the Ethiopian endemic mammals and occurs between 1500 and 3200 m asl. During the present study, the abundance of *M. Mahomet* was low (0.9%) because of its small body weight, which was less likely to sprung the traps.

6. 2. Species richness and habitat preference

The present study demonstrates that the species richness of rodents in the Komto Protected Forest was comparable with the findings of Alemu Fetene (2003); Dawit Kassa and Afework Bekele (2008), who have recorded five species from Bale Mountains National Park and seven species from Wondo Genet, respectively. The low species richness of the present study also agrees with the findings of Afework Bekele (1996a) and Ejigu Alemayehu (2008), who have recorded six species of rodents each from Menagesha State Forest and Birsheleko and nearby natural habitats, respectively. However, it is less than the findings of several other studies carried out in different parts of Ethiopia. For instance, Afework Bekele (1996b) recorded 12 species from Menagesha State Forest; Demeke Datiko *et al.* (2007) recorded 14 species from Arbaminch forest and farmlands; Mohammed Kasso (2008) recorded 14 species from Mount Chilalo and Galama Mountain Ranges; Tadesse Habtamu and Afework Bekele (2008) recorded 23 species from Alatish National Park. The restricted number in the diversity of species in the present study area might be attributed to anthropogenic effect.

Grassland and maize farm had the highest species richness and diversity. Grassland might be preferred by most of the rodent species because of its sufficient understory cover with grasses and herbs such as *Medicago polymorpha, Medicago sativa, Cynodon aethiopicus, Pennisetum thumbergi*, *Digitaria velutina* and its well protection from grazers. Moreover, at the beginning of the wet season, newly regenerated grasses after harvest attracted rodent species because fresh grasses might be nutritionally high and easily palatable. As noted by Mahlaba and Perrin (2003) and Auffray *et al*. (2009), rodents are known to respond to habitat quality such as food, vegetation cover and rainfall. The effect of ground cover on habitat preference of rodents and shrews in Africa is widely accepted by several investigators (Rosenzwerg and Winakur, 1969; Parmenter and MacMahan, 1983; Maccracken *et al*., 1985; Leis *et al*., 2008). As stated by Monadjem (1997), species diversity of rodents and insectivores was correlated with grass cover and vertical vegetation density.

Though rodent abundance was low in the maize farm, it harboured few rodents from each species except *P. harringtoni*. The high species richness of rodents in the maize farm agrees with the findings of Eshetu Moges (2008). Studies carried out elsewhere in Africa also reported similar findings. For instance, a comparative study carried out by Caro (2001) on species richness and abundance of small mammals in and out of Katavi National Park, Tanzania, showed more number of species outside the park (open area inhabited by agriculturalists and pastoralists) than inside the park.

Similarly, Jeffrey (1977), in Western Ghana, found that the removal of high forest and its replacement by farm increases diversity though the mechanism by which it occurred were unknown. However, as reported by Decher and Bahian (1999), traditional agricultural practices may contribute to a high local diversity by maintaining a variety of resources. Brown (1984) stated that abundance and distribution of organisms are influenced by both biotic and abiotic factors. This is because species may be favoured from the combination of environmental variables that most likely suites its requirements. Moreover, species richness in the grassland and maize farm habitats might also increase due to sporadic movement of rodents to the area.

Fewer rodents were captured in maize farm during the wet season than the dry season. This might be due to the removal of cover during land preparation affecting their distribution. Moreover, farmers continuously scoop out the base of the maize farm following its germination in order to reduce weed growth. This might also be the cause for reduction of rodents during the wet season. However, reduced disturbance by humans, availability of seeds following seed fall from harvested remains and as a result of prolonged rain during the study period and better protection of the maize farm might be the cause for their increase during the early dry season. Species richness in the maize farm increased from 3 to 5 during the dry season. Caro (2001) noted that species richness was highest in the garden and farmlands during the dry season when several food types were available. Furthermore, burrow construction during the dry season has a great contribution for the survival of rodent population.

The forest floor is mostly covered by *Hypoestes forskaolii* and few *Girardinia diversifolia* and *Urtica simensis,* all of which have similar height. In addition to *Hypoestes forskaolii,* the bushland harbours *Cynodon aethiopicus, Medicago sativa* and *Medicago polymorpha* that forms understory covers. However, bushland and forest habitats are less heterogeneous, albeit the ground has covers. Habitat heterogeneity could enhance diversity thereby allowing specialization of different species. Hence, species habitat association provides a useful way to determine how different species respond to environmental heterogeneity (Cramer and Willig, 2002). However, during the present study, increased habitat homogeneity in the bushland and forest habitats may favour only *S. albipes* and *L. flavopunctatus,* but discourages other rodent species. The result also suggested that different species of rodents may respond differently to different degrees of habitat heterogeneity and plant species composition. This was inferred from the exclusive existence and abundance of *S. albipes* and *L. flavopunctatus* (except few *P. harringtoni*) in the bushland and forest. In fact, an environmental factor which makes one habitat favourable to one animal may not be favourable for other animals. Hence, the species richness of the habitat decreased. Tilaye Wube (2005) noted the abundance of *S. albipes* in the bushland areas. Similarly, Yalden and Largen (1992) reported that both *S. albipes* and *L. flavopunctatus* frequent montane forests. However, trampling by cattle might be the cause for the reduction of rodents in the bushland and forest during the dry season.

According to Ecke *et al.* (2002) and Cramer and Willig (2002), habitats with increased structural heterogeneity positively influence small mammal abundance and richness. Also, Avenant and Cavallini (2007) reported that rodent community structure and species richness are related to habitat structure and complexity, area of productivity, predation and succession of vegetation. Decreased rodent species richness and diversity can also be used to notice ecological disturbance of habitats (Avenant and Cavallini, 2007). Therefore, reduction of rodent species richness in the natural habitat might also be an indicator of disturbance.

S. albipes showed high preference for bushland during the wet season (30.5%) and least for grassland during the dry season (3.3%). However, *L. flavopunctatus* and *P. harringtoni* showed high preference for forest habitat during the wet season. *L. flavopunctatus* did not show preference for maize farm during the wet season and *P. harringtoni* totally neglected the maize farm. *L. striatus* preferred grassland (43.8%) and showed less preference for maize farm (15.6%) and grassland (18.7%) during the dry season. Though *R. rattus* and *M. mahomet* have restricted distribution, both species preferred maize farm during the dry season.

Grassland, bushland and forest habitats have loam soil type with similar percentage of three soil particles but with different plant species composition and degrees of ground cover. However, maize farm has sandy clay loam soil with high percentage of sand particles. As reported by Massawe *et al.* (2008), loam soil is mostly preferred by *M. natalensis* because of its easy burrowing, good aeration and drainage. This is because it offers little resistance to the burrowing of small mammals as it is less compacted and serves as intimate part of their environment in tunnel formation (Jameson, 1949). Furthermore, Hardy (1945) reported that various rodents differ in their digging abilities usually preferring soft soils as it decreases the cost of burrowing. Loamy soil is hospitable and suites for burrowing, albeit no burrows were observed in the forest and grassland during both seasons. However, 11 and 5 active burrows were recorded in maize farm and bushland, respectively, during the dry season. Burrow construction in the maize farm might have increased due to ploughing that softened the ground. Moreover, the high percentage of sand particles might decrease the stickiness of soil particles making burrowing easier and increases drainage and aeration. As noted by Desy (1998), subterranean rodents exhibit a preference for drier and well drained soil as it facilitates easy burrowing. Ellison *et al.* (1993) reported that the lesser pouched rat, *Beamys hindei,* was restricted to coastal forests (in Tanzania and Kenya) and suggested that soil type may be influential in determining the distribution of this species. Particularly they may prefer areas with sandy soils that facilitate burrow construction. During the present study, four burrows from maize farm and two from bushland were recorded in December, 2009. The remaining burrows were recorded in late February, 2010 when the ground cover was highly reduced. Hence, the need for burrow construction might also depend on the extent of ground covers. Probably, that is why more active burrows were observed in the maize farm than in the bushland and no burrows in the grassland and forest during both seasons. Burrow construction in the maize farm and bushland has contributed for large number of rodents during the dry season. As revealed in Massawe *et al.* (2008), the texture of soil is a primary factor that limits the distribution of some fossorial mammals directly and indirectly by influencing other properties of soil and biotic factors. Even though the properties of soil play a great role in small mammal ecology, several ecologists neglect the role of soil properties (Gibson *et al.,* 1990). Therefore, soil type has a paramount importance in constructing nesting sites whenever ground cover was poor during the dry season. However, rodents need not have to construct burrows in the grassland and forest habitats as the habitats have good ground cover to help them that secure their survival during both seasons.

Burrows of rodents were mostly surveyed in all habitats following their tracks during both seasons. The number of burrows recorded during the dry season outnumbered that of the wet season (Table 3). Only three abandoned burrows were recorded in the bushland habitat during the wet season. But during the dry season, a total of 16 active burrows were recorded from both bushland and maize farm habitats. Although burrowing is easy during the wet season, no active burrows were observed in all habitats. This suggested that rodents might not use burrows during the wet season because of the availability of vegetation covers and an adaptation against flooding. As described by Ebensperger (1998) and Carter and Ebensperger (2005), construction of burrows could be essential for individuals living in open and more exposed habitat patches. Hence, rodents prefer to take shelter under grasses, vegetation cover and other debris during the wet season and may use burrows when the ground cover is poor. Burrowing system of rodents was also noticed in the study area. The position of burrowing sites and entrances are oriented in the way that it prevents flooding during the early rainy season and closing of burrows by piled soil. All observed burrows were constructed near the base of bushes and remnant grass patches relatively at hilly grounds. This makes their survival more secured as remnant grass patches decreases visibility from predators and hilly ground prevents flooding during the early rainy season. Food obtained away from their burrow sites were collected and consumed at the entrance of burrows. Burrows may also create a safe site for reproduction and survival of juveniles. As described by Ellison *et al.* (1993), burrows may provide protection from predators, reduce daily and seasonal variation in ambient temperature and serve as food hoarding sites.

During the wet season, rain initiated the growth of fresh *Hyparrhenia hirta, Cynodon aethiopicus, Medicago polymorpha, Medicago sativa* and several other grasses and herbs in the grassland. As a result, rodent abundance may increase due to immigration and or reproduction. This might be the cause for the increased capture of rodents in the grassland during the wet season. Though it is fully grown and dried, grass cover and understory species are remained unchanged during the dry season. But, the number of rodent catch during the dry season decreased. This might suggest that fully grown and dried grasses were not preferred for food compared to the fresh ones. Consequently, rodents migrate to the nearby habitats in search of wet and succulent plants that might also compensate their water need.

The present study has revealed that having enough ground cover alone might not mean that the habitat has high species richness and abundance of small mammals. For instance, grassland with extremely thick ground cover has high species richness but low in population size. However, forest and bushland with relatively less ground cover provided more individuals with few species. This is because all vegetation that makes ground cover may not be preferred for food. As stated by Rhim and Lee (2001), there is a relationship between tree species composition and habitat preference of small rodents. Besides, Brown *et al.* (1972) found that the presence of certain plant species influenced the faunal composition of a given habitat. This is because the foraging preference of rodents in the field depends on the presence of secondary plant compounds and each species responded differently to the same chemicals (Jung and Batzli, 1981). As reported by Bozinovic (1997), mammalian herbivores select plants rich in nutritional components and poor in fiber and secondary metabolites. Plant fibers and secondary metabolites influence foraging behaviours because these compounds decrease the nutritive quality of food and digestibility to herbivores. Therefore, inferring habitat preference and abundance of rodents based on vegetation cover alone might not be sufficient unless dietary information is compared with the plant species composition in the habitats.

6. 3. Seasonal variation and sex ratio

The number of trapped rodents varied from habitat to habitat and between trapping sessions. This may be ascribed to the variation in vegetation structure, ground cover and other related environmental variables between habitats and seasons. Changes in habitat structures decrease food availability, ground cover (Juch, 2000) and hence the overall species composition of small mammals. Habitat changes might be brought about by different factors. Joubert and Ryan (1999) demonstrated that heavy utilization of habitats by wild ungulates and livestock affect small mammal diversity, distribution and abundance. This might cause one species to exist in one habitat during one season and to disappear in the other season. For instance, *L. flavopunctatus* and *M. mahomet* were absent in the maize farm during the wet season but captured during the dry season. *R. rattus* was trapped only from maize farm.

During the present study, variations in age groups and reproductive status were observed between seasons. For example, the number of juveniles and pregnant females were higher during the wet season than during the dry season. This confirms that the reproductive periods of most rodents occurred during the wet season as rain influences germination and growth of vegetations that serves as sources of food and shelter. The capture rate was high during September and low in others trapping sessions. This might be due to the optimal rain, temperature and potential food source at the end of the wet season. The breeding pattern of many African rodents was related to rainfall (Sicard and Fuminer, 1996), but varied with rainfall with increased rate of reproduction at the end of the rainy season (Worknen Gebresilassie *et al.*, 2006). The present finding agrees with the previous report of Delany and Happold (1979) and Afework Bekele (1996a) on the breeding patterns of rodents. Data from snap-trapped rodent revealed that the number of embryos observed during the wet season exceeded that of the dry season in *S. albipes* and *R. rattus*. This is because the number of implanted embryos and litter size might be related to the availability of food. As described by Boutin (1990), food quality or quantity results in significant change during the time of reproduction, litter size and body condition or growth rate. The number of embryos among pregnant females also varied between species. Moreover, the number of embryos in the left and right uterine horn varied between species as noted by Afework Bekele (1996a).

The number of adults and subadults was higher during the wet season than during the dry season. As reported by Tabeni and Ojeda (2005), predators and cattle ranching affect rodent population through habitat simplification. Adults showed a general reduction from the first trapping session to the last. This may be due to the death of adults and subadults as a result of ageing, disease, lack of resource and other environmental conditions. Also, there is a general decrease in the population of rodents during the dry season. This agrees with Delany and Happold (1979) in which small mammal population generally decline during the dry season. As described by Happold and Happold (1991), dry season was the time of high temperature, minimal resources and cover, unlike the wet season, making small mammals to experience considerable seasonal variation during the course of the year. During the present study, the overall population reduction of rodents might be associated with lack of ground cover, food, migration due to disturbance and the discouraging features of other environmental variables.

6. 4. Population estimates and traps success

During the present study, the population of rodent was high durin September, 2009. This might be due to juveniles that were bred during the early wet season and reached trappablity. Moreover, it is the end of rainy season and might have optimal temperature, rainfall and potential food sources. Contrary to this, rodent population was very low in February, 2010. This could be associated with the extreme dryness and high temperature when rodents encounter a serious shortage of food and water. As a result, more rodents especially juveniles may be affected. Fernadez *et al.* (1996) stated that food quality and quantity, vegetation cover, predation and weather condition are the causes for the flactuation of small mammals.

Trap success varied between habitats and seasons. The highest trap success was obtained from bushland (16.0%) and the lowest from maize farm (10.4%). Similarly, the highest trap success was obtained from bushland (20.7%) during the wet seasonand the lowest was from grassland during the dry season (6.8%). Trap success increased in bushland and forest habitats because of large capture rates of *S. albipes* and *L. flavopunctatus*. The mean trap success of the present study area was 13.5% for live traps and 5.7% for snap traps. Trap success of the present study was low compared to several other studies carried out in different parts of Ethiopia. For instance, Demeke Datiko *et al.* (2007; Mohammed Kasso (2008); Tadesse Habtamu and Afework Bekele (2008) have obtained 17.6%, 44.1% and 38.6% trap success, respectively. Trap success obtained during the wet season (16.7%) was greater than the dry season (9.9%). The low trap success during the dry season may be attributed to a decreased density of species as a result of increased home range due to lack of resources. There are different factors that influence trap success of small mammals. For instance, the bait has a considerable influence on the trap success. Baits that have good odour attract rodents from a distance and increase trap success. A higher value of trap success might have been recorded if different baits had been used (Anadu, 1979). Furthermore, Barnett and Dutton (1995) stated that loss of bait to non-target taxa also influences trap success. During the present study, the oiliness nature of peanut butter attracted ants to the traps and caused disturbance to rodents around the traps, especially during the wet season. In addition, low population and bait types might be the cause for low trap success of the present study.

More males were trapped than females which are attributed to their larger ranges (Cross, 1977). As revealed by Hansson (1975), adult males are more likely to enter traps than adult females. Besides, Villa *et al.* (1997) stated that the relative high abundance of males may be ascribed to the more activity and, therefore, have a higher probability of being captured than females. During the present study, not only adult males but also all age categories of males have a higher trap success than their counter female age groups. Moreover, trap success increased with age in both sexes. As reported by Barnett and Dutton (1995) and Barnett *et al.* (2000), pregnant or lactating females and juveniles have lower trap success as they are less likely to move long distances. Likewise, the lowest trap success was recorded for juvenile females (0.5%), followed by juvenile males (0.9%) and pregnant or lactating females (0.9%). Lactating or pregnant females have lower trap success (0.9%) compared to non-pregnant or non-lactating adult females (3.2%) as they move only short distances from their nesting sites.

6. 5. Density and biomass

During the present study, population density of rodents varied between species and habitats. Maximum density was recorded in the bushland and minimum in the maize farm. Large number of *S. albipes* trapped contributed for the higher density of rodents in the bushland. *S. albipes* had the highest density and *M. mahomet* had the lowest. The increased density of *S. albipes* might be attributed to favouring of the habitats compared to other species. According to Doonan and Slade (1995), food supply is the most important factor that influences the biomass of small mammals. The highest biomass was recorded from the bushland and the lowest from the maize farm. Maximum biomass was recorded for *S. albipes* and lowest for *M. mahomet.* The biomass of rodents also varied seasonally. Afework Bekele (1996a) stated that comparisons of densities and biomasses are difficult due to the variation of habitats and weights in different species of small mammals and underestimation of the available numbers. Hence, comparison of density and biomass is difficult and may not be fair.

6. 6. Body measurements and diet analysis

The results of body measurement show a significant variation in the mean body weight of rodents between species and seasons. A similar finding was reported by Taylor and Green (1976). This might be ascribed to the shortage of food and water during the dry season compared to wet season.

During the present study, stomach content analysis revealed a variety of food items consumed by rodents. The result obtained from the stomach of five species of rodents showed the omnivorous and granivorous feeding habit of the species. As reported by Campos *et al.* (2001), the feeding ecology of small mammals is highly diverse. Furthermore, Workneh Gebresilassie *et* *al.* (2004) described that rodents are opportunistic feeders capable of changing their feeding habits based on the availability of food from season to season. Such diversified feeding habits of rodents might have great contribution for their successful species richness and diversity while the ongoing global environmental changes question the sustainability of biodiversity. Consumption of arthropods and worms generally increased more during the wet season than the dry season. This was consistent with the relative abundance of the species during the wet season. Martin and Dickinson (1985) described that the rainy season is a time when population of invertebrates increased serving as source of food for small mammals. Although identification of dietary items to the species level was difficult, food items were generally identified as plant and animal matters. Arthropods were identified by their heads, wings and legs whereas worms were identified by their head parts and body segmentations. Plant materials such as roots or stems and leaves can be identified by slightly coloured cells as a result of alcohol and the structure of epidermal cells. During the present study, maximum amount of arthropods and worms were observed in the stomach of *L. flavopunctatus* during the wet season. *L. flavopunctatus* highly consumes insect agreeing with the previous reports by Cole (1975). The presence of invertebrate taxa in the diet of *L. flavopunctatus* revealed their preference for moist and damp areas as it favours the existence of invertebrates. This unusual consumption of invertebrates may allow the species to occupy areas not usually suitable for rodents (Clausnitzer *et al.*, 2003). Hanney (1964) reported that *L. flavopunctatus* could not survive in captivity unless fed on earth worms, insects and even frogs.

The occurrence of most plant materials in the diet of rodents reached maximum during the dry season. This might be due to the decreased utilization of animal matter during the dry season as the result of the decline of soil dowelling invertebrates and arthropods. The increased consumption of succulent stems or roots during the dry season might compensate the need for water during the driest months. Furthermore, more dicot seeds were consumed during the dry season as seeds increased following seed fall since mid September, 2009. However, monocot seeds were consumed more during the wet than the dry season except for *L. flavopunctatus*. *L. striatus* was the second rodent species that mostly consumes arthropods during both seasons. As revealed by Clausnitzer *et al.* (2003), the occasional consumption of insects, especially during the breeding season has been recorded in many African rodents including *L. striatus, A. niloticus* and *M. natalensis*. Similarly, Demeke Datiko *et al.* (2007) reported that *L. striatus* was highly dependent on insects during the wet season. *L. striatus* consumes more leaves during the dry than wet seasons and no roots or stems during the wet season.

During the present study, few hairs were observed in the stomach of *L. flavopunctatus*, *L. striatus* and *P. harringtoni*. As revealed by Clausnitzer *et al.* (2003), vertebrate remains were observed occasionally in the stomach of *L. flavopunctatus,* which appeared to be the cannibalized remains of other snap trapped rodents. Similarly, Ellis *et al.* (1998) noted feathers and vertebrate meat in the diet of rodents. However, during the present study, only hairs were observed in three rodent species and attributed to grooming as they are social animals rather than cannibalism. As described by Ebensperger (1998), adult rodents spend most of their time in close association with other conspecific individuals usually sharing feeding areas and burrow systems.

7. CONCLUSION AND RECOMMENDATIONS

During the present study, nine species of rodents and one species of insectivore were identified from Komto Protected Forest. Out of these, five rodents and one insectivore species were trapped by both live and snap traps whereas one rodent species was only live-trapped. The other three rodent species were recorded as observed species during the present study.

Generally, grassland and maize farm had the highest species richness and diversity but bushland and forest habitats provided the highest individuals. According to the present study, having thick ground cover alone might not mean that the habitat has high species richness, diversity, abundance and sufficient food. The species composition, distribution and abundance of rodents vary between habitats and seasons. The relative abundance of rodents showed marked variation between seasons. This could be mainly attributed to variation in vegetation cover, availability of food, climate and other environmental factors. Soil types have a paramount significance in the population ecology of rodents. During the present study, rodents of maize farm and bushland used burrows due to reduced ground cover. Probably this has contributed for the increased population of rodents in both habitats during the dry season. Though burrowing of sandy clay loam soil is not as easy as loam soil, its relative burrowing difficulty is solved due the high percentage composition of sand particles which decreases soil stickiness and increases drainage and aeration. Also, ploughing might soften the ground facilitating easy burrowing. Furthermore, the need for burrow construction also depended on the degree of ground cover.

During the present study, most of the rodent species respond differently to different habitats during the wet and dry season. Habitat preference and distribution of rodents in the study area might be determined by the extent of ground cover, habitat structure and availability of food, plant species composition, soil types and other physical and biological variables. But further study on the relationship between plant species compositions and habitat preference of rodents should be recommended rather than generalizing based on vegetation cover alone.

Generally, the stomach content analysis showed that most of the rodent species consumed plant matters than animal matters. The consumption of plant matters increased more during the dry season but animal matters decreased.

The present study presents important baseline information on the species composition, abundance and habitat preference of rodents in Komto Protected Forest. However, further extensive and detailed study in the study area may yield more rodent species that were not trapped due to low population or other related environmental factors.

Komto Protected Forest was one of the remnant forest priority areas in Ethiopia that is affected by serious logging for charcoal and timber production. It is a key forest habitat for the existence of several mammalian communities of the study area. However, logging is frequent. Such continuous logging is due to lack of follow up, tolerance of law and lack of fair enactment at the Woreda and Zonal administration. Tolerance of law can also be confirmed from the formal sale of charcoal and timber in the Nekemte town. This will lead to the destruction of the forest. Based on the baseline information obtained from the study area, the following recommendations are forwarded:

- During the present study, though rodent pest diversity and species composition were low, information about their habitat preference is fundamental for conservation and management programme. However, further investigation on the habitat preference of each rodent is recommended to design their control measures.

- Small mammals play an important role in the ecosystem. Changes in small mammal species is likely to affect predator communities and the ecological roles that the small mammals play regarding seed dispersal, insect predation and herbivory. Therefore, the ecology of small mammals should be conserved.

- The forest area has not been demarcated. Therefore, there should be demarcation to hinder gradual agricultural expansion from the peripheral parts of the forest.

- To restore the forest, plantation of trees and awareness creation on the various benefits of the forest through community based conservation education is recommended. Moreover, deforestation should be stopped.

- Livestock grazing practice should be reduced especially during the dry season.

- Regulation should be respected and zonal administration staff should execute the law properly.

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LIST OF PLATES

Plate 1. Photograph of encroachments around Komto Protected Forest

Plate 2. Photograph of local charcoal production sites (Each household has charcoal production site beside house)

Plate 3. Photograph of illegal timber production sites beside Komto Protected Forest

A B

Plate 4.Photograph of maize farm (A) and grassland (B)

C D

Plate 5. Photograph of bushland (C) and forest (D)

APPENDIX

Appendix: Results of soil sample analysis

Date 06/05/2002

Ref. No 117/01-IV/QB-2002

To Mr. Mosisa Galata

Subject: Result of Your Soil Sample Analysis

Based up on your letter of request for soil texture analysis dated on 18/01/2002 E.C,our research center has made the analysis of your soil sample and tabulated the result as follows:

Gird No	%Clay	%Sand	%Silt	Texture class
1	28	53	19	sandy clay loam
2	18	35	47	loam
3	22	37	41	loam
4	22	35	43	loam

With best regards.

Fayisa Olana Bullo

Administration and Finance Services Head

DECLARATION

This thesis is my original work, has not been presented in any universities seeking for similar specialization or other purposes and all sources of reference materials used for the thesis have been duly acknowledged.

Name: Mosissa Geleta

Date: _______________

Signature ____________