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**SPECIES COMPOSITION, RELATIVE ABUNDANCE, DISTRIBUTION AND HABITAT ASSOCIATION OF RODENTS
IN MEKLITE FOREST AND ASSOCIATED AREAS, ETHIOPIA.**

By

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ABSTRACT

Data collection was carried out in Meklite Forest and associated area during August 2008 - March 2009. The main objective of the study was to assess the species composition, distribution, habitat association and relative abundance of rodents in the study area. Four habitats were selected, three from natural vegetation (forest, bushland, grassland) and one from the farmland (maize farm). Both Sharman live traps and snap traps were used in all data collection sessions. Altogether, 397 individuals were captured by live traps in 2352 trap nights and 68 individuals by snap traps in 1200 trap nights. A total of eight species of rodents and two species of insectivores were recorded. The rodent species identified with their relative abundance in the study area were *Arvicanthis abyssinicus* 165(41.6%), *Stenocephalemys albipes* 62(15.6%), *Mus musculus* 58(14.6%), *Mastomys natalensis* 47(11.8%), *Lophuromys flavopunctatus* 26(6.5%), *Grammomys dolichurus* 17(4.3%), *Rattus rattus* 7(1.8%) and *Dendromus lovati* 2(0.5%). The insectivore species were *Crocidura flavescens* 9(2.3%) and *Crocidura fumosa* 4(1.0%). More number of individuals was caught from the maize farm. The highest species richness and diversity were also observed in maize farms. Population size of rodents and insectivores was higher during the dry season than the wet season.

Key words /Phrases: Diversity, insectivores, Meklite forest, rodents, species richness

1. INTRODUCTION

Among mammals, rodents are the most successful and diversified groups. They were able to exploit a wide variety of habitats and environments throughout the world (Kingdon, 1997; Nowak, 1999; Vaughan *et al.*, 2000; Lange *et al.*, 2004). A total of 5416 species of mammals are recorded globally, of which 2,277 species are rodents. They account for 42% of mammalian species (Wilson and Reender, 2005). More than 1150 species of mammals are recorded from Africa (Kingdon, 1997). Among the mammals of Africa, rodents are the most abundant (Macdonald, 1984; Delany, 1986; Afework Bekele, 1996). In East Africa, about 28% of the total mammal fauna constitute rodents (Kingdon, 1971).

The unique topography and wide climate ranges of Ethiopia have made the country host for diverse biological resources (Hillman, 1993; Yalden and Largen, 1992). Of the 284 mammalian species of Ethiopia, 84(29.6%) species are rodents (Afework Bekele and Leirs, 1997). Out of the total rodent species of the country, the endemic rodent species comprise 21% (Afework Bekele, 1996). Rodents constitute about 50% of the endemic mammals of Ethiopia (Afework Bekele and Corti, 1997).

Rodents are highly successful mammals in different environments throughout the world. They occupy nearly every terrestrial habitat capable of supporting mammalian life. Their success is probably due to their small size, short breeding cycle, and wide variety of food items. In evolutionary terms, rodents are quite young, and hence the populations retain large unexploited store of genetic variability (Macdonald, 1984; Kingdon, 1997; Vaughan *et al.*, 2000).

Rodents live in different microhabitats. Some rodents spend their entire life in the underground tunnel systems. Others such as the ground squirrels dig extensive burrow systems used for resting and caring for their young, while few are arboreal. Some are gliders, and others are adapted for semi-aquatic life (Wright *et al.*, 2002; Nowak, 1999). Rodents show great diversity in their ecology, morphology, physiology, behaviour and life history strategies (Delany and Happold, 1979; Nedbal *et al.*, 1996).

Variation among members of rodents ranges from tiny pigmy mice to the big Capybaras, from arboreal flying squirrels to subterranean mole-rats, from opportunistic feeders to specialist feeders and from diurnal to nocturnal forms. Their shelter ranges from tree holes, rock fracture or simple burrows to hidden nests on the forest floor, leaf and stick structures in tree crowns, mounds of cut vegetation built in aquatic environments, or complex networks of tunnels. Rodents may be active all year or enter periods of dormancy and deep hibernation. Even though rodents show these wide ranges of variations, they are characterized by the presence of a pair of continuously growing incisors in each jaw (Macdonald, 1984; Kingdon, 1997).

Habitat selection has been considered as an important factor in community dynamics of rodents. Rodents show habitat preferences (Happold and Happold, 1989, 1991; Shanker, 2001; Fitzherbert *et al.*, 2006). Some rodents are restricted to a narrow altitudinal range, but others live in wide altitudinal ranges; yet others are altitude generalists (Krasnov *et al.*, 1996; Mukinzi *et al.*, 2005; Clausnitzer and Kityo, 2001; Yalden, 1988). The habitat preference of rodents is mainly dependent upon the vegetation type and the life history strategies (Iyawe, 1988; Krasnov *et al.*, 1996; Fitzherbert *et al.*, 2006). Their distribution and abundance are influenced by environmental factors such as the nature and density of

vegetation (Wike *et al.*, 2000; Clout and Russell, 2004; Parmenter and MacMahon, 2004; Workneh Gebresilassie *et al.*, 2004), climatic conditions, disease, predation and habitat exploitation by humans (Nandawa, 1973; Hubert, 1978; Odhiambo and Oguge, 2003; Johnson and Horn, 2008). Loss of food and cover greatly affects abundance of rodents. The loss of ground vegetation leads to loss of cover and food supply for small mammals thereby decreasing rodent diversity but increasing predation risk (Waters and Zabel, 1998; Cramer and Willig, 2005; Hoffmann and Zeller, 2005). Likewise, habitat structure and risk of predation influences rodent community composition in different habitats (Wywiałowski, 1987; Massawe *et al.*, 2006). Bushy vegetation provides safe sites for germination and growth of herbaceous vegetation, thereby enhancing the diversity of the potential rodent food resources (Kerley *et al.*, 2004). Availability of food increases rodent density in farmlands, bushland, grassland and forest habitats (Halvorson, 1982; Lentic and Dickman, 2005). Habitat heterogeneity leads to higher species diversity as it provides variety of resources (Monadjem, 1997; Cramer and Willig, 2005). Diversity of rodents is positively correlated with diversity of flora as well as high rainfall and humidity (Li *et al.*, 2003). The diversity of rodent species is high in natural ecosystems than in modified ecosystem (Demeke Datiko *et al.*, 2007).

Reproduction success and population dynamics of rodents are greatly influenced by seasonal variation. Their population grows during the rainy season (Happold and Happold, 1989; Feliciano *et al.*, 2002; Tilaye Wube, 2005; Massawe *et al.*, 2006; Workneh Gebresilassie *et al.*, 2004; Tadesse Habtamu and Afework Bekele, 2008). Therefore, rainfall is one of the decisive factors that causes variation in reproductive success and population dynamics of rodents (Caro, 2002). Reproductive success of

rodents is also greatly affected by diet type (Jackson and Aarde, 2004; Marcello *et al.*, 2008). Temperature and humidity have also a significant factor in determining the rodent activity (Cheeseman, 1977; Ghobrial and Hodiieb, 1982; Windberg, 1998). Breeding time and frequency, length of gestation, and litter size vary widely among the species of rodents.

Rodents have been the subject of anatomical, physiological, ethological, and ecological studies. Few species of rodents have been extensively used as models in biomedical research (Lange *et al.*, 2004). They also have medicinal, economical, social and cultural values (Singleton *et al.*, 2004). Rodents are useful experimental animals to identify chemical substances that cause cancer development in humans (Bennett and Davies, 2002). In addition to these, rodents have served as model organisms for studying the effects of habitat fragmentation (Kim *et al.*, 1998; Lambert *et al.*, 2003; Wu and Fu, 2008; Bentley, 2008). They are also useful in studies on environmental gradients (Heaney, 2001; Mena and Vazque-Dominguez, 2005). Rodents are good biological indicators of ecosystem changes (Leis *et al.*, 2008). They form vital components of ecosystems, and hence monitoring them may be a relatively quick and inexpensive method to identify different types of ecosystem functions (Avenant and Cavallini, 2008). Some rodents are also considered as pioneers of ecosystem succession (Davies, 2002; Ferreira and Aarde, 2000).

Interactions between organisms and their environments are major determinant factors for the distribution and abundance of species. Rodents interact extensively with their biotic, physical, and chemical environments and their activities have beneficial effects on other organisms in different ecosystems. They are important dietary components for many

small mammal carnivores, raptors and reptiles (Ewer, 1973; Ray, 1998; Davies, 2002). Jungle cat (*Felis chaus*), caracal (*Caracal caracal*) and golden jackal (*Canis aureus*) feed on rodents as the vital food item in India (Mukherjee *et al.*, 2004). Likewise, the giant mole-rats are the most vital food item for the survival of the Ethiopian wolf (*Canis simensis*) (Sillero-Zubiri and Gottelli, 1995; Zelalem Tefera *et al.*, 2005; Sillero-Zubiri *et al.*, 2008). Rodents are also important food sources for humans in Africa. In Benin, young people and children consume rodents on an average six times per person per month. Grass cutters and giant rats cost 8-10 and 2-4 US dollar, respectively in Benin (Assogbadjo *et al.*, 2005). Certain species of rodents are also consumed food items by Gumuz indigenous people residing near Alatish National Park, northwestern Ethiopia (Tadesse Habtamu and Afework Bekele, 2008).

Members of Rodentia show more variation in form and function than mammals of any other Order. Many rodents are important ecosystem engineers as they play a great role in controlling ecosystem structure and development by modifying their environment thereby enhancing resource flow to other organisms (Nimwegen *et al.*, 2008). Physical modification of habitats by organisms has important effects for maintaining high species richness by increasing habitat heterogeneity and facilitating resource flow (Jones *et al.*, 1994). Many rodents alter the structure of their environment by surface tunneling, construction of leaf or stick nests, arranging gravel around burrow entrances, or stripping bark from trees (Wolfe-Bellin and Moloney, 2000). These activities provide living space or resource opportunities for other organisms. Burrowing rodents such as pocket gophers, prairie dogs and mole-rats deposit soils on the ground surface and alter the soil texture and structure, aid in the formation, aeration and mixing of soil, nutrient cycling and

infiltration of rain water. Such activities result in increased local environmental heterogeneity thereby improving vegetation growth and structure. Thus, rodents exert remarkable effects on the growth and species composition of plant communities in the ecosystem (Martinsen *et al.*, 1990; Reichman and seabloom, 2002; Zhang *et al.*, 2003; Kerley *et al.*, 2004; Davidson *et al.*, 2008;). Gopher mounds increase species diversity and spatial heterogeneity of plant communities around. Rodents also engineer local environments biotically by dispersing seeds (Ostfeld *et al.*, 1997; Munoz and Bonal, 2007), and the storage organs of geophytes as well as the spores of hypogean fungi that form mycorrhizal associations with plants. Beavers (*Castor canadensis*) engineer their environment by cutting trees and building dams, dramatically altering riparian habitats. Beaver ponds harbour more aquatic invertebrates than undisturbed water bodies. The dams create favourable environment for various species of frogs. Reptiles are also attracted to beaver ponds. Beavers also dig canals, which can extend hundreds of metres into the surrounding forest. These activities of beavers increase the species richness in the area (Wright *et al.*, 2002; Nummi and Hahtola, 2008). Rodents, therefore, are vital for healthy ecosystem functioning. Management of pest rodents should be ecologically-based to sustainably control only the target species (Wright *et al.*, 2002; Meerburg *et al.*, 2008).

Despite their crucial role in ecosystem structure and development, rodents are often viewed as having negative impacts in modified ecosystems as they are responsible for loss of agricultural yields and spreading of diseases (Ghobrial and Hodieb, 1982; Makundi *et al.*, 1999; Singleton *et al.*, 2004). Extensive crop damage by rodents is a major concern in the world (Elmoultie and Wilson, 2005). It is an important cause of crop loss worldwide. Farmers often list rodents as one of the most notorious agricultural pests

(Singleton *et al.*, 1999), and they use different mechanisms to control rodent damages (Brown *et al.*, 2005). In developing countries, where agriculture is the major economic activity, pest rodents pose serious problems. They cause loss of various crops or commodities directly by gnawing and feeding, and indirectly by spoiling and contaminating food items. Many species of rodents have been recorded as pests in agriculture causing a wide range of damage and losses in cereals, legumes, vegetables, root crops, cotton and sugarcane (Davies, 2002). Rodent causes major economic losses in Africa (Stenseth *et al.*, 2001). *Mastomys* spp. and *Arvicanthis* spp. are the major known rodent pests in Africa (Taylor and Green, 1976; Leirs, 1993, 1999). Of these pests, *Mastomys* occur all over the continent in natural grasslands, thicket, cultivated areas and human habitations. Population explosions of these rodents occur at irregular intervals (Leirs *et al.*, 1996). Mostly, rodent damages crops during the seedling stage and just before harvest (Workneh Gebresilassie *et al.*, 2005, 2006). As observed in experimental fields on maize farms at Ziway, about 12.6% maize seedling is damaged by rodents, which accounts for 26.4% yield loss (Afewerk Bekele *et al.*, 2003). In Ethiopia, rodent pests are considered as a major problem in agriculture. Maize, enset and potatoes are the most affected crops in Ethiopia (Makundi *et al.*, 1999). *Arvicanthis dembeensis* and *M. erythroleucus* are the major rodent pests of agriculture in Ethiopia (Makundi *et al.*, 2005).

In addition to the loss of agricultural yields, rodents are trouble makers in public health. Historically, they have been responsible for more human illness and death than any other group of mammals. They are reservoirs and vectors of zoonotic diseases (Rao, 2003; Kilonzo *et al.*, 2005). Hantaviruses are carried by rodents and insectivores in which they cause persistent and generally asymptomatic infections (Vaheri *et al.*, 2008). Rodent-

borne diseases spread directly through bite or contaminated food, water or air and indirectly through invertebrates. Some of the rodent-borne diseases include plague, murine typhus, Leptospirosis, Salmonellosis and Rickettsial pox (Mackenzie, 1972; Ylönen, 2001).

In Ethiopia, few ecological studies of rodents have been carried out in different regions of the country. These investigations are not enough in order to have comprehensive understanding about the ecology of rodents in the country. Hence, further studies should be carried out in each and every part and habitat types of the country. In this context, the present study is aimed to assess species composition, distribution, relative abundance and habitat association of rodents in Meklite Forest and associated areas.

2. OBJECTIVES

2.1. General objective:

The general objective of the present study is to carry out an ecological survey and assess the species composition, distribution, habitat association and relative abundance of rodents in Meklite Forest and Associated Areas.

2.2. Specific objectives:

- To identify the species composition of rodents in different habitat types of the study site
- To estimate relative abundance of rodents in the study area
- To describe the distribution and habitat association of rodents among the different habitat types
- To estimate rodent density in different habitat types
- To estimate the biomass of rodents in the study site

3. THE STUDY AREA

3.1. Location

The present investigation was carried out in Meklite Forest and associated areas near Motta Town, in the Eastern Gojjam Zone of the Amhara Regional State, Ethiopia. The area is situated in Hulet Ejue Ennesie Woreda about 371 km northwest of Addis Ababa. It is formally designated as a Wildlife Reserve in the year 1974 during the Derg regime. It is situated between $11^{\circ} 05' - 11^{\circ} 06'$ N latitudes and $37^{\circ} 51' - 37^{\circ} 52'$ E longitudes. The altitude of the area ranges between 2200-2400 m asl. The total area coverage of the forest is around 443 ha (Fig.1).

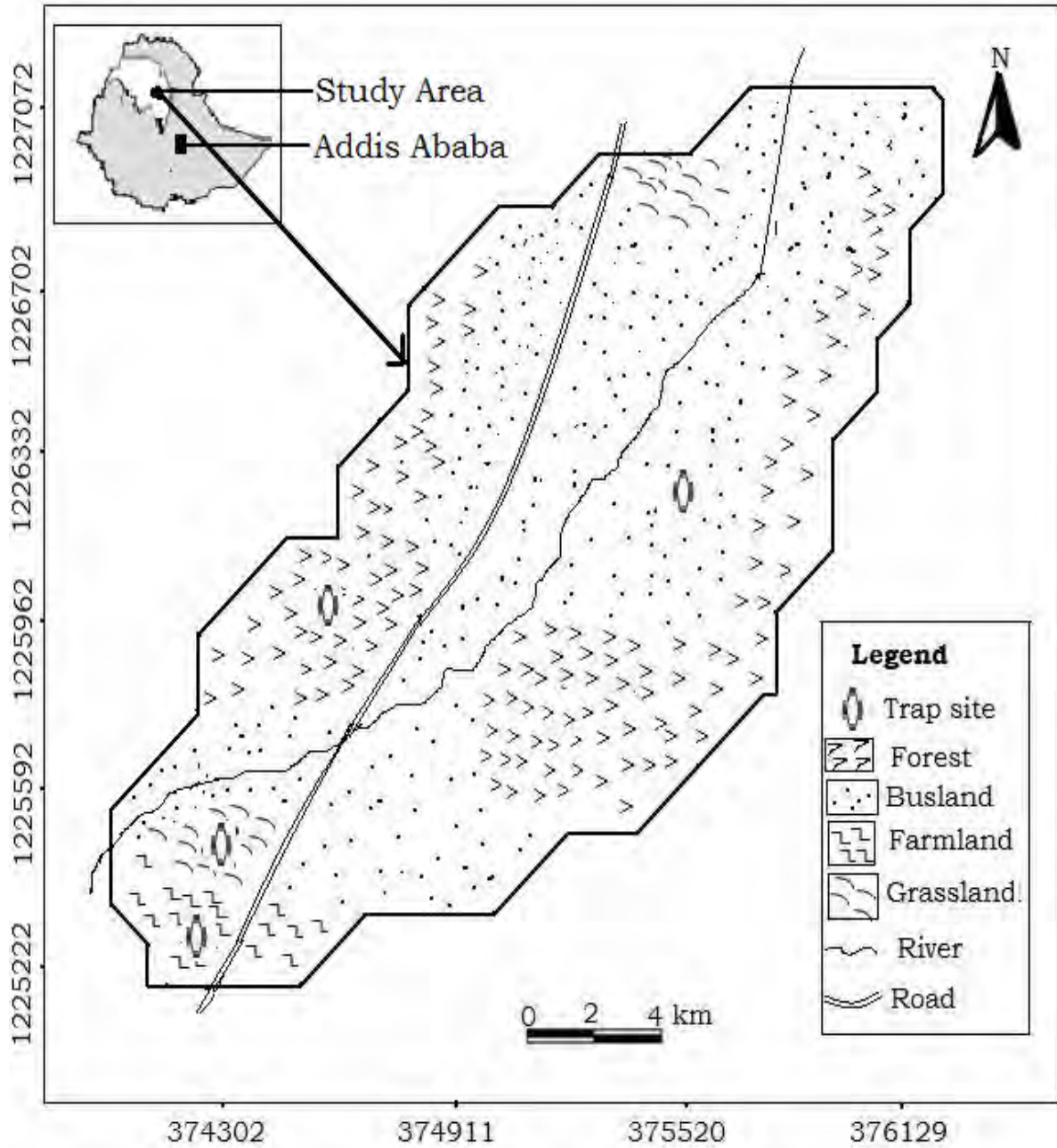


Figure 1. Map of the study area.

3.2. Climate

The climate of the study area is characterized by a unimodal rainfall having single wet and dry seasons. June, July, August and September are the months which receive high rainfall (Fig. 2). The average minimum temperature ranges between 6.7-11.2 °C, while the average maximum temperature ranges between 20.5-26.3 °C. The hottest months of the year are February, March, April and May and the coldest is December.

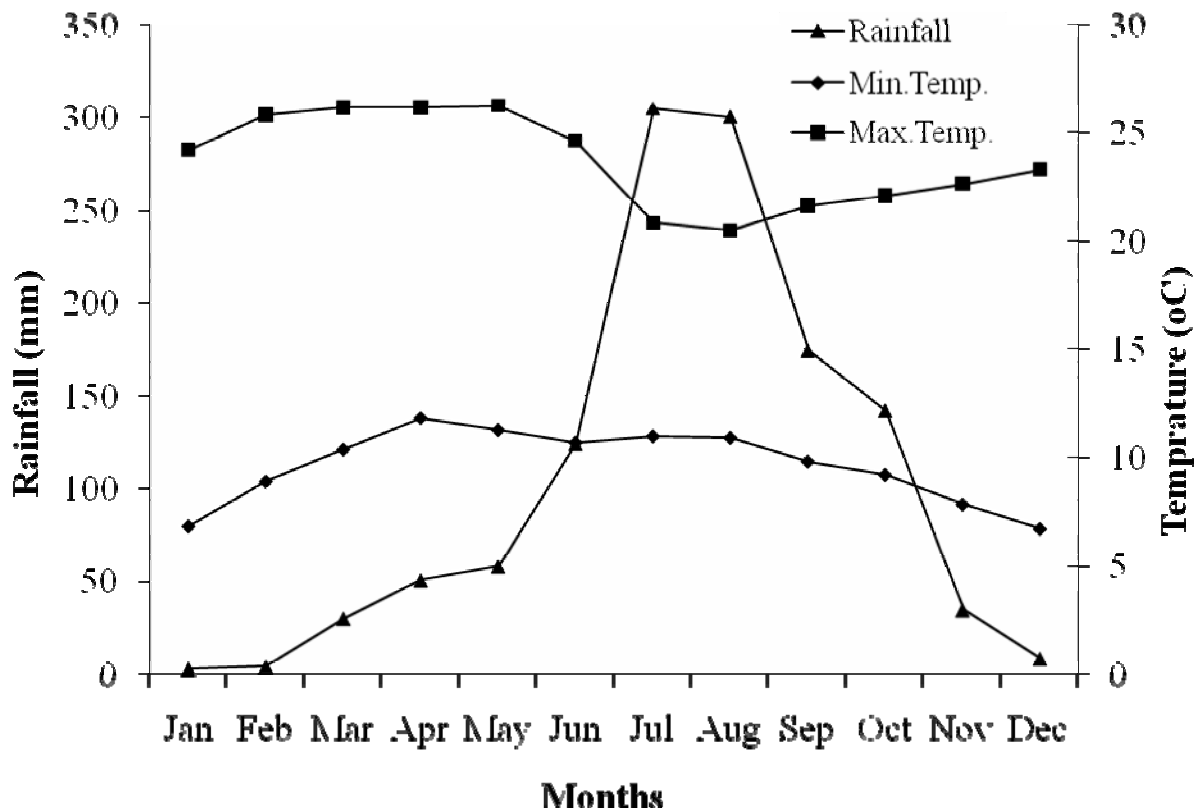


Figure 2. Monthly average maximum and minimum temperature and rainfall from 1997 to 2008 (Source: Ethiopian Meteorological Agency).

4. MATERIALS AND METHODS

4.1. Materials

Global Positioning System (GPS), Tape measure, Digital camera, Pesola spring balance (300 g), Polythene bag, Dissecting kits, Protective gloves, Snap traps, Sherman live traps, Stove, Baits (peanut butter and barely flour) Glass slides, 70% ethyl alcohol and Compound microscope were used for the present study.

4.2. Methods

4.2.1. Preliminary survey

A preliminary survey was conducted during the last two weeks of July, 2008. During this period, all the available and relevant information about the study area were gathered.

4.2.2. Sampling design and grids

Based on the information gathered during the preliminary survey, the total area of the study area was classified into four habitat types. The vegetation type in the forest was classified as forest (Fig. 3), bushland (Fig. 4) and grassland (Fig. 5). Maize farm was taken as a representative habitat type for farmlands (Fig. 6). Permanent grids were used during both seasons.



Figure 3. A view of the forest habitat in the study area (Photo by Ayenew)



Figure 4. A view of the bushland habitat in the study area (Photo by Ayenew)



Figure 5. A view of the grassland habitat in the study area (Photo by Ayenew)



Figure 6. A view of the maize farm in the study area (Photo by Ayenew)

4.2.3. Data Collection

Data collection was carried out on the four grids during both the wet and dry seasons. The first wet season data collection was carried out in August, 2008 and the second in October, 2008. The first dry season data collection was carried out in December, 2008 and the in March, 2009. Both Sherman live traps and snap traps were used.

4.2.3.1. Data collection by live traps

A permanent 4900 m² live trapping grid was established in each selected habitat types. The traps were set in a 7×7 arrangements (Fig. 7). A total of 49 Sherman live traps were set per grid at 10 m intervals. The traps were baited with peanut butter and barley flour. Traps were covered by hay and plant leaves during the dry season in order to provide protection against strong heat. The traps were checked twice a day early in the morning (07:00 a.m. to 08:00 a.m.) and late in the afternoon (05:30 p.m. to 06.30 p.m.) for three consecutive days in each grid. Information on weight, sex, approximate age (juvenile, sub-adult, adult), and reproductive conditions (for females, closed or perforated vagina and for males, the position of testes) of the trapped animals were recorded. They were marked by toe clipping and released at the site from where they were trapped.

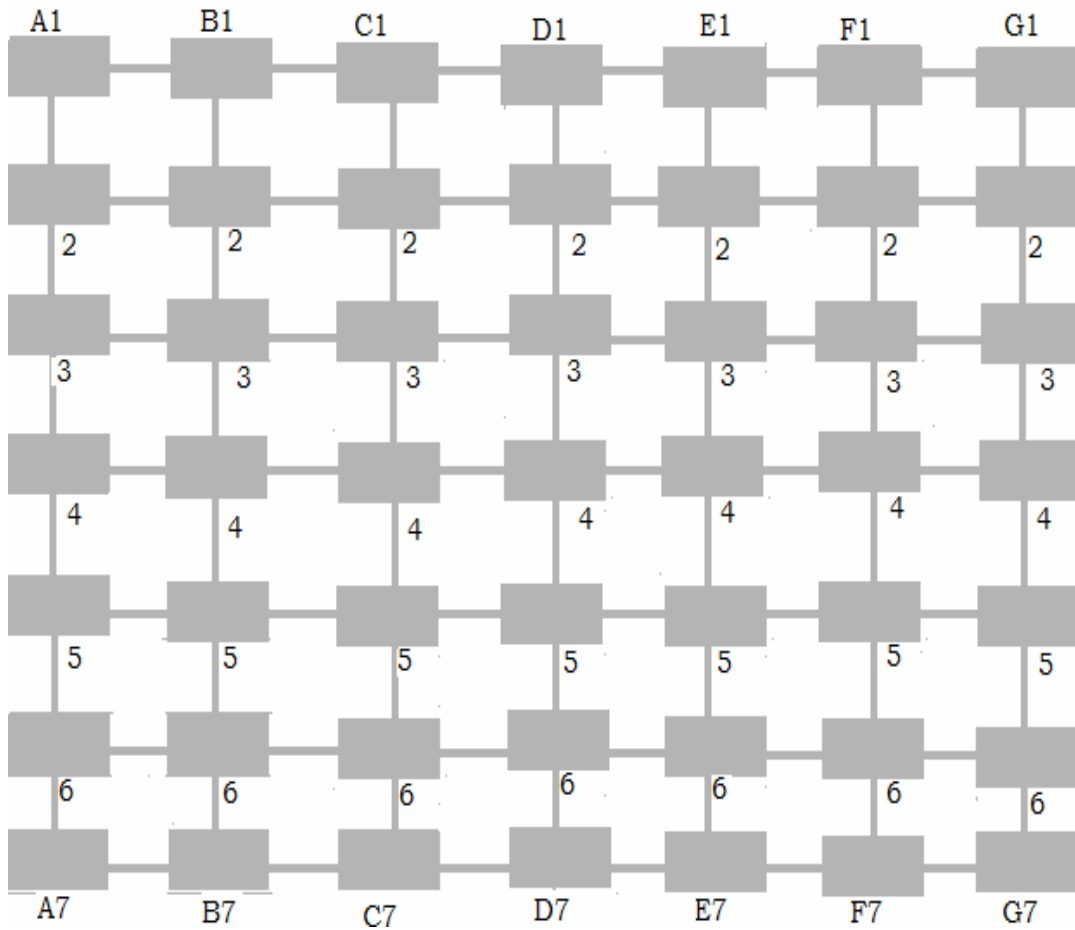


Figure 7. Diagrammatic representation of a live trap grid

4.2.3.2. Data collection by snap traps

Twenty-five snap traps were used in both seasons in each of the data collection sessions. The traps were set in a 5×5 arrangement, set at 20 m away from each other and 200 m away from the live traps. The snap traps were baited with peanut butter and checked twice a day late in the afternoon and early in the morning. Each trapped animal was weighed. Head and body length, hind foot length, ear length and tail length measurements were recorded. They were then dissected and the number of embryos was counted for pregnant females. The stomach content was collected from each individual and preserved in 70% alcohol in both seasons for diet analysis (Afework Bekele, 1996; Monadjem,

1997; Iyawe, 1988). The skin and skull of representative specimens (voucher specimens) of each species were prepared and taken to the Addis Ababa University Zoological Natural History Museum for species identification. Field guide and catalogue (Yalden *et al.*, 1976) were also used for species identification.

4.2.4. Diet analysis

The stomach contents of snap trapped rodents were analyzed following the method of Workneh Gebresilassie *et al.* (2004). The stomach content from the dissected animals removed during both seasons and preserved in 70% alcohol until further microscopic examination was carried out. Before microscopic examination, the stomach contents were dried at 50 °C for 24 hours in the oven and then the dried specimen was washed by distilled water to homogenize for proper identification under the microscope. Four glass slides were used for each specimen and observed under the microscope. The fragments were grouped into animal matter, plant leaves, seeds, plant root and unidentified matters.

4.3. Data analysis

SPSS version: 15.0 computer program and appropriate statistical tests like Chi-square and Shannon-Weiner diversity index (H') were used during data processing.

5. RESULTS

5.1. Species composition and relative abundance

A total of 465 small mammals belonging to eight species of rodents and two species of insectivores were trapped during the study period. Out of the total captured small mammals, 397 were trapped by Sherman live traps in 2352 trap nights and 68 individuals by snap traps in 1200 trap nights. The species recorded were *Arvicanthis abyssinicus* (Rüppell, 1842), *Stenocephalemys albipes* (Rüppell, 1842), *Mus musculus* (Linnaeus, 1758), *Mastomys natalensis* (Smith, 1834), *Lophuromys flavopunctatus* (Thomas, 1888), *Grammomys dolichurus* (Smut, 1832), *Rattus rattus* (Linnaeus, 1758), *Dendromus lovati* (Winton, 1900), *Crocidura flavescens* (Geoffroy, 1827) and *Crocidura fumosa* (Thomas, 1904).

Live trapped rodents and insectivores showed variations in their relative abundance in the study area (Table 1). *A. abyssinicus* 165(41.6%) was the most abundant species followed by *S. albipes* 62(15.6%), *M. musculus* 58(14.6%), *M. natalensis* 47(11.8%) *L. flavopunctatus* 26(6.5%), *G. dolichurus* 17(4.3%), *C. flavescens* 9(2.3%), *R. rattus* 7(1.8%), and *C. fumosa* 4(1.0%). *D. Lovati* 2(0.5%) was the least abundant species in the study area.

Table 1. Species composition and relative abundance of live trapped small mammals in the study area (Figures in parenthesis represent number recaptured).

| Species | Total caught | Relative abundance (%) |
|--------------------------|--------------|------------------------|
| <i>A. abyssinicus</i> | 165(35) | 41.6 |
| <i>S. albipes</i> | 62(10) | 15.6 |
| <i>M. musculus</i> | 58(7) | 14.6 |
| <i>M. natalensis</i> | 47(5) | 11.8 |
| <i>L. flavopunctatus</i> | 26(3) | 6.5 |
| <i>G. dolichurus</i> | 17(3) | 4.3 |
| <i>C. flavescens</i> | 9(0) | 2.3 |
| <i>R. rattus</i> | 7(0) | 1.8 |
| <i>C. fumosa</i> | 4(0) | 1.0 |
| <i>D. lovati</i> | 2(0) | 0.5 |
| Total 10 | 397(63) | 100 |

5.2. Distribution and habitat association

Out of the total live trapped rodents, the maximum number of individuals 189 (47.6%) were captured from the maize farm, followed by the bushland habitat 92(23.2%) and grassland 81(20.4%). The minimum number of individuals 35(8.8%) were captured in the forest habitat. The highest number of species was also caught from the maize farm (Table 2).

Table 2. Distribution of rodents and insectivores in the study sites.

| Species | No. number of individual captured | | | | Total caught |
|--------------------------|-----------------------------------|----------|-----------|------------|--------------|
| | from different habitats | | | | |
| | Forest | Bushland | Grassland | Maize farm | |
| <i>A. abyssinicus</i> | - | - | 64 | 101 | 165 |
| <i>S. albipes</i> | 13 | 49 | - | - | 62 |
| <i>M. musculus</i> | - | 15 | - | 43 | 58 |
| <i>M. natalensis</i> | - | - | 13 | 34 | 47 |
| <i>L. flavopunctatus</i> | 5 | 21 | - | - | 26 |
| <i>G. dolichurus</i> | 17 | - | - | - | 17 |
| <i>C. flavescens</i> | - | 7 | - | 2 | 9 |
| <i>R. rattus</i> | - | - | - | 7 | 7 |
| <i>C. fumosa</i> | - | - | 4 | - | 4 |
| <i>D. lovati</i> | - | - | - | 2 | 2 |
| Total | 10 | 35 | 81 | 189 | 397 |

M. natalensis and *A. abyssinicus* were the most common species from both in the farmland and grassland habitats. *S. albipes* and *L. flavopunctatus* were found both in the forest and bushland habitat. *M. musculus* and *C. flavescens* were caught both in bushy and farmland habitats. *G. dolichurus*, *C. fumosa*, *R. rattus* and *D. lovati* were the most restricted species in their distribution. *G. dolichurus* and *C. fumosa* were trapped only in forest and grass vegetation, respectively. *R. rattus* and *D. lovati* were captured only in the

maize farm. The type of species recorded among the four habitat types did not show statistically significant variation ($\chi^2=1.8$, $p > 0.05$).

Out of the total individuals of *A. abyssinicus* trapped, 61.2% was recorded from the maize farm and 38.8% individuals of the species was trapped from the grassland habitat. *S. albipes* was more abundant (79.1%) in bushland habitat than in the forest habitat (20.9%). More of the individuals of *M. musculus* (74.1%) were captured from the maize farm compared to bushland habitat (25.9%). Out of the total individuals of *M. natalensis* trapped, 72.3% was from the farmland and 27.7% was captured in the grassland habitat. More individuals of *L. flavopunctatus* were captured from the bushland habitat (80.8%) than the forest habitat (19.2%). Out of the total individuals of *C. flavescens*, 77.8% was trapped from the bushland and 22.2% from the maize farm. All individuals of *G. dolichurus* were caught from the forest vegetation. Individuals of *R. rattus* and *D. lovati* were captured only in the maize farm (Table 3). *C. fumosa* was trapped only from grassland habitat. The habitat preference of *A. abyssinicus* and *M. natalensis* between the farmland and grassland habitat was statistically significant ($\chi^2=8.3$, $p < 0.01$; $\chi^2=9.4$, $p < 0.01$, respectively). *S. albipes* and *L. flavopunctatus* also showed statistically significant habitat preferences between forest and bush habitat types ($\chi^2=20.9$, $p < 0.01$; $\chi^2=5$, $p < 0.05$, respectively). *M. musculus* also revealed statistically significant habitat preference ($\chi^2=13.5$, $p < 0.01$) between bushy vegetation and maize farm. However, *C. flavescens* did not showed statistically significant habitat preference between maize farm and bushy vegetation habitat types ($\chi^2=2.8$, $p > 0.05$).

Table 3. Percentages of trapped rodents and insectivores from different habitats.

| Species | Percentages of trapping | | | |
|--------------------------|-------------------------|----------|-----------|------------|
| | Forest | Bushland | Grassland | Maize farm |
| <i>A. abyssinicus</i> | - | - | 38.8% | 61.2% |
| <i>S. albipes</i> | 20.9% | 79.1% | - | - |
| <i>M. musculus</i> | - | 25.9% | - | 74.1% |
| <i>M. natalensis</i> | - | - | 27.7% | 72.3% |
| <i>L. flavopunctatus</i> | 19.2% | 80.8% | - | - |
| <i>G. dolichurus</i> | 100% | - | - | - |
| <i>C. flavescens</i> | - | 77.8% | - | 22.2% |
| <i>R. rattus</i> | - | - | - | 100% |
| <i>C. fumosa</i> | - | - | 100% | - |
| <i>D. lovati</i> | - | - | - | 100% |

5.3. Species richness and diversity

Species richness and diversity varied from habitat to habitat (Table 4). The highest species richness was observed in the maize farm followed by bushland habitat, with six and four species, respectively. The highest diversity ($H'=1.20$) was observed in the maize farm followed by bushland habitat ($H'=1.16$) and forest habitat ($H'=1.00$), while the highest species evenness was observed in the bushland vegetation ($E=0.84$), followed by maize farm ($E=0.67$) and forest habitat ($E=0.61$). The lowest diversity ($H'=0.47$) and species evenness ($E=0.57$) were observed in the grassland habitat.

Table 4. Species richness and diversity of rodents and insectivores.

| | No. species and diversity index | | | |
|----------------------|---------------------------------|----------|-----------|------------|
| | Forest | Bushland | Grassland | Maize farm |
| Rodents trapped | 35 | 85 | 77 | 187 |
| insectivores trapped | 0 | 7 | 4 | 2 |
| No. of species | 3 | 4 | 3 | 6 |
| H' | 1 | 1.16 | 0.63 | 1.20 |
| H _{max} | 1.1 | 1.1 | 1.1 | 1.79 |
| E | 0.61 | 0.84 | 0.57 | 0.67 |

(H' = Shannon-Weiner diversity index, H_{max} = natural logarithm of the total number of species, E= evenness).

5.4. Seasonal variation of population size and sex ratio

A total of ten species of small mammals were captured during all trapping sessions (Table 5). Except *R. rattus* and *D. lovati*, the other species were captured both during wet and dry seasons. Abundance of rodents was high during the dry season (60.2%) compared to the wet season (39.8%). The abundance of rodents showed statistically significant variation during dry season compared to the wet season ($\chi^2=22.7$, $p < 0.01$). The total number of individuals captured in the second trapping session of the wet season showed statistically significant variation ($\chi^2=13.3$, $p < 0.01$) from the total number of individuals captured in the first trapping session of the same season. Similarly, the total number of individuals captured in the first trapping session of the dry season showed statistically significant variation ($\chi^2 =13.6$, $p < 0.01$) compared to the total number of individuals trapped in the second trapping session of the dry season. The population

sizes of *S. albipes*, *M. musculus*, *L. flavopunctatus*, *M. natalensis*, *G. dolichurus*, *C. flavescens* and *C. fumosa* did not show statistically significant variation ($P > 0.05$) between the wet and dry seasons. However, population size of *A. abyssinicus* showed statistically significant variation between wet and dry seasons ($\chi^2 = 19.7$, $p < 0.01$). Out of the total individuals captured by live traps in all trapping sessions, males comprised 50.9% and females 49.1%. The ratio of live trapped males to females did not show statistical significant variation (1:1) ($\chi^2 = 0.12$, $p > 0.05$).

Table 5. Seasonal variation and sex distribution of rodents and insectivores (M = male, F =female).

| Species | Sex distribution of rodents and insectivores | | | | | | | | Total |
|--------------------------|--|-----------|------------------------|-----------|------------------------|-----------|------------------------|-----------|------------|
| | Aug/2008 Wet season | | Oct/2008 Wet season | | Dec/2008 Dry season | | Mar/2008 Dry season | | |
| | F | M | F | M | F | M | F | M | |
| <i>A. abyssinicus</i> | 7 | 9 | 18 | 20 | 22 | 24 | 33 | 32 | 165 |
| <i>S. albipes</i> | 5 | 7 | 7 | 5 | 12 | 11 | 8 | 7 | 62 |
| <i>M. musculus</i> | 2 | 3 | 8 | 11 | 14 | 12 | 3 | 5 | 58 |
| <i>M. natalensis</i> | 3 | 4 | 5 | 6 | 12 | 20 | 3 | 4 | 47 |
| <i>L. flavopunctatus</i> | 4 | 3 | 2 | 5 | 5 | 2 | 2 | 3 | 26 |
| <i>G. dolichurus</i> | 1 | 1 | 2 | 3 | 4 | 5 | 1 | 0 | 17 |
| <i>C. flavescens</i> | 1 | 0 | 3 | 1 | 2 | 2 | 0 | 0 | 9 |
| <i>R. rattus</i> | 2 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 7 |
| <i>C. fumosa</i> | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 4 |
| <i>D. lovati</i> | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | 28 | 28 | 46 | 56 | 71 | 67 | 50 | 71 | 397 |

5.5. Trap success

Trap success was maximum (32.1%) in maize farm and minimum (6.0%) in the forest vegetation. The overall trap successes in bush and grassland vegetations were 15.6% and 13.8%, respectively. Trap success was high during dry season compared to the wet season during the course of the study (Fig. 8).

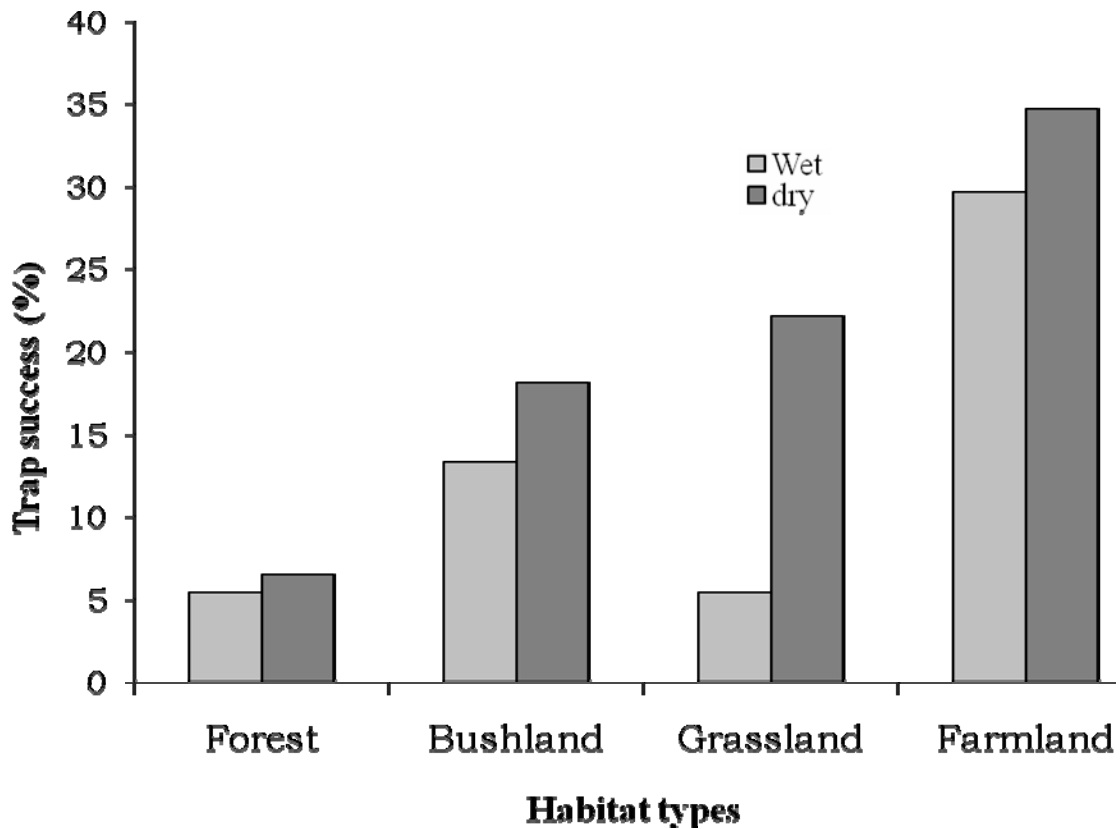


Figure 9. Seasonal variation of trap success among the four habitat types.

Trap success also varied from trapping session to trapping session and from habitat to habitat (Table 6). The overall trap success for the two seasons was 16.8%. However, among the different habitat types in different trapping occasions, capture rates varied from 2.7% to 60.5%. There was statistically significant variation in trap successes during the dry season compared to the wet season in the grassland habitat ($\chi^2=29.6$, $p < 0.01$).

However, statistically significant variation in trap success was not observed in the forest, bushland and farmland habitats between wet and dry seasons ($p > 0.05$).

Table 6. Trap success at different habitats in each trapping session.

| Gird | Habitat type | Season | Trapping | | Total caught | Trap night | Trap success (%) |
|------|--------------|--------|----------|----------------|--------------|------------|------------------|
| | | | session | Month | | | |
| G1 | Forest | Wet | 1 | August, 2008 | 7 | 147 | 4.8 |
| | | Wet | 2 | October, 2008 | 9 | 147 | 6.1 |
| | | Dry | 1 | December, 2008 | 15 | 147 | 10.2 |
| | | Dry | 2 | March, 2009 | 4 | 147 | 2.7 |
| G2 | Bushland | Wet | 1 | August, 2008 | 18 | 147 | 12.2 |
| | | Wet | 2 | October, 2008 | 21 | 147 | 14.3 |
| | | Dry | 1 | December, 2008 | 32 | 147 | 21.8 |
| | | Dry | 2 | March, 2009 | 21 | 147 | 14.3 |
| G3 | Grassland | Wet | 1 | August, 2008 | 8 | 147 | 5.4 |
| | | Wet | 2 | October, 2008 | 8 | 147 | 5.4 |
| | | Dry | 1 | December, 2008 | 12 | 147 | 8.2 |
| | | Dry | 2 | March, 2009 | 53 | 147 | 36.1 |
| G4 | Farmland | Wet | 1 | August, 2008 | 23 | 147 | 15.6 |
| | | Wet | 2 | October, 2008 | 64 | 147 | 43.5 |
| | | Dry | 1 | December, 2008 | 89 | 147 | 60.5 |
| | | Dry | 2 | March, 2009 | 13 | 147 | 8.8 |

5.6. Age-class distribution

Out of the total 397 individuals of live trapped rodents and insectivores, juveniles comprised 13.9%, sub-adults 35.0% and adults 51.1%. During the wet season, juveniles comprised 30 (54.5%), sub-adults 41 (29.5%) and adults 87 (42.9%), whereas during the dry season juveniles comprised 25 (45.5%), sub-adults 98 (70.5%) and adults 116 (57.1%) (Fig.9).

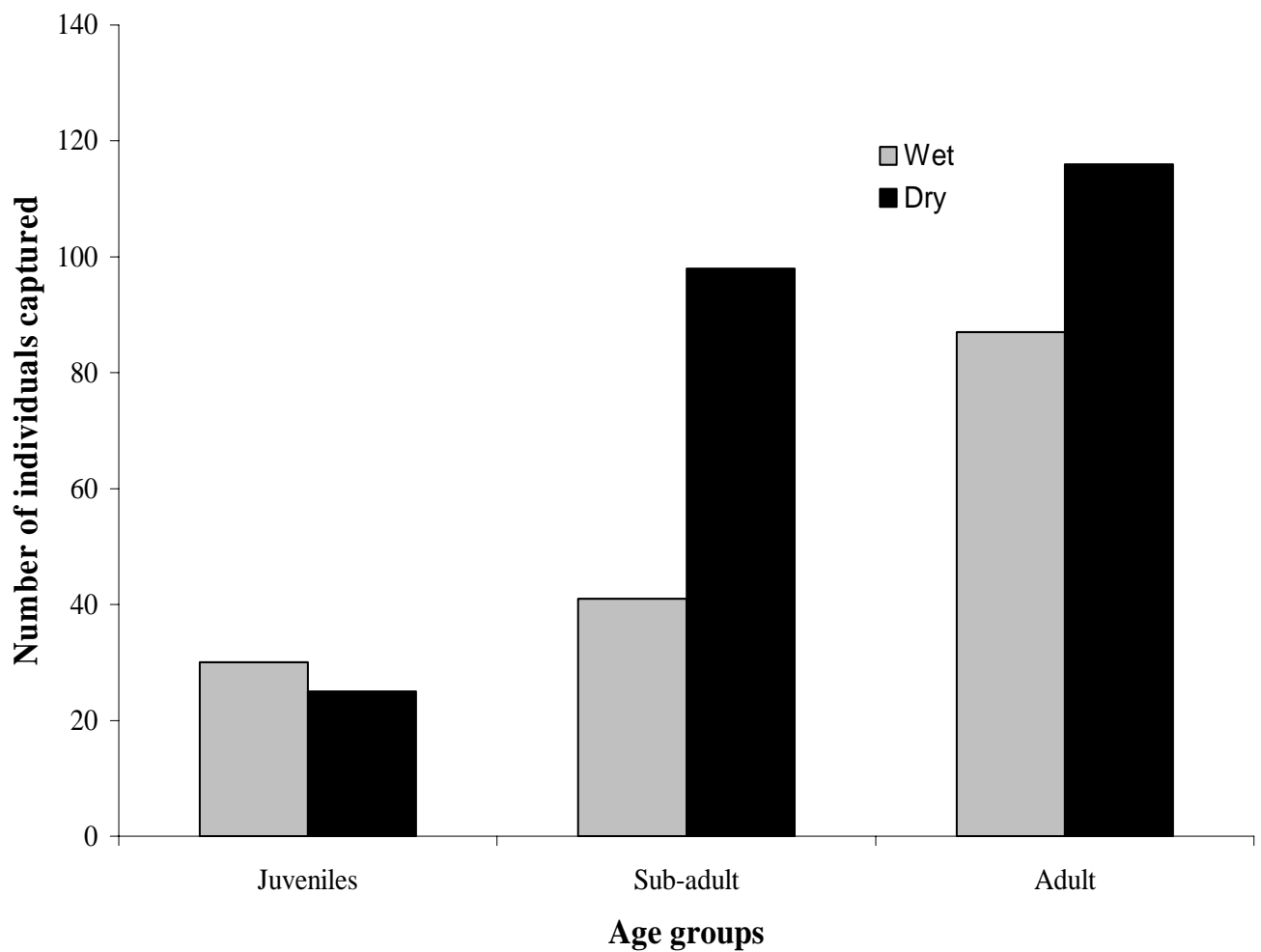


Figure 10. Age group distribution during the different seasons.

Juveniles of *A. abyssinicus* and *M. natalensis* were recorded during both seasons, but juveniles of the other captured species were recorded only during wet season (Table 7). The number of juveniles captured during the wet and dry seasons was not statistically significant ($\chi^2=0.46$, $p >0.05$). However, statistically significant number of sub-adults ($\chi^2= 23.4$, $p < 0.01$) and adults ($\chi^2 = 9.1$, $p < 0.05$) were captured during the dry season compared to the wet season.

Table 7. Age-class distribution of live trapped rodents and insectivores.

| Species | season | No. of individuals of different age groups | | | Total |
|--------------------------|--------|--|-----------|-------|-------|
| | | Juvenile | Sub-adult | Adult | |
| <i>A. abyssinicus</i> | Wet | 15 | 11 | 28 | 54 |
| | Dry | 22 | 39 | 50 | 111 |
| <i>S. albipes</i> | Wet | 5 | 8 | 12 | 25 |
| | Dry | 0 | 20 | 17 | 37 |
| <i>M. musculus</i> | Wet | 5 | 6 | 9 | 20 |
| | Dry | 0 | 14 | 24 | 38 |
| <i>M. natalensis</i> | Wet | 2 | 7 | 10 | 19 |
| | Dry | 3 | 11 | 14 | 28 |
| <i>L. flavopunctatus</i> | Wet | 0 | 5 | 9 | 14 |
| | Dry | 0 | 7 | 5 | 12 |
| <i>G. dolichurus</i> | Wet | 0 | 2 | 7 | 9 |
| | Dry | 0 | 6 | 2 | 8 |
| <i>C. flavescens</i> | Wet | 2 | 0 | 3 | 5 |
| | Dry | 0 | 1 | 3 | 4 |
| <i>R. rattus</i> | Wet | 1 | 2 | 4 | 7 |
| | Dry | 0 | 0 | 0 | 0 |
| <i>C. fumosa</i> | Wet | 0 | 0 | 3 | 3 |
| | Dry | 0 | 0 | 1 | 1 |
| <i>D. lovati</i> | Wet | 0 | 0 | 2 | 2 |
| | Dry | 0 | 0 | 0 | 0 |
| Total | | 55 | 139 | 203 | 397 |

5. 7. Population density

The lowest population density was recorded in the grassland (32 individuals/ha) and forest habitats (30 individuals/ha), whereas the highest density was recorded in the maize farm (146 individual/ha), followed by bushland (71 individuals/ha) in wet season. During the dry season, farmland supported the highest density (165 individuals/ha) followed by grassland habitat (111 individuals/ha). The lowest density was observed in the forest (17 individuals/ha) habitat during the dry season (Table 8). Statistically significant variation of rodent density was recorded between the wet and dry seasons ($\chi^2= 18.7$, $p < 0.01$).

Table 8. Population density of rodents and insectivores during the wet and dry seasons.

| Season | Grid | Population density(ha ⁻¹) | | | | | | | | | | Total |
|-----------|------|---------------------------------------|------------|------------|------------|------------|------------|-------------|------------|-------------|-------------|-------|
| | | <i>A.a</i> | <i>S.a</i> | <i>M.m</i> | <i>M.n</i> | <i>L.f</i> | <i>G.d</i> | <i>C.fl</i> | <i>R.r</i> | <i>C.fu</i> | <i>D.lo</i> | |
| Wet | F | 0 | 10 | 0 | 0 | 8 | 12 | 0 | 0 | 0 | 0 | 30 |
| | BL | 0 | 33 | 12 | 0 | 18 | 0 | 8 | 0 | 0 | 0 | 71 |
| | Gl | 16 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 6 | 0 | 32 |
| | Mf | 73 | 0 | 31 | 22 | 0 | 0 | 2 | 14 | 0 | 4 | 146 |
| Sub-total | | 89 | 43 | 43 | 32 | 26 | 12 | 10 | 14 | 6 | 4 | 279 |
| Dry | F | 0 | 16 | 0 | 0 | 2 | 16 | 0 | 0 | 0 | 0 | 34 |
| | BL | 0 | 47 | 16 | 0 | 18 | 0 | 6 | 0 | 0 | 0 | 87 |
| | Gl | 93 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 2 | 0 | 111 |
| | Mf | 81 | 0 | 45 | 37 | 0 | 0 | 2 | 0 | 0 | 0 | 165 |
| Sub-total | | 174 | 63 | 61 | 53 | 20 | 16 | 8 | 0 | 2 | 0 | 397 |
| Total | | 263 | 106 | 104 | 85 | 46 | 28 | 18 | 14 | 8 | 4 | 676 |

(F = forest, BL = bushland, GL = grassland, Mf = maize farm, *A.a*= *A. abyssinicus*, *S.a*= *S. albipes*, *M. m*= *M. musculus*, *M.n*= *M. natalensis*, *L.f*= *L. flavopunctatus*, *G.d*= *G. dolichurus*, *C.fl*= *C. flavescens*, *R.r* = *R. rattus*, *C.fu* = *C. fumosa*, *D.lo*= *D. lovati*).

5.8. Biomass

The biomass of live trapped rodents and insectivores varied from season to season and from habitat to habitat (Table 9). The maximum biomass was recorded in the maize farm followed by the bushland and grassland habitats. The lowest biomass was recorded in forest habitat. *A. abyssinicus*, *M. musculus*, *M. natalensis* and *S. albipes* comprised the largest proportion of biomass both during wet and dry seasons in the study area. Statistically significant variation of biomass was observed during the dry season compared to the wet seasons ($\chi^2=870.6$, $p<0.01$).

Table 9. Biomass (g/ha) of live trapped rodents and insectivores at different trapping sessions.

| Season | Grid | Species | | | | | | | | | | Total | |
|-----------|-----------|--------------|-------------|-------------|------------|------------|------------|-------------|------------|-------------|-------------|-------------|--------------|
| | | <i>A.a</i> | <i>S.a</i> | <i>M.m</i> | <i>M.n</i> | <i>L.f</i> | <i>G.d</i> | <i>C.fl</i> | <i>R.r</i> | <i>C.fu</i> | <i>D.lo</i> | | |
| Wet | Mbw | 79.4 | 53.5 | 15.2 | 59.8 | 50.3 | 45.5 | 17.5 | 87.4 | 23.3 | 13.2 | | |
| | N | 89 | 43 | 43 | 32 | 26 | 12 | 10 | 14 | 6 | 4 | | |
| | F | 0 | 10(515) | 0 | 0 | 8(386.4) | 12(546) | 0 | 0 | 0 | 0 | 30(1447.4) | |
| | BL | 16(1174.4) | 0 | 0 | 10(558) | 0 | 0 | 0 | 0 | 6(139.8) | 0 | 32(1872.2) | |
| | Gl | 16(1174.4) | 0 | 0 | 10(558) | 0 | 0 | 0 | 0 | 6(139.8) | 0 | 32(1872.2) | |
| | Mf | 73(5358.2) | 0 | 31(427.8) | 22(1227.6) | 0 | 0 | 2(35) | 14(1223.6) | 0 | 4(52.8) | 146(8325) | |
| | Sub-total | | 89(6532.6) | 43(2214.5) | 43(593.4) | 32(1785.6) | 26(1255.8) | 12(546) | 10(175) | 14(1223.6) | 6(139.8) | 4(52.8) | 279(14519.1) |
| | Mbw | 74.5 | 45.7 | 12.5 | 52.3 | 45.6 | 40.5 | 15.3 | 0 | 19.5 | 0 | | |
| | N | 86 | 32 | 30 | 26 | 10 | 8 | 4 | 0 | 1 | 0 | | |
| | Dry | F | 0 | 16(731.2) | 0 | 0 | 2(91.2) | 16(648) | 0 | 0 | 0 | 0 | 34(1470.4) |
| BL | | 0 | 47(2147.9) | 16(200) | 0 | 18(820.8) | 0 | 6(91.8) | 0 | 0 | 0 | 87(3260.5) | |
| Gl | | 93(6370.5) | 0 | 0 | 16(820.8) | 0 | 0 | 0 | 0 | 2(39) | 0 | 111(7230.3) | |
| Mf | | 81(5548.5) | 0 | 45(562.5) | 37(1898.1) | 0 | 0 | 2(30.6) | 0 | 0 | 0 | 165(8039.7) | |
| Sub-total | | | 174(11919) | 63(2879.1) | 61(762.5) | 53(2718.9) | 20(912) | 16(648) | 8(122.4) | 0 | 2(39) | 0 | 397(20000.9) |
| Total | | 263(18451.6) | 106(5093.6) | 104(1355.9) | 85(4504.5) | 46(2167.8) | 28(1194) | 18(297.4) | 14(1223.6) | 8(178.8) | 4(52.8) | 676(34520) | |

(Numbers in parentheses represent biomass in g/ ha, Mbw = mean body weight, N = total number of individuals captured F = forest, BL = bushland, GL = grassland, Mf = maize farm, *A.a*= *A. abyssinicus*, *S.a*= *S. albipes*, *M. m*= *M. musculus*, *M.n*= *M. natalensis*, *L.f*= *L. flavopunctatus*, *G.d*= *G. dolichurus*, *C.fl*= *C. flavescens*, *R.r*= *R. rattus*, *C.fu* = *C. fumosa*, *D.lo*= *D. lovati*).

5.9. Snap trapping

A total of 68 individuals of rodents were captured in 1200 trap nights, with a trap success of 5.7%. The snap trapped rodents were *A. abyssinicus*, *S. albipes*, *M. musculus*, *M. natalensis*, *L. flavopunctatus*, *R. rattus* and *G. dolichurus*. *D. lovati*, *C. flavescens* and *C. fumosa* were not captured by the snap traps during both seasons.

5.9.1. Body Measurements

The body weight and measurements of head to body length, tail length, hind foot length and ear length of seven species of snap trapped rodents are given (Table 10). Even though statistically significant variation of body measurements was not observed between the same species between seasons ($p > 0.05$), weight of the same species varied between seasons. Their weight was more during the wet season. However, there was no seasonal variation on other body measurements.

Table 10. Body weight (g) and measurements (mm) (mean \pm standard deviation) of snap trapped rodents both during wet and dry seasons.

| Species | Season | Body weight | Head to body length | Tail length | Hind foot length | Ear length |
|--------------------------|--------|-----------------|---------------------|-----------------|------------------|----------------|
| <i>A. abyssinicus</i> | Wet | 79.4 \pm 7.3 | 133.4 \pm 11.1 | 150 \pm 1.3 | 25.3 \pm 3.2 | 15.8 \pm 2.5 |
| | Dry | 74.5 \pm 9.6 | | | | |
| <i>S. albipes</i> | Wet | 53.5 \pm 6.2 | 118.0 \pm 5.4 | 132.0 \pm 7.5 | 24.5 \pm 3.1 | 19.8 \pm 3.5 |
| | Dry | 45.7 \pm 5.3 | | | | |
| <i>M. musculus</i> | Wet | 27.2 \pm 2.5 | 71.0 \pm 4.3 | 73.0 \pm 8.3 | 12.0 \pm 2.5 | 13.0 \pm 5.4 |
| | Dry | 25.5 \pm 1.5 | | | | |
| <i>M. natalensis</i> | Wet | 59.8 \pm 5.8 | 112.4 \pm 3.6 | 109 \pm 1.3 | 25.3 \pm 2.1 | 16.1 \pm 0.3 |
| | Dry | 52.3 \pm 3.5 | | | | |
| <i>L. flavopunctatus</i> | Wet | 50.3 \pm 6.4 | 119.0 \pm 5.4 | 58.0 \pm 4.5 | 19.5 \pm 0.5 | 18.8 \pm 0.7 |
| | Dry | 45.6 \pm 5.2 | | | | |
| <i>R. rattus</i> | Wet | 87.4 \pm 12.5 | 170.5 \pm 3.5 | 185.3 \pm 2.5 | 28.4 \pm 2.5 | 19.2 \pm 0.9 |
| | Dry | 75 \pm 10.5 | | | | |
| <i>G. dolichurus</i> | Wet | 44.5 \pm 5.4 | 79.7 \pm 1.5 | 139.5 \pm 1.4 | 22.4 \pm 0.9 | 17.2 \pm 0.2 |
| | Dry | 40.5 \pm 3.5 | | | | |

5.9.2. Reproductive condition

The number of pregnant females and embryos recorded during snap trapping sessions is given in Table 11. More of pregnant females were captured during the wet season than during the dry season ($\chi^2=16.03$, $p < 0.05$). The number of embryos observed among the snap trapped pregnant females ranged between 2-12 and 2-11 during the wet and dry seasons, respectively.

Table 11. Number of pregnant females and embryos recorded during the wet and dry seasons

| Species | Season | No .pregnant dissected | No. of embryos recorded |
|--------------------------|--------|------------------------|-------------------------|
| <i>A. abyssinicus</i> | Wet | 8 | 5-7 |
| | Dry | 3 | 5-7 |
| <i>S. albipes</i> | Wet | 6 | 3-5 |
| | Dry | 2 | 3-4 |
| <i>M. musculus</i> | Wet | 5 | 5-6 |
| | Dry | 3 | 2-4 |
| <i>M. natalensis</i> | Wet | 5 | 8-12 |
| | Dry | 3 | 7-11 |
| <i>L. flavopunctatus</i> | Wet | 4 | 3-6 |
| | Dry | 0 | 0 |
| <i>G. dolichurus</i> | Wet | 3 | 2-5 |
| | Dry | 0 | 0 |
| <i>R. rattus</i> | Wet | 3 | 6-7 |
| | Dry | 0 | 0 |

5.9.3. Diet

The proportion of food items varied in different seasons and from species to species. Monocot seeds, dicot seeds, monocot leaf, dicot leaf, plant roots and animal matter were observed in the stomach contents of snap trapped species (Table 12). The varieties of food items did not vary though the proportion of the food items varied from season to season and from species to species. More amount of animal matter was observed during the wet season than the dry season. More proportion of animal matter was observed in the stomach content of *L. flavopunctatus* compared to the other species in both seasons.

Table 12. Mean percentage of diet components of rodents during the wet and dry seasons.

| Species | Season | Percentage of diet composition | | | | | | |
|--------------------------|--------|--------------------------------|------|------|------|------|------|------|
| | | MS | DS | ML | DL | PR | AM | UM |
| <i>A. abyssinicus</i> | Wet | 6.6 | 3.5 | 29.4 | 20.3 | 8.4 | 13.5 | 18.3 |
| | Dry | 24.4 | 3.5 | 31.7 | 18.6 | 3.5 | 5 | 13.3 |
| <i>S. albipes</i> | Wet | 23.5 | 15.3 | 19.9 | 2.1 | 2.6 | 17.5 | 19.1 |
| | Dry | 15.8 | 18.6 | 20.8 | 9.7 | 6.7 | 10.5 | 17.9 |
| <i>M. musculus</i> | Wet | 18 | 10.4 | 16.3 | 10.4 | 16.2 | 17.9 | 10.8 |
| | Dry | 20.3 | 12.5 | 17.7 | 12.4 | 11.1 | 12.4 | 13.6 |
| <i>M. natalensis</i> | Wet | 21.9 | 13 | 19.2 | 13.4 | 6.5 | 15 | 11 |
| | Dry | 26.2 | 4.3 | 13.2 | 17.4 | 16.3 | 7.2 | 15.4 |
| <i>L. flavopunctatus</i> | Wet | 9.6 | 15.8 | 11.4 | 10.3 | 3.4 | 37.6 | 11.9 |
| | Dry | 13.5 | 10.5 | 10.2 | 8.7 | 12.6 | 26.8 | 17.7 |
| <i>G. dolichurus</i> | Wet | 8.5 | 6.4 | 37.2 | 9.6 | 2.9 | 17.2 | 18.2 |
| | Dry | 5.5 | 3.5 | 40.2 | 20.5 | 4.3 | 9.4 | 16.6 |
| <i>R. rattus</i> | Wet | 23 | 5.4 | 27.3 | 4.4 | 7.5 | 13.4 | 19 |
| | Dry | 16.1 | 4.4 | 25.3 | 10.2 | 11.5 | 7.5 | 25 |

(MS = monocot seed, DS = dicot seed, ML = monocot leaf, DL = dicot leaf, PR = plant root, AM = animal matter, UM = undifferentiated material).

6. DISCUSSION

Currently we report more diversity of rodent species in the farmland than in the natural habitats. However, Demeke Datiko *et al.* (2007) reported more diversity of rodent species in natural ecosystems than in modified ecosystem.

A. abyssinicus is one of the endemic species of the Ethiopian plateaux (Yalden *et al.*, 1976). Tilaye Wube (2005) stated that more individuals of the species were recorded in the crop field than bushland habitat. However, Manyingerew Shenkut *et al.* (2006) recorded more individuals of *A. abyssinicus* in the natural vegetation than farmlands. In the present study, predominantly more individuals of *A. abyssinicus* were captured before harvest in the maize farmland, and after harvest in the grassland area. The species might reproduce rapidly as a result of the presence of nutritious food in the farm areas or might have moved into the grassland habitat from the surrounding areas in search of food and shelter.

S. albipes was the second most abundant species in the study area next to *A. abyssinicus*. Yalden and Lagen (1992) described the species as one of the most common and abundant endemic rodent species of Ethiopia. Yalden *et al.* (1976) reported that the species frequently occurs in the natural vegetation. Afework Bekele (1995, 1996) also captured the species in the forest and bushy vegetation in the Menagesha State Forest. Tilaye Wube (2005) has captured the species both in bushy vegetation and agricultural fields. In the present study, the species was trapped both in the bushy and forest vegetation.

Mus musculus is a widespread species in Ethiopia (Yalden, 1988). Demeke Datiko *et al.* (2007) described that the species was more abundant in maize farm than bush habitats. Similarly, this species was more abundant in the maize farm than bush habitat in the present study.

M. natalensis is a widely distributed species in most regions of Ethiopia (Yalden *et al.*, 1976; Afework Bekele and Liers, 1997). Demeke Datiko *et al.* (2007) stated that the species was more common in crop fields than in natural vegetation. Tadesse Habtamu and Afework Bekele (2008) recorded the species in different habitat types including human habitation. In the present study, the species was found in the grassland and farmland areas and was more abundant in the maize farm than in grasslands.

L. flavopunctatus was more abundant in the bushy vegetation than in forest habitat. Yalden *et al.* (1976) described *L. flavopunctatus* as a widely distributed species in Ethiopia. Clausnitzer and Kityo (2001) stated that the species has a wide range of distribution along the different montane and highland habitats of East Africa. The wide distribution of the species is associated with the insectivorous feeding habit (Clausnitzer *et al.*, 2003). Tilaye Wube (2005) recorded more individuals of this species in the bushland habitat than in crop fields. In the present investigation, this species was recorded in bush and forest vegetation types. These habitats could probably provide more varieties of insects than the agricultural field and grassland vegetation.

G. dolichurus was confirmed to Ethiopia (Yalden *et al.*,1976). Demeke Datiko *et al.* (2007) reported this species in Arbaminch forest in the forest habitat and cotton plantations. *G. dolichurus* is an arboreal species (Clausnitzer and Kityo, 2001; Fitzherbert

et al., 2006). Makundi *et al.* (2005) recorded the species only in the forest habitat type. Likewise, *G. dolichurus* was recorded in forest habitat in the present investigation. The arboreal habit of the species probably limits the distribution of the species in the different habitats other than forest vegetation.

R. rattus is one of the major pests of agricultural crop and stored food grains. The species commonly inhabits near the human habitation (Selvaraj and Archunan, 2002). In the present study, this species was trapped from the maize farm. Intra-specific competition and predation might force this to widen the distribution into farm areas from the surrounding human settlements.

D. lovati is an endemic species of the Ethiopian plateaux. Yalden and Largen (1992) have trapped the species from both sides of the Rift Valley. Yalden *et al.* (1976) recorded the species from areas of altitudes ranging from 2500 - 3550 m asl. In the present study, this species was recorded at altitudes ranging from 2200-2400 m asl. Yalden *et al.* (1976) and Yalden and Largen (1992) reported that *D. lovati* is an uncommon grassland species and information on its behaviour is unknown. This species was the least abundant in the present study area and it was captured in the maize farm area. Bentley (2008) described that habitat fragmentation and disturbance affect the pattern of habitat use and movement of animal. *D. lovati* was not captured from grassland habitat, but was commonly captured by Yalden *et al.* (1976) and Yalden and Largen (1992). The loss and shrinkage of the grassland habitat as a result of expansion of agricultural fields might force the species to shift and expand its habitat to the agricultural fields.

C. flavescens is one of the common and widespread shrews in Ethiopia (Yalden *et al.*, 1976). Delany (1964) described this as a typical forest species. However, in the present study, the species was recorded in the bushland and farmland habitats. The species might shift its niche from the forest habitat into bushland habitat and agricultural fields in search of enough food and cover.

C. fumosa is a common insectivore in Ethiopia. Yalden (1988) described *C. fumosa* as a highland species common in the moorland habitat. In the present study, the species was recorded in the grassland vegetation.

There were few differences in species richness and diversity among the habitat types. However, the relative abundance of rodents showed variation across habitat types with high number of individuals captured from the maize farm. Moreover, the distribution of species was not uniform in the present study area across the habitat types. The highest number of species was recorded from farmland habitat than the natural habitats during the study period. Farmlands usually harbour higher number of rodent pests than natural forests (Demeke Datiko *et al.*, 2007). The higher preference of the farmland habitat than the natural habitat might be due to the availability of nutritious food in the farmland. Availability of resources increases rodent abundance (Halvorson, 1982; Lentic and Dickman, 2005). The farmland habitat was preferred more during the fruiting and before harvesting time. This habitat type might provide enough cover and nutritious food in the fruiting and maturation stages as the farmers practice traditional farming system. Prior to the harvesting season, an agricultural area becomes highly favourable for rodents as it provides food and cover (Tsegaye Gadisa and Afework Bekele, 2006). The bush habitat type was also inhabited by more species than the grassland habitat and the forest habitat.

The bushy vegetation could probably provide enough food and cover than the grassland and forest habitats. Bushy vegetation provides safe sites for germination and growth of herbaceous vegetation, thereby enhancing the diversity of the potential food resources for small mammals (Kerley *et al.*, 2004).

Significant fluctuation of population size was observed in the maize farm and grassland during the study periods. Population size of rodents fluctuates greatly as a result of change of quality and quantity of resources in an environment (Makundi *et al.*, 2005). The movement pattern of rodent changes from time to time based on season and on the availability of essential resources (Taylor and Green, 1976). In the agricultural field, the maximum population size of rodents recorded in the fruiting and maturation periods of the vegetation, and the maximum population size of rodents was recorded in grassland habitat near the farmlands after harvesting the agricultural crop. The species might move from the vicinity to the maize farm in search of food or the species might migrate from agricultural fields into the grassland in search of cover and food. The pattern of rodent movement varies with a change of season and availability of shelter and food (Workneh Gebresilassie *et al.*, 2006). When there is inadequate food and cover, rodents are forced to migrate to areas where food and shelter are available (Tsegaye Gadisa and Afework Bekele, 2006). On the other hand, in the more heterogeneous habitats (bushy and forest), significant variation of population sizes was not observed with seasonal variations in the present study. The more stability and relatively lower disturbance of the bushy and forest vegetation might help the species to attain stable population, which does not show remarkable population size fluctuations at different seasons. Species that live in relatively

stable habitats show less changes in number compared to those living in disturbed habitats (Makundi *et al.*, 2005).

Trap success varied from season to season and from habitat to habitat types during the present investigation. Population size affects trap success (Tsegaye Gadisa and Afework Bekele, 2006). Trap success was maximum (32.1%) in maize and minimum (6%) in the forest vegetation. However, among the different habitat types in different trapping occasions, capture rate varied from 2.7% to 60.5%. Trap success was significantly high during the dry season compared to the wet season. This might be due to unattractiveness of the bait during the wet season as a result of the presence of different food resources in the surrounding area. It is also possible that most of the individuals probably did not reach trappable age in wet season as most of these rodents reproduce during the wet season. The overall trap success in the present study area was 16.8%. This trap success is comparable to the finding of Demeke Datiko *et al.* (2007) who have reported 17.6% in Arbaminch forests and farmlands and that of Tsegaye Gadisa and Afework Bekele (2006) who have reported 15.4% in Bilalo areas, Arsi, Ethiopia.

Out of the total number of live trapped rodents and insectivores, adults comprised the maximum number of individuals 203(51.1%) followed by sub-adults 139(35%). Comparatively, fewer individuals of juveniles 55(13.9%) were captured in the study area. This could probably be due to larger home ranges for adults and sub-adults to alleviate the cost of competition with juveniles. Adult and sub-adult individuals have wider home range than young rodents (Workneh Gebresilassie *et al.*, 2006).

Population density of rodents was higher during the dry season compared to the wet season. This was maximum in the maize farm and minimum in the forest habitat (Table 8). Farmlands provide essential resources better than grasslands (Workneh Gebresilassie *et al.* 2005). *A. abyssinicus*, *M. musculus* and *M. natalensis* had a higher population density in maize farm than in any of the other sites. Higher density of the species in agricultural field than natural vegetation might indicate the pest status of the species. Workneh Gebresilassie *et al.* (2005) described that pest rodents occur at higher densities in farmlands than natural habitats. In the present study, maximum density was obtained during the dry season. Availability food in agricultural fields before harvest during the dry season might have influenced the density of small mammals.

Maximum biomass was recorded from the maize farm and minimum in the forest vegetation during both seasons. The presence of nutritious food in the maize farm compared to other habitats could probably have increased the weight of rodents and their reproductive potential for females thereby increasing the biomass. Workneh Gebresilassie *et al.* (2005) stated that habitats that possess sufficient food resources support highest rodent biomass. In the present study, maximum biomass was recorded during the dry season compared to the wet season.

From the stomach content analysis, it was confirmed that rodents eat both plant and animal matter. The feeding ecology of small mammals is highly diversified (Campos *et al.*, 2001). Martin and Dickinson (1985) and Frith and Frith (1990) described that the abundance of invertebrates increases during the wet season. In the present study, more fragments of animal matter were observed from the stomach contents collected during the wet season than stomach contents collected the during the dry season. Workneh

Gebresilassie *et al.* (2004) described rodents as opportunistic feeders. The present study also supports the idea that rodents are able to shift their feeding habits depending on the availability of food resources. Compared to the other species of rodents, more animal matter fragments were observed in the stomach contents of *L. flavopunctatus* during both seasons. Clausnitzer *et al.*(2003) described *L. flavopunctatus* as an insectivorous species supporting the present finding.

7. CONCLUSION AND RECOMMENDATIONS

Data collected during the present investigation provided valuable information on the species composition, relative abundance, distribution and habitat association of the rodent species in Meklite forest and nearby areas. Eight species of rodents and two species of insectivore were identified during the present study. Out of the total species captured, *S. albipes* and *D. lovati* were endemics of Ethiopia. This study indicated that the distribution of species varies with habitat types. *G. dolichurus*, *L. flavopunctatus*, *S. albipes* and *C. fumosa* were recorded only from the natural vegetation whereas *D. lovati* and *R. rattus* recorded in farm area. Rests of the species were recorded from both natural vegetation and farmland. The maize farm had the highest species diversity, followed by bushland habitat. The endemic species, *D. lovati* was expected to be trapped in the grassland habitat; however, during the present study the species was trapped in the agricultural fields.

The growths of human population as well as poverty are causing major destruction of natural habitats. This is also true in Meklite Forest. It was observed during the data collection periods that on an average, more than ten large trees were cut per day in the forest for fuel wood, fence and other purposes. If deforestation continues at this rate, the forest will totally be destroyed in the near future. This will affect the endemic species leading to their disappearance from the area as a result of habitat disruption. Therefore, the following recommendations are made to alleviate the problems in the area:

- Sensitizing the local people about the potential negative impacts of loss of wildlife in the area.
- Implementing community based conservation strategies to change the attitude of the local people
- Organizing the local fuel wood sellers and help them to generate other alternative source of income, for example providing farm plots that can be irrigated, and
- Implementing effective law enforcement.

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