College of Natural Sciences

School of graduate studies

Department of Biology

Relative Abundance, Diet Composition and Breeding Season of Rodents in Cultivated Field and Grassland Habitats in Shashogo District, Hadiya Zone, South Ethiopia

A Thesis Submitted School of Graduate Studies of Jimma University, Department of Biology, College of Natural Sciences in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology

(Ecological and Systematic Zoology Stream)

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December, 2013

Jimma, Ethiopia

Acknowledgement

First and for most, I would like to express my deepest gratitude to the most my research advisor Dr. Tsegaye Gadisa who provided valuable professional guidance, thoughtful suggestions and consistent encouragement, throughout my thesis work. He always showed willingness to provide field materials and key information. I am grateful to his critical follow up, immediate response, encouragement, friendly approach and also constructive criticism starting from proposal up to the whole thesis work with continuous follow up. I am also grateful to Dr. K.K. Subhash Babu for encouraging me to work on the relative abundance, diet composition and breeding season of rodents in cultivated field and grassland habitats.

I would like to thank the Department of Biology, Jimma University, College of Natural Sciences for providing me financial support to carry out this research.

I am also thankful to Shashogo District Administrative Office for allowing me to pursue my postgraduate studies. I would like to convey special thanks to Ato Markos Hirgo, Shashogo District Chief Administrative Office for his invaluable support and encouragement.

I extend my special thank to Lopiso Shamebo, a GIS specialist, who helped me in mapping the study area. I would like also to thank Mulatu Hankiso for his help in providing me digital camera.

I would like to express my deep sense of gratitude to my friends Tagesse Ladoro, Kedir Feiso, Mesaye Tagessa, Abriham Debeba and Tadesse Terefa and also classmates who have been in great help and encouragement all the way up to the completion of this study.

Finally, the unfailing prayers and support rendered from my parents Kassa Aliye and Workenesh Abode deserves great thanks. I am also grateful to my sister Deselach and my brother Abenet for the moral and every support they all gave me.

Above all, I would like to praise the Almighty God for giving me all the endurance and everything I ever needed.

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List of Acronyms

ANOVA	Analysis of variance
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization of the United Nations
GPS	Global Positioning System
IPM	Integrated Pest Management
NMA	National Meteorological Agency
SPSS	Statistical Package for Social Sciences

Abstract

Ecological study on the relative abundance, diet composition and breeding season of rodents in cultivated and grassland habitats in Shashogo District, Hadiya Zone, Southern Ethiopia was carried out from February, 2013 to August 2013. The study was carried out using snap traps in farm and grassland habitats. A total of 106 individuals belonging to three species were captured using snap-traps, in 450 trap nights. The three rodent species recorded in this were: - Arvicanthis dembeensis (38.7%), Mastomys erythroleucus (23.6%) and Rattus rattus (37.7%). The distribution of species varied between habitats and months. Three and two rodent species were trapped from farm and grassland habitats respectively. The populations of these species were also varied from month to month; highest number of rodents was captured during the months of June to August and less during the months of March to May. More individuals were trapped from the farmlands. There was also significant variation in trap success between the two habitat types. The proportion of adult, sub-adult and young individuals showed significant variation among species and months. Number of pregnant females and embryo count was higher during the months of June to August than the months of March to May. Diet analysis of the stomach content of the rodents of snap trapped individual showed higher proportion of plant matter than animal matter. Vegetation cover, rainfall and human interference were the major factors affecting the abundance and distribution of rodents in the study area.

Key words/ phrases: Breeding season, diet composition, relative abundance, rodents, traps success, Ethiopia

1. Introduction

1.1. Background

Mammals are the highest evolved group of the animal Kingdom (Ghose and Manna, 2003). Among mammals, rodents (Order Rodentia) constitute the most diverse group (Vaughan *et al.*, 2000). They range from tiny pigmy mice to big capybaras, from arboreal flying squirrels to subterranean mole rats, from opportunistic omnivores to specialist feeders and from diurnal to nocturnal forms. Traditionally, rodents have been grouped into three suborders based largely on jaw musculature and associated structure of the skull (Vaughan *et al.*, 2000). These are Sciuromorpha (squirrel-like rodents), the Myomorpha (rat-like rodents) and Hysticomorpha (porcupine-like rodents).

A total of 5416 species of mammals are recorded worldwide, of which 2,277 species are rodents accounting for 42% of mammalian species (Wilson and Reender, 2005). More than 1150 species of mammals are currently listed from Africa (Kingdon, 1997). In East Africa, rodents account for about 28% of the total mammal fauna (Clausintzer, 2003).The most common rodents in sub-Saharan Africa belong to the genus *Mastomys* (Stenseth *et al.*, 2001). They occur all over the continent in natural grasslands, thickets, cultivated areas and in human habitations. Rodent fauna of Ethiopia consists of 84 species and comprising more than 25% of the total mammalian fauna of the country (Yalden and Largen, 1992). Out of these, 15 species are endemic to Ethiopia (Afework Bekele and Corti, 1997).

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 largely arboreal. Some are gliders, and others are adapted for semi-aquatic life (Wright *et al.*, 2002). They occur in every habitat from the high Arctic Tundra, where they live and breed under the snow to the hottest and driest of deserts (Kingdon, 1997; Stoddart, 1984). Rodents are primary consumers of seeds and herbs (Mulungu *et al.*, 2008). They are in general opportunistic feeders, capable of changing their diet based on the availability of food from season to season (Workneh Gebresilassie *et al.*, 2004).

This behavior makes them the most destructive pest in agriculture (Leirs, 1999). All *Mastomys* species cause problems in agriculture and public health (Odhiambo and Oguge, 2003).They can feed on a variety of food items (green plant materials, seeds, fruits and insects) and thus survive in many different types of crops that become available in large amounts (Leirs *et al.,* 1994). Mole rats are specialized on root and tubers of different plants (Sidorowicz, 1974).

Reproduction success and population dynamics of rodents are greatly influenced by seasonal variation. Breeding time and frequency, length of gestation, and litter size vary widely among the species of rodents. Their population grows during the rainy season (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 (Marcello *et al.,* 2008). 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). Diet quality is the most important factor that regulates the onset of rodent breeding (Jackson and Vanaarde, 2004). Temperature and humidity have also a significant role in determining the rodent activity (Windberg, 1998). Reproduction is highly energy consuming. Therefore, it requires coinciding with the time of the year that the habitat is rewarding (Shanas and Haim, 2004).

According to Singleton *et al.* (2003), rodents have ecological, economical, social and cultural values. Rodents play an important part in natural communities, and provide the main supply of living food for many of the predatory mammals, birds and reptiles (Davies, 2002). Rodents are preferred as a delicious food source in several countries of Africa because of rich of protein content in their flesh (Fiedler, 1990). For instance, they are important component of diet in some indigenous people of Ethiopia (Tadesse Habtamu and Afework Bekele, 2008). They have been also used as a model organism in laboratories for years and contribute to biological and bio-medical research (Nowak, 1999). In addition to these, rodents have served as model organisms for studying the effects of habitat fragmentation and they are good biological indicators of ecosystem changes (Wu and Fu, 2008; Bentley, 2008; 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 of these are considered as pioneer species of ecosystem succession (Daveis, 2002).

Rodents play important structural roles in different ecosystem services. Like, pruning or eliminating vegetation types, aerating soil through their digging and burrowing activities, spreading seeds (Kingdon, 1997).

Several 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). 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 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 (Kerley *et al.*, 2004). 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 (Davidson *et al.*, 2008). Rodents also engineer local environments biotically by dispersing seeds (Munoz and Bonal, 2007), and are vital for healthy ecosystem functioning.

Despite their ecological and economical importance, some rodents are the most noxious among mammals' in terms of their pest and vector status (Singleton *et al*., 2003). Farmers in many parts of the world, particularly those in developing countries, tend to view economic losses due to rats and mice as unavoidable (Singleton *et al*., 1999). Therefore, rodents disproportionately affect the poor, having multiple impacts upon natural and human capital by damaging food crops and stores, by spreading disease, contaminating food and water, and reducing productivity. However, of the 2,277 species of rodents worldwide, less than 5% cause significant losses to agricultural crops (Singleton *et al*., 2003). Globally, rodents damage and destroy 30% of the crops in both pre-harvest and post-harvest conditions (Singleton, 2001). Most damage occurs during the sensitive young seedling stage and just before harvest.

In Africa, rodents are the most important pre-harvest pests in economic terms. In Tanzania an estimated annual yield loss of 5-15% of maize is recorded (Leirs, 2003).

In Ethiopia, although comprehensive studies on the effect of rodent damage to agricultural crops are lacking, few studies estimated that rodents destroy 20-26% of cereal crops (Afework Bekele *et al.*, 2003). In addition, they are also reservoirs and carriers of zoonotic diseases that can infect both humans and livestock. As humans and livestock are in regular contact with rodents, their potential for transmission of zoonotic diseases is very high (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 are Murine typhus, Leptospirosis, Salmonellosis and Plague (Rao, 2003).These diseases are of great social and public health importance. Therefore, by considering their economic importance, controlling rodent population using appropriate pest management methods such as Integrated Pest Management (IPM) approach is important to reduce crop damage by rodents (Stenseth *et al*., 2001).

In Ethiopia, few ecological studies of rodents have been carried out in different regions of the country (Afework Bekele, 1996a, b; Afework Bekele *et al*., 1993; Afework Bekele *et al*., 2003; Afework Bekele and Leirs, 1997; Afework Bekele and Corti, 1997; Lavrenchko *et al*., 1998; Tadesse Habtamu, 2005; and Alemu Fetene, 2003). However; these studies were concentrated in protected areas, open grasslands, non- irrigated fields and in laboratories. These studies are not enough in order to have comprehensive understanding about the ecology of rodents in the country. In this context, the aim of the present study is to generate information on the relative abundance, diet composition and breeding season of rodents in cultivated and grassland habitats in Shashogo District, Hadiya Zone, South Ethiopia.

1.2. Statement of the problem

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 (Singleton *et al*., 2004). Extensive crop damage by rodents is a major concern and it is an important cause of crop losses worldwide (Elmouttie and Wilson, 2005). Farmers often list rodents as one of their most significant crop pests (Stenseth *et al*., 2001). 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).

According to Stenseth *et al.* (2001), rodents cause major economic losses in Africa. Similarly, in Ethiopia, rodent pests are considered as a major problem in agriculture. Studies show that rodents are the most important problems causing major damages to crop plants such as maize, sorghum, barley, teff, wheat, and others. Farmers in Shashogo District faced similar problems and complained economic loss due to rodents is significant. Designing appropriate rodent control strategy is important to reduce such rodent pest problems. Preparing sound rodent pest control strategy requires basic ecological knowledge such as the relative abundance, breeding season and diet composition of rodent species. But there is no documented information in the study area. Therefore, the present study was aimed to fill the gap by generating basic information on the relative abundance, diet composition and breeding season of rodents in cultivated and grassland habitats in Shashogo District, Hadiya Zone, South Ethoipia.

1.3. Objective of the study

1.3.1. General Objective

- To assess the relative abundance, diet composition and breeding season of rodents in cultivated and grassland habitats in Shashogo District, Hadiya Zone, South Ethiopia.

1.3.2. Specific Objectives

- To determine the relative abundance of rodents in the study area
- To identify the diet composition of rodents at different habitats
- To identify breeding season of rodents

1.4. Significance of the study

The results of the present study will provide information on the relative abundance, diet composition and breeding season of rodents which help to develop sound rodent control program. In addition the results will also serve as a baseline for other researchers interested to carry out further research on the ecology of rodents of the study area.

1.5. Limitation of the study

Some limitations were faced during the present study. These were lack of enough financial support to conduct the investigation and insufficient time to collect the research data. During the data collection period unfavorable climatic condition such as rainfall, temperature and the like affected the research work. The study area intended to be studied was used for domestic or livestock forage, which in turn maximizes disturbance, and minimizes the captured rate of the target population.

2. Literature review

2.1. Biology of rodents

Mammals are diverse groups of vertebrates with an estimated number of 5416 species, of which 2,277 species are rodents. Rodents account for 42% of mammalian species (Wilson and Reender, 2005). Rodents were recorded first from the late Paleocene epoch, about 55 million years ago (Futuyma, 2005). However, rodents of the family Muridae, which comprise more than half of all rodent species, did not appear until 6 million years ago (Kingdon, 1997). Though murids are believed to be late comers of African rodents, they have become widespread and dominant species by progressively replacing other types of rodents and by relegating more conservative groups to the status of relict (Kingdon, 1997).

Out of the 284 species of mammals that occur 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). The diversity and success of rodents in the country is as a consequence of diverse factors such as altitude, variation in rainfall and climatic patterns, soil variability, vegetation and habitats. 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 have been adapted to diverse habitats. They are widely distributed throughout the world. They dwell in various habitats. Some species are aquatic, some are terrestrial, and some live in burrows in the ground. Some are arboreal, and about 35 species are semi aerial, gliding from one tree to another (Vaughan *et al*., 2000). Rodents are the most diverse group of mammals (Vaughan *et al*., 2000). They show great diversity in their ecology, morphology, physiology, behaviour and life history strategies (Nedbal *et al*., 1996). The success of rodents as a group is no doubt. They combine three adaptations to thrive: ability to produce large litters in a short period of gestation, ability to adapt quickly to environmental changes and they are relatively small animals, which can easily hide from predators (Vaughan *et al*., 2000).

Species diversity of small mammals can be influenced by many factors. The habitat heterogeneity hypothesis states an increase in habitat heterogeneity leads to increase in species diversity (Cramer and Willig, 2002). Habitat heterogeneity could enhance diversity when habitats are large enough to support distinct populations. In addition to this, the presence of dominant species (both numerically and competitively) can also have strong influence on community structure and diversity (Anderson, 1992). Disturbance is also another important factor affecting species diversity in natural ecosystems (Sousal, 1984). These effects are more prevalent on those species that share niche requirements with the dominant species, whereas species with little niche overlap are unaffected (Heske *et al.*, 1994). Diversity of a community can be measured either by number of species present (species richness) and distribution of individuals among the species present (species evenness) (Krebs, 1989). Both richness and evenness can be affected by interactions among species leading to changes in diversity. Interactions among species, lead to changes in species richness (Brady and Slade, 2001).

2.2. Breeding of rodents

Breeding in rodents begins some weeks after the onset of rainy season 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. Rodents have high rate of reproduction (Hvass, 1965). Mice and rats are extremely fast breeders. Mice have gestation period of three weeks. Litter size between different species is apparently variable. The average litter sizes of *Mastomys* sp. are eleven to twelve (Delany, 1964). Most rodent species commonly have 6-7 young per breeding season (Workneh Gebresilassie *et al.*, 2006). Stanbury (1972) reported that brown rat (*Rattus norvegicus*) has an average litter size of 5-8 and breeds up to five times a year.

Rodents have short life span and are prolific breeders (Meehan, 1984). They multiply rapidly under favorable conditions. A female rat may give birth up to five litters. *Rattus norvegicus* and *R. rattus* produce 7-8 young in each litter. The multimammate rat (*Mastomy natalensis*) can have up to 20 young in a litter, the average being about 11 (Proctor, 1994). Seasonal distribution of food and quantity of rainfall are considered as the major variables determining population dynamics of rodents in East Africa (Leirs, 1994; Quy *et al*., 2003).

Extended rainy seasons result in longer periods of breeding and higher litter size, which in turn lead to high population (Leirs *et al*., 1994). Studies in grassland and maize field in central Ethiopia also revealed that breeding in rodents is seasonal and is related to rainfall (Afework Bekele and Liers, 1997). Their high fecundity is one of the factors that contribute to the success of rodents. Most rodents reproduce rapidly. They produce large litters quickly (Vaughan *et al*., 2000). For example, *Mastomys* species have been reported to be exceptionally fecund (Kingdon, 1997). Rodents, such as rats are extremely prolific, breeding 1 to 13 times a year and producing 1 to 22 young in a litter. These rodents multiply so rapidly that a pair could have more than 15,000 descendants in a year's life span (Canby, 1997).

Many environmental factors have effects on the timing of reproduction in rodents (Happold and Happold, 1989).Vaughan *et al*. (2000) indicated that temperature, energy and nutrition are probably of prime importance. Afework Bekele and Leirs (1997) showed that extended rainy season results in high litter size, which leads to an increase in population size. Thus, the correlation between rainfall and the seasonality of reproduction for most of the small mammals in Africa has gained acceptance (Tadesse Habtamu and Afework Bekele, 2008). Although breeding often appears to reach a peak during the latter part of the rainy season, continuous breeding occurs in irrigated lands (Taylor and Green, 1976). Several species in the tropics and subtropics do not show seasonal breeding. *Acomys* sp., *Otomys* sp., *Taterillus gracilis* and *Arvicanthis* sp. breed continuously during some seasonal situations (Delany, 1986). *Arvicanthis* sp. is obviously highly adaptable being both a seasonal and an aseasonal breeder and the same is true of *Otomys* sp. as suggested by Delany (1986). *Lophuromys flavopunctatus* and *Mus minutoides* breed in almost every season (Delany, 1964).

In general, climatic conditions and possible changes in food availability trigger reproduction in most African rodents (Cheeseman and Delany, 1979). Full reproductive activity in the Nile rat (*Arvicanthis niloticus*) reaches only when the nutritive environment is adequate and complete, while sterility might be caused by the restriction of food intake, either in a quantitative or qualitative manner (Ghobrial and Hodieb, 1982). According to Taylor and Green (1976), *Rhabdomys pumilio* breed when cereals are plentiful but is also found breeding when its diet is mainly clover (noted for its high crude protein content).

Similarly, Rabiu and Fisher (1989) suggested that increase in the proportion of high protein foods (animals and seed matter) in the diet as the rainy season progresses is presumably of importance in maintaining reproduction in *Arvicanthis* sp. in northern Nigeria.

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

2.3. Feeding ecology of rodents

The diets of rodents are diverse. Rodents consume all sorts of plant material; primarily seeds, but also stems, fruits, flowers and roots. They also consume insects and other invertebrates (Nowak, 1999). There tend to be specialized structures depending on their feeding habits. Herbivores have broad incisors, mill-like grinding teeth and a stout skull, while insectivores tend to have sharp-cusped molars and a slender muzzle; and omnivores tend to be intermediate (Kingdon, 1997). Rodents show a variety of feeding patterns. Food is one of the most important dimensions of niche and therefore information about diet is a major component of ecological research. Diet is extremely significant for determining day to day activity, evolution, life history strategies and ecological role of rodents niche (Krebs, 1998).

Generally, many rodents are opportunistic feeders, and capable of changing their feeding habits depending on the availability of food from season to season (Happold, 2001).

Their behavioural traits make them the most distructive pest of cultivated plants (Workneh Gebreselassie *et al*., 2004). In the wild, brown rats eat snails, insects, crustaceans and freshwater shellfish. Commensal rats *(Rattus norvegicus* and *Rattus rattus*) utilize garbage for food and rubbish piles for shelter (Schroder and Hulse, 1979). *Mastomys* feeds mainly on seeds and also eats certain insects such as termites and other vertebrates (Taylor and Green, 1976). As stated by Macdonald (1984), the Australian water rat feeds on small fish, frogs and mollusks, and seldom eats plant material. Mice are omnivorous. They eat anything that can be digested but their favorite foods are cereals and cereal products. Mole rats are specialized on roots and tubers (Sidorowicz, 1974). Deer mice (*Peromyscus* sp.) have an omnivorous foraging strategy, while montane voles (*Microtus sp.* is granivorous) (Stanbury, 1972). Rodents can master simple tasks for obtaining food. They can be readily conditioned, and easily trained to avoid fast-acting poisoned baits (Macdonald, 1984). This enables them to try out quickly new potential source of food in the face of new environmental conditions. The fact of their success is that rodents have a very wide ranging diet.

2.4. Rodents as pests

Rodents are among the most noxious pests of agriculture (Singleton *et al.*, 2003). Rodent pests are a worldwide problem, and are responsible for considerable damage to crops, stored cereals and food and human properties (Jacob *et al*., 2003). They threaten food production and thereby lower food security for the poor. Thus, farming families, living in or near poverty and nutritional catastrophe, suffer a double loss of their crop (both before and after harvest). They damage and destroy 30% of the crops in both pre-harvest and post-harvest conditions (Singleton, 2001).Geddes (1992) indicated that rodent pests are the most important pre-harvest pests, causing annual losses of 17% in rice in Indonesia. The overall loss of food grain to rodent pests - in India was approximately 25% in pre-harvest and 25-30% in post- harvest situations (Hart, 2001). Singleton *et al.* (2003) indicated, in Asia alone, the amount of grain consumed by rodents in rice fields each year would provide enough to feed 200 million Asians for a year, with rice providing 50-60% of their daily caloric intake. For example, annual loss due to rodents in rice production is between 2-5% in Malaysia (Singleton and Peach, 1994), >10-20% in China (Qinchuan *et al*, 2003), 6-7% in Thailand and > 10% in Vietnam (Bonsong *et al*., 1999).

In Africa, especially in those countries that live far below the poverty line, rodent pests are partially responsible for food insecurity. It is painful to note that with increased exports of agricultural products, reduced food availability can have grave consequences for the poor. Thus, rodent pests play a significant role in influencing food security and poverty alleviation programs for the rural poor (Singleton *et al.,* 2003). For instance, in Tanzania, rodents cause about 15% loss to maize (Makundi *et al.*, 1991). Earlier reports indicated 20-30% damage to maize crops and a 34-100% loss during rodent out breaks in Kenya (Taylor, 1968). Recently, Odhiambo and Oguge (2003) reported that serious outbreaks of rodents cause serious damage and loss on maize up to 90% in Kenya. It has been estimated that rodents consume or destroy up to 20% of the cereal crops in Ethiopia (Goodyear, 1976). Afework Bekele *et al.* (2003) have estimated that rodent related damage in maize farm in Ziwuay to be 26%. As Makundi *et al.* (2005) indicated in Ethiopia, crop damages by rodents are common. Maize is the most affected crop in Ethiopia in addition to'enset' and potatoes. Thus, rodent pests are adversely affecting the economy of the country.

In sub-Saharan Africa, the major rodent species causing severe damage to crops belong to the Genus *Mastomys* (Muridae). They occur all over the continent in natural grasslands, cultivated areas and human habitats. Recurrent outbreaks of the Nile rat (*Arvicanthis niloticus*) and the multimammate rat (*Mastomys natalensis)* have revealed that weather has a distinct influence on occurrence of mass appearance of rodents. Population explosions happen at irregular intervals and crop losses of over 50% have been recorded during such outbreaks in Kenya (Leirs *et al.*, 1996). Therefore, population dynamics of rodent population is essential to forecast the probability of outbreak of rodent populations within the year.

Limited numbers of rodents cause problems in agriculture (Leirs, 2003). In Africa, for example, out of the 406 species of rodents, only 77 species have been reported to cause damage to agriculture. Fiedler (1988) reported that in Australia only 7 out of 67; in Europe only 16 out of 61; in India only 18 out of 128 and in Indonesia, only 25 out of 164 species are clearly identified as pests. Similarly, in Ethiopia, Afework Bekele and Leirs (1997) have reported that 11 out of 84 species of rodents were identified as major and minor agricultural pests. According to Demeke Datiko *et al.* (2007) and Workneh Gebreselassie *et al.* (2006), the most important pest rodents in Ethiopia are *Mastomys erythroleucus, M. natalensis, Arvicanthis dembeensis* and *Mus musculus.*

In cereal crops in African savanna regions, most damage occurs during the sensitive young seedling stage and just before harvest (Fiedler, 1994). Rodent damage may even necessitate late replanting, resulting in lower yields. Although efficient techniques exist to kill rodents, none of the traditional methods have been able to control populations over the long term (Singleton *et al*., 1999). Methods with immediate effect may be more effective in order to protect the crop during sensitive stages, but only if applied before damage is made (Workneh Gebresilassie *et al*., 2004). Another risk that rodents pose is disease. A number of rodents are carriers of human disease such as typhus, salmonella, bubonic plague and hanta fever (Menhhorst, 1996). Mice and rats can carry leptospiral jaundice (Weil's disease) in their urine and droppings as they contaminate food and kitchen equipment. Beside spreading disease, they also bring parasites such as fleas, mites and lice to humans (Kingdon, 1997), particularly those rodents living inside homes (Mohebali *et al.*, 1998).

Sewnet Mengistu and Afework Bekele (2003) indicated that rodents damage irrigation canals and divert the direction of water flow. Mice and rats have also been known to gnaw and damage the carryings of electrical wires, pipes and furnitures (Stanbury, 1972). Considering all this, there is a pressing need for effective in-field rodent management program. Thus, for feasible rodent pest control and management activities in any given habitat, scientific knowledge of rodent ecology, population dynamics, habitat association and distribution are mandatory.

2.5 .Rodent pest management strategies

Rodent management strategies are clearly dependent on the population dynamics of the targeted species. The objective of rodent management will normally be to lower the long–term equilibrium around which population size fluctuates. Leirs *et al*. (1996) suggested that some species may have relatively high average population sizes and consequently cause considerable damage every year, but also show irregular outbreaks. Some rodent species will be very sensitive to changes to crop varieties, land-use and field management patterns, while others will be affected only marginally. Given due to the diversity between rodent pest and the agro ecosystems where they occur, a number of management strategies have been designed in the past(Gratz, 1997). Some of the rodent management strategies in East Africa include rodenticides, bio-control with predators, and shift of agro-forestry pattern, fertility control and traditional farm storage systems. As suggested by various agencies, Integrated Pest Management (IPM) may have a major role to play in the context of rodent pests in East Africa (Stenseth *et al*., 2001).

For centuries, rodents have been a problem for humans. They have found human civilization to be ideal environments for sources of food, shelter, and for transportation to new territories, and even to continents. This has been responsible for rodent pest outbreaks in urban, agricultural, and other environments throughout the world (Gratz, 1997). Historically, vertebrate pest problems have not received as much attention as other agricultural pests. Public health problems and the economic aspects of rodent infestations have, in many instances, overshadowed the pest status associated with rodents (Krebs, 1999). However, due to the diversity between rodent pest and the agro ecosystems where they occur, a number of management strategies have been designed in the past (Gratz, 1997). Most of them have been successful under specific conditions and this has encouraged people to try to apply them elsewhere in very different ecosystems. However, none of them is a panacea. The people who designed those methods are well aware of this fact. But policy makers do not always appreciate the details that make a strategy useful in one area but not necessarily elsewhere (Makundi *et al*., 1999). In the past, humans have used various rodent pest management strategies to reduce the problems that rodents cause. Some of the methods used were burning vegetation around, trapping and poisoning as well.

The primary aim of rodent pest management is to reduce rodent population at or below economically and culturally acceptable levels rather than to eradicate them (Adler *et al*., 1996). The principles of efficient rodent control have been established over the last fifty years with the advances in knowledge of the biology of the pest, the continual development of improved rodenticide formulation, and methods of application and increasing appreciation of the management procedure (Kotler, 1984). Moreover, as Rao (1992) suggested, the benefits of nonchemical methods of rodent control are increasingly recognized. However, lethal chemical agents are presently the main stay of all practical rodent control programs both in the urban and agricultural environments and this situation is expected to remain for long. The reasons for this are the great strides towards the increased safety of rodenticides with the introduction of anticoagulants.

2.5.1. Biological control

Biological control is the means of reducing rodent pests with predators. It is an effective method for rodent control (Chambers *et al*., 1999). But as Chambers *et al. (*1997) revealed, the use of animals such as cats, dogs and snakes are ineffective for the economic control of field rodents. Instead, the other form of biological control (killing) through the introduction of diseases is a relatively alternative solution, although there is a general concern that these diseases may be spread to humans and domestic animals unless maximum precautions are practiced. Moreover, there are also other biological control methods, involving altering rodent fertility, use of immunosterilants delivered by a virus vector. However, the success and side-effects on humans, domestic animals and other non-target and beneficial organisms of this interesting approach is yet to be fully evaluated and determined (Leirs, 1999).

According to Singleton *et al*. (1999), biological control method is founded on two ecological principles: 1) organisms can be used to control another and 2) some control organisms have a limited host range. Host range generally refers to the set of species on which a control organism can feed and develop. The safe and effective use of biological control requires assessment of the ability of the control organisms to harm non-target organisms, to survive, to reproduce, to disperse, and to evolve. Ideally, biological control represents a pest control technology that is effective, environmentally safe and self-sustaining with minimal need for repeated interventions. However, some of the characteristics that make biological control organisms effective in controlling rodent pests also make them potentially dangerous invaders (Rajab *et al*., 2003).

In biological control, host specificity tests typically measure the potential of the control organism to complete its life cycle on the target organism and also on the non-target organisms that it consumes (Smith and Buckle, 1994). Although such host specificity tests are necessary to estimate the probability and severity of target and non-target effects, at present they are far from sufficient. Because a control organism may harm a non-target one in several ways such as direct trophic interaction, direct interference competition and indirect interactions that may arise when the control organism and the non-target organisms interact via intermediate species. Therefore, there should be a critical thinking before applying this control method to rescue the non-target species from total extermination.

2.5.2. Chemical control

Currently, chemical control is the primary method for managing rodents (Buckle, 1994). But as Fiedler (1994) reported, in developed countries the use of chemicals raises a number of concerns such as the risk to non target species, the humaneness of its action, high usage patterns, conflict with marketing and low efficacy of action when high quality food is available. In developing countries, these issues also apply with the additional concerns of affordability, quality control of products and correct usage patterns.

Rodenticides are chemicals that are used to kill rodents and the most commonly used control measure for rodent pests. The requirements by which to judge the potential of a compound to act as an effective rodenticide should depend on its efficacy and safety (Buckle, 1994). The efficacy of a rodenticide is determined by several factors. Among these, toxicity to target rodents is one of the prerequisites of a rodenticide. Furthermore, rodenticides can be more useful if they are potent to a wide range of target species and are equally effective against all individuals regardless of sex, age and strain (Ferguson, 1980). On the other hand, specificity to rodents is one of the safety requirements of a rodenticide that is highly desirable.

Rodents are the prey base of predators in many ecosystems. Due to this fact, they may expose their predators to rodenticides if the predators preyed upon either poisoned rodents or scavenge their dead bodies. Therefore, compounds that are rapidly broken down in the bodies of rodents and that are not secondarily toxic are desirable (Savarie, 1991). In addition, as explained by Delai (1997), the need to use rodenticides near man and domestic animals because of the pests' commensal nature, leads to accidental exposure of non-target animals to rodenticides. Thus, the availability of a specific antidote is of great importance. A slow mode of action is also highly beneficial on these occasions so that sufficient time is available to recognize the symptoms of poisoning and administer the antidote, in case human beings and domestic animals are accidentally exposed to such a situation.

There are different types of rodenticides. The majority of rodenticides are administered as poisoned baits, although some compounds are available in forms such as liquid, contact dust, and poisonous gas (Smith *et al*., 2002). They are classified into two major categories: acute (fast acting) rodenticides and anticoagulants (relatively slow acting). But more recently, the development of several rodenticides that are in some respects intermediate has resulted in the third group, sub-acute rodenticides.

Acute rodenticides are fast in action. The onset of toxicity is rapid after an effective dose has been ingested. Generally, symptoms appear in less than 24 hours and with some compounds even in minutes (Meehan, 1984). However, rodents may repel to eat the poisoned bait, eventually. Therefore, these rodenticides may not be as effective as anticoagulants. Moreover, due to their effects on non-target animals, there are limitations in their usage in most countries. Hence, acute rodenticides can be applied only by professionals. Often, their use is further restricted to premises, which can be locked or to locations such as warehouses, sewers, and ships inaccessible to the public (Palazoglu *et al*., 1998). Zinc Phosphide, Sodium Fluoro acetate, Fluoroacetamide, Alphachloralose, Thallium Sulphate, and Red Squill are some commonly used acute rodenticides.

The sub acute rodenticides have more or less similar characteristics with acute rodenticides except in some aspects. When these rodenticides are applied, rodents may take lethal dose of these compounds during the first 24 hours, but repeated feeding may occur and death is normally delayed for several days (Eason *et al*., 1999). Calciferol, Bromethalin and Flupropadine compounds are sub acute rodenticides.

Anticoagulants are rodenticides, which have slow mode of action as compared to the acute ones. They reduce the clotting abilities of the blood and cause death as a result of hemorrhage. This anticoagulant effect is brought about indirectly by the rodenticide interfering with the function of vitamin K in the liver, which is responsible for the synthesis of blood clotting factors, 'prothrombin complex'. The effect of these rodenticides generally takes 4-10 days. This delay prevents rodents from associating the symptoms of toxicosis with the anticoagulant that has caused it and, therefore, bait shyness is unknown (Mount *et al*., 1986). There are two groups of anticoagulants: first generation anticoagulants, and second generation anticoagulants. The former include compounds developed as rodenticides prior to 1965 (Buckle, 1994). The latter was developed for the control of commensal rodents in areas where they had become resistant to the first generation anticoagulants.

2.5.3. Ecological based rodent management

Ecological based management of rodent pests is aimed at combining basic and applied research on rodents through focusing on the population ecology of rodents and developing management actions directed at the agro-ecosystem level. It is a concept that was developed in developing countries since the late1990s (Krebs, 1999). According to Leirs (1999), this concept is appealing because it promotes actions that facilitate sustainable agriculture and has minimum environmental impacts. However, to apply this management technique effectively, it requires a good understanding of the basic ecology of individual rodent species. This in turn, is dependent on access to field methodology that enables to understand the population dynamics and field ecology of rodents (Aplin *et al.*, 2003).

High emphasis on ecological-based rodent management has emerged in recent years both in developed and developing countries (Belmain *et al.*, 2003). In agricultural areas where rodents cause significant impacts, control activities over the past 25 years tended to focus on choice of rodenticides and its carrier, structure and placement of bait stations, and genetic and behavioural resistance to rodenticides (Quy *et al.*, 2003). The concept of ecological-based rodent management was developed as a formal description of the sound ecological basis required for developing management strategies for rodent pests (Singleton *et al.*, 1999).

Chambers *et al*. (1999) explained that this method is based on the sound knowledge of farming systems and natural factors, such as the availability of food and shelter that contribute to the limitation of rodent pest populations. For these reasons, modification of habitats to minimize the availability of food and shelter for rodents by controlling the growth of grasses and synchronizing planting and harvesting are important. The process of developing effective, ecological based rodent management is a learning cycle that involves phases of observation, formulation and testing of hypotheses, and further observations or experimentation; with each round of activities leading to a better understanding is important (Belmain *et al.*, 2003). But, despite the nature of the learning process, it is useful to distinguish the three distinct phases in any investigation of rodent problems. These phases are defining the problem clearly, detailed ecological and historical studies and designing and testing management options (Leung, 1998).

Studies in southeast Asia highlighted that ecological based rodent management provides increased yields, lowers rodent population, reduces use of toxic rodenticides, decreases rodent control costs, improves health conditions of the rural poor and provides an impetus for a more cohesive interaction among community members (Singlton *et al*., 2003; Palis *et al*., 2004). In recent years, applied research on ecological based rodent management has taken place in many countries throughout Asia and Africa, involving a number of research and extension institutions working together in collaboration with farming communities to develop effective, sustainable, environmentally safe and cost-effective rodent management strategies (Belmain, 2007). Various studies have also been carried out in East Africa to establish the relationship between ecological parameters and rodent population dynamics (Afework Bekele and Leirs, 1997).

3. Materials and Methods

3.1. Location of the study area

The present study was conducted in Shashogo District, Hadiya Zone, South Ethiopia, which is located about 284 km southeast of Addis Ababa. The area is situated between latitudes 7°3′19″-7°56′1″N and 37°33′14″-38°52′12″ E longitudes. The District covers a total area of 32,310 ha (Fig.1). With a total population of 116,287 people (CSA, 2007), Shashogo District is one of the densely populated Districts in Hadiya Zone. The District has a total of 36 Kebeles, and Shamesamise is the Kebele where the study site is located.

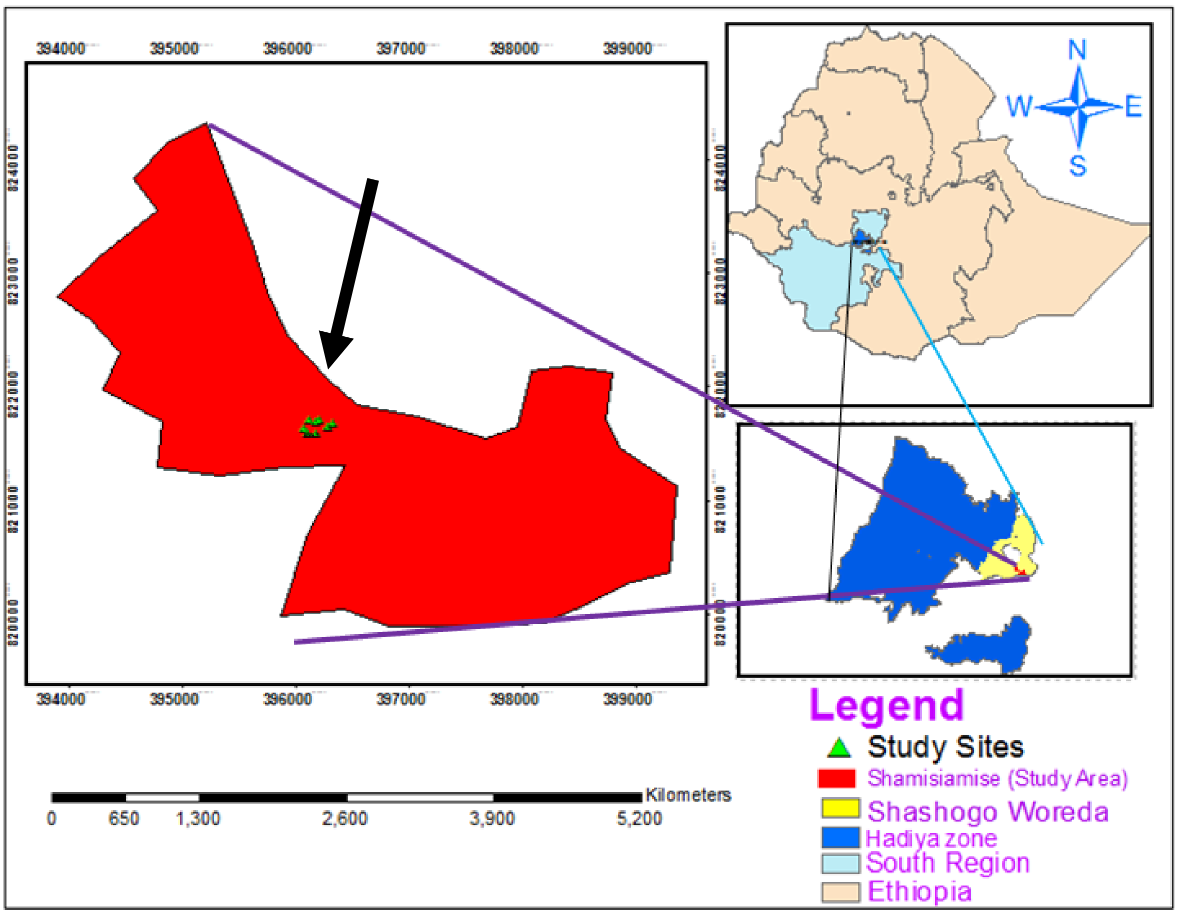

Figure 1. Map of the study area.

3.1.1. Climate

There is no meteorological station in the study site. The rainfall and temperature data collected by Ethiopian National Meteorological Agency (NMA) at Alaba Kulito Station, which is located about 20 km southeast of the study site, was used to describe the climate of the study area.

The rainfall in the study area has a bimodal nature in which the months from March to May and June to September are marked by relatively higher rainfall records; while months from November to February are dry. The long rainy season in the area is between March to September, during this season crop cultivation is practiced in this area. The average monthly rainfall of the study area ranges from 2002 to 2012. The total annual rainfall is 1005.1 mm (Fig. 2).

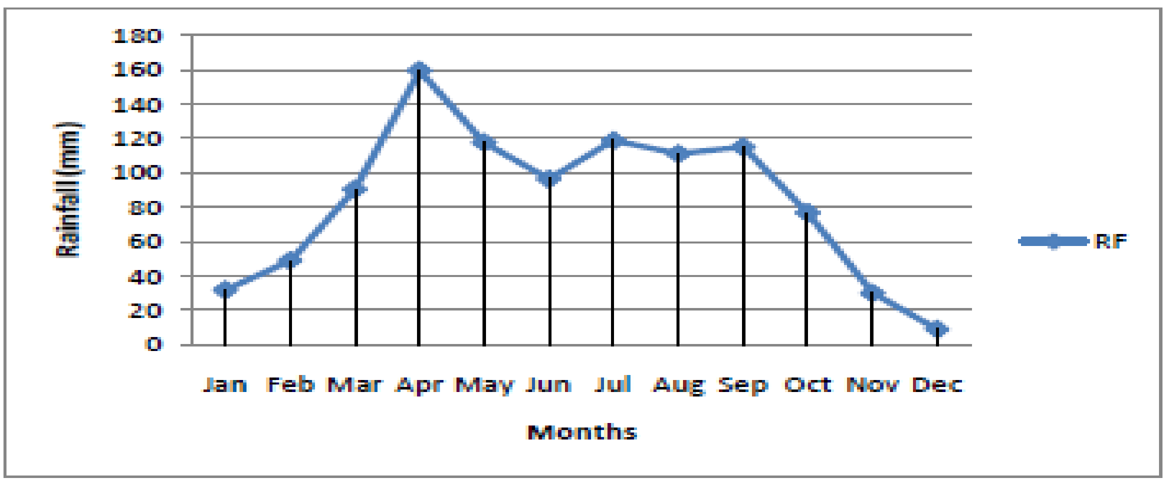

Figure 2. Mean monthly rainfall of the study area (2002-2012) (Source; ENMA, 2013).

Figure 2 shows temperature of the study area between 2002 and 2012. The highest mean maximum monthly temperature was generally observed during the dry season. The mean maximum and minimum temperature during February and July was 21.6 ^{o}C and 18.5 ^{o}C respectively.

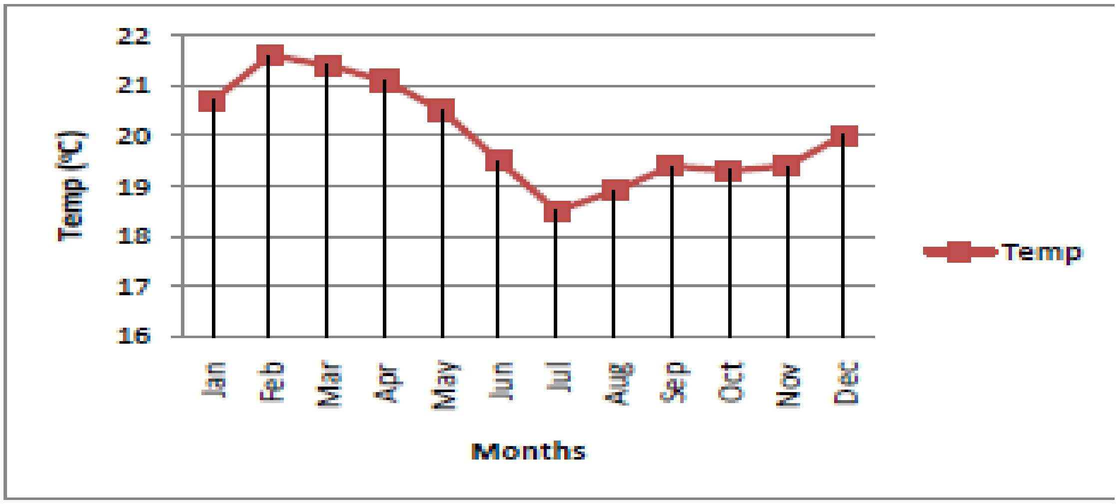

Figure 3. Mean monthly temperature of the study area (2002-2012) (Source; ENMA, 2013).

3.1.2. Topography

The altitude of the study area ranges from 1876 to 2257 m.a.s.l. in terms of topography. The District has suitable land for agriculture. Flood is a serious problem in the flat topography areas. According to FAO classification system, the most dominant soil in the area is Vitric andosol covering the whole District (UNDP/FAO, 1984). The District has four rivers; Bilate, Guder, Metenchose, and Meranche. All rivers (except, Bilate) are seasonal. Bilate is a perennial river, even though the volume of water decreases substantially during the dry season. Recent studies have indicated that the water table of the Shashogo District is shallow. Boyo swamp is also found in this area and it covers an area about 3,210 hectares.

3.1.3. Natural vegetation

The commonly remnant tree species observed in the area are *Acacia* species, *Cordia africana*, and *Eucalyptus* species. These tree species are observed throughout the District mostly scattered in the cultivated landscape. Because of long history of agriculture and high population in the area, vegetation cover is very low. Consequently, erosion problems on the steep slope areas are enormous. Huge gullies are observed towards the southern end of the District and around Bilate River, where soils are totally removed beyond recovery.

3.1.4. Agriculture

In the study area agriculture is the dominant economic activity, which includes crop farming and livestock rearing. Cropping patterns in the area follow rainfall. Maize, teff, wheat, pepper, haricot bean, sorghum and millet are the dominant crops with regard to area coverage. Other than these crops, many other crops are also grown, but economically less important. Maize is grown in more than 50% of the cultivable land in the District, while all other crops account for the remaining 50% of the area. Pepper is the main cash crop in the area. Shashogo District being one of the commonly drought affected areas in SNNPR, livestock rearing is poor. Grazing lands are converted into farmlands due to human population pressure, and hence crop residues are important feed resources.

3.2. Materials

Materials used during the present study were: Snap-traps, bait (peanut butter and maize flour), spring balance, ruler, dissecting kit, digital camera, GPS, field guides, data sheets, 0.25 mm sieve, gloves and glass slides. Compound microscope was used for stomach content identification and 5-10% formalin was used as preservatives.

3.2.1. Preliminary Survey

Before starting the main research work, preliminary survey about the study area was conducted during February, 2013. During this survey, all the available and 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 gathered and selection of the study habitats was made. Based on the information gathered during the preliminary survey, continuous field work on ecological study of rodents in the study area was carried out. The total area of the study area was classified into farmland and grassland habitat types.

Based on the preliminary survey of the study area, different habitat types were identified as farmlands (Maize farm, teff and wheat) and grassland habitats. The study sites were selected randomly from each habitat type. Samples were selected randomly based on representation of the main rodent species in the grassland and farmland (Maize farm, teff and wheat). Of the 36 Kebeles in the District, one Kebele which contained farmland and grassland habitat and samples were selected purposively using systematic survey methods. Selected habitats for the study area are indicted in plates 1, 2 and 3.

Plate 1. Grassland habitat (Photo by: Mulugeta Kassa, 2013).

Plate 2. Post harvest maize farmland habitat (Photo by: Mulugeta Kassa, 2013).

Plate 3. Maize farmland habitat (Photo by: Mulugeta Kassa, 2013).

3.2.2. Sampling of rodents

Rodents were trapped using rat- traps. Based on the habitat type and topography 25 rat traps were used to collect rodent species at 20 meter interval 13 and 12 rat-traps were used both in farm and grassland habitats respectively. All of the rat-traps were baited with a mixture of peanut butter and maize flour and checked twice a day early in the morning and late afternoon hours for three consecutive days and nights every month. These traps were placed in areas where frequently rats and droppings of rats were observed. That means the traps were placed in the rodent pest's runway and burrow openings, in order to catch more rodents. The trapped rodents were examined soon after removed from the traps, body measurements like head-body length, tail length, hind foot length, and ear length as well as the number of mammae and number of embryo from pregnant females were recorded. Dissection of all snap-trapped rodents was carried out for stomach content analysis and to check the internal reproductive conditions.

Standard body measurements;- were taken after snap traps collection of the rodent pests. The collected rodents' body weight was measured by using a calibrated spring balance (a Pesola spring balance). Before starting to weigh the rodent pests the spring balance were calibrated to zero in each session of balance. Then the balanced weights were recorded according to the procedure (Kirsten, 2009).

Head- body length;- was measured by using standard ruler. Before measuring the length, the rodent pests were made to be a straight line along the animal's vertebral column, the measurement were taken from the tip of the nose to the middle of the anus. Then the measured head- body length were recorded following (Kirsten, 2009). Tail length;- was measured in a straight line along from the middle of the anus to the tip of the tail. The tail length measurement was taken without suspending the animal or rodent pests (Aplin *et al*., 2003). Pes length (hind-foot);- was measured from the heel to the tip of the central (longest) toe, but without including the claw. Ear length;-was measured from the bottom of the notch of the ear to the furthest point along the rim. The measurement was not taken if the margin of the ear was damaged as a result of fighting. All measured values were recorded according to standard procedures of (Kirsten, 2009).

For species identification, distinguishing taxonomic keys developed by Yalden *et al.* (1976); Afework Bekele *et al.* (1993), Afework Bekele (1996a) and Nowak (1999) were used. Rodent species are most often distinguished/ identified on the basis of morphological characteristics, such as differences in body size and shape as well as fur texture and colour (Aplin *et al*., 2003). Standard Key was used to identify small mammals (rodents), and especially problem rodents, found in farmland and grassland areas (Kirsten, 2009).

Reproductive conditions were determined based on both external and internal body features. The reproductive conditions in males were identified by the position of testicles (scrotal or abdominal) and the size of the testicles. The reproductive conditions of the females (closed or perforated vagina, pregnant or non-pregnant and lactating and non-lactating) were identified by their enlarged nipples, large swollen abdomen and high body weight (Aplin *et al*., 2003). In addition to the above, each of this trapped specimens were examined for sex, the age structure (juvenile or young ,sub-adult and adult) based on their weight and morphology (pelage colour) following Afework Bekele (1996a) and body measurements were taken from the snap trapped rodents. 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. 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.

Diet of stomach contents in snap trapped rodents were analyzed following the methods of Campos *et al.* (2001) and Workneh Gebresilassie *et al*. (2004). The trapped rodents were removed from the trap, identified and records on date, location, sex; sexual conditions and approximate age, weight, code number (type of species) and habitat type, were recorded. From the total snap-trapped rodents some representative individuals of rodent species were dissected for stomach content analysis from each habitat and season or months. The stomach was removed and preserved in individual containers in 5-10% formalin solution, until further microscopic examination. All stomach contents were brought to Zoological Sciences Unit Laboratory of Jimma University for microscopic examination of the diets.

The stomach contents were kept in open air for 24 hours to dry and weighed by using digital balance. 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. For each sample, four glass slides were prepared and observed using compound light microscope to identify the type as well as the proportion of the diet. The food items were grouped into plant matter (leaves, stems, roots, and seed) and animal matter (arthropods) and unknown materials. To quantify the food items (counting the fragments) of the stomach samples, a microscope at 40X magnification was used for all samples. Each food fragment was counted from the entire slide, summed up and converted to the mean percentage for each sample.

3.2.3. Data Analysis

Data analyzed were carried out using SPSS Version (16.0) computer program, T- test and one way ANOVA.T- test was used to compared variation in sex ratio, habitat types, reproductive condition and one way ANOVA was also used to compared age-class distribution and body measurements among species of rodents and months.

4. Results

4.1. Relative abundance of rodent species

Overall three species *Arvicanthis dembeensis, Mastomys erythroleucus* and *Rattus rattus* were recorded in the study area. The relative abundance of *A.dembeensis, M. erythroleucus* and *R. rattus* was 38.7%, 23.6% and 37.7%, respectively. *A.dembeensis* was the most abundant species followed by *R. rattus* and *M.erythroleucus*. The trapped rodent species and their abundance are shown in Table 1.

Table 1. Relative abundance of rodents in the study area

Species	Total capture	Relative abundance (%)
A.dembeensis	41	38.7
M.erythroleucus	25	23.6
R. rattus	40	37.7
Total (3)	106	100

4.2. Species composition and distribution of rodents

In the present study, a total of three species of rodents were recorded from farmland and grassland area. From the total of 450 trap nights, 106 rodents were captured by snap-traps. The three trapped rodent species during this study were:-*Arvicanthis dembeensis, Mastomys erythroleucus* and *Rattus rattus* are belonging to family Muridae. Both *Arvicanthis dembeensis* and *Mastomys erythroleucus* were commonly found in the farmland and grassland area but *Rattus rattus* was restricted to the farmland only (Table 2).

Table 2. Species composition of snap trapped rodents.

Species	No of individuals snap-trapped in each habitat		
	Farmland	Grassland	Total
A.dembeensis	12	29	41
M.erythroleucus	14	11	25
R. rattus	40	-	40
Total	66	40	106

Two rodent species were trapped in the month of March, April and May while all the three rodent species were trapped in the month of June, July and August, but *R. rattus* not trapped from March to May (Table 3).

Table 3. Monthly variation of rodents from farmland and grassland habitats

	Habitat type with species in each month						
	Farmland			Grassland			
Months	*A. dembeensis*	*M. erythroleucus*	*R. rattus*	*A. dembeensis*	*M. erythroleucus*	*R. rattus*	Total
March	3	-	-	8	1	-	12
April	3	1	-	7	2	-	13
May	2	1	-	5	2	-	10
June	2	5	10	4	3	-	24
July	1	4	15	3	2	-	25
August	1	3	15	2	1	-	22
Total	12	14	40	29	11	-	106

4.3. Monthly variation and sex ratio

A total of three rodent species were trapped from June to August and two during March to May trappings. *R. rattus* was captured during the June to August months but not trapped during the March to May months. The overall number of species between months were statistically significant ($P<0.05$). The total number of individuals captured in June, July and August was more than the total individuals during March to May. Out of the total 106 rodents trapped during all trapping sessions, females comprised 42 (39.6%) and males 64 (60.4%). However, the difference in the sex ratio was not statistically significant ($P>0.05$) (Table 4).

Table 4. Monthly variation and sex distribution of different species of snap- trapped rodents

Months	*A. dembeensis*		*M. erythroleucus*		*R. rattus*		Total
	M	F	M	F	M	F	
March	9	1	1	1	-	-	12
April	8	1	1	1	-	-	11
May	7	2	1	2	-	-	12
June	4	3	5	4	6	5	27
July	2	2	3	2	7	7	23
August	1	1	2	2	7	8	21
Total	31	10	13	12	20	20	106

(M=male, F=female)

4.4. Age-class distribution

Out of the total 106 individuals of snap trapped rodents, juveniles comprised 16.98%, sub-adults 35.8% and adults 47.1% respectively. From June to August, juveniles comprised 17 (16.0%), sub-adults 26 (24.53%) and adults 27 (25.5%), whereas during March to May juveniles comprised 1 (0.94%), sub-adults 12 (11.3%) and adults 23 (21.69%). More number of adults, sub adults and juveniles were captured during June to August than during March to May months. There was a significant variation among the three age classes of rodents during different trapping sessions ($P<0.05$). Juveniles of *M. erythroleucus* species were recorded in all months. However, juveniles of *R. rattus*, species were trapped only during June to August but, juveniles of *A. dembeensis* species were not trapped in all months. Variation in the number of juveniles captured among months was statistically significant ($P<0.05$). The difference in the total capture of juveniles during the different trapping sessions also varied significantly ($P<0.05$) (Table 5).

Table 5. Age-class distribution of snap- trapped rodents

Months	Species with their different age groups									Total
	A. dembeensis			*M. erythroleucus*			*R. rattus*			
	Juvenile	sub adult	Adult	Juvenile	sub adult	Adult	Juvenile	sub adult	Adult	
March	-	3	7	-	-	1	-	-	-	11
April	-	4	6	-	1	1	-	-	-	12
May	-	3	5	1	1	2	-	-	-	12
June	-	1	5	2	2	2	3	5	5	25
July	-	1	4	2	2	2	3	6	4	24
August	-	-	2	3	2	1	4	7	3	22
Total	-	12	29	8	8	9	10	18	12	106

Rodent catch and trap success in the study months in each habitat are given in (Table 6). Mean trap success during June to August and March to May months was 35.5% and 11.24 %, respectively. High number of rodents was captured during June to August from farmland with 47.9% trap success, and the lowest trap success was also recorded in farmland during March to May with trap success of 8.6%. The difference in the total number of capture and trap success was significant between habitat types and months ($P<0.05$).

Table 6. Monthly trap success of rodents from the two habitat types

Months	Habitat types					
	Farmland			Grassland		
	Trap nights	Total catch	Trap success (%)	Trap nights	Total catch	Trap success (%)
March	39	2	5.13	36	4	11.1
April	39	4	10.3	36	5	13.9
May	39	4	10.3	36	6	16.7
June	39	22	56.4	36	10	27.8
July	39	18	46.2	36	10	27.8
August	39	16	41.0	36	5	13.9

4.5. Body measurements

The body weight and measurements of head to body length, tail length, hind foot length and ear length of three species of snap trapped rodents are given in (Table 7). The mean body weight in *A. dembensis* with *M.erythroleucus* and *R. rattus* among species were statistically significant ($P<0.05$) but not statistically significant difference in *M.erythroleucus* and *R. rattus* ($P>0.05$). However, there was significant difference in the external body measurements among species ($P<0.05$).

Table 7. Body weight (g) and measurements (mm) (mean±standard deviation) of snap-trapped rodents.

		Body measurements				
Species	No.	BW	HB	TL	HF	ER
A. dembensis	41	123.1±23.7	151.8±157.3	136.5±11.1	37.7±3	27.7±3.05
M.erythroleucus	25	59.8±30.8	112.6±31.3	114.4±42.8	31.7±6.5	25.2±5.3
R. rattus	40	63.9±34.9	137.6±26.1	157.8±33.3	37.5±3.6	28.6±2.3
	-	-	-	-	-	-

(BW = body weight, HB = head + body length, TL= tail length, HF= hind foot length, EL=ear length).

4.6. Reproductive condition

The number of pregnant female rodents and embryos recorded for each species from March to August are given in (Table 8). A total of 8 pregnant female rodents of three species were captured by snap-tapping. The number of embryos of pregnant females varied within species and among months in the same species. The highest number of embryos was recorded from *M. erythroleucus* (8-10) and the least from *A. dembeensis* (5-7). More number of embryos was recorded in *M. erythroleucus* during June to August. The number of embryos in the left and right uterine horn varied within species.

Table 8. Number of pregnant females and embryos recorded from snap- trapped rodents from March to August months.

	Species					
	A. dembensis		*M. erythroleucus*		*R. rattus*	
Months	No. of Pregnant	No. of embryos	No. of Pregnant	No. of embryos	No. of Pregnant	No. of embryos
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	-	-	1	6	-	-
June	1	5	1	8	-	-
July	1	7	1	8	1	7
August	-	-	1	10	1	9
Total	2	12	4	32	2	16

Out of the total females trapped, 32 (76.2%) were perforated. Among the perforated ones, 9 (21.4%) were sub-adults, 5 (11.9%) were non pregnant adults, 10 (23.8%) were pregnant and 8 (19.0%) were lactating. The abundance of breeding females during June to August and March to May was 16 (38.09%) and 2(4.77%), respectively. There was significant variation in the abundance among months ($P< 0.05$). Relatively more breeding females of *A.dembeensis* and *M.erythroleucus* were captured during June to August. There were no breeding individuals of *R.rattus* during March to May (Table 9).

Table 9. Reproductive status of females trapped from March to August months.

Months	*A.dembeensis*					*M. erythroleucus*					*R. rattus*					Total
	Yo	Sa	Nb	Pr	La	Yo	Sa	Nb	Pr	La	Yo	Sa	Nb	Pr	La	
March	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	2
April	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	2
May	-	1	-	1	-	1	-	-	1	-	-	-	-	-	-	4
June	-	1	-	1	-	1	-	-	1	-	1	1	1	-	1	8
July	-	1	-	1	1	1	1	-	1	1	2	1	1	1	1	13
August	-	-	-	-	1	1	-	-	2	1	3	2	-	1	2	13
Total	-	4	1	3	2	4	1	2	5	2	6	4	2	2	4	42

(Yo = young, Sa = sub adult, Nb = none breeding adult, Pr = pregnant, La = lactating)

4.7. Diet Analysis

The mean percentages of stomach content of snap trapped rodents from March to August are given in (Table 10). The food items were grouped into plant matter (grass, seed, stem and leaf) and animal matter. Some food items that were not identified were grouped under unknown materials. The percentage frequency of plant matters in the stomach was higher than animal matters in all species. The percentages of seed and stem in most stomach contents were higher during the March to May than during June to August months. The percentage of leaves in all stomach contents was higher during June to August than during March to May months. The percentage of animal matter was also higher during June to August than during March to May months. The percentage of unknown materials was higher in the stomach samples collected during March to May months.

Table 10. Mean percentage of diet components of snap-trapped rodents from March to August months.

Species	Months	No. of individuals	Percentage of diet composition					
			Plant matters				Animal matter	UM
			Gr	Se	St	Le		
A. dembeensis	June-August	6	35.8	35.8	12.5	50.3	8.36	2.3
	March-May	10	15	55.8	54.8	16.8	2	29.5
M.erythroleucus	June-August	8	23.5	21.1	13.8	47.4	2.2	2.03
	March-May	3	8.75	45.8	46.3	15	1.26	7.08
R. rattus	June-August	13	38.5	32.3	19.33	57.7	20.4	13.28
	March-May	-	-	-	-	-	-	-

(Gr=Grass, Se= seed, St= stem, Le= leaf, AM=animal matter, UM= unknown materials).

5. Discussion

During the present study, a total of three species of rodents were recorded from the farmland and grasslands area, these were *A. dembeensis, M. erythroleucus* and *R. rattus*. *A. dembeensis* and *M. erythroleucus* were distributed both in the farm and grasslands. This is also reported by Demeke Datiko *et al* (2007). *A. dembeensis* is a major agricultural pest in Ethiopia (Afework Bekele *et al.*, 1993; Lavrenchenko *et al.*, 1998). Therefore, its occurrence in the farm is expected. *A. dembeensis* is a lowland species with most records between sea level and 2200 masl (Capanna *et al.*, 1996). According to Delany and Monoro (1985) and Capula *et al.* (1997), *A. dembeensis* is common in the savanna regions of northern and central tropical Africa. Moreover, *Arvicanthis* is also an African diurnal rodent of grasslands extending from the Sahel as far as northern Tanzania (Corti and Fadda, 1996).

A.dembeensis is a common rodent in Ethiopia. Most of the studies have revealed the existence of this species in different parts of Ethiopia. Afework Bekele (1996b) from Menagesha Stae Forest usually at 2200 m asl. Afework Bekele & Leirs (1997), from Ziway maize farm and Bulatova *et al.* (2002) from Gambela. *M .erythroleucus* is also reported by Afework Bekele and Leirs (1997) from central Ethiopia (Ziway), Bulatova *et al*. (2002) from Gambela and Tadesse Habtamu (2005) from Alatish Proposed National Park.

R. rattus was found only in the farm land especially from the maize farm. This is in agreement with Selvaraj and Archunan (2002) who stated that *R. rattus* commonly inhabits near the human habitation. Intra-specific competition and predation might force this to widen the distribution into farm areas from the surrounding human settlements. *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 (Mosissa Geleta, 2010).

The present study showed that the area has less species richness of rodents, as compared with other findings such as Yalden (1988), Afework Bekele (1996a) and Dawit Kassa and Afework Bekele (2008), who have recorded seven species of rodents from Bale Mountains, six species from Menagesha-Suba State Forest and seven species from WondoGenet, respectively. Moreover, Demeke Datiko *et al*. (2007), Tadesse Habtamu and Afework Bekele (2008) and Mohammed Kasso *et al*. (2010) have recorded 14, 23 and 17 species of rodents from Arbaminch forest and farmlands, Alatish National Park and Mount Chilalo and Galama Mountain Ranges, respectively. Generally, the presence and absence of rodent species in the different habitats might have depended upon the microclimate, altitude and vegetation types of the areas (Yonas Terefe, 2011).

The number of rodent species showed variation across the two habitat types with high number of individuals captured from the farm land. 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 grass land 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 (Ayenew Gezie, 2009).

A. dembeensis was the most abundant species from March to May. The present study is in line with the finding of Delany (1986) and Afework Bekele *et al*. (1993) who stated that *A. dembeensis* reaches maximum number during the dry season. The number of trapped rodents varied from habitat to habitat and between trapping sessions. This might be due to variation in habitats and availability of food between seasons. Similar result is also reported by Juch (2000) changes in habitat structures decrease food availability, habitats and ground cover affects 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 three month and to disappear in the other month.

During the present study, variations in age groups and reproductive status were observed among months. For example, the number of pregnant females and juveniles (young) were high in number from June to August, and less from March to May. The pregnant and young individuals were rarely trapped from March to May. This shows that breeding of most of the rodent species was related with food availability during the rainy season as rain influences germination and growth of vegetations that serves as sources of food and shelter. The capture rate of *R. rattus* was high from June to August. Similar finding was reported by Sicard and Fuminer(1996) the breeding pattern of many African rodents was related to rainfall but varied with rainfall with increased rate of reproduction at the end of the rainy season (Workneh Gebresilassie *et al*., 2006).

In the present study, pregnant females of *M .erythroleucus* and A. *dembeensis* were trapped in all months. This might be due to their reproductive condition is increased with increased food source. This result is in agreement with Leirs *et al*. (1994) stated that *M .erythroleucus* breeding appears to be strongly correlated with rainfall. Continuous breeding throughout the year was reported by Delany and Roberts (1978).

During the present study, trap success varied from month to month and from habitat to habitat types. The highest number of rodents trapped from farmland and the lowest was from grassland. Similarly, the highest trap success was obtained from farmland during the rainy season and the lowest was from grassland. Trap success increased in farmland because of large numbers capture rates of *R. rattus*. 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 was greater than the dry season. The low trap success from March to May may be attributed to a decreased density of species as a result of increased home range due to lack of resources such as food limitation.

During this study the number of males trapped was more than the females. In all months, male individuals comprised the highest percentage of trap success in the two habitat types. Several other studies have revealed similar results with the present record on the seasonal variation of different age groups of rodents (Demeke Datiko *et al*., 2007; Tilahun Chekol, 2009;

Mossisa Geleta, 2010). The highest trap success for the males could be associated with their high rate of mobility.

Trapping success for females was less during all months. This might be related with their reproductive behaviour. Odhiambo and Oguge (2003) have explained that males make wider field excursions than females, which usually care for the litters. This might have limited the mobility of females and, hence, lowering their trap success. Higher trap success for juveniles from June to August could be due to the higher rate of breeding in the rainy months.

The number of embryos varied from species to species and from month to month. The highest embryo count among the rodents was recorded from June to August. From March to May months, less number of pregnant females was obtained for *A.demebeensis.* According to Boutin (1990) the presence of good quality and quantity of food in a given habitat may have significant effect on the time of reproduction, litter size and body growth rate of rodents. Extended rainy seasons result in longer periods of breeding and higher litter size (Taylor and Green, 1976; Leirs *et al.*, 1994). The reason for the observed difference in embryo count between seasons in the present study area might be that weeds and weed seeds might have high stimulating effect on their reproductive process. Tadesse Habtamu and Afework Bekele (2008) also reported lower number of embryo count when rodents reproduce a seasonally.

The result of body measurement shows a significant variation in the mean body weight of rodents among species and months. A similar result was observed by Taylor and Green (1976). This might be associated to the limited availability of food sources during the dry months than wet months.

During the present study, stomach content analysis revealed a variety of food items consumed by rodents. The result obtained from the stomach of three species of rodents showed the omnivorous and granivorous feeding habit of the species. According to the study by Campos *et al*. (2001) the feeding ecology of small mammals throughout the world 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 (Mosissa Geleta, 2010).

The result of the stomach content analysis showed that regardless of the proportional difference, all rodents consumed plant and animal matters. The stomach contents of *A. dembeensis*, *M. erythroleucus* and *R. rattus* had grass, seeds, stem and leaves and animal matters. Similar result was reported by Azied Osman (2007) who stated the stomach contents of *M. natalensis* and *A.dembeensis* included monocot seeds; monocot leaves and animal matters. In the present study, more fragments of animal matter were observed from the stomach contents collected from June to August than stomach contents collected from March to May. Similar result is also reported by (Ayenew Gezie, 2009).

6. Conclusion and Recommendations

The present study provided valuable information on the relative abundance, diet composition and breeding season of rodents in cultivated and grassland habitats. Three species of rodents were recorded from the study area. These were *A. dembeensis, M. erythroleucus* and *R. rattus.* This study indicated that the distribution of species varies with habitat types. *A. dembeensis* and *M. erythroleucus* were recorded from the farm and grassland habitats whereas *R. rattus* was recorded only in farm area.

The mean body weight of rodents in this study was higher during the months of June to August than March to May. This monthly variation in the weight of rodents was associated with the monthly availability of food sources in the area. These makes high populations of rodents were seen in the months of June to August. And the numbers of pregnant females were also increased during June to August months. This reveals that breeding of rodents is strongly correlated with rainfall.

Based on the stomach content analysis, it is possible to conclude that most rodents are opportunistic in their feeding, in that they depend on the available resources. Rodent pests had high impact on farmland crops, especially in the stored food. In the present investigation, the feeding habit of the three species of rodents almost similar in consuming of plant and animal matters. 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 March to May, but animal matters decreased. The present study presents important baseline information on the relative abundance, diet composition and breeding season of rodents from cultivated and grassland habitats. However, further extensive and detailed study in the study area may yield more rodent species than currently recorded. In addition, studies on population ecology of rodent community and their effect on crops are still poorly known in many regions of Ethiopia. Therefore, these also need attention.

Based on the results of the present study, the following recommendations are made:-

Detailed studies on the biology and ecology of each species of rodents in the area are required for designing appropriate measures to control major rodent pests in the area.

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