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The diversity, diet composition and breeding season of rodents in agricultural and grasslands of Bucha Kebele, **Angacha District, Kembata Tembaro Zone, South Ethiopia.**

By

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Acronyms

ANOVA:-Analysis of Variance

CSA:-Central Statistical Agency

EBRM:-Ecologically Based Rodent Management

EMA:-Ethiopian Meteorology Agency

GPS:-Global Positioning System

IPM: - Integrated Pest Management

m.a.s.l: - meters above sea level

PHC: - Population and Housing Census

SNNPRS:-Southern Nations Nationality and People Regional State

SPSS: - Statistical Package for Social Sciences

Abstract

The diversity, diet composition and breeding season of rodents was studied in Bucha Kebele, Angacha district, Kembata Tembaro Zone, South Ethiopia, covering both dry and wet seasons. Snap traps were used to capture rodents from cultivated and grassland habitats. A total of 900 trap nights, from the two trapping habitats, yielded 185 individuals that represented 6 species of rodents. The species composition and their relative abundance of rodents trapped from the two habitats in both season include: Arvicanthis dembeensis (44.9%), Mastomys erythroleucus (21.1%), Rattus rattus (15.7%), Mastomys natalensis (8.6%), Mus musculus (7%) and Mus mahomet (2.7%). The relative abundance of rodents varied between habitats and seasons, more from farmland and highest during the dry season. A. dembeensis was widely distributed in both habitat types. Number of pregnant females and embryo count was higher during the wet season than dry season. The stomach content of rodents was mostly plant matters and few animal matters. Grass was the dominant food item in the stomach of A. dembeensis during both seasons as compared to other rodent species, whereas seed was eaten by all species in more proportion, indicating that they all are pests of the study area. Livestock grazing, lack of cover, rainfall and human interference were the major factors affecting the abundance and distribution of rodents in the study area.

Key words/ phrases:-Angacha, breeding season, cultivated field, diet composition, grassland,rodent.

Introduction

1.1. Background

Rodentia is the richest order in terms of species number in class Mammalia. Out of 5416 species of mammals recorded globally, more than 2,277 species are rodents; comprising about 42% of mammalian species (Wilson and Reeder, 2005). In Africa, rodents are the most ubiquitous and numerous among mammals in both species and in numbers (Delany and Monoro (1985). In East Africa, rodents account for about 28% of the total mammal fauna of the region (Kingdon, 1997). The most frequent rodents in sub-Saharan Africa belong to the genus *Mastomys.* They occur all over the continent in natural grasslands, thickets, cultivated areas and in human habitations (Stenseth *et al.,* 2001).Out of the 300 species of mammals in Ethiopia, 84 species are rodents accounting about 30% of all mammalian species of the country (Afework Bekele and Yalden,2014). Among these 15 species are endemic, constituting 18% of the total rodents in the country (Afework Bekele and Corti, 1997).

Rodents have high reproductive potential. Their reproductive success and population dynamics are greatly influenced by seasonal variation of environmental variables. Their population grows during the rainy season (Tadesse Habtamu and Afework Bekele, 2008) indicating that rainfall is one of the decisive factors that causes variation in reproductive success and population dynamics of rodents as suggested by Caro (2002). Reproductive success of rodents is also greatly affected by availability of diet type (Marcello *et al*., 2008). Temperature and humidity have also a significant factor in determining reproductive activity of rodents (Windberg, 1998).

Rodents are primarily consumers of seeds and herbs (Mulungu *et al.,* 2008). They consume plant materials such as cereals, grasses, tubers, seeds, roots and fruits. However, most rodents are opportunistic feeders capable of changing their diet based on the availability of food from season to season (Workneh Gebresilassie *et al.*, 2004). Rodent like mole rats are specialized on roots and tubers and cause major problems in cassava field and "enset"(Sidorowicz, 1974).

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

Despite the above roles, some rodent species are important pest to agriculture, and are responsible for considerable damage to crops, stored food and human properties (Jacob *et al.*, 2003). They are nuisance in agriculture, forestry and public health, causing severe economic losses (Tristiani and Murakami, 2003). Thus, feasible rodent pest control and management activities are crucial in any given habitat, in which knowledge of rodent ecology and population dynamics are mandatory.

Only limited studies on rodent ecology and their interaction with farmlands and grassland have been made in the country (Afework Bekele and Leirs, 1997; Afework Bekele *et al.*, 2003; Workneh Gebresilassie *et al.*, 2004; Makundi *et al.*, 2005; Manyingerew Shenkut *et al.*, 2006; Demeke Datiko *et al.*, 2007; Ejigu Alemayehu and Afework Bekele, 2008). Thus detailed studies on population ecology, habitat selection, habitat use, and population dynamics of the rodent community are still poorly known for many regions of Ethiopia. The present study was planned for extended survey of rodent species diversity, diet composition and breeding season in farm and grassland habitats of Angacha district, Kembata Tembaro Zone, South Ethiopia.

1.2. Statement of the problem

Rodents are among the most noxious pests of agriculture (Singleton *et al.*, 2003). Pest rodents are a worldwide problem, and are responsible for considerable damage to crops, stored cereals, food and human properties. 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) (Jacob *et al.,* 2003). In Africa, especially in those countries that live far below the poverty line, rodent pests are partially responsible for food insecurity. Thus, rodent pests play a significant role in influencing food security and poverty alleviation programs for the rural people (Singleton *et al.*, 2003).

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 at Ziway (central Ethiopia) to be 20- 26%. Similarly, rodents are claimed to be the major agricultural pests in Angacha district. Though, Farmers in Angacha district faced rodent pest problem in agriculture which in turn leads to considerable economic loss. Reports from the district Agricultural department shows that Bucha Kebele (the present study area) is particularly mostly affected. However, no attempt was made to study the ecology of the pest rodents of the area. Therefore, the present study was designed to fill the gap by surveying basic information on the diversity, diet composition and breeding season of rodents in Angacha district, Kembata Tembaro Zone, South Ethiopia.

1.3. Objective of the study

1.3.1. General Objective

The general objective of the present study was to gather information on species diversity, diet composition and breeding season of rodents in Angacha district, Kembata Tembaro Zone, South Ethiopia.

1.3.2. Specific Objectives

- ❖ To identify rodent species of the study area.
- ❖ To compare the relative abundance of rodents in different seasons and habitat types.
- ❖ To identify the breeding seasons of rodents of the study area.
- ❖ To examine the diet of rodent species in different seasons.
- ❖ To evaluate pest potential of rodent in the study area.

1.4. Significance of the study

The agricultural sector is given particular emphasis for the overall future transformation of the country’s economy through poverty reduction strategy. One of the factors for its success is the sustainable pest identification and management strategies. The study conducted will provide valuable information on the ecology of rodents as well as their status in terms of diversity as base line for the study area. The study will have significance in predicting rodent population dynamics and deduce ways to manage or control them in eco-friendly way. Since most damage to agricultural crop occurs during the sensitive young seedling stage and just before harvest and thus, the study on diversity, diet composition and breeding season of rodent in Angacha district, Kembata Tembaro Zone, South Ethiopia, will have great importance for farmers of the study area to take timely control measure. It helps in understanding the potential loss of crops to rodents and to evaluate future prospects. Furthermore, it may serve as cue to draw the attention of researchers on the dynamics of pest rodent species.

2. Literature review

2.1. Taxonomy and Diversity of Rodents

Rodents (Order Rodentia) are the most diverse order of mammals, due to an extraordinary proliferation of rats and mice within the last 10 million years (Futuyma, 2005). The distribution and species richness of order Rodentia is highly skewed; representing rodents are approximately half of the species while other orders have only few extant species (Purvis and Hector, 2000). 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).

Conventionally, rodents have been grouped into three suborders based largely on jaw musculature and associated structure of the skull. These are Sciuromorpha (squirrel-like rodents), the Myomorpha (rat-like rodents) and Hysticomorpha (porcupine-like rodents). They range from tiny pigmy mice to big *Capybaras*; from arboreal flying squirrels to subterranean mole rats and from opportunistic omnivores to specialist feeders (Vaughan *et al*., 2000). About two third of the living rodent species belongs to the family Muridae (Singleton *et al.,* 2003). The genus *Rattus* accounts for most of the species (Proctor, 1994). Among the nine families of rodents in Ethiopia, the family Muridae comprises 57 species, accounting about 84% of the total rodents and 93% of the total endemic rodents in the country (Afework Bekele and Corti, 1997). Endemic rodents accounted for about 50% of the endemic mammals in Ethiopia (Afework Bekele and Corti, 1997).

Rodents most likely originated in Central Asia (Hartenberger, 1996); and within a few millions of years they diversified and dispersed on all continents to the exception of Antarctica and South America (Hartenberger, 1998). As early as in the Early Eocene, 11 families of rodent are already recognized (Hartenberger, 1998). Thirty-four living rodent families are currently recognized when including the Diatomyidae, a family recently reactivated (Huchon *et al.,* 2007) to include *Laonastes aegnimamus* discovered in Laos in 1996 and described by Jenkins *et al.* (2005). Studies on African rodent taxonomy and systematics suggest that the biodiversity is much larger than previously estimated, so that the list is expected to increase rapidly (Corti *et al*., 2005). The taxonomy of several taxa of African rodents is chaotic; and the taxonomic revision of many genera is far from completion (Corti *et al.*, 2005). The situation is not different in Ethiopia. Several genera of Ethiopian rodents are also a matter of controversy. Some chromosomal, morphological and molecular studies have been used in Ethiopia to clarify the systematics of such controversial groups and even to describe new species (Bulatova and Lavrenchenko, 2005).

2.2. Feeding ecology of rodents

Food is one of the most important dimensions of niche and therefore information about diet is a major component of ecological study. Diet is extremely significant for determining day to day activities, evolution, life history strategies and ecological roles of rodents (niche) (Krebs, 1998). Studies on diet and habitat preferences of rodents are important to understand relationships between species, and between rodents and their environment (Bar *et al*., 1984).

Rodents often occur in close association with humans, so consume huge quantities of stored food and spread fatal disease by contaminating food and water (Leirs *et al.*, 1993).They show a variety of feeding patterns. Many rodent species are opportunistic omnivores. They can live on a variety of food items and thus survive in many different types of farmlands (Leirs *et al.,* 1994). Most rodents consume all sorts of plant materials, primarily seeds, leaves, stems, flowers and roots (Futuyma, 2005). They also consume small invertebrates such as insects, spiders and worms. A few are specialized carnivores; for example, the Australian water rat feeds on small fish, frogs and molluscs and seldom eats plant materials (Macdonald, 1984). Granivorous genus such as the *Mastomys, Arvicanthis, Mus, Tatera* and *Rattus* prefer farmlands and grasslands for their food resources (Afework Bekele and Leirs, 1997). Rodents, like mole rats are specialized on roots and tubers and cause major problems in cassava field and "enset"(Sidorowicz, 1974).

2.3. Rodents as pests

In developing countries rodent infestation poses a serious threat for reduction of income and widespread of food shortage by causing substantial damage to food and cash crops worldwide (Stenseth *et al.,* 2001). They damage and destroy 30% of the crops in both pre-harvest and post-harvest conditions, being major agricultural pests globally (Singleton, 2001). In most of the developing tropical countries, rodents are serious pests, and Farmers often list rodents as one of their most significant crop pests (Stenseth *et al*., 2001). They cause direct damage to various crops or commodities by gnawing and feeding, and indirect damage by spoiling and contamination.

One of the serious threats to adequate world food production is the large volume of food production being consumed or contaminated by rodents. Fortunately, on global-scale, only about 5-10% of the 2,277 species of rodents are serious agricultural pests (Singleton *et al*., 2007). Among these rodents, *Mastomys natalensis* (Multimammate rats) are important pests in agriculture and the most successful seed and cereal feeders (Workneh Gebresilassie *et al.*, 2006). They consume grass stems and rhizomes, and they are the only animals to feed on covered seed from a ploughed land (Workneh Gebresilassie *et al*., 2006).

The genus *Mastomys* occur all over the continent in natural grasslands, cultivated areas and human habitats. According to Workneh Gebresilassie *et al*. (2004), *Mastomys erythroleucus* occur more frequently in vegetative fields, whereas *Arvicanthis dembeensis* occur more frequently in habitats with monocot plants. As Makundi *et al.* (2005) indicated, in Ethiopia, the crop damage 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.

Out of the 84 species of rodents in Ethiopia, 11 species were identified as agricultural pest (Afework Bekele and Leirs, 1997). According to Workneh Gebreselassie *et al.* (2006); and Demeke Datiko *et al.* (2007), the most important pest rodents in Ethiopia are *Mastomys erythroleucus, M. natalensis, Arvicanthis dembeensis, Mus mahom*et and *M. musculus.* 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. Hence population dynamics of rodent population is essential to forecast the probability of outbreak of rodent populations within the year (Leirs *et al.*, 1996).

2.4. Rodent pest management strategies

From the very beginning, man has tried all possible means to minimize the damage caused by rodents. Killing rodents by trapping, hunting, flooding and fumigation has been practiced traditionally in many parts of the world, but rarely has great effects to control their populations (Smith and Buckle, 1994). Rodent control programme would be more effective if applied during the pre-breeding season, which also coincides with the reproductive phase of the vegetation around (Workneh Gebresilassie *et al*., 2004). The most commonly used control measure for rodent pests is rodenticides (Buckle, 1999). 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).

Given the diversity among rodent pests and the agro-ecosystems where they occur, a number of management strategies have been designed in the past. 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. Integrated Pest Management (IPM) may have a major role to play in the context of rodent pests in East Africa (Stenseth *et al*., 2001). Knowledge on population dynamics and characteristics of pest rodents will allow prediction of rodent population fluctuation probabilities, which would help to formulate appropriate pest management strategies (Tsegaye Gadisa and Afework Bekele, 2006).

Studies in Southeast Asia highlighted that, Ecologically Based Rodent Management (EBRM) 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 (Singleton *et al*., 2003). Farmers often use inappropriate methods to reduce the impacts of rodents, and rely heavily on chemicals, causing risks to non target species and to the environment, and generally providing poor return on investment (Singleton *et al*., 2003). Nevertheless, rodenticides are likely to remain the central management tool for controlling rodent damage in tropical agriculture (Wood and Fee, 2003). Some rodent species are very sensitive to changes in crop varieties, land use and field management patterns, while others are affected only marginally. Thus, a sound biological knowledge of rodent species is a prerequisite for the development of more effective, ecologically based, rodent management strategies (Leirs *et al*., 1999). The concept of EBRM was developed as a formal description of the sound ecological basis required for developing management strategies for rodent pests (Singleton *et al*., 1999).

2.5. Breeding in rodents

Reproduction plays a major role in the recruitment of diverse species of rodent population density (Workneh Gebresilassie *et al*., 2006). Reproduction is highly energy consuming. It requires coinciding with the time of the year that the habitat is rewarding (Shanas and Haim, 2004).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). Breeding time and frequency, length of gestation, and litter size vary widely among the species of rodents. Most rodent species commonly have 6-12 young in each litter and a female can have one litter each month. Due to their high reproductive potential and ability to invade diverse habitat types, rodents are able to spread and multiply quickly (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). Moreover, many environmental factors have same effect on the time of reproduction in rodents. Among these temperature and nutrition are the most important factor (Vaughan *et al*., 2000).

The social biology of rodents is diverse and results from a series of interactive and complex selective forces for optimal foraging, maximizing reproduction, avoiding predation, survival, and life history traits (Wolff and Sherman, 2007). The spacing patterns of females are a function of reproduction, relatedness, and protection of offspring, whereas male mating tactics depend on female defensibility. Females typically are intra sexually territorial defending exclusive space with respect to unrelated females. The vulnerability of young to infanticide appears to be the selective force that shapes female spacing and mating behaviour. Food does not appear to be a defensible resource for rodents, except for those species that larder hoard non perishable items such as seeds. Males exhibit four mating tactics depending on access and defensibility of females. Males defend individual females (monogamy), exhibit female- or resource-defense polygyny, occupy large home ranges that overlap two or more females and those of other males (promiscuity), or live communally with several males and females (Wolff and Sherman, 2007).

Diet quality is the most important factor that regulates the onset of rodent breeding (Jackson and Vanaarde, 2004). Food produces a significant change in life history traits such as initiation of time of reproduction, litter size, body condition and growth rate (Boutin, 1990). Breeding in rodents begins some weeks after the onset of rainy season (Hubert, 1978), but varies with rainfall with increased rate at the end of the rainy season when resources are plenty (Workneh Gebresilassie *et al.,* 2006). Most rodent species commonly have 6-7 young per breeding season (Workneh Gebresilassie *et al.*, 2006). 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).

3. The study Area and Methods

3.1. The study area

The present study was conducted in Bucha Kebele in Angacha district. Angacha is one of the eight districts that are found in Kembata Tembaro Zone, in Southern Nations Nationality and People Regional State (SNNPRS). The district is sub-divided in to 17 rural and 2 urban Kebeles, one of which is Bucha. Bucha is situated at a latitudinal and longitudinal rage of 7^0 15'N to 7^0 24' N and 37^0 47' E to 37^0 52'E respectively (Fig.1).

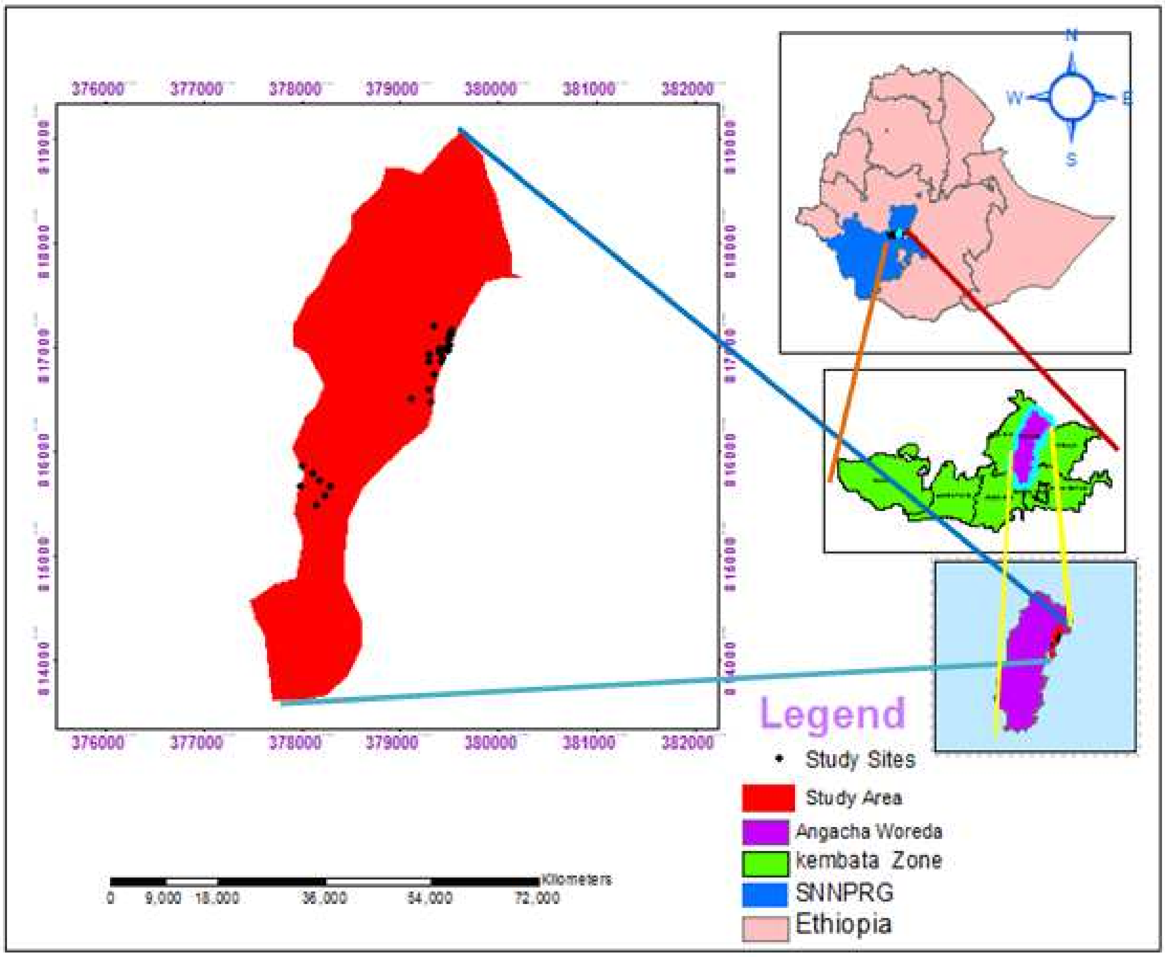

Figure 1. Map of the study area

It is located at about 250 Kms South West of Addis Ababa. According to CSA, PHC (2007), the total population of Kebele is 4120 and out of this total population, 2002 (48.6%) are males while 2118 (51.4 %) are females. The total land area of the Bucha Kebele is 868 kilo meters square and the farmland distribution of an area is less than

0.5 hectare per farmer (Mesfin Desalegn, 2010). The altitude of the area ranges from 1500 to 2480 m asl.

3.1.1. Land-use and Agriculture

Land use denotes the pattern of land allocation to various agricultural activities. It is hold both at private and communal basis and used mainly for farming, grazing, forest and settlement. In the present study area, out of the total 1190 ha cultivated land 556 ha (46.7%), 139 (11.7%) and the rest 495 ha (41.6%) is used for annual permanent crops, and gardening and settlement respectively. Crop production and animal husbandry is the main agricultural activity and livelihood of the population. The agricultural practice employed in the area is traditional oxen-plough and hoe-culture practices. Most of the area is known to have fertile loam soil, which is suitable for agricultural activities. Intensified mixed agricultural practices are prominent in this area. The main food crops grown in this Kebele include teff, barley, wheat, maize, peas and beans. Root crops, enset, and potato are also grown in the area. Among the perennial crops enset (*Ensete ventricosum*) plays an important role in the life of the people by its multi-uses as a source of food, fibber, animal fodder, constructional material, to make mats for sleeping, its leaf serves as an umbrella during the rainy season.

3.1.2. Flora and Fauna

The flora and fauna of the study area are not studied in detail. However, the dominant riverine vegetation includes *Podocarpus falcatus*, fig tree (*Ficus carica*), tid (*Juniperus procera*) and dense bushes. Recently, due to increased human population and the extended agricultural activities, the area is considerably depleted of natural vegetation. Deforestation of natural habitats resulted in loss of previously inhabiting wildlife populations like baboons, monkeys, leopard, civet, wildcat, etc. The process of devastation is continuing. The local people practiced intensified mixed agricultural activities. The cultural practices remained primitive and at subsistence level, where crop yield is low to feed such a high population.

3.1.3. Climate

The wet season is characterized by eight months of rainfall from April to November followed by the dry season that ranges from December to March. The mean annual rainfall is 1579.5 mm with a bimodal pattern. The peak rainy months are April, July, August and September (Figure 2). In general, the district belongs to "Dega" (cool) climatic zone (35%) with altitude above 2400m asl, and the "Woina-dega" (Temperate) climatic zone (65%) with altitude between 1500 to 2400m asl (Ambericho, 1997). The mean annual maximum temperature is 24 ^{0}C and monthly values range between 23 and 24 ^{0}C. The mean annual minimum temperature is 14 ^{0}C and monthly values range between 13 and 14 ^{0}C. The coldest months are June and August, whereas February is the hottest month (Figure 3).

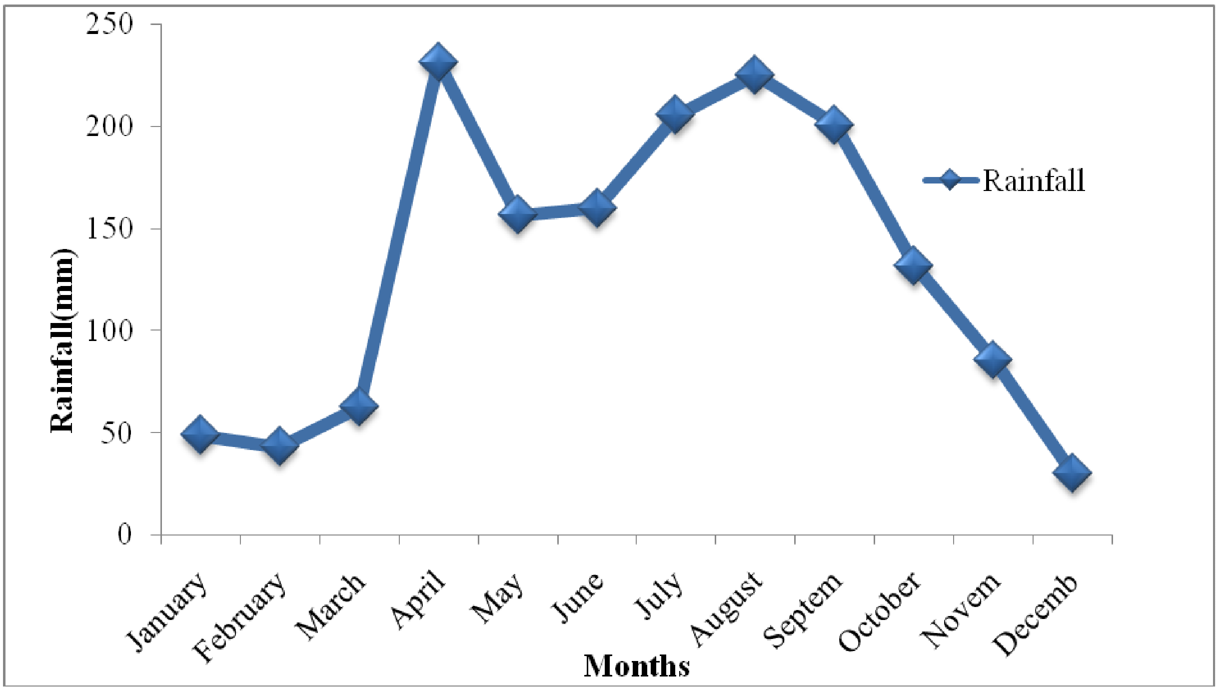

Figure 2. Mean monthly rainfall of (EMA, 2014).

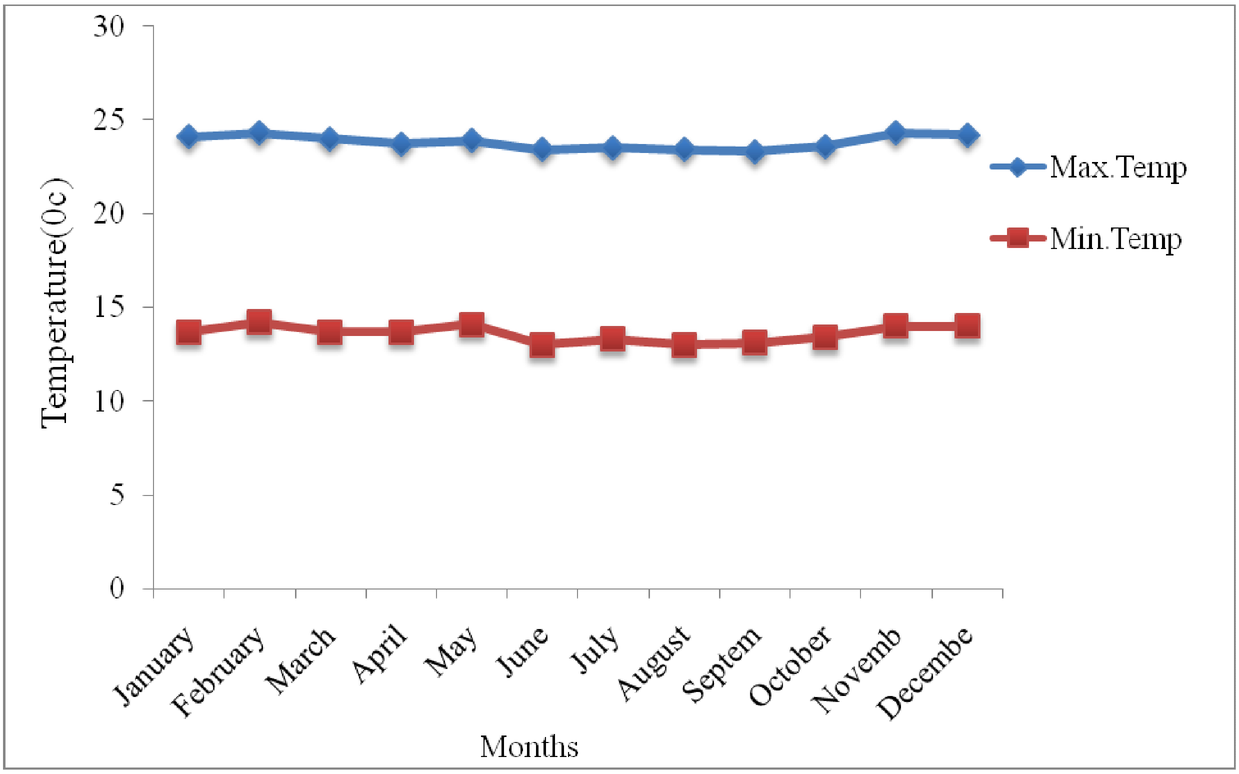

Figure 3. Mean monthly maximum and minimum temperature (EMA, 2014).

3.2. Habitat description

During the preliminary survey the habitat of the study area was classified in to two, grassland and farmland.

3.2.1. Grassland

This habitat is a fallow land under the management of World Bank, comprising about 68 ha of land which is located at the altitudinal range of 2017 to 2144. The area is totally covered with dense grasses and sparsely populated trees including newly planted species such as *Grevillea robusta*, *Cordia africana*, *Accasia* species and old *Ficus vasta*. The grass is used for hay preparation and touching houses. The corners of grass field were surrounded by sisal plants. The area surrounding this habitat is used as pasture in both wet and dry seasons (Figure 4).

Figure 4. View of the grassland habitat (Photo by Tagesse, January, 2014).

3.2.2. Farmland

Farmland is the other habitat identified for this study which is at an altitude of 2019-2369 m asl. Maize farm was taken as representative of farmland sampling site among farmland habitat types within the study area. During dry season farmland habitat of maize was composed of dried, harvested and falling maize plants, purposefully planted elephant grass (*Pennisetum purpureum),* Wild growing weed species and dried leaf of maize were used as surface cover. Maize is the main staple food crop which is sown in the area (Figure 5).

Figure 5. View of the post-harvest maize farm (Photo by Tagesse, January, 2014).

3.3. Materials and Methods

3.3.1. Materials

Global Positioning System (GPS), digital camera, Pesola spring balance (500 g), standard ruler, dissecting Kits, protective Gloves, Snap traps, Baits (peanut butter and barely flour or maize scrap), Data sheet, Field guide, Glass slides, 10% Formalin solution, 0.25 mm Sieve and compound light microscope were used for the present study.

3.3.2. Preliminary Survey

Prior to the main research work, preliminary survey was conducted in the study area. During this survey, all the available and relevant information about the area (climatic condition, habitat type, approximate size of the area, cultivated crops and related information about the study site) were gathered. Based on the information gathered during the preliminary survey, the study habitat was identified as farmland and grassland; and the study sites were selected purposively from each habitat type.

3.3.3. Sampling Design

In the present study longitudinal design was implemented to sample rodent species in each habitat for two seasons. Rodent trapping was performed using fifty snap traps (mouse trap for mice and rat trap for rats, twenty five each) fixed with string and placed in both agricultural and grassland habitats.

3.3.4. Data collection by snap traps

Field data, regarding diversity, diet composition and breeding season of rodents, in farm and grassland was collected and noted both during dry and wet seasons starting from January, 2014 to March,2014 for dry season and April,2014 to July, 2014 for wet season. Data collection was carried out in each and every month for three consecutive days in each habitat during both seasons at thirty day interval between subsequent data collection session. Snap traps are efficient to capture rodents (Nicolas and Colyn, 2006) and used commonly in ecological studies (Hansson and Hoffmeyer, 1973). Fifty snap-traps (metal commercial "break-back" traps) mouse -trap for mice and rat- trap for rat, twenty five each were used for seasonal data collection. Each snap-trap was baited with a mixture of peanut butter and maize scrap, and refilled each day if rodents or other animals (insect) ate it or dried and lost its smell and placed at the same field for three days. The traps were checked twice a day early in the morning 6:30 and 8:00 a.m. and late in the afternoon between 17:00- 18:00 p.m. for three consecutive days in each habitat. Trapped rodents were examined for sex, age structure soon after removed from the traps, body measurements like head-body length, tail length, hind foot, and ear length as well as the number of embryo from pregnant females were recorded following the methods of Aplin *et al*. (2003).

Dissections of snap trapped rodents were carried out for stomach content analysis as well as to determine reproductive conditions based on internal reproductive features. The stomach from the dissected rodent was removed, tagged with species code number and preserved in glass containers containing 10% formalin, until further microscopic examination. The contents were kept in open air for 24 hrs to dry. The dried samples were washed on a sieve with 0.25 mm mesh by water to remove fine particles. After sieving each sample, four slides were prepared and the identification of food constituents and proportion of the different food items were observed using compound light microscope following the techniques of Leirs (1994), as used by Workneh Gebresilassie *et al*. (2004). Each food items was grouped into plant matter (leaves, stems, roots, and seed), animal matter (arthropods, worms and hair) and unidentified, if impossible to be distinguished. Stomach content analysis was made through calculating the mean percentage proportion of food fragments per slides (Demeke Datiko *et al*., 2007).

Age structure for juvenile male and females were identified by their low body weight, soft fur and by small cartilages left between their digits in common (Barnett and Dutton, 1995). As stated by Afework Bekele (1996), juvenile females were identified as non-perforated vagina and invisible nipples and juvenile males were identified with abdominal testes, while sub-adult were assessed based on their pelage colour in common non-perforated vagina ,visible but not fully developed nipple for females and position of the testes, which was scrotal (with in hairy scrotal sac),for male and hairless scrotal sac, darker than the surrounding skin often projects behind and obscures, the anus confirms adult male and that of adult females were identified by those characters opposing sub adult females (Aplin *et al*., 2003).

Snap-trapped rodent reproductive conditions were noted based on both external and internal body conditions. Pregnant females were identified by their enlarged nipples, large swollen abdomen, more prominent teats. A female that is currently nursing a litter of pups (lactating), were identified on the bases of enlarged teats capable to release a droplet of milk while squeezing the base of teats, and active mammary glands. The non-lactating adult female rodents were confirmed by smaller teats and fur at the bases of teats, but the teats remain larger and more raised than those of a sexually immature individual (Aplin *et al*., 2003).In males, external signs that were useful to distinguish sexual maturity or reproductive conditions is the three conditions of the testes and scrotal sac (Aplin *et al*., 2003).

In females, reproductive activity from internal characteristics was noted through dissection and examination of the left and right uterine horns. Uterine horns of juveniles were identified with very thin, short and a poorly developed blood supply. Sub adult and adult were identified on the basis of slightly thicker and more elongated, with a more obvious blood supply but without embryos or placental scars and, thicker and with embryos or scars present in one or both uterine horns respectively (Aplin *et al*., 2003).

Rodent species were most often distinguished or 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). Furthermore, for species identification, taxonomic keys developed by Afework Bekele *et al.* (1993), and Nowak (1999) were used in addition to standard key listed in Kirsten (2009), as an identifying key for small mammals (rodents), especially problem rodents, found in farmland and grassland areas.

Body measurements were taken after removing captured rodents from the traps by using standard ruler and Pesola spring balance. Then the measured values of body weight and lengths were recorded in data sheet according to Aplin *et al*. (2003).
Head-body length measurement was accomplished by taking head-body measurement in a straight line along the animal's vertebral column, from the tip of the nose to the distal end of the anus (while, the animal lying on its back). Tail length Measurement was taken along a straight line from the middle of the anus to the tip of the tail, without suspending the animal by its tail to take this measurement. Pes or hind foot length measurement was taken from the heel to the tip of the central (longest) toe, but without including the claw. Ear length measurement was taken from the bottom of the notch of the ear to the furthest point along the rim. Body weight of rodents was measured using a calibrated spring balance (Pesola spring balance, accurate to the nearest g). Only adult rodents were considered for standard morphological body measurements, and all standard morphological measurements were measured to the nearest mm except body weight (which was in g) (Aplin *et al*., 2003).

3.3.5. Data Analysis

The analysis of collected data was carried out by using appropriate statistical procedures like, Chi-square test, one way ANOVA and SPSS version 16.0 computer software programs were used to analyze the data. Furthermore, the Shannon-Wiener diversity Index (H') was used to compute rodent species diversity of the two habitats, following the formula:

$$H' = -\sum_{i=1}^{S} (Pi) \ln (pi).$$

Where, H´= species diversity

S= the number of species

Pi=the proportion of individuals of the total sample belonging to i^{th} species.

ln = the natural logarism

4. Results

4.1. Species diversity and relative abundance

The 900 trap nights yield a total of 185 individuals of rodents belonging to six species. The rodent species were: *Arvicanthis dembeensis, Mastomys erythroleucus, Rattus rattus, Mus musculus, Mastomys natalensis and Mus mahomet.* The capture rate of rodent declines between trapping sessions from session one to session six. Among the trapping session, more individuals (66) was trapped in session one (January), from both habitats while session six (July), had the least individuals (13) from both habitats (Table 1). The relative abundance of the rodent species in the study area vary, highest for *A. dembeensis (*44.9%), followed by *M.erythroleucus (*21.1%) while, *M.mahomet* was the least (2.7%) and the difference was significant (χ^2 =129.63, df =5, $p<0.05$) (Table 2).

Table 1.Number of rodent species captured in the two habitat types in different trapping sessions.

Trapping session	Habitat	Rodent species						Total
		A.d	*M.e*	*R.r*	*M.ma*	*M. mu*	*M. n*	
January	Farmland	16	14	13	-	4	6	53
	Grassland	12	-	-	-	1	-	13
February	Farmland	11	10	3	-	1	3	28
	Grassland	14	-	-	-	-	-	14
March	Farmland	6	4	3	-	1	-	14
	Grassland	-	-	-	5	-	-	5
May	Farmland	4	2	5	-	1	-	14
	Grassland	8	4	-	-	1	3	14
June	Farmland	4	1	3	-	-	2	10
	Grassland	4	2	-	-	1	-	7
July	Farmland	2	1	2	-	2	2	9
	Grassland	2	1	-	-	1	-	4
Total	Farmland	43	32	29	-	9	13	126
	Grassland	40	7	-	5	4	3	59

Note: *A.d, Arvicanthis dembeensis, M.e, Mastomys erythroleucus, R.r, Rattus rattus, M.ma, Mus mahomet M. mu, Mus musculus and M. n, Mastomys natalensis.*

Table 2. Species composition and their relative abundance.

Species	Habitats		Relative abundance (%)	
	Farmland	Grassland	Farmland	Grassland
A.dembeensis	43	40	23.2	21.6
M.erythroleucus	32	7	17.2	4
R.rattus	29	-	15.7	0
M. musculus	9	4	4.9	2.3
M. natalensis	13	3	7	1.8
M. mahomet	-	5	0	2.7
Total	126	59	68	32

Out of the trapped rodents, the maximum number of individuals 126 (68%) was captured from the farm land, followed by the grassland habitat 59 (32%) (Table3). There were statistically significant variation (χ^2=32.508, df=1, $p<0.05$) in the number of individuals captured during dry and wet seasons with in farm land habitat, whereas there was no variation (χ^2=.53, df=1, $P>0.05$) in grass land habitat in both seasons. *A.dembeensis* and *M. musculus* were the species trapped from farmland and grassland habitats during both season, whereas *M.erythroleucus* and *M.natalensis* were captured from both habitats only during wet season. *R.rattus was* restricted only to farmland in their distribution in both seasons. Few individuals of *M. mahomet* were trapped only from grassland habitat during dry season. The variation in species composition between the two habitat types was statistically insignificant (χ^2=.74, df=1, $p>0.05$).There were also significant variation (χ^2=56.76, df=1, $p<0.05$) in overall relative abundance in both habitat types.

Table 3. Relative abundance (%) of each species in two habitats and seasons.

	Relative abundance (%)				
Species	Farmland		Grassland		Total
	Dry	Wet	Dry	Wet	
A.dembeensis	33(39.8%)	10(12%)	26(31.3%)	14(16.9%)	83
M.erythroleucus	28(71.8%)	4(10.3%)	-	7(17.9%)	39
R.rattus	19(65.5%)	10(34.5%)	-	-	29
M. musculus	6(46.2%)	3(23%)	1(7.7%)	3(23%)	13
M. natalensis	9(56.3%)	4(25%)	-	3(18.7%)	16
M. mahomet	-	-	5	-	5
Total	95(51.3%)	31(16.7%)	32(17.3%)	27(14.7%)	185

Species richness between the two habitats showed variation, during dry season. From the two habitats, farmland constituted the highest species richness, with five species. The least species richness was registered from the grassland habitat with three species. However, the overall species richness for the two habitats was similar with five species each. The farmland was more diversified habitat in terms of rodent species with Shannon- Wiener Index (H') of 1.475(Table 4).

Table 4. Species richness (H') of trapped rodents between habitats.

Habitat	**No. o**f species	No. of captures	H'
Farmland	5	126	1.475
Grassland	5	59	1.141

4.2. Trap success in habitat types and seasons

Trap success varied between habitats as well as seasons (Table 5). The overall trap success was high during dry seasons (28.2%) compared to the wet seasons (12.8%) throughout study period in both habitat types. There was statistical significant variation in trap success between the two habitat types (χ^2=24.265, df=1, P<0.05) more in the farmland habitat, and between the two seasons (χ^2=25.735, df=1, p<0.05) with more trap success in the dry season.

Table 5. Seasonal trap success of rodents in the two habitat types.

Habitat types	Season	Trap night	Total catch	Success (%)
Farmland	Dry	225	95	42.2
	Wet	225	31	13.8
Grassland	Dry	225	32	14.2
	Wet	225	27	12
Overall		900	185	20.5

Farmland had the highest trap success (42.2%) than the grassland (14.2%) during the dry season. The trap success during wet season in the farm and grassland was respectively 13.8 and 12. The overall trap success for farmland and grassland during both season of trapping was 28% and 13.1%, respectively yields the average trap success of 20.5.

4.3. Age-class distribution

Out of 185 individuals of snap trapped rodents adults comprised 60% sub-adults 33.4% and juveniles 8.6%. During the wet season, juveniles comprised 13.8%, sub-adults 13.8% and adults 72.4%. During the dry season, juveniles comprised 6.3%, sub-adults 39.4% and adults 54.3%. Adults were largely caught in both dry n=69 and wet n=42 seasons. In contrast juveniles were the least caught groups n=8 during both seasons (Figure 6).

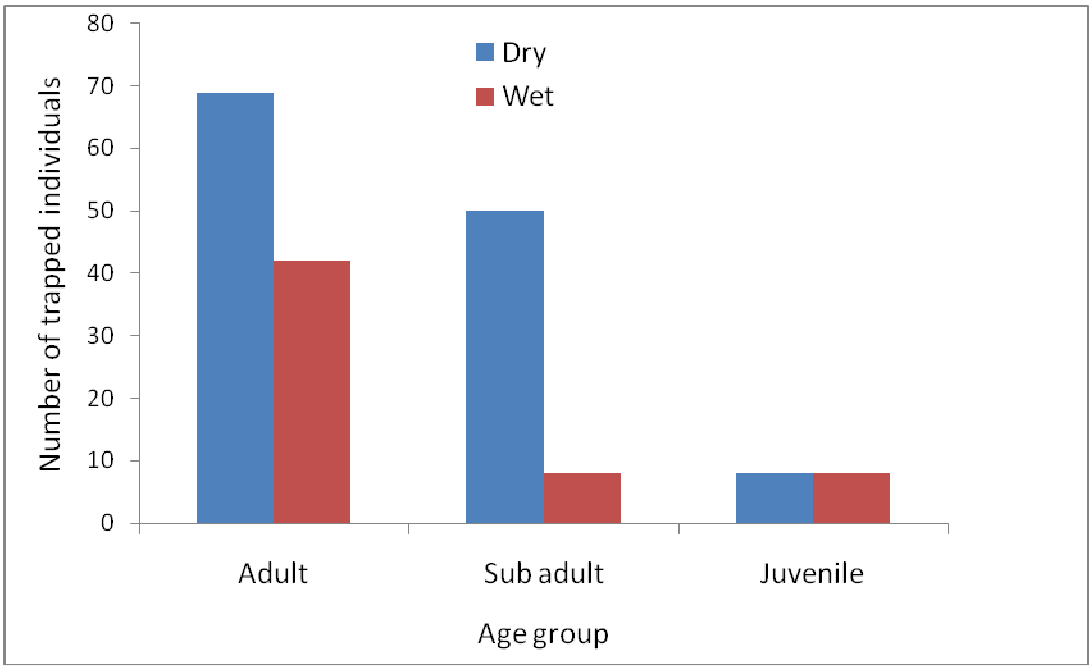

Figure 6. Age group distribution during both seasons

No juvenile individuals of *M.erythroleucus* and *M. musculus* were trapped during both sessions of trapping. Furthermore, sub-adult of *M.erythroleucus* was not captured during wet session .However, there was more number of trapped rodent individuals in each first sessions of dry (January) and wet (May) sessions (Table 6).Variation in the number of juveniles captured during both session wet (May, June and July), and dry (January, February and March) was not statistically significant (χ^2=0.0,df=1,P>0.05). But, there was statistically significant variation (F=6.706, df=2, $p < 0.05$) between the three age groups captured during the dry sessions as compared to the wet sessions.

Table 6. Age-class distribution of trapped rodents.

Species	Age groups	No. of individuals in trapping sessions						Total
		Januar	Februa	Marc	May	June	July	
A.dembeensis	adult	8	9	3	8	3	2	33
	sub adult	16	16	1	3	-	2	38
	juvenile	4	-	2	1	5	-	12
M.erythroleucus	adult	9	9	3	6	3	2	32
	sub adult	5	1	1	-	-	-	7
	juvenile	-	-	-	-	-	-	-
R. rattus	adult	8	3	3	3	3	2	22
	sub adult	4	-	-	1	-	-	5
	juvenile	1	-	-	1	-	-	2
M. musculus	adult	2	1	-	2	-	3	8
	sub adult	3	-	1	-	1	-	5
	juvenile	-	-	-	-	-	-	-
M.natalensis	adult	4	2	-	3	2	-	11
	sub adult	1	1	-	-	-	1	3
	juvenile	1	-	-	-	-	1	2
M.mahomet	adult	-	-	5	-	-	-	5
	sub adult	-	-	-	-	-	-	-
	juvenile	-	-	-	-	-	-	-
Total		66	42	19	28	17	13	185

4.4. Seasonal variation and sex distribution

The overall sex ratio in the study area was 1:1, however, there was seasonal variation between male and female (χ^2=25.74, df=1, P<0.05), more males 40 (69%) was captured during the wet season than females 18 (31%), while there was more females n=75 than males n=52 during the dry season, and the variation was significant (χ^2=4.165, df=1, P<0.05).

4.5. Body Measurements

The mean adult body measurements and body weight for six snap trapped rodents are given in Table 7. Variations in the mean body weight showed significant difference between seasons within most of the species (χ^2 = 5.35, df=1, P< 0.05 for *A. dembeensis*, χ^2 = 17.5, df=1, P< 0.05 for *M. musculus* and χ^2 = 11.18, df=1, P< 0.05 for *M. erythroleucus).* There was no significant variation for the remaining rodent species (Table 7).

Table 7.Weight and body measurements of snap-trapped rodents (Mean± SD).

Species	Season	No.	Body measurements HB	TL	HF	ER	BW
A. dembeensis	Dry	20	140±10.5	125±5	28.8±3	20±1.9	91.5±27
	Wet	13	136.5±10.8	125±11	28.5±4	22.3±3	125.4±21
M. erythroleucus	Dry	21	149.3±15.3	173.6±29	28.9±4	23.5±4	83.3±22
	Wet	11	154.5±19.2	181.8±17	30.3±2	20.1±3	132.7±25
R. rattus	Dry	14	156.4±8.9	188.6±15	31.4±3	20.7±2	118.2±27
	Wet	8	152.5±15.6	168.8±16	27.5±2	19.9±2	123.1±19
M. musculus	Dry	3	120±14.1	146.6±9.4	20.6±3	23.3±4	19.3±0.9
	Wet	5	119±29.4	147.8±39	22±7.0	20.3±4	55±11
M. natalensis	Dry	6	148.3±13.4	161.6±25	26.6±4	20±0.0	85±17
	Wet	5	146±13.6	175±17.3	31±2	20.8±2	100±18
M. mahomet	Dry	5	110±6.3	72±2.4	19±0.9	18.4±0	51±5.8
	Wet	-	-	-	-	-	-

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

4.6. Reproductive condition

Table 8 shows the reproductive status of female rodents trapped during both seasons. During wet season, 53.4% male and 20.7% female individual were in their reproductive age. From the adult females trapped during the dry season 30 (62.5%), 4 (8.3%) and 2(4.2%) respectively were non breeding (quiescent), pregnant and lactating individuals, whereas 2 (4.2%), 8(16.7) and 2 (4.2%) respectively were non breeding (quiescent), pregnant and lactating females during wet season. Therefore, seasonal variation between breeding (pregnant and lactating), and non breeding females was statistically significant (χ^2=4.79, df=1, p<0.05). As can be seen in table below, the pregnant females of *R. rattus* was more during the dry season, unlike other species of rodents.

Table 8.Reproductive status of females trapped during both seasons.

		Number of trapped female rodents					
Species	Season	juveniles	Sub-adult	Non -p. Adult	Pregnant	Lactating	Total
A.dembeensis	Dry	2	24	5	1	1	33
	Wet	2	1	-	3	1	7
M.erythroleucus	Dry	-	4	12	-	-	16
	Wet	-	-	1	3	1	5
R. rattus	Dry	1	3	6	3	1	14
	Wet	1	1	-	1	-	3
M. musculus	Dry	-	2	2	-	-	4
	Wet	-	1	1	-	-	2
M. natalensis	Dry	1	2	4	-	-	7
	Wet	-	-	-	1	-	1
M. mahomet	Dry	-	-	1	-	-	1
	Wet	-	-	-	-	-	-

Total	7	38	32	12	4	93
(%)	7.5	40.9	34.4	12.9	4.3	100

- indicates absence

The number of pregnant females and embryos recorded during both season were given in Table 9**.** Except for *M. musculus* and *M. mahomet*, pregnant females were captured for the remaining four species. A total of 12 pregnant females were trapped during the two trapping season. The maximum number of pregnant females was recorded for *A. dembeensis* and *R. rattus* while minimum was recorded for *M. natalensis.* There was no significant seasonal difference in the total number of trapped pregnant females (χ^2=1.33, df=1, P>0.05).

Table 9. Number of embryos and pregnant females trapped during both seasons.

Species	Seasons	No. of Pregnant females	No. of embryos recorded
A.dembeensis	Dry	1	4
	Wet	3	4-6
M. erythroleucus	Dry	-	-
	Wet	3	8-11
R. rattus	Dry	3	5-7
	Wet	1	7
M. natalensis	Dry	-	-
	Wet	1	9
Total		12	

4.7. Diet analysis

A total of 38 individual stomachs from the six rodent species were analysed for food items and their proportion. A variety of food items were grouped into plant matter (grass, seed, stem and leaf,) and animal matter (arthropods, worms and hair) and the food items that were not recognized were grouped under unidentified materials (Table 10). Grass was the dominant food item in the stomach of *A. dembeensis.* Plant aerial parts were the most frequently eaten diet components during the dry season, whereas, consumption of animal matter was more during the wet season. Diet analysis indicated that there was no significant seasonal variation in types of food items. The proportion of different food items varied significantly between different species and within the same species in both seasons (χ^2=48.1, df=1, $p < 0.05$). Seed of maize, teff, grasses and other plant was identified from stomachs of all species in more proportions, indicating that most species are considered pest to the crops in the study area.

Table 10. The proportions of items in the stomach contents of trapped rodents during both seasons.

Species	Seasons	Samplings	Food items					
			Plant matters				Animal matter	U
			GR	S	St	L	AM	U
A. dembeensis	Dry	6	32.8	39	9.5	14	3.2	1.5
	Wet	4	38.8	23.8	11.8	11.3	7	7.3
M.erythroleucus	Dry	5	17.5	41.6	13.2	7.4	6.6	14.2
	Wet	3	17.1	28	10.3	8.3	17.3	19
R. rattus	Dry	4	8.8	45.3	16.3	5.3	10	14.3
	Wet	3	18	38.6	11.3	2.3	13.8	16
M. musculus	Dry	3	17	41	12	10.1	9.6	10.3
	Wet	2	16.5	43.5	10.5	7.5	9	13
M. natalensis	Dry	4	15.5	42.5	15	7	9	11
	Wet	3	11.5	35.7	10.3	7.5	18	17
M. mahomet	Dry	1	22.2	31.5	8.3	12.7	5.5	19.8
	Wet	-	-	-	-	-	-	-

(GR=Grass, S= seed, St= stem, L= leaf, AM=animal matter, U= unidentified material).

5. Discussion

In the present study, a total of six species of rodents were recorded from agricultural and grassland habitats. The species recorded were:-*A. dembeensis, M. erythroleucus, R. rattus, M. musculus, M. natalensis and M. mahomet.* This low species number might be due to the fact that monoculture plantations of the area. However, it is comparable with other reports elsewhere in Ethiopia. For instance, Afework Bekele & Leirs (1997) recorded 5 species of rodents from maize fields and grassland in central Ethiopia; Demeke Datiko *et al. (*2007) recorded 6 species of rodents from Arbaminch farmlands; Ejigu Alemayehu and Afework Bekele (2008) recorded 5 species of rodents from Bir Farm Development and nearby farmland area. Related studies in farmland (Manyingerew Shenkut *et al*., 2006) recorded even less/three rodent/species than the present study area.

During this study, unstripped grass rat, *A. dembeensis* was trapped from farmland and grassland habitats of the current study area, and it was the commonest and dominant species with respect to other species in both seasons. However, its abundance reach maximum in dry season. This observation is in line with the findings of Delany and Monro (1986); and Afework Bekele *et al*. (1993) in which their number attain its maximum during the mid-dry season. Thus, the high number of individuals of *A. dembeensis* in cultivated area, and grassland reflects its habitat preference. On the other hand, its opportunistic feeding and breeding behavior (Tilaye Wube, 1999) might have contributed to its adaptation to various habitats and hence, its distribution. Workneh Gebresilassie *et al.* (2004) also confirmed that, this species is abundant in areas of monocots and grasses. According to Afework Bekele *et al*. (1993) and Lavrenchenko *et al*. (1998), *A. dembeensis* is a major agricultural pest in Ethiopia. Therefore, its occurrence in the farmland is expected.

M. erythroleucus was recorded as the second most common and abundant species in the present study area, and is widely distributed and relatively associated with *A.*

dembeensis in agricultural land and grassland habitats. This species was recorded in different areas of Ethiopia by Afework Bekele & Leirs (1997); Bulatova *et al*. (2002) from Gambela, Tadesse Habtamu and Afework Bekele (2008) from Alatish Proposed National Park. It has also been recorded as widespread and most common species in natural habitat and farmlands from central Ethiopia (Afework Bekele *et al*., 2003). According to Fiedler (1994), *M. erythroleucus* occur all over the continent in natural grasslands, thicket, cultivated areas and human habitations; and considered important pest of maize crops in east Africa (Odhiambo *et al*., 2005).

During the present study, *Mastomys natalensis* was trapped both from farmland and grassland; however it was more abundant in the former habitat. This is in line with Demeke Datiko *et al.* (2007), in which this specie was more common in cultivated areas than other habitat types. *M. natalensis* was the most common rodent pest in sub-Saharan African countries (Fiedler, 1994). It occurs all over the continent in grasslands, cultivated areas and in human habitats (Lavernchenko *et al*., 1998). It has wider distribution in different parts of Ethiopia in altitudinal ranges of 500-2900m asl (Yalden *et al*., 1976). Compared with other rodents, Multimammate rats are the most successful seed and cereal feeders. Even after harvest, they continue to feed on fallen seeds for months. They are the only animals to feed on covered seed from a ploughed land (Taylor & Green, 1976).

Rattus rattus was the third abundant rodent specie in the present study area and it was trapped typically from the farm land habitat. This is in line with the finding of Solomon Mengistu (2011), in which *Rattus rattus* was exclusively trapped from farm land. This might be associated with the adaptability of the species to the modified and anthropogenic habitats (Auffray *et al*., 2009).As Mossisa Geleta (2010) stated that, *R. rattus* might make a visit to farmlands and back to human habitations based upon the availability of food and ground cover. It is known to be abundant in cities, villages, cultivated fields and in some natural forests (Nowak, 1999). *R. rattus* was one of the major pests of agricultural crop and stored food grains causing localized damage to crops (Smythe, 1986). It was a global commensal rodent that occurs frequently around human settlement areas, farmlands, and feeds in both fields and houses (Singleton *et al*., 2007).

Mus musculus was occurred more commonly in farmland than grassland habitat during the present study. This correlates with the finding of Solomon Mengistu (2011), in which *M. musculus* is more commonly trapped from farmland than other habitat types. As stated by Bates (1988), this species is exclusively urban and village dweller. It is a widespread species in Ethiopia (Yalden, 1988). This species is particularly abundant, not only in natural habitats, but also in man-made habitats (Lavernchenko *et al*., 1998).

M. mahomet was the least abundant rodent species in the present study area. It was rarely trapped from grass land habitat during only dry season. Happold and Happold (1987) have stated that within a community of small mammals, one or more responses may occur in relation to the changing conditions. Those species, which can fully adapt to the changing environmental factors, would survive better, whereas others, which can only partially adapt to the effects of changes, will decline in their population, resulting in changes in species composition and abundance. Hence, some species that occur in one season might not occur in the other season. It might be due to this reason that *M. mahomet* was not trapped during wet season.

In the present study, predominantly more individuals of each species were captured after harvest in the farmland habitat, and after some time elapse of post harvest there is a decline in number and shift towards grassland area were recognized. It is in accordance with the statement of Douangboupha *et al*. (2009), rodents appeared to move between habitats in response to the availability of food resources. As Magige & Senzota (2006) indicated, habitat heterogeneity and seasonal variations of the area are known to influence species richness, diversity and abundance of rodents. Habitat changes might be brought about by different factors. According to Joubert and Ryan (1999) diversity, distribution and abundance of small mammals are affected by wild ungulates and livestock due to overgrazing. Agricultural activities may play a role in habitat disturbance, decreasing cover with increased risk of predation, unfavourable to rodent populations while cultivating the agricultural field this is why, a shift towards grassland habitat is occurred in this study area just after the fields were harvested and lost its areal cover. Moreover, lack of cover after harvest might have exposed the animals to predators which could force them to migrate to more suitable habitats (Hansson, 1999). This might be the reason that the individuals of certain species have moved into the grassland habitat from the surrounding areas in search of food and shelter.

All the species trapped in this study area during dry season were also trapped in the wet season except *M. mahomet*, where population abundance of rodents was higher during the dry season compared to the wet season being maximum in the farm land and minimum in the grassland habitat (Table 3). This variation might be caused by seasonal variation in ground cover, food resources and other related environmental variables. In the present study area most rodent species were found to prefer the cultivated land habitat during dry season. This might be due to the granivorous nature of the species in search of fallen seeds as food and fallen plants as shelter, and this is in accordance with Workneh Gebresilassie *et al*. (2006),and who stated that, farmlands provide essential resources better than grasslands.

Rodent trap success varied widely between seasons as well as habitats. The farmland habitat had the highest trapping success (42.2%) relative to the grassland. The average total trap success of the present study was 20.5%. More over; the capture success of rodent was very high during the dry season (28.2%) when compared to the wet season (12.8%). According to Tadesse Habtamu and Afework Bekele (2008), such variation might be associated with the wet season breeding behaviour of most of the rodents of the area that can reach trappable age where they move away from the nest site by gaining weight through time reaching sub-adult and adult stages during the dry season.

Individuals of all age categories were present during this study in both trapping period. As far as the number of all age groups was compared during both trapping periods, 60% adults, 31.4% sub adults and 8.6% juveniles were recorded. This finding correlates with the findings of Mesele Yihune and Afework Bekele (2012), and Workneh Gebresilassie *et al*. (2006),in which the increase in trap success with age could probably reflects the presence of large home ranges for adults and sub- adults to alleviate the cost of competition with juveniles. When reproduction is seasonal, it is expected that all age groups appear in the population within that specific season. On the other hand, in some species of rodents, all age groups appeared irrespective of the season (Tadesse Habitamu, 2005). In this study, 69 % of the total captured individuals were males while the left 31%were females during wet season of trapping. This variation in the proportion of males and females might be due to mobility of males. Odhiambo and Oguge (2003) stated that males generally make wider field excursion than females. On the other hand the responsibility of females in nursing their litters might have hindered their movement from one area to the other, consequently limiting the chance of entering the traps.

The result of body measurement for *A. dembeensis*, *M. erythroleucus and Mus musculus* (Table 8), shows a significant decrease in body weight during the dry season. This result is consistent with Azied Osman (2007) in which there was significant decrease of body weight for most of the rodent species. This might be associated to the limited availability of food sources both in quality and quantity during the dry season than wet season.

In the present study, pregnant females of *A. Dembeensis* were trapped during both seasons. This is consistent with the finding of Delany and Roberts (1978), in which continuous breeding throughout the year was reported. In similarly fashion pregnant females of *R. rattus* was also trapped during both seasons. This is in line with the findings of Grzimek (2003), who has reported that the species of *R. rattus and P. harringtoni* are able to breed throughout the year if conditions allow. During wet season of trapping, 53.4% and 20.7% of reproductively active males and females were captured. Among females trapped during wet season, relatively more individuals of pregnant females were captured. As Marcello *et al.* (2008) pointed out that, the wet season is full of more nutritious food which could promote breeding of animals. In addition to this, Tilaye Wube (2005) stated that, breeding decreases during the dry months.

Diet analysis from the stomach content confirmed that rodents feed on a variety of food sources, both plant and animal matters. This is in agreement with Campos *et al.* (2001), in which who indicated that, the feeding ecology of small mammals throughout the world is highly diverse. There was a high percentage of animal matter during the wet season, and plant matter during the dry season. This is in line with the reports of Workneh Gebresilassie *et al.* (2004), who described rodents as opportunistic feeders, capable of changing their feeding habits depending on the availability of food from season to season. Also Frith and Frith (1990) indicated that the number of invertebrates increases with an increase in precipitation and the number declines during the dry months. Furthermore, Martin and Dickinson (1985) also described the rainy season as a time of abundant invertebrate populations, which may be a source of food for small mammals.

In the present study the stomach content analysis of the *Mastomys erythroleucus, Rattus rattus, Mus musculus, Arvicanthis dembeensis, Mastomys* natalensis and *Mus mahomet* indicate that there was comparatively prominent amount of seed in almost all species of rodents illustrating that they are pests. Afework Bekele and Leirs (1997) and Makundi *et al*. *(*2005), reported that, there are eleven species of rodents in Ethiopia that can be classified as pests, among which *Arvicanthis dembeensis* and *Mastomys erythroleucus* are the major ones in the agricultural field of Ethiopia.

6. Conclusion and Recommendations

The data collected during the present study provided valuable baseline information on diversity, diet composition and breeding season of rodents in agricultural field and grassland area. Six species of rodents were recorded from the area. The species identified and recorded were *A. Dembeensis, M. erythroleucus, R. rattus, Mus musculus, M. natalensis and M. mahomet. A. Dembeensis,* with highest individual was recorded from both habitat types together with *Mus musculus,* during both seasons. From the results of present study it is important to observe that farmland had relatively highest species richness and diversity resulting in more individuals to be recorded during dry season. But there is a habitat shift of certain species towards grassland area during wet season. Furthermore variation in species richness among the rodents was observed in both habitats due to seasonal migration of rodents from farmland to grassland habitats and vice versa. This confirm that the abundance of rodents consistently respond to habitat disturbance, decreased cover with increased risk sensitivity and reduced movements with regard to food availability.

Individuals of all age categories were present during this study in both trapping period. . In this study, 69 % of the total captured individuals were males while the left 31%were females during wet season of trapping. The capture success of rodent was very high during the dry season when compared to the wet season. Among females trapped during wet season, relatively more individuals of pregnant females were captured. The maximum number of pregnant females was recorded for *A. dembeensis* and *R. rattus* while minimum was recorded for *M. natalensis*. Grass was the dominant food item in the stomach of *A. dembeensis* during both seasons as compared to other rodent species, where as seed was eaten by all species in more proportion. Therefore, what an animal eats is surely one of the most important aspects of its relationship with its environment, detailed knowledge of each species' auto ecology is necessary to understand the ecological processes in which it is involved, such as its population dynamics and its interactions with other species within communities.

Based on the baseline information obtained from the study area, the following recommendations are familiar:

- During the present study, even if rodent diversity and species composition were low, detailed information on the ecology of each species is essential to design conservation and management programme. Therefore, further extensive and detailed study in the study area should be conducted that may yield more rodent species that were not trapped due to various reasons.

- High levels of livestock grazing also affect the quality of the habitat suitability for rodents in both habitat types through a reduction in ground cover resulting in altered predation risks. Therefore in order to record and have detailed information regarding rodent abundance and species composition high level of livestock grazing should be minimized in both habitats.
- Removal of refuges surrounding agricultural habitats, field sanitation as part of habitat manipulation should be conducted to avoid periodic migration of certain species of rodents between habitats, and to reduce shelter and food availability should be recommended as management techniques within the framework of ecologically-based rodent management.

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Declaration

I, hereby, declare that, this thesis is my original work, that it has not been submitted and presented in any universities to achieve an academic grading for similar specialization or for another purposes. Where ever contributions of others are involved, every effort is made to indicate this clearly, with due references to the literature and acknowledgement source made; and this thesis has been in partial fulfilment for M.Sc. degree at Jimma university.

Name________________________________

Date______________________

Signature___________________