College of Natural Sciences

School of Graduate Studies

Department of Biology

Distribution, Abundance,diet composition and pest status of common mole rats *(Tachyoryctes splendens)* in some selected kebeles of Gimbo Woreda Kaffa Zone southwest Ethiopia.

By:-Teshome Mulatu

Advisor: -Tsegaye Gadisa (PhD.)

A Thesis submitted to the Department of Biology, College of Natural Sciences and School of Graduate Studies, Jimma University in partial fulfilment for the requirement of the Degree of Master of Science in Biology (Ecological and Systematic Zoology).

OCTOBER, 2015

JIMMA, ETHIOPIA

DECLARATION

I, the undersigned, hereby declare that this thesis is my original work; it has not been presented in University, college or Institution. All sources of material used for the thesis have been duly acknowledged.

Name:Teshome Mulatu Signature:

Date: 23/10/15

Place:Jimma university

Date of submission: October, 2015

ACKNOWLEDGEMENTS

First and foremost, I would like to honor and extend my sincere gratitude to my God, for providing me the opportunity to make my long term dream a reality and for being with me in every piece of life and activity during my stay in the university. I would like to extend my heartfelt thanks to my main advisor Tsegaye Gadisa (Ph D) for his valuable advice, insight and guidance starting from the inception of the proposal idea to the completion of the thesis, materializing this research work. Without his unreserved support, not only instructive, but also fatherly follow-up, advice and provision of all necessary equipment, it might not have been finalized. In addition, commenting on the draft document and provision of reference materials are appreciated.

I am also thankful to all my colleagues and relatives especially, Tadele Abebe(Msc) the one who encourages me in my research work, material and assisting all direction . My appreciation also goes to Melaku Haile(Msc)the one who is with me in all my work supporting morally and giving direction in my work. I would like to express my deepest appreciation for who acted as father Ashebir Mulatu (MA.)for his un reserved material, moral and financial support. In addition my thanks also go to gimbo woreda agricultural and rural development office, agricultural extension workers and biology department too.

Finally, my special recognition goes to my wife W/ro Addisalem Teshome for being with me all the time providing me moral, financial and support, and encouragement by shouldering all family burdens in my absence with patience and endurance. I express also my heartfelt thanks to my children Mekilit Teshome, Rediet Teshome, for all the cooperation they did during my academic and research work.

TABLE OF CONTENT

CONTENTS **PAGE**

APPENDIXIS

List of tables

List of figures

Acronyms

GPS Global Positioning System

IBC Institute of Biodiversity Conservation

IUCN International Union for the Conservation of Nature

Abstract

Mole rat is the main rodent pest on Enset though its effect is minor on other crops. This study was conducted to assess current distribution, abundance,diet composition and pest status of common mole rats in some selected kebeles of Gimbo woreda, Kafa Zone, Southwest Ethiopia from September 2014 to Feburar2015 E.C. Field observation was used to estimate the population of common mole rat and plant damage due to common mole rat. Structured questionnaires and interviews have been conducted for gathering information. Stomach content analysis was carried out to confirm its diet. Direct total count was carried out from fresh surface signs (mounds) to estimate abundance and distribution of mole rats. "Mesh trap" was used to capture the mole rats . The "Dega" climatic zone sites have more mole rat population than the "Woina-dega" climatic zone sites. In addition wet season has high mole rat which is about 68.75% and dry season31.25%..It is generally assumed that the abundance of Common mole rats increases with increasing altitude, high number of common mole rat were recorded in dega climate Maligawa site whose altitude was 2203m-2291m asl the number of mole rat listed were 11 and in ceraba site whose altitude was 1733-1751 m asl low number (6)common mole rat were recorded .In this investigation external body measurement of the animal showed that there was no significant variation from the population of other localities of Ethiopia. The head-body length measurement were between 192 to 244 mm; tail length 48 to 66 mm body weight between females and in a males weight ranges from 210 to 281g and females ranges from 213 to 282g ,this indicates weight is sex independent. In diet analysis highest fragments of enset and grass were identified in both dry and wet seasons. Loss on enset plantation is high, about 16.9% .So it is calculated that mole rats are potential pest of enset plant; therefore, it needs further investigations to minimize the pest status. Habitat modification is very important since periodic cultivation is probably the greatest value to reduce its foraging site.

Key Words: Burrow, systems, Common, Enset, Dega, Woeina dega, Wet, Dry

1. INTRODUCTION

1.1. Background

Rodents are the most diverse group of mammals (Vaughan *et al.*, 2000). They show great diversity in their ecology, morphology, physiology, behaviour and strategy (Nedbala *et al.*, 1996). They are adapted to wide ranges of environments (Nowak, 1999). Common mole rats prefer open habitats like grasslands, wooded savannah with scattered trees and cultivated areas with loose soil and they occur at altitudes ranging from 1300 to above 4000m asl in different regions in Ethiopia (Yalden, *et al.,* 1976; Bekele and Leirs,2003).

The East African common mole rat (*Tachyoryctes splendens*) belongs to the class Mammalia, Order Rodentia, family Spalacidae and is distributed in Ethiopia, Somalia, the Democratic Republic of Congo, Burundi, Rwanda, Kenya, Uganda, Tanzania and other parts of East and Central Africa (Musser.*et al*., 2005).The systematic position of mole rats is not well established. According to Nowak (1999), the total number of species in the genus *Tachyoryctes* is not clearly known. But Baskevich, et *al*., (1993) considered *Tachyoryctes splendens* as one of the 14 species of the genus *Tachyoryctes*. However, Kingdon, (1997) recognized 11 species of the genus *Tachyoryctes* in the Family *Rhizomyidae*. Recently many taxonomists agree to include two species in the genus *Tachyoryctes:* the widespread, *T. splendens* and the larger, *T. macrocephalus* which is confined only to the Bale Mountains of Ethiopia (Yalden, *et al*., 1976).

East African common mole rats construct a burrow system consisting of multipurpose central nest, bolt-hole to retreat and numerous foraging tunnels (Jarvis and Sale, 1971). The foraging tunnels of the common mole rats are usually just below the root levels. Due to this reason common mole rat always get fresh underground plant parts (roots, rhizomes, tubers,) as well as stem bulbs and grasses. These are indiscriminately taken into underground hole (Bennett and Jarvis, 1995; Jarvis and Sale, 1971; Kingdon, 1997; Mengistu and Bekele, 2003).

Common mole rat stores food in nesting chambers for adverse conditions (Yaba *et al.*, 2011).Although the usual foraging is through complex underground tunnels, it sometimes comes out to the surface in order to collect nesting materials and food (Bennett and Faulkes, 2000).

In the burrow system, the foraging tunnels may reach up to 52 m depending upon the availability of food (Jarvis and Sale, 1971; Nowak, 1999, and Zumbera, *et al.*, 2008).

The mole rat is known pest on enset, grass, potatoes and other crop plants and cause significant reduction of yield (Kokiso, 2006).This reduction of yield could be a serious problem in areas where the major food crops are root crops such as enset and potatoes. To reduce this crop loss, proper control and sustainable management of pests should be given priority (Greaves, 1982 and Singleton, *et al.*, 2003). Therefore, the present study aims at identifying the distribution, abundance and diet of common mole rat with its burrow system.

1.2. Statement of the problem

Gimbo is one of the Woredas in Kafa Zone where different underground root plants such as enset, potatos, sugarcane, and different cereals are grown. Common mole rats destroy different types of crops such as enset, coffee, sugarcane, potatoes, vegetables, cereals and grasses due to their ubiquitous feeding habits. Due to high abundance of common mole rat, significant amount of crops are destroyed each year. As a result, there is high complaint from farmers about the damage they pose on root plants and cereals. Most of their agricultural products are exposed to common mole rats, due to this reason seasonal or yearly yields of agriculture were less when compared with that of secured farmers.

Due to lack of knowledge to control common mole rats, farmers are suffering from the attack of common mole rat .Gimbo is among the Woredas in southwest Ethiopia that harboured large number of common mole rat. Thus, proper control and sustainable management of common mole rats is pre-requisite to keep food security in the district mostly for farmers who depend on monoculture (enset). However, no study has been conducted on common mole rat to assess its distribution, abundance, diet composition and pest status design control measures. Therefore, this study tried to identify distribution, abundance and diet common mole rat, and so this research can give some clue for interested persons, NGOs, Rural development offices and also who wanted to conduct further researches in the future.

1.3. Objectives

1.3.1 General objective

The general objective of this study was to determine distribution, abundance, diet composition and pest status of common mole rats *(Tachyoryctes splendens)* in Gimbo Woreda, southwest Ethiopia.

1.3.2 Specific objectives

- To determine habitat preference of common mole rats in Gimbo woreda
- Determine abundance of common mole rats in Gimbo woreda
- To determine the burrow system of common mole rat in Gimbo woreda
- To identify the type of crops most affected by the common mole rat in Gimbo woreda
- To quantify the extent of damage to agricultural products in the selected sites

1.4. Significance of the Study

This study focuses on distribution, abundance and diet of common mole rats and estimating crop loss due to common mole rats. These pest animals specially damage crop plants such as enset, coffee, sugarcane, potatoes, vegetables, cereals and grasses. Therefore, this study provides information about the crop species mostly destroyed by common mole rat. In addition, it expresses the problems that famers face due to the conflict in regard to agricultural yield loss and energy expenditure to mitigate the problem. Furthermore, it express the seasons associated with severe crop plant damage and the farmers whose crops are most exposed to such damage. This documentary evidence was aimed at bringing about conservation and socio-economic stability of the farmers who are suffering from the attack of common mole rats. It is also beneficial for affected farmers by screening out their problems for concerned bodies. So it gives ways to local, national and international agencies that, may develop appropriate measures to control common mole rat.

2. Literature review

2.1. Some important features of common mole rat

The East African mole rat (*Tachyoryctes splendens*) is common across most of its range and its population seems stable. It does not face any major threats and for this reason, the IUCN lists it as being of "Least Concern" in its Red list of threatened species (Schlitter, *et al., 2013).*It is the least modified among the East African mole rats (Jarvis and Sale, 1971). Their external morphology is basically rat like; cylindrical with small eyes and ear pinnae, short limbs and tail, broad feet and large prominent incisors are modifications for underground life. The head-body length is 160 to 260 mm; tail length is 50 to 100 mm and weighs from 160 to 280g (Nowak, 1999). The other species in the genus *macrocephalus* is large in size. Its head body length reaches about 313 mm and body weight ranges from 330 to 930 g (Nowak, 1999; Yalden, 1975).The short tail of *Tachyoryctes* is about twice the length of the hind feet and usually well haired (Darlington, 1985).

In south Ethiopia, Kokiso (2006) in Angacha district from 14 specimens recorded, head and body length of 222 to 268 mm, tail length 54 to 80 mm, hind foot length 29 to 33 mm, and skull length of 47 to 57 mm. The colour and size of common mole rats are very variable. They can be black, brownish, reddish brown, pale gray (Kingdon, 1974; Bekele, 1986; Nowak, 1999; Yalden, 1976). Hence colour variations are not used as taxonomic characteristics. The young are black in colour. However, counter shading develops at advanced age. This counter shading disappears at old age in naked mole rats (Braude, 2000). *Tachyoryctes rex* is a very large species with fluffy fur (Yalden, 1983). Males are larger than females. Young animals are dark-furred, with some irregular white areas on their under parts. In young animals, the crown area of the molars is small, but it grows with wear in adulthood until reaching a maximum, after which it shrinks again. The iris is dark gray-brown (Hickman, 1990).In comparison to those of *Tachyoryctes audax*, the nasal bone is larger and has angles at the sides. *T. annectens*, which is nearly large, has smaller teeth and nasals; in *T. rex*, the back part of the mandible (lower jaw) is better developed and has the capsule of the incisor placed further to the front (Musser, et *al.*, 2005).Some taxonomic works have included *T. rex* and many other *Tachyoryctes* species in *T. splendens*; though without evaluation of the distinctive characters of the previously recognized species (Musser and Carleton, 2005).

Modern description and classification of species uses karyotype and DNA analysis. Analysis of karyotype number and karyotype morphology is important in the study of the biology and characterization of the species (Baskevich, *et al.*, 1993).Matthey, (1976) and Jotter and-Bellomo (1984) demonstrated that karyotype is a species characteristic as a rule. Despite this, karyotypes of subterranean, fossorial rodents exhibit greater diversity both between the species and within the species than most rodents (Nevo, *et al.*, 1986; Antinuchi and Busch, 1992). This view is not still accepted by some authors (George, 1979; Patton and Sherwood, 1983). Despite controversies among authors on subterranean rodents on common mole rats, the karyotype study shows 2n = 48, but autosomal fundamental numbers and centromere position of sex chromosomes are variable (Baskevich, *et al.*, 1993; Ziyine, 2005).Burda *et a*l., (2000) provided additional information using more material, and affirmed the relationship between *T. rex* and *T. audax*. He noted that the two were similar in coloration, but that *T. rex* was much larger. According to Musser and Carleton, (2005), *T. audax* is somewhat darker in colour.

2.2. Distribution of common mole rats

The distribution pattern of the East African common mole rat (*Tachyoryctes splendens*) is discontinuous ranging from Ethiopia and parts of Somalia as far as Eastern Zaire, Burundi and Northern Tanzania (Nowak, 1999). It is native to East Africa and the eastern parts of Central Africa. It is found at elevations of up to 3,300 metres in Ethiopia and up to 3,000 metres in other parts of its range (Musser.*et al.*, 2005). It is an adaptable species and able to live in a range of habitats including savannah, moist tropical forest, agricultural land, pasture, coffee plantations and gardens. They seldom occur in areas with less than 500 mm rainfall per annum, but they are best established in wet uplands (Kingdon, 1974, 1997; Herbst *et al.*, 2006; Nowak, 1999).

The distribution pattern of common mole rat varies and fluctuates seasonally based upon altitude and vegetation cover as well as climatic factors like precipitation (Bekele and Mengistu, 2003). *Tachyoryctes* favours deep, well-drained, often-volcanic soils, rainfall over 510 mm a year and vegetation cover of grass to open forests (Jarvis and Sale, 1971).Thus, local distribution of common mole rat is influenced by topography, soil and vegetation characteristics of the habitat. Since areas of suitable soil and vegetation are patchily distributed, individuals also tend to be spatially clumped (Bennett and Faulkes, 2000).

It is easily observed in *Tachyoryctes splendens* (Broekman *et al.,* 2006).However, *Ctenomys australis* that inhabits ecologically homogeneous sand dune has a relatively continuous local distribution (Zenuto and Basch, 1998).

2.3. Tunnel system and feeding habit of common mole rat

The physical surface and structure of burrow system indicate signs of presence/ absence of common mole rat in an area. Since common mole rat is a ubiquitous feeder, its habitats should provide grass roots, rhizomes, stems and leaves, herbs, shrub and tree roots, tubers, bulbs and corms (Broekman *et al.*, 2006).

Common mole rats feed upon wide range of roots and shoots searching through underground tunnels. They spend limited periods on the surface (Sklíba *et al.,* 2007). According to Jarvis and Sale (1971), the depth of foraging tunnels is regulated by root (rhizome) level of the plant on which the mole rats feed upon. Its presence results in a change in vegetation on the mounds, which have fewer grasses and more woody plants; because the animal eats plant roots or the soil is altered (Rundel, *et al.*, 1994).

For many mammals including rodents, subterranean burrows play an important role in their environment. Burrows may be used as places of refuges and storage as well as nest sites (Carter and Encarnacao, 1983; Carter and Rosas, 1997).The construction, use and maintenance of the burrow are the central element to the subterranean species. Despite the assumptions that a subterranean lifestyle imposes similar selective pressures on mammalian inhabitants, regional variation in climate, soil and vegetation is considered important in generating adaptive differences among populations and species. As a result, convergent taxa may display different local adaptive peaks that reflect variation in local environment (Musser and Carleton, 2005). Burrow system of mole rats contains either one functional nest for *Cryptomys* (Hickman, 1979 and Marino, 2003) or accessory nest chambers may be present for *Spalax* (Sumbera *et al.*, 2003).

The diameter of the nest chamber difference is related to the size, number of occupants and the function of the nest. The nest chamber is primarily sleeping, resting and breeding site for *Cryptomys* (Hickman, 1979), and *Heterocephalus* and *Heliophobius* (Jarvis and Sale, 1971). Spalax builds nest during the breeding season (Sumbera *et al.*, 2003).*Tachyoryctes splendens* constructs large, single, multipurpose nest for food storage, sleeping, sanitation as well as for breeding (Jarvis, 1973; Jarvis and Sale, 1971).As the mole rat is alarmed, it retreats into this tunnel and plugs it in order to mislead the source of the alarm. Thus, bolt hole serves as escaping tunnel from the danger (Jarvis and Sale, 1971). However, Hickman (1977) argued that the deep tunnel bolt hole primarily functions to keep humidity high in the burrow system.

3. Study area and methods

3.1. The study area

The present study was carried out in Gimbo woreda, Kaffa Zone, Southwest Ethiopia (Figure 1). The area is located between 6^0 35' to 07^0 15'N latitude and 35^0 25'E to 36^0 42'E longitude , 18 km south of Bonga town, the capital of Kafa Zone and 431 km southwest of Addis Ababa. The altitude of the area ranges between 1150 and 2650m asl (Gimbo woreda agricultural development office). The Woreda is bounded by Oromia National Regional State in the east and north east, Gewata woreda in the North, Adiyo woreda in the South west and Bonga town towards west.

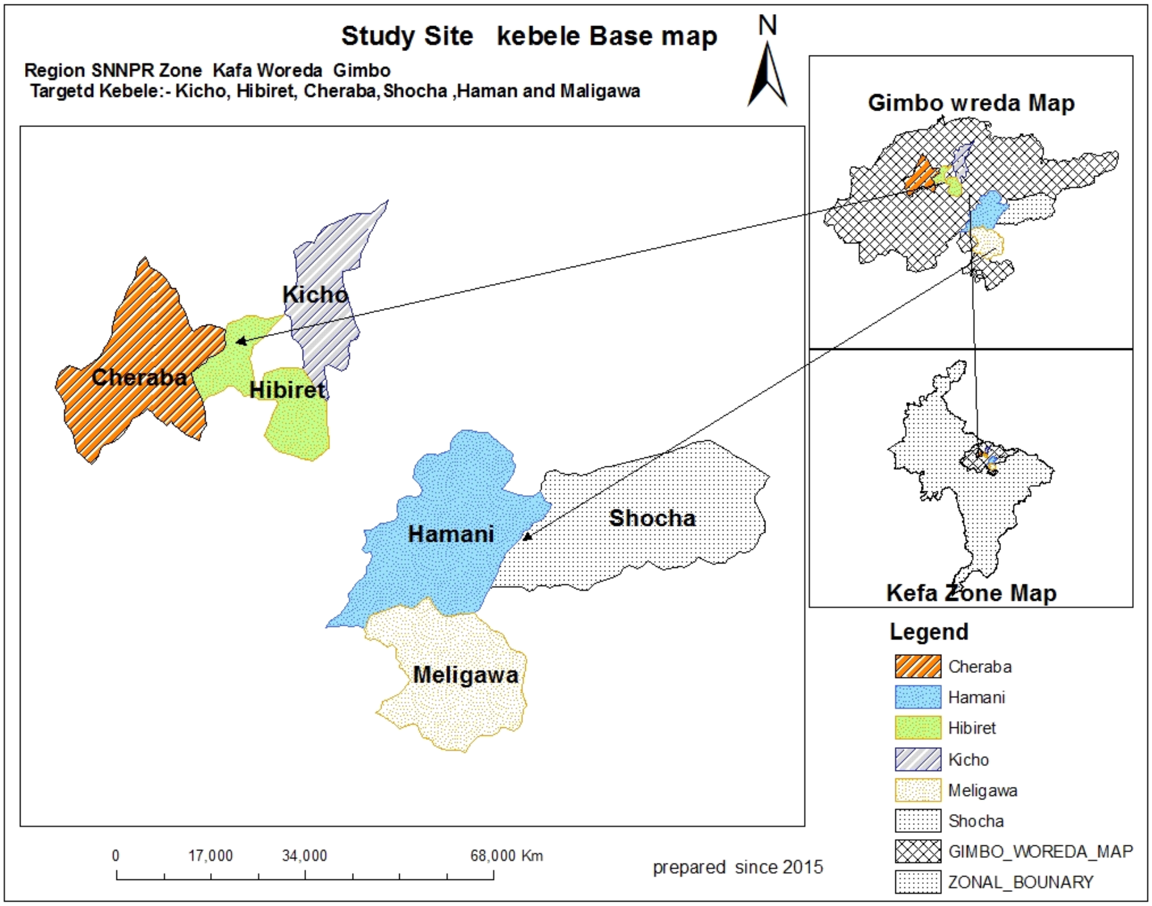

Figure.1. Map of Gimbo Woreda and the study sites

The Woreda covers 87186.05 km^2 and has a population of 147500 (Gimbo woreda finance and economy office 2007 E.C. report). The major land covers of Gimbo woreda is forest and agriculture associated with human settlement. Forests found in the study area cover about 29499 km^2 among the remaining natural forests in Ethiopia, where different kinds of mammals and aves are found. The study area consisted of six kebeles, three from dega climatic zone and other three from woeinadega climatic zones (Figure 1). Table1below shows the climatic zones and altitudinal ranges of the study sites of the present study (Haman, Maligawo, Shocha, Kico, Hibiret and Ceraba.)

Table.1.The climatic zones and altitudinal ranges of the study sites

Sites	Climatic zone	Altitude in m above sea level
Haman	Dega	2153.3-2219.4
Maligawo	Dega	2203-2291
Shocha	Dega	1922-2013
Kico	Woyina-Dega	1737-1758
Hibiret	Woyina-Dega	1738-1752
Ceraba	Woyina-Dega	1733-1751

3.2. Climate

3.2.1. Temperature

According to the Ethiopian meteorological service agency of Bonga station, the mean minimum annual temperature ranges from 6.63^0C to 13.5^0C, mean maximum temperature ranges to 26.16^0C to 30.87^0C variations were observed in the warmest years 2011, 2012, 2013and2014 while temperature drops from 2005-2010 during the peak rainy years due to the effect of cloud cover (Figure 2).

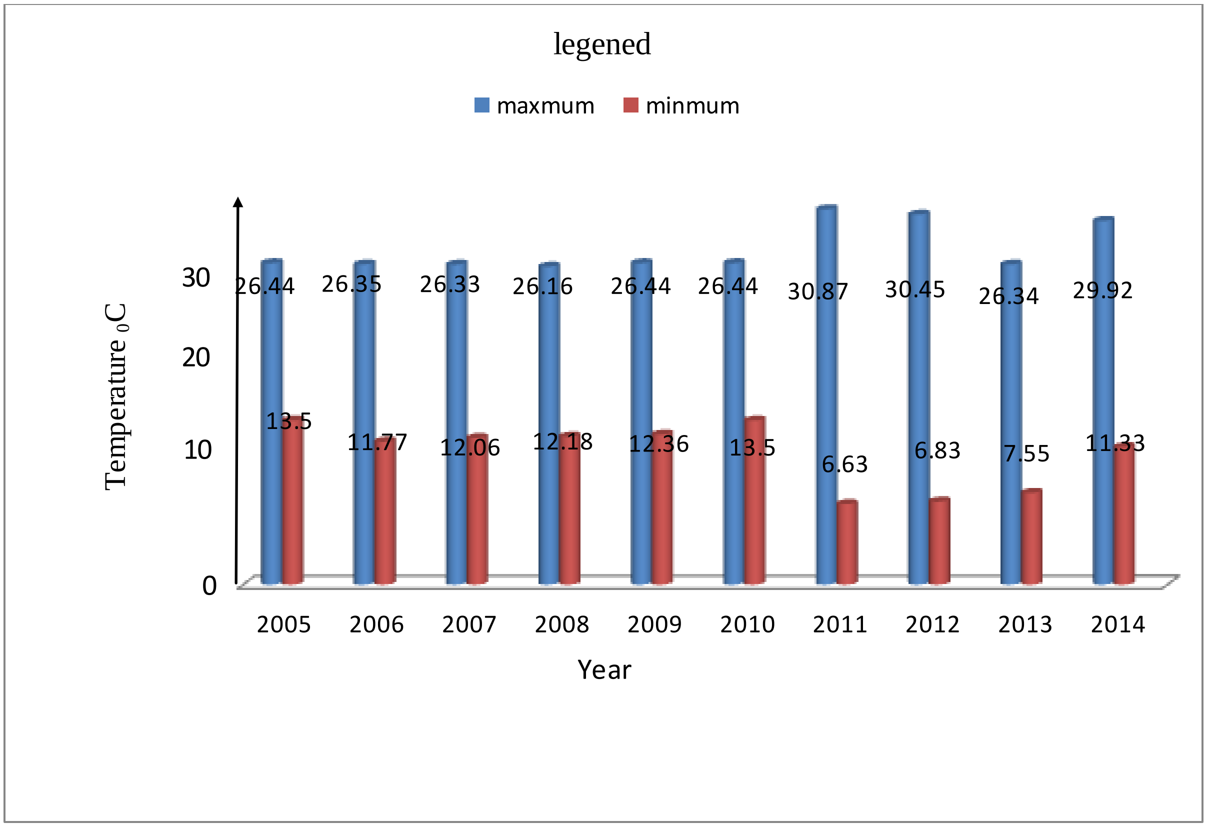

Figure2.Mean annual maximum and minimum temperature of Gimbo woreda for the years 2005 to 2014 Source: NMSA 2005 to 2014

The mean monthly minimum temperature of the area ranges from 9.36^{0}C to 11.9^{0}C,mean monthly maximum temperature ranges 25.5^{0}C to 30.21^{0}C and the mean monthly temperature varies 11.1^{0}C to 27^{0}C.The warmest months are December, January, March , April and, May, while temperature drops during the peak rainy months September, October, November , February ,June ,July, August(Figure 3).

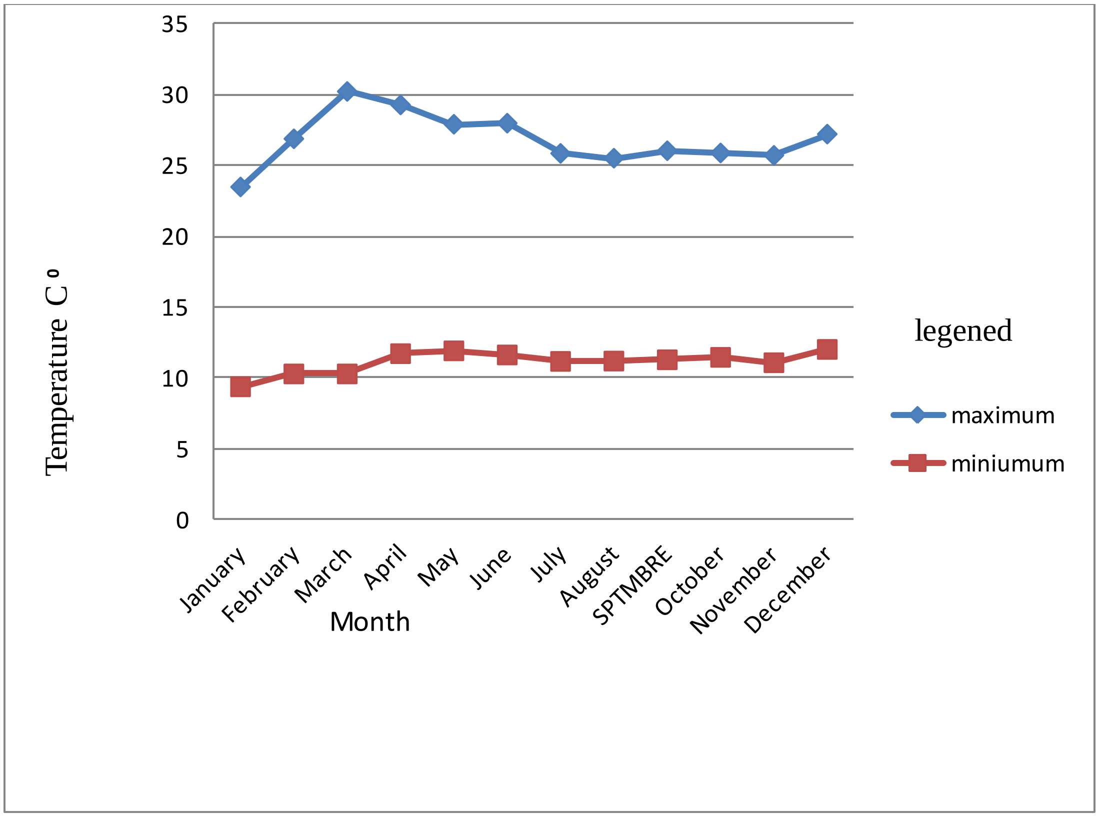

Figure.3. Monthly average maximum and minimum temperature of Gimbo for the

Year 2005 to 2014 Source: NMSA 2005 to 2014

3.2. 2. Rainfall

Gimbo Woreda is part of the southwest Ethiopian highlands which receive the highest amount of rainfall in rainy seasons. This is attributable to the presence of the evergreen forest cover on top of the windward location to the moist monsoon winds. The mean annual rainfall of the woreda is 1935.4mm. But the mean annual rain varies among years (Figure 4)

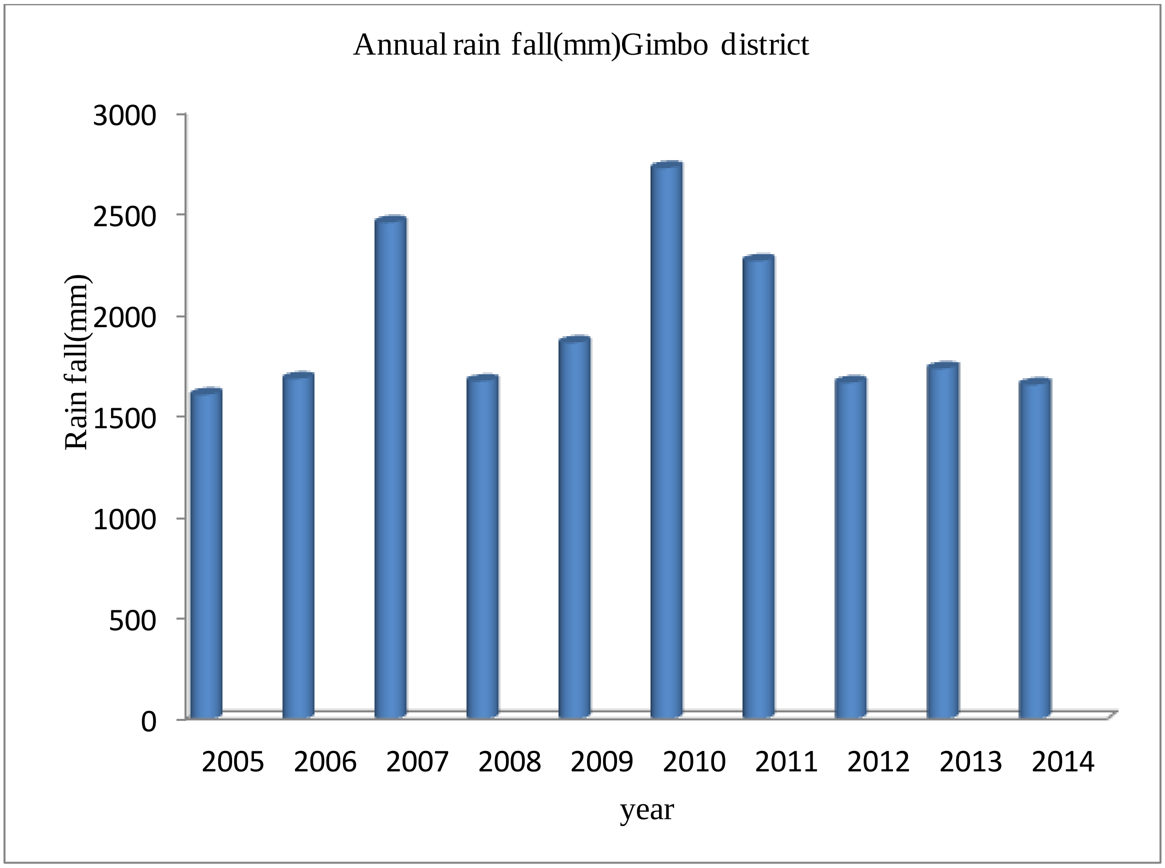

Figure 4 .Total annual rain fall (mm) of Gimbo woreda from 2005 to 2014

The monthly rainfall of the woreda is between55.58- 271.43mm. The largest amount of rain occurs between April and September. The peak rainy months are June, July, August and September while December, January, February and March are the drier months.

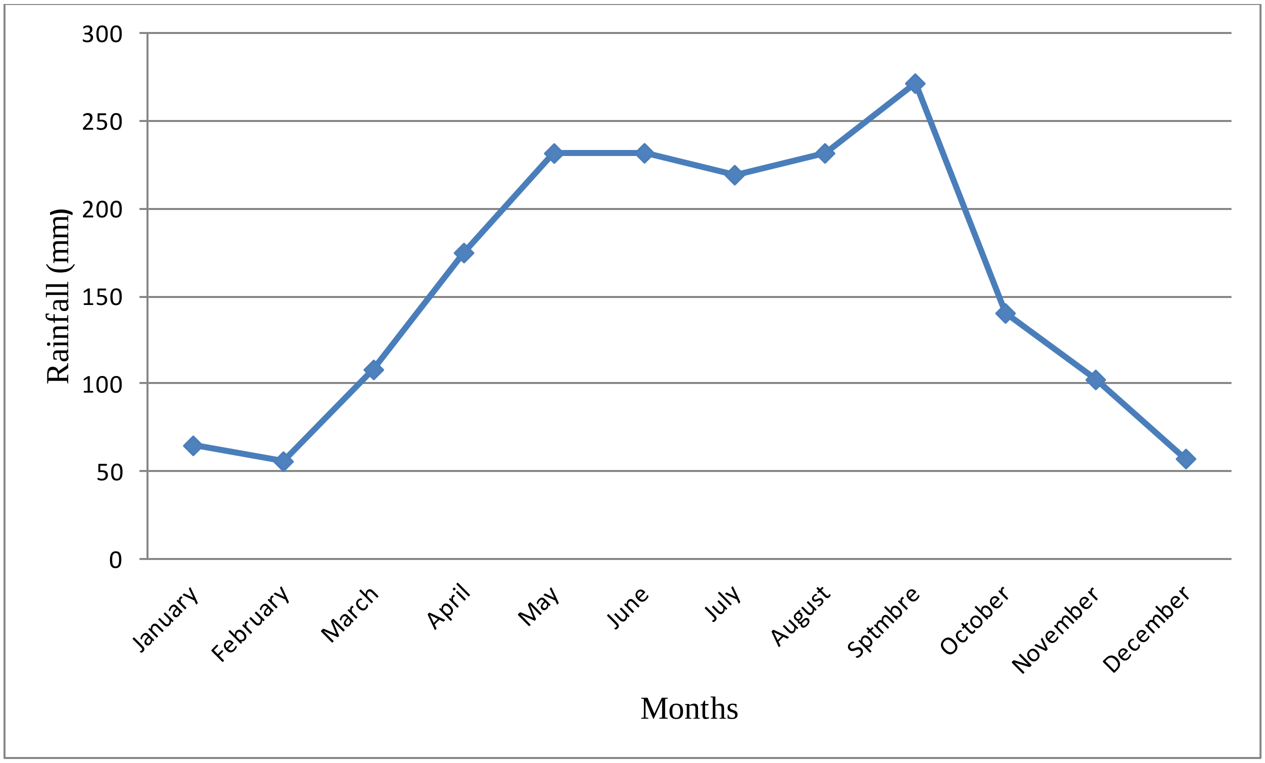

Figure. 5 Mean monthly annual rain fall Source: Bonga branch metrological station

3.3. Preliminary survey

Preliminary survey was conducted for fifteen days before the actual data collection to gather relevant information about the study area. This helped to determine the specific study sites based on the abundance of common mole rat sign and the severity of crop damage. The survey was also important to gather current information on farming activities of the society and to map the study area. Relevant information was gathered from concerned bodies including local people living around the study area, agricultural extension workers and Gimbo woreda agriculture and rural development office workers.

3.4. Materials

The materials used to collect data were GPS, Camera, Dissecting kits, meter tape, ruler, pesola spring balance, spade and axe. The Conical local trap made of Iron wire, string, "Woficho" and"Mesh trap"was employed for trappings common mole rats. Baits used were potato (*Solanum tuberosum*), garlic (*Allium sativum*), and spicy herbs like bite (*Ocimum sanctum varanisatum* (cosereto, shoobo) in kafinoono.

3.5. Methods

The study covered both wet (September - November) and dry (December - February) seasons. Among 32 kebeles of Gimbo woreda, 6 kebeles were selected by purposive sampling. Three sites were selected from "Dega" and the other three from "Woina-dega" climatic zones based on information from rural and agricultural development office and by observing the amount of crop loss caused by common mole rat (*Tachyoryctes splendens)* in the area. The abundance of mole rat in each of selected farm field was estimated based on mound sign count and the technique used were 0.1 to 0.2 ha per crop field to determine the abundance of common mole rat. The common mole rat trapped from each site were extrapolated to calculate the number (Kokiso, 2006).Total count from surface signs (mounds)(Figure 6) was also carried out to estimate the number of mole rat in the specific site and it helped to count the number of common mole rat of area used (Katandukila., *et al*., 2013).

Figure.6.Mound signs (Photo Teshome M.)

The burrow system of the mole rat was determined by using map of the surface by digging the burrow line of common mole rat.

The abundance of mole rat among the selected sites was compared between the dry and wet seasons. The diet of common mole rat in the selected study sites was studied through observation, questionnaire and microscope of fecal sample. Animals were trapped (Figure 7b) to determine the number of common mole rat in the study site by using mesh trap(Figure 7a).Trapped common mole rats external body measurements from study sites were measured. Weight in(g) and length in(mm)were used as standard measurements; body weight (W), total length (TL), head - body length (HB), tail length (T) and hind foot length (HF) were measured in (mm) by using ruler and putting the captured mole rat on flat surface dorsoventrally. Body weight was recorded using Pesola spring balance to the nearest 1g (Figure 8).

.

Figure 7(a)Yeshibowotimed and7(b)trapping process (PhotoTeshome M.)

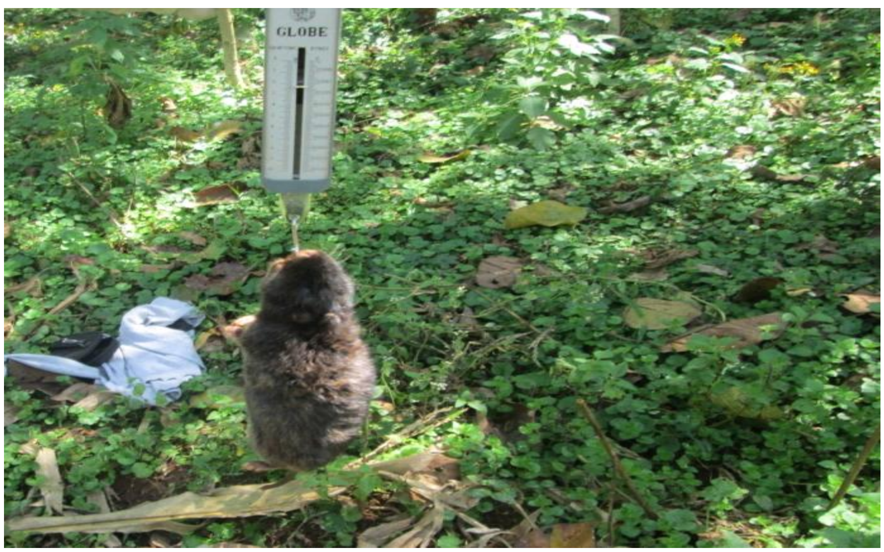

Figure 8.Measuring body weight of common mole rat (Photo Teshome M.)

Count on damaged crop plants and grazing grasses per plots was carried out to determine feeding habit and pest status of the common mole rats as well as its impact on agricultural farmland in the selected kebeles in the woreda.

Total count was carried out to estimate the damage caused by common mole rat on enset due to the accessibility to count easily. The damaged eset plants were counted for 10 to 12 days per month in both wet and dry seasons. From the damaged enset plants percentage losses were calculated per study sites based on direct count of enset per hectare.

During counting, 667 enset plants were counted per hectare, therefore the number of damaged enset plants was divided by 667and multiplied by 100 to calculate the percentage loss and finally it was changed to year by doubling the result, since the result were only six months. In addition, the incomes in birr for each locality were calculated. Farmers evaluated the loss of enset plant based on its growing stage; big which is 5-7 year=75 birr, medium3-5 years 30 birr and small less than 2 year =10 birr. Therefore, the researcher used the mean value for his work which is 38birr per each enset plant as information gained from farmers. However, damage on potatoes, cereals and pulses was estimated in non-parametric method. During the time of my observation I recorded the damage happened on those actual days and also taken documented recorded data from the assigned persons from the data sheet. This means in every period of observation the number of damaged crop, and the stage at which the pests caused damage was documented on field data sheet (appendix IV), to estimate the damaged enset it was counted for 10 to 12 days per month in both wet and dry seasons (Kokiso,2006).

For diet analysis, common mole rats were dissected and their stomach was preserved in 70 % alcohol and later used for analysis in the laboratory as done by Yaba (2007). Each sample was washed, filtered and dried separately for observation under the microscope at high power of magnification(X40),four slides were prepared for each sample. In addition, local people were interviewed to get information about the animal and to work out control mechanism. Information about the damage of crops by common mole rat (*Tachyoryctes splendens)* was collected by structured questionnaire and interview. To assess the damage and to determine the extent of damage and perception from local farmers, the number of sample respondents was determined using formula of Cochran (1977). The sample was then allocated to the different study site based on the population of each study site. Accordingly Meligawa= 7 female and14 male, Hamani=9 female and 17 male, Shocha=8 female and 16 male,Hibret=7 female and15 male, Ceraba=9 female 19 male and Kico=7 female and 14 male.

3.5. Data analysis

Data was analyzed using SPSS software of version 16. Descriptive statistic was used and responses were compared using t-test at 0.05 level of significance. T-test was used to compare two related means (external body measurement between dega and woena dega, sex ratio, and burrow system between climatic zones).

4. RESULT

4.1. Captured common mole rats

Totally 72 local (Meshtraps), 12 on randomly selected points of each of the six study sites were set to trap common mole rats in the early morning. Using these seventy two traps, 48 common mole rats were captured. From the 48 specimens 30 were males and 18 were females (Table2).

Table.2**.** Number of common mole rats trapped

Site	Climatic zone	Traps in each study site	Number of mole rat trapped	Sex		
				M	F	T
Haman	Dega	12	10	6	4	10
Maligawo	Dega	12	11	7	4	11
Shocha	Dega	12	8	5	3	8
Kico	Woyina-Dega	12	6	4	2	6
Hibiret	Woyina-Dega	12	7	4	3	7
Ceraba	Woyina-Dega	12	6	4	2	6
Total		72	48	30	18	48

4.2. External body measurements of common mole rat

From the 48 captured common mole rats, 31 adults were used for taking external body measurement. Out of 31, 18 and13 common mole rats were taken from dega and woeina dega sites respectively. The head-body length ranges from192 to 244 mm; tail length was from 48 to 66 mm and the body weight ranged from 210 to 282g (Table. 3). Significant variation was observed in body weight between the two climatic zones(in dega mean weight=263.277and in woenadega mean weight=230.583 (t=5.144, p=0.00) However, there was no significant difference in TL, HB, T, and HF between the two climatic zones (t=1.104, p= 0.291, HB; t= 2.654, P=0.051, T: t=0.065, p=0.949, TL, t=0.64, p=0.53, 12, HF).

Table 3**.**Body weight in g and other external body measurements in mm of the common mole rat

Site	Mean Body measurement of adult common mole rat				
	W	TL	HB	T	HF
Dega	263.277	259.444	212.1176	56.72	30.8333
woena dega	230.583	257.166	218.666	60.66	31.333

In addition to differentiating the body measurement of different climatic sites, body measurement between male and female common mole rat (Table 4) were also recorded. As indicated in Table 5and6 the body weight measurement of males range from 210g to 281g and females range from213g to282g, tail length of males range from 230mm to 270 mm and females range 230mm to 290 mm, head body length of males range from 192mm to244 mm and females range 210mm to 232 mm, tail length of males range from 49mm to 66 mm and females range 49 mm to 63 mm, and hind foot length of males range from 28mm to 34 mm male and females range 30mm to 35 mm (Table5 and 6). The difference in body weight between males and females was statistically significant (t=5.705, p=0.00) .However, there was no significant differenceinTL,HB,T,HF(t=0.521,p=0.614,HB;t=0..052,P=1,T:t=1.343,p=0.209,TL;t=0.62,p=0.548,HF).)

Table.4**.**The body weight in (g) and other external body measurements in (mm) of adult common mole rat

SEX	Mean Body measurement of male adult common molrat				
	W	TL	HB	T	HF
F	248.36	263	215.9	59.181	31.72
M	250.26	257.52	214.42	57.89	30.631

4.3. Demographic feature of common mole rats.

Out of 48 trapped common mole rats, 30 were males and 18 were females. The sex ratio was male biased (t= 7.746, p=0.001). Among the trapped common mole rats 31 (64.59%) were adults, 9(18.75%) sub-adult and 8(16.67%) juveniles. Among these, 20(41.67%), adults 7(14.58%) sub adults, and 6 (12.5%) juveniles were captured during the wet season while 11 (22.9%), 2(4.17%) and 2(4.17%) adult, sub adult and juveniles respectively were trapped during the dry season.

Table.5. Population structure of common mole rats from six study sites

season	Sex		Age			
	M	F	Adult	Sub-adult	Juvenile	Total
wet	19	14	20	7	6	33
dry	11	4	11	2	2	15
Wet in%	39.58	29.17	41.67	14.58	12.5	68.75
Dry in%	22.9	8.25	22.92	4.17	4.17	31.25

4.4. Abundance and distribution of mole rats

The current study showed that common mole rats were more abundant in the Maligawa site with 14 individuals per hectare followed by Haman site with 13 individuals per hectare both in the dega climatic zones. On the other side the observed abundance in Kico and Ceraba sites both in woena dega climatic zones, each with 8 individuals (Table 6). However, the difference in abundance of common mole rats in between two climatic zones was statistically significant (t=4.00,p=0,047)

Table.6. Abundance of common mole rats in the habitats among the different site

Study sites	No. of plots (Crop fields)	Mean ± SD/plot	Individual/ hectare	
Haman	6	2.5.±0.75	13	
Maligawa	6	2.75±0.5	14	Dega
Shocha	6	2±0.75	10	
Kico	6	1.5±1.34	8	
Hibiret	6	1.75 ±.98	9	Woinadega
Ceraba	6	1.5±1.34	8	

The total count of common mole rats from surface sign (mounds) in each crop fields at different seasons varied from site to site (Table 7). The highest number of common mole rats from mounds was 19 in Maligawa, Kico and Hibret and the least (16) were in Shocha and Haman. The numbers of common mole rat based on surface sign (mound) count in wet season were about 106 whereas in dry season it was 93 (Table 9).However when compared the count of surface sign mound dega with woena dega climatic condition there was no significant variation in between the two climatic zones (t= .128, p=.0.910). In addition, surface sign count showed that there was no significant variation between wet and dry season (t=1.904, p=0.115).

Table.7.Total count of mole rats from surface sign in each crop field at different seasons

season	plant	Haman	Maligawa	shocha	Kico	Hibiret	Caraba	Total
Wet	Enset	4	5	5	5	4	6	29
	Potato	2	4	2	4	4	3	21
	Cereals and pulses	2	3	1	3	3	1	13
	Sugar cane	1	1	2	1	1	-	6
	Grass	6	5	6	5	6	5	33
	Coffee	1	1	-	1	1	2	6
	Total	16	19	16	19	19	17	106

Dry	Enset	3	3	4	3	3	3	19
	Potato	2	4	4	3	2	4	19
	Cereals and pulses	3	2	1	1	3	3	13
	Sugar cane	2	-	4	4	3	-	13
	Grass	4	4	5	3	4	2	22
	Coffee	1	2	1	2	-	1	7
	Total	15	15	19	16	15	13	93

The total number of common mole rats was high in grasslands followed by enset during both seasons. Grasslands and enset have 4-6 and 3-5 mole rats per plot and 23 and 20 individuals per hectare, respectively. Maximum numbers were counted during wet season which was 27 in grassland and the least was 5 sugar cane and coffee lands. On the other hand, during the dry season, the highest was 18 mounds and the lowest was 6 mounds. The least damaged crop field was coffee with 1plant per plot and 6 individuals per hectare (Table 8).

Table.8. Density of common mole rats in the crop field

Crop field	season	Estimated population size	
		Mean ± SD/plot	Individuals/ha
Enset	Wet	4.83 ±1.09	24
	Dry	3.16 ± 0.71	16
Potato	Wet	3.16 ± 0.71	16
	Dry	3.16 ±0.71	16
Cereal and	Wet	2.5 ±1.09	12
pulses	Dry	3.o ± 0.75	15
Sugarcane	Wet	1 ± 0.35	5
	Dry	2.16 ± 1.2	11
Grasslands	Wet	5.5 ± 0.5	27
	Dry	3.67 ± 0.71	18
Coffee	Wet	1±0.35	5
	Dry	1.17±081	6

4.5. The burrow system of common mole rat

Different length of borrows was recorded. The highest length was 17.5m which was dug by male common mole rat. The smallest length was 10 m dug by female common mole rat. In case of foraging tunnel depth, the deepest tunnel was 210mm which was burrowed by female common mole rat and the least depth (the shallow one) was 1.04m dug by male common mole rat. The longest foraging tunnel in mm was 20 m and the shortest was 8.4m, which was made by adult male common mole rat as indicated in (Table 9) The t-test for burrow system in between different climatic zone showed the absence of significant difference (t= 1.521, p=0. .226)

Table.9.Adult mean burrow measurement length (mm) and foraging tunnel nest in (mm)

sex	**Burrow length in mm**	**Foraging tunnel**		**Nest**
		Depth in mm	Length in mm	Depth in mm
Female	12155.56	166.4	12885.71	470
Male	13361.67.	169.08	11752	497.5

4. 6. Stomach content analysis

A total of 31 (20 male and 11 female) common mole rats were dissected for stomach content analysis and directly correlated with the vegetation of the habitat. Grass was predominant, followed by enset and potatoes.

.

Table.10. Stomach content analysis of mole rats collected from the study site

	Season	Haman	Maligawo	Shocha	Kico	Hibiret	caber
Esnet	Wet	*	*	*	*	*	*
	Dry	*	*	*	*	x	*
Potato	Wet	*	x	*	x	*	*
	Dry	x	x	*	*	*	*
sugarcane	Wet	*	x	x	*	x	x
	Dry	*	*	x	x	*	*
Coffee	Wet	x	x	x	*	*	x
	Dry	x	*	x	*	x	*
Grass	Wet	*	*	*	*	*	*
	Dry	*	*	*	*	*	*
	Wet	x	*	*	*	*	*
Undefined roots	Dry	*	x	*	x	*	*

"*" = presence "x"= absence

4.7. Impacts of common mole rats on agriculturally important plants

The estimated damage on cereals, pulses, and grasslands from its soil hill diameter coverage and nesting materials within the nest showed that the loss in grass was high. Severe damage on Enset was observed in Dega climatic zone sites (Shocha, Maligawa and Haman). The total number of damaged enset was 52, 50, and 32 during wet and 39,37and33 during dry seasons, respectively (Table 11).The loss of damaged plant and income reduction are indicated in Table 12.The hoarded potatoes in the mole rat nests were measured in kilogram per nest. During the study period, the observed maximum amount of potato hoarded was about 3.1 kg per ha. Since the expected potato yield is approximately 8 -quintals per ha, when this result is analyzed and changed it resulted about 0.4% loss

Table.11**.** Monthly total count of damaged enset plants in study sites

Seasons	Habitats Months	Shocha	Maligawa	Hamani	Hibiret	Kico	Ceraba
Wet	September	11	10	7	4	7	5
	October	27	25	13	5	8	6
	November	14	15	12	5	6	5
Total		52	50	32	14	21	16
Dry	December	11	14	12	5	4	3
	January	15	10	9	7	7	4
	February	13	13	12	5	5	6
Total		39	37	33	17	16	13

As compared to the dry season (7.6%) the Percentage loss of enset plant was higher during wet season, which was nearly about 9%. In general about 16.92% of enset plants were lost throughout the year (Table12).

Table .12. Loss of enset plants and income reduction due to mole rat impact

	Wet season		Dry Season			
Seasons Study sites	Loss in number	Loss in birr	Loss in number	Loss in Birr	Annual loss	Annual Loss in birr
Haman	32	1216	33	1254	65	2470
Maligawa	50	1980	37	1406	87	3306
Shocha	52	1976	39	1482	91	3458
Kico	21	798	16	608	37	1406
Hibiret	14	532	17	608	31	1026
Ceraba	16	608	13	494	29	1102

.

Figure9. Damaged enset plant (Photo Teshome M.)

4.7.1. **Socio demographic characteristics of respondents and farmers response about pest status, crop damage and method of control**

Among the total of 142 respondents, 95 (66.9%) were males and 47 (33.1%) were females. Most of the respondents were in the age range of 25 -55years. Majority of the respondents were married. The educational background the majority of the respondents (88.73%) were none educated, but others (6.34%) and (4.93%) were with Primary and Secondary education and above respectively. Amount of land owned by respondent in hectare 0.5, 1, 1.5, 2 and more than 2 of land were owned by 35%, 33.8%, 12%, 15% and 10% of farmers respectively.

Table.13**.** Socio demographic characteristics of respondents

character	**reference**	
sex	male	95
	female	47
age	20-24	6
	25-55	132
	≥56	4
Marital status	married	138
	Un married	4
Educational status	illiterate	126
	Primary	9
	Secondary	7
	Above secondary	-
Economic activity	farming	127
	trading	4
	both	7
	others	4
Amount of land owned by the respondent	Less than 0.5hectar	50
	1 hectare	48
	1.5 hectare	17
	2hectar	13
	Above 2 hectare	14

Among the study participants, 91(64.08%), 22 (15.5%), and 8 (11.4%) farmers considered common mole rat as a serious pest on enset, potato and coffee respectively. Moreover 80 (56.33%), 34 (23.94%), 6 (4.23%) and 18 (12.65%) of the farmers responded that the methods used to minimize this pest were trapping, burrowing, flooding and fumigation respectively.

Table.14. Farmers 'response about pest status, crop damage and method of control.

Questions	Damage on	Number of respondents					
		Haman	Maligawo	shocha	Hibiret	Kico	Ceraba
Cultivated crop type	Enset	14(9.86%)	10(7.04%)	10(7.04%)	10(7.04%)	9(6.34%	12(8.45%)
	Potatoes	-	1(.7%)	1(.7%)	2(1.4%)	1(.7%)	2(1.4%)
	Others	-	1(.7%)	1(.7%)	1(.7%)	1(.7%)	1(.7%)
	coffee	3(2.11%)	-	1(.7%)	3(2.11%)	5(3.52%)	4(2.82%)
	Maize	5(3.52%)	5(3.52%)	10(7.04%)	11(7.75%)	9(6.34%)	10(7.04%
	sugarcane	1(.7%)	3(2.11%)	3(2.11%)	2(1.4%)	3(2.11%)	5(3.52%)
Season of highest attacks	Wet	18(12.68%)	19(13.3%	21(14.8%)	16(11.3%)	17(12.%)	20(14.08)
	Dry	8(5.63%)	2(1.4%)	3(2.11%)	8(5.63%)	4(2.82%)	8(5.63%)
Most affected crop plants by mole rat	Enset	22(15.49%)	14(9.86%)	16(11.27	12(8.45%)	13(9.15%	14(9.86%
	potato	2(1.4%)	4(2.82%)	3(2.11%)	6(4.23%	4(2.82%)	3(2.11%)
	sugarcan	1(.7%)	1(.7%)	2(1.4%)	2(1.4%)	3(2.11%)	3(2.11%)
	coffee	-	1(.7%)	4(2.82%)	1(.7%)	2(1.4%)	4(2.82%)
	Maize	-	-	3(2.11%)	-	2(1.4%)	3(2.11%)
	Others	1(.7%)	1(.7%)	1(.7%)	1(.7%)	3(2.11%)	1(.7%)
Effective methods to control and manage mole rats	Trapping	15(10.56%)	10(7.04%)	18(12.7%)	10(7.0%)	13(9.15%	14(9.86%
	flooding	1(.7%)	3(2.11%)	-	2(1.4%)	-	-
	burrowing	6(4.23%	8(5.63%)	3(2.11%)	6(4.23%	5(3.52%)	6(4.23%
	Rodenticides	-	-	-	2(1.4%)	-	2(1.4%)
	Fumigating with smoke	4(2.82%)	1(.7%)	3(2.11%)	3(2.11%)	3(2.11%)	4(2.82%)
	others	-	-	-	-	-	2(1.4%)

Figure.10.Respondents and interviewer (Photo Addisu G.)

5. Discussion

5.1. External Body measurements

The present study showed that there were no significant variations in TL, HB, T, and HF of common mole rat in two climatic zones (dega and woena dega). There are significant differences in body weight at different climatic zone. The highest weight was recorded in Maligawa (282 g) and Haman (277 g). Whereas the least weight was recorded in Ceraba (210 g) and, Kico (212 g) respectively as shown in (Table.3). Large loss in body weight was seen in woena dega climatic zone during dry season (Nowak 1999; Bekele and Leris ,2003; and Kokiso ,2006).

5.2. Population structure

In this study 30 male and 18 female common mole rats were trapped in the study sites, the ratio of male to female common mole rats were approximately 2:1 (t= 7.746, p=0.001) shows that there is a significant difference in sex ratio. The finding of the present study was similar with a research conducted in angecha (Kokiso, 2006). Moreover common mole rat was adult biased; since common mole rats were solitary and aggressive characters. In addition, common mole rats are vulnerable to early age death. The age structures of common mole rats in this study were nearly similar to the findings of Jarvis (1973) with 66% adult individuals. In addition,the highest numbers of male and female common mole rats in dega climatic zone than woena dega. Dega climate is very favourable for most common mole rates due the availability of variety food and suitable reproductive conditions. Therefore, common mole rats are common in Dega climate and agree with other research conducted (Bekele and Leirs, 2003).

5.3. Abundance and distribution

As observed in this survey, the density of common mole rats increases as altitude increases, when the habitats are stable, the land is not regularly cultivated and when there is sufficient amount of food resources. This goes in line with the findings of Spinks et al., (2000), Faulkes and Bennett 2007). Similar to the finding of Kokiso (2006), the highest density of common mole rats in the present study were recorded in areas of grassland and enset fields which contain 27and

24 mounds respectively during the wet season but their number slightly decreases in dry seasons. Altitudes, vegetation cover and climatic factors favour the abundance and distribution of common mole rats. Therefore, more number of common mole rats was listed in dega climatic zones of wet seasons. In present study, common mole rats were most abundant in Maligawa in both wet and dry seasons, whose altitude was higher than other sites. The least abundance and distribution were observed in low altitude habitats of Kico and Ceraba kebele each with 8 individuals (Table 8).Generally, the East African common mole rats are highly distributed in dega climatic zone than woeinadega, and abundant in wet season than dry season. This is in line with study by Bekele and Leris (2003) who reported that seasonal cultivation affects the distribution of the common mole rat population.

5.4. Burrow system

The current study indicated that the burrow system in dega climatic zone has 10 to 17.5m and in woeina dega climatic zone 8 to 20m long foraging tunnels. In addition, 0.29m to 0. 6m deep nest and 1.2 to 4.1m long bolt hole per a single multipurpose tunnel were examined (Table 9). As compared to the finding of Jarvis *et al.*, (1998) which is 18 – 52m at Chiromo Estate and Mount Kenya the total length of the burrow system of common mole rat in this study is highly reduced. Spinks *et al.*, (2000) mentioned that the hardness of soil can be considered as a limiting factor for excavation especially in arid habitats. However, for the study sites in this research, the soil is very loose and deviation might happen due to the availability food in quantity and quality near the site. The variation in size and length of male and female borrow system is very small (Table.9).This may be due to the similarity in digging and food searching ability of both male and female common mole rats. This goes in line with the findings of Busch *et al.*, (2000).

The present study showed that common mole rat digging activity did not cease even during the advanced dry season. This is because, in the present study, during excavation of burrow it were seen that there was soil mounds inside the burrows. This indicates that common mole rat continuously excavates in dry conditions to find food, therefore the present study goes in line with the study conducted by Sumbera *et a*l. (2003). Furthermore, during the survey period, the new mounds that have been seen realize that in the dry season the digging activity of the common mole rats goes throughout the season continuously. This study is in line with the findings of Jarvis et al. (1998), and Sklíba *et al.,* (2009). As described by many studies, mound construction were used for refuges, foraging, storages and breeding as well as nest, these activities of mole rats were also investigated in the study sites of some selected kebeles (Sumbera *et al.*, 2003) .

5.5. Stomach contents

The Stomach content analyses of 31 common mole rats were carried out to determine food content of the trapped common mole rats. During investigation process different kinds of vegetation were observed. As observed from stomach content analysis, the type of the plant found in the site where common mole rat trapped was similar with that of the stomach content found. In addition to these ,farmers response clearly indicates that common mole rats were assumed to be generalist feeder, because it feeds any kind of plant where available. The analysis of this study goes in line with the finding of (Kokiso, 2006 and Yaba, 2007).

5.6. Impact of mole rat in agriculturally important plants

In the present study more number of damaged enset was observed in Dega climatic zone sites than the woinadega climatic zone sites (Table 11). The percentage loss analyzed for each study site showed that highest damage was observed in Maligawa site and followed by Shocha and Haman. However, the percentage loss for Kico, Ceraba and Hibiret were low (Table 12). As mentioned by Kokiso (2006), common mole rats are very active and high ability to find their foods in dega and wet climatic conditions, the reason behind is dega climatic and wet season lands were very loose and easy for excavation and searching food. The damage was critical on enset plantation and grassland due to the attack of common mole rats. Common mole rats were common in open grasslands bordering specially near enset plantations, this is because the land near it were not cultivated, thus common mole rats hide themselves there and then when the land disturbance decreases(stops)they turn back into crop plants to damage (feed) it.

Farmers keep grasslands as a feed source for their cattle, this grass land also served as foraging site for common mole rats. During the present study the mounds that covered grasslands were observed, this mounds reduce grass yield that left for cattle's to feed it. Single mound which covers the grass were about 300mm-500mm. So the reduction of grass will result in loss food for cattle, it is known that the grass harvested from $2m^2$ area feeds at least 4 cows per day. Therefore common mole rats were really pest of plant in many directions. This study goes in line with (Kokiso, 2006)

The major crop plant susceptible by common mole rat in the study site were enset, due to this the researcher categorizes enset plant in one of the three stages young, medium and matured enset. Young's are more vulnerable for damage than medium and matured enset plants (Figure 9). Approximately mature enset plant takes 5 to 7 years but farmers sometimes use these plants before they reach maturity stage when it is necessary. Each plant costs from10 to 75 birr. Matured enset plant costs average about 75 birr per enset plant as indicated by local farmers.

The average percentage loss when converted in terms of money valued about 12768 birr (Table 12). Therefore, common mole rats have major economic impact on enset plantation in the study site. Farmers in other side keep grasslands as a feed source for their cattle. However, these reserved area acts as the main outreach for the pest common mole rats. It served for invasion and hiding sites for common mole rats.

Common mole rats are pests of different plants as well as enset, which are the main food of the people of the area, but farmers give priority for enset plantation even if it is seriously attacked by common mole rat, the mean loss of enset plant is nearly 16.98 %,(Table12) which is very high as compared with findings of Kokiso (2006). Since common Mole rats were serious problem of the area, carrying out different mechanisms such as proper periodical cultivation as well as introduction of indigenous predators (owls, cat and eagles) helps to reduce and regulate common mole rat population. Overall damage was comparing with the former number of plants in the farm and the percentage of the damaged enset on each stage of growth was calculated by computing from the estimated total number of the enset plant. In line with the findings of Kokiso, (2006), this study showed the existence of the problem (Table 12).

5.7. Farmers response about pest status, crop damage and method of control

Majority of the respondents in the present study expressed that the tendency of crop damage by common mole rat were increased from time to time. This is due to uncontrolled increase of common mole rat population in the area. As the crop plant damage increases, economic loss of the farmers increases. This leads to starvation and adverse living condition. As the farmers' responded the lack of knowledge was one of the problems to controlling common mole rats in the study area. It was seen that farmers were forced to stop cultivating crop plants especially enset in the area. About 45.8% of the respondents reported that they lose enset and 31% of respondents reported maize was damaged by common mole rats. Likewise 10.56% of potato and12.68% of sugarcane was damaged by these serious pest common mole rats. Generally it indicates there was a severe problem in the study area which needs quick responses from concerning bodies to minimize the problem of the area and to keep food security

6. Conclusion and recommendations

6.1. Conclusion

- The present study showed that the population of common mole rats in the study area are male and adult biased and no significant variation in length but body weight variation were seen.
- Abundance and distribution of common mole rats among sites showed the presence of high number of common mole rats in dega climatic zone and wet seasonal conditions.
- The burrow system consists multipurpose nest, bolt hole and foraging tunnels, highest length were 17.5m this is only for Dega which was dug by male common mole rats, the least length were 10m .and dug by female common mole rats.
- In the case of foraging the deepest tunnel were 2.1cm. which was burrowed by female common mole rat the shallow ones was 1.04m.dug by male common mole rats.
- Grass, enset and potatoes were obtained during stomach content analysis, which were observed during both wet and dry seasons. Enset is the main crop which is cultivated by most of the farmers in the study area.
- From questionnaire most of the farmers responded that common mole rats damages the enset plant seriously.
- Thus, common mole rats are major rodent pests of enset plants, so by considering this the living status of farmers were endanger, even little damage have a big economic impact, therefore for priority should be given by the concerned institutions to minimize the problem.

6.2. Recommendations

Based upon the findings of the present study, the following recommendations were made to control the common mole rat which damages enset and other plants in the study area**.**

- The government should discuss with farmers about the problem of crop damage, especially the main crop plant (enset) of the area.
- Mole rats were serious problem of the area, so carrying out different mechanisms such as proper periodical cultivation as well as introduction of indigenous predators (owls, cat and eagles) helps to reduce and regulate common mole rat population.
- Due severity of the problem farmers are using different toxicants such as, rodenticides, toxic bites, The use of such chemicals should be regulated.
- Common mole rats hide themselves on the border where the land was cultivated. Periodic cultivation is probably the greatest value to reduce its foraging site.

References

Allen, M. (1993). A check list of African Mammals.a; physiological aspects. In:Nyberg F, SharmaHS,Wiesenfe against inbreeding as the system of mating, *Behav. Ecol.* **11**: 7-12.

Antinuchi, D. and Busch, C. (1992). Burrow structure in the subterranean rodents CtenomystalarumZeitsch.Saugetierk**57:**163 – 168

Baskevich, J., Orlov, N., Afework,B. and Assefa, M. (1993). Notes on thekaryotype of *Tachyoryctessplendens*(Ruppell, 1836) (Rodentia: *Rhizomyidae*) from Ethiopia. *Trop. Zool.* **6**: 81 – 88

Bekele, A. (1995). Post natal development and reproduction in captive bred *ProamysAlbipes*(Mammalia: *Rodentia*) from Ethiopia. *Mammalia* **59:**109 – 118.

Bekele, A. (1986). The status of some mole rats of the genus *Tachyoryctes*(Rodentia:*Rhizomidae*) based on craniometricstudies.*Afri. J. Zool.* **99:** 411- 417.

Bekele, A and Leirs, H. (2003). Rodent crop damage in maize fields in Zeway, centralEthiopia.. In: *Rats, Mice and People: Rodent Biology and Management* Singleton, G. R., Hinds, L.A., Krebs, C. J. and Sprott, D. M. eds.) pp.262 -263

Bekele, A.andLeirs, H. (1997). Population Ecology of Rodents in maize fields andgrasslands in Central Ethiopia. *Bel. J. Zool.* **124:**39 – 48.

Bennett,N.,Faulkes,G(.2000).AfricanMoleRats:EcologyandEusociality.CambridgeUniversity Press,Cambridge,UK.

Bennett, N. and Jarvis, J. (1995).Coefficients of digestibility and nutritional valuesof geophytes and tubers eaten by southern African mole rats. (Rodentia:Bathyergidae) *J. Zool. Lond.***236**: 189 – 198

Braude, S. (2000) Dispersal and new colony formation in wild naked mole rats:evidenceagainst inbreeding as the system of mating, *Behav. Ecol.* **11**: 7-12.

Broekman, M., Bennett, N., Jackson, R. and Scantlebury, M. (2006). Mole-rats from higheraltitudes have greater thermoregulatory capabilities. *PhysiolBehav* **89:**750-754

Burda, H., Honeycutt, R., Begall. S., Locker-Grütjen, O. and Scharff, A. (2000). Are naked and common mole-rats eusocial and if so, why? BehavEcolSociobiol**47**:293–303

Busch, C., Antinuchi .D., del Valle. J., Kittlein. J., Malizia. A., Vassallo. A. and Zenuto.R.(2000). Population ecology of subterranean rodents. In: Life Underground, the Biology of Subterranean Rodents, Lacey EA, Patton JL, Cameron GN (Eds.), University of Chicago Press, Chicago, pp183-226.

Carter, T. and Rosas, M. (1997). Biology and Conservation of the giant otter, change their burrow architecture seasonally*Pteronarabrasiliensis*. *Mamm. Rev*. **27**:1 – 26.

Carter, T. and Encarnaca, O. (1983).Characteristics and use of burrows by four species of mole rat.armadillo in Brazil.*Mammal*ogy**64**: 103 – 108.

.Cochran, W. (1977).*Sampling techniques* (3rded).John Wiley and Sons New York.pp:74-76.

Darlington, J. (1985) Lenticular soil mounds in the Kenya highlands. Oecologia **66(1):**116–121.

Faulkes, C. and Bennett, N. (2007). African mole-rats: social and ecological diversity. In: Rodent Societies: an ecological and evolutionary perspective, Wolff JO, Sherman PW (Eds.), Chicago: The University of Chicago Press, pp. 427–437.

George, W. (1979). Conservation in karyotypes of two African mole rats (Rodentia:*Bathyergidae*). *Z. Saugetierk*. **44**:278 – 285.

Greaves, H. (1982).*Rodent Control in Agriculture*: FAO Plant Production and ProtectionPaper No. **40:** Pp 88.

Halle, S. and Stenseth, N. (2000). Activity patterns in small mammals: an ecological approach. Springer-Verlag, Berlin – HeidelbergBehav. Ecol.Sociobiol.**52**: 53–58

Herbst,M,and Bennett., N. (2006). Burrow architecture and burrowing dynamics of the endangered Namaqua dune mole rat (Bathyergusjanetta) (Rodentia: Bathyergidae). J Zool, **270:**420–42.

Hickman, G. (1990). Adaptiveness of tunnel system features in subterranean mammal burrows. In: Evolution of Subterranean Mammals at the Organismal and Molecular Levels, Nevo E, ReigOA (Eds.), Alan R. Liss, Inc, New York, pp 185-210

Hickman, G. (1979). Burrow system structure of Bathyergid: *Cryptomyshottentotus*(Rodentia: *Rhizomidae*) during flood conditions in Kenya. *J. Zool*. **200**:71 – 82.

Hickman, G. (1977). Burrow system structure of *Papogeomyscastanops*(*Geomidae*) inLaboacountry, Texas. *Am. Midl. Nat*. **97**:50 – 58

Jarvis, M. (1973). The population structure of the mole rat, *Tachyoryctessplendens*(Rodentia: Rhizomyidae) *J. Zool*.**171**: 1- 14.

Jarvis, M. and Sale, J. (1971). Burrowing and burrow patterns of the east African mole-rats,*Tachyoryctes, Heliophobius*and*Heterocephalus. J. Zool*..**163**:451 – 479.

Jarvis ,M., Bennett N.and Spinks, A. (1998). Food availability and foraging by wild coloniesofDamaraland mole-rats (Cryptomysdamarensis): implications for sociality. Oecologia**113:**290–298.

Jotter,G. and Bellomo, K. (1984).New developments in vertebrate cytotaxonomy. Nowak, R. M**.**(1999). *Walkers Mammals of the World* Vol. **II** 6th ed.

Katandukila, V.; Faulkes, G.; Chimimba, T. and Bennett, N. (2013). "Reproduction in the East African root rat (*Tachyoryctessplendens*; Rodentia: Spalacidae) from Tanzania: the importance of rainfall". *J. Zool*.doi:10.1111/jzo.12067

Kingdon, J**.** (1997). *Field Guide to African Mammals*.Harcourt Brace and CompanyPublishers, London.Harcourt brace and company publisher, 159-254

Kokiso, A.(2006).Common mole_rat,*Tachyoryctessplenden*(Ruppell,1836)distribution and its impacts in agricultural fields in angecha, centeralEthiopia.M. Sc. Thesis,Addis Ababa University, Addis Ababa

Marino, J.(2003).Spatial ecology of the Ethiopia wolf, canissimensis .Ph.D. Thesis ,Linacre College, University of Oxford.

Matthey,R. (1976). Les chromosome des Eutheriens. Retrospectives ernovelled onnies *mammalian* **40**: 453 – 466.

Mohammed,Y., Tariku, M., Afework,B. and James, M., (2011). Food Selection and Feeding Behavior of Giant Mole Rat (*Tachyoryctesmacrocephalus*, Ruppell, 1842) from the Sanetti Plateau of Bale Mountains National Park, Ethiopia. AJAS, **4:**735-740.

Mohammed, Y. (2007). Ecology of the Giant Mole Rat, Tachyoryctesmacrocephalus (rüppell, 1842)on the feeding ecology from the sanetti plateau of bale mountains national park (bmnp), Ethiopia

Musser, G.; Carleton, M. (2005). "Superfamily Muroidea".In Wilson, D. E.; Reeder, D. M. *Mammal Species of the World* (3rd ed.). Johns Hopkins University Press.p. 925

Nedbal, A., Honeycutt, R. andSchitter, A. (1996).Higher level systematic.Nevo, E. (1979). Adaptive convergence and divergence of subterranean mammals.*Ann.Rev.Ecol. Syst*. **10**: 269-308.

Nevo,E.,Cappanna, E., Corti, M., Jarvis, J.andHickman,G.(1986). Karyotypedifferentiation in the endemic subterranean mole rats of South Africa (Rodentia:*Bathyergidae)* Z. Saugetierk.**51**:36 – 49.

Nowak, R**.** (1999). *Walkers Mammals of the World* Vol. **II** 6th ed. The John HopkinUniversity Press, Baltimore and London.

Patton, J. and Sherwood,W. (1983).Chromosomal evolution and speciation inrodents.*Ann. Rev*. *Ecol. Syst*. **14**:139 –158.

Rundel, W., Smith, A. and Meinzer, F. 1994. Tropical alpine environments: plant form and function. Cambridge University Press, pp 376

Schlitter, D., Agwanda, B.andCorti, M. (2008). "*Tachyoryctes splendens*". *IUCN 2013.IUCN Red List of Threatened Species.Version 2013.1*.

Sewnet,M. and Afework,B.(2003).Geographic variation in Ethiopian common mole rat,*Tachyoryctessplendens*based on morphology.*Ethio. J. Biol.Sci*. **2**: 73-89.

Sichilima,A., Bennett, N., Faulkes, G. and Le Comber, S. (2008). Evolution of African mole rat sociality: burrow architecture, rainfall and foraging in colonies of the cooperatively breeding Fukomysmechowii. *J Zool.* **275:**276–282

Singleton, R., Hinde, A., Krebs, J. and Sprott, D.(2003).*Rats, Mice andPeople:Rodent Biology and Management*.AustralianCenter for InternationalAgricultural Research, Canberra.

Sklíba, J., Šumbera, R., Chitaukali, W.andBurda, H. (2009).Home-range dynamics in a solitary subterranean rodent.*Ethology* **115(3):**217-226.

Sklíba J, Šumbera R, Chitaukali WN, Burda H (2007). Determinants of daily activity patterns in a free-living Afrotropical subterranean rodent.*J Mammal*. 88(4): 1009-1016.

Spinks, A., Bennett, N., Jarvis, M. (2000). A comparison of ecology of two populations of common mole rat, Cryptomyshottentotushottentotus: the effect of aridity on food, foraging and body mass. Oecologia**125:**341–349

Sumbera, R., Burda, H., Chitaukali,N. andKubová J (2003). Silvery mole-rats (Heliophobiusargenteocinereus, Bathyergidae) change their burrow architecture seasonally. Naturwissenschaften**90:**370-373.

Vaughan,M,.Ryanand,C.(2000).Mammalogy.**4th**Ed.,Harcourt Inc.,London,UK.

Yalden, D. (1983). The extent of high ground in Ethiopia compared to the rest of Africa. *SINET: Ethiop. J. Sci.* **6:** 35-39

Yalden, D., Largen**,** J. and Kok, D. (1976).Catalogue of the Mammals of Ethiopia**II**Insectivora and Rodentia.*Monit. Zool. Ital*. (N.S) *Suppl***. 8**: 1-118.

Yalden,D.(1975). Some observation on giant mole rat, *T.macrocephalus* (Mammalia :*Rhizomyidae*) of Ethiopia. *Monit. Zool. Ital*. (N.S) Suppl**. 6**:125-303.

Zenuto, R. and Busch, C. (1998). Population biology of the subterranean rodent Ctenomysaustralis (tuco-tuco) in a coastal dune fields in Argentina. Z. Saugertierk. 60: 277 – 285.

Ziyine,M. (2005). *Chromosome Studies on the Common Mole Rat*(*Tachyoryctes splendens*) *in Ethiopia*. M. Sc. Thesis,Addis Ababa University, Addis Ababa

Zumbera, R., Šklíba, J., Elichová,M., Chitaukali ,W.urda,H (2008). Natural history and burrow system architecture of the silvery mole-rat from Brachystegia woodland. J ZoolLond 274:77-84

Appendix-I

Data collection sheet for population of Common mole rat, *Tachyoryctessplendens*

Name of data collector________________________________

Species____________________

Season___________________

Place ____________________

Site______________________

Altitude_________ _________

S.No	Sex		Total	age		
				Adult	Sub adult	Juvenile
	M	F				
1						
2						
3						
4						
5						
6						
7						

Appendix II

Farmers' questionnaires

I. Background 1.Age of respondent...........

2. Residence...............

a. District ....b Kebele .... c. Village........... d. Climatic Zone.............

3. Educational status of respondents

a. None educated ....b. Primary ....c. Secondary ....d. above----------------.

4. Family size..................... Male..................... Female.................................

II. Economic activities (make “X” mark in the box).

1. a. Farming .... b. Trading ....c. Both .... d. Others..............

2. How many hectares of land do you own?

<0.5 ha................ 1 ha .... 1.5 ha............. 2.0 ha........ >2.0 ha.................

3. Cultivated farmland size by crop in hectares

Enset...... Potatoes....... Others vegetables........ Maize...... Cereals & Pulses--------

4. Grazing grasslands.....................................

5. Crop types valued most: a. .... b. .... c. .... d. .... e. ------------

6. Types of crop mostly damaged by mole rat area .a.ensetb.potatoc,maize d. cereals and pulses e,eoffee,f others

III. Crop pests

1. Which of the above rodent pests severely attack the crop plants? .... If molerats mention the extent of the damage. High........ Medium........ Least.............

2 What part of the crop is most likely attacked by common mole rat? ....

3. The season of the highest mole rat attacks

Dry................ Wet.................. Both dry & wet..............................

4. Replanting mole rat attacked fields

4.1. Do you replant mole rat attacked fields? Yes.............. No.............if yes what is the result? If no, why not you plant it? Explain?

4.2. Which crop fields were replanted? ....

4.3. What proportion was replanted? ....

4.4. How much of each crop types are damaged by mole rats? Use traditional methods such as

Arm, feet etc

Enset(use counting method).......... Potatoes....... Cereals & pulses............Grasslands....................

5. Which method is more effective to control and manage mole rats?

A. Trapping ....B. Rodenticides ....C. Mention if there is other..................

6. Based on your above answer try to write the reason why this method is more effective?

AppendixIII

Date-------------------------

I,Ato---agreed with AtoTeshomeMulatu student of Jimma University Msc. program in Biology to the following issues .

1, To fill questionnaires regarding his research

2, To submit information about the trapped mole rat based on their age and sex

3, To count and report damaged Enset plant by specifying their size,

4,To accomplish supplementary activities

Finally we agreed each other, he to pay 250(two hundred fifty) birr monthly and Ito receive the mentioned money after accomplishing the work each month.

Name of the agreed worker---

Signature---

Date---

Name of the researcher--

Signature---------------------------------------

Date---------------------------------------

Appendix IV

Format used to collect damaged Enset

Kebel---

Year---

Season	Month	Number of damaged Enset	No of damaged enset by size			Remark
			small	Medium	Large(Matured)	
Dry	September					
	October					
	November					
	Total					
Wet	December					
	January					
	February					
	Total					

Appendix V

Different photo




Appendix-VI (SPSS OUT PUT)

Table 1. Body weight

Paired Samples t- test **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper			
Pair 1 VAR00001 - VAR00002	2.25385E1	15.79882	4.38180	12.99133	32.08559	5.144	3	.000

Paired samples t- test for sex ratio

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper			
Pair 1 VAR00001 - VAR00002	2.00000	.63246	.25820	1.33628	2.66372	7.746	3	.001

Table 2 TL

Paired Samples t- test **for total length.**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	46154	25.51998	7.07797	-15.88311	14.96003	.065	3	.949

Table 3 HB

Paired Samples t- test **head body**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	6.07692	19.83877	5.50229	18.06537	5.91153	1.104	3	.291

Table for tail

Paired Samples t- test **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	4.23077	5.74679	1.59387	7.70352	.75802	2.654	3	.051

Table HF

Paired Samples t- test for hid foot **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	23077	1.30089	.36080	1.01689	.55535	640	3	.534

Table Part ii male female

Paired Samples t- test for weight **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	1.71818 E1	9.98817	3.01155	23.89197	10.47167	5.705	3	.000

Table TL

Paired Samples t- test total length **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	9.09091	22.44751	6.76818	-24.17135	5.98954	1.343	3	.209

Table H.B

Paired Samples t- test for head body length **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	2.72727	17.36140	5.23466	8.93627	14.39082	.521	3	.614

Table T

Paired Samples t- test **tail length Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	.00000	7.16938	2.16165	4.81645	4.81645	.052	3	1.000

Table H.F

Paired Samples t- test **hind foot Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	45455	2.42337	.73067	2.08259	1.17350	.622	3	.548

Paired Samples t- test**for abundance between dega and woenadega Test**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAR00001 - VAR00002	4.00000	1.73205	1.00000	-.30265	8.30265	4.000	3	.047

T-test abundance

Haman

Paired Samples t- test abundance **Test** Haman

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAR00001 - VAR00002	.16667	1.16905	.47726	-1.06017	1.39350	.349	3	.741

Maligawa abundance

Paired Samples abundance Maligawa **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	.66667	1.03280	.42164	.41719	1.75052	1.581	3	.175

Shocha abundance

Paired Samples t- test abundance Shocha **Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	.50000	1.37840	.56273	1.94655	.94655	.889	3	.415

Kico abundance

Paired Samples t- test abundance Kico**Test**

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 VAR00001 - VAR00002	.50000	2.07364	.84656	1.67616	2.67616	.591	3	.580

Hibret abundance

Paired Samples t- test abundance **Test in** Hibret

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	VAR00001 - VAR00002	.66667	1.50555	.61464	.91331	2.24664	1.085	3	.328

Charaba abundance

Paired Samples abundance **Test** in Charaba site

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	VAR00001 - VAR00002	.66667	2.06559	.84327	1.50104	2.83437	.791	3	.465

Burrow system

Burrow length in mm

Paired Samples t- test **Test**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	VAR00001 - VAR00002	1.03333E3	2763.15038	921.05013	1090.61206	3157.27873	1.122	3	.294

Foraging tunnel (depth in mm)

Paired Samples t- test **Test**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAR00001 - VAR00002	3.22222	39.66667	13.22222	33.71272	27.26828	244	3	.814

Foraging tunnel (length in mm)

Paired Samples t- test **Test**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAR00001 - VAR00002	7.77778E2	39974.54746	13324.84915	29949.37947	31504.93502	.058	3	.955

Nest (length in mm)

Paired Samples t- test **Test**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	VAR00001 - VAR00002	3.77778E1	164.75571	54.91857	88.86467	164.42023	.688	3	.511

Paired Samples Test for burrow system in between different climatic zones

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	VAR00001 - VAR00002	1.64932E3	2168.99694	1084.49847	1802.03315	5100.68315	1.521	3	.226

Paired Samples Test Total count of common mole rats from mounds for dega verses woenadega

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	VAR00001 - VAR00002	.33333	4.50925	2.60342	-10.86826	11.53493	.128	3	.910

Paired Samples Test Total count of common mole rats from mounds common mole rat between wet and dry

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	VAR00001 - VAR00002	2.16667	2.78687	1.13774	.75798	5.09131	1.904	3	.115