

**ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE
STUDIES**



**An Ecological Study on Rodents and Their Significance to the Ethiopian
Wolf (*Canis simensis*, Rüppel 1838) in the Afroalpine Belt of Mt. Abune**

Yoseph, Ethiopia

By

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DEDICATION

This work is dedicated to my mother (Emahoy Alemnesh Abera) who ever wished success in my professional career and my two daughters (Hermela Teklu and Meklit Teklu) who should be more dedicated in their future life than me.

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ABSTRACT

An investigation was made on the ecological and biological attributes of rodents and their significance to the endangered Ethiopian wolf (*Canis simensis* Rüppell, 1835) in the afroalpine ecosystem of Mt Abune Yoseph, northeast part of Ethiopia. Investigation of small mammals was conducted by using extensive live and removal trap samplings. Live-trapping was conducted using Sherman traps. The common break back traps were used for snap trapping. Trapping was carried out in five marginally different habitats between 3650-4102 m asl. Transect and point observations were carried out in order to collect data on wolf activity and density in relation to habitat types and rodent biomass. Sociological data was collected in the form of interviews and informal discussions to understand the attitude of the locals about the Ethiopian wolf and small mammals. A total of seven rodent species of which six endemic and one insectivore shrew (*Crocidura bayileyi* Osgood, 1936) were trapped in habitats sampled during the wet and dry seasons. The rodent species include *Arvicanthis abyssinicus* (Rüppell, 1842), *Stenocephalemys griseicauda* Petter, 1972, *Lophuromys flavopunctatus* Thomas, 1888, *Otomys typus* (Heuglin, 1877), *Pelomys harringtoni* Thomas, 1903, *Dendromus lovati* De Winton, 1899 and *Mericulus imberbis* (Rüppell, 1842). A total of 925 individuals of rodents were captured during 4212 trap nights. The rodent species were found to be varied in abundance, trap success and population density among the different habitats. Modified habitats supported less species diversity and population abundance than those with better natural vegetation cover. The abundance of rodents in barely farm was the least of all followed by over grazed alpine meadow. This indicates that habitat modification by human activities could probably cause a decline effect on small mammals. Breeding and age structure of rodent species were intimately correlated with season. The overall rodent density and biomass was lower than the records in the Bale Mountains while, they were comparable to the Simen Mountains. There were thirty nine observations on the Ethiopian wolf during the present study. There was an estimated population of one pack that includes 8-10 adult and sub adult individuals and 2-3 cubs. The local people had positive attitude towards wolf conservation, despite the mountain was the only place to graze their livestock throughout the year. Mt. Abune

Yoseph harboured endemic small and large mammals, avifauna and unique vegetations. As a result, it is one among the unique biodiversity hot-spots and spectacular natural heritages. Without the proper management of small mammals and the concomitant habitat, effective conservation of the endangered Ethiopian wolf can be very difficult. At the same time, conservation of the Ethiopian wolf in the area can not be successful without the keen involvement of local communities, whose lives are strictly entwined with the wildlife and their habitats. In order to effectively conserve the Ethiopian wolf and endemic rodents in Mt. Abune Yoseph, an integrated management programme that addresses the problem of wildlife; especially habitat modification without compromising the benefits of local people is required. The unique vegetations such as the guassa grass and giant lobelias, which are currently at risk also need immediate attention. Otherwise the next generations in this area will perceive only their names and past histories through literature.

Key words: Abundance, Mt. Abune Yoseph, afroalpine rodents, Ethiopian wolf, *Euryops-lobelia*, habitat association

1. INTRODUCTION

East Africa is noted for its physical and ecological diversity, which is predominantly a region of plateau (Kingdon, 1971). Its fauna broadly represents the fauna of Africa as a whole. According to Delany and Happold (1979), the largest number of endemic families, genera and species in the African continent has contributed to be a primary reason for its spectacular features.

Ethiopia has an area of 1,023,050 km² (Leykun Abune, 2000). With its dramatic geological history, broad latitudinal spread and immense altitudinal range, Ethiopia, one of the countries in the Horn of Africa spans a remarkable number of the world's broad ecological regions. It is a country of great geographical and climatic diversity. Its topographic features range from the depression in Afar 110 m below sea level to a number of high peaks and spectacular mountain tops. Ras Dejen, with its peak of 4620 m asl in the northern massif and the Bale Mountains in the southern massif, with a peak of 4377 m asl are ranked the first and the second among the high altitude ranges in the country. Mount Kaka in Arsi, with the peak of 4245 m asl is recognized as the third highest. The recorded height of Mt. Abune Yoseph in the past was 4190 m asl (Yalden *et al.*, 1980). In the present study, however, using the Garmin GPS measurement, the height of Mt. Abune Yoseph at its summit at Rim Gedel was 4270 m asl. Thus Mt. Abune Yoseph is possibly the third highest mountain in the country. This greater range of altitudinal variation in the country is associated with several important biological changes and results in a series of vegetation zones, supporting diverse faunal composition (Happold and Happold, 1989). The two major climatic elements; rain fall and temperature are governed by altitudinal ranges. These in turn are agreeable with the quality and quantity of floral and faunal elements found in every range. On account of geographical and climatic diversity, the vegetation of Ethiopia includes from desert Xerophilous species, savanna woodland, montane dense forests to afro-alpine grass and moorlands (Yalden and Lagen, 1992). The biodiversity richness in the country is thus robustly correlated to the existing ecological and climatic diversity.

Ethiopia comprises a greater proportion of high ground compared to other African countries. Consequently, the initial knowledge for afroalpine ecosystem came to science from this country (Yalden, 1983; Hedberg, 1986). From the total upland of Afro-tropical region, 50% of land above 2000 m asl and 80% of land above 3000 m asl are the share of the country (Yalden, 1983; Hillman, 1993). According to Afework Bekele and Corti (1997) the country is attributed by extensive highlands and about 40% of the land is above 2500 m asl. These chains of highlands are bisected by the Great Rift Valley. Ethiopian highlands are the home of many unique flora and fauna, although fewer in quantity than the lowland habitats (Shibru Tedla, 1995). The relative long ecological isolation of the Ethiopian highlands from the rest of the African mainlands have resulted a high level of endemism (Hillman, 1986). Ethiopian highlands are also noted as the centers of crop diversification. In line with, the country is widely recognized as one of the Vavilov's Centers of Biodiversity (Edward, 1991).

At present, an estimated number of 7000 species of higher plants, 284 species of mammals, 861 species of avifauna, 201 species of reptiles, 63 species of amphibians and 145 species of fresh water fish have been described in Ethiopia (www.telecom.net.IBCR). Among the described 284 species of mammals in Ethiopia, 31 are endemic, which comprise 11% of the total mammal species of the country. These make second only to Madagascar for mammalian species endemism (WCMC, 1992). Of all the mammalian orders, rodents contain the largest number of species with three major divisions: squirrel forms (Sciuriforms), porcupine forms (Hystricomorphs) and rat forms (Myomorphs) (Kingdon, 1997; Vaughan *et al.*, 2000). Worldwide, more than 2000 species of rodents that comprise about 40% of the mammalian fauna are described (Meehan, 1984). Of these, Ethiopia has 84 species where 21% is endemic (Afework Bekele, 1996a, 1996b; Afework Bekele and Corti, 1997; Laverenchenko, *et al.*, 1998; Workneh Gabreslassie *et al.*, 2006). Rodents have contributed fifty percent of the endemic mammals in Ethiopia (Afework Bekele and Corti, 1997).

Delany (1986) has indicated the small size and abundance of rodents makes them ideal subjects for study. In contrast, many workers in this field believed that scientific studies on rodents have not been given enough attention. According to Afework Bekele (1986), as compared to the other orders of mammals, the rodents are the most inadequately understood and most studies were concentrated on faunal lists and distribution.

Accordingly, in Ethiopia only limited research effort on the biology and ecology of rodent species has been carried out so far (Afework Bekele, 1996a). However, with this limited studies, rodents have been described as diversified and dominant group of mammalian order (Afework Bekele *et al.*, 1993; Afework Bekele, 1996a, 1996b; Afework Bekele and Corti, 1997; Afework Bekele and Leirs, 1997). More effort is required to boost the scientific information on rodents. Only limited parts in Ethiopia have been extensively surveyed, while most parts of the country are either less or totally not surveyed for small mammals (Yalden and Largen, 1992). The study area, Mt. Abune Yoseph in the northeastern part of the country, is one of the poorly surveyed areas with respect to small mammals. A sighting of the Ethiopian wolf in 1862 was reported only by Von Heuglin around this area (Yalden *et al.*, 1980). However, the area is not cited in any other faunal accounts (Sillero-Zubiri and Macdonald, 1997).

Small mammals play a vital role in the ecological interaction of a given ecosystem. Accordingly, one of the reasons for the restriction of rare and endemic Ethiopian wolf (*Canis simensis*) in the pockets of afro-alpine habitats is suggested to be due to the presence of various highland rodent species that are crucially important as major source of food (Hillman, 1986; Yalden, 1988; Gotteli and Sillero-Zubiri, 1990; Yalden and Largen, 1992; Sillero-Zubiri *et al.*, 1995a). Several studies have confirmed that alpine and afro-alpine rodent species are the predominant prey of the Ethiopian wolf. The range of habitat for the Ethiopian wolf once believed to inhabit the *dega* belt has already been reduced and at present only concentrated in afroalpine pockets which are threatened by further loss (Sillero-Zubiri and Gotteli, 1994). Based on this finding, it can be suggested that habitat loss of the Ethiopian wolf has a direct link with the decline and/or loss of several rodent species, especially the habitat specialists.

As most of the rodent species found in the afro-alpine belt are endemic, the survival fate of the Ethiopian wolf is strictly dependant on them. Designing ecological and biological studies on rodents is vital to identify the pros and cons and augment our knowledge to recommend appropriate and sustainable management options for the Ethiopian wolf, rodents as well as the concomitants. Man's rapid destruction of the world's most diverse ecosystems especially in the tropics has led to cause a loss of natural habitat and a serious risk of extinction on huge biodiversity elements (Raven, 1998). The Ethiopian highland altitude, which constitutes less than 50% of the country's total width, carried 74% of the human population (Afework and Corti, 1997). This affects the vegetation cover and the fauna.

In Ethiopia, the overwhelming human population and livestock pressure coupled with inappropriate land-use are major causes for habitat loss and continuous decline of these national as well as global natural heritages. Persecutions of wildlife result from the socio-economic impacts and cultural implications are also leading to the loss of wildlife (Shibru Tedla, 1995; Sillero-Zubiri and Macdonald, 1997).

Therefore, to draw attention and foster solutions to the threats confronting the Ethiopian wildlife in general and afroalpine wildlife in particular, further surveys and scientific researches are mandatory. Cognizant of this need, a proposal to carry out an extensive pioneer research study on the ecology of rodents and their significance for the survival of the Ethiopian wolf in Mt. Abune Yoseph was geared up. The main objective of this study is to gather and analyze data on species composition, abundance, habitat association, distribution, and estimate the rodent density and biomass to summarize the status and identify the rodent species on which the Ethiopian wolf depended most in the study area.

2. LITERATURE REVIEW

Among mammals, rodents are the most ubiquitous and numerous in both their number and species type (Delany and Monoro, 1986). In East Africa, rodents account 28% of the total mammal species (Delany, 1986; Kingdon, 1997; Clausnitzer, 2003).

The distribution of rodents is nearly worldwide (Davis, 1963; Kingdon, 1997; Nowak, 1999; Vaughan *et al.*, 2000). Though distribution among habitat types is not uniform, members of the order Rodentia occupy diverse habitats ranging from high Arctic Tundra to tropical forests and desert sand dunes (Stoddart, 1984; Vaughan *et al.*, 2000). They are adapted to terrestrial, fossorial, aquatic, and arboreal life styles. Some also dwell in close association with humans. Rodents are almost cosmopolitan in their distribution and exploit a broad spectrum of food items. This is a result of their different morphological and physiological adaptation (Vaughan, *et al.*, 2000). Even though, relatively little is known of the factors that determine the distribution and abundance of small mammals, experimental results have suggested that they might be associated with habitat structure, amount of rainfall, temperature, presence of potential competitors and altitudinal range that can act singly or in combination to determine their distribution (M'Closkey and Lajoie, 1975; Happold and Happold, 1989). Soil type, predators and food type are also ultimate factors for distribution (Afewerk Bekele and Corti, 1997). According to Delany (1966), the main factors accounting for the distribution and abundance of small mammals are the nature of vegetation through the food and cover it provides and the extent to which these habitat components are modified by large mammals and human activity. Therefore, the species distribution pattern is not random and follows geographic features (Hanson, 1999). Rodents can have broad or narrow range of distribution, depending upon these determining factors. Some rodents are adapted from lowlands to afroalpine belts while others are particularly restricted in either of them. Rodents with broad eco-geographic distribution show variation in population density among different habitats, tended to increase with a specific habitat type and altitudinal range and decrease in others (M'Closkey and Lajoie, 1975). The narrow range groups are mostly specialists of certain factors, which most of the

highland rodents are in this group. With the ability of retreating to their burrows and adapting better vegetation cover to avoid temperature fluctuations and being the dominant herbivores, rodents unlike larger mammals are particularly well suited to the afroalpine environment (Marino, 2003).

Species diversity and abundance of small mammals are largely conditioned by the nature of the habitat. The vegetation, its nature of palatability and the cover it affords, the extent to which it has been modified by large mammals and human activities and the incidence of fire are all significant components to this feature (Delany, 1964). The major influence by large mammals is apparent in the modification of habitats by causing food shortage for herbivores and loss of cover for all rodent species. Several rodent species can reach high densities at their favourable environmental ranges (Gotteli and Sillero-Zubiri, 1990). It has been suggested that food surplus, though is not the only factor, would encourage population explosion. Based on the results of rat out-breaks in Kenyan farmland (Kingdon 1974) suggested the greatly extended rainy season in the previous year could be the likely factor to cause a longer period of plant growth which in turn prolongs the rodents breeding period. Tropical grasslands often support a rich and varied assemblage of small mammals compared to their temperate counterparts (Martin and Dicknson, 1985; Shanker, 2001).

The prominent gnawing tooth is the most obvious common feature of rodents. The dental specialization of rodents is primarily for gnawing plant materials and this is why most rodents are herbivores (Kingdon, 1974; Vaughan *et al.*, 2000). Through the course of evolution, however, rodents have developed diverse food habits, including animal matter. According to their food adaptation rodents are classified as herbivorous, omnivorous, and insectivorous (Delany, 1964). Feeding specialization among species of rodents indicate the ecological relationships of prolific rodent species. Diet partitioning also help them to coexist with in a particular habitat (Cheeseman, 1977). Variation in timing activity as diurnal, nocturnal and crepuscular helps to avoid active competition among related groups for the same resources (Vaughan *et al.*, 2000). Most rodents are opportunistic feeders adapted for diverse diet.

Breeding is the most vital source of recruitment that influences the population density and structure of rodents. The breeding activity of rodents is linked with the rain fall periods and patterns, and most breed in peaks at the end of the rainy season (Delany, 1964; Kingdon, 1971; Delany and Monro, 1986; Leirs *et al.*, 1994; Afework Bekele and Leirs, 1997). Increased availability of food and land cover at the end of the rainfall season are suggested as main ground to this hypothesis. Sufficient food make males sexually energetic, induces maturation of individuals and leading females to produce more litters (Workneh gebresilassie *et al.*, 2006). It is also a periodic strategy to equip the young with better food and cover after weaning. The breeding pattern of rodents follows seasonality, while the rhythm varies from species to species (Kingdon, 1971). Rodents are polyestrous with short gestation period (Taylor and Green, 1976). Most rodents produce 6-7 young that mature rapidly. Population dynamics of rodents can show at least three different basic patterns: stable or irregularly fluctuate, seasonally fluctuate or eruptive with irregular peak years alternating with periods of lower populations (Afework Bekele and Leirs, 1997).

The role of rodents as pests and transmitters of human diseases led to a considerable economic and social importance (Delany, 1986; Singleton *et al.*, 2003). Rodents play a central role in the ecological chains of natural communities, and serve as a main source of food for large mammals, reptiles and birds of prey (Davies, 1963; Ray, 1998). Even though, rodents are thought to be least beneficial to man, some species are used as a source food in many parts of the world (Macdonald, 1984). The Gumuz indigenous people in Ethiopia have been long skilled for using rodents as diet (Tadesse Habtamu, 2005). In general, rodents are one of the significant elements in a given ecosystem where by they are involved in: pruning the vegetation, spreading seeds, competing with other animals, affecting the pasture by making burrows, supporting the survival of other animals and serving as indicators for habitat and population changes (Kingdon, 1997). Burrowing and pilling of the soil also lead to moisture loss and soil erosion which are the characteristic features of land degradation in a long period (Kingdon, 1974).

Some species of rodents have also been recorded for their destructive habits in agriculture and threat to human health (Kingdon, 1974). From globally described 2000 species of

rodents, only few of them are recognized as pests. In Africa, 77 species of rodents have been reported to cause damage in agriculture (Wilson and Reeder, 1993). The major rodent pests in Africa belong to the family Muridae. The genus *Arvicanthis* and *Mastomys* in this family are most widespread and abundant rodents in Africa (Afework Bekele and Leirs, 1997; Kingdon, 1974). Crop damage by rodents varies both spatially and temporally. Consequently, different species of rodents are a threat for certain varieties at different growth stages of crops. Most of the described rodents in Ethiopia have been known as major agricultural pests causing a significant amount of crop damage. For example, the pre-harvest damage rate on maize farmland at Ziway was estimated to be 26% (Afework Bekele *et al.*, 2003). Man has developed every available means to minimize the negative impact caused by rodents. Modern and traditional traps, poisons, barriers, fumigation, predators, etc. have been applied to exterminate rodents from earth. In spite of all these measures, rodents have continued to exist and affect man's endeavour.

The Ethiopian wolf is a specialist rodent hunter, endemic to the Ethiopian highlands. It is currently less common, and has a more reduced range than in the past (Sillero-Zubiri *et al.*, 1995a; Sillero-Zubiri and Gottelli, 1994). They survive in a group of 5-7 individuals. The total number of the Ethiopian wolf is estimated to be about 400 (Malcolm and Sillero-Zubiri, 1997). As a result, the IUCN has listed this species as endangered. Currently certain small populations live in isolated afroalpine mountain massifs and the distribution probably follows that of its primary prey species of rodent community in the Afro-alpine grassland and heathlands (Sillero-Zubiri and Gottelli, 1994). Various factors seriously threaten the survival of the Ethiopian wolves. These include increase in human pressure for subsistence highland agriculture and grazing, direct persecution, hybridization and infectious disease (Sillero-Zubiri and Gottelli, 1994; Laurenson *et al.*, 1997). Although signs of recovery have been reported from local communities, recent reports suggest that Ethiopian wolves have further declined (Sillero-Zubiri and Macdonald, 1997) Therefore, to conserve this rare and endangered species, the causes that have made them decline should be addressed through proper conservation measures. The wolves almost exclusively feed up on diurnal small mammals in the afroalpine habitat. The giant mole-rat (*Tachyoryctes macrocephalus* Rüppell, 1842), *Arvicanthis blicki* Frick, 1914 and *Lophurmys melanonyx*

Petter, 1972, which are the local endemic rodents of the Bale Mountains are the major food sources (Yalden and Lagen, 1992; Sillero-Zubiri *et al.*, 1995a). *Otomys typus* Heuglin, 1877, *Lophuromys flavopunctatus* Thomas, 1888, *Arvicanthis abyssinicus* Rüppell, 1842, and common mole-rat (*Tachyoryctes splendens* Rüppell, 1836) are other common foods in areas where giant mole rat is absent. Wolves are diurnal for the probable reason to synchronize with the activity of most of their rodent preys (Sillero-Zubiri *et al.*, 1995a). However, wolves have also shown a sign of nocturnal feeding which is suggested to minimize human contacts. Management of the afroalpine ecosystem must balance the value of the natural resources used by humans with the intrinsic value of the biological heritages of the area (Malcolm and Zelealem Tefera, 1997)

3. OBJECTIVES

3.1 General objective

The general objective of the present study is to carry out an ecological survey of species identification and abundance, density and biomass estimation on rodent communities to determine the availability of prey for the endangered Ethiopian wolf. The survey also assesses the socio-economic significance of rodents and wolf in the study locality.

3.2. Specific objectives

- To identify the species composition of rodents in the study area.
- To estimate the relative abundance of rodents with regard to habitat association and seasonal variation.
- To determine the distribution pattern of rodents in relation to altitude ranges and habitat structure.
- To extrapolate the availability of rodent prey to the endangered population of the Ethiopian wolf.
- To determine the socio-economic impacts of rodents and the Ethiopian wolf and their interaction with man.
- To recommend appropriate measures for conservation of the endemic Ethiopian wolf and rodents in the study area.

4. DESCRIPTION OF THE STUDY AREA

4.1. Location

The present study area, Mt. Abune Yoseph is located in the Amhara National Regional State (ANRS) of North Wollo Zone, Lasta Wereda. It is locally administered as a communal grazing land by three Kebeles: Wedebiye, Telfetit and Abune Yoseph. The study area is 742 km north of Addis Ababa. It is also 42 km away from Lalibela, the central town for Lasta Wereda. The study area lies between $12^{\circ} 8' 7''$ N and $39^{\circ} 15' 7''$ E. It is one of the long isolated mountains in the northern massif with a total area of 50 km^2 (EWCP, 2002/03). The altitude of the study area varies from 3600 m asl at crop field grid in Wedebiye Kebele to 4270 m asl at the peak of the mountain. The study area is bounded by the residences and farmlands of Abune Yoseph in the north, Wedebiye and Waghimra Zone in the west, Enjafat in the east and Telfetit Kebeles in the south (Fig.1). The plateau extends to Enjafat Kebele where the topographic features and habitat structure is closely similar to the study area.

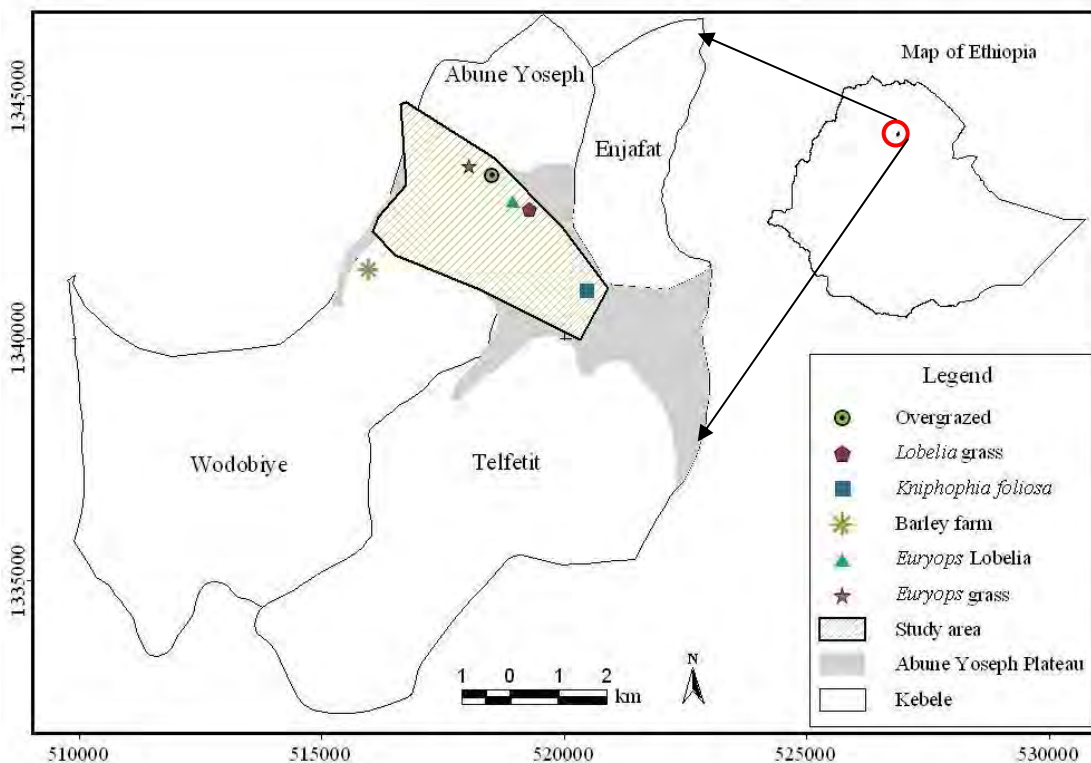


Figure 1. Map of Mt. Abune Yoseph showing grid locations. Outline of Ethiopia is shown INSET

4.2. Climate

The area is categorized in “Alpine belt” (3200 - 3700 m asl) and “Afroalpine belt” (>3700 m asl) agro-climatic zone of the country (modified from, Hurni, 1986). These are characterized by moist and cold conditions. The mean annual rainfall of the area ranges from 800 to 900 mm. The area has bi-modal rainfall known as ‘Meher’ (long rainfall period: from June to September) and ‘Belg’ (short rainfall period: from February to May). The mean annual temperature of the study area ranges from 7.5°C to 12°C (Anonymous, 2002).

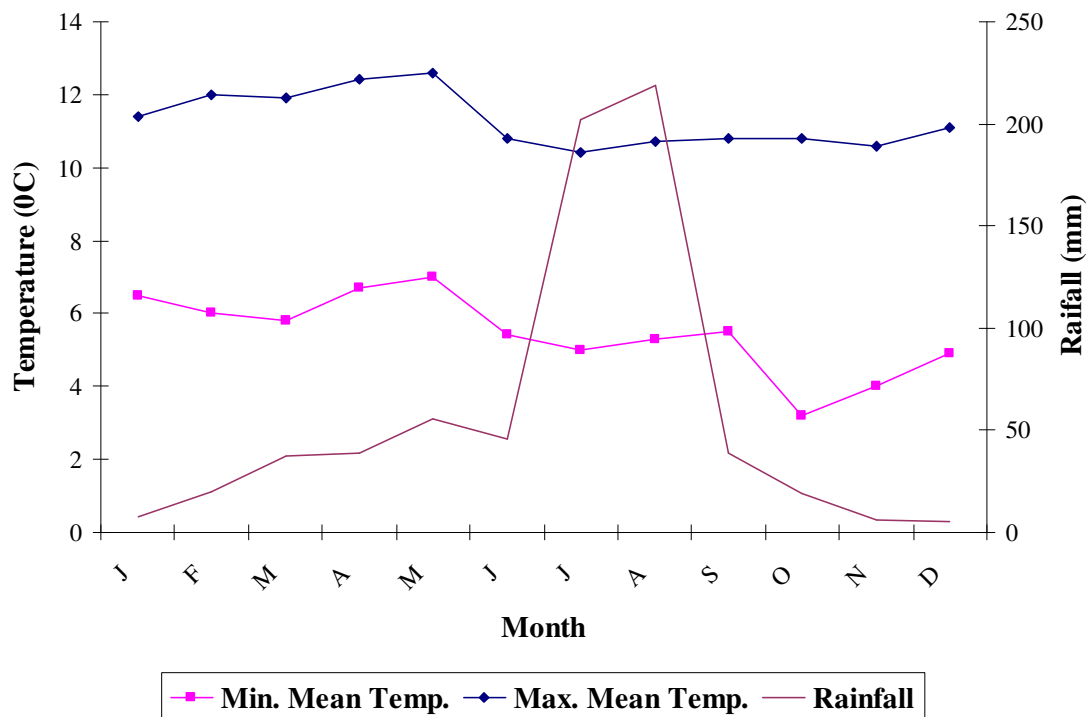


Figure 2. Monthly average rain fall (mm), mean maximum and minimum temperatures (°C) of the high plateau of Lasta area (2003- 2006). (Source: Kombolcha Regional Office of Meteorology).

4.3. Topography

An intensive dissection of the plateau has resulted in a landscape dominated by steep slopes and isolated mountains with a wide range of altitudes. The eastern part of Lasta Wereda, where the study area was based, is characterized by rugged topography. Mountains, plateau remnants, escarpments and gorges are the frequent features rendering the area with very spectacular scenery comparable to the Simen and other highlands in the country.

4.4. Soil

The high altitude plateau contains silty soil (MoWR, MoA and EPLAUA, 2002) that has less water infiltration and results the low ground water recharge. Infiltration is relatively better at the base of the mountain where the farmlands occur. The underlying soil has been farmed for millennia and its organic content is generally low resulting in low agricultural productivity.

4.5. Vegetation and wild animals

Remnant natural forest patches around the Church Compounds, and the middle belts of the mountain (i.e. at boundaries between mountain and farmland) have indicated that the area was formerly covered by forest. The type of plant species along the study area includes *Erica arborea*, *Hypericum revolutum*, *Hagenia abyssinica* and guassa grass with other grass types and associated herbs. Except *E. arborea* and *H. revolutum* species that occurred in scattered patches, other vegetation types have been mostly observed in the Church Compounds and less frequently in homesteads and farmlands. The plateau is predominantly characterized by alpine vegetation types, such as the giant lobelia, guassa grass and *Euryops* sp. (Zealelem Tefera *et al.*, 2000). *Euryops* sp is locally known as 'Chirfa' and 'Kirshiba'. Grasslands mostly occur in association with the *Euryops* shrub. Open grasslands are small sized and scattered at the mountain. The mountain also contains few small sized swampy areas. The remnant giant lobelia (*Lobelia rhyncopetalum*), which

formerly existed in all afroalpine regions is only restricted at the top of the mountain and covers a small tract of land. The largest area of the mountain is covered by short shrub plant *Euryops* sp.

The area harbours a variety of wild fauna. Ethiopian wolf, Gelada baboon (*Theropithecus gelada*), Leopard (*Panthera pardus*), Klipspringer (*Oreotragus oreotragus*), Common jackal (*Canis aureus*), Rock hyrax (*Procavia capensis*), different species of rodents and avifauna including Wattled ibis (*Bostrychia carunculata*), Black-headed siskin (*Serinus nigriceps*), Abyssinian long claw (*Macronyx flavicollis*), Chough (*Pyrrhocorax pyrrhocorax*), Thick-billed raven (*Corvus crassirostris*), Black kite (*Milvus migrans*), Augur bussard (*Buteo rufofuscus*) and the huge lammergeyer (*Gypaetus barbatus*) are the common ones.

4.6. Accessibility

Only one graveled main road from Gashena to Sekota passes through the Lasta Wereda via Lalibela. This road links Lalibela to Addis Ababa and other towns of the country. All other roads constructed by manual labour are dry weather roads. The only road accounted for accessibility to the study area is the Telfetit-Wedebiye manual dry weather road. The road provides service from Lalibela up to ‘Telba Ersha’ a sub-Kebele in Wedebiye, which is about 15 km from Mt. Abune Yoseph. Trekking animals or foot are the only means of transport to Mt. Abune Yoseph.

4.7. Socio-economics

The population in Kebeles surrounding Mt. Abune Yoseph is estimated to be 20,000 (MoWR, MoA and EPLAUA, 2002). They are commonly engaged in mixed agriculture. People use the middle belt and the base of the mountain for agriculture and residence activities. Livestock is the main source of income. The livestock is grazed on communal mountain lands, which are classified as marginally suitable due to low potential feed production. The sheep density in the study area is high. The high livestock density relative

to the total area of grazing land causes severe habitat degradation. Both rain fed crop and livestock production are potentially low.

5. MATERIALS AND METHODS

5.1. Materials

Various field and office materials were used during data collection and thesis writing. These are camera, binocular, Sherman traps, break back snap traps, rodent and wolf guides, dissecting kits, preservatives, stretching boards, GPS, rolling meter, ruler, spring balance, bait, data sheet, questionnaire formats and soft ware programmes.

5.2. Methods

5.2.1. Site selection

Access can only be gained to Mt. Abune Yoseph by foot. During the end of August/ 2007 a three day reconnaissance survey was carried out in the study area to investigate the habitat types available for the proposed study. Although the study area was characterized by less diverse vegetation types and structure, habitat classification was mainly based on the vegetation, landscape types and marginally different altitude ranges. The habitats of the study area were stratified into six categories (units) from which six permanent grids were carefully selected (Fig. 1). Each grid represents the unit from which it was sampled. Four of the six, *Euryops*-grass, *Euryops*-lobelia, overgrazed Alpine meadow and *Lobelia*-grass habitats were located within the central part of Mt. Abune Yoseph. The other two grids, the Barely farm and *Erica* grass were approximately 3-5 km away from the centre of the mountain. In addition to these permanent grids, two additional survey sites characterized by mosaic vegetation types (*Kniphophia*, guassa, *Lobelia*, *Euryops* and including the swamp areas) of the permanent habitats were randomly selected within the mountain area. These two sites were surveyed only once during the first session of wet and second session of the dry season. All the selected sites lay scattered within the study area ranging 3650-4102 m asl. The farmland and *Erica* grass grids were located at the same altitude range of 3650 m asl. The Barely farm grid (Plate 1e) was selected in Wedebye Kebelle (and its specific place is known as Tigu Kebelle) was located at the foot of the mountain in the west direction. *Erica* grass grid, in the east direction of the mountain was situated at the

steep hill of Abune Yoseph Church Compound. It was covered by thinned out and overgrazed ericaceous heath (>5 m canopy). This habitat was laid outside of the wolf habitat range and achieved a zero trap success. As a result the habitat was not included in the data analysis. *Euryops*-grass habitat (3891 m asl) was characterized by long and dense cover of *Euryops* and located north of the mountain (Plate 1d). Alpine meadow (3901 m asl) was characterized by overgrazed short grass; located along the northeast periphery of the mountain (Plate 1f). The *Euryops*-lobelia and *Lobelia*-grass grids were located at the central top of the mountain. The *Euryops*-lobelia grid at 4050 m asl was characterized by certain vegetation mixture of giant lobelia, *Kniphophia foliosa*, *Euryops* sp. and grass (plate 1a and b). The *Lobelia*-grass grid (4102 m asl) was covered by giant lobelia (*Lobelia rhyncopetalum*) and overgrazed short grass (Plate 1c). It is only in these habitats and the surrounding areas where the remnant of lobellia vegetation was retained. Sample site selections were carried out randomly following Sutherland (1996). Even though survey grids were selected for comparison the data was not used for analysis. Data for analysis of this study was taken from the permanent grids, excluding *Erica* grass habitat.

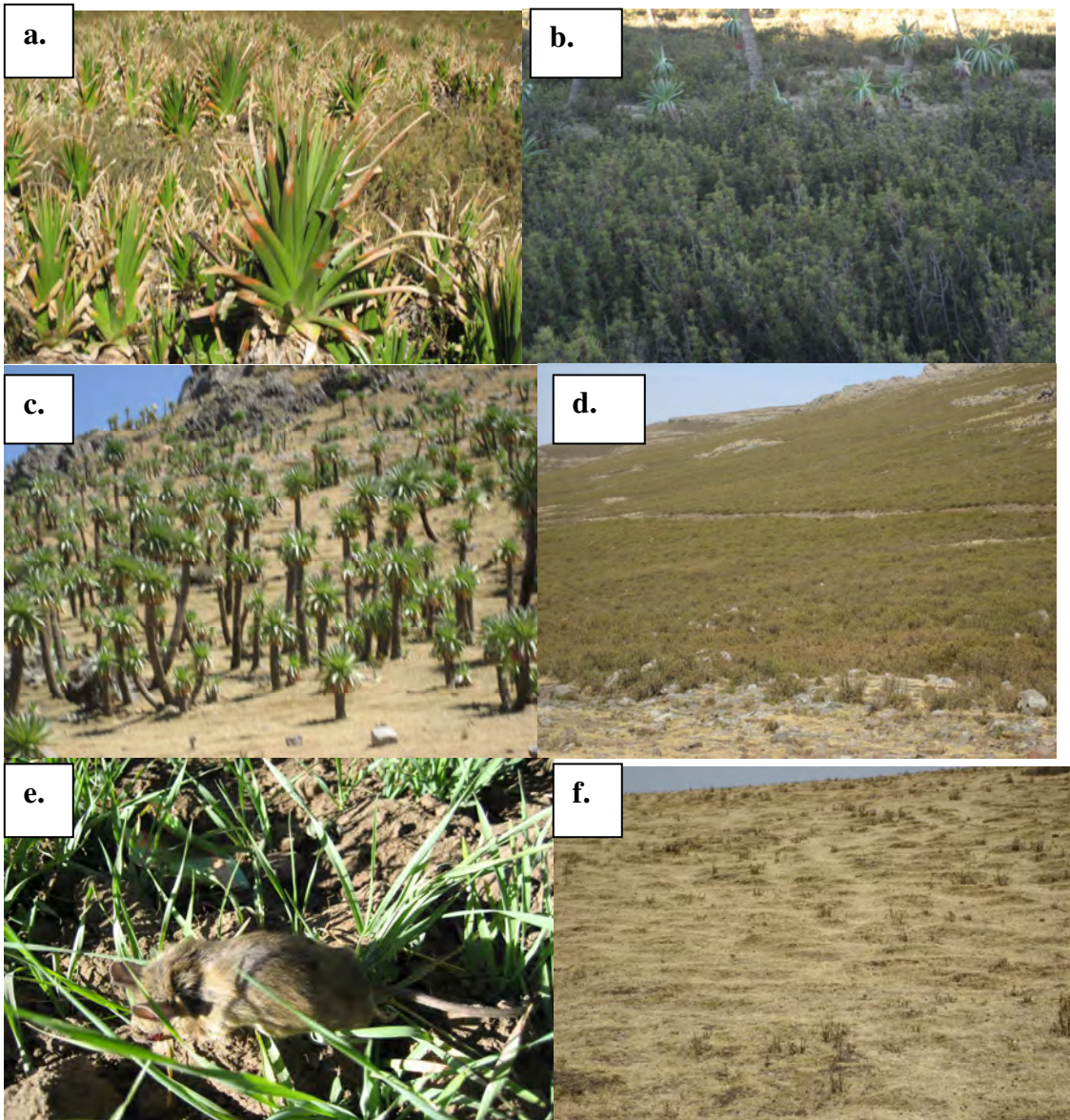


Plate 1. Habitat types at Mt. Abune Yoseph afroalpine area. (a. *Kniphophia* dominated, b. *Euryops*-lobelia, c. *Lobelia*-grass, d. *Euryops*-grass, e. Barely farm (*P. haringtoni* in Barely crop) , f. Alpine meadow)

5.2.2. Data collection

Both live and removal rodent trapping were used during the data collection period from September 2007 to March 2008. Two trapping sessions were conducted in each of the wet (September and October) and dry seasons (December and March). The two sessions wet season data collection were conducted in closer periods for the reason that dry season of the area will be started after the month of October. Data on types of species, sex, weight, habitat type, time of collection, altitude range, reproductive status and seasonal occurrences were recorded. At the same time, additional data on topography, climatic condition, list of larger fauna and vegetation type and status were gathered. Data on socio-economic impact of rodents and Ethiopian wolf including interaction of man and wildlife were collected using structured interviews. A Global Positioning System (GPS) was used to record the co-ordinates and altitude readings for each sampling site.

5.2.3. Traps and trapping design

In each of the selected permanent grids, a total of 49 Sherman-live traps and 25 snap-traps were used and intensive ecological study on rodent population was carried out. The Sherman traps were permanently arranged in 7 rows and 7 columns at 10 m intervals between each trap within a 70 x 70 m² grid (Yalden, 1988). Except the farmland, all grids contained an estimated total area of 4900 m² or 0.49 ha. The snap-trap grids were arranged 100 m away from each live trap grid. The vegetation homogeneity between snap-trapping and live-trapping grids was taken into account at each site. Twenty five snap traps were arranged within 625 m² grid in 5 rows and 5 columns at 5 m interval in both directions. In grids, that have sufficient vegetation cover, traps were set under the shade of the vegetation, while in open areas live-traps were covered with herb branches to give some insulation. Traps were positioned along the sides of rodent run way and burrows, under dense shades and big stones to increase the probability of capture.

5.2.4. Trapping and processing

Traps were baited with a paste of peanut butter and floured with dried and crushed garlic to give strong odour. Bait was replaced or added during checking periods. Rodents were trapped for three consecutive nights and days at each grid in every session. Traps were checked twice a day; in the early morning (between 06:30 and 08:30 am) and late afternoon (between 05:00 and 07:00 pm). Data on trap number, date, time of capture, and grid site were recorded for both trappings.

All live captured small mammals were removed from the trap and kept in a cloth bag. An animal within the bag was gently rotated for easy handling during examination. Identification code (species type), sex and weight of each captured animal were recorded. For females, pregnancy status (i.e. whether the animal is pregnant or non-pregnant) was recorded through detection of enlarged uterus and weight of animals. The age of rodents classified as young, sub-adult and adult were identified by relative comparison of weight measurements and morphological appearance based on Afework Bekele (1996a). Animals were then marked by toe clipping and released to the station where they were caught. For those captured and marked previously, only the type of species and the code of recapture data were taken.

Among snap-trapped rodents, data on pregnancy condition and embryo counts were recorded from dissected females. Based on morphological differences, skin specimens were prepared for later identification and verification. Moreover, few doubted live-trapped rodents were sacrificed at the end of the study and retained their skin and skull for later identification at the museum.

5.2.5. Species identification

Identification process was conducted using different guidelines. Criteria listed by different authors Kingdon (1974), Yalden *et al* (1976), Hillman (1986), Afework Bekele *et al.* (1993) and Nowak (1999) were used for identification. This was supplemented by

comparative identification with the specimens in the Zoological Natural History Museum of the Addis Ababa University. Voucher specimens were deposited in the Museum.

5.2.6. Wolf observation

Wolf observation in the study area was carried out using line transects and point observation techniques. Three transect lines that had an estimated length of two km and four permanent point observation points were arranged. Each transect was assessed once in each data collection session. But, each point observation was carried out for three days in each session. Information about the number and trend of wolf in the area was also gathered from the local communities through interviews and informal discussions. Based on this data, the den and other common areas of wolves were checked often during early morning and late afternoon. Their presence was also traced from foot prints and faecal droppings at different habitats of the study area.

5.2.7. Climatic and habitat variables

Comparative variation for temperature was observed between the mountain (>3800 m) and the relatively low altitude (3650 m) farmland and *Erica* grass grids. This variation was actually based on simple physical observation, but not from measured results. The mountain temperature was colder than the farmland and *Erica* grids and this might be the reason for the residence areas situated at relatively low altitude of these grids.

Vegetation cover status and plant species richness were visually estimated and taken into account during habitat classification. The habitat classification also accounts the level of habitat modification by human induced activities to compare the habitat productivity and habitat association of rodents between semi-natural and highly modified habitats. This will help to design a sustainable natural resource utilization that can benefit both the community and the wildlife in the area.

5.2.8. Socio-economic survey

Socio-economic impact on rodents and Ethiopian wolf was surveyed using structured interviews of local people from two Kebeles (Abune Yoseph and Wedebye) located at the periphery of the afroalpine area. Twenty individuals were selected by stratified sampling from the poor (groups that have no livestock and farmland and primarily supported by safety net program of either food or cash for work), medium economic group, (group that have fewer livestock and small sized farmland), wealthy (group that have high number of livestock, large size farmland and ranked wealthy in the area), elder (age >50 years old), young (<30 years old), male and female populations. Interviews were primarily carried out individually and response was given without restriction to collect all relevant information. A short group discussion was arranged among the selected respondents to confirm whether personal responses deviated from the reality because of self interest or not.

5.2.9. Data analysis

All the data obtained from the study area were analysed using SPSS version 15.0 software program. Appropriate statistical techniques such as Chi-square and One Way ANOVA were applied to compare the results computed from the original data. Ratio comparison was applied for the data that had apparent range of similarity or difference. The Shannon Weaver (H') index (Shannon and Weaver, 1948) was used to determine indices of the rodent diversity in all habitat types. Minimum Number Alive (MNA) method was used to estimate the population size.

6. RESULTS

6.1. Number of species captured and observed in Mt. Abune Yoseph

A total of seven rodent species belonging to the family Muridae were encountered from live and snap trapping grids. They are: *Arvicanthis abyssinicus*, *Lophuromys flavopunctatus*, *Stenocephalemys griseicauda*, *Otomys typus*, *Pelomys harringtoni*, *Dendromus lovati* and *Muriculus imberbis*. The first five of these species were captured by both snap and live trappings. *M. imberbis* was trapped by snap trap during the dry season while *D. lovati* was trapped by live trapping during the wet season. In addition, one species of shrew, *Crocidura baileyi* was captured only by live trapping. Other small mammals that were either visualized or only noted for their presence from the indirect observation were rock hyrax (*Procavia capensis*), common mole-rat (*Tachyoryctes splendens*) and crested porcupine (*Hystrix cristata*). The distribution of shrew was encountered in most of the selected mountain grids, except the alpine meadow. The shrew was not trapped in the farmland grid. Sighting and vocalization of rock hyrax were common in all rocky areas of the mountain (Table 1).

Table 1. Species composition of captured and observed small mammals in the study area.

Species	Common names	family
<i>Arvicanthis abyssinicus</i> (E)	Grass rat	Muridae
<i>Lophuromys flavopunctatus</i>	Brush-furred mice	Muridae
<i>Stenocephalemys griseicauda</i> (E)	Gray-tailed narrow-headed rat	Muridae
<i>Otomys typus</i>	Swamp rat	Muridae
<i>Pelomys harringtoni</i> (E)	Dega rat	Muridae
<i>Dendromus. lovati</i> (E)	Lovat's climbing mouse	Muridae
<i>Muriculus imberbis</i> (E)		Muridae
<i>Tachyoryctes splendens</i> *	Common mole-rat	Rhizomyidae
<i>Procavia capensis</i> *	Rock hyrax	Procavidae
<i>Hystrix cristata</i> *	Crested porcupine	Hystriidae

E= endemic *= Shows species observed but not trapped

6.2. Live-trapping

6.2.1. Species composition and relative abundance of rodents

A total of six rodent species were trapped in live-trapping grids during the four trapping sessions. The species identified were *A. abyssinicus*, *L. flavopunctatus*, *S. griseicauda*, *O. typus*, *P. harringtoni* and *D. lovati* (Table 2). Live trapping grids achieved a total of 957 captures from 2,712 trap nights. From these total trapped rodents, 694 were newly trapped individuals and the remaining 263 were recaptured at least once.

Arvicanthis abyssinicus was the most abundant species in the selected habitats or grids and comprised the largest percentage of the total capture (50.4%). *Stenocephalemys griseicauda* and *Lophuromys flavopunctatus* were being second and third most abundant species, respectively. *Otomys typus*, *P. harringtoni* and *D. lovati* had lower catches by decreasing order (Table 2). Variation in abundance among the rodent species was significant ($\chi^2 = 760$, $df = 5$, $P < 0.001$).

Table 2. Total catch and relative abundance of live-trapped

Species	Total new captures	Recapture individuals	Relative abundance (%)
<i>A. abyssinicus</i>	351	151	50.4
<i>L. flavopunctatus</i>	146	52	20.9
<i>S. griseicauda</i>	150	50	21.7
<i>O. typus</i>	36	8	5.3
<i>P. harringtoni</i>	9	2	1.4
<i>D. lovati</i>	2	0	0.3
Total	694	263	100

6.2.2. Distribution of rodent species

Arvicanthis abyssinicus and *Stenocephalemys griseicauda* were distributed in all habitat types. *Lophuromys flavopunctatus* and *Otomys typus* were occurred in three habitats only. *Pelomys harringtoni* and *Dendromus lovati* were only trapped in one habitat type (Table 3).

Table 3. Distribution of rodent species in five habitats.

Species	Habitat types					occurrence
	BF	EG	EL	LG	AM	
<i>A. abyssinicus</i>	*	*	*	*	*	5
<i>S. griseicauda</i>	*	*	*	*	*	5
<i>L. flavopunctatus</i>	-	*	*	*	-	3
<i>O. typus</i>	-	*	*	*	-	3
<i>P. harringtoni</i>	*	-	-	-	-	1
<i>D. lovati</i>	-	-	-	-	*	1
Total species/ habitat	3	4	4	4	3	

* = show presence, (-) = absence, BF= barely farm, EG= *Euryops*-grass, AM= alpine meadow, EL= *Euryops*-lobelia, LG= *Lobelia*-grass

6.2.3. Abundance distribution and habitat association of rodent species

Arvicanthis abyssinicus and *S. griseicauda* were the most widely distributed species throughout the grids. These two rodent species were distributed in high abundance at *Euryops*-lobelia and *Euryops*-grass habitats and at low levels in other habitats. The other four species showed a limited range of distribution. *L. flavopunctatus* and *O. typus* were distributed in *Euryops*-lobelia, *Euryops*-grass and *Lobelia*-grass habitats. They were absent in barely farm and alpine meadow habitats. The distribution of *P. harringtoni* and *D. lovati* was restricted only in barely farm and alpine meadow grids, respectively. These species were identified as the least distributed among the randomly selected grids of the study area

(Table 4). The distribution of rodents among the different habitat types was significantly different ($\chi^2=448.56$, $df=20$, $p<0.005$).

Four rodent species such as *A. abyssinicus*, *S. griseicauda*, *L. flavopunctatus* and *O. typus* were commonly trapped in *Euryops*-grass, *Euryops*-lobelia, and *Lobelia*-grass habitats. The highest abundance of *A. abyssinicus* and *S. griseicauda* was from *Euryops*-lobelia grid. The second preferred habitat for these animals was *Euryops*-grass where the second highest proportion was recorded. Their abundance in the rest grids was scattered and comparative with other rodent species. *Euryops*-grass and *Euryops*-lobelia habitats together also contributed for the highest abundance of *L. flavopunctatus* (91.8%). The *Lobelia*-grass habitat supports low abundant rodent species. In contrast abundance of *O. typus* was highest at *Lobelia*-grass habitat and this habitat recognized as the primary preference. The habitat association and preference for *P. harringtoni* and *D.lovati* was exclusively restricted to barely farm and alpine meadow, respectively (Table 4). The number of rodent species distributed among the different habitat types was not significant ($\chi^2=0.92$, $df=4$, $P>0.08$).

Table 4. Abundance distribution and habitat association of live-trapped rodent species (not including recaptures) in five habitats.

Species	Habitat types (Grids)					Total
	BF	EG	EL	LG	AM	
<i>A. abyssinicus</i>	4 (1.1)	116 (33.1)	150 (42.7)	59 (16.9)	22 (6.3)	351
<i>L. flavopunctatus</i>	-	72 (49.3)	62 (42.5)	12 (8.2)	-	146
<i>S. griseicauda</i>	12 (8)	49 (32.7)	51 (34)	11 (7.3)	27 (18)	150
<i>O. typus</i>	-	4 (11.1)	5 (13.9)	27 (75)	-	36
<i>P. harringtoni</i>	9 (100)	-	-	-	-	9
<i>D. lovati</i>	-	-	-	-	2 (100)	2
Total	25 (3.6)	240 (34.6)	268 (38.6)	110 (15.9)	51 (7.3)	694

BF= barely farm, EG= *Euryops*-grass, AM= alpine meadow, EL= *Euryops*-lobelia, LG= *Lobelia*-grass, (-) shows absence, (Figures in parentheses) = Percentage habitat association of rodents

6.2.4. Rodent species diversity

Rodent species diversity indices were 0.862, 1.013, 1.053, 1.092, and 1.154 for alpine meadow, barely farm, *Euryops*-lobelia, *Euryops*-grass and *Lobelia*-grass habitats, respectively. Diversity of rodents was low in alpine meadow and high in *Lobelia*-grass habitat (Fig. 3). The difference in species diversity among different habitats was insignificant ($\chi^2 = 0.054$, $df = 4$, $p > 0.95$).

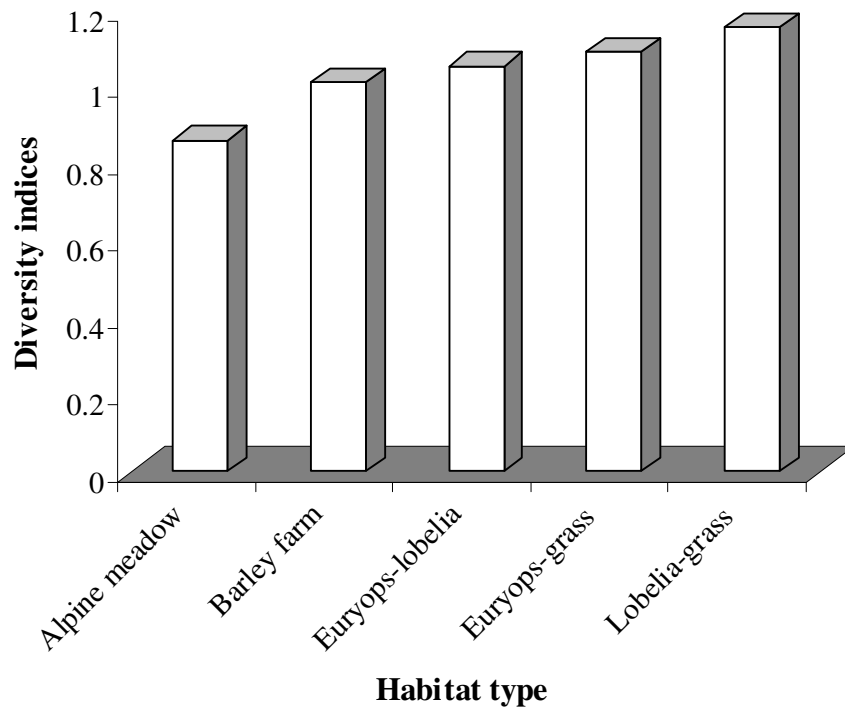


Figure 3. Rodent species diversity among different habitats.

6.2.5. Effect of seasonal variation on rodent distribution and abundance

The number of rodent species and population abundance recorded in wet and dry seasons is given in Table 5. The ratio of rodent species captured during the wet and dry seasons was 1.0: 0.8. The difference in the number of species captured during the wet and dry seasons was statistically insignificant ($\chi^2= 0.091, df = 1, P > 0.76$). Rodent abundance during the wet and dry seasons showed minor variation. The difference of overall rodent abundance between the two seasons was statistically insignificant ($\chi^2= 0.83, df = 1, P > 0.36$). Rodent abundance during the two seasons vary within the species. The difference in abundance of *A. abyssinicus*, *L. flavopunctatus*, *S. griseicauda* and *D. lovati* between the two seasons was significant ($P<0.029$). The abundance variation of *O. typus* and *P. harringtoni* between the two seasons was insignificant ($P>0.07$) (Table 5).

Table 5. Rodent species occurrence and abundance during the wet and dry seasons.

Species	Season		Total
	Wet	Dry	
<i>A. abyssinicus</i>	155	196	351
<i>L. flavopunctatus</i>	89	57	146
<i>S. griseicauda</i>	91	59	150
<i>O. typus</i>	18	18	36
<i>P. harringtoni</i>	4	5	9
<i>D. lovati</i>	2	-	2
Total	359	335	694
Percentage	51.7	48.3	100
No. of species	6	5	6

(-)= indicates absence

Euryops-lobelia and *Lobelia*-grass habitats supported the maximum number of rodent species during both the wet and dry seasons. Habitat type of *Euryops*-grass was found to support the maximum number, which was four rodent species during the dry season. On

the other hand *Euryops*-grass during the wet season contains only three species. The number of species trapped in the Barely farm habitat remained the same; three species were captured in both seasons. The lowest number of rodent species, which was two, trapped from alpine meadow habitat during the dry season (Fig. 4). The interaction of season and habitat showed significant difference on the number of species among habitats ($\chi^2=1.85$, df =9, $p<0.01$).

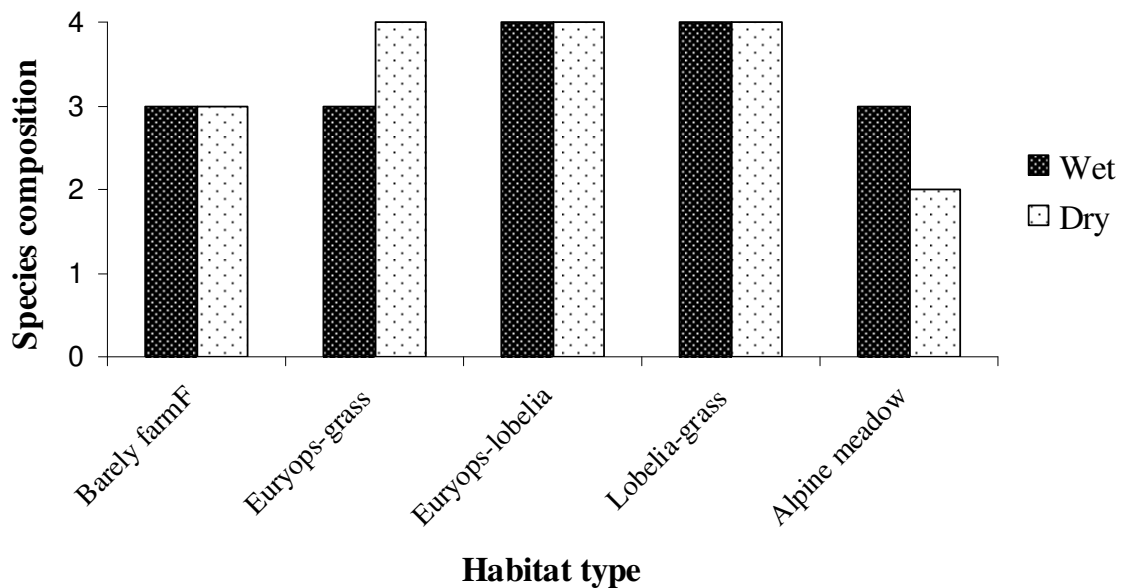


Figure 4. Species composition in each habitat between wet and dry seasons.

Total rodent captures during the dry season was high in *Euryops*-grass habitat (138), when compared to 118 captured during the wet season. Higher number of rodents were captured during the wet season in *Euryops*-lobelia habitat (152) than the number (116) of rodents captured during the dry season. The number of rodents trapped in other habitats such as barely farm, *Lobelia*-grass and alpine meadow between wet and dry seasons was more or less similar and did not show significant differences (Fig. 5). The variation of overall rodent abundance between wet and dry seasons among different habitats was significant ($F_{(4, 684)}=2.43$, $P<0.046$).

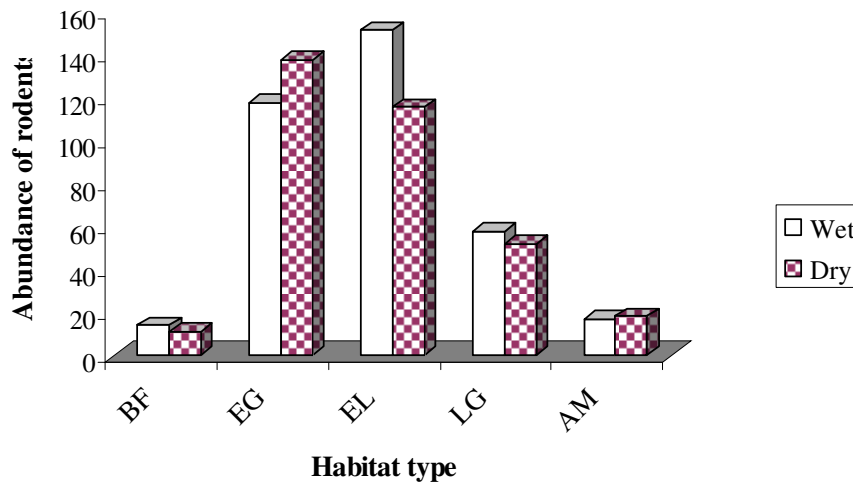


Figure 5. Rodent abundance among habitats during wet and dry seasons (BF= barely farm, EG= *Euryops*-grass, EL= *Euryops*-lobelia, LG = *Lobelia*-grass, AM= alpine meadow).

6.2.6. Trap success

The overall trap success in all grids and trapping sessions was 25.6%. Trap success was highest in *Euryops*-lobelia habitat. *Euryops*-grass habitat contributed the second highest trap success followed by *Lobelia*-grass habitat. The least trap success was recorded in barely farm and alpine meadow (Table 6). The difference in trap success among the different habitat types was significant ($\chi^2 = 348.83$, df =3, $p < 0.001$). High percentage (51.7%) trap success during wet season was achieved in *Euryops*-lobelia grid, while in the dry season highest percentage of trap success was achieved in *Euryops*-grass grid (40.8%). The least trap success both during wet and dry seasons was recorded in alpine meadow and barely farm habitats (Fig. 6). Rodent trap success in each trapping session was significant ($\chi^2 = 11$, df = 3, $p < 0.012$).

Table 6. Percentage of trap success of live-trapped rodents in the randomly selected habitats.

Habitat type	Total catch	Trap nights	Trap success (%)
Barely farm	25	360	6.9
<i>Euryops</i> -grass	256	588	43.5
<i>Euryops</i> -lobelia	268	588	45.6
<i>Lobelia</i> -grass	110	588	18.7
Alpine meadow	35	588	5.9
Erica-grass*	-	290	-
Total/average	694	2712	25.6

(-) shows absence of trapped individuals and trap night did not include.

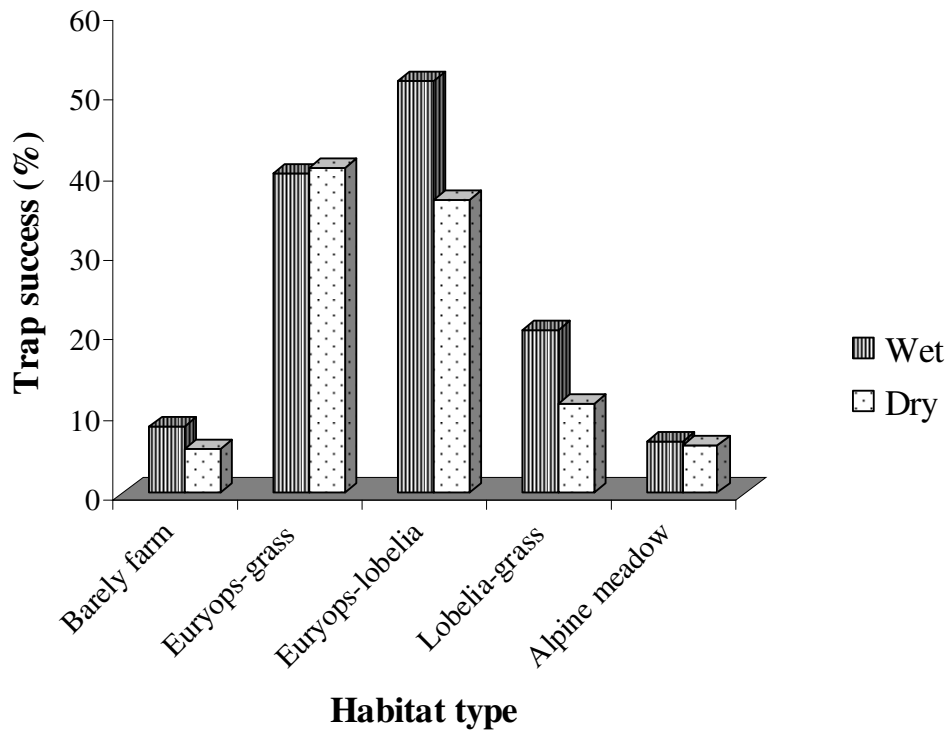


Figure 6. Percentage of trap success in each habitat between the wet and dry seasons.

A. abyssinicus contributed the highest over all trap success in the study area. *Stenocephalemys griseicauda* and *L. flavopunctatus* contributed the second and third high trap success, respectively. *O. typus*, *P. haringtoni* and *D. lovati* contributed the least trap success in decreasing order (Fig. 7).

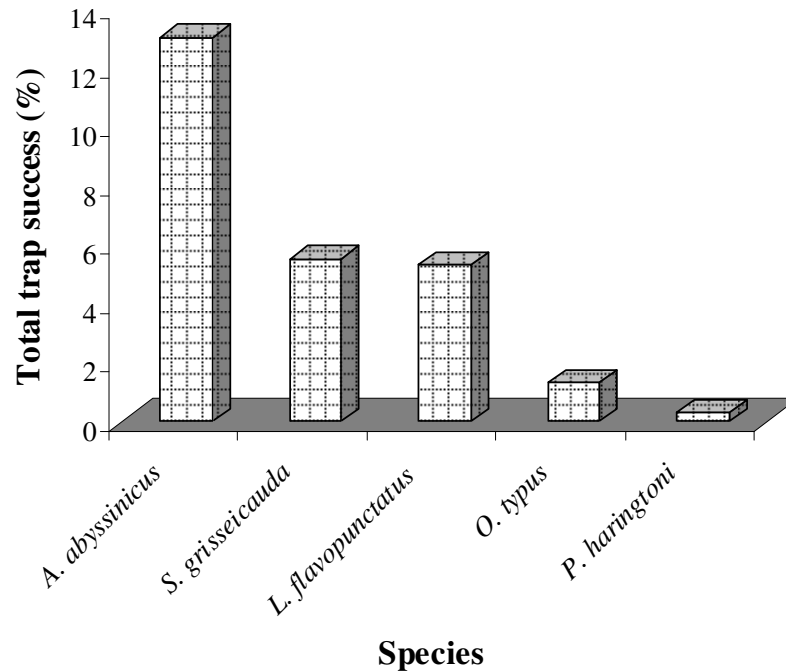


Figure 7. Percentage trap success of each live trapped rodent species.

6.2.7. Population dynamics

The abundance and trap success of the four commonly trapped rodents during the four trapping sessions was analysed to investigate the trend of population and is given in figure 8. High number *A. abyssinicus* was captured during the first session of the dry season (31%). Low number of individuals and trap success for this species was recorded during the second session of the wet season (19%). Abundance of this species in other two sessions was more or less similar around (24%). The fluctuation of abundance of *A. abyssinicus* was not seasonal. The population abundance of *L. flavopunctatus* was higher

during the first session of wet season (38.4%). Abundance of this species significantly decreased during the second session of the dry season (15%). *O. typus* also did not show any seasonal population fluctuation. Consequently abundance in every session of the two seasons was up and down. The population abundance of *S. griseicauda* was higher during the first session of wet season (32.2%) and decreased to wards the end of dry season (28, 25, 15%, respectively). Abundance in this species during the four sessions seemed to be correlated slightly with season (Fig. 8). The difference in overall abundance of the four species type during the four sessions was statistically significant ($\chi^2 = 11.87$ df = 9, $P < 0.01$). In general the change in population size of the rodent community was not season dependant.

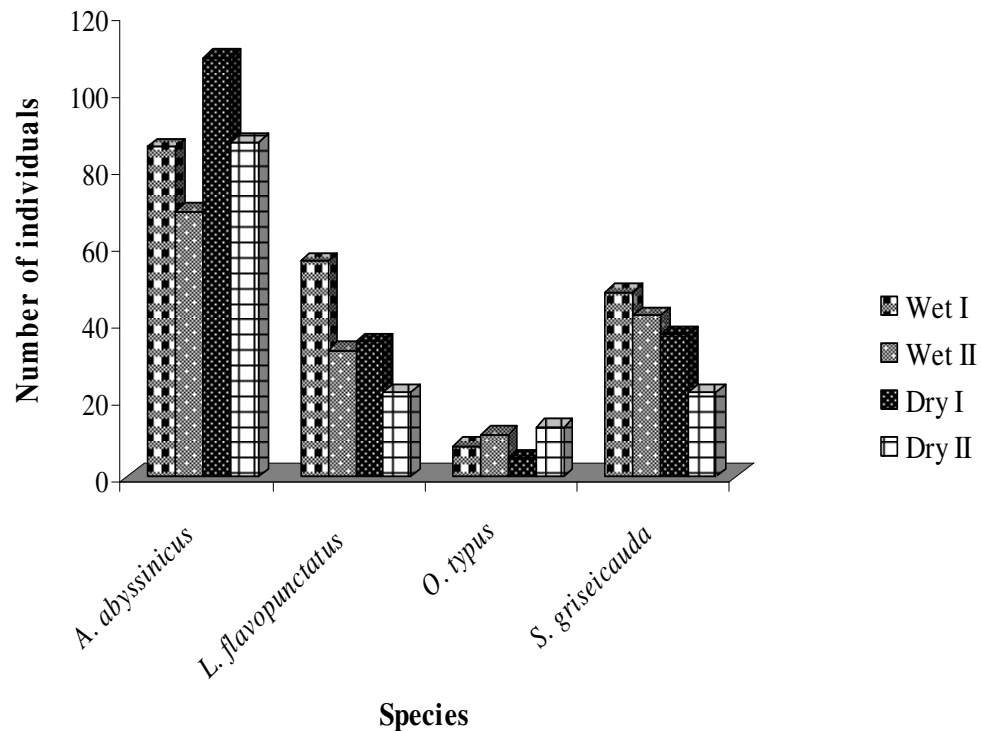


Figure 8. Number of trapped rodents during the four trapping sessions.

6.2.8. Age structure and sex ratio

Out of the total captured individuals, the number of males and females was 300 (43.2%) and 394 (56.8%). The difference between male and female rodent was significant ($\chi^2 = 12.73, df = 1, p < 0.001$). More females were captured than males during both dry and wet seasons (Table 7). Seasonal difference of male to female ratio was significant ($\chi^2 = 8.66, df = 1, p < 0.003$). In the same way *A. abyssinicus* and *S. griseicauda* contributed more female than male sex and the variation was significant ($\chi^2 = 6.84, df = 1, P < 0.001$), while variation in *L. flavopunctatus* was insignificant ($\chi^2 = 1.17, df = 1, P > 0.28$). The difference of sex ratio in *P. haringtoni* and *D. lovati* was also highly insignificant ($P < 0.001$).

Table 7. Absolute and percentage sex distribution during the wet and dry seasons.

Season	Absolute		Percentage	
	Male	Female	Male	Female
Wet	136	224	37.8	62.2
Dry	164	170	49.1	50.9
Total	300	394	43.2	56.8

Mean % ⇨

From the total captured population (694), the young, sub-adult and adult captures were 74, 289 and 331 comprising 10.7%, 41.6% and 47.7%, respectively (Fig. 9). The difference in rodent age structure was significant ($\chi^2 = 163.69, df = 2, p < 0.001$).

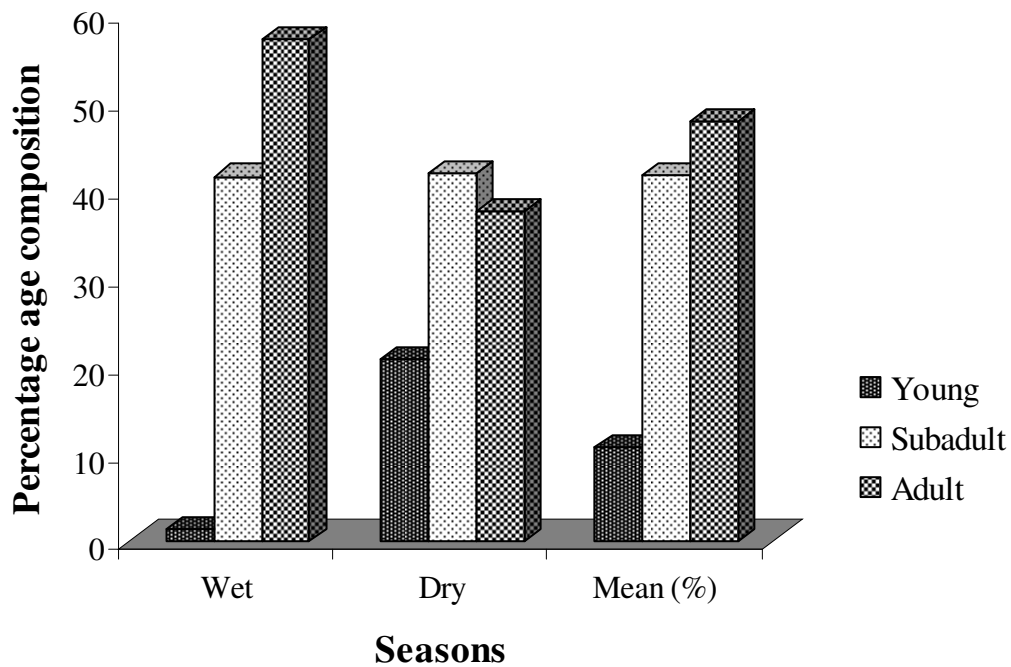


Figure 9. Percentage of young, sub-adult and adult rodents between wet and dry seasons.

Out of the 74 young rodents, 5 individuals (7%) were captured during the wet and 69 (93%) during the dry season. The number of young individuals captured between the wet and dry seasons was significantly different ($\chi^2 = 55.35, df = 1, p < 0.001$). The capture rate of sub-adult rodents during the dry season was 51.5% compared to 48.5% during the wet season. The sub-adult variation between season was not significant ($\chi^2 = 0.28, df = 1, P > 0.59$). From the total adult rodents, 69% were captured during the wet season and 31% during the dry season (Table 8).

Table 8. Age distribution of rodents during the wet and dry season.

Age category	Season		Total
	Wet	Dry	
Young	5	69	74
Sub adult	149	140	289
Adult	205	126	331
Total	359	335	694

6.2.9. Reproductive status of live trapped rodents

Of the 185 live trapped adult female rodents, 105 (56.75%) were pregnant and 85 (43.25%) were non-pregnant. The difference between pregnant and non-pregnant rodents was insignificant ($\chi^2 = 3.4$, $df = 1$, $P > 0.07$). From pregnant rodents, 92.4% were caught during the wet season and 7.6% during the dry season (Table 9). The pregnancy status of rodents between wet and dry seasons was statistically significant ($\chi^2 = 93.46$, $df = 1$, $p < 0.001$). Breeding was high during the wet season and decreased towards the dry season (Fig. 10).

Table 9. Number of pregnant and non-pregnant adult rodents during wet and dry seasons.

Season	Reproductive status	
	Pregnant (n)	Non-pregnant (n)
Wet	97	18
Dry	8	62
Total	105	80

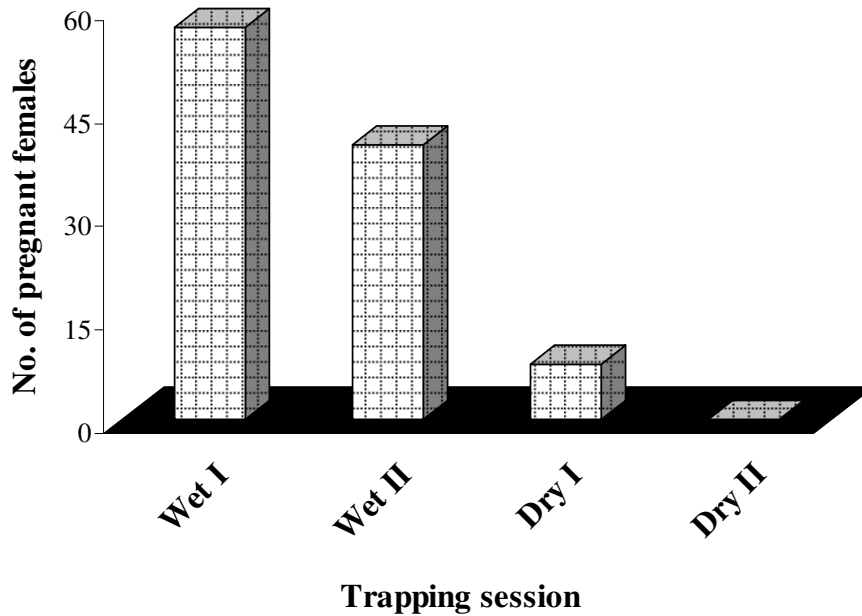


Figure 10. Number of live-trapped pregnant rodents during the four trapping session.

6.2.10. Timing of activities

The daily timing activity of each rodent species is given in Table 10. *S. griseicauda* and *D. lovati* were exclusively trapped during the night time. A significant number of *L. flavopunctatus* was also trapped during the night time. *L. flavopunctatus* was partly trapped during the day time. About 32.5% of *O. typus* was captured during the night time. A significant number of *P. harringtoni* was also trapped during the night time. *A. abyssinicus* was recorded entirely during the day time (Table 10). The difference in the number of rodents captured during the day and during the night was significant ($F_{.05(1\ 692)} = 346.2$, $P < 0.001$).

Table 10. Percentage timing activity of rodents during the night and day period: a measure of timing activity.

Species	Percentage		
	No. of capture	Night	Day
<i>A. abyssinicus</i>	351	4.0	96.0
<i>L. flavopunctatus</i>	146	21.4	78.6
<i>S. griseicauda</i>	150	96.0	4.0
<i>O. typus</i>	36	32.5	67.5
<i>P. harintoni</i>	9	34.0	66.0
<i>D. lovati</i>	2	100.0	0.0
Total	694	29.7	70.3

6.2.11. Population estimation

Estimated population of rodent species using the Minimum Number Alive (MNA) was 25, 256, 268,110 and 35 in the barely farm, *Euryops*-grass, *Euryops*-lobelia, *Lobelia*-grass and alpine meadow habitats, respectively. Estimates of rodent captured during different trapping sessions are given in Figure 11. High estimates of rodent population were recorded during the first trapping session of wet and dry seasons and marginally declined during the second session of the two seasons.

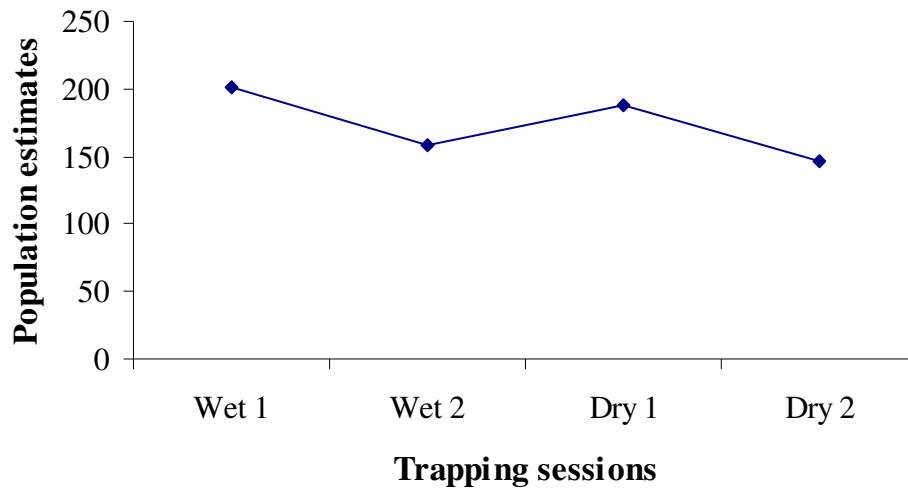


Figure 11. Estimates of rodent population during the four trapping sessions

6.2.12. Population density

The population density of *A. abyssinicus*, *L. flavopunctatus* and *S. griseicauda* in the different habitats ranged between 8-306/ha, 0-145/ha and 22-133/ha, respectively. The density range of *O. typus* was 0-55/ha and the range of *P. harringtoni* and *D. lovati* was very small. *A. abyssinicus* was attributed by larger population density and showed significant variation from others (Table 11).

Table 11. Density estimate of rodent population (per ha) in five habitats.

Species	Population density/ha					Mean density
	BF*	EG	EL	LG	AM	
<i>A. abyssinicus</i>	8	237	306	120	45	177
<i>L. flavopunctatus</i>	0	145	126	27	0	75
<i>S. griseicauda</i>	24	133	104	22	22	70
<i>O. typus</i>	0	8	10	55	0	18
<i>P. harringtoni</i>	18	0	0	0	0	*
<i>D. lovati</i>	0	0	0	0	4	*
Total	50	523	546	224	67	240

BF= barely farm, EG= *Euryops*-grass, AM= alpine meadow, EL= *Euryops*-lobelia, LG= *Lobelia*-grass, * = not included.

6.2.13. Biomass of the rodent population

Biomass of the area was estimated based on the commonly captured *A. abyssinicus*, *L. flavopunctatus*, *S. griseicauda* and *O. typus* (Table 12). These rodents have different mean body weight and the variation was significant ($F=36.75$, $df =5$, $P<0.001$). *A. abyssinicus* contributed most to the biomass. The mean biomass varied in different habitats. The difference of rodent biomass among habitats was significant ($F=6.45$, $df= 4$, $P<0.001$). The estimated mean biomass was highest at *Euryops*-lobelia habitat. *Euryops*-grass habitat contributed the second highest biomass. Estimated biomass for *Lobelia*-grass and alpine meadow habitats was low. The mean biomass of the four species together within the entire mountain grids was estimated to be 6.8 kg (14 kg/ha) (Table 13). The mean estimated biomass of *A. abyssinicus* was almost three fold of the mean biomass of the other rodents. The variation in the mean rodent biomass during wet and dry seasons was significant ($F_{0.05(1\ 692)} = 150.5$, $P<0.001$)

Table 12. Mean weight, number of capture and rodent biomass (gram per grid) during different trapping sessions.

Session	Grids	Species				Total
		Aa N=347 MBW= 85.9	Lf N= 146 MBW= 55.6	Sg N=138 MBW= 78.8	Ot N=36 MBW=105.9	
Wet I	EG	20 (1718)	27 (1501)	24 (1891.2)	0 (0)	71 (5110.4)
	EL	48 (4123.2)	20 (1112)	17 (1339.6)	1 (105.9)	86 (6680.7)
	LG	14 (1202.6)	9 (500.4)	2 (157.6)	7 (741.3)	32 (2601.9)
	AM	4 (343.6)	0 (0)	3 (236.4)	3 (0)	8 (580)
Wet II	EG	15 (1288.5)	16 (889.6)	16 (1260.8)	0 (0)	47 (3438.9)
	EL	34 (2920.6)	16 (889.6)	14 (1103.2)	2 (211.8)	66 (5125.2)
	LG	14 (1202.6)	0 (0)	3 (236.4)	9 (953.1)	26 (2392.1)
	AM	4 (343.6)	0 (0)	4 (315.2)	0 (0)	9 (658.8)
Dry I	EG	38 (3264.2)	12 (667.2)	17 (1339.6)	2 (211.8)	69 (5482.8)
	EL	46 (3951.4)	21 (1167.6)	12 (945.6)	0 (0)	79 (6064.6)
	LG	12 (1030.8)	2 (111.2)	4 (315.2)	2 (211.8)	21 (1669)
	AM	11 (944.9)	0 (0)	2 (157.6)	0 (0)	13 (1102.5)
Dry II	EG	43 (3693.7)	16 (889.6)	8 (630.4)	2 (211.8)	69 (5425.5)
	AL	22 (1889.8)	5 (278)	8 (630.4)	2 (211.8)	37 (3010)
	LG	19 (1632.1)	2 (111.2)	2 (157.6)	9 (953.1)	31 (2854)
	AM	3 (255.9)	0 (0)	2 (157.6)	0 (0)	5 (413.5)
	Total	29805.5	8117.6	10874.4	3812.4	52609.9
	Mean	1862.8	507.4	679.8	2383.3	3288

EG= *Euryops*-grass, AM= alpine meadow, EL= *Euryops*-lobelia, LG= *Lobelia* grass, Figures in parentheses= the biomass of each species per session at a given grid, MBW= Mean Body Weight, N= Total number of individuals captured

Table 13. Estimated mean biomass of four rodent species (kg per grid and per hectare) in the mountain habitats.

Grids (= 0.49 ha)	species				Total/grid	Total/ha
	Aa	Lf	Sg	Ot		
EG	5.1	2	2.6	0.2	9.9	20.2
EL	6.6	1.8	2.1	0.3	10.8	22
LG	2.6	0.4	0.5	1.5	5	10.2
AM	0.95	0	0.5	0	1.5	3.1
Mean biomass	3.8	1.1	1.4	0.5	6.8	14

Aa = *A. abyssinicus*, Lf = *L. flavopunctatus*, Sg = *S. griseicauda*, Ot = *O. typus*,

6.3. Snap trapping

6.3.1. Species composition and distribution

Six species were trapped from the removal grids (Table 14). The total number of rodents trapped from 1500 trap nights was 231 with trap success rate of 15.4%. This trap success was lower than the live trap success. The predominantly captured rodent species was *A. abyssinicus* (47.6%). *L. flavopunctatus* and *S. griseicauda* with the capture rates of 25% and 24% were the second and third dominant species, respectively. *D. lovati* was not captured in any of the snap trap grids. The proportion of *O. typus* captured by snap trapping was the least. A single *Mericulus imberbis* was recorded from one of the snap trapping survey grids located near the swamp area and contain dominant *Kniphopia sp.*, *Euryops* and grass vegetation. Distribution and abundance of snap trapped rodents varied markedly in different habitats. Throughout all trapping sessions in barely farm and *Lobelia*-grass only two species types were trapped. Comparative high abundance and species diversity was recorded from *Euryops*-grass (Table 14). No animal was captured in the alpine meadow habitat.

Table 14. Species composition, distribution and relative abundance of snap trapped rodents from five habitats.

Species	Habitats					Total(n)	Abundance (%)
	BF	EG	EL	LG	AM		
Aa	-	38	52	20	-	110	47.6
Lf	-	24	25	9	-	58	25.1
Sg	5	33	17	-	-	55	23.8
Ot	-	1	2	-	-	3	1.3
Ph	5	-	-	-	-	5	2.2
Mi*	-	-	1	-	-	1	
Total	10	96	95	29	-	231	100

BF= barely farm, EG = *Euryops*-grass, EL= *Euryops*-lobelia, LG = *Lobelia*-grass, AM= alpine meadow, * = trapped in survey grid, (-) = absence of capture, Aa = *A. abyssinicus*, Lf = *L. flavopunctatus*, Sg = *S. griseicauda*, Ot = *O. typus*, Ph=*P. harringtoni*, Mi = *Mericulus imberbis*

6.3.2. Sex distribution and reproductive status of rodents

Of the total 231 snap trapped rodents, 100 were males and 131 were females. Sex distribution in snap trap was similar to live trap, which both result female biased population. From the total adult female population captured by snap traps, 91 were non-pregnant and 40 were pregnant (Table 15). Pregnancy status varied between species and less than the live trap. The overall mean number of embryo counted in pregnant females was 5.1 ± 1.41 . The number of embryo count ranged between two and seven. High count of pregnancy and number of embryo was recorded in *A. abyssinicus*, which contributed 52% of the total pregnant rodents followed by *S. griseicauda* (27.5%) and *L. flavopunctatus* (22.5%). Species that contributes high rate of pregnancy in snap trap were similar with the live trap. The difference in the number of embryos among the species was significant ($\chi^2 = 17.5$, df =6, P<0.01).

Table 15. Count and mean number of embryo for snap trapped rodents.

Species	No. of pregnant	No. of embryos	Mean \pm SD
<i>A. abyssinicus</i>	21	5-7	6.7 \pm 1.1
<i>S. griseicauda</i>	11	3-5	3.4 \pm 2.4
<i>L. flavopunctatus</i>	8	3-4	3.4 \pm 1.1

6.3.3. Breeding pattern

The pregnancy status of snap trapped rodents varied significantly ($\chi^2=19.2$, $df=1$, $P<0.001$). The non-pregnant females were higher than pregnant ones. Breeding pattern showed seasonal trends (Fig. 12). Breeding was high during the first session of wet season and subsequently decreased towards the dry season until there was no pregnant individual during the second session of the dry season (March). The breeding patterns of snap trapped rodents were similar to the live trapped rodents.

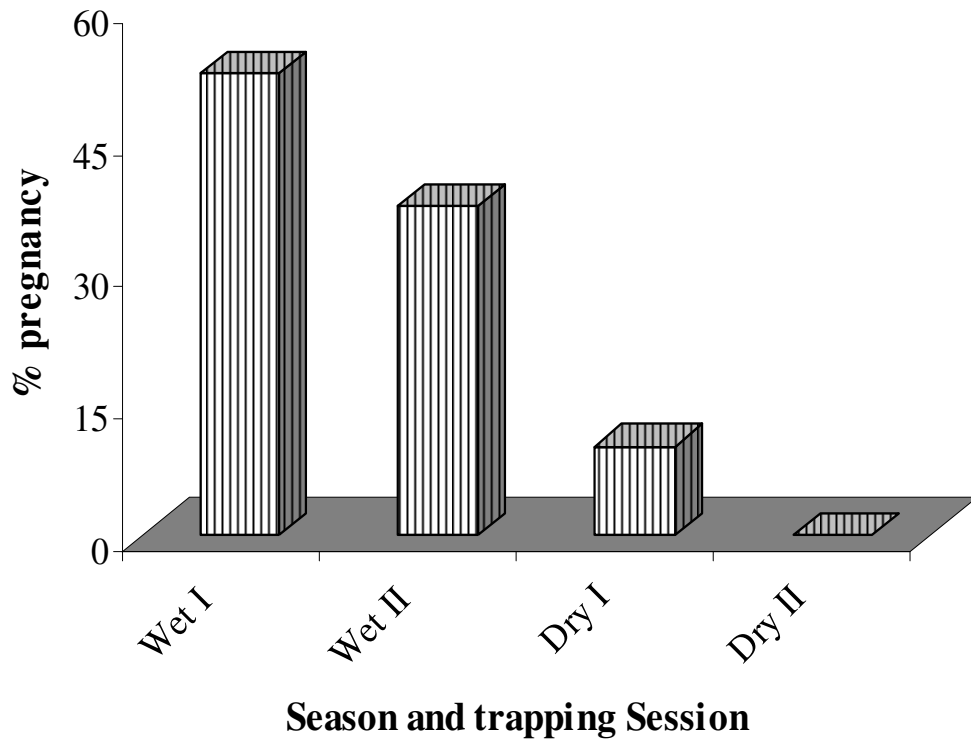


Figure 12. Percentage of pregnant snap trapped female rodents during the four trapping sessions.

6.3.4. Timing of activities

The overall diurnal activity pattern of rodents from snap trapping was similar to the result of live trapping. The difference in timing activity of rodents was significant ($\chi^2=29.8$, $df=1$, $P<0.001$). The difference between the diurnal and nocturnal activity among the rodent species was significant ($\chi^2=169.9$, $df=4$, $P<0.001$). *A. abyssinicus* was almost exclusively diurnal. The snap trap also confirmed that *L. flavopunctatus*, *O. typus* and *P. harringtoni* are partly nocturnal and partly diurnal species. *S. griseicauda* was found exclusively nocturnal from snap trapping (Fig. 13).

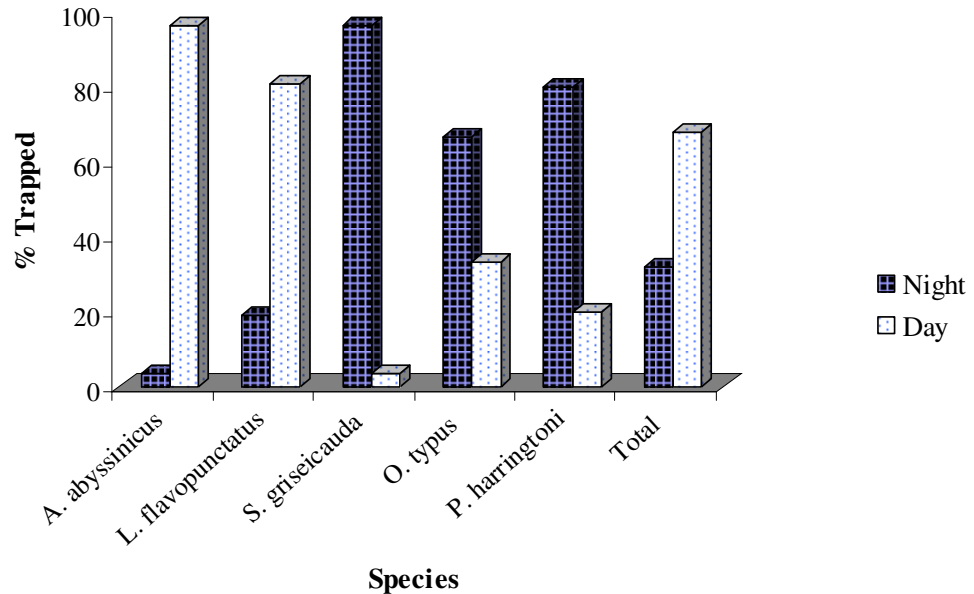


Figure 13. Timing activity of rodents, captured during day and night periods.

6.4. Rodent ecology and Ethiopian wolf association

The number of Ethiopian wolf observed through the transect sampling varied with season. The overall mean number of wolves observed at a time during both seasons was 2.4 ± 1.4 individuals. The difference in the mean number of wolves observed during the wet and the dry season was significant ($t = 7.3$, $df = 31$, $P < 0.001$) and the Chi-square test also indicated that wolf frequency was marginally different between seasons ($\chi^2 = 10.3$, $df = 4$, $P < 0.036$). High number and frequency of wolves were observed during the dry season. Movement and foraging activities of the Ethiopian wolf were time and place dependent (Table 16). The difference of wolf observation time within a day was significant ($\chi^2 = 52.6$, $df = 2$, $P < 0.001$). The frequency of Ethiopian wolves observed in different types of habitat varied significantly ($P < 0.001$). The frequency and distribution of Ethiopian wolf were greater in habitats that support high rodent abundance and density. The existence of Ethiopian wolves probably depends on the commonly available rodents of *A. abyssinicus*,

S. griseicauda, *L. flavorpunctatus* and *O. typus*. *A. abyssinicus* as contributed most to the biomass, abundance and density of most habitats was supposed to be the predominant prey of Ethiopian wolf.

Table 16. Number of encounter of Ethiopian wolf observed in Mt. Abune Yoseph during the study period.

Season	Observation			
	Habitat type	Time	Number of encounter	Pattern
Wet	AM	Before 4 am	1	Single
		After 4:00 pm	1	
Dry	EG	After 4:00 pm	3	Single
	AM and EG	before 4:00 am	2	Single
		After 4:00 pm	2	
	EL	Before 4 am	3	Single
		Mid day	2	
		After 4 pm	2	
	EL and LG	Before 4 am	2	Single
		Mid day	2	
	EL and LG	Before 4 am	1	Single
		Mid day	2	
After 4: 00pm		5	Group	
EL and LG	Before 1 am	3	Group	
	Mid day	2		
	Before 4 am	6		Group
Total			39	
Mean frequency			2.43	

AM= alpine meadow, EG= *Euryops*-grass, EL= *Euryops*-lobelia, LG= *Lobelia*-grass

6.5. Socio-economic impact questionnaire survey

6.5.1. Socio-economic impacts of rodents and the Ethiopian wolf

. Of the twenty people interviewed, 25% were female households; 90% of which were grouped in the poor category. The young males represent 12.5% and the rest 62.5% were elder and adult male households represented all economic groups. Subsistence agriculture is the major economic source of the two rural Kebelles. Among respondents 75% possessed livestock and 25% had no livestock. The owned number of livestock varied from 1 cattle to 60 sheep per individual. The mean number of livestock was 2.4 ± 2.6 , 10.5 ± 18 , 1.9 ± 3 and 1.2 ± 1.1 , for cattle, sheep, goat and equine, respectively. The difference among mean number of livestock was significant ($P < 0.001$).

No farmer had a private grazing land. Mt. Abune Yoseph was the only place where their livestock grazed throughout the year. Shrub and dung fuel sources were the commonly fetched resource on the mountain. People were commonly aware of the Ethiopian wolf presence but did not know why wolves have been protected (Table 17). The difference in awareness was insignificant ($\chi^2 = 0.8$, $df = 1$, $P > 0.3$) in that most people were not aware about the objective of the Ethiopian wolf protection.

Of the females interviewed 80% did not know the reason of conservation. Conservation of the Ethiopian wolf was assessed positively by 48%, as harmful by 16%, and 36% of the respondents were uninformed. All respondents never know of any benefit from the species. Except one Ethiopian wolf died from ageing, no death was observed either from anthropogenic or natural phenomenon for the last 5 years, since the beginning of the Ethiopian wolf protection in the area by the Wereda Office of Agriculture and the involvement of the Frankfurt Zoological Society (FZS) in the afroalpine conservation. A threat of wolf from infectious disease such as rabies was not appeared on wolves because dogs were vaccinated in the past two years. But, during the study period people from Abune Yoseph were claimed that the disease was appeared in the area. As a result of uncontrolled dog movement in the mountain habitat, the wolf could be affected if contact

with the infected dog was there. Increased trend of wolf number was claimed by 61%, 16% periodical decline, 4.8% number varies depending on temporal situation and 23.8% of the people did not have any idea. Difference on response of the wolf trend was insignificant ($\chi^2 = 60$, $df = 57$, $P > 0.36$). The response about the wolf trend was correlated with sex and age. Consequently, 90% of female respondents did not know about the population trend and elders stated a decline in the number compared to the past. Wolf predation on sheep was the main cause of negative attitude. Analysis of responses about the level of conflict between wolf and human showed 33.3%, 38.1%, 9.5% and 19% for increased, decreased, conditional and has no idea, respectively (Fig. 14). The poor did not have information about the level of conflict. Wolf predation affected 87% of the farmers that reared livestock and only 13% of representatives who owned livestock were not affected within the past two years.

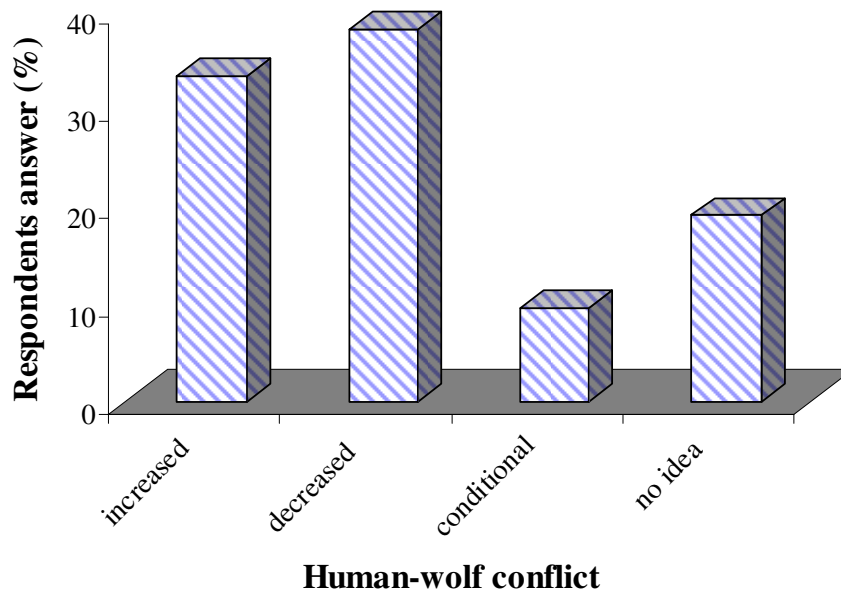


Figure 14. Level of human wolf conflict in the study area.

Predation of the Ethiopian wolf on sheep was highly correlated with season, particularly during the season of draught. Sheep herding was the only source of control. The presence

of rodents in the area was totally recognized as harmful by the entire respondents. Problems caused by rodents were listed from cloth damage, entry to buckets of water, milk and other food items in home to yield reduction in farmlands and pasture fields. Information was gathered that before some years ago the Woreda Office of Agriculture provided the community with poison chemicals for rodent control. During that time people used poison, however, this has stopped at present. Traditional rodent control methods such as cat predation, snap trapping, stone trapping and closing of burrows in farmlands and homesteads are commonly listed by all respondents.

7. DISCUSSION

Highest species richness is a result of heterogeneous climate and habitat with high productivity (Delany, 1964, 1972). High habitat productivity can support diverse and abundant life. Kasangaki *et al.* (2003) and Happold and Happold (1989) have reported heterogeneity and productivity decreased with increasing altitude, suggesting low species diversity and abundance in high altitude mountains. These suggestions are congruent with the monotypic habitat and climate attributes of Mt. Abune Yoseph. This has resulted in low species diversity compared to the diversity reported by Yalden (1988) and Sillero-Zubiri *et al.* (1995a) in the Bale Mountains National Park, Ethiopia and Delany (1964) in Mt Elgon, Uganda. In addition to natural factors, habitat modification and destruction through overexploitation could be suggested as one of the factors for the less diversity in the present study area. In comparison with Guttinger *et al.* (1998) in Simien Mountains National Park (SMNP) that caught five rodent species at similar habitat and altitudinal ranges, a relatively higher number of rodent species was recorded during the present study at Mt. Abune Yoseph than in the Simien Mountains. The study by Busby *et al.* (2006) in SMNP has reported the same number of rodent species captures to the present study from five afroalpine grids. This suggests that Mt. Abune Yoseph is at least on the same line of species richness with SMNP, even though the latter was a protected area since the 1970s.

Although some rodent species were not recorded in some of the selected grids the difference on rodent species diversity among the five habitat types was not significant. Numerically, the barely farm and overgrazed alpine meadow have supported less number of rodent species as a result of low vegetation cover due to human activity. This numerical variation was also marginally reflected in the diversity index (H') ranks. *Euryops*-grass, *Euryops*-lobelia and *Lobelia* grass habitat types have supported relatively high species diversity in the present study. The very likely reason for this high association can be the need of rodents for a dense and high vertical layer vegetation cover from these grids. The result is in line with Rosenzweig and Winakur (1969) and Avenant and Cavallini (2007) who reported that species diversity and perhaps community structure are a function of the availability of complex microhabitat that provides diverse niches.

Arvicanthis abyssinicus and *S. griseicauda* were observed in all grids. They are recognized as the most widely distributed species throughout the entire afroalpine habitat types. Similarly, Guttinger *et al.* (1998) from SMNP revealed the trapping of these two species in a remarkable variety of high altitudes. Yalden (1988) in BMNP reported the altitude range for *S. griseicauda* was 2400-3300 m, and above this limit, the species was replaced by its congener *S. albocaudata*. This differs from the present study as *S. griseicauda* has been distributed and commonly trapped up to 4050 m suggesting that altitude limit *per se* might not be accounted as a sole factor to determine the species distribution. Accordingly, the more likely reason for the low abundance of *S. griseicauda* in the high altitudes of BMNP could be the inter-specific competitive pressure exerted by its congener for identical scarce resources. As a result, the two congeners may have experienced habitat partitioning. The occurrence of *S. griseicauda* at higher altitude in large numbers during the present study can be attributed to absence of its congener. As depicted by M'Closkey and Lajoie (1975) and Happold and Happold (1989) the presence of potential competitors is a factor that acts either singly or with other factors to limit the distribution of rodents. In addition, the destruction of suitable habitat by human induced activities in Mt. Abune Yoseph might have forced the species extend to higher altitudinal ranges than the Bale Mountains. This assumption corresponds with Delany (1966) who stated that the nature of vegetation through the food and cover and the extent to which the vegetation are modified by large mammals and human activity determine the distribution of animals.

The distribution of *L. flavopunctatus* and *O. typus* was restricted to three habitat types such as in *Euryops*-grass, *Euryops*-lobelia and *Lobelia*-grass with better vegetation density, but entirely absent in the modified habitats of barely farm and overgrazed alpine meadow. The findings of Sillero-Zubiri *et al.* (1995a) in BMNP was similar to the present study that the nocturnal activity of *L. flavopunctatus* and *S. griseicauda* limited their distribution in habitats that contain long vegetation cover to get protection from extreme night cold. According to Guttinger *et al.* (1998) and Marino (2003) these species were intolerant in grazing areas and preferred micro-habitats with long cover. The distribution of *O. typus* increases with increasing altitude and it was relatively abundant in *Lobelia*-grass habitat at

the top of the mountain, near the two swamp areas that had open grassland with sparse lobelia stands. Guttinger *et al.* (1998) reported that the species preferred the swampy area and its abundance increased with increasing range of altitude. Although Sillero-Zubiri *et al.* (1995a) found *O. typus* to decrease with increasing altitude; Yalden (1988) found the reverse and supportive of the present study.

The distribution of *D. lovati* was restricted only in alpine meadow habitat at 3950 m and the result corresponds to the finding of Yalden (1988) and Sillero-Zubiri *et al.* (1995a) who described the species as a grassland specialist with low abundance. *P. harringtoni* was exclusively restricted in farmland habitat. According to Yalden and Largen (1992) the habitat preference of this specie was uncertain.

Mericulus imberbis was described as a less abundant endemic mouse and most collectors have failed to find in many areas (Yalden, 1988). Such low abundance in recent years might reflect destruction of its habitat by agriculture and over-grazing. The present study managed to collect only a single individual of *M. imberbis* trapped in *Kniphopphia* dominated habitat type at 3900 m.

The rodent abundance and population density within the study area varied markedly across the habitat types as a result of marginal difference in vegetation and altitudinal ranges. Moreover, the degree to which the habitat was modified by human induced activities seemed to be the major factor for causing this variability. The highest overall abundance and density of rodents was recorded in grids that contained better vegetation patches. In highly modified barely farm and alpine meadow habitats, rodents were less abundant. This was positively correlated with M'Closkey and Lajoie (1975) and Busby *et al.* (2006), who stated that a decline in vegetation structure and density would result in a negative influence on rodent diversity and abundance. The distribution of *A. abyssinicus* and *S. griseicauda* in barely farm and alpine meadow at low abundance indicates probably that habitat once formerly was the suitable habitat of these species, at the same time the main habitat for the Ethiopian wolf. But, late in time as a result of agricultural, grazing and settlement activities the land might became modified and led to support low number of individuals. Thus, the

habitat loss of Ethiopian wolf and the entwined small mammals seemed to be caused more by anthropogenic factors than the natural phenomenon.

The rodent abundance and density in the study area varied among species type that all species were not equally abundant in any specific habitat. *A. abyssinicus* had an overall high abundance and population density in the study area. Guttinger *et al.* (1998) in SMNP reported that *A. abyssinicus* is the most commonly caught and densely populated species in the grassland steppe. This resulted from the species ability to tolerate moderate habitat modification and its adaptation in short grass vegetation (Busby *et al.*, 2006). According to Massawe *et al.* (2007), *Arvicanthis* species usually have high abundance and density as a result of successful breeding strategies. The mean population density of *A. abyssinicus* in Mt. Abune Yoseph was 177/ha. This is comparative with the study by Gottelli and Sillero-Zubiri (1990) in BMNP, who estimated the density of *A. blicki* (117/ha) and *L. melanonyx* (104/ha). In comparison with the study of Manyingerew *et al.* (2006) in farmlands of Aleltu Wereda, the population density of *A. abyssinicus* in Abune Yoseph is by far greater than Aleltu. The overall mean density of rodent community with in the study area was estimated to be 240/ha. This density was low compared to studies by Gottelli and Sillero-Zubiri (1990) and Sillero-Zubiri *et al.* (1995a) in the BMNP. This is because both the number of species and the population abundance of rodents are higher in BMNP than Mt. Abune Yoseph. The population densities of certain rodent species in BMNP outnumber the rodent density in Mt. Abune Yoseph. For example, the sum density of *A. blicki* and *L. melanonyx* together in BMNP was 221/ha, which was almost comparable with the overall mean rodent density in Mt. Abune Yoseph. This high density was probably the main reason for the presence of large number of Ethiopian wolf population in BMNP than any other suitable afroalpine habitats in the country. The total capture of 925 individuals during 4212 trapping nights in this study showed high population abundance and density compared to the captures by Guttinger *et al.* (1998) and Busby *et al.* (2006) in SMNP, who caught 173 individuals during the 1100 trap nights and 156 individuals during 1200 trap nights, respectively.

The overall abundance and density of rodents in the study area was not significantly affected by seasonal changes. This is because afroalpine areas do not show a drastic change on vegetation structure and climatic conditions between the wet and dry seasons.

The trap success in Mt. Abune Yoseph ranges from 0% in the *Erica*-grass to 45.5% in *Euryops*-lobelia habitat. This poor trap success well corresponds with the finding of Rupp (1980) who reported 0% success at low altitudes of southeast Ethiopia. The result also coincides with Yalden (1988) that yielded very few mammals in the *Erica* forest of BMNP as a result of heavy livestock grazing. This can also be the likely reason for low trap success in the present study area. The trap success was highest in *Euryops*-lobelia and *Euryops*-grass habitat where better vegetation density and diversity existed. *Lobelia*-grass habitat contributed a medium trap success with moderate abundance and density of *A. abyssinicus*, *S. griseicauda* and *L. flavopunctatus*. In comparison with other habitats, *O. typus* attained highest trap success, abundance and population density in this habitat. The least trap success was recorded in habitats of barely farm and overgrazed alpine meadow. Of all habitat types, the barely farm where *P. harringtoni*, *S. griseicauda* and *A. abyssinicus* were rarely trapped contributed the least trap success, abundance and density of rodents. The difference in trap success, abundance and density among the selected habitat types highlights that productivity of afroalpine habitat varies at microhabitat level. The overall trap success throughout the selected grids was 25.6%, which is higher than the trapping success reported by Guttinger *et al.* (1998) in SMNP as 15.7%, Busby *et al.* (2006) as 13% and Yalden (1988) with variable trap success conducted at different sites in BMNP. Sillero- Zubiri *et al.* (1995a) suggested that the trapping success of *A. blicki*, *L. melanonyx* and *S. albocaudata* in the dominant habitats of BMNP was greater than any of those other afroalpine areas.

Trap success varies among the species type. In the present study, *A. abyssinicus* contributed the highest trap success which was about 13%. The trap success contributed by *S. griseicauda*, *L. flavopunctatus* and *O. typus* were 5.5%, 5.4% and 1.3%, respectively.

The rates of trap success in this study for the latter three species are higher than those reported rate by Sillero-Zubiri *et al.* (1995a) in BMNP.

Most rodent species generally favour habitats with protective canopy (Windberg, 1998). The distribution, abundance, density and trap success of rodents achieved in each habitat indicate the degree of a specific habitat preference by each species. *A. abyssinicus* and *S. griseicauda*, which were widely distributed and numerically dominant species in the present study are acknowledged as habitat generalists, whereas *L. flavopunctatus* and *O. typus* are only restricted in three habitat types. But, the uneven population abundance and density for those species that occupy similar habitat type and altitude range signifies that each rodent species preferred certain types of microhabitats than others within the same ecosystem. Accordingly, *A. abyssinicus*, *S. griseicauda* and *L. flavopunctatus* were abundant in habitat types of *Euryops*-grass and *Euryops*-lobelia. Consequently, these habitats are regarded as the primary preference for most commonly trapped rodent species. This is because the availability of food and cover for rodents was higher in the more dense habitats (Windberg, 1998). Abundance and density of these three rodent species were moderate in *Lobelia*-grass habitat at the top of the mountain because the habitat was open type and may contain less food and cover. At the same time, the habitat was located at peak altitude range, where less diversity and abundance was suggested. This habitat type seemed less preferred by these species as they were not commonly trapped. Abundance of *O. typus* was highest (77.8%) in *Lobelia*-grass habitat and *Lobelia*-grass is suggested the most preferred habitat for the species. *P. harringtoni* and *D. lovati* were exclusively (100%) restricted to barely farm and alpine meadow habitat type, respectively. They are considered to be habitat specialists. Low community structure, population abundance and density were observed in barely farm and alpine meadow habitats.

Happold and Happold (1992) have suggested that rodents in high altitude mountains have less seasonal population fluctuation as a result of low productivity of the afroalpine ecosystem. This description seems to be true for the present study, because the population density during wet and dry seasons did not fluctuate much. The total rodent abundance was

51.7% and 48.3% during the wet and dry seasons, respectively. The number of species that occurred during the wet and dry seasons was the same (six species in each season). *D. lovati* only occurred during the wet season. *M. imberbis* was captured only during the dry season. The seasonal trend of *D. lovati* was also encountered by Sillero-Zubiri *et al.* (1995a) in BMNP that seven out of the total ten captures were during the warmer wet season. *S. griseicauda* and *L. flavopunctatus* have shown marginal fluctuation trend to seasonal changes, but the general trend of population fluctuation did not show changes of population with a change to season. The slight periodic population dynamics for these species is also in agreement with the findings of Happold and Happold (1992). *A. abyssinicus*, *O. typus* and *P. harringtoni* did not show seasonal trend of fluctuation.

Delany (1972, 1986), Happold and Happold (1989), Sillero-Zubiri *et al.* (1995a) and Massawe (2003) reported that the breeding season of rodents was closely related to rainfall. Most rodents reach breeding peak beginning just after the main rainy season and declined subsequently. Most results have revealed that large numbers of pregnant females were found just after the rainfall period, while pregnancy was not recorded by the end of dry season. Müller (1977) also examined the population dynamics of rodents in the Simien Mountains afroalpine habitat and observed that breeding took place in the four months following June-September rains, and subsequently maximum population density was found from January to March. The finding of the maximum population density by Müller (1977) is an exact coincidence with high population trapping during December of the present study. In general, all the above findings correspond to the breeding season and pattern of rodents observed in Mt. Abune Yoseph. Most adult female rodents during the present study were found pregnant at the end of the main rainy season and pregnancy declined subsequently during the dry season. Of the 105 trapped pregnant females, *A. abyssinicus*, *S. griseicauda*, *L. flavopunctatus* and *O. typus* contributed 55%, 23.6% 15.3% and 4.8%, respectively. This showed that breeding activity is significantly different among species type. The ratio of pregnant females was higher than the non-pregnant females. *A. abyssinicus* was found to have high breeding success compared to other species in this study area. Similar findings have also been reported by several ecologists (Kingdon, 1974;

Taylor and Green, 1976; Delany, 1986) that *A. abyssinicus* has high breeding strategies. The findings include that *Arvicanthis* species are characterized by continuous breeding, numerous litter size during favourable season and less litter size during unfavourable seasons with fast young development.

The overall rodent capture indicates that adults outnumbered the capture of sub-adults and juveniles. Large numbers of adults were captured during the wet season as compared to the dry season. The capture rate of sub-adults was high during the dry season. Though sub-adults and adults differed greatly with respect to the season, total capture of each group was almost comparable. Comparative ratio between adult and sub-adult groups was evident for the population stability and indicates the presence of continuous recruitment of young and sub-adults towards the upper age class. This finding goes in line with the result of Delany (1972), who reported that mature animals are most numerous in each population towards the end of the rainy season. The total young capture during the wet and dry seasons was lower than both adult and sub-adult captures. In this study, age structure seemed to be correlated with the trend of season because low number of young were captured during the wet while large number of young were captured during the dry season. Delany (1972) who revealed the age structure of a population can vary at different times of the year and depending on the regularity and continuity of fecundity and ageing. Review by Massawe *et al.* (2007) in the study at central Tanzania also found that young ones were in large numbers during the period from January to July just after the rainy season and hence age structures were reflections of breeding pattern of each population, which has close association with the climatic pattern in the area.

In most populations an even sex ratio is expected (Hardy, 1997). However, in the present study, female-biased sex ratio of rodents was observed during both seasons. A similar female-biased population was observed by Demeke Datiko (2007) who reported that number of females increased along with the increase in abundance of the species. The female-biased rodent population suggested high reproductive potential of the species because the population could contain several fertile females. The low number of males is

not expected to affect the breeding pattern of each population, as a single male can copulate with several females in most natural populations.

The study area harboured both diurnal and nocturnal rodent species. *S. griseicauda* and *D. lovati* were trapped strictly during the night time. Yalden (1988) and Gottelli and Sillero-Zubiri (1990) also trapped these species during the night and identified them to be exclusively nocturnal. *A. abyssinicus* was a predominantly diurnal species because more than 96% of the captures were during the day time. This is also supported by Guttinger *et al.* (1998) who revealed that grass rats are active during the day with a slight peak in the morning hours. *L. flavopunctatus*, *P. harringtoni* and *O. typus* were captured partly during the day and partly during the night. Yalden (1988) and Sillero-Zubiri *et al.* (1995a) in BMNP also had similar observations and reported that *L. flavopunctatus* was trapped both during the night and the day time.

Rodent biomass in Mt. Abune Yoseph has a direct dependence on abundance, population density and average body weight which in turn depended on food, cover and other resources in the habitat. Consequently, high biomass was found in habitats that have good vegetation density and vertical layer attributed to support large abundance and density of animals. Biomass at population and community level was highest in *Euryops*-lobelia and the *Euryops*-grass habitats. The *Lobelia*-grass habitat with intermediate densities supported a biomass that ranked third. Rodent biomass varied among different habitats. Delany (1972) revealed that population and biomass can vary considerably from one vegetation type to another and even within the different savanna. This implied that microhabitats within an umbrella ecosystem (for example the selected grids in afroalpine habitat) can produce different rodent biomass. *A. abyssinicus* being the most abundant and densely populated animal in the study area contributed most to the biomass. Pregnant females and older males were heavier than other groups.

The number of rodent species captured by the snap trapping and live trapping was similar. But the proportion of rodent abundance, density and trap success using snap trapping was

less than live trapping. Alpine meadow and *Erica*-grass habitats had nil snap trap success. *S. griseicauda* and *O. typus* were not encountered in *Lobelia*-grass habitat of snap trapping grid throughout the entire period. This led to suggest the small area covered by snap trapping might not be successful to encounter the less abundant rodents at the top of the mountain and in the highly modified alpine meadow. The unique achievement from snap trapping was the capture of a single specimen of *M. imberbis* which has been described as a very rare species by former researchers (Yalden, 1988; Yalden and Largen, 1992).

The distribution and density of the Ethiopian wolf is determined by the predominant rodent prey density and biomass in a given area (Sillero-Zubiri *et al.*, 1995a). This analysis was true for the present study sites; that wolf distribution and frequency on the mountain area was highest in and around the grids that supported high rodent density and biomass. Negative relationship was observed, for example, the wolf frequency at *Euryops*-grass was less, despite high rodent density and biomass in the habitat. The reason to be suggested might be because the grid location was near the main walking road and the human shyness nature of the wolf did not allow frequenting that habitat. The Ethiopian wolf distribution and frequency was also time dependant, while most observations were successful before and after the presence of the herdsmen on the mountain. Herdsmen were frequently observed chasing away the wolves when they were foraging. This has resulted from the fear of sheep loss. This situation made the wolf unstable while foraging and develop high human shyness and becoming time specific for its activity. Wolf depredation on sheep was not observed during the four sessions of camping on the mountain.

Respondents from Mt. Abune Yoseph and Wedebye Kebelles confirmed that Mt. Abune Yoseph is the only place where their livestock can graze throughout the year. Because the private land holding size in this area was very small (0.5-2 ha) and the yield from such land was also less because of the poor land quality. Similarly, all respondents declared the gathering of the entire bio-fuel materials from the mountain shrub vegetation and cow dung. Only 10% of the respondents had homestead afforestation, which they planted for the purpose of selling; to increase income but not to be used for their fuel requirement. All

these human pressures exerted on the entire rodent and Ethiopian wolf habitats would result in a remarkable change in vegetation structure and diversity, which in turn reduce rodent species diversity and abundance. The Ethiopian wolves, a rodent-dependent animal would also suffer from the reduced density and biomass of rodents.

Attitudes of People towards wolf conservation were positive (48%), but people have shown this attitude simply because of the effort of the government. Earlier, Derese Dejene (2003) in Mt. Abune Yoseph revealed that the local communities were not entirely antagonistic to wildlife. Most respondents (38%) responded that human wolf conflict has decreased. However, 87% of the people who owned livestock were affected more from sheep loss by the wolf. Sheep depredation by wolf decreased as a result of strong herding leading to minimal conflict. However, the study result in the same area by Derese Dejene (2003) indicated that wolves were a problem for most respondents, the present study respondents indicate that the problem of Ethiopian wolf is minimal, if proper sheep herding can be carried out. They argued that the Ethiopian wolves can easily be chased away by herdsman as compared to the common jackal which could not be easily chased away by children and is a big problem for most sheep loss. Most respondents also claimed the intensity of sheep depredation by wolf is seasonal; this increased depredation appeared probably when the density and biomass of rodents become reduced either due to natural causes such as recurrent drought or as a result of the human impacts. The number of wolves showed increasing trend for most respondents and Derese Dejene (2003) also revealed the same result in this area. The suggested reasons for increasing trend of the Ethiopian wolf are banning of persecution which was widely experienced in the past. This was also supported by Derese Dejene (2003). However, people suggested uninterrupted reproduction as one reason for wolf increasing evidence was observed that people have tried to close the den of the wolf using stones and the giant lobelia stems. All respondents believed that rodents did not have any benefit but harmful effects. Individuals observed touching rodents were not greeted. This is due to cultural attributes.

8. CONCLUSIONS AND RECOMMENDATIONS

The study area, Mt. Abune Yoseph is one of the afroalpine ecosystems in Ethiopia. In this study seven rodent species of, which six endemic were identified. Distribution and diversity of rodent species in the study area was less probably because of the monotypic environment and climatic conditions of the area. The distribution and abundance of rodent species in various habitat types was predicted to be determined by several factors but habitat modification by man was the key factor. Trap success was positively correlated with population abundance, density and species diversity of the habitat. As a result, habitats that supported high abundance and density resulted in high trap success. Habitat generalists like *A. abyssinicus* contributed most to the trap success, abundance, density, biomass and for the existence of the Ethiopian wolf. Thus, conserving *A. abyssinicus* is essential to the wolf survival. The breeding pattern and age structure of rodent populations depend up on seasons. The study area harbours high proportion of diurnal species and habitat generalists than nocturnal and specialists. Ethiopian wolves take advantage of the availability of diurnal and generalist rodents. The density and biomass of rodents in this area are proportionally different from other areas that have close ecological patterns like BMNP. As Ethiopian wolf is a specialist rodent hunter, it can be highly affected by reduction of the rodent biomass. The number of Ethiopian wolf present with in the study area was estimated to be 8-10 individuals but previously it has been estimated 15-20 individuals (Anonymous, 2002/03). The low number is probably associated with the less rodent density and biomass.

The livestock composition in Abune Yoseph area is dominated by sheep and this increases the more likely attack of wolves on sheep which is higher potential for human wolf conflict in the area. The local community have positive attitude towards wolf conservation and at present people claimed the wolf number has increased. Further, detailed study with prolonged duration is required to yield more information from the area.

Afroalpine rodents are of special interest to study because most are endemic and give support to the survival of the Ethiopian wolf and endemic birds. Highlands are the home of many unique fauna and flora (Shibru Tedla, 1995). The study area also possesses certain high altitude endemic plants for example *Euryops* sp. and the unique Giant lobelia (*Lobelia rhyncopetalem*). The area has also a very impressive escarpment with spectacular scenic beauty and is comparative to other high mountains of the country. These features make the area to be listed among unique biodiversity hotspots and spectacular natural heritage. Farmland expansion, extensive livestock grazing and overexploitation of land cover is increasing due to human population growth.

Abune Yoseph at present is an area among the highest conservation priorities required to conserve the endemic species. As a result, the following recommendations are forwarded to help enhance and maintain the survival of the highland unique biodiversity:

- ❖ Conservation priority has to be given to the mountain ecosystem before the rare Ethiopian wolf decreased from the current inviable number.
- ❖ Farmers should properly herd and monitor their livestock to minimize the human-wolf conflict,
- ❖ Organizing the landless locals and assist them to be involved in related jobs like tourism. This will enhance their attitude towards wolf conservation,
- ❖ Supplying improved livestock through loan or cash and providing technical assistance to farmers on yield increase,
- ❖ Supplying with improved local forage and bio-fuel seeds and seedlings including assistance,
- ❖ Awareness creation for local administrators and communities on the status and objectives of Ethiopian wolf conservation and the entwined ecological chains with the endemic small mammals,
- ❖ Upgrading the mountain to community based protected area with the involvement of local communities.
- ❖ Delimit the boundary to regulate farmland expansion.

- ❖ Constructing infrastructures (i. e. roads, tukuls) to enhance tourism activities,
- ❖ Conducting detailed population census with frequent monitoring on the Ethiopian wolf and further investigation on small mammals,
- ❖ Enhancing different stakeholder cooperation with the main focus developing strategies that can involve local communities in sustainable conservation of small mammals, Ethiopian wolf and the afroalpine habitat,
- ❖ Formulating strategies that can bring conservation based economic development primarily for locals,
- ❖ Provision of annual dog vaccination, and
- ❖ Poison supply should not be started and awareness creation for local people about the negative effect of poison on wild life. Poison application should be banned.

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DECLARATION

I, the under signed, confirm that this thesis is my original work and it has not been presented for a degree or other purposes in any other university. All the source materials used for the thesis are fully acknowledged.

Teklu Damtie
