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Species Composition, Abundance and Habitat Association of Rodents in Awash National Park and Metahara sugarcane Plantation

By

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Table of Contents

Abstract

A study on the species composition, distribution, relative abundance and habitat association of rodents species was carried out in Awash National Park and Metahara Sugarcane Plantation from August 2005 to 2007. Eight trapping grids were randomly selected based on the vegetation composition in Awash (riverine forest, *Acacia* woodland, Shrub bushland and grassland) and on growth stages of cane in Metahara (immature sugarcane plant, young sugarcane plant, and old sugarcane plant). An additional grid was selected from shrub bushland area outside the sugarcane plantation. A total of 1002 captures were obtained in 5880 trap nights. Of these, 309 individuals (40.98%) represented six species of rodents (*Mastomys natalensis, Acomys cahirinus, Arvicanthis dembeensis, Mastomys erythroleucus, Tatera robusta* and *Mus musculus)* in Awash and 445 (59.02%) represented eight species of rodents (*M. natalensis, A. dembeensis, A. cahirinus, Mylomys albipes,Tatera robusta, M. musculus,and Rattus rattus)* in Metahara. *M. natalensis* was the most abundant species constituting 26.5% of the total catch. *A. dembeensis* (17.8%), *A. cahirinus* (16.2%), *M. erythroleucus* (12.3%), *T. robusta* (11.8%), *M. albipes* (7.3%), *M. musculus* (5.4%), and *R. rattus* (2.7%) constituted the total catch. Variation in abundance among the rodent species between the two sites was significant. Most of the rodent species from Awash were trapped from shrub bushland and grassland areas. Riverine forest was the least preferred habitat by rodents in the study area. *M. natalensis*, *A. dembeensis, A. cahirinus, M. albipes and M. erythroleucus* preferred young sugarcane plants to other growth stages of the cane. *T. robusta* and *R. rattus* were trapped in more number in old sugarcane than other growth stages. *M. musculus* was equally abundant in both young and old sugarcane growth stages. The overall difference of the species abundance between the different stages of sugarcane plantation was significant. There was seasonal difference in the abundance of the rodent species in both Awash and Matehara. However, the overall difference in the abundance of rodents species between the two seasons was not statistically significant in Metahara. Variation in trap success in different habitats of Awash was statistically insignificant. Variation in trap success between different growth stages of the canes was statistically significant. However, there was no significant difference in trap success between the seasons. All age groups were represented in the population of most species with seasonal variation. The highest damage of sugarcane was recorded in old sugarcane plantation during both wet and dry seasons, followed by young and immature sugarcane plantations.

Keywords: Abundance, Awash National Park and Metahara sugarcane plantation, habitat association of rodents, seasonal variation, species composition, trap success .

Chapter 1

1. Introduction and Literature Review

1.1. Introduction

Ethiopia has rich diversity of wildlife that reflects the unique topography and wide ranging climate, making it the home for diverse biological resources (Shibru Tedla, 1995; Leykun Abune, 2000). There are 284 species of mammals, 861 species of birds, 201 species of reptiles and 63 species of amphibians in Ethiopia (Hillman, 1993). Ethiopia is one of the few countries in the world, which possesses a unique and characteristic fauna with a high level of endemism. Various authors (Yalden and Largen, 1992; Hillman, 1993; Yalden *et al.,* 1996; Afework Bekele and Corti, 1997; Tadesse Habtamu and Afework Bekele, 2005) indicated that rodents represent 40% of the entire mammal species and nearly 50% of the endemic mammalian fauna of the country. This shows the importance of rodents in Ethiopia, but most of them are yet to be studied with respect to their ecology and their economic implications. Out of the over 5000 species of mammals over the world, 2052 species are rodents (Nowak, 1999). Thus, they comprise 41% of the entire mammalian species. Among the 84 species of rodents recorded in Ethiopia, 15 species are endemic (Yalden and Larger, 1992; Hillman, 1993).

Rodent ecology, distribution, pest problems and control measures are discussed in detail in various contexts. However, only limited studies have been carried out in Ethiopia on rodents (Afework Bekele *et al*., 1993, Afework Bekele 1996a; 1996b; Afework Bekele and Corti, 1997; Afework Bekele and Leirs, 1997; Lavernchenko *et al*., 1998; Shimelis Beyene, 1986; Yalden, 1988; Sillero-Zubiri *et al*., 1995; Bekele Tsegaye, 1999; Corti *et a*l., 1999; Tilaye Wube, 1999; Alemu Fetene, 2003; Tadesse Habtamu and Afework Bekele, 2008; Demeke Datiko *et al.*, 2007; Dawit Kassa, 2006; Serekebirhan Takele *et al*., 2011; Serekebirhan Takele *et al*., 2008; Solomon Argaw, 2009).

Rodents have acute sense of hearing, smell, taste and touch (Nowak, 1999). They are social animals and use their sensory abilities to communicate effectively from time to time. Some rodent species such as wild house mouse (*Mus musculus taneus*) possess integumentary glands in various body regions for olfactory communication Balakrishnan and Alexander,1985). Their behaviour is highly adaptive.

Rodents are widely distributed. The success is attributed to their higher reproductive potential, and young age in evolutionary terms between 26 and 38 million years (Macdonald, 1984). Most rodent species commonly have 6-12 young in each litter and a female can have one litter each month. Due to their high reproductive potential and ability to invade diverse habitat types, rodents are able to spread and multiply quickly. Adaptability to a wide range of food items is the other reason for their success. Thus, rodents occur in every habitat from the high Arctic Tundra (eg. Lemmings), in the hottest areas such as capybaras and muskrats and others glide from tree to tree (eg. Flying squirrels) (Macdonald, 1986; Kingdon, 1997; Vaughan *et al*., 2000).

Many rodent species are opportunistic omnivores. They can live on a variety of food items (green plant materials, seeds, fruits, tubers and insects) and thus survive in many different types of farmlands (Leirs *et a*l., 1994). Rodent like mole rats are specialized on roots and tubers and cause major problems in cassava field and 'enset' (Sidorowicz, 1974). Some rodent species are very sensitive to changes in crop varieties, land use and field management patterns, while others are affected only marginally. Thus, a sound biological knowledge of rodent species is a prerequisite for the development of more effective, ecologically based, rodent management strategies (Leirs *et al*., 1999).

Economic and ecological significance of rodents is far reaching. Rodent pests are a worldwide problem, and are responsible for considerable damage to crops, stored food and human properties (Jacob *et al*., 2003). They are nuisance in agriculture, forestry and public health (Fielder, 1994), causing severe economic losses (Tristiani and Murakami, 2003). They are also valued as food sources of humans in many parts of the world (Stoddart, 1984; Tadesse Habtamu and Afework Bekele, 2008).

From the very beginning, man has tried all possible means to minimize the damage caused by rodents. Mouse traps were already in use in the Turanian Civilization. Idea of the above ground granary with “mush room”posts is developed to stop rats and mice from climbing up into the stored grain. Killing rodents by trapping, hunting, flooding and fumigation has been practiced traditionally in many parts of the world, but rarely has great effects to control their populations (Smith, 1994; Greaves, 1989). The most commonly used control measure for rodent pests is rodenticides (Buckle, 1999).

Recent studies on immunocontraception of house mice in the laboratory and in enclosed field population has been promising (Chambers *et al*., 1999; Parshad, 1999). However, such strategies are useful in one area may not necessarily work elsewhere, effectively. The success of the method depends on the knowledge of the ecology of rodents (Tilaye Wube, 1999). Thus, for feasible rodent pest control and management activities in any given habitat, knowledge of rodent ecology and population dynamics are mandatory. However, studies on population ecology, habitat selection, habitat use, and population dynamics of the rodent community are still poorly known for many regions of Ethiopia.

The present study is planned for extended survey of rodents in both Awash National Park (ANP) and Matehara Sugarcane Plantation (MSP) areas to determine the species composition, abundance, habitat association and the pest status in sugarcane plantation area. It also is also expected to provide information on the damage caused by mammalian pests in Metahara Sugarcane Plantation.

1.2 Literature Review

1.2.1 Rodent distribution

Of all the mammalian orders, Rodentia with 29 families, 468 genera and 2,052 species has the largest number of species (Daves, 1963; Rosevear, 1969; Kingdon, 1974; Delany and Happold, 1979; Nowak, 1999). Rodents are among the most ubiquitous and numerous mammals, in both species and individual numbers (Delany, 1986; Afework Bekele, 1996a). They account for more than 42% of the known mammalian species (Singleton *et al.*, 2003). According to Tadesse Habtamu and Afework Bekele (2008), rodents account for 28% of the total mammalian fauna in East Africa. Similarly, the rodent fauna of Ethiopia contains 84 species and comprises more than 25% of the total mammalian fauna of the country (Yalden and Largen, 1992; Hillman, 1993; Afework Bekele and Leirs, 1997; Lavernchenko *et al*., 1998; Afework Bekele *et al*., 1999; Workneh Gebresilassie *et al*., 2004; Manyingerew Shenkut *et al*., 2006). Of the total rodent species, 21% is endemic (Afework Bekele, 1996b) and they account for 50% of the Ethiopian endemic mammals (Afework Bekele and Corti, 1997).

Rodents occur in every habitat from the high Arctic Tundra, where they breed under snow (e.g. lemmings) to the hottest and driest of desert as exemplified by gerbils (Happold, 1974; Delay and Happold, 1979; Stoddart, 1984; Happold and Happold, 1991; Oguge, 1995; Kingdon, 1997). Some species spend their entire lives above the ground in canopy of rainforest; others seldom emerge from beneath the ground (e.g. mole rat) (Kingdon, 1971). Rodents are generally terrestrial but a few species such as squirrels are arboreal and beavers are aquatic (Stanbury, 1972). Thus, their distribution is nearly cosmopolitan, covering almost all habitats of the earth except seas (Prashad and Kashay, 1995).

A characteristic topographical feature of Eastern Africa is the chain of isolated mountains and plateaux, which stretches from Ethiopia in the north to the Drakensberg Mountains in the south (Happold and Happold, 1989). The high plateaux of Ethiopia (200 - 4000 m) are very extensive with many high peaks. These mountains and plateaux are separated by lower savannas and woodlands. Each mountain and plateau has its characteristic flora and fauna. These changes in altitude result in a series of vegetation zones associated with several important biological changes. The changes in the distribution of vegetation have been associated with concomitant changes in the distribution of grasslands and their associated small mammals as indicated by Happold and Happold (1989). Likewise, the distributional abundance of rodents is related to the physiological constraints imposed by altitude or climate and availability of food resources (Pizzimenti and Sale, 1981). Thus, altitude in itself is not an important factor rather vegetative, physical and climatic changes are associated with changes in elevation (Delany, 1986).

In Arid and semiarid regions of Africa, rodents occupy burrows or rock crevices for shelter and, in many cases, to protect themselves from the adverse, high daytime temperatures (Delany, 1986). Diurnal rodents emerge after dawn when there is a peak of activity which this is followed by a subsidiary peak later after the hottest time of the day (Delany, 1986). Most species of lowland forest rodents are unable to survive when forest is cut down and replaced by secondary growth, farmland, and plantation (Happold and Happold 1989). Delany (1964) showed that the species, composition in savanna farmlands is different from that of undisturbed savanna.

According to Capelli (2005), in addition to climatic factors, soil characteristics (soil density, type, and depth), predation density and cover are also important ecological factors that have significant influences on rodent abundance. The nature and density of vegetation determine distribution and relative abundance of rodents, in addition to microclimate variation (Iyawe, 1988, Afework Bekele and Leirs, 1997; Clausntzer, 2003). Vegetation provides protection against predators and determines the number and dynamics of rodents (Happold and Happold, 1991; Oguge, 1995; Hansson, 1999). Flood disasters can also reduce population density, species abundance, species diversity and evenness (Zhang *et al*., 2005).

1.2.2. Feeding ecology of rodents

Rodents show a variety of feeding patterns. Food is one of the most important dimensions of niche and therefore information about diet is a major component of ecological research. Diet is extremely significant for determining day to day activity, evolution, life history strategies and ecological role of rodents (niche) (Krebs, 1998). Studies on diet and habitat preferences of rodents are important to understand relationships between species and between rodents and their environment (Zimmerman, 1965; Bar *et al*., 1984). These relationships may determine community structure, species diversity, relative abundance and resource partitioning among species and individuals.

Generally, many rodents are opportunistic feeders, capable of changing their feeding habits depending on the availability of food from season to season (Taitt, 1981; Leirs *et al.,* 1994; Happold, 2001). In the wild, brown rats eat snails, insects, crustaceans and freshwater shellfish. Commensal rats (*Rattus norvegicus* and *Rattus rattus*) utilize garbage for food and rubbish piles for shelter (Schroder and Hulse, 1979). *Mastomys* feeds mainly on seeds and also eats certain insects such as termites as well as skin and muscles of other vertebrates (e.g. frogs) (Taylor and Green, 1976). As stated by Macdonald (1984), the Australian water rat feeds on small fish, frogs and mollusks, and seldom eats plant material. Mice are omnivorous. They eat anything, but their favorite foods are cereals and cereal products. Mole rats are specialized on roots and tubers (Sidorowicz, 1974). Deer mice (*Peromyscus* sp.) has an omnivorous foraging strategy, while montane voles (*Microtus sp.* is granivorous) (Stanbury, 1972).

Rodents can master simple tasks for obtaining food. They can be readily conditioned, and easily trained to avoid fast-acting poisoned baits (Macdonald, 1984). This enables them to try out quickly new potential source of food in the face of new environmental conditions. The fact of their success is that rodents have a very wide ranging diet.

1.2.3 Breeding

Rodents have high rate of reproduction (Hvass, 1965). Mice and rats are extremely fast breeders. Mice have gestation period of three weeks. Litter size between different species is apparently variable. The average litter sizes of *Mastomys* sp. are eleven to twelve (Brambell and Davis, 1941; Chapman *et al.,* 1959; Delany, 1964). Most rodent species commonly have 6-7 young per breeding season (Workneh Gebresilassie *et al.,* 2006). Stanbury (1972) showed that brown rat (*Rattus norvegicus*) has an average litter size of 5-8 and breeds up to five times a year. Delany (1986) showed that *Praomys* sp. has litters of 12-16 and *Tarerillus* and *Rhabdomys* have litter size of 3-6.

Many environmental factors have effects on the timing of reproduction in rodents (Happold and Happold, 1989). Vaughan *et al*. (2000) indicated that temperature, energy and nutrition are probably of prime importance. Afework Bekele and Leirs (1997) showed that extended rainy season results in high litter size, which leads to an increase in population size. Thus, the correlation between rainfall and the seasonality of reproduction for most of the small mammals in Africa has gained acceptance (Tadesse Habtamu and Afework Bekele, 2008). Although breeding often appears to reach a peak during the latter part of the rainy season, continuous breeding occurs in irrigated lands (Taylor and Green, 1976).

Several species in the tropics and subtropics do not show seasonal breeding. *Acomys* sp., *Otomys* sp., *Taterillus gracilis* and *Arvicanthis* sp. breed continuously during some seasonal situations (Delany, 1986). *Arvicanthis* sp. is obviously highly adaptable being both a seasonal and an aseasonal breeder and the same is true of *Otomys* sp. as suggested by Delany (1986). *Lophuromys flavopunctatus* and *Mus minutoides* bred in almost every season (Delany, 1964).

In general, climatic conditions and possible changes in food availability trigger reproduction in most African rodents (Dieterlen 1967b; Delany and Neal, 1969; Cheeseman and Delany, 1979; Delany and Roberts, 1978; Dieterlen, 1985). Full reproductive activity in the Nile rat (*Arvicanthis niloticus*) reaches only when the nutritive environment is adequate and complete, while sterility might be caused by the restriction of food intake, either in a quantitative or qualitative manner (Ghobrial and Hodieb, 1982). According to Taylor and Green (1976), *Rhabdomys pumilio* bred when cereals are plentiful but is also found breeding when its diet is mainly clover (noted for its high crude protein content). Similarly, Rabiu and Fisher (1989) suggested that increase in the proportion of high protein foods (animals and seed matter) in the diet as the rainy season progresses is presumably of importance in maintaining reproduction in *Arvicanthis* sp. in northern Nigeria.

1.2.4. Rodents as pests

Rodents are among the most noxious pests of agriculture (Ghobrial and Hodieb, 1982, Prakash, 1988; Makundi *et al.,* 1999; Singleton *et al.*, 1999, 2003). Rodent pests are a world wide problem, and are responsible for considerable damage to crops, stored cereals and food and human properties (Jacob *et al.,* 2003). They threaten food production and thereby lower food security for the poor. Thus, farming families, living in or near poverty and nutritional catastrophe, suffer a double loss of their crop (both before and after harvest). Rodents damage 30% of the crops in both pre-harvest and post-harvest conditions (Singleton, 2001). Geddes (1992) indicated that rodent pests are the most important pre-harvest pests, causing annual losses of 17% in rice in Indonesia. The overall loss of food grain to rodent pests in India was approximately 25% in pre-harvest and 25-30% in post- harvest situations (Hart, 2001). Singleton *et al*. (2003) indicated, in Asia alone, the amount of grain consumed by rodents in rice fields each year would provide enough to feed 200 million Asians for a year, with rice providing 50-60% of their daily caloric intake. For example, annual loss due to rodents in rice production is between 2-5% in Malaysia (Singleton and Peach, 1994), >10-20% in China (Qinchuan *et al,* 2003), 6-7% in Thailand and > 10% in Vietnam (Bonsong *et al*., 1999).

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

As Makundi *et al.* (2005) indicated in Ethiopia crop damages by rodents are common. Maize is the most affected crop in Ethiopia in addition to'enset' and potatoes. Thus, rodent pests are adversely affecting the economy of the country. in most of the developing tropics, rodents are serious pests.

In sub-Saharan Africa, the major rodent species causing severe damage to crops belong to the Genus *Mastomys* (Muridae). They occur all over the continent in natural grasslands, cultivated areas and human habitats. Workneh Gebresilassie *et al*. (2004) have indicated that *Mastomys erythroleucus* occur more frequently in vegetative fields, whereas *Arvicanthis dembeensis* occur more frequently in habitats with monocot plants. Recurrent outbreaks of the Nile rat (*Arvicanthis niloticus*) and the multimammate rat (*Mastomys natalensis)* have revealed that weather has a distinct influence on occurrence of mass appearance of rodents. Population explosions happen at irregular intervals (Leirs *et al.,* 1996) and crop losses of over 50% have been recorded during such outbreaks in Kenya. Hence population dynamics of rodent population is essential to forecast the probability of outbreak of rodent populations within the year.

There are 2,052 species of rodents so far identified (Nowak, 1999), but only a limited number of them cause problems in agriculture (Paul and Robertson, 1989; Leirs, 2003). For instance, in Africa, out of the 406 species belong to 11 families (Wilson and Reeder, 1993), only 77 species are reported to cause damage to agriculture (Fiedler, 1994). In East Africa, only 35 species of rodents are known to damage crops (Fielder, 1994). But even in this group, most species only occasionally damage crops and only less than 20 species of them cause serious damage over most of their distributional ranges (Leirs, 2003). Fiedler (1988) reported that in Australia only seven out of 67; in Europe only 16 out of 61; in India, only 18 out of 128 and in Indonesia, only 25 out of 164 species are clearly identified as pests. Similarly, in Ethiopia, 11 out of 84 species of rodents are known to be pests (Afework Bekele and Leirs, 1997). According to Afework Bekele *et al*. (1993), Demeke Datiko *et al.* (2007) and Workneh Gebreselassie *et al.* (2006), the most important pest rodents in Ethiopia are *Mastomys erythroleucus*, *M. natalensis, Arvicanthis dembeensis Mus mahom*et and *M. musculus.*

In cereal crops in African savanna regions, most damage occurs during the sensitive young seedling stage and just before harvest (Fiedler, 1994). Workneh Gebreselassie *et al.* (2004) indicated that abundance of rodents was high during the reproductive phase of agricultural plants and their effect was more intense during the fruiting phase of the plant. Although efficient techniques exist to kill rodents, none of the traditional means has been able to control populations over the longer term (Singleton *et al.*, 1999a). Short-lasting measures may be effective in order to protect the crop during the sensitive stage, if they are applied before the damage is made (Myllymaki, 1987).

Another risk that rodents pose is disease. A number of rodents are carriers of human disease such as typhus, Salmonella, bubonic plaque and hanta fever (Stanbury, 1972, Menhhorst, 1996). Rat-borne diseases are alleged to have taken more human lives than all wars and revolutions put together during this last millennium (Macdonald, 1984). For instance, the bubonic plaque is responsible for the death of 25 million people in Europe in the 14-17th centuries (Bere, 1962). Mice and rats can carry

leptospiral jaundice (weil's disease) in their urine and droppings as they contaminate food and kitchen equipment. Beside spreading disease, they also bring parasites such as fleas, mites and lice to humans (Kingdon, 1997), particularly those rodents living inside homes (Mohebali *et al.*, 1998).
Rodents also destroy infrastructure plant population and paper products by gnawing. Sewnet Mengistu and Afework Bekele (2003) indicated that rodents damage irrigation canals and divert the direction of water flow. Mice and rats have also been known to gnaw and damage the carryings of electrical wires, pipes and furnitures (Stanbury, 1972).

Considering all this, there is a pressing need for effective in-field rodent management program. Thus, for feasible rodent pest control and management activities in any given habitat, scientific knowledge of rodent ecology, population dynamics, habitat association and distribution are mandatory.

1.2.5. Positive effects of rodents

Some evidence indicated that fungi, including mycorrizae are abundant in the disturbed soil around rodent burrows (Hawkins, 1996). Such fungi assist in the establishment of vascular plants. Rodent burrows' create underground shelters for several other organisms (Dickman, 2003).

The diggings and surface disturbances created by long-haired rats appeared to favour increased plant cover such as some species of grasses, herbs and plant seeds (Dickman, 2003). Digging allows easier penetration of water into the soil profile, or creates a rough ground surface that traps organic debris and returns nutrients to the soil. These environmental effects would facilitate germination and help to promote seedling establishment in the vicinity of rodent burrows. Hill (1982) indicated that beaver ponds create standing water, which increases vegetation diversity and edge effects, and reduces erosion. They are the primary, non-human force determining wetland habitat conditions. Australian desert rodents can have subtle effects on the abundance, resource use and local diversity of a wide range of plants and animals (Dickman, 1999). Foraging by kangaroo rats suppresses the cover of grass and facilitates open foraging areas for granivorous birds (Thompson *et al.*, 1991). Rodents are the base of the vertebrate food chain.

According to Sillero-Zubiri *et al*. (1995) and Cleveland (2007), the giant mole-rat and the diurnal rats *(Lophuromys melanonyx* and *Arvicanthis blicki*) make up the vast majority of the Ethiopian wolf's diet in Bale Mountains National Park. Many small carnivores such as jungle cat (*Felis chaus*), Caracas (*Caracal caracal*) and golden jackal (*Canis aureus*) largely feed on rodents (Yalden and largen, 1992; Mukherjee *et al*., 2003). Many predatory birds such as owls and reptiles such as snakes feed on rodents.

According to Veyrunes *et al*. (2006), various rodent species are economically important as sources of food or fur in many parts of the world. This high demand is due to their abundance, accessibility and easy trappability (Tadesse Habtamu and Afework Bekele, 2008). Rodents such as grass cutter (*Thryonomys swinderianus*) giant rats *(Cricetomys gambianus*), Gambian sun squirrel (*Heliosciurus gambianus*), ground squirrel (*Xerus erythropus*), Crested porcupine (*Hystrix cristala*), grass rat (*Arvicanthis niloticus*), slender gerbil (*Taterillus gracilis*), Kempi's gerbil (*Tatera Kempii*), multimammate rats (*Mastomys* sp.) and grass mouse (*Lemniscomys striatus)* are important food source for villagers near the Lama forest reserve in southern Benin (Assogbadjo *et al*., 2005). Similarly, in Ethiopia, porcupines, squirrels, *Arvicanthis* and *Desmomys* species are the most preferred rodents for food by Gumuz tribes (Tadesse Habtamu and Afework Bekele, 2006).

In South America, Capybaras (*Hydrochoerus hydrochaeris*) are often hunted or even ranched for their meat (Ingles,1999) and in Europe, the muskrat (*Ondatra zibethica*) and nutria (*Myocastor coypus*) are used as fur sources (Lawrence and Brown,1995). Khiem (2003) reported that the annual production of rat meat for human consumption was 3300-3600 tones with a market value of 2 million US dollars in Mekong delta of Vietnam.

Some rodents provide benefits by acting as natural insect and weed control agents (Bere, 1962; Capelli, 2005). According to Diaz *et al.* (2007), Gopher's burrowing activity buries exotic barbed goat grass plant (*Aegilops triuncialis*) and thus slows down its expansion over the landscape. They also reduce the infection of goat grass seed heads by the fungus *Ulocladium*, thus retarding germination and putting this exotic species in a disadvantaged position with respect to native grasses.

1.2.6. Sugarcane

Sugarcane is a type of giant grass known as '*Saccharum*', the generic name of sugarcane. One of the cultivated species of '*Saccharum*' is known as *Saccharum officinarum*. The wild form of sugarcane belongs to the family *Saccharum spontaneum*. The cultivated wild varieties of sugarcane have played an important role in the development of new commercial varieties of sugarcane, at present grown by hybridization and selection techniques. Thus, all the sugarcane varieties grown in different countries have the origin from *Saccharum officinarum* and *Saccharum Spontaneum*.

Sugarcane is cultivated in tropical and subtropical countries throughout the world. Sugarcane grows to a height of 3 to 6 m and is about 2 to 5 cm thick. A hot, moist climate with a dry ripening season is suitable for its growth, while a very low temperature or suddenly lowering temperatures may affect it adversely. Several varieties are commonly cropped, which can differ in stem colour, height and whether the leaves fall off before harvesting or not (Pervez and Ali, 2001). In tropical areas, sugarcane will grow all year and can be harvested between January and August. Most of the cane in the world is harvested by hand, though cane cutting machines have been used, most notably in Australia. The manual cutting instrument is a long steel blade about 50 cm long.

When the stems are cut into pieces with a number of buds on each piece, they are called 'setts', which can be used for propagating the crop (Dubey and Kawasthi, 1991). Stems developed from the buds, which grow into stalks or canes are ready for harvesting from 10 to 24 months. After the first harvest, the underground buds on the stool develop to give a second, third or even more crops in a similar or slightly shorter growth period, which are known as ratoon crops (Khan and Smythe, 1981). Thus, the usual period of maturity is 16 months in the case of plant canes and 11-12 months in that of ratoons (Mathur, 1981). Cane is cut at or near the ground and only the stem is used in sugar industry. Cane is also used to produce the fuel ethanol.

1.2.7. Rodent damage on sugarcane plant

Rodents are major pests of sugarcane. They can potentially damage sugarcane at all stages of the cane growth (Smith *et al*., 2003). In ratoon cane, rats gnaw the stems and apical meristems of young plants besides their direct damage resulting in reduced sugar content and harvestable tonnage (Wilson and Whisson, 1993). They also expose the cane stem to infestation by insects, bacteria and fungi and desiccation (Meyer, 1994; Roberton *et al*., 1995). In the 1999-2000 harvest seasons, rats in Australian cane fields destroyed approximately 825,000 tonnes of sugarcane valued at US $50 million (Rao, 2003; Smith, 2003). Rao (2001) indicated that rodent damage can cause brittle cane that shatters when harvested, or deteriorated cane quality through the fermentation of the cane juice. Leung (1998) reported that in Hawaii sugarcane plantations, rodent caused severe losses that have been estimated as 4.5 million dollars annually. Similarly in Ethiopia, Serekebirhan Takele *et al*. (2008) reported that rodent damage was estimated to be more than 4% in Wonji Sugarcane Plantation.

Rodent infestations represent one of the most important pest problems for sugarcane growers. Rodents colonize cane fields that provide them relatively undisturbed habitat for burrowing, feeding and breeding as well as protective cover from avian predators for most part of the year (Parshad, 1999). Sugarcane being a long duration crop provides an ideal monoculture ecosystem for the pests and facilitates continuation of the same pest generations after generations. Ratooning, a common practice in sugarcane plantation aggravates the pest problem (Rao *et al*., 2004).

Sugarcane fields are burned before harvest to eliminate extraneous leafy trash (to reduce hauling and avoid interference with processing, insects, rodents and weeds). Most rodents living in cane fields either die or migrate to surrounding areas during harvesting, and therefore, their populations do not rebuild until the second half of the crop cycle (Gratz, 1996). However, most rodents prefer to forage in adjacent areas of the young sugarcane fields or grasses on field edges, or shrub dominated areas that provide suitable habitat refuges.

Rodent damage in sugarcane fields is identified by open holes at lower internodes and small chips on the ground where they have fed. For example, pigs *(Sus scrofa*) chew on the entire stalk, leaving it with a shredded appearance (Mwanjabe, *et al*., 2002). Trampled vegetation is further evidence of pig activity; thus rodent damage can be easily distinguished in plantation.

Although rodents damage sugarcane at all stages of cane growth, the degree of damage varies from stage to stage. For example, in the field of very young sugarcane plant of about 1 to 8 months old (immature sugarcane), there are only few rodents in the field. This is because the young sugarcane provides very little cover and food. Thus, for the first four months of age, no evidence of rodent damage was observed (Khokhar and Razvi, 1998). Rajab *et al*. (2003) reported that rodent damage may commence when the cane is nearing 7-8 months. On the other hand, young sugarcane plants (8-15 months old) have more ground cover; provide more adequate food sources and available burrowing and nesting sites than those of immature sugarcane field. During this stage, rodents attack the internodes of the growing stalks of cane either killing the stalk or exposing to secondary infection by microorganism. Thus, the losses caused by microorganisms are more severe than direct damage caused by rodents (Blackburn, 1984; Caughtey *et al*., 1998).

Mature sugarcane plants (15-24 months old) establish a closed canopy making an ideal habitat for rodents than those of immature and young sugarcane plants. As a result, during this stage, rodent damage increases substantially and progressively until harvest. Trapping rodents during this stage is extremely labour intensive due to closed and inpenetratable canopy formation. In Hawaii, about 5% of the stalks are attacked each month (Fauconnier, 1993) and may reach 20 to 40% by harvest. Therefore, cane at this stage needs maximum protection and follow up to protect the plants from severe rodent damage.

1.2.8. Rodent pest management strategies

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

1.3. Objectives

1.3.1. General Objectives: the general objective of the present study is to conduct ecological survey and assess the current species composition, abundance and habitat association of rodents in Awash National Park and Metahara Sugarcane Plantation with respect to pest status in sugarcane plantation.

1.3.2. Specific Objectives

- To identify the rodent species in the study areas.
- To determine the composition and abundance of rodents at different growth stages of the sugarcane plants.
- To assess habitat association of different rodent species.
- To assess the extent of damage caused by rodents on sugarcane plants.
- To suggest ecologically sound rodent control and management strategy for sugarcane plantation.

Chapter 2

2. The study Areas and Methods of Study

The study was conducted both in Awash National Park (ANP) and Metahara Sugar Plantation (MSP) about 210 km south of Addis Ababa. These areas are located at altitude range of 750-2007 m above sea level in the Rift Valley Ecological Zone of Ethiopia.

2.1. Awash National Park

ANP is situated in lowlands to the east of Addis Aaba in the Afar and Oromia regions, on the Addis-Djibouti highway. It lies in the middle of Rift Valley around the point where the Ethiopian Rift Valley joins with the Afar Triangle, between latitudes 8^0 45'N and 9^0 15'N and longitudes $39^0$45'E and $40^0$5'E. Metahara Sugar Plantation borders the Park along the west. According to Jacobs and Schloeder (1993) despite one of the two gazetted National Parks in Ethiopia, ANP does not have a legally described boundary area. The dormant volcano of Fantale has a height of 2007 m on its rim whereas most of the Park area lies at an altitude of around 900 m. Temperature in the Park is hot and can reach as high as 42^{o}C. Nights are cooler with temperatures between 10^o and 22^{o}C. Rain is bimodal in between February and April, and June to August.

ANP is a habitat for 81 species of mammals, 435 species of birds and poorly documented list of reptiles and invertebrates (Jacobs and Schloeder,1993).The *Beisa oryx* and *Soemmerring's gazella* occur in the more open areas (Ilala Sala grassland) and wood grassland. Water buck (*Kobus ellipsiprymnus*) is found only near Filwoha. There are two species of baboons (the *Anubis baboon* and the *Hamadryas baboon*) in ANP. Colobus and Vervet monkeys occur in riverine forest along the Awash River.

2.2. Metahara Sugar Factory (MSF)

Metahara with an altitude of 950 m above asl has a semiarid climatic condition and the average annual rainfall is 543 mm. The mean annual maximum and minimum temperatures are 32.8^{o}C and 17.5^{o}C, respectively. The hottest period of the year extends from March to June whereas the coldest period extends from September to January.

The MSF currently has a total concessions of area of 14,733 hectares out of which about 10,300 hectares is covered with cane plantation.

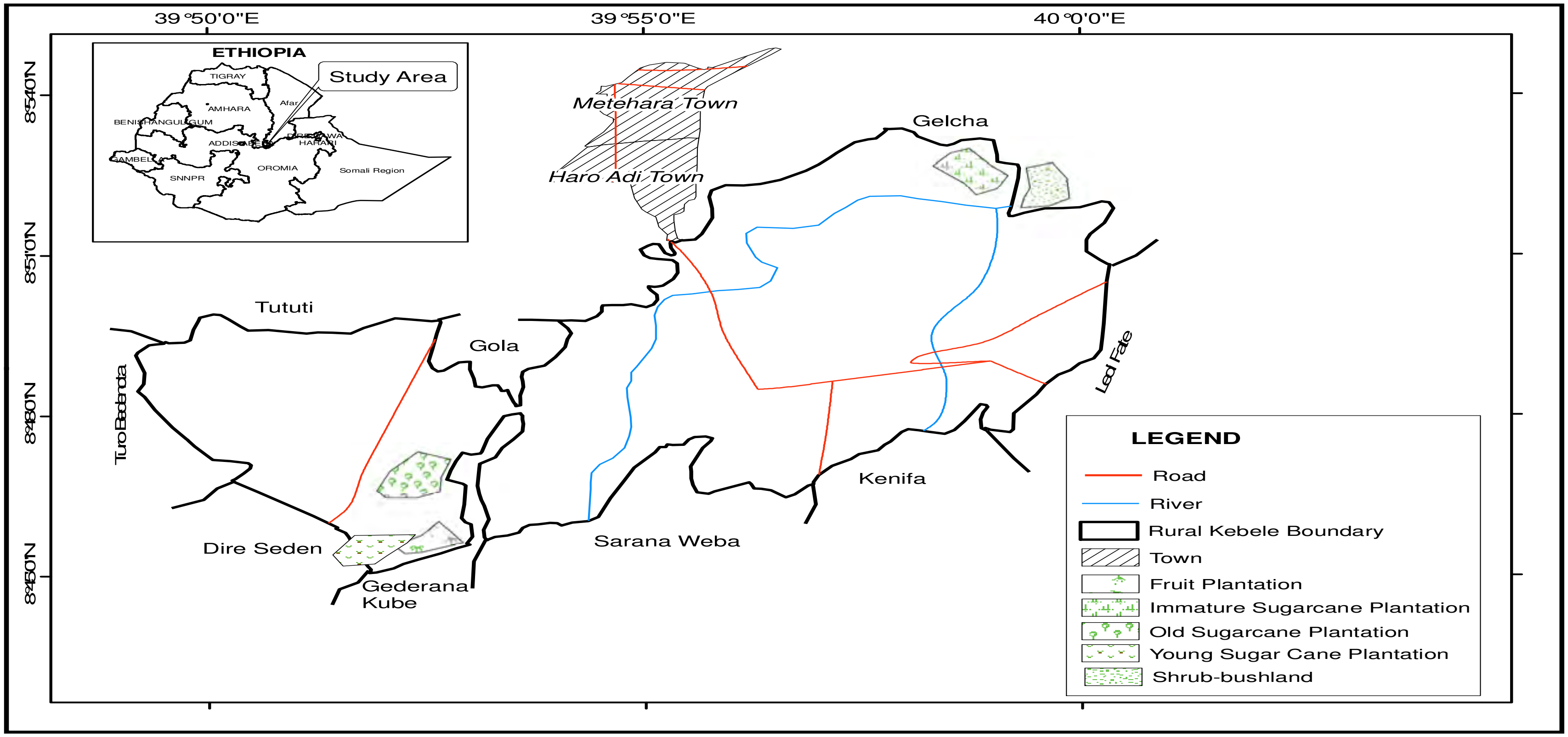

Figure1a The location of the Study Area(MSP) *Source:-GIS data CSA, 2007*

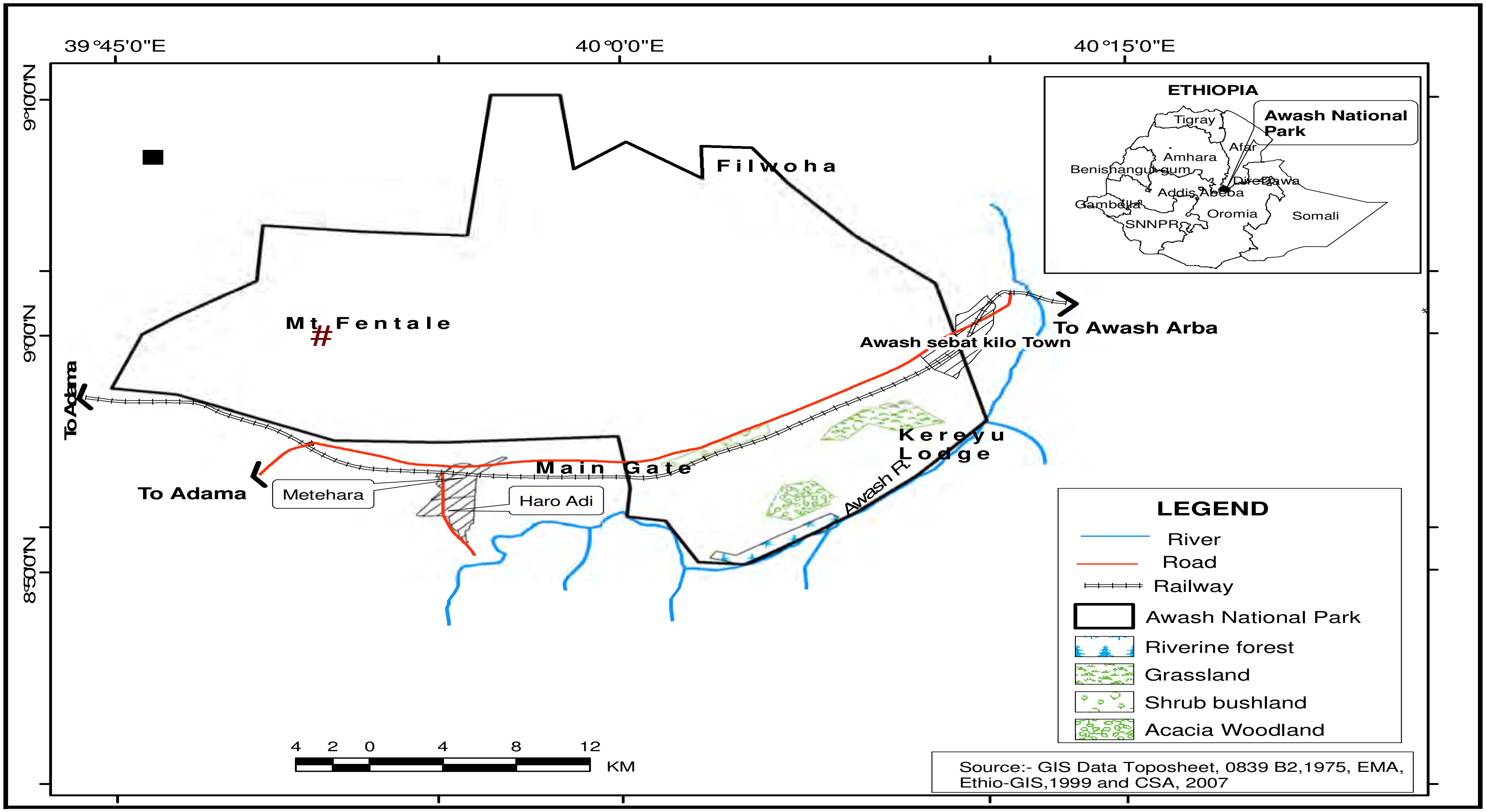

Figure1b The location of the Study Area(ANP)

2.3. Methods

An ecological survey of rodents in both Awash National Park and Metahara Sugarcane Plantation was carried out in August 2005 until March 2007, covering both wet and dry seasons. The first wet season data collection was carried out from end of August 2005 to the middle of September 2006 and the second in September 2006. The first and the second dry season data collection were conducted in December 2006 and End of January to middle of March 2006. The third dry season data collection was carried out in January 2007. Selection of the different habitats was carried out based on the variations in plant composition. During this survey, all the necessary information about the area (climatic condition, topography, and site of the area) was gathered.

Field data, regarding distribution, habitat association of rodents, and pest status in sugarcane plantation were collected both during wet and dry seasons August to middle of September were a period of the wet (long rainy) season; November January, and March were a period of dry season.

The grid site was based on random selection and representation of the main vegetation zone, plantation area and uncultivated area. On the basis of this criterion, 8 sample areas were selected randomly. These are, *Acacia* woodland, shrub bushland, riverine forest and grassland in ANP and in MSP immature, young and old sugarcane plant and shrub bushland of uncultivated neighbouring area of sugarcane plantation. The study area was randomly divided into blocks by using natural and or artificial boundaries (Sutherland, 1996). In the whole study area, six 70x70 m live trapping grids were established for capture mark recapture (CMR) study. A single grid was set up in each representative site of the habitat in every study period based up on approximate representation of different habitats as well as easy accessibility. These sites served as sampling grid for all seasons. Each of the grids consisted of 49 Sherman traps, 7x7 lines at 10 m intervals. The Sherman live traps were of 7.6x8.9 x22.9 cm. The traps were set at equal distance as shown in Figure 2.

Trapping stations were marked with consecutively numbered yellow and white scotch tape tied on marked plant or object. Traps were baited with peanut butter. The traps were covered by hay and plant leaves during the dry season to minimize temperature changes and to avoid from sight of baboons. This also provided protection for the trapped animals against the strong heat.

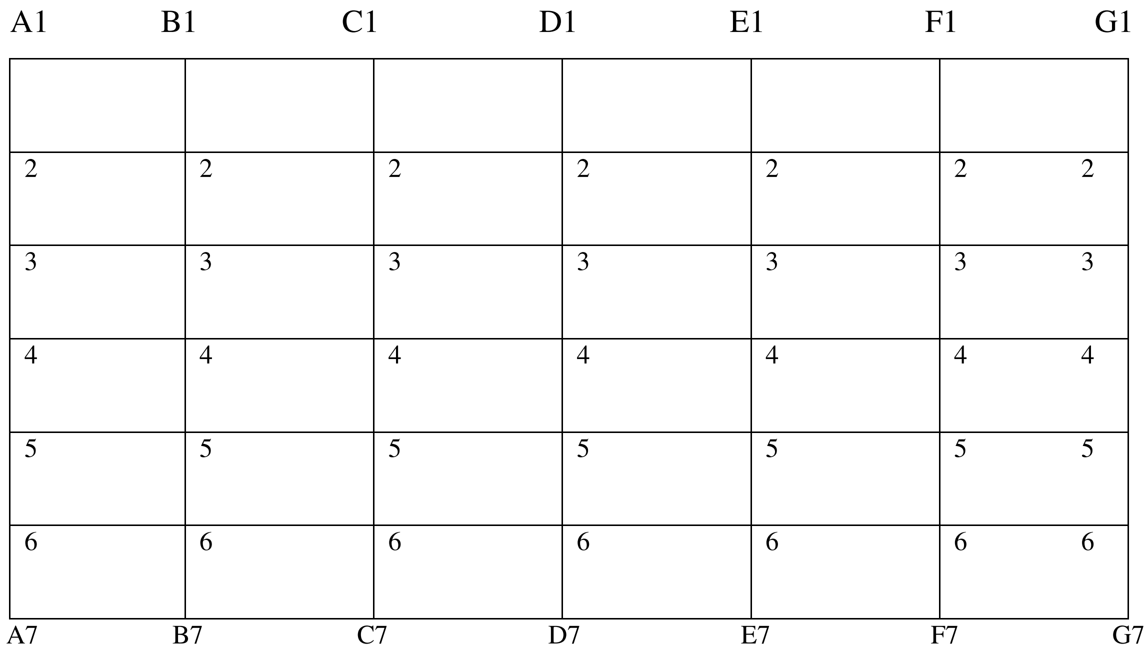

Figure 2. Diagramatic representation of live trapping grid and grid location area.

The traps were checked twice a day; early morning between 6:30 and 8:00 a.m. and late in the afternoon between 5:00- 6:00 p.m. for three consecutive days in each habitat. The trapped specimens were soon removed from the trap and kept in a polyethylene bag. For each individually trapped specimen, grid and trap station number, toe clipping code, body mass and sexual conditions were recorded (Linzey and Kesner, 1997; Clausnitzer, 2003) before releasing the trapped specimens into their respective trap sites safely. The reproductive conditions of the females (closed or perforated vagina, pregnant or non-pregnant and lactating and non-lactating) were identified by their enlarged nipples, large swollen abdomen and body weight (Ghobrial and Hodieb, 1982; Aplin *et al*., 2003).

The sexual conditions in males were detected by the position of testicles (scrotal or inguinal) (Ghobrial and Hodieb, 1982). In addition to the above, each of this trapped specimens was examined for sex, age (juvenile or young, sub-adult and adult) based on their weight and morphology (pelage colour) following Afework Bekele (1996a) and body measurements were taken from the snap trapped animals.

2.3.1. Snap trapping

A total of 25 snap traps (metal commercial "break-back" traps) were placed at 20 m interval in each habitat at 200 m away from live trapping grids. The trapping was conducted for three consecutive days in each habitat.

Rodents were examined soon after removed from the traps, body measurements like head-body length of tail, hind foot, and ear as well as the number of mammae and number of embryo from pregnant females were recorded. Dissections of all snap-trapped rodents were carried out for stomach content analysis. The stomach contents from the dissected rodents were removed and preserved in 70% alcohol until further microscopic examination. The contents were put on a glass slide and observed under a light microscope to identify the type as well as the proportion of the diet following the techniques of Leirs (1994).

2.3.2. Damage Analysis

The extent of damages caused by rodents at different growth stages of the cane was assessed. Each grid was subdivided into 49 cells of 100 m^2 area. Out of the 49 cells in a grid, 12 cells (24.5% of the total) were randomly selected and individual stalks that were damaged by rodents in these cells were counted in both seasons to calculate the extent of damage by rodents. The total stalk count per hectare was known from the factory's record. Then, the damage proportion of this stalk was estimated.

2.3.3. Species identification

For species identification, distinguishing taxonomic characteristics listed in Yalden *et al.* (1976); Kingdon (1974), Afework Bekele *et al.* (1993), Afework Bekele (1996a) and Nowak (1999) were accomplished. Rodent species are most often distinguished/ identified on the basis of morphological characteristics, such as differences in body size and shape a well as fur texture and colour (Aplin *et al.*, 2003). Species identification was also supplemented by comparison with a specimen available in the

Zoological Natural History Museum of Addis Ababa University, where the voucher specimens prepared for this work were deposited.

2.3.4. Data Analysis

Appropriate statistical tests such as Chi-square test and cross tabulation were used to compute the type of species, relative abundance, distribution and the vegetation association of rodent Species. SPSS version (14.0) computer program was used to analyze the data. Shannon-Weaver Index (H') was used to compute rodent species diversity of the different habitats. Simpson's Similarity Index was calculated to assess the similarity of the different habitats with respect to the presence of rodent species.

Chapter 3

3. RESULTS

A total of 1002 capture of 754 individuals of small mammals belonging to the orders Rodentia were obtained in 5880 trap nights from ANP and MSP. Of these, 309 individuals (40.98%) represented 6 species of rodents trapped in ANP and 445 (59.02%) represented 8 species of rodents in MSP (Table1). The live trapped rodent species were *Mastomys natalensis, Arvicanthis dembeensis, Acomys cahirinus, Mastomys erythroleucus Tatera robusta*, *Mylomys albipes, Mus musculus* and *Rattus rattus*. Among these, *M. albipes*, and *R. rattus* were restricted to Metahara Sugarcane Plantation site. *M. natalensis* was the most abundant species constituting 26.5% of the total catch. *A. dembeensis* (17.8%), *A. cahirinus* (16.2%), *M.erythroleucus (12.3%) T. robusta* (11.8%), *M. albipes* (7.3%), *M. musculus* (5.4%) and *R. rattus* (2.7%) constituted the total catch. Variation in abundance among the rodent species and insectivore between the two sites was significant (χ^2=81.45, df=7, $p<0.05$) and the overall variation in total relative abundance among the rodent species and insectivore was greatly significant (χ^2=339.8, df=7, $p<0.05$).

Table 1. Total catch and species abundance of rodents and insectivores in ANP and MSP (Figures in parenthesis are recaptures).

Species	ANP	MSP	Total catch in both sites	Relative abundance(%)
Mastomys natalensis	121(33)	166(54)	287(87)	26.5
Arvicanthis dembeensis	67(15)	106(24)	173(39)	17.8
Acomys cahirinus	98(27)	74(23)	172(50)	16.2
Mastomys erythroleucus	58(14)	57(8)	115(22)	12.3
Tatera robusta	53(12)	63(15)	116(27)	11.8
Mylomys albipes	-	68(13)	68(13)	7.3
Mus musculus	17(4)	34(6)	51(10)	5.4
R.attus rattus	-	23(3)	23(3)	2.7
Total new catch	309	445	754	100
Total catch	414	588	1002	

The distribution of species varied from habitat to habitat. *M. natalensis* was the most abundant and widespread species in all selected habitat types. It was trapped from all the habitat types in large numbers than compared to other species. *A. dembeensis*, *A. cahirinus* and *M. erythroleucus* were also the most widely distributed species in all selected habitat types. *T. robusta* and *M. musculus* were not trapped in the riverine forest. *M. albipes*, and *R. rattus* were trapped only in MSP habitats (Table 2).

Most of the rodent species trapped were from the MSP. The order of habitats preference in study area were shrub bushland area (SBL), young sugarcane plant (YSP), old sugarcane plant (OSP) and immature sugarcane plant (ISP).

Less number of rodent species was trapped in ANP in selected habitats. The order of habitat preference was shrub bushland area (SBL), Grassland area (GL), *Acacia* woodland area (AWL) and riverine forest (RVF). Species richness was highest in all selected habitats of MSP with 8 species of rodents. The lowest species richness was obtained at riverine forest with only four species of rodents. The distribution of each rodent species in the eight randomly selected grids in both sites is shown in Table 2. Comparison of species within the habitat types was not statistically significant (P>0.05)

Most of the rodent species from ANP was trapped from shrub bushland area and grassland area in large numbers (Table 3). The species composition and abundance in shrub bushland area were *M. natalensis* (25.7%), *A. Cahirinus(25.7%), A. dembeensis*, *M. erythroleucus* (15.2%), *A. dembeensis* (14.3%), *T. robusta* (12.4%) and *M. musculus* (6.7%). In grassland habitat, the abundance was *M. natalensis* (26%), *A. Cahirinus (21.2%), A. dembensis* (19.2%), *T. robusta* (16.3%), *M. erythroleucus* (14.4%) and *M. musculus* (2.9%).

Table 2. Distribution and habitat association of rodents in ANP and MSP areas.(RVF= riverine forest; ACw= *Acacia* woodland; SBL= Shrub bushland; GL= grassland; ISP= immature sugarcane plant; YSP=young sugarcane plant; OSP= old sugarcane plant).

Species	Habitat types								Occurrence
	ANP				MSP				
	RVF	ACW	SBL	GL	ISP	YSP	OSP	SBL	
M. natalensis	13 (6.5)	21 (10.5)	27 (13.5)	27 (13.5)	14 (7)	41 (20.5)	32 (16)	25 (12.5)	8
A. dembeensis	5 (3.7)	12 (8.9)	15 (11.2)	20 (15)	10 (7.5)	28 (20.9)	16 (11.9)	28 (20.9)	8
A. cahirinus	3 (2.5)	19 (15.6)	27 (22.1)	22 (18)	7 (5.7)	13 (14)	11 (11.8)	24 (19.4)	8
M. erythroleucus	1 (1.1)	12 (15.6)	16 (17.2)	15 (16.1)	7 (7.5)	13 (14)	11 (11.8)	18 (19.4)	8 8
T. robusta	-	11 (12.4)	13 (14.6)	17 (19.1)	7 (7.9)	8 (8.9)	15 (16.9)	18 (20.2)	7
M. albipes	-	-	-	-	7 (12.7)	19 (34.5)	15 (27.3)	14 (25.5)	4
M. musculus	-	3 (7.3)	7 (17.1)	3 (7.3)	3 (7.3)	8 (19.5)	8 (19.5)	9 (22)	7
R. rattus	-	-	-	-	4 (20)	3 (15)	5 (25)	8 (40)	4
Total specis per habitat	4	6	6	6	8	8	8	8	
Total individuals	22 (2.92)	78 (10.34)	105 (13.93)	104 (13.79)	59 (7.82)	133 (17.64)	109 (14.46)	144 (19.1)	54 (100)

(figures in brackets are habitat association)

Riverine forest was the least preferred habitat in the study area. *T. robusta* and *M. musculus* was not trapped in this habitat during the study periods. Rodent abundance in the riverine forest was *M. natalensis* (59.1%), *A. Dembeensis* (22.7%), *A. cahirinus* (13.6%) and *M. erythroleucus* (4.6%). The overall rodent abundance in the observed habitats was statistically significant (χ^2=58.76, df=3, P<0.05)

Table-3 Abundance and habitat association of rodent species in selected habitats of ANP. (RVF= riverine forest; ACW= *Acacia* woodland; SBL= shrub bushland; GL= grassland).

Species	RVF	ACW	SBL	GL	Total
M. natalensis	13	21	27	27	88
	(14.8)	(23.8)	(30.7)	(30.7)	
A. cahirinus	3	19	27	22	71
	(4.2)	(26.8)	(38)	(31)	
A. dembeensis	5	12	15	20	52
	(9.6)	(23.1)	(28.8)	(38.5)	
M. erythrolecus	1	12	16	15	44
	(2.3)	(27.3)	(36.4)	(34.1)	
T. robusta	-	11	13	17	14
		(26.8)	(31.7)	(41.5)	
M. musculus	-	3	7	3	13
		(23.1)	(53.8)	(23.1)	
Total	22	78	105	104	309
	(7.1)	(25.2)	(34)	(33.7)	

(figures in brackets are habitat association)

In MSP, *Mastomys natalensis* was the most abundant species in all habitats except in shrub bushland where it ranked second next to *Arvicanthis dembeensis. A. dembeensis* was the second abundant followed by *M. albipes, A. cahirinus* and *M. erythroleucus*.

M. natalensis, *A. dembeensis*, *A. cahirinus, M. albipes*, *and* *M.erythroleucus* preferred YSP to other growth stages of canes. *T. robusta* and *R. rattus* were trapped in more number in OSP than other growth stages of the canes. *M. musculus* was equally represented in both YSP and OSP growth stages of the cane. The overall difference of species abundance between ISP, YSP and OSP was significant (χ^2=29.38, df=2, P<0.001) as shown in Table 4.

Table 4. Abundance of rodent at different growth stages of the sugarcane plantations and in shrub bushland of at MSP Area.(ISP= immature sugarcane plant; YSP= young sugarcane plant; OSP=old sugarcane plant SBL= shrub bushland).

Species	Growth stages of sugar cane			SBL	Total
	ISP	YSP	OSP		
M. natalensis	14	41	32	25	112 (25.2)
A. dembeesis	10	28	16	28	82 (18.4)
A. cahirinus	7	13	7	24	51 (11.5)
M. albipes	7	19	15	14	55 (12.4)
M. erythroleucus	7	13	11	18	49 (11.00)
T. robusta	7	8	15	18	48 (10.8)
M. musculus	3	8	8	9	28 (6.3)
R. rattus	4	3	5	8	20 (4.5)
Total (%)	59 (13.5)	133 (30.2)	109 (24.8)	144 (31.5)	445 (100)

(figures in brackets are abundance)

In shrub bushland area A. *dembeensis* (19.3%) was the most abundant followed by *M. natalensis* (17.2%) and *A. cahirinus* (16.6%). Most rodents were trapped in YSP followed by OSP. Less number of rodents was trapped in ISP. The order of rodent abundance in the three sugarcane growth stages were YSP (30.2%), OSP (24.8%), ISP (13.5) and the nearby shrub bushland constituted 31.5% of the total catch in the area.

A total of eight rodent species were trapped during wet and dry season trappings. The over all number of species between the two seasons was not significant. Some of the rodent species that were trapped during the dry season were not trapped during the wet season (Table 5). *M. musculus* and *R. rattus* were not trapped during the wet season in an ISP. During wet season, there was significant difference (χ =52.92 fd=8, P<0.001) in abundance of rodent in different habitats of both Awash National Park and Metahara Sugarcane plantation areas (Table 5.).

Table 5. Seasonal variation of rodents ANP and MSP (ANP=Awash National Park; MSP= metahara Sugarcane plantation).

Species	Seasons						Grand total
	Dry			Wet			
	ANP	MSP	Total	ANP	MSP	Total	
M. natalensis	55	67	122	33	45	78	200
A. dembeensis	31	34	63	21	48	69	134
A. cahirinus	40	23	58	31	28	59	122
M. erythroleuus	27	31	58	17	18	35	93
T. robusta	18	30	48	23	18	41	89
M. albipes	-	32	32	-	23	23	55
M. musculus	8	16	24	5	12	17	41
R. rattus	-	10	10	-	10	10	20
Total	179	243	422	130	202	332	754

All trapped rodent species were relatively more abundant in MSP than ANP, except *A. cahirinus* during the wet seasons. In dry season, *A. dembeensis* was the most abundant rodent species in MSP, whereas *M. natalensis* was the most abundant in ANP. There was significant difference of rodent abundance in MSP and ANP. The overall variation was greatly significant between the wet and dry seasons (χ^2=10.77, df=1, p<0.001)

Species composition between the two seasons in ANP was similar (6:6) in ACW, SBL and GL habitats. But, the composition of species in RVF was two during the wet season and 4 during the dry season. *A. cahirinus* and *M. erythroleucus* were trapped only during the dry season in RVF. The overall seasonal variation in abundance was significant (χ^2=7.77, df=1, P<0.05). All rodent species were trapped in both seasons irrespective of their habitats. During the wet season, more individuals of rodent species were trapped in large number than during the dry season except for *T. robusta* which was trapped in more number during the dry season (Table 6).

Table 6. Abundance and composition of rodent species at different seasons in different selected habitats of Awash National park.(RVF= riverine forest; ACW acacia woodland; SBL= shrub bushland; GL= grassland)

Species	Habitat types									
	RFV		ACW		SBL		GL		Total	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
M. natalensis	6	7	9	12	10	17	8	19	33	55
A. Cahirinus	3	-	8	11	11	16	9	13	31	40
A. dembeensis	2	3	5	7	6	9	8	12	21	31
M. erythroleucus	1	-	4	8	6	10	6	9	17	27
T. robusta	-	-	7	4	6	7	10	7	23	18
M. musculus	-	-	1	2	2	5	2	1	5	8
Total	12	10	34	44	41	64	54	61	130	170
Total no. of species	4	2	6	6	6	6	6	6	6	6

Species composition in MSP between the two seasons was similar (9:9). But, the composition of species between seasons in ISP and OSP was different. *M. musculus* and *R. rattus* were not captured in ISP during the wet season while *A. cahirinus* was not captured in OSP during the wet season. Thus, composition in YSP and SBL habitats was the highest in both seasons. Irrespective of the seasons, Similarity Index (SI) was 1. However, it was 0.73 and 0.91 during the wet and dry season, respectively. The Shannon-Weaver Index (H') result for the species diversity was 2.084; 1.943; 2.022 and 2.028 for ISP, YSP, OSP and SBL habitats respectively.

Some of the rodent species showed differences in their abundance between season. *M. natalensis*, *M. erythroleucus*, *T. robusta*, *M. albipes, M. musculus* were abundant during the wet seasan. On the other hand, *A. dembeensis* and *A. cahirinus* were dominant during the dry season (Table 7). The overall difference in abundance of rodent species between the two seasons was not statistically significant (χ^2=3.83, df=1, p>0.05)

Table 7. Composition and abundance of rodent species and seasonal variation at different growth stages of cane and shrub bushland habitats in MSP. (ISP= immature sugarcane plant; YSP= young sugarcane plant; OSP= old sugarcane plant; SBL= shrub bushland)

Species	Abundance of rodent specie at different growth stages of cane									
	ISP		YSP		OSP		SBL		Total	
	Wet	dry	Wet	dry	Wet	dry	wet	dry	wet	dry
M. natalensis	5	9	27	14	19	13	16	9	67	45
A. dembeensis	3	7	12	16	7	9	12	16	34	48
A. cahirinus	3	4	7	6	-	7	13	11	23	28
M. erythroleucus	4	3	8	5	7	4	12	6	31	18
T. robusta	5	2	5	3	9	6	11	7	30	18
M. albipes	3	4	11	8	9	6	9	5	32	23
M. musculus	-	3	5	3	5	3	6	3	16	12
R. rattus	-	4	2	1	3	2	5	3	10	10
Total no. of Individuals	23	36	77	56	59	50	84	60	243	202
Total no of species	6	8	8	8	7	8	8	8	8	8

In ANP, trap success was highest in the shrub bushland (14.3%), followed by grassland (14.2%), *Acacia* woodland (10.6%) and riverine forest (3%). Variation in trap success was statistically insignificant (χ^2=8 df=3, p< 0.05). The trap success for wet season was 15.2% and for dry season 7.4%.

In MSP, trap success was highest in the shrub bushland (19.7%), followed by YSP (18.9%), OSP (15.5%) and ISP (8.4%). Variation in trap success between different growth stages of the cane was statistically significant (x^2=8.92 df=2, p<0.05). In ISP and OSP, there was no significant difference in trap success between the seasons. However, YSP showed variation (χ^2=4.68, df=1, p<0.05) in trap success between seasons.

Table 8. Trap success of rodent and insectivore species at different seasons in different habitats and different growth stages of canes in ANP and MSP.

Types of habitats or cane growth stages	seasons	Trap nights	Captures	Trap success (%)
Riverine forest	wet	294	10	3.4
	dry	441	12	2.7
Acacia woodland	wet	294	44	14.9
	dry	441	34	7.7
Shrub bushland	wet	294	64	21.8
	dry	441	41	9.3
Grassland	wet	294	61	20.7
	dry	441	54	12.2
Immature sugarcane plant	wet	294	23	7.8
	dry	441	36	8.2
Young sugarcane plant	wet	294	77	26.2
	dry	441	56	12.7
Old sugarcane plant	wet	294	59	20.1
	dry	441	50	11.3
Shrub bushland	wet	294	84	28.6
	dry	441	60	13.6

Of the total 754 individual rodents captured, females comprised 392 (52%) and males 362 (48%). The difference in sex ratio was not significant (χ^2=1.25 df =1, p>0.05). This was also true for sex ratio between seasons; male and female 46.5:53.4 for wet and 49.7:50.3 for dry season, respectively (Table 9).

Table 9. Seasonal variation and sex distribution of different species of live- trapped rodents (M=male, F=female)

Species	***Season***				***Total***	
	Wet		***Dry***			
	M	F	M	F	M	F
M. natalensis	58	64	43	35	101	99
A. dembeensis	29	36	34	35	63	71
A. cahirinus	26	37	32	27	58	64
M. erythroleucus	31	27	16	19	47	46
T. robusta	23	25	17	24	40	49
M. albipes	13	19	9	14	22	33
M. musculus	13	11	9	8	22	19
R. rattus	4	6	5	5	9	11
Total	197	225	165	167	362	392
%	46.6	53.4	49.7	50.3	48	52

Young, subadult and adult individuals constituted 16.4%, 17.1% and 66.5%, respectively. During both the wet and the dry seasons, more adult individuals were captured than young and subadult individuals. During the wet season, young individuals accounted for 15.9% whereas subadult and adult individuals accounted for 13.7% and 70.4% of the total capture, respectively. During the dry season, subadult, young and adult constituted 21.4%, 17.2% and 61.4%, respectively (Table 10).

The difference in the total capture of the number of adult individuals during the different seasons varied significantly (χ^2=17.66 df =1 p<0.05). However, there was no statistically significant variation in the total capture of the number of young (χ^2=1.48, df=1, p>0.05) and subadult individuals (χ^2=0.79 df= 1 p>0.05) during the different seasons.

Table 10. Composition of different age groups of live- trapped rodents in AWP and MSP.

Seasons	Age grope			Total
	Adult	Sub adult	Young	
Wet	297	58	67	422
	(70.4%)	(13.7%)	(15.9%)	(55.9%)
Dry	204	71	57	332
	(61.4%)	(21.4%)	(17.2%)	(44.1%)
Total	501	129	124	754
	(66.5)	(17.1%)	(16.4%)	(100%)

Table 11 shows the estimated damaged stalks of sugarcane plantation from randomly selected sites of different growth stages of the cane. During the wet season, 147, 1617 and 2499 damaged stalks were recorded from ISP, YSP and OSP, respectively. This accounts for 0.24%, 2.45% and 4.38% of the total stalk for ISP, YSP and OSP in the grid, respectively. During the dry season, damaged stalks increased for both ISP and YSP but that of OSP decreased. The extent of damage during this season was 1.6% for ISP, 3.5% to YSP and 3.7% for OSP of the total stalks in the respective grids (Table 11). The highest damage was recorded in OSP during both wet and dry seasons, followed by YSP and ISP.

Table 11. Damaged stalk counts of sugarcane plants at three growth stages of the cane during wet and dry seasons.(figures in brackets are percentage of sugarcane damaged

Growth stages of can	Grid area (m^2)	Totalstalkcount grid		Stalk coun/100m^2		Average damaged stalk count/100m^2		Damaged stalk no/grid	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
ISP	4900	61474 (0.24)	55127 (1.62)	1255	1125	3	18	147	882
YSP	4900	65863 (2.45)	58834 (3.5)	1344	1201	33	42	1617	2058
OSP	4900	57017 (4.38)	46301 (3.7)	1164	945	51	35	2499	1715

Chapter 4

4. Discussion

In the present study, the recorded composition of the rodent fauna was eight species during the trapping sessions. Among the recorded rodents, 6 and 8 rodent species were documented from ANP and MSP, respectively. There are many reasons for the abundance of rodents in a certain area such as altitudinal variations and vegetation types. According to Workneh Gebresilassie *et al* (2004), rodent abundance is usually associated with reproductive phase of the crop.

Low species number obtained in the present study area in Awash National Park is comparable to the studies conducted in other regions of Ethiopia (Afework Bekele, 1996a; Afework Bekele and Leirs; 1997, Afework Bekele *et al*., 2003). Similarly, seven rodent species in Mt Elgon, Uganda was reported (Delany, 1964) and Dawit Kassa and Afework Bekele (2008) reported seven rodent species in Wondo Genet. However, the number of species obtained during the present study was low compared to similar studies by Tadesse Habtamu (2005) who recorded 23 species in Alatish National Park and Demeke Datiko (2005) who recorded 14 species of rodents and two species of insectivores in Arbaminch Forest and farmlands. This low species diversity might be due to many factors. Over-grazing and encroachment of local pastoralist tribes are factors for less diversity in the study area. As Afework Bekele (1996b) stated habitat manipulation by human may affect the survival of some rodent species. Human interference also influences the diversity of small mammals (Tadesse Habtamu and Afework Bekele, 2008).

The abundance of rodents in Metahara Sugarcane Plantation was attributed to the presence of continuous food availability and ground cover in the study area. This abundance of rodents in the study area varied with the different growth stages of the cane. YSP contained the highest number of rodents and insectivore, followed by OSP and ISP. This finding contradicts with Blackburn (1984), who stated that mature sugarcane provides heavy cover and enough food for a relatively high population of rodents. This might be due to the following reasons. First, adjacent to YSP, there was fruit field fence where a number of rodent burrows were observed and rodents were constantly crossing to YSP field. Therefore, the migration of rodents might have resulted in an increased estimate of abundance in YSP. Haque *et al*. (1985) stated that there is high level of probability for the migration of rodents between adjacent sugarcane fields. In ISP, the abundance of rodents and insectivores was the least compared to YSP and OSP. This is due to limited ground cover and food (Whisson, 1996). However, as the age of the cane increased during latter trapping sessions of the dry season, more individuals were caught.

Shrub bushland area, which was the fourth sample area in MSP study area, was located next to Awash River and west of ANP. This area was less disturbed than other nearby areas. This can be a preferred habitat reducing the risk of predation. The availability of different food items in the shrub bushland might have also contributed to the high number of individuals. As a result, a high catch rate was obtained.

Generally, variation in the species composition of rodents among the four sample area of MSP and between the two seasons was not significant, but there was remarkable difference in abundance of different rodent and insectivore species from season to season. Similar study in western Serengeti, Tanzania (Magige and Senzota 2006) showed that species composition did not vary significantly among the different habitats like the present study in MSP.

M. natalensis, *M. erythroleucus*, and *M. albipes* were significantly more abundant during the wet season than dry season. Taylor and Green (1976), Hubert and Adam (1985) and Stenseth *et al.(*2001) indicated that rainfall has a positive impact in the breeding of *M. natalensis*, Similarly, Leirs *et al.*(1994) reported that the African multimammate rat, *M. natalensis* shows a strict breeding seasonality, linked to rainfall periods, probably through the stimulating effect of germinating weeds. Thus, rainfall also favoured the growth of weeds in the sugarcanes plantations and hence provided ground cover for rodent species to be abundant during this season.

A. dembeensis was significantly abundant during the dry season. This observation is well in line with the findings of Delany (1986) and Afework Bekele *et al. (1993*). Other rodent species, *A. cahirinus*, *M. musculus* and *R. rattus* and did not show significant variation between seasons.

All the trapped rodents inhabited all the three growth stages of the sugarcane plants and shrub bushland area. However, there was a difference in the relative abundance. *M. musculus* and *R. rattus* were not trapped in the early stage of ISP during the wet season. This was due to limited ground cover during initial growth stage of the plant that was not a suitable habitat compared to the other sugarcane stages. But, in the later ages of ISP, as the ground cover improved, more rodents species were attracted. This was in line with Tobin *et al*. (1990), who confirmed that during the long growth periods of sugarcane, cane stalks grow tall and big, and rows are shaded or hidden by foliage, which provide a suitable resting and breeding place for rodents.

M. natalensis was a common rodent in most parts of the west, central and east African countries (Laverncheenko *et al*., 1998). It was also distributed widely over most Ethiopian regions such as southwestern Ethiopia Gambela, Dembia, Maji, lake Shalla shore, along Takeze and Godere Rivers at altitudes ranging between 500-2900 m asl (Yalden *et al.,* 1976; Buckworth *et al*., 1993; Yalden *et al.* 1996; Afework Bekele and Leirs,1997; Bulatova *et al*,2002 and Tadesse Habtamu and Afework Bekele, 2008). Similarly, it was also the most widely distributed and abundant rodent species in the present study area. It was the dominant species in all ages of the sugarcane plant. In shrub bushland, it had 17.2% of the total catch, which was the second in abundance in this habitat. This observation is in line with the findings of Serekebirhan Takele (2006).

A. dembeensis is a common rodent in Ethiopia. According to Yalden *et al.* (1976), its distribution in Ethiopia is widespread. In the present study, it was recorded as the second abundant species next to *M. natalensis*. This species usually favours savanna habitats at lower altitude.

A. cahirinus is a common rodent in sandy deserts and semidesert regions from sea leve to 1500 m asl (Sokolov *et al*., 1993). According to Kingdon (1997), *A. cahirinus* was known xto be primarily savannah species. During the present study, it was the third abundant species next to *A. dembeensis* and *M. natalensis* in the overall relative abundance. In shrub bushland, it was trapped in significant number next to *M. natalensis* and *A. dembeensis.* However, it was not observed in OSP during the wet season.

M. musculus was also trapped in all habitat types with few individuals except in riverine forest. This species usually occurs in urban and village areas, which consume and contaminate large quantities of human food and animal feed. According to Yalden *et al.* (1976), its distribution in Ethiopia is widespread. Taddsse Habtamu (2005) and Demeke Datiko (2006) reported the occurrence of *M. musculus* in lowland northwestern of Ethiopia and around Arbaminch area in wild habitats, respectively.

One of the endemic rodents of Ethiopia, *M. albipes* was trapped only in MSP area in all selected habitat types. It had the third position in both YSP and OSP next to *M. natalensis* and *A. dembeensis*. Afework Bekele and Corti (1997) revealed that its habitat varied from forest to scrubs in altitudes between 1500-3300m a.s.l. The present finding is in agreement with that of Serekebirhan Takele (2006) in Wonji sugarcane plantation as agricultural pest species. This species has been recorded from various parts of Ethiopia. Afework Bekele (1996a) indicated the species as the most widespread of the Ethiopian endemics.

Among the four species of *Tatera* in Ethiopia, *T. robusta* was recorded in the study area in all habitat types except in riverine forest habitat. It was the less distributed species in the study area. In the present study, it was recorded in more number in shrub bushland, grassland and old sugar cane habitats. This species mostly occurred in the altitudinal ranges of 200-1700 m asl (Yalden, 1988) such as central Ethiopia (Afework Bekele and Leirs, 1997) and Koka (Tilaye Wube, 1990), as well as in Arbaminch (Demeke Datiko *et al.,* 2007). The black rat, *R. rattus* was the least abundant and least distributed like *M. albipes* in the study area. This was in line with that of Serekebirhane Takele *et al*. (2011) in Wonji Sugarcane plantation.

In general, the low number of rodent species in the study area of ANP is unusual compared to species listed by Jacobs and Schloeder (1993). Several factors have been responsible in varying degrees for these changes which include encroachment and exploitation by the pastoralists and their livestock resulting in natural habitat degradation, exposing rodents to predators. Loss and fragmentation of natural habitats result in a change in the quality or quantity of available food which limits the distribution of rodents and their abundance. It is evident that forest species can survive in grasslands, but grassland species can rarely survive in forest. This ecological difference is important because, in the event of forest contraction or disappearance, forest species and individuals may survive in grassland, but the total disappearance of grassland (encroachment of *Acacia* species as observed in the ANP) would result in the local extinction of the grassland species. Happold and Happold (1987) revealed that the change from natural forest to plantation caused decline in both total numbers of individuals and species number. The present study is compatible with the above conclusion. The decline in the number of rodent species could be the presence of less underground and absence of diversity in microhabitats.

Trap success varied among the different habitat types and growth stages of the sugarcane plant. The trap success was higher during the wet season than the dry season in both sites. During the wet season in ANP, RVF had the least trap success. This may be due to over flow of Awash River during the rainy season which limits the available habitat for rodents. The highest trap success was obtained from shrub bushland, followed by grassland during the wet season. This is mainly due to the adaptation of different rodents to different habitats with available food source as well as vegetation cover as shelter or protection. Vertical vegetation density affects the microclimate and also provides protection for rodents against predators. However, the trap success declined almost by half during the dry season. This was due to the effect of decline in cover and extensive over-grazing by livestock. This adversely affects the available quality habitat and exposes rodents to predators.

In MSP, the highest trap success was obtained in young sugarcane plants among the different growth stages of the cane. ISP had the least trap success. This was due to the absence of less ground cover in ISP, which can improve as the cane age increases. The trap success in OSP was less than in YSP despite its highest ground cover which gives maximum protection from predators. This probably is due to a closed canopy formation. The probable reason was that before harvesting commences, old sugarcane site was flooded and hence become unfavourable for rodents. As a result of these, less number of rodents was trapped compared to young sugarcane plantation. This conclusion was in line with the finding of Serekebrrhan Takele *et al*. (2011) in Wonji Sugarcane Plantation. The trap success was higher in nearby shrub bushland habitat than any growth stages of the cane. This was probably due to the presence of continuous ground cover and migration of rodents to this site during burning of old sugarcane during harvest. This also acts as refugia for many rodent species depending on seasonality changes.

The overall trap success in the present study area was 13.1% in ANP. The present trap success was low compared to the study by Taddesse Habtamu and Afework Bekele (2008) with trap success of 38.6% in Alatish National Park and Demeke Datiko *et al.* (2007) with trap success of 17.6% around Arbaminch area. However, the present trap success was high compared to other studies such as that of Manyingerew Shenkut *et al.* (2006) with 8.42% in Allelitu Woreda and Afework Bekele (1996b) with 9.1% in the Menagesha state forest. The present trap success was comparable to the trap success of 13.8% in Wonji sugarcane plantation (Serekebirhan Takele *et al.*, 2011).

In the present study, all age groups were represented in population of all rodent and insectivore species. However, there was significant difference in the numbers of subadult and adult between seasons and age groups. In most of the study periods, adults dominated the population structure. However, there was significant decline in number of adult individuals during the dry season. Happold and Happold (1991) also reported that during the dry season the young population increased while adult population decreased.

In general, the difference in age group in the present study area was mainly due to seasonal reproduction of most of the rodent species. However, the presence of all age groups indicates aseasonality in breeding. This was in line with the findings of Tadesse Habtamu and Afework Bekele (2008), who reported that in some species of rodents, all age groups appeared irrespective of the season.

Some species showed seasonal breeding and some reproduced throughout the study period. No pregnant females of *M. musculus*, *T. robusta* and *M. erythroleucus* were trapped during the dry season. This showed that breeding in these species was seasonal. However, pregnant females of *M. natalensis*, *A. cahirinus*, *M. albipes* and *R. rattus* were trapped in both seasons. Similarly, Grzimek (2003) has reported that *R. rattus* breed throughout the year if conditions allow. Happold (1974) and Perrin *et al*.

(1992) reported that pregnant females of *M. albipes* and *M. natalensis* were trapped during both seasons.

During the study period, the population of most rodent species declined during the dry season. They showed seasonal fluctuation. Among different trapping sessions, the first trapping period of wet season had the highest rodent population while the last trapping session of the dry season had the least rodent population. This was in line with the findings of Serekebirhan Takele *et al*. (2011) at Wonji sugarcane plantation. The causes of population fluctuation of rodents are variable. Different investigators noted that food quality and abundance, vegetation cover, climate, and predation have great role for the occurrence of high population of rodents during the wet season.

During the present study, the population fluctuations observed between seasons may be mostly attributed to variation in line with reproductive patterns and related factors (food and better ground cover). Rainfall facilitates the growth of ground vegetation, which further provides suitable habitats and food. This has a strong impact in the breeding of many rodent species.

During the dry season, besides the less availability of rainfall, there were two major reasons for the decline of population of rodents in sugarcane plantation. Before harvest of OSP, it was highly watered which might cause migration of rodent population to the adjacent cane fields. This is why relatively less damage was observed in later trapping session in OSP. Secondly, in the last trapping session no rodent species were trapped since OSP was already harvested leaving fallow land.

In agricultural areas, rodent damage is rarely uniform in time, but follows crop phenology. Rodents cause more damage at some stages in the growth of rice than others (Leirs, 2003). Oguge (1995) and Workneh Gebresilassie *et al*. (2004) have revealed that the presence of more rodents in farmlands is associated with reproductive phase of crops. In the present study area of sugarcane plantations, rodents and insectivores were the major pest species. The extent of their damage varied with seasons and ages of the cane. Maximum damaged stalks of the cane per grid was observed in OSP during the wet season, followed by YSP during dry season. This is because of the breeding season for most rodent species. The present result is in line with the findings of Leirs (2003), who stated that high rodent damage in agricultural fields is attained during the breeding season of the rodent species.

There was clear indication that rodent damage increased with the ages of the cane. There was less damage in early stage of ISP but the damage increased with age of the cane. This is in agreement with Greaves (1982), who reported that the levels of rodent damage in agricultural fields were more intense when the crop was approaching the harvest stage. This was because as the age of the cane increases, it provides more suitable habitat and ground covers for rodents to avoid predation.

In the present study area, common pest rodents of the sugarcane were *M. natalensis*, *M. albipes*, *R. rattus* and *M. musculus*. Other rodent species such as *A. dembeensis* and *M. erythroleucus* were also recordred as pests. *A. cahirinus* and *T. robusta* had also contributed for the damage of the sugarcane plantation. This was also shown by Serekebirhan Takele *et al.* (2008) in Wonji Sugarcane Plantation. The multimammate rats (*M. natalensis*) and *A. dembeensis* were recorded as the most noxious murid pests in Easter Africa (Fiedler, 1994; Leirs *et al.,* 1996). Similaly, Afework Bekele *et al*. (2003) reported that *Mastomys* and *Arvicanthis* were major pests, while *Tatera* sp. and *Mus* sp. were minor pest in Ziway Maize farm, Ethiopia.

Porcupine (*Hystrix cristata*) was rarely observed in the plantations. However, local people reported that they are pest of vegetables and legumes in the area. The presence of their quil in the plantation indirectly indicates that they probably use the plantation for hiding and escaping from villages. During burning of the cane for harvest, it was common practice to find dead porcupine in burned cane field.

Larger mammals such as hippopotamus, warthog and *Anubis* and *Vervet* monkeys were also seen in the plantation. Warthogs cause great damage on sugarcane in the study area. Besides their damage by direct feeding, they also destroy large number of stalks when they move through the plantation and as well as when they burrow their hiding hole. To minimize the damage caused by warthog, the MSP authorities pay 20 Ethiopian Birr and 10 Ethiopian Birr per female and male warthog killed in the sugarcane field by cane guards. As reported by the Foreman in 2005, 120 warthogs had been killed in Abadir Camp site and 160 warthogs in north site west of ANP. Hippopotamus usually attack plantations along the border of Awash River.

Sugarcane stalks damaged by rodent species are easily distinguished from those damaged by large mammals. Rodent damage is identified by open holes at lower internodes and small chips on the ground as left over. In some cases, the damaged stalks fall on the ground providing additional advantage for rodents as a shelter. Warthog chew the lower part of the stalk and young leaves of the cane. In most cases, ISP is the most frequently damaged by warthogs because of its palatability. Monkeys cut the standing cane, carry and immediately climb on tree to eat. They usually consume the younger canes or upper nodes of the cane, which are not hard to cut.

The present study at MSP shows that a close relationship exists between the age of the cane and the population dynamics of the rodents in the plantation. The damage caused by rodent species increases with the age of the cane.

In general, damage caused by rodents in plantation sites was 4.38%. This is in agreement with the report of 4% by Serekebirhan Takele *et al.* (2008) from Wonji sugarcane plantations and comparable with that of 2-5% by Stensteth *et al.* (2003) from Australian sugarcane plantation. However, this was less as compared to Hawaii (40%), South America (12-20%) and Andhra Pradash (20.7%) sugarcane fields (Stensteth *et al.* 2003). This may be due to the irrigation systems that overflood the furrow in the cane plantation which discourage permanent habitat site for the rodents. This is why as the age of the cane increase rodent pests damages increases as they can easily make their nests on the canes that form a closed canopy and avoid flooding. This shows that rodent distribution is determined by microhabitats rather than macrohabitats.

Chapter 5

5. Conclusion and recommendations

The data collected during the present study provided information on the species composition, habitat association and abundance of the rodent and insectivore species in both ANP and MSP areas. The distribution and abundance as well as habitats of rodents are mainly governed by numerous environmental factors such as rainfall, vegetation type and cover, food and water supply, temperature, soil type and predators. In general, the effect of habitat fragmentation by pastoralists and their livestock are the main factors that contribute to low species richness and abundance of rodents in the area.

Variation in the abundance of rodents and insectivores in different growth stages of sugarcane shows the role of ground vegetation and furrow irrigation in the sugarcane plantation. The abundance of rodents in YSP was higher than the OSP. The low abundance in OSP was probably due to flooding and burning of cane before harvesting which resulted in lower abundance compared to YSP.

In the present study, the abundance of rodents was correlated with rainy season (wet season) in both the study areas. In MSP, the highest rodent abundance was recorded in SBL followed by YSP and OSP during the wet season. Rodent abundance was the least in ISP during the wet season than during the dry season and it is correlated with the age of the cane. As the age of the cane increased, there was increase in good ground covers which attract rodents as suitable habitat and protect them from predators. Their direct and indirect damage could be high through years unless control measures are taken as soon as possible.

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

- Clearing adjacent habitat around the sugarcane plantation in order to reduce the effect of migration of rodents from adjacent area to the plantation.

- Rodents in fruit plantations adjacent to sugarcane provide permanent refugia for rodents and should be kept clear of weeds and needs further investigation for designing appropriate control measures.
- There should be effective weed and grass growth control programms in the plantation from time to time.
- Awareness creation for local people on the significance of conservation area is important
- Local people should keep their livestock away from the conservation area to prevent habitat loss.
- There is need for an integrated approach by Federal and Regional governments with respect to habitat management in wild fauna and rodent population control programs in farm lands.

Chapter 6

6. REFERENCES

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Declaration

I, the undersigned, declare that thesis is my original work and that all sources of materials used for the thesis have been correctly acknowledged.

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