The Distribution and Abundance of Rodents in Alleltu Woreda, Oromia Region, Ethiopia.

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By

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Abstract

The study on the distribution and abundance of rodents was carried out inside and outside agricultural areas at Alleltu peasant association from Oct. 2002 to April, 2003. The study was conducted in three live trapping grids inside the wheat, bean and lentil field in agricultural areas. A survey study was also conducted in different habitats outside the cultivated fields using live and snap traps. During the whole study period, a total of 260 and 61 captures of rodents were made inside and outside the cultivated fields respectively, by Capture Mark Recapture (CMR) method. A total of 321 specimens were trapped from 3762 trap nights. The rodent species were: *Mastomys natalensis, Mus mahomet and Arvicanthis abyssinicus.*

Population size estimate on the live trapping grids was made using minimum number of animals (MNA) method as the numbers of recaptures were very few to use the Stochastic Jolly- Seber model. Population size fluctuated in the different stages of crops. It reached its peak when the crops were maturing and declined after harvest. Outside the cultivated field, the snap trapping resulted in zero capture while the live trapping showed an increase in the number of rodents from March to April.

Biomass varied in response to fluctuation of population size and differences in abundance of each species in the three grids.

Most of the distribution and abundance of rodents showed significant temporal variation. The spatial variation of rodents showed that *M. natalensis* was the dominant species in the cultivated fields. But, A. *abyssinicus* was revealed to be in a relatively higher number outside the cultivated field around the bushes.

1. Introduction

Rodents form a diverse group of mammals, ranging from the tiny pygmy mice (*Mus minutoides)*, which weighs about 5g to the big capybaras *(Hydrochaeris hydrochaeris*), which may exceed 50 kg; from the arboreal flying squirrel (*Callosciurus erythraeus*) to the subterranean mole rat (*Myospalax fontanieri*) and from the opportunistic and widely distributed Norwegian rats, *Rattus norvegicus* to specialist feeders such as, the North African fat sand rats, that feed on a single family of plants only (Buckle and Smith, 1994). The majority of the rodents are seedeaters, but some are insect eaters and versatile omnivores. It is therefore no surprise that some species thrive well under the conditions that are found in agricultural fields (Leirs, 2003).

There are about 2000 species of rodents in 35 families that include 389 genera. A further 12 families and 300 genera are also known only from fossils. Their principal unifying feature is the possession of one pair of incisors above and below and the use of these incisors for gnawing (Leirs, 2003). Only a limited number of them are known as agricultural pests. In Africa, for example, out of the 406 species belonging to 11 families only 77 species have been reported to cause damage to agriculture (Wilson and Reeder, 1993) and most of the harmful rodents are members of the family Muridae. Out of the 77 African rodent species, 12 species are recognized as the most notorious rodent pests in east Africa (Fiedler, 1994).

In Africa south of Sahara, the major rodent species causing severe damage to crops belong to the genus *Mastomys* and the commonest and by far the most serious rodent pest in East Africa is *Mastomys natalensis* (Fiedler, 1988, 1994). Certain characteristics of *Mastomys natalensis* such as high reproductive capacity and dispersal are thought to contribute to its success as a serious pest (Leirs et al., 1993).

11 of the 84 rodent species in Ethiopia are major agricultural pests. *Arvicanthis* sp. *and Mastomys* sp. are the major pests of maize, bean and tomato plantation (Afework Bekele and Leirs, 2003). Both species have a wide distribution in many parts of Ethiopia (Afework Bekele et al., 1993) and are commonly found in agricultural fields.

Agricultural fields are fairly homogenous landscapes, with the vegetation dominated by one or two crop species. The crop species grown are selected with reference to high productivity. Farmers attempt to increase soil fertility and water availability for further enhanced productivity. As a result, agricultural fields make energy rich food available for the rodent pests. Most agricultural crops, however, are harvested within 4-6 months. Hence, the availability of food and cover in the fields change drastically over the seasons. These changes are linked with seasonal changes in light, temperature and precipitation, which can be fairly predicted in advance. Similar changes also occur in natural conditions, and many species of rodents have developed methods to use environmental clues for predicting seasonal changes (Boyce, 1979). Rodent species that can take advantage of the temporarily abundant food and at the same time overcome adverse environmental conditions when food is in short supply are the agricultural pests. They are common in fields with cereal crops, which constitute the largest part of the total area used for agriculture in the world (FAO, 2002). Although agricultural fields are very productive habitats and are largely practiced in almost all nations, several nations like Ethiopia are yet to reach self-sufficiency in food production. In such poor nations, over 30% of the produced food may also be lost to pests (Afework Bekele and Leirs, 1997).

Rodent pest species are often thought to have a number of common features, such as a high fecundity followed by adaptation to survive in a variety of habitats. The ''pest'' status of a species is a combination of its own biology and the nature of the agro ecosystem in which it occurs (Leirs, 2003).

Regular cyclic populations of rodents seem to be rare in agricultural crops. This may be due to the fact that feedback mechanisms in trophic interactions, a common explanation for cyclic population dynamics (Stenseth, 1999), is rare in agricultural fields. Plant-herbivore interactions, where plant quantity and quality vary between years as a result of herbivory, may not be important in annually planted crops. Predator-prey interactions are rare because predators are actively hunted in many agro ecosystems, as they are considered pests themselves. Social regulation, an alternative explanation for cyclic population dynamics (Krebs, 1996), is unlikely in agricultural fields due to the instability of the environment caused by frequent disturbances such as ploughing, weeding or harvesting.

It is generally accepted that the population dynamics of rodent pests in agriculture can show at least three different basic patterns. Populations may be relatively stable or irregularly fluctuating, as in *Rattus tiomanicus* in oil palms; they may show strong seasonal fluctuations combined with interannual differences, as in the African multimammate mouse, *Mastomys natalensis*, in maize fields; or they may be eruptive with irregular peak years alternated with periods when there are lower number of mice, as in *Mus domesticus* in Australia (Leirs, 2003).

Different patterns of population dynamics are the results of differences in life history and interactions with the environment. The African multimammate mouse shows a strict breeding seasonality, closely linked to rainfall periods, probably through the stimulating effect of germinating grasses (Leirs et al., 1994). This induces maturation of sub adult females, which then can produce a large number of young in a short period due to the high litter size (up to 24 young, with an average of around 11). The young, however, do not start reproducing until the next wet season, and in the mean time there is no reproduction while survival is low (Leirs et al., 1993). Favorable conditions of food and cover lead to high population numbers that escape the normal density dependent regulation and lead to population eruption (Pech et al., 1999).

Pest species tend to be r-selected. The majority of rodent pests are small and extremely fertile. Many species become sexually mature at 2 to 3 months of age and the females produce litters of six or seven young after a short gestation period of 2-3 weeks. The females are usually capable of post partum estrus; i.e., they become pregnant immediately after giving birth and so another litter is produced as soon as the previous one is weaned. Obviously, this maximizes the reproductive success, but only under favorable conditions. It is the longevity of these conditions that determines whether logistic or irruptive population growth occurs. The majority of rodent pests, especially the *Muridae* are polygnous or promiscuous (Buckle and Smith, 1994).

Rodents with a stable pattern of population size are kept within restricted limits by density-dependent mechanisms. In those species with a clear seasonal pattern of reproduction, density-independent environmental mechanisms cause the observed regular patterns. The objective of rodent management is to keep their populations at lower levels. Such a strategy seems irrelevant in eruptive species, where population size is usually low. In the case of such species, population management will focus on avoiding the build up eruptions, or at least the initiation of control early in the build up phase. However, some species have relatively high population size and consequently cause considerable damage to agriculture. They also show irregular population outbreaks (Leirs et al., 1996).

Diet is another aspect in which rodents show considerable diversity. Many rodent pests are opportunistic omnivores. They can live on a variety of foodstuffs (green plant materials, seeds, fruits and insects), and thus survive in a variety of crops. They also take advantage of a single food item. For example, grain seeds those become available in large amounts as in multimammate mice in Africa (Leirs et al., 1994), or house mice in Australia (Bomford, 1987). However, this is not a general feature. The rice field rat, *Rattus argentiventer*, shows more specialized dietary requirements and thrives only in grasslands such as rice fields (Singletone and Petch, 1994). Mole rats are specialized on roots and tubers and cause major problems in cassava fields (Sidorowicz, 1974). Some rodent species are sensitive to changes in crops in the field and changes in land use pattern and field management, while others are only marginally affected by such changes (Tristiani and Murakami, 1998).

Rodent damage is rarely uniform in time, but follows crop phenology. Rice field rats cause more damage at some stages during the growth of rice than during other stages (Tristiani and Murakami, 1998). Multimammate mice dig up planted maize seeds but are harmless during the growth of maize plants until the cobs start ripening (Makundi et al., 1999). The wood mouse, *Apodemus sylvaticus*, is a threat to sugar beet fields only for the two weeks after they have been sown (Peltz, 1989). In perennial crops such as coconut or cocoa, rodent damage is more continuous, but may vary to coincide with fruiting (Wiliams, 1985).

Changes in phenology of the crop may exacerbate rodent damage. When irrigation is not synchronized over a large area, adjacent fields will have crops of different ages and rats may move between fields to benefit from the optimal crop stages during a prolonged period.

Moreover, fields are not isolated entities from which rodents can be excluded. The fields may be interspersed with different vegetation types, and even when they are large, they are associated with structural variation around hedges, fence lines, roads, irrigation canals, and wind shelters. Such elements increase not only the attractiveness but also the accessibility of the fields for rodents, as they may serve as refugee or dispersal corridors (Brown et al., 2001).

The problem of rodent damage in agriculture is complex because any crop can be the target of rodent attack (Fiedler, 1988). Dramatic rodent out breaks have been reported in many countries, where intensive and extensive cultivation of agricultural crops is undertaken (Singleton and Redhead, 1990). Such out-breaks, particularly in cereals, such as rice, maize, wheat and barley, have caused serious losses and wide-spread food shortages (Walker, 1990).

Rodent pests represent a significant constraint in agricultural production in many agro-eco-systems (Meenhan, 1984). Globally, estimates of pre-harvest losses to rodents typically fall between 5-15% in rice, wheat and maize production systems, with more extreme, episodic losses in systems that experience irruptive rodent outbreaks, driven either by climatic fluctuations or by pulsed environmental variations (Douganboupha et al., 2003). In many areas, the scale of crop losses to rodents is said to have increased in recent decades. This is sometimes attributed to the intensification within the crop production system. In some cases, it is also linked to changes in market systems (Kenney, et al., 2003).

Habitat use of rodents may be linked to patterns of land-use (Twigg and Kay, 1994; Leirs et al., 1997). Seasonal changes in food supply may cause movements of animals between refuge habitats and impact habitats (crops) (Hansson, 1977).

Unlike insects, rodents are secretive and may not be easily observed. Many of them are nocturnal. Often, the investigator must rely on various signs such as tooth marks, missing plant parts and characteristics of the damage and burrows to identify rodent species (Fiedler, 1988). To assess rodent damage, a larger area must be investigated than is the case with insects. This is because rodents are more mobile, far from homogeneously distributed in the crop, and a single individual typically can cause damage to several plants in one night (Fiedler, 1988).

Knowledge of the spatial activity of rodent pests is vital in developing appropriate management strategies because control measures should be adopted during key times in the source (refuge) habitats, where high numbers of the pest species are found (Stenseth, 1977; Singleton, 1989; Twigg and Kay, 1994).

For decisions to be made about rodent control in any cropping system, the density and population fluctuation of them must be estimated. However, little is known about rodent density-crop loss relationship functions all over the world, and particularly in Africa (Leirs, 2003). Rodents have received relatively little attention in Africa as vertebrate pests (Fiedler, 1994; Afework Bekele and Leirs, 1997). Their capacity for crop depredation and as agents of transmission of diseases is known to be high in the tropical African habitats and hence need special attention as an applied aspect of rodent ecology.

In Ethiopia, comprehensive studies on the effects of rodent damage to agricultural crops are lacking. However, Afework Bekele and Leirs (2003) have presented the preliminary data about the rodent species, population composition and the damage they may cause in maize plantations in central Ethiopia. More importantly, we often do not have information on the diversity and distribution of rodent pests in an agricultural field where rodent pests are known to cause crop damage.

The present study aims at finding out the diversity as well as spatial and temporal distribution patterns and relative abundance of rodent pests along different crops, in Mikawa peasant Association, Central Ethiopia, where crop damage due to rodent pests has been reported to the plant protection department of the ministry of agriculture in Addis Ababa and control measure of rodenticides were applied on it before two years.

2. OBJECTIVES

2.1 General objective

The general objective of the present study was to find the current diversity, distribution and abundance of rodents in the cultivated and outside cultivated fields of Mikawa peasant association in Alleltu, Oromia region.

2.2 Specific objectives

- To understand the diversity, abundance and distribution of rodent pests in wheat, bean and lentil fields.
- To understand the temporal and spatial distribution of rodent pests in wheat, bean and lentil fields.
- To identify potential factors that affects the temporal and spatial distribution of rodent pests in the study area.
- To study the distribution of rodents with in the study area compound.

3. The Study Area

3.1. General Location and topography

The present investigation was carried out in a school compound belonging to the Ethiopian Children Fund, which is located at $9^0 11'$ N and 39^0 08' E, in Mikawa Peasant Association, Allelitu Woreda, Fiche zone of the Oromia region, approximately 55 km North West of the city of Addis Ababa on the Dessie road. The altitude of the study area is about 2645 m.a.s.l. The total area of the school compound in which the study was conducted is about 18 hectares and the area of the farmland, which is considered, as the main study site is 6.35 hectares. It has a relatively flat topography.

3.2. Specific location

The study was conducted in wheat, bean and lentil fields inside the Ethiopian Children Fund school compound. The major land cover and land use feature of the school compound includes offices and classrooms, agricultural crop field, grain stone, eucalyptus plantation, grass land, rock piles, all weather roads, play ground (foot ball fields) (Fig. 1).

The school compound lies to the right on the road to Dessie and fenced on all its sides. The farmland is situated on the southern side of the compound covering the area starting at the main gate to the southeastern end of the compound. Towards the eastern side of the compound: offices, classrooms, kitchens and stores are found some 100 and 200m. away from the farmland. There are also places close to the classrooms and kitchen where there are rock piles and meadows where one finds burrows of rodents. Just behind the offices and classrooms, there are different rock piles and a space covering most of the areas beside the rock piles. In front of this, there is a football ground. The area on the northern side of the compound is covered mainly by eucalyptus trees and a little vegetable garden. The main gate is found adjacent to the main road and the southern side of the fence is bounded by another farmland. The northern side of the fence is close to the river called Mikawa (named after the woreda) that flows towards 'Kesem' river. The eastern side of the fence is adjacent to the roadside, on the other side of which is found a farmland.

The wheat field is situated at the southeastern end of the compound close to some rock piles and burrows.

The bean field is found adjacent to the main asphalt road, another farmland in the southern side of the field and close to the main gate, very far from the rock piles and stores.

The lentil field is found some 200m. away from bean field but adjacent to wheat field at the eastern side of the compound.

Planting in the study area is usually done in July, August, and September and harvested in November, January and February. The major crop types sown during the study period were wheat, bean, teff and lentil. During the study period, a total of three grids were established in the wheat, bean and lentil fields. The wheat was sown in August, 2002 and harvested in January 2003. The bean was sown in July 2002 and harvested in November, while the lentil was sown in September 2002 and harvested in February 2003.

3.3. Climate

The nearest weather station for the study area is that of Allelitu, located about 1km. north of the study area. This station, however, did not record data on temperature. A look at the last 10 years annual precipitation data (Fig. 2) shows that the mean annual rainfall for the study area is 1088.54mm. The mean monthly rainfall data (Fig. 3) for the last 10 years also shows that the study area gets low rainfall between March and April and high rainfall between July and September. The rainfall data recorded during the study period shows that the monthly rainfall was similar to the mean monthly rainfall (Fig. 4) of the period from 1993- 2002.

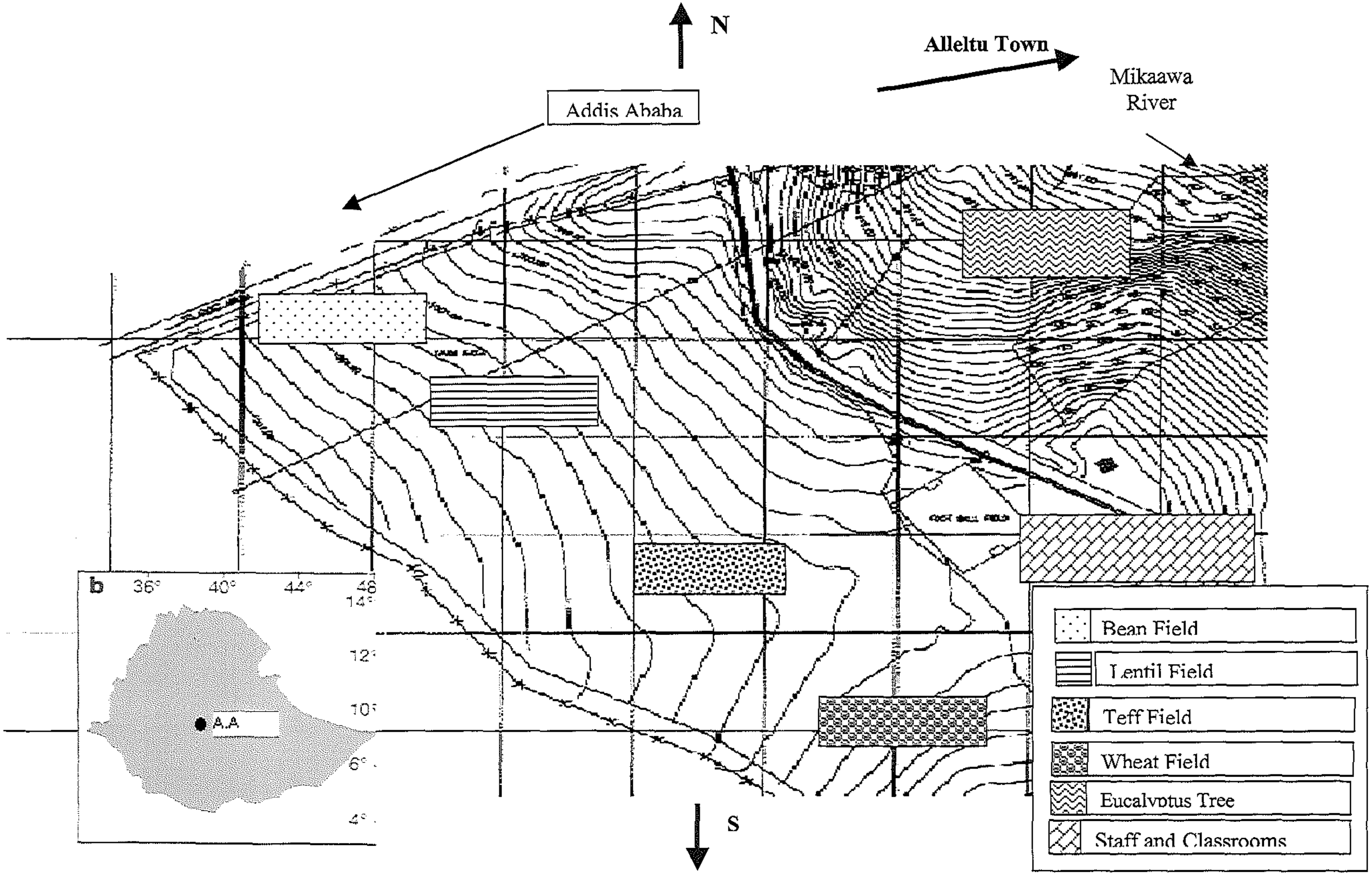

Fig. 1Map of the study area

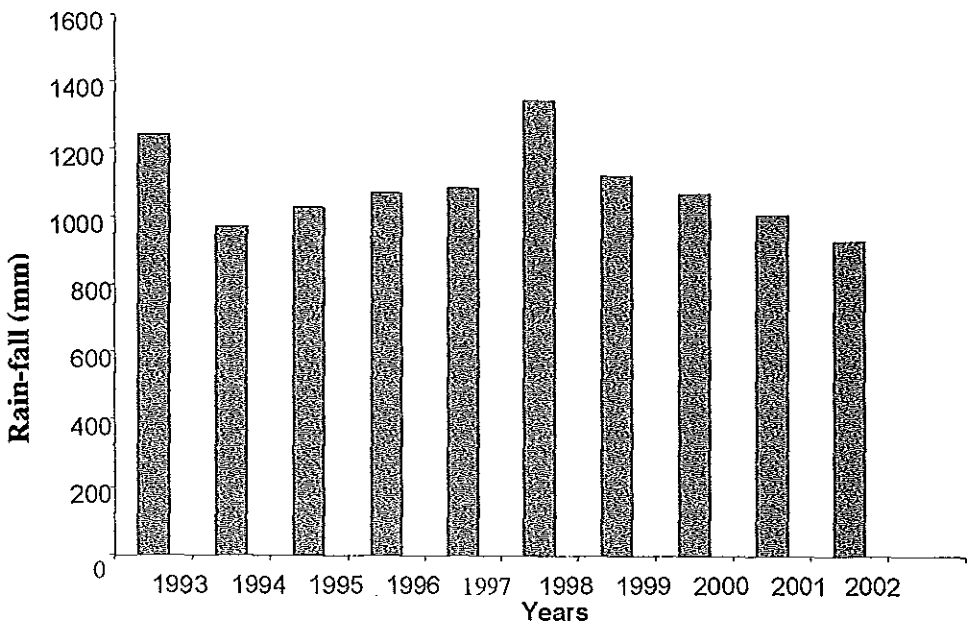

Fig. 2 Annual precipitation in the study area from 1993-2002

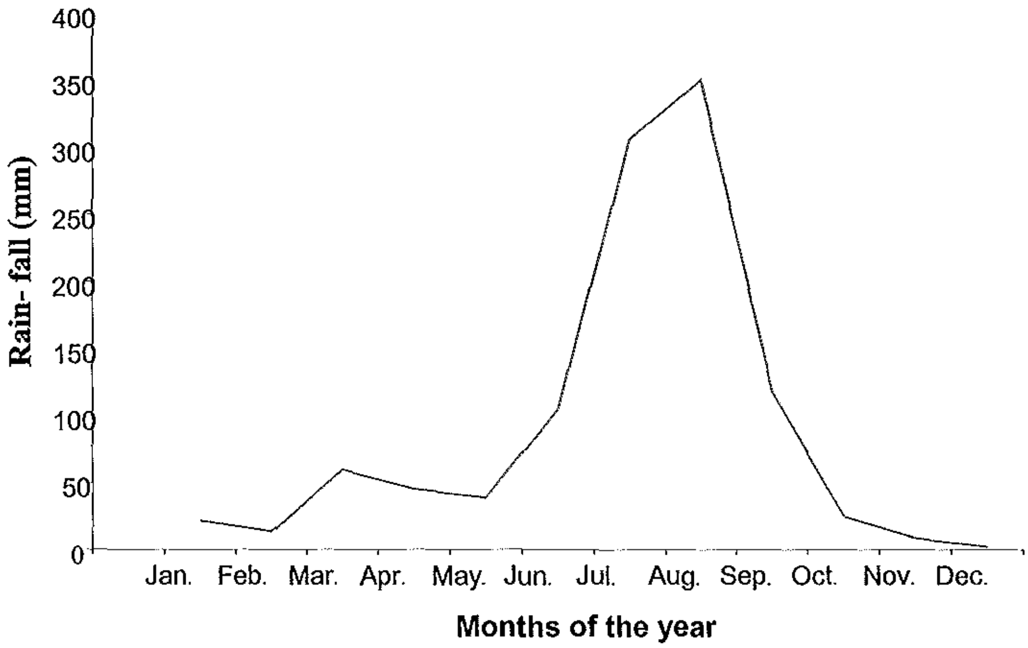

Fig. 3 Mean monthly rainfall for ten consecutive years, from 1993 to 2002

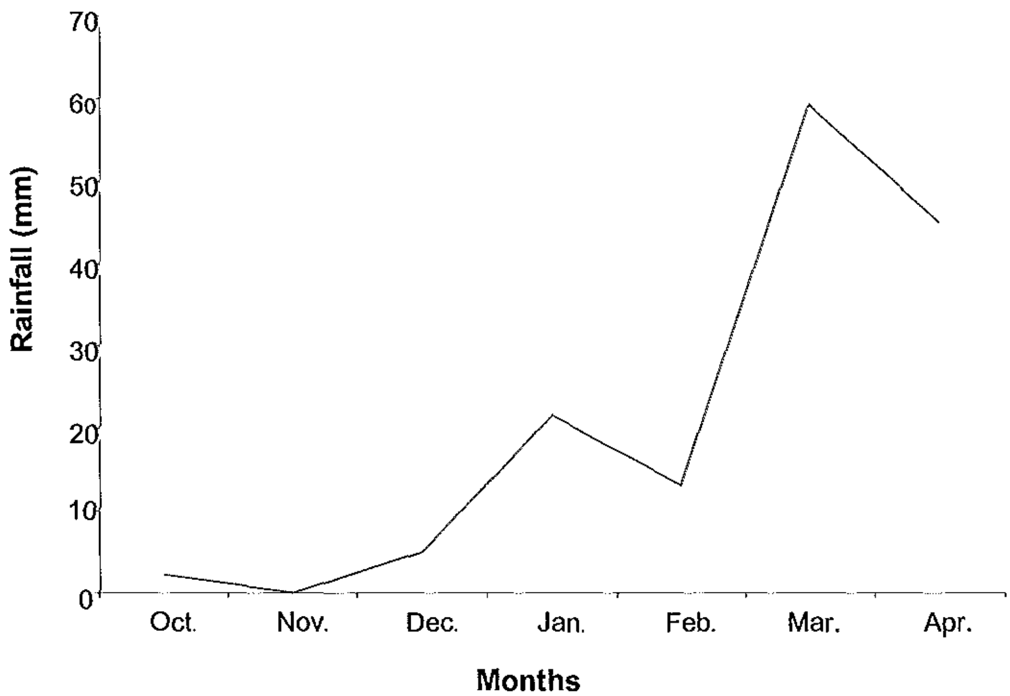

Fig. 4 Monthly rainfall during the study period (October 2002 to April 2003)

4. Materials and Methods

Live-trapping grids

Three 60m. x 60m. live trapping grids were established for CMR (Capture Mark Recapture) study: one in wheat, one in bean and one in lentil fields. Each of the grids consisted of seven lines, 10m. apart, with a trap station at every 10m. Each trap station was identified by coordinates; A to G and 1 to 7 (Fig. 5).

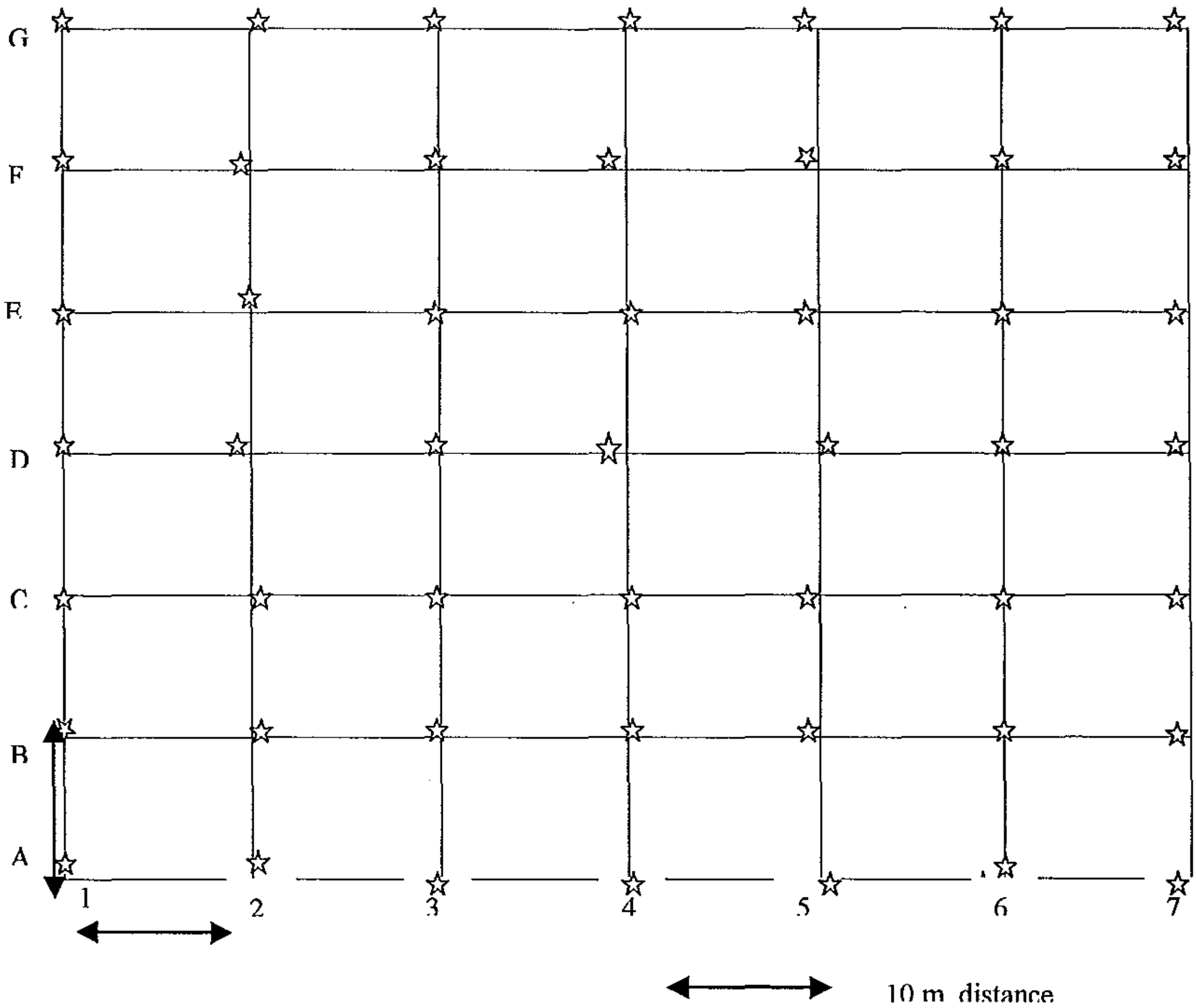

Figure 5. Schematic representation of a CMR grid at Allelitu.

- Key
  - ☆ Trap Stations

A total of 49 aluminum Sherman traps of size 7.6x 8.9x 22.9 cm. were used in each grid. The traps were set at equal distance as shown in Figure 5. The total area of one grid was thus 0.36ha.

The site of each grid was selected on the basis of the following factors: 1. The extent of the area to accommodate the proposed number of traps. 2. Each grid was established in different crops (wheat, bean and lentil) so as to reveal the spatial distribution of rodents in different crops. 3. The distance between different crops where the grids were established were considered to give a common edge effect.

Trapping was conducted for three consecutive days at intervals of two weeks from October 2002 to April 2003 in the cultivated fields. For the first 10 trapping sessions, there were a total of 2940 trapping nights every two weeks. On the eleventh session, however, there were 147 trapping nights. The total number of trapping nights for the study period, therefore, was 3087, for the cultivated areas.

In all the three grids, trapping was made from the vegetative to the post harvest stage of the respective crops. Based on the differences in the longevity of these crops, trapping sessions varied from October 2002 to March 2003. In wheat grid the trapping started in the second week of October 2002 and ended in the first week of March 2003. There were 10 trapping sessions in this grid and the last two trapping sessions were during the post harvesting period, while the rest were during pre harvest sessions. In the bean grid, trapping started in the second week of Oct. 2002 and ended in the second week of Dec. 2002. There were only five trapping sessions in this grid and the last two sessions were during post harvesting period, while the rest were during pre harvest period. In the lentil grid, trapping started in the first week of Jan.

2003 and concluded in the second week of March 2003. There were six trapping sessions in this grid and the last two sessions were post harvesting sessions, the rest pre harvest sessions. Generally the first session in the cultivated area was started to be carried out in the second week of Oct. 2002 and the last session was carried out in the second week of March 2003.

Following the eleventh trapping session in the farm fields, 75 Sherman live traps were set at different habitat types (under rock piles, near burrows, under the eucalyptus tree, in the store and around class rooms) in the compound. This was carried out from March to April and these trapping are considered as the twelfth, thirteenth and fourteenth trapping sessions. A total of 675 trap nights were utilized for this survey.

The distribution and abundance of rodents in different habitats of the compound was also looked in parallel to that in the farm field. Under the rock piles, some 300m. away from wheat field located at the back side of the office, 12 snap traps were set on each day of trapping. Thus a total of 396 trap nights were used for snap trapping.

Traps were kept covered with hay and weeds mainly to avoid excess heat during the day and cold during nights. This was also found important in preventing people and animals from being attracted by shiny and glittering objects. Traps were also easily identified during trap checking since wooden pegs were erected at every 10m. distance, near the place where traps were set. The usual bait (peanut butter) was used during all trapping operations. Bait and hay replenishing was done when necessary.

Traps were set in the late afternoon (3:00- 4:00 p.m.) and left in the field for three consecutive days and nights. They were visited twice each day between early in the morning (6:00 – 8:00 a.m.) and late in the afternoon (4: 30 – 6:00 p.m.).

Handling of captured small mammals was done following Gurnell and Flowerdew (1990). Toe clipping (one toe per foot) was done to mark the individuals captured. A number was assigned to each toe. An individual mark consisted of a combination of clipped toes. No two animals on the same grid were given the same mark if they are the same species. The rodents were then released at the point of capture after recording information pertaining to species, date of capture, grid type, the coordinates of the trap station, the identification mark, body weight (to the nearest gram using Pesola spring balance), reproductive status and any other unusual or striking feature observed. Only the trap station and the code of the individual were recorded for recaptures within one trapping occasion.

Reproductive status of the captured rodents was determined using external genitalia and palpable embryos. In males, size of scrotum and position of testes were used to determine reproductive maturity or immaturity. Large visible scrotum and testes descended into scrotum proved sexual maturity. Females were checked for the onset of breeding, pregnancy and lactation. Size of mammary nipples was used as a clue for recent or current lactation. Enlarged abdomen and palpable embryos proved the stage of latter pregnancy.

Species identification was accomplished using distinguishing taxonomic characters listed in Yalden et al. (1976). This was also supplemented by making comparison with specimens available at the Zoological Natural History Museum of the Addis Ababa University and consulting experts at the Plant Protection Department of the Ministry of Agriculture, Federal Republic of Ethiopia.

The purpose of live trapping grids was to study the abundance, diversity and distribution of rodents. Population size estimates during each trapping session were carried out using the minimum number of animals known to be alive (MNA) method (Kreb, 1996). MNA method counts all animals whose presence is documented. This is done by adding the number of captured animals at time "t" to the number of animals that were not captured at time "t" but that had been captured before and even if they were not captured later.

The species diversity between the three grids was calculated using Shannon- Weinner diversity index. The Shannon- Weinner diversity index, H, is defined as follows:

$$H = -\sum_{i=1}^{n} p_i \ln p_i$$

where p_i is the proportion of individuals found in the i^{th} species and n is the number of species for a given grid.

Population densities of rodents were estimated for each trapping session by dividing the number of rodents alive per area of the grid.

Biomass was calculated after obtaining the mean weight of each species and applying these figures to the population estimates (MNA).

Concerning pre harvesting and post harvesting sessions, χ^2 test was used to interpret the temporal variation in all grids. The significance of spatial variation of captured species between different grids was also analyzed by χ^2 method.

5. Results

5.1. In the cultivated area

5.1.1. Species diversity

Three rodent species and two unidentified shrews were captured in the cultivated areas inside the three grids. The species were: *Mastomys natalensis, Mus mahomet, and Arvicanthis abyssinicus.*

Out of the three grids studied, the wheat and lentil grids showed the presence of all the three species of rodents while the bean grid had only two species (*Mastomys natalensis, M. Mahomet*). The bean grid had only two rodent species with in 5 sessions. Namely: *Mastomys natalensis* and *M. Mahomet* (Fig. 6). In addition to them, the shrews were also captured from this grid. The lentil grid constituted the three species with in 6 sessions. Namely: *Mastomys natalensis, M. mahomet, A. abyssinicus* (Fig. 7). The wheat grid constituted the three species within the 10 sessions (Fig. 8).

A total of 260 captures of 232 individuals of rodents were made in 3087 trap nights (Table 1). The total capture gave a trap success of 8.45%. *Mastomys natalensis* comprised the largest number (68.5%), followed by *M. mahomet* (25.4 %) and *A. abyssinicus* (6.4%) (Table 2).

Out of the three species, it was the *Mastomys natalensis* that comprised the largest number (65.4%), in the wheat field followed by *M. mahomet* and *A. abyssinicus* which constituted 27.2% and 7.4% respectively. The bean grid had *Mastomys natalensis* comprising 81.5% followed by *Mus mahomet* (18.5%). In the lentil grid also *Mastomys natalensis* was recorded with the highest capture (61.9%) followed by *M. mahomet* (28.6%) and *A. abyssinicus* (9.5%) (Table 2).

Differences in species diversity between wheat and lentil grids were low unlike the species diversity between bean and the other two grids (Wheat and lentil). Shannon-Weinner – diversity indices revealed diversity index of 0.82, 0.49 and 0.876 for wheat, bean and lentil grids, respectively.

Most of the rodents captured in the live trapping grids were captured only once. The trap success varied both between grids and trapping sessions. It was 10.9% in the wheat grid, 7.8% in the bean grid and 4.8% in the lentil grid. In all the three grids, the maximum trap success was immediately before the harvest and the minimum was during the first trapping session in the bean and wheat grid and during the second trapping session in the lentil grid. The maximum and the minimum trap successes in the wheat grid were 20.41 % and 0%, respectively. Whereas, these values were 23.13 % and 0%, in the bean grid and 10.88 % and 1.36 %, in the lentil grid.

Table1. Number of rodents captured on the live trapping grids in different trapping sessions. The numbers in the parentheses show the number of recaptures.

Session	Grid	*M. natalensis*	*Mus mahomet*	*A. abyssinicus*	Total
First	Wheat	0	0	0	0
	Bean	0	0	0	0
Second	Wheat	4	6	0	10
	Bean	6	8	0	14
Third	Wheat	4	6	4	14
	Bean	34	0	0	34
Fourth	Wheat	16 (2)	4 (2)	2	22(4)
	Bean	4 (2)	0	0	4(2)
Fifth	Wheat	2	2	0	4
	Bean	0	2	0	2
Sixth	Wheat	6	4	0	10
	Lentil	0	4	0	4
Seven	Wheat	23 (7)	7 (1)	0	30(8)
	Lentil	0	2	0	2
Eighth	Wheat	8 (2)	6	0	14(2)
	Lentil	14 (2)	2	0	16(2)
Ninth	Wheat	10 (2)	2 (2)	0	12(4)
	Lentil	8	0	2	10
Tenth	Wheat	16 (6)	0	4	20(6)
	Lentil	2	2	2	6
Eleventh	Lentil	2	2	0	4
Total new		159	59	14	232(28)
Total Capture		182	64	14	260

Table 2. Species composition and the respective number trapped from each grid. (figures in parentheses give percentage of the relative abundance of each species).

Species	Wheat	Bean	Lentil	Total
M. natalensis	89 (65.4)	44 (81.5)	26 (61.9)	159 (68.5)
M. mahomet	37 (27.2)	10 (18.5)	12 (28.6)	59 (25.4)
A. abyssinicus	10 (7.4)	0	4 (9.5)	14 (6.1)
Total	136	54	42	232

5.1.2. Estimates of Population size

The peak population size was recorded in all grids during the session immediately before harvest (Fig. 9). After harvest, the rodent population declined in all grids, except in the wheat grid where a relatively higher number of rodents were captured during post harvest stage (Table 3). There were no captures during the first session in the bean and wheat grids.

Table 3. Number of rodents known to be alive (MNA) during each session.

Species	Session										
	Grid	1	2	3	4	5	6	7	8	9	10	11
M. natalensis	Wheat	0	4	4	16	2	6	23	8	10	16	
	Bean	0	6	34	4	0						
	Lentil						0	0	14	8	2	2
A. abyssinicus	Wheat	0	0	4	2	0	0	0	0	0	4	
	Bean	0	0	0	0	0						
	Lentil						0	0	0	2	2	0
M. mahomet	Wheat	0	6	6	4	2	4	7	6	2	0	
	Bean	0	8	0	0	2						
	Lentil						4	2	2	0	2	2
Total		0	24	48	26	6	14	32	30	22	26	4
No. of species	Wheat	0	2	3	3	2	2	2	2	2	2	
	Bean	0	2	1	1	1						
	Lentil						1	1	2	2	3	2

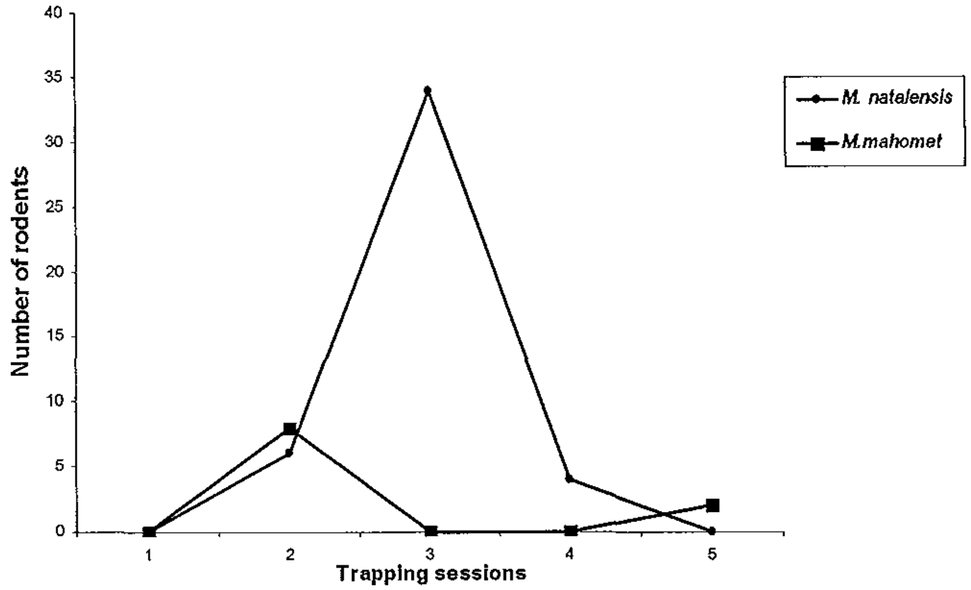

Fig. 6 Diversity and abundance of rodents in the bean grid

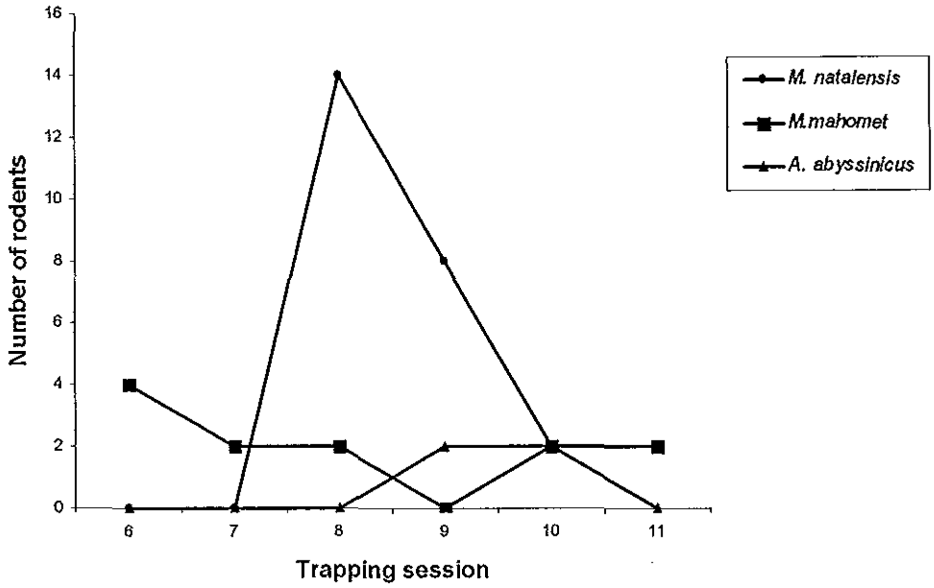

Fig. 7 Diversity and abundance of rodents in the lentil grid

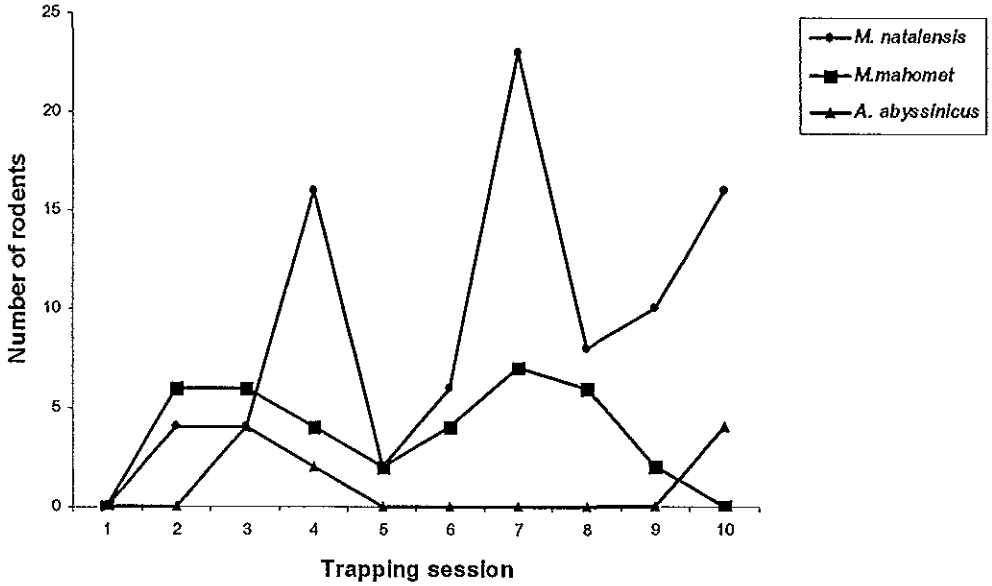

Fig. 8 Diversity and abundance of rodents in the wheat grid

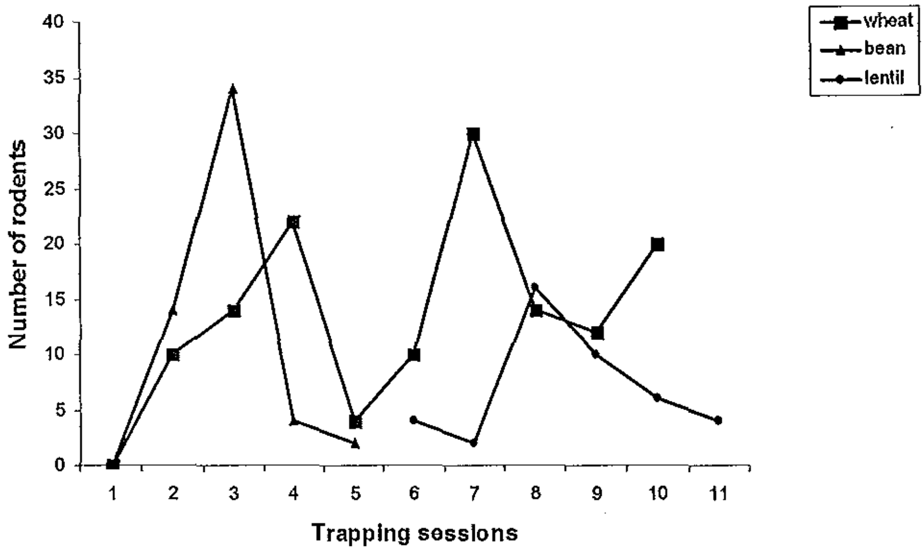

Fig. 9 Total number of rodents known to be alive (MNA) in all grids during the 11 trapping session

5.1.3. Density

Wheat grid

Density of *M. natalensis* ranged between 6/ha during the fifth session and 64/ha during the seventh session (Fig. 10). Density of *M. mahomet* ranged between 6/ha during the fifth session and 19/ha during the seventh session and it reached its peak density in this grid (Fig. 11). *A. abyssinicus* ranged between 6/ha during the fourth session and 11/ha in the third session (Table 4).

Bean grid

Density of *M. natalensis* ranged between 11/ha during the fourth session and 94/ha during the third session and it reached its peak density just before the harvest stage (Table 4). Density of *M. mahomet* ranged between 6/ha during the fifth session and 22/ha during the second session (Fig. 11).

Lentil grid

Density of *M. natalensis* ranged between 6/ha during the tenth and eleventh session and 39/ha during the eighth session. Density of *M. mahomet* ranged between 6/ha during all sessions where it was recorded except the third session which was11/ha. Density of *A. abyssinicus* remained the same in the two sessions where they were observed (Table 4).

Table 4. Density (per ha.) of *M. natalensis, M. mahomet* and *A. abyssinicus* in the wheat, bean and lentil grid.

Species	Grid	Trapping sessions										
		1	2	3	4	5	6	7	8	9	10	11
M. natalensis	Wheat	-	11	11	44	6	17	64	22	28	44	
	Bean	-	17	94	11	-						
	Lentil						-	-	39	22	6	6
M. mahomet	Wheat	-	17	17	11	6	11	19	17	6	-	
	Bean	-	22	-	-	6						
	Lentil						11	6	6	-	6	6
A. abyssinicus	Wheat	-	-	11	6	-	-	-	-	-	11	
	Bean	-	-	-	-	-					0	
	Lentil						-	-	-	6	6	-

Density of *M. natalensis* was higher in wheat grid. In contrast, *A. abyssinicus* had the lowest density in the lentil grid. Highest density was recorded in the wheat grid and the lowest density was recorded in the lentil grid (Table 5).

Table 5. Density of each and all species in each and all grids.

Grid	*M. natalensis*	*M. mahomet*	*A. abyssinicus*	Total
Wheat	247/ha	104/ha	28/ha	379/ha
Bean	122/ha	28/ha	0/ha	150/ha
Lentil	73/ha	35/ha	12/ha	120/ha
Total	442/ha	167/ha	40/ha	649/ha

Peak density occurred in the third session on the bean grid just before harvest. The lowest densities of rodents were recorded in the fifth and seventh sessions of bean and lentil grids respectively. The bean grid showed the highest density one session before harvest. Unlike the bean grid, the highest densities were observed in the wheat and lentil grids two sessions before harvest (Table 6).

Table 6. Rodent density in each grid during each trapping session

Session	Wheat	Bean	Lentil
1	---	---	---
2	28/ha	39/ha	---
3	39/ha	94/ha	---
4	61/ha	11/ha	---
5	12/ha	6/ha	---
6	28/ha	---	11/ha
7	83/ha	---	6/ha
8	39/ha	---	45/ha
9	34/ha	---	28/ha
10	55/ha	---	18/ha
11	---	---	12/ha

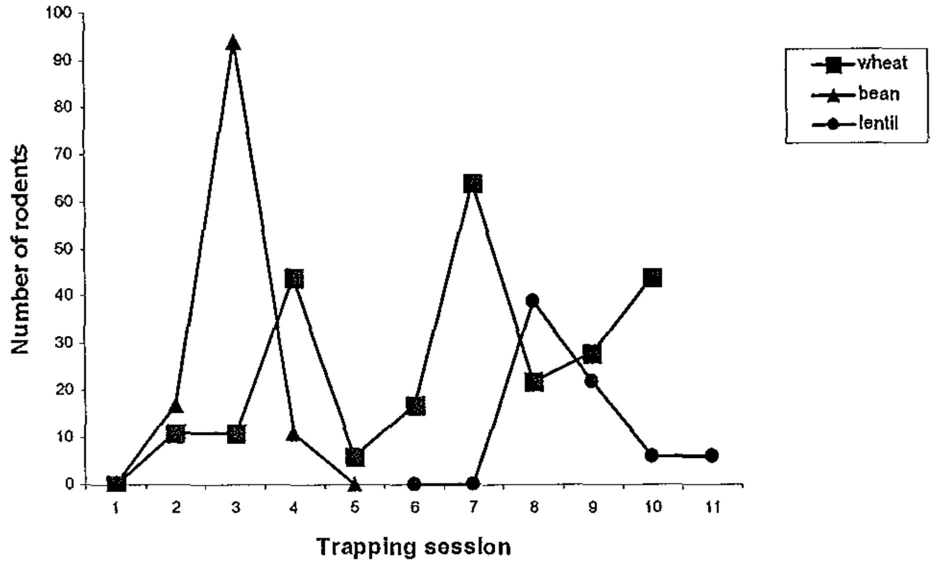

Fig. 10 Density of *M. natalensis* in the wheat, bean and lentil grid

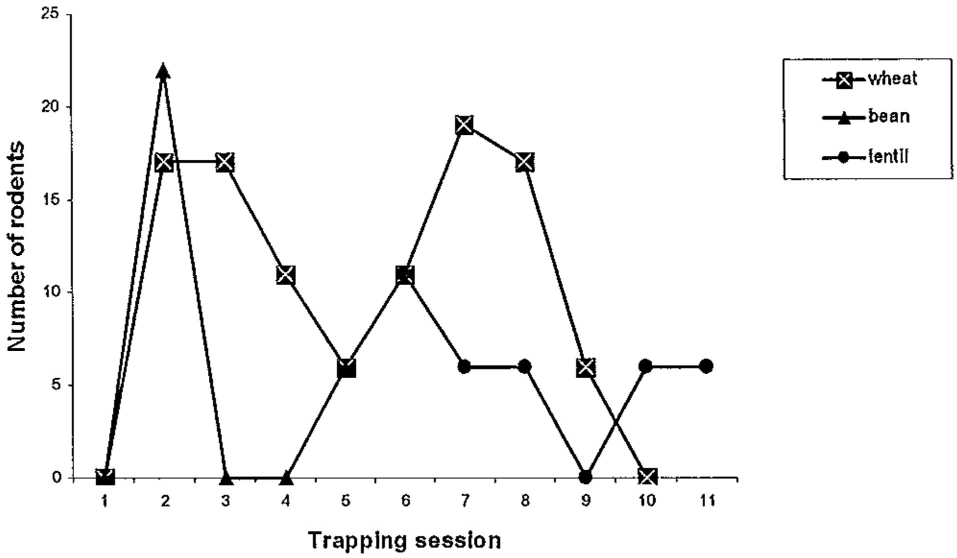

Fig. 11 Density of *Mus mahomet* in the wheat, bean and lentil grid

5.1.4. Male to female trap ratio

Out of the total 232 individual rodents captured, males comprised 150 (64.6%) and females 82 (35.4%). Males outnumber females in all the species for all grids except for *Mastomys natalensis* in lentil grid where the females outnumber the males (Table 7).

Table 7. The male to female trap ratio of rodents in all grids. The ratios are the number of males: females.

Species	Wheat	Bean	Lentil
M. natalensis	2:1	8:3	5:8
M. mahomet	5:4	10:0	2:1
A. abyssinicus	4:1	---	4:0
Total (All species)	11:6	18:3	11:9

5.1.5. Temporal variation

Wheat grid

The abundance of *M. natalensis* remained at the same level in the second and third sessions and increased in the fourth session. Its abundance decreased in the 5th and 6th session and then increased to reach the peak in the seventh session, during the pre harvest stage. During the post harvest stage, no immediate decline was observed, but there was variation in abundance between the 9th and 10th session. There was also similarity in abundance between the 4th session and the 10th session. The abundance of *M. mahomet* remained at the same level during the 2nd, 3rd, and 8th trapping sessions and similar abundance was also observed in the 4th and

6th sessions during preharvest stage. No individual was recorded in the 1st and 10th sessions. There was similarity in abundance in the 5th session and 9th session. *A. abyssinicus* was recorded only in the 3rd and 4th sessions during pre harvest stage and in the 10th sessions during postharvest stage and there was similarity in abundance between the 3rd session and the 10th session.

Bean grid

M. natalensis was recorded in the 2nd and 3rd sessions during the preharvest stage. The abundance was unequal in these two sessions (2nd and 3rd). None was recorded in the 5th session. *M. mahomet* was recorded only during the 2nd session of the three sessions in the pre harvest stage. During the postharvest stage, it was recorded only in the 5th session.

Lentil grid

M. natalensis was recorded only in two (8th and 9th sessions) of the four sessions during pre harvest stage and it was unequal in abundance. However, there was equal abundance in the 10th and 11th sessions during post harvest stage. *M. mahomet* showed similar abundance in the 7th and 8th sessions which showed unequal abundance with the 6th session. No individual was recorded in the 9th session during preharvest stage. However, both sessions (10th and 11th) showed equal abundance during post harvest stage. There was also similarity in abundance between the 7th and 8th sessions as well as in the 10th and 11th sessions. *A. abyssinicus* was recorded in only one (9th session) of the four sessions during the preharvest stage. It was also recorded in one (10th session) of the two sessions during postharvest stage. However, there was equal abundance in the two sessions (9th and 10th).

Table 8. Abundances of rodents captured in pre and postharvest sessions in the three grids.

Grid	Species	Pre-harvest session	Post-harvest session
Wheat	*M. natalensis*	63	26
	M. mahomet	35	2
	A. abyssinicus	6	4
Bean	*M. natalensis*	40	4
	M. mahomet	8	2
Lentil	*M. natalensis*	22	4
	M. mahomet	8	4
	A. abyssinicus	2	2
Total		184	48

5.1.6. Spatial variation

Substantial variation was observed in the abundance of rodents among the three grids (Table 9). The abundance of *M. natalensis* and *M.mahomet* differ significantly (χ^2 =39.74, df = 2 P < 0.001 and χ^2 =23.02, df=2, p<0.001 respectively) among the three grids. The small sample size of *A. abyssinicus* does not permit statistical test (Table 9).

The spatial variation of *M. natalensis* and *M. mahomet* in the wheat and bean grids were significantly different (χ^2 = 15.23, df =1, P < 0.001 and χ^2 = 15.51, df =1, P < 0.001, respectively). No significance test for *A. abyssinicus* (Table 9).

The spatial variation of *M. natalensis* and *M. mahomet* in the wheat and lentil grids were significantly different ($\chi^2 = 34.5$, df=1, p<0.001 and $\chi^2 = 12.75$, df=1, p<0.001 respectively). It was not significantly different for *A. abyssinicus* ($\chi^2 = 2.571$, df=1, p=0.109) (Table 9).

The spatial variation of *M. natalensis* and *M. mahomet* in the bean and lentil grids were not significantly different (χ^2 = 4.629, df =1, p=0.031 and χ^2 = 0.182, df =1, p=0.670 respectively). No significance test for *A. abyssinicus* (Table 9).

Table. 9 Abundance of rodent species in the three grids studied.

Species	Wheat	Bean	Lentil
M. natalensis	89	44	26
M. mahomet	37	10	12
A. abyssinicus	10	-	4

M. natalensis was not uniformly distributed in all the three grids through out the whole sessions (Table 10). It was not recorded during one of the ten sessions in the wheat grid; it was not recorded in two of the five sessions in the bean grid and in two of the six sessions in the lentil grid. *M. mahomet* was also not uniformly distributed in all the three grids (Table 10). It was not recorded in two of the ten sessions in the wheat grid, in three of the five sessions in the bean grid and in one of the six sessions in the lentil grid. *A. abyssinicus* as well not uniformly distributed in all the three grids (Table 10). It was not recorded in seven of the ten sessions in the wheat grid, and in four of the six sessions in the lentil grid. It was absent in the bean grid.

Table 10. Distribution of the three rodent species in the given session over the three grids in the farm fields. The number in the parentheses refers to the overall sessions in each grid.

	Species		
Grid	*M. natalensis*	*M. mahomet*	*A. abyssinicus*
Wheat	9(10)	8(10)	3(10)
Bean	3(5)	2(5)	0(5)
Lentil	4(6)	5(6)	2(6)

5.1.7. Biomass

M. natalensis constituted for the greater proportion of biomass in all the three grids (Table 11). It constituted 83.8% in the wheat grid. 94.5%, in the bean grid, and 80.8% of the captured rodents in the lentil grid.

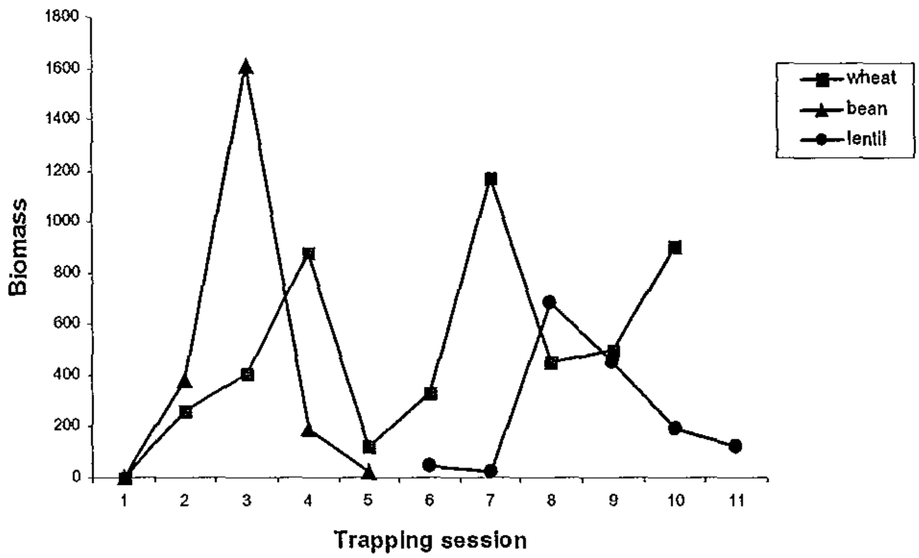

Fig. 12 The biomass of rodents in wheat, bean and lentil grids

Table11. Mean biomass (g) of each species trapped in each session. (Numbers in the parentheses are mean body weight).

Session	Grid	*M. natalensis* (47.24g)	*M. mahomet* (12.19g)	*A. abyssinicus* (36.36g)	Total
1	Wheat	----	-----	------	------
	Bean	-----	-----	----	------
2	Wheat	188.96	73.14	-----	262.1
	Bean	283.44	97.52	-----	380.96
3	Wheat	188.96	73.14	145.44	407.54
	Bean	1606.16	----	----	1606.16
4	Wheat	755.84	48.76	72.72	877.32
	Bean	188.96	----	----	188.96
5	Wheat	94.48	24.38	----	118.86
	Bean	----	24.38	----	24.38
6	Wheat	283.44	48.76	----	332.2
	Lentil	----	48.76	----	48.76
7	Wheat	1086.52	85.33	----	1171.85
	Lentil	----	24.38	----	24.38
8	Wheat	377.92	73.14	----	451.06
	Lentil	661.36	24.38	----	685.74
9	Wheat	472.4	24.38	----	496.78
	Lentil	377.92	----	72.72	450.64
10	Wheat	755.84	----	145.44	901.28
	Lentil	94.48	24.38	72.72	191.58
11	Lentil	94.48	24.38	----	118.86
Total	Wheat	4204.36	451.03	363.6	5018.99
	Bean	2078.56	121.9	----	2200.46
	Lentil	1228.24	146.28	145.44	1519.96

The rodent biomass varied between trapping sessions on each grid and between grids (Fig.12). In the wheat grid, the maximum biomass recorded was 1171.85g in the seventh session and the minimum was 261.1g in the second session. In the bean grid, the maximum was 1606.1g in the third session and the minimum was 24.38g in the fifth session. In the lentil grid, the maximum biomass was 685.74g in the third session and the minimum was 24.38g in the second session.

5.2. Survey outside the cultivated area

5.2.1 Species composition and abundance

From a survey conducted in different habitats, outside the cultivated area, a total of 61 captures of 56 individual rodents were made during 675 trap nights. This was accomplished during the 12^{th}, 13th, and 14^{th} sessions of trapping. The species that were captured were *Mastomys natalensis*, *M. mahomet* and *A. abyssinicus.* The highest numbers of individuals were recorded in the 14^{th} session and the lowest in the 12^{th} session. It was *A. abyssinicus* that comprised the largest number of captured individuals followed by *Mastomys natalensis* and *M. mahomet* (Table 12). The snap trapping sessions resulted in zero capture.

Table 12. Species composition, number of individual of each species from the 12th to 14th session. (Figures in the parentheses show the number of recaptures).

Species	12th session	13th session	14th session	Total
M. natalensis	5	2	14	21
M. mahomet	1	2	10(1)	13 (1)
A. abyssinicus	-	8(1)	14(3)	22 (4)
Total	6	12(1)	38(4)	56(5)

5.2.2. Spatial variation in the abundance of rodents

Three species were observed around the bush and class room habitats. These are: *M. natalensis, A. abyssinicus and M. mahomet.* Only *M. mahomet* was observed in the crevices (rock piles). There was no individual rodent species observed around the eucalyptus woodland habitat (Table 13).

The highest trap success was observed in the bush habitat (4.5%) followed by classroom habitat (3.1%) and around the crevices (0.5%). The highest trap success rate belonged to *A. abyssinicus* (39.5%). *M. mahomet* was the only one observed in all the three habitats where rodents were recorded. *A. abyssinicus* and *M. natalensis* were recorded only in the bush, around classrooms habitats (Table13).

Table 13. Distribution and abundance of rodents in areas outside the grids. Species richness and trap success of each habitat type and that of the whole area surveyed are also shown. Aa= *A. abyssinicus,* Mn= *M. natalensis* Mm= *Mus mahomet*

Habitat and their location	Species			Trap success and species richness		
	Aa	Mn	Mm	Total capture	Trap success	Species richness
Bush (Meadows)	18	8	5	31	4.50%	3
Around stores, classrooms	4	13	4	21	3.1%	3
crevices(rock piles)			4	4	0.5%	1
Eucalyptus wood land						
Total	22	21	13	56	8.10%	3
% of each sp. In the overall catch	39	37.5	23.2			
No. of habitats each sp. trapped from	2	2	3			

6. Discussion

The distribution and abundance of rodents in the study area were not revealed to be quite complex. The distribution of rodents was shown to vary from each other in different cultivated fields as well as outside cultivated fields.

The present study has shown that there are three species of rodent pests that harbor in the study area,out of which *Mastomys natalensis* is the dominant one. Likewise, *Arvicanthis* sp. and *Mastomys* sp. are known to have a wide distribution in many parts of Ethiopia. Both of them are considered to be major pests in maize, bean and tomato plantations (Afework and Leirs, 2003).

According to the result of the study, *Mastomys natalensis* is the dominant and most common species among the three species, whereas *M. mahomet* and *A. abyssinicus* are relatively rare as they are found in lower numbers in the cultivated fields. A species is considered to be common if its population size is equal to or greater than the number obtained by dividing the total number of the rodent community by the species richness (Yu, 1994). Thus *Mastomys natalensis* can be considered as a major rodent pest in the area. Besides the rodent species, there were two unidentified shrews that were captured in the second trapping session (on the first and second trapping nights). However, there was no capture of shrews again and hence it was impossible to identify the species. They were captured in the bean grid, when the bean was closer to the harvesting stage. The reason why the shrew was not captured again might be because the bait was not meant to trap shrews or they might have been lower in number in the area. Shrews are the ones known to be very sensitive animals and due to trapping effect they may have avoided being trapped again (Balakrishnan, 1975).

The species diversity index revealed that the differences in species diversity between the wheat and lentil grids were low as there were three species of rodents in both the wheat and lentil grids. The relative abundance of the species in these two grids was close to each other. As a result, high species diversity was shown in them. This is due to the fact that when species are equal in abundance; there will be high diversity (Maggurran, 1988). In contrast, the difference in species diversity between wheat and lentil grids with bean grid is higher as there are only two species of rodents in the bean grid. The relative abundance of species in the bean grid was not close to the wheat and lentil grids. Thus, low species diversity was shown in the bean grid. This is due to the fact that when species are not equal in abundance, there will be low diversity.

The overall trap success obtained in this study was very low. In the present study, the probable factors that influence trap success could be due to low population density and trap shyness of rodents. This is due to the fact that other factors such as tunnel entrance obstruction, treadle obstruction by bedding material, improper working of door and door catch, badly sited trap (Gurnell and Flowerdew, 1990) that may have influenced trap success were worked out properly.

Even though the over all trap success in all grids was low, the trap success in the wheat grid was relatively higher than the bean and lentil grids. The trap success in the bean grid is also relatively higher than that of the lentil. In relation to the population density, this result shows that rodent pests prefer to harbor in the cereal crop, particularly wheat, than bean and lentil. The trap success on the same grid also varied across the different sessions of the study period. The highest trap success was obtained just immediately before harvest, which showed that it becomes highly favorable for rodents when crops were at their maturing stage as it provides abundant food and hiding places. After harvest, the trap success declined. This is in agreement with the fact that agricultural environment is characterized by instability (Taylor and Green, 1976). i.e. the highly favorable habitat of maturing crops is destroyed during the course of a few days by harvesting. However, the reason for the trap success in wheat grid after harvest to be relatively higher would probably be due to the fact that there were nesting sites in the ground (there is a sort of crack in the ground). It was observed that they used to immediately throw themselves to the cracks in the ground while they were released in the process of mark-recapture technique.

The number of recaptures during most trapping sessions was low. Hence, it was not possible to use Stochastic Jolly- Seber model to make monthly estimates of population size as the model is imprecise when the number of recaptures is not greater than 10 (Sutherland, 1996). In such cases, valuable estimate of population size can be made using MNA method (Kreb, 1996). However, this method is not free from problems. Some of the problems associated with the method are:

i) It is impossible to know whether an individual has escaped capture by chance or whether it was temporarily dispersing during the trapping session and returned later.

ii) Animals may enter the population, stay there for some time and then disappear without ever being captured.

iii) Animal that escaped capture once accidentally and disappeared before the following trapping session will be considered "not present".

As a result, the population size estimated in every trapping session would be smaller than the actual population size that could occur (Kreb, 1996).

The crop is highly favorable for rodents at their maturing stage since it provides them with abundant food and hiding places. At this time, individuals breed with their maximum potential, and the population is expected to increase rapidly. After harvest, the habitat changes in few days. This results in having insufficient hiding place and food for the rodents that they are exposed to their predators and food shortage. This condition forces them to leave the area to search of food and shelter to a different place (Taylor and Green, 1976). A similar trend of population size fluctuation was observed in this study. The maximum population size was recorded when crops were matured and closer to get harvested. After harvest, the population size of rodents on the live trapping grids declined rapidly. The study on two Kenyan highlands showed the same result especially to *M. natalensis*. The *M. natalensis* might be present in low number in a particular area and then rapidly increase in number (the increase often associated with ripening cereals); an equally rapid decline in numbers usually followed (Taylor and Green, 1976).

Rodent densities were generally low throughout the study period. This was also the case for *Mastomys natalensis* which was the most common species in the study. Leirs (1995) reviewed the population size estimates of different *Mastomys* species in Africa. It was revealed that fluctuations with maximum of up to a thousand animals per hectare in outbreak years, and more typically, several hundreds during usual seasonal peaks. In the present study, the densities in the farm land ranged from 6- 94/ha for *Mastomys natalensis* (Table 5). An "outbreak" was shown before two years in the farm lands (report from crop protection). It was the damage that rodents caused in the farmlands and their presence in too great numbers interfered with the daily activities of people in the area that made the report to be considered as a sort of outbreak. Thus it looks that the rodent population did not revive after the "outbreak" though there were no report about the population density of rodents one year before the study time.

Males were captured more frequently than that of females. This may probably be males were more mobile to get food and mate or there may have been genuinely fewer numbers of females that contributed to the reduction in the density of the population as a whole.

Temporal variation in species richness of rodents occurred at three out of the ten sessions in wheat grid (Table 3). Since one rare species was not shown in seven sessions, most of the time there were only two species recorded in the wheat grid. These were *Mastomys natalensis* and *M. Mahomet*. Moreover, the relative abundance of *Mastomys natalensis* and *M. mahomet* (Table 7) varied significantly (χ^2= 15.382, df =1, P < 0.001 and χ^2= 29.432, df =1, p< 0.001 respectively) between the pre and postharvest sessions. In contrast, the relative abundance of *A. abyssinicus* did not fluctuate significantly (χ^2= 0.4, df =1, p= 0.527) between pre and post harvest sessions in the same grid.

Temporal variation in species richness of rodents occurred at only one session out of the four sessions where rodents were recorded. Hence, it was only one species of rodent mostly recorded in the bean grid. In this case, it was *Mastomys natalensis* that was recorded in two of the sessions where only one session was recorded (Table 3). Moreover, the relative abundance (Table 8) of *M. natalensis* in this grid vary significantly (χ^2= 29.45, df =1, p< 0.001) between pre and post harvest sessions. In contrast, the relative abundance of *M. mahomet* (Table 8) occurring in this grid did not fluctuate significantly (χ^2 = 2.571, df =1, p=0.109) between pre and post harvest sessions. As a result, the variation is considered insignificant.

There was temporal variation in species richness in the lentil grid which showed that the two species *M. natalensis* and *M. mahomet* are the commonly found species of the lentil field. Moreover, the relative abundance of *M. natalensis* (Table 8) in this grid vary significantly (χ^2= 12.46, df =1, p< 0.001) between pre and post harvest sessions. In contrast, the relative abundance *M. Mahomet* and *A. abyssinicus* (Table 8) occurring in the same grid did not vary significantly (χ^2= 1.33, df =1, p< 0.25 and χ^2= 0.00, df =1, p= 1 respectively) between pre and post harvest sessions.

The fact that temporal variation of rodent pests during pre and post harvest was found to be significant in all grids (wheat, bean and lentil), proved that the number of these rodents in pre harvest is higher than the post harvesting one. Such a result is in agreement with what has been obtained by Jacob and Brown (2000). They emphasized that harvesting do not only remove much of the food, it also removes shelter and get them exposed to predators. The reduction of shelter exposes small mammals to increased predation risk. This showed that post harvest results in reduction in the number of rodents.

The fact that no rodent species was recorded regularly in all grids showed that the rodent species was not uniformly distributed throughout the cultivated field. However, it is possible to say that *M. natalensis* was a relatively regular visitor of the wheat field as it was recorded in nine of the ten sessions and the same species can also be considered as the commonly found species (Table 10). Therefore, it can be proved that *M. natalensis* is the commonly found species of the cultivated field. *M. mahomet* can be considered as the commonly found species of wheat and lentil fields but is rarely found in the bean field (Table 10). *A. abyssinicus* can be considered as a rarely found species in the wheat and lentil fields. This can support the idea that *A. abyssinicus* did not prefer the farm land (Bekele Tsegaye, 1999).

The variation in biomass in different trapping sessions was mainly associated with fluctuation in population size in all grids. The sessions in which records of maximum and minimum biomass were made are those where the population size was at its peak and minimum respectively. Different reasons can be mentioned for the variation of biomass between the three grids. In most of the study periods, rodent population of wheat grid was greater than the population size of rodent on the other two grids. Correspondingly, the rodent biomass in wheat grid was also greater than in the other grids. The same was true for the population size between bean and lentil. The population size on bean grid was greater than the population size of rodent on lentil grid. In the same way the biomass on bean grid was greater than the biomass of rodents captured in the lentil grid.

The other most probable reason for the variation of biomass between the three grids was the difference in abundance of each species in the three grids. Greater proportions of heavy weight rodents (*Mastomys natalensis*) were captured on wheat grid. Thus their biomass was also greater. In one trapping session (the third), the population size of rodents on bean grid was greater than that of wheat grid. As a result, the biomass was greater on bean grid than on wheat and lentil grid (Table 11). This was because *Mastomys natalensis* constituted the largest proportion of rodents captured during the third session of bean grid, whereas, wheat grid consisted of lesser proportion of *Mastomys natalensis* in the same trapping session.

A survey trapping conducted to investigate the relative abundance and distribution of rodents in different habitats was found to have the lowest trap success of 8%. In this survey, the dominant species was *A. abyssinicus*, which was considered rare and found in a lower number in the farm grids. The very low population in the cultivated fields suggests *A. abyssinicus* had a better success around short grassland even when frequented and impacted by humans and large mammals and this fact goes in agreement with the study conducted in Entoto Natural Park by Bekele (1999). The density of *A. abyssinicus* on that park was very low on the more or less natural and relatively protected area than the area with short grassland and frequented by humans and large mammals. Next to *A. abyssinicus*, *M. natalensis* was found to be relatively more abundant. This observation was closer to the study carried out on Kenyan highlands (Taylor and Green, 1976). The ability of *M. natalensis* to find cereals on those highlands during the time where there were no cereals is indicative of the great mobility exhibited by the species.

A survey that was conducted using snap traps may show that there were no rodents distributed far away from the farm field while the study was conducted in parallel, with the farm grids. Therefore, it is possible to conclude that when there were crops in the farm, the rodents were concentrated in and around the farm. As the study goes on from twelfth to fourteenth session, the rodents continue to be distributed throughout the compound in different places where they can get food and shelter. The number of rodents from twelfth to fourteenth sessions was shown increasing in the surveyed area. Thus, as the population increases, there would be a probability for their distribution in different habitats of the compound. Perhaps, it took them sometime to multiply and distribute far from the farm, where they get food and shelter. The fact that most rodents were captured some 100 and 200 m. away from the wheat field showed that the rodents didn't start to be distributed to the different places in the compound. This might be due to their low population density. However, the fact that some rodent species were captured about 300m. away from the farm field during the last session, could point out that rodents continue to be distributed all over out the compound. But throughout the study period, there has been no capture under the eucalyptus trees until the last session. As it is the case in plantations of some other exotic species, the eucalyptus plantation provides poor habitat diversity. This would be so at the expense of replacement of natural vegetation, which could have contributed more to the lower end of the animal food chain. Thus the success of exotic plants including eucalyptus plant in places where introduced emanates from their unpalatability (Poore and Freis, 1985). There was also zero capture in the crevices, about 300 m. away from the wheat field.

As observed from the study, low population density was observed and hence serious crop damages by rodents were not seen in the fields. This might be due to several factors.

I) The rodenticide applied two years before the study period might have a long time effect until now.

II) Some unknown cats were seen intruding to the compound and hovering around the farm field that might contribute in the reduction of density of the population.

III) The area of the compound that was under farming during the present investigation was much larger than the pervious years, thus the distribution of the animals to the different crops might have an effect in the reduction of their population density.

Recommendations:-

The recommendations that can be given to the farmers will be:

I) Using the rodenticide in a place where there is a favorable habitat for rodents (under burrows, rock piles).

II) Natural predators, such as cats will also be helpful.

III) It is better not to leave uncultivated lands between cultivated fields, so that rodents will not get refugee.

IV) Adopting clean farming practices (remove all shrubs and rock piles near cultivated fields).

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