SINET: *Ethiop. J. Sci.*, 30(2):127–134, 2007
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FEEDING ECOLOGY OF PEST RODENTS FROM ARBAMINCH FOREST AND FARMLSNDS, ETHIOPIA

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ABSTRACT: Eleven species of rodents were recorded from Arbaminch forest and farmlands of Ethiopia during a study carried out from August 2005 to April 2006 to assess diet and pest status based on stomach content analysis. A total of 196 specimens were trapped in 1800 trap nights. Feeding ecology of most rodents was highly diverse. Most species of rodents appeared to be opportunistic in their feeding, subsisting on a variety of food items. During the dry season, most of the rodent species relied heavily on seeds. Arthropods were consumed more during the wet season. The body weight of most rodents decreased during the dry season and increased during the wet season. Four species (*M. natalensis, A. dembeensis, M. musculus* and *Hystrix cristata*) were recorded as major pests of maize crops. *M. natalensis* consumed more quantity of maize seed fragments. These rodents caused 5.75% damage on maize crops. The damage level was high at the periphery (7.1%) and low at the centre (4.4%) of maize plantation. The present study has shown that rodent pests were not uniformly distributed in maize farmlands. The pattern of rodent pest distribution may be mostly attributed to proximity of the farm to the natural cover.

Key words/phrases: Arbaminch Forest, farmlands, feeding ecology, pest rodents

INTRODUCTION

Rodents have great ecological, economical, social and cultural values. They play an important role in natural communities, and from the main source of food for many predators (Hvass, 1961; Linzey and Kesner, 1997; Ray, 1998). They are also valued as important food sources in many regions of Africa and elsewhere. They comprise an important component of the diet of the Gumuz indigenous people in Ethiopia. In addition to these, rodents have served as ecological models in biological studies (Adler, 1994; Lambert *et al.*, 2003; Heaney, 2001; Mena and Vazque-Dominguez, 2005). Some of them are considered as pioneer species of ecosystem succession (Lambert *et al.*, 2003). Generally, rodents play important structural roles in different ecosystem services by pruning or eliminating vegetation types, aerating soil through their digging and burrowing activities, spreading seeds, pollen and competing with other animals (Kingdon, 1997).

On the other hand, some rodents are nuisance to agriculture, forestry and public health (Fiedler, 1994), causing severe economic losses (Tristiani and Murakami, 2003). Their damage is an important cause of harvest loss worldwide. For instance, in Ethiopia eleven species of rodents consume up to 20% of the cereal crops in some years (Afework Bekele and Leirs, 1997). Hence, rodents are known as major vertebrate pests of agriculture (Stenseth *et al.*, 2001). They cause direct damage to various crops or commodities by gnawing and feeding, and indirect damage by spoiling and contamination. More than 25 species of rodents have been recorded as pests in agriculture causing a wide range of damage and losses in cereals, legumes, vegetables, root crops, cotton and sugarcane (Workneh Gebresilassie *et al.*, 2004). Among these rodents, *Mastomys* are important pests in agriculture (Leirs *et al.*, 1993; Gratz, 1997). Most damage occurs during the sensitive young seedling stage and just before harvest. However, the pattern and levels of rodent infestation, and the extent of damage vary in different crop and geographical regions.

Diets are extremely significant for determining evolution, life-history strategies and ecological role of organisms in their natural habitats. Food is one of the most important dimensions of the niche and, therefore, information on diets of animals is a prerequisite for most ecological research. Study of diets of animals is crucial for understanding relationships between species (Zimmerman, 1965; Bar *et al.*, 1984), and between an animal and its environment. Even though there are 84 rodent species identified so far in Ethiopia, studies on their diet analysis and pest status are poorly

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known. Therefore, the present study attempts to identify feeding ecology of pest rodents of Arbaminch area of Ethiopia and estimates the impact as well as the extent of damage they cause on agriculture.

MATERIALS AND METHODS

The study area

The study area, Arbaminch Forest and farmlands (State Farm) is located in southern Ethiopia about 510 km South of Addis Ababa, between longitudes 37°32'-37°48' East and latitude 05°59'-06°30' North (Fig. 1). The elevation of this area ranges from 1200-1212 m asl. Arbaminch Forest, which is part of the Nechisar National Park, covers about 2120 ha. The farmlands (State Farm) comprise cultivated open land to the north of the Park. The habitat is dominated by settlements and cultivated crops. The dominant crop species cultivated in this area include maize (*Zea mays*) and cotton (*Gossypium hirtutum).*

Snap-traps baited with a mixture of peanut butter and maize scrap were used in both seasons following the standard trapping techniques (Afework Bekele, 1996a&b; Linzey and Kesner, 1997; Shanker, 2001; Workneh Gebresilassie *et al.*, 2004). The snap-trapping was arranged in two parallel lines, each 200 m long; separated from each other by about 50 m. Each snap-trap was set at an interval of 20 m. and placed at the same trap station for three consecutive days. The traps were checked twice a day early in the morning and late afternoon hours. From snap trapped animal, stomach was taken and kept in formalin solution for diet analysis. In addition to weight and sex, additional body measurements were recorded. The skin and skull of representative specimens were prepared and deposited as voucher specimens in the Zoological National History Museum, Department of Biology, Addis Ababa University, Addis Ababa. Then the specimens were compared and identified at species level by referring to the reference materials deposited in the Museum.

Diet analysis

Diet analysis was carried out following the methods of Johnson (1961); Reichman (1975); Kronfeld and Dayan (1998); Campos *et al.* (2001) and Workneh Gebresilassie *et al.* (2004). All the representative snap-trapped animals were dissected for stomach content analysis. Representative individuals of each species from each habitat and each season were collected. The stomach was removed and preserved in individual containers and preserved in 10% formalin solution or in 70% alcohol, until further analysis was carried out. The samples were washed with distilled water to remove fine particles for proper identification. Four slides were prepared from each sample and observed under a microscope at 60X magnification to identify the type as well as the proportion of the diet. The proportion of food fragments in the diet was carried out by counting the fragments from the focal area.

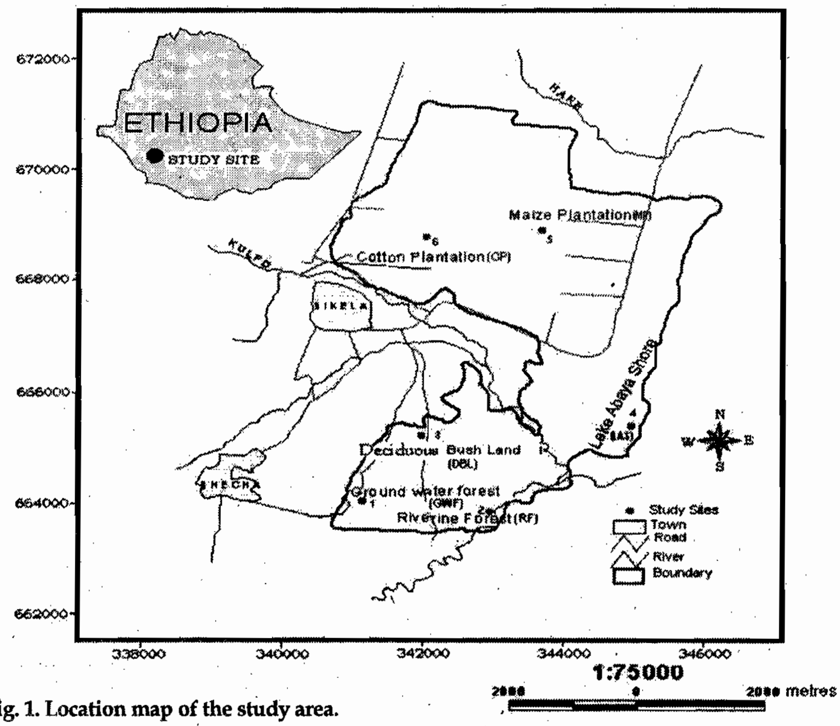

Fig. 1. Location map of the study area.

Estimation of damage on maize crops

Two samples of maize plantation, each of one hectare were randomly selected at the pre-harvest stage; one from the centre and the other from the periphery. Maize was sown in a row 1 m^2 consisting of six heads (cobs) of individual maize plants. About 60,000 individual maize heads were expected from a hectare. To estimate the loss, direct damage assessment of seed cobs was carried out from 50 randomly selected rows during pre-harvest period, a week before the intended date of harvest. Individual damage was recorded as totally damaged, half damaged and one-fourth damaged from each hectare of each randomly selected row. Then, the damage proportion of each sampled cob was estimated. The method that best describes damage of maize crop by rodents was modified from Brown and Singleton (1999) as follows:

$$\% \text{ maize crop damage} = 100(a/b)$$

where:

a= number of damaged individual maize cobs in the sample,

b= total number of individual maize cob in the sample.

SPSS software version 11.0 and statistical methods such as Chi-square test and Correlation Coefficient were used for the analysis of the data.

RESULTS

A total of 196 individual rodents were captured in 1800 trap nights. Snap trapping surveys revealed 11 species of rodents in the present study area (Table 1). They were *Arvicanthis dembeensis*, *A. niloticus*, *Mastomys natalensis*, *M. erythroleucus*, *Acomys cahirinus*, *Lemniscomys striatus*, *Tatera robusta*, *Stenocephalemys albipes*, *Grammomys dolichurus*, *Mus musculus* and *M. tenellus*.

A. dembeensis was the most snap trapped rodent followed by *M. natalensis*. These two species together comprised 66.9% of the total rodents collected during all trapping occasions. *M. tenellus* was rarely captured in the study area.

Food fragments obtained from stomach samples of six rodent species from the study area during the study period are shown in Table 2. Food items were grouped into plant seeds, plant leaves, plant roots, earthworms and arthropods. Plant materials were the most common food items identified. Few root fragments were also observed in some species.

Table 1. Species composition, abundance and distribution of snap trapped rodents from different habitats

Species	Total Catch [Percentage]	GWF	RF	DBL	LAS	MP	CP
A. dembeensis	73(37.3)	-	-	10	17	25	21
M. natalensis	58(29.6)	1	2	8	6	29	12
A. cahirinus	19(9.7)	3	5	9	2	-	-
L. striatus	12(6.1)	-	-	5	7	-	-
M. erythroleucus	9(4.6)	2	-	3	3	-	1
T. robusta	7(3.6)	-	-	5	2	-	-
A. niloticus	5(2.6)	-	1	1	-	1	2
S. albipes	4(2.0)	1	-	1	2	-	-
M. musculus	4(2.0)	-	-	-	-	3	1
G. dolichurus	3(1.5)	-	1	-	2	-	-
M. tenellus	2(1.0)	-	-	1	-	-	1
Total	196(100)	7	9	43	41	58	38

Note: (GWF=ground water forest, RF=riverine forest, DBL=deciduous bush land, LAS=Lake Abaya shore, MP=maize plantation, CP= cotton plantation).

Table 2. Food fragments from stomach samples of six rodent species from the study area.

Species	Seeds		Leaves		Roots	E-worm	Arthropds		
	Monocot	Dicot	Monocot	Dicot			Termites	Ants	Unknown
A. dembeensis	*	*	*	*	*	-	*	*	*
M. natalensis	*	*	*	*	*	*	*	*	*
A. cahirinus	*	*	*	*	*	*	-	-	*
L. striatus	*	*	*	*	-	-	*	*	*
T. robusta	*	*	*	*	*	-	*	*	*
M. musculus	*	*	*	*	-	*	*	*	*

* Presence of fragments, - No fragment

Even though the six rodent species studied mostly depended on plant matters, the relative proportion of the food items differed significantly among seasons and among species (Table 3). Significant differences ($p<0.05$) in consumption of seeds, leaves, roots and arthropods were observed among these rodents during the two seasons. The consumption of earthworms was more during the wet season; whereas, consumption of root was more during the dry season. Arthropods were used more during the wet season than during the dry season. Except *L. striatus* and *T. robusta*, the other four species mostly depended on seeds of monocot and dicot plants during the dry season. There was no significant seasonal variation in types of food items identified. However, there was a significant variation ($p<0.05$) in the proportion of diet of each species.

Data on the composition of stomach contents of four rodent species in relation to sexual status from the study area are given in Table 4. The contents of stomach samples of non-pregnant and lactating females were not statistically significant ($p>0.05$) in their diet composition and percentage proportion of stomach contents. However, the stomach samples of most adult male rodents revealed the presence of a wide variety of diet compared with pregnant and lactating females. Earthworm fragments were not observed from stomach samples of *A. dembeensis* and *L. striatus*. Pregnant females of the above species showed relatively narrow range of diet diversity, except *A. cahirinus*, which fed on all the above described food items.

Lactating females of *A. dembeensis*, *L. striatus* and *M. natalensis* had more seeds and leaves of both dicot and monocot plants in their stomach contents, whereas in *A. cahirinus* arthropods were the most common component of the diet, especially during the wet season.

Table 3. Composition of stomach contents (% frequency) of six rodent species in relation to seasons.

Species	Season	Percent frequency of food fragement observed								
		MS	DS	ML	DL	R	EW	T	A	U
A. dembeensis	Dry	17.2	17.3	21.5	18.5	17.5	-	9.7	2.0	6.3
	Wet	17.4	18.1	22.6	29.0	-	-	1.6	4.8	6.5
M. natalensis	Dry	24.5	20.4	16.3	18.4	4.1	1.0	4.1	5.1	6.1
	Wet	13.1	15.2	19.6	23.9	4.3	10.9	3.3	4.3	5.4
A. cahirinus	Dry	21.1	23.7	21.1	18.4	2.6	5.2	-	-	7.9
	Wet	20.7	20.7	13.8	17.2	3.5	17.2	-	-	6.9
L. striatus	Dry	19.4	18.6	29.7	24.0	-	-	-	-	8.3
	Wet	21.2	19.7	22.7	24.3	-	-	3.0	6.1	3
T. robusta	Dry	25.9	29.6	3.17	7.4	11.1	-	5.6	9.3	7.4
	Wet	26.7	31.1	8.9	4.4	13.3	-	4.5	4.4	6.7
M. musculus	Dry	19.4	23.5	15.8	19.6	-	3.9	5.9	7.8	3.9
	Wet	17.8	15.6	22.2	13.3	-	11.1	6.9	4.4	8.9

Note: - =absence of data) (MS=monocot seed, DS= dicot seed, ML= monocot leaf, DL= dicot leaf, R = root, EW= earthworm, T = termites, A= ants, A = Arthropods, U = Undifferentiated.

Table 4. Composition of stomach contents (% frequency) of four rodent species in relation to sexual status.

Species	Sex	Female type	MS	DS	ML	DL	R	EW	A
A. dembeensis	M		19.7	25.4	22.5	2.8	2.8	-	8.5
	F	Pregnant	16.7	20.8	25	-	-	-	8.3
		Lactating	19.2	21.9	17.8	2.7	2.7	-	13.7
M. natalensis	M		21.1	15.8	18.4	26	26	5.3	10.5
	F	Pregnant	30.1	19.2	15.1	-	-	8.2	11
		Lactating	24.5	20.4	26.5	-	-	4.1	8.2
A. cahirinus	M		15.7	23.5	19.6	11.8	11.8	3.9	9.8
	F	Pregnant	22.2	29	24.1	2.1	2.1	8.9	6.7
		Lactating	20.7	24.1	13.3	1.7	1.7	5.2	6.9
L. striatus	M		13.6	18.2	33.8	29.8	-	-	4.6
	F	Pregnant	29.1	25.5	20.0	21.8	-	-	3.6
		Lactating	18.7	21.3	26.1	19.7	-	-	14.2

Note: (MS= monocot seed, DS= dicot seed, ML= monocot leaf, DL= dicot leaf, R= root, EW= earthworm, A= arthropod).

A total of four rodent species (three trapped and one observed) were recoded as pests of maize crops on the farmlands (Table 5). The trapped rodent pests were *M. natalensis, A. dembeensis* and *M. musculus*. The non-trapped but observed rodent pest was *H. cristata*, which was the largest and major rodent pest of the area. The most abundant species was *A. dembeensis* (106–51.0%), followed by *M. natalensis* (97–6.6%) and *M. musculus* (5–2.4%).

The composition of maize seed fragments in relation to other food items in the stomach contents of the three rodents is shown in Figure 2. The percentage of maize seed fragments was high in the stomach contents of *A. dembeensis* and *M. natalensis*. More maize fragment was observed in the stomach contents of *M. natalensis* (80.7%) than those of others. However, maize fragments were less than other food contents in the stomach of *M. musculus*.

Table 5. Species composition and relative abundance of rodent pests from the maize plantation.

Species	Total catch	Live-trapping (%)	Snap trapping (%)
A. dembeensis	106	81(53.7)	25(43.8)
M. natalensis	97	68(45.0)	29(50.9)
M. musculus	5	2(1.3)	3(5.3)
H. cristata	*	*	*
Total	208	151(100.0)	57(100.00)

Table 6 shows the estimated damage of maize crop by rodents. Damage level was statistically significant ($P<0.01$) with high loss in the peripheral site (61.7%) and less in the central sites (38.3%) of the maize plantation.

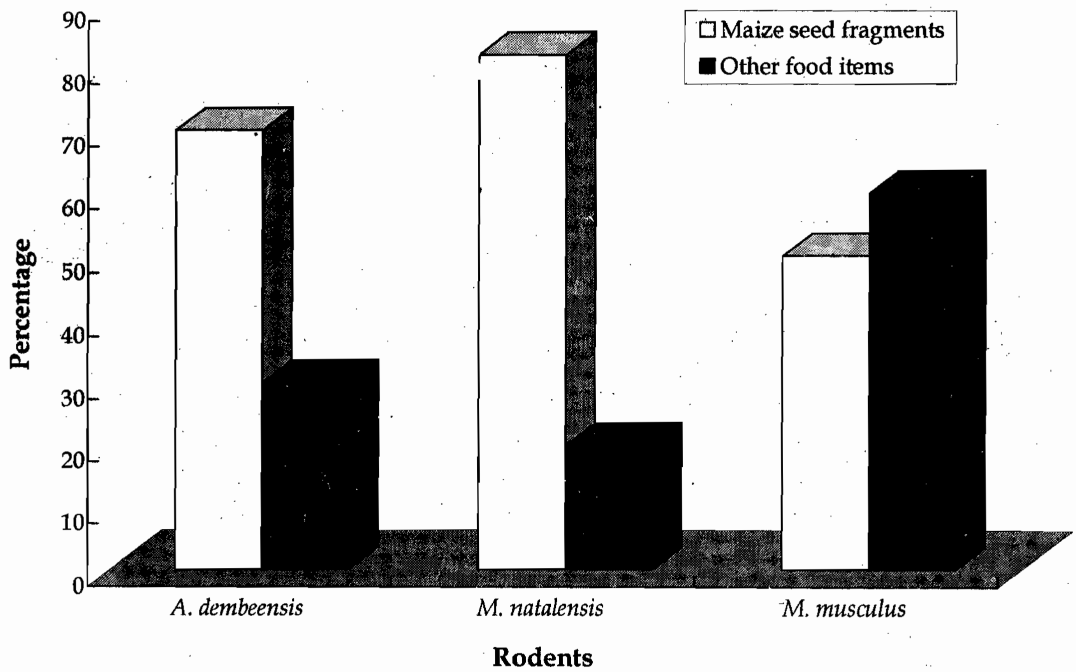

Fig. 2. Percentage of stomach analysis of rodent species. (Maize seed fragment and other food items).

Table 6. Damage estimate from two plots of maize plantation (individuals of maize cobs).

Damage status	Site of damaged areas		Average
	Peripheral	Central	
Fully damaged	321 (321)	203 (203)	262
Half damaged	817 (408.5)	429 (214.5)	311.5
One-fourth damaged	1326 (331.5)	957 (239.3)	285.4
Damage out of 50 randomly selected rows	1061	656.8	858.9
Percentage loss (out of 60,000 cobs/ha)	7.10	4.4	5.75

DISCUSSION

Based on the food preferences of rodents, one can predict control measures and management programs for the concerned species. However, the feeding ecology of small mammals throughout the world is highly diverse (Campos *et al.*, 2001). Most species of rodents appear to be opportunistic in their feeding habit (Johnson, 1961). The present findings also support this view. The result of the present study shows that the available six species of rodents studied for stomach contents were omnivorous and granivorous. However, differences in the proportion of both major food types and specific plant and animal species consumed varied temporally and spatially for each rodent species. Studies that attempt to infer diet by analyzing the contents of stomachs or faeces suffer from a number of problems (Campos *et al.*, 2001). For example, the food items that are more rapidly digested may be under estimated (Putman, 1984; Kronfeld and Dayan, 1998), while some consumed only in small proportion may be over estimated when consumption is measured in terms of frequency of occurrence (Reynold and Abischer, 1991). In addition, more frequent consumption of a particular food does not necessarily reflect the importance of that food in terms of its nutritional benefits (Roper and Mickeuicius, 1995).

The result of the stomach content analysis showed that all examined rodents consumed plant matters and arthropods during both seasons. However, earthworms were recorded at high frequency in the stomach contents of *A. cahirinus* during the wet season. *A. dembeensis* preferred dicot plant matters during the wet season and depended more on monocot plants during the dry season. Taylor and Green (1976) reported that *Arvicanthis* switched its diet dramatically first to dicotyledon plant and then almost completely to grasses during the wet and dry seasons, respectively. Few root fragments and no earthworms were observed from the stomach contents of *A. dembeensis*. *M. natalensis* mostly preferred monocot plants during both seasons. However, unlike others, they feed on all types of described food items. *L. striatus* and *T. robusta* showed similar feeding patterns. This might be an indication for its success in being distributed widely. Unlike others, both species possessed more seeds during the wet season than the dry season. Root was absent in the stomach contents of both the species. *L. striatus* was observed to be highly dependant on insects during the wet season. There was no root in its diet.

The result of diet analysis in relation to the reproductive conditions of four abundant species of rodents in the study area showed that adult males and lactating females fed on diverse types of food items. This might be related to the additional energy requirement of reproductively active individuals. However, in the case of pregnant females of *M. natalensis* and *A. cahirinus*, there was no significant change in food preferences. Generally, seeds, leaves and arthropods were the main diet components of the rodent species at different reproductive conditions.

The common pest rodents of maize crops were *M. natalensis*, *A. dembeensis* and *M. musculus*. The stomach content analysis showed that *M. natalensis* consumed the highest quantity of grain followed by *A. dembeensis* and *M. musculus* (Fig. 2). These species were earlier recorded as major pests in most parts of Africa including Ethiopia (Afework Bekele and Leirs, 1997). Multimummate rats (*M. natalensis*) and *A. dembeensis* are the most noxious murid pests in eastern Africa (Fidler, 1994; Leirs *et al.*, 1996). *Mastomys* as a pest in Ethiopia was documented in maize fields (Afework Bekele and Leirs, 1997). The extent of damage is related to the presence of cover near to the maize plantations. The extent of damage and the number of pests were more at the periphery rather than in the centre of the plantation. This might be due to heterogeneity of the habitat at the peripheral areas. In the central areas of the maize plantation, the habitat was more homogenous.

The result of damage estimation from the two hectares shows that pest rodents caused at an average of 5.75% damage in the maize plantation. However, the damage was high at the periphery and low in the centre of maize plantation. This shows that rodent distribution is determined by microhabitats rather than macro-habitats. Further, heterogeneous cover is a preferred habitat to harbour different species of rodents.

During the study period, it was also observed that a close relationship existed between the disturbances caused by farming activity in the field and the population dynamics of the rodents in the farmland. Plowing has both direct and indirect effect on animals by destroying their refuge (habitat cover), food resources and exposing the animals to predators. Similarly, some studies have shown that reduction of shelter exposes small rodents at increased predation risk (Jacob and Brown, 2002; Sheffield *et al.*, 2001). As observed during the present study period, during land preparation and after harvest, the population of rodents decreased considerably. This might be due to the harvesting of the maize crop and plowing the field that removed much of the food and cover essential for the rodents.

ACKNOWLEDGEMENT

We thank Addis Ababa University for the financial support and for facilities received during the study period.

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