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Species Composition, Distribution and Habitat Association of Rodents in Bir Farm Development and Nearby Natural Habitat Area, Ethiopia

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ABSTRACT

This study compares species diversity, distribution, relative abundance and habitat association of rodents in Bir Farm Development (Birsheleko) and nearby natural habitats during August 2007 to February 2008. Live-trapping in the forest, bushland, grassland and agricultural fields revealed the presence of *Arvicanthis dembeensis* (33.6%), *Lophuromys flavopunctatus* (21.8%), *Mus mahomet* (16.8%), *Stenocephalemys albipes* (14.4%), *Tatera robusta* (11.4%) and *Pelomys harringtoni* (2.0%). The distribution of species varied between habitats. *L. flavopunctatus* had a wider range of distribution than other small mammals trapped. Diversity of rodents was higher in maize farms from local farmed areas than the extensive Farm Development due to less disturbance and chemical applications.

Key Words: Agricultural Fields, Diversity, Mammals, Population Size, Richness, Trap Success

INTRODUCTION

Mammals are the most successful animals with the possible exception of insects (Hickman et al. 1988). Globally, small mammals form a major proportion of the mammalian fauna and are also a common feature of agricultural landscapes (Jacob et al. 2003). Of the mammalian orders, rodents contain the largest number of species (Kingdon 1997) and they account for nearly 44% of the mammal species (Wolff 2007).

Of the 284 mammalian species of Ethiopia, 84 species are rodents (Bekele and Leirs 1997) and 21% are endemic (Bekele 1996) constituting 50% of the Ethiopian endemic mammals (Bekele and Corti 1997). For instance, *Tachoryctes macrocephalus*, *Arvicanthis dembeensis* and *Stenocephalemys albipes* are endemic rodents to Ethiopia (Yalden 1985, Bekele 1995). There are nine families of rodents in Ethiopia. The family Muridae alone comprises 57 species (84% of the total number of species) and 93% of the total endemic rodents of Ethiopia (Bekele and Corti 1997).

Small mammals select and utilize some habitats more than others (Happold and Happold 1989) and the habitat selection of different species of small mammals depends mainly upon the vegetation type and ground cover (Iyawe 1988). Their distribution and abundance are influenced by environmental factors, mainly upon the nature and density of vegetation (Clout and Russell 2004), climatic conditions, disease, predation and habitat manipulation by humans (Nandwa 1973, Hubert 1978, Odhiambo and Oguge 2003). Abundance of small mammals is significantly affected by loss of food and cover. Abundant food increases rodent density in agricultural areas, grassland and forest habitats (Halvorson 1982, Lentic and Dickman 2005).

Despite being the most numerous, widespread and diverse group of mammals, the population ecology of rodents remains poorly understood and unappreciated by the general public. Although few ecological studies on rodents have been carried out in different parts of Ethiopia, population ecology, habitat association, distribution and relative abundance of rodents in many regions are also poorly known. Therefore, an ecological survey was made in Bir Farm Development and nearby natural habitats to determine the species diversity, distribution and habitat association of rodents in the region.

The Study Area

The Bir Farm is located approximately 400 km northwest of Addis Ababa in the Amhara National Regional State, Western Gojjam Zone, Jabi Tenhan Woreda. It is situated between 10º 27' to 10º 42' N latitude and 37º 6' to 37º 13' E longitude at an altitude ranging from 1400-2000 m above sea level (Figure 1). The farm has an area of 8854 ha of which the utilized area is around 7500 ha.

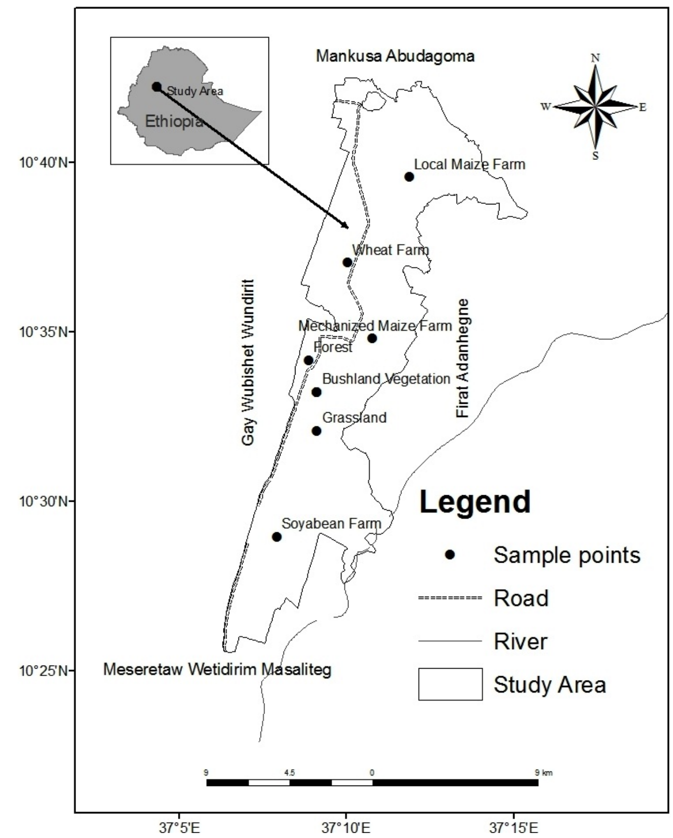

Figure 1. Map of the study area showing sampling locations

The rest of the area is covered with forest, grass and bushlands. The major crops cultivated in the Farm Development includes maize (*Zea mays*), soybean (*Glycine max*), wheat (*Triticum sativum*) and other cereals. In the nearby plots, farmers also cultivate maize of the same varieties with the Farm Development. Agronomic practices such as fertilizer application and weeding were carried out equally in all areas of crop types except the one from the local farmed areas. The wheat farm was planted using broadcast sowing whereas maize and soybean farm was planted using rows. The climate of the area is tropical with well demarcated wet and dry seasons. The annual rainfall follows unimodal regime that includes the main rainy season from June to September. The annual rainfall is around 1100 mm. Most of the area falls into 'Weina Dega' agro-climatic zone with average minimum temperature of 8.2 ºC in July and the average maximum of 33.8 ºC in March.

METHODS

Data on rodents were collected during both wet and dry seasons based on the capture-mark-recapture (CMR) method. Based on the habitat type, the total area was identified into forest (F), bushland (BL), grassland (GL), wheat farm (Wf), maize farm (Mf) and soybean farm (Sf). Representative sample grids were set in the different habitat types.

Trapping was made in four sessions covering both wet and dry seasons. Trapping session one (August 2007) coincided with the main rainy season when the growth was approaching fruiting condition. The second trapping session was during mid-September to mid-October (2007) which coincided with the flowering and fruiting phase of cereal crops. The third trapping session (December 2007) coincided with maturity before pre-harvest season (two weeks before harvest). The fourth session (February 2008) was during the post-harvest period. In all these trapping sessions, trappings were also carried out in the forest, bushland and grassland areas.

Sherman live trap was used to trap rodents. A permanent 4900 m^2 live trapping grid was established in all the different crop types and nearby natural habitat area. Seven rows by seven columns were set at 10 m intervals between trap stations. Live traps were baited with peanut butter, checked twice a day, late afternoon (between 05:00 and 06:00 p.m.) and early the next morning (between 07:00 and 08:00 a.m.). Traps were set for three consecutive nights, giving a standard trapping effort of 147 trap nights per grid. The trapped animals were marked by toe-clipping (Mahlaba and Perrin 2003).

The Shannon-Weaver diversity index (H'), Simpson index of diversity (D), Degree of dominance (DI) and trap success were used to analyze the data. In addition, SPSS software Version 13.0 was used for Chi-square test and ANOVA to analyze the data.

RESULTS

In the four trapping sessions, a total of 298 individuals (427 captures) were made in 4116 trap nights with a capture rate of 10.4%. Six species of rodents were identified: *A. dembeensis, L. flavopunctatus, M. mahomet, S. albipes, T. robusta* and *P. harringtoni*. The relative abundance of live-trapped species was: *A. dembeensis* (33.6%), *L. flavopunctatus* (21.6%), *M. mahomet* (16.8%), *S. albipes* (14.4%), *T. robusta* (11.4%) and *P. harringtoni* (2.0) (Table 1).

L. flavopunctatus occured in all the sampled habitat areas. Among the rodents trapped, *S. albipes* and *P. harringtoni* had less distribution in the area. *P. harringtoni* was restricted in the forest and bushland vegetation. Two individuals of this species were captured in maize farm from the local farmed areas.

A. dembeensis showed variation between maize farm from the local farmed areas and other habitat types ($p < 0.05$). *M. mahomet* also showed a significant variation between the natural vegetation and the farm lands ($p < 0.05$). The captured population from the maize farm in the local farmed areas showed significant variation from the maize farm in the farm development ($p < 0.05$). However, there was no statistical significant variation between wheat and soybean farms ($P > 0.05$). *L. flavopunctatus* population did not show any statistically significant variation between maize, wheat and soybean farms from the Farm Development and grassland (Tukey HSD test: $p > 0.05$). *S. albipes* showed statistically significant variation between farmlands and the natural vegetation ($p < 0.05$). However, there was no significant variation in its distribution between forest and bushland areas ($p > 0.05$). *P. harringtoni* population did not show any significant mean variation between forest, bushland and maize farm from the locally farmed areas ($p > 0.05$). A statistically significant mean variation of *T. robusta* was also observed between the bushland habitat and other habitat types in the study area ($p < 0.05$). High percentage of habitat association of *A. dembeensis* and *M. mahomet* with farmlands, *S. albipes* and *P. harringtoni* with the forest, *L. flavopunctatus* and *T. robusta* with the bushland habitat was observed (Table 2).

Bushland and grassland habitats had the highest Shannon-Weaver diversity index, whereas the grid on maize farm from the Farm Development showed the lowest value (Table 3).

Simpson's (D') index had a highest value of 0.72 in the bushland area and lowest 0.41 in maize farm from the Farm Development. The highest species diversity index was obtained in the bushland vegetation and grassland, followed by forest from the natural vegetation.

The lowest species diversity was obtained from the agricultural field of the maize farm from the Farm Development. Species richness was highest at the bushland vegetation and grassland, followed by forest habitat. Lowest species richness was recorded in the maize farm from the Farm Development.

Table 1. Species diversity, relative abundance and distribution of live-trapped rodents in different habitat types (Dash indicates absence of capture).

Species	Habitat Types							Total	Relative
	F	BL	GL	Mfd	Mf	Wf	Sf	catch	Abundance (%)
A. dembeensis	-	-	14	16	44	16	10	100	33.6
L. flavopunctatus	19	31	2	1	10	1	1	65	21.8
M. mahomet	-	2	2	5	19	12	10	50	16.8
S. albipes	23	18	2	-	-	-	-	43	14.4
T. robusta	-	15	12	-	6	-	1	34	11.4
P. harringtoni	3	1	-	-	2	-	-	6	2.0
Total	45	67	32	22	81	29	22	298	100

F = forest, BL = bushland vegetation, GL = grassland, Mfd = maize farm from the farm development, Mf = maize farm from the local farmed area, Wf = wheat farm, Sf = soybean farm

Table 2. Percentage of habitat association of each species with different habitat types (Dash shows the absence of trapped individuals).

Species	Habitat types						
	F	BL	GL	Mfd	Mf	Wf	Sf
A. dembeensis	-	-	14.0	16.0	44.0	16.0	10.0
L. flavopunctatus	29.2	47.7	3.1	1.5	15.5	1.5	1.5
M. mahomet	-	4.0	4.0	10.0	38.0	24.0	20.0
S. albipes	53.5	41.9	4.6	-	-	-	-
T. robusta	-	44.1	35.3	-	17.6	-	3.0
P. harringtoni	50.0	16.7	-	-	33.3	-	-

F = forest, BL = bushland vegetation, GL = grassland, Mfd = maize farm from the farm development, Mf = maize farm from the local farmed areas, Wf = wheat farm, Sf = soybean farm

Table 3. Species richness and diversity of rodents during both wet and dry seasons.

Grid \	F	BL	GL	Mfd	Mf	Wf	Sf
Rodent individuals	45	67	32	22	81	29	22
Species richness	4	5	5	3	5	3	4
H'	1.11	1.44	1.42	0.70	1.22	0.91	0.97
D	0.63	0.72	0.71	0.41	0.63	0.56	0.56

F = forest, BL = bushland vegetation, GL = grassland, Mfd = maize plantation from the farm development, Mf = maize farm from the nearby farmer's plot, Wf = wheat farm, Sf = soybean farm, H' = Shannon-Weaver diversity index, D=Simpson's index of diversity

Trap success ranged from 1.4% in soybean and maize farm from the Farm Development to a maximum of 20.4% in maize farm from the farmer's plot, two weeks before harvest (Table 4). The number of individuals captured in each of the habitat types was statistically significant ($\chi^2 = 81.18$, df =6, p <0.01). The number of individuals from maize, wheat and soybean farms from the Farm Development before two-weeks of harvest and after harvest showed statistically significant variation ($\chi^2 = 5.40$, df = 1, p < 0.05, $\chi^2 = 9.78$, df = 1, p < 0.01, $\chi^2 = 10.89$, df = 1, p < 0.01, respectively). However, maize farm from the local farmed areas did not show statistically significant variation between pre- and post-harvest periods ($\chi^2 = 2.47$, df = 1, p > 0.05). Statistically significant high population in the post-harvest session of the agricultural field in grassland habitat was also observed ($\chi^2 = 4.0$, df = 1, p < 0.05).

DISCUSSION

A total of six rodent species was captured during the present investigation. *A. dembeensis* was the most dominant and abundant species in farmlands and nearby grassland areas. The species was also commonly trapped from Maynugus irrigation field (Gebresilassie et al. 2005), Bilalo area, Arsi (Gadisa and Bekele 2006) and Arbaminch forests and farmlands (Datiko, Bekele and Belay 2007). The decreased species abundance after harvest in agricultural fields might be due to the diurnal activity of the species, making them susceptible to predators as cover was absent. At the same time, migration to other areas is a possibility because of limited resources.

L. flavopunctatus was captured in all the farmlands and natural vegetation though it was more abundant in the natural vegetation than in crop fields. This goes in line with Wube's findings (2005) in Entoto Mountain

Table 4. Number of rodents captured in different habitats, trap nights and trap success during the wet and dry seasons.

Grid	Habitat types	Seasons	Month	Total catch	Trap night	Trap success (%)
G_1	Forest	Wet	August 2007	10	147	6.8
		Wet	September-October 2007	5	147	3.4
		Dry	December 2007	14	147	9.5
		Dry	February 2008	16	147	10.9
G_2	Bushland	Wet	August 2007	16	147	10.9
		Wet	September-October 2007	16	147	10.9
		Dry	December 2007	18	147	12.2
		Dry	February 2008	17	147	11.6
G_3	Grassland	Wet	August 2007	7	147	4.8
		Wet	September-October 2007	9	147	6.1
		Dry	December 2007	4	147	2.7
		Dry	February 2008	12	147	8.2
G_4	Maize farm	Wet	August 2007	2	147	1.4
	(Farm Development)	Wet	September-October 2007	5	147	3.4
		Dry	December 2007	12	147	8.2
		Dry	February 2007	3	147	2.0
G_5	Maize farm	Wet	August 2008	11	147	7.5
	(farmer's plot)	Wet	September-October 2007	21	147	14.3
		Dry	December 2007	30	147	20.4
		Dry	February 2008	19	147	12.9
G_6	Wheat farm	Wet	August 2007	3	147	2.0
		Wet	September-October 2007	3	147	2.0
		Dry	December 2007	19	147	12.9
		Dry	February 2008	4	147	2.7
G_7	Soybean farm	Wet	August 2007	2	147	1.4
		Wet	September-October 2007	2	147	1.4
		Dry	December 2007	16	147	10.9
		Dry	February 2008	2	147	1.4

that the species is more abundant in bushland areas compared to crop fields. The species was more recorded in bushland areas (47.7% of the total capture) because it prefers places with better ground cover, abundant and diversified grasses and herbs. (Happold and Happold 1987) have stated that the species avoid exposed areas. *M. mahomet* is mostly dominant in farmlands and better covered areas of bushland and grassland. The species was also categorized as an agricultural pest by Bekele, Leirs and Verhagen (2003) in Ziway, Gadisa and Bekele (2006) in Bilalo area, Datiko, Belay and Bekele (2007) in Arbaminch forests and farmlands and Shenkut, Mebrate and Balakrishnan (2006) in Alleltu Woreda, Ethiopia. *S. albipes* was captured only from the natural vegetation (i.e. forests, bushland and grassland). Yalden, Largen and Kock (1976) described the species to be associated with more of the natural vegetation. Bekele (1995) and (1996) also explained the species as widespread in forests (Menagesha State Forest) and bushy vegetation. Wube (2005) described the species as more abundant in bushland areas than in crop fields. *T. robusta* was widely distributed in the bushland, grassland and also in farmlands. Bekele, Leirs and Verhagen (2003) also described the species as a minor pest in agricultural areas. This species was captured from maize fields and grasslands from central Ethiopia (Bekele and Leirs 1997) and from Arbaminch forests and farmlands (Datiko, Belay and Bekele, 2007). *P. harringtoni* is the least captured (2.0%) rodent species in the study area. Bekele (1996) also trapped the rodent in the Menagesha State Forest with less trap success. As the species has semi-arboreal habits (Yalden, Largen and Kock 1976), it may be underestimated as the traps were set on the ground.

Bushland and grassland habitat types had the highest species richness and diversity. This is consistent with Kotler's (1984) observation that these areas provide enough food and predation risk is low thereby increasing the richness and diversity. The forest habitat was the third richest and diversified habitat. This indicates that the natural vegetation (i.e. bushland area, grassland and forest) supports comparatively more number of species than the crop fields. The high number of species in the natural vegetation resulted from complex vegetation structure and micro-habitats (Iyawe 1988, Avenant and Cavallini 2007). The highest species diversity in the bushland and grassland areas might be associated with better cover than the others. This increases availability of suitable sites for breeding, foraging and refugia (Conde and Rocha 2006, Jacob 2008). The dense forest has relatively less ground cover compared to the bushland and grassland areas. Ground vegetation cover in the bushland and grassland habitats results in increased food supply and avoids predation risk. Hoffmann and Zeller (2005) stress the loss of ground vegetation cover leading to reduced food supply and enhanced predation risk.

Species richness and diversity in the maize farm from the Farm Development relatively supports less number of species than both the natural vegetation and other farmland sites. Extensive application of different insecticides, herbicides, rodenticides and fungicides prevents the ground cover weeds and herbs from growing. This may result in less species diversity and number of rodents. Barrett and Darnell (1967) also described that application of such chemicals would lead to reduced level of rodents as a result of food shortage. This might be associated also with shortage of cover as discussed by Jacob and Brown (2000) and Hoffmann and Zeller (2005) that ground vegetation cover increases food supply and avoids predation risk thereby increasing species number and diversity.

The maize farm from the local farmer's area compared to the grids from the Farm Development showed more species diversity. As the local farmers do not apply chemicals in their area except fertilizers, rodents may take the nearby area as refugia from the Farm Development during the high disturbance period, mechanized farming, and application of insecticides, herbicides, rodenticides and fungicides. Avenant and Cavallini (2007) and Fox and Fox (2000) also described that areas with high disturbance show lowest species diversity. In addition, the base of the farmer maize farm was relatively covered with weeds and herbs, which may be preferred by rodents for shelter. Utrera *et al.* (2000) also explained that subsistence agricultural plots are more variable and showed more species richness and diversity, whereas mechanized farms have less species diversity. At the same time, extensive human activities in different areas of the Farm Development as the result of disturbances leading to the shift in habitat types (Happold 1975).

The present study showed that rodents are not uniformly distributed in the agricultural fields. More number of individuals was observed at the marginal areas (near roads and canals) in the agricultural fields of the Farm Development. Makundi, Massawe and Mulungu (2005) described that human activity, change in vegetation type and clearing of natural forests for agricultural development affect the distribution of small mammals. Local distribution of small mammals is also influenced by food availability and land preparation methods as more number of individuals was restricted to the margins of mechanized farms (tractor ploughing) than in areas of traditional farming practices. Marginal areas such as canals and roads act as refugia for small mammals (Aplin and Singleton 2003). Yeboah and Akyeampong (2001) also described that mechanized farms destroy the burrow of rodents or even kill some individuals resulting in the destruction of their food sources. As a result, the population may be restricted to the margins of the mechanized farms. This also goes in line with Massawe et.al. (2003) that abundance of rodents is influenced by land preparation methods.

The maximum population size in agricultural fields recorded was at a time when crops matured and ready for harvest. Rodents in the surrounding area would move to the agricultural fields during the attractive stage of the crop when food resources are plenty. This is consistent with the observations of Taylor and Green (1976) that matured cereal crops are highly favoured habitats of rodents as they provide cover and food sources. As a result, the area attracts several species of rodents and their population size increases (Gadisa and Bekele 2006). The population size of rodents in the Farm Development decreased after harvest. This is because agricultural areas are unstable, being highly favourable during the matured stage of the crop and become vacant few days after harvest. This results in inadequate food and loss of cover, exposing rodents to their enemies and food shortage. This goes in line with the findings of Gadisa and Bekele (2006) that inadequate food and cover exposes rodents to their natural enemies and is forced to migrate to areas where food and shelter are available. This may partly explain the higher population density in the grassland habitat during the post-harvest season of the agricultural fields.

On the other hand, the population size in natural vegetation was comparatively similar during both wet and dry seasons and relatively supported high number of individuals during the post-harvest session of the agricultural fields. This might be due that natural vegetation relatively is characterized by stability or little disturbance compared to the agricultural fields. This goes in line with Shenkut, Mebrate and Balakrishnan (2006) that nearby agricultural fields relatively support higher number of rodents than agricultural fields during unfavourable periods. Generally, disturbance decreases density of small mammals as discussed by Wijesinghe and Brooke (2005).

The overall trap success in Bir Farm Development and nearby natural habitat was 10.4%. This is low compared to Datiko, Bekele and Belay (2007) who had 17.6% trap success in Arbaminch forests and farmlands and Gadisa and Bekele (2006), who had 15.4% trap success in Bilalo areas, Arsi, Ethiopia. The low trap success of the present study in both the farmland and the natural vegetation might be associated with low population density in the study area. Gadisa and Bekele (2006) also reasoned out that population size affects trap success and for higher population size, trap success was also higher. On the other hand, this is higher than the findings of Bekele (1996) and Shenkut, Mebrate and Balakrishnan (2006) who have revealed only 3.5% and 8.42% trap success, respectively.

The trap success in February 2008 (post-harvest session of agricultural fields) in the wheat, soybean, and maize farms from the Farm Development was less compared to that of the natural vegetation. During the harvesting season, the area will be more disturbed as combiners and tractors move in the process. This causes disturbance and disturbed habitats result in less diversity and population number (Hoffmann and Zeller 2005). As a result, rodents will be forced out to move to less disturbed areas. Makundi, Massawe and Mulungu (2005) also described that agricultural fields are variable and populations fluctuate greatly as resources change in quality and quantity. However, the maize farm from the local farmed areas supported relatively high number of rodents even during the post-harvest season. This might be due to the degree of disturbance during the traditional method of harvest was low and some remnant seeds and fruits may lie on the ground to be available for rodents. On the other hand, the high disturbance in the Farm Development may affect the populations.

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