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# SPECIES RICHNESS, ABUNDANCE AND HABITAT PREFERENCE OF RODENTS FROM KOMTO PROTECTED FOREST, WESTERN ETHIOPIA

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**A study on the species richness, abundance and habitat preference of rodents of Komto Protected Forest was carried out from July, 2009 to Feburary, 2010 encompassing both wet and dry seasons. The study investigates rodent species richness and their habitat preference in the study area. Furthermore, the role of different soil types associated with rodent habitat preference and abundance was also investigated. The study was carried out using Sherman live and snap traps in maize farm, grassland, bushland and forest habitats. A total of 312 individual rodents (live traps) and 66 (snap traps) were captured over 2352 and 1200 trap nights, respectively. The species composition and relative abundance were: *Stenocephalemys albipes* (48.4%), *Lophuromys flavopunctatus* (27.6%), *Lemniscus. striatus* (10.3%), *Pelomys harringtoni* (7.7%), *Rattus rattus* (5.1%) and *Mus mahomet* (0.9%). In addition, a shrew *Crocidura flavescens* was also captured. *Mastomys natalensis and Arvicanthis* species were absent which was unexpected as these species were most common in sub-Saharan Africa. Most of the rodent species preferred grassland and maize farm to bushland and forest. Bushland and forest habitats provided more number of individual rodents with few species. This is because environmental variables, for example, plant species composition might not favor all animals equally. Males comprised 52.9% and females 47.1% of the total capture. Among the total rodents captured, adults, subadults and juveniles comprised 60.6 %, 28.8% and 10.6%, respectively. Loamy soil formed the grassland and forest habitats, whereas the maize farm had sandy clay soil. Active or new burrows were not recorded in all habitats during the wet season. This might be a mechanism of avoiding the effect of flooding, and due to the presence of suffcient ground cover in wet season. However, during both seasons, new burrows or/and abandoned burrows were not recorded from grassland and forest habitats because of sufficient ground cover. Therefore, the effect of soil should be considered in ecological based rodent management in agricutural system.**

**Keywords**: Diversity, Ethiopia, habitat preference, Komto Protected Forest, rodents

## INTRODUCTION

Mammals are evolutionarily the most successful groups of animals with the possible exception of arthropods (Stanbury, 1972). Among mammals, the order Rodentia represents the most diverse group (Kingdon, 1997; Vaughan *et al*., 2000). Approximately, 44% of all mammals are rodents with 30 extant families (Casanovas-Villar, 2007), 468 genera and about 2,052 species (Nowak, 1999). Rodents of Africa are the most ubiquitous and numerous among mammals (Delany, 1986). There are about 14 families, 89 genera and 381 species of rodents in Africa (Singleton *et al.,* 2007). Ethiopia has varieties of different species of animals and plants. The country is known in having diverse faunal community. The diverse topographic features of Ethiopia produce a range of climate which affects the distribution of both plants and animals (Yalden and Largen, 1992). In Ethiopia, there are 84 species of rodents that account for 30% of all mammalian species (Afework and Leirs, 1997). Rodents are cosmopolitan in distribution and show great diversity in morphology, ecology and behavior (Delany and Happold, 1979). Rodents breed rapidly and make quick response to environmental changes. Their small body size, fast life history and behavioral plasticity enables them respond quickly to habitat qualities such as climate, food, vegetation cover and rainfall. Their response to climatic changes depended on their dispersal ability and acclimatization (Auffray *et al*., 2009). Rodents are good subjects for study because of their great ecological values such as pruning vegetation, aerating soil, spreading pollens, seeds and fungal spores allowing colonization of new habitats and habitat modification (Kingdon, 1997; Pearson *et al*., 2001). They also have an economical and medical value. Their study is very easier as they have short lifespan (Delany, 1986; Kingdon, 1997). Rodents are a good source of food in many parts of Africa. For instance, they make up the most important component of the diet of the Gumuz indigenous people in Ethiopia (Tadesse *et al*., 2008). Rodents are also important as predators of invertebrates and link between primary producers and secondary consumers (Avenant and Cavallini, 2007). Furthermore, they play an essential role as prey for reptile, bird and mammal predators.

The distribution and abundance of organisms are influenced by the interplay of abiotic and biotic factors to varying degrees (Brown, 1984). Several habitat variables such as foliage height, vegetation cover (Rosenzweig and Winakur, 1969), soil structures and types (Massawe *et al.,* 2008) are some of the several factors that affects rodents by reducing ground cover, food and resources(Silva *et al.,* 2005). This lowers fecundity, increases predation risk and affects abundance of rodents in a given habitat (Grant *et al.,* 1982). Habitat selection of small mammals has an adaptive basis. Habitat preference is determined primarily by the type of vegetation cover available (Iyawe, 1988). But, as revealed by Suarez-Gracida and Alvarez-Castaneda (2009), isolated environmental factors were not adequate to distinguish rodent abundance, species composition and habitat preference. Properties of soil are very important in rodent population ecology (Rhodes and Richmond, 1983). Even though, the properties of soil play a great role in small mammal ecology, several ecologists neglect the role of soil properties (Gibson *et al*., 1990). Grant and French (1980) stated that the study of small mammal ecology is incomplete without considering the role of soil in structuring small mammal populations. Soil texture, moisture, aeration, soil chemical contents, soil fertility and soil types have direct and indirect effect on the distribution and abundance of animals. Soil directly affects the distribution of fossorial mammals by providing shelter and indirectly by affecting the distribution of plants (Hardy, 1945).

In Ethiopia, limited areas were extensively surveyed for the diversity of small mammals (Yalden and Largen, 1992). Several studies have been restricted to the northern, southwestern, southeastern highlands and central parts of the country (Yalden, 1988; Afework, 1996a,b; Afework and Leirs, 1997; Tilaye, 2005; Tadesse and Afework, 2008). This might be because of the remoteness of the area as well as the inconvenience and inaccessibility of transportation to reach the region. There are several scientific reports on mammals of the country in general but have been neglected from the western parts of Ethiopia. Hence, its faunal community is poorly known. Therefore, there is a need for survey of this region where the diversity of small mammals were not sufficiently investigated. The present study, therefore, aims to fill the gap on species composition and habitat preference of small mammals from the western part of Ethiopia. Furthermore, the study focused on the effect of soil on small mammal ecology which provides a cue for rodent control systems in agro-economy and to design rodent control measures on a local scale.

## THE STUDY AREA

The study was carried out in Komto Protected Forest in the Oromia Regional State of East Wollega Administrative Zone. It is located about 330 km west of Addis Ababa and 12 km east of Nekemte town. The study area is situated at 9$^{o}$ 05' 10" – 9$^{o}$ 06' 35" N latitude and 036$^{o}$ 36' 47" – 036$^{o}$ 38' 10"E longitude with an elevation ranging from 2,135 to 2,482 m asl (Figure 1). The study area was established as protected area in 1991 with an estimated total area of 9,100 ha including natural forests, plantations and encroached areas. At present, because of encroachments (settlement of people in and around the forest), agricultural expansion and logging of trees for charcoal and timber production, the area of the forest has been reduced to about 500 ha. The study area is characterized by warm temperate (Woina Dega) climatic condition and receives a unimodal annual rainfall. The rainy season mostly extends from April to October with maximum rain from June to August. The mean annual rainfall of the area obtained from 1998 to 2007 was 2,031 mm. The mean minimal temperature registered was 12.2$^{o}$C and the mean maximum was 27.9$^{o}$C.

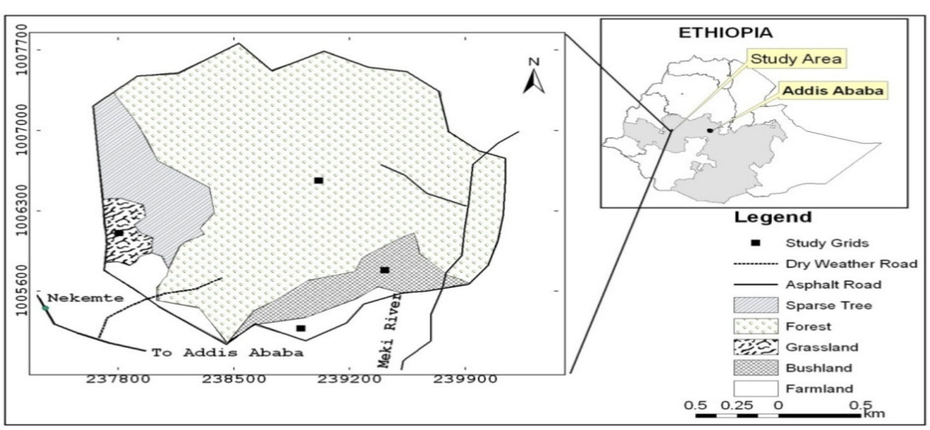


**Figure 1.** Map of the study area

Komto Protected Forest consists of broad leafed and evergreen moist afromontane forests which include: *Pouteria adolfi-friedrici*, *Syzigium guineense* ssp. *afromontanum*, *Maesa lanceolata*, *Maytenus undata*, *Teclea nobilis* and *Croton macrostachyus* tree species. The ground cover is dominated by *Hypoestes forskaolii* and few seedlings of dominant tree species. Extensive agricultural expansion was observed at the periphery of the forests. The most common crops that are cultivated around the study area are teff, wheat, maize, barley and sorghum. The grassland is dominated by *Hyparrhenia hirta* with *Medicago polymorpha, Medicago sativa, Cynodon aethiopicus* forming understory covers. The bushland is mostly covered by *Hypoestes forskaolii* species with *Medicago polymorpha* and *Medicago sativa* forming understory covers. Soil types were described separately for all habitats (Table 2). Detailed habitat description for each habitat is given in Table 1.

Table 1. Habitat description of the trapping grids

| Habitats | Dominant and understory plants species | Description | |
|---|---|---|---|
| | | Wet season | Dry season |
| Maize farm | *Zea mays*, *Guizotia scabra, Bidens camporum, Digitaria velutina, Setaria megaphyla* | Ground is covered with weeds (grass and herbs). The maize plants gave ground cover. There are grass covers at the edge. No burrows were recorded. | Harvested, dried, falling and slightly decomposed maize plants covered the ground. Dry grasses are distributed sparsely. Limited ground cover but remnant grasses at the edge. Ground cover was generally poor. 11 new burrows were recorded. |
| Grassland | *Hyparrhenia hirta, Medicago polymorpha, Medicago sativa, Cynodon aethiopicus, Pennisetum thunbergii, Digitaria velutina* | Grasses (30 to 50 cm long) and very dense understory covers. Areal cover contains grasses and several other herbs. All land covered except few piled soil from burrow sites of mole rats. Understory cover is very thick and dense. No burrows were recorded. | Grasses were about 2 m high and thick. There is no variation in ground cover from wet season except that all the grasses and other understory species are dried up especially at the last trapping session. No burrows were recorded. |
| Bushland | *Vernonia auriculifera, Hypoestes forskaolii, Medicago sativa, Cynodon aethiopicus, Medicago polymorpha* | Fairly distributed bushes of about 1.5 to 2 m long, wood and leaf debris on the floor. Large *Ekebergia capensis* and *Croton macrostachus* in the grid. Ground is mostly covered with few grasses. Several herb species make close understory cover under *Hypoestes forskaolii* species. Generally ground cover was moderate. 3 abandoned burrows were recorded. | Slightly shed bushes, dried grass species and other understory covers are reduced as the result of intermittent trampling of cattle. Grass patches at the floor of the bushes and sparsed *Hypoestes forskaolii.* Generally ground cover was sparse. 5 new burrows were recorded. |
| Forest | *Hypoestes forskaolii, Urtica simensis, Girardinia diversifolia* | Long tree species above 30 m high form closed canopy. Other trees of about 5 m high forming secondary layer under the tall trees. Ground covered by *Hypoestes forskaolii* and young seedlings of dominant trees. It also contains leaf and epiphyte debris. The floor is moist and damp. Understory cover is moderate. No burrows were recorded. | The densities of *Hypoestes forskaolii* species decreased. Understory cover was sparse. But tall tree species that form secondary forest layer serve as a good ground cover and shade from a distance. There were no grasses. Ground cover was better than bushland and maize farm. No burrows were recorded. |

## MATERIALS AND METHODS

The study was carried out during July, 2009 to February, 2010 encompassing both wet and dry seasons. Sherman live traps and snap traps were used to trap rodents in the Maize farm, grassland, bushland and forest. A permanent trapping grid (70 X 70 m) was set in all representative habitats and 49 Sherman live traps were used per grid during the entire trapping sessions. All habitats were sampled sequentially one after the other. Traps were baited with peanut butter and set for three consecutive nights (Afework , 1996a, b). Traps were checked twice a day, early in the morning hours (0700-0800 h) and late afternoon hours (1700-1800 h). A single trap was placed at each trap station and labelled with a different number. Trapped rodents were removed, placed in a transparent polythene bag and weighed to the nearest gram using Pesola spring balance. Rodents were identified to species level, sexed and approximate age was determined (Adult, subadult and juvenile). Trapped rodents were marked by toe clipping and released at the point of capture for further recognition. Marked and recaptured individuals were not counted as a new individual or species. Twenty five snap traps were used along with Sherman live traps to collect data for stomach content analysis, both during the wet and dry seasons. Each snap trap was spaced at about 10 m interval along five transect lines in all habitat types. Trap lines were also spaced about 10 m from each other and about 200 m away from the live trapping grids. Snap traps were baited with peanut butter and set in different habitat types for three consecutive nights. Snap traps were shifted randomly at a distance were capture independence can be insured during each trapping sessions in order to assess rodent species that might exist in the different habitats. Snap traps were checked twice a day after Sherman live traps were checked.

The dominant plant species, dominant understory species, soil texture and soil types were collected. Except for soil texture, vegetation parameters were described qualitatively following vegetation inventory and description methods of Whites and Edwards (2000). A qualitative description describes a habitat's most obvious features subjectively instead of numbers. About 0.5 kg of eight soil samples was taken randomly and diagonally across the two opposite angles of each grid at the depth of 30 cm. Thirty two soil samples were collected and packed in plastic bags for further soil texture analysis at Nekemte Soil Research Laboratory Centre. Soil samples from the same grid were mixed thoroughly in the laboratory. About a kilogram of soil sample was taken from each grid for laboratory processing. Soil particle size analysis and their percentages were obtained by using the hydrometer method. Soil types were characterized by using soil texture triangle (Gee and Bauder, 1986). Besides, rodent burrows, the positioning of burrows and sites selected for burrowing were surveyed, during each trap session, following their track lines during both seasons. Diet analysis was carried out following the methods of Ellis *et al*. (1998); Kronfeld and Dayan (1998); Demeke *et al*. (2007). Stomach contents were spread onto a petridish and mixed thoroughly. The contents were poured in 0.25 mm sieve and washed with a jet of water to remove the digested food and fine particles for proper identification. The stomach contents were dried in open air for a day. A preliminary examination was carried out to identify the most common types of food items. Four slides were prepared for each sample and the contents were put on a glass slide to observe the type and proportion of food items under dissecting and compound light microscopes. Each food fragment was counted from the entire slide, summed up and converted to the mean percentage for each sample. Relative abundance was calculated as catch per unit effort excluding recaptures. Species richness is determined by the number of species captured at each grid. Habitat preferences of rodents were inferred by comparing the number of captured rodents in each habitat. Shannon-Wiener diversity Index (H'), Simpsons Similarity Index (SI) and Chi-square test were used to compare data across habitats.

## RESULTS

Grassland, bushland and forest habitats had loamy soil with similar percentage of soil particles. But maize farm has sandy clay loam with sand particles comprising the largest portion (Table 2).

Table 2. Physical properties of soil types for each habitat

| Habitats | Particle size analysis (%) | | | Soil texture |
|---|---|---|---|---|
| | Clay | Sand | Silt | (Soil types) |
| Maize farm | 28 | 53 | 19 | Sand clay loam |
| Grassland | 18 | 35 | 47 | Loam |
| Bushland | 22 | 37 | 41 | Loam |
| Forest | 22 | 35 | 43 | Loam |

There were no burrows in maize farm during the wet season. Burrows were absent in both grassland and forest habitats during both seasons. However, eleven active burrows during the dry season were recorded in the maize farm. Similarly, three abandoned and five active burrows were recorded in the bushland habitat during the wet and dry seasons, respectively. The difference in the number of burrows between habitats and seasons was significant ($\chi 2=19.94$, df=3 $P<0.005$ and $\chi 2 = 8.90$, df=1, $p< 0.005$), respectively.

A total of 395 captures of 312 individual rodents were made in 2352 trap nights from the four selected habitat types. Rodents trapped by Sherman live traps were: *Stenocephalemys albipes* 151 (48.4%), *Lophuromys flavopunctatus* 86 (27.04%), *Lemiscomys striatus* 32 (10.3%), *Pelomys harringtoni* 24 (7.7%), *Rattus rattus* 16 (5.1%), and *Mus mahomet* 3 (0.9%). In addition, a species of *Crocidura flavescens* was captured from the grassland and forest habitats. *S. albipes* and *L. flavopunctatus* were the most widely distributed species whereas *R. rattus* was the least. Bushland habitat had the highest trap capture (30.1%). However, it is represented only by two species. The lowest individual captures but with the highest number of species was from grassland (23.1%) and maize farm (19.6%). Species richness varied across habitats from a minimum of 2 species in bushland to a maximum of five species in the grassland and maize farm habitats. Simpson's Similarity Index (SI) showed less than 50% similarity between habitat types (27.0%). Shannon-Weiner diversity Index (H') showed high species diversity in the grassland and maize farm.

*S. albipes* (43.7%) highly preferred the bushland habitat. However, *L. flavopunctatus* (38.4%) and *P. harringtoni* (62.5%) preferred a forest habitat. *R. rattus* (100%) and *M. mahomet* (66.7%) preferred maize farm, whereas *L. striatus* (62.5%) preferred grassland habitat (Table 3). There was a significant difference in the number of *S. albipes*, *L. flavopunctatus, P. harringtoni*, *L. striatus,* and *R .rattus* captures between habitats ($\chi 2=32.49$, df=3, $P<0.005$; $\chi 2=25.89$,df=3, $P<0.005$; $\chi 2=27.0$, df=3, $P<0.005$; $\chi 2=48.0$,df=3, $P<0.005$ and $\chi 2=36.0$, df=3, $P<0.005$, respectively) but the captures of *M. mahomet* was insignificant ($\chi 2=3.66$, df=3, $P>0.005$).

**Table 3**. Habitat preference of rodent species in different habitats (Figures in bracket show % occurrence)

| | Species | | | | | |
|---|---|---|---|---|---|---|
| Habitat types | S. a | L. f | P. h | R. r | L.s | M. m |
| Maize farm | 29(19.2) | 2(2.3) | - | 16(100) | 12(37.5) | 2(66.7) |
| Grassland | 19(12.6) | 23(26.7) | 9(37.5) | - | 20(62.5) | 1(33.3) |
| Bushland | 66(43.7) | 28(32.6) | - | - | - | - |
| Forest | 37(24.5) | 33(38.4) | 15(62.5) | - | - | - |

S. a= *S. albipes,* L. f= *L. flavopunctatus,* R. r= *R. rattus,* P. h= *P. harringtoni,* L.s= *L. striatus,* M.m= *M. mahomet*

There was no variation in the number of species between seasons. However, more rodents were captured during the wet season than the dry season. The overall abundance of rodents between wet and dry seasons was 196 (62.8%) and 116 (37.2%), respectively. The difference in the abundance between seasons was significant ($\chi 2=20.51$, df= 1, $P<0.01$). Among the 312 live-trapped individuals, males comprised 165 (52.9%) and females 147(47.1%). However, the difference was not significant ($\chi 2=1.04$, df=1, $P>0.05$).

Out of the 312 individuals trapped, 60.6% were adults. Subadults and juveniles comprised 28.8% and 10.6%, respectively. Variation in juvenile captures between seasons was significant ($\chi 2=5.12$, df=1, $P<0.05$). Adult males comprised 92 (29.5%), followed by adult females (non-pregnant or non-lactating) 75 (24.0%). Juvenile females comprised 3.8% and juvenile males 6.7%). Adult females (non-pregnant or non-lactating) constituted 3.2% whereas pregnant or lactating females had 0.9% (Table 4). Abundance between pregnant or lactating females and non-pregnant or non-lactating adult females showed significant variation ($\chi 2=28.86$, df=1, $P<0.005$). Pregnant or lactating females, juvenile males and juvenile females had the lowest trap success (0.9%, 0.9% and 0.5%, respectively). Overall trap success increased with age in both sexes**.** The trap success of each male reproductive group was greater than their female counter age groups**.**

**Table 4.** Age, sex groups and trap success of live-trapped rodents from the study area (Am= Adult males, Af= Adult females, P/Lf= Pregnant or lactating females, Sam= Subadult males, Saf= Subadult females, Jm= Juvenile males, Jf= Juvenile females, - indicates absence of capture)

| | Trap success | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | Am | Af | P/Lf | Sam | Saf | Jm | Jf | Total |
| *S. albipes* | 33 | 36 | 12 | 23 | 18 | 18 | 11 | 151 |
| *L. flavopunctatus* | 30 | 23 | 4 | 15 | 13 | 1 | - | 86 |
| *R. rattus* | 7 | 2 | 2 | 4 | 1 | - | - | 16 |
| *P. harringtoni* | 8 | 4 | 3 | 6 | 3 | - | - | 24 |
| *L. striatus* | 12 | 9 | 1 | 4 | 3 | 2 | 1 | 32 |
| *M. mahomet* | 2 | 1 | - | - | - | - | - | 3 |
| Total | 92 | 75 | 22 | 52 | 38 | 21 | 12 | 312 |
| Abundance (%) | 29.5 | 24.0 | 7.1 | 16.7 | 12.2 | 6.7 | 3.8 | 100 |
| Trap success (%) | 3.9 | 3.2 | 0.9 | 2.2 | 1.6 | 0.9 | 0.5 | 13.3 |

The highest number of individuals was obtained for *S. albipes* and the lowest was for *M. mahomet*. Trap success was high in the bushland habitat (16.0%) and low in the maize farm (10.4%). The difference in the number of rodent captures was significant between habitat types ($\chi2=8.07$, df= 3, $P<0.05$). Mean trap success during the wet and dry seasons was 16.7 % and 9.9%, respectively. High number of rodents was captured during the wet season from bushland (with 20.7% trap success) and low in the grassland (6.8%) during the dry season. The population number of rodents per habitat during the wet and dry season was given in Figure 2. The highest number of individual rodents was trapped from bushland and maize farm habitats during the wet and dry seasons, respectively. However, the lowest individual captures were recorded from maize farm during the wet season and from grassland during the dry season.

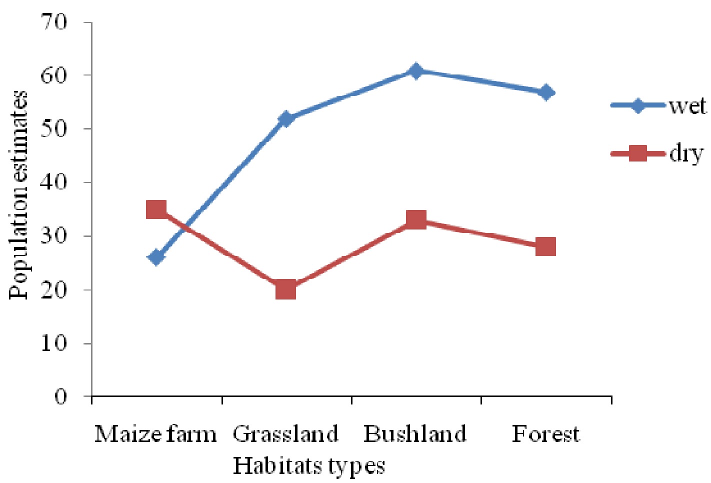


**Figure 2.** Seasonal population estimate of rodents per habitat

Maximum embryos were counted from *S. albipes* and least from *L. striatus.* The number of embryos in the left and right uterine horns varied within species. The number of embryos in the left uterine horn mostly exceeded that of the right horn in all other species. Moreover, the number of embryos in each uterine horn of *S. albipes* and *R. rattus* was reduced during the dry season. Diet items were categorized as monocot seeds, dicot seeds, leaves, stems or roots, worms and arthropods. Plant matters were the dominant food items identified from all rodent species. The consumption of worms and arthropods increased more during the wet season than during the dry season. *R. rattus* usually preferred plant matter to animal matter. Monocot and dicot seeds were mostly consumed by *R. rattus*. *S. albipes* mostly preferred monocot seeds, dicot seeds and leaves. However, considerable amount of arthropods were consumed during the wet season. *P. harringtoni* mostly consumed monocot seeds, leaves and stems or roots. Arthropods and worms were highly consumed by *L. flavopunctatus.* Unlike other rodents, few hairs were observed in the stomach of *L. flavopunctatus,* only during the dry season and in *L. striatus* and *P. harringtoni* during both seasons.

## DISCUSSION

The absence of *Mastomys natalensis and Arvicanthis* species from the present investigation was unexpected. Because several studies confirmed the wider existence of *M. natalensis* in eastern Africa (Massawe *et al*., 2008; Makundi *et al*., 2007) and *Arvicanthis* species in Ethiopia (Afework and Leirs, 1997; Demeke *et al*., 2007; Tadesse *et al*.,, 2008). The absence of both species might be ascribed to a prolonged habitat disturbance and application of rodenticides.

The present study demonstrates lowest species richness of rodents in the Komto Protected Forest compared to several other studies in Ethiopia (Afework Bekele, 1996b; Demeke, 2007; Tadesse *et al.,,* 2008). This might be attributed to anthropogenic effect. Grassland and maize farm had the highest species richness and diversity. Grassland might be preferred than maize farm, bushland and forest habitats because of its sufficient understory cover with grasses and herbs such as *Medicago polymorpha, Medicago sativa, Cynodon aethiopicus, Pennisetum thunbergii*, *Digitaria velutina* and its well protection from grazers. Moreover, at the beginning of the wet season, newly regenerated grasses after harvest attracted rodent species because fresh grasses might be nutritionally high and easily palatable. Consequently, rodents might increase due to immigration and or reproduction during the wet season. As noted by Auffray *et al*. (2009), rodents respond to habitat quality such as food, vegetation cover and rainfall. The number of rodent catch during the dry season decreased. This might suggest that fully grown and dried grasses were not preferred for food compared to the fresh ones. Therefore, rodents migrate to the nearby habitats in search of food for wet and succulent plants that might also compensate their water need. Furthermore, juvenile mortality might be the cause for reduction of rodents during the dry season.

High species richness in the farmland agrees with the findings of Jeffrey (1977) and Caro (2001). Availability of seeds following seed fall from harvested remains and as a result of prolonged rain during the study period might be the cause for their increase during the dry season. Caro (2001) noted increased species richness in the garden and farmlands during the dry season when several food types were available. Generally, species richness in the grassland and maize farm habitats might also increase due to sporadic movement of rodents to the area.

The forest floor is mostly covered by *Hypoestes forskaolii* and few *Girardinia diversifolia* and *Urtica simensis.* Though *Hypoestes forskaolii* is a dominant species, the bushland also harboured *Cynodon aethiopicus, Medicago sativa* and *Medicago polymorpha* that forms understory covers. However, increased habitat homogeneity in the bushland and forest habitats favored only *S. albipes* and *L. flavopunctatus,* discouraging others. The result also suggested that diverse species of rodents may respond differently to different degrees of habitat heterogeneity and plant species composition. An environmental factor, for instance plant species composition, might not favor all animals equally. This is because all plants species are not used as diet for all animals. This was inferred from the exclusive existence and abundance of *S. albipes* and *L. flavopunctatus* (except few *P. harringtoni*) in the bushland and forest. The reduction of rodent species richness in the natural habitat might be an indicator of disturbance and habitat homogeneity.

The present study revealed that having enough ground cover alone might not be the only cause for high species richness and abundance of small mammals. Vegetation cover is not preferred only for sheltering but also for food. But all vegetation cover might not be preferred for food. Habitats with sufficient ground cover might have high species richness and abundance if most of the pant species are preferred for diet. As stated by Rhim and Lee (2001), there is a relationship between tree species composition and habitat preference of rodents. Besides, Brown *et al*. (1972) found the influence of certain plant species on the faunal composition of a given habitat. This is because the foraging preference of rodents depends on the presence of secondary plant compounds (Jung and Batzli, 1981). As reported by Bozinovic (1997), herbivores select nutritionally rich plants but poor in fibres and secondary metabolites. Fibres and secondary metabolites decrease the nutritive quality of food and digestion. Therefore, during the present study, the dominance of *Hypoestes forskaolii* species in the bushland and forest habitats might have discouraged the other rodent species. *S. albipes* showed high preference for bushland during the wet season and least for grassland during the dry season. However, *L. flavopunctatus* and *P. harringtoni* showed high preference for the forest habitat during the wet season. *L. flavopunctatus* did not show preference for maize farm during the wet season and *P. harringtoni* totally neglected the maize farm. *L. striatus* preferred grassland and showed less preference for maize farm and grassland during the dry season. Though *R. rattus* and *M. mahomet* have a restricted distribution, both species preferred maize farm during the dry season.

Grassland, bushland and forest habitats have loam soil with similar percentage of soil particles but with different plant species composition and degrees of ground cover. However, maize farm has sandy clay loam soil with high percentage of sand particles. As reported by Massawe *et al*. (2008), loam soil is mostly preferred by *M. natalensis* because of its easy burrowing, good aeration and drainage. Loam soil offers little resistance to burrowing as it is less compacted for tunnel formation (Jameson, 1949). Furthermore, Hardy (1945) reported that rodents differ in their digging abilities usually preferring soft soils. Though loam soil is hospitable and suitable for burrowing, no burrows were observed in the forest and grassland habitats during both seasons. However, 11 and 5 active burrows were recorded in the maize farm and bushland, respectively, during the dry season. Burrows were very close together that might indicate underground connection of tunnels. Increased burrow in the maize farm might be due to ploughing that softened the ground. Moreover, the high percentage of sand particles might decrease the stickiness of soil particles making burrowing easier. The need for burrow construction might also depend on the extent of ground covers. Probably, that is why more active burrows were observed in the maize farm than in the bushland and no burrows in the grassland and forest habitats. Therefore, soil type has a paramount importance in constructing nesting sites whenever ground cover was poor during the dry season. However, rodents need not have to construct burrows in the grassland and forest habitats as the habitats have good ground cover to help them secure their survival during both seasons. Although burrowing is easy during the wet season, no active burrows were observed in all habitats. This suggested that rodents might not use burrows during the wet season because of the availability of vegetation cover and an adaptation against flooding. As described by Ebensperger (1998), construction of burrows could be essential for individuals living in open and more exposed habitat patches. Hence, rodents prefer to take shelter under grasses, vegetation covers and other debris during the wet season and may use burrows when the ground cover is poor. The position of burrowing sites and entrances are oriented in the way that it prevents flooding during the early rainy season and closing of burrows by piled soil. Hence, pilled soil during burrow construction was removed downhill. All observed burrows were constructed near the base of bushes and remnant grass patches relatively at hilly grounds. This makes their survival more secured as remnant grass patches decrease visibility from predators and hilly grounds might prevent flooding during the early rain season. Food obtained away from their burrow sites were collected and consumed at the entrance of burrows. Burrows may also create a safe site for reproduction and survival of young and food hoarding sites.

Trapped rodents varied from habitat to habitat and seasons because of variation in vegetation structure, ground cover and other environmental variables. Changes in habitat structures decrease food availability, ground cover (Juch, 2000) and hence the overall species composition of small mammals. The number of juveniles and pregnant females were higher during the wet season than during the dry season. This confirms that the reproductive periods of most rodents occurred during the wet season as rain influences germination and growth of vegetation that serve as sources of food and shelter. The capture rate was high during September and low in other trapping sessions. This might be due to the optimal rain, temperature and potential food source at the end of the wet season. The number of embryos observed during the wet season exceeded that of the dry season in *S. albipes* and *R. rattus*. This is because the number of implanted embryos and litter size might be related to the availability of food. As described by Boutin (1990), food quality or quantity results in significant change during the time of reproduction, litter size and growth rate. The number of embryos among pregnant females also varied between species. Moreover, the number of embryos in the left and right uterine horns varied between species as noted by Afework (1996a). The number of adults, sub-adults and juveniles decreased during the dry season. This might be due to death as a result of ageing, disease, lack of resource, migration and other environmental conditions.

Trap success varied between habitats and seasons. Trap success increased in the bushland because of large capture rates of *S. albipes* and *L. flavopunctatus*. The mean trap success of the present study area was 13.5% for live trapped rodents which is very low compared to several other studies in Ethiopia. For instance, Demeke *et al*. (2007) and Tadesse et al., (2008), have obtained 17.6% and 38.6% trap success, respectively. Trap success obtained during the wet season (16.7%) was higher than the dry season (9.9%). The low trap success during the dry season may be attributed to a decreased density of species as a result of death and migration due to lack of resources. The bait type has also a considerable influence on the trap success. Barnett and Dutton (1995) stated that loss of bait to non-target taxa also influences trap success. During the present study, the oiliness nature of peanut butter attracted ants to the traps and caused disturbance to rodents around the traps, especially during the wet season. In addition, low population and bait types might be the cause for the low trap success. More males were trapped than females which are attributed to their larger home ranges (Cross, 1977). As revealed by Hansson (1975), adult males are more likely to enter traps than adult females because males might be more active and have a higher probability of being captured. Moreover, trap success increased with age in both sexes. As reported by Barnett and Dutton (1995) and Barnett *et al*.

(2000), pregnant or lactating females and juveniles have lower trap success as they are less likely to move long distance and exploit different habitats.

Increased number of *S. albipes* might be attributed to favoring the habitats compared to other species. Stomach content analysis revealed a variety of food items consumed by rodents. The result obtained from the stomach content showed the omnivorous and granivorous feeding habit of the species. As reported by Campos *et al*. (2001), the feeding ecology of small mammals is highly diverse. Such diversified feeding habits of rodents might have great contribution for their successful species richness and diversity while the ongoing global environmental changes question the sustainability of biodiversity. Consumption of arthropods and worms generally increased more during the wet season than the dry season. This was consistent with the relative abundance of invertebrate species during the wet season. Food items were generally identified as plant and animal matters. Arthropods were identified by their heads, wings and legs whereas worms were identified by their head parts and body segmentations. Plant matters such as roots or stems and leaves can be identified by slightly colored cells as a result of alcohol and the structure of epidermal cells. Maximum amount of arthropods and worms were observed in the stomach of *L. flavopunctatus* during the wet season. *L. flavopunctatus* consumes high number of insects agreeing with the previous reports by Cole (1975). The presence of invertebrate taxa in the diet of *L. flavopunctatus* revealed their preference for moist and damp areas as it favors the existence of invertebrates. This unusual consumption of invertebrates may allow the species to occupy areas not usually suitable for rodents (Clausnitzer *et al*., 2003). The consumption of plant matters reached maximum during the dry season. This might be due to the decreased utilization of animal matters as the result of the decline in soil dowelling invertebrates and arthropods during the dry season. The increased consumption of succulent stems or roots during the dry season might compensate the need for water. More dicot seeds were consumed during the dry season as seeds increased following seed fall since mid-September. However, monocot seeds were consumed more during the wet than the dry season. *L. striatus* was the second rodent species that mostly consumed arthropods during both seasons. As revealed by Clausnitzer *et al*. (2003), the occasional consumption of insects, especially during the breeding season has been recorded in many African rodents including *L. striatus, A. niloticus* and *M. natalensis*. Similarly, Demeke *et al.* (2007) reported that *L. striatus* was highly dependent on insects during the wet season. *L. striatus* consumed more leaves during the dry than the wet seasons and no roots or stems during the wet season.

Few hairs were observed in the stomach of *L. flavopunctatus*, *L. striatus* and *P. harringtoni*. As revealed by Clausnitzer *et al*. (2003), vertebrate remains were observed occasionally in the stomach of *L. flavopunctatus,* which appeared to be the cannibalized remains of other snap trapped rodents. However, during the present study, only hairs were observed in three rodent species and attributed to grooming as they are social animals rather than cannibalism. As described by Ebensperger (1998), adult rodents spend most of their time in close association with other conspecific individuals usually sharing feeding areas and burrow systems.

During the present study, though rodent pest diversity and species composition were low, information about their habitat preference is fundamental for conservation and management program. However, further investigation on the habitat preference of each rodent is recommended to design their control measures. Changes in small mammal species composition affect predator communities and the ecological roles that the small mammals play in seed dispersal, insect predation and herbivory.

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