Diversity and habitat association of small mammals in Aridtsy forest, Awi Zone, Ethiopia

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ABSTRACT

Here, we conducted a survey to examine the diversity, distribution and habitat association of small mammals from August 2011 to February 2012 incorporating both wet and dry seasons in Aridtsy forest, Awi Zone, Ethiopia. Using Sherman live traps and snap traps in four randomly selected trapping grids, namely, natural forest, bushland, grassland and farmland, a total of 468 individuals comprising eight species of small mammals (live traps) and 89 rodents of six species (snap traps) were trapped in 2352 and 1200 trap nights, respectively. The trapped small mammals included seven rodents and one insectivore: *Lophuromys flavopuntatus* (30.6%), *Arvicanthis dembeensis* (25.8%), *Stenocephalemys albipes* (20%), *Mastomys natalensis* (11.6%), *Pelomys harringtoni* (6.4%), *Acomys cahirinus* (4.3%), *Lemniscomys zebra* (0.2%) and the greater red musk shrew (*Crocidura flavescens*, 1.1%). Analysis showed statistically significant variations in the abundance and habitat preferences of small mammals between habitats during wet and dry seasons.

Keywords: Abundance; Aridtsy forest; Awi Zone; Diversity; Distribution; Small mammals

INTRODUCTION

Varied climatic conditions helped create a diversity of ecosystems in terms of climate, topography and vegetation, which are home to a large number of endemic species. On a global scale, Wilson & Reeder (2005) estimated some 5 416 mammalian species, of which a large number were small mammals. To date, rodentia remains the largest order of mammals in the world comprising 2 277 species 41% of which the small mammal species, 481 Genera and 33 Families (Wolff & Sherman, 2007). Insectivore fauna are also diverse, having 429 species worldwide, of which 312 are shrews, 140 of which are found in East Africa (Kingdon, 1997). Small mammals such as rodents and insectivores are highly mobile animals whose distribution is influenced by the altitude and vegetation types (Mulungu et al, 2008; Prakash & Sing, 2001) as well as human disturbance (Liu et al, 2008) and the presence of large mammals (Hoffmann & Zeller, 2005), whose intensive grazing degrades the land and makes it uninhabitable for rodents because of loss of cover and food (Baker et al, 2003; Vieira, 2003; Liu et al, 2008). Rainfall also plays a significant role in the occurrence of high population of rodents during the wet season (Linzey & Kesner, 1997; Prakash & Sing, 2001; Tadesse & Afework, 2008). [1]

Previous reports of high faunal biodiversity in Ethiopia highlight the existence of a large number of species of mammals and other higher vertebrates (Jacobs & Schloeder, 2001; Melaku, 2011; Yalden & Largen, 1992). In line with global trends, of the 284 mammal species of Ethiopia, a large share (84, 29.6%) of species are rodents (Afework & Leirs, 1997). Out of the total rodent species of the country, the endemic rodent species comprise 21% (Afework, 1996), which make up nearly half of the endemic mammals of Ethiopia (Afework & Corti, 1997). Endemicity itself is associated with particular faunal regions or habitat types (Yalden & Largen, 1992), but despite numerous reports on the small mammals of Ethiopia (Afework & Corti, 1997; Afework & Leirs, 1997; Yalden et al, 1976; Yalden & Largen, 1992), no attempt was made to investigate the population status and habitat association of small mammals in Aridtsy forest in Awi Zone. Accordingly, in the present study we report on a survey undertaken aimed at collecting data on the diversity, distribution and habitat association of rodents and shrews in this largely unexplored habitat.

MATERIALS AND METHODS

Study area

This study was conducted in Aridtsy Forest in Awi Zone,

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northwestern Ethiopia, Amhara Regional State. Aridtsy Forest is located in Ankesha Guagusa Woreda, about 30 km from the main administrative Zone in Injibara). The area coverage of the forest is around 127 ha, and it is a natural forest. The study area of our survey was located between N10°43'40"—10°44'20" and E36°46'40"—36° 48'0" (Figure 1). The maximum and minimum temperature and the mean annual rainfall near the study site at Ayehu agricultural development station are collected by the Ethiopian National Meteorology Agency. The climatic condition of the study area is in the warm agro-climatic zone. This area has one long rainy season, mainly from early May to mid November, and a dry season from January to April. This particular seasonal difference explains the large variations in average rainfall, with 6.47 mm in February and 240.84 mm in August. In aggregate, annual rainfall of the study area is 2 890.1 mm. Mean monthly temperature also vary, ranging form 9.7 to 32.0 ℃. Suitable agro-climatic conditions allow for the production of different commercial and food crops in the area.

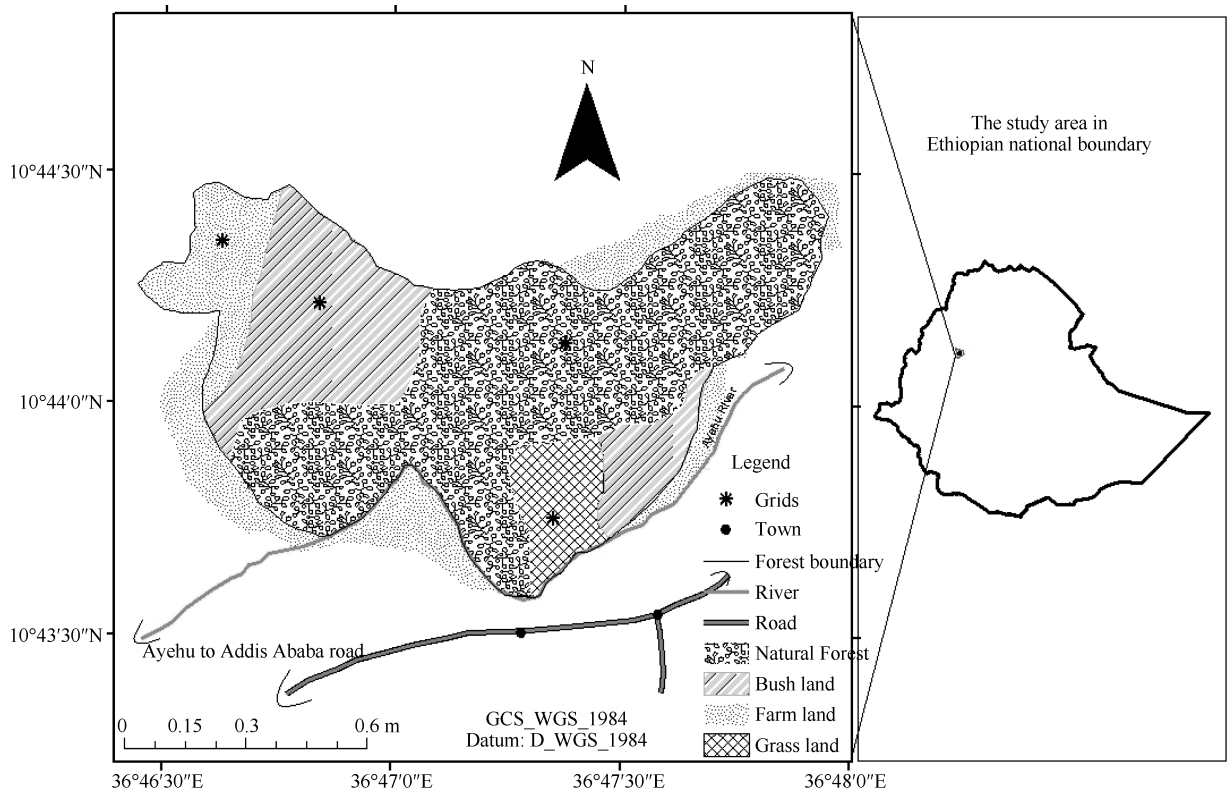

Figure 1 Map of the study area

Methods

Following the preliminary survey, continuous field work on ecological study of small mammals in the study area was carried out during August 8, 2011 to February 3, 2012, covering both wet and dry seasons. Based on the topography and habitat type, four sampling plots were selected, one for each habitat type. The inclusions of the four randomly selected habitats was based on different criteria, including altitudinal differences and vegetation cover were natural forest, bushland, grassland and farmland. In each sampling at each locaiton, permanent trapping stations at 10 m intervals square grid were placed at randomly selected plots and 25 snap traps at an interval of 20 m square grid were used at least 200 m away from the live-trapping sites. Both Sherman live-traps and snap-traps were utilized during the study period, in order to better sample small mammals specifically able to be captured by Sherman live-traps and snap-traps (Lee, 1997).

In each habitat type, a 3 600 m^2 (0.36 ha) live-trapping grid was established. In total, 49 live traps were set over an area of 60 mx60 m positioned at 10 m intervals for each grid. Trapping stations were marked with red plastic tap approximately one meter above the traps. The traps were baited by peanut butter and checked twice daily, early in the morning hours (0600h—0800h) and late in the afternoon hours (1700h—1800h) and rebaited as necessary. For each individual trapped, the grid and trap station number, body mass and sexual conditions were recorded and a toe-clipping was performed. Furthermore, trapped specimens were also distinguished as adults, subadults and juveniles on the basis of weight, pelage colour (which is usually very grey in juveniles). Reproductive condition of males was assessed via examination of scrotal and abdominal testes, while for females conditions were recorded including being

pregnant or with suckling nipples, perforate or imperforate vagina. All live trapped individuals were released with the same site as they were trapped.

Species identification was carried out based on the taxonomic characteristics listed in Nowak (1999), Yalden et al (1976) & Kingdon (1997). Additionally, when species identification was difficult in the field; skin and skull measurements were prepared and compared with the specimens deposited in the Zoological Natural History Museum of Addis Ababa University. Dissection was carried out on the snap trapped specimens for stomach content analysis and in pregnant females for embryo count. Stomach contents were removed and preserved in 5% formalin for diet analysis. The stomach contents were spread onto a petridish and mixed thoroughly, after which the contents were sieved through 0.25 mm sieve, washed by distilled water to remove finely digested food and fine particles for proper identification of the remaining parts and dried in open air for a day. For each sample, four slides were prepared and the contents were put on a glass slide to observe the type and proportion of food items under a compound microscope. The food items were grouped into plant matter (leaves, roots, and seed), animal matter (earthworms and arthropods) and unrecognizable items. From the entire slide, the particles were counted, then summed up and converted to the mean percentage for each sample.

Data analysis

Abundance of small mammals in each habitat was assessed by the percentage of trap success between the seasons. The Shannon-Weiner diversity index was used to estimate the diversity for the small mammals trapped in the study area. In addition, a *Chi*-square test was used to interpret variations of small mammal species in different trapping seasons and grids. Habitat association of small mammal species (rodents and insectivores) was also analyzed using *Chi*-square test. All statistical data were analyzed using SPSS 15.0 (SPSS inc., Chicago, IL, USA).

RESULTS

Results of this study revealed the presence of eight species of small mammals in the study area, of which seven species were the following rodents: *Lophuromys flavopuntatus*, *Arvicanthis dembeensis, Stenocephalemys albipes*, *Mastomys natalensis*, *Pelomys harringtoni*, *Acomys cahirinus* and *Lemniscomys zebra*. The eighth species was an insectivore, the greater red musk shrew (*Crocidura flavescens*). A total of 2 352 trap nights yielded 468 live-trapped individuals. Among 468 live-trapped individuals, 372 individuals were new captures and 96 individuals were recaptures (Table 1). Porcupine (*Hystrix cristata*), bush squirrel (*Parexerus flavovittis*) and hyraxes (*Procavia capensis*) were observed throughout the study period, but not trapped. In addition, indirect evidences of mound of *Tachyoryctes splendens* was observed in study site, especially in the grassland habitat.

Arvicanthis dembeensis, A. cahirinus and *C. flavescens* were not captured from the natural forest both during wet and dry seasons. *Lemniscomys zebra* was exclusively captured from the maize farm during the second dry season. *Lophuromys flavopunctatus*, *S. albipes* and *M. natalensis* were recorded from all habitat types during both seasons (Table 2). *Lophuromys flavopunctatus* was the most abundant species in the bushland habitat, followed by *S. albipes*. *Arvicanthis dembeensis* being the most abundant rodent in the grassland habitat.

There was a significant difference in the number of *L. flavopunctatus* trapped between habitat types (χ^2=42.49, *df*=3, *P*<0.05), *A. dembensis* (χ^2=69.76, *df*=3, *P*<0.05), *S. albipes* (χ^2=40.7, *df*=3, *P*<0.05), *M. natalensis* (χ^2=22.95, *df*=3, *P*<0.05) and *P. harringtoni* (χ^2=12.34, *df*=3, *P*<0.05), but the captures of *A. cahirinus* (χ^2=6.5, *df*=3, *P*>0.05), *L. zebra* (χ^2=3, *df*=3, *P*>0.05) and *C. flavescens* (χ^2=2, *df*=3, *P*>0.05) were

Table 1 Species composition and relative abundance (%) of live-trapped small mammals in wet and dry seasons in the study area (figures in parenthesis are recaptures)

Family	Species	Wet	Dry	Total catch	Relative abundance (%)
Muridae	*Lophuromys flavopuntatus*	69	45	114 (29)	30.6
	Arvicanthis dembeensis	42	54	96 (25)	25.8
	Stenocephalemys albipes	54	20	74 (18)	20
	Mastomys natalensis	37	6	43 (11)	11.6
	Pelomys harringtoni	19	5	24 (7)	6.4
	Acomys cahirinus	-	16	16 (6)	4.3
	Lemniscomys zebra	-	1	1	0.2
Soricidae	*Crocidura flavescens*	3	1		1.1
Hystricidae	*Hystrix cristata*			*	*
Sciuridae	*Parexerus flavovittis*			*	*
Procaviidae	*Procavia capensis*			*	*
Rhizomyidae	*Tachyoryctes splendens*			*	*
Total				372 (96)	100

*: Observed species.

Table 2 Seasonal Species composition, distribution and abundance of live- trapped small mammals from different habitats with both wet and dry seasons

Species	Individuals trapped from different habitats during wet and dry seasons								
	NF		BL		GL		FL		
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Total
Lophuromys flavopunctatus	24	15	31	20	9	8	5	2	114
Arvicanthis dembeensis	–	–	4	5	21	30	17	19	96
Stenocephalemys albipes	13	5	31	10	4	2	6	3	74
Mastomys natalensis	3	1	6	3	4	2	24	–	43
Pelomys harringtoni	6	1	9	3	4	1	–	–	24
Acomys cahirinus	–	–	–	7	–	4	–	5	16
Lemniscomys zebra	–	–	–	–	–	–	–	1	1
Crocidura flavescens	–	–	1	–	1	–	1	1	4
Total	46	22	82	48	43	47	53	31	372
Total/season	68		130		90		84		

–: Absence of trapped individuals; NF: Natural forest; BL: Bushland; GL: Grassland; FL: Farmland.

not statistically significant. The natural forest had the least number of species, while Bushland, grassland and farmland habitats shared similar abundance, all with seven species. There was no significant variation in species abundance among habitats (χ^2=1.08, *df*=3, *P*>0.05). As expected, the number of individuals trapped during the wet season was significantly higher than those trapped during the dry season (χ^2=15.52, *df*=1, *P*<0.05).

The distribution of species varied between the wet and dry seasons in all habitat types. The difference between habitat preference of small mammals during the wet and the dry seasons (Table 2) was statistically significant (χ^2 =20.04, *df*=3, *P*<0.05 and χ^2=13.02, *df*=3, *P*<0.05, respectively), with variation in species diversity between habitat types. Species diversity indices of small mammals were relatively high in farmland and low in natural forest. The result of Shannon-Weiner Index (H') for the species diversity from highest to least was 2.34, 1.55, 1.37 and 1.07 for farmland, bushland, grassland and natural forest, respectively. The variation in species diversity across the different habitat types not statistically significant (χ^2=0.56, *df*=3, *P*>0.05).

Results also showed a marked variation in richness index of small mammal species along with habitat types (Table 3). The highest species richness index was registered by *L. flavopunctatus* with RI value of (0.82) from forest habitat and the lowest by *C. flavescens* (8.7) from the farmland habitat. Among the four habitat types, farmland comprised the lowest species richness index, while both bushland and grassland had the highest value of species richness index; for example, the highest species richness of *A. dembeensis* was obtained from farmland (1.7) and the least was from the bushland (2.41).

During the wet season, more pregnant rodents were trapped (65.8%). One *L. flavopuntatus* gave birth to four youngs inside the trap during the second wet season. A greater number of (25 individuals) pregnant females were caught during the wet season than during the dry season (13 individuals), explaining the significant variation between seasons (χ^2=3.78, *df*=1, *P*<0.01). Males contributed for higher number from the total catch for all species than females, and each species had a higher proportion of males from all seasons and habitats, except for *L. zebra* (no captured male).

Table 3 Species richness index (RI) and Simpson's similarity index (SI) of small mammal species in the study area among the habitat types (cumulative for wet and dry seasons)

Species	Species richness index of small mammals from different habitat types				
	NF	BL	GL	FL	SI
Lophuromys	0.82	1.53	2.12	3.1	
Arvicanthis	–	2.41	1.53	1.7	
Stenocephalemys	1.04	1.62	3.35	2.7	
Mastomys natalensis	2.2	2.73	3.35	1.9	
Pelomys harringtoni	1.54	2.41	3.73	–	
Acomys cahirinus	–	3.08	4.33	3.7	
Lemniscomys zebra	–	–	–	0	
Crocidura flavescens	–	0	0	8.7	
Species richness (S)	4	7	7	7	0.48

NF: Natural forest; BL: Bushland; GL: Grassland; FL: Farmland.

Dietary information was obtained from six snap-trapped rodent species, *Lophuromys flavopunctatus* with seventeen specimens, *Arvicanthis dembeensis* with twelve specimens, *Mastomys natalensis* with seven specimens, *Stenocephalemys albipes* with eleven specimens, *Pelomys harringtoni* with twelve specimens and *Acomys cahirinus* with seven specimens, which is presented in Table 4. In the present study, plant matter was seen in the diets of all species. Animal matter in the stomach contents of rodents averaged (7.8±9.7) and plant matter

averaged (12.9±8.2) in all observed species of rodents. The remaining unidentified food items were averaged (5.9±3.9).

Overall, the highest percentage of animal matter was found in the diet of *L. flavopunctatus* during the wet season. However, plant matter, particularly grasses were the major type of food item in the diet of *A. dembeensis. Mastomys natalensis* preferred plant matter the major type of food item in the entire study. Stomach contents of *S. albipes* consisted with highest percentage of grasses, monocot leaves and dicot seeds, which form a major part of their diet during both wet and dry season. A higher percentages of animal matter was found in the diet of *A. cahirinus* during the wet season. Among the species, there was significant variation in types and relative amounts of food items in the stomach sample (χ^2=1262.74, *df*=2, *P*<0.05). Statistically, there was also significant variation in the proportion of food items consumed by the rodents between seasons (χ^2=3.9, *df*=1, *P*<0.05). Statistical test illustrate a significant difference of food items between each species, *L. flavopunctatus* (χ2=83.94, *df*=5, *P*<0.05), *A dembeensis* (χ^2=338.79, *df*=5, *P*<0.05), *M. natalensis* (χ^2=217.6, *df*=5, *P*<0.05), *S. albipes* (χ^2=207.5, df=5, *P*<0.05), *P.harringtoni*(χ^2=273.6, *df*=5, *P*<0.05),*A. Cahirinus* (χ^2=141.3, *df*=5, *P*<0.05).

Table 4 Percentage of food items of six snap-trapped rodent species in the stomach contents collected during wet and dry seasons

Species	Food items (%)									
	Season	Ml	Ms	Dl	Ds	Ro	Gr	E	A	U	H
Lophuromys flavopunctuats	Wet	5	2.5	10.6	5.9	2.9	11.5	30.2	29.8	1.9	*
	Dry	6.5	11.8	5.4	10.8	7.5	9.7	8.6	35.5	4.3	–
Arvicanthis dembeensis	Wet	11.5	10.7	6.1	22.1	3.1	42.7	1.5	–	2.3	–
	Dry	16.3	8.8	8.2	18.4	5.4	36.1	2	0.7	4.1	–
Mastomys natalensis	Wet	16.3	12.5	7.7	28	3.8	10.6	7.7	4.8	8.7	*
	Dry	16	10.6	19.1	25.5	6.4	8.5	4.3	2.1	7.4	–
Stenocephalemys albipes	Wet	9.2	18.3	7.1	12.2	4.1	28.6	5.1	7.1	8.2	*
	Dry	5.3	20	4.2	21.1	6.3	26.3	4.2	3.2	9.5	
Pelomys harringtoni	Wet	17.3	16.7	13.3	23.7	10.3	10.7	–	4	4	*
	Dry	13.8	20	6.2	24.6	3.1	16.9	–	1.5	13.8	–
Acomys cahirinus	Wet	–	–	–	–	–	–	–	–	–	–
	Dry	20.2	16.7	14.3	21.4	6	10.7	–	3.6	7.1	–

Ml: Monocot leaf; Ms: Monocot seed; Dl: Dicot leaf; Ds: Dicot seed; Ro: Root; Gr: Grass; E: Earthworm; A: Arthropods; U: Unrecognized food items; H: Hairs; *: Observed hairs; –: Absence.

DISCUSSION

One interesting result of the present survey was that although the total capture included eight species of small mammals, only 1.1% of all were shrews. The type of traps used (Sherman)—as opposed to pitfall traps—may be one of the key reasons for the capture of low number of shrews. Similarly, Fichet-Calvet et al (2010) only collected a few species of shrews from Upper Guinea. Some other variations are also worth noting. For example, our results show a largely male biased sex ratio, likely attributable to the males traveling over greater distances. Such assumptions are consistent with those made by Hansson (1978), making them more likely to be trapped, as well as results from both Smith et al (1975) & Tilahun et al (2012) who have recorded higher capture frequency of males. Another variation worth noting is that *Lophuromys flavopunctatus* is one of the most common rodents in the moist areas of East Africa (Clausnitzer & Kityo, 2001) and in the Magamba Forest Reserve in Tanzania (Makundi et al, 2007). Here, *Lophuromys flavopunctatus* was commonly captured in all grids, but was predominate in bushland habitat. This distribution may be due to the species' diverse feeding habits, a highly adaptable feature that allows it to inhabit a wide range of habitats.

Seasonal variations were also seen in terms of overall capture numbers. For example, *A. cahirinus* and *L. zebra* were not captured during the wet season, potentially due to the availability of food, or changes in seasonal diet that may include arthropods, seeds and snail in their natural habitat during the wet season, which may limit their capture. This result is not unexpected; studies have shown seasonal variation and availability of food results less trap success (Kronfeld-Schor & Dayan, 1999). This is also consistent with our survey, wherein the rarest rodent species captured area was *L. zebra,* as well as earlier reports (Tadesse & Afework, 2008) in which only few individuals were trapped out of a total captures from Alatish National Park, Ethiopia. Meanwhile, across all habitats, *M. natalensis* was trapped, but was most abundant in the farmland and less abundant in forest, potentially due to the preference for crop fields. Similarly Massawe et al (2005) revealed that agricultural activities increase the abundance of *M. natalensis.*

Overall, more individuals were caught in bushland habitat as compared to the other habitats, likely as a result of the habitat's composition of plants such as, *Pterolobium stellatum*, *Capparis tomentosa* and *Urtica simensis*, which are thorny, and relatively prevent movement of humans and livestock, thereby resulting in more shelter for small mammals. Similarly, food and

adequate cover influence diversity of rodents (Tadesse & Afework, 2008).

The Forest habitat contributed for the least number of small mammals compared to other habitats, likely because the habitat is quite steep as compared to other habitats. This topography directly results in flooding during the wet season, thereby reducing ground cover. Bennett (1990) stated that, clearing and fragmentation of the natural forest vegetation have had a marked impact on the small mammal fauna. The lowest species richness in the natural forest habitat is mostly due to the absence of small mammals typical of other habitats, including *A. dembeensis*, *A. cahirinus*, *L. zebra* and *C. flavescens*. The high species richness and diversity of small mammals in the farmland contradicts with the findings of Aplin & Singleton (2002), who noted that agricultural landscapes are structurally simple and contain relatively low biotic diversity.

The observations made in the current study suggest that breeding of most of the small mammal species in the study area was during the wet season, which is consistent with several earlier investigations (Prakash & Sing, 2001; Tadesse & Afework, 2008) reported that that reproduction is often linked with the rainy season and with the availability of sufficient resources for rearing the young. Moreover, several studies suggest that seasonal variations in weather, particularly rainfall, influences the nutritional aspects, which affects the life strategies of rodents (Makundi et al, 2007). Indeed, Linzey & Kesner (1997) reported that rainfall could indirectly govern reproductive success by affecting the supply of insects.

Stomach content analysis showed a variety of food items consumed by rodents, illustrating both omnivorous and granivorous feeding habits. *Lophuromys flavopunctatus* had more animal matters, consistent with previous reports by Barnett et al (2000). This situation is related to the type of habitat they live in and abundance of prey species in the vicinity. For example, consumption of animal matter was highest during the wet season, potentially due to the formation of a suitably moist environment allowing for an abundance of arthropods and worms, which consistently increase the relative abundance of small mammals during the wet season. Significant differences in consumption of food items were previously observed among rodent species and seasons, such as Ellis et al (1998) in Argentina. Conversely, plant matters were consumed by all species throughout the entire study periods. *Arvicanthis dembeensis* highly preferred grass as a major food item. Workneh et al (2006) from Maynugus irrigation field, northern Ethiopia also revealed similar findings. *Mastomys natalensis* showed a relatively a high percentage of dicot seed in their stomach contents during entire the study period, but it consumed all analyzed food items. According to Massawe et al (2005), opportunistic behavior enables *M. natalensis* to take advantage of changes in habitats, particularly in relation to food resources. During the present study, out of the total species captured, *S. albipes* and *P. harringtoni* were endemics of Ethiopia.

Overall, the present results of our survey indicate that variations in small mammal abundance occurred not only in terms of habitat, but also in terms of season. These results suggest that all analyzed rodent species seem to be near generalists in relation to diet composition, containing both animal and plant materials.

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